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Pennsylvania Muskellunge Management Plan 2017 Update



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Introduction

The Pennsylvania Fish and Boat Commission (PFBC) published its first [Statewide Muskellunge Management Plan](#) in 2012. We provide this bullet point update to the 2012 plan to: 1) determine if the PFBC is meeting plan objectives; 2) deal with new issues in Muskellunge management; and 3) bring interested parties up to date on Muskellunge management in Pennsylvania.

IS THE PFBC MEETING PLAN OBJECTIVES?

○ **Objective 1. Improve and standardize the design and sampling methods of all surveys evaluating the management of Muskellunge in Pennsylvania.**

- **Strategy 1: Muskellunge should be a primary species of concern when choosing sampling times and gear to maximize effectiveness and accuracy of surveys in waters where they are managed.**

Progress: Muskellunge are now a primary target species in PFBC surveys.

- **Strategy 2. Because of their rarity of catch all efforts should be taken to obtain all possible information on these fish when sampling waters where they are managed even when they are not the primary target of a survey.**

Progress:

- All Muskellunge captured during PFBC surveys are now weighed and sexed. Going forward, PFBC biologists will use a cradle or sock net to hold Muskellunge when taking weights.
- Pelvic fin rays were retained in the nine Passive Integrated Transponder (PIT) tag study lakes and in other waters. At this point, there is no need to retain additional pelvic fin rays. Fisheries Management Area 2 has enough rays to complete this project and plans to begin aging them in 2017.
- The Fisheries Management Division plans to expand the PIT tag study to all waters where Muskellunge are routinely monitored.
- PIT tags should be placed in the dorsal or anal fin areas. They should not be placed in the pelvic girdle due to poor retention.

○ **Objective 2. Critically examine Muskellunge stocking and management programs on all currently managed waters to ensure quality fisheries have been developed by 2022.**

- **Strategy 1. Establish a minimum catch rate of at least 0.01 per hour for PA trapnets (1 Muskellunge for every four 24 hour trapnet sites) in order to continue stocking Muskellunge and tiger muskellunge managed lakes.**

Progress: The minimum trap net catch rate of 0.01 per hour was established as the PFBC standard for lake evaluations. Most recent catch rates for stocked lakes are presented in Figures 1 through 3. Since plan inception, 22 lakes have met the minimum criterion in targeted Muskellunge surveys. Stocking has been terminated at eight lakes (Beltzville Lake, Chambers Lake, East Branch Clarion River Lake, Hills Creek Lake, Lackawanna Lake, Shenango River Lake, Tuscarora Lake, and Union City Reservoir) for poor performance. In addition, stocking has been suspended at three lakes (Belmont Lake, Lake Somerset, and Tamarack Lake) due to completed or impending drawdowns.

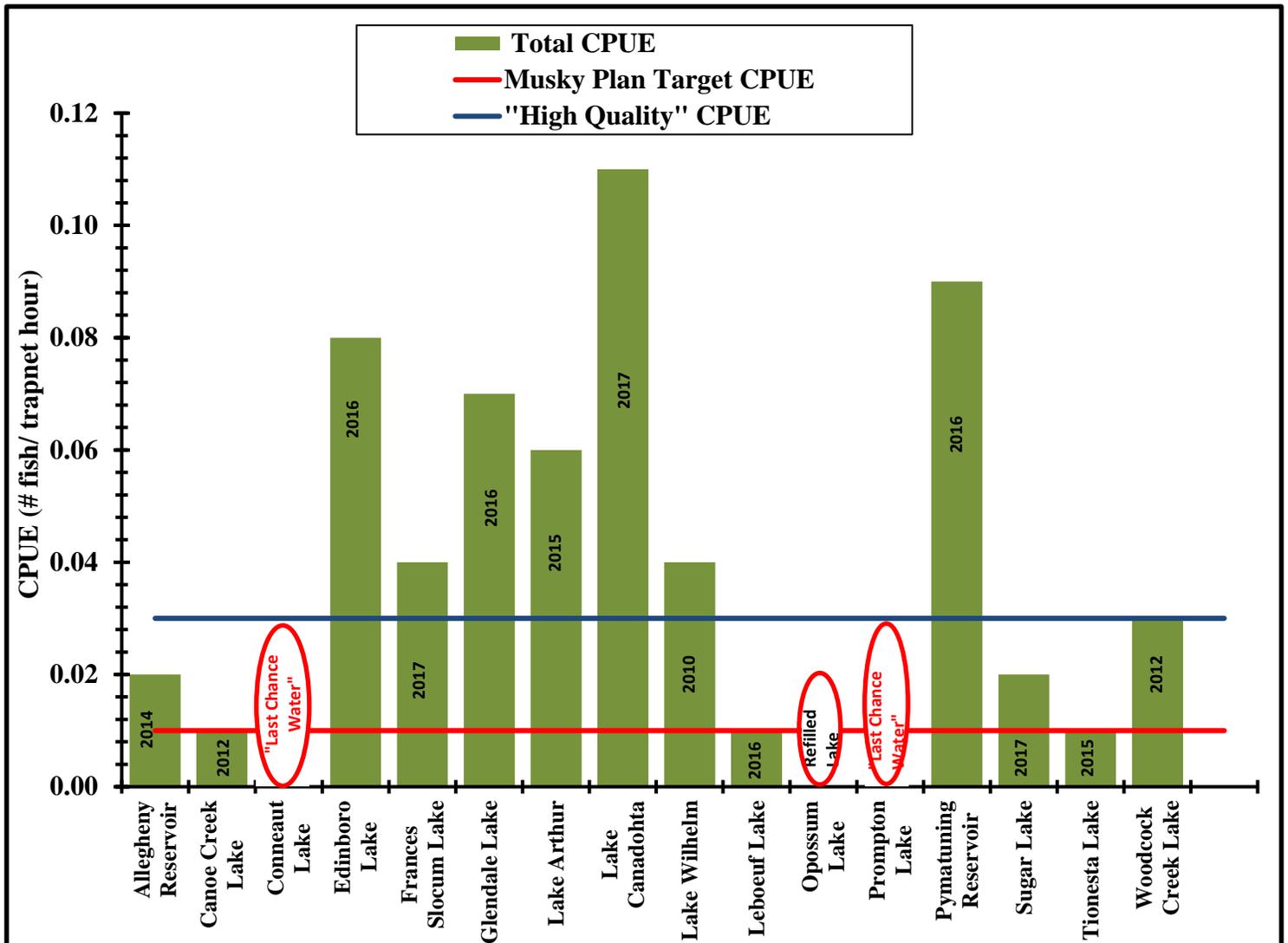


Figure 1. Total CPUE of adult Muskellunge from trap net surveys in Pennsylvania, 2010 - 2017.

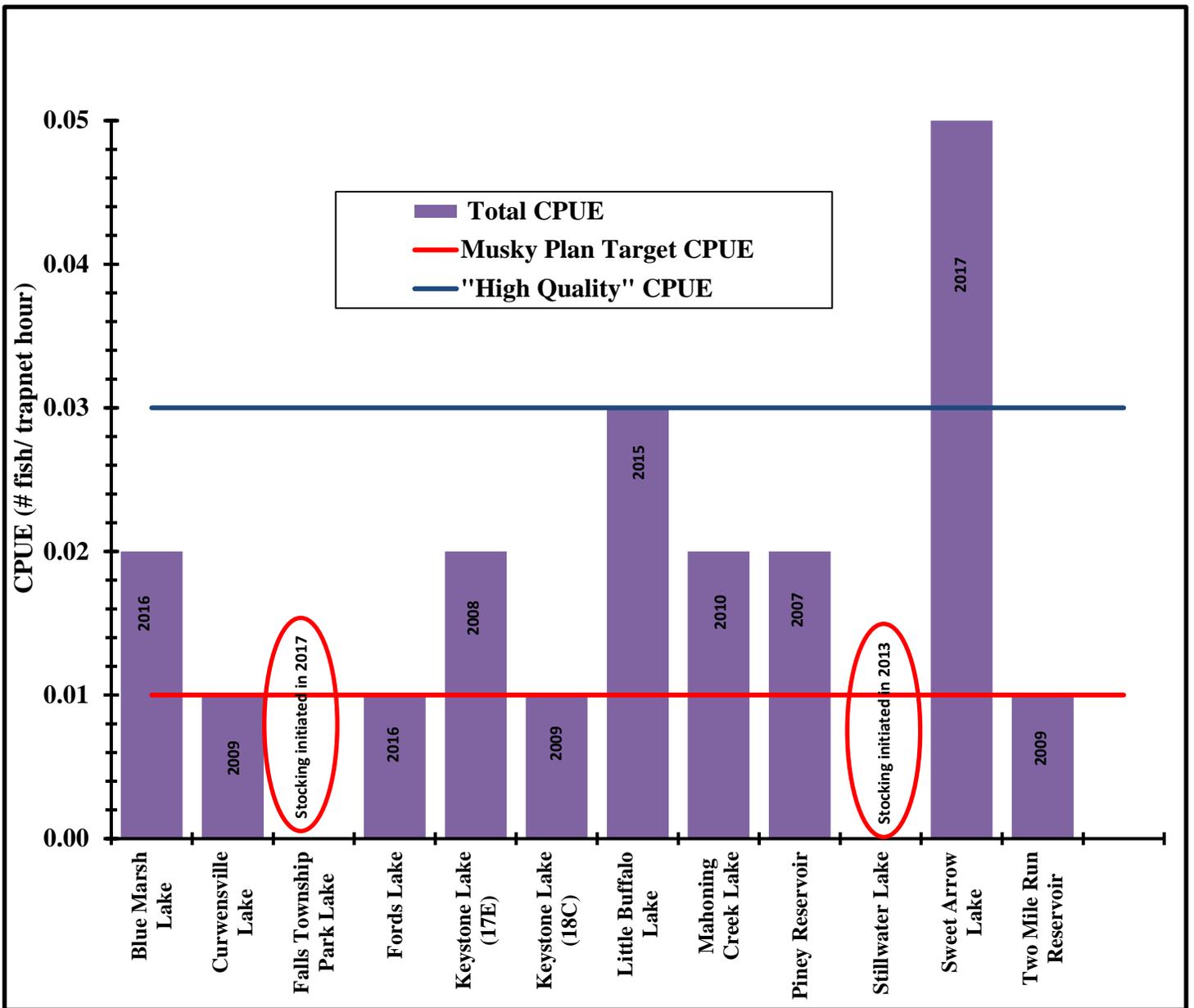


Figure 2. Total CPUE of adult tiger muskellunge from trap net surveys in Pennsylvania, 2008 - 2017.

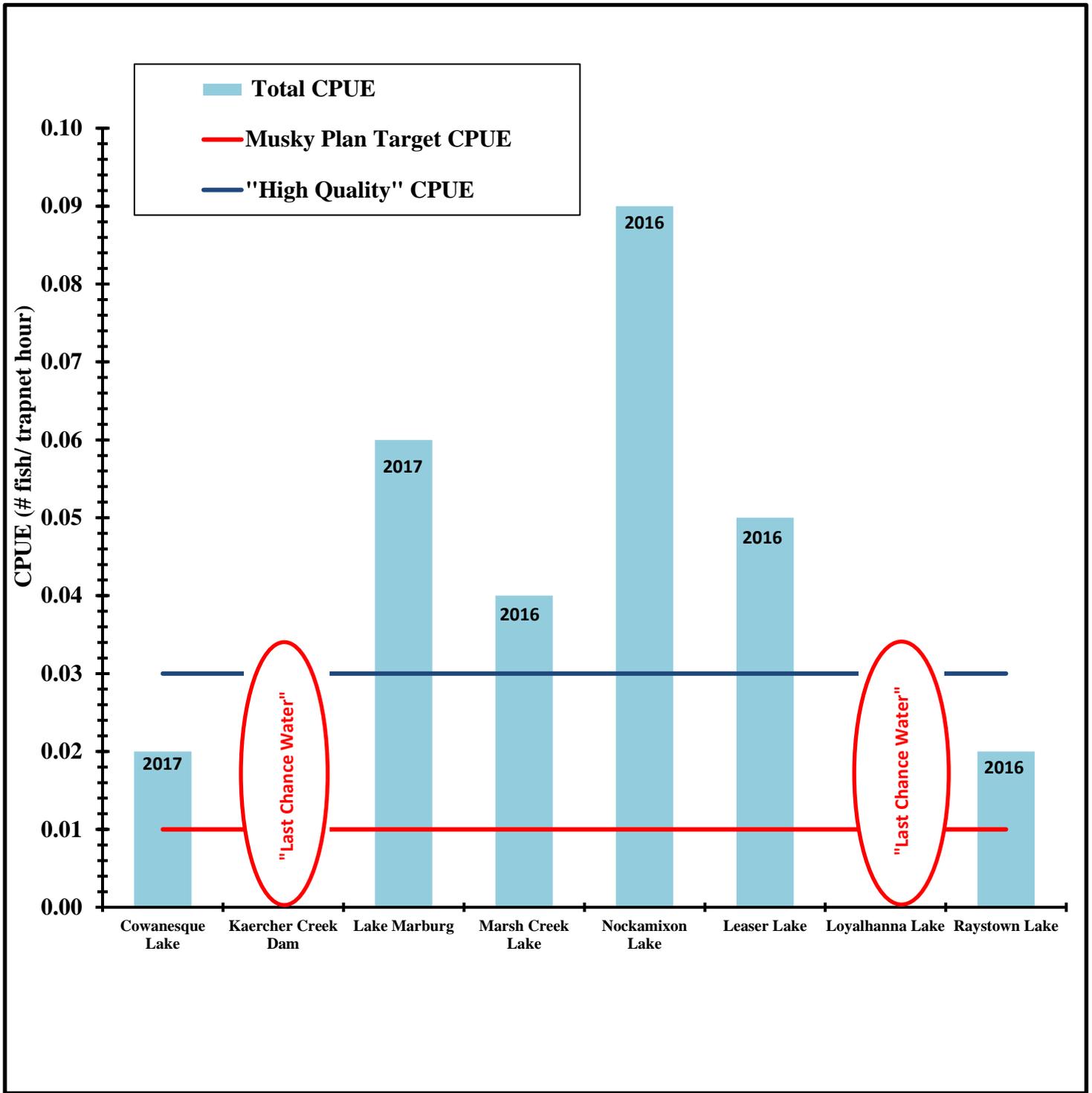


Figure 3. Combined CPUE of adult Muskellunge and tiger muskellunge from trap net surveys in Pennsylvania, 2010 - 2017. CPUE at Leaser Lake is based on tiger muskellunge only. Purebred Muskellunge had not yet gotten big enough to recruit to the gear. Purebred Muskellunge at Nockamixon Lake and Marsh Creek Lake are stocked by a private club.

Fourteen stocked lakes have not been surveyed since plan inception. Given staffing limitations and current commitments to mandatory spring surveys, it may not be possible to examine all remaining stocked Muskellunge lakes by 2022. However, there are four lakes where 1) the PFBC has never conducted a targeted survey; 2) the PFBC has not conducted a targeted survey in the last 10 years; or 3) the PFBC has conducted a recent targeted survey but the water did not meet the minimum criterion for continued stocking. Those lakes are:

Water	Fisheries Management Area	Last Survey	Muskellunge Catch per Hour
Conneaut Lake	2	2012	0.00
Prompton Lake	5	1991	0.00
Kaercher Creek Dam	6	2001	0.02
Loyalhanna Lake	8	2016	< 0.01

The above lakes are now considered "last chance" waters similar to the Walleye plan (PFBC 2011). These waters must be surveyed for Muskellunge by 2018. If they fail to meet the minimum criterion or if they are not surveyed, stocking will be terminated.

The minimum criterion of 0.01 Muskellunge/hour was established using data from historic trap net surveys. Many of the historic surveys were general inventories that did not specifically target Muskellunge. We will revisit the minimum criterion in the next version of this plan as the PFBC collects more data from targeted Muskellunge work.

- **Strategy 2. Due to a general lack of historical data on Muskellunge in flowing water, a benchmark catch rate could not be calculated. Develop a benchmark catch per hour of boat electrofishing on flowing waters by making their sampling a high priority in future sampling plans in the Division of Fisheries Management.**

Progress: Fisheries management staff conducted targeted boat electrofishing for Muskellunge on three rivers (12 sections) between 2012 and 2016. Mean electrofishing catch per hour (CPH) values for all sizes of Muskellunge were:

Water	Sections	CPH	Number Caught	Technique (Day or Night)
Delaware River	07	0.00	0	Day
North Branch Susquehanna River	01 - 10	1.54	24	Day
Youghiogheny River	06	1.20	6	Night

The table below provides electrofishing CPH values for Muskellunge from flowing waters in other states:

Water	Mean CPH	Number Caught	Technique (Day or Night)
New River, VA (1998-2003) ¹	1.36	236	Day
Upper Niagara River NY (2009) ²	2.61	54	Day
Kentucky Streams (1980-1983) ³	0.60	179	Day
Shenandoah River, VA (2009 - 2015) ⁴	1.0 - 2.2	Unknown	Unknown
Tahquamenon River, MI (2008) ⁵	2.95	Unknown	Unknown

1. Brenden et al. 2007.
2. Kapuscinski et al. 2010.
3. Axon and Kornman 1986.
4. Hallacher et al. 2016
5. Waybrant and Zorn 2008.

Given the above, the benchmark electrofishing catch rate for Muskellunge in Pennsylvania rivers shall be 1.00 Muskellunge/hr.

Of the 12 river sections examined between 2012 and 2016, the Delaware River Section 07 was the only one that did not meet the benchmark criterion. The Area 6 Fisheries Manager terminated stocking in this section. Area 6 also terminated Muskellunge stocking in the Schuylkill River Section 05 because of lost public access. The North Branch Susquehanna River Sections 01 - 10 met the benchmark criterion. However, the Area 4 Fisheries Manager terminated stocking in favor of management through natural reproduction.

Lack of data prevented the PFBC from developing river sampling protocols in the 2012 Muskellunge plan. With our experiences sampling rivers since 2012, we were able to develop standard electrofishing protocols for both adult and young-of-the-year (YOY) surveys. Appendices 1 and 2 provide protocol details. However, electrofishing may not be appropriate for all rivers. In these cases, Area Fisheries Managers should attempt evaluation with other

gear types as they deem appropriate. Benchmark catch rates for other gear types will be developed as the PFBC generates more data with alternate methods.

There are 47 stocked river sections that have not been evaluated since implementation of the 2012 Muskellunge plan. Those sections are:

Water	Sections	Fisheries Management	
		Area	Species
Beaver River	02	1	Tiger Muskellunge
Conneaut Creek ¹	03	2	Muskellunge
Connoquenessing Creek	07	1	Tiger Muskellunge
Shenango River	05	1	Muskellunge
Allegheny River	06-17	2	Muskellunge
Cussewago Creek	02	2	Muskellunge
French Creek	03-06	2	Muskellunge
Mahoning Creek	04	2	Muskellunge
West Branch Susquehanna R	07	3	Muskellunge
Delaware River	05-06	5	Muskellunge
Lehigh River	09	5	Muskellunge
Schuylkill River	11-12	6	Tiger Muskellunge
Schuylkill River	06-07	6	Both
Susquehanna River	05	6	Muskellunge
Conodoguinet Creek	05	7	Tiger Muskellunge
Juniata River	02-04, 07	7	Muskellunge
Raystown Branch Juniata R	05,08	7	Tiger Muskellunge
Susquehanna River	01, 03	7	Muskellunge
Susquehanna River	04	7	Tiger Muskellunge
Swatara Creek	05	7	Tiger Muskellunge
Allegheny River	19-21	8	Muskellunge
Monongahela River	04	8	Muskellunge
Ohio River	03	8	Tiger Muskellunge

1. Mean Muskellunge catch rate on Conneaut Creek Section 03 was 5.68/hr during a 2006 mini-boom survey.

Given staffing limitations and current commitments to mandatory spring surveys, it will not be possible to examine adult Muskellunge in all stocked river sections by 2022. However, we encourage Area Fisheries Managers to conduct targeted adult surveys in these sections as their schedules permit.

YOY surveys are much easier to fit into crowded field schedules because they are conducted in summer. Additionally, YOY surveys will be critical in coming years. Changes to the sizes of stocked Muskellunge beginning in

2018 (see the section on new issues for details) are expected to produce much higher survival rates. This could lead to dilution of gene pools and reduction of fitness in wild populations. Therefore, we recommend that Area Fisheries Managers give high priority to targeted surveys for YOY Muskellunge in flowing waters stocked with purebreds. YOY surveys have great potential to advance Muskellunge management in Pennsylvania by identifying waters that can support a fishery solely through natural reproduction.

There is no consensus on the level of reproduction that is needed to sustain a riverine Muskellunge population in the absence of stocking. Instead, we suggest that managers consider stocking termination when they find that Muskellunge reproduce throughout a system and that reproduction occurs in most years. Below we provide three recent examples where agencies chose to manage riverine Muskellunge for natural reproduction.

The Area 4 Fisheries Management Office terminated Muskellunge stocking on the North Branch Susquehanna River beginning in 2017. In 2016, wild YOY CPUE in the North Branch was 2.85/hr (N = 31 YOY in 33 sampling sites). Further, age and growth analyses indicated that most if not all of the adult Muskellunge captured in 2016 were of wild origin.

Virginia has successfully managed the lower New River Muskellunge population through natural reproduction for approximately ten years. During annual monitoring since stocking termination, YOY CPUE has averaged 2.0/hr (Joe Williams, Virginia Department of Game and Inland Fisheries, personal communication 2016). Virginia samples YOY in March when the fish are approximately 11 months of age.

Tennessee recently terminated Muskellunge stocking in the upper Caney Fork River System. The decision to terminate stocking came from research which showed that Muskellunge were reproducing throughout the system and that stocked Muskellunge had very poor survival (Warren 2013). Summer wild YOY CPUE in the upper Caney Fork River System was 1.90/hr.

There is a minimum YOY Muskellunge CPUE value established for lakes in Wisconsin. Wisconsin defines a self-sustaining lake population as one in which YOY CPUE averages at least 0.24/mile (Simonson 2013). Caution must be used in translating this value to rivers, however, because lake sampling frequently involves electrofishing the entire

shoreline while river sampling only targets suitable habitat. To translate this value to a river, one must include all of the river mileage searched for YOY habitat (river mile distance between the most upstream and most downstream points you can reach from a given boat launch) and then divide by two. Division by two is necessary because a river has two shorelines.

- **Objective 3. Beginning in 2012, begin evaluating the management changes enacted by the PFBC in 2007. This includes the change in the minimum size limit from 30 to 40 inches, the reduction of creel limit from 2 to 1 per day, and the increases in stocking rates on select waters.**
- **Strategy 1. Choose at least eight waters from around Pennsylvania with five or more years of previous survey catch data on Muskellunge. Sample these waters for five additional years by 2022.**

Progress: The Fisheries Management Division is on target to complete this study by 2022. It began on nine lakes in 2013. Five of the eight lakes are being sampled in consecutive years and the others are being sampled every other year. Four lakes, Lake Arthur, Nockamixon Lake, Little Buffalo Lake, and Blue Marsh Lake, are nearing completion. There may be reason to continue the study on Nockamixon Lake given the high number of tagged fish at large. Statewide to date, 521 adult Muskellunge have been captured and PIT tagged. There have been 79 recaptures.

Beginning in 2017, Beltzville Lake will no longer be part of the statewide Muskellunge study. Beltzville Lake produced very few fish and stocking was terminated.

- **Objective 4. Maximize effectiveness of stocking methods.**
- **Strategy 1. Evaluate the survival of fall fingerling versus spring yearling stocked Muskellunge in lakes.**

Progress: The PFBC began this study in 2010. In a five year period, 17,260 fish were coded wire tagged (CWT) and stocked into three northwestern study lakes: Edinboro Lake, Lake Canadahota, and Tionesta Lake. The tagging and stocking portion (phase 1) of the fall fingerling versus spring yearling study was completed.

Trap netting for adult CWT Muskellunge began in 2013 when tagged fish were of appropriate size and maturity to be vulnerable to sampling gear. A total of 183 Muskellunge from the three study lakes have been captured to date. Of

these, 90 were CWT. Preliminary results revealed a higher return rate (4:1) of spring yearlings to fall fingerlings.

Two of three study lakes are used for broodstock collection by Union City Fish Hatchery. Area 2 staff will continue to work with hatchery staff to scan for the presence of tagged adults as fish are brought back to the hatchery to be spawned.

- **Strategy 2. Monitor the reliability of coded wire tags to retain and be detectable in Muskellunge several years following implantation as fingerlings.**

Progress: Fall fingerlings and spring yearlings were successfully tagged in two body locations (the dorsal and cheek areas). Retention rates during the five years of study averaged 94%. The highest mean retention rate was 99.5% in 2012.

- **Strategy 3. Create a new designation system for Muskellunge in the stocking request allocation system for large (250-300 mm) Muskellunge fall fingerlings.**

Progress: This strategy is no longer relevant because of changes in Muskellunge stocking. Please see the section on new issues for details.

- **Strategy 4. Create a warm/cool water work group within the Bureau of Fisheries between the Division of Fisheries Management, Division of Fish Production, Fish Production Services and Division of Habitat Management to improve the exchange of ideas and cooperation between the various groups within the Bureau dealing with Muskellunge management. This group could also cooperate on issues dealing with other stocked warm/coolwater fish such as Walleye, Channel Catfish, and Striped Bass.**

Progress: Fisheries Management staff, Fish Production staff, and a select group of Muskellunge anglers met as a work group in 2014. Fisheries Management and Fish Production staff developed a PFBC workgroup to guide this update to the Muskellunge Management Plan and routinely work together on Muskellunge issues. Additionally, the PFBC met with Muskellunge anglers in the spring of 2017 at Muskie Max.

- **Objective 5. Identify, evaluate, rehabilitate, conserve and enhance the potential of waters to support recreational Muskellunge fisheries through natural reproduction.**
- **Strategy 1. Identify a reliable method of tagging stocked fingerlings to differentiate hatchery from wild Muskellunge.**

Progress: There are several reliable methods. As discussed above, CWT has proven effective and PIT tags could be used as supported by the literature and personal communications from other state and federal agencies. Genetic testing offers another option should we be able to locate a "true" wild Muskellunge population. This is currently being done by Dr. Matthew White (Ohio University) with Walleye *Sander vitreus* in the Allegheny River.

There are two methods for differentiating wild from hatchery fish that do not require tagging. Sampling for YOY prior to stocking is reliable. Back-calculated length at age 1 can also be effective, particularly in rivers.

Warren and Bettoli (2014) demonstrated that wild YOY Muskellunge grew between 1.8 and 2.34 millimeters per day. By applying the maximum possible growth rate of 2.34 mm per day to the known average length at stocking and assuming that the growing season lasts until the end of October, managers can calculate how long an average size stocked fish could be at the end of its first year. Fish with back-calculated lengths at age 1 far in excess of the maximum possible value for stocked fish are assumed to be of wild origin.

The above analysis is conservative. It is unlikely that stocked Muskellunge would grow at the maximum possible rate in their first month or so at large. Stocked fish first have to avoid predation, find nursery cover, and acclimate to a natural diet before beginning to grow. At Frances Slocum Lake, stocked Muskellunge grew at an average rate of 0.66 mm/day from stocking to the end of October (Wnuk unpublished data).

- **Strategy 2. Maintain current minimum size and creel limits to enhance the capability of Muskellunge populations to naturally reproduce through the protection of older and larger individuals in the population.**

Progress: The minimum size and creel limits established in 2007 (40 inch minimum size limit, 1 fish/day creel limit) have been maintained. Pymatuning Lake will serve as a control lake to further compare the effects of the 2007 regulation change. Pymatuning is managed under a 30 inch minimum size limit and a two fish per day creel limit.

- **Strategy 3. Identify barriers to successful reproduction and recruitment to the sport fishery and the means of removing them. Many of these barriers are habitat related and are a consequence of a broad spectrum of environmental factors such as**

sedimentation, organic enrichment, loss of water quality, loss of aquatic vegetation and human induced development.

Progress: There has been no progress on this strategy.

○ **Objective 6. Maintain and improve the exchange of information between the PFBC and anglers.**

- **Strategy 1. Continue to use the assistance of the Musky Clubs in stocking operations to maximize survival of stocked fingerlings.**

Progress: Muskellunge clubs (Nittany Valley Alliance, Three River Muskies Inc., Penn/Jersey Chapter #50 of Muskies Inc., and Albion Sports Club) assist the PFBC through scatter stocking of fish by boat into appropriate habitats including aquatic vegetation beds and downed trees. Some agencies (i.e. Ontario Ministry of Natural Resources; Kerr and Lasenby 2001) recommend this practice. However, we should note that research has shown that it does not significantly increase fingerling survival (Johnson 1982; Margenau and Snow 1984; New York Department of Environmental Conservation 2001).

Muskellunge clubs also raise and/or purchase large fingerlings for stocking in some waters. Stocking rates of these fish are coordinated with Area Fisheries Managers and generally off-set or replace PFBC stockings in the waters of club interest.

- **Strategy 2. Construct a special section of the online angler log book that deals specifically with reporting the catch of Muskellunge and tiger muskellunge anglers to take advantage of the high interest and willingness to participate that is characteristic of most avid Muskellunge anglers. This program would replace the Muskellunge angler log books, which have not had high return rates.**

Progress: The PFBC attempted to construct an online Muskellunge angler log book but the program was cancelled because it proved too complicated. A simpler version was tested for the Youghioghney River but it also failed (R. Burman, PFBC Business Solution Analyst, personal communication 2016). Given staff limitations, budget constraints, and poor results from similar initiatives, this item is considered complete.

- **Strategy 3. Develop a means of capturing angler use and harvest information that does not require on the water surveys. If a list of Muskellunge anglers could be developed then a telephone survey could be conducted to gain information on waters fished, effort expended, fishing success, opinions on the quality of the fishing and contribution by the angler to the economic community.**

Progress: Fisheries Management Area 2 has a list of Muskellunge anglers that attended the last two PFBC Muskellunge Management Plan Meetings. Further, at the 2014 public Muskellunge meeting, anglers were asked to rank priority waters where they target Muskellunge and tiger muskellunge and to identify those waters that should not be stocked due to poor fishing results or general lack of interest.

NEW ISSUES IN MUSKELLUNGE MANAGEMENT

Maintenance Stocking

PFBC hatcheries have been raising larger fall fingerlings. This has produced demonstrated increases in short-term fingerling survival (Wnuk unpublished data). However, hatcheries have reached the point where they cannot achieve further gains in fingerling size, and producing larger fingerlings has meant that the hatcheries can produce fewer fish. As a result, Fisheries Management requests have exceeded production capacity for the last several years and some waters have not been stocked.

Size at stocking is a major factor in stocked Muskellunge survival (Stein et al. 1981; Szendrey and Wahl 1996; Margenau 1999; McKeown et al. 1999; Wahl 1999; Kerr and Lasenby 2001). Further, yearlings survive better and contribute more to the fishery than fingerlings (Hoff and Serns 1986, Margenau 1992, PFBC's ongoing CWT study). Thus, to produce larger fish with improved survival rates, we will switch production to yearlings. The target size for yearlings will be 12 to 14 inches. Tiger muskellunge will achieve the target size by early May and purebred Muskellunge by early June. To prevent mortality from thermal stress, tiger muskellunge will be stocked no later than the third week of May and at water temperatures $\leq 75^{\circ}\text{F}$ (Inskip 1982). Muskellunge will be stocked no later than the second week of June and at water temperatures $\leq 80^{\circ}\text{F}$ (Cook and Solomon 1987). In general, this will require stocking waters south of Interstate 80 first.

With the switch to yearlings, maximum production capacity in the hatchery system will be 40,000 Muskellunge and 7,000 tiger muskellunge annually. This requires cuts to stocking rates and a change from annual to alternate year stockings. These measures are necessary to prevent stocking requests from exceeding production capabilities and to insure against overpopulation given the expected high survival rates of summer yearlings.

Beginning in 2017, the maximum permitted alternate year stocking rate for all waters will be 0.75 fish/acre. Managers will be permitted to stock at rates lower than the maximum. The maximum

rate will apply to both Muskellunge and tiger muskellunge. In cases where both are stocked in the same water, alternate year stocking rates will be 0.375/acre for each and they will be stocked in the same year. Under this system, annual Muskellunge requests will be 33,950 in even numbered years and 34,025 in odd numbered years (Appendix 3). Annual tiger muskellunge requests will be 6,175 in even numbered years and 6,325 in odd numbered years (Appendix 4).

We derived the 0.75 fish/acre rate from the experiences of other states and of Fisheries Management Area 6 with stocking large (12 to 14 inch) fingerlings. We elected alternate year stockings because of substantial predation by older Muskellunge on newly stocked fish (Margenau 1992). Alternate year stockings still allow agencies to achieve management objectives (Larscheid et al. 1999). Minnesota (Minnesota Department of Natural Resources 2008), Wisconsin (Simonsin 2013), and Michigan (Dexter and O'Neal 2004) generally employ alternate year strategies when using large fall fingerlings for maintenance stocking.

Managers should be aware that stocking summer yearlings at the alternate year rate of 0.75/acre could produce an overly dense population with few trophy fish available. This situation is equivalent to Wisconsin's "Action Lakes". It may be desirable because there are anglers who enjoy high Muskellunge catch rates and who are not seeking truly large fish. However, if a trophy fishery is desired and assessment data indicate that the maximum permitted stocking rate is producing too many Muskellunge and limiting trophy potential, managers should cut the alternate year stocking rate below the maximum permitted.

The switch to summer yearlings is considered experimental. If summer yearlings do not produce the desired fisheries, the PFBC will return to fall fingerlings. A trial time of at least five years is recommended.

Transitioning from Fall Fingerlings to Spring Yearlings

The first summer yearlings will be stocked in 2018. During the transition year of 2017, PFBC hatcheries will have approximately 30,000 Muskellunge and 20,000 tiger muskellunge available for stocking as fall fingerlings.

Purebred Muskellunge stocked as fall fingerlings in 2017 will be allocated at the rate of 1/ac. They will only be stocked into waters which will not receive summer yearlings in 2018 (Odd year waters in Appendix 3). Beyond that, we used a priority system to allocate the fish. Priority 1 waters were Broodstock Lakes. Priority 2 waters were those which did not receive fall fingerlings in 2016 because fisheries management requests

exceeded production capacity. Priority 3 waters were those where managers are attempting to restore fisheries. Priority 4 waters were the remaining lakes that won't be stocked until 2019. We prioritized lakes over flowing waters because there is a greater potential for natural reproduction to contribute to Muskellunge fisheries in flowing waters.

The prioritized set of waters to be stocked with fall fingerling Muskellunge in 2017 is:

Water	Number	Priority
Conneaut Lake	925	1
Edinboro Lake	250	1
Lake Canadohta	175	1
Cussewago Creek 02	125	2
French Creek 03	75	2
French Creek 04	550	2
French Creek 05	150	2
French Creek 06	700	2
Juniata River 02	200	2
Juniata River 03	300	2
Lake Marburg	1,250	2
Loyalhanna Lake	475	2
Mahoning Creek 04	325	2
Susquehanna River 05	3,975	2
Sugar Lake	100	3
West Branch Susquehanna River 07	2,050	3
Canoe Creek Lake	150	4
Cowanesque Lake	1,100	4
Frances Slocum Lake	175	4
Lake Arthur	3,225	4
Leaser Lake	125	4
Prompton Lake	275	4
Raystown Lake	8,300	4
Tionesta Lake	575	4
Total: 25,550		

Tiger muskellunge stocked as fall fingerlings in 2017 will be allocated at the rate of 1/ac. They will only be stocked into waters which will not receive summer yearlings in 2018 (Odd year waters in Appendix 4). All odd year tiger muskellunge waters will receive fall fingerlings in 2017 except for Blue Marsh Reservoir. The Area 6 Fisheries Manager did not want Blue Marsh Reservoir stocked in 2017 because it received very large fall fingerlings at 5/acre in 2016.

The set of waters to be stocked with fall fingerling tiger muskellunge in 2017 is:

Water	Number
Cowanesque Lake	1,100
Fords Lake	75
Kaercher Creek Dam	25
Leaser Lake	125
Schuylkill River 06	125
Schuylkill River 07	350
Schuylkill River 11	200
Schuylkill River 12	400
Raystown Branch Juniata River 05	75
Raystown Branch Juniata River 08	425
Raystown Lake	8,300
Loyalhanna Lake	475
Monongahela River 02	1,675
Total: 13,350	

Priority System for Alternate Year Stockings

PFBC hatcheries expect to have little problem meeting the new Muskellunge and tiger muskellunge requests. Fish numbers and sizes should be consistent both annually and geographically. Nevertheless, a priority system is needed in case of unexpected problems. The priority system below is based on species and number of fish available.

Purebred Muskellunge

- If 15,000 or more fish are available, stock all waters at the rate of 0.375 fish/acre. If fish still remain after the rate cut, allocate up to the full quota of 0.75 fish/acre in priority order.
- If less than 15,000 fish are available, cut the stocking rate to 0.375 fish/acre and stock in priority order.

Priority Order for Purebred Muskellunge

Priority 1: Restoration Fisheries. These are new/reclaimed lakes or other waters where managers are attempting to restore fisheries. Currently, there are three lakes where the PFBC expects to restore Muskellunge stocking once their dams are repaired (Belmont Lake, Lake Somerset, and Tamarack Lake) and three waters where managers are attempting to restore fisheries. The restoration fisheries are West Branch Susquehanna River Section 07 (acid mine drainage), Sugar Lake (Muskellunge population collapse), and Presque Isle Bay (Great Lakes Muskellunge).

Priority 2: Brood Lakes. These are Pymatuning Reservoir, Conneaut Lake, Edinboro Lake, Lake Canadohta, Lake Wilhelm, Tamarack Lake, and Woodcock Creek Lake. Pymatuning Reservoir should be the first priority in even numbered years because it is the main brood lake for the hatchery system.

Priority 3: Statewide Muskellunge Study Lakes. Statewide study lakes that are not in the Brood Lakes category and that are stocked with purebreds from PFBC hatcheries are Lake Arthur, Glendale Lake, Francis Slocum Lake, and Loyalhanna Lake.

Priority 4: Preferred Waters. These are waters which do not fit the above categories but were ranked as preferred fisheries (average angler ranking ≤ 3) by Muskellunge anglers in a 2014 meeting. These waters are:

Water	Section	Average Angler Ranking ¹
French Creek	03	1.0
French Creek	05	1.0
Juniata River	07	1.0
Delaware River	05	1.5
Allegheny River	08	2.0
Schuylkill River	07	2.0
Lehigh River	09	2.4
Allegheny River	09	2.5
Delaware River	06	2.5
Schuylkill River	06	2.5
Allegheny River	17	3.0
Cowanesque Lake	0	3.0
Canoe Creek Lake	0	3.0
Susquehanna River	03	3.0

1. Lower average angler ranking indicates a greater angler preference.

The PFBC may add to the preferred waters list as angler or fish population surveys are updated.

Priority 5: Remaining Lakes. In the absence of angler use data, these are prioritized by size with larger lakes getting higher priority. Larger lakes have greater angling potential than smaller lakes.

Priority 6: Remaining Flowing Waters. Flowing waters are the last priority because there is greater potential for natural reproduction to contribute to these fisheries. As

with remaining lakes, these are prioritized by size with larger waters getting higher priority.

Tiger Muskellunge

- If 3,000 or more fish are available, stock all waters at the rate of 0.375 fish/acre. If fish still remain after the rate cut, allocate up to the full quota of 0.75 fish/acre in priority order.
- If less than 3,000 fish are available, cut the stocking rate to 0.375 fish/acre and stock in priority order.

Priority Order for Tiger Muskellunge

Priority 1: Restoration Fisheries. These are new/reclaimed lakes or other waters where managers are attempting to restore fisheries. Currently, Lake Somerset is the only water in this category.

Priority 2: Statewide Muskellunge Study Lakes. Statewide study lakes that are stocked with tiger muskellunge from PFBC hatcheries are Blue Marsh Lake, Little Buffalo Lake, and Loyalhanna Lake.

Priority 3: Preferred Waters. These are waters which do not fit the above category but were ranked as preferred fisheries (average angler ranking ≤ 3) by Muskellunge anglers in a 2014 meeting. These waters are:

Water	Section	Average Angler Ranking ¹
Swatara Creek	05	1.0
Conodoguinet Creek	05	2.0
Curwensville Lake	0	2.7
Cowanesque Lake	0	3.0

¹. Lower average angler ranking indicates a greater angler preference.

The PFBC may add to the Priority 3 waters list as angler or fish population surveys are updated.

Priority 4: Remaining Waters. In the absence of angler use data, these are prioritized by size with larger waters getting higher priority. Larger waters have greater angling potential than smaller waters.

Given the low numbers requested with the new stocking rates and frequencies, we do not expect any production shortfalls.

Further, if shortfalls do occur, it's very unlikely that they would be severe enough that some waters would not be stocked on their alternate year schedules. However, should that happen, managers may not request fish the following year. Waters need to remain on the odd/even schedules in Appendices 3 and 4 to provide PFBC hatcheries with consistent annual requests. Given the 40 inch length limit plus the increased size of fish being stocked, Muskellunge populations should remain relatively stable despite an occasional missed stocking.

Supplemental Requests

Supplemental requests for summer yearlings will be allowed. However, these requests will only be filled in unexpected cases of hatchery overproduction.

The hatchery system expects to have 5,000 to 10,000 surplus purebred Muskellunge available as fall fingerlings every year when they cull fish prior to winter. Fisheries Management Areas 1, 2, 3, and 8 should make annual supplemental requests for these fall fingerlings in waters close to Linesville Hatchery.

The hatchery system expects to have few if any surplus tiger muskellunge. Nevertheless, the hatcheries would like to have two or three waters with supplemental requests for fall fingerlings as release valves. Fisheries Management Areas 4, 5, and 6 should make these requests in waters close to Pleasant Mount Hatchery.

Stocking New or Reclaimed Lakes

New or reclaimed impoundments offer different stocking challenges. If at least a moderate fusiform forage fish base is present or developing and predators are not yet established in quantity, we recommend an initial stocking of 3-4 inch fingerlings at the rate of 5 to 10/acre. If Largemouth Bass or other predators are already established, even as yearlings, we recommend the standard alternate year rate of summer yearlings. The maximum rate may be violated and shifted to 1/acre during the second stocking if it is discovered that the initial stocking failed or produced less than desirable numbers of young fish. Fry stockings, which produce a wide range of results, are not recommended since there is no control over Muskellunge or tiger muskellunge fingerling abundances following fry stockings.

Adding New Waters to the Program

Managers may initiate stocking in new waters. However, new waters will require approval because fisheries management requests may not exceed production capacities. Based on stocking rates in this plan update, current purebred Muskellunge requests

are 5,975 fish below production capacity while tiger muskellunge requests are 675 fish below production capacity.

The procedure for adding new waters is:

- The manager reviews stocking requests for his area. If possible, the manager should manipulate stockings on his current waters to offset the new request. This can be done by terminating stocking and/or reducing stocking rates and frequencies in one or more current waters.
- The manager requests approval for the new water from the Muskellunge committee.
- The Muskellunge committee reviews the new water request to determine if there is a high probability that a targeted fishery will develop and if the changes requested by the manager will cause fisheries management requests to exceed production capacities.
- The Muskellunge committee forwards its recommendation to the Division Chief and Warmwater Unit Leader.
- The Division Chief and Warmwater Unit Leader make the final decision on adding the new water to the program.

Brood Stock Management

Under the new stocking rates and frequencies, PFBC hatcheries will have to spawn far fewer females to get the required number of eggs. This could lead to problems with brood stock management including disease, inbreeding, genetic deterioration of domesticated stock, and the influence of founder stock on survival and ultimate size. To help prevent these issues, the hatchery system will use the following brood lakes on a rotational basis and will utilize brood from at least four lakes annually: Pymatuning Lake, Pymatuning Sanctuary, Lake Wilhelm, Woodcock Lake, Lake Canadohta, Edinboro Lake, and Conneaut Lake. These waters contain a genetic variant of "Ohio" strain *Esox masquinongy ohioensis* (Becker 1983) and a wild muskellunge within the Ohio River drainage. To maximize genetic diversity during annual spawning, hatchery staff will fin clip or utilize PIT tags to prevent spawning the same individuals (male and female) multiple times. Hatchery staff will increase the number of brood female, taking smaller lots of eggs while also increasing the number of males spawned for each female. Based on needing fewer eggs for annual production, this will still require the capture and spawning of fewer females annually but maximize the genetic variation within the program.

Brood Lakes Cleanup

Regulations for the Brood Stock Lakes Program are designed to prevent harvest of Muskellunge while they are undergoing

withdrawal from hatchery anesthetics. The lakes that the hatchery system uses for spawning operations have changed and no longer match the waters formally managed under Brood Stock regulations. We recommend the following changes to the Brood Stock Lakes Program:

1. Add: Lake Wilhelm
2. Delete: Duck Harbor Pond, Lake Wallenpaupack, Miller Pond, and Union City Reservoir.

Angling Regulations

Some have asked if current Muskellunge regulations are adequate and if the PFBC should add waters to the "Enhanced Muskellunge Program". We will be in a better position to judge this after completing the statewide Muskellunge study in 2022. Until then, changing statewide or water specific regulations would be premature.

Creating a Focus on Targeted Fisheries

We recommend the following:

- 1) Create web reports focusing on good Muskellunge waters
- 2) Send photos of big Muskellunge caught during surveys to local media
- 3) Invite the press to Muskellunge surveys where we expect good catches
- 4) Invite Education and Information personnel to film Muskellunge surveys and put the footage on the PFBC website

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Appendix 1. Standard protocols for sampling adult Muskellunge and tiger muskellunge in flowing waters.

- Electrofishing may be conducted either during daylight hours or at night. At least for the North Branch Susquehanna River, daylight electrofishing was more effective than night electrofishing.
- Electrofishing should be conducted during the spring spawning period when water temperatures range from 10.0 to 14.9°C. It is possible that Muskellunge can be sampled effectively during the fall but this has not yet been established. Work on fall Muskellunge sampling will continue in 2017.
- Adult river Muskellunge surveys involve targeted electrofishing. Habitats to target include main river pools, eddies, side channels, mud flats, island backwaters, downed trees, and weed beds. The primary requirement is slow moving water.
- The electrofishing unit should be set at 120 pulses per second. Voltage settings should be adjusted to achieve at least 7 amps in the water.
- Electrofishing speed is important. You need to shock faster than normal but not so fast that the fish come up at the back of the boat. This takes practice.
- Shocking in an "S" pattern while moving between the shoreline and about 8 feet of depth is more effective than simply following the shoreline. This is particularly true when sampling main river pools and mud flats.
- The goal is to sample 10% of the stocked portion of the section length on major rivers and 5% of the stocked portion of the section length on all other resource categories. These targets are goals, not requirements, because access limitations may prevent achieving the targeted distances. In cases where multiple contiguous river sections are stocked, managers may consider the entire stocked length as a single section for Muskellunge evaluation purposes.
- Site lengths should be variable. Because Muskellunge are rare, it is best to shock the entire length of suitable habitat.
- Mean catch per unit effort must meet or exceed the benchmark catch rate of 1 Muskellunge per hour for continued stocking.

Appendix 2. Standard protocols for sampling YOY Muskellunge in flowing waters.

- Electrofishing should be conducted during daylight.
- Electrofishing should be conducted before the hatcheries stock to ensure that the fish are wild.
- Boat electrofishing is the most effective method to sample YOY on major rivers. Backpack or towed boat electrofishing may be necessary for small rivers and warmwater streams.
- YOY Muskellunge are most vulnerable to boat electrofishing when they are between 6.0 and 10.0 inches in length. This usually occurs at the end of July or the beginning of August and runs through the end of August.
- YOY river Musky surveys involve targeted electrofishing. Habitats to target include weed beds and mud flats with woody debris. The primary requirement is slow moving water.
- The electrofishing unit should be set at 120 pulses per second. Voltage settings should be adjusted to achieve at least 7 amps in the water.
- Electrofishing speed is the same as used for Black Bass.
- Shocking the edge of a weed bed is more effective than shocking through the middle of it.
- The goal is to sample 5% of the section length on all resource categories. This target is a goal, not a requirement, because access limitations may prevent achieving the targeted distance. In cases where multiple contiguous river sections are stocked, managers may consider the entire stocked length as a single section for Muskellunge evaluation purposes.
- Site lengths should be variable. Because Muskellunge are rare, it is best to shock the entire length of suitable habitat.
- Note that these techniques are also effective for sampling YOY Muskellunge in lakes.

Appendix 3. Projected alternate year Muskellunge stocking requests at 0.75 fish/acre. Assumptions: a) managers currently stocking at less than 0.75/acre will continue to do so; b) currently drained lakes will return to the program when refilled.

Water	Fisheries Management Area	Request in Even Numbered Years	Request in Odd Numbered Years
Conneaut Creek 03	1	0	100
Lake Arthur	1	0	2,425
Presque Isle Bay	1	0	2,475
Pymatuning Reservoir	1	10,450	0
Shenango River 05	1	0	775
Allegheny Reservoir	2	9,075	0
Allegheny River 06	2	225	0
Allegheny River 07	2	225	0
Allegheny River 08	2	250	0
Allegheny River 09	2	1,400	0
Allegheny River 10	2	1,100	0
Allegheny River 11	2	525	0
Allegheny River 12	2	1,900	0
Allegheny River 13	2	1,225	0
Allegheny River 14	2	550	0
Allegheny River 15	2	675	0
Allegheny River 16	2	725	0
Allegheny River 17	2	850	0
Conneaut Lake	2	0	700
Cussewago Creek 02	2	0	100
Edinboro Lake	2	0	175
French Creek 03	2	0	50
French Creek 04	2	0	400
French Creek 05	2	0	100
French Creek 06	2	0	525
Lake Canadohta	2	0	125
Lake Wilhelm	2	1,300	0
Leboeuf Lake	2	50	0
Mahoning Creek 04	2	0	225
Sugar Lake	2	0	75
Tamarack Lake ¹	2	0	425
Tionesta Lake	2	0	425
Woodcock Creek Lake	2	250	0
Glendale Lake	3	1,200	0
West Br Susquehanna R 07	3	0	2,100
Cowanesque Lake ²	4	0	400
Frances Slocum Lake	4	0	125
Belmont Lake ¹	5	0	125
Delaware River 05	5	0	1,675
Delaware River 06	5	0	1,050

Lehigh River 09	5	0	800
Prompton Lake	5	0	200
Lake Marburg	6	0	950
Leaser Lake ²	6	0	50
Schuylkill River 06 ²	6	0	50
Schuylkill River 07 ²	6	0	125
Susquehanna River 05 ³	6	0	2,050
Canoe Creek Lake	7	0	125
Juniata River 02	7	0	150
Juniata River 03	7	0	225
Juniata River 04	7	0	1,525
Juniata River 07	7	0	200
Opossum Lake	7	0	25
Raystown Lake ²	7	0	3,125
Susquehanna River 01	7	0	275
Susquehanna River 03	7	0	4,800
Allegheny River 19	8	525	0
Allegheny River 20	8	825	0
Allegheny River 21	8	700	0
Lake Somerset ^{1, 2}	8	0	100
Loyalhanna Lake ²	8	0	175
Monongahela River 02 ²	8	0	625
Youghiogheny River 06	8	0	1,450
Totals:		33,950	34,025

1. Lake is drained or faces an impending drawdown so there are no current stocking requests.
2. Estimated at 0.375 Muskellunge/acre because this water is also stocked with tiger muskellunge.
3. Manager is currently stocking at less than the maximum rate permitted by this plan.

Appendix 4. Projected tiger muskellunge stocking requests according to plan guidelines. Assumptions: a) managers currently stocking at less than 0.75/acre will continue to do so; b) currently drained lakes will return to the program when refilled.

Water	Fisheries Management Area	Request in Even Numbered Years	Request in Odd Numbered Years
Beaver River 02	1	375	0
Connoquenessing Creek 07	1	75	0
Keystone Lake (17E)	2	725	0
Mahoning Creek Lake	2	200	0
Piney Reservoir	2	525	0
Two Mile Run Rs - Justus Lake	2	100	0
Curwensville Lake	3	600	0
Cowanesque Lake ¹	4	0	400
Fords Lake	4	0	50
Stillwater Lake	4	75	0
Blue Marsh Lake	6	0	875
Falls Township Park Lake	6	50	0
Kaercher Creek Dam	6	0	25
Leaser Lake ¹	6	0	50
Schuylkill River 06 ¹	6	0	50
Schuylkill River 07 ¹	6	0	125
Schuylkill River 11 ³	6	0	50
Schuylkill River 12	6	0	300
Susquehanna River 04	6	525	0
Conodoguinet Creek 05	7	525	0
Little Buffalo Lake	7	75	0
Raystown Branch Juniata River	7	0	50
Raystown Branch Juniata River	7	0	325
Raystown Lake ¹	7	0	3,125
Swatara Creek 05	7	225	0
Sweet Arrow Lake	7	75	0
Keystone Lake (18C)	8	50	0
Lake Somerset ^{1, 2}	8	0	100
Loyalhanna Lake ¹	8	0	175
Monongahela River 02 ¹	8	0	625
Ohio River 03	8	1,975	0
Totals:		6,175	6,325

1. Estimated at 0.375 tiger muskellunge/acre because this water is also stocked with purebred Muskellunge.
2. Lake is drained or faces an impending drawdown so there are no current stocking requests.
3. Manager is currently stocking at less than the maximum rate permitted by this plan.