EVALUATION OF THE BONUS FISHERY CREATED BY THE LOW-DENSITY STOCKING OF STRIPED BASS (*MORONE SAXATILIS*) IN BULL SHOALS LAKE

Dissertation Proposal Draft

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INTRODUCTION

Impounding flowing water for human use has a long history in North America, dating back to the first reservoir built in New Hampshire in 1738. As of 1996, there were over 1,700 impoundments greater than 500 acres (202 hectares) in North America with a combined area of more than 11 million acres (4.45 million hectares) (Miranda 1996). Alteration of the biological communities following impoundment compelled the new specialization of reservoir fisheries management. Although fishery managers initially considered reservoirs unproductive following an opening period of post-impoundment productivity, early studies demonstrated fisheries did not actually collapse after impoundment (Eschmeyer and Tarzwell 1941; Moffett 1943; Stroud 1948; Miller 1950), which led to liberalization of harvest regulations and emergence of biomanipulative management approaches (Miranda 1996). Techniques such as water level drawdowns, stocking, new species introduction, habitat augmentation, and a variety of controls for unwanted species have been employed to manipulate reservoir fisheries to increase yield of desirable species. Increases in recreational angling since the 1950s altered reservoir fisheries management goals from primarily maximizing yield to also include satisfying angler desires (Miranda 1996). However, this increasing attention to social concerns brings with it the challenge for reservoir managers to incorporate expectations of diverse user groups (e. g. tournament anglers, residents, guides, catch-and-release anglers), while balancing other reservoir uses such as flood control and power generation, with the existing biological issues present in fisheries management (Allen et al. 2008). Despite nearly a century of development of reservoir fisheries management practices, questions continue to emerge, the answers to which enhance understanding and management of these dynamic systems.

Stocking is a management tool used to enhance existing native populations and to add non-native species to increase angling opportunities in reservoirs (Erickson et al. 2008). Identifying and understanding what biotic and abiotic factors most influence stocking success is of primary importance for development of successful fisheries (Sutton et al. 2013). Often, success may be based on suitable growth, survival, and distribution of stocked fish that managers can use to alter stocking protocols and/or harvest regulations. For example, growth may be related to diet and/or forage availability, which can influence maximum size attainable during the first summer and directly affect over-winter survival (Sutton and Ney 2001). Seasonal changes in water temperature and/or dissolved oxygen may drive fish movement, survival, and habitat selection (Wooley and Crateau 1983; Coutant 2013). Harsher winters (i.e. lower water temperatures) may limit maximum attainable length resulting in smaller juveniles and size-dependent over-winter mortality limiting recruitment to age-1 (Hurst and Conover 1998). Optimal stocking rates may exist which maximize survival (Moore et al. 1991). Interrelationships among the factors affecting stocking are complex and vary among systems, so system-specific data are useful to fully evaluate the result of stocking, and enable managers to better predict the type of fishery that may be expected under alternative management scenarios.

Management goals arise through a combination of biological considerations and stakeholder expectations, so decisions about what, when, how many, and even whether to stock depends on achieving a balance of social and biological concerns. The need to communicate with and understand user expectations and to address conflict over stocking is a pervasive challenge in fisheries management (Decker and Krueger 1999). For example, Minnesota Department of Natural Resources Muskellunge (*Esox masquinongy*) stocking raised concerns with anglers over potential predation on Walleye (*Sander vitreus*), despite research indicating numbers do not decline following Muskellunge introductions. However, a vocal citizen group still mobilized and pushed for introduction of a bill to the state Senate proposing to ban Muskellunge stocking and redirect funds to a study intended to gauge stakeholder desires. In the northwestern U.S. biologists have raised concerns related to decreases in forage base, reduced number of salmonids, and changes in fish community structure that were observed following stocking of Walleye and Northern Pike (*Esox lucius*) (McMahon and Bennett 1996). Conversely, lake associations in northern Wisconsin often vehemently request they be allowed to stock Walleye in small inland lakes where both survival to creel and reproduction are highly unlikely due to low lake productivity, lack of spawning habitat, and/or existing fish communities (H. Boehm, personal experience). Therefore, understanding and addressing stakeholder opinions and concerns needs to be an integral part of the decision making process in fisheries management.

The introduction of Striped Bass (*Morone saxatilis*) to impounded freshwater inland systems may exemplify the challenge of interweaving social and biological components of reservoir fisheries management. Management agencies have introduced Striped Bass to impounded systems to complement existing fisheries, utilize limnetic zones, and control overabundant forage species (Van Horn 2013). Reservoir managers are often able to rapidly create trophy and/or high density Striped Bass fisheries, providing both recreational and economic benefits (Bettoli 2005). In some of these impoundments (Scruggs 1957; Gustaveson and Blommer 2013) Striped Bass are able to successfully reproduce on their own, however, most of these fisheries lack natural reproduction, so population control is dependent on stocking and harvest regulations. Today in North America, Striped Bass are present in 37 states (33 inland, 4 coastal populations) in the U.S. and one Canadian province (Figure 1).

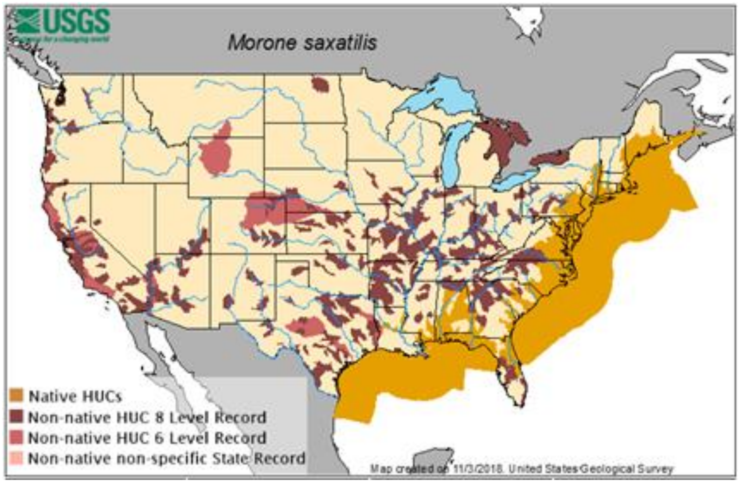

Figure 1. North American Striped Bass range map (USGS, Fuller 2019).

In Missouri, the Missouri Department of Conservation (MDC) stocks Striped Bass in Lake of the Ozarks at a rate of 1 fish/ac (2.5 fish/ha) every other year, and Arkansas Game and Fish Commission (AGFC) annually stocks Norfork Lake at a rate of 7 fish/ac (17.3 fish/ha), and nearby Beaver Lake in northern Arkansas at a rate of 7 fish/ac (17.3 fish/ha) (N. Recktenwald, personal communication). The MDC also began stocking Striped Bass into Bull Shoals Lake (Table 1), which is the focus on our study.

Table 1. MDC Striped Bass stocking in Bull Shoals Lake.

Year	**Month**	**Length (in)**	**Length (mm)**	**Number**	**Stocking Location**
2013	Jun-Jul	3	76	8,000	K-Dock
2013	Jun-Jul	3	76	8,000	Theodosia Bridge
2015	Jun-Jul	2.5	64	10,879	K-Dock
2015	Jun-Jul	2.5	64	10,879	Theodosia Bridge
2017	Sep	4-5	102-127	8,381	K-Dock
2017	Sep	4-5	102-128	7,728	Theodosia Bridge
2018	10-May	8-10	203-254	30	Theodosia Bridge

New introductions of Striped Bass to reservoirs can illustrate the management challenge of reconciling stakeholder and biological concerns, with the controversy surrounding Striped Bass stocking in Norris Reservoir in Tennessee (Churchill et al. 2002) being an excellent example. In the 1940s, within 5-10 years following impoundment of a major Tennessee river system, abundance of native sport fish was extremely high in Norris Reservoir. As stocks of sport fish began to decline over the next 20 years, fishery biologists initiated stocking programs to increase abundance of crappies and Walleye, and create new fisheries through introduction of non-native species. Striped Bass were among introduced species first stocked in the 1960s to use the limnetic zones that had a high density Gizzard Shad (*Dorosoma cepedianum*) population. Though a successful Striped Bass fishery was created, the concurrent declines in native sport fish led some anglers to conclude that the introduced Striped Bass were responsible for those declines, causing a two decade conflict over Striped Bass stocking. In the mid-1990s an adaptive fisheries management plan was developed to address stakeholder concerns, and in the late 1990s a study was undertaken by Mississippi State University to identify potential impacts of Striped Bass on native sport fish. Despite findings that sport fish predation by Striped Bass was negligible, and that the potential for competition among Striped Bass and other predator species only occurred during periods of low forage (Miranda et al. 1998), the conflict continued. A series of legislative actions and persistent mistrust of agency motivations for stocking by some user groups led to creation of an advisory committee representing all stakeholders, with decision-making power by "informed consent," and a neutral facilitator (i.e. not Tennessee Wildlife Resources Agency). Churchill et al. (2002) acknowledged that in hindsight earlier attention to angler attitudes and economic benefits of the fishery may have diffused the conflict sooner, and they highlight an important lesson learned about the need to integrate traditional biological data with an understanding of users and why they value particular resources.

Bull Shoals is the last of a series of impoundments along the White River, lying on the Missouri-Arkansas border with approximately 27% of the surface area in Missouri (Figure 2). It was formed by completion of Bull Shoals Dam in 1951 on the upper White River approximately 42 river miles (68 km) upstream of where the Norfork Lake tailwaters enter the White River (Figure 2). The upper part of Bull Shoals Lake is more riverine with shallower depth and narrower, winding channels, while the lower part of the reservoir is lacustrine with depths up to approximately 50 m at full pool. River mile 0 occurs in the southeast part of Bull Shoals Lake near Bull Shoals White River State Park and the Bull Shoals Dam, and river miles proceed upstream toward Powersite Dam. The 18,390 ha reservoir has 1,191 km of shoreline at maximum conservation pool. The reservoir was initially authorized for flood control and hydroelectric power generation, but today it also supplies water, recreation, and supports fish and wildlife (U.S. Army Corps of Engineers, USACE). Shorelines are often steep rocky bluffs or more gradual gravel flats, and water clarity is high due to relatively low nutrient input.

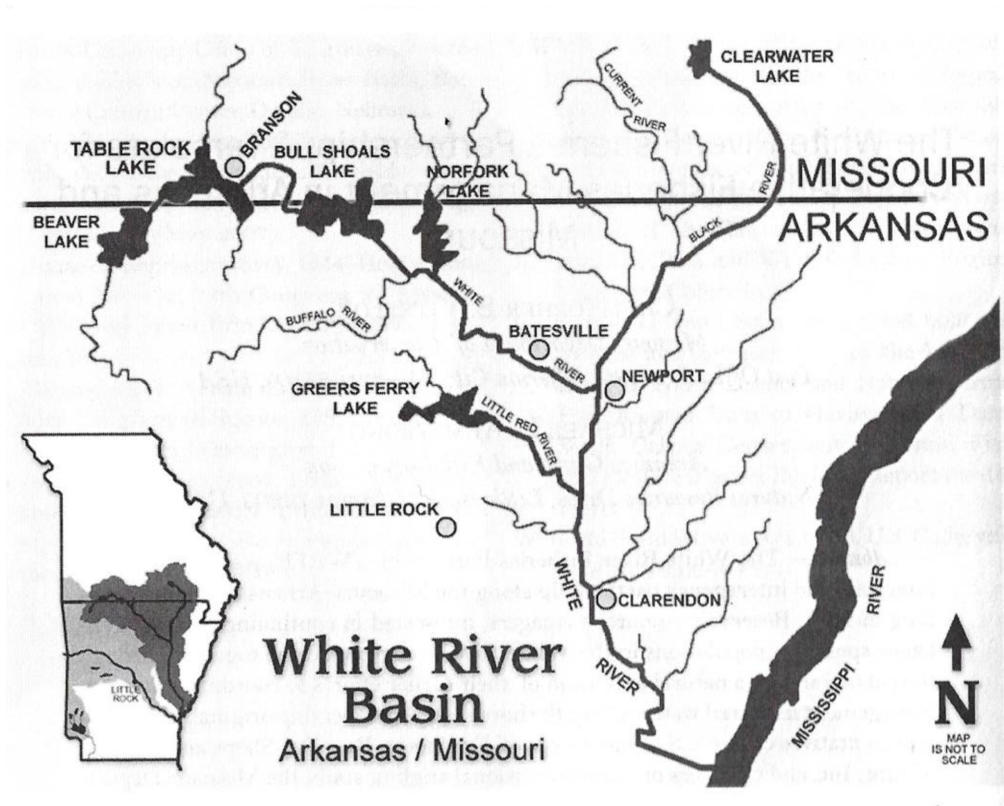

Figure 2. White River basin, Missouri and Arkansas. Reprinted from Vitello and Armstrong 2008.

The Bull Shoals Lake sport fish community contains Walleye (*Sander vitreus*), black bass (*Micropterus* spp.), White Bass (*Morone chrysops*), catfish (*Ictalurus* spp.), and crappies (*Pomoxis* spp.). Pelagic forage include Gizzard (*Dorosoma cepedianum*) and Threadfin Shad (*D. petenense*) and smaller centrarchid species in littoral zones. The MDC and AGFC are responsible for the fisheries management activities within the reservoir following the USACE January 2016 Master Plan for Development and Management of Bull Shoals Lake. Representatives of both agencies meet annually to discuss management of border reservoirs as part of the White River Fisheries Partnership (Vitello and Armstrong 2008).

A low abundance of Striped Bass currently exists in Bull Shoals. In 1998, AGFC stocked 19,000 Striped Bass into the lake in a single stocking event. In Missouri waters, this stocking yielded angler catches of fish over 60 lbs. (23 kg) since the late-2000s, with a potential world-record 68-lb (31 kg) Striped Bass caught in Arkansas waters in 2013. The MDC's goal is to supplement current angling opportunities by sustaining a low density, trophy Striped Bass fishery in Bull Shoals Lake. Plans for stocking began in 2009; however, stakeholder concerns about the potential impacts of Striped Bass on other sport fish in the reservoir were voiced, so an experimental stocking plan at a rate of approximately 0.33 fish/acre (0.89 fish/hectare) every other year was undertaken for 2013-19 (Table 1). To both learn from this experimental stocking and address stakeholder concerns, MDC in collaboration with the Missouri Cooperative Fish and Wildlife Research Unit at the University of Missouri have developed a project to inform future Striped Bass stocking plans and management decisions in Bull Shoals.

Fishery managers need to understand the survival, growth, and dispersal of Striped Bass to evaluate the stocking program at Bull Shoals Lake. Producing and maintaining a trophy fishery of long-lived, fast-growing fish will require a unique stocking strategy that considers growth and survival. Figure 3 provides a conceptual diagram of information needs and the decision process for evaluation of the Striped Bass fishery in Bull Shoals. Understanding interrelationships between Striped Bass population dynamics, community interactions, movement, diet, and physical habitat characteristics are necessary to predict the likely outcomes of different management actions. For example, determination of both survival and its variability for stocked fingerlings will help managers decide how often and how many fingerlings to stock. Information about forage availability and diet content can inform managers about both Striped Bass dietary needs and address the potential overlap with other sport fish. Knowing how factors like growth rate and temperature or water level are related can help managers make stocking decisions as lake conditions change. If an optimal stocking rate exists for maximum survival

(Moore et al. 1991), it will be useful for managers trying to create a trophy fishery to know whether there might also be an optimum stocking rate to create trophy size. Also, understanding seasonal, or size/age based movement patterns of Striped Bass will help managers in the creation of appropriate harvest regulations, inform stocking location, and identify species interactions. Therefore, MDC Fisheries and Resource Science Division identified two primary and broad information needs to be evaluated by researchers: 1) define population dynamics of the Striped Bass population and 2) identify potential impacts, if any, to other sport fish populations.

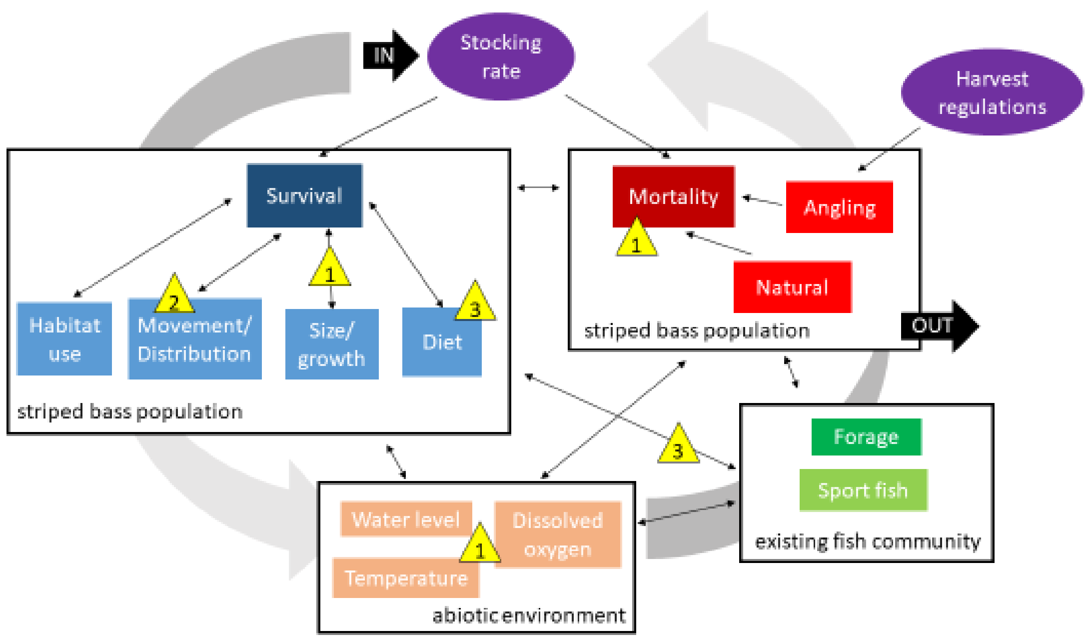

Figure 3. Conceptual diagram of evaluating Striped Bass management in Bull Shoals Lake. Thin black arrows show directionality of population dynamics, management actions, and physical/habitat characteristics. The yellow triangles denote the dissertation chapter number in which each item will be addressed. Purple circles denote MDC management actions that the agency may choose to adjust based on information obtained during the course of the project. Thick black arrows represent the input and output of Striped Bass into or out of the population. Because of the complexity of incorporating both social desires from anglers and other users with the uncertainty inherent in fisheries management, information needs for this project will be addressed using a Structured Decision Making framework. Thus, the large gray cyclical arrows represent the adaptive nature of the management approach to be taken.

More specifically, MDC's identified information needs will be addressed by answering the research questions below in a PhD dissertation with the following chapters:

Chapter 1 - POPULATION LEVEL CHARACTERIZATION OF A STOCKED LOW DENSITY TROPHY BONUS STRIPED BASS FISHERY DURING EARLY YEARS OF ESTABLISHMENT IN BULL SHOALS LAKE.

1. What is the survival and growth rate of Striped Bass stocked in Bull Shoals, and does it change with age/size?
2. What Striped Bass abundance and size structure might be expected within 10-30 years?
3. What stocking regime would produce and maintain a trophy Striped Bass fishery in Bull Shoals, and how would alternative stocking plans change the fishery?

Chapter 2 - DISPERSAL AND MOVEMENT PATTERNS OF STOCKED JUVENILE AND ADULT STRIPED BASS IN BULL SHOALS LAKE.

1. What are the spatial and temporal movement pattern of Striped Bass, and does it change with size/age?

Chapter 3 - STRIPED BASS POTENTIAL DIET OVERLAP WITH OTHER SPORT FISH SPECIES IN BULL SHOALS LAKE.

1. What is the diet overlap between Striped Bass and other sport fish species (black bass, Walleye, and crappie), and is diet overlap dependent on age/size of Striped Bass and/or other sport fish?

Chapter 4 - SUMMARY AND MANAGEMENT RECOMMENDATIONS

Chapter 4 of the dissertation will consist of conclusions and management recommendations using the information from chapters 1-3. The management recommendation will be developed in consultation with MDC to provide science-based information to evaluate current or potential alternative stocking strategies (e.g., rates, frequency, and/or location), and whether the current Striped Bass regulation and stocking rate is appropriate to achieve a trophy fishery in Bull Shoals (Table 2). We will consider development of a simulation tool in a program like R or Microsoft Excel, which would be based on system specific data and allow MDC managers to efficiently model and compare alternative management scenarios to achieve their desired fishery objectives.

Table 2. MDC and AGFC angling regulations for Bull Shoals and Norfork reservoirs.

State	Lake	Daily Creel Limit	Length Limit
MO	Norfork	15 combined SB, WB, and HB; only 3 may be SB	20 in (51 cm) minimum for SB
AR	Norfork	3 combined ST and HB	20 in (51 cm) minimum for SB
MO	Bull Shoals	15 combined SB, WB, and HB; only 3 may be SB	20 in (51 cm) minimum for SB
AR	Bull Shoals	3 combined ST and HB	none

SB = Striped Bass, WB = White Bass, HB = Hybrid Bass

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CHAPTER 1 – POPULATION LEVEL CHARACTERIZATION OF A STOCKED LOW DENSITY TROPHY BONUS STRIPED BASS FISHERY DURING EARLY YEARS OF ESTABLISHMENT IN BULL SHOALS LAKE.

QUESTIONS

1. What is the survival and growth rate of Striped Bass stocked in Bull Shoals, and does it change with age/size?
2. What Striped Bass abundance and size structure might be expected within 10-30 years?
3. What stocking regime would produce and maintain a trophy Striped Bass fishery in Bull Shoals, and how would alternative stocking plans change the fishery?

GENERAL METHODS

We will use telemetry to answer these questions. These methods are applicable to all the questions above, and details of the analytical methods will be listed below for specific questions. Telemetry offers a range of options for monitoring movement (Combs and Peltz 1982; Wilkerson and Fisher 1997; Jackson and Hightower 2001), habitat preference (Douglas and Jahn 1987; Cheek et al. 1985; Sammons and Glover 2013) and tolerance (Bettoli 2005; Moss 1985), and mortality (Hightower et al. 2001; Young and Isely 2004; Thompson et al. 2007) of Striped Bass, and acoustic telemetry performs best in large, deep, low conductivity systems like Bull Shoals Lake (Koehn 2012). Therefore, we will use a combination of active and passive tracking of juvenile and adult Striped Bass implanted with acoustic transmitters to estimate survival and to inform placement of sampling gears to best target Striped Bass for capture to obtain length and weight measurements and collect structures for age and growth estimation.

We will annually implant at least 100 juvenile (age-0, > 8 inches, 203 mm) Striped Bass with acoustic transmitters (Figure 1) and use a combination of manual and passive tracking to determine survival within the first few months post stocking, and over-winter survival. We will also implant transmitters in at least 30 adult (> 12 inches, 305 mm; Figure 1) Striped Bass, so the combined number of juvenile and adult Striped Bass implanted with tags annually will be approximately 120 individuals. Larger transmitters with longer battery life (> 800 d) will enable us to use a combination of active and manual tracking to monitor survival of adult Striped Bass for the duration of the project.

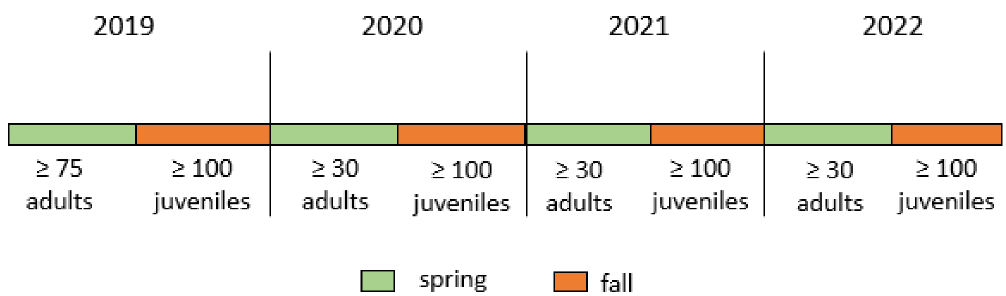

Figure 1. Estimated stocking time and number of juvenile (age-0, > 203 mm) and adult (> 305 mm) Striped Bass to be implanted with acoustic transmitters and stocked in Bull Shoals Lake. In 2019, spring stocking will occur in late June, though in future years it will occur earlier. Fall stockings will take place in October.

Juvenile Striped Bass Acoustic Transmitter Implantation

We will implant age-0 Striped Bass with coded acoustic telemetry transmitters during their first fall and obtain these juveniles through existing hatchery and stocking efforts. The MDC will stock 16,000 fingerling Striped Bass at a rate of 0.33/acre (0.89 fish/hectare) (2-3 inches, 51-76 mm) into Bull Shoals Lake in late-June or early July of 2019 and 2021. A subsample of those fingerlings will be held each year in the MDC Lost Valley Hatchery in Warsaw, Missouri to produce a minimum of 100 8 inch (203 mm) fish, and will subsequently be implanted with acoustic transmitters. In 2020 and 2022, MDC will obtain fingerlings to be implanted with acoustic transmitters from a Striped Bass hatchery. Each juvenile will be implanted with a Vemco V9-2X coded acoustic transmitter with a signal delay of 60-180 seconds. At these settings the expected battery life of the implanted transmitters is approximately 803 days. Choice of this size tag is based on a pilot study in 2018-2019 where MDC biologists used both Vemco V7-2X (1.6 g in air) and V9-2X (4.7 g in air) tags in fingerlings of this size, and determined that the 8 inch (203 m) fish had little in hatchery mortality and short-term expulsion with the V9 tags (A. Turner, MDC, personal communication).

Transmitter implantation will take place at Lost Valley Hatchery in September, following the same procedure used during the 2018-19 pilot year. Prior to tagging, we will measure total length (mm) and weight (g) of all tagged individuals. Tagging will be conducted by a team of three people; one person will hold the fingerling immobile, another team member will conduct the surgery, and the third team member will record data and confirm the tag is transmitting. Fish will not be anesthetized prior to transmitter implantation, and each surgery will take 2-3 minutes (A. Turner, MDC, personal communication). The transmitter will be inserted into the body cavity through a small mid-ventral incision posterior and slightly to the side of the pelvic girdle (Figure 2). The surgery needle, suture, and scalpel will be soaked in 70-95% ethanol for disinfection prior to implantation. Both the surgery site and the transmitter will be washed with iodine prior to inserting the transmitter. All members of the three person tagging team will wear nitrile gloves. Once the transmitter has been inserted, the incision will be closed with 2-3 simple interrupted sutures of absorbable 3-0 or 2-0 chromic gut material using a 3/8 inch (0.95 cm) curved 19-24 mm reverse cutting needle (Dunn and Philips 2004).

Although fingerlings tagged during the pilot year recovered and incisions healed well, MDC did find it necessary to hold tagged fingerlings in the hatchery for up to 30 days post implantation to allow incisions to fully heal so they did not break open during loading and transport. All tagged fingerlings will be held in Lost Valley Hatchery for approximately one month post-tagging. The fish tagged in 2019 will then be stocked into Bull Shoals Lake at the Theodosia bridge in late October or early November. All tagged individuals will be marked with t-bar Floy tags, with unique IDs, implanted into the left dorsal musculature. These external tags will alert anglers that they have caught a fish containing an acoustic tag. The phone number of the West Plains MDC office is listed on external tags, and may facilitate recovery of still functioning transmitters from harvested fish and alert us to angling mortalities.

Figure 2. Vemco V9-2X tag and incision wound on a ~8 inch (203 cm) Striped Bass fingerling implanted with a transmitter during the 2018-19 pilot year.

Adult Striped Bass Acoustic Tag Implantation

In spring 2019, approximately 500 adult (> 12 inches, 305 mm) Striped Bass were obtained by Lost Valley Hatchery and in May 2019 up to 110 of these adult Striped Bass will be implanted with V13-1X (11 g in air) or V16-4X (24 g in air) acoustic transmitters following the same procedure described for juveniles above. Choice of tag size will be based on weight so as not to exceed 2% of the pre-tag body weight (Winter 1996). Wounds will be closed with 2-0 absorbable chromatic gut sutures with 27 mm needles, but adults will also be held at Lost Valley Hatchery for up to 30 days post tagging, and externally marked with t-bar Floy tags with unique identification numbers. These adults will be stocked in early summer 2019 from the Theodosia bridge.

The Lost Valley Hatchery will maintain a supply of adult Striped Bass from those received in 2019 for adult stockings for the duration of the study. In 2020-22, an additional ≥ 30 adult Striped Bass will be implanted annually with V13 or V16 transmitters depending on size, held in the hatchery, and stocked each spring.

Passive Tracking

Receiver Placement

Prior to placing remote receivers, we wanted to determine the range at which acoustic transmitters could be reliably detected in Bull Shoals Lake. While freshwater lakes and reservoirs are usually optimum environments for acoustic tagging studies, the presence of rocky bottom and sides in Bull Shoals Lake increases the possibility of echoes from coded tags, which could result in missed detections (Pincock and Johnston 2012). To address this potential problem, we conducted a range test prior to receiver installation to determine detection probability.

Between 15 and 17 January 2019, we positioned a series of nine Vemco VR2Tx receivers approximately linearly at distances of 100 m, 200 m, 300 m, 350 m, 400 m, 450 m, 500 m 550 m, and 600 m from a Vemco V9-2X range test tag, which is the smallest and lowest power tag we will use in this study. The range test tag was set to transmit at fixed intervals, and internal transmitters in VR2Tx receivers were silenced to reduce collisions.

Vemco's Range Test Manual recommends a detection probability of at least 80% under optimal conditions, and 50% under poor conditions. Our results found that there was 80% detection up to 350-450 m across a range of conditions. Detection probability decreased below

50% between 300-400 m during a rain event (i.e. noisy conditions), and multiple valleys in detection probability below 50% begin to occur in the 450-550 m range. Based on the results of this initial range test, we identified 350-400 m as a conservative estimate of the distance at which all tags (V9 and larger) can be reliably detected in Bull Shoals.

In March 2019, we deployed 24 Vemco acoustic receivers (3 x VR2W and 21 x VR2Tx) throughout Bull Shoals Lake (Figure 3). Receiver locations were chosen in an attempt to maintain no greater than a 350-400 m distance to shore, per range test results. Because little is known about distribution of Striped Bass in Bull Shoals Lake, we opted to spread receivers as evenly as logistically possible (i.e. optimal channel width/steepness, absence of submerged trees, and shoreline tree anchor availability) throughout the system during the first year of the study. We will download data from these receivers upon retrieval for the first time approximately six months after deployment (fall of 2019). This preliminary movement data will be used to inform future receiver placement as the study progresses.

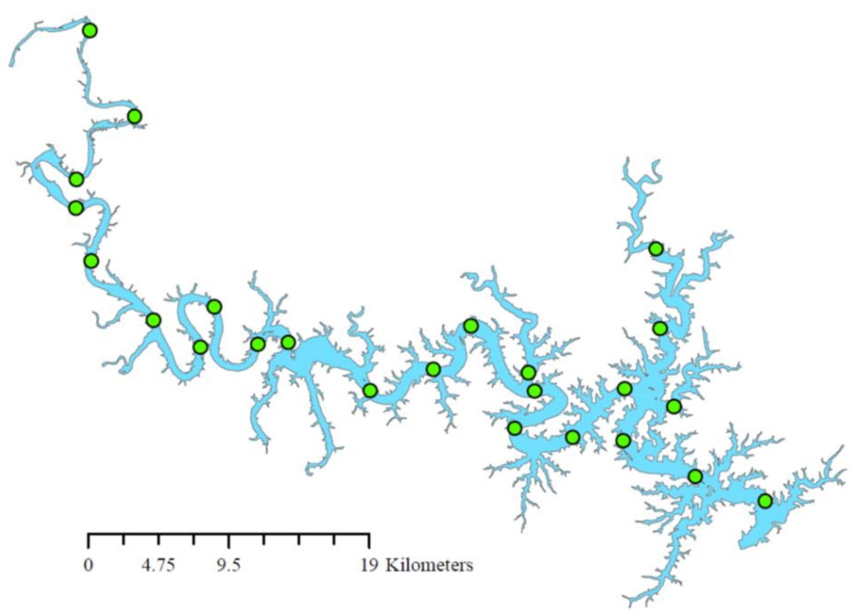

Figure 3. Green dots indicate locations of 24 acoustic receivers deployed throughout Bull Shoals in March 2019.

To minimize tipping and meet boat safety concerns expressed by the US Army Corps of Engineers, we opted to moor receivers using an anchored subsurface buoy design with a weighted rope run to shore and tied to a tree. Receiver mounts consist of a foam PVC buoy (4.8 kg buoyancy) attached to a concrete anchor (approx. 23 kg) with a 2-m length of 0.95 cm diameter stainless steel cable looped at both ends and attached with cable clamps (Figure 4). Receivers were fixed between 1-1.5 m from the anchor, to ensure the buoy does not interfere with transmitter detection, and attached to the cable using a combination of metal hose clamps and a large plastic zip tie. We ran braided nylon rope (0.64-0.95 cm diameter) weighted with split lead net weights, from anchors to shore. Anchor ropes were tied loosely around trees, and a garden hose yoke was used to protect tree trunks from abrasion. We marked all receiver locations and onshore tie off locations using a GPS. Receivers and anchor ropes will be periodically checked, and if lost we can transpond within detection range to VR2Tx receivers to determine location, and check battery life and number of detections.

Figure 4. Mooring design used for acoustic receivers.

Manual Tracking by Boat

We will complement tag detection from deployed passive receivers with manual tracking by boat. Manual tracking will likely constitute a large time portion of our field sampling, but it will allow us to obtain finer scale movement and location information than remote receivers alone (Ng et al. 2007). It also has the potential to help us identify dead fish when tags are repeatedly located at the same location and/or consistently weak (Melnychuk and Christensen 2009). We will also have real time information, rather than having to wait for periodic receiver downloads. We will use a Vemco VR100 deck box receiver and bow mounted omnidirectional and directional hydrophone attached to a depth and angle adjustable pole. Once we detect a signal, we will switch to the VH110 directional hydrophone and move in the direction of the signal. We will manually lower the gain so the signal is still audible, but not very strong then slowly sweep the hydrophone back and forth watching for signal strength values, and periodically checking the other three directions to rule out the possibility we are hearing echoes. When we believe we are on top of the tag, we will rotate the hydrophone 360 degrees to determine if a strong consistent signal persists (Vemco Acoustic Telemetry User Guide). Active tracking will occur most intensively for an initial period following stocking events, then will shift to approximately monthly tracking periods by reservoir section. In June 2019, we conducted blind tests to determine how accurately we can locate stationary tags. First detection with the omnidirectional hydrophone occurred at approximately 275 m, and we were able to get signal readings > 80 dB between 11-60 m of known locations of tagged test fish.

QUESTIONS

1. What is the survival and growth rate of Striped Bass stocked in Bull Shoals, and does it change with age/size?

Background/Prediction

Estimating survival of the Striped Bass stocked in Bull Shoals Lake is necessary to inform future stocking decisions. Stocking of inland Striped Bass fisheries has often been a trialand-error process with regard to size at stocking, rate, location, and timing (Sutton et al. 2013). Establishment of a Striped Bass fishery following stocking does not always occur (Bailey 1975), and when it does occur first year survival may be relatively low (e.g. 20.8 % mean annual survival across 11 years, Moore et al. 1991). Survival may increase after age-1 (Moore et al. 1991) until fish attain large enough size after which hooking mortality (Bettoli and Osborne 1998) and/or habitat stress (Coutant 2013) become primary sources of mortality.

Data Collection

Approximately 100 juvenile Striped Bass will be implanted with acoustic transmitters annually and released off-shore by boat at Theodosia Bridge in falls from 2019 to 2021. Within the first week of stocking we will attempt to locate each stocked individual at least once by boat to assess initial survival and identify potential stocking-related mortality. Manual boat tracking will begin in the Theodosia arm near the bridge and expand as necessary and logistically possible to detect each stocked individual at least once within the first week post-stocking. Passive receivers deployed in the Theodosia arm and the rest of the system will simultaneously monitor post-stocking movement and will detect any fish that may move too quickly out of the arm to be detected by manual tracking.

After the initial post-stocking week of tracking, we will make approximately monthly visits to actively track for 5-7 day periods. Ideally, we will cover the entire reservoir during each tracking trip. However, it is likely time will be the limiting factor in our ability to do this. We will have a better estimate of the daily area which we can cover while manually tracking as the project progresses. We have divided the reservoir into 24 sections centered on locations of passive receivers, and more broadly into three major sections (Figure 5). If we find we cannot cover the entire reservoir each tracking trip we will use random stratification to select a feasible number of small sections within each of the major sections throughout the reservoir during each tracking event. We may be able to further guide manual tracking efforts by transponding to VR2Tx receivers to determine if there have been, and the number of tags detected. Date, time, and location of tag detections will be recorded during manual tracking, and passive receivers will automatically log these values for later download.

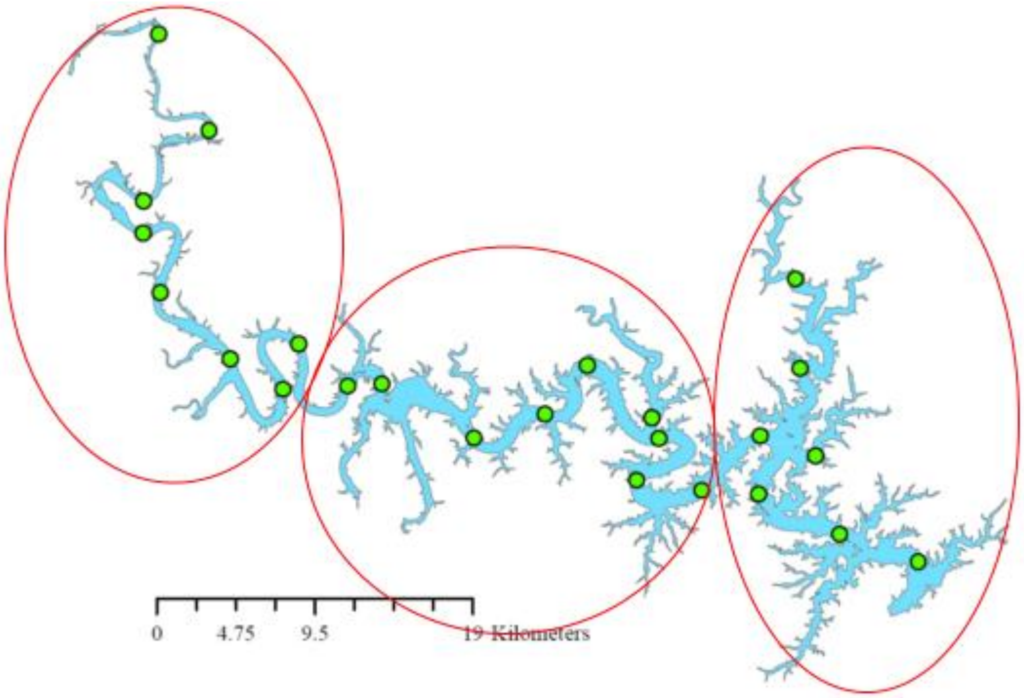

Figure 5. The twenty-four segments Bull Shoals may be divided into for tracking purposes. Each section is centered on a passive receiver (green dots). Red ovals denote major sections from which a series of subsections may be randomly chosen to cover during tracking trips.

Receivers that were deployed in March 2019 will continuously detect fingerling movement when we are not actively tracking. We will download receivers in December 2019, which will have captured the first approximately three months post stocking. In another three months (March 2019) we will download receivers again and replace batteries. These data, combined with our active tracking will be used in calculating over-winter survival and will inform further tracking efforts and receiver placement as the project progresses.

Analysis

We will determine survival by following individually tagged Striped Bass over time using acoustic telemetry. We will use the capture-recapture model developed by Pollock et al. (1995) for radio-tagged animals to estimate Striped Bass survival. Detections using acoustic telemetry will serve as nonphysical recaptures. Individual binomial capture histories will be developed over time with capture denoted by 1 and no capture denoted by 0. Data will be structured into rows by individual (i.e. tagged individual) and a column for each capture history (e.g. 111 would denote capture of an individual during each of three sampling periods). This model combines Jolly-Seber type capture-recapture models (Lebreton et al. 1992) with Kaplan-Meier survival analysis models (Pollock et al. 1989), so can be applied to open populations, may include observations of live animals and dead animals, and allows for capture probabilities between 0 and 1 (Pollock et al. 1995). Model parameters (including survival probability) will be estimated from capture history data using maximum likelihood estimation in a statistical software package such as the package “survival” or “RMark” in R.

2. What Striped Bass abundance and size structure might be expected within 10-30 years?

Background/Prediction

Arkansas Game and Fish Commission stocked a low density of Striped Bass into Bull Shoals Lake in 1998, and within 10 years anglers began catching record-breaking fish as a result of this stocking. Thus, it has been demonstrated that a very low density trophy Striped Bass fishery can develop within 10 years in Bull Shoals Lake. Anglers have already reported catching Striped Bass from the 2013 stocking in Bull Shoals Lake. Angler reports from September 2015 included fish averaging 22 in (559 mm) and 5 lbs (2.3 kg) at 3 years of age. Reports from almost a year later in July 2016 included angler catches of multiple 8-10 lb (3.6-4.5 kg) Striped Bass reaching lengths of at least 27 in (686 mm) at 4 years of age (N. Reckenwald, MDC, personal communication). These reported sizes are in the range considered to be above average growth by age-class when compared to other reservoirs containing Striped Bass (Wilson et al. 2013), suggesting growth rates in Bull Shoals Lake have the potential to rapidly produce a fishery of large individuals.

Data Collection

Beginning in late fall 2019 and through 2022 we will use short-term experimental gill net sets to sample Striped Bass. Depending on location, nets may be suspended anchored in the water column or drifted downstream. During summer of 2018, MDC spent several days running standard monofilament experimental gill nets. However, necessary short net set durations combined with the likelihood of encountering individuals at a very low density in a large system resulted in very low catch during the pilot year. However, in fall 2019 we will have location results from the previous summer of manual telemetry tracking and the first download of passive receivers to inform net set sites to better target Striped Bass. It is likely Striped Bass will only be able to survive in gill nets for a short period, so we will begin with 1-2 hour net sets to ensure survival of netted fish. Because we do not know what bycatch may be or the likely number of Striped Bass that may be caught per gill net and require processing, we will start with a maximum of two sets at a time to ensure we can drive to and process nets within a 1-2 hour period.

The timing, location, and frequency of gill netting will depend on the results of manual and passive tracking during the first summer. Initial locations will be based on reservoir reaches with high numbers of transmitter-tagged Striped Bass. Previous sampling by MDC has determined that Striped Bass may congregate in reaches near Powersite Dam in fall (as water temperatures cool). Therefore, this reach may be a likely starting location.

We will collect total length (mm) and weight (g) for all gill netted Striped Bass. Striped Bass will not be intentionally sacrificed to collect otoliths for age estimation, however, MDC has partnerships with several Striped Bass anglers who fish Bull Shoals Lake who provide lengths and heads of fish they have harvested for otolith removal. Annuli will be read using a dissecting microscope by MDC staff at the West Plains office. In addition, age structures, total length, and weight will also opportunistically be collected from other Striped Bass caught during MDC standard sampling surveys. Otoliths will be collected from any Striped Bass that experience sampling mortality. If we recapture known age (i.e. acoustic tagged) fish we will record tag number and include in analysis of length at age. Angling surveys may also be used to supplement gill net surveys to obtain increased sample sizes of Striped Bass.

Analysis

We will calculate some basic population dynamics for Striped Bass in Bull Shoals Lake. We will estimate von Bertalanffy (1938) growth curve parameters using collected total length measurements and otolith-based age estimations. While Gabelhouse (1984) defines trophy Striped Bass as being 45 inches (1140 mm), we will use L_∞ (maximum theoretical length) based on Striped Bass collected from Bull Shoals to inform a system-specific trophy definition. MDC will also be consulted on the definition of a trophy Striped Bass in Bull Shoals Lake, as weight may also be considered in the definition. We will determine the length-weight relationship for stocked Striped Bass using the equation $W = aL^b$, where W = weight (g), and L = total length (mm). The length:weight equation will be log-transformed to obtain a slope estimate for use in the simulations described below. We will use estimates of survival obtained from telemetry detections.

We will create a yield per recruit (YPR) model in the Fishery Analyses and Simulation Tools (FAMS v1.64; Slipke and Maceina 2014) software program to predict size structure and abundance of the Striped Bass fishery over time at observed survival and growth rates for a cohort of fish. FAMS uses the Jones (1957) modification of the Beverton-Holt (1957) yield equation as described in Ricker (1975). The YPR model allows for simulations of effects of variable exploitation, natural mortality rates, and length limits on the population. The YPR model requires input values from the weight-length relationship, number of recruits (cohort size), maxiumu age, estimates of angling and natural mortality, and von Bertalanffy growth parameters (L_{∞}, k, and t_0). We will simulate size structure and abundance across a range of values for fishing mortality, given the fishery is relatively new and exploitation levels that may develop are yet unknown.

3. What stocking regime would produce and maintain a trophy Striped Bass fishery in Bull Shoals Lake, and how would alternative stocking plans change the fishery?

Background/Prediction

The 1998 one time low density stocking of Bull Shoals Lake by AGFC resulted in trophy sized Striped Bass. However, we do not yet know how long this fishery will exist. The MDC stockings beginning in 2013 have already yielded catches of fast-growing Striped Bass. The rate at which MDC is stocking Bull Shoals is very low relative to the rate used to support other nearby Striped Bass fisheries.

During the 2018-19 pilot year, MDC collected otoliths from 16 Striped Bass from a combination of angled and gill netted individuals. Two of these Striped Bass were from the initial stocking in 1998, so fortunately large fish were represented in the growth curve (Figure 5), which suggests that Striped Bass will begin to obtain trophy size (Gabelhouse 1984) within approximately 10-15 years post stocking.

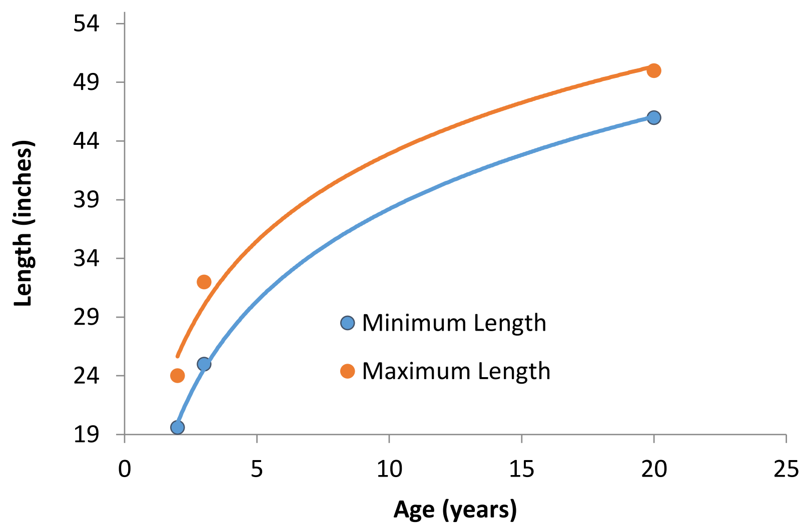

Figure 5. Growth curve for minimum and maximum lengths of Striped Bass sampled during 2018-19 pilot year in Bull Shoals Lake.

Data Collection

Data collection methods will be the same as those used to address research question 2.

Analysis

We will create a dynamic pool model in FAMS to predict size structure, abundance, and other population dynamic output variables for the predicted Striped Bass fishery under different stocking (i.e. recruitment) rates. We will use this model because it allows recruitment and mortality to vary across years. The dynamic pool model requires the same parameters as the YPR model described above, but includes age-specific estimates of mortality, and allows us to simulate the fishery under alternative stocking scenarios and/or survival rates. We will run this model for multiple potential stocking scenarios identified by MDC and angler stakeholders. Because MDC is stocking Striped Bass, and there is no natural recruitment, we have exact values.

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CHAPTER 2 – DISPERSAL AND MOVEMENT PATTERNS OF STOCKED JUVENILE AND ADULT STRIPED BASS IN BULL SHOALS LAKE.

QUESTION

1. **What are the spatial and temporal movement pattern of Striped Bass, and does it change with size/age?**

Background/Predictions

Understanding seasonal and/or size/age based movement and dispersal patterns of Striped Bass will help fishery managers in the creation of appropriate harvest regulations, help inform stocking location and timing, and identify whether certain areas of the reservoir may be more affected by Striped Bass. Seasonal movement of Striped Bass in inland reservoirs is often driven by temperature and oxygen requirements (Cheek et al. 1985). Striped Bass prefer water temperature below 26° C and dissolved oxygen levels above 2 mg/L (Coutant 1985), and move to areas of thermal refuge during hot summer months (Moss 1985; Wilkerson and Fisher 1997; Young and Isely 2002). However, younger/smaller Striped Bass have wider thermal tolerances and may persist in and be able to use areas that large adults cannot (Coutant 2013). Adults generally move to the coolest water available with adequate dissolved oxygen during summer, and they may seek the warmest water available during winter moving into tributaries until spring (Farquhar and Gutreuter 1989). This may mean using tailwaters of dams to upstream impoundments (Jackson and Hightower 2001), or seeking refuge in deep open water of the main lake during hot summer months (Combs and Peltz 1982). During the 2018-19 pilot year, MDC staff and anglers noticed a consistent congregation of Striped Bass at Powersite Dam near Forsyth from late spring through the end of summer. This observation suggests thermal stressors may be present during summer in Bull Shoals, and that Striped Bass may be seeking cooler tailwater entering the system from Lake Taneycomo upstream.

Despite general seasonal movement patterns, individual Striped Bass may exhibit site fidelity to specific reservoir areas throughout all seasons (Jackson and Hightower 2001). Alternatively, Striped Bass may exhibit high site fidelity only during certain seasons (Young and Isely 2002). While the majority of individuals may occupy a certain area of a system most of the time, specific individuals may be continually located in specific localized habitat areas (Wilkerson and Fisher 1997) or repeatedly detected within meters of previous detections (Ng et al. 2007). While seasonal temperature based differences in Striped Bass movement are well established, consistent patterns in Striped Bass movement by size are less apparent. Correlations between movement and size have been noticed in fall though size differences were not significant (Wilkerson and Fisher 1997; Sammons and Glover 2013).

Data Collection

In spring of 2019, up to 110 adult (> 305 mm) Striped Bass will be implanted with Vemco V13-1X or V16-4X acoustic transmitters at Lost Valley Hatchery as described in the general methods for Chapter 1. These fish will be released off-shore by boat in late-June from the Theodosia bridge. The Lost Valley Hatchery will maintain a supply of adult Striped Bass for the duration of the study, and ≤ 30 adults will be implanted with acoustic transmitters and stocked each spring in 2020-22. In 2019-22, ≤ 100 juvenile (age-0, 203 mm) Striped Bass will be annually implanted with Vemco V9-2X acoustic transmitters following the same procedure and stocked in late fall.

We will use acoustic telemetry to track the movements of juvenile and adult Striped Bass in Bull Shoals Lake between 2019 and 2022. In March 2019, we deployed an array of 24 passive Vemco VR2W (3) and VR2Tx (21) receivers throughout the reservoir (Figure 1). Positon of these receivers is such that they can cover the entire channel at point of placement, which divides the reservoir into 24 segments within three major zones (Figure 1).

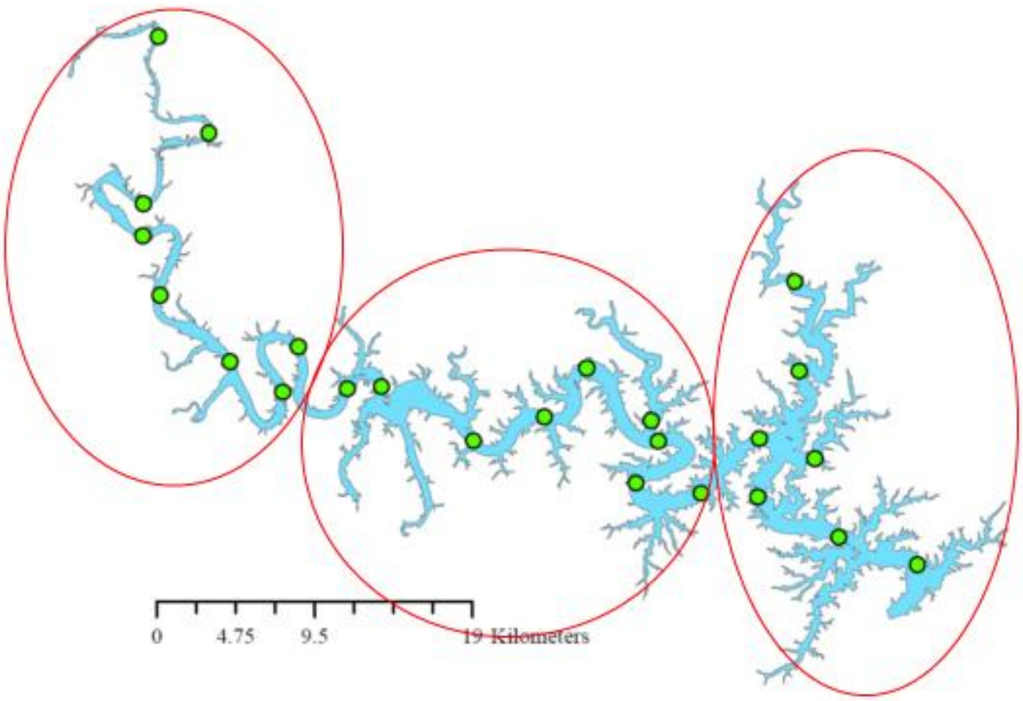

Figure 1. Green circles denote location of passive receivers deployed in Bull Shoals Lake in March 2019. Red ovals show the three major segments.

We will download detections from passive receivers in fall of 2019 before juveniles are stocked and again in winter after juveniles have been at large for approximately three months. The results of the first 6-9 months of combined manual and passive tracking will inform future receiver array design. If Striped Bass widely distribute throughout the reservoir, we may maintain the current widely spaced passive array layout. However, if the fish undergo seasonal movements and concentrate in a certain area(s) of the lake, we may move passive receivers to that area during certain seasons to obtain finer scale movement information.

We will record temperature and dissolved oxygen profiles at monthly intervals over the receiver within each of the 24 reservoir zones. We will obtain water level and discharge data from the Army Corps of Engineers.

Analysis

Logistic regression will be used to predict whether the number of Striped Bass in a reservoir segment is influenced by fish size, season, and environmental variables that are likely to influence Striped Bass percent detection. We will calculate percent detection by reservoir segment (i.e. number of individuals captured in a particular segment divided by total number of individuals detected in the reservoir across all segments) based on locations form the passive receiver array. Size-specific models will be developed for small juvenile (age-0, > 203 mm at tagging) and large adult (age-1+, > 305 mm at tagging) Striped Bass to determine if the factors affecting distribution differ by size. Due to V9-2X transmitter life span (~803 days), juveniles implanted with transmitters in 2019 will make the transition to adult status during the course of the study. Model variables will include average depth at which temperature exceeds 26°C, depth at which dissolved oxygen falls below 2 mg/L, difference between these two depths (i.e. available oxythermal habitat), reservoir discharge, water level, and reservoir segment, and data will be compared by season. We will create both single and multi-variable models and use an information-theoretic approach to compare models (Burnham and Anderson 2002) that best explain distribution of Striped Bass based on physical and temporal characteristics (reservoir zone, month or season), biology (fish size), and water quality (water temperature, dissolved oxygen, water level) and will compare them using AIC scores.

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CHAPTER 3: STRIPED BASS POTENTIAL DIET OVERLAP WITH OTHER SPORTFISH SPECIES IN BULL SHOALS RESERVOIR.

QUESTION

1. **What is the diet overlap between Striped Bass and other sport fish species (black bass, Walleye, and crappie), and is diet overlap dependent on age/size of Striped Bass and/or other sport fish?**

Background/Predictions

The addition of Striped Bass to Bull Shoals Lake has some anglers and stakeholders concerned that a low-density bonus Striped Bass fishery may impact other sport fish (A. Turner, MDC, personal communication). Stocking of Striped Bass in reservoirs often raises concerns among anglers about negative interactions with traditional sport fisheries (Miranda and Raborn 2013), with common concerns including competition between introduced Striped Bass and sport fish and predation of sport fish by Striped Bass. Black bass, crappies, and Walleye are among the most popular managed sport fishes in Missouri reservoirs (Michaletz and Siepker 2013). We will focus on these sport species and respective forage species for diet comparisons, because it is important to both managers and anglers that stocking Striped Bass creates a popular fishery that is not detrimental to these traditional fisheries.

Many studies (e.g. Stevens 1958; Higginbotham 1979; Miranda et al. 1998; Shepherd and Maceina 2009) have examined Striped Bass diets and found over 95% of the contents of their diets to be clupeids, with very low numbers (< 10%) of sport fish species. It is likely we will observe similar diet trends in Bull Shoals, because Striped Bass are primarily pelagic feeders and focus on clupeids in reservoirs, whereas black bass and crappie species generally spend more time in littoral areas and prey on smaller centrarchids. However, other sport fishes such as

Walleye may occupy a combination of pelagic and littoral habitats. Understanding diet overlap and the extent of that overlap between Striped Bass and other popular sport fishes in Bull Shoals will enable MDC to address angler concerns about potential competition and predation by providing system-specific estimates.

During the 2018-19 pilot year, samples for stable isotope analysis were collected from Bull Shoals Lake during spring using electrofishing (Figure 1). Species collected included Striped Bass, Black Crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), Brook Silverside (*Labidesthes sicculus*), Common Carp (*Cyprinus carpio*), Gizzard Shad (*Dorosoma cepedianum*), Golden Redhorse (*Moxostoma erythrurum*), Largemouth Bass (*Micropterus salmoides*), Spotted Bass (*Micropterus punctulatus*), Spotted Gar (*Lepisosteus oculatus*), and Walleye (*Sander vitreus*). Results suggest Striped Bass, medium sized Walleye, and White Bass may have similar diets.

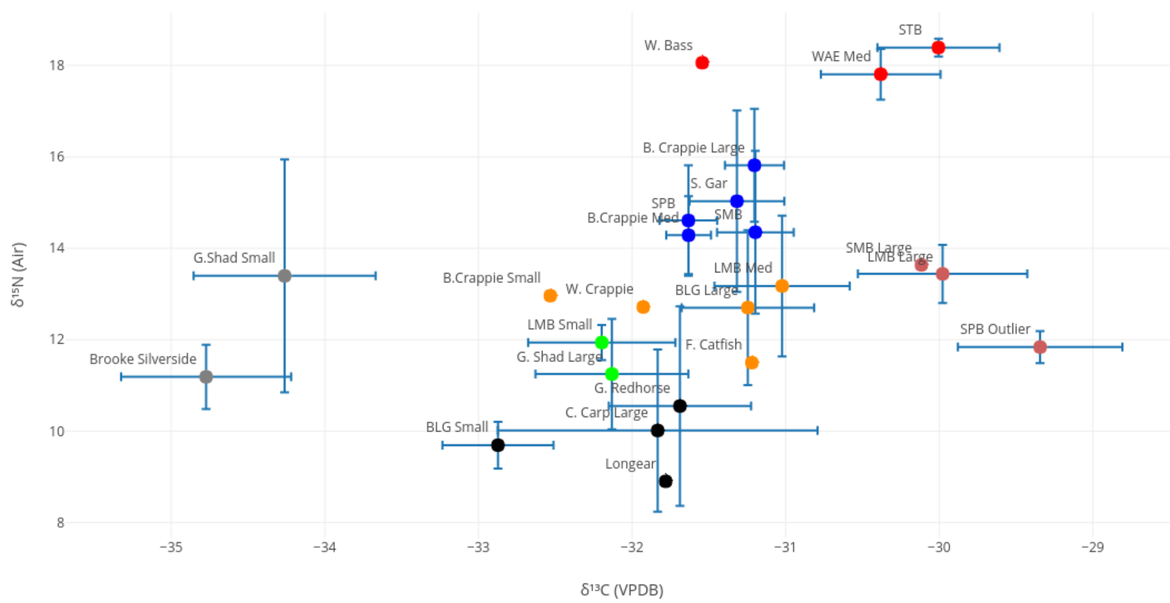

Figure 1. Preliminary isotope data. Confidence intervals represent the variation in C and N isotope signatures. Overlapping bars indicate an overlap in diet. Points represent average isotope signatures and colors represent species with the most similar diets.

Potential diet overlap may not only differ by species, but also by size or life stage, and season. Young Striped Bass consume a combination of invertebrates, and larval and juvenile fish (Van Den Avyle 1983), though fish make up most of juvenile Striped Bass diets after mid-summer (Sutton et al. 2002). While some larval *Lepomis*, *Pomoxis*, and *Notropis* spp. have been observed in juvenile Striped Bass diets, juvenile shad (*Dorosoma* spp.), Brook Silversides (*Labidesthes sicculus*), and/or Alfewives (*Alosa pseudoharengus*) made up the majority of juvenile Striped Bass diets (Van Den Avyle 1983; Sutton 2002). Thermal tolerance is related to Striped Bass size, with younger fish being able to withstand greater temperatures than older, larger fish (Coutant 2013). It is therefore possible, that if large Striped Bass oxythermal tolerances force them into areas of the reservoir where prey are absent, they may have different distributions and potential diet patterns than juveniles under stressful temperature conditions.

Data Collection

We will use stable isotope analysis to determine if diet overlaps exist between Striped Bass and sport fish species in Bull Shoals Lake. Stable isotope analysis is a commonly used method to identify fish feeding history and quantify energy flow in aquatic systems (Garvey and Chipps 2012), and has been used to determine overlap of introduced species (Whiting et al. 2014; Spurgeon et al. 2015). While gut content analysis provides a detailed snap shot of the content of fish diets, it requires a large sample size, and does not yield diet information when stomachs are empty. Stable isotope analysis does not require a large sample size, allows for determination of trophic level and energy source of assimilated food, and is time integrated.

Naturally occurring stable isotope ratios of carbon ($\delta^{13}C/\delta^{12}C$) and nitrogen ($\delta^{15}N/\delta^{14}N$) can be used to identify energy source and trophic level of a sampled organism. Because ^{15}N content increases with trophic level in consumers, $\delta^{15}N$ levels can be used to define the trophic level occupied by an organism (Kling et al. 1992). Carbon content remains relatively stable by location in ecosystems, so $\delta^{13}C$ levels provide information about energy source (i.e. benthic or pelagic in aquatic systems; Fry and Sherr 1984; France 1995).

MDC staff will collect up to five individuals of each species and/or sport fish size class in spring and fall and immediately put on ice for transport back to the West Plains MDC office. At a minimum, species collected will include Striped Bass, Walleye, black bass, crappie, and forage species. Fish species will be captured using boat electrofishing in the Theodosia and Drury-Mincy areas of the reservoir, but locations may change as we learn more about where Striped Bass congregate. Fish will be measured for total length and a skinless dorsal muscle sample (1 x 2 x 2 cm; Miller et al. 2015) will be removed and frozen, and sent to the Stable Isotope Mass Spectrometry Laboratory at Kansas State University, the Kentucky Stable Isotope Geochemistry Lab at the University of Kentucky, or a similar university lab for preparation and analysis of C and N isotope ratios. Standard reference materials used will be carbon in Pee Dee belemnite, and atmospheric nitrogen gas (Peterson and Fry 1987). Stable isotope ratios will be expressed in delta notation and defined as the parts permil (‰) deviation from these standard materials.

In future years additional replicates and species will be added, and we may identify alternative collection location and/or timing based on Striped Bass distribution patterns. We may consider use of alternative tissues if characterizing diet over a longer time period becomes a question of interest. We may also complement stable isotope analysis with gut content analysis to provide taxa and size specific information about diet.

Analysis

Stable-isotope ratios for for $\delta^{13}C$ or $\delta^{15}N$ will be expressed as parts per mille (‰) and calculated using $\delta X = (R_{sample}/R_{standard} - 1) \times 1000$, where $X = {}^{13}C$ or ${}^{15}N$ and $R = {}^{13}C/{}^{12}C$ or ${}^{15}N/{}^{14}N$. Results will be grouped by season and species for forage fishes, and each sport fish species will be separated into three size classes based on length frequency data obtained during MDC standard sampling and separated by season (Feiner et al. 2013). We will calculate means and standard errors for each of these sampling groups.

To infer trophic relationships among species, we will calculate trophic position using the formula: $TP_{fish} = ([\delta^{15}N_{fish} - \delta^{15}{}_{baseline}]/3.4) + 2$ where $\delta^{15}N_{fish}$ is the $\delta^{15}N$ value from the sample fish tissue and $\delta^{15}N_{baseline}$ is the baseline macroinvertebrate sample, and 3.4 is the assumed shift between successive trophic levels (Post 2002).

We will construct bi-plots of mean $\delta^{15}N$ ‰ on the y-axis and $\delta^{13}C$ ‰ on the x-axis for each species with standard ellipses and convex hull polygons (Spurgeon et al. 2015). We will adopt metrics from Layman et al. (2007) to quantify trophic structure and highlight resource overlap among fish species. These metrics may include trophic niche width, ranges in $\delta^{15}N$ and $\delta^{13}C$, population niche size, standard ellipse or convex hull area, trophic diversity, mean distance to centroid, trophic evenness, and the standard deviation of the mean nearest neighbor distance (Spurgeon et al. 2015). Analyses will be done using Stable Isotope Analysis in R

We will examine differences among size and species using a multivariate ANOVA with pairwise comparisons to test where differences in mean $\delta^{13}C$ and $\delta^{15}N$ among species and/or size classes exist.

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CHAPTER 4 - SUMMARY AND MANAGEMENT RECOMMENDATIONS

The primary goals of is this project is to provide MDC Fisheries and Resource Science Divisions staff with the information outlined in this proposal. Funding was allocated to address these information needs to help create and sustain a low-density bonus Striped Bass fishery in Bull Shoals Lake that is both popular and not detrimental to other traditional fisheries in the lake. Understanding population dynamics of the Striped Bass fishery, distribution patterns of stocked Striped Bass, and identifying amount of diet overlap between Striped Bass and other popular sport fish species in Bull Shoals were identified as priority information needs to inform management decisions. When sampling has concluded, we will be able to use growth, survival, and size data to simulate the structure and abundance of the Striped Bass population that could be developed in Bull Shoals Lake under different stocking strategies or regulations. Survival estimates may determine timing, rate, location, and frequency of future stockings. Understanding how movement may be related to physical factors like temperature, water level, and discharge will enable managers to incorporate environmental variables into decision making processes. Seasonal patterns in movement of Striped Bass will reveal whether certain areas of the reservoir may be more affected by Striped Bass and subsequently targeted by anglers in the future. As the project progresses, we will be able to provide the results of this work to MDC managers to use in future management and regulation discussions.

While providing the above information about the fishery itself is important to MDC managers, management goals arise through a combination of both biological considerations and stakeholder expectations. Decisions about when, how many, what size, and even whether to stock Striped Bass depends on achieving a balance of social and biological concerns. Therefore, the information used on this study can help MDC provide science-based information to stakeholder groups so management of the fishery can incorporate both biological responses to management actions and stakeholder expectations.

Ultimate management recommendations will be developed in consultation with MDC and any other identified stakeholders. We will likely provide estimated outcomes across a range of several management actions or combination of actions (e.g., stocking frequency and rates; possible harvest regulations). However, after this project is finished, MDC managers may like to be able to simulate additional alternate management actions in the future. This will be particularly true if the Striped Bass fishery in Bull Shoals Lake becomes very popular and anglers decide they would like to see greater numbers of Striped Bass. Therefore, we will develop a simulation tool in Microsoft Excel, which would be based on system-specific data and allow MDC managers to efficiently model and compare alternative management scenarios to achieve their desired fishery objectives.

Appendix A.

Below is an approximate sampling timeline. Exact timing of sampling events are likely to be adjusted as the project progresses. Seasonal temperature and dissolved oxygen profiles will also be collected from throughout the reservoir.