ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

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INSIDE

Spillway Escapement of Muskellunge

Many of the quality recreational fishing opportunities in Illinois occur in reservoirs. Fish emigration from reservoirs during periods of overflow is termed "dam" or "spillway escapement." Escapement can detract from recreational fishing opportunities in the reservoir and can disturb downstream ecosystems by creating an influx of unwanted and/or non-native fish. Previous research on spillway escapement has been limited, but existing studies highlight the magnitude of the issue. In a two-year period, 10,000 largemouth bass, sunfish, and bullheads were estimated to have escaped from a 65-hectare lake in Illinois. Another study showed losses of up to 30% annually for a largemouth bass population.

INHS Fisheries Technician Dan Schermerhorn with a muskellunge. **Photo by Max Wolter, INHS**

A simulated spillway.
Photo by Max Wolter, INHS

Muskellunge are stocked by the Illinois Department of Natural Resources (IDNR) into over 30 lakes across Illinois. Escapement of muskellunge is observed and reported from many of these reservoirs. In some instances, high-density muskellunge populations persist in tailwaters below spillways, presumably supported by annual influxes of escaping fish, and are popular angling destinations. In smaller tailwaters, however, prey and oxygen resources are often not adequate to support these large predators and high rates of mortality can occur.

The Illinois Natural History Survey (INHS) recently began a research project aimed at gathering data that would further our understanding of muskellunge spillway escapement and lead to management solutions. A laboratory study incorporating a simulated reservoir and spillway was conducted to observe escapement under varying levels of ambient light, turbidity, habitat, and flow. Conventional thought going into this project was that escapement predominantly occurred at night when muskellunge are largely inactive and situate high in the water column. However the laboratory study revealed that escapement was more likely to occur during the day when muskellunge activity rates are high.

The INHS was also interested in collecting real-time data on escapement of muskellunge in the field. Passive integrated transponder (or PIT) tags are often used in fisheries research and management to differentiate among individuals. These tags can be as small as a grain of rice and are inserted into the body of the fish. Typically, PIT tags are read when a fish is recaptured using a handheld wand to "excite" the tag, which then transmits a unique numeric code. An antenna

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Environmental Contaminants in Asian Carp from the Illinois River

Silver (*Hypophthalmichthys molitrix*) and bighead (*Hypophthalmichthys nobilis)* carp, two invasive species of cyprinid native to Asia, escaped from aquaculture facilities in the lower Mississippi River basin in the 1970s and rapidly spread throughout the river system. Populations of these Asian carp in the Illinois River increased dramatically in the 1990s, to the point where they caused safety concerns for boaters and became a potential detriment to native fish populations. Concerns that the carps would reach Lake Michigan through greater Chicago waterways led to implementation of measures designed to decrease the likelihood of that occurring. One such measure is to commercially harvest the fish in order to reduce their populations. This has led to the creation of markets for Asian carp to make commercial fishing for them an economically viable activity.

In addition to use as a protein source for animal feed and fertilizer, Asian carp from the Illinois River are now served in high-end restaurants ("silverfin"), provided as a protein source for needy people, and, ironically, shipped to China for human consumption. There are also continued efforts to introduce the fish into the diets of the typical U.S. consumer.

Experimental electrical barrier designed to prevent Asian carp from migrating from the Illinois River into Lake Michigan. **Photo from INHS Image Archives**

Based on the result of a pilot study we conducted in 2005 (Environ Monit Assess. 2009 157:211-22), we determined that mercury (Hg) was present in some individuals of both species at levels that would trigger consumption advisories. Selenium (Se) levels in some fish exceeded the FDA tolerance levels for feed additives (0.3 ppm), and given consumption of a large meal of these individuals, could exceed the recommended daily allowance of selenium for pregnant woman (60 μg/day). Concentrations of arsenic (As) and Se also differed by species and location. Polychlorinated biphenyls (PCBs) were detected in a few fish in our pilot study, and detectable concentrations were well below the FDA action level of 2.0 ppm in the edible portion of the fish.

A larger study was needed to better quantify the effects of species, size, and location on contaminant burdens in Asian carps. Therefore, we measured concentrations of As, cadmium (Cd), Hg, Se, PCBs, chlordane, hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), polybrominated diphenyl ethers (PBDE), and fluorinated compounds (FLC) in fillets (skinless) and samples of ground bighead and silver carp from a number of locations on the Illinois River. This allows state agencies to better assess the risks associated with the use of these species as a commercial protein source.

We collected 120 fillets from silver and bighead carp during 2010 and 2011 from the Alton, LaGrange, and Peoria pools of the Illinois River. We also took samples of whole, ground carp from the Alton, LaGrange, Peoria, Starved Rock and Marseilles pools.

Concentrations of elements differed by pool and species, but were not of concern as animal feed. Mercury in fillets was below the FDA Action Level and EPA Screening Value for recreational fishers, and was comparable to levels in low-mercury commercial food fish such as pollock and catfish. Mercury concentrations in some larger fish fell within more conservative guidelines for consumption restrictions. Arsenic was below detection in most fillets, although some were within thresholds for consumption limits. Concentrations of selenium, an essential element, were not of concern.

Researchers at the INHS Great Rivers Field Station sample bighead and silver carp in the Mississippi River with trammel nets. **Photo courtesy of INHS Great Rivers Field Station**

Organochlorine pesticides were detected in over half of the whole fish samples; concentrations increased in bighead, and decreased in silver, carp, respectively, moving upstream. Chlordane predominated the organochlorine pesticides we measured, perhaps not surprisingly as the state of Illinois issues fish consumption advisories for this chemical. Chlordane concentrations in some fish exceeded the FDA limit for animal feed. Lindane (and isomers) and HCB concentrations were not of concern. Pesticides were below detection limits in most fillets, and concentrations were similar across pools.

Polychlorinated biphenyls are synthetic chemicals that were widely used as insulating and hydraulic fluids and were banned in the U.S. in 1979 due to their persistent and toxic characteristics.

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Asian Carp

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Mean PCB concentrations were higher in bighead carp than in silver carp; however, the maximum value in whole fish was in a silver carp. This value approached the USDA tolerance level for PCBs in animal feed. Total PCBs generally increased upstream in both species, and dramatically so in silver carp fillets from above the Alton pool. The greater Chicago area provides a large source-area for contaminants, thus increased concentrations of industrial pollutants like PCBs in fish collected further upstream is not surprising. PCB concentrations were well below the FDA Action Level and were lower than in many commercially available fish such as salmon. Some fillets, primarily silver carp, fell within sportfish consumption advisory levels for sensitive cohorts. Some fillets, including all but one from silver carp, were above the Do Not Eat threshold for cancer health endpoints (U.S. EPA).

Polybrominated diphenyl ethers (PBDE) are flame-retardants that are virtually ubiquitous in the environment. Consumers of wild fish are exposed to PBDEs, and, although health risks to humans from consumption of PBDEs are not clear at this time, exposure to low doses of these compounds has produced endocrine and neurodevelopmental abnormalities in animal models. PBDE concentrations in our whole fish samples generally increased upstream. Concentrations of PBDEs in fillets were very low and highly variable. Concentrations of deca- and penta- forms, considered two of the most problematic, did not exceed the maximum acceptable oral dose

Fluorinated compounds (FLC) are stick- and stain-resisting chemicals used in a variety of consumer products. FLCs are recently emerged contaminants that are present in fish in the upper Mississippi River and Great Lakes, and fish consumption is a source of human exposure. Health effects of exposure in humans and animal models include modulation of the endocrine system and developmental abnormalities. Fluorinated compounds in our samples were present in very low concentrations and were well below the Minnesota Department of Health's sportfish meal advisory.

Overall, concentrations of environmental contaminants that we measured were low and of little concern. However, it is noteworthy that individual fish may contain levels that exceed consumption thresholds and that concentrations of some chemicals differ between the species and among pools, and between the two types of tissues we examined. These findings should be considered when developing recommendations for use and consumption of Asian carp from the Illinois River.

Jeff Levengood, Dave Soucek, Amy Dickinson, Greg Sass, and John Epifanio, INHS

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INHS Human Dimensions Research Program

The Human Dimensions Research Program at the Illinois Natural History Survey conducts social research throughout Illinois and North America on various issues affecting wildlife management, ecosystems restoration, and environmental health. Our clients include the Illinois Department of Natural Resources, other state and federal agencies, as well as private foundations. We are dedicated to enhancing stakeholder values and the perceptions they hold in respect to specific problems involving wildlife and natural resources management. Our projects focus on the social-psychological aspects of conservation issues by identifying potential sources for conflict and determining management solutions preferred by various concerned segments of the public. The Human Dimensions Research Program strives to better our understanding of the complex nature of decisions concerning resource management. Using a variety of research approaches, including mail and Internet surveys, we gather data from stakeholders on specific issues of interest. A portion of our projects involves investigating harvest, participation, and attitudes toward wildlife management of hunters and trappers for the Illinois Department of Natural Resources under longstanding contractual agreements. The balance of our studies focuses on public perceptions and support for policies regarding natural resources management, such as wildlife diseases, water quality, and land management. We provide quantitative and qualitative social science data based on scientific survey methods to assist decision makers in understanding the complex perspectives of stakeholders.

Hunters in the field representing our hunter harvest survey. **Photo by Mark Alessi**

INHS grad students Elizabeth St. James (L) and Molly Spacapan (R) processing mail survey responses. **Photo by Mark Alessi**

Craig Miller, INHS

Sharpshooting for Chronic Wasting Disease Control Has Minimal Effects on White-tailed Deer Reproduction

In 2002, chronic wasting disease (CWD) was first found in white-tailed deer (*Odocoileus virginianus*) populations in northern Illinois (Fig. 1). CWD is a spongiform encephalopathy, similar to "mad cow" disease and Creutzfeldt-Jakob disease in humans. Like these diseases, CWD is caused by an infective misfolded protein, or prion that causes degenerative damage in the central nervous system, and is always fatal. At present, there is no cure for CWD, and although the specific routes of transmission are unclear, infective prion proteins have been found in saliva, urine, and feces of deer, any of which might have infective agents.

Figure 1. Comparison of deer showing symptoms of chronic wasting disease (left), and a healthy deer (right). **Photo on left by Dr. Terry Kreeger, reprinted with permission of the Chronic Wasting Disease Alliance. Photo on right by Macomb Paynes, courtesy of the U.S. Fish and Wildlife Service.**

Controlling CWD is important for at least two reasons. First, although the probability of natural transmission from deer to other animals is exceedingly low, it is known from experiments that CWD can cross the species barrier and infect other animals. Second, without control, CWD would spread, reducing the overall health of deer herds. This would impact deer hunting, which is an important source of revenue for the state of Illinois, provides recreation for many hunters, and helps with the management of natural resources that support other native species.

To manage CWD, the Illinois Department of Natural Resources (IDNR) implemented a control strategy based on identification of infected sites followed by a sharpshooting program aimed at reducing deer densities at locations where CWD has been found.

The sharpshooting season occurs from mid-January until mid-March. IDNR biologists collect fetuses from the sharpshot animals during this time of the year. Examining fetuses allows researchers to study the effects of localized CWD management on reproduction. While sharpshooting is a necessary means for CWD control, it is important to assess whether it has had reproductive consequences in white-tailed deer.

University of Illinois researchers, Drs. Nohra Matteus-Pinilla, Damian Satterthwaite-Phillips, Mary Beth Manjerovic, Michelle L. Green, and Jan Novakofski (from the Illinois Natural HIstory Survey (INHS) and the UI Department of Animal Sciences) have been investigating these questions. Using a data set from eight years of sharpshooting (2003–2010), including data from over 2,800 does and 3,600 fetuses, they analyzed whether sharpshooting affected: (1) overall and age-specific pregnancy rates; (2) number of offspring per pregnant doe—litter size; (3) fetal sex ratios; (4) fetal mass as an indicator of overall health of the mother, as well as an indicator of the likelihood of the newborn fawn surviving; and (5) population structure measured as the proportion of different age classes (fawns, yearlings, and adults). They analyzed these parameters in response to the average number of deer sharpshot annually over 8 years at 53 different locations. Across locations and time, sharpshooting varied in intensity from 0 – 72 does culled annually.

They found that the proportion of fawns in the sample increased as sharpshooting intensity increased (Fig. 2). However, even at the highest sharpshooting intensity, the number of fawns in the population only increased by10% compared to no sharpshooting. The wide

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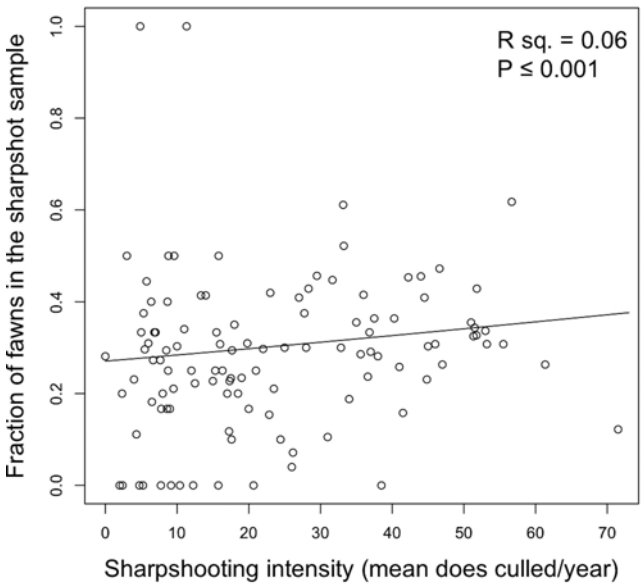

Figure 2. Proportion of fawns in the sample in response to sharpshooting intensity. The line represents a generalized linear model fit by least squares. Fawns make up 27% of the population when no sharpshooting has occurred, and increases to only 37% at the highest sharpshooting intensity. The poor fit of this model (r2 = 0.06), indicates that sharpshooting does a poor job at explaining the variation seen in the proportion of fawns.

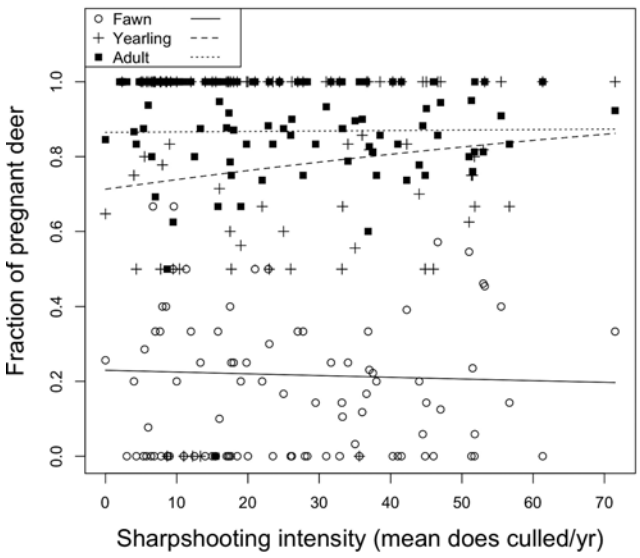

Figure 3. Age-specific pregnancy rates in response to sharpshooting intensity. The increase in yearling pregnancy rates was significant (p = 0.04). The changes in adult and fawn pregnancy rates were not significant.

distribution of points around the model line indicate that factors other than sharpshooting can cause much of the variation seen in the proportion of fawns here.

Pregnancy rates (number of pregnant does / total number of does) and mean litter sizes (average number of fetuses per doe) decreased slightly as sharpshooting intensity increased. These changes could be attributed to the increase in fawns. There are two reasons for this. First, many fawns are not yet mature enough to reproduce, so a smaller proportion becomes pregnant than older deer. Second, when fawns do become pregnant, they tend to have smaller litter sizes than older deer. Thus, more fawns results in both lower overall pregnancy rates and mean litter size. However, sharpshooting did not affect age-specific pregnancy rates for either adults or fawns, although pregnancy rates increased for yearlings as sharpshooting increased (Fig. 3).

Fetal sex ratios did not change significantly in response to sharpshooting. Fetus size has been shown to correlate with both adult size and probability of survival while total fetal mass has been considered an indicator of health of the doe and the resources that she is able to allocate to reproduction.

The findings of this study indicate that individual fetus size was not significantly affected by sharpshooting. As expected, older mothers tended to have more and larger fetuses and total fetal mass also increased with the mother's age. These findings also indicate that total fetal mass increased slightly with increased sharpshooting, independent of mother's age or litter size. Comparing the highest sharpshooting intensity to no sharpshooting, the increase in total fetal mass was 4% for single-fetus litters, and 2% for litters of two or more.

Because of the type (actual fetuses) and size of the data set, the researchers were able to detect small differences in reproductive parameters associated with sharpshooting with high statistical confidence. Still, observed changes were small indicating that the impact of sharpshooting on reproduction has been minimal. Considering the small impact of sharpshooting and the fact that it is a very localized event, occurring only within about a two-mile radius of known CWD-positive deer, sharpshooting is expected to have an even smaller impact on the deer populations at a larger geographical scale. The researchers recommend continued monitoring of reproductive characteristics as sharpshooting continues, adding an evaluation of the temporal changes in hunter-harvested deer to monitor long-term effects on reproductive parameters.

Damian Satterthwaite-Phillips and Nohra Matteus-Pinilla, INHS; Michelle L. Green and Mary Beth Manjerovic, INHS and UIUC Animal Sciences; Jan Novakofski, UIUC Animal Sciences

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Species Spotlight

Ticks

Jen Mui

This time of year we all love to be outside, hiking through the woods and grasslands, exploring the diversity of life around us. After spending a day watching birds and butterflies soar, seeing bumble bees fly from flower to flower, and listening to frogs sing, we return home only to find that unexpected visitors have hitched a ride on us or on our beloved dog. Ticks!

The mention of ticks brings a shudder to many, but this diverse and often misunderstood group deserves our attention. For years, when I discovered a tick, I would simply remove it and put it in a vial of alcohol to save for the Illinois Natural History Survey (INHS) Entomology Collection or an educational display. I never gave them much consideration, until this year, when for the first time, there was a red circle surrounding an attached tick on my shoulder. As I began reading about ticks and tick-borne diseases, I realized I had discovered a fascinating group of organisms and the potential consequences of encountering them.

Although many people think of ticks as insects, they are actually arachnids, more closely related to spiders and scorpions. Adult ticks have four pairs of legs and no antennae. Ticks cannot jump or fly, only crawl to the edges of plants where they wait for an animal to pass by. Holding onto the vegetation with their hind legs, they stretch their front legs to detect and grab onto the next host. The Haller's organ, found on the forelimbs of a tick, enables it to sense changes in temperature and humidity as well as increases in carbon dioxide from an animal exhaling.

Approximately 20 species of ticks occur in Illinois, divided in to two groups, the "soft bodied" and the "hard bodied." "Soft" ticks typically feed on birds and bats so we rarely encounter them. The "hard" ticks commonly found in Illinois are the American dog (wood) tick, blacklegged (deer) tick, lone star tick, and the brown dog tick.

Typical bull's-eye rash that resulted from infection by a black-legged tick. **Photo by Jen Mui, INHS**

The "hard" tick requires three blood meals to complete its life-cycle, which can take up to three years. Ticks feed by plunging their hypostome (a rodlike structure with barbs) into the host animal. The barbs on the hypostome keep the tick from being easily removed. Most ticks also secrete a gluelike substance that cements the tick in place until it is done feeding. Once engorged, the tick removes its hypostome, falls off the host, goes underground, and transforms to the next life stage.

The "hard" tick hatches as a tiny, six-legged larva and after feeding on the blood of an animal, transforms to an eight-legged nymph. The nymph must find another animal to feed on before molting to its adult form. After the adult finds a meal, the female lays eggs and the process begins again.

Because an individual tick must feed on several animals throughout its life cycle, they are capable of transmitting certain diseases from one animal to another. Tick-borne diseases include Rocky Mountain spotted fever, tularemia, Lyme disease, babesiosis, anaplasmosis, and ehrlichiosis.

It is important to note that most ticks are not infected with these pathogens, but some regions may have a higher level of infection potential.

Ticks are found in shaded, humid areas in a variety of habitats including woodlands, grasslands, and urban areas. Black-legged (deer) ticks are the main vector of Lyme disease to humans, dogs, and other animals. This species was believed to be most common in wooded areas, acquiring *Borrelia burgdorferi* (the bacteria that causes Lyme disease) from white-footed mice. Recent research by INHS wildlife epidemiologist Nohra Mateus-Pinilla and Jennifer Rydzewski found that in the fragmented landscape of central Illinois, where forests are limited, prairie voles are serving as hosts to the *Borrelia burgdorferi* bacteria. This additional host allows the bacteria to survive in open habitats as well as the forest. This research has shown that there is still much more to learn about these beguiling creatures.

Four Species of Hard Tick

*American dog ticks, (*Dermacentor variabilis*) are the most commonly encountered ones in Illinois. Adults are active from April to September and can carry the pathogens for Rocky Mountain spotted fever and tularemia.* **Photo by Jen Mui, INHS**

*The black-legged tick (*Ixodes scapularis*) is present year round and can carry the pathogens for Lyme disease, babesiosis, and anaplasmosis. All life stages of the black-legged tick will bite humans, dogs, and other animals.* **Photo by Jen Mui, INHS**

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The Naturalist's Apprentice

Keeping Yourself Tick Free While Exploring the Outdoors

Jen Mui

*The lone star tick (*Amblyomma americanum*) is found from April through fall and all stages will bite humans. The lone star tick can carry the pathogens for Rocky Mountain spotted fever, tularemia, and erlichiosis.* **Photo by Jen Mui, INHS**

*An engorged brown dog tick (*Rhipicephalus sanguineus*) rarely bites humans and is not an important carrier of diseases for humans. This tick is a tropical species and unable to survive outdoors during Illinois winters.* **Photo by Jen Mui, INHS**

Keeping Yourself Tick Free While Exploring the Outdoors

There are so many things to see out in nature, and fear of ticks should never be a reason to avoid exploring. Taking proper precautions while enjoying the outdoors can greatly decrease your risk of being bitten by a tick.

Step 1: Preventing Tick Bites

- Wear light colored clothing to make it easier to spot ticks.
- Wear long pants tucked into your socks and secured with duct tape.
- Use a bug spray containing DEET.
- Stay on trails and avoid overhanging brush where ticks might be.

Step 2: Inspecting Yourself for Ticks

Even with the above precautions, there is still the possibility of bringing home a tick.

- Carefully inspect yourself and your pets for any ticks, paying extra attention to warm moist areas such as armpits, waistlines, etc.
- Wash your clothing immediately to prevent ticks on clothing from biting later.

Step 3: Removing a Tick

If a tick has attached to your skin, do not panic. While not all ticks carry diseases, it is important to remove a tick as soon as you notice it to decrease the chance of infection.

- Using fine-point tweezers, grab the tick as close to the skin as possible. Avoid squeezing the body of the tick as that may force its contents into your body.
- Gently and repeatedly tug until the tick releases from your skin.
- The tick can be saved in a jar of alcohol for identification or killed and flushed down the toilet.
- Clean the bite area as you would any insect bite and watch the area over the next several weeks for signs of a spreading rash.
- If a rash appears or flulike symptoms occur, consult your doctor and tell them that you were bitten by a tick (it is helpful to still have the tick in a vial of alcohol for identification).

For more information about ticks in Illinois see:
http://www.inhs.illinois.edu/outreach/animals/ticks.html

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Spillway Escapement

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A PIT tag antenna at Lake Sam Dale, Illinois. **Photo by Max Wolter, INHS**

capable of reading PIT tags was installed on the spillway at Lake Sam Dale, Illinois. A tag interrogator and datalogger along with a battery to power the system were housed nearby. Fish were sampled and tagged in early spring and a population estimate for the lake was acquired. The antenna was activated as soon as water began to top the drop-box style spillway of the lake.

During the spring of 2011, the Lake Sam Dale spillway had almost continuous overflow for two months between March and late April. When examining tag detections by the antenna, we determined that during this period of time 21% (24 of 117) of the muskellunge that were tagged in the lake escaped over the spillway. Our sampling estimates indicated that there were 190 muskies inhabiting the lake at the beginning of the season. By extrapolating the 20% escapement rate, we estimated that about 40 muskellunge had escaped in 2011. Tag numbers recorded by the antenna were matched to fish survey data and showed that escapement was mostly restricted to adults as 22 of the 24 escaping fish were age 3 or older. There was no difference between sexes as male and female fish escaped in proportions very similar to those observed in the general population. Time stamps for each tag detection revealed that, like in the lab experiments, a majority of escapement happened in the daytime or evening hours. Heavy rain in the fall produced several days where the amount of overflow was comparable to that observed in the spring, but no muskellunge were shown to escape during this time.

Understanding the magnitude and mechanisms of escapement is important as this phenomenon could be one of the primary factors structuring and limiting sportfish communities in reservoirs. Initial conclusions are that adult muskellunge are more likely to escape than juveniles, and escapement happens more often during daytime when the fish are more active. Additionally, seasonal timing and the disproportionate escapement of adults indicate that escapement may be related to post-spawn behavior, making fish less susceptible to it in the fall. The data generated by these studies could be used to develop a variety of management practices to mitigate or limit spillway escapement, including the improved application of nets and physical barriers, adjustment of stocking rates, and alternative spillway designs and dam operation procedures.

Max Wolter and David Wahl, INHS

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