THE REPRODUCTIVE SUCCESS OF THE HOODED MERGANSER (*Lophodytes cucullatus*) AT MOSQUITO CREEK WILDLIFE MANAGEMENT AREA

by

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ABSTRACT

The goal of this study was to examine factors that influence the reproductive success of hooded mergansers, *Lophodytes cucullatus*, nesting at Mosquito Creek Wildlife Management Area (MCWMA). I examined nesting activities of the hooded merganser at MCWMA from March through July 1998. I collected at least two unincubated hooded merganser eggs from active nests to determine eggshell thickness and organochlorine (OCs) concentrations. My data were compared with an intensive study of nest boxes at MCWMA in 1994 and 1995 and with previous studies and historical collections of eggshells.

The mean eggshell thickness of hooded merganser eggs was 0.605±0.004 mm, 9% thicker than a previous study done in 1981. Based on eggshell thickness, it appears that OCs are not a concern. However, results of this study indicate a population of nesting hens that appear to be stressed by high nest density. An increase in nest box use from 21% (1994-1995) to 33% (1998) was inversely correlated with a decrease in nesting success from 80% (1994-1995) to 69% (1998). In addition, a significant decrease in hatching success was noted from 90% (1994-1995) to 79% (1998) ($p<0.05$) while intraspecific nest parasitism increased from 13% (1994-1995) to 75% (1998). In conclusion, it appears that reproduction in this population of hooded mergansers is being influenced by nest box management, which promotes high density nesting, high levels of parasitism and nest abandonment, and not by external factors, such as environmental contaminants.

ACKNOWLEDGMENTS

Sincerest thanks to my advisor, Courtenay Willis, for her guidance, patience, and encouragement throughout this journey. I thank her for turning my ears and eyes to an avian world I never knew. And I sincerely thank Renee Falconer for all her support and guidance and for giving me a greater appreciation of chemistry. I thank both Courtenay and Renee for not giving up on me.

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I will be forever grateful to my parents for their love and support and giving me the opportunity to attend college. Above all, I thank my husband for all his love, patience, and understanding through my field work and writing.

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INTRODUCTION

The goal of this study was to examine factors that influence the reproductive success of hooded mergansers, *Lophodytes cucullatus*, nesting at Mosquito Creek Wildlife Management Area. My objectives were (1) to compare local organochlorine levels and eggshell thickness with data from previous studies and historical eggshell collections, (2) to correlate the eggshell thickness of unincubated hooded merganser eggs and reproductive success of hooded mergansers using nest boxes, and (3) to determine if nest box parasitism has influenced the nest box use and reproductive success of hooded mergansers at MCWMA over the past five years.

Natural History of the Hooded Merganser

The hooded merganser is a small North American duck in the tribe mergini (Batt 1992). It measures approximately 45 cm in length and 700 g in weight (Bellrose 1976), comparable in size to the wood duck, *Aix sponsa*. It is the smallest of the mergansers. Long, narrow, serrated bills distinguish them as a merganser. Male and female hooded mergansers are sexually dimorphic most of the year (Dugger *et al.* 1994). The male is mostly black and white with a white crest bordered in black. The female is brown with a grayish brown crest. Both sexes have white wing markings on the secondaries and tertials (Gooders and Boyer 1986, Bellrose 1976).

The breeding range of the hooded merganser is found throughout the northern half of the US and southern Canada (Phillips 1986). They are more commonly found in forested areas in the Great Lakes region (Dugger *et al.* 1994). Eastern birds winter mainly in the southeastern United States and western populations winter around northern

California (Bellrose 1976, Root 1988). However, wintering mergansers can be found throughout the entire southern United States, north of Mexico (Bellrose 1976).

Wooded streams, sloughs, and ponds in swamps are habitat preferred by the hooded merganser (Bellrose 1976). However, nests have been recorded in grasslands in man-made boxes in Minnesota (Zicus and Hennes 1988) and in non-forested riparian corridors in North Dakota (Doty *et al.* 1984).

The population size of the hooded merganser is not very well known due to its secretive nature. In 1976, the population was estimated to be around 76,000 individuals (Bellrose 1976). However, due to the 70,000 to 100,000 birds harvested each year by hunters (U.S. Department of the Interior 1988), this is likely an underestimate. Based on harvest numbers, estimates of annual survival, and an assumption of 100% annual mortality due to hunting, estimates lie between 270,000-385,000 birds (Dugger *et al.* 1994). Nest box management may be effective in increasing local hooded merganser populations.

Hooded mergansers are top predators in aquatic ecosystems. They forage visually by diving in clear aquatic habitats, such as forested ponds, rivers, streams, and flooded forest. Their slender serrated bill is used for grasping and handling mobile prey such as fish and aquatic insects (Dugger *et al.* 1994).

Prior to arriving on breeding grounds, hooded mergansers are paired. At Mosquito Creek Wildlife Management Area in northeastern Ohio, hooded mergansers arrive from late February to early March. Shortly after arrival, females begin checking nest boxes and/or tree cavities. They also use pre-excavated cavities, commonly from pileated woodpeckers (*Dryocopus pileatus*) in both living and dead trees within close proximity to water (Morse *et al.* 1969). Nest boxes are typically placed over or near water and are filled partially with wood chips. Nest construction begins with laying. In constructing a nest, no new material is added. A nest bowl is made from materials present in the cavity or nest box and by scratching an indentation.

Hooded merganser eggs are white and almost spherical. Eggs range in length from 51.3 to 56.7 mm, in width from 42.5 to 45.4 mm, and in weight from 51.5 to 62.9 g. They have disproportionately thicker shells compared to other species of ducks. Average eggshell thickness (mean ± standard error) at the equator from 17 states is 0.576 ± 0.007 mm (White and Cromartie 1977).

Hens typically lay one egg every other day. Clutch size ranges from five to twelve eggs (Baicich and Harrison 1997). Final clutch size may be considerably larger if the nest is parasitized. After the clutch is nearly complete, down is plucked to line the nest and cover the eggs. The female incubates for approximately 30 days. The male leaves the female shortly after she begins incubation. The female incubates the eggs, taking two to three breaks throughout the day. About 72 hours prior to hatching, chicks begin tapping and peeping. Thirty to forty-eight hours before hatching, a star shaped crack appears, and 12-24 hours before, the first hole appears. Within 24 hours of hatching, chicks jump off the nest and begin diving and feeding (Dugger *et al.* 1994).

Both intraspecific and interspecific nest parasitism are commonly found in nesting hooded mergansers. Parasitism occurs when a female lays her eggs in the nest of another. Hooded merganser hens will lay eggs in other hooded merganser nests (intraspecific) and will also parasitize the nests of wood ducks (interspecific). Also, interspecific parasitism is common between hooded mergansers, common goldeneye

(*Bucephala clangula*) and common mergansers (*Mergus merganser*) where their breeding range overlaps (Dugger *et al.* 1994).

Factors Influencing Reproductive Success

In a study completed on nest boxes at MCWMA in 1994 and 1995, hooded mergansers were found to be using 21% (15/73) of available nest boxes. Their nest success was 80% (12/15) and hatching success was 90% (151/168) (Willis 1996). Nest success was determined by dividing the number of successful nests by the number of nest attempts. Hatching success was determined by dividing the number of eggs hatched by the number of eggs laid. Both nest success and hatching success are proportions used to determine overall reproductive success. Reproductive success is defined as the proportion of nests that successfully hatch at least one duckling (Dugger *et al.* 1994). This study was used to determine the reproductive success of hooded mergansers using nest boxes at MCWMA and determine if there had been any changes from the 1994-1995 study to 1998. There are two factors that were considered in this study as possible impacts on the reproductive success of hooded mergansers using nest boxes at MCWMA, organochlorine contamination and nest parasitism.

Use of Organochlorines

Organochlorines (OCs) were introduced commercially over 70 years ago as pesticides and polychlorinated biphenyls (PCBs). They are hydrocarbons that have any number of hydrogen atoms replaced with chlorine atoms (Manahan 1994). Organochlorines have similar properties. Because they are resistant to oxidation and hydrolysis, OCs are persistent in the environment, remaining in soils and sediments years after their use has discontinued (Bunce 1994).

Organochlorines are semi-volatile and can be transported great distances in the atmosphere. They are removed from the atmosphere by wet or dry deposition. They have relatively low solubility in water (Bunce 1994). Because they are non-polar, they have a high affinity for sediments which are high in humic matter (Manahan 1997). Due to their lipophilic nature, they have the ability to bioaccumulate in the fatty tissues of individual organisms and biomagnify in the food chain. Bioaccumulation is the uptake and concentration of environmental chemicals by living systems. It occurs when an organism has taken in, by diffusion or ingestion, a chemical, such as an organochlorine, contained in sediment, soil, food, or water. Biomagnification refers to the passage of chemicals up the food chain, from the herbivores to the carnivores or top predators (Manahan 1997). As the chemical passes up the food chain the concentration increases.

The organochlorines of interest in this study were PCBs, DDT (1,1,1-trichloro-2,2-bis-(p-chlorophenyl)ethane), DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene), aldrin (1,2,3,4,10,10-hexachloro-1,4,4α,5,8,8α-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene), dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4α,5,6,7,8,8α-octahydro-1,4-endo,exo-5,8-dimethanonapthalene), heptachlor (1,4,5,6,7,8,8α-heptachlor-3α,4,7,7α-tetrahydro-4,7-methanoindene), and heptachlor epoxide (1,4,5,6,7,8,8α-heptachloro-2,3-epoxy-3α,4,7,7α-tetra-hydro-4,7-methanoindene). These compounds were selected because they are some of the most common contaminants found in ecosystems and are among the most widely studied organochlorines in aquatic systems.

In 1929, PCBs were first commercially manufactured and sold in North America under the tradename of Aroclor (Bunce 1994). The Aroclor products each carried a four digit number in which the first two digits represent the 12 carbon atoms of biphenyl while the percent by weight of chlorine in the mixture was represented by the last two numbers (Bunce 1994). By substituting one to ten chlorine atoms onto the biphenyl structure, 209 different PCB compounds can be formed (Manahan 1994). PCBs were produced for use as dielectric fluids in power transformers and capacitors, plasticizers, de-inking fluids for recycling newspapers, and in production of non-carbon copy paper (Bunce 1994). In 1966, PCB's were first noticed in wildlife and shortly thereafter found to be ubiquitous in the environment (Bunce 1994). The manufacturing, processing and distribution of PCB's were banned in 1976 under the Toxic Substance Control Act (Manahan 1994). The continued use of PCB containing transformers and disposal of PCB waste are two important sources of continued contamination today.

In 1939, Paul Müller discovered DDT's capability as an insecticide (US PHS 1992 a). DDT was sprayed during World War II in the jungles of the Pacific islands and Asia in order to prevent insect-borne diseases such as typhus and malaria (Bunce 1994). Besides being used against typhus and malaria, DDT was used all over the world agriculturally to control insects (Bunce 1994). Its agricultural use thrived because it was cheap, effective, had a low acute toxicity to mammals, and was persistent (Bunce 1994). DDT gets into bodies of water by direct spraying for insects over open waters, from wastes of DDT producers, or with its metabolites, DDE and DDD, through runoff from contaminated soils. In 1972, the EPA banned the use of DDT, except in cases of public health emergencies. It is still produced and used in some Central and South American countries and in India (US PHS 1992 a).

Aldrin and Dieldrin are two structurally similar synthetic compounds used as insecticides. In 1948, aldrin was first introduced as a pesticide (US EPA 1986 a). Once in the environment, sunlight and bacteria readily convert aldrin into dieldrin. For this reason, dieldrin is predominantly found in the environment. These two compounds were primarily used to control corn pests (by treating the soil) and in the citrus industry from 1950 until 1970. Other uses of dieldrin and aldrin included; general crop protection from insects, timber preservation, and termite proofing of plastic and rubber coverings of electrical and telecommunication cables, plywood and building boards. The EPA cancelled all uses of the compounds, except as a termiticide, in 1974, although this use has since been cancelled also (US PHS 1992 b).

In 1952, heptachlor was registered for use as an insecticide in the United States. From 1953 to 1974, heptachlor was applied extensively to soil and seeds to protect corn, small grains, and sorghum from pests. In both cultivated and uncultivated soils it was used to control ants, cutworms, maggots, termites, thrips, weevils, and wireworms. Nonagriculturally, it was also used to control termites and household insects. Heptachlor is broken down to the more toxic heptachlor epoxide in the body of animals and in the environment by bacteria. Both compounds enter surface water from waste discharges of facilities producing heptachlor and from runoff of treated soils. Heptachlor is also a component of the pesticide chlordane and can enter the surface water by the same means (US EPA 1986 b). The EPA cancelled most registered uses of heptachlor in 1974, and as of 1988, sale, distribution, and shipment of heptachlor products were prohibited in the

United States. Currently, heptachlor is only permitted to be used commercially for the control of fire ants in power transformers (US PHS 1992 c).

Organochlorine Impacts on Birds

Ten to twenty years after their initial use, OC residues were discovered in wildlife. Some of the first records of OC residues in wildlife were in birds (Barnett 1950, Mitchell *et al.* 1953). One of the earliest studies looked at the effects of insecticides on game birds, after several reports of dead pheasants in apple orchards in Washington came out. Besides acute fatal toxicity at high concentrations, DDT was found to cause symptoms such as tremors, paralysis, and erratic flight (Barnett 1950). Another early study focused on the concentration of DDT in the food source of affected birds, earthworms (*Lumbricus terrestris*). Shortly after American elms (*Ulmus americana*) were sprayed for Dutch elm disease on the University of Illinois campus, dead and dying American robins (*Turdus migratorius*) were found. Earthworms were concentrating DDT and its metabolite DDE mainly in their crop and gizzard from feeding on leaf litter which had been sprayed. The robins would feed on the contaminated worms, as well as feed them to their nestlings. This resulted in tremors and eventually death to the robins (Barker 1958).

Barkers study led to more studies involving different species at various levels of the ecosystem. OCs were soon found in many different ecosystems and biota with the highest concentrations in top predators (Hunt and Bischoff 1960, Meeks 1968, Korschgen 1970, Niethammer *et al.* 1984). Chlorine-36 ring-labeled DDT was applied to a marsh and traced through an entire wetland system; water, phytoplankton, sediments, aquatic plants, invertebrates, fish, amphibians, reptiles, birds, and mammals. Concentrations of varied at each level depending on diet but in general concentrations tended to se up the food chain (Meeks 1968). Niethammer *et al.* (1984) found similar results ow lakes in northeastern Louisiana. Tertiary consumers (top predators) tended to igher concentrations of OC residues and primary consumers (herbivores) had the levels.

Today, OCs are still of concern due to the great impact they have on various bird tions, especially top predators. Impacts are mainly on eggshell thickness and uction. For example, DDT and its metabolites inhibit calcium deposition in avian s by inhibiting the production of the enzyme, carbonic anhydrase (Friend and r 1970). Carbonic anhydrase is the enzyme which makes calcium from the stream available to the oviduct for deposition of the eggshell (Peakall 1970). By ing this enzyme, resulting eggshells are often too thin to withstand the weight of an ting adult (Molholt 1994). Several field studies of DDT and DDE found a high nce of cracked eggs and eggshell thinning in different species of birds (Ohlendorf 1985, Henny *et al.* 1984, Kiff *et al.* 1979, Hickey and Anderson 1968). In black-ed night-herons, *Nycticorax nycticorax*, when levels of DDE exceeded only 8 ppm , the incidence of cracked eggs increased, resulting in smaller clutch sizes (Henny 1984). To confirm the relationship of DDT and eggshell thinning, studies have lone comparing eggshell thickness prior to and after the widespread use of OCs. In eggshell thicknesses of common and red-breasted mergansers (*Mergus serrator*) compared to pre-1947 museum collections. Eggshells of both species were found to nificantly thinner in 1977 compared to before 1947, (23.5% and 17.7% tively) (White and Cromartie 1977).

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Males spent less time on activities such as nest site selection, wing-flipping, preening, and bow-cooing (Haegele and Hudson 1977).

Susceptibility of Hooded Mergansers

Hooded mergansers are top aquatic predators that consume mostly fish, crustaceans, and aquatic insects (Dugger *et al.* 1994). Due to the ability of their prey to bioaccumulate contaminants, hooded mergansers are at risk of receiving relatively high doses of organochlorines from their food sources (White and Cromartie 1977). Previous studies have investigated organochlorine residues and eggshell thinning in hooded mergansers, as well as in common and red-breasted mergansers. These studies have been conducted in New York, Maine, New Hampshire, Vermont, Michigan, Iowa, North Dakota, Arkansas, Missouri, Tennessee, and Minnesota (Table 1) (White and Cromartie 1977, Zicus *et al.* 1988). These states were divided into three regions: northeast, mid-west, and south central. The lowest levels of organochlorine residues and thickest eggshells were found in the south central region. The highest levels of organochlorine residues and thinnest eggshells occurred in the northeast. Eggshells were found to be 8.3% thinner in a study from 1973-1975 (White and Cromartie 1977) of hooded mergansers from 10 different states than in pre-1927 museum collections. In a 1981 study, eggshells were found to be 9.6% thinner in Minnesota than in years prior to DDT use (Zicus *et al.* 1988).

No studies were found that examined the impact of OCs on hooded mergansers and their eggshell thickness in Ohio. In this study I attempted to determine how hooded mergansers nesting in Ohio compare to the previously mentioned studies in other states.

Table 1. Hooded merganser eggshell thickness comparisons (mean ± standard error) from previous studies and historical collections. A decrease in eggshell thickness is shown from the pre-OC era, through OC use, and after most OCs were banned in the late 1970's.

OC Time Period	Date	Thickness (mm)	Sample Size (#clutches/ #eggs)	Location	Source
Pre-OC	1880–1927	0.628±0.025	6/55	IA, MI, MN, ND, WI	White and Comartie, 1977
During use	Pre-1947	0.614±0.009	?/44	WI	Faber and Hickey, 1973
During use	1970	0.599±0.017	?/11	WI	Faber and Hickey, 1973
During use	1973-1975	0.576±0.005	28/174	IA, MI, MN, ND, WI	White and Comartie, 1977
Post OC	1981	0.568±0.007	21/70	MN	Zicus et al. 1988

Occurrence of Nest Parasitism

Nest parasitism, also called brood parasitism, occurs when a hen lays her eggs in the nest of another. When they are laid in the nest of the same species it is called intraspecific nest parasitism. When eggs are laid in the nest of a different species it is called interspecific nest parasitism. Nest parasitism, both intraspecific and interspecific, is a common occurrence in cavity nesting waterfowl such as hooded merganser, wood duck, and common goldeneye (Morse *et al.* 1969, Semel *et al.* 1988, Andersson and Eriksson 1982, Bouvier 1974).

Nest parasitism appears to impact reproductive success of waterfowl using nest boxes. At Max McGraw Wildlife Foundation, Illinois, a significant decrease was found in hatching success between 1976 and 1987 in wood ducks using nest boxes. A significant increase in intraspecific nest parasitism was inversely correlated with the decrease in hatching success (Semel *et al.* 1988). In natural conditions, such as tree cavities, normally parasitism tends to be less frequent and hatching success tends to be greater. Bellrose and Holm (1994) found hatching success to be 94% and intraspecific nest parasitism to be 12% for wood ducks in natural nest cavities. In comparison, the hatching success of wood ducks using nest boxes at MCWMA was 86% and intraspecific nest parasitism was 98% (Willis 1996). Interspecific nest parasitism also tends to have an impact on reproductive success. Doty *et al.* (1984) found a decrease in hooded merganser and wood duck nest success in nests where interspecific nest parasitism (what they called dual nests) occurred. Hooded merganser nest success was 73%, wood duck nest success was 79%, and dual nest success was 65%.

A possible explanation for the increase in nest parasitism in waterfowl using man made nest boxes may be the density and visibility of the nest boxes. Semel *et al.* (1988) tested this by comparing wood duck nests that were visibly isolated, visibly clumped, and well-hidden. Hatching success of well-hidden nests was 82.0% and visibly isolated and visibly clumped nests were 73.7% and 74.1%, respectively. Parasitism was only 30% in well-hidden nests and 50% for visibly isolated and clumped nests, combined. Overall the study showed that hatching success was inversely correlated with population density, frequency of parasitism, and clutch size. Some of the negative impacts found due to parasitism were nest abandonment, damaged eggs, and eggs laid after incubation began (Semel *et al.* 1988).

In 1994-1995, intraspecific nest parasitism of hooded mergansers nesting at MCWMA was only 13% (2/15) and interspecific nest parasitism by wood ducks was 80% (12/15) (Willis 1996). This study attempted to determine if there had been a change in nest parasitism of hooded merganser using nest boxes at MCWMA and if there was an impact on their reproductive success.

METHODS

Null Hypotheses

This study was designed to test the following null hypotheses:

1. Eggshell thicknesses of hooded merganser at Mosquito Creek Wildlife Management Area do not differ from eggshell thicknesses of historical collections.
2. Eggshell thicknesses of hooded mergansers at MCWMA do not differ from eggshell thicknesses of previous studies.
3. The reproductive success in the hooded merganser from this study does not differ from the reproductive success in 1994 and 1995 at MCWMA
4. Eggshell thickness does not correlate with reproductive success of hooded mergansers at MCWMA.
5. Organochlorine concentrations of hooded mergansers at MCWMA are not greater than concentrations from previous studies.

Study Site

I conducted this study on Eagle Marsh and Wood Duck Marsh at Mosquito Creek Wildlife Management Area in Trumbull County, Ohio (Fig. 1). The northern tip of the Mosquito Creek Reservoir is located in the wildlife management area. The rest of the reservoir extends south into Mosquito Creek State Park between State Route 88 and 305. The West side of Eagle Marsh, which is divided by North Park Avenue, is 13 ha in size and contained nine nest boxes (Fig. 2). Wood Duck Marsh, which is located on State

Figure 1. Location of study site at Mosquito Creek Wildlife Management Area in Trumbull County, Ohio.

Mosquito Creek Wildlife Management Area

Trumbull County

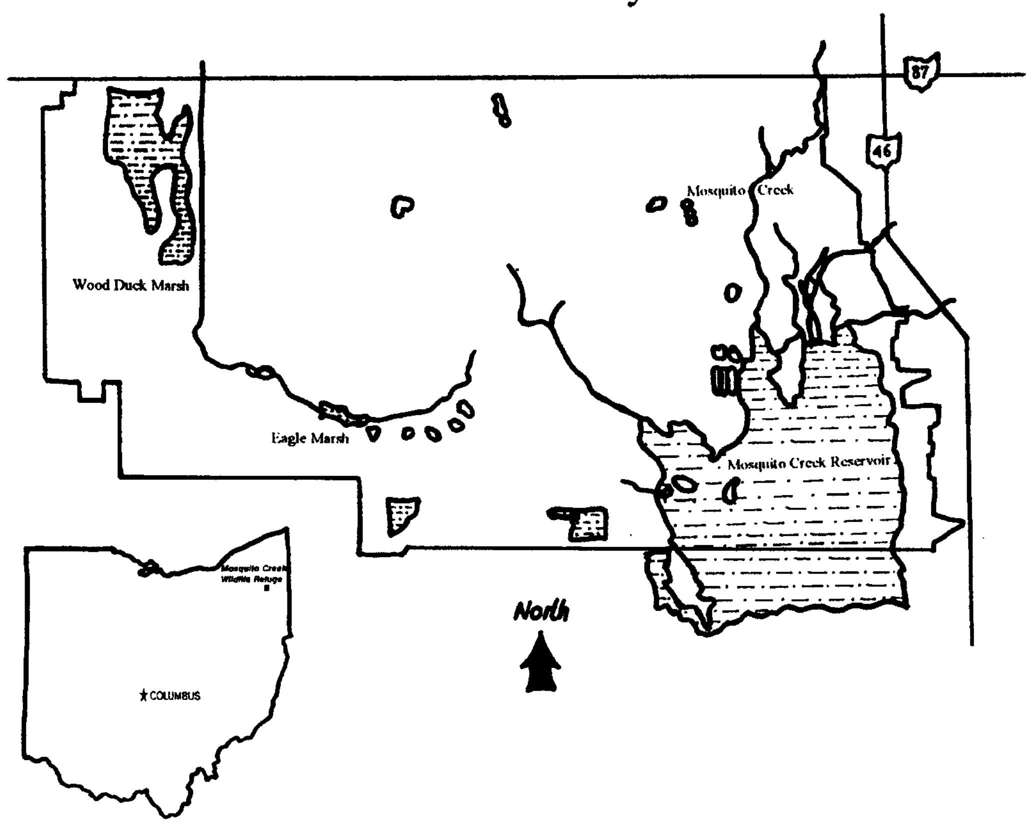
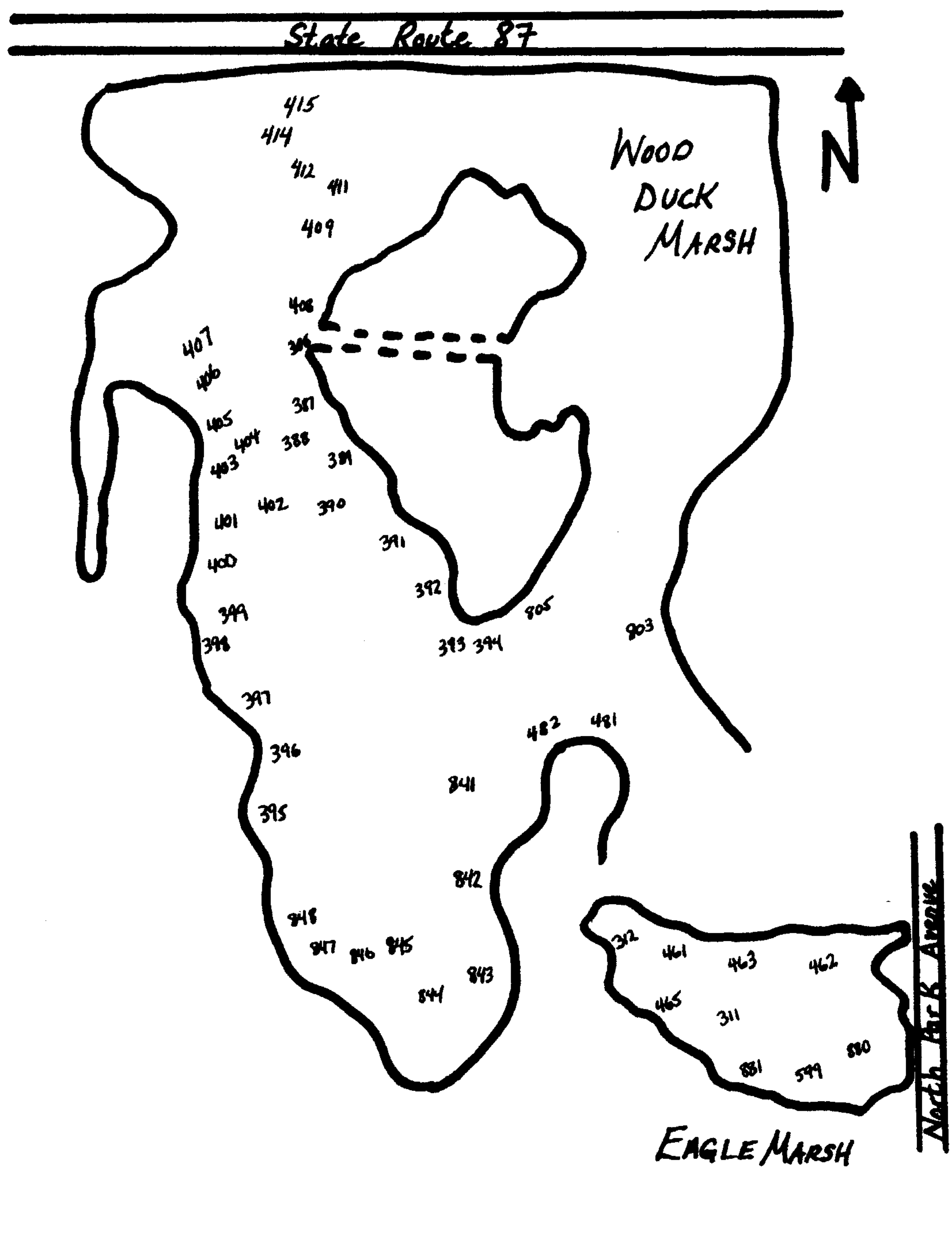


Figure 2. Location of nest boxes used for this study at Eagle and Wood Duck Marsh.


State Route 87
Wood Duck Marsh
Eagle Marsh
North Park Avenue
N

Route 87, approximately one mile east of State Route 45, is 113 ha in size and contained approximately 58 nest boxes, 40 of which were used in this study (Fig. 2). The majority of the nest boxes are old fiberglass water softener cylinders placed 1 to 2 m directly above the surface of the water on predator proof posts. A few nest boxes consist of old metal rocket boxes, which are aluminum cylindrical structures with a pointed top. I selected these study sites for two reasons: (1) at least 20 pairs of hooded mergansers were known to use these nest boxes in the past five years (Willis 1996 and ODNR-DOW nest records 1992-1996), and (2) close proximity to Youngstown State University allowed for intensive nest box checks.

Behavioral Observations

From February 26 until March 22, 1998, I made behavioral observations on Eagle Marsh. Every other morning from 0700 until 0930 h, I recorded visits to nest boxes by hooded mergansers and wood ducks. These observations were made in order to document first nesting attempts of the season by hooded mergansers and by wood ducks. Observations were made from my vehicle parked on North Park Avenue using a spotting scope and binoculars.

Nest Box Checks

Permits were obtained from the US Fish and Wildlife Service and the Ohio Department of Natural Resources (ODNR), Division of Wildlife to conduct research at MCWMA. Beginning on March 24, 1998, I monitored the nesting activities of hooded mergansers and wood ducks. Johnboats provided by Ohio Department of Natural

Resources, Division of Wildlife (ODNR-DOW), and a canoe provided by YSU Department of Biology were used to access nest boxes. I checked nest boxes after 1200 h, in order to avoid disturbing females during the egg-laying stage. It generally took one hour to check nest boxes on Eagle Marsh and three hours to check nest boxes on Wood Duck Marsh. During each nest visit, I recorded the number of hooded merganser eggs and wood duck eggs. I numbered each egg from each species with a *Sharpie* marker on the blunt end of the egg before placing it back in a box. If eggs from both species were present in the same box, I numbered them separately. I measured the length and width of all hooded merganser eggs with *Mitutoyo* calipers to the nearest 0.02 mm and weighed them with a *Pesola* scale to the nearest 0.5 g. Once a female began incubating, her nest box was not checked for three weeks in order to minimize the risk of abandonment. After three weeks, I visited each nest box to record final clutch size in order to estimate hatching success.

Collection of Samples

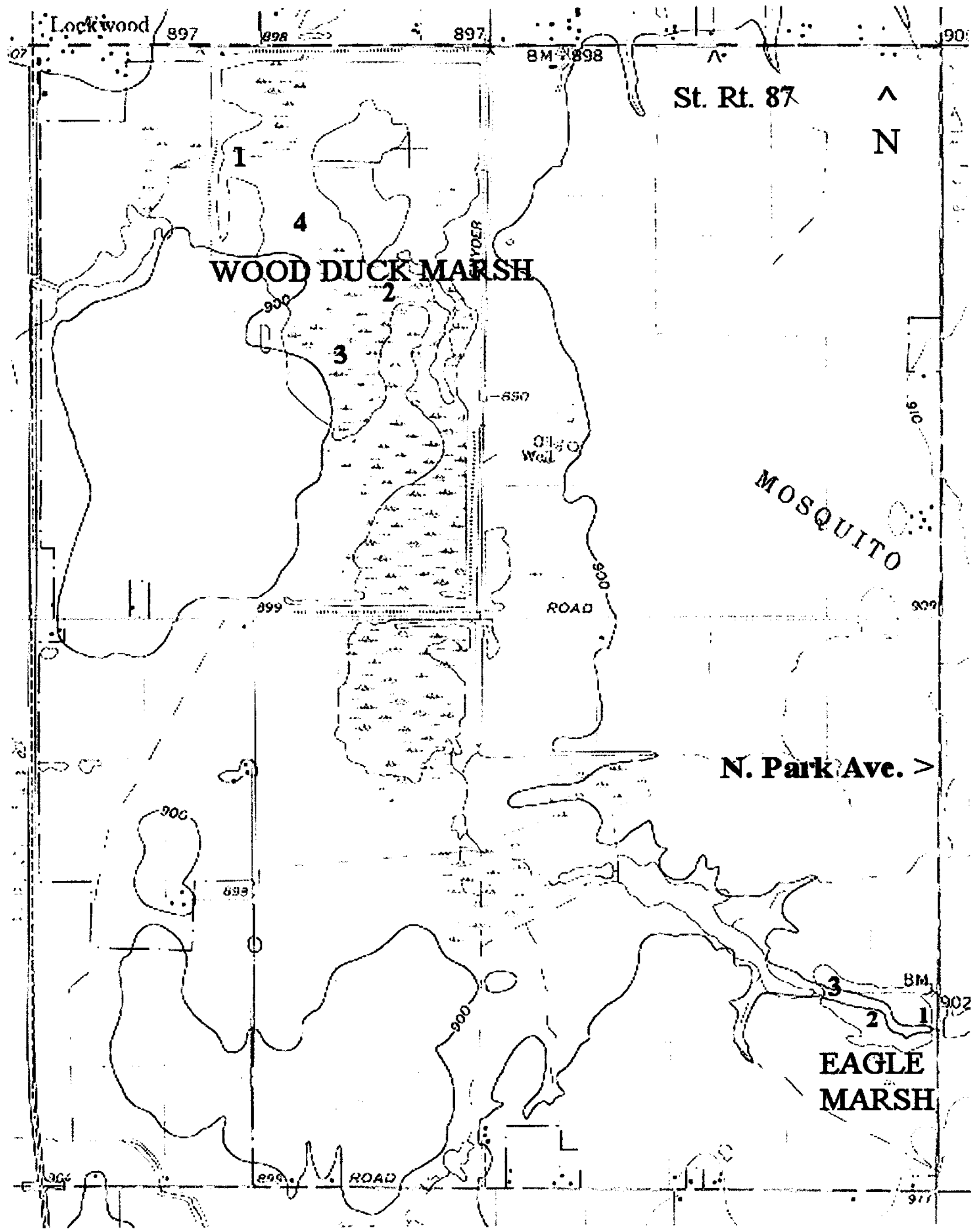
I randomly removed two unincubated hooded merganser eggs (Zicus *et al.* 1988) from each active hooded merganser nest, one egg per nest visit. One egg was removed early in the egg laying stages and one late in the laying stage in order to minimize bias towards either end of the laying period. Active hooded merganser nests contained at least five hooded merganser eggs that were laid at a rate of one egg per two days. Any parasitic hooded merganser eggs were removed from active wood duck nests after seven wood duck eggs were laid. Abandoned hooded merganser eggs were also collected from nest boxes. A previously active nest was considered to be abandoned if a full clutch, between five and twelve eggs, had been laid but never incubated. Abandoned eggs were collected during the first week of May in order to allow another hen to nest in the box. Three entire clutches were removed from three different nest boxes to account for within clutch variation (Zicus *et al.* 1988). One clutch from Eagle Marsh, containing 12 eggs, was removed from an abandoned hooded merganser nest that was parasitized by at least one other hooded merganser hen. The other two clutches were collected from Wood Duck Marsh. The first clutch, containing 10 eggs, was removed from an active wood duck nest, which was being parasitized by at least one hooded merganser hen. The second clutch removed was from an abandoned nest, which contained 12 eggs, and was also parasitized by at least one hooded merganser hen. Five eggs were collected from a drop nest as well. A drop nest is a nest containing less than five eggs that was never incubated. All collected eggs were stored at 5°C until further analysis.

Water and sediment samples were collected from four random locations on Wood Duck Marsh on July 7, 1998 (Fig. 3). Samples were collected from Eagle Marsh at three random locations on September 1, 1998 (Fig. 3). Water samples were collected in pre-cleaned 4-L amber solvent jugs. One 4-L jug was filled per sample location. Water samples were stored at °5C until further work up. Sediment samples were collected at the same locations as the water samples using a core-sampling device. Core samples were frozen upright at -15°C in plastic tubes until extraction and work-up.

Egg Analysis

Prior to processing each egg, I remeasured its length, width, and weight and measured the volume by water displacement (White and Cromartie 1977). I cut each egg

Figure 3. Topographic map of study site at MCWMA. Numbers on each pond indicate the location of water and sediment samples.



Lockwood
St. Rt. 87
^
N
WOOD DUCK MARSH
1
2
3
4
MOSQUITO
ROAD
N. Park Ave. >
EAGLE
MARSH
3
2
1

open near the equator with a scalpel, placed the contents in a four-ounce pre-cleaned jar, and froze it at -15°C until analysis. Eggshells with membranes were air dried at room temperature for at least 30 days (White and Cromartie 1977). Using a *Starrett T216RL* micrometer with ball attachments, eggshell thickness was measured to the nearest 0.001 inch at three random spots near the equator to obtain a mean thickness. The mean thickness in inches was then converted to mm. The eggshells were also weighed using a *Denver Instruments M 120* scale measuring to 0.0001 g.

Egg contents were homogenized with a *Brinkmann Homogenizer*. Four to 9 eggs were pooled together based on eggshell thickness, which resulted in 12 samples (A-L). Approximately 5 g of each egg were pooled together and approximately 10 g of the pool were removed for work-up. Sodium sulfate was mixed with the 10 g sample to dry the egg and spiked with 50 µL of d_6-αHCH (deuterated alpha-hexachlorocyclohexane) (0.1ng/µL). The egg was then placed in a pre-cleaned cellulose thimble and Soxhlet extracted for 7 h in dichloromethane (White and Cromartie 1977). The extract was reduced to 10 mL using rotary evaporation.

Prior to placing the 10 mL sample on a clean-up column, % lipid was determined for each of the 12 samples. One mL of the sample was placed in a pre-cleaned beaker, weighed, and left out to air dry over night (approximately 24 h). The beaker was reweighed the next day. Percent lipid was determined using the calculation found in Appendix B from Patuxant Wildlife Research Center.

A clean-up column, to remove lipids, used 15 g Florisil (2% water added) topped with approximately half an inch of Sodium Sulfate. The column was cleaned with 45 mL of hexane. The 10 mL sample was placed on the column and eluted 6 mL of 6% ethyl ether in hexane. The sample was reduced and solvent exchanged into 1 mL of iso-octane under a gentle stream of nitrogen.

Blanks and duplicates were run with every other set of samples as quality assurance and went through the same work up as samples.

Six organic chicken eggs were used as quality control to make sure the procedure for extraction worked. Three were spiked with 100µL of a pesticide mixture (20ng/µL for each pesticide) and three were spiked with 100µL of Aroclor 1268 (10.5ng/µL). These controls went through the same work up as samples.

Water Analysis

Each water sample was filtered through a 47 mm *Whatman* glass fiber filter (grade GD1UM) to remove suspended organic matter. Filters were cleaned by baking in a *Thermolyne Muffle Furnace* at 450°C for 24 h and individually stored in pre-cleaned aluminum foil. Each of the 4-L water samples were spiked with 10 µL of PCB 103 (729 ng/µL). Water samples were placed in a pre-cleaned stainless steel canister which was pressurized by nitrogen to force the water through the filter. The filtered water was extracted with a *Varian* 1 g *Mega Bond Elut* C8 solid phase extraction cartridge, to collect the organochlorine compounds. The volume of the water extracted was measured and cartridges were wrapped in aluminum foil, sealed in plastic bags, and stored at -15°C.

Before extraction, cartridges were allowed to thaw for approximately an hour. Ten mL of hexanes were pushed through the cartridge, reduced and solvent exchanged into 2 mL of iso-octane under a gentle stream of nitrogen. A clean-up and fractionation column was made with 3 g Silicic Acid (3% water added) followed by 2 g Alumina (6%

water added) and topped with approximately an inch of Sodium Sulfate. The column was cleaned with 30 mL of dichloromethane (DCM) and 30 mL of petroleum-ether (PE). The sample was placed on the column and eluted in two fractions. Fraction 1 (F1) was eluted with 30 mL PE and contained PCBs and some DDE. Fraction 2 (F2) was eluted with 30 mL DCM and contained the remaining OC pesticides. Both fractions were reduced and exchanged into 2 mL iso-octane with nitrogen. 200 μL were removed from F_2 and stored in microvials for analysis of heptachlor epoxide and dieldrin. The remaining F_2 and all F_1 were cleaned with 1 mL sulfuric acid before analysis.

Blanks and duplicates were run with every other set of samples as quality assurance and went through the same work up as samples.

Sediment Analysis

Core samples were removed from the freezer and water was run over the surface of the plastic tube for approximately five min to loosen the sediment. Layers were sliced into sections approximately 10 mm thick using a circular saw with a pre-cleaned carbide blade. Slices were placed into pre-cleaned sixteen-ounce jars and placed back in the freezer until work-up.

Sediment samples were freeze dried for approximately 4 days and weighed. Dried sediment was placed directly in cellulose thimbles and Soxhlet extracted for at least 12 h in DCM. The extracted sample was reduced to 10 mL using rotary evaporation and cleaned using the Florisil column described above. The sample was reduced and solvent exchanged into 1 mL of iso-octane using nitrogen.

Blanks and duplicates were run with every other set of samples as quality assurance and went through the same work up as samples.

GC Analysis

Quantitative analysis was carried out with a *GC Varian Star 3400CX* gas chromatograph equipped with an electron capture detector (GC-ECD) using a DB-5 column (60 m, 0.25 mm i.d., 0.25 μm film thickness; J&W Scientific). Samples were injected splitless (split opened after 1.0 min) at an initial temperature of 90 °C. After a 1-min hold, the oven was ramped at 10 °C min^{-1} to 160 °C, 2 °C min^{-1} to 240 °C, 20 °C min^{-1} to 270 °C, and held for 10 min. Injector and detector temperatures were 250 °C and 300 °C, respectively. The carrier gas was hydrogen at 60 cm s^{-1}. Samples were quantified versus 4-8 standards that spanned a 1000-fold concentration range.

Statistical Analysis

I estimated the reproductive success of hooded mergansers at Eagle Marsh and Wood Duck Marsh. Reproductive success is the proportion of nests that successfully hatch at least one duckling (Dugger *et al.* 1994). Data from each successful nest was used to calculate means and standard error (SE) for total clutch laid, clutch size at hatch, and number of ducklings leaving the nest (Zar 1996). From this data proportionate measures were also calculated: nest box use (number nest attempts/ number of boxes available), nest success (number of successful nests/ number of nest attempts), hatching success (number of eggs hatched/ number of eggs laid), nest abandonment (number of nests abandoned/ number nest attempts) and nest predation (number of nests predated/

number of nest attempts). Intraspecific and interspecific nest parasitism for both hooded merganser and wood ducks was calculated. Data from drop nests were not used in any reproductive success calculations. Only eggs present in the nest box at the time of hatching were used to calculate hatching success. Two-way contingency tables were used to compare reproductive success of hooded mergansers between this study and a 1994-1995 study (Willis 1996 and Zar 1996).

I also estimated reproductive success and intraspecific and interspecific nest parasitism of wood ducks nesting at MCWMA using the proportionate measures above. Two-way contingency tables were used to compare reproductive success of wood ducks between this study and a 1994-1995 study (Willis 1996 and Zar 1996).

Means and standard errors (SE) were calculated for egg length, egg weight, egg mass, eggshell weight, eggshell thickness, and the Ratcliffe thickness index (Zar 1996). The Ratcliffe thickness index is used to determine eggshell thickness while taking variation of egg size into account (Ratcliffe 1967). It is calculated by dividing the weight of the eggshell (mg) by the product of the length and width of the egg (Ratcliffe 1967). To correlate hooded merganser reproductive success with mean eggshell thicknesses, the Spearman's rank correlation was used (SPSS 1998).

RESULTS

Behavioral Observations

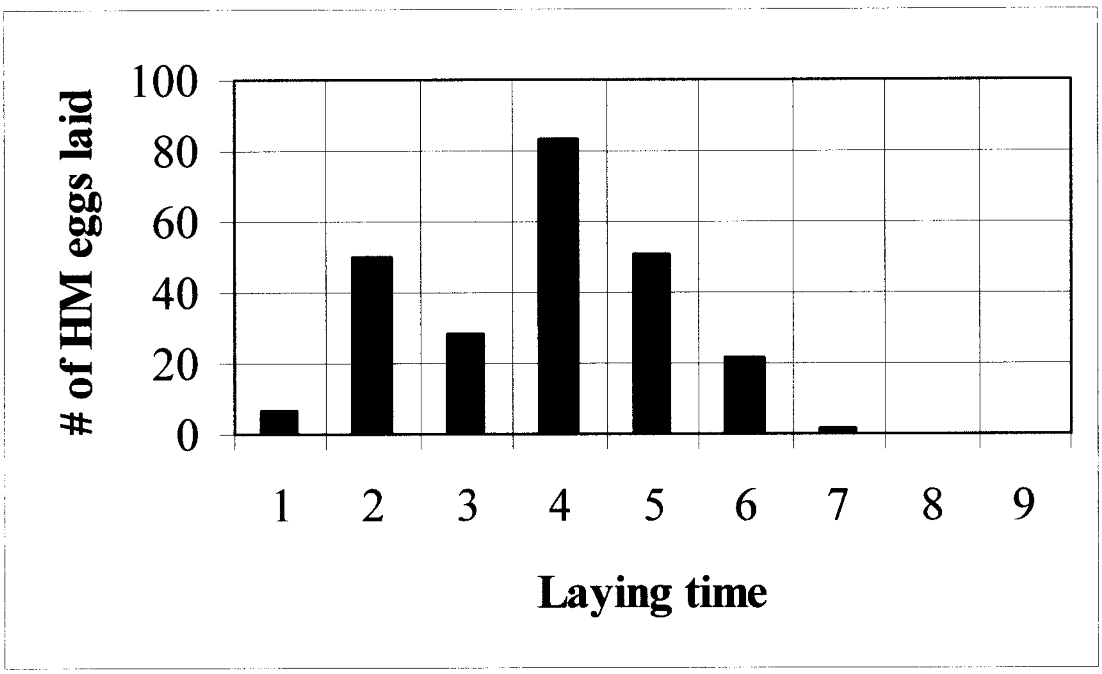
At least one pair of hooded mergansers was at Eagle Marsh on the first day of observations, February 26, 1998. I observed the female of the pair checking one nest box for approximately 2 min. Approximately a week later another pair was spotted on the pond along with 3 single males. By March 15, there were at least 17 hooded mergansers on Eagle Marsh. Nest box checking was not observed by hooded mergansers again until March 7 and 17. After March 17 nest box checking by hooded mergansers was observed regularly.

The first pair of wood ducks was observed on Eagle Marsh on March 7, 1998. I observed the male of this pair checking a nest box. He appeared to be trying to get the female to go into the box he had checked by displaying, circling, and looking at the nest box. Wood ducks were not observed checking nest boxes again until March 17. After that date only females were observed entering the nest boxes.

Laying Chronology

Female hooded mergansers began laying eggs at Mosquito Creek Wildlife Management Area approximately March 24, 1998. Seven eggs were found in a single nest box on Wood Duck Marsh with the first box check. Nest boxes were checked for 78 days, from 24 March to 9 June 1998. The first wood duck egg was found on Eagle Marsh on March 26. Mergansers had a peak of laying during the first ten days of nest box checks and a second peak around day thirty (Fig. 4). Wood ducks had one peak around

Figure 4. Chronology of hooded merganser egg laying at MCWMA. Time 1 = March 24, when first eggs were found. Each block represents 10 days with the first block starting at 1.



100
80
60
40
20
0
# of HM eggs laid
1
2
3
4
5
6
7
8
9
Laying time

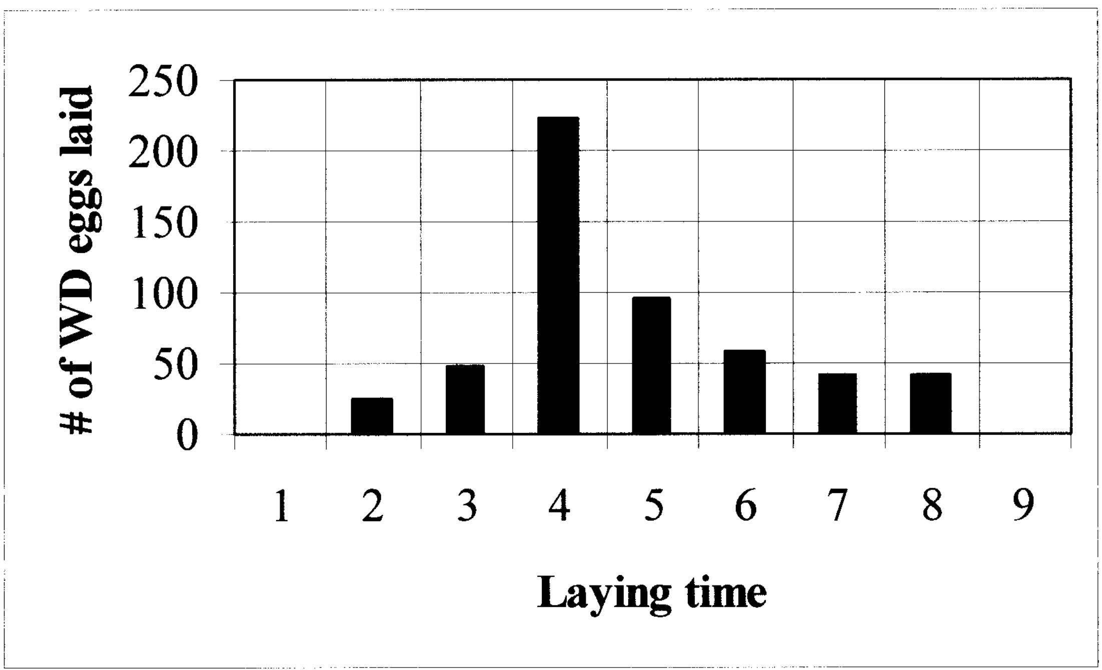
day thirty, which gradually tapered off (Fig. 5). The last recorded hooded merganser egg was laid approximately 15 May 1998 and the last wood duck egg was laid approximately 30 May 1998. There was a total of 258 hooded merganser eggs laid and 594 wood duck eggs laid. Of the 258 hooded merganser eggs, 243 (94%) were used to determine the laying chronology. To determine wood duck laying chronology, 532 of 594 (90%) eggs were used. Eggs laid during the three week incubation period, when nests were not checked, were not used to determine laying chronology.

Egg Parameters

During the study, hooded merganser eggs were measured in 30 nest boxes and were collected from 25 of those boxes. On average, two eggs were removed from each of those 25 nests. One dump nest was collected that contained 5 eggs. Three full clutches were removed from three different nests. Two clutches were removed from abandoned nests and the other was removed from a wood duck nest that was being parasitized by at least one hooded merganser hen (10 total eggs). One of the abandoned nests was collected from Wood Duck Marsh (12 eggs) and the other was collected from Eagle Marsh (12 eggs). Parasitic hooded merganser eggs found in wood duck nests were also collected.

Of 258 hooded merganser eggs laid during this study, field data was recorded for 238 eggs (length, width, and mass). Eggs that were laid during the three week incubation period were not measured. There were also additional eggs that inadvertently did not have any measurements recorded. The mean length and SE was 54.1±0.1 mm (range: 50.54 - 59.78 mm). The mean width and SE was 44.1±0.1 mm (range: 41.15 - 47.93

Figure 5. Chronology of wood duck egg laying at MCWMA. Time 1 = March 24 when first when first eggs were found. Each block represents 10 days with the first block starting at 1.


250
200
150
100
50
0
# of WD eggs laid
1
2
3
4
5
6
7
8
9
Laying time

mm). The mean mass and SE was 61.6±0.3 grams (range: 46.5 - 84.0 g) (Appendix A, Table 6).

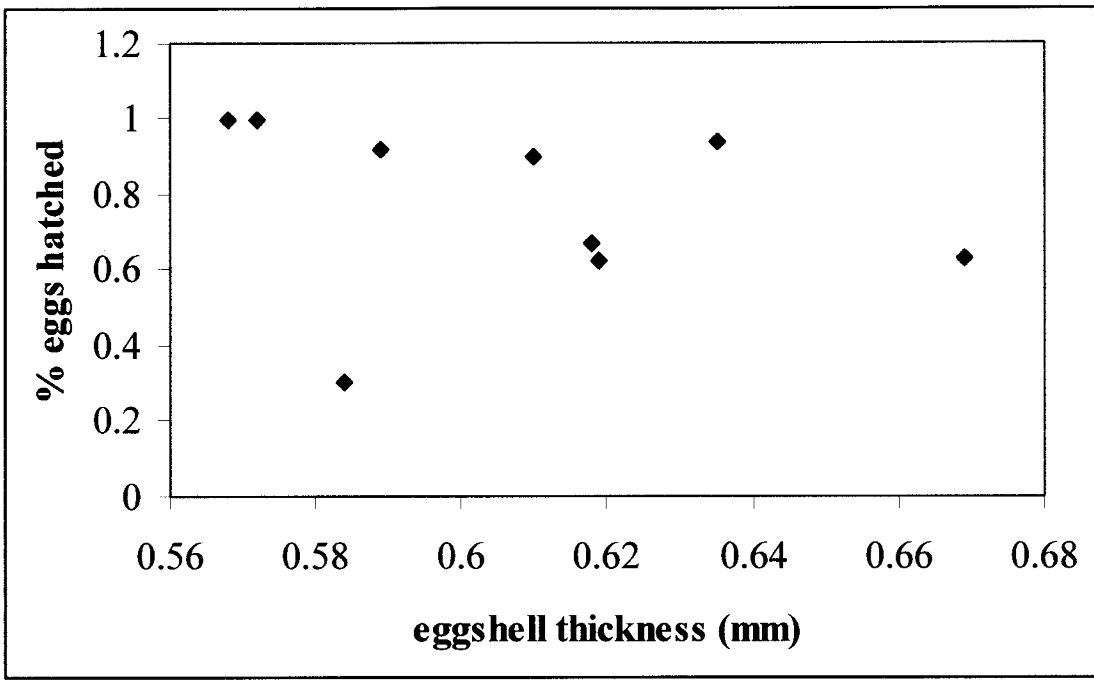
Eighty-three eggs were collected and used in lab analysis. The means and SE for those 83 eggs include; 54.1±0.2 mm in length, 44.3±0.1 mm in width, 62.5±0.5 g in mass, 9.76±0.08 g in eggshell mass, 0.605±0.004 mm in eggshell thickness, and a Ratcliffe Index of 4.069±0.028 (Appendix A, Table 6 and 7). Eggshell mass ranged from 6.8855 - 11.4362 g. Eggshell thickness ranged from 0.483 - 0.669 mm. The Ratcliffe Index ranged from 3.083 - 4.589.

Of 14 represented clutches, 9 of those nests were successful. Spearman's rank correlation was used to determine if there was a correlation between reproductive success of hooded mergansers and eggshell thickness (Figure 6). The correlation coefficient (r_s) was 0.444 and found not to be significant (SPSS 1998).

Nest Box Summaries

During this study, hooded mergansers attempted to use 16 of the 49 available nest boxes (33%) at Eagle Marsh and Wood Duck Marsh which appeared to be an increase from 1994-95 (21%) (Willis 1996). Eleven nests were successful (69%) and hatched at least one duckling. This appeared to be a slight decrease in nest success from 1994-95 at 80% (Willis 1996). There was a significant decrease in hatch success from 90% in 1994-95 (Willis 1996) to 79 % (116/147) in 1998 (P <0.05). Two nests were abandoned (13%) after 12 eggs had been laid. One nest was predated (6%) after 11 eggs had been laid. Two additional nest attempts were made in nest boxes where wood ducks had already started a nest. The two nest boxes were located next to each other. Both hooded

Figure 6. Correlation between reproductive success of hooded mergansers and eggshell thickness at MCWMA. Reproductive success was determined from the % ducklings that hatched in successful nests (# eggs hatched/# eggs laid). The correlation coefficient (r_s) was 0.444, P=0.232 (SPSS 1998).



1.2
1
0.8
0.6
0.4
0.2
0
% eggs hatched
0.56
0.58
0.6
0.62
0.64
0.66
0.68
eggshell thickness (mm)

merganser and wood duck hens laid full clutches in both of these boxes. Both, however, were initiated and incubated by a wood duck. Only one drop nest was recorded during this study, which contained 5 eggs. A summary of nest box activities can be found in Table 2. A summary of the fate of nests can be found in Table 9 (Appendix A).

Clutch size for successful hooded merganser nests was 15.1±1.5 (mean±SE). For non-parasitized and parasitized successful nests, clutch sizes were 10.5±1.9 and 17.7±1.2, respectively. Mean and SE for clutch size at time of hatch in successful nests was 13.4±1.3. Clutch sizes at time of hatch for non-parasitized and parasitized nests were 9.3±1.7 and 15.7±1.2, respectively. The mean and SE for number of ducklings leaving successful nests was 10.5±1.2. In non-parasitic and parasitic successful nests the mean number of eggs hatched were 7.0±0.9 and 12.6±1.3 (mean±SE), respectively. A summary of means and SE of hooded merganser nesting activities in successful nests can be found in Table 3.

The first hooded merganser clutch hatched on May 8, 1998. Twelve chicks were observed in nest box 390 on that visit. Box 389 may have hatched off a day or two earlier than that. On May 8, there were only 5 unhatched eggs and one dead chick out of 20 eggs left in box 389. Only one clutch had not hatched by June 7, 1998. By final box inspection on July 1, all clutches had hatched.

Wood ducks attempted to use 37 of the 49 available nest boxes (76%) at Eagle Marsh and Wood Duck Marsh, which was an increase from 1994-95 (64%) (Willis 1996). Nineteen nests were successful (24%) and hatched at least one duckling in 1998. This appeared to be a decrease in successful nests from 1994-95 (47%) (Willis 1996). Hatch success also appeared to slightly decrease from 86% in 1994-95 (Willis 1996) to

Table 2. Summary of hooded merganser nest box activity at MCWMA. The data from this study was compared to a study done in 1994 and 1995 on the same ponds using 2x2 contingency tables (Willis 1996).

	1994-1995	**1998**	***P**
% Nest box use	21 (15/73)	33 (16/49)	NS
% Nest success	80 (12/15)	69 (11/16)	NS
% Hatch success	90 (151/168)	79 (116/147)	<0.05

*Chi square analysis
NS = not significant

Table 3. Summary of means and standard error of successful hooded merganser nests at MCWMA. Means and standard error are also shown for parasitized (intraspecific) and non-parasitized hooded merganser nests for comparison.

Means	**All successful nests**	**Non-parasitized nests**	**Parasitized nests**
Parasitic eggs in successful nest boxes	4.2±1.4		
Clutch size for all eggs laid in successful nest boxes	15.1±1.5	10.5±1.9	17.7±1.2
Clutch size for eggs in successful nests prior to hatch	13.4±1.3	9.3±1.7	15.7±1.2
Number of ducklings leaving nests	10.5±1.2	7.0±0.9	12.6±1.3

81% (261/324) in 1998. Eight nests were abandoned (22%) and ten nests were predated (27%). There were no drop nests found for wood ducks during this study. A summary of wood duck nest box activities can be found in Table 4.

One wood duck clutch hatched around May 16. Ten unhatched eggs out of 24 were found in a box on Eagle Marsh during that visit. Several wood duck clutches continued to hatch after June 7.

Parasitism

The mean number of parasitic hooded merganser eggs laid in all successful nests was 4.2±1.4 (mean±SE). In the 7 parasitized nests the mean number of parasitic hooded merganser eggs was 6.6±1.5. Intraspecific nest parasitism in successful nests for hooded mergansers significantly increased from 13% in 1994-95 (Willis 1996) to 75% (12/16) in 1998. However, interspecific nest parasitism in successful hooded merganser nests by wood ducks significantly decreased from 80% in 1994-95 (Willis 1996) to 44% (7/16) in 1998 (Figure 7). Interspecific nest parasitism in successful wood duck nests by hooded mergansers was 43% (16/37). That was a significant decrease from 98% in 1994-95 (Willis 1996). Intraspecific nest parasitism for successful wood duck nests did not appear to change from 1994-95 (47%) (Willis 1996) to 1998 (43%). Intraspecific and interspecific nest parasitism of hooded mergansers and wood ducks is summarized in Table 5.

Table 4. Summary of wood duck nest box activity at MCWMA. The data from this study was compared to a study done in 1994 and 1995 on the same ponds using 2x2 contingency tables (Willis 1996).

	1994-1995	**1998**	***P***
% Nest box use	64 (47/73)	76 (37/49)	NS
% Nest success	47 (22/47)	24 (19/37)	NS
% Hatch success	86 (249/290)	81 (261/324)	NS

*Chi square analysis
NS = not significant

Figure 7. Interspecific nest parasitism of an active hooded merganser nest at MCWMA. Hooded merganser eggs are white, considerably larger, and more spherical than wood duck eggs, which are beige, smaller, and more elliptical.

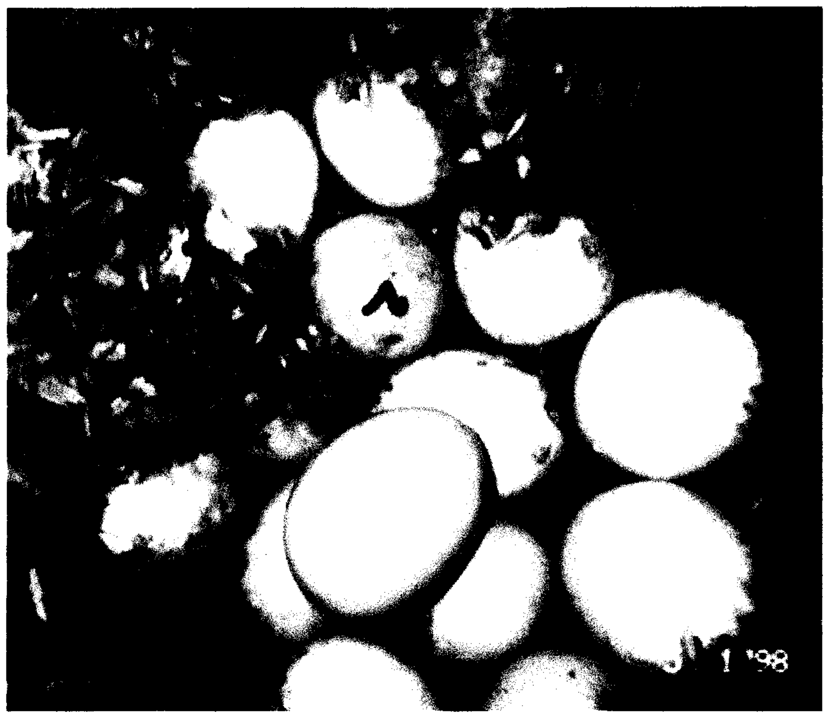

1 '98

Table 5. Intraspecific and interspecific nest parasitism summaries of hooded merganser and wood ducks at MCWMA. The data from this study was compared to a study done in 1994 and 1995 on the same ponds using 2x2 contingency tables (Willis 1996).

% Hooded merganser nests parasitized by…	**1994-1995**	**1998**	***P***
Wood duck	80 (12/15)	44 (7/16)	<0.05
Hooded merganser	13 (2/15)	75 (12/16)	<0.05

% Wood duck nests parasitized by…			
Wood duck	98 (46/47)	43 (16/37)	<0.05
Hooded merganser	47 (28/60)	43 (16/37)	NS

*Chi square analysis
NS = not significant

Lab/GC Analysis

Egg, water and sediment samples were worked up in the lab according to the methods mentioned previously. The percent lipid determination for 83 collected eggs was 15.88 ± 0.17 (mean±SE). No results were obtained on organochlorine concentrations in egg, water, or sediment samples. Organochlorine spikes in all of the samples, duplicates and controls were not recovered either. The methods I used in the lab may have been incorrect, particularly the clean-up column. Although, it is assumed that there were OCs in samples, the failure of spiked controls to give results shows the methods did not work. In the future, different methods should be tried to find a successful way.

DISCUSSION

Laying Chronology

Hooded merganser hens began laying approximately March 24 at MCWMA. This is consistent with most documented studies, where nest initiation usually begins between February and April, depending on latitude (Dugger *et al.* 1994). Maryland and Indiana, near the same latitude as Ohio, reported similar findings for nest initiation between March 13 and 24 (McGilvrey 1966, Mumford 1952).

It appears as though the laying chronology for hooded mergansers nesting at MCWMA is typical. Nest initiation and peak laying times appear to correspond with studies done on hooded mergansers in other parts of the country. Two peaks were observed in hooded merganser laying at MCWMA. One was found during the first ten days of laying and another approximately 20 days later. This trend was also noticed in a study in Western Oregon, where a peak in laying was found during the first week of nest starts and again approximately 3 weeks later. These two separate peaks may indicate two different age groups of hens (Morse *et al.* 1969). Older, more experienced hens may begin laying very early and younger, less experienced hens may begin laying later. Adding to the second peak may also be renesting attempts. Hooded merganser hens that may have been unsuccessful on their first attempt will usually attempt to renest.

Wood Duck laying chronology also appears to be typical compared to a 1994-95 study conducted at the same study site (Willis 1996). The first wood duck eggs were found in my study on March 26 and the first eggs were found in 1994-95 around March 28. A peak in laying was also found during the first week of laying in 1994-95.

Egg Parameters

Hooded merganser eggs at MCWMA appeared to be slightly larger than studies reported in Missouri and South Carolina. Kennamer (1988) reported hooded merganser eggs in South Carolina with an average length, width, and mass of 53.6±0.3 mm, 43.7±0.1 mm, and 59.0±0.6 g (mean±SE), respectively for 26 eggs. In Missouri, the mean length, width, and mass of hooded merganser eggs were 53.7 mm, 43.8 mm, and 57.9 g, respectively for 24 eggs (Dugger *et al.* 1994). In comparison, length, width, and mass of eggs measured in this study were 54.1±0.1 mm, 44.1±0.1 mm, and 61.6±0.3 g (mean±SE), respectively. A possible explanation for the variations in size could be the sample sizes. The studies from South Carolina and Missouri had very small sample sizes while the sample size for this study was 238 eggs. Another factor to consider is natural variation in hooded merganser eggs in one location. A great deal of variation in size and shape was noticed in eggs measured during this study. Egg shape ranged from almost completely round to slightly elliptical. A few other factors to consider in egg variation are diet, genetics, and order in which egg was laid.

Eggshell Thickness

Eighty-three hooded merganser eggs were sampled for a mean eggshell thickness of 0.605±0.004 mm (mean±SE). In comparison to previous studies between 1970 and 1981, eggshells from this study appear to be thicker (Table 6). They are almost as thick as historical eggshell collections from the pre-OC era. There was a 9.4% increase in thickness between this study and Zicus' study in 1981. This increased thickness may be an indication of the health of the laying hooded merganser hens at MCWMA.

Table 6. Comparison of eggshell thickness of hooded mergansers at MCWMA with previous studies and historical collections. A decrease in eggshell thickness is shown from the pre-OC era, through OC use, and after most OCs were banned in the late 1970's. In 1998, hooded mergansers using nest boxes at MCWMA appear to have eggshells close to pre-OC era thickness.

OC Time Period	**Date**	**Thickness (mm)**	**Sample Size (#clutches/ #eggs)**	**Location**	**Source**
Pre-OC	1880–1927	0.628±0.025	6/55	IA, MI, MN, ND, WI	White and Comartie, 1977
During use	Pre-1947	0.614±0.009	?/44	WI	Faber and Hickey, 1973
During use	1970	0.599±0.017	?/11	WI	Faber and Hickey, 1973
During use	1973-1975	0.576±0.005	28/174	IA, MI, MN, ND, WI	White and Comartie, 1977
Post OC	1981	0.568±0.007	21/70	MN	Zicus et al. 1988
Post OC	1998	0.605±0.004	14/83	OH	This Study

The increase could be an indication of an absence of or low OC concentrations. It appeared that even though the use of most OC's were banned in the 1970's, they still persisted in the environment with thin eggshells recorded in 1981 (Zicus 1981). It is possible that with thicker eggshells in 1998, hooded mergansers may have rebounded from OC contamination. However, without chemical analysis, this cannot be proven.

It is easy to see a trend in decreased eggshell thickness in relation to use of OCs over time. Organochlorines came to use over seventy years ago (approximately 1930). Historical collections show the thickest eggshells (White and Cromartie 1977), prior to OC use. From approximately 1930 to 1975, organochlorines continued to be introduced into the environment (Bunce 1994, US PHS 1992a, US EPA 1986a, US EPA 1986b). In the mid 1970's most OC production and use had been banned (Manahan 1994, US PHS 1992a, US PHS 1992b, US PHS 1992c). However, a decrease in eggshell thickness continued into at least the early 1980s (Zicus *et al.* 1988). Eggshell thickness from hooded mergansers nesting at MCWMA appears to approach the pre-OC use range.

Reproductive Success and Parasitism of Hooded Mergansers

Hooded mergansers used 16 of the 49 available nest boxes on boxes on both Eagle Marsh and Wood Duck Marsh. This appeared to be an increase from the 94-95 study, however it was not found to be significant. Nest success appeared to have decreased between the two studies, however that was also not found to be significant. Hooded merganser hatching success did have a significant decrease from 94-95 to 1998 (80%-69%). This indicates that hooded merganser nest box use may be increasing and that increase appears to be impacting their ability to hatch off ducklings.

Zicus (1990) found that hooded merganser hatching success decreased as clutch size increased. This could be true for hooded mergansers at MCWMA as well. Between the 94-95 study and the study in 1998, mean clutch size increased from 14±4.0 to 15±1.5 (mean±SE). An increase in clutch size could be the result of an increase in intraspecific nest parasitism. From 94-94 to 1998 the mean number of parasitic hooded merganser eggs in hooded merganser nests increased from 4.5±0.5 to 6.6±1.5. In addition, between 94-95 and 1998 there was a significant increase in the number of hooded merganser nests parasitized by hooded mergansers from 13% (2/15) to 75% (12/16).

Interspecific nest parasitism of hooded mergansers by wood ducks does not appear to be a significant problem for hooded mergansers since it decreased significantly. Interspecific nest parasitism of wood ducks by hooded mergansers does not appear to be impacting wood ducks either because there was no significant change in hatching success between the two studies.

There also appears to be a slight decrease in reproductive success as eggshell thickness increases. Although it is not a significant decrease, it may represent an interesting relationship. It would be expected that thicker eggshells would be produced by a healthier hen and that she would have a high reproductive success. However, the data from this study seem to indicate the opposite. A possible consideration is that parasitic hens may lay eggs with thicker eggshells. In this study, some parasitic eggs may have been inadvertently collected from active hooded merganser nests, resulting in thicker eggshells per clutch. When they are layed in a box that is near or at the end of incubation, there is a very good chance that the parasitic eggs will not hatch. This would lower the percentage of eggs hatching. Since there was a relatively high incidence of intraspecific nest parasitism of hooded mergansers, a lower hatching success would be expected from eggs laid late in the laying period or after incubation had begun.

Nest box density could also be a contributing factor to the increase in intraspecific nest parasitism of hooded mergansers nesting at MCWMA. Nest box density on Eagle Marsh and Wood Duck Marsh was 10 nest boxes/ha (Willis 1996). Typical densities of natural nest cavities for wood ducks is approximately 3 cavities/ha (Gilmer *et al.* 1978, Prince 1968, Strange *et al.* 1971). Hooded merganser natural nest cavity density is thought to be similar to that of the wood duck. Intraspecific nest parasitism of wood ducks was found to be significantly greater in nest boxes at 10 cavities/ha when compared to 2 cavities/ha (Willis 1996). Semel *et al.* (1988) found similar results when comparing visible clumped (VC), visible isolated (VI), and well hidden (WH) nest boxes. Wood duck clutch sizes in VC nests (16.3 eggs) and VI nests (15.7 eggs) were significantly larger than clutches in WH nests (12.4 eggs). The larger clutch sizes appeared to be the result of a high incidence of intraspecific nest parasitism. This was inversely correlated with a decrease in hatch success from well hidden nests (82%) to visible nests (74%) (Semel *et al.* 1988). High density and visibility of nest boxes at MCWMA may have helped to increase the population and nest box use of hooded mergansers however, they may be adversely impacting their overall reproductive success.

Reproductive Success and Parasitism of Wood Ducks

From the 94-95 study to this study, there appeared to be a slight increase in nest box use and slight decreases in nest success for wood ducks, however not significant. There was also no change in hatching success between the two studies for wood ducks.

Parasitism does not appear to be a contributing factor in the decrease in nest success for wood ducks. Both intraspecific and interspecific nest parasitism decreased significantly from 94-95 to 1998.

Predation and abandonment were probably the biggest reason for the decrease in wood duck nest success. Nest predation accounted for 27% of wood ducks nest attempts, most of which appeared to be by raccoons and a few woodpeckers. Crushed eggs and remnants of fur around the nest box entrance was an indication that raccoons had predated a nest. Holes poked in eggs were usually a sign of woodpecker predation. Nest abandonment accounted for 22% of all nest attempts. Combined together, nest predation and abandonment accounted for almost half of all wood duck nest attempts at MCWMA in 1998.

Lab/GC Analysis

Unfortunately, due to unknown circumstances, nothing was found in water, sediment, or egg samples taken at MCWMA. It is very possible that the Florisil clean-up column was set up incorrectly and over cleaned the samples, removing any OC residues that may have been in the samples and all spikes that were added. The method should have been tested first by running spiked control chicken egg samples on the GC prior to running actual samples through the clean-up column. There is also a possibility that OC concentration were actually below a detectable level in the samples and the spikes used were either old and ineffective or I calculated the concentration of the spike wrong.

However, it can be assumed that with the mean eggshell thickness increasing 9.4% from the last study in 1981, OC levels would have been low or absent. For all 83 collected eggs, the mean eggshell thickness was 0.605±0.004 mm (mean±SE). That is near pre-OC era eggshell thickness.

Results of Null Hypotheses Tests

Eggshell thickness of hooded merganser eggs at MCWMA do differ from the eggshell thickness of historical collections. The results of this study found the mean eggshell thickness of hooded merganser eggs only slightly thinner than historical collections from the pre-OC era.

Eggshell thickness of hooded merganser eggs at MCWMA do differ from the eggshell thickness of previous studies. The results of this study found mean eggshell thickness to be thicker than means found in previous studies (from 1970-1981).

The reproductive success of hooded mergansers from this study does differ from the reproductive success in 1994 and 1995. There is a significant decrease in hatching success of from 94-95 to 1998.

Hooded merganser eggshell thickness does correlate with reproductive success, although not significantly. As eggshell thickness increased, reproductive success tended to decrease.

I was unable to determine concentrations of OCs in hooded merganser eggs to compare to concentrations of previous studies. However, it can be assumed that they would be low based on the increase in eggshell thickness.

Conclusions

Based on the thicker eggshells found in hooded mergansers nesting at MCWMA, it would be assumed that hens laying there were healthier. Generally, thicker eggshells would indicate the absence of or low levels of OCs, healthy hens, and a healthy ecosystem. However, the results of this study indicate a population of nesting hens that may be stressed inspite of their thicker eggshells. Other factors seem to be impacting these birds.

Although this study indicated an increase in nest box use by hooded mergansers, their hatching success decreased significantly. This may be due to the significant increase in intraspecific nest parasitism. However, parasitism by parasitic wood ducks does not appear to be impacting hooded merganser nesting.

Future Work

Although relatively thick eggshells were found during this study and it would be assumed that organochlorine levels were low, organochlorine levels need to be confirmed. A new method should be used for extraction and clean-up of samples.

With the high occurrence of nest parasitism, more intensive nest box checks should be conducted. Rather than checking boxes every two to five days, boxes should be checked every day. This would allow for determining the number of hens parasitizing a box as well as a chronology of parasitic eggs.

In order to establish the trends of increased nest box use, increased parasitism, and decreased hatching success, nest boxes should continue to be intensively studied at least every 2 years. This would confirm any trends that were found in this study.

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APPENDIX A

FIELD DATA

Table 7. Field measurements for eggs measured at Eagle (E) and Wood Duck (WD) Marsh. Sample #'s indicate eggs that were collected for lab analysis.

Sample #	Pond	Box#	Egg #	length (mm)	width (mm)	weight (grams)
	E	311	1	58.86	46.23	82.0
1	E	311	2	57.09	47.84	82.0
	E	311	3	56.78	47.02	84.0
	E	311	4	54.63	46.64	69.5
	E	311	5	56.31	46.02	71.0
	E	311	6	53.19	43.67	59.0
	E	311	7	55.97	46.72	69.5
4	E	311	8	55.94	47.82	71.0
	E	311	9	56.89	42.74	60.0
	E	311	10	55.02	46.00	67.0
	E	311	11	55.27	43.31	61.5
	E	311	12	52.69	42.80	57.0
79	E	312	1	52.64	41.93	53.0
47	E	312	2	51.77	44.35	58.0
68	E	312	3	51.06	43.46	57.5
51	E	312	4	51.69	43.71	59.0
40	E	464	1	54.42	44.32	61.5
17	E	464	2	54.30	44.44	61.5
39	E	464	3	52.91	43.27	59.0
44	E	464	4	53.45	44.24	63.0
52	E	464	5	52.95	44.30	61.5
	E	465	1	53.34	43.71	59.5
	E	465	2	54.50	43.42	59.0
	E	465	3	54.57	43.42	60.0
	E	465	4	52.28	43.65	59.0
	E	465	5	52.14	44.12	58.5
	E	465	6	53.14	44.12	60.5
	E	465	7	53.77	42.95	57.0
21	E	465	8	55.90	46.57	71.0
	E	465	9	53.76	44.83	62.5
53	E	599	1	54.03	42.71	58.0
54	E	599	2	52.56	43.19	56.5
55	E	599	3	53.04	43.11	57.5
56	E	599	4	52.80	44.64	61.0
57	E	599	5	53.73	42.11	56.0
58	E	599	6	53.72	43.56	60.0
8	E	599	7	54.14	44.54	63.5
65	E	599	8	53.93	44.55	60.5

66	E	599	9	54.72	44.91	65.0
7	E	599	10	59.32	42.01	71.0
64	E	599	11	53.63	44.66	62.5
67	E	599	12	55.94	43.70	62.5
	E	880	1	51.69	43.24	56.0
	E	880	2	55.80	44.20	65.0
	E	881	1	52.81	43.69	46.5
82	E	881	2	51.74	43.68	56.0
72	WD	388	1	56.30	44.97	62.0
43	WD	388	2	54.91	43.72	61.5
83	WD	388	3	54.18	43.70	60.5
73	WD	388	4	55.93	43.69	62.0
23	WD	388	5	56.55	43.36	62.5
74	WD	388	6	55.10	44.68	64.5
75	WD	388	7	54.33	44.74	64.0
76	WD	388	8	53.56	44.73	63.5
16	WD	388	9	56.45	46.90	72.5
77	WD	388	10	54.87	46.79	71.0
37	WD	388	11	53.96	44.90	64.0
84	WD	388	12	54.01	44.90	65.0
	WD	389	1	55.34	43.25	60.0
	WD	389	2	54.84	44.94	61.0
	WD	389	3	55.39	44.95	60.0
	WD	389	4	54.27	43.06	58.0
	WD	389	5	56.04	44.15	63.0
	WD	389	6	53.11	44.18	61.0
	WD	389	7	56.06	43.66	61.0
	WD	389	8	53.31	43.13	58.0
	WD	389	9	54.33	44.81	60.0
	WD	389	10	54.42	44.59	61.0
	WD	389	11	56.83	44.60	64.0
	WD	389	12	55.98	44.65	62.0
	WD	389	13	53.07	44.02	60.5
3	WD	389	14	53.35	45.91	62.0
	WD	389	15	54.26	44.26	62.0
	WD	389	16	53.41	43.44	59.0
	WD	389	17	52.31	43.67	58.0
	WD	389	18	59.78	43.37	62.0
	WD	389	19	55.52	44.74	64.0
2	WD	389	20	59.68	47.93	77.0
	WD	390	1	53.20	42.89	54.0
	WD	390	2	54.12	41.73	55.0

5	WD	390	3	56.19	44.72	65.0
	WD	390	4	53.73	42.73	56.0
	WD	390	5	53.17	42.11	56.0
	WD	390	6	54.91	44.31	62.0
6	WD	390	7	52.16	45.36	64.5
	WD	390	8	53.36	43.07	57.0
	WD	390	9	50.54	43.93	54.5
	WD	390	10	54.30	44.30	62.5
	WD	390	11	53.25	44.96	60.0
	WD	390	12	56.14	44.15	62.5
	WD	390	13	54.01	45.14	65.0
	WD	394	1	53.83	44.59	63.0
14	WD	396	1	53.62	44.88	64.0
13	WD	396	2	53.33	44.18	62.0
15	WD	396	3	53.52	44.32	61.5
	WD	396	4	53.29	44.41	62.0
	WD	398	1	53.08	41.15	51.0
	WD	398	2	53.52	44.93	64.5
	WD	398	3	53.58	44.09	62.5
45	WD	398	4	54.10	44.66	60.0
	WD	398	5	55.54	44.20	63.5
	WD	398	6	53.77	44.31	63.0
	WD	398	7	53.54	43.40	60.0
46	WD	398	8	52.72	45.50	65.0
	WD	398	9	53.90	43.73	60.0
	WD	398	10	53.50	44.91	63.5
	WD	398	11	54.14	45.02	65.0
	WD	399	1	54.93	45.22	65.0
	WD	399	2	55.90	45.03	65.5
69	WD	399	3	53.66	43.66	61.5
	WD	399	4	54.79	45.16	66.0
	WD	399	5	53.62	43.63	61.5
	WD	399	6	53.31	45.49	66.0
	WD	399	7	54.80	43.51	60.5
	WD	399	8	54.25	45.41	65.0
	WD	399	9	52.88	45.12	61.0
80	WD	399	10	54.49	43.50	61.0
	WD	399	11	53.36	45.88	65.0
59	WD	400	1	54.69	43.95	61.0
60	WD	400	2	54.47	43.96	61.5
61	WD	400	3	53.61	43.44	59.5
62	WD	400	4	53.03	45.38	64.5

63	WD	400	5	54.25	43.38	60.0
70	WD	401	1	53.86	43.24	58.0
71	WD	401	2	53.59	42.56	55.5
27	WD	406	1	53.40	43.02	59.5
38	WD	408	1	55.60	43.79	63.0
35	WD	408	2	55.03	44.37	64.0
50	WD	408	3	56.01	43.74	63.0
	WD	412	1	54.00	43.93	58.5
	WD	481	1	55.58	42.77	59.5
41	WD	481	2	53.86	42.98	59.5
	WD	481	3	54.54	42.28	57.5
	WD	481	4	54.80	43.18	61.0
	WD	481	5	53.72	42.60	58.0
	WD	481	6	55.12	43.72	61.5
42	WD	481	7	53.93	44.13	60.0
	WD	481	8	54.63	43.27	60.0
	WD	481	9	53.95	43.92	60.5
	WD	481	10	54.40	43.78	60.0
	WD	481	11	54.03	44.58	62.5
	WD	481	12	55.25	43.48	59.5
	WD	481	13	55.18	43.46	61.0
	WD	481	14	55.52	43.88	61.5
	WD	481	15	53.71	45.77	65.5
	WD	481	16	52.14	41.85	54.0
	WD	481	17	54.00	43.82	61.0
	WD	481	18	53.11	45.77	66.0
	WD	482	1	56.42	41.77	55.5
	WD	482	2	52.68	43.35	58.0
	WD	482	3	55.09	41.93	53.0
	WD	482	4	52.30	43.47	58.5
	WD	482	5	56.00	42.90	57.0
	WD	482	6	53.26	43.56	59.0
	WD	482	7	54.73	43.69	60.0
	WD	482	8	54.34	42.38	57.0
	WD	482	9	53.36	42.02	54.5
	WD	482	10	53.79	43.10	57.5
	WD	482	11	53.03	43.74	60.5
	WD	482	12	52.19	41.89	53.0
	WD	482	13	54.41	43.82	60.0
	WD	482	14	54.87	42.45	58.0
18	WD	803	1	54.51	45.30	66.0
9	WD	803	2	54.31	43.23	62.5

11	WD	803	3	55.48	44.50	66.5
	WD	804	1	56.98	45.04	64.5
	WD	804	2	56.76	44.65	65.0
	WD	804	3	53.78	45.05	63.0
	WD	804	4	51.55	42.58	55.5
	WD	804	5	53.05	43.30	57.5
	WD	804	6	54.90	44.68	64.5
12	WD	804	7	51.29	44.43	60.5
	WD	804	8	51.65	43.69	58.5
	WD	804	9	52.39	45.21	62.5
	WD	805	1	52.87	44.91	62.0
	WD	805	2	53.74	43.81	60.5
	WD	805	3	54.95	44.45	65.0
	WD	805	4	53.10	46.30	66.0
	WD	805	5	53.82	44.07	61.5
	WD	805	6	54.04	44.75	63.5
	WD	805	7	52.43	44.32	59.0
	WD	805	8	53.81	43.09	58.5
	WD	805	9	53.26	45.25	62.5
19	WD	805	10	52.64	43.22	57.0
	WD	805	11	52.67	42.99	57.5
	WD	805	12	53.46	45.15	63.0
	WD	805	13	53.09	43.39	59.0
	WD	805	14	54.27	45.60	65.0
	WD	805	15	55.73	44.83	65.0
20	WD	805	16	53.94	44.89	63.5
	WD	805	17	54.78	43.71	60.5
	WD	805	18	55.06	44.93	65.0
	WD	805	19	53.85	44.31	62.0
	WD	805	20	52.84	43.31	58.0
	WD	805	21	54.13	44.07	62.0
	WD	805	22	52.43	44.29	60.5
	WD	841	1	52.39	45.57	64.0
	WD	841	2	53.02	45.12	63.5
	WD	841	3	52.93	45.24	63.0
	WD	841	4	53.35	45.57	66.0
	WD	841	5	53.72	45.12	65.0
	WD	841	6	53.87	44.84	64.5
10	WD	842	1	52.54	43.78	60.5
24	WD	843	1	51.97	42.98	55.0
	WD	844	1	52.54	45.01	64.0
	WD	844	2	56.06	43.64	63.0

	WD	844	3	54.28	45.52	66.0
	WD	844	4	50.65	42.63	56.0
30	WD	844	5	53.78	44.49	63.5
	WD	844	6	54.35	44.26	63.0
	WD	844	7	51.70	43.81	59.0
	WD	844	8	54.66	44.42	64.0
	WD	844	9	55.72	44.48	63.5
78	WD	844	10	52.91	43.78	60.0
	WD	844	11	51.36	44.33	59.0
	WD	844	12	52.06	42.58	56.0
	WD	844	13	54.71	43.05	59.0
	WD	844	14	55.00	43.00	59.0
	WD	844	15	55.14	43.62	61.0
33	WD	845	1	54.42	45.22	67.0
25	WD	845	2	53.96	44.05	63.0
36	WD	845	3	52.42	45.58	65.5
29	WD	845	4	55.73	43.45	63.0
22	WD	845	5	53.40	44.69	63.5
32	WD	845	6	53.72	44.92	64.0
28	WD	845	7	55.12	43.05	61.0
31	WD	845	8	54.29	43.32	61.0
34	WD	845	9	55.01	45.04	64.5
26	WD	845	10	52.27	43.14	58.0
	WD	846	1	52.41	43.90	61.0
	WD	846	2	53.44	42.98	58.0
	WD	846	3	53.91	43.19	61.0
	WD	846	4	53.33	43.48	60.0
49	WD	846	5	52.84	45.70	64.5
	WD	846	6	54.07	43.46	60.0
	WD	846	7	53.20	43.04	58.5
	WD	846	8	54.55	45.15	60.0
48	WD	846	9	55.77	44.74	65.5
***Mean +/- SE**				**54.1+/- 0.1**	**44.1+/- 0.1**	**61.6+/- 0.3**

Table 8. Field and lab measurements for 83 eggs collected from Eagle (E) and Wood Duck (WD) Marsh.

Sample #	Box#	Egg #	length(mm)	width(mm)	weight(g)	thickness(mm)	Shell wt (g)	**Ratcliffe
1	311	2	57.09	47.84	82.0	0.584	10.2493	3.753
2	389	20	59.68	47.93	77.0	0.593	10.7973	3.775
3	389	14	53.35	45.91	62.0	0.643	10.4579	4.270
4	311	8	55.94	47.82	71.0	0.559	10.5728	3.952
5	390	3	56.19	44.72	65.0	0.542	9.3642	3.727
6	390	7	52.16	45.36	64.5	0.635	10.5277	4.450
7	599	10	59.32	42.01	71.0	0.618	11.4362	4.589
8	599	7	54.14	44.54	63.5	0.567	9.4423	3.916
9	803	2	54.31	43.23	62.5	0.584	10.1725	4.333
10	842	1	52.54	43.78	60.5	0.635	10.0978	4.390
11	803	3	55.48	44.50	66.5	0.593	10.4320	4.225
12	804	7	51.29	44.43	60.5	0.610	9.8149	4.307
13	396	2	53.33	44.18	62.0	0.635	10.2613	4.355
14	396	1	53.62	44.88	64.0	0.627	10.3225	4.289
15	396	3	53.52	44.32	61.5	0.635	10.0754	4.248
16	388	9	56.45	46.90	72.5	0.660	11.3549	4.289
17	464	2	54.30	44.44	61.5	0.635	9.9717	4.132
18	803	1	54.51	45.30	66.0	0.635	10.2914	4.168
19	805	10	52.64	43.22	57.0	0.584	9.3540	4.111
20	805	16	53.94	44.89	63.5	0.584	10.1075	4.174
21	465	8	55.90	46.57	71.0	0.669	11.3693	4.367
22	845	5	53.40	44.69	63.5	0.610	10.1884	4.269
23	388	5	56.55	43.36	62.5	0.601	9.3295	3.805
24	843	1	51.97	42.98	55.0	0.483	6.8855	3.083
25	845	2	53.96	44.05	63.0	0.584	9.6724	4.069
26	845	10	52.27	43.14	58.0	0.610	8.9838	3.984
27	406	1	53.40	43.02	59.5	0.635	9.9165	4.317
28	845	7	55.12	43.05	61.0	0.610	9.6107	4.050
29	845	4	55.73	43.45	63.0	0.627	9.4887	3.919
30	844	5	53.78	44.49	63.5	0.584	9.6288	4.024
31	845	8	54.29	43.32	61.0	0.635	9.9718	4.240
32	845	6	53.72	44.92	64.0	0.618	9.6362	3.993
33	845	1	54.42	45.22	67.0	0.635	10.7413	4.365
34	845	9	55.01	45.04	64.5	0.559	9.5907	3.871
35	408	2	55.03	44.37	64.0	0.635	10.5408	4.317
36	845	3	52.42	45.58	65.5	0.601	9.7773	4.092
37	388	11	53.96	44.90	64.0	0.635	10.1381	4.184
38	408	1	55.60	43.79	63.0	0.610	9.9602	4.091
39	464	3	52.91	43.27	59.0	0.610	9.6363	4.209
40	464	1	54.42	44.32	61.5	0.610	9.7468	4.041
41	481	2	53.86	42.98	59.5	0.593	9.1728	3.962
42	481	7	53.93	44.13	60.0	0.542	8.7559	3.679
43	388	2	54.91	43.72	61.5	0.635	9.6055	4.001
44	464	4	53.45	44.24	63.0	0.669	10.3594	4.381
45	398	4	54.10	44.66	60.0	0.610	10.0962	4.179
46	398	8	52.72	45.50	65.0	0.660	10.6644	4.446
47	312	2	51.77	44.35	58.0	0.593	9.0943	3.961

48	846	9	55.77	44.74	65.5	0.610	10.1692	4.076
49	846	5	52.84	45.70	64.5	0.610	10.1253	4.193
50	408	3	56.01	43.74	63.0	0.635	9.7980	3.999
51	312	4	51.69	43.71	59.0	0.618	9.3111	4.121
52	464	5	52.95	44.30	61.5	0.601	9.7924	4.175
53	599	1	54.03	42.71	58.0	0.525	8.1787	3.544
54	599	2	52.56	43.19	56.5	0.584	8.6404	3.806
55	599	3	53.04	43.11	57.5	0.601	9.0469	3.957
56	599	4	52.80	44.64	61.0	0.559	8.7822	3.726
57	599	5	53.73	42.11	56.0	0.593	8.7360	3.861
58	599	6	53.72	43.56	60.0	0.533	9.1135	3.895
59	400	1	54.69	43.95	61.0	0.610	9.2711	3.857
60	400	2	54.47	43.96	61.5	0.525	8.6232	3.601
61	400	3	53.61	43.44	59.5	0.567	8.9706	3.852
62	400	4	53.03	45.38	64.5	0.584	9.7698	4.060
63	400	5	54.25	43.38	60.0	0.610	9.6389	4.096
64	599	11	53.63	44.66	62.5	0.618	10.0173	4.182
65	599	8	53.93	44.55	60.5	0.584	9.3169	3.878
66	599	9	54.72	44.91	65.0	0.618	10.2950	4.189
67	599	12	55.94	43.70	62.5	0.618	9.7718	3.997
68	312	3	51.06	43.46	57.5	0.610	9.1973	4.145
69	399	3	53.66	43.66	61.5	0.635	10.2594	4.379
70	401	1	53.86	43.24	58.0	0.618	9.5045	4.081
71	401	2	53.59	42.56	55.5	0.559	8.3866	3.677
72	388	1	56.30	44.97	62.0	0.627	9.8526	3.892
73	388	4	55.93	43.69	62.0	0.610	9.4417	3.864
74	388	6	55.10	44.68	64.5	0.627	10.3298	4.196
75	388	7	54.33	44.74	64.0	0.660	10.2106	4.201
76	388	8	53.56	44.73	63.5	0.660	10.4632	4.367
77	388	10	54.87	46.79	71.0	0.660	11.1424	4.340
78	844	10	52.91	43.78	60.0	0.610	9.6014	4.145
79	312	1	52.64	41.93	53.0	0.525	7.7186	3.497
80	399	10	54.49	43.50	61.0	0.618	9.7295	4.105
82	881	2	51.74	43.68	56.0	0.559	8.8321	3.908
83	388	3	54.18	43.70	60.5	0.610	9.8379	4.155
84	388	12	54.01	44.90	65.0	0.635	10.5079	4.333
***Mean +/- SE**			**54.1 +/- 0.2**	**44.3 +/- 0.1**	**62.5 +/- 0.5**	**0.605+/-0.004**	**9.76+/-0.08**	**4.069+/-0.028**

** Ratcliffe Index from Ratcliffe, 1967.

Table 9. Nest box summaries for hooded merganser and wood ducks nesting at MCWMA. Duck (WD) Marsh. D=Drop nest, T=tree swallow nest, G=grackle nest, A=Abandoned nest, P=Predated nest, S=Successful nest.

1998 Mosquito Creek Nest Box Data Summary **1**

Box #	Nest #	Spp	Fate	# HM laid	# WD laid	#HM prior	#WD prior	#HM hatch	#WD hatch
400 WD	1	HM	D	5	0	0	0	0	0
387 WD	2	TS	T	0	0	0	0	0	0
404 WD	1	TS	T	0	0	0	0	0	0
414 WD	1	GR	G	0	0	0	0	0	0
599 E	1	HM	A	12	0	0	0	0	0
388 WD	1	HM	A	12	1	0	0	0	0
312 E	1	WD	A	4	13	0	0	0	0
463 E	1	WD	A	0	14	0	0	0	0
881 E	1	WD	A	2	12	0	0	0	0
387 WD	1	WD	A	0	24	0	0	0	0
388 WD	2	WD	A	0	11	0	0	0	0
408 WD	1	WD	A	3	10	0	0	0	0
412 WD	1	WD	A	1	22	0	0	0	0
843 WD	1	WD	A	1	18	0	0	0	0
399 WD	1	HM	P	11	0	0	0	0	0
464 E	1	WD	P	5	23	0	0	0	0
599 E	2	WD	P	0	6	0	0	0	0
880 E	1	WD	P	2	11	0	0	0	0
386 WD	1	WD	P	0	17	0	0	0	0
389 WD	2	WD	P	0	6	0	0	0	0
394 WD	1	WD	P	1	21	0	0	0	0
402 WD	1	WD	P	0	4	0	0	0	0
405 WD	1	WD	P	0	12	0	0	0	0
407 WD	1	WD	P	0	7	0	0	0	0
408 WD	2	WD	P	0	8	0	0	0	0

2

Box #	Nest #	Spp	Fate	# HM laid	# WD laid	#HM prior	#WD prior	#HM hatch	#WD hatch
311 E	1	HM	S	15	1	**13**	0	**13**	0
465 E	1	HM	S	9	2	**8**	2	**5**	2
389 WD	1	HM	S	20	0	**18**	0	**12**	0
390 WD	1	HM	S	15	0	**13**	0	**12**	0
398 WD	1	HM	S	20	0	**18**	0	**17**	0
481 WD	1	HM	S	18	0	**16**	0	**16**	0
482 WD	1	HM	S	14	0	**12**	0	**12**	0
804 WD	1	HM	S	12	0	**10**	0	**9**	0
805 WD	1	HM	S	22	1	**20**	1	**6**	1
841 WD	1	HM	S	6	6	**6**	6	**6**	6
844 WD	1	HM	S	15	0	**13**	0	**8**	0
462 E	1	WD	S	1	24	1	**22**	1	**12**
390 WD	2	WD	S	0	17	0	**17**	0	**11**
391 WD	1	WD	S	2	15	2	**15**	2	**15**
392 WD	1	WD	S	0	12	0	**12**	0	**12**
393 WD	1	WD	S	0	15	0	**14**	0	**14**
395 WD	1	WD	S	0	13	0	**13**	0	**6**
396 WD	1	WD	S	4	13	1	**13**	1	**12**
397 WD	1	WD	S	0	9	0	**9**	0	**6**
401WD	1	WD	S	0	13	0	**13**	0	**10**
403 WD	1	WD	S	0	21	0	**21**	0	**18**
406 WD	1	WD	S	2	9	1	**9**	0	**4**
409 WD	1	WD	S	0	23	0	**23**	0	**16**
411 WD	1	WD	S	0	32	0	**32**	0	**30**
803 WD	1	WD	S	3	21	0	**21**	0	**16**
842 WD	1	WD	S	1	21	1	**21**	1	**17**
845 WD	1	WD	S	10	19	0	**19**	0	**17**
846 WD	1	WD	S	10	11	**8**	**7**	**8**	**7**
847 WD	1	WD	S	0	20	0	**20**	0	**17**
848 WD	1	WD	S	0	23	0	**23**	0	**21**
						147	**324**	**116**	**261**
Totals:	55			258	581				

APPENDIX B

EQUATIONS

STANDARD OPERATING PROCEDURES
PWRC - ECR BRANCH
PACF CHEMISTRY SECTION

INITIATOR: PACF

NUMBER: 21.060 DATE OF IMPLEMENTATION: October 6, 1988

TITLE: Percent Lipid Determinations.

SCOPE: Method is appropriate to determine lipid weights without taking entire sample to dryness.

DATA QUALITY EXPECTATIONS: Coefficient of variation is <5.0%.

Summary: A portion of the extracted lipid solution is placed on a pre-weighed aluminum pan. The solvent is evaporated from pan and the pan is reweighed. The percent lipid is calculated accordingly as described in detail below.

PROCEDURE:

Pre weigh aluminum pan on analytical balance. Pipet into pan either 1 mL if sample extract is at 10 mL prior to florisil cleanup or 2 mL if sample is at 20 mL prior to florisil cleanup. Evaporate solvent and reweigh pan. Check volume of sample tube and mark with a marker. Remember this may affect the dilution factors for the calculation of ppm pesticides.

CALCULATIONS:

PE = Pan Empty
PF = Pan Full after solvent has been evaporated
AL = Sample aliquot

% Lipid = ((PF-PE) * 10/AL) * 100

PROBLEMS: Samples low in lipid such as muscle tissue may be difficult to determine lipid weight.

DOCUMENTATION: All data is included in weightbook.

RESULTS: Percent lipid is reported.