Transactions of the North American Osprey Research Conference

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College of William and Mary, Williamsburg, Virginia
10-12 February 1972

EDITED BY JOHN C. OGDEN

U.S. DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE

TRANSACTIONS AND PROCEEDINGS SERIES NUMBER TWO — 1977

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Library of Congress Cataloging in Publication Data

North American Osprey Research Conference, College of William and Mary, 1972.

Transactions of the North American Osprey Research Conference, College of William and Mary, Williamsburg, Virginia, 10-12 February, 1972.

(Proceedings and transactions—National Park Service; no. 2)

Includes bibliographies and index.

1. Ospreys—Congresses. 2. Rare birds—Congresses. 3. Birds—North America—Congresses. I. Ogden, John C., 1938- II. Series: United States. National Park Service. Proceedings and transactions—National Park Service; no. 2.

QL696.F36N67 1972 598.9'1 77-3638

Acknowledgments

Papers presented at the North American Osprey Conference passed through several hands en route to publication, therefore the time and talents of a small host of people contributed to these published proceedings. Clearly deserving of special acknowledgment are four regional representatives who collected the conference papers and assisted in various degrees with early stages of editing. These are, Gilbert Fernandez, Mitchell A. Byrd, Sergej Postupalsky, and James A. Koplin. The papers then passed through several editings in preparation for publication by the National Park Service. Special thanks go to Robert M. Linn, former Chief Scientist for the National Park Service, who approved publication of these proceedings, and to Jean Matthews, writer/editor for the NPS, who persevered with the manuscript through final publication.

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Preface

The Osprey (*Pandion haliaetus*) is one of several raptorial species in North America which has experienced a substantial decline in numbers in the past 25 years to the point where some populations, especially those in the northeastern United States, are faced with possible extinction. Prompted by this fact, a number of workers now are engaged in research on this species.

Although several research conferences on raptors have been held in recent years, none has been devoted solely to the Osprey. It was felt by many that the current status of research on Ospreys was such that a conference to exchange ideas among people working with the species would be most beneficial.

An invitation was extended by the Department of Biology, College of William and Mary in Williamsburg, Virginia, to hold the conference at that institution 10-12 February 1972. Organizers of the conference were Mitchell A. Byrd, College of William and Mary; John C. Ogden, Everglades National Park; and Robert S. Kennedy, Louisiana State University. A total of 75 persons registered for the meeting, with numerous other persons attending parts of the sessions.

Three sessions of formal papers and three discussion groups were held during the course of the conference. Twenty-six papers were presented at the conference and several additional papers were submitted but not read. The majority of the papers dealt with the present population status of the species in various regions of the United States, Canada, and Mexico. Other papers dealt with research techniques, the effects of environmental contaminants on Osprey productivity, and various other aspects of the biology of the species. The papers presented in this volume constitute the record of these transactions.

The first of the discussion groups, with John C. Ogden as chairman, dealt with the regional and continental status of the Osprey. It was concluded from this discussion that a report on the present continental status of the species would be highly desirable in the near future as more data became available from different parts of the country.

The second discussion group, chaired by Paul Spitzer, dealt with an evaluation of present and future techniques of Osprey research. Consideration was given to methods of pesticide analysis, the role of trapping and color-banding, and the use of such techniques as egg and young manipulation and the induction of second clutches.

The third discussion group, led by Stanley N. Wiemeyer, dealt with the role of environmental contaminants on Osprey reproduction. One of the major points which emerged from this discussion was the feeling that some consistency should be achieved in the future in reporting pesticide and polychlorinated biphenyl levels.

It was pointed out at the conference that the Osprey will receive Federal protection as a result of the Migratory Bird Treaty between the United States and Mexico in 1972. It was felt that an American Osprey Committee could effectively function in drawing up a report on the current status of the Osprey in this country and that such a committee might also serve in an advisory capacity to the Bureau of Sport Fisheries and Wildlife with respect to future work on this species. The committee was elected at the conference and the regional representatives are as follows: Chesapeake Bay Region—Mitchell A. Byrd, College of William and Mary, Williamsburg, Virginia; Southeastern States— John C. Ogden, Everglades National Park, Homestead, Florida; Northeastern States—Gilbert Fernandez, Dartmouth, Massachusetts; Great Lakes Region—Sergej Postupalsky, University of Wisconsin, Madison; and Western States—James Koplin, Humboldt State University, Arcata, California.

The consensus of those in attendance at the conference and of the members of the elected Osprey Committee was that a second conference should be organized at some future date in order to evaluate further the status of the species.

MITCHELL A. BYRD

February 1972

Contents

A Critical Review of Problems in Calculating Osprey Reproductive Success

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Abstract: This paper stresses the need for a minimum of two checks of each occupied nest per breeding season in Osprey population studies in northern temperate regions. The first check, made during early incubation, is needed to count the territorial population, and the second, taken just prior to the time young are due to fledge, is needed to count the number of young raised. Both are required for calculation of reproductive success of the population. The shortcomings inherent in some other methods and the resulting biases are discussed. A standard terminology for describing the status of nests and territories and standard criteria for calculating reproductive success are proposed. Productivity of the population should be calculated on the basis of the total of all territorial pairs, including the nonbreeders, because in raptor populations adult pairs may refrain from breeding in some years, under a variety of conditions.

Concern about decreasing numbers of many raptors in recent years has stimulated numerous local and regional studies of breeding populations of these birds. These investigations range from quick sample counts and inventories of breeding pairs to intensive research into various factors influencing reproductive success and survival rates. The reports presented at this conference offer a representative cross section of the wide range of investigations now underway. The studies of breeding populations and their reproductive success, unfortunately, are often very difficult to correlate because of different methods of censusing, different criteria of evaluation, and different, often vague, terminologies employed by various workers in reporting their findings. Even in studies of the same species, such as the Osprey, the methods used may ultimately be determined by the type and accessibility of habitat, problems of logistics, time and resources available to the investigator, and perhaps by other considerations. Nevertheless, it should be possible to establish some uniform criteria and terminology for the evaluation and presentation of population and reproduction data so that meaningful comparisons with the results of other similar studies done elsewhere would ensue. The present paper is a revision and expansion of a previous manuscript which was circulated to interested raptor workers. It includes a discussion of some of the problems encountered in studies of breeding populations of Ospreys, a critique of some currently used methods, and a proposal for standardized criteria and terminology that could be used to compare different extensive studies with each other and with more detailed studies as well.

GENERAL METHODS AND TIMING

A minimum of two visits is required to each occupied nest during each breeding season. The purpose of the first check, made in early spring, is to locate nests and to determine if they are being used by nesting birds. The time of the first visit is chosen when all pairs are either incubating or are about to lay eggs. For populations which are suspected to be suffering from the thin-eggshell syndrome which leads to increased frequency of egg breakage and nest abandonment (Ratcliffe 1967, 1970; Hickey and Anderson 1968), it is recommended that the first check be made as early during the incubation period as possible.

The purpose of the second visit, made later in the breeding season, is to determine the number of young raised. It is best to count the young late in the season when they are large enough to be seen at a distance, but not too late for them to have left the nest. This timing will also minimize errors due to nestlings dying prior to fledging. The best time is just prior to the earliest known fledging dates for the particular region.

It follows that the investigator must be familiar with the phenology of the Ospreys' breeding cycle and must know the dates when the principal events of the cycle, such as arrival on the breeding grounds, egg-laying, hatching, and first flights of the young, occur in the study area, and visits must be timed accordingly.

I cannot stress sufficiently the importance of the early nest checks. Pairs which fail to produce young for one reason or another may leave their breeding territory, or at least not be in constant attendance at the nest. Thus they may be missed during the late surveys. While it is sometimes possible to determine the status of an empty, unattended nest in summer on the basis of presence or absence of droppings under it, and/or fresh sticks or other fresh nesting material on top, this method is by no means foolproof. Such evidence can usually show recent occupancy of a nest; its lack, however, does not necessarily prove that a nest is unoccupied that year. Heavy rains can wash off droppings, and the amount of new nesting material added may be but minimal. Also, droppings alone tell little about the number of adults present. Because the omission of a number of unproductive pairs from a census by considering their nests as "unoccupied" would seriously bias calculations of reproductive success, a spring check during early incubation is essential.

Some workers try to circumvent the need for the minimal two nest checks by various attempts to relate the observed production of young with what they conceive as the total number of available breeding territories. In absence of the early check, they lack a count of occupied nests (= number of territorial pairs; see next section for definitions), and so they try to relate the count of productive nests (defined below) to the total number of known nests, which includes unknown proportions of unoccupied, occupied earlier in the season and already deserted, and still occupied nests. This procedure may work reasonably well for cliff nesters, such as some Peregrine Falcon (*Falco peregrinus*) populations, for which the number of breeding sites is limited to the number of available cliffs with suitable ledges. While cliff sites tend to be permanent, tree sites tend to be much less so. Osprey nests are particularly transitory because they are built on top of dead or dying trees. Breeding territories, then, are recognizable by the presence of a single nest structure or by several alternate nests belonging to a single pair. But, because of the lack of permanence of tree sites, the counts of territories identified in this fashion are subject to the vagaries of weather and the decaying process of wood, phenomena which bear no relation to population trends. Let us look at a hypothetical example of possible faulty conclusions.

An investigator makes a nest count in summer and from the number and distribution of nest structures estimates 100 recognizable breeding territories in his study area. Forty of these contain one or more young. He then reports that 40% of the known territories are productive. What he does not know is that only, say, 75 of the territories were occupied in spring (i.e., there were 75 pairs). Now, assume that the following winter is characterized by vicious gales and many of the nests are blown down. In spring some, but not all, are rebuilt. Our friend returns in summer and counts 80 nests. Of these again 40 contain young and he reports that 50% of the territories are productive. His report implies an improvement in reproductive success, while in reality it has remained the same, if there are again 75 pairs (which, of course, he does not know because he wasn't there to count them).

Let me stress here that the two-visit survey is minimal for reasonably close calculations of reproductive success, although much better and more accurate data can be obtained through more frequent visits. I have been amused by several recent reports whose authors first cited my earlier paper on the need for a two-visit survey, and then spent the remainder of a paragraph explaining why they chose to check the nests in their study areas more frequently. My purpose here is not to discourage studies involving more frequent nest checks, but rather to warn my colleagues of some of the pitfalls of trying to make far-reaching conclusions about reproductive rates and population trends from single surveys late in the breeding season. In short, the first check is needed to count the breeding population, the second is needed to count the young raised; both are needed to calculate reproductive success of the population.

The two-visit surveys have been working out adequately in northern regions, such as the Great Lakes area and Canada, where nesting in all pairs occurs more or less synchronously. As one proceeds farther south, however, this method becomes less and less adequate because individual pairs may differ by many weeks in initiation of breeding activity. Thus in a given area one pair of Ospreys may be feeding large young, while its neighbors may still be incubating (Ogden 1970, and this conference). More frequent visits are needed under such circumstances to obtain a full census of breeding pairs and to determine the reproductive success of the population.

TERMINOLOGY

Clear definitions of terms used in describing the status of nests and an explanation of how these are subsequently used are essential. While perusing papers and progress reports of inventories of raptor populations and their reproductive success, one soon becomes aware of an urgent need for some uniform system of terminology and presentation of findings. This lack of standardization in reporting population and nest-success data may lead to ambiguities and often makes meaningful comparison of the data of different workers all but impossible.

Nest and Territory

The distinction between nest and breeding territory must not be overlooked. A nest is a structure; a territory, for our purposes here, is an area occupied by one mated pair of Ospreys during the breeding season and it contains one or more nest structures. A failure to make this distinction may give a false impression of population trends. For example, a report that 40 "active" and 60 "inactive" nests were found in a given study area might be taken to imply a recent sharp decline in the numbers of breeding Ospreys in the area. Such misunderstandings may result from an author's failure to state clearly that some pairs of Ospreys may have more than one nest, and that therefore at least some of the "inactive" nests reported in reality represent second and third nests of extant pairs rather than abandoned territories with no birds. While all this may be common knowledge to raptor workers, let us bear in mind that our reports may (hopefully) be used by natural resources managers, who themselves may not be too well acquainted with raptor behavior. The total number of nest structures present may be of limited interest in a population study (although it may be important for protective management purposes); it is the number of breeding territories which is important.

But how does one identify which nest structure belongs to which territory? In areas where the Osprey population is sparse, with but one pair per lake or per swamp, this is not too difficult. Alternate nests (defined below) within one territory usually are situated more or less close together: in adjacent trees or snags, in the same stand, or near the same small body of water. It is in aggregations of breeding pairs, such as we find on some reservoirs, where several pairs may be nesting within 100 yards of each other, that the assignment of nests to territories becomes difficult. Here again, the early nest check helps. Long-term studies over several breeding seasons may ultimately reveal which nest belongs to which pair. But let us not spend too much time and effort pondering about the ownership of a few of these supernumerary nests. It does not really matter much whether a given empty nest, situated halfway between two occupied nests, belongs to the one or the other pair; what is more important is whether it is the nest of yet a third pair which has since disappeared and therefore indicates a recent decline in the population. Unless you were there in previous years, or have a reliable report, you may never learn the answer to that question, and no amount of fancy statistical manipulation of your nest-count data will tell you. Some investigators try to use the proportion of occupied nests to the total number of nests known as an index to population trends. I distrust such conclusions for reasons discussed in the preceding section: one good windstorm can wipe out a large number of nests; and if each pair rebuilds, we would find a greater proportion of occupied nests, and fewer nests per territory in the following year; and these changes would bear no relation to population changes.

Definitions

The terms relating to status of nests and breeding territories are defined as follows.

Nest or eyrie: a structure built by the birds for purposes of breeding.

Breeding territory: for the purposes of Osprey population studies this is defined as an area containing one or more nest structures within the home range of one mated pair of birds. Such nests were presumably built by the same pair (or its predecessors) and are typically situated more or less close together and farther from nests of other pairs.

Occupied nest: any nest at which at least one of the following activity patterns was observed during a given breeding season:

a. Young were raised;
b. Eggs were laid;
c. One adult observed sitting low in the nest, presumably incubating;
d. Two adults present on or near the nest, regardless of whether or not it had

been repaired during the season under consideration, provided there is no reason to suspect that this pair had already been counted elsewhere;

e. One adult and one bird in immature plumage at or near a nest, if mating behavior (display flights, nest repair, coition) was observed. This category is not applicable to Ospreys because immatures are indistinguishable in the field, and one-year-old Ospreys do not return to the breeding areas anyway (Österlöf 1951; Henny and Wight 1969); it is included here because of its theoretical possibility;

f. A recently repaired nest with fresh sticks (clean breaks), or fresh boughs on top, and/or droppings and/or molted feathers on its rim or underneath. Such evidence is acceptable especially late in the season in cases where no earlier check was made. Frustration nests (defined below) should be excluded if the original nest is counted, or vice versa.

All of the above observations indicate the known or inferred presence of one mated pair of Ospreys associated with a nest. Usually, I do not recognize the following observations as sufficient evidence for an occupied nest:

g. One adult near an empty, unrepaired nest;

h. Two adults seen together during the breeding season with no known nest. Such a pair may be included in a population count, but probably should not be used in calculations of reproductive success, unless one has reasons to believe that this pair's nest may have been overlooked.

Occupied breeding territory: consists of one occupied nest and may also include one or more alternate nests (defined below). Since, by definition, there can be only one occupied nest per occupied territory, these two terms can be used synonymously in censuses of breeding populations and in calculations of reproductive success.

Unoccupied breeding territory: a nest or group of alternate nests at which none of the activity patterns diagnostic of an occupied nest were observed in a given breeding season.

Active nest or active breeding territory: a nest in which eggs have been laid. This category is more restrictive than occupied nest and should be used only in studies where sufficient early observations have been made to determine for each nest whether or not eggs have been laid. In short, this category excludes nonnesting territorial pairs (called "housekeepers" by some) and subadults (2-year-old Ospreys?) which may go through the early motions of nest-building and mating but without laying eggs. Activity patterns (a), (b), and, in most cases (c) above are signs of an active nest.

Productive or successful nest: an occupied nest from which at least one young fledged during the breeding season under consideration, or, if actual fledging was not proven, an occupied nest in which at least one young was raised to an advanced stage of development (i.e., near fledging age).

Unproductive, unsuccessful nest, or **nest failure:** an occupied nest from which no young fledged due to any cause:

a. No eggs were laid;
b. Eggs were destroyed or otherwise lost;
c. Eggs failed to hatch (due to infertility, embryonic death, or abnormal development);
d. Young hatched, but are known to have died prior to fledging.

One should also distinguish between what might be called "natural mortality" of nestlings and "unnatural or accidental mortality." The latter category would include deaths due to direct human intervention, such as shooting, disturbance, or removal of young (from nests on channel markers, for example; see Reese 1970), and also deaths due to accidents, such as the crash of a nest. These and similar instances should be noted either in the text of the report or in footnotes to tables. This information may be needed to identify pairs capable of reproduction which may be singled out for special management measures designed for their protection.

Alternate nest: one of several nest structures within the breeding territory of one pair of birds, including frustration nests (defined below). Alternate nests may be on adjacent trees or stubs, or in absence of suitable support nearby, as much as a mile or more apart.

Frustration nest: an alternate nest built, repaired, or frequented by a pair of birds subsequent to a nesting failure at another nest during the same breeding season. The habit of building frustration nests is well known in the Osprey. After failing to rear young in its original nest, a pair may build a new nest later in the season, but as a rule, will not relay in it, this undoubtedly due to the advanced season. The term frustration nest then describes a special case of alternate nest. No implication relative to the psychological state of the birds is intended. The following year the Ospreys may use the frustration nest or their old nest.

Under certain circumstances, Ospreys may be seen at more than one nest within their breeding territory during the course of a single breeding season. In addition to the phenomenon of frustration nests described above, a pair may inspect one structure just prior to laying, and then nest in another structure nearby. In such instances only one nest should be considered as occupied. Obviously, it is important to consider this habit if errors due to counting the same pair twice are to be avoided.

This classification of nests and breeding territories has proven useful in extensive Osprey population studies in which but brief and infrequent visits are made during each breeding season. It is applicable to studies of other raptors also.

REPRODUCTIVE SUCCESS

The term "nesting success" as understood by most ornithologists refers to the percentage of eggs laid which develop into fledging young. In this sense it is not very useful in such extensive studies as some of the Osprey surveys because the number of eggs laid often remains undetermined. Due to this lack of clutch-size data, other criteria must be used to evaluate reproductive success.

1. The proportion of occupied breeding territories (for which the outcome of nesting is known) which produce at least one young to an advanced stage of development. This statistic, expressed as a percentage, may be referred to as percent occupied nests producing young, or, more briefly, as percent nest success, or simply, nest success.

2. The mean brood size (of large young or at fledging), expressed as the number of young per productive nest.

3. The productivity of the population, expressed as the number of (fledging or large) young per occupied nest with known outcome, is equivalent to the number of young produced per territorial pair and describes the annual production relative to the size of the population of potential breeders; it is the reproductive rate. Productivity, as defined here, is the product of nest success and mean brood size and is an important datum in population dynamics.

Recently, Henny and Van Velzen (1972) recommended that reproductive success should be calculated on the basis of active nests only, thus excluding from consideration pairs which do not lay eggs, the so-called "housekeepers." They further suggest that the nonbreeding segment of the territorial population may be identical to the subadult (2-year-old) segment. I disagree and maintain that reproductive success should be computed from occupied nests, that is, the entire territorial population of potential breeders, a view also expressed by Hickey (1969:28). My reasons follow.

1. The suggestion that the nonbreeding pairs are identical to the subadult (2-year-old) cohort has not been proven, and is almost certainly false. Granted that an unknown proportion of these "housekeepers" may well consist of subadults, I find the inherent implication that all adult Ospreys breed hard to accept. Failure to lay eggs is a response to environmental conditions which are less conducive to breeding, and therefore should be considered as another type of nest failure. In temperate regions, undisturbed raptor populations tend to remain stationary from year to year (Wendland 1953; Craighead and Craighead 1956; Hickey 1969:29-32), and may respond to changing prey availability by variable proportions of breeding attempts (Southern 1959; Rusch et al. 1972). Weather conditions at the onset of the breeding season may also depress the proportion of pairs which initiate a clutch. A sizable non-

breeding cohort of adults has been reported in population studies of species in which immatures can be identified readily in the field: the Red-tailed Hawk (*Buteo jamaicensis*) (Orians and Kuhlman 1956; Craighead and Craighead 1956; Hagar 1957; Luttich et al. 1971), and the Bald Eagle (*Haliaeetus leucocephalus*) (Postupalsky unpubl. data).

2. The possibility that organochlorine pesticides may be involved in an increased incidence of nonbreeding in raptors, as observed in the Golden Eagle (*Aquila chrysaetos*) by Lockie and Ratcliffe (1964), is another case for considering nonlaying pairs in calculations of reproductive success. Reduced egg production has been reported in several controlled studies with gallinaceous birds involving dosage with organochlorines, PCB's, and mercury (Genelly and Rudd 1956; Baxter et al. 1969; Dahlgren et al. 1972; Bitman et al. 1972; Fimreite 1971). To omit and ignore pairs which fail to lay eggs in field studies of toxic-chemical effects on reproduction would prejudice one's results.

3. In most of the extensive surveys based only on the minimum of two visits per nest, the exact total of pairs actually producing eggs cannot be determined. The only datum available is the number of occupied nests, a more inclusive quantity than the number of active nests. To insist that all reproductive-success determinations be based on active nests only would invalidate the results of most, if not all, extensive surveys done to date. Often these are the only practical studies that can be achieved with the available resources.

While I agree with Henny and Van Velzen (1972) that ideally the "half-hearted" nesting attempts of subadult Ospreys should be excluded from calculations of reproductive success, I submit that a substantial proportion of the observed "housekeepers" are adults. Unfortunately, subadult Ospreys cannot be identified in the field. This problem emphasizes the need for more information on the behavior of 2-year-old Ospreys and on the age at which Ospreys breed for the first time. This could be accomplished by color-banding large numbers of nestlings a different color each year to identify year-classes. There is no reason to believe that all Ospreys start to breed at the same age. In the White Stork (*Ciconia ciconia*), for example, a few individuals first nest when 3 years old, most do so at ages 4 and 5, while a few may not breed until 6 years of age (various authors, reviewed by Lack 1966). From my own studies to date, I cannot show conclusively that 2-year-old Ospreys of either sex breed, but I know that some 3-year-olds do (successfully), and have one record suggesting that some may not breed until age 5. For life-equation calculations we need to know at what age most Ospreys start to breed. In the meantime, in the absence of more conclusive data, we have to assume that this occurs at age 3.

Let me emphasize that the methods, criteria, and terminology outlined in this paper are not to be viewed as a straight-jacket into which all data are to be forced. Rather they should serve as a conceptual framework into which most data can be organized. Obviously, not all observations will fit the categories listed. The latter can be further subdivided and added to. We may regard the results of the minimal two-visit survey, relating the ultimate total production of young to the number of territorial pairs, as a bare skeleton upon which the "meat" obtained on additional visits can be attached. Regardless of how detailed your study (the amount of "meat"), the basic information (the "skeleton") should be in a form to make it comparable to all similar studies of the Osprey and other raptors. Additional data of considerable interest in studies of reproductive success include: the proportion of non-breeding pairs in the population; total number of eggs laid; mean clutch size; number (and percent) of eggs hatched; number (and percent) of nests in which eggs hatched; number (and percent) of eggs lost to any given cause; number (and percent) of young actually fledged (expressed relative to the number hatched and to the number of eggs laid); and mortality at different stages of the breeding cycle. Territories attended by single adults should also be recorded. Their frequency and the time it takes to replace lost mates may permit us to make inferences about recruitment rates and the status of a population.

A combination of an extensive survey covering a large area, such as an entire state, province, or district, with an intensive study of one or more small sample areas, such as a single county, reservoir, lake, or group of lakes, may well be the best way of handling studies of reproductive success of the Osprey over much of the range of this species.

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Acknowledgments: The methods, criteria, and terminology discussed in this paper have been gradually developed during my long-term study of the Bald Eagle and Osprey populations in Michigan and Ontario, made possible by funds from the National Audubon Society, the Canadian Wildlife Service, and Conservation for Survival, Inc. I wish to thank O. S. Pettingill, Jr., A. Sprunt, IV, and J. J. Hickey for critical advice and encouragement. The following colleagues offered comments and constructive criticism on an earlier version of this paper: J. H. Enderson, J. M. Gerrard, J. R. Koplin, W. C. Krantz, J. G. Reese, C. R. Sindelar, Jr., and A. Sprunt, IV. The responsibility for the content of this paper, however, is mine alone.

Eggshell Thickness-Pollutant Relationships Among North American Ospreys

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Abstract: Nonparametric statistics are used to examine the relationships among the shell thicknesses of 47 Osprey eggs from several North American localities and concentrations of pollutants measured in the eggs. Negative correlations were found between shell thickness and DDE, PCB, and mercury; the best correlation was that with DDE. PCB and DDE concentrations were highest in the northeastern United States, lowest in the Gulf of California.

The Osprey (*Pandion haliaetus*) was among the first species of fish-eating and raptorial birds in North America to show indications of a regional pattern of eggshell-thinning in local populations (Hickey and Anderson 1968; Anderson and Hickey 1972). Field studies of Osprey populations have documented low reproduction in several areas, principally in the Northeast (Ames and Mersereau 1964; Ames 1966; Spitzer this symposium; Puleston this symposium). The first of these studies, begun in 1957, was carried out by Ames in a colony of Ospreys near the mouth of the Connecticut River. The rate of fledgling production was found to be very low, a result of a combination of poor hatching success and disappearance of eggs during incubation (Ames and Mersereau 1964; Ames 1966).

In this paper we examine the shell-thinning of Opsrey eggs from Massachusetts, Connecticut, Long Island, New Jersey, Wisconsin, the Lake

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of the Woods area, and Baja California, in order to determine whether the thinning can be related to the concentrations of one or more pollutants in the eggs. A number of the eggs contained dead embryos; we are currently examining the relationships between the embryonic mortality and both the degree of shell-thinning and the concentrations of the pollutants measured. We intend to report the results of these analyses at a later time.

MATERIALS AND METHODS

Eggs were obtained from Massachusetts, Gardiner's Island in New York, Connecticut, and New Jersey in 1969 and 1970 by P. R. Spitzer; from Wisconsin in 1969 by C. R. Sindelar; from Lake of the Woods, Ontario, in 1971 by J. W. Grier, C. R. Sindelar, and D. L. Evans; from western Baja California in 1969 and 1970 by J. R. Jehl; from the Gulf of California in 1968 by R. W. Risebrough; and from the Gulf of California in 1971 by D. W. Anderson. Eggs from Massachusetts, Gardiner's Island, Connecticut, New Jersey, Wisconsin, western Baja California, and the Gulf of California (1968) were analyzed for the organochlorine compounds in the laboratory of the Institute of Marine Resources, University of California, Berkeley, with methods described in Risebrough et al. (1970). The eggs from the Lake of the Woods were analyzed in the laboratory of the Ontario Research Foundation (ORF) by Lincoln M. Reynolds; the methods used for the organochlorine compounds are described by Vermeer and Reynolds (1970). The eggs obtained in 1971 in the Gulf of California were analyzed in the Denver laboratory of the U.S. Bureau of Sport Fisheries and Wildlife (D. W. Anderson pers. comm.). Mercury concentrations in the eggs from Lake of the Woods were determined in the ORF laboratory by flameless atomic absorption spectrophotometry as described by Vermeer (1971). Mercury concentrations in eggs from Massachusetts, Gardiner's Island, Connecticut, and New Jersey were measured with neutron activation as described in Faber et al. (1972). Eggshell thicknesses were determined by methods described by Anderson and Hickey (1970). Dieldrin and endrin were confirmed by the method of Wiencke and Burke (1969).

Since we compared, in the present study, the shell thicknesses of Osprey eggs from widely separated areas, it was necessary to consider also the geographical variation in shell thickness of eggs that were obtained prior to thinning associated with environmental pollutants. Osprey eggs that were collected before 1945 and are now preserved in museums show shell thickness indices which are essentially identical over the continent (D. W. Anderson pers. comm.). They also show no indication of the shell-thinning characteristic of contemporary populations.

Relationships among the variables are expressed in terms of the nonparametric Spearman's rank correlation coefficient, r_s (Siegel 1956). This test requires no assumption on the nature of the distributions of the respective variables, and in its present application yields a probability level that decreasing shell thicknesses are or are not associated with increasing concentrations of each pollutant. Our total sample size exceeded that normally tabulated, so r_s values were converted to t values for obtaining significance (Siegel 1956).

Since the percentage of lipid in the eggs can be expected to change somewhat during incubation, expression of DDE concentrations in terms of the dry weight of total egg contents would have been preferable to those expressed here in terms of lipid concentrations. Dry weight concentrations, however, were not determined in all of the present series of samples, necessitating therefore the use of the lipid weight basis. A Spearman's rank correlation coefficient was also determined between shell thickness and DDE concentrations in the lipids of those eggs which were fresh when collected.

RESULTS

PCB concentrations (Table 1) are exceptionally high in some of the eggs. The eggs from Massachusetts, Gardiner's Island, and Connecticut and two of the eggs from Lake of the Woods contained levels that are among the highest recorded in North American birds. DDE concentrations (Table 1) were highest in the eggs from Gardiner's Island, Connecticut, and New Jersey. One clutch of eggs from the San Benitos Islands of western Baja California shows moderately high DDE and PCB residues, reflecting the high levels of contamination in the waters to the north (Risebrough 1972), but the residues of both DDE and PCB in Osprey eggs from the Gulf of California are considerably lower than those we have measured elsewhere in North America. Correlation analysis shows a strong relationship between DDE and PCB (Table 2). Thus eggs with high DDE concentrations also tend to have high concentrations of PCB. We were not able to demonstrate any correlation between DDE concentrations on a lipid basis and mercury concentrations on a wet basis in those eggs measured for both (Table 2).

The correlation between thickness and DDE, PCB, or mercury is significant but is greatest for DDE (Table 2). When the fresh, newly laid eggs are considered alone, shell thickness also shows a significant decrease with increasing DDE concentrations. No relationship was found between thickness and dieldrin. A negative correlation was found between thickness and endrin concentrations, but endrin concentrations were comparatively low (Table 1) and we do not attach biological significance to this relationship at this time.

TABLE 1. Shell thickness and pollutant concentrations in Osprey eggs.

Locality	Analysis number, date		Thickness mm	DDE	Total DDT	PCB	Dieldrin	Endrin	Mercury
				ppm lipid weight					ppm wet wt
Massachusetts	(K16)	1969	0.42	121	121	1012	3.4	0.00	NM
	(K18)	1969	0.48	188	213	606	2.9	0.00	NM
	(2P)	1970	0.42	243	279	1300	5.9	0.06	0.305
	(7P)	1970	0.45	222	274	1280	15.6	0.08	NM
	(17P)	1970	0.47	92	109	545	1.0	0.03	0.351
	(K19)	1969	0.44	229	283	1405	5.4	0.06	NM
Gardiner's Island	(G1)	1970	0.41	276	322	1310	4.2	0.05	NM
	(B1)	1970	0.44	534	650	613	5.1	0.50	NM
	(HP7)	1969	0.43	330	371	660	3.6	0.04	NM
	(Q)	1970	0.36	472	582	997	6.0	0.05	NM
	(HP10)	1970	NM	NM	NM	NM	NM	NM	0.159
	(Umb)	1969	NM	NM	NM	NM	NM	NM	0.205
Connecticut	(SW)	1970	0.33	521	610	2270	7.9	0.16	0.311
	(EW)	1970	0.46	465	491	1405	5.0	0.03	NM
	(SG)	1970	0.39	385	413	1590	4.7	0.06	0.27
New Jersey	(2)	1970	0.35	329	378	447	1.4	0.17	NM
	(3)	1970	0.44	390	433	545	1.3	0.11	0.290
	(10)	1970	NM	725	864	686	6.2	0.27	NM
	(21)	1970	NM	525	617	582	4.5	0.32	NM
	(26P)	1970	0.41	259	300	188	1.7	0.09	NM
	(20)	1970	NM	NM	NM	NM	NM	NM	0.139

Wisconsin	(RF10)	1969	0.39	118	131	138	NM	NM	NM
	(FF6)	1969	0.42	56	64	98	NM	NM	NM
	(FF10)	1969	0.45	59	70	31	NM	NM	NM
	(RF15)	1969	0.44	119	141	120	NM	NM	NM
	(SA1)	1969	0.40	127	144	109	NM	NM	NM
	(RF5)	1969	0.42	257	274	37	NM	NM	NM
	(On)	1969	0.40	101	109	72	NM	NM	NM
Lake of the Woods	(275)	1971	0.49	145	186	2661	1.8	0.00	0.06
	(276)	1971	0.53	72	77	42	0.4	0.00	0.07
	(277)	1971	0.51	150	163	16	0.6	0.00	0.23
	(279)	1971	0.48	122	128	1042	2.5	0.00	0.08
	(281)	1971	0.47	61	68	46	1.1	0.00	0.14
	(282)	1971	0.61	156	185	116	5.5	0.00	0.12
	(283)	1971	0.43	146	153	157	2.5	0.00	0.10

TABLE 1 (*continued*). Shell thickness and pollutant concentrations in Osprey eggs.

Locality	Analysis number, date		Thickness mm	DDE	Total DDT	PCB
				ppm lipid		
Western Baja California						
Scammons Lagoon	(2257)	1970	0.56	5	5	6
Scammons Lagoon	(2258)	1970	0.47	32	33	34
Scammons Lagoon	(2259a)	1970	0.58	22	23	36
Scammons Lagoon	(2259b)	1970	0.48	13	14	22
Scammons Lagoon	(2259c)	1970	0.58	10	10	22
San Benitos	(2262a)	1969	0.43	211	215	104
San Benitos	(2262b)	1969	0.45	311	316	104
Gulf of California						
Isla Ventana	(1)	1968	0.51	22	24	2.8
Isla Ventana	(2)	1968	0.52	12	15	1.5
Cardinosa	(6)	1968	0.41	50	55	5.6
Gulf of California						
	(03)	1971	0.49	52		
	(23)	1971	0.59	60		
	(24)	1971	0.53	37		
	(29)	1971	0.45	44		
	(59)	1971	0.49	166		
	(92)	1971	0.45	151		
	(115)	1971	0.48	63		

NM: Not measured.

TABLE 2. Relationships among pollutant concentrations[a] in Osprey eggs and eggshell thicknesses.

	N	Coefficient	t	P
PCB vs. DDE	40	$r_s = +0.72$	6.4	<0.001
Mercury, ppm wet vs. DDE, ppm lipid	12	$r_s = +0.49$	1.8	>0.05
Thickness vs. DDE	47	$r_s = -0.59$	4.9	<0.001
Thickness vs. DDE in fresh eggs	13	$r_s = -0.70$	3.3	<0.01
Thickness vs. PCB	40	$r_s = -0.44$	3.1	<0.001
Thickness vs. Dieldrin	23	$r_s = -0.39$	1.9	>0.05
Thickness vs. Endrin	23	$r_s = -0.68$	4.2	<0.001
Thickness vs. Mercury, ppm wet wt.	12	$r_s = -0.61$	2.4	<0.05

[a]Lipid weight concentrations unless otherwise indicated.

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Acknowledgments: The research was supported by National Science Foundation grant GB 11649 to the Institute of Marine Resources, University of California, Berkeley, by the Canadian Wildlife Service, by the National Audubon Society, and by the U.S. Bureau of Sport Fisheries and Wildlife through data kindly provided by Dr. D. W. Anderson. We thank D. L. Evans, Gilbert and Josephine Fernandez, and J. R. Jehl for assistance in obtaining specimens.

Migration Patterns and Wintering Localities of American Ospreys[1]

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Abstract: North American Ospreys (*Pandion haliaetus carolinensis*), banded primarily in the Middle Atlantic States and New England, apparently migrate to their winter grounds in the West Indies and South America on a broad front. Ospreys do not return to the United States as 1-year-olds, but an estimated 28-55% return to their natal vicinity (state where hatched or an adjacent state) as 2-year-olds. The 2-year-olds (presumably nonbreeders) are estimated to represent 5-10% of the population on the northern breeding grounds. Nest studies suggest that about 6% of the population on the breeding grounds consists of nonbreeders (presumably the 2-year-olds). These birds are associated with nests but do not lay eggs or exhibit brooding behavior. In conducting nest studies on Ospreys, nests should not be classified as active if eggs are not laid, even though a pair is present. If nests with no eggs are excluded from studies, we believe the observed recruitment rates can be compared validly with the recruitment standard (production rate required to maintain a stable population) of Henny and Wight (1969).

The purpose of this paper is to discuss migration routes, winter areas, and the location of nonbreeding American Ospreys during the nesting season. The distribution of recoveries from Ospreys banded in New York, New Jersey, and Delaware was previously discussed by Worth (1934, 1936) and Gillespie (1960). Gillespie presented recoveries from her husband's 16 seasons (1926-41) of banding in Cape May County, New Jersey, and in Delaware. She speculated about the age at sexual maturity (possibly 3 years) and posed a question about the 2-year-old Osprey reported south of its natal area (in North Carolina) in July. Henny and Wight (1969) analyzed the recoveries from Ospreys banded in New York and New Jersey as nestlings through 1961. They indicated that Ospreys did not return to the United States to nest as 1-year-olds but that some returned north to their natal area as 2-year-olds. A similar

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conclusion was reached for Swedish Ospreys (*Pandion h. haliaetus*) by Österlöf (1951).

This paper attempts to refine the earlier descriptions of migration routes and winter areas of Ospreys produced in New York, New Jersey, and Delaware, and to discuss for the first time, the migratory habits of birds produced in Maryland, Wisconsin, and Michigan. A few recoveries are also available from bandings in Virginia, Maine, Connecticut, Ontario, Saskatchewan, Montana, and California. The primary function of this paper, however, is to discuss the location of the 2-year-old segment of the population during the nesting season, and to discuss the effects of the 2-year-old birds (presumably nonbreeders) on studies of production rates that are now in progress. (Is an Osprey nest active if a pair is present for a few weeks but does not lay eggs?) A reevaluation of these points seems appropriate at this time, particularly in view of the large quantity of new band-recovery information that has become available in the last 10 years, and the numerous nesting studies currently underway.

METHODS

All Osprey band-recovery records were extracted from the files of the Bird Banding Laboratory, Laurel, Maryland, on 16 December 1971. A total of 649 recoveries and returns were available for analysis, including some information obtained in 1971. The bulk of the banding occurred along the Atlantic Coast; 78% of the recoveries resulted from banding efforts in New York, New Jersey, and Maryland. Banding efforts in only two states, other than those on the Atlantic Coast, yielded more than 10 recoveries each (Wisconsin and Michigan).

In the migration analysis, we used only records that included the exact date of recovery. Also, all recoveries within 2 degrees of the banding site (120± miles) were not plotted. The migration periods were somewhat arbitrarily chosen as late August through November and March through April. Wetmore (1965) noted that Ospreys arrived in Panama from the north in October and November and left in March and April. Less than 20% of the band recoveries occurring during the migration periods were reported during the spring (only 35 recoveries). No distinct patterns were noted between recoveries in the autumn and the spring; therefore, the data for the two seasons were combined.

All recoveries in South America were used and interpreted as recoveries on the winter ground. Band recoveries of 1-year-olds in the summer in South America were also included because the Ospreys do not return to the United States their first year. An attempt was made to separate the recoveries during the migration period from recoveries during the winter period in the West Indies.

The records from 1-year-olds and 2-year-olds in the United States during the breeding season were reviewed intensively. Generally, the recovery letter was checked and sometimes the bander's schedules. If the band was found with bones only, the recovery was rejected. Bands only were found at nest sites the following year in several instances, but evidently the birds did not fledge. These recoveries were also rejected.

MIGRATION

New England and Middle Atlantic Ospreys

The breeding cycle of the Osprey in New England and the Middle Atlantic states is summarized conveniently by Bent (1937) and Stone (1937), who showed that although the first Ospreys appear regularly during the last week of March, the greatest numbers arrive during the first week in April. The recoveries of Ospreys banded as nestlings in New York and New Jersey indicate similar arrival times at the nesting areas (Henny and Wight 1969).

According to Ferguson and Ferguson (1922), the fall migration of Ospreys near Fishers Island, New York, begins about 1 September but some birds are seen as late as 22 November. In 1935, the greatest numbers of Ospreys passed through Cape May, New Jersey, during the second and third weeks of September (Allen and Peterson 1936). Hackman and Henny (1971) indicated that approximately three-fourths of the Ospreys seen in fall migration at White Marsh, Maryland (1951-61), passed in September, with the remainder in October. The recoveries of birds banded in New York and New Jersey show that some immatures start southward by the end of August, and most young Ospreys have left the state in which they were banded by 31 October (Henny and Wight 1969).

Ospreys banded in New England and the Middle Atlantic States and recovered during fall and spring migration are presented in Fig. 1.

Apparently the birds migrate on a broad front. Band recoveries were reported from the Appalachian Mountain ridges, from along the Atlantic Coast, and from the intervening area. Osterlöf (1951) concluded that Swedish Ospreys also migrate on a broad front. This conclusion is contrary to Worth's (1936) speculation that the migration was restricted to the coastline and mountain ridges. An Osprey recovered in Louisiana may be slightly out of place; however, the individual reporting the bird indicated it was found dead immediately after a hurricane. Ospreys from the Atlantic Coast appear to migrate through the West Indies enroute to and from South America. No banded Ospreys were reported from Mexico or Central America during the migration period.

Northern Interior Ospreys

The nesting season of Ospreys in the northern interior of the United

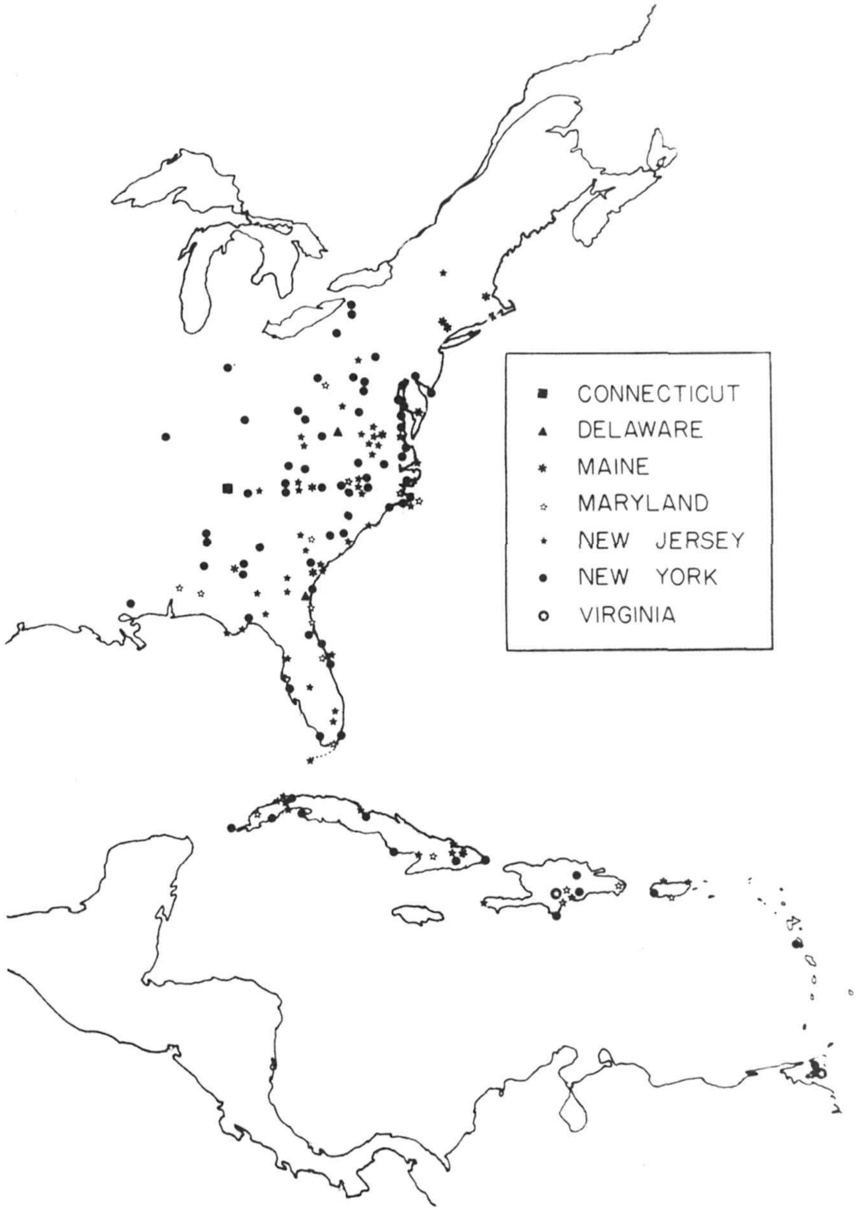

FIGURE 1. Recoveries during migration of Ospreys produced in the Middle Atlantic States and New England.

States appears to be similar to that of the Atlantic Coast birds (Dunstan 1968). Information from band recoveries from this area is insufficient to make positive conclusions regarding migration routes. The recoveries suggest a general movement south to the Gulf of Mexico, then toward South America, following the east coast of Mexico or the West Indies (Fig. 2).

WINTERING GROUNDS

Apparently a few Ospreys from North America winter in the West Indies, but the majority winter in South America (Fig. 3). Fourteen percent of the recoveries were reported from the West Indies with reports coming from Cuba, the Dominican Republic, and Puerto Rico (Table 1).

The birds disperse across much of South America. Band recoveries are reported from along the coast and in the interior with no particular patterns evident other than that they appear to follow the main river systems. Over half of the recoveries were reported from Brazil and Colombia. The distribution of recoveries from bandings in New York, New Jersey, and Maryland show a similar pattern. Although the sample size is small, all recoveries from Wisconsin and Michigan bandings were reported from northwestern South America (Colombia and Ecuador) and Panama.

THE BREEDING SEASON

Location of 1-year-olds During the Breeding Season

Österlöf (1951) notes that Swedish Ospreys did not leave the winter area in Africa during their first summer. A similar conclusion was reached for American Ospreys banded in New York and New Jersey (Henny and Wight 1969). Henny and Wight reported one recovery from North Carolina in May. Upon reexamination of the banding data for this bird, it was found to have been raised in captivity for an undesignated time (although coded as a normal wild bird). Also, the farmer who reported the bird saïd that he found only the bones. Finding bones only tends to nullify the validity of the recovery. The remainder of the recoveries during the breeding season were reported from South America and the West Indies. As a result of not returning north during their first spring, the young Ospreys evidently spend at least 16 continuous months south of the border of the United States. These year-round residents have undoubtedly led to the following quotes: (1) Wetmore (1965:257) "A few remain (in Panama) through the period of northern summer but do not nest"; (2) Herklots (1961:63) "A winter visitor, December to April to both islands (Trinidad and Tobago). Recorded every month of the year though commoner in winter"; (3) Meyer de

FIGURE 2. Recoveries during migration of Ospreys produced in the interior and western portions of North America.

FIGURE 3. The distribution of band recoveries of Ospreys on the winter grounds.

TABLE 1. The distribution of Osprey band recoveries from South America and the West Indies. All band recoveries from South America are included; the recoveries from the West Indies are limited to those other than during the migration period (winter recoveries and summer recoveries of nonbreeders).

	Banding Location					
Recovery Location	Maryland	New Jersey	New York	Wisconsin	Michigan	Totals
Brazil	9	9	4	0	0	22
Colombia	9	4	4	4	0	21
Venezuela	3	4	2	0	0	9
Panama	1	2	1	1	1	6
Cuba	1	1	4	0	0	6
Ecuador	2	1	0	1	0	4
Peru	2	1	0	0	0	3
Dominican Republic	0	2	1	0	0	3
Puerto Rico	1	0	1	0	0	2
Argentina	1	0	0	0	0	1
Guiana	0	1	0	0	0	1
Total	29	25	17	6	1	78

Schauensee (1970:51) "Ospreys are found in South America year-round but do not breed there"; and (4) Land (1970:74) "Nonbreeding immatures of the northern migratory population summer in the tropics."

Location of 2-year-olds During the Breeding Season

Several authors have indicated that all surviving Ospreys return to their natal area and begin breeding as 3-year-olds and that 2-year-olds do not breed, even though some of the latter return to their natal area (Österlöf 1951; Henny and Wight 1969). The percentage of 2-year-olds returning to the breeding grounds has not been estimated in the past; furthermore, it has not been indicated if these birds associate with nests. Henny and Wight (1969) found that a majority of the 2-year-old recoveries were randomly distributed south of the natal area, but that all recoveries reported were from the United States. All recoveries of 2-year-olds during the breeding season (May, June, and July) were tabulated in an attempt to determine what percentage returned to their natal area (Table 2). Ospreys recovered in April were not used in the analysis because they were still arriving on the breeding grounds during the first week of that month (Bent 1937; Stone 1937). If the distribution of band recoveries of 2-year-olds during the breeding season reflects the distribution of the 2-year-old population, the percentage returning to their natal area (or any other area) can be calculated easily. Here we must assume that the factors resulting in the recovery of each banded Osprey

TABLE 2. The distribution of 2-year-old Ospreys during the breeding season (May, June, and July), as determined from band recoveries.

Banded		Recovered	
Location	Date	Location	Date
Delaware	6/18/33	New Jersey	6/7/35
Delaware	7/9/38	Virginia	5/21/40
Maryland	6/20/55	So. Carolina	5/18/57
Maryland	7/11/56	Virginia	6/5/58
Maryland	8/1/58	Virginia	5/14/60
Maryland	7/9/66	Maryland	5/22/68
Maryland	6/25/69	Virginia	5/19/71
New Jersey	7/4/38	Georgia	5/4/40
New Jersey	7/16/39	No. Carolina	5/10/41
New Jersey	7/12/41	No. Carolina	7/8/43
New Jersey	7/6/47	Virginia	5/21/49
New Jersey	6/26/54	Alabama	5/8/56
New Jersey	7/5/68	Pennsylvania	7/23/70
New York	7/23/33	Massachusetts	5/29/35
New York	6/20/36	New York	6/6/38
New York	7/1/38	So. Carolina	5/24/40
New York	7/1/38	New York	7/4/40
New York	7/13/40	Alabama	6/8/42
New York	7/4/41	Virginia	5/27/43
New York	7/4/44	New York	7/10/46
New York	7/7/45	New York	6/29/47
New York	6/29/46	Alabama	5/5/48
New York	7/5/48	Georgia	5/18/50
New York	7/13/57	Maine	6/10/59
New York	6/25/69	New Jersey	5/10/71
Wisconsin	7/15/56	Wisconsin	6/4/58
Wisconsin	7/8/67	Wisconsin	6/21/69
Wisconsin	7/23/67	Michigan	5/12/69

are the same throughout its nesting range. This assumption has some weaknesses, but we do not believe them to be major ones (attitudes toward shooting Ospreys may vary from state to state, and the size of the human population varies from state to state and thus the source for obtaining recoveries varies).

Twenty-eight 2-year-old Ospreys were recovered during the breeding season. Seven of the birds (25%) were reported from within the state where they were initially banded, 15 (54%) were reported from either the state where they were banded or an adjacent state. According to Henny and Wight (1969), approximately 19% of a stable Osprey population should be 2-year-olds (this does not include the 1-year-olds that are spending the summer in South America and the West Indies). If 25-54% of surviving birds in this age class (approximately 19% of population) return to their natal area, approximately 5-10% of the population on the breeding grounds should consist of these 2-year-olds (presumably nonbreeders). If the population is declining in a given area as a result of reduced reproductive success, the percentage would probably be slightly less as fewer young are being produced to eventually join the 2-year-old age class. The percentage may also vary from location to location depending upon how many breeding Ospreys are found north of the study area. (More 2-year-olds would be expected on a study area in Virginia, a more southern area, as compared with a study area in Maine.)

A review of some recent nest studies (Reese 1970; Wiemeyer 1971, this conference) indicates that a small percentage of the Ospreys on the breeding grounds are associated with nests but do not lay eggs (Table 3). The birds in this category—just keeping house—represent an average of 6.2% of the population present on the nesting grounds. These birds initiate nest-building activities at the normal time; however, the nest structures were judged to be poor to average. The birds were usually associated with the nests for 1-2 months and no eggs were laid and no incubation behavior was observed (G. S. Lind and S. N. Wiemeyer pers. comm.). We submit that these birds (well within the range of 5-10%) are nonbreeding 2-year-olds and should not be counted as active breeders. It is interesting that Stone (1937:305) called attention to pairs of Ospreys that did not lay eggs. He stated:

> One year a pair of birds (Ospreys) endeavored to start a nest in the fork of a tree on the edge of the meadows near Cape May Point and when I visited the spot there was more material on the ground than in the crotch. Curiously enough this nest was under construction during July and August (1920) at which time young birds had been hatched in all of the nearby nests. The structure was not completed that summer. Other birds were seen collecting building material on July 7 and August 8, 1921; July 27, 1922; and July 17, 1926; which included sticks of varied sizes, seaweed and masses of trash from truck patches. . . . Just what this late nest building means I do not know, but so far as I am aware, no eggs are laid. Possibly the original nest in such cases was blown down after the eggs were deposited.

It also seems possible that Stone was observing nonbreeding 2-year-olds in their housekeeping activities although they may have been renesting adults. A. J. Meyerriecks (pers. comm.) mentioned a similar situation where subadult Great Blue Herons (*Ardea herodias*) come to breeding colonies and may "fool" with nest twigs but do not breed.

Location of 3-year-olds and Older During the Breeding Season

Band recoveries from 3-year-old and older birds recovered during the breeding season were also tabulated in an attempt to determine what percentage returned to their natal area. Thirty-six birds in this category

TABLE 3. A summary of nonbreeding Osprey pairs observed during nesting studies.

Location	Year	Pairs present	Housekeepers[a]	Percent nonbreeders	Source
Crane Prairie,	1970	49	6	12.2	Lind (Pers. comm.)
Oregon	1971	57	5	8.8	Lind (Pers. comm.)
Potomac River,	1970	46	0	0.0	Wiemeyer (1971)
Maryland and Virginia[b]	1971	94	6	6.4	Wiemeyer (Pers. comm.)
Talbot County,	1965	73	2	2.7	Reese (1970)
Maryland[c]	1966	77	5	6.5	Reese (1970)
	1967	83	7	8.4	Reese (1970)
	1968	93	6	6.5	Reese (1970)
	1969	90	4	4.4	Reese (1970)
All Combined		662	41	6.2	

[a]Birds were associated with nests but either did not lay eggs or did not exhibit incubation behavior.
[b]Only accessible nests are included.
[c]Data from the study in 1963 and 1964 were not used because nest sites were visited less frequently.

were recovered during the nesting season, of which 32 (89%) were reported from the state where banded or an adjacent state. The other four recoveries were reported from North Carolina on 3 May 1960 and 5 May 1950, from Virginia on 14 June 1953, and from Maine on 11 June 1947. One of the recoveries from North Carolina was "found dead" and may have died during migration several weeks earlier. The same may also be true for several of the other birds which were recovered a distance from their natal area. Thus, it appears that probably more than 90% of the adult birds return to the state where banded or an adjacent state.

DISCUSSION

Ospreys from North America winter over a wide area in the West Indies and South America; however, Ospreys from New York, New Jersey, and Maryland all have the same general distribution. Therefore, it would seem that Ospreys produced in the various sections of Maryland would also have similar wintering grounds. Yet, Ospreys in Talbot County (Reese 1970) are reproducing with much greater success than the birds along the Potomac River (Wiemeyer 1971, pers. comm.). This strongly suggests that the breeding success of the population depends upon the condition of the environment in the breeding area. The next question of course is, "How long do birds have to be in an area before adverse effects related to the local environment will occur?" Laboratory experiments with Coturnix Quail *(Coturnix coturnix)* have shown a marked reduction in eggshell thickness in 3 days with a diet containing as little as 2.5 ppm p,p'-DDT (Stickel and Rhodes 1970). It appears that changes can occur quickly—in plenty of time for Ospreys that may spend several weeks in the area before laying their first egg.

Henny and Wight (1969) and Henny and Ogden (1970) assumed that Ospreys begin to breed as 3-year-olds and estimated a recruitment standard accordingly. The estimated 5-10% of the population on the breeding grounds that were 2-year-olds (percentage not discussed in earlier papers) were assumed to be nonbreeders. Field studies tend to confirm that approximately 6% of the population on the breeding grounds do not lay eggs. These birds are associated with nests but should not be counted as active pairs even though they may build a nest and keep house. If the nests in which eggs are not laid (presumably nests of 2-year-olds) are counted as active, the true recruitment rate is underestimated. On the basis of these findings, we caution against the "two-trip nest study" that consists of counting nests with birds near them early in the nesting season and then returning 6-8 weeks later to band the young and obtain an estimate of the recruitment rate. We believe the true recruitment rate of the population would be invariably underestimated (probably by about 5-10%). All data presented substantiate the fact that Ospreys do not begin breeding as 2-year-olds; furthermore, we believe the observed recruitment rates can be compared validly with the recruitment standard of Henny and Wight (1969) if nests where eggs are not laid are classified as inactive.

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Acknowledgments: We thank the Osprey banders who allowed the use of their recovery data, particularly J. G. Reese whose banding effort during the last decade on the Chesapeake Bay of Maryland is unrivaled. Other major banders we would like to recognize include S. L. Wilcox, Mabel Gillespie, J. A. Jacobs, D. E. Davis, J. H. Buckalew, and D. D. Berger. Their contribution to the understanding of the population dynamics of Ospreys is great indeed. The assistance of B. Sharp and Rosemary O'Loughlin in extracting the banding data from the files and in double-checking many of the suspect records is much appreciated. Technical advice from W. H. Stickel and R. D. Porter was helpful.

A Method for Increasing Osprey Productivity

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Abstract: Seven (three control, four experimental) clutches of Osprey eggs were collected to determine if eggs that normally would not hatch in the wild, would hatch in an incubator in the laboratory where the factors of breakage and predation were eliminated, and to determine if the adults would attempt a second nesting. None of the experimental eggs hatched, thus indicating that some factor intrinsic to the egg is the cause of failure. Control eggs hatched with normal frequency. Of the seven pairs of Ospreys from which clutches were collected, five pairs renested and four of these pairs produced seven young. Hatching rate increased from the first nesting (23.8%) to the second nesting (53.8%), though clutch size was smaller (3.00 vs. 2.60 eggs per clutch) for the second clutch. Because of the apparent higher hatching rate of second clutches, renesting experiments may prove to be useful in future Osprey management programs.

A decline in populations of the Osprey (*Pandion haliaetus*) has recently been reported in Maine (Kury 1966), Massachusetts (Fernandez pers. comm.), Connecticut (Ames and Mersereau 1964), New York (Spitzer unpubl. data), New Jersey (Schmid 1966), Maryland (Wiemeyer 1971), Virginia (Kennedy 1971), Michigan (Postupalsky 1969), Wisconsin (Berger and Mueller 1969), and Minnesota (Dunstan 1968). Failure of eggs to hatch has frequently been cited as the cause for this decline (Ames and Mersereau 1964; Ames 1966; Wiemeyer 1971).

Recent investigations, designed to discover the causes of egg failure and to find ways of preventing the decline of these populations, have taken advantage of the Ospreys' ability to tolerate human interference. Spitzer (unpubl. data), by transferring clutches from nests in a stable Maryland population to nests in a declining Connecticut population, and vice versa, has found that the hatching rate for the switched eggs equaled that normally found in the area in which the eggs were laid. This finding demonstrated that some defect in the egg itself results in its failure to hatch, rather than this being due to some extrinsic factor such as abnormal parental behavior. In an attempt to increase New England populations, Spitzer (unpubl. data) and Fernandez (pers. comm.) have transplanted nestlings and eggs from the Chesapeake Bay to selected nests in their study areas in Connecticut and Massachusetts. The populations in the Chesapeake Bay have been considered relatively stable, but recent surveys by Wiemeyer (1971) and Kennedy (1971) demonstrate that some of the Chesapeake Bay Ospreys are producing fewer young than Henny and Wight (1969) consider necessary for continued stability. Because of this, removal of eggs and nestlings may be exerting additional pressure on the Chesapeake populations, thus hastening their decline.

The primary purpose of the investigation reported here was to devise a method for increasing productivity, so that surplus young could continue to be transported to areas where populations are in decline. The procedure was also designed to determine whether eggs collected from nests in which no young had hatched in previous years, due to disappearance or breakage of the eggs, would hatch under controlled incubator conditions where external pressures were eliminated.

MATERIALS AND METHODS

Seven clutches of eggs were collected from nests in three different tidal areas of Virginia, on 10, 11, and 15 April 1971, and were artificially incubated. Three clutches were taken from nests near New Point Comfort, Virginia. Young had been reared in these nests in 1970, and these nests were designated as the control group. Two clutches were collected from each of two other study areas, the James River and the York River. Eggs from these nests had not hatched in 1970 and, in fact, had disappeared from these nests before completion of the incubation period. These four clutches made up the experimental group. Because the adults from these nests were not color-banded, it had to be assumed that the same pair occupied the same nest each year, a habit which is characteristic of Ospreys (Bent 1937). Thus, the experiment was designed: (1) to determine whether or not the eggs in the experimental group would hatch if breakage and predation were eliminated; (2) to see if adults, whose first eggs were removed, would lay a second clutch; and (3) to determine clutch size and hatching success in the second clutch, for comparison of these factors to the first clutch.

A case for the transportation of eggs from nests to an incubator was designed after that used at the Patuxent Wildlife Research Center (Wiemeyer pers. comm.). The case consisted of a suitcase lined with foam rubber, with holes the size of Osprey eggs made in the rubber. Two hot water bottles provided heat, and an internal temperature of approximately 99°F was maintained and regulated by opening the case to reduce heat and refilling the hot water bottles to increase heat.

A Favorite Electric Cabinet Incubator, built by the Leahy Manufacturing Company, was used in this experinent. Circulated air temperature was maintained between 99° and 100°F. The humidity initially was kept at 68% and was gradually increased to a maximum of 73% by the end of the incubation period. Eggs were turned 180° by hand, three times daily, at 7:00 a.m., 3:00 p.m., and 10:00 p.m. Ventilation holes in the incubator were kept one-fourth open, starting 10 days before the first egg was expected to hatch. The time between the collection of the eggs and their placement in the incubator never exceeded 4 hours.

When two of the eggs in the control group began "pipping," they were placed in an active nest in the York River study area. The three eggs already present in this nest were placed in the incubator to complete their incubation period. Young hatching from these latter eggs were allowed to dry in the incubator for several hours and were then transferred to an artificial Osprey nest in an environmental growth chamber, where the humidity was 50% and the temperature was 92°F. At first, the temperature was lowered about 3° every 2 days, but after 10 days, the temperature was lowered to 75°F, with no apparent discomfort to the young.

When the young were 2 days old, they were fed small pieces of chopped fish which had been dipped into cod liver oil. At first the young were reluctant to eat, but after being force-fed for a time, soon ate anything they were offered. An imitation of an Osprey whistle was used to trigger the feeding response. The young were fed four times daily, at 8:00 a.m., 12:00 noon, 4:00 p.m., and 8:00 p.m.

In the incubation experiment, the student's *t*-test for unpaired data was used to compare percentages of eggs hatching. Differences were considered significant at $P<0.05$.

RESULTS

The results of the incubation and renesting experiment are summarized in Table 1. Hatching success for the controls (1.67 young per nest) was identical to that of eggs noted from the same nests in 1970. However, the hatching rate was lower than the average of 2.00 young per productive pair found in 22 nests within this study area. None of the eggs in the experimental group hatched, and the percentage of eggs with obvious embryonic development was significantly lower ($P<0.01$) than in the controls.

Of the five young hatched in the control group, two hatched successfully in the laboratory, but due to improper facilities after hatching, died of heat exhaustion. The third and fourth eggs, upon pipping, were taken

TABLE 1. Results of the incubation and renesting experiments.

Nest no.	1st Nesting				2nd Nesting			
	Clutch size	% with obvious embryonic development	% reaching hatching stage	Young per 1st nest	Renest	Clutch size	% Reaching hatching stage	Young per renest
Control Group								
New Point Comfort 1	4	100	50	2	Yes	3	67	2
New Point Comfort 2	3	100	33	1	Yes	2	100	2
New Point Comfort 3	3	67	67	2	Yes	3	67	2
Average	3.33	90	50	1.67	3/3	2.67	75	2
Experimental Group								
York River 1	3	0	0	0	Yes	3	0	0
York River 2	3	33	0	0	Yes	2	50	1
James River 1	3 (4)[a]	0	0	0	No	–	–	–
James River 2	2 (3)	50	0	0	No	–	–	–
Average	2.75 (3.25)	18	0	0	2/4	2.50	20	.50
Total Average	3.00 (3.29)	52	24	0.71	5/7	2.60	54	1.40

[a]One egg found after collection was thought to be the final egg of the first clutch. Numbers in parentheses are adjusted to include the final egg.

to a nest in the York River study area in order to prevent their loss, and they both hatched. One nestling disappeared when it was one week old, and the second fledged. The fifth egg reached the pipping stage, but the young bird died of an unknown cause before completely hatching.

Two of the three eggs taken from the York River nest hatched and the young were raised successfully in the environmental growth chamber, as described above. When these two young reached 12 and 16 days old, respectively, they were introduced into separate nests on the York River where they eventually fledged.

In five of the seven nests, the adults laid second clutches. About 3 weeks elapsed between removal of the f‘‑st clutch and the laying of the second. The eggs collected from the James River nests may not have constituted full clutches because upon examination 4 weeks after the collection of the first clutch, each of these nests contained a single egg, which may have been the last eggs of the first clutches.

Although the average clutch size per nesting decreased from 3.00 to 2.60 eggs, hatching success improved greatly. In the control group, six out of eight eggs (75%) hatched, while in the experimental group, one out of five eggs (20%) hatched. The average number of young produced per nesting attempt almost doubled, being 0.71 for the first attempt and 1.40 for the second. In the control group, the combined total number of young produced for the first and second nestings was 11 young, or 3.67 young per productive breeding pair.

DISCUSSION

The incubation experiment clearly indicated that the experimental eggs would not ' ıtch, even if the eggs had been exposed to possibly harmful external effects. This finding supports the conclusion drawn by Spitzer (unpubl. data), that factors intrinsic to the egg are the major cause for poor reproductive success in the Osprey. The small number of eggs with obvious embryonic development suggests that these eggs may never have been fertilized. However, because many of these eggs were found to be badly decomposed at the time they were opened, signs of embryonic development may have been obliterated, since Ames (1966) reported a minimum of 73% fertilization in 15 fresh Connecticut eggs, and a minimum of 93% fertilization in 31 Maryland eggs. A high percentage of fertilized eggs was also found by Spitzer (unpubl. data), who reported that six out of nine eggs from Connecticut contained embroys.

Tyrrell (1936), Ames (1966), and Reese (1970) have reported that Ospreys will lay a second clutch of eggs if the first clutch has been lost. This occurred in nests in which the first eggs were lost or taken in early spring (Ames 1966), from 28-29 April (Tyrrell 1936), and from 27-28 May (Reese 1970). Reese (1970) also reported that seven pairs of birds which had lost their nests during a wind storm on 8 May 1967 did not attempt a second nesting. Therefore, in order to increase the likelihood of the birds' producing a second clutch, in this investigation eggs were collected as early in the season as possible, on 10, 11, and 15 April 1971. Although Ames (1966) did not state how many pairs nested again, Tyrrell (1936) found that seven out of eight nests which had lost their first clutches contained a second set of eggs, while Reese (1970) found second clutches in 10 out of 16 cases. In the present study, five of seven pairs produced a second clutch. In all these cases, the second clutch averaged smaller (2.0 for Tyrrell 1936; 2.6 for Reese 1970, and this study) than the first clutch (3.0). In Reese's and Ames' studies, the hatching success in the second nestings was equal to or less than that of the first nestings, but in the present study, the percentage of eggs hatching increased from 24% in the first clutch to 54% in the second clutch. The poorer hatching success for second nestings reported by Reese and Ames may be due to the fact that the first clutches had been lost later in the season or, perhaps, may have involved the past hatching histories of these nests.

The method used in this study could provide a means by which declining Osprey populations might be sustained. The average of 1.40 young per nest in the second nesting attempt exceeds the 1.22-1.30 young per nest considered by Henny and Wight (1969) to be necessary for maintenance of a stable population. For the total experiment, an average of 1.70 young per breeding pair reached the hatching stage. This figure agrees with data from an earlier study, where an average of 1.60 young per nest were produced in 1934, at Smith's Point, Virginia (Tyrrell 1936, cited in Postupalsky 1969).

If a similar program were conducted on a larger scale, the number of young Ospreys produced in an area could be greatly increased. Such a program could be performed by collecting a large number of clutches from nests in which young have been produced for several years in a row, and allowing the adults to produce a second brood. These eggs could be placed in an incubator with the specified temperature and humidity described earlier, or in nests in which young had not been produced in years past. When the latter choice is taken, eggs from these nests with a history of poor reproductive success should also be placed in an incubator. If these eggs begin "peeping," it is recommended that they immediately be transferred to a nest where an unproductive pair are still incubating unviable eggs. This procedure prevents the arduous task of caring for the young after hatching in the laboratory. If young which hatch from the first clutches are to be transferred elsewhere, it is suggested that they remain with their foster parents for about one week in order to insure their survival.

Table 1 shows that one young was reared in a second nesting attempt by an experimental pair in the York River study area. If DDE is the cause of the failure of eggs to hatch, as argued by Heath et al. (1969), and of thin eggshells (Anderson et al. 1969; Peakall 1970; Bitman et al. 1970), then perhaps the failure of the eggs in the experimental group was caused by this compound. Ludwig and Tomoff (1966), working with Herring Gulls (*Larus argentatus*) and Prestt (1970), working with Grey Herons (*Ardea cinerea*), have shown that populations of these species, which are subject to egg loss and breakage in the first clutch, have higher nesting success with the second attempt. These observations, coupled with higher renesting success in both control and experimental pairs of Ospreys described in this paper, suggest that concentration of DDE in the body of the female may decrease with each egg laid. If this is so, it follows that the last egg laid would contain the lowest level of DDE. If the environment were not heavily contaminated with DDE, concentrations in the female might not increase during the 21 days before the second clutch was produced, and eggs in this clutch might contain still lower levels of DDE and might have a greater chance of hatching. Supporting evidence for this hypothesis was provided by Anderson et al. (1969), who showed that in the Double-crested Cormorant (*Phalacrocorax auritus*), eggs in second clutches not only had lower average levels of DDE but thicker eggshells as well. This hypothesis could be tested in Ospreys by marking each egg as it is laid, collecting both the first and second clutches, and measuring the weight, thickness, and the levels of pesticides and heavy metals in the eggs. If the second clutch was found to be less contaminated, removal of the first clutch in Ospreys and other species affected by environmental pollution might become standard procedure, provided that hatching and fledging rates increase.

One factor should be considered before either of the two programs mentioned above is undertaken. As a result of natural selection, the Osprey, like other species, lays its eggs at the time of the year most favorable for survival of the young. If the first clutch were removed, the fledging date for the second brood would be 4-5 weeks later than normal. Therefore, if eggs are collected, they should be taken as early as possible so that there is a sufficiently long period between fledging and fall migration.

It is suggested that the methods and program described in this paper might be utilized to help arrest the present decline in Osprey populations long enough to allow the level of environmental contamination to be reduced, so that the Osprey may once again reproduce at normal rates without the assistance of man.

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Acknowldgements: I wish to thank Dr. Mitchell A. Byrd, under whose guidance this investigation was conducted, for his helpful suggestions and his assistance in the field work. Special thanks is given to Mrs. Sherwin M. Beck for her invaluable aid in the incubation-laboratory rearing experiment. I am indebted to John Farrand and to my wife Linda, for their careful review and criticism of the manuscript. Acknowledgments are also due the many individuals who participated at one time or another during the course of this study.

Sexing the American Osprey Using Secondary Sexual Characteristics

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Abstract: Body weight and tail length were measured for North American Ospreys trapped in the northeastern United States. A reversed sexual size dimorphism was found to exist in the Osprey. The female was found to be significantly heavier and have a longer tail than the male. Breast plumage photographs were also taken of all trapped birds. It was found that the female breast is more heavily streaked than the male breast. By combining these two parameters, trapped Ospreys can be sexed in the field.

INTRODUCTION

The sexing of Ospreys in the field has presented a problem because morphologically male-female differences are slight and subtle. The following illustrates a field method that can be used for sexing Ospreys. Three separate breeding populations were observed in this study. The colonies were located in coastal Massachusetts, eastern Long Island, and southern New Jersey. Three parameters were used for sexing birds in the field: size, breast plumage, and behavior about the nest. This study will also show that if birds are trapped, they can be sexed by measuring the tail.

Carrying out the study early in the breeding season enabled us to determine positively which was the male and which was the female by observing copulation.

"The behavior of Ospreys about their nests is characteristic, quite uniform, and quite different from that of any other bird of prey" (Bent 1937). By observing and getting "to know" the Ospreys before they were trapped, we were able to trap birds of known sex. Birds were trapped using two different methods: a noose carpet (Spitzer unpubl. data) and a dho-gaza net (Hammerstrom 1963:866-869).

BREAST PLUMAGE DIMORPHISM

The sexes are essentially alike in overall coloration (Ridgeway 1914).

The similarity of the sexes according to overall coloration is correct, but the birds Spitzer and I have handled show a marked contrast in the amount of streaking and dusty hue on the breast. The male is definitely less streaked than the female. The male may sometimes show pure white on the breast, whereas the female is always streaked to some degree.

SIZE DIMORPHISM

Our analysis of size dimorphism is based upon body weight and tail length of live specimens trapped in the field. Body weight is used because it has been shown to be the best indicator of general size of a bird (Amadon 1943). Tail length is used because we found that it is an accurate indicator of weight and thus general size in the Osprey. Weight was measured with a portable O-haus triple beam balance. Tail length was measured with a meter stick from the uropygial gland to the tip of the longest tail feather.

The data taken from 17 birds (7 males and 10 females) trapped in Massachusetts, Long Island, and New Jersey are listed in Table 1.

Our data show that the female is heavier and has a longer tail than the male. This size difference is illustrated more clearly in Table 2. There

TABLE 1. Tail length and body weight of 17 northeastern Ospreys.

Adult Females		Adult Males	
Tail (mm)	Weight (g)	Tail (mm)	Weight (g)
220	1628	200	1432
220	1891	201	1534
222	1788	204	1384
222	1705	206	1218
223	1714	206	1466
224	1771	207	1532
225	1822	210	1492
229	1897		
232	1798		
233	1966		

TABLE 2. Summarized tail length and body weight data from 17 northeastern Ospreys.

		Tail length (mm)			Body weights (g)		
Sex	Number	Observed range	Mean	S.D.	Observed range	Mean	S.D.
Male	7	200–210	205	±3	1218–1534	1437	±100
Female	10	220–233	225	±4	1628–1966	1798	± 96

was no overlap between the weight of the female Osprey and the weight of the male Osprey in this sample. There was also no overlap in the length of the tail between the two sexes.

The method of sexing Ospreys by a tail measurement was derived because it was found to be both easy to measure in the field and a reliable indicator of sex.

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Application of Radio-Telemetric Techniques to Osprey Research

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Macomb

Abstract: Various aspects of Osprey behavior can be studied successfully by radio-tagging nestling, juvenile, and adult Ospreys with miniature radio transmitters. Transmitters weighing between 2 and 8% of the bird's body weight are placed on the back of the subject and held in place by a double-loop harness. Additional information on nest location and feeding habits can be gathered by monitoring the location of dead, radio-tagged fish that the Ospreys readily pick up, carry, and eat.

During the last decade, techniques for tagging birds with miniature radio transmitters have been developed and refined. Radio transmitters that have long range and life can now be built small enough to be placed on almost all bird species.

This paper describes radio-telemetric techniques that are applicable to Osprey research. Radio telemetry can be used to study: (1) home range or territoriality; (2) fishing behavior; (3) parent-young relationships; (4) post-fledging activities; (5) dispersal and migration; (6) pesticide ecology; and (7) physiological functions.

APPLICATIONS OF TECHNIQUES

Nestling, juvenile, or adult Ospreys can be tagged with a radio transmitter by using a double-loop harness made of 18-gauge rubber-insulated stranded wire or of one-quarter inch wide teflon tubing (Fig. 1). This harness design has been used successfully on Ospreys and 16 other species of raptorial birds (Dunstan 1972). The package is positioned on the bird's back as shown in Fig. 2.

Transmitter life varies with the type of battery used. Total package weight, transmitter life, approximate range, and percentage of package weight to body weight are given in Table 1. The radio transmitters that I used were self-pulsed, crystal-controlled transistor oscillators and operated at frequencies greater than 100 megacycles. The circuitry was

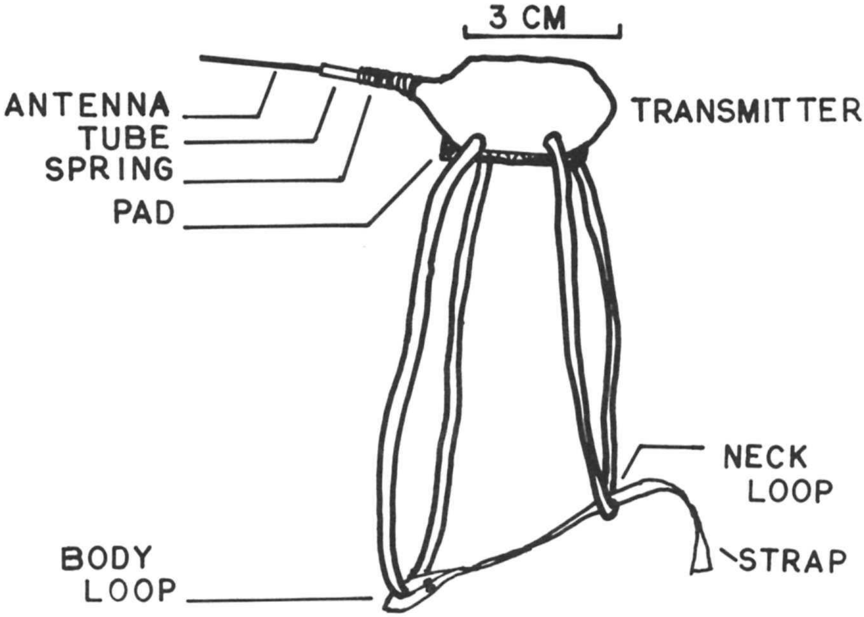

FIGURE 1. Diagram of harness design showing position of loops and size of 24-g package used on Ospreys. The harness loops are embedded into the protective covering (epoxy or acrylic) of the transmitter. A nylon pad is bonded to the package to minimize abrasion of the feathers and skin. Note spring at posterior end of the package to minimize the chance of antenna breakage.

modified after that of Cochran (1967).

Radio-tagged birds can be tracked with: (1) hand-held; (2) temporary-fixed station; and (3) mobile receiver systems. Data are gathered by direct observation or by using triangulation techniques such as those described by Southern (1965) and Cochran et al. (1967).

Information on Osprey behavior can also be gathered by "bugging" dead prey species (fish) with radio transmitters and then placing them at various locations throughout the study area. I implanted 5-12 g transmitters in Bluegills (*Lepomis machrochirus*) and Yellow Perch (*Perca flavescens*) as shown in Fig. 3. Cork-covered transmitters were placed within the abdominal cavity of the fish and the incision was sutured with 000 silk suture. Additional pieces of cork were also placed within the cavity to maintain bouyancy. The whip antenna protruded to the outside of the fish.

Tagged fish were picked up readily and carried to feeding perches or active nests. I then determined such things as length of feeding flights, relationship of feeding activities to weather factors (wind velocity and direction, rain, nebulosity), location of unknown nests, favored foraging areas and feeding perches, and interactions with other fish-eating birds. I also collected remains of favored prey species from feeding perches and nest sites. I then collected live fish of preferred species from portions of lakes fished upon and analyzed them for the presence of or-

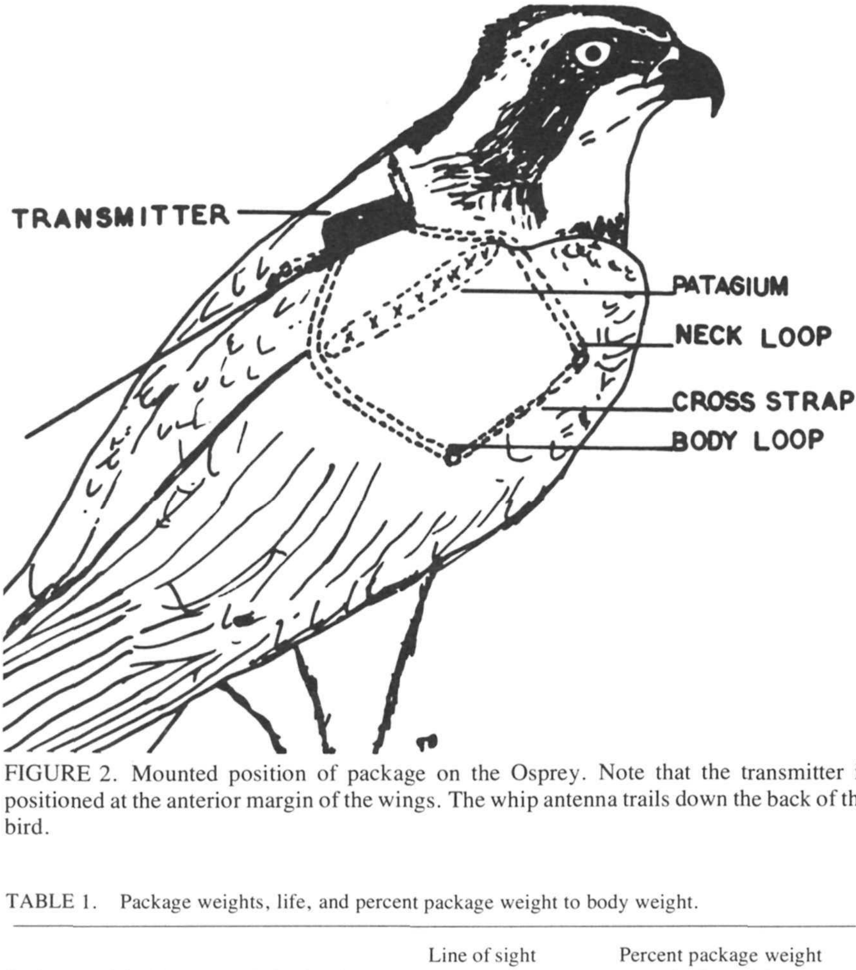

FIGURE 2. Mounted position of package on the Osprey. Note that the transmitter is positioned at the anterior margin of the wings. The whip antenna trails down the back of the bird.

TABLE 1. Package weights, life, and percent package weight to body weight.

Package weight (g)	Life (days)	Line of sight range (mi.)	Percent package weight to body weight[c]
25–40[a]	200+	12+	2.5
75[a]	500+	12+	5.0
120[b]	300+	22+	8.0

[a] Single-stage transmitter.
[b] Two-stage transmitter.
[c] Average weight of male.

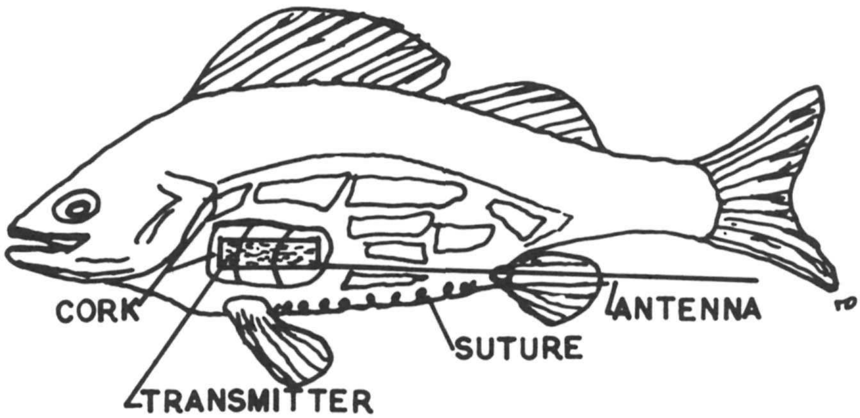

FIGURE 3. Diagram showing the position of cork-covered transmitter inside of fish. Cork around the transmitter keeps the transmitter afloat in case a gull eats the fish and tears the transmitter loose.

ganochlorines, polychlorinated biphenyls, and mercurial compounds.

Radio telemetry can also be used to determine migration routes and dispersal activities. In order to understand the complete life cycle we must know where individual Ospreys are for 365 days of each year. Radio-telemetric techniques and equipment will be developed in the future which will enable persons to measure core temperature and heart rate of free-flying birds at great distances. Future studies will then provide much needed information on metabolic rates and physiological functions of wild Ospreys.

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Acknowledgments: The technical assistance of William C. Cochran is gratefully acknowledged. Financial support for portions of studies from which various techniques were developed was given by the National Audubon Society, the Grants-in-Aid of Research Committee of the Society of the Sigma Xi, and the National Geographic Society. The Department of Biological Sciences of Western Illinois University and the Western Illinois University Research Council provided monies for tracking expenses and other field equipment.

The Status of the American Osprey on National Wildlife Refuges

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Abstract: The current utilization of national wildlife refuges by the American Osprey is reported. Data are based on questionnaire returns from 189 refuge units in 42 states. Ospreys utilize 140 of these units, though 89 reported peak populations of two or less. The highest refuge populations occur along the Gulf and Atlantic coasts, the Mississippi River Valley, and in the state of Montana. Seasonal distribution, nesting and utilization trends are discussed.

A status survey of the American Osprey on national wildlife refuges was conducted by questionnaire in December 1971. The questionnaire (Appendix A) was distributed to each refuge with a resident staff, except those in Alaska and Hawaii. A total of 178 refuges and 11 waterfowl management districts in 42 states responded.

OSPREY USE

The distribution of refuges which responded to the questionnaire and their utilization by Ospreys are summarized in Fig. 1. No national wildlife refuges are in the states of West Virginia, Connecticut, and New Hampshire. Kentucky has only a portion of Reelfoot National Wildlife Refuge and no responses were received from refuges in Ohio or Rhode Island. Ospreys occur on refuges in every other state except Colorado and Indiana.

The American Osprey has been observed on 140 of the 189 refuge units that responded (Table 1). Occurrence on 29 of these refuges is rare, and peaks of no more than two occur on 60 additional refuges. Annual peak populations of 3-10 Ospreys are seen on 33 refuges.

The highest populations of Ospreys occur along the Atlantic Coast, the Gulf Coast, the Mississippi River Valley, and in the state of Montana (Fig. 2). The highest concentration on one refuge is 151 at St. Marks, Florida. The 18 refuges reporting concentrations of more than 10 Ospreys are listed in Table 2.

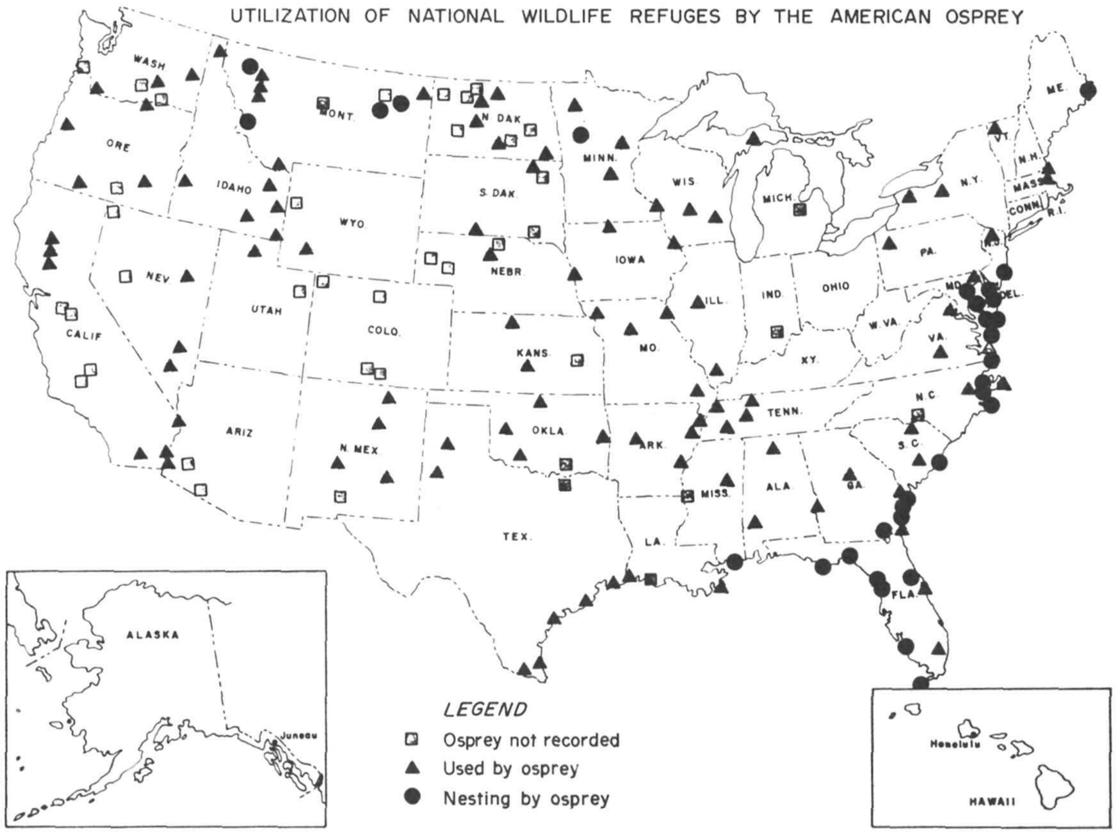

FIGURE 1. Map of the United States showing utilization of national wildlife refuges by the American Osprey.

TABLE 1. Utilization of National Wildlife Refuges by the American Osprey.

Nearest City	Refuge	Months of use	Average peak population	Population trend	Remarks
ALABAMA					
Gilbertown	Choctaw	8-2	4	Stable	–
Eufaula	Eufaula	1-12	2	Stable	–
Decatur	Wheeler	3-4, 9-10	2	Stable	Population declined in last 20 years
ARIZONA					
Yuma	Kofa	None	–	–	
Yuma	Imperial	11-3	1	Decrease	–
Yuma	Cabeza Prieta	None	–	–	–
ARKANSAS					
Dewitt	White River	2-8	2	Stable	–
Dardenelle	Holla Bend	None	–	–	–
Manila	Big Lake	1-12	1.5	Stable	–
Turrell	Wapanocca	None	–	–	Some Osprey use in past
CALIFORNIA					
Blythe	Cibola	10, 4	2	Stable	–
Needles	Havasu	9-5	1	Stable	–
Calipatria	Salton Sea	1-12	1	Stable	–
Maxwell	Delevan	Rare	–	–	1 record in 5 years—May
Colusa	Colusa	Rare	–	–	2 records—spring & summer
Willows	Sacramento	Rare	–	–	1 record in May 1960
Delano	Kern	None	–	–	–
Delano	Pixley	None	–	–	–
Los Banos	San Luis	None	–	–	–
Los Banos	Merced	None	–	–	–
Los Banos	Kesterson	None	–	–	–

TABLE 1 (*continued*). Utilization of National Wildlife Refuges by the American Osprey.

Nearest City	Refuge	Months of use	Average peak population	Population trend	Remarks
COLORADO					
Monte Vista	Monte Vista	None	–	–	–
Craig	Browns Park	None	–	–	–
Walden	Arapaho	None	–	–	–
Alamosa	Alamosa	None	–	–	–
DELAWARE					
Milton	Prime Hook	3-10	5	Stable	State reports 116 eggs, and 48 fledglings from 3 WMA's
Smyrna	Bombay Hook	3-9	4	Decrease	–
FLORIDA					
St. Marks	St. Marks	1-12	151	Decrease	Reproduction noticeably down
DeLeon Springs	Lake Woodruff	1-12	45	Increase	–
Titusville	Merritt Island	1-12	12	Stable	–
Delray Beach	Loxahatchie	1-12	5	Stable	–
Fort Myers	"Ding" Darling	1-12	24	Increase	–
Homosassa	Chassahowitzka	1-12	39	Stable	–
Cedar Key	Cedar Key	1-12	67	Stable	–
Appalachicola	St. Vincent	1-12	11	Increase	–
Big Pine Key	Nat. Key Deer	1-12	74	Stable	–
GEORGIA					
Waycross	Okefenokee	2-9	30	Stable	–
Grey	Piedmont	12-2	1	Stable	–
Savannah	Savannah	3-10	4	Decrease	–
Darien	Wolf Island	2-9	2	Decrease	–
Townsend	Harris Neck	1-10	4	Decrease	–
Townsend	Blackbeard	2-9	2	Decrease	–

Savannah	Wassaw	2-11	8	Stable	–
IDAHO					
Idaho Falls	Camas	Rare	–	–	Spring transients
Bonners Ferry	Kootenai	5-9	2	Stable	–
Montpelier	Bear Lake	Rare	–	–	Spring & fall migrations
Nampa	Deer Flat	Rare	–	–	Two records in 5 years—spring
Montpelier	Grays Lake	Rare	–	–	–
Rubert	Minidoka	4-7	2	Stable	–
ILLINOIS					
Havana	Chautauqua	Rare	–	–	Two records in 5 years
Carterville	Crab Orchard	4-5, 9-10	3	Stable	–
Quincy	Mark Twain	3-4, 9-12	5	Stable	Peaks of 3 in spring, 7 in fall
Savanna	Upper Mississippi	5, 8-9	12	Stable	–
INDIANA					
Seymour	Muscatatuck	None	–	–	–
IOWA					
Titonka	Union Slough	4-9	2	Stable	–
Missouri Valley	DeSoto	5-12	3	Increase	Peak of 5 in 1971
Guttenberg	Upper Miss.	4, 9-10	4	Increase	Spring & fall migrations
Lansing	Upper Miss.	5-10	5	Stable	–
KANSAS					
Stafford	Quivira	Rare	–	–	One record since 1964
Kirwin	Kirwin	4-5, 9-10	1.5	Stable	–
Burlington	Flint Hill	None	–	–	–
LOUISIANA					
Hackberry	Sabine	9-3	1	?	–
Lake Arthur	Lacassine	None	–	–	–
Venice	Delta	1-3	1	Stable	–

TABLE 1 (*continued*). Utilization of National Wildlife Refuges by the American Osprey.

Nearest City	Refuge	Months of use	Average peak population	Population trend	Remarks
MAINE					
Calais	Moosehorn	4-10	10	Stable	–
Troy	Carlton Pond (WPA)	4-10	2	Stable	–
MARYLAND					
Cambridge	Blackwater	3-10	10	Stable	–
Crisfield	Glen L. Martin	3-10	45	Increase	24 artificial nesting structures
Rock Hall	Eastern Neck	3-11	10	Stable	–
Harve de Grace	Susquehanna	(See remarks)	–	–	No sight record but common in vicinity
MASSACHUSETTS					
Newburyport	Parker River	Rare	–	–	–
Sudbury	Great Meadows	4-6, 9-11	4	Stable	Spring & fall migrants
MICHIGAN					
Saginaw	Shiawassee	None	–	–	–
Manistique	Seney	4-9	2	Stable	–
MINNESOTA					
McGregor	Rice Lake	5-9	1.5	Stable	–
Ortonville	Big Stone	None	–	–	–
Middle River	Agassiz	Rare	–	–	Very rare
Princeton	Sherburne	8-10	1	Stable	Few sightings till 1971
Benson	Benson WMD	Rare	–	–	3 records since 1965
Rochert	Tamarac	5-8	15	Stable	–
Fergus Falls	Fergus Falls WMD	None	–	–	–
MISSISSIPPI					
Glen Allen	Yazoo	None	–	–	–
Starkville	Noxubee	Rare	–	–	–

Biloxi	Gulf Island	1-12	14	Stable	–
MISSOURI					
Puxico	Mingo	Rare	–	–	–
Sumner	Swan Lake	Rare	–	–	Spring & fall migrants
Mound City	Squaw Creek	9-5	1	Stable	–
MONTANA					
Lima	Red Rock Lakes	6-8	2	Stable	–
Kalispell	North Western WPA	6-10	12	?	New area
Pablo	Pablo	6-10	2	Stable	–
Charlo	Ninepipe	6-9	1	Stable	–
Charlo	Nat. Bison Range	6-11	2	Stable	–
Great Falls	Benton Lake	None	–	–	–
Stevensville	Ravalli	4-9	5.5	Increase	–
Medicine Lake	Medicine Lake	4-10	1	Stable	–
Malta	UL Bend	4-9	2	Stable	–
Malta	Bowdoin	None	–	–	–
Lewistown	Chas. M. Russell	4-9	10	Decrease	–
NEBRASKA					
Valentine	Fort Niobrara	None	–	–	–
Valentine	Valentine	Rare	–	–	–
Ellsworth	Crescent Lake	None	–	–	–
Hastings	Hastings WMD	None	–	–	–
NEVADA					
Fallon	Stillwater	None	–	–	–
Elko	Ruby Lake	4	1	Stable	–
Las Vegas	Desert Range	Rare	–	–	–
Las Vegas	Pahrangat	Rare	–	–	–
NEW JERSEY					
Basking Ridge	Great Swamp	4-5, 9-10	2	Stable	–
Atlantic City	Brigantine	3-1	22	Decrease	Estimates zero Osprey use by 1980

TABLE 1 (*continued*). Utilization of National Wildlife Refuges by the American Osprey.

Nearest City	Refuge	Months of use	Average peak population	Population trend	Remarks
NEW MEXICO					
Las Cruces	San Andres	None	–	–	–
Las Vegas	Las Vegas	10	1	Stable	–
San Antonio	Bosque del Apache	10-11, 3-4	1	Stable	–
Roswell	Bitter Lake	9, 5	2	Stable	–
NEW YORK					
Seneca Falls	Montezuma	4, 8-9	2	Stable	–
Batavia	Iroquois	4-5, 9-10	1	Stable	–
NORTH CAROLINA					
Belhaven	Pungo	3-10	1.5	Decrease	–
Wadesboro	Pee Dee	None	–	–	–
Cedar Island	Cedar Island	3-11	3.5	Stable	–
Washington	Mattamuskeet	3-11	40	Stable	–
Washington	Swan Quarter	3-11	25	Stable	–
Manteo	Pea Island	4-10	2.5	Stable	–
NORTH DAKOTA					
Bismark	Garrison WMD	None	–	–	–
Dunn Center	Lake Ilo	None	–	–	–
Kenmarc	Des Lacs	None	–	–	–
Devils Lake	Devils Lake WMD	4-5	1	Increase	First record in 1970
Dawson	Slade	None	–	–	–
Lostwood	Lostwood	None	–	–	–
Upham	J. Clark Salyer	10-11	1.5	Stable	–
Crosby	Lake Zahl	None	–	–	–
Kulm	Kulm WMD	None	–	–	–
Minot	Upper Souris	4-10	1	Stable	Not seen every year

Valley City	Valley City WMD	None	–	–	–
Coleharbor	Audubon	Rare	–	–	About 1 record annually
Carrington	Arrowwood	None	–	–	–
Cayuga	Tewaukon	Rare	–	–	Two records in 7 years
Moffit	Long Lake	Rare	–	–	One record in 1969; two in 1971
OKLAHOMA					
Cache	Wichita Mountains	4-5	2	Stable	6 Osprey at nearby lake
Butler	Washita	4-5, 9-11	4	Increase	–
Tishomingo	Tishomingo	None	–	–	–
Vian	Sequoyah	3-4	1	Stable	–
Jet	Salt Plains	4, 9-10	1	Stable	–
OREGON					
Klamath Falls	Klamath Basin	3-4	2	Stable	–
Umatilla	Umatilla	3-10	2	Stable	–
Lakeview	Sheldon	None	–	–	–
Lakeview	Hart Mountain	None	–	–	–
Corvalis	William Finley	4-6	2	Stable	Active nest 2 miles off refuge
Burns	Malhuer	4-6	1	Stable	–
PENNSYLVANIA					
Guys Mills	Erie	4-5, 9-10	1.6	Stable	–
SOUTH CAROLINA					
Summerton	Santee	1-12	20	Stable	–
Charleston	Cape Romain	3-9	5	Increase	–
McBee	Carolina Sandhills	Rare	–	–	Winter sightings
SOUTH DAKOTA					
Waubay	Waubay	None	–	–	–
Martin	Lacreek	Rare	–	–	Recorded Oct., 67 & Apr. 71
Columbia	Sand Lake	Rare	–	–	3 records in 12 years
Madison	Madison WMD	None	–	–	–
Lake Andes	Lake Andes	None	–	–	–

TABLE 1 (*continued*). Utilization of National Wildlife Refuges by the American Osprey.

Nearest City	Refuge	Months of use	Average peak population	Population trend	Remarks
TENNESSEE					
Dover	Cross Creeks	2-5, 9-10	2	Stable	–
Samburg	Reelfoot	3-11	4	Decrease	2 active nests off refuge
Paris	Tennessee	1-12	2	Decrease	–
Brownsville	Hatchie	Rare	–	–	–
TEXAS					
Alamo	Santa Ana	10-3	1	Stable	–
Muleshoe	Muleshoe	Rare	–	–	Only 2 records—1942, 1963
San Benito	Laguna Atascosa	10-2	1	Stable	–
Sherman	Hagerman	None	–	–	–
Umbarger	Buffalo Lake	10-4	3	Stable	5-year peak was 5
Freeport	Brazoria	10-11	2	Stable	–
Austwell	Aransas	8-1	3	Increase	–
Anahuac	Anahuac	Rare	–	–	April and Oct.-Dec.
UTAH					
Vernal	Ouray	None	–	–	–
Brigham City	Bear River	4, 11	1	Stable	–
VERMONT					
Swanton	Missisquoi	4-10	2	Stable	–
VIRGINIA					
Chincoteague	Chincoteague	5-8	7	Increase	–
Hopewell	Presquile	4-9	4	Stable	–
Woodbridge	Mason Neck	3-11	1.5	?	New refuge
Virginia Beach	Back Bay	3-9	6	Stable	Two active nests destroyed in 1971
Knots Island	Mackey Island	3-9	8	Increase	–

Cape Charles	Fisherman Island	3-9	10	Increase	–
WASHINGTON					
Othello	Columbia	10-11, 3-4	1	Increase	Spring & fall migrants
Burbank	McNary	None	–	–	–
Toppenish	Toppenish	None	–	–	–
Ridgefield	Ridgefield	6-8	1.5	Increase	First seen in 1971
Cheney	Turnbull	Rare	–	–	–
Ilwaco	Willapa	None	–	–	–
WISCONSIN					
Necedah	Necedah	4-12	2	Stable	–
Mayville	Horicon	Rare	–	–	Only one record
Cassville	Upper Miss.	4-10	4	Decrease	–
LaCrosse	Upper Miss.	4-10	6	Decrease	1971 peak was 2
Trempealeau	Upper Miss.	3-10	3	Stable	–
WYOMING					
Green River	Seedskadee	4-5	1.5	Stable	Spring sightings
Jackson	National Elk	None	–	–	–

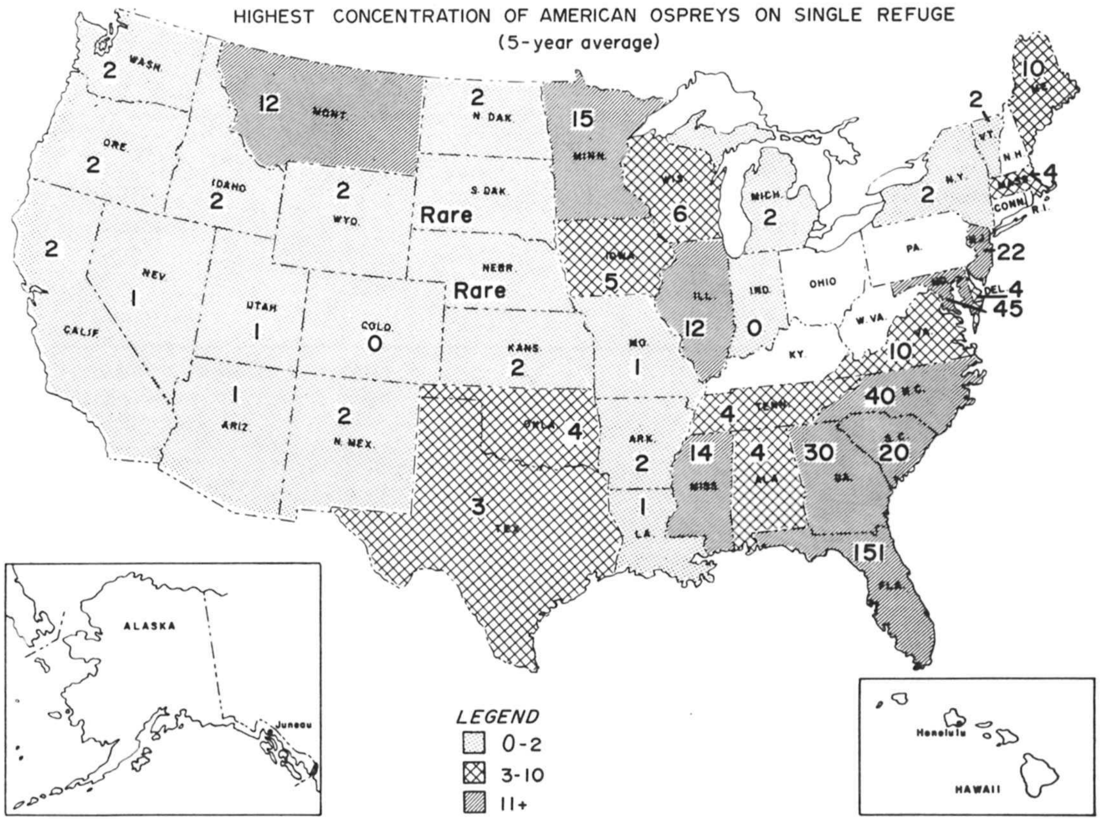

FIGURE 2. Map of the United States showing the highest concentrations of American Ospreys on single refuges.

TABLE 2. Refuges with peak Osprey populations of more than 10.

State	Refuge	Peak Osprey population
Florida	St. Marks	151
Florida	National Key Deer	74
Florida	Cedar Key	67
Florida	Lake Woodruff	45
Maryland	Glen L. Martin	45
North Carolina	Mattamuskeet	40
Florida	Chassahowitzka	39
Georgia	Okefenokee	30
North Carolina	Swan Quarter	25
Florida	J. N. "Ding" Darling	24
New Jersey	Brigantine	22
South Carolina	Santee	20
Minnesota	Tamarac	15
Mississippi	Gulf Islands	14
Florida	Merritt Island	12
Illinois	Upper Mississippi	12
Montana	North Western WPA	12
Florida	St. Vincent	11

SEASON OF USE

Seasonal use of national wildlife refuges by the Osprey is shown in Fig. 3. A total of 17 of the most northern states have Osprey use on refuges during the warm-season months. Refuges in Arizona, Texas, Louisiana, and Missouri are utilized only during the cool-season months. Between these summer refuges and wintering refuges are 11 states where refuges are used during migration in either, or both, spring and fall. There is year-round use of refuges in California and the southeastern states of Arkansas, Tennessee, Mississippi, Alabama, Georgia, South Carolina, and Florida.

NESTING

A total of 193 active Osprey nests are currently known to exist on 31 national wildlife refuges where nesting occurs (Table 3). Over 54% of these nests occur on only four refuges: St. Marks, Florida; Key Deer, Florida; Lake Woodruff, Florida; and Glen L. Martin, Virginia. The locations of refuges with active Osprey nests are shown in Fig. 1. Nesting on refuges occurs only on the Atlantic Coast, the Gulf Coast, and in the states of Montana and Minnesota.

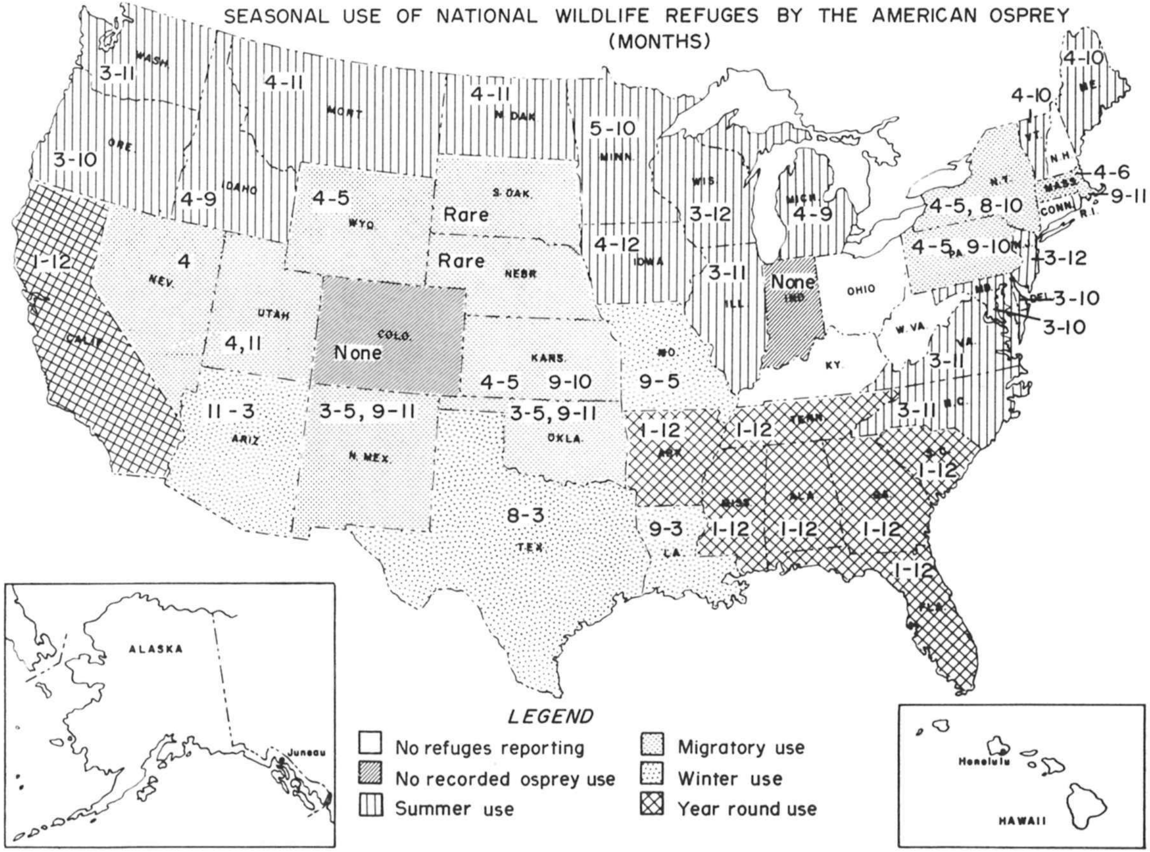

FIGURE 3. Map of the United States showing seasonal use of national wildlife refuges by the American Osprey.

TABLE 3. Summary of nesting by American Ospreys on National Wildlife Refuges in 1971.

State	Refuge	No. active nests	Ave. annual production	Reproductive trend
Minnesota	Tamarac	3	3.0	Stable
Montana	North Western WPA	5	?	?
Montana	Ravalli	1	2.5	Increase
Montana	U L Bend	1	0.5	Decrease
Montana	Charles M. Russell	4	0.33	Decrease
Delaware	Prime Hook	1	0.0	(New)
Delaware	Bombay Hook	1	0.0	Stable
New Jersey	Brigantine	6	0.34	Decrease
Maine	Moosehorn	2	2.0	Stable
Georgia	Okefenokee	9+	?	?
Georgia	Harris Neck	2	2.0	?
Georgia	Blackbeard	1	?	?
Georgia	Wassaw	4	1.0	Stable
Florida	St. Marks	30	1.27	Decrease
Florida	Lake Woodruff	23	1.4	Increase
Florida	J. N. "Ding" Darling	9	2.0	Increase
Florida	Chassahowitzka	2	1.6	Increase
Florida	Cedar Key	3	1.5	Decrease
Florida	St. Vincent	4	1.0	Stable
Florida	Key Deer	30	1.8	Stable
South Carolina	Cape Romain	1	0.8	Increase
North Carolina	Cedar Island	2	0.2	Stable
North Carolina	Mattamuskeet	13	2.0	Stable
North Carolina	Swan Quarter	8	2.0	Stable
Virginia	Chincoteague	2	1.5	Increase
Virginia	Mackey Island	6	0.2	Increase
Virginia	Fishermans Island	5	0.5	Increase
Maryland	Blackwater	2	1.0	Stable
Maryland	Glen L. Martin	22	1.5	Increase
Maryland	Eastern Neck	1	0.75	Stable
Mississippi	Gulf Islands	5	1.25	Stable

The average number of Ospreys fledged per nest is shown in Table 3. Many of these figures are estimates based on limited ground observations of the nests and, therefore, should be used with care. Twelve refuges reported that reproductive success was holding steady over the last 5 years. Five refuges noted a downward trend and nine reported increasing reproduction.

TABLE 4. Trends of Osprey occurrences on National Wildlife Refuges.

State	Increasing	Stable	Decreasing
Alabama		3	
Arizona			1
Arkansas		2	
California		3	
Delaware		1	1
Florida	3	5	1
Georgia		3	4
Indiana		2	
Illinois		3	
Iowa	2	2	
Kansas		1	
Louisiana		1	
Missouri		2	
Maryland	1	2	
Massachusetts		1	
Michigan		1	
Minnesota		3	
Mississippi		1	
Missouri		1	
Montana	1	6	1
Nevada		1	
New Jersey		1	1
New Mexico		3	
New York		2	
North Carolina		4	1
North Dakota	1	2	
Oklahoma	1	3	
Oregon		5	
South Carolina	1	1	
Tennessee		1	2
Texas	1	4	
Utah		1	
Vermont		1	
Virginia	3	2	
Washington	2		
Wisconsin		2	2
Wyoming		1	
Totals	16	77	14

POPULATION TRENDS

The trends on numbers of Ospreys utilizing national wildlife refuges over the last 5 years are summarized in Table 4. In the judgment of the refuge managers polled, there is reason for optimism. Only 14 refuge managers reported a downward trend, while 16 reported an upward trend. By far the majority, 77 managers, reported stable Osprey numbers.

APPENDIX A

Sample Questionnaire
Population Status of Ospreys on National Wildlife Refuges

The information requested below is needed for a Bureau report at a North American Conference on Ospreys being held at Williamsburg, Virginia, February 11-12, 1972. The data should be readily available from the Form NR-1A in the annual narrative reports. Negative reports are requested.

1. Refuge ____________

2. Nearest City ____________ State ____________

3. Are ospreys seen on your refuge? ____________
   (If not, please sign below and return as indicated)

4. Dates usually seen on refuge—From ________ To ________

5. Average peak concentrations ____________

6. Number of active nests now on refuge ____________

7. Average annual production per active nest for last 5 years ________

8. Population trends for last 5 years:

   Peak concentrations: ______% increase ______ Stable ______% decrease

   Number fledged: ______% increase ______ Stable ______% decrease

9. Remarks:

Signed ____________

Title ____________

Please return to Regional Office by January 10, 1972.

Assessing the Hawk Counts at Hawk Mountain

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ALEXANDER C. NAGY, Hawk Mountain Sanctuary, Route 2, Kempton, Pennsylvania

Abstract: The records of the fall migration at Hawk Mountain in Eastern Pennsylvania have recently been used by the pesticide interests to "prove" that hawk populations have not been seriously affected, and in some cases, particularly that of the Osprey, have actually flourished during the pesticide era. This use is unwarranted. Hawk Mountain Sanctuary personnel have long doubted the scientific value of making regular counts of the passing hawks because of the many variables involved. Recent increases in yearly hawk counts at Hawk Mountain coincide with the opening of several new lookouts on the mountain and continuing increases in the numbers of practiced hawkwatchers and in the total hours they spend on the mountain. All these factors tend to distort the value of year-to-year comparisons of Osprey totals.

As laboratory and field research has increasingly implicated persistent pesticides as contributing factors in the decline of various populations of birds of prey, the pesticide interests have sought to find data that would demonstrate that no decline is, in fact, taking place. One major source used in this effort is the annual report of the hawk migration at Hawk Mountain, on the Kittatinny Ridge near Kempton, Pennsylvania. Over the past 10 years, the Osprey counts in particular have shown a dramatic rise. In 1962, 290 Ospreys were counted there, and since then the annual numbers recorded have been: 190, 328, 444, 405, 457, 403, 530, 600, and 603. This has been taken in some quarters as proof that Osprey populations generally have increased.

For years, long before such questions became part of the pesticide debate, the sanctuary's first curator, Maurice Broun, expressed doubt that the annual hawk totals for the mountain had much scientific value (pers. comm.).

THE HUMAN ELEMENT

The hawks passing the sanctuary have never been counted by a sensitive instrument, such as a radar scanner able to differentiate between species. The counters, perforce, have been human. Their numbers and their competence vary, especially over a period of 35 years. The places they stand to do their counting also vary. The conditions under which they operate vary according to wind and weather.

The importance of numbers of watchers cannot be underestimated. Large numbers may mean the thorough coverage of several observation points. And it can be stated as a rule-of-thumb that the more watchers there are on a given lookout, the more hawks will be spotted. Two pairs of eyes can cover twice the area of sky and landscape at any given moment than one pair of eyes. Furthermore, other watchers spotting hawks enhances the competition and makes the individual more alert, over a day's time, than he would be if he were watching alone.

NEW COMPLICATIONS

Particularly in the past decade, complications have been added that make comparisons between the present counts and earlier totals very hazardous. In 1941, membership in the Hawk Mountain Sanctuary Association numbered 536, and 3312 visitors were checked through the sanctuary's gates. By the end of 1970, the association had 4000 members and counted 33,969 visitors for the year. Since 1960, the number of members had grown by 1000 and the attendance figures had doubled (*Hawk Mountain Newsletter* Nos. 8, 31, 43). Though many of the visitors are nonbirders, and come mainly to look at the spectacular scenery, the large numbers demonstrate the spreading reputation of the sanctuary, which, of course, attracts serious birders as well as foliage lovers. No figures are available for the increasing numbers of birders who contribute their eyes and expertise to the count, although the growing membership in the association may be some indication. The founding of the Raptor Research Foundation in 1965 and of the Society for the Preservation of Birds of Prey in 1966 are other signs of an increased interest in hawks. And with this growth in interest, there also comes an increase in the numbers of competent hawkwatchers.

In addition, Hawk Mountain Sanctuary began in 1967 to open new lookouts on the mountain. In the early years of the sanctuary, the counts were taken mainly from a single point, now called North Lookout. The Kittatinny Ridge narrows to a hogback as it approaches Hawk Mountain, dips slightly, then rises abruptly to an outcropping of sandstone which gives long views to the north and northeast, into the line of flight. That outcropping is the North Lookout. From there, the mountain zigzags off toward the southeast, with a valley, called the Kettle, lying between the ridge and spur. Along the spur there are a number of other outcroppings, but in the old days they were not often used as lookouts. On occasion, the passing hawks were counted from one or another, or from the headquarters building on the spur less than a mile away from North Lookout; birds seen outside the sanctuary were sometimes included in the totals. In general, however, the major part of the counting was done at North Lookout.

In 1966, Mr. Nagy, who had replaced Maurice Broun when he retired as curator, began to look for other possible lookout sites. The sanctuary staff had long been aware that on easterly and southerly winds many hawks passed the mountain on flight paths that carried them too far from North Lookout to be seen, or if seen, too far away to be identified. The birds seemed to leave the main stem of the ridge well east of the lookout and drift across to the spur. The investigation of this phenomenon involved stationing one man on North Lookout and another at different points along the face of the spur. Both men were equipped with radios, so that they could discuss specific situations as the birds passed. They soon discovered that there was a point beyond which the observer on North Lookout could not see all the birds that passed; that was to be expected. But they were surprised to discover that from North Lookout, on days with a southerly or easterly wind, a competent observer with good optical equipment was missing more than half the hawks that actually passed the mountain (Nagy 1967).

As a result, the sanctuary opened a new major observation point on the spur, South Lookout, the next year. It was somewhat lower in altitude and more than half a mile across the valley from North Lookout.

Subsequently, the "regulars" among the visiting hawkwatchers learned of, and began to use frequently, two smaller lookouts between the two, as well as another lookout more than 2 miles to the east of North Lookout, called Owl's Head.

With the increase in hawkwatchers, the increase in competence, and the addition of the new lookouts, one would expect an increase in the hawk totals, and that is exactly what has happened. Total hawk counts for the season had exceeded 20,000 only four times (1939: 22,704, 1948: 21,173, 1952: 20,639, and 1955: 20,191) (Nagy 1968). In 1967, when South Lookout was used for the first time on a regular basis, the count was 20,196. In 1968, it was 29,765, 1969: 23,419, 1970: 24,000, and in 1971: 22,177. It should be noted that the 1968 count was influenced by a record number of Broad-winged Hawks totaling 18,507. In 1969, the weather was particularly favorable.

THE OSPREY

The case of the Osprey is, in some ways, an amplified version of the problems outlined above.

Ospreys utilize the updrafts off the ridges, but it is suspected that they do not depend on these updrafts as much as do the Buteos. Since Ospreys also migrate along the coast in some numbers, it may be that the species follows the Appalachians and the coast partly as navigational aids.

If that is so, once the numbers of watchers and lookouts at Hawk Mountain have stabilized, perhaps averages of annual counts over 5- or 10-year periods might give a rough indication of population trends for the Osprey away from the coast. If the Ospreys follow the Appalachians because they are navigational guides, the Hawk Mountain Ospreys are likely to be inland breeders almost exclusively, and not confronted with the same environment pollution that faces coastal breeders. Taylor (1971) has suggested that if there is an increase of actual numbers of Ospreys passing Hawk Mountain, it may represent an increase of inland breeders whose competition on the wintering grounds has been markedly reduced by the observed decimation of northeastern coastal-breeding Ospreys. However, no research has been done on the factors controlling the Ospreys' utilization of the Appalachians during migration, or on the breeding territories of the Ospreys that pass Hawk Mountain.

The greater coverage of the migration at Hawk Mountain coincides with the increase in Osprey totals there. Some other species also show an increase, but Bald Eagles and Golden Eagles, among others, appear to be continuing their decline. Osprey totals climbed while the attendance at the sanctuary doubled in the 1960s. The year 1967, when South Lookout was first used, was a record year for the Osprey at Hawk Mountain; 457 were recorded. Since then, the record has been broken frequently, and now stands at 613. Ospreys not seen from North Lookout are spotted from South Lookout; some of those missed by the major lookouts are seen by watchers who have posted themselves on the various isolated observation points between North and South, or on the lookout at Owl's Head. Owl's Head, in fact, deserves special attention, which is given later in this paper.

COMPETITION

The element of competition cannot be discounted in a discussion of the rising Osprey counts at Hawk Mountain. The hawkwatchers want to set new Osprey records, and each successful year has encouraged this spirit.

"By October 18 [1970]," wrote Nagy [1971], "the osprey count for the season was 598. A single bird on the 24th brought the season count to 599 and there it remained for the balance of October. Though many sharp-eyed observers remained on the Lookout to the brink of darkness for the remaining days, no additional osprey was anywhere to be seen." The 600th Osprey appeared on 1 November.

By 4 p.m., on most days, the hawk flight is about over. The only birds to pass after that hour are a few eagles, perhaps an occasional Goshawk, and particularly Ospreys. At that hour, other needs call the watcher off the mountain—a softer seat than the rocks provide, a drink, dinner, perhaps even a heated room. Most watchers would leave, having seen enough hawks, Ospreys included, for one day. But the competition for the Osprey record now regularly inspires at least a few people to stay until the evening is well advanced. To be sure, in earlier years Broun, Nagy, and others indulged in late Osprey watching, but never so consistently as now, nor by so many observers.

Until recently, the sanctuary did not keep hour-by-hour counts after 4 p.m., and consequently no comparative figures are available. But it is reasonable to expect that Ospreys have recently been added to the count that no one would have troubled to wait for if a record were not at stake.

OWL'S HEAD

Owl's Head is somewhat more than 2 miles as the hawk flies from North Lookout, and 1.25 miles from South Lookout. It is a small observation point, accommodating no more than six watchers. Normally, far fewer hawks are seen from Owl's Head than from other lookouts. However, those birds that are seen at Owl's Head often pass at eye-level or below, and very close to the observer; this entices some hawkwatchers to the lookout, particularly in certain kinds of weather. North or northwest winds tend to hold the hawks, particularly Buteos, Accipiters, and Falcons to the main ridge; Ospreys and Marsh Hawks will often leave the main ridge, in any weather, and head southwest across the Kettle, but they and other hawks are far more likely to do so in "Owl's Head weather."

An Owl's Head day has a light to variable wind and often a lot of haze; the wind direction may be southwest or south or any point on the eastern half of the compass up to northeast. Such wind conditions tend not to hold the hawks to the main ridge (see above and Fig. 1), and a good many of the birds leave the ridge well to the east of the major lookouts and drift across the valley to the Pinnacle or Owl's Head.

Owl's Head was manned only infrequently during the early years of the sanctuary. In the 1960s the growing numbers of competent enthusiasts who came to the mountain gradually increased the coverage at Owl's Head, as at the other lookouts. Finally, Owl's Head was manned on a fairly regular basis, for the first time, in 1971; one observer in particular made it his project to cover the lookout 2 or 3 weekdays each week in September and October, which meant that it was manned for

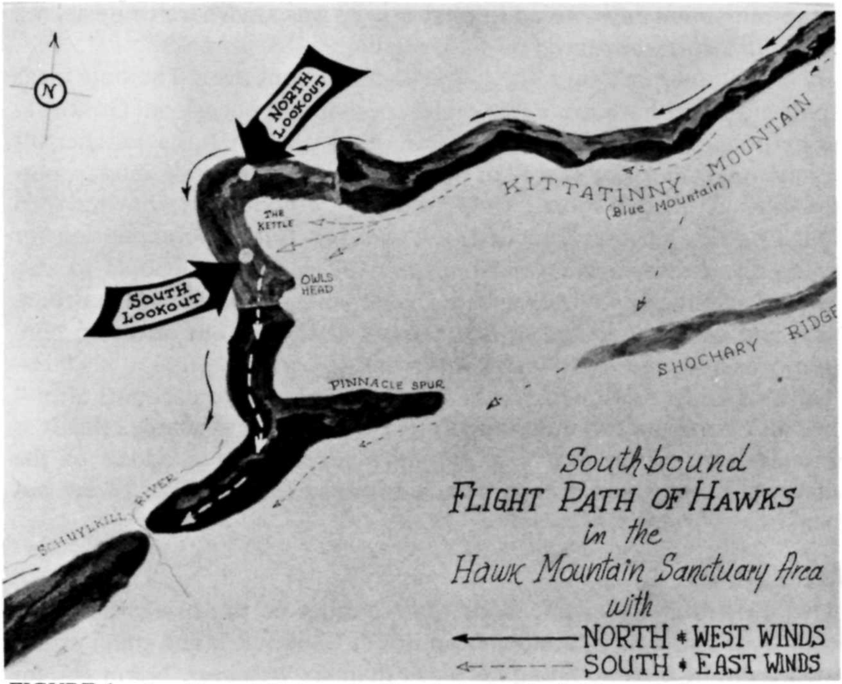

FIGURE 1 . Southbound flight path of hawks in the Hawk Mountain Sanctuary.

about one-third of the total migration days in the season.

As it happened, there was a great deal of "Owl's Head weather" during the 1971 fall migration, and 93 Ospreys were counted there in 31 days of observation. Had no one been at Owl's Head, and had the sanctuary's count been taken only from North Lookout, all or almost all of those 93 Ospreys would have passed unobserved or been listed as unidentified hawks.

However, the recent Osprey "records" were set under conditions that included the new major lookout, South, and that should be considered in relation to the Owl's Head figures. In Owl's Head weather, the sanctuary's daily count operation is usually based at South Lookout; either a staff member or a qualified volunteer is in charge. If Owl's Head is covered, it is normally connected to South Lookout by radio. The two lookouts keep each other apprised of approaching birds, particularly when the observers at one lookout can see the birds but not identify them, or when there is a possibility that both lookouts will spot them and duplicate the count. Of the Ospreys that are counted at Owl's Head, perhaps as many as 15-20% are also observed and recognized at South Lookout, particularly if the haze is not thick. Subtracting 20% of the Owl's Head Osprey totals for 1971 (93 less 19) leaves 74 Ospreys that passed the mountain and would have gone uncounted from South Lookout. The 1971 Osprey count would then have been 539 and might have been considered possible evidence of a decline in the northeastern population.

DISCUSSION

Under the circumstances, any increases in hawk totals should be credited to the more intensive coverage from the sanctuary, at least until the situation stabilizes at Hawk Mountain. Perhaps long-term declines that continue (as for the eagles, the peregrine, and the accipiters), despite the increase in the effort given to the count, may be meaningful. But even here, the Hawk Mountain staff would hesitate to put forward the figures as proof of such a decline. For other interests, looking only at Hawk Mountain's raw figures, to claim increases in overall populations of any hawk, particularly the Osprey, is absolutely unwarranted. This paper does not, in any sense, represent a conclusion. Rather it is a treatment of the variables. Numbers of Ospreys may, in fact, be on a gradual increase, but Hawk Mountain Sanctuary could not offer conclusions based on numbers alone. We look to the time when eastern Osprey nests can be surveyed and the young color-dyed for visual observation along flyway check points. Only with the cooperation of many trained observers at integrated stations can we begin to analyze our data. When we begin to correlate birds from eastern nesting sites with those observed along southerly migratory routes, we can, perhaps, begin the long process of population interpretation.

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An Osprey Population Aided by Nest Structures

LEON I. RHODES, Tennessee National Wildlife Refuge, Paris

Abstract: The project of constructing Osprey (*Pandion haliaetus*) nest structures at Glen L. Martin National Wildlife Refuge, Smith Island, Maryland, was initiated to offset a lack of suitable nesting sites in the area. Ospreys quickly adapted to the artificial nest structures and total Osprey production from the island refuge increased. The number of young Ospreys per active nest over a 5-year period was 1.50.

INTRODUCTION

Glen L. Martin National Wildlife Refuge is a 4313-acre island located in the Chesapeake Bay approximately 10 miles west from the Delmarva Peninsula. The island refuge has a substantial history of Osprey nesting but adequate nesting sites are few. Only a few scattered trees and other sites are available for Osprey nesting on the refuge, which is composed primarily of juncus marsh (*Juncus roemarianus*). Abandoned crab traps from commercial fishermen generally were the desired nesting sites but these were not adequate to supply the needs of the Martin Refuge Osprey population. Thus the program was undertaken to erect artificial nesting platforms which would supplement the few natural nesting sites on the island.

This is certainly not the first time that man-made nest structures have been tried. Many others have been successful with this same innovation. Reese (1970) erected over 100 Osprey platforms between 1964 and 1969 in the Chesapeake Bay area with good results. Nest poles have also been put up for Bald Eagles (*Haliaeetus leucocephalus*) such as the "king-size" 34-ft unit in Florida (*Popular Mechanics* 1971).

It was the desire of Martin Refuge employees to construct a nest platform which Ospreys would adapt to readily. The nest structure had to be strong enough to withstand stiff ocean winds and be accessible to the refuge personnel for clutch checks and banding operations.

The ultimate goal of placing artificial nest structures at Martin Refuge was to attract the Ospreys, which could not find a suitable nesting site elsewhere, to set up housekeeping on one of the man-made platforms. It was hoped that the total Osprey production of the island refuge could be increased because it was apparent that there were more active pairs in the immediate area than could find good nest sites. The project was basic wildlife enhancement. Schmid (1966), Kury (1966), Reese (1970), and Zimmerman (1973) have all documented the plight of the American Osprey.

MATERIALS AND METHODS

The Osprey nest structures at Martin Refuge were made from 20-ft creosoted poles. Generally no more than a 5-inch diameter pole was used because of the weight involved. The tops of the poles were notched on either side and two 2 × 4's bolted horizontally in place. Additional 2 × 2-inch material was then added on top of this to make a flat surface approximately 4 ft^2. Welded wire was placed on the platform to act as an adhesive base for the Osprey nest.

A hole was dug into the marsh with a standard, hand-operated rotary post hole digger. The hole was approximately 5 ft deep which left 15 ft of pole and nest platform above the ground. It was believed that the height was adequate for Opsrey nesting and that it would also prove to be a deterrent for predators. This height also kept the few refuge visitors from letting their curiosity get the best of them by having a "look-see" into the nest.

The poles were usually placed near the edge of the island, where the Ospreys could view the water, or along some tidal creek within the interior of the island. The nest structures were placed some distance apart in order to give the birds adequate territorial areas. Boating is the only method of transportation at Martin Refuge and the poles were erected in places where they could be easily reached under normal tidal conditions. Routine nest checks by an observer using a mirror on a hand-held pole would be easier with this accessibility.

Twelve of the 20-ft poles were erected for the 1968 production season. Later, six were added for the 1969 season. No new poles were put up until 1971 when another six were erected. The height of the final six poles was reduced from 20 to 14 ft.

RESULTS AND DISCUSSION

Ospreys favorably accepted the nest structures during the first season they were available (Fig. 1). In 1968, 10 out of the 12 available artificial platforms were active (Table 1). These 10 active nests produced 20 young Ospreys along with 10 other young produced at other sites on the

FIGURE 1. Artificial nest platform at Glen L. Martin National Wildlife Refuge.

TABLE 1. Utilization of nest structures by Ospreys on Glen L. Martin National Wildlife Refuge, 1968–72.

Season	No. of structures present	Active nests: On structures	Active nests: On other sites	Active nests: Total	Successful nests: On structures	Successful nests: On other sites	Successful nests: Total
1968	12	10	6	16	10	5	15
1969	18	14	1	15	5	1	6
1970	18	15	3	18	12	2	14
1971	24	20	2	22	18	2	20
1972	24	16	4	20	13	4	17
Total		75	16	91	58	14	72

island (Table 2). First observations indicated that the man-made nest structures might make a significant contribution to enhancing the Martin Refuge Osprey population. High initial acceptance during the first year that structures were available has also been reported by Reese (1965).

Because of the original high acceptance of structures by Ospreys, six new poles were added for the 1969 nesting season. Poor production success (Table 2) during 1969 delayed the construction of any additional new structures. Only six nests were actually productive during that year.

The year 1970 proved to be another productive season with 15 active nests out of a possible 18 on the artificial platforms. These 15 active nests produced 21 young Ospreys. A total of five other Ospreys were reared at other sites on the island, making a total of 26 for the season. Banding was initiated on the island during 1970, a first for Ospreys in the history of the refuge. Luckily, all 26 of the Osprey fledglings were banded before they left the nest (Fig. 2).

TABLE 2. Osprey production on the 4313-acre Martin National Wildlife Refuge, 1968–72.

Season	Young produced: On structures	Young produced: On other sites	Young produced: Total	Average young produced per active nest: On structures	Average young produced per active nest: On other sites	Average young produced per active nest: Total	Average young per productive nest	Osprey banded
1968	20	10	30	2.0	1.7	1.9	2.0	0
1969	5	1	6	0.4	1.0	0.4	1.0	0
1970	21	5	26	1.4	1.7	1.4	1.9	26
1971	30	6	36	1.5	3.0	1.6	1.8	29
1972	29	10	39	1.8	2.5	1.9	1.9	28
Total or Mean	105	32	137	1.4	2.0	1.5	1.9	83

FIGURE 2. Banding a young Osprey at Glen L. Martin National Wildlife Refuge.

Refuge personnel constructed six more Osprey nesting structures for the 1971 season. The poles used for the new units were 14 ft long instead of the 20-ft lengths used previously. The shorter lengths were tried because it was felt that height may not be advantageous to Ospreys and also the shorter poles were much easier to erect in the marsh. When arriving at the refuge in the spring of 1971, the Ospreys adapted to the lower platforms with about the same acceptance factor as the taller ones.

Osprey production continued to rise and in 1971 a total of 36 young Ospreys were reared on the 4313-acre island wildlife refuge. Some 30 of these young Ospreys were produced on the artificial structures, while 6 others were reared on discarded crab traps (Table 2). Bureau personnel banded 29 of the 36 birds.

No new poles were added for the 1972 nesting season. However, the island recorded more Ospreys produced than in any previous year; 39 were reared to the flight stage. The man-made poles were responsible for 29 of those produced, while 10 were reared at other sites. Banding again took place for the third consecutive year with 28 of the 39 Ospreys banded (Table 2).

Banding took place on Martin Refuge 3 of the 5 years during which the nest platform study had been undertaken. The nests were easy to reach via an aluminum extension ladder and the actual banding was accomplished on the site. A total of 83 immature Ospreys were banded on the nest during this 3-year period. Recovery data have already been collected on one immature Osprey. An Osprey banded on the nest 22 June 1970 with a "lock-on" type band was recovered on 2 November 1970 after being shot on the Pacific coast of Ecuador, just north of the equator.

Certainly one of the most interesting statistics to come from this 5-year study of Ospreys is the high number of birds produced per active nest. A total of 91 active nests produced 137 Ospreys which is an average of 1.5 Ospreys per active nest (Tables 1 and 2). This figure is considerably higher than the 0.95-1.30 rate that Henny and Wight (1969) determined the breeding population must produce each year if the Osprey was to maintain a stable population. Other reported Chesapeake Bay Osprey populations had a productive rate slightly less than this 1.5 figure, with Reese (1970) reporting between 0.96 and 1.16 during the years 1965-69 and Wiemeyer (1971) reporting 0.70 in 1970.

CONCLUSIONS

It is apparent that Ospreys will adapt to man-made nesting structures when other suitable sites are not available. Some selection preference for the elevated sites may also exist over ground nests, crab traps, or other sites on the island. Records of active nests over a 5-year period at Martin Refuge indicate that this preference occurs at a rate of 4.7:1 (Table 1).

Past records showed that Martin Refuge had an average of four to six active Osprey nests prior to the establishment of nesting structures although total Osprey numbers indicated a much larger potential breeding population. The acceptability of the nesting poles raised this active nest figure to over 20 during the last 2 years of the study (Table 1). Although small in size, Glen L. Martin Refuge is proving to be a most productive area for Ospreys in the Chesapeake Bay region.

It is not suggested that artificial nesting structures will work successfully in all areas even if a considerable number of "homeless" Ospreys are present. There are, no doubt, a number of factors which contribute to the acceptability of the platforms and their successful use. Martin Refuge proved to be "ripe" for the project partly due to the near nakedness of the topstory and the high prevalence of breeding pairs of Ospreys.

It appears that nesting structures may not be as efficient in productivity as other sites on the island. During the 5-year period, nesting poles produced 1.4 young per active nest while other "natural" sites produced an average of 2.0 young per active nest (Table 2). I am at a loss to explain this difference. The old truism of "its hard to duplicate mother nature" may be correct. The nests on artificial structures are generally much higher than those on other sites and thus may be susceptible to stronger winds, chilling effects, or other unknown factors. No real conclusion can be stated for this statistic in lieu of a lack of firm evidence.

Glen L. Martin National Wildlife Refuge has quite a high overall rate (1.5) of young Ospreys produced per active nest. Several theories may be expressed as to factors affecting this relatively high productivity. The island refuge is located approximately 10 miles from the mainland and is relatively free from the disturbances of pleasure boaters and fishermen. The island's central location in the Chesapeake Bay may place it in an area that has fewer pesticides and other chemical pollutants than are found in the tributaries that feed the bay. Hickey and Anderson (1968) clearly showed the direct relationship between chlorinated hydrocarbons in the diet of raptors and the resultant eggshell thinning which tend to cause reduced hatching success. The combination of less pollutants in the diet and the lack of significant human disturbance may contribute to the high nesting success of Ospreys at Martin Refuge.

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Osprey Survey on the Maine Coast, 1971

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SUMMARY

During May, June, July, and August 1971, I made a survey of 23 active Osprey nests on the Maine coast. These nests were all located between Casco Bay and Mount Desert Island. Twenty-two young birds were produced and fledged successfully from these nests. Twelve of the 23 nests under my surveillance failed during the breeding season. Casco Bay, which had six active nests in May, produced ten young birds; Muscongus Bay, which had six active nests in May, produced four young birds; and Mount Desert Island, which had eight active nests in May, produced three young birds. There were three nests under my surveillance which I did not include in the major areas already mentioned above because of their locations. One nest was located on the Damariscotta River below Damariscotta Mills. This nest produced two young birds. The second nest was located in East Boothbay and three young birds were produced. The third nest was located on Harper Island and this pair of birds failed to fledge any young. I understand from the owners of the island, however, that young birds had been produced, but that they had disappeared. The nesting success of the nests under my surveillance for 1971 was 0.9 young birds produced per nesting attempt.

Over the summer, I located one hundred new nests for my survey starting in May 1972. These nests are all located between Casco Bay and Mount Desert Island.

The methods I used to locate these nests varied. A good number of the nests were reported to me through various people in Maine in response to articles put in *The Maine Times*, *The Bar Harbor Times*, and *The National Fisherman*. Nests not located by this method were located by me after reading reports of past surveys done in Maine by Dr. Peter L. Ames of Chicago, Illinois; Mr. Channing Kury of Sunbury, Pennsylvania; and Mr. George Appell of South Harpswell, Maine.

Osprey Populations in Labrador and Northeastern Quebec

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Abstract: A block census in western Labrador in 1971 yielded 1.03 Osprey territories per 100 square miles. A strip census in northeastern Quebec in 1972 yielded 1.23 Osprey territories per 100 square miles. Productivity in western Labrador fluctuated between 0.2 and 1.1 young per occupied nest (1970-72) and in east-central Labrador between 0.2 and 1.3 young per occupied nest (1969-72).

During 1969-72, the Newfoundland and Labrador Wildlife Service and the Canadian Wildlife Service conducted a series of aerial surveys of waterfowl, caribou (*Rangifer tarandus*), Bald Eagle (*Haliaeetus leucocephalus*), and Osprey (*Pandion haliaetus*) populations in Labrador and northeastern Quebec.

A block census in July 1971 of 21,688 square miles (3.47% coverage) of western Labrador west of longitude 63° W yielded an estimated 1.03 Osprey nesting territories per 100 square miles. We followed nest success in this area during 1970-72 by checking as many nests as possible from late May to mid-June and made follow-up checks of occupied nests from late July to mid-August. Generally, nests were checked with a helicopter; fixed-wing aircraft were used in a few occasions. Nest success varied greatly over the 3 years (Table 1).

In late July 1972, a strip census of 52,733 square miles (3.06% coverage) of northeastern Quebec, between latitude 55° N and 58° N and longitude 64° W and 70° W, yielded an estimated 1.23 Osprey nesting territories per 100 square miles. We have no productivity information for this area except for data gathered during the strip census. The proportion of occupied nests (38%, N = 21) was similar to that observed

TABLE 1. Nest success of east-central and western Labrador Osprey populations, 1969–72.

	1969	1970	1971	1972	Total
EAST-CENTRAL LABRADOR					
Occupied nests	10	35	50	60	155
Same; known outcome	8	27	39	56	130
Productive nests	2	4	30	26	62
Percent nest success	25	15	77	46	48
Number of young	4	5	52	41	102
Young/productive nest	2.0	1.3	1.7	1.6	1.7
Young/occupied nest[a]	0.5	0.2	1.3	0.7	0.8
WESTERN LABRADOR					
Occupied nests		15	26	20	61
Same; known outcome		12	25	18	55
Productive nests		4	19	4	27
Percent nest success		33	76	22	49
Number of young		6	27	4	37
Young/productive nest		1.5	1.4	1.0	1.4
Young/occupied nest[a]		0.5	1.1	0.2	0.6

[a]Nests with known outcome.

in western and east-central Labrador in 1972. Therefore, we conclude that nest success may be similar to that in the other two areas studied.

In east-central Labrador, between latitude 52°30′ N and 54°30′ N, and longitude 57° W and 61° W, funding limitations did not permit a nest census. Nest success was checked during 1969-72 in the same manner as in western Labrador and also was found to fluctuate greatly (Table 1).

Using the method and survival rates estimated by Henny and Wight (1969) we calculated that the Osprey populations in western and east-central Labrador should be declining at annual rates of 8 and 6%, respectively. However, the greater nest success in 1971 makes us optimistic about the future of these Osprey populations. We now have eggs undergoing pesticide analysis and we are analyzing weather data. Hopefully, we will be able to make a statement about factors influencing these populations in our final report.

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Some Instant Benefits and Long-Range Hopes from Color-Saturation Banding of Ospreys

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Abstract: After six seasons of banding nestlings in the Osprey colony of eastern Massachusetts with only negative results, we added coded color-banding, in 1969, to our survey work and began marking adults as well as nestlings. Color bands proved beneficial at once in generating information, indicating precise percentages of returning individuals, the prevalence of the nest or territorial bond, and the variations in performance of known individuals from year to year. The first case of polygyny in the colony was discovered as the result of following the color bands, and the special details involved with that situation could be observed. In the following year, color bands enabled us to ascertain the existence of five distinct breeding trios, involving 55% of the nesting females. The question is raised whether the shortage of males here could reflect higher mortality among males attributable to their practice of eating the head and brain of a fish before delivery to the nest, assuming that pesticides are in higher concentration in that part of the prey fish. Of the polygynous pairings, 50% were unsuccessful in hatching their eggs. Preliminary conclusions from observation of color-banded Ospreys suggest that these birds are faithful to territory, nest, and mate in that order of preference. Positive proof that Massachusetts-born Ospreys return to breed in their native colony has not been established at this time.

Since the proclaimed purpose and justification of banding birds is the value of the information it produces, and since negative information is still information and therefore of some value, we must recognize and evaluate all the data generated and occasionally reassess our aims and techniques. It took us 6 years to reach this conclusion in working with our small colony of Ospreys in Massachusetts.

In 1963, Allen Morgan, Executive Director of Massachusetts Audubon, started us off with a survey of our area and banding nestlings with Fish and Wildlife bands. In the first 5 years we learned nothing about the fate of our nearly 50 banded fledglings except that they stayed away from their birthplace. Yet we could not draw conclusions about even this negative information, for our banding program had not included every hatchling known. Had some of the unbanded birds returned meanwhile?

It was in the 6th year that we spotted the first banded bird. It was a late arrival, and a transient. Here at last was positive information, but it was impossible to trap the bird or read her number without a scope. We decided we were not learning much or fast.

In the 7th year we changed our methods and our luck. We started to use plastic color rings to supplement Fish and Wildlife lock-ons. We processed every nestling we could reach, a high percentage, and as many adults as we could trap, which has averaged about 25% of the unmarked breeding birds each year. To date, we have color-banded 46 nestlings and 20 adults. We look forward to the coming season in keen anticipation of sighting at least some of those natives that fledged 3 years ago.

Meantime, the past 3 years have brought us an appreciation of the immediate benefits of color bands on adults, and in observing them we have begun to accumulate some positive and useful information. In 1969 we worked with 17 pairs, a population drop of 23% from the previous year. Of these adults we color-banded 10, with the youthful help of Paul Spitzer and Robb Hernandez, which included two pairs, and equal numbers of males and females. In 1970 we saw nine of these return to the colony, mostly to their same territories. The one missing female never has reappeared, but we were impressed with the 90% return figure.

During this second season of trapping, we added six more adults to the color group, including one more mated pair. That made 15 known individuals we were watching in 1970, nearly half the population of 16 pairs. It was the first year we had noticed a shortage of males and witnessed the colony's first known case of polygyny.

In this instance a marked male returned early, by about a week, to his old nest. Within a week, a female flew into the territory, but for a number of reasons she did not appear to be his old mate. She did sit with him in one of his favorite perch trees but would not stay long on his nest.

One day during that first week of the courtship we rebuilt the nest in the adjoining territory that winter storms had destroyed. Meanwhile, the female had accepted the male's food, and copulation had taken place in his territory. Very shortly after we rebuilt the other nest, she flew to it and stayed. He followed with food, nesting material, and copulation, just as before. She accepted it all and remained on the nest, while he ignored the handy perch there and kept returning, between activities, to his old territory.

The next week another female came into his area and immediately settled on his nest. To us she looked like his old mate, and she apparently struck him the same way, for he set to work at once gathering nesting material, bringing food, and copulating frequently. But he did not let the first female get lonesome. He continued to take care of her, too, in every way necessary for a successful breeding season. The only favor he did not show her was the "togetherness" we humans ascribe to the pair when we see the male loafing nearby when off duty. But this busy sire was alert and dedicated, he defended her territory like his very own, which he could do without great difficulty for the nests were about 250 yards apart.

Within 2 more weeks a second male arrived, relieving the first bird of his extraterritorial duty. There was no struggle, as far as we know. The polygynous male settled back to keeping steady company with the female on his old nest for the balance of the season. We were astonished as we witnessed this wonderful and natural adaptation, and delighted that it was the little red and yellow identification on his right leg that made certain knowledge of the event possible.

Curiously enough, in the territory adjacent to his on the opposite side, still another female that year made her choice of nest but waited in vain for a mate. Well on in the season we decided to investigate the reason for her constant incubation posture. When we approached to check, she flushed very reluctantly but long enough for us to discover that she was sitting hopefully on a round white stone. Within the week she deserted, the first casualty of a shortage of males that we had observed. It was an unsuspected harbinger of a truly remarkable situation in 1971.

The 1971 season was curiously noteworthy because we had an increase in active nests of 12%, along with a population decrease of more than 3%. This incongruity was made possible by a number of hard-working males. For not one, but five females returned to our Westport River colony without mates. Before they could desert or find comfort in a white stone, they were courted, dined, and comfortably bedded by gallant males from adjoining territories, one of them being our old friend red-and-yellow leg. Although their response was heart-warming to see, at the same time it raised the sobering question whether male Ospreys are on a crash course to extinction, thereby creating a floating population of females. Is it possible that the male, as provider for his family, may be ingesting more than a normal amount of pesticide residues? His eating habits do differ during the nesting season, at least, in the respect that before delivery to his dependents, and he makes a great many of them in a season, he generally eats the head and brain of the fish. Could the toxins be accumulated there in greater density than in the lean, fleshy tissue of the body?

Our extensive observation of the 1971 phenomena, in which 10 of the

18 nestings, or 55% of the colony, were polygynous, was made possible in great measure by the high percentage of color bands in use. Thirteen of the total 31 individuals were visually distinguishable, or 42%. We enjoyed a 62.5% return of color-banded adults in 1971. It enabled us to follow individuals, learn their special habits and characteristics, and document their activity and productivity. It led to some preliminary general conclusions that Ospreys, whether male or female, are faithful first to territory, then nest, and finally to each other, in that order of preference.

Here we might explicate with a bit of typical evidence we used for such inferences. Male red-over-yellow served a female in a separate territory but never spent the night with her, literally speaking. He was a homing hero. But the significance of his attachment was lost in the return-to-normal situation that developed. The real depth of his devotion to territory was not revealed until 1971 when he again took care of the females of the same two territories. This time there were two factors that must have brought pressure on him to make a change of address, but yet he did not. First, no other male ever came in to take over the extra territory, so that female needed and welcomed red-and-yellow all season. That he did not stay with her was remarkable in consideration of the second pressure factor, his own nest-mate. This disagreeable female, who wore a Fish and Wildlife band, was obviously not his old, easygoing mate. She flared up at him a number of times, never sat content with him, and although she did allow him incubator duty, she had made breeding very difficult for him during courtship. We think we witnessed the first suspected case of Opsrey rape here. Despite her hostility, as opposed to the natural gentility of the female in the extra territory, old red-and-yellow never abandoned his home perch, even though his home-base female deserted after their single nestling was taken by a predator.

Of these ten nests involving trios, five failed, of which four were double failures for the males concerned, suggesting that these two males may have been sterile or impotent. The fifth failure was under a seemingly aged female with a number of problems besides lack of a full-time mate. She had severe bumblefoot, a host of feather mites, and many feathers badly worn or missing completely. To distract her further from continuous incubation there was a serious problem of river traffic and boldly pestiferous gulls, so that her eggs were repeatedly chilled, we feel certain.

The site of one of the 1971 successful triangles is based in the east branch of the river on Lower Spectacle Island, home for countless generations of Westport Ospreys. We have observed the pair at this classic nest for several years. The female is strongly protective of her offspring and aggressive in defense of the nest. We once observed her as she vigorously drove away a healthy, newly fledged youngster from the adjacent territory who, in confusion or exhaustion, just happened to touch down beside her own offspring.

At the far end of the island is another old faithful tree nest, and in the center of the island had been a platform we had once erected to replace a third tree nest that had tumbled. For three seasons the platform had remained unused, so we concluded it was poorly placed.

Early in 1971 we moved this platform to an outside point on the island and secured it to a natural tree. The banded pair at the far end did not return, but late in March a lone female appeared, considered both sites, and at last settled on our fabricated job. She had not long to wait for the neighborly male at the occupied tree nest to offer encouragement and help. He and his female had arrived early, settled quickly, and were already working on a clutch. Remarkably, in this situation there was no competition or territorial hassling between females. Easy co-existence may have been due to the fact that the nests were so close together, less than 100 yards, and fully visible. Perhaps initial friction was averted by the fact the nest selections were not simultaneous.

The male evinced complete impartiality to territory. The whole island was his, and he generally took a perch just southeast and equidistant from both. He favored neither in attention or feeding.

We mentioned earlier witnessing the discrimination the tree-nesting female had shown between a foreign fledging at her nest. Our belief in her powers of discernment was reinforced during the summer of 1971 when we saw her calmly accept the visit of one of the fledglings from the neighboring platform nest. The little step-daughter stayed as long as she wished and flew back home when ready without prompting. What accounted for the change of attitude toward neighborhood young?

Because of the age and size of these fledglings, we decided against using the noose carpet to trap the adults. We ferried "Bubette," our pet owl, to the island for a Dho Ghaza Set. She looked suitably menacing on the marshgrass below the tree nest, where the nearly frantic female called loud admonitions to her young one almost continuously, as she always did at the slightest threat of danger. She made several feints at the owl, swift and strong, but always pulled up abruptly, with a thunderous turbulence, from the power dive. It must have been very unsettling for poor Bubette, for we never caught the Osprey. There was something about the platform nest the owl did not relish, either. The two fledglings there were nearly full grown. Maybe the prospect of being strafed by three huge hawks seemed grim.

Most unfortunately, the great female at the tree nest mysteriously vanished one night. But the male continued to provide for the fledgling which soon was venturing out on extended solo flights.

Shortly thereafter, what pleased us above all was further evidence of Osprey adaptability and intuitive understanding: the sight of the three color-banded fledglings together at the platform nest. The orphan had been accepted at once, just as if she truly belonged there. The whole family consolidated here when migrant Ospreys moved through shortly, pre-empting the tree nest.

This is what color-banding of fish hawks is all about. We see this young bird in a tree and we recognize him at once. We know his colorful name, his rank and serial number, birthday, birthplace, parents, their comparative age and health. We know his brothers, sisters, half-sisters, and his step-mother. What we do not know yet is when and if he will come back to us.

Osprey Population Studies on Gardiner's Island

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Abstract: During the 1930s and 1940s, Gardiner's Island, New York, supported a colony numbering some 300 Osprey nests, producing an average of about 2.2 fledglings per active nest. Since the early 1950s, drastic declines have been noted, both in terms of active nests and in numbers of fledglings per nest. In 1971 there were only 34 active nests, producing a total of 17 fledglings. Although the island has been sprayed only once (with DDT in 1957), analyses of overdue eggs collected in the past few years reveal high concentrations of DDT and its metabolites. Broken eggshells have been found in many nests. Some of the factors that have been suggested for Osprey reproductive failure in other areas do not apply here. There are only four permanent, human residents on this 3300-acre island, which is protected strictly from human intrusion. There are no predatory animals; and although there is a large gull colony at one of the Osprey breeding sites, reproductive success appears to be as high there as at other sites where gulls are not present. In addition to DDT as a contaminant in Gardiner's Osprey eggs, polychlorinated biphenyls (PCB's) are now also suspected, as they are being found at high levels in fish taken in local waters.

During the 1930s and 40s, it is highly probable that Gardiner's Island, located off the eastern end of Long Island, New York, was the site of the world's greatest concentration of nesting Ospreys. While earlier in the century visitors estimated not more than 150 nests on the island (Chapman 1905), construction and clearing on neighboring Plum Island (Allen 1892) and Shelter Island forced many of the birds nesting there to move to Gardiner's, where such disturbance was nonexistent. Some birds probably moved there from the mainland for the same reason; thus, in 1932 Knight (1932) reported more than 300 nests on the island. Although no precise counts were made, other observers have arrived at about the same total. On my first visit in the late spring of 1948, I was ready to agree with the estimate of 300 nests, and in fact this was the figure given me by one of the resident workers.

Gardiner's Island, with a total area of 3300 acres, is about 8 miles long and 3 miles wide at its broadest point. At the north end lies Bostwick Meadows, an extensive area of low sand dunes and a salt lagoon;

behind it is a broad forest of ancient oaks and other hardwoods. The remainder of the island, which is gently rolling in contour, consists mainly of open grasslands and heath interspersed with woodlots and a few ponds and swamps. Several large, shallow lagoons lie in back of the shorelines. The shores themselves are comprised of beach sand and pebbles, with a scattering of large boulders. More boulders lie out in the water.

The Ospreys, therefore, have had a wide selection for their nest sites. Some were in high trees, both dead and living, some in a scattering of low, dead cedars on Bostwick Meadows, some on offshore rocks, some on man-made structures such as sheds, docks, and wreckage, and many on the beach itself. Abbott (1911) describes 22 nests spaced rather closely along the southwesterly beach. In 1940 there were 20 nests on Cartwright Shoal (Leroy Wilcox pers. comm.), a low sandbar extending from the southern tip of Gardiner's. In spite of the current greatly reduced population, all these types of nest locations are still used on the island.

The most remarkable feature of Gardiner's ecology, however, is the complete absence of predatory mammals, which in other areas may have adverse effects on Osprey breeding success. There is not a single raccoon, mink, fox, weasel, skunk, opossum, or rat to be found there. I have been unable to learn when and how any such animals, that can be presumed to have been present in the past, were exterminated. However, since the island has been stocked on several occasions with upland game birds, it is likely that vigorous efforts were made to eliminate any predators. Such efforts have obviously been successful.

Being privately owned, the island has been strictly protected from human intrusion. No one is permitted to land there without obtaining prior permission from the Gardiner family members, who are very solicitous about the welfare of the Osprey population. For the past 10 years there have been only four permanent residents, who serve as custodial and maintenance staff.

I will attempt to discount one more suggested cause of Osprey reproductive failure on the island, possible disturbance by gulls. In the case of the Osprey nests on Bostwick Meadows, we have a situation where birds are nesting in the very midst of a dense and steadily growing colony of Herring and Great Black-backed Gulls (*Larus argentatus* and *L. marinus*). In fact, when gull chicks have reached the stage of wandering from their nests, some can be found crouched within a few feet of active Osprey nests. And yet reproductive success in these nests is no lower than in tree nests remote from gull interference in other parts of the island.

Thus, surrounded by waters teeming with fish, with no natural enemies and no human interference, Gardiner's Ospreys are presented with optimum breeding conditions. In the 1940s, better than two fledglings for each active nest were recorded. For instance, in 1941 L. V. Wilcox (pers. comm.) reported banding an average of 2.2 large nestlings per active ground nest he visited.

In 1948 the decline set in, both in terms of active nests and of reproductive success per active nest. S. Yeaton (pers. comm.), for instance, reported finding only 8 active nests on Bostwick Meadows in the mid-50s, whereas 30-40 nests were there 10 years before. The decline in fledged young reached its lowest point in 1965 and 1966, when just four young were fledged in each of those years from 55 to 60 nests. Since then, there has been an increase in fledgling totals but a continued decline in active nests. In 1969, when Paul Spitzer (pers. comm.), whom I have had the privilege of assisting, first included Gardiner's Island in his intensive studies on Osprey populations in the northeastern United States, we had 25 fledglings from 38 active nests. These numbers were repeated exactly in 1970, but in 1971 we found the number of fledglings had dropped to 17, from 34 active nests. Thus, from over two young per nest in the 1940s, we now have 0.5 young per nest.

How can we explain these statistics? And what can we predict for the future of Gardiner's Osprey colony? In spite of the dismal picture presented by this decline, it is still much better than that on Long Island and Shelter Island. For instance, the eight active nests on Orient Point in 1969 failed to produce a single young. The picture is only a little better elsewhere on Long Island.

Since human and animal disturbance and lack of an adequate food supply can be definitely ruled out as factors contributing to the decline on Gardiner's, we must look elsewhere. It is not difficult to pinpoint the causes. The answer is toxic chemicals. In the mid-1960s I collected several long-overdue eggs from Gardiner's nests and had them analyzed at Brookhaven National Laboratory by gas chromatography. One egg had 13.8 ppm wet weight of DDT and its metabolites DDD and DDE; others had slightly lower concentrations. An egg laid in 1967 had 11.3 ppm, and in 1969 two eggs had a total of 13.7 ppm, plus 0.28 ppm of dieldrin. Since dieldrin is many times more toxic than DDT, the latter figure is quite significant. Fragments of eggshells and dented eggs found recently in many nests indicate that some birds are suffering from an inability to metabolize sufficient calcium for healthy eggshells, which is one of the symptoms of DDT ingestion (Ratcliffe 1967; Risebrough et al. 1971). From these findings, it must be concluded that chlorinated hydrocarbon pesticides, especially DDT, are primarily responsible for the lack of hatching success.

I should mention here that Gardiner's Island has been sprayed with

DDT only once. This was in 1957 when the U.S. Department of Agriculture launched an ill-advised and totally futile effort to prevent gypsy moth infestations in the Long Island area. On Long Island itself, however, the Suffolk County Mosquito Control Commission was aerially spraying DDT routinely during every spring and summer from the late 1940s until 1966, in their largely unsuccessful attempts to control mosquitoes. In 1966, a local lawsuit succeeded in bringing an end to this activity; and since farmers are now finding DDT ineffective, residues in the local environment could be expected to decline steadily from then on. With Gardiner's separated from the mainland by several miles of deep tidal waters, it could be assumed that Gardiner's Ospreys would be the first to recover as a result of the lowered contamination in the fish they were catching. I suggest that the increase in reproductive success following the low in the mid-1960s is at least partially a result of this decrease in the local use of DDT. In spite of any decrease in DDT levels, however, we are seeing, in 1971, a continuing decrease in breeding pairs. Can this be attributed in part to the fact that some of the older breeding birds are now reaching the end of their normal life span, and that there are insufficient younger ones to replace them, a naturally occurring process in a viable colony? If this is so, then the colony will continue to dwindle over the next decade or so, until no more birds remain.

In 1971, another synthetic compound became suspect as a source of Osprey reproductive difficulties. We noticed that almost all of 15 overdue eggs collected on the island showed no signs of shell-thinning. Since PCB's (Hammond 1972) produce many of the same symptoms in wildlife as do the DDT family of pesticides, but do not induce shell-thinning, is it not possible that this material, already a worldwide contaminant, is now affecting the Gardiner's Ospreys? Studies by Hays and Risebrough (1971) on a recent high incidence of malformations in tern chicks on nearby Great Gull Island indicate the probability that PCB's are the causative agent there. They report having found relatively high levels of these compounds in the tissues of the terns and the fish upon which the terns feed. Since PCB's are even more stable than DDT, they will probably remain in the local environment for a long time.

A further ominous sign in the dwindling Osprey population in the area must be reported. In 1971 we found a male bird, banded as a nestling 2 years before, now mated with a female. Eggs were laid, but they did not hatch. Since under normal conditions Ospreys do not mate until their third year, I wonder if we are witnessing a phenomenon that has been recorded in other animals when their numbers are in a state of drastic decline. In the case of the great whales, for instance, many individuals have been observed to reach maturity at an earlier age than normal. I suggest that we look for more cases of this abnormal behavior in the Osprey in areas where its numbers are in a serious decline.

To summarize, I am convinced that the sole reason for the steady decline in the Osprey population on Gardiner's Island is due to the presence of stable chemical pollutants in the environment. DDT is the major pollutant, but it is probable that more recently PCB's are also implicated. These chemicals, which are in the fish taken by the adult birds, are transmitted through their reproductive systems to the eggs and young. Due to the unique conditions for Osprey breeding on the island, where factors sometimes held responsible for lack of reproductive success in other areas do not exist, the effects of DDT on the Gardiner's Osprey cannot be denied.

I must add a final comment, which concerns not only the Osprey but many other bird species whose populations are declining. It is a shocking commentary that the Federal Government has not seen fit to protect such birds. On page 4 of Wildlife Leaflet 486 (USDI 1969) there appears a list of birds specifically not provided federal protection. This list includes "flamingos, caracaras, falcons, hawks, ospreys, owls, pelicans, and spoonbills." In response to an inquiry I directed to the Department of the Interior recently, I was told that certain species had been excluded from protection "either because when the treaties (between Canada and Mexico) were effected it was thought that those birds did not migrate between the two contracting nations, or they were considered injurious to man's interests and should not be protected for that reason." I consider that for such a rationale to exist at the present time, which I can only attribute to bureaucratic lethargy, indifference, and ignorance, is a national disgrace.

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Comparison of Osprey Nesting Success Between the 1940s and 1970s in Cape May County

JOSEPH JACOBS, Pennsauken, New Jersey

Abstract: The subject-area of the discussion is Seven Mile Beach on the east coast of New Jersey, 15 miles north of Cape May Point, the nesting area for more than half of all New Jersey Ospreys. Predominantly a tidal salt marsh, it supports but a few old trees. The author has banded here continuously since 1944, but allows that inconsistencies in his coverage made evaluation of his data difficult. Most of the Ospreys in this area nested in trees, a few choosing the open meadow, others settling on various man-made structures. When 1964-65 surveys showed open marsh nests produced better than tree nests, the author initiated a program of erecting low platforms for nesting. The birds readily accepted them; and although the production theory proved untenable, the author continued for various other reasons to construct platforms until 1970, when it was decided the number was adequate for the population. The percentage of successful pairs in the study area during the 4 years 1968-71 experienced a drastic drop 33%.

I am sure most of you are familiar with New Jersey's southern tip, or the Cape. The area I will discuss is on the east side of the Cape and about 15 miles north of Cape May Point. This area is called Seven Mile Beach on the maps, and I feel sure that presently over half the nesting Ospreys in New Jersey nest in this area, between the barrier beach and the mainland and between Townsend's Inlet and Stone Harbor. I would say that less than 1% of this extensive *Spartina* marsh has trees. These trees, red cedar, holly, cherry, and post oak, grow on elevated areas that are quite unique, since they are long and narrow, run in a north-south direction, and are obviously ancient dune remnants. The balance of the area consists of tidal salt marsh covered with *Spartina alterniflora* and *S. patens*.

I began banding the young Ospreys in this area in 1944 and have banded them every year since then with the exception of 2 years (1948 and 1959) when they were banded by others.

I have had a problem trying to evaluate my data over the years due to inconsistencies in my coverage of the area. I used only a rowboat for the first 16 years that I banded, but during the last 12 years I used a power boat. During those early years, I spent only one day banding and banded only a small part of the birds, but now I may spend 4 or 5 days and I get to every nest that has young. Another reason I spent only one day afield during the early years was the insects. They were awful. However, for some years now I have found very few insects and can be perfectly comfortable wearing a bathing suit while on the meadows.

While the majority of the Ospreys nest in the trees, there are a few that choose to nest on the open meadow. I found two such nests: one on the bow of an abandoned rowboat with two young; and the other, just on the meadow by a post, contained three young. They also nest on duck hunters' blinds. It was in 1964 and 1965 that I found five nests on the meadows that produced an average of two young per nest, while those in the trees averaged 1.7 per nest. Although the number of nests involved were not enough to be significant, I felt I would like to encourage more low nesting on the open meadows to see if they might be more successful. In 1966, I built one platform and nest away from any trees in a remote part of the meadow. Although there were unoccupied nests in trees only 300 yards away, a pair nested on this platform the first year and every year thereafter, although they did not raise any young during the first 2 years. Although I found I was wrong about their raising more young in a meadow nest, I found the platform design satisfactory and quite acceptable to the Ospreys.

Development came slowly to this area, and it changed little geographically during the first 20 years. In 1967 construction began on a new, high-level bridge that crossed the meadows in a path that bisected the trees where most of the nests were located. Since the platform I constructed the year before was accepted so readily, I decided to build two more and place them about a mile south in an area of meadow that had no trees or development, to see if I might encourage the birds to move to a less vulnerable location. My assistant and I loaded the boat with parts for two platforms and placed them where we felt they would be safe from boaters. It seemed as though the birds were waiting for a place to nest because we no sooner had left the platforms when Ospreys appeared on them. We finished this season by erecting ten platforms, nine of which were occupied; however, only one young was raised on these. The nests on these platforms vary considerably. I built the first nest of flotsam gathered near the platform, and the birds added sticks to this.

In 1970, I erected the last of the platforms and was satisfied that there were enough for any birds that might need one.

One boardwalk nest was located along the inland waterway and was farther west from the beach than any other nest. It could be reached only by boat. However, for the 5 years that I visited this nest, it proved unsuccessful. I did, on one or two occasions, find bad eggs still in the nest long after the young should have hatched. For this reason in 1970 we erected a platform about 300 yards east of this nest, back from the waterway away from boat traffic. When we visited the nest later, we found the birds had moved over to it and the nest contained five eggs. On a later visit, we found only shell fragments, but no clues as to what might have happened. In 1971, this platform produced two young.

There was a drastic drop in breeding birds that returned in 1971. I cannot account for this in any way. No other population of Ospreys that I know of has experienced a 33% drop this year, so I feel these birds are still alive. We can expect the usual attrition which could account for 2 or 3 pairs, but what happened to the other 11 of 12 pairs? It would seem that these birds relocated for some unknown reason, but I found only one nest south of Seven Mile that was reactivated after being empty for 3 years. There may have been a northward movement, and I feel this could be the answer.

Osprey Feeding Problems on the New Jersey Coast

HERBERT MILLS,[1] South Jersey Wetlands Institute, Bridgeton

Abstract: I have been interested in Ospreys in southern New Jersey since 1917, and I offer these notes and observations to provoke thought and help restore Osprey populations. I have watched numerous nests on the bayshore and coastal stretches. Apart from destruction of birds and nests by maintenance crews of utility and railroad lines, the species thrived until 1945, when the count of nests in this general area under scrutiny was 148. Approximately 40 remain today, about half of which are irregularly productive. Bayshore country on the New Jersey side of Delaware Bay is traditional Osprey country and one of the most heavily sprayed agricultural areas. Today's count, extending over 110 miles, compares unfavorably with 100+ counted in the 1880s at Seven Mile Beach alone, or 20 nests on the tip of Cape May as recently as 1936. Many old sites have disappeared because of industrial and housing developments, and various kinds of serious disturbance by humans have hastened the decline of the species. I feel that diminished food supply, a result of widespread use of pesticides and herbicides, may also have contributed to the decline. In the late 1940s and early 1950s there were 20 fish pounds, each 1000 ft long, a mile offshore from a 30-mile coastal strip where some 80 Osprey nests existed. Until the mid-1950s, observation of Ospreys fishing or carrying fish, especially Menhaden (*Brevoortia tyrannus*), were commonplace. By 1964 all pounds had disappeared, for Menhaden fishing was taken over by fast trawlers that overfished the waters. The loss of the pounds and the Menhaden coincided with the decline of the Ospreys. Since 1966, close observation of the fishing of Ospreys from Seven Mile Beach indicated that fish nearby are very scarce and small; and in the bay or sound Ospreys are taking crabs instead of fish. This latter practice led the author to experiment with supplemental feeding of a particular nesting pair. He left thawed Menhaden at a known perch, where the male Osprey readily took the food proffered, as many as three per day. The question is raised whether availability of adequate food affects the reproductive urge and clutch size of breeding Ospreys, for it does with some birds of prey, and whether the Osprey's decline is related to diminished food supply.

The Osprey (*Pandion haliaetus carolinensis*) has held great interest for me since early childhood, and I have been watching and studying these birds since 1917 when I first knew them on the Seven Mile Beach in

[1]Now deceased.

Cape May County, New Jersey. While my activities have never permitted the kind of close study that science requires, the sketchy notes I have kept and the observations I have made should at least provoke thought and may perhaps be of some help in restoring Osprey populations.

HISTORY OF THE OSPREY IN SOUTHERN NEW JERSEY

Over the years, I have been able to keep an eye on a number of nests both on the bayshore and on the Seven Mile Beach, where I have been a summer visitor since childhood. As late as the 1940s Ospreys thrived and were productive, and until 1945 two pairs nested at my farm on the Delaware Bay, midway between Salem and Cape May and 3 miles in from the mouth of Cohansey Creek. At that time, on the bayshore there were 32 nests that I knew of between Salem and Cohansey Creek, 14 from the Cohansey to the Maurice River, 17 between Mauricetown Road and Bennett, and 6 in the Town Bank area—all active. Along the coastal marshes from Cold Spring Inlet to the Stone Harbor Causeway, there were eight nests. On the Seven Mile Beach, where the largest concentration occurred, there were 46 active nests—in cedars, on the old boardwalks leading to clammers' shacks on the marsh, on the shacks and duck blinds, and a few on poles. Most of the nests in trees along the railroad right-of-way had been destroyed. Fifteen nests on Ludlam Beach backwater meadows were active, but a dozen or more between Townsend's Inlet and Strathmere were systematically destroyed and the birds shot by utility maintenance crews. There was one nest at the Palermo exit to Ocean City; this was the farthest north that we maintained regular observations. These are only the nests known to me, and do not represent a systematic search of all areas.

Of these 69 known nests on the 80-mile stretch of bayshore, only 5 remain; and of the 79 known along the 30-mile coastal stretch, about 35 are now occupied, with about half being irregularly productive.

From 1932 through 1942 I was contracting for tomatoes and other farm produce for South Jersey canners, which necessitated covering some 50,000 acres along the bay shore on the New Jersey side of Delaware Bay. This traditional Osprey country has been one of the most heavily sprayed agricultural areas in the state—and it is now virtually devoid of nesting Ospreys. Today's count of 40-odd known nests along 110 miles of ocean and bay shore compares rather unfavorably with figures of the 1880s when, according to Stone (1937), there were a hundred or more nests on the Seven Mile Beach alone. As late as 1936, Drs. Stone and Choate counted up to 20 occupied nests on the southern tip of the peninsula below Town Bank.

POSSIBLE REASONS FOR DECLINE

I well remember when the note of the Osprey was very much a part of summer at the seashore, and an almost constant reminder of the bird's presence. Too, the very large nests and the gathering of nesting materials throughout the breeding season were characteristic. Today's nests appear small and poorly constructed, and activity seems to be at a minimum.

Many former nesting sites have given way to housing and industrial development, and disturbance due to the closer proximity of man has played a considerable part in the bird's decline. Accessibility to highways and watercourses is an additional problem. For example, a nest close to the highway, which we kept under observation last year, was disturbed and the brooding bird kept off the nest sometimes several times a day by photographers and others through the crucial months of May and June.

Some shooting of Ospreys continues, and birds that manage to nest may have their young bludgeoned by diversion-seekers who traverse the marshes in speed boats.

While in recent years much emphasis has been placed on hatching failure of the eggs of this species because of DDT and other pesticides, I have long felt that a diminished food supply due to the widespread use of pesticides and herbicides might well be a major factor. Over the last few years I have given much thought to the relationship of the Osprey's increasingly irregular productivity to what would seem to be a lack of suitable and adequate food from the time of the birds' arrival in spring until their departure in August.

On the 30-mile coastal strip where 79 or more nests formerly existed, there were, in the late 1940s and 1950s, twenty 1000-ft-long fish pounds a mile offshore. Until the mid-1950s a dozen or more Ospreys could be seen at one time perched on the pounds off Wildwood, Stone Harbor, Avalon, and Townsend's Inlet. This 12-mile stretch had by far the greatest concentrations of nests, and they were situated where they could be observed easily and the birds' traffic patterns followed. One could invariably see a bird or two coming or going between nest and fishing area throughout the day. Menhaden—a preferred fish—were abundant, and the birds were frequently seen with fish so large they had difficulty lifting them from the water.

Then, Menhaden fishing became a highly mechanized operation, with large fast boats and the use of aircraft for spotting schools of fish; by 1960 only one small pound remained, and that fisherman went out of business about 1964. The loss of the old fish pound in favor of trawling, and the resultant overfishing, coincides with the decline of the Osprey.

Since 1966 we have given particular attention to the remaining birds on Seven Mile Beach. We have watched as many as five or six birds fishing in the ocean gullies in front of our house day after day and have seen them returning after many, many attempts, with empty talons or with fish so small that one wonders how they were able to hold them. Watching Ospreys fishing in the bay or sound, we have noted that fiddlers and blue crabs have replaced the sizeable fish of bygone days.

EXPERIMENTAL FEEDING PROGRAM

It seems to be generally agreed that the Osprey eats only live food—and certainly I have never seen one feeding on dead fish on the beach, as did the Bald Eagle. Despite this fact, we decided to experiment. After nesting was well under way last year, finding that the fishing Ospreys were returning mostly with small crabs and not with any substantial catches, we undertook to supply frozen Menhaden at a regularly used perch near a particular nest. We began by supplying one thawed fish each day. They were taken immediately. Increased to two, then three, the fish were picked up by the male Osprey as soon as we departed from the perch area.

Certainly, no definite conclusions can be reached from such an isolated experiment, particularly in view of the late date on which we began feeding. However, if availability of adequate food prior to and during nesting affects the urge to breed or clutch size, as with some other birds of prey, is it not reasonable to assume that the Osprey's decline may be, in part at least, related to the diminished food supply?

Now that we have under protection more than 5000 acres of the tidal marsh on which this last concentration of Ospreys on the Jersey coast nest, we are considering supplying, at four or five trial sites, a regular supplemental feeding to be available at the birds' arrival in the spring and continuing through the nesting season. We would also like to try a large, shallow fish impoundment to supply live fish.

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Nesting Success of Ospreys in Central Chesapeake Bay

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Abstract: This paper summarizes the nesting success of a central Chesapeake Bay Osprey population. Data are presented on percentage of nests with eggs, nestlings, and fledglings; percentage of eggs hatching and nestlings fledging; and productivity of successful nests with comparisons with data from other areas. Some factors are discussed such as food supply, nest site availability, and disturbance which may have had an influence on nesting success.

This study of nesting success of Osprey was conducted in Talbot County, Maryland, during the period 1965 through 1971. A more comprehensive evaluation of nest success and methods used are given in (Reese 1970a, b, 1971) and will not be repeated here. Factors affecting nest success discussed here are not contained in the above references.

NEST SUCCESS

From 73 to 105 active nests were accessible for study each year from 1965 through 1971. The percentage of nests with eggs ranged from 90 through 97 annually (Fig. 1). The percentage of nests with nestlings ranged from 54 through 61% during the same period. The large annual percentage differences between nests with eggs and nests with nestlings reflect attrition of complete clutches which occured in as many as 42% of the nests studied during one year (1969). The percentage of nests with fledglings fluctuated from 48 to 58 during the 7 years. The percentage difference between nests with nestlings and nests with fledglings ranged from 1 to 9% annually, and reflects nestling mortality.

The percentage of eggs hatching decreased annually from 50 in 1965 to 41 in 1969, rose slightly (43) in 1970, but dropped to 42 in 1971 (Fig. 2). This decrease in the percentage of eggs hatching contributes heavily to unsatisfactory productivity observed in recent years and is a serious problem facing Osprey fecundity today. The percentage of eggs

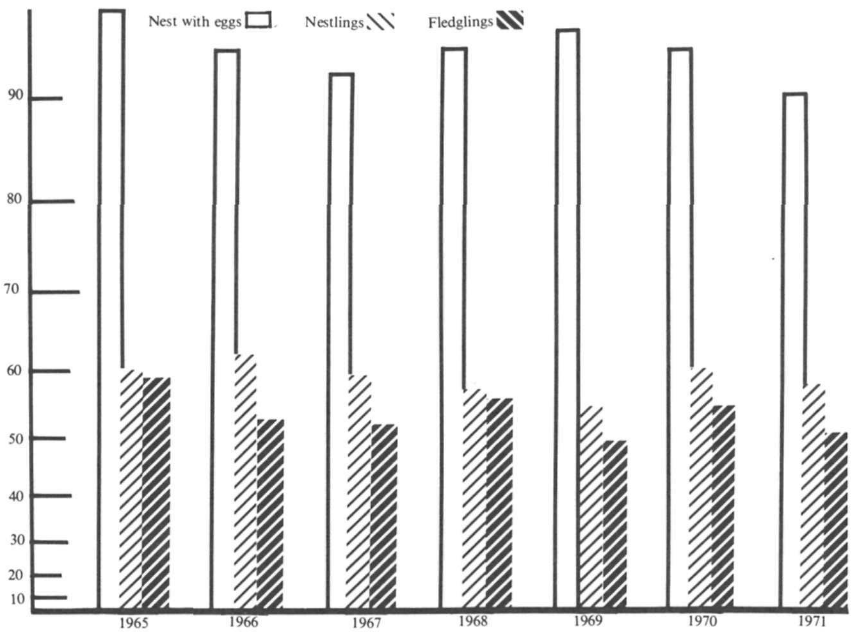

FIGURE 1. Percentage of nests successful.

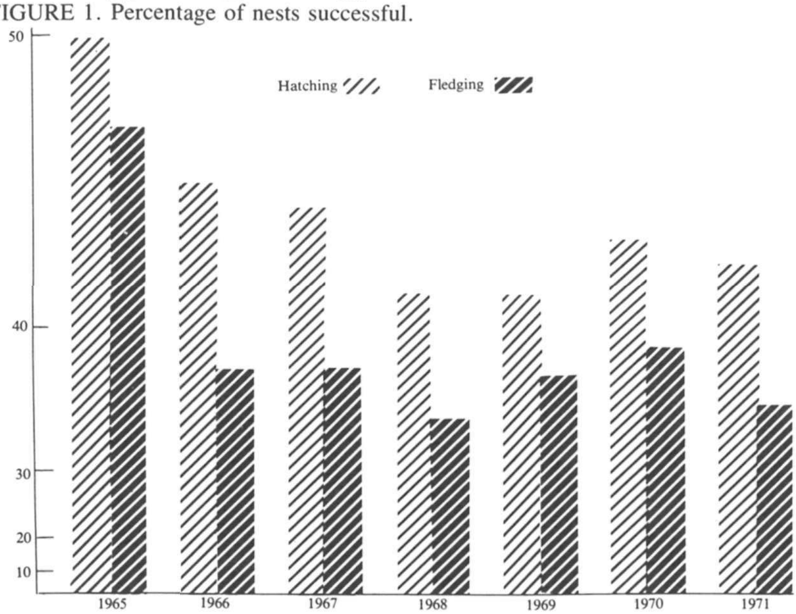

FIGURE 2. Percentage of nests hatching and fledging.

producing fledglings decreased annually from 47 in 1965 to 32 in 1968, rose to 35 in 1969 and 38 in 1970, but dropped to 34 in 1971.

Throughout the 7 years, the average number of young fledged per productive nest has been near 2.0, which is close to pre-1960 averages and is probably the best in the country today. The average number of young fledged per active accessible nest decreased from 1.16 in 1965 to 0.96 in 1969, rose sharply to 1.04 in 1970, but dropped to a low of 0.87 in 1971. These averages are among the best observed in the country (Reese 1970a, b) and have been within the estimated range of production necessary to maintain population stability (Henny and Wight 1969) each year except 1971.

FACTORS INFLUENCING NEST SUCCESS

Food Supply

There are 26 common species of fish available to Ospreys in Chesapeake Bay (Hildebrand and Schroeder 1927). Of these species, seven form the bulk of the Osprey's diet. In order of importance, those species are: eel, menhaden, striped bass, alewife, white perch, killifish, and sunfish. The species represent anadromous, catadromous, transit, non-transit, long-lived, and short-lived forms. A single species makes up the bulk of the Osprey's diet in any given month as a result of the differences in movement and spawning time of various species. Eels, however, are available in all months.

In the last 10 years, state biologists have found no serious population decrease in any fish species found in Chesapeake Bay (Joe Boone, Fish Management Section, Md. Fish and Wildlife Admin. pers. comm.). Fish populations are generally good, though some short-lived or long-distance migrant species will fluctuate severely from year to year. Today's shad and croaker populations are much reduced, but they have been dwindling since the turn of the century. Average commercial landings for five species most important to Ospreys are given in Table 1 and may be used as an indicator of yearly abundance in Talbot County during the last 12 years.

Commercial fishing in Chesapeake Bay has decreased 80% since the 1950s (based on licenses registered with the state), while sports fishing

TABLE 1. Talbot County commercial fish landing averages for 1960–71.[a]

Species	Pounds/Year
Menhaden	645,700
Striped bass	395,450
Alewife	286,900
White perch	151,600
Eel	27,400

[a]Data taken from landings registered with National Marine Fisheries Service, Division of Statistics and Market.

has increased several-fold with popularization of outboard motors, trailers, and portable boats. It is suspected that sport fishermen now harvest more bay fish than commercial fishermen (personnel at National Fisheries Service pers. comm.). Despite these demands, bay fish populations maintain adequate numbers.

Nesting Sites

Talbot County is classified as 70% farmland, 27% woodland, and 3% commercial. In the last decade farmland has decreased 12% and woodland 25%, while other classifications have risen 24% (based on figures given in annual county reports of land trends, State Agricultural Extension Service). Despite the decrease in wooded habitat, trees suitable for nesting remain plentiful in proportion to their actual use by Ospreys. Nest sites on offshore duck blinds and channel markers seem to be preferred by Ospreys and are most successfully utilized. In 1971, 158 such structures were available for Ospreys nesting along the 400 miles of shoreline in my study area. Seafood processing plants, waterfront condominiums, and marinas are the only operations threatening Osprey nesting habitat in my area, but they are not of serious proportion yet. In view of the Chesapeake Osprey's acceptance of a wide variety of nest sites and the abundance of such sites in Talbot County, I presently see no problems with housing.

Disturbance

It is difficult, if not impossible, to monitor the influence of various types of disturbances on reproduction. Investigating the magnitude of potential sources of disturbance may give meaningful indications of their effects.

Since Ospreys have no natural enemies and most nests studied were not subject to terrestrial predation, I do not consider natural predation as having serious influence on reproduction.

Weather quite seriously influences reproduction in some years, 1971 being a good example (Reese 1971). Summer thunderstorms with high winds and driving rain are most important here, but storms have to be anticipated annually.

People-related disturbance is most important in influencing reproduction, and I can only begin to consider the more obvious sources here. Foremost is the United States Coast Guard, which was responsible for destroying 9% of the accessible nests studied from 1965 through 1970 (Reese 1970a, b). Since most of the nests studied are located on offshore structures, people with boats or those living along the shoreline possess the greatest potential for disturbance. The population in Talbot County has increased 10% in the last decade (U.S. Census Bureau pers. comm.). It should be pointed out here that 80% of the human population in the area live along the tributaries. Even more serious is state boat registration, which has risen 50% in the last decade (Office of Chesapeake Bay Affairs pers. comm.). This probably gives nearly all local residents access to these offshore structures. The county maintains 23 public landings in the study area where free boat launching and parking are available. Weekends find these landings jammed with people from metropolitan areas west of Chesapeake Bay. Many of these people do not have boats, but wade with dip nets and floating baskets to catch crabs. It has been estimated that 3 million pounds of crabs are caught annually by these means (National Marine Fisheries Service pers. comm.). Yachting is a big industry in the area and many merchants make a living solely from transient yachtsmen. Of course, all of these water activities coincide with critical stages of Osprey reproduction.

People-related disturbance is definitely on the increase annually, and locally I suspect that its influence on reproduction is much more serious than that observed. Horn blowing, shooting, water skiing, night lights, fast boats, and seaplanes are a few other sources warranting consideration.

Pollution

Environmental contaminants such as pesticide residues or industrial chemical wastes may have a greater influence on reproductive success than any factors mentioned above. However, no chemical analyses have been made of any materials collected in my study area.

SUMMARY

Summarizing the 7-year period, of 627 nesting attempts, 38% suffered complete egg failure. Of 1693 eggs layed, only 43% hatched and 36% fledged. Despite low hatchability and fledgling success, Talbot County Ospreys are producing at a rate of nearly 1.0 fledglings per active nest. Adequate food supply and ample nesting sites enhance this production, but human disturbance and environmental contamination are increasing annually.

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Reproductive Success of Potomac River Ospreys, 1971

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Abstract: Reproductive success of Ospreys on two study areas on the lower Potomac River was determined in 1971. In the Maryland and Virginia study areas, fledglings were produced in only 34 and 13% respectively, of the accessible active nests with known outcome. Only 0.55 and 0.17 young fledged per accessible active nest with known outcome in the Maryland and Virginia study areas, respectively. Egg failure was a major factor in the poor reproductive success in both areas; young disappearance was also involved in the low fledging rate in the accessible active nests with known outcome in the Virginia area. Shell-thinning was found for eggs from both study areas. Reproductive success was well below that considered necessary to maintain a stable population.

This is a report on the reproductive success of Potomac River Ospreys in 1971. The study was initiated in 1970 to determine the status of the Osprey population along the Potomac River, and to evaluate the factors that relate to its reproductive success (Wiemeyer 1971). Osprey reproduction has been studied in some segments of the Chesapeake Bay Osprey population, which is the largest known population of Ospreys in the United States, but information is needed from more segments of this regional population so that its status and trends can be properly evaluated.

METHODS

The main study area is located along the Maryland shore of the lower Potomac River, in Charles and St. Marys counties (Wiemeyer 1971). All field activities in this area in 1971 were conducted between 8 April and 3 August. Most nests were visited initially during the first half of April. Each nest was visited at about 2-week intervals thereafter until the nest failed or the young fledged.

The secondary study area is located along the Virginia shore of the Potomac River in Westmoreland County (Wiemeyer 1971). This area was visited on 20 April, 17 May, 3 and 18 June, 13 and 22 July, and 6 August. Nearly all active nests in the study area were checked on each visit. The study area was expanded so that a number of nests not checked in 1970 were included in the 1971 survey. Both study areas are along tidal portions of the river.

The term "accessible active nest," refers to a nest at which adult birds were present on several consecutive visits during the first half of the reproductive season, and whose contents could be examined at least occasionally. An "inaccessible active nest" refers to one where adult birds were observed on more than one visit during the first half of the reproductive season, and whose outcome was determined by observations from the ground which usually made it possible to determine presence or absence of young in an advanced stage of development. The contents of many nests that were classed as inaccessible in 1970 were checked with the aid of a mirror in 1971, and hence are now included in the accessible category.

Nearly all nest sites were located by paralleling the shore line in a boat and looking for nests with the aid of binoculars. Some inland nests undoubtedly were not found. Accessible nests (including those that were mirrored) were on duck blinds, navigational markers, special nesting platforms for Ospreys, pilings, towers, trees, a dock and dock roof, and a house chimney. Inaccessible nests were on trees, house chimneys, a powerline tower, a silo, and a cross monument.

RESULTS

The total number of active nests found in the main study area in Maryland increased from 94 in 1970 to 114 in 1971. This increase was due in part to better coverage of the study area, although about one-half of the increase could be due to an actual population increase of nesting Ospreys on the study area.

In the secondary study area, 12 active nests were found in 1971 in areas that were not searched in 1970. Five nest sites that were active in 1970 were inactive in 1971, and there was one new nest site in 1971 in the area covered both years.

The reproductive success in Osprey nests in both study areas on the lower Potomac River is given in Table 1. Egg failure was the major cause of poor production in the accessible active nests on both study areas.

One hundred-thirty-three eggs failed to hatch in accessible active nests with known outcome on the main study area on the Maryland shore of the river. Of these, 109 disappeared between visits to the nests; eggshell fragments were found in many of the nests involved. Thirteen eggs remained in the nests following the normal incubation period; five eggs were found damaged in the nests and were collected; three eggs

TABLE 1. Reproductive success of Potomac River Ospreys—1971.

	Main study area St. Marys and Charles counties, Maryland		Secondary study area Westmoreland County, Virginia	
	Accessible nests	Inaccessible nests	Accessible nests	Inaccessible nests
Active nests found	69	45	25	13
Nests with nesting incomplete[a]	4	7	2	2
Active nests with known outcome[b]	65	33	23	9
Nests with eggs	65	—	23	—
Eggs laid	175	—	64	—
Eggs per nest with eggs	2.69	—	2.78	—
Nests producing hatchlings[c]	25 (38)[d]	7[e] (21)	10 (43)	—
Eggs producing hatchlings	42 (24)	11[e] (—)	16 (25)	—
Nests producing fledglings[c]	22 (34)	5 (15)	3 (13)	4 (44)
Eggs producing fledglings	36 (21)	7[e] (—)	4 (6)	5[e] (—)
Average number fledged per nest producing fledglings	1.64	1.40	1.33	1.25
Average number fledged per nest with known outcome	0.55	0.21	0.17	0.56
Percent of hatchlings fledged	(86)	(64)	(25)	(—)

[a]Nest sites that were active at least for a short period of time during the first half of the reproductive season, but where no eggs were known to have been laid or where incubating birds were not observed. No young were produced at these nests. Birds were not known to have moved to another site.
[b]Excludes nests with nesting incomplete and those where the outcome was not determined.
[c]Percent is based on active nests with known outcome.
[d]Numbers in parentheses indicate percent.
[e]Minimum values.

were lost when nest sites fell; one was destroyed when a nest obstructing a lighted navigational marker was destroyed; one was abandoned by the parents; and another was lost when the nest site was destroyed by humans. Six nestlings failed to fledge; three disappeared between visits to the nests; and three were probably killed by a predator in one nest. In addition to the data given in Table 1 for this area, eight eggs were laid in five second clutches, but none hatched.

Forty-eight eggs failed to hatch in accessible nests with known outcome on the secondary study area in Virginia; 40 disappeared between visits to the nests; eggshell fragments were found at some nest sites involved. Five eggs exceeded the normal incubation period, and three were lost when a nest obstructing a lighted navigational marker was removed. Twelve nestlings died; all disappeared between visits to the nests. Predation could have been a factor in the loss of these young because raccoon tracks were observed on the marshy island where the losses occurred. I walked to many of the nest sites where the losses occurred but did not climb the nest trees to examine the nest contents.

Shells from Osprey eggs collected in 1970 and 1971 were saved for thickness measurements. These eggshells were primarily from nests in which no young were hatched, but nests where young were hatched were also represented. Most eggshells were from eggs which failed to hatch, and included shells from eggs that were found broken at the nest sites; a few were from eggs that were believed to have hatched. The samples were not randomly collected, and statistical comparisons with pre-1947 thickness data are not appropriate. However, some basic comparisons are still of interest. Eggshells from the Maryland study area (24 nests sampled; $\bar{x} = 0.439$ mm) averaged 13% thinner than the pre-1947 norm, and those from the Virginia study area (11 nests sampled; $\bar{x} = 0.475$ mm) averaged 6% thinner than the pre-1947 norm (Anderson and Hickey 1972). Eggs from the Maryland area ranged from 31% thinner to 3% thicker than the pre-1947 norm; those from the Virginia study area were from 17% thinner to 3% thicker than the pre-1947 norm. Eggshell-thinning is believed to be an important factor in the high rate of egg disappearance.

DISCUSSION

Reese (1970) studied Osprey reproductive success on the eastern shore of the Chesapeake Bay in Talbot County, Maryland. In accessible nests for the years 1965 through 1969, he found that young hatched in 54-61% of the nests per year; 41-50% of the eggs hatched per year; fledglings were produced in 48-58% of the nests per year; and an average of 0.96-1.16 young were fledged per active accessible nest per year. Henny and Wight (1969) reported that 1.22-1.30 young must be produced per year per female of breeding age to maintain stability of New York-New Jersey Osprey populations.

The rates of reproductive success in the Potomac River Osprey population in both 1970 (Wiemeyer 1971) and 1971 are considerably below the reproductive rate reported by Reese (1970) and the production level required to maintain population stability (Henny and Wight 1969; Henny and Ogden 1970). There is also evidence that the rate of reproductive success on the study area has declined since the early 1960s (Wiemeyer 1971). Although no numerical decline in the breeding population has yet been observed, one is to be expected if production of young does not return to a level adequate for population stability.

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Acknowledgments: I wish to thank John Maestrelli for assistance with the field work.

The Status of the Osprey in Tidewater Virginia, 1970–71

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Abstract: A survey of the Ospreys of Tidewater Virginia was conducted to determine their population size and breeding status. The study area, consisting of approximately 1087 square nautical miles, was subdivided into nine geographical regions, and included parts of the James River, the tidal area extending from Goodwin Island at the mouth of the York River to Dameron Marsh, just south of the Great Wicomico River, and the entire Eastern Shore of Virginia. In 1970, 194 active nests were located and 0.96 young per nest fledged, while in 1971, 309 active nests were located and 0.69 young per nest fledged. The increase in number of active nests from 1970 to 1971 is due primarily to an increase in area surveyed in 1971 and not to an observed population rise. Fledging rate decreased 28% from 1970 to 1971 and is attributed to an increase in the number of eggs failing to hatch. Nestling mortality decreased from 16.1% in 1970 to 10.8% in 1971. Minimal annual rate of decline (calculated) for the Virginia population is 6.1%.

The Osprey (*Pandion haliaetus carolinensis*) has always been a common breeding bird in the Tidewater area of Virginia. Though still common in some areas, many observers have noted a gradual population decline during the past two decades. This decline is paralleled in other populations of Ospreys, especially those in the northeastern United States (Ames and Mersereau 1964; Ames 1966; Spitzer 1970), and by other raptorial and fish-eating birds. Because of these declines and because the many large populations of Ospreys in Tidewater Virginia have never been quantified (except for Tyrrell's [1936] work at Smith's Point, Virginia), a comprehensive study of these populations was begun to determine their size and breeding status. This is a report on the findings of this study during the 1970-71 nesting seasons.

STUDY AREA

The study area (Fig. 1) consists of approximately 1087 square nautical miles and includes most of the Tidewater area and Eastern Shore of

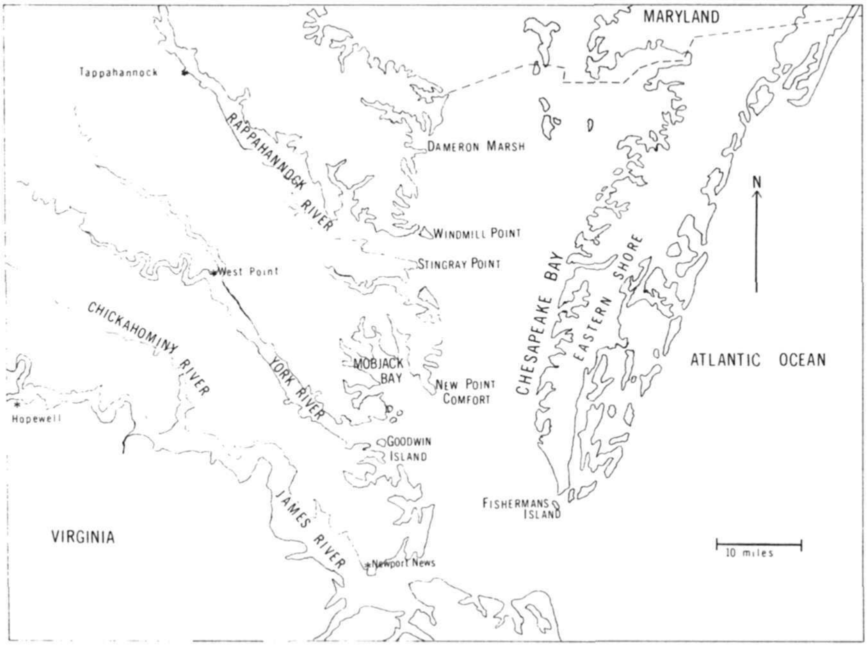

FIGURE 1. Map of study area in Tidewater, Virginia.

Virginia. This region is characterized by its large number of estuarine systems which divide the land into an intricate maze of peninsulas and islands. For purposes of comparison, the study area was subdivided into nine geographical regions. These regions are described below:

1. James River (160 square nautical miles)—extends between Hopewell and Newport News, Virginia, and includes all tributaries except the Chickahominy River.
2. Chickahominy River (29 square nautical miles)—begins one mile from the mouth of the Chickahominy River and ends at Chickahominy Lake.
3. York River (91 square nautical miles)—includes the entire York River.
4. Mobjack Bay (72 square nautical miles)—includes Mobjack Bay and its four tributaries: the Severn River, the Ware River, the North River, and the East River.
5. New Point Comfort (47 square nautical miles)—borders the Chesapeake Bay between the Island of New Point Comfort and Stingray Point and includes the Piankatank River.
6. Rappahannock River (170 square nautical miles)—includes the Rappahannock River and its tributaries from the Tappahannock to its mouth at the Chesapeake Bay.

7. Fleets Bay (42 square nautical miles)—borders the Chesapeake Bay between Windmill Point, at the mouth of the Rappahannock River, and Dameron Marsh, and includes Fleets Bay and Dividing Creek.
8. Eastern Shore Ocean Side (360 square nautical miles)—includes all of the marshes and barrier islands which occur from Fishermans Island (ocean side) to the Virginia-Maryland border.
9. Eastern Shore Bay Side (120 square nautical miles)—borders the Chesapeake Bay between Fishermans Island (bay side) to the Virginia-Maryland border, and includes Watts Island.

The Chickahominy River, the Eastern Shore Bay Side, and parts of Fleets Bay, the York River, the James River, and the Rappahannock River were not studied in 1970. These areas were included in 1971 to give a broader spectrum of population trends.

Common to all of these areas is the harvesting of seafood and the utilization of bordering land for agricultural purposes. Boating, fishing, and hunting are recreational activities which are increasing in all of the study areas. These activities, combined with the reduction of nesting habitat, may be a cause for lowered Osprey density in some areas.

MATERIALS AND METHODS

Population Surveys

In 1970, study areas were visited at least twice. In 1971, visitation of the study areas was correlated directly with the phenology of the species. Therefore, each area was visited from April through early May to determine the number of active nests and to accumulate a sizable sample of data on clutch size, from mid-May through June to determine the outcome of hatching, and from late June through July to collect information on fledging success. Following this scheme, every study area was visited at least three times. Coverage of the area was made by cruising along the coastlines of each area by boat, recording the precise location of each nest site on geological survey maps. In 1971, aerial surveys were made over the James River and both subdivisions of the Eastern Shore.

Terminology

The terminology used in this paper is based on that reported by Postupalsky (1968). The term "active nest" refers to a nest in which eggs were found or, if inaccessible, to a nest where an adult was observed squatting as if incubating. Active nests are of two types: accessible, in which the contents could be examined; and inaccessible, in which the contents could not be examined. However, in inaccessible nests, the presence of young could be ascertained by the behavior of the adults. The term "productive nest" as used in this paper differs slightly from Postupalsky (1968). Here it refers to nests in which one or more eggs hatched, whether or not the young survived to fledge.

Egg Collection

Eggs were collected when they were found to be cracked, dented, pierced, or addled, or when they were known to have been incubated 5 days longer than the normal incubation period of 35-37 days (Spitzer pers. comm.; Kennedy pers. observ.). Data collected on these eggs, which includes eggshell weight and thickness and pollutant residue levels, will be reported on at a later date.

Nesting Platforms

Aluminum poles, 15 ft long and mounted with four 30-inch prongs, were used as artificial nesting platforms for Ospreys (Fig. 2). After choosing a platform location either in an open marsh or in a peninsula of open land, a 3-ft-deep hole was dug and the preconstructed platform was cemented in place. Before installation, nesting material was woven into chicken wire which lined the prongs.

Banding

Size 8, clip-on Fish and Wildlife Service aluminum bands were used with 10 mm plastic wrap-around colorfast bands to mark nestling Ospreys. Seven colors (red, yellow, blue, light green, dark green, black, and white) were chosen for this marking program. Possible combinations using two color bands and the aluminum band, with no more than two bands per leg, were found to number 288. This allowed for a

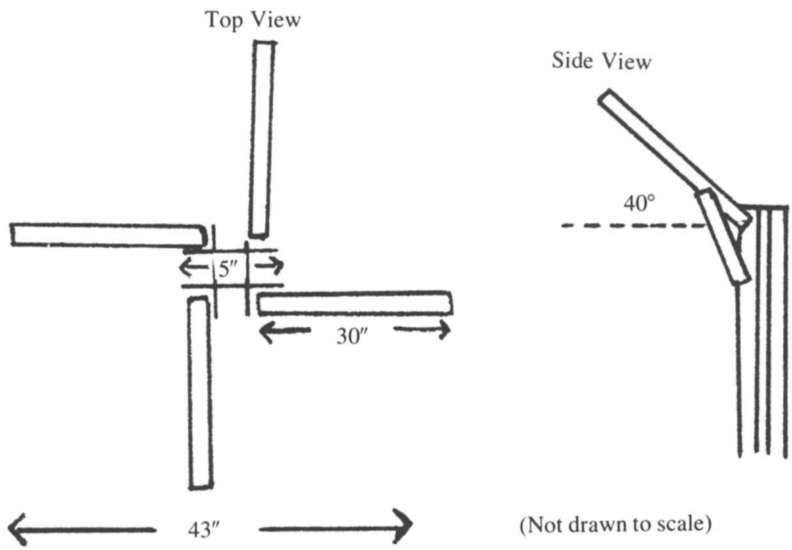

FIGURE 2. Diagram of aluminum nesting platform.

distinct combination for each nestling banded; thus, after fledging, each bird could be individually identified.

RESULTS

During the study period, the earliest arrival date of an Osprey was on 25 February 1971. The majority of birds returned between 8 and 15 March, each year.

Nests

The total number of active nests found during the 2-year study is shown in Table 1. The increase in nests from 1970 to 1971 is quite substantial in the Rappahannock River, York River, Fleets Bay, and in the total for the whole state. However, this increment is due to an increase in area surveyed in these regions during 1971, and not to an observed population rise.

The various types of nest sites used by Ospreys can be classified into two categories: natural, consisting of dead snags, live pines (*Pinus virginiana*, *P. taeda*), bald cypress (*Taxodium distichum*), red cedar (*Juniperus virginiana*), and live hardwood trees (*Quercus virginiana*, *Quercus* sp., *Liriodendron tulipifera*, *Platanus occidentalis*), making up 49% of the total in 1970 and 47.6% in 1971; and man-made, consisting of a myriad of diverse structures from abandoned ships to active docks, making up 51% in 1970 and 52.4% in 1971. The dead snag was the predominant structure used, and was the site of more than one-third of all nests. Channel markers, both lighted (16% for the 2 years) and day (9% average) markers, and duck blinds (12% average), most of which occurred over water, were the most utilized man-made nesting structures.

Eggs

In 1970, though the first egg laid was on 30 March, the major laying period extended from 3-27 April, with an apparent peak on the 19th or 20th. During 1971, the major laying period was longer, extending from 3 April to 1 May. The highest peak for 1971 was reached on 11 April.

Clutch-size data are presented in Table 1. The average clutch size was almost identical for 1970 and 1971, being 2.87 and 2.85, respectively. Within each area, the values fluctuated somewhat more, but the differences were not found to be significant ($P>0.05$, *t*-test). The percentages of two-, three-, and four-egg clutches were, in that order, 25.0 ($n = 13$), 63.5 ($n = 33$), and 11.5 ($n = 6$) for 1970; and 27.5 ($n = 33$), 60.0 ($n = 72$), and 12.5 ($n = 15$) for 1971.

Causes of egg loss are reported in Table 2. Disappearance of eggs between surveys represented the greatest loss (58%) for both 1970 and 1971. The disappearance of these eggs is very likely due to their

TABLE 1. Summary of Virginia Osprey reproduction, 1970–71.

	James River		Chickahominy River		York River		Mobjack Bay		New Point Comfort		Rappahannock River		Fleets Bay		Eastern Shore Ocean		Eastern Shore Bay		Total	
	'70	'71	'70	'71	'70	'71	'70	'71	'70	'71	'70	'71	'70	'71	'70	'71	'70	'71	'70	'71
Active nests	3	6	–	12	11	28	15	17	50	45	57	77	17	29	41	46	–	49	194	309
Average clutch size[a]	ND[b]	2.8	–	ND	2.8	2.9	3.0	2.9	3.0	3.0	2.5	2.9	3.0	2.7	2.7	2.9	–	2.4	2.87	2.85
No. of nests productive	0	0	–	4	3	11	7	6	28	28	40	39	10	13	29	16	–	14	117	131
% of nests productive	0	0	–	33	27	39	47	35	56	62	70	51	59	45	71	35	–	29	60	42
Calculated no. of young produced[c]	0	0	–	6	5	18	14	12	60	56	75	76	20	20	48	27	–	26	222	240
% of eggs producing hatchlings	ND	0	–	ND	16	22	31	25	40	41	53	34	39	25	43	20	–	22	40	27
Average no. of young per productive nest	0	0	–	1.50	1.67	1.67	2.00	2.00	2.14	2.00	1.88	1.94	2.00	1.58	1.65	1.66	–	1.83	1.88	1.84
Average no. of young per active nest	0	0	–	0.50	0.45	0.66	0.93	0.71	1.20	1.24	1.32	0.98	1.18	0.68	1.17	0.58	–	0.52	1.15	0.78
No. fledgings per productive nest	0	0	–	1.25	1.67	1.67	2.00	1.50	1.79	1.86	1.53	1.61	1.30	1.28	1.48	1.54	–	1.83	1.59	1.63
No. fledglings per active nest	0	0	–	0.42	0.45	0.66	0.93	0.53	1.00	1.16	1.08	0.81	0.76	0.57	1.05	0.54	–	0.52	0.96	0.69
Minimal annual rate of decline in %[d]	18.5		12.0		9.2		7.3		1.7		3.9		8.6		6.4		10.4		6.1	

[a]These values represent averages based on nests sampled.

[b]No data.

[c]Average number of young per productive accessible nest per area multiplied by number of productive nests per area.

[d]Calculated using the formula from Henry and White (1969).

TABLE 2. Causes of Osprey egg and young loss 1970–71.

Cause of loss	1970 Eggs		1970 Young		1971 Eggs		1971 Young	
Disappeared between surveys	62	(58)[a]	18	(50)	139	(58)	17	(65)
Eggs collected	30	(28)	–		64	(27)	–	
Young found dead (unknown cause)	–		8	(22)	–		5	(19)
Eggs found dented, broken, cracked or with pin hole	3	(3)	–		15	(6)	–	
Eggs collected for experiment	–		–		21	(8)	–	
Predation	9	(8)	–		–		–	
Wind	2	(2)	2	(5)	2	(1)	–	
Heat	–		–		–		1	(4)
Taken by humans	–		1	(4)	–		–	
Sent to Connecticut	–		5	(14)	–		3	(12)
Fell from nest and starved	–		2	(6)	–		–	
Total	106	(100)	36	(100)	241	(100)	26	(100)

[a]Numbers in parentheses indicate percent.

breakage; however, the probability of predation cannot be eliminated. Eggs classified as "Eggs Collected" account for a considerable loss (reasons for collection have already been discussed). "Eggs Collected for Experiment" were freshly laid eggs used for an incubation-renesting experiment which is described elsewhere (Kennedy 1972). The number of eggs found dented, broken, cracked, or with small pin holes increased from 3% in 1970 to 6% in 1971. Eggs found dented were reported only in 1971. Predation, probably by humans, accounted for the loss of nine eggs in 1970. Nests blown down by wind accounted for the loss of two eggs in both 1970 and 1971.

Young

The number of young produced per productive nest (Table 1) ranged from 1.50 to 2.14 during the 1970 and 1971 seasons. For both years, the averages for each area were almost identical (differences were not statistically significant, $P>0.05$, *t*-test). The percentages of nests containing one, two, and three young were, respectively: 30.8 ($n = 28$), 50.5 ($n = 46$), and 23.5 ($n = 17$) for 1970; and 39.2 ($n = 40$), 37.3 ($n = 38$), and 23.5 ($n = 24$) for 1971.

Causes for the loss of young are summarized in Table 2. In 1970, a total of 36 young were lost, representing a mortality rate of 16.1%. Fewer young were lost in 1971 (26, at 10.8% mortality). The greatest loss of young (50 and 65%) was their disappearance between surveys. Many young in accessible nests were thought to have been taken by humans, but this form of loss, except in one instance, has not been documented. In both accessible and inaccessible nests, the loss might have been caused by some natural predator as discussed in Reese (1970) and in Ames and Mersereau (1964). Young that died in the nests of unknown causes accounted for the second highest (22 and 19%) loss of young. Eight young were collected from the Rappahannock River area, and sent to Connecticut to maintain the declining population there. Two young were lost when their nest, located on top of a day channel marker, was blown down during a severe windstorm in 1970. Also in 1970, two fledging-age birds were found dead at the base of their nest, apparently having starved to death after falling out of their nest. One 8-day-old bird, suspected of dying from heat exhaustion, was found in its nest in 1971. Heat exhaustion might account for the loss of young that disappeared (in which case the parents might have removed the dead chick from the nest) or that died of unknown causes.

Percentages of eggs producing hatchlings (hatching success) and number of young fledging per active nest are summarized in Table 1. The highest value determined for fledging success was the 1.16 young found at New Point Comfort in 1971. New Point Comfort and the York River were the only areas to have increased production rates from 1970 to 1971, while the remaining areas showed a decrease in rate. The largest decrease can be found in the Eastern Shore Ocean Side, where hatching success and fledging success decreased about 50%. The overall production was down 28% from 1970, though differences between numbers fledging per productive nest and per active nest for 1970 and 1971 were not statistically significant ($P>0.05$, t-test). The James River area, for the second straight year, did not produce a single young.

The minimal annual rate of decline for each study area is shown in Table 1. As expected, New Point Comfort has the lowest annual rate of decline, while the James River has the maximum value of 18.5% annual rate of decline. Other areas with apparently severely declining populations are the Chickahominy River (12.0%), the Eastern Shore Bay Side (10.4%), and the York River (9.2%). These percentages are calculated values and are not based on observed population decreases.

Platform Utilization

Of the 20 platforms constructed, 11 were placed in the Eastern Shore Ocean Side study area and 9 were erected in the New Point Comfort area. Six platforms were used for the first nestings by Ospreys. "Frustration nests," which adult birds build after they have lost their eggs or young late in the nesting season, and in which no eggs are laid that season, accounted for four more utilizations.

Banding

In 1970, 114 nestlings were color-banded, while in 1971, the number was increased to 143. Six additional young were banded in 1970, but were not color-banded.

DISCUSSION

The reproductive failure witnessed in the Osprey and other raptor populations throughout North America and Europe is also being experienced by Ospreys in Virginia. The number of young fledged per active nest in the study area declined from 0.96 young per nest in 1970 to 0.69 young per nest in 1971. Earlier fledging data for Virginia (Tyrrell 1936, cited in Postupalsky 1969) indicate that 1.60 young fledged per active nest in 1936. As Henny and Wight (1969) have shown, when shooting is eliminated as a cause of mortality, only 0.95 young fledged can maintain a stable population. This would seem to indicate that the 1970 population was producing enough young to maintain a stable population. However, by including shooting as a factor of mortality, the number of young needed increases from 1.22 to 1.30. At the present fledging rate, Virginia's Osprey population is declining (calculated value, not observed decline) at the rate of 6.1% annually.

The James River study area is of particular concern. No young were produced on this river during the 2 years it was studied. This large river is well suited for the Osprey, providing numerous nesting sites and no apparent lack of food. However, the low numbers of breeding birds found there indicate that this river system has been suffering low reproductive success for a number of years. Though no early population data are available, the population crash in this area might have paralleled that reported in Connecticut by Ames and Mersereau (1964), Ames (1966), and Peterson (1969). The minimum annual rate of decline for the James River population was calculated as 18.5%, and is the highest rate of decline that can be calculated using Henny's and Wight's (1969) equation. However, as indicated by the 30% annual decline actually found in the Connecticut population, the calculated value may be low and misleading.

Other areas fledging low numbers of young include the York River in 1970, with 0.45 young fledged per active nest, and the Bay and Ocean sides of the Eastern Shore in 1971, fledging 0.52 and 0.54, respectively. As noted earlier, the Ocean Side population suffered a 50% decline in the number of young fledged from 1970 to 1971. The low hatching success of the Eastern Shore may be related to the heavy contamination of this area by DDT, which is still used extensively, particularly on the sweet corn crop. The Rappahannock River, though showing a 25% reduction of young fledged in 1971, has the highest fledging rate for any river system in Virginia. The high fledging rate of 1.16 at New Point

Comfort approximated the stability level. For comparison of Virginia population figures with other North American populations see Reese (1970).

Low hatching rate, as a reason for poor reproductive success of Ospreys, has been reported by Ames and Mersereau (1964), Ames (1966), Wiemeyer (1971), and Spitzer (unpubl. data). The hatching rate for the Virginia population in 1971 was 27%, and is thought to have accounted for the reduced fledging rate for that season. Nestling mortality for 1971 was lower (10.8%) than in 1970 (16.1%), and was therefore eliminated as a possible cause for the reduced fledging rate.

The average number of eggs per clutch and the average number of young produced per productive nest have not varied from the information published before 1947 (when pesticides were first widely used) by Tyrrell (1936) and Bent (1937). If some environmental factor such as pesticide contamination is the cause for the failure of production of young in some nests, then it would seem that birds which lay eggs that hatch have either lower body contamination or lower equilibrium levels. Another explanation might be that some birds which can resist high levels of pesticides are subject to selective pressures. In Virginia, the apparent poor hatching success for the James River, York River, and Eastern Shore as opposed to the high hatching success for the New Point Comfort and Rappahannock River areas is thought to be due to the varying levels of environmental pollutants. However, there are no data available at this time to support this suggestion.

The discussion, at this point, raises the following pertinent question. If persistent chlorinated hydrocarbons are the cause for reduced hatching success (Heath et al. 1969) and for thin eggshells (Anderson et al. 1969; Bitman et al. 1970; Peakall 1970), what immediate effect would the discontinued use of these chemicals have on birds of prey? Stickel et al. (1966) and Wesley et al. (1965) have shown that with suspended food dosage of DDT, body levels of this pesticide would decrease in Bald Eagles (*Haliaeetus leucocephalus*) and in domestic fowl. In the case of the eagles, levels would be reduced one-half in 3-5 months. In Scotland, Lockie et al. (1969) and Everett (1971) have reported that with discontinued usage of dieldrin in the mid-1960s, there was a corresponding 50% decrease of dieldrin in the eggs of Golden Eagles (*Aquila chrysaetos*), an increase in shell thickness, and an increase of fledging success from 31% in 1963 to 69% in 1967. After discontinuation of a 20-year program of spraying the salt marshes of eastern Long Island, New York, the reproductive success of the Ospreys of Gardiners Island began to show signs of improvement. In 1966, when the program was stopped, the birds fledged 0.05 young per active nest. Four years later, the fledging rate had increased to 0.66. It would appear, therefore, that discontinued usage of DDT and dieldrin might well result in higher chances for survival in Ospreys as well as in other raptors.

Although man appears inadvertently to have been the major factor in the decline of the Osprey, he has, at the same time, helped the species by providing artificial lakes and reservoirs (Berger and Mueller 1969) which have increased available nesting habitat, and by provision of man-made nesting structures, such as duck blinds (Tyrrell 1936; Reese 1970) and channel markers (Reese 1970).

The utilization of channel markers accounts for 25% of the nesting structures used by Virginia Ospreys. The U.S. Coast Guard, until recently, has destroyed many nests and their contents which were found on channel markers. On lighted markers, the nests were destroyed either because they obstructed the beacon, thus creating a hazard to navigation, or because the nest interfered with the changing of the batteries for the beacons. On day markers, the nests were destroyed when they reduced the legibility or recognition of the structure. Reese (1970), in Maryland, attributed the loss of 35 eggs and six nestlings to the Coast Guard. Because of the high percentage of Ospreys nesting on channel markers in Virginia, the Coast Guard may have been imposing a heavy factor of mortality on this population. However, Mr. Gilbert Fernandez has recently instructed the Chesapeake Bay Coast Guard to inform either him or the College of William and Mary when nests are going to be destroyed, so that experienced persons can accompany them. Two trips were made with the U.S. Coast Guard during this study, and in both cases, the nests could be manipulated in such a way as to prevent their destruction.

Reese (1970) has shown that two-thirds of his population in Talbot County, Maryland, nests on structures occurring over water. This fraction is somewhat higher than that of Virginia, where approximately one-half of the nests occur over water. Though in more recent investigations, Ospreys have been reported nesting over water, this has not always been the case. Tyrrell (1936) found that 93% of 76 nests in Smith's Point, Virginia, were located on land nesting sites. Shifting from land to water nesting structures can be caused by at least two factors: (1) the birds were forced to move out over water because of the destruction of natural sites by man; and (2) the birds, showing a preference for open, well-exposed nest sites, readily move to water sites. I believe that a combination of the two reasons explains the adaptation to water nesting sites. The variety of man-made nesting structures that the Osprey uses demonstrates the partial adaptability of this species to a changing environment.

The purpose of constructing artificial nesting structures for Ospreys is to attract nesting birds to an isolated area and to a structure which is virtually mammalian predator-proof. Ames and Mersereau (1964) and

Peterson (1969) described 21 nesting platforms they constructed on Great Island, in Connecticut. Postupalsky (unpubl. data) described cedar platforms in Michigan, while Valentine (1967) described a very elaborate type of platform, also utilized in Michigan. Reese (1970) has constructed 133 platforms in Maryland, during the period from 1963 to 1969, all of which were made of scrap wood. All of these structures have proven very successful in attracting Ospreys.

The importance of offshore nesting structures cannot be overemphasized. Large-scale programs in Virginia should be undertaken to install artificial nesting platforms along all the river systems. Proper location of these platforms is essential. Postupalsky (unpubl. data) noted lowered utilization of his cedar platforms when they were placed in water near other potential nesting sites. Therefore, it is suggested that erection of platforms should be in open, shallow water, from 50 to 200 yards offshore. These offshore platforms, along with predator-proof aluminum poles already constructed, would provide ideal nesting sites for the birds and would reduce losses of eggs and young to land predators, and to possible destruction of natural sites by wind (Valentine 1967; Reese 1970) and by flooding (Ames and Mersereau 1964; and Reese 1970), and will open up new areas for nesting.

Although the present study reveals a drastic reduction of young fledged from 1970 to 1971 and provides evidence for the decline of Ospreys in Virginia noted by naturalists, it should be stated that long-term population trends cannot be evaluated from the data collected during a 2-year study. It is desirable, therefore, in view of the declining North American Osprey population, to continue the population survey for at least another 2 years in order to ascertain if any definite trends can be discerned.

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Acknowledgments: I wish to thank Mitchell A. Byrd, Department of Biology, College of William and Mary, under whose guidance this investigation was conducted, for his helpful suggestions and his assistance in the field work. Special thanks are due R. Hernandez, J. C. Ogden, F. R. Scott, P. R. Spitzer, and S. N. Wiemeyer for their kind advice. Also, for their time and assistance in the field work, I would like to thank Mr. and Mrs. S. M. Beck, W. L. Butman, C. W. Hacker, J. Olney, G. Seek, D. Smith, W. Smith, C. R. Terman, T. F. Wieboldt, and J. W. Williams, Jr. I am grateful to my wife, Linda, for preparing the map and for typing the manuscript.

A 1934 vs. 1967 Comparison of the Osprey Nesting Populations

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Abstract: A survey was made in estuaries where W. Bryant Tyrrell banded in 1934, and a number of additional areas on the south shore of the Potomac River. From observed populations it is concluded that there was a drastic change in numbers of Ospreys in that entire area. There must be a multitude of factors responsible for the Osprey decline, including incidents of shooting reported here.

I reported on the status of the Ospreys in Cape May County, New Jersey (Schmid 1966), as projected from banding data on these birds for 1937-39. In 1967 I had the opportunity to survey the Smith Point, Virginia, area where Tyrrell (1936) banded 33 years before.

The Smith Point area is in Northumberland County on the south shore of the Potomac River. It is typical of a salt estuarine bay community. The biogeographical areas of the Potomac-Chesapeake region are well described by Stewart (1962). I covered approximately 390 miles of estuaries by boat between 11 and 13 July (Table 1). Another short foray by car was made with William Krantz, Bureau of Sport Fisheries and Wildlife, and Fairfax Settle, Virginia Inland Fish and Game Commission, in May 1967. It should be realized that some upland nest sites may have been overlooked, but they would represent a very small proportion of the total seen from the water.

In the entire Great Wicomico and Little Wicomico, 25 adults, 4 young, and 13 nests were found. I did not get into the Owen Pond area. Apparently, Tyrrell did not band there, but he did find 12 nests. Unfortunately, Tyrrell did not count adults. Some nests were inaccessible and some young were too small to band. He stated that the actual number of young was much greater, and that he could have banded two or three times that number with better facilities, or roughly 120-180 young. For those days, I do not think he was exaggerating.

In the additional areas (Table 1), 55 adults, 19 young, and 37 nests were seen. No young were seen on the wing. In all areas, 80 adults, 23

TABLE 1. Census of Ospreys of Northumberland County, Virginia.

	Adults	Young	Nests
		Lower Machodoc (and reaches)	
	13	2	9
		Nomini Bay (and reaches)	
	2	0	2
		Currioman Bay and Hollis Marsh	
	20	7	14[a]
		Little Wicomico (and reaches)	
	8	2	7
		Great Wicomico (and reaches)	
	17	2	6
		Gardner-Jackson Creeks	
	4	1	3
		Yeocomico (and reaches)	
	16	9	9
TOTAL	80	23	50

[a]Approximate coverage.

young, and 50 nests were seen. That averaged 0.46 young per nest; whereas, using Tyrrell's figures, we would have three birds per nest for 25 nests, which is excellent productivity.

Two areas I visited in 1967 compared favorably with Tyrrell's findings: Currioman Bay, with its adjacent Hollis Marsh, and the Yeocomico, in Westmoreland County. These areas are in the brackish estuarine bay community of the lower Potomac described by Stewart. They are across from that area covered by Patuxent Research Center personnel in 1963 and 1964 for pesticide research (Stickel et al. 1964). Production there compared favorably with older records from New Jersey, and those of Jan Reese at Tilghman Island, Maryland. These two Virginia estuaries resemble the relatively undisturbed habitats of the late 1920s and early 1930s. They required more detailed mapping and censusing of adults and young.

Everywhere that I have been, boating and marina development increase rapidly. Stewart, in his study, remarked on the effects of boating as did Ames and Mersereau (1964).

Aside from pesticide problems, rapid increase of human activities on coastal regions, and the probable decline in numbers of fish as food for Ospreys, indiscriminate shooting of Ospreys has occurred in some areas. I have a personal communication telling of 18 Ospreys shot at a private hatchery in one spring season. This happened in 1964 in a state where they were protected. The owner justified his actions by saying he was not raising trout for Ospreys. From another communication, "In response to your specific question, the questionable practice of disposing of ospreys, hawks, and, perhaps, eagles, was carried out at several National Fish Hatcheries. Of my own knowledge, I observed this practice on several occasions between 1963 and 1965 at the Harrison Lake NFH near Richmond, Virginia. I understand that this was common practice by hatchery managers but that the practice was stopped by official edict shortly after I brought it to your attention." I have personally witnessed an attempt at shooting an Osprey on a federal hatchery. And at Glebe Point on the Great Wicomico, Atwell Booth told me of Osprey nestlings being taken from the nest to be trained for falconry.

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Osprey Reproductive Success in Southeastern North Carolina

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Abstract: The reproductive success of the Osprey (*Pandion haliaetus carolinensis*) at Orton Pond in southeastern North Carolina is discussed. This lake has supported an Osprey breeding concentration since the early 1900's. In a 3-year study beginning in 1969 between 30 and 38 pairs of Ospreys produced between 1.03 and 1.50 young per active nest. Most mortality was due to the unexplained loss of single eggs from active nests. Some loss of entire clutches was recorded and at least two clutches were infertile. Several possible predators were present. No pesticide anaylsis was conducted, but pesticide damage appears low or absent. It appears that the population is stable, as no reduction in production was noted during the study, and production figures compare very favorably with those from other East Coast locations.

Orton Pond, an old, man-made lake in Brunswick County, North Carolina, has been the site of a concentration of nesting Ospreys for many years (Pearson et al. 1942). In early 1969, 68 nest structures were found on the lake. Most of the active nests were easily accessible and a program designed to evaluate the nesting success of Ospreys at Orton Pond was begun. Studies were known to be in progress in eastern Virginia and in Florida, and it was felt that data from this intermediate site would be valuable. This report covers the nesting seasons of 1969, 1970, and 1971.

Orton Pond is located about 10 miles south of Wilmington, North Carolina, and only about 0.50 mile from the Cape Fear River estuary and about 4 miles from the Atlantic Ocean. The lake was constructed by placing an earthen dam across a small tributary of the Cape Fear River. The lake is about 200-300 yards wide and nearly 5 miles long. The very irregular shoreline is bordered by pine woodlands or by stands of cypress. The lake is shallow and filled with stumps and snags. Many stands of small to medium-sized cypress trees (*Taxodium distichum*) extend out into the lake.

The nests were placed usually on stumps or in low cypress trees over water. A few nests were in tall, dead pines along the edge of the pond.

The nest contents were checked at roughly 2-week intervals from early March until the last young had fledged in late July. A small boat allowed access to the nests and a 30-ft telescoping pole with mirror attached was used to determine the nest contents. The few nests that were too high to be censused by this technique were not included (Table 1).

RESULTS

Ospreys arrived at Orton Pond in early March and occupied territories almost immediately. A few birds began egg-laying as early as mid-March and all active nests generally had their full complement of eggs by the first week of April. Eggs thus began hatching during the last week of April, and by the end of the first week in May most nests had young birds present. By early July most young had fledged and the number of birds over the lake began to diminish.

In 1969, 68 nest structures were counted at Orton Pond. Of these, 37-47 were regularly attended by adult birds during the 3 years of the study. Between 30 and 38 active nests (nests in which at least one egg was laid) were censused regularly each year. Clutch sizes for apparently active nests above 30 ft were unknown, and these nests were excluded from calculation of reproductive success.

In 1971, the height of apparently active nests ranged from only 4 ft above the water to about 55 ft. The average height of all apparent active nests was 23 ft.

Nesting success was generally good. The average clutch size for the 3-year study period was 2.81 eggs per active nest (one in which at least one egg was laid). From this average clutch, 1.55 birds hatched and 1.21 birds fledged. Most mortality occurred during incubation and appeared to stem from a variety of factors. In many cases single eggs disappeared from active nests during incubation. It was generally not possible to determine whether this was the result of broken eggs or predation. In a few cases entire clutches disappeared, and predation was suspected. In two instances infertility was indicated when eggs were incubated far beyond the normal period of development. Two active nests were destroyed by storms during the 3-year period.

Several potential egg predators were present at Orton Pond. Fish Crows (*Corvus ossifragus*), raccoons (*Procyon lotor*), Great-horned Owls (*Bubo virginianus*) and brown water snakes (*Natrix taxispilota*) were present. While no instance of actual predation was observed, Ospreys were often seen chasing Fish Crows from the vicinity of their nests.

As can be seen from Table 1, once an egg hatched the chances were excellent that the young bird would fledge. If the young bird survived to feathering, it was virtually assured of fledging. Thus, in 1971 when field

TABLE 1. Osprey nesting success at Orton Pond, Brunswick County, N.C.

	1969	1970	1971
Apparent active nests[a]	43	37	47
Active nests censused[b] (at least one egg laid)	36	30	38
Total eggs laid	104	87	101
Total eggs hatched	54	54	53
Percent of eggs laid that hatched	52	62	52
Total young fledged	37	45	44[c]
Young fledged/eggs laid	36%	52%	44%[c]
Young fledged/eggs hatched	68%	83%	83%[c]
Number fledglings per active nest	1.03	1.50	1.16

[a]All nests regardless of height which were regularly attended by adults for some prolonged period.
[b]Those nests under 30 ft in height in which at least one egg was laid.
[c]Estimated, as field work was ceased prior to fledging of all young birds.

work ceased prior to the fledging of the last few young, all were assumed to have fledged.

DISCUSSION

The breeding population of Ospreys at Orton Pond appeared quite stable with between 37 and 47 apparent active nests recorded during each of the past 3 years (Table 1). This stability may extend back to the early 1900s. On 4 May 1920, H. H. Brimly and T. G. Pearson counted 42 nests at Orton and noted that 36 were occupied at the time (Pearson et al. 1942). Thus, about 35-50 apparently active nests may represent maximum ecological density of this lake.

The Osprey population appears healthy at present. In spite of a relatively high loss of eggs, over one young per active nest fledged each year of the study. This compares very favorably with conditions found at other East Coast and north-central locations as discussed by Henny and Ogden (1970). They reported a high of 1.22 birds fledged per nest in south Florida studies and a low of 0.27 birds fledged per nest in studies in Connecticut. Our 3-year average of 1.21 fledglings per active nest falls at the high end of the scale and fits well with their estimated value of 1.22-1.30 young per female of breeding age needed to sustain a population.

While no comparable data are available from other sites in the Carolinas, the above production values may represent something approaching current optimum production for this region. Orton Pond is privately owned, access is carefully regulated, and human interference is at a minimum.

The Cape Fear estuary is close by and apparently provides adequate food. No work has been done to determine whether or not there are pesticide accumulations in the eggs or whether eggshell thinning is occurring. However, the high level of hatching success and the low number of total nest failures would indicate minimal interference by pesticides.

Pesticide-induced nest failures were suspected in a nesting concentration near Georgetown, South Carolina. In 1969, Beckett (1970), in a brief study, found a very low level of fledging in a population of about 35 active nests. Thin shells had been documented in nearby nesting populations of other fish-eating birds.

The rather sizable loss of eggs was unexplained but predation by Fish Crows was suspected. Crows nested along the edge of the pond and were seen regularly in the vicinity of Osprey nests. Their pattern of egg thievery fits the observed loss of single eggs from many nests. Other possible predators were abundant and probably contributed to the loss of eggs and young.

This small concentration of Ospreys nesting in a protected situation with an adequate food supply nearby and no apparent large pesticide load may represent a situation relatively unchanged over the past 50 years. A continued monitoring of this nesting concentration is anticipated, with some pesticide analysis added to the study of the breeding biology.

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Acknowledgments: This work would not have been possible without the gracious assistance of the Sprunt family, owners of the lake and adjacent lands. Tom Mills and James Martin, students at the University of North Carolina at Wilmington, provided very valuable assistance and did much of the field work in 1969 and 1970.

Preliminary Report on a Study of Florida Bay Ospreys

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Abstract: Approximately 55 pairs of Ospreys (*Pandion haliaetus*) nesting on three islands in western Florida Bay, Everglades National Park, Florida, have been studied since 1967. This study is designed to establish Ospreys as an indicator species for measuring the ecological well-being of the Florida Bay estuarine ecosystem. The number of active Osprey nests and percentage of successful nests have remained approximately constant during the 5 years, 1968-72, with an average 0.84 young fledged per active nest. Recruitment of new breeders into the study area has been slow, with nesting attempted in the study area by only 4 of 199 Ospreys color-marked as nestlings since 1968, through the 1972 nesting season. Evidence of adult helpers at nests is presented. Florida Bay Ospreys are nonmigratory, but short northward dispersal by most subadults, and presumably some adults, occurs during the summer months. I also briefly discuss some plumage characteristics in Florida Bay Ospreys and summarize results of egg analyses for chlorinated insecticides and PCB's.

Ospreys are one of several fish-eating vertebrates known to have deteriorating rates of nesting success in some segments of the species' breeding range. Failing productivity is apparently due to two factors: environmental contamination by agricultural and industrial chlorinated hydrocarbon compounds; and loss of nesting and feeding habitats during human expansions (Ames 1966; Postupalsky 1968). This Osprey study in western Florida Bay, Everglades National Park, should determine biological characteristics for an Osprey population we believe to be insignificantly contaminated by chlorinated insecticides and polychlorinated biphenols (PCB's) and allow quantification of effects should these contaminants become more concentrated in the park's estuaries. In this respect, future monitoring of Osprey productivity can serve as an indicator to assess the general well-being of the Florida Bay ecosystem, and more specifically, the well-being of other local fish-eat-

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ing vertebrates, including Brown Pelicans (*Pelecanus occidentalis*), Great White Herons (*Ardea herodias*), Roseate Spoonbills (*Ajaia ajaja*), Bald Eagles (*Haliaeetus leucocephalus*), and American Crocodiles (*Crocodylus acutus*). Ospreys were chosen for the indicator role because of the relative abundance of this species and large numbers of accessible nests in Florida Bay, and because data collected during several studies of more seriously contaminated Osprey populations in other regions will aid in interpretation of local data. This study was begun during the 1967-68 nesting season, and is expected to continue several more years. Since the study is incomplete, interpretation of the following data must be considered tentative and incomplete.

STUDY AREA

Ospreys are common nesting birds in Everglades National Park, near large inland lakes, along coastal bays and rivers, and on Florida Bay keys (islands). The total number of active nests in coastal portions of the 1.5 million acre park is estimated at 300. Three adjacent keys in northwestern Florida Bay support a particularly large concentration of 55 nesting pairs and were selected as the area for intensified study of Ospreys. The keys lie parallel to the mainland and about 2 miles offshore, and are surrounded by broad, shallow-flooded mud banks. These banks support dense beds of marine grasses (*Thallasia*), and are ideal feeding sites for Ospreys, long-legged waders, and pelicans. Palm Key is 1300 m long and 700 m wide, and is covered by knee- to waist-high halophytes, sedges, and shrubs (*Batis*, *Salicornia*, *Spartina*, *Borrichia*), known collectively as "coastal prairie." There are small mangroves (*Rhizophora*, *Avicennia*, *Laguncluaria*) and buttonwood trees (*Conocarpus*) scattered in the interior, and a narrow shoreline fringe of larger mangroves. Frank Key, approximately 1100 × 500 m, has a similar mangrove border, and contains a dense interior thicket of buttonwood and thorn scrub (*Pithecollobium*, *Piscidia*, *Buemelia*). Murray Key, 1100 × 400 m, has a mangrove border and coastal prairie interior, and contains several small patches of thorn scrub thickets inside the mangrove border. There are no mammalian predators on the three keys.

NESTING SITES

Important as nesting sites, each of the three keys has many large, upright trunks and stumps of long-dead mangrove trees killed by past storms. In 1968, 29 active Osprey nests located on these dead trees averaged 12 ft above ground and ranged from 3 ft to 22 ft above ground. Also in 1968, 17 active nests were located in living trees, primarily black mangrove. Nests in living trees averaged 16 ft above ground and ranged from 3 ft to 25 ft in height. Since 1968, there have been four nests built directly on the ground (two in 1970, one each in

1969 and 1972) located in the interior of Palm Key. Ground nests are constructed largely of mats of *Thallasia* picked up by Ospreys from drift lines along the island shore, with each nest holding eggs in a slight depression in the nest center.

NESTING SUCCESS

Florida Bay Ospreys nest during the winter and spring months, with egg-laying occurring between late November and early March. Characteristics of egg-laying and productivity during the 5 years, 1968-72, are quantified in Tables 1 and 2.

The most frequently observed reasons for egg or nestling losses from study area nests will not be quantified here, but are generally similar to those reported by Reese (1970) in Chesapeake Bay Osprey nests. The losses in Florida Bay are due to one or more eggs in a clutch failing to hatch, eggs breaking in nests or falling to the ground during winds, nestlings falling from nests, and starvation of one or more nestlings in nests containing three or four. There were also some nests in the study area where eggs or nestlings disappeared between nest visits and cause of losses was not determined. Nestlings less than 4 weeks old which fall from nests, even when uninjured by the fall, are ignored by adults and soon starve. However, in some instances, when large, mostly feathered nestlings fall from low nests, adults continue to feed these young on the ground until they fledge. Nest predation is apparently infrequent, and has been recorded only at two nests where Common Crows (*Corvus brachyrhynchos*) destroyed eggs. One of these two nests disturbed by Common Crows had probably been deserted by the Ospreys shortly before for other reasons. The occasional disappearance of nestling Ospreys from nests is somewhat puzzling to understand, although it is possible that adults carry off dead nestlings. Another possible explanation might be nestling predation by one or more Bald Eagles. There are seven pairs of eagles which nest either in the Osprey study area or on adjacent keys within 2 miles. Although I have not witnessed attempts by eagles to take nestling Ospreys, Dr. William Robertson discovered the remains of a 4- to 5-week-old Osprey in an active eagle nest in another portion of Florida Bay in May 1971.

Three-egg clutches laid during December produce the greatest number of young per egg, while most two-egg clutches are laid in January-February and are less productive. Unusually high rates of production occasionally occur on single keys, exemplified on Palm Key in 1968 and Frank Key in 1972. I do not yet understand why these instances of higher productivity occur. However, the poor nesting effort on Murray Key in 1972 is understood, and resulted from prolonged conflict between the nesting Ospreys on Murray and an intruding pair of Bald

TABLE 1. Month of laying, size of clutches, and productivity on Palm, Frank, and Murray Keys, 1971, and Palm and Frank Keys, 1972.

Clutch size	Clutch laid December		January		February		March		Young fledged per egg
	Number nests	Young fledged	Nests	Fledged	Nests	Fledged	Nests	Fledged	
4 eggs	1	2	0	0	0	0	0	0	—
3 eggs	39	51	14	9	4	4	0	0	0.37
2 eggs	3	1	13	2	5	4	1	0	0.16
1 egg	0	0	2	0	0	0	0	0	—
Totals	43	54	29	11	9	8	1	0	—

TABLE 2. Production (young fledged) from all active nests (nests receiving eggs), 1968–1972, Palm, Frank, and Murray keys.

	1968[a] Active succ. yng. nests-nests-prod.	1969[a] Active succ. yng. nests-nests-prod.	1970[a] Active succ. yng. nests-nests-prod.	1971 Active succ. yng. nests-nests-prod.	1972 Active succ. yng. nests-nests-prod.
Palm Key	25 – 19 – 30	24 – 12 – 20	23 – 9 – 14	25 – 12 – 19	24 – 13 – 17
Frank Key	15 – 6 – 12	15 – 8 – 12	14 – 8 – 11	19 – 8 – 11	18 – 13 – 20
Murray Key	11 – 5 – 10	10 – 8 – 13	10 – 6 – 12	11 – 9 – 13	11 – 3 – 4
Annual totals	51 – 30 – 52	49 – 28 – 43	47 – 23 – 37	55 – 29 – 43	53 – 26 – 41
Percent nest successful	58%	57%	49%	52%	49%
Young per active nest	1.01	0.87	0.78	0.78	0.77
Young per successful nest	1.73	1.53	1.60	1.48	1.57
No. visits study area	8	10	10	18	19

[a] Figures for 1968, 1969, and 1970 have been conservatively adjusted to compensate for too few trips into study area and early-failing nests being missed. Production figures for these 3 years may still be too high.

Eagles. This interesting interspecific conflict will be watched in the future for signs of adjustment by the two species.

I consider Ospreys in the study area to be maintaining stable numbers in spite of the fact that the 5-year average of 0.84 young per active nest is less than the 0.95-1.30 young per active nest calculated by Henny and Wight (1969) as a requirement for population stability in Ospreys. At this stage in the Florida Bay study, I am unable to identify certainly the factors which regulate this population, but presumably there are enough differences in population dynamics between our birds and the more northern Ospreys analyzed by Henny and Wight to result in different rates of nestling production. Two probable differences at least deserve mention here as stimulation for future thought and field study. First, average clutch size for our Ospreys appears to be less than occurs in more northern Ospreys, and second, annual survival rates of south Florida Ospreys may be greater than in northern birds due to the lack of long-range migration by the former birds.

RECRUITMENT AND AGE STRUCTURE

A total of 199 nestling Ospreys of near-fledging size have been color-marked since 1968 as follows: 50 in 1968; 40 in 1969; 31 in 1970; 40 in 1971; and 38 in 1972. Observations of these known-age Ospreys in the study area are beginning to provide data required for an understanding of age of first breeding, and age structure of the local Osprey population. Three-year-old female Ospreys are capable of producing eggs, but there are other 3- and 4-year-old birds that do not attempt nesting or construct only partial nests (lack mates?). At four nests where eggs were produced and one adult in the pair was known-age, either 3 or 4 years old, laying occurred after the December laying peak (two in January and two in February), and clutches averaged small (1 nest with 3 eggs, 2 nests with 2 eggs each, and 1 nest with 1 egg). Combined production from these four nests was one fledged, this one from a nest with a 4-year-old female. It appears that approximately 10% of the total Ospreys in the study area during winter-spring months are nonbreeding, subadult birds. This subadult class includes Ospreys as young as 1 year old (2nd calendar year) and as old as 4 years (5th calendar year) that are known to be nonbreeders.

Two nests on Palm Key were found to have three adults in attendance for prolonged periods, with all three playing an active role in care of nestlings. The frequency of three-adult nests is unknown, but could be more regular than presently realized since few nesting adults have been color-marked and few nests have yet been systematically watched. The significance of three-adult nests is uncertain, but may occur where there are concentrations of nesting Ospreys and where a surplus of young adults exists.

DISPERSAL

Ospreys nesting in Florida Bay do not migrate, but most birds do disperse relatively short distances northward from the study area following completion of nesting. Counts of Ospreys on the study area keys reveal slightly less than one-half the number of birds present between late May and October as are present during the breeding season months. Ospreys that do remain on the keys in summer include both adults and color-marked subadults.

Observations of marked Ospreys, plus recoveries of banded birds that were shot or found dead, suggest that most subadults disperse northward each year beginning in May. We have seen nine color-marked Ospreys during May-June at sites 5-75 miles north of the study site. There also have been two distant recoveries during the same 2 months, 150 and 225 miles north of Florida Bay. What becomes of these Ospreys after June is uncertain, as observations of marked birds during the remainder of the nonbreeding season, July-October, have been almost nonexistent. During November, the number of Ospreys in the study area increases as both adults and subadults return to the keys. Yet some subadults may remain some distance away during winter, as evidenced by observations of a less than 1-year-old Osprey in Miami, 60 miles northeast of the study site, in late November, and a 4-year-old bird found dead south of Miami in February, where no Ospreys are known to nest. The movements of adult Ospreys during summer are unknown, but suspected to be a northward dispersal similar to that of the younger birds.

FOOD

A collection of 125 identifiable food-item remains found in active Osprey nests was made during 1968 and 1969. These food items consisted entirely of fish, in the following order of abundance, beginning with the most frequent: catfish (*Galeichthys*); jack (*Caranx*); mullet (*Mugil*); Needlefish (*Scomberesox*); spotted trout (*Cynoscion*); Sheepshead (*Archolsargus*); ladyfish (*Elops*); barracuda (*Sphyraena*); and filefish (*Monacanthus*). Catfish and jacks totaled nearly 80% of the collected items, but both have boney portions uneaten by Ospreys, so the accumulation of their remains in nests results in disproportionately greater numbers than the true proportion of these two species in the total capture. Conversely, mullet, trout, and ladyfish are often entirely consumed by Ospreys, and these three genera must make up a greater percentage of diet than was recorded. Undoubtedly, small numbers of fish species other than those listed above are captured. There are also two observations by other National Park Service personnel of Ospreys capturing other vertebrates (very young alligator, marsh rabbit).

PLUMAGE, AGE, AND SEX CHARACTERISTICS

During observations of known-age, color-marked Ospreys in Florida Bay, I have discovered patterns of wing molt in 1-year-old Ospreys and some 2-year-old Ospreys which appear characteristic of these two ages. I believe further study of marked birds will show these molt patterns to be useful in recognizing Ospreys in these two age classes seen in other regions of south Florida. One-year-old Ospreys apparently begin a molt of primaries and secondaries sometime prior to December in their first calendar year, but this molt halts before completion and remains incomplete during the breeding season months, December-April. The resulting wing pattern on 1-year-old Ospreys consists of several new, dark inner primaries and inner secondaries adjacent to patches of old, faded outer secondaries and outer primaries. This incomplete molt does appear to be inactive during the breeding season, since none of the 1-year-old Ospreys studied during these months showed missing remiges. Some 2-year-old Ospreys show uniform wing feathers during the winter-spring months, but other 2-year-old Ospreys show a pattern of old and new remiges which is different from the pattern in first year birds. The 2-year pattern consists of old secondaries and new primaries, with a small patch of 2-3 old primaries located at approximately positions 3-5, counting from the inner edge. All Ospreys 3 years old and older observed in the study area during the breeding season months show remiges which appear to be of uniform age.

The sex of the adult Ospreys can usually be determined in the field due to different behavior by males and females at active nests, the lack of streaking on the breast of males, and the lower-pitched calls by females. There is one other character discovered by Caulion Singletary when he photographed Ospreys from a blind on Palm Key. Singletary noted that there was a slight difference in eye color between the adult male and female, a difference we have since found to exist in other pairs in the study area. The difference is not conspicuous, but should be useful for sexing adult Ospreys in the hand. Both adults have yellow eyes, but the tone of the yellow differs, being more pure yellow in females, and yellow with a slight orange tint in males. We presently believe this difference in eye color to represent true sexual dimorphism and not a factor of age, but there is need for additional investigation for confirmation.

Most all field workers familiar with northern Ospreys, upon first seeing the breeding birds in Florida Bay, comment on the whiteness of these latter birds. This whiteness is strongest in adult males which are often white-breasted, and in some individuals nearly all white-headed. In this character, and almost certainly other characters as well, Florida Bay Ospreys tend toward similarity with Ospreys which breed in the West In-

PHOTO 1. Ospreys are easily banded on the artificial nesting structures. An aluminum extension ladder is all that is needed to reach the nest. All structures were placed along the shoreline for easy accessibility.

dies, *Pandion h. ridgwayi*, rather than the continental form, *P. h. carolinensis*.

EGG ANALYSES AND SHELL THICKNESS

Fifteen Osprey eggs collected between 1969 and 1972 in the study area were analyzed by WARF, Inc., Madison, Wisconsin, for chlorinated insecticides and polychlorinated biphenols. The Armour-Burke method was used for separation of insecticides from PCB's. Readings for the insecticide in greatest concentration in the eggs, DDE, ranged between 0.59 and 2.55 ppm, whole wet weight (mean: 1.18 ppm), while readings for PCB's from five Frank Key eggs ranged between 0.64 and 2.27 ppm, whole wet weight (mean: 1.43 ppm). Conversions of these data to a fresh, wet-weight basis will result in a slight reduction in most readings. These low residue concentrations are to be expected in an Osprey population which is apparently reproducing itself, as reported above. Shell-thickness measurements obtained from dried shells collected below active nests, and including the inner lining, averaged 0.555 mm for 9 eggs measured in 1972, and 0.560 mm for 11 eggs measured in 1970.

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Status of the Osprey in Michigan

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Abstract: Michigan's Osprey population was estimated at no more than 100 breeding pairs in 1971, when 75 occupied nests were located. During 1964-66, productivity was very low (0.2-0.4 young per occupied nest), and the population was declining 15% per year. Since 1967, productivity has been gradually improving and recently approached normal levels in at least two local populations. This recovery was confined largely to nests in the interior; Ospreys nesting near the shores of the Great Lakes continue reproducing poorly. The recent statewide population trend is difficult to evaluate, as some local populations have been increasing, while others continue decreasing. In two closely watched colonies during 1966-71, mean minimum clutch size (N = 103) was 2.94; 37% eggs (N = 303) hatched; and 32% resulted in young fledging. Of chicks hatching (N = 112), 88% fledged. The low productivity resulted largely from a low proportion of nests raising young. Shells of a random sample (N = 9) of fresh eggs were 17% thinner than normal. Egg breakage and disappearance is the most important immediate cause of nesting failures; embryonic mortality is also a factor.

The Osprey population in Michigan came under my scrutiny only gradually. Having become acquainted with the small colony at the Dead Stream Flooding in the north-central part of the state (Fig. 1) in 1959, I began watching it more closely the following year. In 1962 I started observations at another colony on Fletcher Pond in northeastern Michigan. During 1961-64, while censusing the Bald Eagle (*Haliaeetus leucocephalus*) population, I learned of many additional Osprey nests throughout northern Michigan. This knowledge and reports of declining Osprey populations in the northeastern United States (Ames and Mersereau 1964) led me to launch a statewide breeding survey of this species in 1965 (Postupalsky 1968a, 1969).

The survey methods generally followed those described in my unpublished paper *Bald Eagle and Osprey Studies—Recommended Methods and Terminology*, of which a revised version appears elsewhere in these proceedings. Most nest sites received the recommended minimum of

FIGURE 1. Map showing distribution of Osprey territories in Michigan during 1963–71.

two checks per season: the first during the incubation period; and the second shortly prior to the fledging of young. These observations were made from a chartered light plane. The two colonies mentioned above and nests at several small wildlife floodings were visited by boat with greater frequency.

In Michigan, Ospreys nest in two principal types of habitat: (1) in lowland conifer swamps, nests are built on top of live or dead, sometimes topped, spruces (*Picea alba* and *P. mariana*), cedars (*Thuja occidentalis*), or tamaracks (*Larix laricina*); frequently also on top of tall, white pine (*Pinus strobus*) stumps, less frequently in live pines. Nests on live deciduous trees are very rare; the few I know have dead tops or had originally been built by eagles and later taken over by Ospreys. Nests are not always close to water, they may be as far as 3-4 miles from the nearest body of water of any size; (2) in man-made reservoirs, wildlife floodings, and beaver ponds, nests are placed on top of dead trees and stumps, sometimes quite low.

STATEWIDE DISTRIBUTION AND POPULATION TRENDS

In 1971 I located 75 occupied Osprey nests in Michigan. Their distribution was not uniform, but rather more or less distinctly clumped (Fig. 1). The population trends vary widely between these groups, making an assessment of the population status on a statewide basis very difficult.

In the Lower Peninsula nearly half of the breeding population of 35 pairs nests on Fletcher Pond, another 25% are on the Dead Stream and other floodings in Roscommon County, and another small clump is indicated in Mecosta County in the west-central part of the state.

In the Upper Peninsula five discrete groups are recognizable. These are, from west to east:

1. A rather diffuse group in the western Upper Peninsula, which is contiguous with a larger group in northeastern Wisconsin (7 pairs left on the Michigan side in 1971).
2. A group in the mid-section of the peninsula, centered about the West Unit of Hiawatha National Forest (5 pairs left in 1971).
3. A well-defined local population in the Manistique Lakes area (12 pairs).
4. A group in the St. Ignace area, just north of the Straits of Mackinac (5 pairs in 1971).
5. Drummond Island and vicinity at the eastern end of the Upper Peninsula (6 pairs remained in 1971).

As a whole, Michigan's Osprey population was definitely declining during the mid-1960s. I recorded a drop of 27% between 1964 and 1965 (Postupalsky 1969) and 15% between 1965 and 1966. These population changes are not evident from the totals in Table 1 because the effect of lost pairs was often counterbalanced by discoveries of previously unreported pairs. This is especially true for the early years of the survey. In recent years the high rate of decrease has leveled off. Local populations in Lower Michigan and in the Manistique Lakes area have, in fact, increased during the last 5 years. The other four groups in the Upper Peninsula apparently continue to diminish in numbers.

What proportion of the actual breeding population do the totals in Table 1 represent? Despite a greater overall effort, fewer previously unknown nests have been discovered in recent years. Considering this

TABLE 1. Osprey reproduction in Michigan, 1962–71.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	Total
LOWER PENINSULA											
Occupied nests	22	22	24	25	24	27	30	29	33	35	271
Same; known outcome	20	21	22	24	23	27	29	29	30	35	260
Productive nests	7	12	4	5	4	9	11	14	15	19	100
Percent nest success	35	57	18	21	17	33	38	48	50	54	38
Number of young	14	18	7	9	9	17	20	20	26	40	180
Young/productive nest	2.0	1.5	1.8	1.8	2.3	1.9	1.8	1.4	1.7	2.1	1.80
Young/occupied next[a]	0.7	0.9	0.3	0.4	0.4	0.6	0.7	0.7	0.9	1.1	0.69
UPPER PENINSULA											
Occupied nests			35	28	30	37	41	41	52	40	304
Same; known outcome			22	27	27	35	40	39	50	40	280
Productive nests			7	6	5	8	14	9	18	22	89
Percent nest success			32	22	19	23	35	23	36	55	32
Number of young			9	9	6	13	20	13	35	39	140
Young/productive nest			1.3	1.5	1.2	1.6	1.4	1.4	1.9	1.8	1.62
Young/occupied nest[a]			0.4	0.3	0.2	0.4	0.5	0.3	0.7	1.0	0.51

[a]Nests with known outcome.

observation and the fact that I have checked nearly all areas of suitable habitat at one time or another, I am confident that my census is approaching the total for the actual nesting population in the Lower Peninsula, and that I have located the greater proportion of nest sites present in the Upper Peninsula. In 1972, I doubt that there were more than 40 pairs of Ospreys in Lower Michigan, or more than 100 in the whole state.

REPRODUCTIVE SUCCESS

The Osprey generally has been reproducing better in the Lower Peninsula than in the Upper Peninsula (Table 1). Productivity was very low in both areas during 1964-66, only 0.2 to 0.4 young per occupied nest. A slow recovery began in 1967, especially in Lower Michigan, and, after a relapse confined largely to the Upper Peninsula, was followed by an even greater rise during the last 2 years. An alternate interpretation of the Upper Peninsula productivity data would be that recovery in this area did not start until after 1969. In 1971 productivity in both peninsulas reached 1.0 young per occupied nest for the first time during my study.

Productivity, as used here, is the product of two parameters: (1) the proportion of territorial pairs which raise young to an advanced stage of development (percent nest success); and (2) the mean brood size in successful nests (young per productive nest). The low productivity was largely due to a low proportion of nests raising young. In the Lower Peninsula brood size fluctuated widely, but no long-term trend is evident from the data (Table 1). The mean for the early period is similar to that for 1967-71. In the Upper Peninsula, however, an increasing tendency is evident. In the 1964-66 period, brood size was lower in the Upper Peninsula (1.2-1.5 young per productive nest) than in Lower Michigan (1.8-2.3 young per productive nest). By 1970-71 this value was nearly equal for both parts of the state (mean for the 2 years was 1.9).

It is generally accepted that Great Lakes biota tends to be more heavily contaminated with organochlorine pesticide residues (Hickey et al. 1966; Hickey 1969; Reinert 1970) than that in the smaller inland lakes and streams (Kleinert et al. 1968), and a causal relationship between DDE and reproductive failures in raptorial and piscivorous birds is well documented (Ratcliffe 1967, 1970; Hickey and Anderson 1968; Heath et al. 1969; Wiemeyer and Porter 1970; Blus et al. 1971). For the Bald Eagle, I noted a very significant and consistent difference in reproductive success between pairs nesting near the shores of the Great Lakes and those breeding in inland situations (Postupalsky 1963, 1967, 1968b; Sprunt 1963). Productivity in Great Lakes eagles has been only about one-fifth of that shown by inland eagles. A similar pattern is now emerging from my recent Osprey data (Table 2), but is less well pronounced. In order to increase the sample size for Osprey nests near the Great Lakes, I include several Canadian nests on and near St. Joseph Island, which are adjacent to the Drummond Island, Michigan, local population. During 1964-69, inland Ospreys were reproducing somewhat better than those near the Great Lakes. This was true for 5 of these 6 years; the only exception was in 1965. This difference in productivity became much greater during 1970-71. The improvement in reproductive success in Michigan Ospreys since 1967 has been confined almost entirely to the inland segment of the population. Ospreys nesting near, and presumably feeding on, the Great Lakes continue doing rather poorly.

TABLE 2. Osprey reproduction: Great Lakes shores compared with inland areas.

	1964	1965	1966	1967	1968	1969	1970	1971	1964-71
GREAT LAKES SHORES AND ISLANDS (MICHIGAN AND ST. JOSEPH ISLAND, ONTARIO)									
Occupied nests	11	11	11	11	12	18	21	14	109
Productive nests	1	4	0	2	4	5	6	4	26
Percent nest success	9	36	0	18	33	28	29	29	23.9
Number of young	1	5	0	2	6	6	10	6	36
Young/prod. nest	1.0	1.3	0	1.0	1.5	1.2	1.7	1.5	1.38
Young/occup. nest	0.1	0.5	0	0.2	0.5	0.3	0.5	0.4	0.33
INLAND AREAS (MICHIGAN)									
Occupied nests	33	40	39	52	58	51	62	64	399
Productive nests	10	7	9	15	21	18	27	37	144
Percent nest success	30	18	23	29	36	35	44	58	36.1
Number of young	15	13	15	28	34	27	51	71	256
Young/prod. nest	1.5	1.9	1.7	1.9	1.6	1.5	1.9	2.0	1.78
Young/occup. nest	0.5	0.3	0.4	0.5	0.6	0.5	0.8	1.1	0.64

FLETCHER POND AND DEAD STREAM COLONIES

Fletcher Pond is a 7000-acre water storage reservoir established in the 1930s by the Alpena Power Company. The much smaller Dead Stream Wildlife Flooding was established in 1940 by the Michigan Department of Natural Resources. These two Osprey colonies have been subject to more thorough surveillance than Ospreys nesting elsewhere in the state, and may now be regarded as managed populations. They have recently been subject to the following two management measures:

1. A "foster parents plan," in which I break up large broods by placing the odd-sized chick (usually the smallest) in another nest where eggs failed to hatch. This procedure, taken within the first few days after

hatching, should reduce nestling mortality. To date I have transferred 10 young, all of which were successfully raised by their foster parents. For the purposes of calculating reproductive success parameters, the adopted young are credited to nests where they hatched.

2. Artificial nest platforms: 25 of these were first erected on Fletcher Pond (20) and the Dead Stream Flooding (5) early in 1967. Seven more have been added since then, plus 10 in other locations in Michigan. Their purpose was to provide sturdy, storm-proof supports for nests to replace deteriorating, wobbly, and often very low stumps on which Ospreys had been nesting on these reservoirs. The platforms prevent losses of eggs and young formerly sustained when nests were destroyed during windstorms, reduce possibility of predation by mammals, and make nests more accessible for study.

The Fletcher Pond colony had dropped to 11 pairs by 1966 (Table 3). The early counts of occupied nests may be incomplete because I made but one visit in 1962 and 1963 (late July), and may have missed some unsuccessful pairs. The gradual increase in numbers after 1967 was made possible by our platforms, as durable stumps had become very rare. In 1971, of 17 pairs breeding on the pond, 15 were using our platforms. Productivity, which had reached a low point during 1964-65 (0.4 young per occupied nest), has been steadily improving here also; in 1971 it was 1.2 young per occupied nest, close to the level Henny and Wight (1969) calculated to be required to offset mortality estimated from recoveries of banded Ospreys.

Reproductive success at the Dead Stream Flooding was also low during the mid-1960s (Table 4). The total failure of this colony in 1964 coincided with a drawdown of this impoundment that spring as a waterfowl-management measure by the Michigan Department of Natural Resources. Productivity improved in 1967, remained in the 0.6-0.8 young per occupied nest range for 4 years, and rose to an unprecedented high of 2.2 young per occupied nest in 1971, when of five pairs, four were productive with a total of 11 young. Two of these young had been placed in unproductive nests, so that actually six pairs had contributed parental care to this high rate of production.

Closer surveillance of the two colonies during 1966-71 yielded data on clutch size and the fate of eggs. For 103 nestings at Fletcher Pond and the Dead Stream, mean clutch size was 2.94. This value, however, is slightly biased. I believe it should be a little in excess of 3.00; this because of an observed relationship between the number of eggs found in certain nests and the timing of the first census in spring. The earlier in the incubation period nests are checked, the higher the count of eggs tends to be. This observation is consistent with the phenomenon of egg breakage due to abnormally thin shells.

TABLE 3. Osprey reproduction on Fletcher Pond, Michigan, 1962–71.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1962–71
Occupied nests	10	10	13	12	11	12	15	15	15	17	130
Same; known outcome	10	10	13	12	11	12	15	15	13	17	128
Productive nests	3	7	3	3	3	5	7	8	7	10	56
Percent nest success	30	70	23	25	27	42	47	53	54	59	44
Number of young	6	11	5	5	8	10	12	13	11	21	102
Young/productive nest	2.0	1.6	1.7	1.7	2.7	2.0	1.7	1.6	1.6	2.1	1.8
Young/occupied nest[a]	0.6	1.1	0.4	0.4	0.7	0.8	0.8	0.9	0.9	1.2	0.8

[a] Nests with known outcome.

TABLE 4. Osprey reproduction on the Dead Stream Flooding, Michigan, 1960–71.

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1960–71
Occupied nests	7	7	7	7	7	6	6	6	6	5	6	5	75
Same; known outcome	6	7	7	7	7	6	6	6	6	5	6	5	74
Productive nests	2	3	4	4	0	1	1	2	2	2	2	4	27
Percent nest success	33	43	57	57	0	17	17	33	33	40	33	80	37
Number of young	3	5	8	5	0	2	1	4	4	3	5	11	56
Young/productive nest	1.5	1.7	2.0	1.3	0	2.0	1.0	2.0	2.0	1.5	2.5	2.8	2.1
Young/occupied nest[a]	0.5	0.7	1.1	0.7	0	0.3	0.2	0.7	0.7	0.6	0.8	2.2	0.8

[a] Nests with known outcome.

PHOTO 1. Low Osprey nest on Fletcher Pond, Michigan, 29 July 1962.

Thirty-seven percent of known eggs (N = 303) hatched, and 32% resulted in fledged young. Of young that hatched (N = 112), 88% fledged. This is very close to nestling survival of 86% (N = 590) in Chesapeake Bay reported by Reese (1970). I do not believe that the heretofore very limited experimental application of my "foster parents plan" had altered this percentage appreciably. The effect of our artificial nesting platforms is difficult to measure in absence of a control group. Note that the above hatching and fledging rates were obtained during the period of recovering reproductive success; they are not

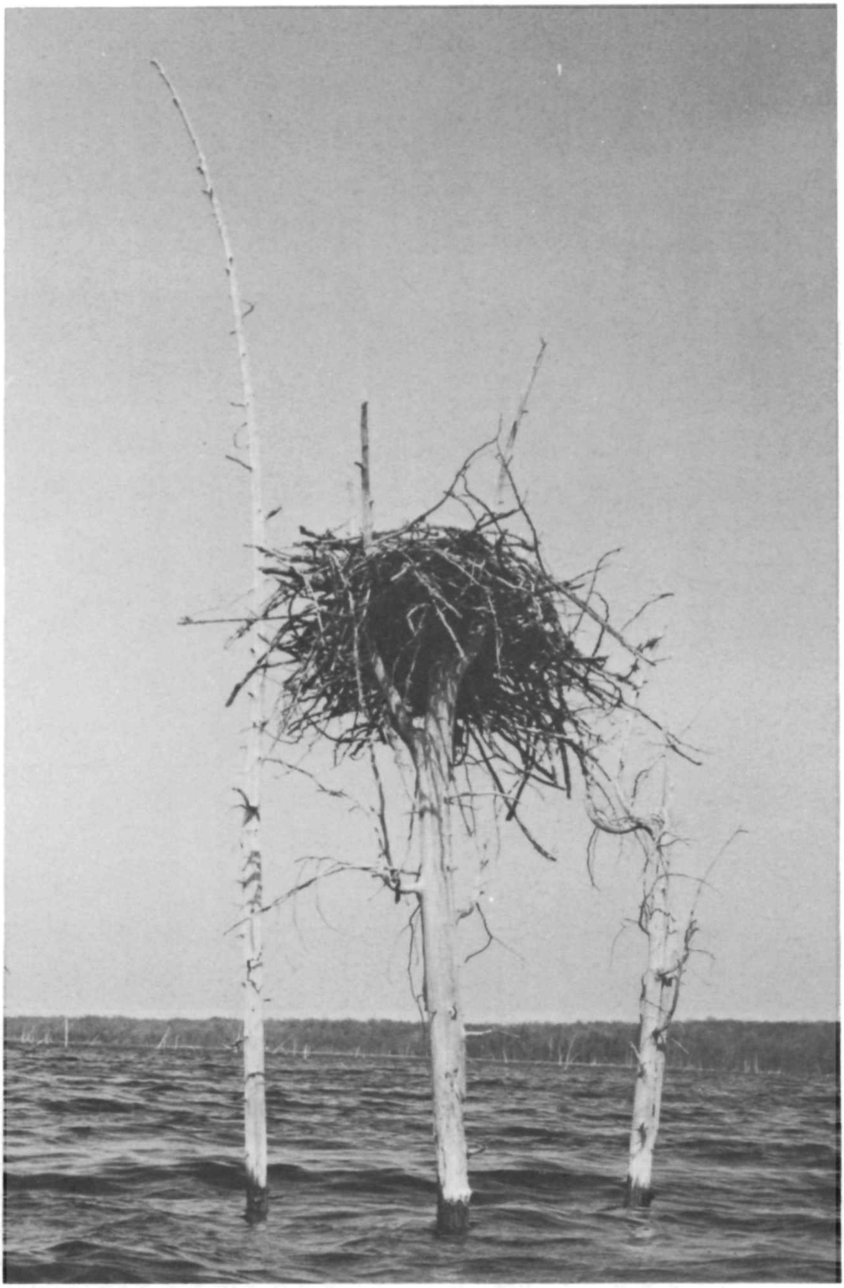

PHOTO 2. Osprey nest, Fletcher Pond, Michigan, 1967. (Photo by Conservation for Survival.)

PHOTO 3. Tripod-type platform in cattail marsh, Dead Stream Flooding, Roscommon County, Michigan, 1969.

PHOTO 4. Osprey nest near edge of marsh, Clare County, Michigan, 10 June 1969.

representative of the period of extremely low success during the mid-1960s.

The abnormally low reproductive rate in Michigan Ospreys was largely due to egg failures. I noted dented or broken eggs on numerous occasions; many eggs just disappeared between visits, often leaving tiny shell fragments in the lining of the nest. Shells in a random sample of fresh eggs (N = 9), taken in 1969 from Fletcher Pond and the Dead Stream, averaged 17% thinner than normal. Data on normal shell parameters from pre-1947 Osprey eggs in museums were kindly supplied by D. W. Anderson and J. J. Hickey (pers. comm). Embryonic mortality in absence of shell breakage also occurs. It may be caused either by water loss through DDE-induced thin shells or by a toxic chemical or combination of chemicals yet to be identified. As all my egg samples have not yet been analyzed, I defer a discussion of toxic chemical residues until a later date.

CONCLUSIONS AND OUTLOOK

The poor reproductive success and dismal population status of the Osprey prevalent in Michigan during the mid-1960s appears to have been reversed. The gradually improving productivity during the last 5 years and the increasing tendency of the Lower Peninsula Osprey population as a whole and of at least one local population in the Upper Peninsula permit some guarded optimism concerning the species' outlook in Michigan. Barring any unprecedented increase in mortality rates, the next few years should bring a continued increase in several local populations in the state, as survivors of the greater number of young raised in the last 2 years return to breed. I have already recaptured four females banded as nestlings on Fletcher Pond during 1965-67, which are now breeding (successfully) there and on the Dead Stream Flooding. I am planning to launch a color-banding project in 1972. Hopefully, this method will yield data on age at first breeding, fidelity to nest site and mate, survival rates, etc.

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Acknowledgments: During 1965-70 my research was made possible through travel funds from the National Audubon Society. In 1967, Conservation for Survival, Inc., a private organization spearheaded by Stephen M. Stackpole, began building and maintaining artificial nesting platforms on Fletcher Pond, the Dead Stream, and several other floodings, and provided me with additional logistic support. The 1971 research was funded entirely by this organization. Over the years, personnel of the Michigan Department of Natural Resources and the U.S. Forest Service and many interested private individuals assisted in locating nests and in various other ways.

Reproduction in Wisconsin Ospreys[1]

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Abstract: A statewide survey of the Osprey was under taken in Wisconsin during 1966-70. Each year the number of known nests increased due to better coverage; 89 occupied nests were known in 1969. During 1971-72, only partial coverage of the state was maintained. Productivity varied between 0.6 and 1.2 young per occupied nest. The number of young per successful nest varied between 1.6 and 2.0. Nest success varied between 34 and 62%. The maximum of 89 occupied nests reported in 1969 was not a complete census but certainly includes the majority of nests present in the state.

Prior to 1965, little was known about the distribution, size, or reproductive success of the Osprey (*Pandion haliaetus*) population in Wisconsin, with the exception of the colony on Rainbow Reservoir in Oneida County which had been monitored from 1952 through 1964 (Berger and Mueller 1969). The object of this study was to map breeding distribution of the Osprey in Wisconsin and to monitor its reproduction. Many nests were already known; my problem was to locate the people who had seen them. Queries were sent out to the U.S. Forest Service supervisors of Chequamegon and Nicolet National Forests, the Department of Natural Resources, to all members of the Wisconsin Society for Ornithology, and to all licensed fishing guides. Several newspapers ran stories on the study. These efforts proved effective in varying degrees in obtaining nest locations. I located many additional nests while searching for reported nests and incidental to my field work on the Bald Eagle (*Haliaeetus leucocephalus*). Alexander Sprunt IV, Research Director of the National Audubon Society, also located several Osprey nests incidental to his work on the Bald Eagles in Wisconsin as part of the "Continental Bald Eagle Project."

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[1]Funded by the Wisconsin Society for Ornithology, Mrs. Charles Sindelar, Jr., the North Central Audubon Council, and the Steenbock Scholarship.

STUDY AREA

The Osprey's breeding range in Wisconsin is limited to the northern one-third of the state and to several nests in the central portion (Fig. 1). The Osprey in Wisconsin typically nests at the apex of dead trees. A few nest on tops of live trees, and several have accepted man-made structures, such as high-tension poles, fire towers, windmill towers, etc.

METHODS

I checked nests by climbing the nest tree itself, by climbing a nearby tree and looking down into the nest, or by flying over the nest at low altitude with fixed-wing aircraft. Gaining access to nests was accomplished by using outboard motor boat, canoe, or by walking, and in most cases by a combination of these methods. My observations were usually aided by binoculars and spotting telescopes.

During 1966-69, all known nests in the state were checked at least once and in most cases twice. The first check was made in mid-May to determine presence of incubating adults and the followup check was made in mid-July to determine nest success. Beginning in 1971, I concentrated my efforts on nests on Flambeau Flowage and Rainbow Reservoir (Fig. 1) as these nests could be checked relatively quickly. The remaining nests in the state are scattered widely, and for many access is either difficult, time-consuming, or expensive; thus, only a few were checked.

PRODUCTIVITY

For the first 4 years of the study the number of occupied nests increased each year due to better coverage of the state (Table 1). I strongly suspect that I had located the majority of the nests in the state.

For the purposes of this study, an occupied nest is one that was used by a pair of Ospreys during the nesting season. A successful nest is one in which at least one young was raised to an advanced stage of development.

In most cases it was impractical to determine actual fledging of young, but it is assumed that little attrition takes place after the young reach an advanced stage of development, and thus in all likelihood most young counted in this study did fledge.

Reproductive success in Wisconsin Ospreys during 1966-72 is presented in Table 1. The 1966 and 1967 values for percent nest success and young per occupied nest are biased upward because some nests did not receive an early check in these 2 years. Thus, a number of nests were considered "inactive" and excluded from my study. Of these, some were probably occupied but abandoned prior to the late check. This bias does not affect the number of young per successful nest.

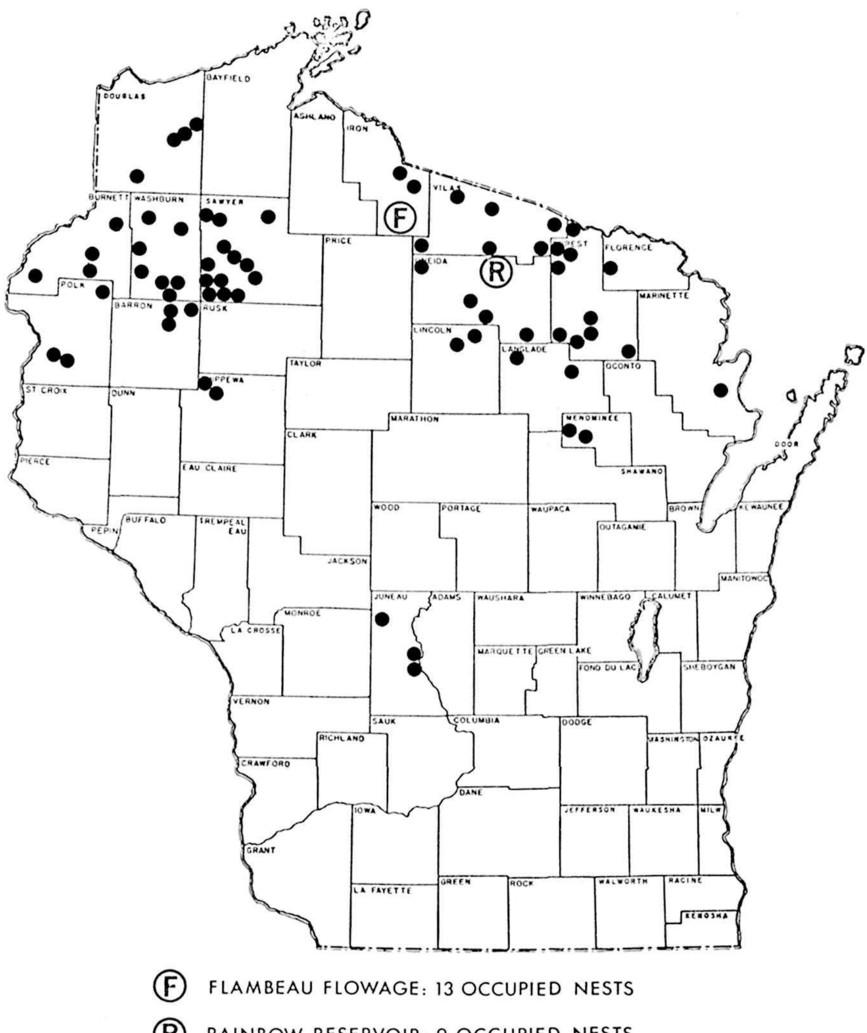

FIGURE 1. Map showing distribution of occupied Osprey nests in Wisconsin in 1969.

TABLE 1. Osprey nest success in Wisconsin, 1966–72.

	1966	1967	1968	1969	1970	1971	1972
Occupied nests	45[a]	64[a]	79[a]	89[a]	84[b]	44[b]	41[b]
Same; known results (A)	29	58	64	86	83	37	31
Successful nests (B)	15	36	31	29	35	15	11
Percent nest success (B/A)	52[c]	62[c]	48	34	42	44	35
Number of young (C)	24	68	48	53	65	26	22
Young/successful nest (C/B)	1.6	1.9	1.6	1.8	1.8	1.7	2.0
Young/occupied nest (C/A)	0.8[c]	1.2[c]	0.8	0.6	0.8	0.7	0.7

[a]The greater number of active nests each successive year only reflects better coverage, not a population increase.
[b]Many nests that were occupied in previous years were not checked in 1971–72.
[c]These figures are surely too high, due to a bias discussed in the text.

The proportion of successful nests fluctuated between 34 and 62% during 1966-72; brood size at late nestling stage fluctuated between 1.6 and 2.0 young per successful nest; and overall productivity, between 0.6 and 1.2 young per occupied nest. The number and percentage of Osprey nests with 0, 1, 2, and 3 young are shown in Table 2.

It has been calculated (Henny and Wight 1969) that each female Osprey of breeding age must produce between 0.95 and 1.30 young each year to maintain a stable population. During only one year of my study (1967) did the Wisconsin Osprey reproduce within this range.

In 1969 eight eggs were collected early in incubation for chemical analysis and eggshell-thickness measurements. In addition to these eggs, each year at banding time I collected unhatched addled eggs. These data will be published at a later date. Preliminary analysis indicates that shell-thinning (Hickey and Anderson 1968; Ratcliffe 1967, 1970) has affected the Wisconsin Osprey population and may well be the cause of reproductive failure of the Osprey in Wisconsin.

Reproduction in Rainbow Reservoir has been poor for 6 of the 7 years of my study (Table 3). For a history of the Rainbow Reservoir Ospreys prior to 1966 see Berger and Mueller (1969). However, be careful when comparing their data with mine (see Sindelar 1971:81).

Reproduction on the Flambeau Flowage (Table 4) fluctuated widely from year to year, but 1971 and 1972 were the first 2 consecutive years with very low reproduction, perhaps indicative of a trend.

Although the Flambeau Flowage and Rainbow Reservoir are separated by approximately 30 air miles, we know that there is at least some exchange between these two populations. In 1969 I trapped an adult at a nest on Flambeau Flowage; this bird had been banded as a nestling on Rainbow Reservoir by Dan Berger 16 years before.

TABLE 2. The number and percentage of Osprey nests with 0, 1, 2, and 3 young.

	1966	1967	1968	1969	1970	1971	1972
Occupied nests with known outcome	29	58	64	86	83	37	31
0 young	14 (48%)	22 (38%)	33 (52%)	57 (66%)	48 (58%)	22 (60%)	29 (65%)
1 young	6 (21%)	13 (22%)	13 (20%)	12 (14%)	14 (17%)	6 (16%)	3 (10%)
2 young	9 (31%)	14 (24%)	13 (20%)	13 (15%)	12 (14%)	7 (19%)	5 (16%)
3 young	0 (0%)	9 (15%)	2 (3%)	5 (6%)	9 (11%)	2 (5%)	3 (10%)

TABLE 3. Osprey nest success on Rainbow Reservoir, 1966–72.

	1966	1967	1968	1969	1970	1971	1972
Number of occupied nests	6	9	6	8	9	7	7
Successful nests	0	3	1	2	2	4	1
Percent nest success	0	33	17	25	22	57	14
Total young produced	0	5	1	3	4	7	1
Number young/successful nest	0	1.7	1.0	1.5	2.0	1.8	1.0
Number young/occupied nest	0	0.6	0.2	0.4	0.4	1.0	0.1

TABLE 4. Osprey nest success on Flambeau Flowage, 1966–72.

	1966	1967	1968	1969	1970	1971	1972
Number of occupied nests	5	13	12	13	13	13	10[a]
Successful nests	2	9	7	5	8	5	3
Percent nest success	40	69	58	38	62	38	30
Total young produced	3	21	12	9	14	7–11[b]	5
Number young/successful nest	1.5	2.3	1.7	1.8	1.8	1.4–2.2	1.7
Number young/occupied nest	0.6	1.6	1.0	0.7	1.1	0.5–0.9	0.5

[a]Three nests known to have been occupied in previous years were not checked in 1972.
[b]There were five productive nests. However, I was unable to determine the exact number of young for two of these. Thus, two nests had two young, one nest had one young, and two nests had one to three young. Total minimum number is seven. Total maximum number is 11.

The breeding Osprey population in Wisconsin is certainly reproducing below a normal rate. On the basis of disappearance of breeding pairs from their territories from year to year, I calculated that during 1966-69 the Osprey population in Wisconsin was declining at a rate of approximately 19% per year. This method of calculation would show a slight decline even for a stationary population, as some breeding sites are abandoned in favor of others which may not be discovered right away.

Considering the subnormal reproductive rate, I am not at all optimistic about the future of the Osprey in Wisconsin.

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Acknowledgments: I would like to acknowledge gratefully the help of the following: The Wisconsin Department of Natural Resources, the U.S. Forest Service, and the National Audubon Society; Errol Schluter for the use of his boat, motor, and trailer; Don Follen, Errol Schluter, Tom Erdman, David Evans, and others who helped in various ways with the field work. Special thanks are due Allen K. Jacobson who was my almost constant companion for most of the field work. James Grier, Sergej Postupalsky, Daniel D. Berger, and Drs. F. N. and F. Hamerstrom aided in many ways during the study. I spent most of my vacations and summer weekends in the field. In addition to subsidizing this project each year, my wife, Mary Ann, has shown extremes of patience and understanding, thus making this study possible.

The Status of Ospreys in the Chippewa National Forest

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Abstract: Osprey populations have been studied intensively in the Chippewa National Forest in north-central Minnesota since 1968. This report summarizes nesting data obtained from aerial surveys for the period 1968-71. There are approximately 100 known Osprey nests in the Chippewa, with many more yet to be found. The number of successful pairs has ranged from 32 to 54%. Of 190 nesting attempts during this period, only 156 young were fledged (0.8 young per active nest). Comparison with nesting data from other sources and geographic locations suggests the breeding population is declining.

Efforts to evaluate the breeding population and reproductive success of Ospreys in the Chippewa National Forest were initiated in 1963, although intensive surveys using aircraft were not begun until 1968. The results of nesting surveys for the period 1968-71 are summarized in this paper.

The Chippewa National Forest is located in north-central Minnesota and occupies an area of 1.650 million acres. The physiography is characterized by exceedingly flat terrain with many lakes and marshes. There are approximately 354,000 acres of surface water and almost 180,000 acres of wetlands in the Forest. Commercial forest land accounts for most of the remaining area and includes typical associations of the boreal forest such as upland conifers, lowland conifers, aspen, and northern hardwood types. Forestry is the dominant land use, although recreation is becoming increasingly important as an economic and sometimes ecologic consideration.

OSPREY NEST INVENTORY

Little was known concerning the breeding population of the Osprey prior to 1963. When interest in the preservation and management of Bald Eagles (*Haliaeetus leucocephalus*) became an official U.S. Forest Service concern in 1963, efforts to develop a nesting inventory for this species resulted in finding locations of Osprey nests as well. It soon became apparent that the Chippewa was supporting a substantial breeding population of this unique raptor. In 1968 the Bureau of Sport Fisheries and Wildlife, Refuge Division, provided aircraft for observations, and this rewarding and cooperative effort has continued to the present time.

The locations of Osprey nests are determined from field personnel who frequently observe nests during routine activities, and from aerial observation during the flights for checking Bald Eagle and Osprey nests. We have not had the funds or opportunity to make an intensive, systematic search for Osprey nests to determine the total breeding population in the forest. Although we have recorded up to 100 nest sites, there are many more to be found, perhaps twice this number. A nest inventory for this species is exceedingly difficult to maintain over a large area because of frequent nest destruction by windstorm and poor observability both from the ground and air. Approximately 60 Osprey nests are known to have blown down since 1965. Only rarely have we found new construction in the general vicinity of destroyed nests. We must assume, therefore, that many of the Osprey pairs displaced by storms have established new nests in unrecorded locations.

NESTING SURVEYS

We attempted to observe all recorded Osprey nests from the air soon after incubation commenced in mid-May to determine which nests were occupied. A second check was made of occupied nests just prior to fledging in early August to determine breeding success.

The survey data are expressed as number and percent of active nests (an active nest having an adult in incubating posture), number and percent of successful nests (a successful nest having at least one young near fledging), average brood size, and young per active nest (synonymous with young per breeding pair).

The statistics for percent of active nests are somewhat misleading because of the problem of alternate nests. The use of "territory" designations would be more descriptive, but we found it almost impossible to group many of the nests into their respective territories. Ospreys in the Chippewa usually nest as isolated pairs, but there are some areas where semi-colonial nesting occurs. In one case, for instance, there are nine nests within a mile of one another. The results of the Osprey survey from 1968 through 1971 are shown in Table 1. There was little variation in the relative number of occupied nests during the 4-year period. Since alternate nests would account for many of the "unoccupied" nests, it appears that most of the Ospreys in the Chippewa initiate an attempt at breeding.

The number of successful pairs, however, has ranged from 32 to 54% (average 45%). Of 190 nesting attempts during this period only 156

TABLE 1. Results of Osprey survey, Chippewa National Forest, 1968–71.

Year	Known nests	Observed nests	Active number	Nests percent	Successful number	Nests percent	Number of young	Average brood size	Young/ active nest
1968	73	56	40	71	13	32	19	1.5	0.5
1969	89	69	49	71	23	47	50	2.2	1.0
1970	99	71	52	77	28	54	48	1.7	0.9
1971	90	74	49	66	22	45	39	1.8	0.8
Average and Totals		270	190	70	86	45	156	1.8	0.8

young were fledged (0.8 young per active nest). If Henny and Wight (1969) are correct in their calculations that an annual production of 1.22-1.30 young per breeding pair is necessary to maintain a stable population, we must conclude that the Chippewa population is declining (provided other mortality factors are comparable).

Dunstan (1968), reporting on 161 nesting attempts in Minnesota from 1966-68, indicated 1.0 young per active nest, and a nesting success of 65%. We might conclude from these reasonably comparable data that Osprey productivity has declined appreciably in this area since 1968. Further comparisons can be made with other populations from data presented by Henny and Ogden (1970). The range of young per active nest was from 0.27 in Connecticut to 1.22 in Florida. Successful nests ranged from 27 to 70%.

Reasons for nesting failure have not been scientifically evaluated in the Chippewa although assumptions can be made. Direct mortality of nestlings from windstorms can be of considerable importance in certain years. Disturbance by human activities may cause some nest abandonment although there are no data to support such a contention. Most Ospreys in the Chippewa are breeding in very isolated habitats, often in mosquito-infested wooded swamps where few people are likely to be found. Even logging is restricted to the winter months. Direct mortalities from shooting undoubtedly account for some losses of adults, but there are very few known instances in which this occurs.

Pesticides have been identified in other Osprey populations as a factor in reproductive failure and population declines (Ames 1966). It is likely that Chippewa Ospreys are likewise contaminated although no testing has been done. It is extremely difficult to obtain specimens for pesticide analysis. Even addled eggs are largely out of reach because dead trees make climbing an extremely hazardous, if not an impossible, undertaking.

OTHER DATA

Upwards of 80% of Chippewa Ospreys have selected dead trees for nest sites. The most common tree species utilized are black spruce and tamarack. Nests are also found in red pine, white pine, white cedar, and a few in hardwoods. Most of the nests are located in lowland conifer swamps, often some distance from open water. Nest-site characteristics were described in detail and compared to Bald Eagle nest sites by Mathisen (1968). There are some interesting correlations between Osprey nest locations and other wildlife species in the forest. Ospreys frequently are found nesting in beaver flowages where the trees have been killed, providing acceptable nesting supports. Likewise, we find Ospreys nesting along with Great Blue Herons (*Ardea herodias*), where the herons have killed or partially killed the trees. Of 12 known heron rookeries in the forest, six have an Osprey nest within the rookery. Three cases are known where Ospreys have taken over Bald Eagle nests.

The U.S. Forest Service recognizes the Osprey as an important part of the wildlife community in national forests. Official policy prohibits timber cutting and other disturbances within 330 ft of a nest at any time. Another buffer zone of 660-ft radius from the nest prohibits activity during the nesting season.

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Reproduction and Toxicants in Lake of the Woods Ospreys[1]

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Abstract: Nesting Ospreys censused at Lake of the Woods, Ontario, showed a turn-over rate of nest structures of over 20% between 1967 and 1971; yet the total number of nests remained unchanged and did not differ from a census in 1964 by Mansell (1965). During 1971, 48 occupied nests were surveyed at incubation and again just prior to fledging young. Of these, an estimated 91% produced eggs and 64% raised young to late nestling stages at a rate of 1.0 young per occupied nest. Effects of research activity were assessed experimentally and found to be insignificant. Toxic chemical contamination in eggs averaged, on a dry-weight basis, 23 ppm DDE, 3.85 ppm DDD, 0.38 ppm dieldrin, 13.67 ppm PCB (excluding one value of 446 ppm), and 0.58 ppm mercury. Two dead chicks contained lower levels for all toxicants except mercury, which averaged 2.12 ppm. Values were compared by nonparametric statistics. However, no significant relationships were observed, possibly because of small sample size.

During the course of fish research by personnel of the Ontario Ministry of Natural Resources and research on Bald Eagles by us, we found several nests of Ospreys in the Lake of the Woods region of Ontario, Canada. The locations of these nests were recorded when found. Mansell (1965) observed the success of known nests in 1964; Grier (unpubl. data) censused the Ospreys in 1967; and we conducted a thorough survey of the nests in 1971. The 1971 observations included a census of nest occupancy, sampling of eggs for toxic chemical contamination and embryonic mortality, and a controlled field experiment to determine the

[1]Funded in 1967 by a grant from the National Audubon Society and in 1971 by contract with the Canadian Wildlife Society.

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effects of our climbing to nests and removing a few eggs. This paper presents the results of the 1971 study as well as comparisons with the 1964 and 1967 censuses.

STUDY AREA

Lake of the Woods is located in Ontario at the junction of its borders with Manitoba and Minnesota. The bounds of the Osprey study area are 49°00′ to 49°50′ latitude and 93°50′ to 95°10′ longitude.

The area's flora and fauna are of typical boreal forest type, with predominant tree species being balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), and trembling aspen (*Populus tremuloides*). Ospreys in this region typically nest at the tops of either live or dead pine and spruce trees, with white pine used most frequently.

Nests usually did not contain prey items when climbed, although the birds were frequently seen catching fish, carrying fish, or eating while perched. The few prey items we found in nests included walleye (*Stizostedion vitreum*), burbot (*Lota lota*), rock bass (*Ambloplites rupestris*), and various suckers (probably *Catostomus* sp). Other common potential prey species in the region include various whitefish and ciscoes (*Coregonus* sp.), lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius*), muskellunge (*E. masquinongy*), large-mouth bass (*Micropterus salmoides*), and yellow perch (*Perca flavescens*). We did not attempt to quantitate feeding habits.

The major uses of this region by man include commercial timber pulp cutting and processing, commercial fishing, fur-animal trapping, sport fishing, waterfowl and big-game hunting, and tourism. These activities are not new to this particular region as they have been popular here for most of the 20th century.

METHODS

We located nests while traveling on the water or from low-flying, fixed-wing aircraft being used in other research. For actual observations and work with the Ospreys, however, we traveled to the nests with outboard-motor boats only. We observed the Osprey with binoculars, spotting telescopes, and by climbing to the nests.

The percentage of nests located to those actually existing in the region is not known. With the extensive coverage of Lake of the Woods by provincial personnel and by us, however, we believe that the majority of Osprey nests present within sight of the shoreline were located.

During 1967 and 1971 we visited the Osprey nests twice: once late in the incubation period during mid- to late June and again when young were at an advanced age of 4-6 weeks in late July. We collected a limited number of eggs in 1971 during the first visit to determine toxic chemical residues.

Bald Eagles in this region were previously checked experimentally for potential effects of research disturbance (Grier 1969). To assess the effects of our activities on the Osprey and to insure that any possible disturbance would be minimal, we conducted our observations through a controlled field experiment as follows. Prior to the first visit, we randomly allotted 65 previously known Osprey nests to two groups: one with occupied nests to be climbed at the first visit; and the other, a control group, to be left alone without climbing and only observed from a distance. Nests found for the first time during the census were also randomly allotted to one group or the other by flipping a coin at the time the nest was found. Since we desired to produce a minimal effect and were interested only in inter- (not intra-) clutch variation, we planned to collect one egg each from the first 10 nests climbed which contained two or more eggs. This choice of nests was not random, but we wanted to get eggs as early in incubation as possible and we did not want to take the only egg when only one was present since it might be the only potential young for the pair to raise. Single eggs could represent single-egg clutches, incomplete clutches, or the remnants of larger clutches from which the other eggs disappeared prior to our visit. In the latter case, a bias in the sampling of toxic chemicals might be introduced by not collecting such eggs. We hoped, however, that any such bias would be slight and we preferred instead not to lessen the chance of a pair of birds completing their reproductive cycle that season.

Collected eggs were opened and contents placed into acetone-rinsed jars sealed with acetone-rinsed aluminum foil. The contents were then frozen until analysis. The eggshells were rinsed in tap water and dried at room temperature for at least 3 months. After drying the shells, we measured the dimensions and weight (for the thickness index, after Ratcliffe 1967); we also measured the thickness directly, including dried membranes, at the girth with a Starrett micrometer to 0.01 mm.

Methods used for analyses of toxic chemicals by the Wisconsin Alumni Research Foundation (W.A.R.F.) are described by Enderson and Berger (1968). Organochlorine measurements performed by the Ontario Research Foundation (O.R.F.) are described by Vermeer and Reynolds (1970). PCB estimations were made with Aroclor 1260 as the reference standard, with averaged calculations for peaks number 8 and 10, except for specimen numbers 744-746 in which Aroclor 1254 was used as the standard. Mercury content was determined by "flameless" atomic absorption spectrophotometry as described by Vermeer (1971).

From the wet-weight values reported to us, we calculated the residue levels on a dry-weight basis. Water content of the eggs varies with length of time since the egg was laid; and the lipid content depends on the degree of embryonic development (Romanoff 1932). Hence, we prefer to use dry-weight values (cf. Lincer et al. 1970) rather than wet- or lipid-weight values (cf. Berger et al. 1970). Adjustment of values to a fresh wet-weight basis would also appear to yield a fairly reliable basis for comparisons (cf. Postupalsky 1971).

Nonparametric techniques were used for statistical analyses of data since some of the measurements were not exactly comparable at different levels of magnitude and we were unwilling to make some of the distribution parameter assumptions required for techniques based on the normal distribution.

OSPREY PRODUCTIVITY

The number of breeding adults in an area is commonly assessed by the number of "active" or "occupied" nests (Postupalsky, this conference). Since 1971 was the first year that a thorough check of occupied nests was conducted by the standard method used by others working with Ospreys, i.e., censusing the presence of adults during the incubation period, Ospreys at Lake of the Woods cannot be compared with previous years on an occupied-nest basis. If one simply looks at the total number of known nest structures existing in the area as a rough index, however, the number of nests has remained remarkably constant from 1964 to 1971 (Table 1). Osprey nests disappear fairly rapidly in this region unless maintained, as evidenced by a turn-over rate of over 20% between censuses at Lake of the Woods (see Table 2 for changes between 1967 and 1971). If the breeding population changes in size, one would expect this change to be reflected in the number of nest structures present, assuming no significant changes in the proportion of alternate nests. We thus have no evidence of a change in the breeding population of Ospreys at Lake of the Woods from 1964 to 1971.

TABLE 1. Osprey productivity[a] at Lake of the Woods, Ontario, 1964–71.

Year	1964[b]	1967	1971
Total number nest structures known	63	63	64
Number nests known or believed to contain young 4–6 weeks of age	(40)	35	31
Number young per nest with young	(1.2)	1.8	1.6
Estimated number young to reach 4–6 weeks of age[c]	48 ± 6	63 ± 8	50 ± 6

[a]Occupied and active rates not available for 1964 and 1967, see text; for 1971, see Table 3.
[b]From Mansell 1965; all observations from below the nests without climbing.
[c]95% confidence limits based on binomial probability of living (vs. dying) of 0.80, see Table 3 line Q.

An estimated 91% of the occupied nests contained eggs, with an average clutch size at late incubation of 2.6 (Tables 2-4). With a high loss during and following incubation, 64% of the occupied nests produced an average of 1.0 young per occupied nest, or 1.6 young per nest with young of advanced age (4-6 weeks old). Approximately 42% of the eggs produced young to the advanced stage; this rate is very similar to the rates observed in an apparently stable population of Ospreys in Maryland (Reese 1970). Causes of nestling mortality included one young shot on the nest in 1967, one accidentally trapped in the nest structure in 1967, one which may have died by suffocation from food over the aditus laryngis in 1971, and 11 undetermined cases in 1971.

Reproductive success may be subject to yearly fluctuations and the rate we observed in 1971 may not necessarily be representative of average conditions over a long period. With this in mind, the reproductive rate that we observed can be tentatively compared with the success of Ospreys in various geographical regions during different years (Reese 1970). Using Reese's table as a basis of comparison, the observed rate of 1.0 young per occupied nest for Lake of the Woods is similar to the rates seen elsewhere, except for lower rates reported for declining populations in New England and the Great Lakes area; it is significantly exceeded only by current rates in Florida and the 1934 rate in Virginia. This rate of 1.0 young per occupied nest also falls within the calculated range (0.95-1.30) required to maintain a stable population, based on mortality rates estimated from East Coast banding data (Henny and Wight 1969). Henny and Ogden later (1970) used higher estimates of 1.22-1.30 which may be too high and narrow of range in view of Reese's comparisons and the problems involved with estimating mortality rates from banding data.

TABLE 2. Osprey nests censused at Lake of the Woods in 1971.

Previously known nests (1967–70)	
Nest not found in 1971 (believed gone)	14
Nest found but in poor condition (includes 2 alternate)	10
Tree cut down by man	1
Nest (in tree) used by Herring Gull (!)	1
Nest in good condition but unoccupied or failed early	2
Occupied in 1971	37
Total	65
Nests found for the first time in 1971	
Occupied nests (includes 1 former Bald Eagle nest)	13
Built after failure at another nest	2
Total	15

TABLE 3. Results of 1971 Osprey census at Lake of the Woods, Ontario.[a]

A. OCCUPIED NESTS[b] found on first visit	50
B. Occupied nests checked on second visit[c]	48
C. Occupied nests climbed at first visit	22
D. Number of climbed nests with eggs or newly-hatched young on first visit, i.e., ACTIVE NESTS	20
E. Number of eggs and or newly-hatched young[d]	51
F. Number of eggs collected[e]	8
G. Eggs with dead embryos when collected[e]	4
H. Nests with live and apparently healthy young at second visit	31
I. Number of nests with young climbed at second visit[f]	29
J. Number of healthy young in climbed nests	48
K. Number of young found dead or dying at second visit	12
L. PERCENT OCCUPIED NESTS WITH EGGS (i.e., ACTIVE) at late incubation (D × 100/C)	91
M. AVERAGE CLUTCH SIZE at late incubation[g] (E/D)	2.6
N. PERCENT OCCUPIED NESTS "SUCCESSFUL" (with young 4–6 weeks of age) (H × 100/B)	64
O. AVERAGE NUMBER YOUNG PER "SUCCESSFUL" NEST (J/I)	1.6
P. AVERAGE NUMBER YOUNG PER OCCUPIED NEST (J/B-2)[f]	1.0
Q. Observed percent mortality rate *at* mid-to-late nestling stage (K × 100/J + K)	20
R. Estimated percent mortality rate from incubation to late nestling stage[g] (([M × (L/100) × B] − J) × 100/[M × (L/100) × B])[h]	58
S. Estimated number of embryos and young that died prior to advanced nesting stage[g] in 50 Occupied nests, all causes[i] at 95% confidence interval[j]	69 ± 12

[a]Lines in this table that were obtained by methods used by other persons working with Ospreys are capitalized. Such values should be reasonably comparable with results of other projects, assuming no observer bias.
[b]Occupied defined by agreed upon usage, see text.
[c]Inclement weather prevented the second visit at two nests.
[d]See Table 4 for breakdown of distribution of numbers.
[e]Includes one newly-hatched young found dead.
[f]Two nests were in trees unsafe for climbing.
[g]Value of M probably less than initial clutch size; R and S thus may be biased.
[h]Assumes for these purposes that there was no infertility.
[i]Includes 4 eggs collected with live embryos.
[j]From binomial probability of dying of 0.58 (line R) at 95% interval (n = 100) 0.48 to 0.68. Estimated number of eggs at late incubation for 50 nests = (M) (L/100) (A) = 118.

CLIMBING AND COLLECTING EFFECTS

Although previous experience with Ospreys has shown no evidence of reduced productivity from careful investigations (Reese 1970, where nests were checked as often as once every 12 days), we wanted to be safe and check for any such effects, particularly those involving the removal of eggs. Inclement weather prevented the recheck of two active nests. Unfortunately, both of these had been climbed and collected from

TABLE 4. Frequency distribution of eggs and young in occupied nests with known contents.

	Eggs or newly-hatched young at first visit		Healthy young of advanced age at second visit	
Number in nest	Number nests	Percent	Number nests	Percent
0	2	9	17	37
1	2	9	14	30
2	5	23	11	24
3	13	59	4	9
Total	22	100	46	100

on the first nest check. This reduced the expected values of numbers of nests below five for some chi-square cells, thus preventing analysis on a nest basis. Analyses of numbers of young are still possible, however. Also, analyses of the effects of climbing per se are possible on a nest basis by combining both nest categories of "climbed but not collected from" and "climbed and collected from."

No decrease in productivity resulting from our activities can be detected in any of the possible analyses. Using control values (Table 5) for the nests not climbed at the first visit, expected numbers of young can be calculated for the two experimental groups. On an occupied nest basis (Table 5, first line multiplied by control value of sixth line) the expected numbers of young for the two experimental groups are 14 and 6, respectively. The difference between these numbers and observed is 2 in both cases, which yields a total chi-square of 0.96 (not significant).

TABLE 5. Effects of climbing to Osprey nests at incubation time and of collecting eggs.

	Control (not climbed at first visit)	Climbed only	Climbed and one egg per nest collected
Occupied nests rechecked	28	14	6
Number of nests with healthy young	18	10	3
Number of nests with known number of young[a]	16	10	3
Number of nests that failed	10	4	3
Observed number of young	28	16	4
Average number young/occupied nest	1.0	1.1	0.7
Average number young/nest with young	1.8	1.6	1.3

[a]First row minus two nests where young were present but number not determined during second visit because trees were too dangerous to climb.

Expected numbers of young calculated on a nest-with-young basis (Table 5, values in third line multiplied by control value of seventh line) are 18 and 5, respectively. These differ from observed by 2 and 1; chi-square is 0.42 (not significant). A contingency table test on the numbers of nests that produced young with those that failed (Table 5, second and fourth lines) compared with the control group and the combined experimental groups yielded a chi-square of nearly zero (not significant). And finally, we observed no effect from climbing at incubation on subsequent nestling mortality (Table 6).

TABLE 6. Effect of climbing to Osprey nests at incubation time on subsequent nestling mortality.

Number young	Control	Climbed at incubation	Total
Live and healthy	28	20	48
Dead or dying	7	5	12
Total	35	25	60

Chi-square (1 d.f.) = 0, $P > 0.05$, not significant.

We deliberately collected few eggs in order to minimize any effect on the overall productivity. And, as shown in the above tests, the deliberately small sample size did in fact yield no statistically significant difference in those nests that we collected from. The effects of collecting seem even less significant in view of the fact that only four of the eggs contained live embryos; this is a small fraction of the estimated 69 embryonic and nestling deaths occurring prior to our second visit. If increasing numbers of eggs were collected at late incubation, one would expect to produce eventually a detectable effect on the subsequent numbers of young. If eggs were collected early in incubation, soon after being laid, the birds might re-lay and actually compensate for the collections.

Climbing to nests at late incubation clearly produced no adverse effects. Unlike the insignificant effect of collecting eggs, we do not believe that this lack of significant effect resulted from small sample size (see numbers of nests involved, Tables 5 and 6). Our first visit coincided with the final stages of incubation; it was later than intended, due to our miscalculation of egg-laying time. Climbing at earlier stages of incubation might create more disturbance, although there is little reason to suspect this with Ospreys.

TOXIC CHEMICAL RESIDUES IN EGGS AND CHICKS

The levels of toxic chemicals in Osprey eggs and nestlings from Lake of the Woods (Table 7) are generally comparable with species showing

TABLE 7. Toxic chemicals in Osprey eggs and chicks from Lake of the Woods, 1967 and 1971.

Specimen number	Condition when collected[a]	Eggshell thickness	Thickness index[b]	% fat	% water	Residues in ppm dry-weight[c] DDE	DDD	Dield.	PCB[d]	Hg
1967 addled eggs collected during nesting period, analyzed by W.A.R.F.										
0267	(D)		2.65	8.2	64.1	33.4	10.4	0.31		
0268	(D)		2.90	6.8	65.1	16.1	3.58	0.49		
1971 fresh eggs collected during late incubation, analyzed by O.R.F.										
275	D ½ devel.	0.49 mm	2.46	2.8	83.3	24.2	6.59	0.30	446.1	0.36
276	L > ¾ devel.	0.53 mm	2.44	2.4	84.5	11.2	0.52	0.06	6.45	0.45
277	D < ½ devel.	0.51 mm	2.32	6.4	77.2	42.1	2.81	0.14	3.47	0.80
279	L > ¾ devel.	0.48 mm	2.16	2.4	85.2	17.8	2.77	0.40	16.9	0.54
281	L > ¾ devel.	0.47 mm	2.02	2.8	84.0	10.7	0.88	0.19	8.00	0.88
282	D < ¼ devel.	0.61 mm	2.60	5.6	73.8	33.2	6.26	1.18	24.7	0.46
283	L > ¾ devel.	0.43 mm	2.10	2.4	83.3	21.0	0.84	0.36	22.5	0.60
Mean of values above		0.50 mm	2.41			23.3	3.85	0.38		0.58
1971 dead chicks, analyzed by O.R.F.										
284	approximately 2 days old			2.0	81.2	23.7	1.22	0.37	70.7	2.02
744	over 3 weeks of age, Liver			2.9	75.5	2.20	ND[e]	ND	11.9	2.78
745	Brain			2.9	84.3	0.64	ND	0.13	7.07	1.59
746	Breast muscle			2.0	76.0	1.91	ND	0.08	10.9	2.08

[a]Assumed to be alive if no sign of spoilage. L = live, D = dead.

[b]After Ratcliffe 1967.

[c]Other residues (p, p'DDT, HCB, HE) less than 0.68 ppm.

[d]PCB not analyzed in 1967 samples; some PCB residues may be included in the other organochlorine values.

[e]ND = none detected; < 0.01 ppm dry-weight.

relatively low or medium levels of contamination (e.g., Fimreite et al. 1971, which includes a review of much of the literature on mercury; for organochlorines, see Reynolds 1969; Cade et al. 1971; Keith and Gruchy 1971; Kochert 1972) and are much lower than most values reported for Peregrine Falcons (Moore and Walker 1964; Cade et al. 1968; Enderson and Berger 1968; Cade et al. 1971) and Bald Eagles (Reichel et al. 1969; Krantz et al. 1970; Mulhern et al. 1970; Postupalsky 1971; Wiemeyer et al. 1972) including those Bald Eagles from the same region of Ontario (Grier in prep.). The levels of toxic chemical residues are generally lower in the Osprey chicks than in the eggs, except for mercury which is considerably higher in the two chicks (Table 7).

Using a Spearman rank test (Snedecor and Cochran 1967), we found no significant correlation in our sample of Osprey eggs between shell thickness and any of the residues (including DDE). We believe this is because of the small sample size, however, as a significant rank correlation does exist between shell thickness and DDE when larger sample sizes of Osprey eggs, including these, are used (Spitzer et al. these proceedings). The average actual shell thickness of the eggs we collected (Table 7) is essentially identical to the pre-1947 mean of 0.505 mm for the eastern United States as reported by Anderson and Hickey (1972), but the mean thickness index (after Ratcliffe 1967) is 6% lower than the pre-1947 eastern United States mean of 2.57. The eggshell-thinning phenomenon in other species is discussed elsewhere (e.g., Hickey and Anderson 1968; Porter and Wiemeyer 1969).

We performed a Wilcoxon two-sample rank test (Snedecor and Cochran 1967) on the live vs. dead embryos to test whether embryonic death may be associated with levels of toxic chemicals. No significant results were obtained with any of the toxicants, but again this may be because of the very small sample sizes and we view these results as inconclusive.

The long-term effects of these levels of contamination on the Osprey population at Lake of the Woods are not known. Our observations suggest only that the Osprey breeding population in our study area remained stationary between 1964 and 1971.

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Acknowledgments: We would like to acknowledge gratefully Joyce Grier for field assistance in 1967; G. Allez, R. Motlong, Dana Murphy, R. and Joyce Newcom, D. Tikalsky, and the Ontario Ministry of Natural Resources for various help in travel and housing; V. Macins for additional observations; J. J. Hickey and D. W. Anderson for providing the measurements of eggs collected in 1967; and the Ontario Ministry of Natural Resources for permits to collect fresh Osprey eggs.

Osprey Reproduction in the Lake Nipigon Area

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Abstract: Of 58 Osprey nestings recorded during 1967-71, 45% were productive. The observed productivity of 0.8 young per occupied nest was below that considered necessary to maintain a stable population. Two eggs analyzed contained 2.7-6.7 ppm DDE, 0.07-0.23 ppm dieldrin, 1.4-7.1 ppm PCB's, and 0.05-0.11 ppm of mercury; their shells were 11-16% thinner than normal. Reproduction observed in this limited area may not necessarily be representative of that found throughout Ontario. For 14 other nests elsewhere in the province, 0.5 young were raised per occupied nest.

The Osprey is one of three species of piscivorous birds I have been studying in the Thunder Bay District of Ontario. This study began in 1968 incidental to an investigation of the status of the Bald Eagle (*Haliaeetus leucocephalus*), financed that year by the National Audubon Society. Since 1969, the Osprey work has been part of my research into the effects of toxic chemicals on populations of selected fish-eating birds done under contract with the Canadian Wildlife Service, Department of the Environment.

The Osprey study area consists of the north shore of Lake Superior from the Minnesota border east to Terrace Bay, including the peninsulas and islands separating Thunder, Black, and Nipigon bays, and north to Lake Nipigon and the Ogoki River. Initial emphasis was on birds nesting close to, and presumably feeding on, Lake Superior and Lake Nipigon. More recently, I have been watching Ospreys nesting on Ogoki Reservoir and at small inland lakes.

Lake Nipigon is located 30 miles north of Nipigon Bay, the northernmost part of Lake Superior. It extends 65 miles north to south and 43 miles east to west at an altitude of 852 ft above sea level, 250 ft higher than Lake Superior into which it drains via the Nipigon River. Nipigon is a very deep obligotrophic lake. It contains more than 1000 islands and has 580 miles of shoreline.

The Ogoki River, draining into James Bay via the Albany River, has been dammed up at a point 36 miles north of Lake Nipigon. Water from this reservoir is diverted into Lake Nipigon as needed to maintain flow rate required by power dams on the Nipigon River farther below.

In this part of Ontario most Osprey nests are found in either of two situations: (1) in conifer swamps where the nests are placed on top of live or dead spruce trees, many of which are wind-topped; and (2) in man-made reservoirs and at beaver floodings where nests are placed on top of stubs of trees killed by inundation.

The number of nests under observation increased each year as new breeding sites were located. In 1971 I watched 23 occupied nests: 3 near Lake Superior, 8 at Lake Nipigon, 10 on Ogoki Reservoir, and 2 near small inland lakes. I used the same survey methods as in my Michigan study; a minimum of two aerial checks of each occupied site, including one overflight during incubation and one late in the season when nestlings are large and approaching fledging age.

Except for Ogoki Reservoir, where the results of my census approach the total for the breeding population, the numbers of pairs reported in this paper probably represent only a fraction of the actual population present in the area. The numerous and extensive conifer swamps in this water-rich region undoubtedly harbor many yet undiscovered nests. The sample reported here, however, should be representative of the reproductive success of the Osprey in this part of Ontario.

Of 58 nestings during 1968-71 (including one in 1967), 45% produced at least one young to an advanced stage of development (Table 1). At this late stage of nestling life, broods averaged 1.7 young per productive nest, and the productivity of the population was 0.8 young per occupied nest (= territorial pair). This is below the 0.95-1.30 fledged young per breeding female Henny and Wight (1969) calculated necessary to offset mortality of adults, estimated from recoveries of Ospreys banded in the northeastern United States.

In 1971 I collected one egg each from two nests on Ogoki Reservoir for toxic-chemicals analysis. On a wet-weight basis, corrected for weight loss during development and/or decomposition, the eggs contained 2.73 and 6.70 ppm DDE, 0.07 and 0.23 ppm dieldrin, 1.36 and 7.08 ppm PCB's, and 0.05 and 0.11 ppm of mercury. These residue levels are low as compared to those found in Bald Eagle eggs from Lake Nipigon (Postupalsky 1971). The egg with the consistently higher residue levels came from a nest that had been unproductive for 3 years, while the egg with the lower residues was obtained from a usually productive nest (2 young in 1969, none in 1970 when nest was destroyed by wind, 2 young in 1971 when one egg was collected and the other two hatched). The shells of the two eggs were 11 and 16% thinner (Ratcliffe 1967

TABLE 1. Distribution and productivity of Osprey nests at Lake Nipigon and vicinity, Thunder Bay District, Ontario.

	1967	1968	1969	1970	1971	1967–71
Distribution of nests						
Near Lake Superior	1	2	2	2	3	10
Small inland lakes		1			2	3
Lake Nipigon		4	2	4	8	18
Ogoki Reservoir			8	9	10	27
Number of occupied nests	1	7	12	15	23	58
Reproductive success						
Productive nests	1	3	6	5	11	26
Percent nest success		43	50	33	48	45
Number of young	1	4	10	13	17	45
Young per productive nest		1.3	1.7	2.6	1.4	1.7
Young per occupied nest		0.6	0.8	0.9	0.7	0.8

thickness index) than the mean of museum eggs collected in eastern North America prior to 1947. The pre-1947 egg-shell data were supplied by D. W. Anderson and J. J. Hickey (pers. comm.). An inverse relationship between levels of DDE in eggs and shell thickness has been demonstrated for several avian species (Hickey and Anderson 1968; Anderson et al. 1969; Ratcliffe 1970; Wiemeyer and Porter 1970; Blus et al. 1971). Mercury levels in these two Osprey eggs were well below those associated with reduced hatchability of the Ring-necked Pheasant (*Phasianus colchicus*) eggs (Fimreite 1971).

My data are insufficient to permit a comment on the status of the Osprey population in the study area as a whole. This difficulty is partly due to the fact that individual pairs are hard to follow from year to year. Osprey nests in the north are not very persistent, being built on the very tops of trees which are often dead or dying. A pair which has lost its nest may be hard to relocate. In absence of just the right kind of nest support in the immediate vicinity, the birds may move some distance. When they are found, the question whether it is the same pair or another one, not previously recorded, cannot usually be answered.

The group breeding on Ogoki Reservoir has been maintaining its numbers, in fact it may still be increasing.

This study is still in progress. The data and conclusions presented here should be regarded as preliminary.

OSPREYS ELSEWHERE IN ONTARIO

Incidental to my work in Michigan, I also have been watching several Osprey nests on and near St. Joseph Island, Algoma District (Table 2).

TABLE 2. Distribution and productivity of Osprey nests elsewhere in Ontario.

	1967	1968	1969	1970	1971	1967–71
Distribution of nests						
Algoma District	1	1	1	3	4	10
Manitoulin District					2	2
Parry Sound District					1	1
Dufferin County				1	1	2
Number of occupied nests	1	1	1	4	8	15
Reproductive success						
Occupied nests[a]	1	1	1	4	7	14
Productive nests	0	0	0	1	3	4
Percent nest success	0	0	0	25	43	29
Number of young	0	0	0	1	6	7
Young per productive nest	0	0	0	1.0	2.0	1.8
Young per occupied nest[a]	0	0	0	0.3	0.9	0.5

[a]Nests with known outcome.

These nests have been consistently unproductive. The only successful nesting known occurred about 4 miles inland, north of Bruce Mines. This pair evidently feeds on a small inland lake.

In 1971 I also checked several nest sites elsewhere in the province. Of two pairs in Manitoulin District, one located at a small lake on Manitoulin Island fledged two young, and the other, nesting near the mainland shore, was not rechecked. A pair near Parry Sound failed, and one breeding on a shallow reservoir in Dufferin County, within 60 miles of Toronto, produced two young. Except as indicated otherwise, all nests mentioned in this section were located near the shores of the Great Lakes.

CONCLUSIONS AND RECOMMENDATIONS

The reproductive success reported here for a small group of Ospreys in a limited area may not necessarily be typical or representative of that in Ontario as a whole. The species evidently is distributed throughout most of the vast province, save for the more densely settled and developed southern portion. Cards in the Ontario Nest Record Scheme maintained at the Royal Ontario Museum indicate recent nesting in the eastern portion. The remoteness of much of the suitable habitat, especially in northern Ontario, would make a province-wide survey very difficult at best. Instead, the checking of several selected local areas could yield useful data upon which to base an assessment of the bird's reproductive rate and population trends. The report by Grier et al. and my present study are a start in that direction. I recommend thorough local surveys in areas such as Lake Nipissing, Algonquin Provincial Park, the Kawartha Lakes, the Rideau Lakes, and perhaps others. Also all hydro reservoirs and other impoundments containing dead timber should be checked, as Ospreys are often attracted to such habitat.

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Productivity of Northern Idaho Osprey Populations

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Abstract: Historical accounts indicate that Ospreys (*Pandion haliaetus*) were relatively uncommon in the northern Idaho lake region as recently as 1956. During the past two nesting seasons (1970 and 1971), at least 50 pairs nested in the Pend Oreille watershed, 45 pairs nested in the Coeur d'Alene watershed, and 11 pairs were found nesting in the Clearwater drainage. Productivity (mean number of young fledged per active nest) ranged from 1.00 to 1.09. Based on this brief study, these populations appear to be stable or continuing to increase. Studies of pesticide levels, mercury contamination, and nest predation are in progress.

Annotated bird lists for northern Idaho briefly mention the Osprey but no early accounts describe large nesting concentrations (Merrill 1897; Snyder 1900; Rust 1915; Hand 1941; Avery 1947). Yocum and Yocum (1946) reported only one Osprey nest at the mouth of the St. Joe River where a large colony occurs today. Ospreys were described as common to uncommon on the larger lakes and rivers by Larrison et al. (1967) who summarized distributional data through 1956. They indicated that there were three to four pairs nesting along the levees of the lower St. Joe River and another 15 pairs nesting on Lake Pend Oreille.

Nesting populations of Ospreys in northern Idaho were surveyed during 1970 and 1971 in an effort to (1) census the breeding populations; (2) determine nesting success; (3) identify the numbers and kinds of fish used as food; and (4) determine the threats to nesting success. Results of the census and productivity studies are reported here.

Osprey populations in three watersheds of northern Idaho were censused during the 1970 and 1971 nesting seasons.

The Coeur d'Alene watershed, examined in 1970, consisted of Lake Coeur d'Alene, the St. Joe River from its mouth to 3 miles above

Calder, the Coeur d'Alene River from its mouth to Killarney Lake, the St. Maries River from its mouth to the limit of slack water, and the many small lakes within these boundaries. In 1971 the study area was enlarged to include the Coeur d'Alene River as far upstream as Cataldo. In 1970, 32 active nests were located in this watershed and in 1971, 44 nests were found (Table 1). This increase in active nests probably results from a more thorough search and an expansion of the study area rather than an increase in the nesting population.

The Clearwater watershed, surveyed in 1971 only, comprised the Middle Fork above Kooskia, the Selway River from its mouth to Selway Falls, and the Lochsa River from its mouth to Powell. The area contained 109 miles of river and 11 active Osprey nests (Table 1), or 10 miles of river per active nest. The Middle Fork, the largest tributary surveyed, possessed the greatest nesting density (4 river miles per active nest).

The Pend Oreille watershed included Lake Pend Oreille, the Clark Fork River from its mouth to the Montana border, the Pend Oreille River to the Washington border, the lower Pack River, Priest Lake, Upper Priest Lake, and several small lakes near Lake Pend Oreille. A thorough investigation of this watershed has not been conducted as yet. At least 25 nests produced young in 1971 (Table 1). We believe that further investigation will reveal that this watershed has the largest number of active Osprey nests in the region. The Pend Oreille watershed has both the highest number of young fledged per successful nest (Table 1) and the largest percentage of nests fledging three young (Table 2).

Active nests were identified as those in which (1) eggs were laid; (2) the female was seen in an incubating position; or (3) the parents threatened when the nest was approached closely. We excluded from productivity calculations those nests which were attended briefly early in the season and those which were successful but discovered late in the season. Productivity (average number of young fledged per active nest) ranged from 1.00 to 1.09 (Table 1).

Based on band returns from New York and New Jersey, Henny and Wight (1969) calculated that a productivity of 1.22-1.30 was necessary in order to maintain a stable population. The southern Florida Osprey population, which is presently stable, has a productivity of 1.22 (Henny and Ogden 1970). Our brief observation and the historical evidence indicate that Osprey populations on Lakes Pend Oreille and Coeur d'Alene have increased in recent decades. We have no reason to believe at this time that a productivity of between 1.0 and 1.1 is not adequate to maintain these populations. They are likely subjected to a different (and

TABLE 1. Productivity of northern Idaho Osprey populations.

	Coeur d'Alene		Clearwater	Pend Oreille
	1970	1971	1971	1971
Total nests located	55	77	22	67
Additional nests located late	18	17	4	
Active nests	32	44	11	
Inactive nests	5	16	7	
Successful nests	20	26	7	25
Unsuccessful nests	12	18	4	
Total young fledged	32	46	12	52
Young/successful nest	1.60	1.77	2.00	2.08
Productivity	1.00	1.05	1.09	
Young produced in late-located nests	7	3	0	

apparently less rigorous) mortality schedule than those of New York and New Jersey.

Productivity varied between watersheds (Table 1) and between nest sites (Table 3). Nests located in black cottonwoods (*Populus trichocarpa*) had a lower success than those found in other structures (Table 3). Black cottonwoods comprised 43-49% of the nest sites in the Coeur d'Alene drainage (Table 4), the watershed with the lowest productivity measured. We have not determined the factors reducing productivity in this watershed. Pesticide, mercury, and nest predation studies are in progress. Surveys of other northern Idaho watersheds are planned.

TABLE 2. Number of fledglings from successful nests.

	Nests with		
	1 Fledgling	2 Fledglings	3 Fledglings
1970			
Coeur d'Alene Watershed	8	14	1
1971			
Clearwater Watershed	4	1	2
Coeur d'Alene Watershed	10	12	5
Pend Oreille Watershed	7	9	9
Totals	29 (35%)	36 (44%)	17 (21%)

TABLE 3. Nesting success and productivity at specific nest sites.

Nest site	Number of nests	% successful	Young/ successful nest	Productivity
Black cottonwood	37	45.9	1.65	0.76
Dead conifer	28	67.9	1.68	1.14
Live conifer	9	88.9	1.50	1.33
Piling	9	77.8	2.14	1.67
Utility pole	3	66.7	1.50	1.00
Bridge	1	0	0	0

TABLE 4. Nest sites within watersheds.

	Coeur d'Alene				
Support structure	1970	1971	Pend Oreille	Clearwater	1971 Total
Black cottonwood	27 (49)[a]	33 (43)	6 (9)	0	39 (23)
Dead conifers	17 (31)	21 (27)	23 (34)	15 (68)	59 (36)
Live conifers	3 (5)	8 (10)	28 (42)	7 (32)	43 (26)
Pilings	5 (9)	7 (9)	9 (13)	0	16 (10
Utility poles	3 (5)	7 (9)	0	0	7 (4)
Bridges	0	1 (1)	1 (1)	0	2 (1)
Total	55	77	67	22	166

[a]Percentages in parentheses.

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Acknowledgments: The study was supported in part through a grant-in-aid from the American Museum of Natural History (Chapman Fund). Motor boats were provided on occasion by the Idaho Department of Fish and Game and the Water Resources Research Institute, University of Idaho. We wish to thank Robert Goodman, U.S. Forest Service; Charles Wells, Idaho Parks Department; Keith Hawn, Idaho Department of Game and Fish; D. E. Anderegg and E. J. Larrison, University of Idaho; Glenn Addington, Harrison, Idaho; and Jerry Botts, St. Maries, Idaho, for field assistance.

Food Resources and Fledgling Productivity of California and Montana Ospreys

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Abstract: Fledgling productivity of three populations of Ospreys (*Pandion haliaetus*) breeding at two oligotrophic lakes and one mesotrophic lake, all burdened with similar levels of pesticide contamination and subjected to similar levels of human disturbance, were compared with three measurements of available food resources as a means of assessing the importance of different levels of food resources on fledgling productivity of Ospreys. Average daily quantities of fish provided to large broods, fishing success of nesting Ospreys, and average duration of time parent birds were absent from their nesting territories on fishing forays were the three measurements of available food resources. Measurements of available food resources were recorded at the mesotrophic lake and one of the oligotrophic lakes. Annual productivity per nesting pair of Ospreys averaged 1.17 fledglings at the mesotrophic lake and 0.81 and 0.97 fledglings at the oligotrophic lakes. In addition, 19% of pairs of Ospreys breeding at the mesotrophic lake fledged broods of three and four young, whereas only 9 and 11% of the pairs of Ospreys breeding at the oligotrophic lakes fledged similar-sized broods. Daily quantities of fish provided to large broods averaged higher at the mesotrophic lake than at the oligotrophic lake. Average duration of time parents were absent from their nesting territories on fishing forays was twofold higher at the oligotrophic lake than at the mesotrophic lake. Fishing success, which averaged slightly higher at the oligotrophic lake than at the mesotrophic lake, now is considered to be less a measure of available food resources and more a measure of relative capabilities of different populations of Ospreys to capture prey once prey are located. Thus the meaningful measures of food availability correlated with relative productivity of fledglings at two of the lakes. It was concluded that differences in levels of available food resources did influence fledgling productivity and affected an average difference of 0.20 fledglings per nesting pair of Ospreys.

INTRODUCTION

Population declines among birds of prey and fish-eating birds—recently documented in Peregrine Falcons (*Falco peregrinus*) by Hickey (1969); in Prairie Falcons (*F. mexicanus*) by Fyfe et al. (1969);

in Merlins (*F. columbarius*) by Fox (1971); in Bald Eagles (*Haliaeetus leucocephalus*) by Sprunt (1969); in Ospreys by Ames and Mersereau (1964), Schmid (1966), Dunston (1968), Burger and Mueller (1969), Peterson (1969), Postupalsky (1969), Sindelar (1971), Wiemeyer (1971), and others; in Western Grebes (*Aechmophorus occidentalis*) by Herman et al. (1969); and in Brown Pelicans (*Pelecanus occidentalis*) by Gress (1970)—have been attributed to impairment of reproductive physiology by chlorinated hydrocarbons concentrated through food chains in which these birds occupy terminal positions (Hunt and Bischoff 1960; Hickey and Anderson 1968; Porter and Wiemeyer 1969; Bitman et al. 1970; Peakall 1970). Critics of this theory (Beebe 1969; Robinson 1969; Spencer 1969a, b) propose several alternate explanations, including limited food resources, to account for these population declines.

The purpose of this paper is to provide information on the relationship between different levels of food resources and fledgling productivity of Ospreys in the West. Quantitative studies to determine the relative influence of high versus low food resources on reproductive performance of Ospreys were designed to test the following null hypotheses: (1) fledging success would be the same under both conditions; (2) quantities of fish provided broods would be the same under both conditions; and (3) fishing success of Ospreys would be the same under both conditions.

Three lakes supporting nesting populations of Ospreys were chosen for study: Flathead Lake in Lake and Saunders counties, Montana; Eagle Lake in Lassen County, California; and Lake Almanor in Plumas County, California. Flathead Lake and Lake Almanor are oligotrophic, supporting relatively low biomasses of fish (Garber 1972; D. L. MacCarter 1972; D. S. MacCarter 1972), while Eagle Lake is mesotrophic, supporting a higher biomass of fish (Garber 1972).

Chemical analysis of fish with similar ecology (suckers, *Catostomus* sp.) from the three lakes indicated that all three contained similar burdens of pesticide residues. Eight suckers from Flathead Lake contained 0.27-0.65 ppm DDT residues (D. S. MacCarter 1972), one sucker from Eagle Lake contained 0.22 ppm DDT residues, and two suckers from Lake Almanor contained 0.05 and 0.36 ppm DDT residues (Garber 1972). Human disturbance, primarily recreational, was most intense at all three lakes from early June through the remainder of the summer (Garber 1972; D. L. MacCarter 1972). Therefore, differences in fledgling productivity of Ospreys nesting at these lakes would be expected to reflect gross differences in available food resources to a larger extent than would minor differences in levels of pesticide burdens and human disturbance.

METHODS

Measurements of fledgling productivity were obtained by D. L. MacCarter (1972) from Flathead Lake and by Garber (1972) from Eagle Lake and Lake Almanor.

Measurements of fishing success and quantities of fish provided broods were obtained by D. S. MacCarter (1972) for Flathead Lake and by Garber (1972) for Eagle Lake.

Fishing success was measured by recording the number of dives expended by individual Ospreys for each fish captured. Fishing success was recorded one day per week from dawn to dusk at localities habitually fished by Ospreys.

Quantities of food delivered to nests were measured from vantage points near nests from dawn to dusk one day per week by recording numbers and body lengths of fish delivered.

The length of time the providing parent was absent from the nesting territory also was recorded during observations at nests. As will be discussed, this parameter proved to be a more meaningful measure of availability of food resources than did fishing success.

RESULTS

Fledgling Productivity

Seventy-nine annual nesting efforts of Ospreys breeding at Flathead Lake produced an average of 0.97 fledglings per breeding pair, 53 annual nesting efforts of Ospreys breeding at Lake Almanor produced an average of 0.81 fledglings per breeding pair, and 48 annual nesting efforts of Ospreys breeding at Eagle Lake produced an average 1.17 fledglings per breeding pair (Table 1). The postulate that all three means are equal was tested by one-factor analysis of variance. The F value was statistically insignificant ($F_{(2,177 d.f.)} = 1.22$; probability = 0.50-0.75.

Table 1 also shows that 19% of the pairs of Ospreys breeding at Eagle Lake fledged broods of three and four young, whereas only 11 and 9% of the pairs of Ospreys breeding at Flathead Lake and Lake Almanor, respectively, fledged similar-sized broods. A chi-square homogeneity test of the relative frequencies of brood sizes fledged by Ospreys breeding at the three lakes showed that percentage differences in Table 1 are statistically insignificant ($\chi^2_{(8 d.f.)} = 5.15$; probability = 0.50-0.75).

Daily Quantities of Fish Provided Large Broods

Observations on daily quantities of fish provided to broods containing different numbers of young were conducted from 15 June through 5 August at Flathead Lake (D. S. MacCarter 1972) and from 30 June through 26 July at Eagle Lake (Garber 1972). Because daily quantities of fish provided to broods increased as chicks grew (D. S. MacCarter

TABLE 1. Relative fledgling productivity and percentages of broods differing in number of young fledged by Ospreys breeding at Flathead Lake, Montana, and at Lake Almanor and Eagle Lake, California.

Locality	Av. annual no. fledglings per nesting effort	% fledging 0 young	% fledging 1 young	% fledging 2 young	% fledging 3 young	% fledging 4 young
Flathead Lake (79)[a]	0.97	53	11	25	10	1
Lake Almanor (53)	0.81	57	15	19	9	0
Eagle Lake (48)	1.17	43	17	21	17	2

[a]No. of nesting efforts.

TABLE 2. Average daily quantities of fish provided by Ospreys to broods differing in number of young at Flathead Lake, Montana, and Eagle Lake, California.

	Av. no. fish provided per day		Av. size index of fish provided per day[b]		Av. quantity of fish provided per day	
No. young in brood	Flathead Lake (A)	Eagle Lake (B)	Flathead Lake (C)	Eagle Lake (D)	Flathead Lake (A) (C)	Eagle Lake (B) (D)
1	3.4 (27)[a]	3.0 (24)	1.5	2.0	5.1	6.0
2	2.7 (22)	3.9 (31)	2.1	2.0	5.7	7.8
3	4.6 (38)	4.6 (37)	2.0	2.2	9.2	10.1
4	—	5.0 (40)	—	2.2	—	11.0

[a](No. fish provided.) Data for each brood obtained over a total of 8 days from late June through early August. Data from Flathead Lake were obtained in 1969 and 1970 and were combined and averaged for a sample size of 8 days to permit statistical comparison with data from Eagle Lake obtained in 1971.
[b]Size index: 1 = fish $<$ 6 inches long; 2 = fish 6 to 12 inches long; 3 = fish 12 to 18 inches long; 4 = fish $>$ 18 inches long.

1972; Garber 1972), we felt justified only in comparing data obtained from broods in which young were similar in body size at the two lakes. Since Osprey eggs began hatching in early June at the two lakes (Garber 1972; D. L. MacCarter 1972), we assumed nesting chronology was similar and compared only data obtained from late June through early August. Measurements recorded during this time interval averaged higher at Eagle Lake than at Flathead Lake (Table 2).

The postulates that all broods were provided the same average daily quantities of fish and that there was no difference in average daily quantities of fish provided broods at the two lakes from late June through early August were tested by two-factor analysis of variance. The postulate that all broods were provided the same average daily quantities of fish was rejected ($F_{(2,42)} = 13.56$; probability <0.001) and the postulate that there was no difference in average daily quantities of fish provided broods at the two lakes was accepted, but at a marginal level of significance ($F_{(1,42)} = 4.04$; probability = 0.1-0.05). A t-test of the postulate that the same average daily quantities of fish were provided broods of three and four young was accepted ($t_{(14 d.f.)} = 0.884$; probability = 0.3-0.4).

Comparisons among average daily quantities of fish provided broods of different size were conducted with a *sum of squares simultaneous test procedure* (Sokal and Rohlf 1969:235-237). Differences among average daily quantities of fish provided broods containing one and three chicks and broods containing two and three chicks were statistically significant and differences in average daily quantities of fish provided broods containing one and two chicks were statistically insignificant ($\alpha = 0.05$).

We feel that only differences in average daily quantities of fish delivered to large broods were meaningful measures of relative availability of food resources, because if fish were sufficiently available for some parents successfully to fledge broods of three and four young, they must have been sufficiently available for other parents successfully to fledge broods of one and two young. It may be argued that this interpretation is valid only if all parents are equally capable of supplying quantities of food required by larger broods; and Lack (1966) has shown for several other species of birds that older, more experienced parents are more capable of successfully rearing large broods than are younger, less experienced parents. Unfortunately, we have no known information to contribute on the abilities of young Ospreys to provide for their broods. In fact, assuming the same parents return to the same nesting territory year after year, we can contribute only information on the abilities of older Ospreys to provide for their young.

All of the nesting territories from which we obtained measurements on provision of daily quantities of fish had been in use for at least 2-4 years (Garber 1972; D. L. MacCarter 1972; D. S. MacCarter 1972), and we have no reason to doubt that any of these territories had not been in use for longer periods of time. Therefore, we feel that the data summarized in Table 2 most likely were obtained from Ospreys that had been nesting for 2 or more years, and consequently are considered to be representative of birds with similar capabilities for providing quantities of food resources required by their broods. Accordingly, Table 2 indicates that these parents supplied food resources roughly in direct relation to the requirements of their broods. We have additional information in support for this interpretation of Table 2. One nest from which we obtained measurements on quantities of fish provided broods during 2 years of study at Flathead Lake contained a brood of three the first year and a brood of one the second year. The parents, presumably the same in both years, supplied a daily average of 9.0 fish the first year and a daily average of 6.8 fish the second year (refer to Table 2 for calculation of average daily quantities of fish supplied). Thus, it is on the basis of these considerations that we feel average daily quantities of fish delivered to broods of three and four young are the most meaningful measure of relative availability of food resources in these two lakes.

Fishing Success

Fishing success of Ospreys was slightly higher at Flathead Lake than at Eagle Lake (Table 3). A contingency test of the relative frequencies of successful and unsuccessful fishing attempts showed that percentage differences in Table 2 are statistically insignificant ($\times^2_{(1d.f.)} = 0.0015$; probability = 0.90-0.95).

Length of Time Expended by Providing Parents on Fishing Forays

The length of time expended on 124 fishing forays by providing parents at Flathead Lake averaged 68.1 minutes per foraging trip (95% confidence estimate of mean = 68.1±4.8 minutes). The amount of time expended on 11 fishing forays by providing parents at Eagle Lake averaged 32.5 minutes per foraging trip (95% confidence estimate of mean = 32.5±17.3 minutes). A *t*-test of the postulate that the means are equal was rejected ($t_{(133d.f.)} = 4.25$; probability <0.001).

DISCUSSION

Of the differences in fledgling productivity and measurements of available food resources among the lakes, only the difference in average time providing parents were absent from their nesting territories was statistically significant.

Thus, on the basis of purely statistical considerations, we must accept our three original null hypotheses and reject only the fourth hypothesis, formulated only after some of our data were collected. To do otherwise

TABLE 3. Relative capture success of Ospreys fishing Flathead Lake, Montana, and Eagle Lake, California.

No. dives per successful fishing effort[a]	Flathead Lake (percent of 158 fishing efforts)	Eagle Lake (percent of 25 fishing efforts)
1	63	60
2	12	8
3	7	4
4	1	4
Total percent successful fishing efforts.	83	76
Total percent unsuccessful fishing efforts.	17	24

[a]One fishing effort = fishing activities of an individual Osprey while in view of the observer.

is to commit scientific heresy in the view of the statistical purist. At the risk of being considered scientific heretics, we would like to do just that.

If, as we were forced to do because of the limitations of available statistical tests known to us, each statistical test is considered solely on its own, we would accept the individual hypothesis and conclude that there was no relationship between fledgling productivity and available food resources among the three lakes. However, we feel our data should be analyzed collectively, and we know of no statistical procedure for doing so.

When our data are considered collectively an interesting and, we feel, a meaningful pattern emerges: (1)overall fledgling productivity of Ospreys averaged higher at the mesotrophic lake than at the two oligotrophic lakes (Table 1). (2) Nineteen percent of the breeding pairs of Ospreys at Eagle Lake fledged three and four young, whereas only 11 and 9% of the breeding pairs of Ospreys at Flathead Lake and Lake Almanor, respectively, fledged three and four young (Table 1). (3) Daily quantities of fish supplied to broods of three and four averaged higher at Eagle Lake than at Flathead Lake (Table 2). Further indication of better food conditions at the mesotrophic lake than at the oligotrophic lakes was the frequent presence of partially eaten or uneaten prey remains at the bases of nest trees at Eagle Lake and the complete absence of prey remains at the bases of nest trees at Flathead Lake and at Lake Almanor. (4) Even though Ospreys at Flathead Lake had a higher fishing success than Ospreys at Eagle Lake (Table 3), the length of time expended on fishing forays by providing parents at Eagle Lake averaged approximately half that of providing parents at Flathead Lake.

We interpret these results to indicate that Ospreys fishing both lakes had approximately equal capabilities of capturing prey once the prey were located, but it was more difficult to locate prey in the oligotrophic than in the mesotrophic lake.

Thus the meaningful measures of food availability correlated with fledgling productivity of Ospreys breeding at the lakes and we conclude that gross differences in levels of available food resources did influence fledgling productivity of these three populations of Ospreys. Our data infer that differences in levels of food resources were responsible for up to 0.20 fledglings per nesting pair of Ospreys, the difference in fledgling productivity between Eagle Lake and Flathead Lake (Table 1). However, we cannot support the inference that differences in levels of food resources accounted for differences in fledgling productivity up to 0.36 young per nesting pair, the difference in fledgling productivity between Eagle Lake and Lake Almanor, because Ospreys at Lake Almanor were not maintained under surveillance as closely as were Ospreys at Flathead and Eagle lakes.

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Acknowledgments: This project was supported by the California Dept. of Fish and Game (Federal Aid in Wildlife Restoration Project W-54-R), Montana Cooperative Wildlife Research Unit, National Geographic Society (Grant Numbers 771 and 891), New York Zoological Society, Lassen National Forest, U.S. Fish and Wildlife Service (Contract Number 14-16-0008-508), University of Montana Biological Station, Welder Wildlife Foundation, Wilderness Research Foundation, Wildlife Management Institute, and the Flathead Lakers.

We are grateful for their advice and assistance to: R. A. Solberg, Past Director, University of Montana Biological Station; A. R. Gaufin, Assistant Director, University of Montana Biological Station, J. J. Craighead, Leader, Montana Cooperative Wildlife Research Unit; P. Tourangeau, Laboratory Technician, University of Montana; J. Kahl, Wildlife Biologist, Lassen National Forest; G. I. Gould, G. Gagermeier, M. McInnis, J. M. French and M. Ueoka, current and former students at the University of Montana and Humboldt State University

Status of the American Osprey in Oregon

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Abstract: Federal and state agencies plus interested private individuals were surveyed in an attempt to estimate the number of breeding pairs of Ospreys in Oregon. A total of 231 nest sites were reported, of which 121 were active in 1971. Major concentrations of nests were found at Crane Prairie Reservoir, Lookout Point Reservoir, and in the Rouge River drainage.

Historical records of Osprey abundance in Oregon have been few, and only designated the bird as "rare" or "common" with no attempt at enumeration (Townsend 1839; Newberry 1857; Bendire 1877; Mearns 1879; Merrill 1888; Applegate 1905; Gabrielson and Jewett 1940). Marshall (1969) attempted a statewide count of nesting Ospreys and recorded 56 active nests plus an additional seven pairs that probably nested. On this basis, he judged the bird as rare in Oregon.

In the 1960s, numerous reports indicated that Osprey numbers in the eastern and midwestern states were declining (Ames and Mersereau 1964; Reese 1965, 1970; Kury 1966; Dunstan 1968; Berger and Mueller 1969; Postupalsky 1969; Peterson 1969; Henny and Wight 1969). In 1968, the Committee on Rare and Endangered Wildlife Species (1969) listed the Osprey as "status undetermined" pending accumulation of information on populations throughout its range.

While eastern and midwestern populations were declining, an apparent increase in Osprey numbers was noted at Crane Prairie Reservoir in the Deschutes National Forest. W. E. Nelson (pers. comm.) recorded a gradual increase from 16 nesting pairs in 1947 to 26 in 1966. In 1966 and 1967, personnel of the Oregon State Game Commission (OSGC) counted 46 and 56 Ospreys, respectively, at Crane Prairie Reservoir (Bright 1967). These counts did not include an estimate of the number of active nests. Anderson (1968) counted 27 active nests in 1968, and

United States Forest Service (USFS) records showed 48 active nests in the Deschutes National Forest in 1969; 37 of these were on or near the reservoir (Roberts 1970, 1971).

The USFS and OSGC agreed to protect Ospreys and their habitat in the vicinity of Crane Prairie Reservoir in recognition of the uniqueness of this population. The Crane Prairie Reservoir Osprey Management Area (10,600 acres) was officially established by Memorandum of Agreement on 10 October 1969, and signed by the Regional Forester, Pacific Northwest Region, USFS and Director, OSGC (Roberts 1969).

The two agencies agreed to support research on Osprey ecology as part of the Management Plan for the area. An agreement was reached with the Department of Fisheries and Wildlife at Oregon State University, and the junior author was the investigator for the initial 2 years of this work.

The national recognition resulting from the establishment of the Osprey Management Area and classification of the Osprey as rare in Oregon apparently triggered much statewide interest in the species. Suddenly, there were numerous reports of Osprey nesting activities from the entire western half of the state. These reports indicated that many pairs were nesting on public lands.

METHODS

In order to determine the recent status of the Osprey throughout the state, all public agencies in the natural resources fields were surveyed by mail. Information was requested on nest locations, nest activity, productivity data for the 1970 and 1971 breeding seasons, and general sightings of Ospreys throughout the state.

RESULTS

Information was contained in 46 returns of 70 questionnaires mailed, and ranged from no birds sighted to reports of nest concentrations. All reports were evaluated carefully to eliminate duplication. The data were grouped according to major drainages or aggregates of lakes, with further breakdowns by counties and status of land ownership (Fig. 1).

Deschutes River: The upper Deschutes River drainage (Deschutes and Klamath counties) contained the largest concentration of nests in the state. Forest Service records (Roberts 1970, 1971) showed that 151 nest sites have been located since 1968. Of these, 102 were still usable at the end of the 1971 breeding season. The center of the concentration was Crane Prairie Reservoir and the surrounding 2-3 miles of forest. Other nests were located at Big and Little Lava, Davis, Crescent, Odell, and Paulina lakes, and on the Deschutes and Little Deschutes rivers. A majority of the nests were located within the Crane Prairie Reservoir

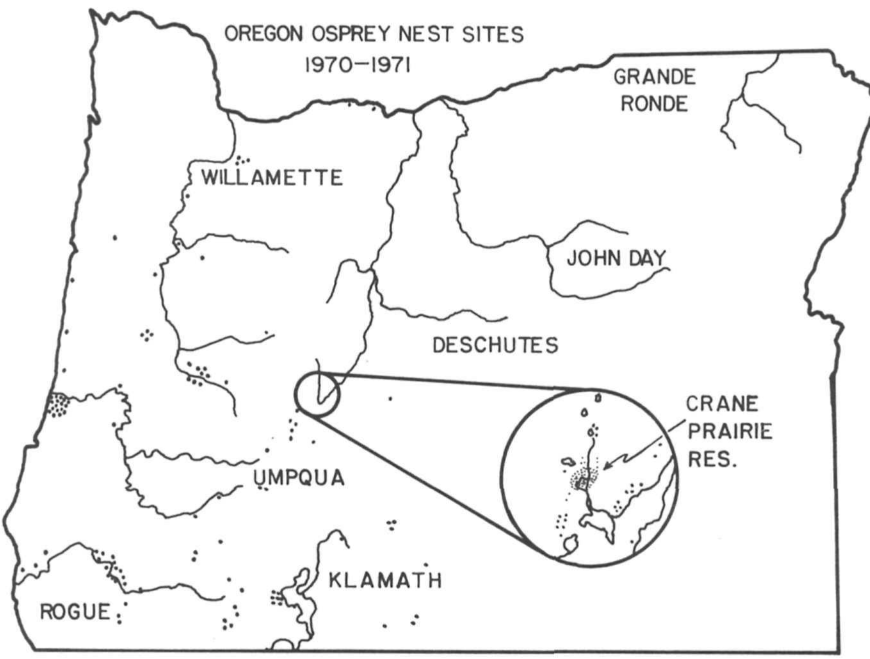

FIGURE 1. Map of Oregon showing Osprey nesting sites.

Osprey Management Area. All but two were located in the Deschutes National Forest; these two being adjacent to the forest, one on private land and the other on public domain.

Detailed nesting records have been kept on this population for the last 3 years (Roberts 1969; Lind 1972). There were 48 active nests in 1969, 47 in 1970, and 60 in 1971. Except for two 1971 nests for which production data were not obtained, young produced were 35, 47, and 66 respectively. Six additional pairs of birds were seen around nest sites in 1971, but did not nest. These were classified as "playing house" and were presumed to be subadult birds. The total post-nesting population in 1971 was estimated to be 200 birds.

Rogue River: The second largest concentration of Osprey nests in the state was found in the Rogue River drainage, including the reservoirs and lakes at its headwaters in Curry, Josephine, and Jackson counties. Twenty-four nests were reported within 1 mile of the river between its headwaters and the Pacific Ocean. Thirteen of these were located on a

17-mile stretch of the river, most of which is public domain and OSGC lands. The nest count on the lower portion of the river was incomplete, with unconfirmed reports of at least nine more nests on the river in Curry County. Nine other nests were reported: one on the Applegate River, two on Lake Selmac, one on Fish Lake, three on Hyatt Reservoir, and two on Howard Prairie Reservoir.

For the entire drainage, 17 nests were reported as active in both 1970 and 1971. Incomplete production data indicated 4 young were fledged in 1970 and 12, in 1971.

Willamette River: The center of Osprey nesting activity in this drainage was Lookout Point Reservoir on the Middle Fork of the Willamette River. Fifteen nests were located here as the result of a Forest Service survey in 1971, plus one on neighboring Hills Creek Reservoir. Additional single nests were reported on Fall Creek and Blue River reservoirs and the North Fork of the Willamette River. All of the above are in the Willamette National Forest, Lane County.

Nests in the Willamette Valley were: one on the South Santiam River; two on Long Tom River; four on Fern Ridge Reservoir; one on Valsetz Lake; four on Champoeg Creek; and two on the main river between Albany and Salem in Lane, Linn, Benton and Marion counties. Eight nests were reported as active in 1970 and 13, in 1971. Seven of the 13 were on Lookout Point Reservoir. At least six young fledged throughout the drainage in 1971.

Coastal Lakes: This unit comprised the fresh-water lakes and streams within 5 miles of the Pacific Ocean, between Waldport and North Bend in Lincoln, Lane, and Coos counties. Six nests were located on North Tenmile Lake, eight on South Tenmile Lake, two on Clear Lake, three on Eel Lake, one on Mercer Lake, one on Tahkenitch Lake, two on Siltcoos Lake, and one on Alsea Bay.

All nests listed on North and South Tenmile lakes were active in 1971 as were those on Mercer Lake and Eel Lake, and one on Clear Lake. A total of 19 active nests were recorded for this area. Production was unknown except for one nest at Clear Lake where three young were fledged. Two of these nests were in the Siuslaw National Forest, and the rest were on private land.

Umpqua River: Seven nests were found on this drainage: two on the main branch of the Umpqua River; two on the South Umpqua River; two on Diamond Lake; and one on Lemolo Lake in Douglas County. There were unconfirmed reports of six to eight additional nests on the lower part of the Umpqua River. Of the total, two were reported as active in 1970, with two fledglings. In 1971, two were active with four fledglings. Four nests were located in the Umpqua National Forest, with the remainder on public domain and private land.

Klamath Basin: This area included the drainage of the Klamath River in Klamath and Lake counties. Seven nests were found on Upper Klamath Lake. Single nests were located on the Williamson River, Gerber Reservoir, Big Swamp Reservoir, and Butcher Flat. Three of these nests were active in 1970 and 1971, with a known production of four young both years. Of the 11 nests, 10 were located in the Winema National Forest, and one on public domain.
Inland Lakes: This area included the drainages of Lake and Harney counties that flow into the Great Basin. There were four known nests: three at Thompson Reservoir; and one at Heart Lake. Three were active in 1970 and four, in 1971. No production data were available. All nests were located in the Fremont National Forest.
Columbia River: Three nests were found near the Columbia River in Wasco, Hood River, and Clackamas counties. Two, located near Hood River, Oregon, were active in both 1970 and 1971, and one of these had two young on it in 1970. The third nest, located at Hope Lake near Sandy, Oregon, produced two young in 1971. All three nests were on private land.

DISCUSSION

The locations of all known Osprey nests (active and inactive) in Oregon are shown in Fig. 1. A total of 231 nests was reported, with 81 active in 1970 and 121 active in 1971 (Table 1). This increase in the number of active nests between the 2 years is attributable to better surveillance in the latter year rather than to a population increase.

Nesting sites were found on both sides of the Cascade Range, in 16 of the state's 36 counties. Conspicuously absent were positive reports from

TABLE 1. Total nests found and active nests reported from specific locations in Oregon, 1970 and 1971.

Location	No. of nest sites found	No. of nests active	
		1970	1971
Deschutes River	102	47	60
Rogue River	42	16	17
Willamette River	32	8	13
Coastal Lakes	24	—[a]	19
Umpqua River	13	2	2
Klamath Basin	11	3	3
Inland Lakes	4	3	4
Columbia River	3	2	3
Statewide Total	231	81	121

[a]No counts made in 1970.

the 13 counties which make up the eastern half of the state. The last known Osprey nest in this area was recorded approximately 10 years ago in Wheeler County. The southeast quarter of the state is primarily high desert, with little habitat available for Osprey. Although no nests have been found in the northeast quarter of the state, reports from observers on the John Day, Grand Ronde, and Wallowa rivers and Olive Lake in Grant County, and Phillips Lake in Baker County indicate that there were Ospreys in these areas throughout the nesting season. In all probability, nests will be found in these areas in the future.

During 1970 and 1971, there were sightings of Ospreys in all but Gilliam, Morrow, Yamhill, Washington, Columbia, and Clatsop counties. Gilliam and Morrow counties are sparsely populated areas with minimal amounts of public lands. Surveillance was limited in the area, and birds probably were undetected. Washington County is heavily populated, and there is little available Osprey habitat. It is impossible to say why Ospreys were not observed in the other three counties. However, Marshall (1969) reported them present in Columbia County.

Of interest is the fact that many of the observations in extreme eastern Oregon, adjacent to the Snake River, were made in March, April, and May, indicating that this may be a migration route. Other sightings were made along the Snake River during December, January, and February, suggesting that some birds winter there.

We feel that a production estimate based on all of the reports would be erroneous since, in most cases (aside from the Deschutes River population), no effort was made to count fledglings. The Deschutes River population, however, has been intensively studied for 3 years (Roberts 1969; Lind 1972). The average production for this population was 0.97 young fledged per active nest. Henny and Wight (1969) stated that Osprey populations in New York and New Jersey must maintain an average of between 0.95 and 1.30 young fledged per active nest to insure population stability. Since the production figure from the Deschutes River population falls within this range, and since the number of active nests has increased over and above those new nests found as a result of better surveillance, we believe that this population is probably remaining stable.

CONCLUSIONS

The survey revealed that a large majority of Osprey nesting sites in Oregon is on public lands. Continued surveillance of these nests by federal and state biologists, who contributed greatly to this report, should provide data that can be used to manage the species and its habitat.

Also, a large majority of the reported nests was on or adjacent to man-made impoundments. Osprey nests were found on 11 reservoirs, a fact which suggests that this land management practice is beneficial to the welfare of the bird.

We wish to emphasize the fact that the 121 active nests reported here is a minimal estimate of breeding pairs of Ospreys in Oregon. Using these data as a baseline, future surveys may establish a population trend.

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Acknowldgments: The authors wish to thank all persons who took time to complete the questionnaire circulated to determine the status of Ospreys in Oregon. Public agencies submitting information were the Oregon State Game Commission (5 regions), Bureau of Land Management (10 district offices), Forest Service (12 National Forests), Bureau of Sport Fisheries and Wildlife (2 National Wildlife Refuges, Division of Wildlife Services and Game Management Agents), Crater Lake National Park, and Warm Springs Indian Reservation. Salem and Oakridge Chapters of the Audubon Society also contributed information. Private citizens who assisted were Ron Jameson, Larry McQueen, William Thackaberry, L. R. Steeves, Otis D. Swisher, Mrs. Joanne Ralston, Howard P. Taylor, John B. Crowell, Bob Ziak, Dr. Charles J. Henny, Donald F. Carr, and Ren D. Sims.

We also wish to thank Dr. Paul A. Vohs, Department of Fisheries and Wildlife, Oregon State University, and Howard M. Wight, Leader, Oregon Cooperative Wildlife Research Unit, who reviewed the manuscript.

Distribution, Abundance, and Breeding Status of Ospreys in Northwestern California[1]

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Abstract: This paper presents information on the distribution, abundance, and breeding status of Ospreys (*Pandion haliaetus*) in northwestern California. As of August 1972, 125 Osprey nests, representing a minimum of 59 breeding pairs, were known to be present in Humboldt, Del Norte, northern Mendocino, and western Trinity counties. One hundred three nests (82%) were located in the coastal regions east of Humboldt Bay and Usal Creek, and on the lower reaches of the Klamath and Eel rivers. A total of 63 nesting efforts for which breeding success was determined resulted in the production of 64 fledglings, an average of 1.02 fledglings per nesting effort. Ospreys appear to be maintaining stable population levels in all but one locality of the study area. The effects of available nest sites, weather, predation and interspecific interactions, human disturbance, food resources, and pesticides on fledgling productivity are discussed.

Prior to 1970, little information was available on Ospreys in northwestern California. Fisher (1902) reported a nest northeast of Humboldt Bay and Mailliard (1922) reported one on the lower Klamath River and one on the Eel River. Jenkins (1945) noted a pair of Ospreys nesting on the Eel River. Hines (1952) located four nests—three near Humboldt Bay and one on the South Fork of the Trinity River.

We suspected that the breeding populations of Ospreys in northwestern California were greater than these isolated observations suggested, and in 1970, with the cooperation of wildlife biologists from the California Department of Fish and Game and the U.S. Forest Service, initiated a study to survey all major streams and standing bodies of water in northwestern California for nesting Ospreys. The survey was intensified in 1971 and continued through the 1972 breeding season.

[1]Supported by NSF Grant GU3233 and the National Geographic Society.

STUDY AREA

Geographic Location

The study was conducted in northwestern California in Humboldt, Del Norte, western Trinity, and northern Mendocino counties on the lower reaches of the Smith, Klamath, Trinity, Eel, Van Duzen and Mattole rivers; the coastal regions of Usal, Redwood, Freshwater, and Salmon creeks and Mad, Little, and Elk rivers; the upper reaches of the Mad River at Ruth Reservoir; Humboldt Bay; Big, Freshwater, and Stone lagoons; and Shelter Cove (Fig. 1).

Physical Description

Mountains dominate the topography of northwestern California. The region is drained by numerous streams in steep, narrow canyons. Areas of nonmountainous terrain occur along the Pacific coast on river deltas and coastal plains. Most of the streams originate in northwestern California. The Klamath River originates in central Oregon.

Seasonal rainfall causes stream flows to fluctuate during the year. During the characteristically dry summer, stream flows are much reduced (Table 1). Most of the streams are free-flowing; the only major impoundment is Ruth Dam near the headwaters of the Mad River in western Trinity County. Dams outside the study area alter flows on the Klamath, Trinity, and Middle Fork of the Eel rivers.

Most streams within the study area drain primarily forested watersheds. The Klamath River drains the Klamath Basin where alfalfa, other hay crops, potatoes, and small grains are grown (Oregon State Water Resources Board 1971). There is some agricultural activity along the lower reaches of the South Fork of the Eel River and along much of the Mattole River (USDI 1956).

Humboldt Bay and Big, Freshwater, and Stone lagoons are shallow coastal bodies of water; all but Freshwater Lagoon have a continuous connection to the Pacific Ocean for at least some period during the year. Usal, Freshwater, and Salmon creeks and Little and Elk rivers are small coastal streams draining limited areas. Shelter Cove is a semi-protected cove approximately 0.5 mile in length.

Climate

The coast of northwestern California is characterized by high annual precipitation, primarily rain, occurring mainly between October and June. Mean annual precipitation at Eureka is 39.5 inches (USDC 1971), with precipitation increasing from south to north in the study area.

Summers on the coast are cool and accompanied by dense and often persistent fogs. High summer temperatures and clear weather are common inland. Moderate northwesterly winds occur along the coast during the spring.

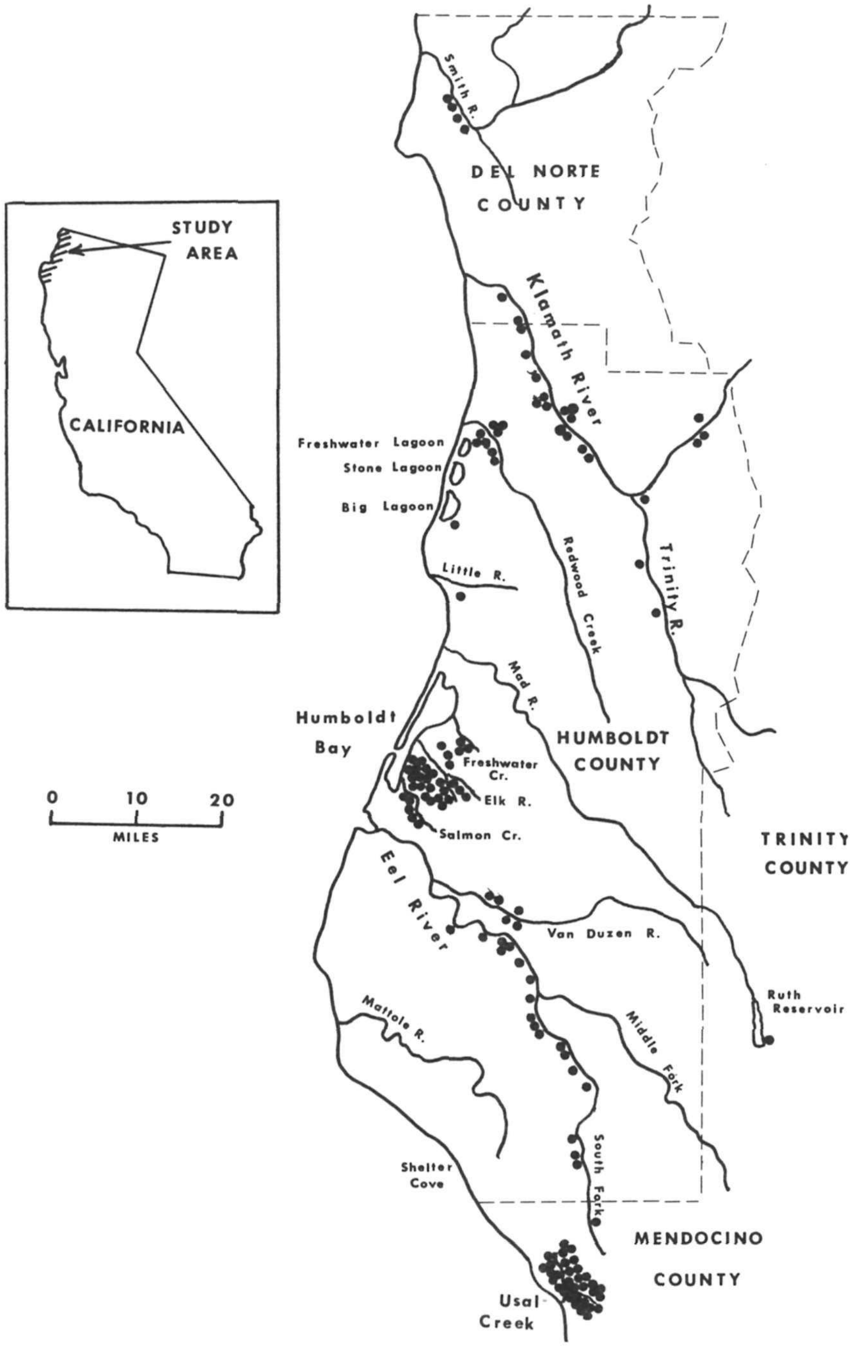

FIGURE 1. Distribution of known Osprey nest sites in Humboldt, Del Norte, northern Mendocino, and western Trinity counties, 1972.

TABLE 1. Comparison of winter and summer mean monthly streamflows in northwestern California.[a]

Area	Mean monthly stream flow (to nearest 10 ft ^{3} per sec)					Period of record
	Jan.	June	July	Aug.	Sept.	
Smith River—main branch	8620	1320	540	340	280	1932–1968
Smith River—mid reaches, Middle Fork	1040	190	90	70	60	1959–1965
Smith River—lower reaches, South Fork	3880	560	240	150	140	1912–1913; 1955–1961
Klamath River—above Trinity River[b]	11710	6630	2960	2230	2370	1928–1968
Klamath River—near mouth	34230	13000	5440	3470	3400	1951–1968
Trinity River—main branch	7710	2370	950	590	470	1961–1968
Redwood Creek—mid reaches	800	70	30	10	10	1954–1958
Redwood Creek—near mouth	2660	230	90	50	40	1954–1968
Little River—near mouth	340	20	10	10	10	1956–1968
Mad River—upper reaches[b]	940	60	60	80	100	1962–1968
Mad River—near mouth[b]	3470	170	80	70	90	1962–1968
Van Duzen River—upper reaches	1190	40	10	10	0	1954–1968
Van Duzen River—lower reaches	2370	140	40	20	20	1950–1968
Eel River—above Van Duzen River	18170	1230	330	150	130	1910–1914; 1917–1968
Eel River—mid reaches, Middle Fork[b]	11350	590	130	50	50	1956–1968
Eel River—mid reaches, South Fork	5210	310	120	70	60	1939–1968
Eel River—upper reaches, South Fork	500	30	10	0	0	1948–1968
Mattole River—near mouth	3820	200	80	60	50	1912–1913; 1951–1968

[a]From Jorgensen et al. (1971).
[b]Stream flow regulated by dam(s).

Vegetation

Most of the study area is forested. At lower elevations and along the coast, redwoods (*Sequoia sempervirens*) are dominant. At higher elevations and further inland, Douglas fir (*Pseudotsuga menziesii*) predominates. Willows (*Salix* spp) and red alder (*Alnus rubra*) are common along streams, although high rainfall tends to minimize the distinction between riparian and forest vegetation.

Land Use

The forests of the region support a timber industry which contributes much to the economy of northwestern California. Dairying and livestock ranching comprise the bulk of agricultural activity. Commercial and sport fishing and summer tourism are also important to the local economy.

METHODS

The majority of the survey to locate nests and to maintain active nests under surveillance was conducted by automobile. Portions of the Klamath and Trinity rivers were surveyed by raft and powerboat. Travel on foot was conducted in areas inaccessible by other means. Portions of the survey were conducted by helicopter and fixed-wing aircraft.

Fledgling productivity was determined in 1971 and 1972; each year we started surveillance of previously known nest sites in March and April. Nests located after early June were not included in calculations. Fledgling productivity—the number of young fledged per nesting pair—was measured during July and August. We attempted to visit the majority of occupied nest sites once every 14 days; during the few weeks prior to and during fledging, we visited them once weekly when possible.

RESULTS

Distribution of Nesting Sites

A total of 30 nest sites had been located by 1970. An additional 38 nest sites were located during 1971, and as of August 1972, 125 nest sites had been located (Table 2). One hundred and three nest sites (82%) were in one of four areas: tributaries east of Humboldt Bay, Usal Creek, the portion of the Klamath River within Humboldt and Del Norte counties, the Eel River and the South Fork of the Eel River (Fig. 1). Twenty nest sites were on the lower reaches of Redwood Creek and Little River, the main branches of the Smith and Trinity rivers, and the lower reaches of the Van Duzen River. The remaining two nest sites (2%) were near standing bodies of water. No nests were located on the Middle Fork of the Eel, South Fork of the Smith, Middle Fork of the

TABLE 2. Abundance and distribution of nest sites, nesting territories, and nesting Ospreys discovered in northwestern California, 1971 and 1972.

Area	Total no. nests located		No. nests included in[a] calculating nest use & fledgling productivity		No. nesting territories		No. nesting territories[b] occupied		
	1971	1972	1971	1972	1971	1972	1971	1972	Mean
Smith River	2	4	0	3	2	3	1 (50)	2 (67)	(58)
Klamath River[c]	17	19	11	15	11	11	8 (73)	7 (64)	(68)
Trinity River	0	2	0	2	—	2	— —	1 (50)	(50)[d]
Redwood Creek	5	8	3	5	3	3	2 (67)	3 (100)	(84)
Big Lagoon	0	1	0	1	—	1	— —	1 (100)	(100)[d]
Little River	1	1	1	1	1	1	0 (0)	0 (0)	(0)
Humboldt Bay	19	33	16	24	15	27	10 (67)	14 (52)	(60)
Van Duzen River	5	5	1	5	2	2	1 (50)	1 (50)	(50)
Eel River	15	19	12	18	11	12	7 (64)	8 (67)	(66)
Ruth Reservoir	1	1	0	1	1	1	1 (100)	1 (100)	(100)
Usal Creek	—	32	—	21	—	32	— —	20 (62)	(62)[d]
Total	65	125	44	96	46	95	30 (65)	58 (60)	(62)

[a]Only nests discovered by early June shown.
[b]Percentages in parentheses.
[c]Within Humboldt and Del Norte counties.
[d]1972 only.

Smith, the Mad and Mattole rivers, or at Shelter Cove. However, Ospreys have been observed flying and fishing along the lower reaches of the Mad River and at Shelter Cove.

All nest sites were in proximity of streams or standing bodies of water. Only three nest sites were within one mile of the Pacific coastline, even though Ospreys commonly fished the coastal lagoons, Humboldt Bay, and the Pacific Ocean at the mouth of Usal Creek. The majority of Ospreys which fished these areas nested 2-5 miles inland along streams.

Use of Nest Sites

Twenty-two of 44 nest sites (50%) and 41 of 96 nest sites (43%) located prior to or during the spring of 1971 and 1972, respectively, were used by Ospreys (Table 3). One nest on the Eel River was attended by a single Osprey in 1971 and one nest on the Trinity River was attended by a single Osprey in 1972. One nest was attended by a pair of Ospreys judged to be sexually immature birds in 1972.

Fifty of 93 nest sites (54%) located by 1972 and outside the Usal Creek area were in 20 groups of two to four nest sites per group and were known or suspected to be nesting territories containing multiple-nest sites. Nesting territories containing multiple-nest sites were not difficult to identify along major streams. The distance between previously established nesting territories along the Klamath and Eel rivers in 1972 averaged approximately 5 miles. Nest sites in nesting territories were within 20 ft to 0.25 mile of each other.

Nest sites where Ospreys nested in loose colonies and foraged a common fishing area—Humboldt Bay, coastal lagoons, and Usal Creek—were in close proximity to each other, and identification of individual nesting territories in these areas was more difficult. No attempt was made to enumerate nest sites in territories at Usal Creek where some pairs of Ospreys nested within 100 yards of each other.

Of the 46 nesting territories located by 1971 and the 65 located by 1972, 30 (65%) in 1971 and 38 (58%) in 1972 were used. At Usal Creek, 20 of 32 nest sites (62%) were used in 1972 (Table 2).

Breeding Success

In 1971, 14 of 22 (64%) nesting pairs for which breeding success was measured fledged 27 young, an average of 1.23 fledglings per nesting pair (Table 3); 17 of 27 (63%) nesting within the same area fledged 30 young in 1972, an average of 1.11 fledglings per nesting pair. Fledgling productivity of Ospreys nesting on the Eel and Van Duzen rivers, 1.00 fledglings per nesting pair, and east of Humboldt Bay, 1.11 fledglings per nesting pair, was identical in 1971 and 1972. Breeding success of Ospreys nesting along the lower reaches of the Klamath River was 1.67

TABLE 3. Nest use and fledgling productivity of Ospreys in northwestern California, 1971 and 1972.

	No. nests[a] occupied			No. nests producing fledglings			Av. % occupied nests producing fledglings	No. young fledged			No. young fledged per occupied nest		
	1971	1972	Total	1971	1972	Total		1971	1972	Total	1971	1972	Total
Area	(A_1)	(A_2)	(A_i)	(B_1)	(B_2)	(B_i)	[A_i/B_i (100)]	(C_1)	(C_2)	(C_i)	(C_1/A_1)	(C_2/A_2)	(C_i/A_i)
Smith R.	0	1	1	—	1	1	100	—	1	1	—	1.00	1.00
Klamath R.[b]	6	5	11	4	4	8	73	10	5	15	1.67	1.00	1.36
Trinity R.	0	1	1	—	1	1	100	—	2	2	—	2.00	2.00
Redwood Cr.	0	1	1	—	1	1	100	—	2	2	—	2.00	2.00
Big Lagoon	0	1	1	—	1	1	100	—	2	2	—	2.00	2.00
Humboldt Bay	9	9	18	6	5	11	61	10	10	20	1.11	1.11	1.11
Van Duzen R.	1	1	2	1	1	2	100	1	1	2	1.00	1.00	1.00
Eel R.	6	7	13	3	3	6	46	6	7	13	1.00	1.00	1.00
Ruth Res.	0	1	1	—	0	0	0	—	0	0	—	0.00	0.00
Usal Cr.	—	14	14	—	6	6	43	—	7	7	—	0.50	0.50
Total (excluding Usal Cr.)	22	27	49	14	17	31	63	27	30	57	1.23	1.11	1.16
Total	22	41	63	14	23	37	59	27	37	64	1.23	0.90	1.02

[a]Only nests discovered by early June shown.
[b]Within Humboldt and Del Norte counties.

fledglings per nesting pair in 1971 and 1.00 fledgling per nesting pair in 1972.

Six of 14 (43%) nesting pairs for which breeding success was determined at Usal Creek in 1972 fledged seven young, an average of 0.50 fledglings per nesting pair (Table 3). The number of young fledged per utilized nest and the number of young fledged per successful nest at Usal Creek were the lowest of any locality in the study area.

Twelve of 16 (75%) pairs nesting on the Klamath and Scott rivers within the Klamath National Forest fledged 21 young in 1971, an average of 1.31 young per nesting pair. Eight of 17 (47%) pairs nesting in the Klamath National Forest fledged 14 young in 1972, an average of 0.82 young per nesting pair (R. Gale pers. comm.).

Young began fledging by the third week in July and all were fledged by the end of the first week in August 1971. In 1972, young began fledging in the Humboldt Bay area in early July; at the end of the first week in August, young in four nests along major streams or at Usal Creek had not fledged. However, the majority of young fledged during the same period in 1972 in which they fledged in 1971.

Factors Influencing Abundance, Distribution, and Breeding Success

Nest sites: Nests were constructed on the apices of snags, stumps, dead tops of live trees, and completely live redwoods and Douglas firs. Height of nest trees varied from approximately 50-250 ft; mean height of nest trees exceeded 100 ft. Nests most commonly were in partially or completely dead trees. At Usal Creek, where the relative proportion of dead to live trees was lower than in other portions of the study area, the majority of nests were in completely live trees. Most localities in the study area contained an abundance of trees apparently suitable for nesting sites.

Weather: Three of 30 (10%) nests located by 1971, and 7 of 65 nests (11%) located by 1972 were destroyed, presumably by storms, during the winters of 1970-71 and 1971-72. None of these nests was rebuilt during the subsequent spring, although a new nest was constructed nearby one lost, or an adjacent nest was used in at least three of these instances.

One nest destroyed by wind during the spring of 1971 was rebuilt later in the year by a pair of Ospreys that abandoned a nearby nest. One occupied nest was destroyed by high winds during mid-April 1972; we suspected that the pair from this nest subsequently renested in the same vicinity, although a new nest was not located. Two unoccupied nests were destroyed by wind during the spring of 1972.

Predation and interspecific interactions: No instances of predation were documented during the study. However, the only known loss of young occurred in early July 1972, at Usal Creek where four nestlings, approximately 4-5 weeks old, disappeared from two adjacent nests. Although we were unable to determine the cause of the loss of these nestlings, it may have been avian predators.

Ravens (*Corvus corax*) and Common Crows (*Corvus brachyrhynchos*) were common in the vicinity of Osprey nests and were driven off by the occupants on occasion. Crows frequented trees adjacent to some Osprey nests to such an extent that we suspect they may have nested near Osprey nests. Ravens and crows sometimes were in Osprey nests after young fledged, at times when nests were unoccupied for prolonged periods during the day.

Red-tailed Hawks (*Buteo jamaicensis*) frequented the vicinity of some Osprey nests prior to the time that Ospreys began incubation. The prolonged presence of apparently paired Red-tailed Hawks near some nests suggested that they might attempt to nest in proximity to the nesting Ospreys. The Red-tailed Hawks frequently dove at perched and flying Ospreys and vice versa. After Ospreys began incubation, the hawks frequented the nest sites less commonly and, when soaring in the vicinity of Osprey nests, illicited little response from the Ospreys.

Turkey Vultures (*Cathartes aura*) were abundant throughout the study area. Ospreys reacted to the presence of vultures only by vocalizing when vultures flew low over occupied nests. Ospreys did not drive soaring vultures away from nesting areas.

Great Blue Herons (*Ardea herodias*) nested or fed along all major streams in the study area. Herons commonly flew over Osprey nests without incident, although herons feeding near Osprey nests occasionally were pursued by Ospreys. Heron rookeries were in proximity to several Osprey nests on the Klamath and Eel rivers.

Gulls (*Larus* spp.) were abundant on coastal waters fished by Ospreys, but were common inland only along the Klamath River where no interactions with Ospreys were observed. On coastal waters, gulls, singly or in groups, frequently harassed Ospreys carrying fish. On several occasions groups of gulls forced Ospreys carrying fish to the ground, but no loss of fish to gulls was observed. After Brown Pelicans (*Pelecanus occidentalis*) began arriving on north coastal waters in mid-June, harassment of fishing Ospreys diminished as gulls shifted some harassment to fishing pelicans.

Human disturbance: The most common forms of human activity considered potentially disturbing to Ospreys were logging, vehicular traffic, recreational activity, and shooting.

The majority of nests were on private logging land. All nests at Usal Creek and nearly all nests east of Humboldt Bay were on land owned by lumber companies. No occupied nest sites were felled by loggers during the study, although two of four alternate nest sites, unoccupied at the time, were felled in November 1971. A pair of Ospreys successfully nested in one of the two remaining nests in 1972.

In addition to the obvious detrimental effects of felling occupied nests, it is possible that disturbance associated with nearby logging activities might adversely affect nesting success. Such disturbance generally was of a temporary nature and began after nesting began. In such situations, some nesting pairs of Ospreys abandoned their nests while others successfully raised young.

Many nests were adjacent to roads or highways. In 1972, Ospreys nested in a 250-ft redwood in the median between traffic lanes of U.S. Highway 101, which is heavily traveled. Ospreys also nested in a 230-ft redwood approximately 20 ft from an off ramp on the same highway in 1972. Two alternate nests further removed from the highway were present in the latter nesting territory. Three young were fledged from the latter nest, and adults in this nest apparently were undisturbed by heavy traffic. However, during times when one of us climbed a hillside opposite the highway about 500 ft from the nest, Ospreys at the nest reacted by calling.

Sightseeing, camping, fishing, and swimming were the main forms of summer recreational activity. There was no indication that any of these activities were detrimental to breeding success of Ospreys in the study area.

The use of firearms was common throughout the study area and they were used at times in the vicinity of Osprey nests. Young boys were observed shooting at herons on the Klamath River in 1971 and we were informed that an Osprey was shot by a young boy on the Klamath River during the summer of 1972.

The south spit of Humboldt Bay was used commonly by local residents to hunt small game, for skeet shooting, and for target practice. Gulls, shorebirds, and Barn Swallows (*Hirundo rustica*) reportedly were shot often. Ospreys commonly perched on structures on the south spit to eat prey caught in Humboldt Bay (M. Uekoa pers. comm.). The perched Ospreys offered easy targets, and it is probable that they occasionally were shot.

Although use of firearms was common elsewhere, the height and isolation of most nest sites afforded a measure of protection from such human molestation. In addition, the presence of property owners or loggers provided a deterrent to hunters.

Food: Streams in the study area support a relatively poor variety of fish fauna. Thirty-one species, 14 of which are considered common, are known to occur in streams within the study area. Twelve species are anadromous and 19 species are resident (Table 5).

Identification of fish delivered to Osprey nests along streams was not possible in most instances. The size of 27 fish seen delivered to Osprey nests along major streams ranged from 9 to 16 inches, with the exception of one 24-inch Pacific lamprey (*Entosphenus tridentatus*). French witnessed an Osprey catch a 5-inch fish on the Eel River. However, we never observed Ospreys delivering fish this small to nests along streams.

Ospreys nesting east of Humboldt Bay foraged primarily in the southern portion of Humboldt Bay on surfperch (Embiotocidae), although sculpins (Cottidae), northern anchovies (*Engraulis mordax*), Pacific herring (*Clupea pallasi*) and silversides (Atherinidae) also were caught (M. Ueoka pers. comm.).

Ospreys nesting on the lower reaches of Redwood Creek and at Big Lagoon fished primarily Freshwater Lagoon. Freshwater Lagoon is stocked regularly with hatchery-reared rainbow trout (*Salmo gairdneri*) of catchable size; these fish constitute almost the entire fish fauna of the lagoon (McDaniels and Phillips 1972).

Populations of surf smelt (*Hypomesus pretiosus*) and night smelt (*Spirinchus starksi*) spawn in the surf of the beach at the mouth of Usal Creek throughout the spring and summer (Baxter 1960). At least 20 pairs of Ospreys nested along Usal Creek and fished the Pacific Ocean near the mouth of the creek, usually within 0.25 mile of shore. French witnessed Ospreys catch or carry 124 fish during 1971 and 1972: three (2%) were surfperch, and 121 (98%) were surf smelt or night smelt and averaged approximately 5-6 inches in total length. The remains of an 18-inch pink salmon (*Oncorhynchus gorbuscha*) were found at the base of a feeding perch on the beach.

TABLE 4. Relative fledgling productivity and percentages of utilized Osprey nests fledging broods differing in number of young in northwestern California, 1971 and 1972.

Nesting area	Av. annual no. fledgings per nesting effort	Percentage fledging 0 young	Percentage fledging 1 young	Percentage fledging 2 young	Percentage fledging 3 young
Major streams (28)[a]	1.18	36	25	25	14
Humboldt Bay & coastal lagoons (20)	1.20	35	25	25	15
Usal Creek[b] (14)	0.50	57	36	7	0

[a]No. of nesting efforts.
[b]1972 only.

Pesticides: Information on the incidence of pesticide residues in Ospreys in northwestern California was not available. The use of persistent pesticides within the study area was relatively low. Registered use of the herbicides, 2,4 D and 2,4,5 T, exceeded that of any other pesticide in Humboldt County. Chlorinated hydrocarbons accounted for less than 1% of the total registered use of pesticides in Humboldt County for the same period. A total of 2.55 pounds and 0.02 gallons of DDT was registered for use in Humboldt County during 1970; DDT was not registered for use in 1971. (Humboldt County Agricultural Commission 1970-1971).

DISCUSSION

Population Trends

In all likelihood, the survey did not constitute a complete census of Ospreys nesting in the study area. More pairs probably nested east of Humboldt Bay and at Usal Creek than we found. However, the estimated number of breeding pairs along major streams probably is more accurate.

On the basis of recoveries of Ospreys banded in New York and New Jersey, Henny and Wight (1969) calculated that each breeding pair in the population would have to produce an average of 0.95-1.30 fledglings per year in order to maintain population stability. If Ospreys in northwestern California are subject to the same mortality schedules as are Ospreys in New York and New Jersey, then in most portions of the study area, Ospreys are maintaining stable populations. Only at Usal Creek was breeding success lower than that calculated as necessary to maintain population stability (Table 3).

It is difficult to speculate on population trends from a 2-year study. The apparent increase in nesting pairs from 1971 to 1972 is related to intensified surveillance during the latter year. The only area where Ospreys may be less numerous than in previous years is at Usal Creek, where loggers reported that numbers of Ospreys have declined in the past 10-20 years.

One nesting territory on the Klamath River was occupied in 1971 but not in 1972 (Table 2), suggesting a decrease in abundance of nesting Ospreys along that stream. Even though this is a definite possibility, it is also possible that the missing pair moved to a nearby site that we failed to locate in 1972. Also, eight nesting territories east of Humboldt Bay were used in 1971 but not in 1972. Even though Table 2 indicates a net increase in abundance of nesting pairs of Ospreys east of Humboldt Bay, we cannot be certain whether these eight pairs moved to other territories and were counted in 1972 or whether some or all were lost and increased surveillance efforts in 1972 made it only appear as though they were counted. We support the former alternative because we feel the survival value of continued renesting in existing nesting territories along streams probably is greater than the survival value of continued renesting in specific nesting territories near large bodies of water. Nesting territories along streams are more likely to be associated with specific but limited areas of the stream from which needed food supplies can be secured than are nesting territories near large bodies of water from which a number of Ospreys, regardless of specific nest location, can obtain needed food supplies.

Factors Affecting Abundance, Distribution, and Breeding Success

Nest sites: The presence of large numbers of potential nesting sites within most portions of the study area cannot account for the apparent absence or sparsity of nests along some streams. Potential nest sites were present along many areas of the Pacific coastline, and it is probable that weather conditions rather than a lack of suitable nesting sites per se were responsible for the sparsity of nesting Ospreys along the coast.

Weather: Even though Ospreys may be restricted from nesting in situations exposed to spring and summer on-shore winds and fogs, weather conditions did not appear to impair the breeding success of Ospreys in areas where they did nest.

Prolonged periods of fog may adversely affect the visual ability of Ospreys to locate fish in coastal bodies of water. Particularly at Usal Creek, where average prey size is small and a relatively constant supply of prey therefore must be delivered to broods to sustain growing young, 1 or 2 days of dense and persistent fogs could impair fishing success. Impaired fishing success could result in starvation of nestlings, especially among large broods.

Predation: We feel the incidence of predation upon nesting Ospreys, eggs, and young in the study area was minimal. The attentiveness of Ospreys to nests during incubation and hatching appeared to provide protection against avian predators during this phase of the breeding season. The heights of Osprey nest sites in the study area apparently insured adequate protection from nonavian predators. However, predation is implicated in the loss of the four nestlings at Usal Creek because they disappeared at a time when females began assisting the males in providing fish for the young, leaving the nests unattended during fishing forays.

Food: An average of 15% of the nesting pairs which fished Humboldt Bay and the coastal lagoons and 14% of the nesting pairs which fished major streams in northwestern California fledged broods of three (Table 4). Similar measurements from Flathead Lake, Montana, averaged 11% and from Eagle Lake, California, averaged 19% (Koplin et al. 1972). Koplin et al. (1972) concluded that food resources were less available to Ospreys nesting at Flathead Lake than to those nesting at Eagle Lake and that the differences in available food supply probably accounted for the difference in productivity of 0.20 fledglings per nesting effort between the two lakes.

Productivity of Ospreys breeding at Humboldt Bay and the coastal lagoons averaged 1.20 fledglings per nesting effort, of Ospreys breeding along streams in northwestern California, 1.18 fledglings per nesting effort (Table 3), and of Ospreys breeding at Eagle Lake, 1.17 fledglings per nesting effort (Garber 1972). The similarity in these values and the relatively large difference in percentages of pairs fledging three or more young between the two regions is attributable to differences in percentages of pairs fledging no young, which averaged 43% at Eagle Lake, 35% at Humboldt Bay and the coastal lagoons, and 36% along streams in northwestern California. Obviously, therefore, proportionately more pairs of Ospreys breeding at Humboldt Bay, the coastal lagoons, and along streams in northwestern California fledged their broods, of whatever size, than did those breeding at Eagle Lake. The similarity in the percentages of nesting pairs fledging broods of three at Humboldt Bay and the coastal lagoons, and along streams in northwestern California suggests that, if food resources did limit large brood sizes in these areas, nesting Ospreys in all areas were affected similarly.

No nesting pairs which fished the Pacific Ocean at the mouth of Usal Creek fledged broods of three in 1972 and only 7% fledged broods of two (Table 3). The absence of large broods may have been due to limited food resources. Even though an adequate food supply apparently was available to Ospreys at Usal Creek at most times, it is possible that prolonged periods of dense fog and/or temporary movements of smelt may have occurred in 1972 which led to starvation of nestlings, particularly among large broods.

Even if breeding success of Ospreys which nested in established nesting territories along streams was not limited by food resources, it is probable that the abundance and distribution of nesting territories along streams is determined by available food resources. The effects of nest site availability, weather, human disturbance, and predation were not sufficient to explain the apparent absence, or sparsity, of nesting Ospreys on some streams. Since few Ospreys nested along streams which drained forested watersheds, where to our knowledge there has been no application of insecticides, it is unlikely that their absence was related to pesticide contamination. The only remaining possibility was that limited food resources restricted Ospreys from nesting along these streams.

TABLE 5. Fish inhabiting northwestern California streams within the study area.[a]

Common name	Scientific name	Origin[b]	Migratory[c] status
Geographically widespread in occurrence			
Pacific Lamprey	*Entosphenus tridentatus*	N	A
Green Sturgeon	*Acipenser medirostris*	N	A
American Shad	*Alosa sapidissima*	I	A
Eulachon	*Thaleichthys pacificus*	N	A
Silver Salmon	*Oncorhynchus kisutch*	N	A
King Salmon	*Oncorhynchus tshawytscha*	N	A
Coast Cutthroat Trout	*Salmo clarki clarki*	N	R[d]
Rainbow Trout	*Salmo gairdneri*	N	R
Steelhead Rainbow Trout	*Salmo gairdneri gairdneri*	N	A
Humboldt Sucker	*Catostomus humboldtianus*	N	R
Riffle Sculpin	*Cottus gulosus*	N	R
Prickly Sculpin	*Cottus asper*	N	R
Aleutian Sculpin	*Cottus aleuticus*	N	R
Threespine Stickleback	*Gasterosteus aculeatus*	N	R
Geographically restricted in occurrence			
White Sturgeon	*Acipenser transmontanus*	N	A
Longfin Smelt	*Spirinchus dilatus*	N	—[e]
Pond Smelt	*Hypomesus olidus*	I	A
Pink Salmon	*Oncorhynchus gorbuscha*	N	A
Chum Salmon	*Oncorhynchus keta*	N	A
Kokanee Salmon	*Oncorhynchus nerka kennerlyi*	I	R
Klamath Small-scale Sucker	*Catostomus rimiculus*	N	R
Carp	*Cyprinus carpio*	I	R
Tui Chub	*Gila bicolor*	N	R
Klamath Speckled Dace	*Rhinichthys osculus klamathensis*	N	R
Golden Shiner	*Notemigonus crysoleucus*	I	R
Venus Roach	*Hesperoleucas venustus*	I	R
White Catfish	*Ictalurus catus*	I	R
Brown Bullhead	*Ictalurus nebulosus*	I	R
Western Mosquitofish	*Gambusia affinis affinis*	I	R
Yellow Perch	*Perca flavescens*	I	R
Green Sunfish	*Lepomis cyanellus*	I	R

[a]Modified after Dewitt (1964); Eddy (1957).
[b]N = Native; I = Introduced.
[c]A = Anadromous; R = Resident.
[d]Occasionally anadromous.
[e]Marine, may enter freshwater.

Pesticides: Except at Usal Creek, more clutches hatched throughout the study area than at Eagle Lake, inferring that these areas in northwestern California may have been burdened with smaller levels of pesticides than was Eagle Lake. The percentage of nesting efforts that failed to fledge young at Usal Creek—57% (Table 4)—is more similar to the same measure at Eagle Lake, Lake Almanor, and Flathead Lake—43, 57, and 53%, respectively. These lakes were more burdened with DDT residues (Koplin et al. 1972) than other localities in northwestern California. This observation implies that fish at Usal Creek may have been more heavily contaminated with residues of chlorinated hydrocarbons than were fish elsewhere in northwestern California. Fish from Usal Creek and elsewhere in northwestern California are being analyzed chemically by the California Department of Fish and Game; if their findings correlate with the percentages of nesting pairs of locally breeding Ospreys failing to fledge young, it will suggest a useful field method of assessing levels of chlorinated hydrocarbon burdens in aquatic and marine ecosystems used by Ospreys.

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Acknowledgments: We wish to acknowledge the assistance of F. Reynolds, R. Mapes, and C. Moon, California Department of Fish and Game, for allowing us to participate in survey flights over the study area and for information on known nest locations. C. Kennedy, D. Garber, and R. Gale, Wildlife Biologists, U.S. Forest Service, provided us with equipment for floating streams, aided with the survey in the Six Rivers National Forest, and provided information on breeding success of Ospreys nesting in the Klamath National Forest. E. Roberts, U.S. Bureau of Land Management, allowed us to participate in a flight over portions of the study area. D. Thomas, Humboldt County Agricultural Commissioner, provided information on registered use of pesticides in Humboldt County. G. Gould, M. Ueoka, K. McDaniel, C. Bradshaw, A. Phillips, current and former students at California State University, Humboldt, provided information on nest locations, conducted feeding studies, and assisted in field observations.

History and President Status of Ospreys in Northwestern Baja California

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Abstract: Osprey (*Pandion haliaetus*) populations on the west coast of Baja California, in the area north of Natividad Island, have remained fairly stable since 1946. Human interference is the major threat to birds nesting in this area, particularly on the offshore islands. There is no evidence that Ospreys in this region are suffering impaired reproduction as a result of pesticide pollution.

The decline of Osprey populations in the northern United States, in part as a result of pesticide pollution (Ames 1966; Peterson 1969; Reese 1970), has caused concern for the species in other parts of its range. One area of particular interest is northwestern Baja California because shell-thinning attributed to DDT has been found to affect a wide variety of seabirds there and in adjacent regions of California (Gress et al. 1971; Coulter and Risebrough 1973; Jehl 1973).

The coastal islands of northwestern Baja California and parts of the mainland were once a stronghold for Ospreys (Grinnell 1928). However, in his review of populations in the area north of Natividad Island, Kenyon (1947) found that numbers had been declining slowly since the turn of the century, largely as a result of human activities. In the past several years I have visited all of the islands in this area at least once and the important Scammon's Lagoon area several times, obtaining sufficient data to compare the present status of Ospreys with that reported by Kenyon. For a description of the area and detailed historical information see Kenyon's (1947) study.

ISLAND POPULATIONS

Los Coronados

There is no record of Ospreys nesting on these islands (Howell 1917), nor is there any evidence of old nests. Bald Eagles (*Haliaeetus leucocephalus*) were seen occasionally early in the 20th century (Grinnell

1928), but the only report of their nesting is second-hand (Grinnell and Daggett 1093:33).

Todos Santos Islands

Apparently Ospreys were once common on the Todos Santos Islands, but the "breeding population became much reduced between 1897 and 1910 and may have been entirely gone by 1923" (Kenyon 1947:152). L. M. Huey (unpubl. field notes) found none there on 18 May 1926. It is interesting that nesting pelicans also disappeared from these islands in the 1920s (Jehl 1973), which suggests that human interference at that time may have become intolerable. Kenyon found no Ospreys on the islands in 1946, and I found none on South Island in April 1969. North Island is flat and unsuitable for nesting.

San Martin Island

As many as 30 pairs of Ospreys were estimated at San Martin in 1913 (Wright 1913), but in 1946 Kenyon found only 3 pairs. Between 1969 and 1971 only one pair nested on the island, and a pair was observed collecting nest material on 25 February 1972.

San Geronimo Island

A few pairs nested on this island near the turn of the century, but the population dropped to one pair by 1912. Huey saw no birds on 20 May 1926. Kenyon found no nests in 1946. At present there are no nests or their remains on the island.

Cedros Island

Belding (1883) found Ospreys "very common" in 1882, and Gaylord (1897) considered them abundant on this large island, counting "thirteen well-used nests, within the radius of perhaps a quarter mile, besides many deserted ones." In 1969 and 1970, while searching from a boat, I observed several nests near the shore on the east side of the island, and doubtless there are others on the west side, which remains to be explored fully. Kenyon also found several nests on the east side of the island. It seems unlikely that this population has decreased significantly in the past several decades, but it is probably much smaller than it was at the turn of the century.

San Benito Islands

Kenyon (1947) did not discuss these three small islands, which lie 15 miles west of Cedros. Gaylord (1897) reported that Ospreys nested there in abundance but gave no quantitative data. On four trips to the San Benitos in 1971 (18 January, 1 March, 25-26 May), I made a special effort to determine Osprey status and I estimated the population as follows: West Island, 12-15 pairs; Middle Island, 4-6 pairs; East Island, 7-8 pairs. These figures closely approximate my estimates in 1969 and 1970. In 1970 complete clutches of three eggs were found between 5 February and 19 April. In 1971 and 1972, laying began in mid-February; by late May 1971 all nests were empty and flying young were seen.

Natividad Island

Three pairs of Ospreys nested at the south end of this island in 1969 and 1971, and at least one additional pair nested along the west side (pers. obs., M. N. Kirven pers comm.). The north end of the island, which was not visited, probably has several additional pairs. Apparently, the current population size is similar to that found by Kenyon.

MAINLAND POPULATIONS

Few data on mainland nesting populations have become available since Kenyon's report. It is certain that no Ospreys nest north of Punta Banda, where Kenyon saw a nest in 1946; whether any still occur on that rugged peninsula is unknown. Many areas farther south might harbor Ospreys, but data are few because most coastal localities are inaccessible. D. Bostic (pers. comm.) has observed birds in the nesting season near San Quintín, Puerto San Carlos, Arroyo San José, where he found a nest, and El Cardón; and in 1971, he found at least six nests in the vicinity of Punta Falsa, opposite Natividad Island.

The most important mainland nesting area for Ospreys is Scammon's Lagoon, where they nest on the ground on small sandy islands. Strong tidal currents constantly change the configuration of the islands, allowing access by coyotes (*Canis latrans*) and causing Ospreys to shift nest sites. Yet the population seems stable.

In late April 1946, Kenyon (1947) found 27 pairs in Scammon's Lagoon, 16 of which were on Shell Island, the major colony. Nests there contained all stages from fresh eggs to flying young. On 15-16 February 1957, D. Inman and R. Redfield estimated 25 nests on Shell Island (R. M. Gilmore pers. comm.). Nine nests were examined: one contained newly hatched young; four were empty; one contained two eggs; and three contained three eggs each. On 3 February 1970, I counted 22 active nests on Shell Island alone; ten contained eggs. On 1 February 1971, P. Devillers (pers. comm.) counted 20 nests there; 17 contained eggs. I estimate the total lagoon population at approximately 30 pairs. In 1971, fresh eggs were found between 20 January and 17 March. In 1972, eggs on one nest hatched by 21 February. Apparently, birds in the lagoon begin nesting a month or so earlier than those on the San Benito Islands.

DISCUSSION

The Osprey population of northwestern Baja California declined in the first decades of this century (Kenyon 1947), but seems to have stabilized in the past 25 years. Kenyon attributed much of the original decline to human disturbance, primarily shooting of adults, but also human consumption of eggs and young. Human disturbance remains the largest threat to the population. An increasing number of pleasure boats visit the offshore islands each year. The conspicuous nests draw the attention of sightseers who, by flushing adults from the nest, may cause the loss of eggs to gulls. I have no evidence that adults are shot for sport, but in view of the number of sea lions shot each year it seems probable that many Ospreys suffer a similar fate.

Ospreys in northwestern Baja California have not been affected by conspicuous shell-thinning and egg breakage. Detailed studies of shell thickness remain to be made, but I have found no evidence of collapsed shells in the many nests examined between 1969 and 1972. Preliminary studies (Spitzer and Risebrough 1971) indicate that chlorinated hydrocarbon and polychlorinated biphenyl levels are very low in eggs from the San Benito Islands and Scammon's Lagoon. In contrast, chlorinated hydrocarbon residues are high in pelican eggs from San Martin and the San Benitos, and collapsed eggs are common in those colonies (Jehl 1973).

The polluted waters of southern California seem the most likely source of contamination in pelicans, which wander widely after the breeding season. Ospreys, however, are resident near their nesting islands, so I infer that fish on which they prey are low in chlorinated hydrocarbon residues, which suggests that local pollution levels are also low. Comparative studies of species with differing food chains and migration routes are in progress to test this hypothesis.

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Report on Osprey Sightings and Nest Locations in Coastal Mexico and British Honduras

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Abstract: An aerial survey of water birds along the Gulf and Caribbean Coast of Mexico and British Honduras, 23 April-4May 1971, included counts of Ospreys and Osprey nests. Locations for the 78 Ospreys and 48 nests observed during the survey are presented.

In late April and early May 1971, an aerial survey was made along the entire Gulf and Caribbean coasts of Mexico and along the coast and among the cays of British Honduras. The dates of 23 April through 4 May were spent on the actual surveys. The principal purpose of the trip was to determine, insofar as possible, the locations of breeding colonies of wading and sea birds and to gain some idea of the numbers of these species present. This information will be presented elsewhere.

During the flight, notes were kept on observations of individual Ospreys and all Osprey nests observed. Most of the locations were noted directly on charts which were used for navigation (Operational Navigation Chart 1:1,000,000), thus a fairly close approximation of locations is possible.

The aircraft used was a Cessna 206, piloted by C. Eugene Knoder. Observers were Alexander Sprunt, IV and Mrs. Bradley Fisk. During our time in British Honduras, we were joined and greatly aided by Mrs. Dora Weyer of Belize. Her intimate knowledge of that country and familiarity with place names and the terrain was invaluable. Most of the flights were made at an elevation of 200 ft or less. No special effort was made to search for either Ospreys or their nests so that the figures given are certainly minimal and in no sense constitute a careful census.

SURVEY RESULTS

No Ospreys were seen in the Laguna Madre in Tamaulipas. The first birds were seen in the vicinity of a nest a short distance up the Rio Carrizal from its mouth. The nest was in a large tree on the bank of the river and leaning out over the water. Both birds were near but not on the nest, which was empty. This is located about 60 miles north of Tampico.

Moving south from Tampico, we saw one bird in the Laguna de Tamiahua, three near the mouth of the Rio Tuxpan, and another single bird on the Rio Cazones. None of these was associated with a nest and indeed no nests which could have belonged to this species were seen.

South of the city of Vera Cruz one individual was seen near the Laguna de Alvarado. Just east of a rather extensive marsh area around Alvarado is a small group of mountains which reach an altitude of about 6000 ft and are quite close to the coast. We saw no Ospreys or nests along this part of the coast.

From the town of Coatzacoalcos eastward and north around the Yucatan Peninsula, the land is low and there are many lagoons, replaced by salt flats and mangrove lagoons north of Campeche. Ospreys were more numerous along this part of the coast than they had been previously and a total of 17 birds, or 22% of those observed, were seen. They were spaced out over the whole area with 7% of them being seen in and around the large Laguna de Terminos in the state of Campeche. This last region completes the Gulf coast of Mexico with a somewhat arbitrary but ecologically significant break at the border between the state of Yucatan and the territory of Quintana Roo. A total of 25 Ospreys and only a single nest were noted on the Gulf coast.

From the northeastern corner of the Yucatan Peninsula down the entire Caribbean coast of Quintana Roo and British Honduras, the situation with Ospreys changed. In this area we saw 53 Ospreys, 68% of the total.

The first really significant Osprey breeding area that we saw was the Bahia de la Acension. This area is very similar to Florida Bay, Monroe County, Florida, with shallow salt flats, scattered mangrove islands, and an abundance of fish. Nine Osprey nests were seen here. None of the nests was in use and from their appearance it would seem likely that the birds here were on a nesting schedule close to that used in Florida Bay, laying in late fall and fledging the young in early spring. We did not see any obviously young birds in the area.

South of the Bahia de la Acension is Bahia del Espirito Santo. This bay is smaller and deeper than the preceding one and does not seem to be a favorable habitat for Ospreys. Five nests were noted here.

The swampy coastline and extensive shallows of British Honduras, with many small mangrove-covered islands, seems to be quite suitable for Osprey habitat. Again, the similarity of much of the area to Florida Bay or the 10,000 islands in southern Florida was marked. Nests were much in evidence here. We noted six along the coast and in the cays north of the city of Belize and ten to the south, again on both the coast and in the many cays. The most concentrated group of nests seen, however, was located on Turneffe Islands, one of the famous atolls of British Honduras. We found a total of 17 nests in this group.

This probably constitutes the majority of those present as we did a rather thorough search of this group. Unfortunately, we were not able to visit the Chinchorro Bank off the coast of Quintana Roo or Lighthouse or Glovers Reef off British Honduras.

In summary, we observed a total of 78 Ospreys, 25 of them on the Gulf coast of Mexico and 53 on the Caribbean coasts of Mexico and British Honduras. Of 48 Osprey nests observed, only a single one was on the Gulf coast and the remaining 47 on the Caribbean coasts of the two countries.

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U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

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