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LONG-TERM TRENDS IN OSPREY (*Pandion haliaetus*) NESTING POPULATIONS ON LAKE ISTOKPOGA, FLORIDA

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Abstract.—Nesting Ospreys (*Pandion haliaetus*) were censused on Lake Istokpoga, Highlands County, Florida, from 1989 to 2012 to determine their abundance, distribution, and breeding status. A census conducted on the lake in 1910 recorded 75 occupied nests, however, only 9 nests were documented from a similar census conducted in 1973. The recent data, 190 nests (using only those data directly comparable to those of 1910 and 1973), suggest a dramatic recovery of this population greatly surpassing the early historic level. Nesting and foraging habitat availability at Lake Istokpoga has changed little since the early 1950s, thus a plausible explanation for the decline and subsequent increase in breeding Ospreys on Lake Istokpoga is the use of organochloride pesticides (DDT and Aldrin) beginning in the 1950s until their subsequent ban in the mid 1970s. Today, Lake Istokpoga supports one of the largest concentrations of nesting Ospreys in the world, and this may be related to the introduction of the submerged invasive aquatic macrophyte *Hydrilla*. While the decline and recovery of Osprey populations has been reported for many parts of the species range, it has not been reported from Florida. Ospreys continue to be used as an environmental indicator species.

There has been a general decline and recovery of Osprey (*Pandion haliaetus*) populations in various parts of the species' range. Decline has been related to eggshell thinning linked to the accumulation of organochloride pesticides (Ames 1966, Ratcliffe 1967, Hickey and Anderson 1968). Information on long-term trends in the Florida population during this period is limited. Most studies in Florida are relatively recent: Seahorse Key (Szaro 1978), Gainesville (Collopy

1984; Edwards and Collopy 1988; Edwards 1988, 1989 a, b), Sanibel Island (Westall 1983, Phillips et al. 1984), along the Withlacoochee River and at St. Marks National Wildlife Refuge (Reinman 1984), and at Florida Bay (Ogden 1978; Poole 1979, 1982; Kushlan and Bass 1983, Fleming et al. 1989, Bowman et al. 1989).

An exception is Lake Istokpoga, located along the eastern edge of the Lake Wales Ridge, in south-central Florida. Counts of nesting Ospreys conducted here in 1910 (unpublished journal of Donald J. Nicholson; cited in Howell 1932) and 1973 (James N. Layne, unpubl.) indicated a precipitous population decline. Ospreys were again surveyed on Lake Istokpoga from 1989 to 1990 in order to determine the present status of the breeding population on the lake, and censused from 1991 to 2012 to obtain data on reproductive success and establish a long-term data set.

Ospreys are an excellent indicator of environmental health:

- Diet is almost exclusively fish
- Live long lives and exhibit high nest fidelity
- Nests are visible
- Tolerate human disturbances
- Top level predator, tend to bioaccumulate

Sensitive to contaminants; considerable knowledge about contaminant-related effects especially chlorinated hydrocarbons and mercury pollutants

Information on historical and current population trends is presented. Speculation as to the cause of the population decrease from 1910-1973 is analyzed.

Study Area and Methods

Lake Istokpoga (27° 22' N, 81° 17' W) is Florida's fifth-largest lake. It drains an area of 1,572 km^2 and has a surface area of 11,207 ha. The lake is shallow with an average depth of about 1.6 m. There are two primary influents: Josephine Creek, which carries water from over 30 Lake Wales Ridge lakes to the west, and Arbuckle Creek, which drains a large agricultural tract to the north (McDiffett 1978). There are also two small islands: Bumblebee Island (7.2 ha) located near the southern end of the lake and Big Island (40 ha) located near the center on the eastern side. More than half of the shoreline of the lake, and virtually all the shorelines of the two islands, are ringed with bald-cypress (*Taxodium distichum*). The remaining shoreline is bordered either by bayhead (swamp forests dominated by *Magnolia virginiana*, *Persea borbonia*, and *Gordonia lasionthus*), pine flatwoods, residential development, or fish camps. Residential areas and fish camps account for approximately 12 km (23%) of the shoreline. An ever-widening zone of open marsh, composed primarily of cattail (*Typha domingensis*), water hyacinth (*Eichhornia crassipes*), and water-lettuce (*Pistia striatiotes*), surrounds each island and borders most of the lakeshore. The relatively recent invasion of marsh vegetation presumably began when the C-41A canal and the S-68 water control structures permanently reduced the maximum

annual water fluctuation of the lake from 2.1 m to 0.6 m (Florida Fish & Wildlife Conservation Commission, Lake Restoration Section). Hydrilla (*Hydrilla verticillata*), an introduced submerged weed, has been rapidly expanding since its introduction into Lake Istokpoga in 1979. In 1996 for example, hydrilla coverage was estimated at 10,366 ha (FFWCC, Lake Restoration Section).

A survey is defined as a sampling method designed to produce an estimate. A census is defined as an exhaustive count of actual numbers. In 1989 and 1990, Osprey nests were surveyed in late March or early April, one or two days each year. Beginning in 1991 and continuing through 2012, Osprey nests were censused 8-13 times per year between January and June. The entire shorelines (51.5 km) of the lake and the two islands were censused by boat and the location of each nest was plotted on aerial photographs. Most nests were easily observed from the boat, and binoculars and spotting scopes were used to determine nesting status. These techniques replicate the methods of Nicholson (1910) and Layne (1973). Nests not located on the shoreline (i.e., not visible from the water) were not censused until 1995. Although these nests (n=100) are associated with Lake Istokpoga, they are not included in this paper because nests in these locations would not have been censused by Nicholson or Layne.

The terms used here for describing nest activity are based on Postupalsky (1977) as modified by Bowman et al. (1989). An "occupied nest" was a nest with one or two adults on or near a completed nest; an "active nest" was one containing an adult in the incubation posture. Official nesting status was recorded only after the above criteria were met on two occasions at least seven days apart. Nicholson (1910) did not differentiate between active and occupied nests, therefore Nicholson's data as presented in this paper represent the combination of active and occupied nests.

Results

The Ospreys of Lake Istokpoga were first censused in (10 March-18 April) 1910 by D. J. Nicholson who recorded 75 occupied nests along the shoreline and the two interior islands (Howell 1932; pers. exam. of unpublished journal). In 1973 (11 May), J. N. Layne (unpublished data) with the assistance of C. E. Winegarner censused Osprey nests along the entire shorelines of the lake and islands and found only 9 occupied nests and a total of 22 Ospreys. The data from 1989-2012, 200 active plus occupied nests, reveal that the population has increased dramatically since 1973 and is now much higher than the level reported by Nicholson (Fig. 1).

Osprey nests were often located near one another (ca. 10 m apart) in the 1989-2012 censuses. Densities are highest along the southern, northeastern, and eastern shorelines. Nests on the northeastern shoreline are often located in residential areas near houses while the southern shoreline offers more pristine habitat. Analysis of a subset of data from 1995–2000 reveals that the number of nests observed from mid-March to mid-April in any given year (coinciding with Nicholson's 1910 trip) average 98% of the number of nests observed over the entire field season. From 1995-2000 the number of nests visible by boat (occupied + active) in March/April increased from 104 to 178 nests.

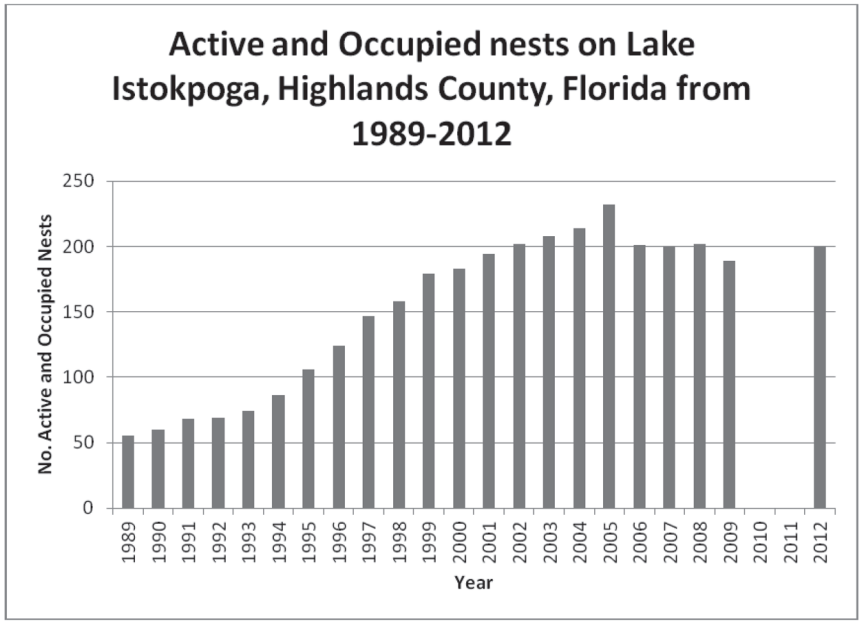

Figure 1. The number of active and occupied nests is displayed by year. For comparison to the Nicholson and Layne surveys, only nests visible by boat are included in these numbers. The additional 100+ active and occupied nests located in 2012 are excluded from this graph.

Discussion

Ogden (1978) speculated that the decline in the number of nesting Ospreys on Lake Istokpoga from 1910 to 1973 was most likely caused by habitat loss. Although a large wooded swamp probably containing some bald-cypress trees, located near the southeastern shore of the lake, and an area around Istokpoga Creek were harvested from the 1940s to the early 1960s to increase agricultural acreage (USDA aerial photos 1940, 1944, 1953), a buffer zone of bald cypress along the lakeshore remains. Cypress trees, which today support the uncommonly large number of Osprey nests, were present as suitable nest sites in the late 1960s and early 1970s when population estimates were low (Glen Tope, J. N. Layne pers. comm.). Therefore, it is unlikely that the low Osprey population of 1973 reflected a lack of suitable nest sites.

Other explanations have been suggested. One of these revolves around permanently altered water levels, resulting from the construction of the C-41A canal and S-68 water control structure in 1962. The persistent annual altered water levels have resulted in the expansion of aquatic vegetation lake-ward, increased vegetation density,

and the formation of floating tussocks. As this vegetated marsh zone expands, less foraging area is available to the Ospreys. The expanding marsh zone is a relatively recent change in the ecological structure of Lake Istokpoga. Additionally, vegetation coverage has increased since the 1973 census by Layne. Therefore, it is unlikely the dramatic decline of Ospreys observed from 1910-1973 at Lake Istokpoga can be attributed to habitat loss.

The most likely cause for the Osprey population decline is the local use of pesticides in the 1950s, 60s and early 70s. During this period, aldrin and toxaphene were used on farms located along the shoreline and most of the Lake Istokpoga watershed (Glen Tope, pers. comm.). Although the effects of aldrin and its main metabolite, dieldrin (four times more toxic than DDT, Milleson 1980) are not fully understood, it has been linked to decreased reproductive success of inland aquatic birds (Faber and Hickey 1973). DDT was sprayed extensively from 1966-1970 in Highlands County, including the Lake Istokpoga drainage area, under a federal program to eliminate the yellow-fever mosquito (*Aedes aegypti;* Dr. Jai Nayars, pers. com.). In 1976, South Florida Water Management District personnel found traces of DDE, the main metabolite of DDT, in sediment samples taken from Lake Istokpoga (Pheuffer 1985). DDT and DDE have been shown to cause lowered reproductive success in Ospreys (Poole 1989). Organochlorines bioaccumulate and reach their highest concentrations among top predators such as the Osprey (Woodwell 1967, Newton 1979). Although Florida ranked lowest of five states tested for DDE, dieldrin, and PCBs (Blus et al. 1977), eggshell thinning in Ospreys has been reported from two locations in Florida (Anderson and Hickey 1972, Szaro 1978). While current evidence is circumstantial (eggshell thickness between 1910 and 1995-1999 are comparable; no data are available from the 1960s-1980s), documentation of the effects of DDT and DDE on higher food-chain organisms suggests dramatic population declines when these chemicals occur in the system. In Florida, DDT/DDE may have adversely affected more than 20 species of birds including Ospreys (Stevenson and Anderson 1994).

I suggest that the most likely cause for the dramatic increase in Osprey numbers on Lake Istokpoga, well beyond historic numbers, began with the accidental introduction of hydrilla in 1979. Hydrilla greatly expanded the littoral-zone of Lake Istokpoga and provided increased structural complexity. Structural complexity of the habitat often reduces predatory efficiency by reducing prey capture rates (Crowder and Cooper 1982) and provides important nursery areas for the fish assemblage (Conrow et al. 1990). While studying macrophytes in Lake Okeechobee, Florida, Chick and McIvor (1994) found the highest density and biomass of fish in hydrilla. The idea that macrophytes can

have a profound effect on fish populations is a widely recognized (Cook and Bergersen 1988, Hinch and Collins 1993, Hosn and Downing 1994, Lyons 1989, Lundvall et al. 1999).

Increases in the structural complexity and fish nursery areas may allow the fish population, at least for some species, to grow beyond natural levels. Artificially high fish populations could explain the rapidly increasing Osprey population. Hydrilla would naturally expand to cover the entire lake; however the State of Florida's aquatic weed control program treated a portion of the lake approximately once every three years. For many years the herbicide Fluridone (SONAR ®) was the chemical of choice. The Fluridone treatment continually represses succession and prevents topped-out hydrilla (huge floating mats which block out all sunlight) from destroying native habitats. More recently, the aquatic weed-control program was forced to change herbicides as hydrilla became resistant to Fluridone. The current herbicide of choice is Aquathol-K and spraying can occur annually.

While increased nutrient loading may account for alterations to fish numbers, growth rates, and species composition, the effects of nutrient loading on fish is unpredictable and may be short-lived (Hasler 1947, Colby et al. 1972, Hayward and Margraf 1987, Carpenter et al. 1998, Turner et al. 1999).

There was a general decline and recovery of Ospreys nesting on Lake Istokpoga. I have presented information on the most probable cause of decline (DDT) and attempted to present plausible alternatives to the hypothesis that habitat loss was the culprit. A hypothesis was developed to help explain the increase in Osprey numbers, well beyond historical values. Despite the cause of decline, today (2012) Lake Istokpoga supports one of the largest concentrations of post-DDT nesting Ospreys in the world with 200 nesting pairs (>300 including all nests associated with Lake Istokpoga; shoreline, islands, and nests not visible by boat and therefore not censused by Nicholson or Layne). Nests are clustered along the southern, northeastern and eastern shorelines and are often found within 10-15 m of each other. The cluster of northeastern nests is located within a residential area. Surprisingly, the two interior islands are nearly devoid of nesting Ospreys. Nicholson recorded at least 20 Osprey nests on the two interior islands in 1910.

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