Quantifying Catch-and-Release Mortality and Determining its Effect on Southern Muskellunge Populations

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PROJECT JUSTIFICATION

Historically, angling for Muskellunge was most popular in the upper Midwest, Great Lakes-St. Lawrence River, and Ontario. Subsequently, management of Muskellunge populations and research activity has received more attention in these regions compared to the southern portion of the Muskellunge's distribution. However, anecdotal evidence suggests increased popularity of Muskellunge fishing in the southern portion of their distribution (e.g., development of destination fisheries, Muskellunge angling groups, and Muskellunge focused guide services, and increased interest in Muskellunge management by anglers). For example, Muskellunge anglers have expressed concern about catch-and-release mortality of Muskellunge during the summer due to warm water temperatures, and have reported observations of dead Muskellunge during this time period to VDGIF and WVDNR personnel (D. Goetz, VDGIF; J. Hansbarger, WVDNR). Although anglers suspect that observed mortalities are the result of thermal stress on fish angled during summer months, catch-and release mortality of Muskellunge in southern waters has not been quantified. Catch-and-release mortality has been documented as an important source of mortality for a variety of recreationally important species, even when it occurs at low levels (see Muoneke and Childress 1994 and Bartholomew and Bohnsack 2005 for reviews), and studies of catch-and-release mortality have resulted in meaningful management actions. For example, South Carolina implemented a closure of summer angling (June 1 through September 30) for Striped Bass following documentation of high rates of catch-and-release mortality during the summer (Bettinger et al 2005; Bettinger and Wilde 2013). In a meta-analysis of catch-and-release mortality studies for Striped Bass, Bettinger and Wilde (2013) estimated that 70% of fish caught using natural baits and 38% of fish caught on artificial baits in the summer died following release. Furthermore, Bettinger and Wilde (2013) estimated that, on average, mortality following release of summer angled Striped Bass in southern reservoirs accounted for 36% (natural baits) and 19% (artificial baits) of total summer catch.

Muskellunge anglers have suggested that closure of the Muskellunge fishing season during warm summer months may be warranted; however, data necessary to make management decisions about summer angling for Muskellunge in the southern portion of their range are lacking. Landsman et al. (2011) documented 100% survival of Muskellunge caught and released in the Ottawa and Rideau Rivers, ON, but, the majority of fish angled in that study were angled at temperatures considered within the realized thermal niche for Muskellunge (22.1 ± 1.8 C; Cole and Bettoli [2014]), and only one fish was angled when water temperature was > 25 C. Because catch-and-release mortality rates commonly increase with temperature (Muoneke and Childress 1994; Bartholomew and Bohnsack 2005) and summer water temperatures in the southern portion of the Muskellunge's distribution frequently exceed 27 C, the results observed by Landsman et al. (2011) may not be applicable to Muskellunge angled during the summer in the southern US. Despite warm water temperatures, summer catches represent a substantial portion of Muskellunge angled during a year (D. Goetz, unpublished data; J. Hansbarger, unpublished data). The increased popularity of Muskellunge fishing in the south has forced managers to proactively manage these muskellunge fisheries. However, given the potential for and uncertainty of high summertime catch-and-release mortality, managing these populations will be difficult until this component is understood.

Southern Muskellunge occupy both rivers and lakes/reservoirs. These systems can differ in terms of the thermal and kinetic habitats available to Muskellunge. Rivers such as the James (VA) and reservoirs like Stonewall Jackson (WV) reach summer temperatures above the preferred temperatures for Muskellunge. Rivers and reservoirs may each have cooler temperatures associated with groundwater or tributary inputs and the thermocline, respectively. However, the availability of cooler temperatures to post-released Muskellunge may be limited by velocity in lotic systems, or low dissolved oxygen in lentic systems. To fully assess whether summer catch-and-release mortality is a significant factor in southern Muskellunge populations requires a broad study that examines mortality in both rivers and lakes. There is significant interest in such a study among biologists and managers in VDGIF and WVDNR, investigators at regional universities, and angler groups. Therefore, we propose to conduct a multi-state collaborative effort involving agency biologists, universities, and anglers to quantify catch-and-release mortality of Muskellunge in the southern portion of their distribution. Conducting research simultaneously in lentic and lotic systems, using duplicate methods will not only provide a broad, comprehensive evaluation of the population-level effects of summer angling for Muskellunge in these systems, but will also provide a firm basis for future Muskellunge management now, and in the face of climate change.

This proposed study represents a collaborative effort between two state agencies (VDGIF and WVDNR), two universities (CCU and WVU), and we anticipate several NGOs (Muskies Inc., Trooper Eric Workman Foundation). The PIs will be Dr. Derek Crane (CCU), Dan Goetz (VDGIF), Jeff Hansbarger (WVDNR), and Dr. Kyle Hartman (WVU). All PIs will be actively involved in carrying out the project across locations, ensuring that methodology, analysis and management outputs are integrated and consistent.

From a practical stand point we have developed proposals and budgets for work in Virginia through VDGIF for Coastal Carolina University and for work in West Virginia through WVDNR for West Virginia University. This proposal focuses on the Virginia portion of the project, which will investigate catch-and-release mortality of Muskellunge in the James River. The specific objectives of the James River portion of the study are to (1) track angled and electrofished (control) Muskellunge tagged with radio transmitters to quantify catch-and-release

mortality of Muskellunge in the upper James River, and (2) estimate population level effects of catch-and-release mortality. The concurrent investigation in WV will (1) use the same methods to quantify catch-and-release mortality of Muskellunge and estimate population level effects of catch-and-release mortality on Muskellunge in a lentic water (Stonewall Jackson Lake), and (2) use a pond experiment to identify temperature thresholds for angling related mortality and vulnerability to angling, and effects of gear type on mortality. Data from the individual components of the study will then be combined to make comparisons between lentic and lotic systems, and examine the effects of factors such as water temperature and number of times angled on catch-and-release mortality.

METHODS

Study location and Muskellunge collection

To estimate catch-and-release mortality of Muskellunge angled during summer months from the upper James River, we will compare mortality estimates of angled (n = 40) and electrofished (n = 40) Muskellunge. Field work will be conducted during 2019 and 2020 and led by a Coastal Carolina University MS student (supervised by D. Crane), working collaboratively with personnel from VDGIF, J. Hansbarger, K. Hartman, local fishing guides, and anglers. We selected the upper James River as a study location because (1) it is a popular Muskellunge fishery for resident and non-resident anglers, (2) anglers have expressed concern about summer catch-and-release mortality in the James River, (3) the Muskellunge population is large enough to reasonably expect collection of the desired sample sizes for angled and control fish, and (4) a soon to be completed tag-return study and upcoming creel survey will allow us to scale results to the population level. If we collect adequate data during year 1 to address the research objectives specific to the James River we are open to replicating the study on the New River during the second year. Angling will occur from 15 June through 15 September (when mean daily water temperatures are generally $\geq$ 25 C). Similar to Landsman et al. (2011), angling and handling of experimental fish will be conducted to simulate typical fishing experiences of Muskellunge anglers and we will use best handling practices that are commonly promoted by Muskellunge angler groups (e.g., Muskies Inc.). We will restrict our study to use of artificial baits (generally one to three 4/0-7/0 treble hooks), because use of live bait for Muskellunge fishing is frequently restricted to colder months when mortality from catch-and-release angling is negligible. The proposed pond experiment (proposed to WVDNR), led by K. Hartman, will investigate the effects of gear type on catch-and-release mortality. Angled fish will remain in the water while removing hooks. If hooks cannot be easily removed, they will be cut above the barb using miniature bolt cutters. Most Muskellunge anglers use this technique to reduce handling time and prevent injury to fish caused by forcibly removing a deeply embedded hook(s) from bone, muscle, or connective tissue. After hooks are removed, the fish will be externally tagged with a radio transmitter following Landsman et al. (2011). This transmitter attachment method can be done quickly, does not require anesthesia, and Arlinghaus et al. (2009) and Landsman et al. (2011) did not observe mortality of esocids tagged using this method. Individuals tagging fish will receive training and be required to demonstrate their ability to effectively perform this tagging method prior to beginning the study. Following transmitter attachment, fish will be lifted from the water, exposed to air for 30 s while measuring the fish and taking a picture, and then placed back in the water. Anglers will revive the fish by facing it into the current and assisting the fish with maintaining orientation if necessary. Anglers will remain with the fish until the fish is able to maintain upright orientation and swim or the fish has died. Hook location, reflex

impairment (Davis 2009; Landsman et al. 2011), time of capture, and air and water temperature will be recorded for each angled fish.

Fish used as controls will be captured and tagged prior to the angling component of the study via boat electrofishing. We propose to electrofish control fish in the winter, when water temperatures are low, to minimize the potential confounding effects of mortality resulting from electrofishing Muskellunge that are thermally stressed in the summer. Because catch-and-release mortality may vary based on fish length (Muoneke and Childress 1994; Bartholomew and Bohnsack 2005), we will use data from a recent tag-return study (D. Goetz, unpublished data) to estimate the length distribution of fish caught by anglers, and then use this distribution to select control fish. Electrofishing will occur in the same reach of the James River that angling occurs in during a given year, so that control and angled fish are exposed to the same environmental conditions. Additionally, we will use the same procedures to attach radio transmitters to control fish as was described for angled fish.

Telemetry

Telemetry has been used to successfully estimate mortality for a variety of fishes including esocids (Arlinghaus et al. 2009; Landsman et al. 2011), and provides detailed information on the movement and fate of control and angled fish (Pollock and Pine 2007). . Angled fish will be manually tracked and located within 6 h of release, the day following release, 2 d following release, 3 d following release, and once per week thereafter for 1 month. Control fish will be tracked and located every other week during the same time period. Based on several Muskellunge telemetry studies in rivers we anticipate a high detection probability and minimal number of fish that cannot be located (Younck et al. 1996; Landsman et al. 2011; Owensby et al. 2017). However, we will conduct a fall electrofishing survey to assess transmitter failure or loss, if we fail to locate multiple fish. A fish will be deemed 'dead' if it is located in the same location during three successive surveys. We will try to visually confirm the state of each individual during tracking events by direct observation or use of an underwater video camera because dead fish may be carried downstream by water currents or live fish may inhabit the same location (e.g., fallen tree) for extended periods of time. We will consider upstream movement evidence of survival. Given the large body size of Muskellunge that will be targeted in this study, we are not concerned with movement of tagged fish ingested by predators resulting in false determinations that fish are alive.

Data analysis

We will use detection histories of fish tagged with radio transmitters, data from a recent 4 y tag-return study, and creel surveys to estimate population level effects of summer catch-and-release mortality on Muskellunge in the James River. Because catches of angled fish will be staggered throughout the summer and angled fish will be tracked for one month we will first calculate the average monthly mortality rate for control fish for the 15 June – 15 September time period and one-month mortality rate for angled fish. We will then estimate catch and release mortality rates based on differences between control and angled fish mortality rates following Pollock and Pine (2007). Because control fish will also be vulnerable to angling and some Muskellunge are likely more vulnerable to angling than others based on individual behaviors (J. Hansbarger, unpublished data), we will offer a $20 reward to anglers for providing photographs (with a date and time stamp) of any study fish that is angled. Photographs will be required to include the attached transmitter and unique ID number that is painted on the transmitter. We will

also ask anglers to report the condition of fish upon release. To increase angler awareness about the study, we will post fliers at boat launches within the study reach and contact local guides. Any control fish captured during the study will be considered an angled fish from the time of capture to the conclusion of the study. Mortality rates will be used to estimate total catch-and-release mortality by multiplying the catch-and-release mortality rate and the total number of fish caught during time periods of elevated water temperature (based on tag return and creel data), which can be defined as a range in dates or days corresponding to a threshold temperature (identified in the analysis described below or pond experiment led by K. Hartman). We propose to calculate multiple estimates of total mortality based on alternate decisions about fate of fish that are not located (i.e., alive, dead, censored), method for estimating total number of angled fish during the summer (creel vs. tag return), and focus period for estimating catch-and-release mortality (specific dates vs. dates based on a threshold temperature). Total catch-and-release mortality estimates can then be divided by estimated populations within the study reaches to estimate the proportional effects of catch-and-release mortality. Finally, to estimate the effects of potential factors influencing mortality of fish we will combine data from the WV and VA portions of the project and use logistic regression to model the probability of mortality (one month time period) based on an indicator variable for treatment (angled vs. control), indicator variable for water type (lentic vs. lotic), water temperature at time of capture, and number of times captured.

OUTREACH

We anticipate that local Muskellunge anglers will play an integral role in this study by assisting with angling for fish and providing information about capture of tagged fish. We propose to provide a presentation on the study to anglers after the first year of data collection and at the conclusion of the project. As noted above, we will contact local Muskellunge guides and anglers, and post fliers at boat launches to inform stakeholders about the project.

ANTICIPATED OUTCOMES

Current tag-return studies and creel surveys for the upper James River, coupled with the proposed work, present a unique opportunity to estimate the effects of catch-and-release angling on an important Muskellunge fishery in the southeastern US. Results from this study will provide managers with information to make data-driven decisions about suggested restrictions on angling for Muskellunge during the summer. This project will result in the training of an MS student and subsequent thesis. It will also provide opportunities for undergraduate students to develop field skills in preparation for careers in fisheries. Results from this study will be presented at an annual meeting of the Virginia Chapter of the American Fisheries Society and the Southern Division or international American Fisheries Society annual meetings. We anticipate submitting at least one manuscript for publication in a peer-reviewed fisheries journal.

QUALIFICATIONS OF INVESTIGATORS

D. P. Crane

D. Crane is an Assistant Professor of Biology at Coastal Carolina University and his research focuses on biology, ecology, and management of sport fishes. Ecology and management of Muskellunge has been a major component of his research program for the past 10 years. He has authored or co-authored five peer-reviewed publications on Muskellunge, co-organized a symposium focused on biology, ecology, and management of Muskellunge at the

2013 American Fisheries Society conference, served on the technical committee for the 2016 Hugh C. Becker International Muskie Symposium, and was co-editor of the Proceedings of the Becker Symposium (Kapuscinski et al. 2017).

D. B. Goetz

D. Goetz is a District Fisheries Biologist with VDGIF. He has an M.S. in Fisheries Science and has been managing the James River Muskellunge population for four years.

K. J. Hartman

K. Hartman is a Professor of Ecology in the Wildlife and Fisheries Resources program at WVU and his research focuses on the ecology and management of fishes. He has been the author or co-author on over 100 journal articles and book chapters. He has worked in a wide variety of lotic and lentic systems and from freshwater to marine. His past telemetry studies involved eight species of fishes.

J. L. Hansbarger

J. Hansbarger is the District 5 Fisheries Biologist for WVDNR, managing nine counties in southwest WV. He has an M.A. in Geography and M.S. in Wildlife and Fisheries Resources. He has led or been involved in several Muskellunge research projects, is the chair of the ad-hoc Southern Esocid Technical Committee, and works closely with Muskellunge Angler groups that frequently fish for Muskellunge in the proposed study waters.

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