Wachusett Reservoir

Creel Survey Report
Survey Year 2017

December 2019

Massachusetts Department of Conservation and Recreation
Division of Water Supply Protection
Office of Watershed Management
Wachusett Reservoir Region

ABSTRACT

A roving creel survey of shore anglers was conducted during the 2017 fishing season (April-November) on central Massachusetts' Wachusett Reservoir, a Class A surface water supply serving 3.1 million people. Anglers were counted and interviewed to collect trip specifics and information about fish landed and harvested. A total of 3,463 anglers were surveyed in 2017 on 99 of the possible 243 days in the legal fishing season. Surveys from 2011, 2012, and 2017 indicate that the reservoir is used as a recreational angling resource by more than 8,000 different anglers, with 97% of anglers being Massachusetts residents. Catch per unit effort for all reservoir fish species was calculated as 0.16 fish per one hour of angling time in 2017, which is lower than catch rates documented in 2011 (0.24) and 2012 (0.20). Estimated totals for the complete 2017 angling season include 8,048 fish caught from a total of 12,959 angling trips. Comparison of the current creel survey results to three other creel surveys conducted since 1979 show that the species most frequently caught by anglers have changed and that this may reflect changes in the reservoir's fish community composition over this time period or changes in angler preferences. Lake Trout and Smallmouth Bass were the species most frequently caught by anglers and Lake Trout accounted for 45% of the total harvest across all species. The harvest rate across all species was 34%, while 39% of Lake Trout and 65% of Rainbow Trout were harvested. The Lake Trout estimated yield per acre of 0.65 pounds per acre observed during the 2017 season was higher than the estimated yield in the previous two surveys and may exceed the recommended estimated yield per acre for this population, which is discussed in depth in this report. Until this estimated yield is reduced, or until a maximum sustainable yield is determined, a change in the current daily limit and minimum length for Lake Trout harvest are recommended. Fish are an important component of the reservoir ecosystem and knowledge of fish population dynamics in the reservoir is important to understanding the Wachusett Reservoir food web and its impacts upon drinking water quality.

Acknowledgements:

This report was prepared by the MA Department of Conservation and Recreation, Division of Water Supply Protection, Office of Watershed Management. The principle authors are Jamie Carr, current Regional Director and former Aquatic Biologist, and Max Nyquist, Aquatic Biologist. Internal review was provided by Joy Trahan-Liptak and Larry Pistrang. External review was provided by Jason Stolarski of the MA Division of Fisheries and Wildlife (MassWildlife) and Bob Maietta of the MA Department of Environmental Protection. Cover based on a photo by Joy Trahan-Liptak.

Many thanks are owed to the personnel who made this study possible by performing angler counts and field surveys of anglers, including DWSP Watershed Rangers, MassWildlife staff and DWSP Aquatic Biologists. Also, the collective 99.94% cooperation rate of the anglers is what makes the survey possible.

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FISH SPECIES DOCUMENTED IN WACHUSETT RESERVOIR

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Banded Killifish	*Fundulus diaphanus*
Black Crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Brook Trout	*Salvelinus fontinalis*
Brown Bullhead	*Ameiurus nebulosus*
Brown Trout	*Salmo trutta*
Chain Pickerel	*Esox niger*
Lake Trout	*Salvelinus namaycush*
Landlocked Salmon	*Salmo salar*
Largemouth Bass	*Micropterus salmoides*
Pumpkinseed	*Lepomis gibbosus*
Rainbow Smelt	*Osmerus mordax*
Rainbow Trout	*Oncorhynchus mykiss*
Rock Bass	*Ambloplites rupestris*
Smallmouth Bass	*Micropterus dolomieu*
Tessellated Darter	*Etheostoma olmstedi*
White Sucker	*Catostomas commersoni*
White Perch	*Morone americana*
Yellow Bullhead	*Ameiurus natalis*
Yellow Perch	*Perca flavescens*

WACHUSETT RESERVOIR

CREEL SURVEY REPORT FOR SURVEY YEAR 2017

1.0 INTRODUCTION

The Massachusetts Department of Conservation and Recreation (DCR), Division of Water Supply Protection (DWSP), Office of Watershed Management was established by Chapter 372 of the Acts of 1984. This division of DCR was created to manage and maintain a system of watersheds and reservoirs to provide water to the Massachusetts Water Resources Authority (MWRA), which in turn supplies drinking water to 3.1 million people and thousands of industrial users in metropolitan Boston and central Massachusetts. Water quality sampling and watershed monitoring make up an important part of the overall mission of the DWSP Environmental Quality Section staff at Wachusett Reservoir in West Boylston and the Quabbin Reservoir in Belchertown.

The Wachusett Reservoir (Wachusett) is a 4,057-surface acre, 59.7-billion-gallon man-made drinking water supply reservoir located in central Massachusetts. It was completed in 1906 and is the second largest water body in the state. It is an oligotrophic reservoir with a watershed of 74,800 acres, a mean depth of 48 feet, and a maximum depth of 128 feet. In addition to the watershed, Wachusett Reservoir receives water from the largest body of water in the state, Quabbin Reservoir, via a 25-mile-long aqueduct.

Fish are an important component of the reservoir ecosystem and the health of fish populations can have a profound impact on the water quality of the reservoir. For example, predatory game fish in the reservoir, including but not limited to Lake Trout and Smallmouth Bass, may have important top down effects on nutrients, smaller fish, zooplankton, and phytoplankton, which directly impact water quality (Holmlund 1999). To further understand these impacts and the underlying food web that drives them, the DWSP collects information about fish populations in the reservoir through mark and recapture studies and creel surveys. A creel survey is a survey of anglers used to estimate the number, type, and size of fish caught by anglers in a specific water body over a specific time period. In this context, a creel survey of Wachusett Reservoir can serve as a tool to directly assess the following fishery attributes: fish populations, fishing pressure, catch rate, and harvest.

The reservoir has historically supported an active recreational fishery, which has produced state record catches of the following five species: Brown Trout (1966), Smallmouth Bass (1981), Rainbow Trout (1999), and White Perch (2016) (MassWildlife 2018a). Wachusett also claims a world record catch; the state record 3-pound 8-ounce White Perch caught by Val Percuoco on October 16, 2016 certified as the all tackle world record catch for that species (IGFA 2018).

Apart from Rainbow Trout, all species currently inhabiting the reservoir are considered naturally reproducing and self-sustaining populations. Rainbow Trout have been stocked in Wachusett Reservoir since at least the early 1990s. From 2000 through the present an average of 2,200 Rainbow Trout are stocked annually each spring by Massachusetts Division of Fish and Wildlife (MassWildlife) staff (Mark Brideau, personal communication). Most recently, 2,000 Rainbow Trout were stocked in the Spring of 2017 and 1,800 in Spring of 2018 (Ken Simmons 2018, personal communication). In 1999, approximately 2,400 surplus Landlocked Salmon young-of-year were stocked in the Quinapoxet River, due to natural reproduction problems (MassWildlife 1996, 1997, 2000, 2001). Approximately 2,500 twelve-inch Landlocked Salmon were stocked by MassWildlife in the fall of 2014 and again in 2015. This was due to excess in the hatchery supply of these fish and none have been stocked since 2015.

The open fishing season on Wachusett Reservoir begins on the first Saturday in April (ice conditions permitting) and continues until the last day of November. Public boating is not allowed on the reservoir. Shore fishing is allowed for 29.7 of the 32.5 miles of reservoir shoreline because public access is prohibited in the intake zone (Figure 1). Fishing is permitted from dawn to dusk and two active lines are permitted per angler.

Angler creel surveys at Wachusett Reservoir were conducted by MassWildlife staff in 1979, 1980, and 1998. No fisheries data was collected in Wachusett Reservoir between 1999 and 2010. Creel surveys led by DWSP staff were conducted in 2011, 2012, and 2017. To gather more fisheries data, the DWSP and MassWildlife initiated a Lake Trout tagging study at Wachusett Reservoir in the fall of 2014, which has continued through 2019.

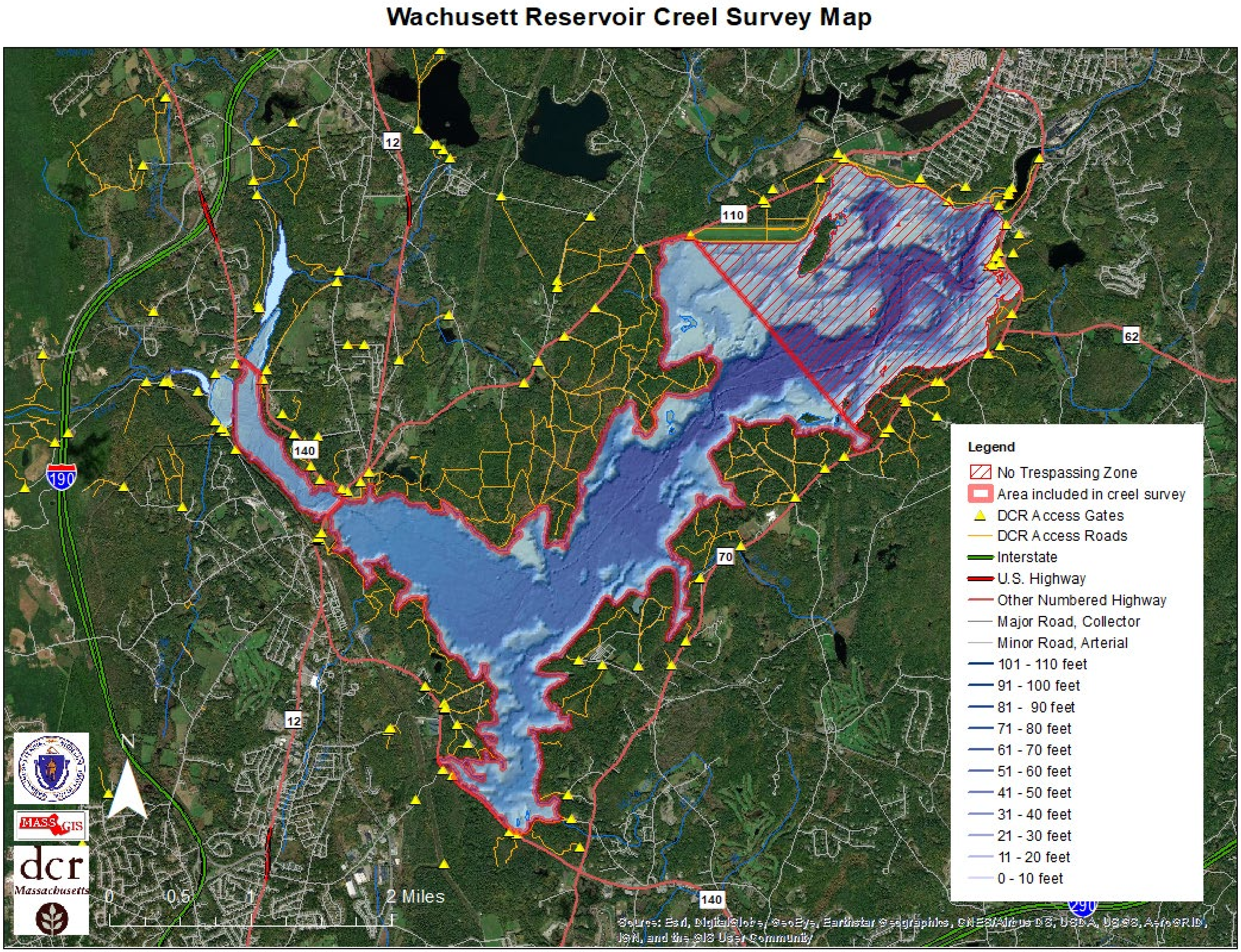
The goal of the creel survey was to document angler catches at Wachusett Reservoir during the 2017 fishing season in order to compare the results to past surveys and establish a baseline for future comparison. A comprehensive report summarizing the 2011 and 2012 creel seasons is available on the MA DCR website (DCR 2015). That report provides additional historical background, as well as in-depth descriptions of the survey methods, analysis, and equations used to reach estimated totals.

2.0 LINK BETWEEN FISH AND WATER QUALITY

It is well established that changes to the fish community can impact the aquatic ecosystem and water chemistry of a reservoir system (Vanni et al. 1997, Estes 2011). Predatory fish are at the top of the reservoir food chain and can have top down effects that influence populations of smaller fish, zooplankton, and phytoplankton (Vanni and Layne 1997, Carpenter 2001). Changes in the fish community, whether from angling, climate change, or other factors have the potential to impact water quality. Therefore, it is important to maintain a basic understanding of the fish community in the reservoir as well as trends in fish populations and potential threats.

It is also well recognized that changes in water quality may impact fish, particularly fish with specific habitat requirements, such as the Lake Trout (*Salvelinus namaycush*). For example, increases in water temperature due to climatic changes are believed to negatively impact Lake Trout by reducing the volume of available cold-water habitat (Dillon 2003, Plumb 2006). Compounding this problem are increases in water temperature that typically favor other species which negatively impact Lake Trout, particularly Smallmouth Bass (Jackson 2007). While potentially benefitting warm water species such as Smallmouth Bass, increases in water temperature may not be as detrimental to the overall water quality of the reservoir even if Lake Trout decline, as the Smallmouth Bass population may provide similar indirect water quality services as a top predator. The impacts of increasing water temperature on the overall water quality, unrelated to the fish community, are being investigated by DWSP, and will be addressed elsewhere. Another example of changing water quality is increasing specific conductance, recently documented in Wachusett Reservoir and across the country; however, its effect on Lake Trout populations is currently unknown (Dugan 2017). The DWSP is interested in protecting this unique Massachusetts fishery because of the recreational and water quality services it provides.

FIGURE 1: WACHUSETT RESERVOIR MAP



3.0 METHODS

3.1 Sampling Design

A roving creel survey with a progressive count was employed during the 2017 fishing season, which ran from April 1 to November 30. The overall survey procedure for 2017 remained almost the same as in 2012 (DCR 2015), with the sole difference being the allocation of the survey days. The number of survey days scheduled in April and May of 2017 was increased to match the higher levels of angler effort and catch documented during April and May in the 2011 and 2012 surveys (Figure 4, Figure 5, Figure 6). This reallocation decision was made to increase the amount of information collected from Wachusett anglers. The total number of scheduled survey days remained the same between 2017 and 2012 (Table 1). Once the number of survey days was assigned to each month and day type (weekday vs. weekend), survey days were selected at random. A schedule was then generated for the fishing season that assigned each survey day to a department (i.e. rangers, biologists, MassWildlife staff, etc.).

TABLE 1: SURVEY DAYS SCHEDULED BY SEASON

	2012 Planned	2017 planned
April	10	23
May	14	17
June	13	15
July	14	14
August	13	11
September	13	7
October	13	7
November	13	9
Total	103	103

Meetings and trainings for survey agents were held prior to the start of each season to ensure standard data collection. The creel survey card was the same as in previous years with one addition of extra lines for more zip codes to be collected on a single card (Appendix A: Creel Survey Form (Front and Back)). Definitions for each item on the creel card were provided with an explanation of each field (Appendix B: Wachusett Reservoir Creel Survey Form Explanation of Fields). The survey agent sheet remained unchanged (Appendix C: Creel Survey Agent Sheet).

Data collected from survey agent sheets and creel survey cards were entered into a Microsoft Access electronic database stored on the W drive of the server at John Augustus Hall in West Boylston; completed creel survey cards are also stored in chronological order at this location.

3.2 Analysis and Estimations

The methods and formulas for analyzing the creel survey data and generating estimated results followed methods outlined in Estimating Angling Effort and Catch from Michigan Roving and Access Site Angler Survey Data (Lockwood et al 1999) and are described in detail in the previous creel report (DCR 2015). The annual harvest rate was calculated by dividing the estimated total fish harvested each year by the total surface area of the reservoir and is reported as fish per acre per year. The estimated yield adds a weight component to the annual harvest rate. The expected weight for the length of each harvested specimen of a species in each season was calculated (Appendix D: Additional Plots). The estimated yield for Lake Trout and Smallmouth Bass was calculated by multiplying the expected weight for that length by the estimated total number of fish harvested. The estimated yield per acre is the estimated yield harvested divided by the reservoir surface area of 4,057 acres.

3.3 Survey Limitations

Bias is introduced in any attempt to survey recreational anglers. This creel survey was designed to limit obvious sources of bias. The size of Wachusett Reservoir and network of access roads allows a survey agent to travel completely around it, view the fishable shoreline and interview anglers in less time than an average complete angling trip. This lends credibility to the progressive counts; however, time spent stopping to interview anglers means that the progressive counts are biased low and angling effort is likely underestimated (Hoenig et al. 1993). Given the current personnel, logistics, and time constraints, the roving creel survey design with a progressive count is considered the best survey design for Wachusett Reservoir.

Anglers can target specific fish habitats, species and sizes. Rainbow Smelt and Banded Killifish are important forage fish in the reservoir, but they are not caught by anglers and thus are not represented in this creel survey. The results provided by a creel survey are not unbiased or random and can be skewed by angler attitudes towards undesirable fish and non-target fish (Lockwood, 1999). Anglers targeting large Lake Trout and Smallmouth Bass expect a lower catch rate as a tradeoff for having a greater chance at a trophy catch. The catch rate results are influenced by angler attitudes and would likely be higher if more anglers focused more effort on catching readily available, albeit smaller, fish.

The DWSP acknowledges the possibility that a portion of the angler reported length data may be skewed due to a propensity for reporting even numbers and the possibility of reporting the exact legal length at Quabbin Reservoir (there is currently no length limit at Wachusett) when in contact with a state employee. However, the DWSP believes the harvest data are accurate and can be used to guide the decision-making process as more Lake Trout population data is collected.

Reallocation of survey effort to match with angling effort produced obvious benefits (more anglers counted, more anglers surveyed), but resulted in only seven survey days scheduled for September and October. Also, while nine days were scheduled for November, only seven were completed due to two missed survey days that month. This reallocation may influence the reported catch rates and may complicate comparison of 2017 results to other surveys in the past.

Due to a rounding error, the numeric values for the 2011 and 2012 estimated total fish harvested were incorrectly reported. They were revised slightly and are reported correctly in this report (Table 2).

4.0 RESULTS

In 2017, the creel survey was conducted on 99 of the 244 possible days within the fishing season (April 1 – November 30). The schedule for the season was designed with a total of 103 survey days; surveys were not completed on only four of the scheduled days due to last minute staff time conflicts, illness, extreme weather, etc.

On an average survey loop (each survey day consisted of one AM loop and one PM loop), the survey agent circumnavigated the reservoir in two hours and 37 minutes, while counting 19 anglers and surveying 10 anglers. Due to time constraints, survey design, and the potential for creating bias towards a low angler count, clerks were not expected to interview all anglers; a rough goal of interviewing half of the anglers was set (Hoenig et al. 1993). In total, survey agent counted 3,463 anglers and surveyed 1,873 anglers (54%).

Due to the change in allocation of survey effort, more anglers were counted and surveyed in 2017 than in 2011 or 2012. Despite only a 4% increase in hours of survey effort compared to 2012, 41% more anglers were counted, and 40% more surveys were completed in 2017 (Table 2).

4.1 Angler Attributes

Anglers were asked to provide their home zip code as part of the interview which generated 1,568 valid responses during the 2017 season. It should be noted that attempting to collect all zip codes from groups of anglers was emphasized during training prior to the 2017 surveys. This resulted in more zip codes being captured than during past surveys when often only a single zip code would be recorded while surveying groups of anglers. Angler trips for 97% of anglers surveyed in 2017 originated in Massachusetts, with a total of 176 different Massachusetts towns represented (Figure 2). Out-of-state angler trips were recorded from 11 other states, including New Hampshire (20), Connecticut (8), Rhode Island (6), North Carolina (3), Texas, (3), Illinois (2), Michigan (2), California (1), Maine (1), New York (1), and Vermont (1). The zip code results demonstrate that Wachusett Reservoir is a regionally important resource for both local and national anglers.

Zip code information is known for 84% of the angler population surveyed, allowing for the town of origin to be assigned to 10,849 of the estimated 12,959 angler trips over the 2017 fishing season. As in previous surveys, Worcester was the most frequently reported municipality reported by zip code (Figure 2).

Over the course of all three survey years, the most angler trips originated from Worcester, which accounted for 25% of all angling trips with an estimated 6,855 trips (Figure 3). Other towns with at least 500 estimated trips included Clinton (2,407), Leominster (1,369), Fitchburg (1,063), Shrewsbury (1,052), West Boylston (963), Sterling (860), Holden (627), Hudson (580), and Boylston (512). As the zip code is not known for all anglers, these numbers underestimate the actual totals.

Across all three survey seasons, 98% of anglers identified as living in Massachusetts. A total of 211 different Massachusetts towns/cities are represented from the 2011, 2012, and 2017 surveys combined (Figure 3).

During the 2017 angling season, 65% (1,216) of anglers surveyed were unique anglers, indicating they had not been surveyed during the current fishing season, while the remaining 35% had been surveyed. It is estimated that 8,413 anglers utilized Wachusett Reservoir as a recreational fishery during the 2017 fishing season (making a total of 12,959 trips). This is similar to the estimated 8,304 unique anglers that used the fishery in 2012 (12,581 trips) and less than the 11,336 anglers that visited in 2011 (16,194 trips).

FIGURE 2: ESTIMATED NUMBER OF ANGLING TRIPS BY TOWN OF ORIGIN FOR THE 2017 SEASON

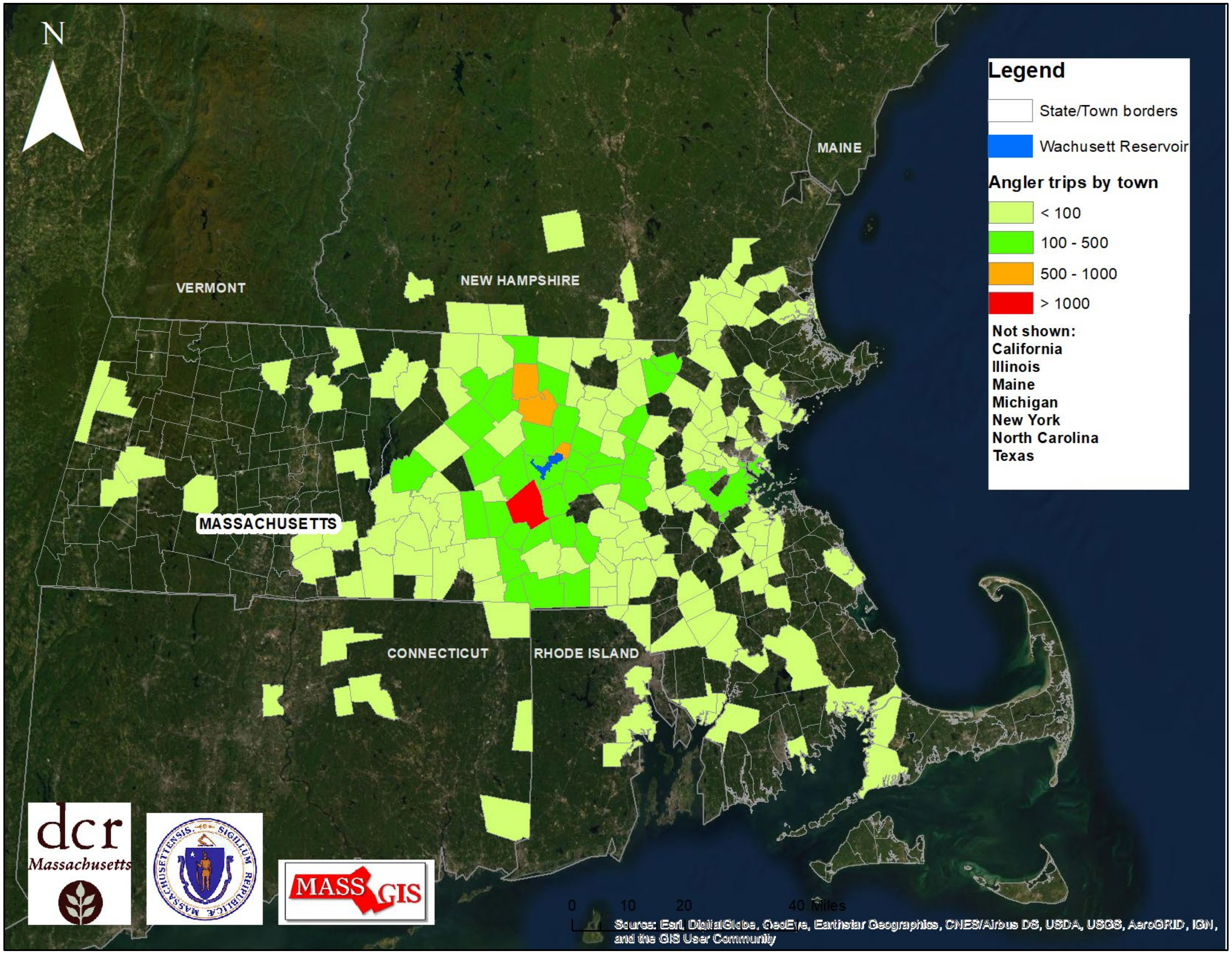
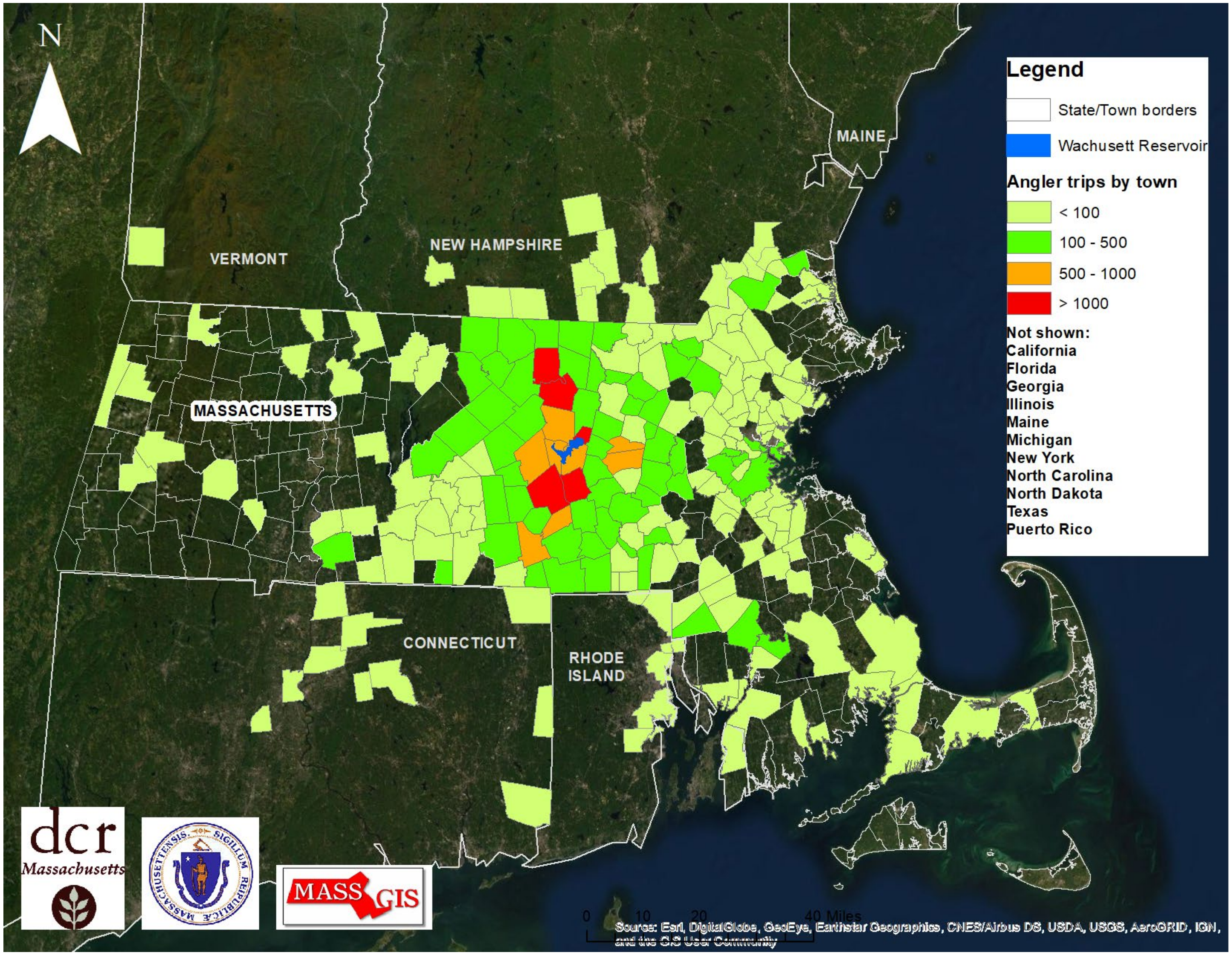


FIGURE 3: TOTAL ESTIMATED NUMBER OF ANGLING TRIPS BY TOWN OF ORIGIN FOR 2011, 2012, AND 2017



4.2 Estimated Angler Effort

During the 2017 angling season, creel surveys revealed that an estimated 13,932 angling trips took place, with a corresponding total of 44,113 hours of angling time representing the effort for the year (Table 2). This means that the angling pressure for 2017 is estimated at 10.9 hours per surface acre. Mean angling trip lengths calculated from complete trip surveys show that the average angling trip during 2017 lasted 3.4 hours. These results are similar to previous surveys, with the estimated total of angling trips, angling hours, and trip time all falling in between totals reported for the 2011 and 2012 seasons.

TABLE 2: SUMMARY OF ESTIMATED CREEL SURVEY TOTALS BY YEAR

	2011	2012	2017
Days in fishing season	236	238	244
Survey days	98	98	99
Anglers surveyed	1,227	1,334	1,873
Completed trips (%)	19.5%	15.8%	14.4%
Total angling trips	16,194	12,581	13,932
Total angling hours	45,407	40,266	44,113
Angling Hours per surface acre	11.2	9.9	10.9
Mean length completed angling trip (hours)	3.1	3.5	3.4
Total fish caught	10,977	7,930	8,048
Total fish harvested (all species)	3,097	1,943	2,718
Fish harvested (%, all species)	28.2%	24.5%	33.8%
Catch per hour	0.24	0.20	0.16
Time to catch one fish (hours)	4.1	5.1	6.4

2017 angler effort was highest in April and May at the opening of the fishing season when Lake Trout and Landlocked Salmon can be found close to shore and are most accessible to anglers. Effort tapered off as the season progressed, with the minimum effort occurring in October. Weekday effort increased in November when water temperatures decreased before the close of the season (Figure 4). The increase in angler effort during November weekends was observed to be greater than in previous seasons. November weekend angling effort was estimated to be 609 hours/day in 2011, 726 hours/day in 2012 and 1,733 hours/day in 2017 (Figure 5).

FIGURE 4: AVERAGE HOURS OF ESTIMATED ANGLING EFFORT PER WEEKDAY

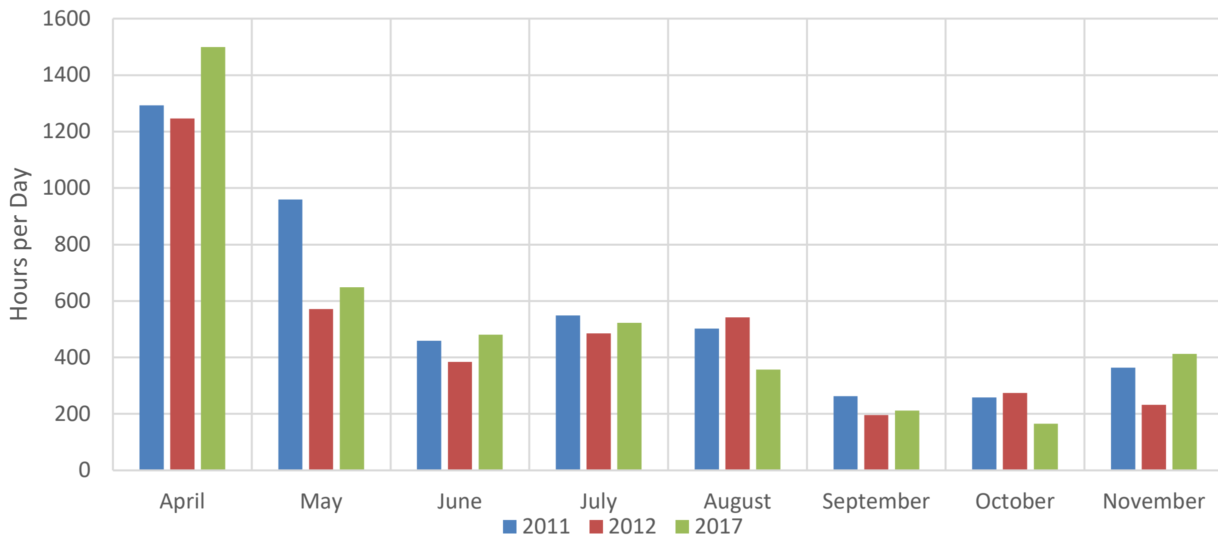
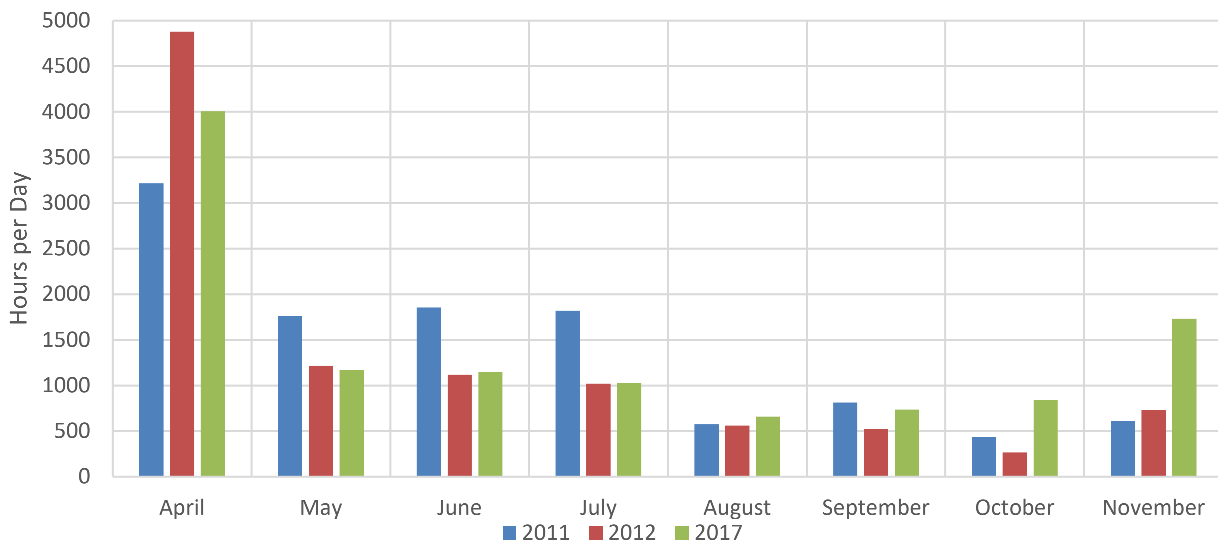


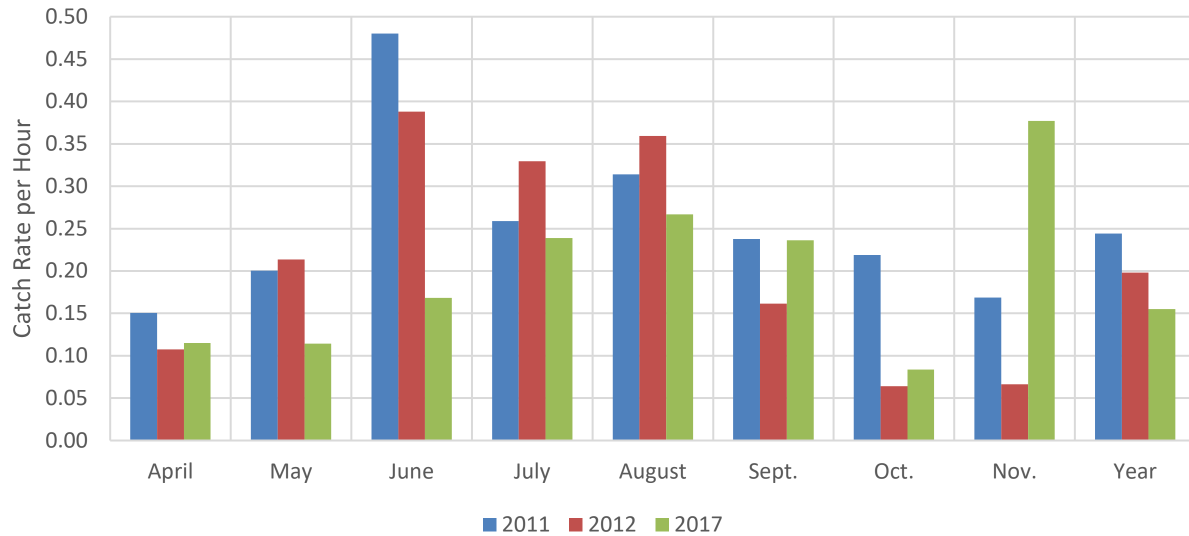
FIGURE 5: AVERAGE HOURS OF ESTIMATED ANGLING EFFORT PER WEEKEND DAY



4.3 Catch Per Unit Effort

Catch per unit effort by anglers is a standard measure of angling success which represents the number of fish caught by anglers per a standard unit of time. Catch rate is reported here as catch of all species combined per angling hour. During the 2017 angling season, creel surveys show an overall catch rate of 0.16 fish. This overall rate was lower than the rate of 0.24 observed in 2011 and 0.20 for the 2012 angling season. Expressed another way, on average it took an angler 4.1 hours to catch one fish in 2011, 5.1 hours in 2012, and 6.4 hours in 2017 (Table 2). The highest catch rate for a given month in 2017 was 0.38 fish per hour in November, the only month for the season with a higher catch rate than the corresponding months during the 2011 and 2012 seasons. Although over 414 Lake Trout were caught in November, it is noteworthy that more than half of the total catch for that month was comprised of Yellow Perch. Atypically low catch rates recorded in May and June were followed by higher catch rates in July, August, and September (Figure 6). In terms of angling success by trip, 40% of angler trips during the 2017 season resulted in at least one fish being caught. This is a lower percentage of successful angler trips compared to 2011 (55%) and 2012 (47%) percentages.

FIGURE 6: WACHUSETT RESERVOIR CATCH RATES



4.4 Size Distribution of Lake Trout and Smallmouth Bass

An analysis of Lake Trout length distribution in Wachusett Reservoir as reported by anglers shows that the most frequently reported Lake Trout length was 18 inches for all three survey years (Figure 7). The proportion of Lake Trout lengths reported as 20 inches or greater was 47% in 2017; higher than the 26% in 2011 and 42% in 2012. It appears that odd number lengths of Lake Trout are under-reported, with lengths of 18 and 20 inches likely being over-reported.

FIGURE 7: LENGTH DISTRIBUTION OF LAKE TROUT CAUGHT IN WACHUSETT RESERVOIR 2011-2017 (N=889)

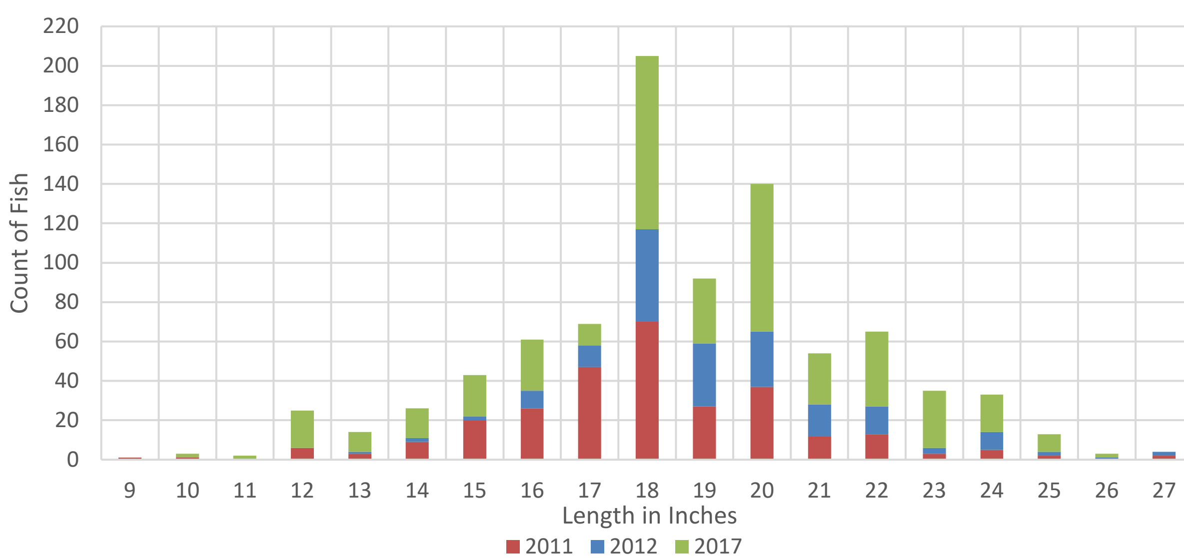
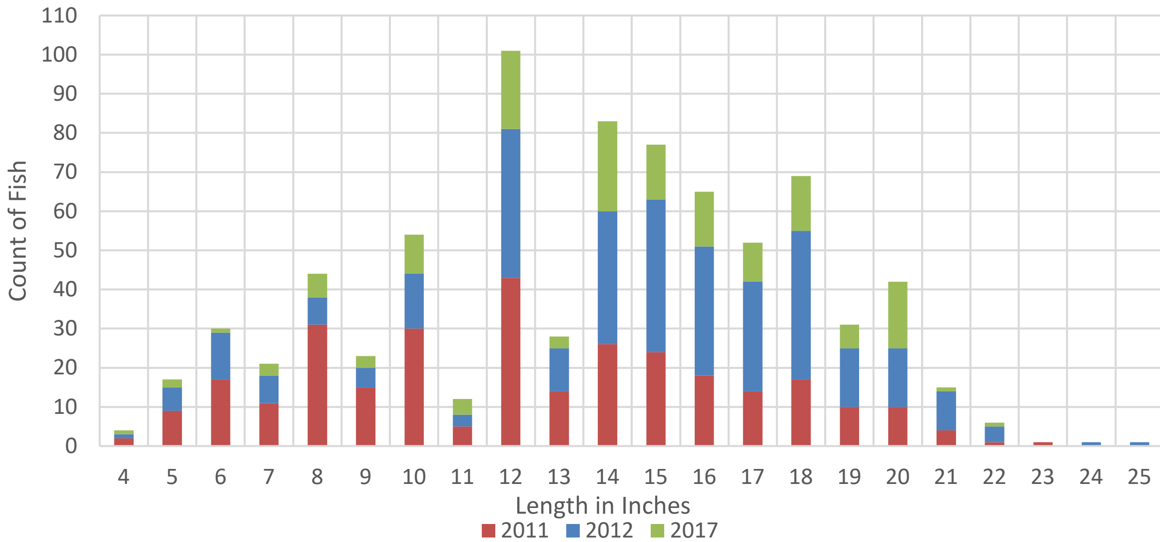
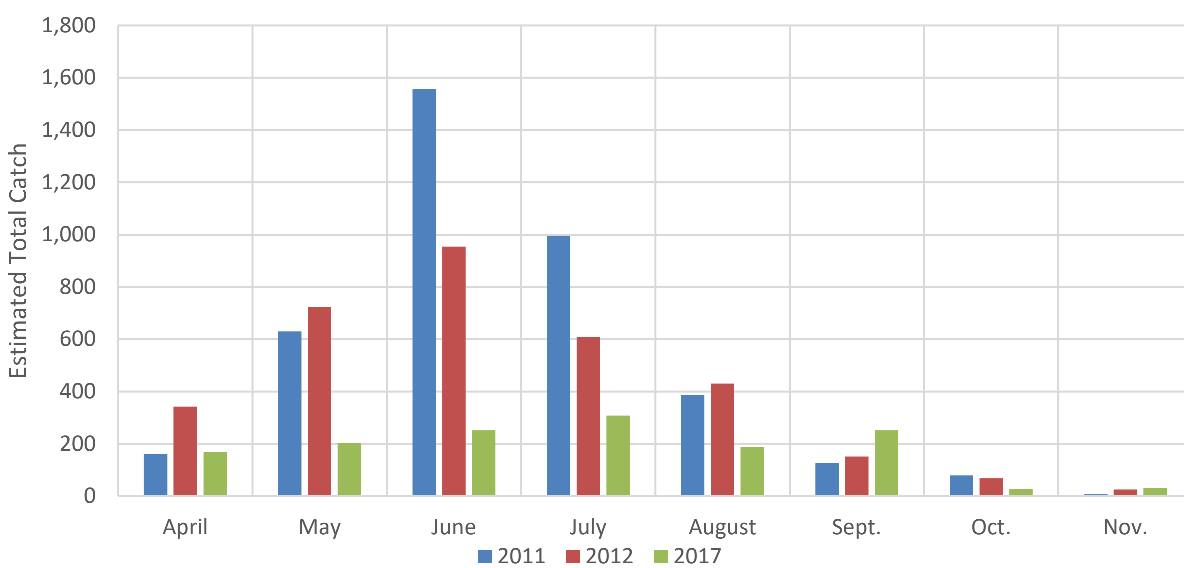


FIGURE 8: LENGTH DISTRIBUTION OF SMALLMOUTH BASS CAUGHT IN WACHUSETT RESERVOIR 2011-2017 (N=777)



Analysis of Smallmouth Bass size distribution in Wachusett Reservoir as reported by anglers shows that the most frequently occurring length was 14 inches in 2017 and 12 inches in the previous two surveys (Figure 8). The proportion of Smallmouth Bass caught reported with lengths 16 inches or greater was 41% in 2017; higher than the 25% in 2011, but lower than the 45% in 2012. Odd number lengths of shorter Smallmouth Bass are consistently under-reported by anglers, who more consistently report even number lengths for small fish. The total number of Smallmouth Bass caught during the 2017 season was far less than during the previous two survey years. Far fewer Smallmouth Bass were caught during the summer months, although slightly more were caught during the month of September (Figure 9).

FIGURE 9: TOTAL CATCH OF SMALLMOUTH BASS BY YEAR



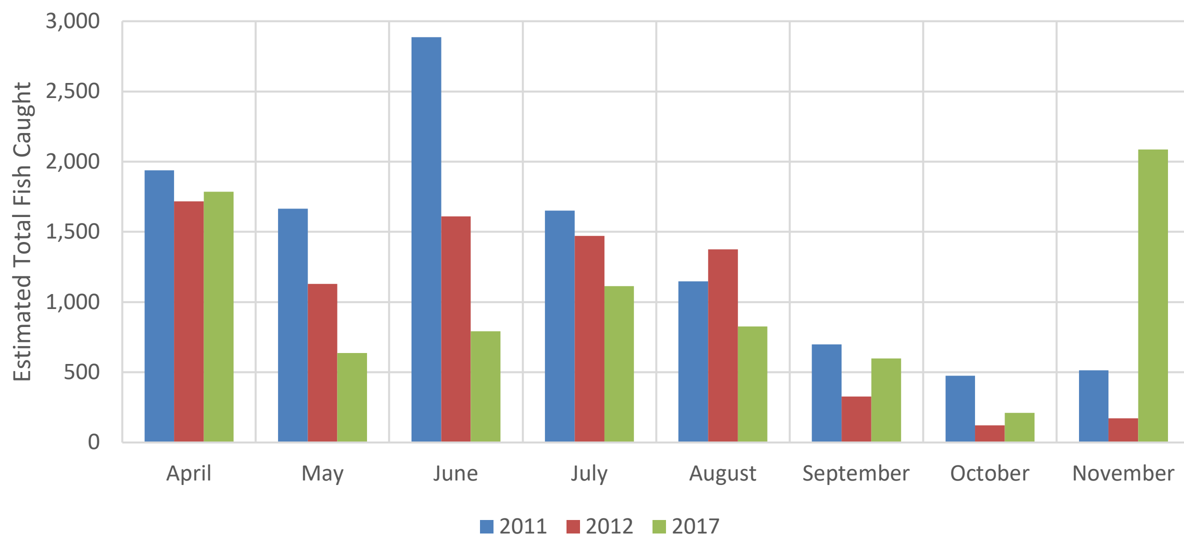
4.5 Estimated Total Catch and Harvest

During the 2017 angling season, creel surveys show an estimated total catch of 8,048 fish (Table 3). Lake Trout were the most frequently caught species in 2017, followed by Smallmouth Bass (Figure 11). Collectively, these two species of game fish accounted for more than half of the total catch (57%). Lake Trout accounted for 39% of the total catch in 2017, a higher proportion than observed in 2011 (26%) or 2012 (20%) (Figure 15). The total estimated catch of Smallmouth Bass declined sharply from the two previous surveys, and Yellow Perch increased to the highest estimated catch since 2011 (Table 5, Figure 11). The total catch of stocked Rainbow Trout was twice the total reported for the 2011 and 2012 survey years (Figure 15, Figure 11).

TABLE 3: ESTIMATED TOTAL FISH CAUGHT DURING 2017 FISHING SEASON BY MONTH
RESULTS ARE WHOLE FISH; ROUNDING MAY RESULT IN DIFFERENT TOTALS BY COLUMN OR ROW.

2017 Month	Black Crappie	Brown Bullhead	Brown Trout	Chain Pickerel	Lake Trout	Landlocked Salmon	Largemouth Bass	Rainbow Trout	Rock Bass	Smallmouth Bass	Sunfish	White Perch	White Sucker	Yellow Perch	Total Fish Caught
April				29	1,154	211	51	114		169		55		4	1,786
May	6	6	6		222	53	23	93		204	12	12			636
June				18	72	9	54	36	36	252	207	54	9	45	791
July	24				95	24	95	95		308	403			59	1,114
Aug.					219		156	47		187	203		16		827
Sept.					189					252	157				597
Oct.					105		13	39		26	26				210
Nov.					1,066	31		108		31	31	15		803	2,085
Total	30	6	6	47	3,121	327	392	532	36	1,429	1,039	136	25	912	8,048

FIGURE 10: ESTIMATED TOTAL FISH CAUGHT BY MONTH AND YEAR



The total estimated harvest by anglers for the 2017 season was 2,718 fish (Table 4). Lake Trout were the most frequently harvested species and accounted for almost half of the total harvest (45%). The overall harvest rate for all species was higher in 2017 than in past years, with 34% of all fish caught being kept as compared to 25% in 2012 and 28% in 2011 (Table 5). This is likely due to the greater proportion of Lake Trout caught during 2017 (Figure 11,). The harvest rate for Lake Trout was the same in 2017 as in 2011 (39% in both seasons) but lower than the 54% harvest rate for Lake Trout reported in 2012 (Table 5, Figure 12). A similar trend was observed for Smallmouth Bass, as 8% and 9% were harvested during the 2017 and 2011 seasons, respectively, while 14% were harvested in 2012 (Table 5, Figure 12). Rainbow Trout were harvested at a rate of 65% in 2017, very similar to the rates of 70% in 2011 and 62% in 2012 (Table 5).

TABLE 4: ESTIMATED TOTAL FISH HARVESTED DURING 2017 FISHING SEASON

RESULTS ARE REPORTED AS WHOLE FISH; ROUNDING MAY RESULT IN SLIGHTLY DIFFERENT TOTALS BY COLUMN OR ROW. SPECIES WITH NO HARVEST NOT SHOWN.

2017	Chain Pickerel	Lake Trout	Landlocked Salmon	Largemouth Bass	Rainbow Trout	Smallmouth Bass	Sunfish	White Perch	White Sucker	Yellow Perch	Grand Total
April	3	448	86	2	74	13		37		3	667
May		86	21	1	60	16	2	8			195
June	2	28	4	3	23	20	36	37	4	30	186
July		37	10	5	61	24	70			40	246
August		85		8	30	15	35		8		180
September		73				20	27				120
October		41		1	25	2	5				74
November		414	13		70	2	5	11		536	1,050
Total	5	1,212	133	19	344	112	180	93	12	608	2,718

Lake Trout were the most frequently harvested fish each season, with an estimated 1,093 harvested in 2011, 834 in 2012, and 1,212 in 2017 (Table 5, Figure 13). Yellow Perch were the second most harvested fish in 2017; many of these were small fish caught in the reservoir and used/kept as bait. The total harvest of Rainbow Trout increased as compared to the two previous surveys, while the number of Smallmouth Bass harvested decreased (Table 5, Figure 13). Anglers indicated that they intended to consume the fish that they harvested 88% of the time; some smaller perch and sunfish were kept for use as bait.

FIGURE 11: ESTIMATED TOTAL FISH CAUGHT BY YEAR

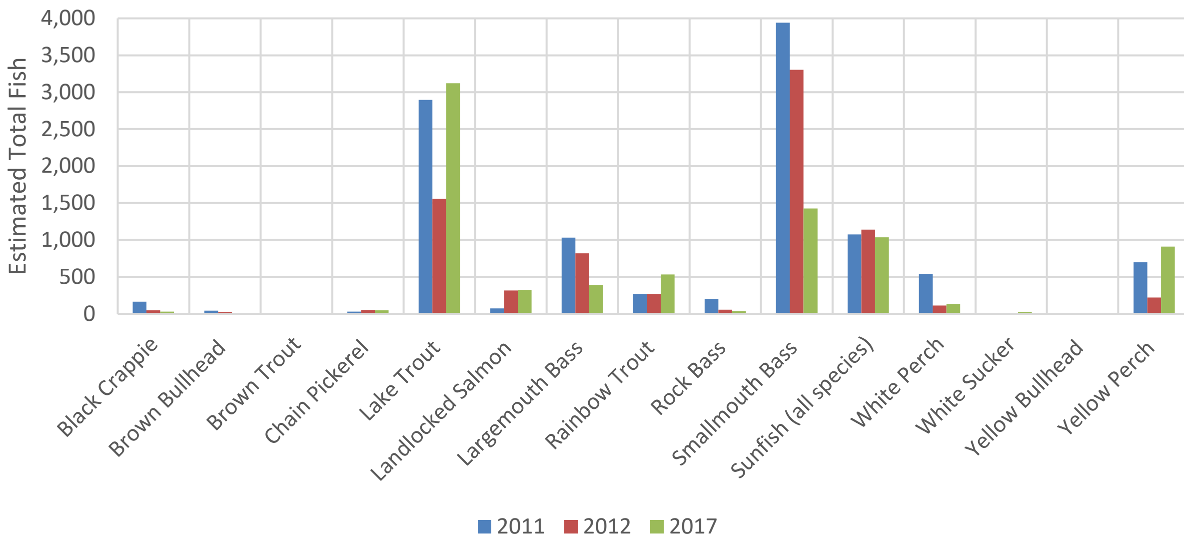


TABLE 5: HARVEST RATE AND ESTIMATED TOTAL FISH HARVESTED BY SEASON

RESULTS ARE REPORTED AS WHOLE FISH; ROUNDING MAY RESULT IN SLIGHTLY DIFFERENT TOTALS BY COLUMN OR ROW. BLANKS INDICATE THE SPECIES WAS NOT REPORTED IN THE SURVEY THAT SEASON; DASH INDICATES THE SPECIES WAS CAUGHT BUT NOT HARVESTED.

	2011		2012		2017	
Species	**Rate**	**Total**	**Rate**	**Total**	**Rate**	**Total**
Black Crappie	0.57	94	-	0	-	0
Brown Bullhead	-	0	1.00	25	-	0
Brown Trout					-	0
Chain Pickerel	-	0	0.14	8	0.11	5
Lake Trout	0.39	1,093	0.54	834	0.39	1,212
Landlocked Salmon	0.50	37	0.76	244	0.41	133
Largemouth Bass	0.08	80	0.01	11	0.05	19
Rainbow Trout	0.70	186	0.62	166	0.65	344
Rock Bass	-	0	-	0	-	0
Smallmouth Bass	0.09	339	0.14	467	0.08	112
Sunfish (all species)	0.32	346	0.09	108	0.17	180
White Perch	0.90	485	0.33	38	0.68	93
White Sucker					0.50	12
Yellow Bullhead	-	0				
Yellow Perch	0.59	412	0.19	42	0.67	608
Total	**0.28**	**3,097**	**0.25**	**1,943**	**0.34**	**2,718**

FIGURE 12: ESTIMATED HARVEST RATE BY SPECIES AND YEAR

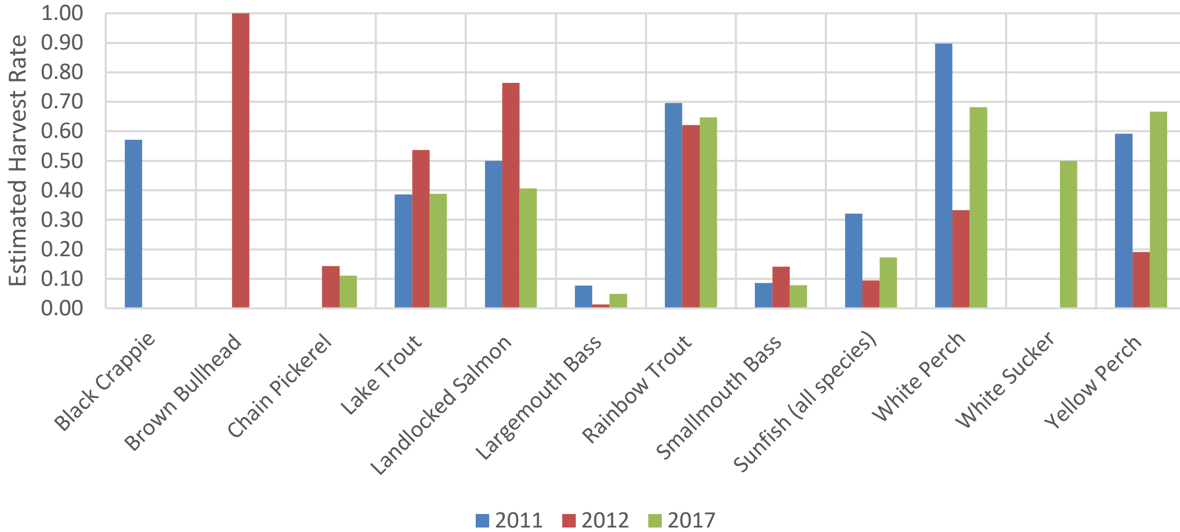
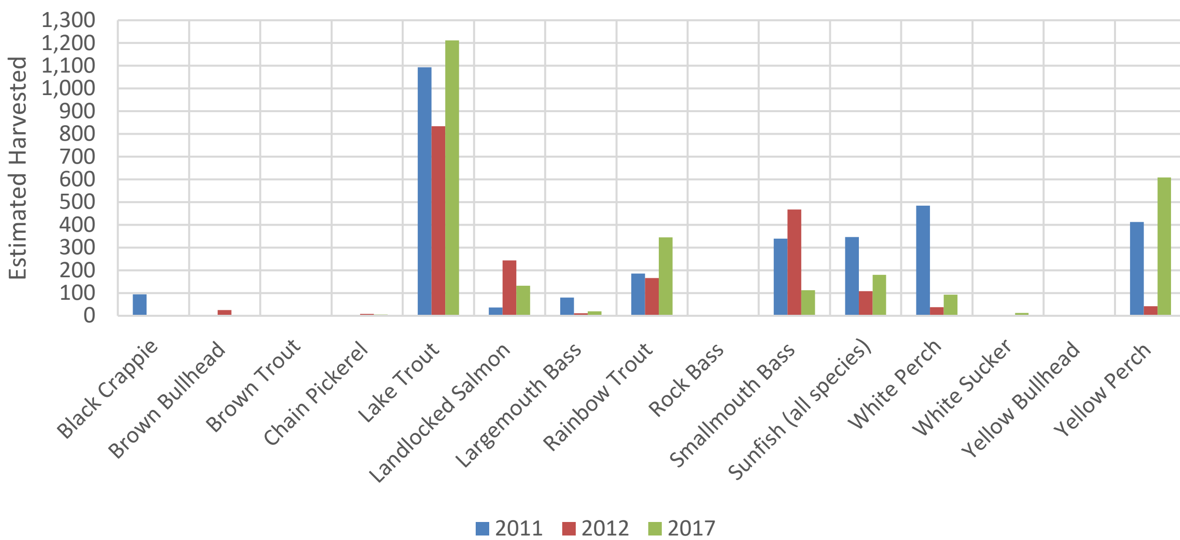


FIGURE 13: ESTIMATED NUMBER OF FISH HARVESTED BY SEASON



4.6 Harvest Rates and Yield

In 2017, the Wachusett Reservoir estimated harvest rate for all species was 0.34 fish per acre. This rate is greater than the estimated harvest rate of 0.28 fish per acre in 2011 and 0.25 in 2012.

The estimated yield and the estimated yield per acre are weight estimates of fish taken from the reservoir each survey year. The full description on how these values were calculated can be found in the 2011-2012 Wachusett Reservoir Creel Survey Report (DCR 2015). The estimated yield per acre was calculated for the two most frequently caught species; Lake Trout and Smallmouth Bass. With respect to Lake Trout, the average length of fish harvested, the estimated yield, and the estimated yield per acre were all greater in 2017 compared to recent seasons (Table 7). The average length of harvested Lake Trout was 19.5 inches in 2017, 18.5 inches in 2011 and 19.3 inches in 2012. The Lake Trout estimated yield in pounds was 2,646 in 2017; higher than 2,020 in 2011 and 1,705 in 2012 (Figure

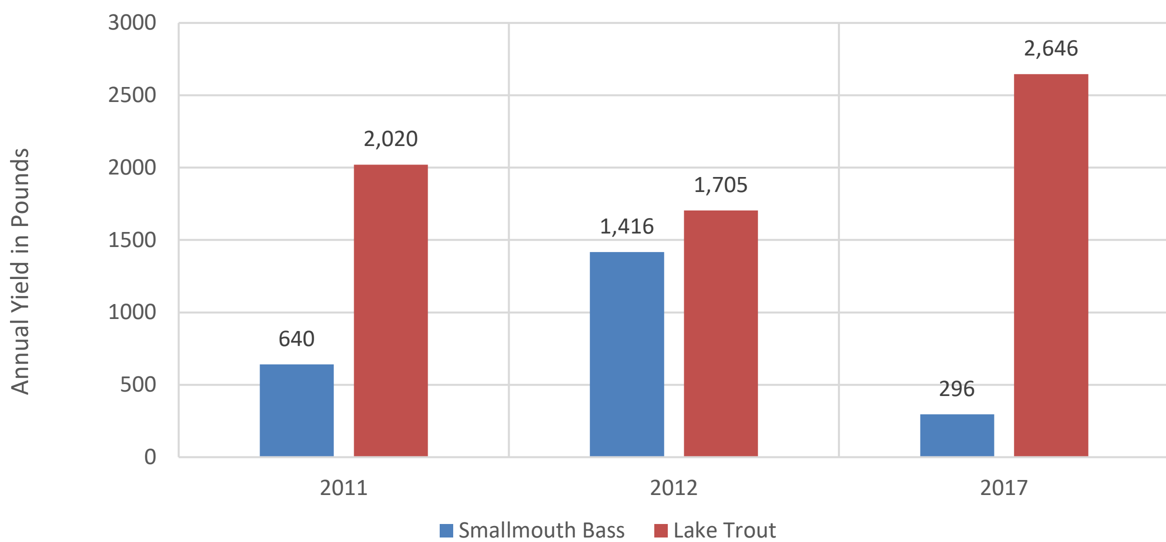
14). The estimated yield per acre for Lake Trout was 0.65 pounds per acre in 2017, higher than the figures of 0.50 and 0.42 reported in 2011 and 2012, respectively.

Smallmouth Bass followed the opposite trend, with the average length of fish harvested, the estimated yield of fish harvested, and the estimated yield per acre all lower than the 2012 season. The average length of Smallmouth Bass harvested was 16.9 inches in 2017, 15.4 inches in 2011, and 17.5 inches in 2012. The estimated yield in pounds was 296 in 2017, less than half of the 640 pounds in 2011, and only 20% of the 2012 harvest of 1,416 pounds (Figure 14). The estimated yield per acre for Smallmouth Bass was 0.07 pounds per acre in 2017, much reduced from 0.16 and 0.35 reported in 2011 and 2012.

It should not be assumed that the fishery will support the same harvest rate of Lake Trout in the future as it does at present or has in the past. The current harvest regulation for Wachusett Lake Trout is three fish of any size per day (321 CMR 4.01). In the case of Wachusett Reservoir, the shoreline access and restricted no fishing zone play a role in limiting angler exploitation of Lake Trout simply by limiting access to the fish. However, this may not be enough to prevent the yield from surpassing a sustainable level. Lake Trout regulations will be discussed later in Section 0 of this report.

FIGURE 14: ESTIMATED ANNUAL YIELD OF LAKE TROUT AND SMALLMOUTH BASS

RESULTS REPORTED IN POUNDS



5.0 COMPARISON TO HISTORICAL CREEL SURVEYS

The first survey effort for Wachusett Reservoir began in 1979 and was repeated in 1980. These surveys concentrated on interviews of anglers fishing at the reservoir throughout the fishing season and used a similar approach to recent surveys. Summary tables with the expanded results of each creel survey are available in the MassWildlife archives (MassWildlife 1979 and 1980) and are presented in Table 6. Another creel survey conducted in 1998 documented a similar number of angling trips to the survey 18 years prior but indicated more angling hours. Detailed methods for the survey design are available (MassWildlife 1998) and an expanded summary table of estimated results was calculated; however, there is no description of survey results, documentation for the number of anglers surveyed, or the methods used to analyze the data.

TABLE 6: HISTORIC ANGLER SURVEYS AT WACHUSETT RESERVOIR

DASHES INDICATE MISSING DATA

	Anglers Surveyed	Avg. Trip Length (hours)	Angling Trips	Angling Hours	Catch/Hour	Catch/Angler
1979 Creel Survey	1,761	2.1	22,029	53,989	0.41	1.00
1980 Creel Survey	1,974	2.3	26,770	63,534	0.56	1.33
1998 Creel Survey	-	-	26,907	83,144	-	-
2011 Creel Survey	1,227	3.1	16,194	45,407	0.24	0.76
2012 Creel Survey	1,334	3.5	12,581	40,266	0.20	0.60
2017 Creel Survey	1,873	3.4	13,932	44,113	0.16	0.50

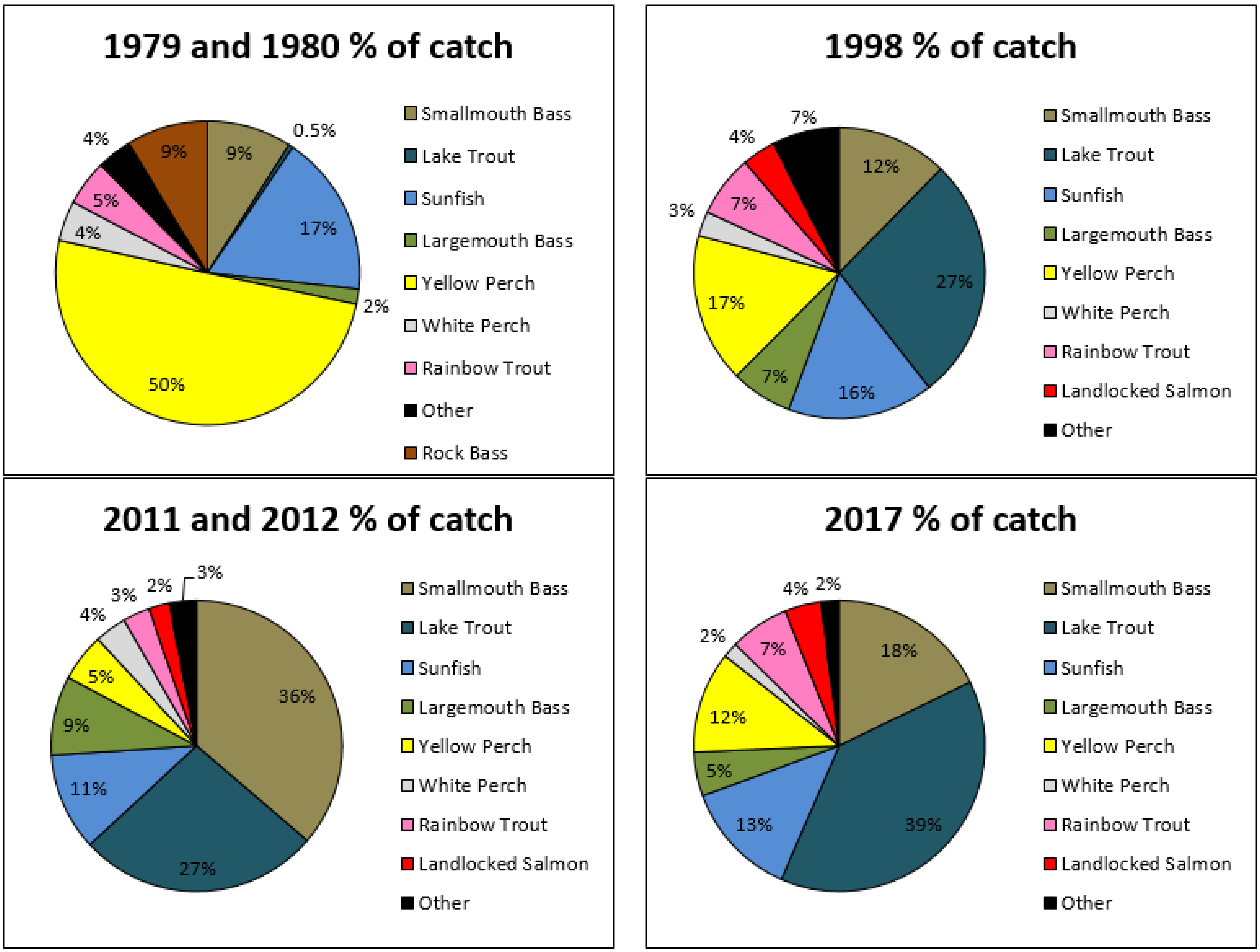
As the result of limited documentation and differences in survey design, it is difficult to directly compare the results of creel surveys conducted sporadically over the past 25 years. In general terms, it appears that there may be fewer annual angling trips now than in the past, and anglers are fishing for longer when they do fish (Table 5). Higher catch rates reported in the 1979/1980 creel surveys could be related to the types of fish that were most frequently caught; Yellow Perch and Sunfish, as opposed to the most recent creel surveys where larger game fish; Smallmouth Bass and Lake Trout, comprised most of the catch (Figure 15).

Fortunately, raw data of the actual fish caught by anglers is available for each of the historic creel surveys. Thus, the proportion of each species caught is comparable across the different surveys and provides some interesting insights into changes in the fish species caught by anglers over the past 40 years. Yellow Perch accounted for 50% of the total catch in the 1979/1980 time period, declined to 17% in 1998 and declined further to only 5% in 2011/2012 (Figure 15). The proportion of Sunfish, White Perch, Largemouth Bass, and Rainbow Trout caught has remained relatively stable. Smallmouth Bass accounted for only 9% of the total catch in 1979/1980 but increased to 12% in 1998 and accounted for 36% of the total catch in 2011/2012.

One of the goals of the 1979 and 1980 creel surveys was to determine how many Lake Trout were caught at Wachusett Reservoir. Results showed that fewer than 20 Lake Trout were caught by anglers surveyed in the entire two-year period. Since that time, this species has become the primary cold-water fish species in the reservoir and the most frequently reported catch by anglers (Figure 15). These results indicate that changes to the reservoir fish community have occurred over the past 35 years.

Creel surveys are not a random sample of the fish population because the fish caught by anglers are only the fish of a catchable size. Anglers considering certain species desirable and subsequently targeting those species increase the odds of catching them. A shift in angler behavior is evident in November of 2017, when the Yellow Perch population reached a density and size class that made it worthwhile for anglers to spend time pursuing them with rod and reel to catch and keep for bait. In other seasons the densities were too low, but the conditions in 2017 were presumably favorable for one age class to reach a catchable size of 4-5 inches by November. Most Yellow Perch (88%) caught during the 2017 season were recorded during this month, with an average length of 4.9 inches.

FIGURE 15: PERCENTAGE OF TOTAL CREEL CATCH BY SPECIES



6.0 DISCUSSION

6.1 Survey Results

Wachusett Reservoir is used primarily by anglers from Worcester County, Massachusetts; however, anglers from outside Worcester County and non-Massachusetts residents frequent the reservoir. Despite the relatively low catch rates, anglers are drawn to the fishery for the chance to catch a trophy fish in an undeveloped setting. The reservoir fishery is used primarily for recreation, as more than two thirds of the fish caught are released. Those fish that are harvested are typically consumed by the angler.

As demonstrated in previous surveys, anglers continued to be very cooperative and many were genuinely interested in the creel survey and its results. Remarkably, only two surveys could not be completed this season due to a lack of angler cooperation. The quality and scale of these angler creel surveys is possible due to the participation and 99.9% cooperation of anglers. Compliance with angling laws and watershed regulations by anglers at the reservoir also remains very high, as 98.6% of anglers encountered in the course of the survey followed applicable regulations. The Wachusett Reservoir Watershed Rangers patrol the reservoir frequently and have regular contact with anglers; this facilitates execution of the creel survey and factors into the high regulation compliance rate.

Overall, the creel survey process and effort from survey agents has been consistent from year to year. Angling effort appears relatively constant, as the total estimated angler trips and angler hours for the 2017 season fall between those recorded in the 2011 and 2012 seasons. Wachusett Reservoir is exclusively a shoreline fishery due to regulations; as a result, angler catch rates and angler effort are likely susceptible to the influence of seasonal weather conditions and water temperatures from year to year. Catch rates and angler effort may also be influenced by the difficulty associated with fishing a reservoir that does not allow boating and by the target species preferences of Wachusett Reservoir anglers. In 2011, ice out was very near to the opening day of fishing in April after an extended freeze 76 days in duration, while in 2012 the reservoir never froze. Consequently, the average water temperature for the month of April was 5.7° C in 2011, far colder than the average of 8.5° C in April of 2012. Winter leading into the 2017 season featured a brief period of ice over in February lasting only 13 days; the average water temperature in April was 5.8° C (MWRA 2017).

Seasonal variation in weather and water temperatures influence the availability of cold-water species to shore anglers. If the most desirable species, such as Lake Trout and Landlocked Salmon, are less available to shore anglers during warmer months, then both the catch rate and the angler effort could be negatively influenced; these are compounding factors that would lead to a lower total catch and yield. Presumably, anglers alter their behavior by fishing more frequently and staying for a longer period when they have experienced angling success themselves, or when they have heard positive reports from other anglers. The reverse effect is also presumably true. This is important to consider within the context of the 2017 season as increased angling effort and the increased catch of Lake Trout were concentrated in April and November: 71% of Lake Trout caught for the season were caught in those two months. While it is possible the updated survey schedule may have increased reporting of Lake Trout catch and harvest, Figure 6 demonstrates that estimated catch rates for all species remained relatively similar in 2011, 2012, and 2017.

Anglers were asked to identify their "target species" and survey agents were instructed to select one response. However, many anglers reported fishing for more than one species and the same fishing methods often do result in the catch of different species of fish. As a result, a detailed analysis of angler effort by target species is not presented. It can be generally stated that some combination of

Lake Trout and/or Smallmouth Bass are the target species for approximately 80% of anglers. Landlocked Salmon are indicated as a desired species by 14% of anglers (counting responses of “Landlocked Salmon” as well as “Lake Trout and Landlocked Salmon”) while Rainbow Trout were targeted by a maximum of 10% of anglers (counting responses of “Rainbow Trout” as well as “Trout”).

The overall annual harvest rate in 2017 of 0.34 fish per acre is higher compared to harvest rates documented in the past two surveys, which ranged from 0.25 to 0.28 fish per acre (Table 5). These rates are the effect of the relatively low overall catch rate combined with the fact that most fish caught by anglers are released. The total harvest is also limited by the fact that anglers are only able to access the fishery from the shoreline and are unable to fish a significant area around the intake. These regulations provide a refuge from angling pressure and thus play a role in the presence of large game fish and state record catches. Although the overall impact of angling on the fish community of Wachusett Reservoir is likely low, popular species, such as Lake Trout, Landlocked Salmon, and Smallmouth Bass, may be disproportionally affected.

6.2 Species Interactions

The current fisheries data for Wachusett Reservoir is not conducive to describing species interactions; however, data collected from the creel survey can be used in combination with the literature on the subject to make inferences on the interactions that occur in the reservoir ecosystem.

Focusing on Lake Trout, these fish are negatively affected by high species richness, especially in combination with high levels of angler harvest (Thill, 2014). Research shows that Smallmouth Bass (Selinger 2006, Kerr 2000, Lepak 2006, Weidel 2007), Yellow Perch, and Rock Bass (Kerr 2000, Ontario 2007) negatively impact Lake Trout abundance and population status. It is interesting to note the inverse relationship between Lake Trout and Smallmouth Bass abundance in the three most recent creel surveys (Figure 14). A reduction in the availability of forage fish following bass introductions has been shown to have adverse impacts on native top predators, including Lake Trout, which in some cases rely on littoral prey fish (Vander Zanden 2004, Lepak 2006). Lake Trout condition can be negatively affected by introduced competitors, especially bass, and may result in a diet shift from forage fish to zooplankton and other pelagic invertebrates (Thill 2014, Lepak 2006, Hammers 2018). It has been further suggested that populations within lakes lacking pelagic forage fish are most vulnerable to the impacts of bass introductions, as bass can outcompete other species in littoral feeding areas (Vander Zanden 2004, Weidel et al. 2007). In some cases, where pelagic fish such as Rainbow Smelt are present, Lake Trout condition is buffered from the negative impacts of bass (Selinger 2006, Kerr 2000). This may be the case in Wachusett Reservoir; however, the population status of Rainbow Smelt is currently unknown. Kerr (2000) highlights that the disadvantages associated with Rainbow Smelt as the primary forage fish include their extreme population fluctuations and a “pronounced post-spawn mortality.” There is evidence to support the idea that in the absence of forage fish such as alewives and smelt, Lake Trout will feed on smaller invertebrates as a primary food source, until they are large enough, and thus less gape-limited, to consume Yellow Perch (Hammers 2018).

The interaction between juvenile Yellow Perch and Rainbow Smelt in Wachusett Reservoir has not been described, but the two species are known to be fierce competitors for eggs and other juvenile fish (Kerr 2000). Historic reports for Rainbow Smelt suggest numbers are declining (Quabbin Reservoir and Wachusett Reservoir 2018), while there is evidence of a large year class of Yellow Perch in 2017 (Section 6.0). Juvenile Yellow Perch compete for zooplankton forage with Rainbow Smelt and can be outcompeted by Rainbow Smelt (Hrabik et al. 2001, Kerr 2000), however, if Rainbow Smelt have a poor year class it is possible that Yellow Perch will benefit by increasing in density. No data is available for Rainbow Smelt in Wachusett Reservoir at this time; however, it is possible that a cycle of Yellow Perch becoming the predominant forage fish in the reservoir is beginning. A decrease in alewives and smelt was observed in Keuka Lake, New York, and it was not until recently that scientists found the first evidence that Lake Trout were feeding on Yellow Perch; however, Yellow Perch were only found in the stomachs of Lake Trout greater than 350 mm (Hammers 2018). Considering that Yellow Perch are more often concentrated in the littoral zones of lakes, and bass species are better adapted to littoral zones than Lake Trout, it is possible that the rise of Yellow Perch as the primary forage fish will negatively affect Lake Trout population size and condition if they are unavailable to the entire Lake Trout population.

It is also possible that increased competition from stocked Land Locked Salmon (Section 1.0) has negatively impacted the Smallmouth Bass population in Wachusett Reservoir (Wathen 2011). Such a large year class of Yellow Perch may be related to lower predation by Smallmouth Bass, which would align with the reduced Smallmouth Bass catch for the 2017 season. The reduced Smallmouth Bass catch in 2017 may also be attributed to changing environmental conditions or changing angler preferences.

6.3 Lake Trout Life History and Yield

Lake Trout are a slow growing member of the char family that typically inhabits very cold, highly oxygenated water found within deep, oligotrophic water bodies (Thill 2014, Gunn and Pitblado 2001, cited by Stolarski 2019). They are less tolerant to increases in water temperature compared to other warm water fish species found in Wachusett Reservoir and are susceptible to high competition and species richness (Thill 2014). Lake Trout are the most popular cold-water game fish in Wachusett Reservoir, which is at the species' southernmost range (Thill 2014). There is currently limited density, growth rate, and condition data for the Lake Trout population in Wachusett Reservoir; however, a recent study investigates the age at maturity, growth rates, and condition of the Lake Trout population in nearby Quabbin Reservoir (Stolarski 2019). As Wachusett Reservoir Lake Trout data are limited, Quabbin Reservoir data will be referenced in portions of this discussion, as the two water bodies are regionally comparable.

Lake Trout in Quabbin Reservoir and nearby New York State reach sexual maturity at approximately 4-6 years and breed in October and November, when water temperatures in the epilimnion drop between 11° C and 17° C (Thill 2014, Stolarski 2019). The DWSP and MassWildlife initiated a Lake Trout tagging study at Wachusett Reservoir in 2014 to learn more about the Lake Trout population which has resulted in capture of spawning fish in water temperatures between 8-15° C. Otoliths have been extracted from incidental Lake Trout mortalities that occurred during sampling at Wachusett Reservoir, but thus far, results of otolith inspection have proved difficult to interpret, as annual cycles of growth appeared extremely inconsistent (Stolarski 2018, personal communication). DWSP staff will continue to collect otoliths from incidental Lake Trout mortalities and will investigate possible reasons for the unclear annual growth patterns. Otoliths of Lake Trout from Quabbin Reservoir were aged successfully and revealed that Lake Trout tend to mature between 4-6 years old and that the length at ages 4-6 ranges from 350 to 500 mm (Stolarski 2019).

The study at Quabbin Reservoir also demonstrated that variability in the forage base of the reservoir, which historically has been dominated by Rainbow Smelt, may affect the age at which Lake Trout reach a total length of 457 mm (18 inches) (Stolarski 2019). A similar study spanning 1997-2016 in Keuka Lake, New York demonstrated that Lake Trout did not reach 18 inches until ages 5-7 and that growth rate and condition have declined as the forage base has changed (Hammers 2018).

The study at Quabbin Reservoir revealed that on average male Lake Trout comprised 89.5% of the gillnet catch and males outnumbered females in every year samples were collected (Stolarski 2019). At Wachusett Reservoir, males comprise 63% of the Lake Trout catch over the study period. High rates of male capture may be attributed to differences in spawning behavior, a greater number of male Lake Trout in the population, and females spawning at later ages and on multi-year cycles (Hartel 2002, Stolarski 2019). Wachusett Reservoir Lake Trout likely fall within a comparable age range at first maturity to Keuka Lake, Quabbin Reservoir, and other regional lakes. However, the total length at first maturity may be less for Wachusett Reservoir Lake Trout, as the lower 25% of fish caught on the spawning grounds are between 350 mm and 500 mm (Appendix D: Additional Plots).

The current Quabbin Reservoir minimum harvest regulations are equivalent to 457 mm (18 inches), which is within this range, while there is currently no minimum length limit for harvest at Wachusett Reservoir. This lack of minimum size for legal harvest at Wachusett Reservoir and the age and size at first maturity from Wachusett Reservoir and other regional Lake Trout fisheries will be addressed in the following paragraphs.

Maximum sustainable yield (MSY) is the threshold at which naturally reproducing populations can be harvested without long-term degradation (Burr 1992, Lenker 2016). MSY is driven by variables including population size, lake size, total dissolved solids (used as a measure of productivity), population dynamics and age-class structure, species interactions, and angler pressure (Shuter 1998). Given that the MSY specific to Wachusett Reservoir has not yet been determined, the MSY values provided by similar fisheries in Maine and Ontario and population data from nearby Quabbin Reservoir will be used to inform management decisions until Wachusett Reservoir-specific data is available. The DWSP plans to continue collection of Lake Trout population data to determine the MSY of the Wachusett Reservoir population.

Studies show that many Lake Trout fisheries can only support very low harvest rates and that this species is highly vulnerable to overexploitation by anglers (Burr 1991, Burr, 2006, Thill 2014, Shuter 1998, Johnson 2001). The harvest rate and estimated yield per acre of 0.65 pounds of Lake Trout per acre documented in the 2017 creel survey is higher than the total yield of 0.50 and 0.42 pounds per acre documented in 2011 and 2012, respectively (Table 7). These harvests exceed the 0.45 pounds per acre per year 'annual harvest rate' suggested as an upper limit for heavily fished, naturally reproducing, non-stocked Lake Trout populations in Maine and the 0.45 pounds per acre 'exploitation limit' for Canadian and Laurentian Great Lake populations described by Healey in 1978 (Johnson 2001). Annual harvest rate and exploitation limit are the terms used in these sources and are considered equivalent to estimated yield per acre. All are reported in pounds per acre. The Maine management plan suggests even lower annual harvest rates of 0.25 pounds per acre, depending on the Lake Trout population age structure and growth rate. The Maine management plan and the management guidelines from the Ontario Ministry of Natural Resources, recommend estimated yield per acre of 1.0 pounds per acre and higher only in populations supplemented by stocking (Johnson 2001, Ontario 2007). Based on these studies, the DWSP suggests maintaining the estimated yield per acre for Wachusett Reservoir Lake Trout at 0.5 pounds per acre per year until enough data are collected to develop a Wachusett Reservoir Lake Trout MSY. The 2017 estimated yield per acre was greater than this recommended 0.5 pounds per acre.

A series of reports written by MassWildlife spanning 1994-2001 demonstrate that Wachusett Reservoir has historically and consistently had lower gillnet sampling catch rates of Lake Trout in comparison with the nearby Quabbin Reservoir (MassWildlife 1996, 1997, 2000, 2001). These lower catch rates are indicative of the differences in spawning habitat sampled at Quabbin Reservoir and Wachusett

Reservoir; they may also support the idea that the Wachusett Reservoir Lake Trout population may be one-third the size of the Quabbin Reservoir population or smaller (MassWildlife 2000). Further investigation, including the volume of available cold-water habitat is required to support this claim and will be considered in future reports/studies. The lower gillnet sampling catch rates at Wachusett Reservoir continue today, leading DWSP and MassWildlife biologists to investigate new possible Lake Trout spawning habitats, while also considering ways to protect the current population from decline via overexploitation.

According to the 1994-2001 reports, the Wachusett Reservoir Lake Trout daily creel limit was increased in April 1996 and the minimum size limit was eliminated, which likely resulted in the current Wachusett Reservoir regulations: a creel limit of three fish and no minimum size (MassWildlife 1996). The stated goal of this regulatory change was to prevent overpopulation; however, the data used to make this change are unclear in the available reports. Biologists at this time likely observed small or lean Lake Trout; therefore, the fishing regulations were changed to increase the harvest to reduce the population size and increase individual fish size. It is unclear whether these proposed regulations had the desired impact of preventing overpopulation because gillnetting was not conducted between 2000 and 2014.

6.4 Current and Proposed Lake Trout Regulation Changes

Based on the reports described above, the estimated harvest and estimated yields in Table 7, and the MSY derived from the literature, the DWSP is recommending a change in the current Wachusett Reservoir Lake Trout fishing regulations which are determined by MassWidlife (321 CMR 4.01). The purpose of the change is to allow recently mature Lake Trout at least one opportunity to spawn. To do so, the DWSP is recommending a change to the current Wachusett Reservoir regulation from a daily creel limit of three Lake Trout of any size, to a daily creel limit of two Lake Trout and an 18-inch minimum length limit. Quabbin Reservoir data and regional Lake Trout population data help demonstrate that Wachusett Reservoir fish less than 18 inches are likely spawning for the first time. If this regulation proposal is accepted, the estimated yield per acre could also decrease to a level at or below 0.5 pounds per acre. As discussed earlier, a reduction in the estimated yield per acre will help protect Wachusett Reservoir Lake Trout from overexploitation. Additionally, the 18-inch length limit and daily creel limit would mirror the Lake Trout fishing regulations at the Quabbin Reservoir, making regulations simpler and easier to enforce.

Under the current regulations, which do not include a minimum length, an estimated 3,139 Lake Trout were harvested from the reservoir in 2011, 2012, and 2017 combined (Table 7). The potential effects of several regulation changes were simulated using the angler reported harvest data from 2011, 2012, and, 2017. For example, harvested fish larger than 18 inches and reported in a survey with two fish or fewer were selected for analysis. Using this selection, the estimated yield was recalculated and is reported in Table 7. As an example of the impact of the proposed regulations if they were in place for previous fishing seasons, the proposed regulation could have reduced the estimated yield of Lake Trout during the 2011 and 2012 seasons to 1,531 and 1,549 pounds respectively (24% reduction in 2011 and 9% reduction in 2012). The regulations would allow other anglers the opportunity to catch those fish and allow fish under 18 inches the opportunity to spawn, potentially resulting in a more sustainable long-term harvest (Table 7) (Lenker 2016). The DWSP also considered a 20-inch length limit to further reduce estimated yield, but this was deemed too conservative and the 18-inch limit was selected (Table 7). This change in regulation would also make the Lake Trout catch and length limits consistent between Wachusett and Quabbin Reservoirs, likely increasing compliance and simplifying enforcement.

Evidence that female Lake Trout do not always spawn on consecutive years and the length at age relationship found in Quabbin Reservoir Lake Trout supports the argument for setting the Wachusett Reservoir Lake Trout minimum length limit at 18 inches (Hartel 2002, Scott and Crossman 1979 cited by Stolarski 2019). The 18-inch limit would allow for at least one spawning opportunity for Lake Trout that have just become reproductively mature. The proposed limit would likely also protect female fish from harvest under circumstances of nonconsecutive spawning years.

TABLE 7: LAKE TROUT ESTIMATED TOTAL YIELD UNDER PROPOSED REGULATIONS

No Length Limit and No Creel Limit (Current Regulations)				
Year	**Estimate Caught**	**Estimate Harvest**	**Estimate Yield (pounds)**	**Estimate Yield (pounds/acre)**
2011	2,832	1,093	2,020	0.50
2012	1,556	834	1,705	0.42
2017	3,121	1,212	2,646	0.65
Total	7,509	3,139	6,371	0.52
18-inch Length Limit and Creel Limit 2 fish per day (Proposed Regulation)				
2011	1,702	657	1,531	0.38
2012	1,339	718	1,549	0.38
2017	2,276	883	2,215	0.55
Total	5,317	2,258	5,295	0.44
20-inch Length Limit and Creel Limit 2 fish per day (For Comparison)				
2011	757	292	960	0.24
2012	636	341	968	0.24
2017	1,388	539	1,586	0.39
Total	2,781	1,167	3,514	0.29

Maintaining a level of Lake Trout harvest below the recommended MSY and estimated yield per acre is important to the DWSP because the Lake Trout is an apex predator in the reservoir ecosystem (Lepak 2006). Research has shown that apex consumers like Lake Trout and Smallmouth Bass likely play an important role in maintaining the health and balance of their respective ecosystems (Estes et al. 2011, Carpenter et al. 2001, Lepak 2006, Weidel 2007). For example, Carpenter et al. (2001) suggests that by consuming smaller planktivorous fish, such as Rainbow Smelt, apex predatory fish can indirectly protect zooplankton, which are then able to feed more heavily on phytoplankton, controlling phytoplankton densities. The data on Rainbow Smelt are currently absent, but the interaction described above between Lake Trout and forage fish is at least partially responsible for maintaining ecosystem links and the existing Wachusett Reservoir food chain.

7.0 RECOMMENDATIONS

Creel surveys are currently the most efficient method to obtain a range of fisheries data at Wachusett Reservoir, given constraints on time and resources. Continuation of these surveys is recommended and anticipated to continue at five-year intervals. Data collection methods may be adjusted and expanded to increase efficiency and data gathered; however, all surveys should be designed such that data continues to be comparable to previous years. Future creel surveys should continue to use the angler effort data collected in this survey to more closely align survey effort and angling effort. Now that the dominant patterns of angler effort have been determined, more survey effort can be concentrated on the time periods that see the heaviest angling pressure (April, May, weekends) and less survey effort can be allocated to periods with the lowest angling effort and harvest (September, October, weekdays).

Repeating the creel survey in the future at regular intervals will be useful to observe changes over time in the proportion of each species of fish caught and harvested by anglers. Much of the limitation of comparing the current survey to past surveys is due to the large time gaps in between surveys. Maintaining a regular interval of five years is recommended. The survey process can be streamlined by utilizing new applications available to the DWSP, such as ESRI's Survey123 application. This may reduce the level of surveyor training required and a large portion of the data quality control process. Additionally, alternative implementation of the creel survey may be possible using online survey methods where angler data is voluntarily entered by anglers. This data collection method could reduce staff time required to conduct the creel survey while potentially increasing the number of angler surveys. Care would be needed to ensure that an accurate count of angler effort is obtained independent of the volunteered information and that results are not biased. For example, angling trips with no fish caught would likely be underreported.

Continued study is necessary to learn more about the current population status, life history, and sustainable yield of Lake Trout and Smallmouth Bass in Wachusett Reservoir. Additional creel surveys and research are needed to explore and establish an appropriate maximum sustainable yield for this naturally reproducing Lake Trout fishery. Research will include the Lake Trout mark and recapture study, but studies involving Lake Trout otoliths, stomach contents, and condition will also be pursued as time and funding allow.

In the meantime, a conservative approach is to maintain a harvest rate and estimated total yield that does not exceed 0.5 pounds of Lake Trout per acre per year as suggested in the Maine and Ontario proposed management targets. Thus, a good starting place would be to use the information from the most recent survey to adjust the minimum length and daily limit regulations for Lake Trout at Wachusett Reservoir. The recommendation is to adopt a minimum length limit of 18 inches and daily creel limit of two fish. This regulation change would match regulations currently in place for Quabbin Reservoir.

In order to make the Wachusett Reservoir estimated yield align with the recommended MSY and estimated yield of other fisheries, data from future creel surveys and the continuation of studies, including the Lake Trout tagging study, will determine if these thresholds are adequate to maintain the desired Lake Trout population in Wachusett Reservoir. Future investigations into the primary forage species at Wachusett Reservoir will also be considered, with the goal of associating changes in the forage base with Lake Trout condition and growth rates. Finally, learning more about the range of age and length at maturity and the condition factor for Wachusett Reservoir Lake Trout would allow the minimum size limit to be adjusted in future years to protect the breeding population and safeguard future recruitment.

8.0 LITERATURE CITED

Brideau, M. 2014. Personal communication with Mark Brideau, MassWildlife Central District Fisheries Manager, January 2014.

Burr, J. 1991. Length Limit Regulations as Applied to Alaskan Lake Trout Fisheries, a Synthesis of Available Data with Recommendations. Fishery Manuscript No. 91-5. Alaska Department of Fish and Game.

Burr, J. 1992. A Summary of Abundance and Density Estimates for Selected Lake Trout Populations in the Alaska Range, and an Examination of Trends in Yield. Fishery Manuscript No. 92-1. Alaska Department of Fish and Game. http://www.sf.adfg.state.ak.us/fedaidpdfs/Fms92-01.pdf

Burr, J. 2006. AYK Lake Trout Management Plan. Fishery Management Report No. 06-52. Alaska Department of Fish and Game. http://www.sf.adfg.state.ak.us/FedAidpdfs/fmr06-52.pdf

Carpenter S.R., J.J. Cole, M.L. Pace, R. Batt, W.A. Brock, T. Cline, J. Coloso, J.R. Hodgson, J.F. Kitchell, D.A. Seekell, L. Smith, B. Weidel. 2001. Early Warnings of Regime Shifts: A Whole-Ecosystem Experiment. Science 332, 1079.

DCR. 2015. Wachusett Reservoir Creel Survey Report. Survey Years 2011 and 2012. https://www.mass.gov/files/documents/2017/09/29/wachusettcreelsurveyreport2011-2012.pdf

Holmlund, C.M., M. Hammer. 1999. Ecosystem services generated by fish populations. Ecological Economics. 29. 253-268.

MassWildlife. 1976. Wachusett ice fishing proposal. Author unknown. Document retrieved from MassWildlife files viewed March 2012 by Jamie Carr.

MassWildlife. 1979. Wachusett Reservoir – 1979 Summary of expanded creel census. Author unknown. Document retrieved from MassWildlife files viewed March 2012 by Jamie Carr.

MassWildlife. 1980. Wachusett Reservoir – 1980 Summary of expanded creel census. Author unknown. Document retrieved from MassWildlife files viewed March 2012 by Jamie Carr.

MassWildlife. 1996. Annual Report for Quabbin and Wachusett Reservoir Projects. Author unknown. Document received from MassWildlife February 2019.

MassWildlife. 1997. Annual Report for Quabbin and Wachusett Reservoir Projects. Author unknown. Document received from MassWildlife February 2019.

MassWildlife. 2000. Annual Report for Quabbin and Wachusett Reservoir Studies. Author unknown. Document received from MassWildlife February 2019.

MassWildlife. 2001. Annual Report for Quabbin and Wachusett Reservoir Studies. Author unknown. Document received from MassWildlife February 2019.

MassWildlife. 1998. Wachusett Reservoir Creel Survey – 1998 Procedures. Author unknown. Document retrieved from MassWildlife files viewed March 2012 by Jamie Carr.

MassWildlife. 2018a. Massachusetts Freshwater Fish Records. Online citation. MassWildlife website. Current as of 1/22/2018. http://www.mass.gov/eea/agencies/dfg/dfw/hunting-fishing-wildlife-watching/fishing/massachusetts-freshwater-fish-records.html

MassWildlife. 2018b. Annual Reports for Quabbin and Wachusett Reservoir Projects spanning 1994-2001. Author unknown.

Dillon P.J., B.J. Clark, L.A. Molot, H.E. Evans. 2003. Predicting the location of optimal habitat boundaries for lake trout (*Salvelinus namaycush*) in Canadian Shield lakes. Canadian Journal of Fisheries and Aquatic Sciences. 60:959-970.

Dugan H. A., S.L. Bartlett, S.M. Burke, J.P. Doubek, F.E. Krivak-Tetley, N.K. Skaff, J.C. Summers, K.J. Farrell, I.M. McCullough, A.M. Morales-Williams, D.C. Roberts, Z. Ouyang,F. Scordo, P.C. Hanson, and K.C. Weathers. 2017. Salting our freshwater lakes. Proceedings of the National Academy of Sciences of the United States of America. 114(17): 4453-4458. https://www.pnas.org/content/pnas/114/17/4453.full.pdf

Estes, J.A., J. Terbough, J.S. Brashares, M.E. Power, J. Berger, W.J Bond, S.R. Carpenter, T.E. Essington, R.D. Holt, J.B.C. Jackson, R.J. Marquis, L. Oksanen, T. Oksanen, R.T. Paine, E.K. Pikitch, W.J. Ripple, S.A. Sandin, M. Scheffer, T.W. Schoener, J.B. Shurin, A.R.E. Sinclair, M.E. Soule, R. Virtanen, D.A. Wardle. 2011. Trophic Downgrading of Planet Earth. Science 333, 301.

Hammers, B.E. 2018. Keuka Lake Salmonine Management Assessment, 2010-2016 Update. New York State Department of Environmental Conservation, Federal Aid in Sportfish Restoration, Project F-53-R, Avon, NY. 48 pp.

Hartel, K.E., D.B. Halliwell, A.E. Launer. 2002. Inland Fishes of Massachusetts.

Healey, M.C. 1978. The dynamics of exploited Lake Trout populations and implications for management. Journal of Wildlife Management. 42(2): 307-328.

Hoenig, J.M., D.S. Robson, C.M. Jones, K.H. Pollock. 1993. Scheduling Counts in the Instantaneous and Progressive Count Methods for Estimating Sportfishing Effort. North American Journal of Fisheries Management. 13:723-736.

Hrabik, T. R., M. P. Carey, and M. S. Webster. 2001. Interactions Between Young-of-the-Year Exotic Rainbow Smelt and Native Yellow Perch in a Northern Temperate Lake. Transactions of the American Fisheries Society 130:568-582.

IGFA. 2018. International Game Fish Association Records. Online citation. IGFA website. Current as of 1/22/2018. http://wrec.igfa.org/WRecordsList.aspx?lc=AllTackle&cn=Perch,%20white

Jackson, B. 2007. Potential effects of climate change on Lake Trout in Atikokan area. Ontario Ministry of Natural Resources, Climate change research note number 4. http://www.climateontario.ca/MNR_Publications/276908.pdf

Johnson, P. 2001. Lake Trout Management Plan. Maine Department of Inland Fisheries and Wildlife. http://www.maine.gov/ifw/fishing/pdfs/laketrout.pdf

Kerr S.J, R.E. Grant. 2000. Ecological Impacts of Fish Introductions: Evaluating the Risk. Fish and Wildlife Branch, Ontario Ministry of Natural Resources. Peterborough, Ontario. 473 p.

Lenker M.A., B.C. Weidel, O.P. Jensen, C.T. Solomon. 2016. Developing Recreational Harvest Regulations for an Unexploited Lake Trout Population. North American Journal of Fisheries Management. 36:385-397.

Lepak, J.M, C.E. Kraft, B.C. Weidel. 2006. Rapid food web recovery in response to removal of an apex predator. Canadian Journal of Fisheries and Aquatic Sciences. 63:569-575.

Lockwood, R. N., D. M. Benjamin, and J. R. Bence. 1999. Estimating angling effort and catch from Michigan roving and access site angler survey data. State of Michigan Department of Natural Resources. http://www.michigandnr.com/publications/pdfs/ifr/ifrlibra/research/reports/2044rr.pdf

MWRA. 2017. Massachusetts Water Resources Authority. Operations Management Monitoring System, Wachusett Reservoir data online retrieval.

Ontario. 2007. Regulatory Guidelines for Managing the Lake Trout Recreational Fishery in Ontario. Fisheries Section, Ontario Ministry of Natural Resources.

Plumb, J.M. 2006. Climate-Mediated changes in habitat use by Lake Trout (*Salvelinus namaycush*). University of Manitoba, Winnipeg Master's Thesis. http://www.utm.utoronto.ca/~collinsn/481_399/John%20Plumb%20Thesis06-%20Final.pdf

Selinger, W. 2006. The Status of Lake Trout populations in Northeast Ontario (2000-2005). Ontario Cooperative Freshwater Ecology Unit.

Shuter, B.J., M.L. Jones, R.M. Korver, N.P. Lester. 1998. A general, life history-based model for regional management of fish stocks: the inland lake trout (*Salvelinus namaycush*) fisheries of Ontario. Canadian Journal of Fisheries and Aquatic Sciences. 55:2161-2177.

Simmons, K. 2018. Personal communication with Ken Simmons, MassWildlife Chief of Hatcheries, October 2018.

Stolarski, J. 2018. Personal communication with Jason Stolarski, MassWildlife Aquatic Biologist, November 2018.

Stolarski, J. Unpublished. Observations on the Growth, Condition, and Ecology of Lake Trout in Quabbin Reservoir, Massachusetts.

Thill, M. 2014. Lake Trout and Climate Change in the Adirondacks. Survey report for the Adirondack Chapter of The Nature Conservancy.

Vander Zanden, M.J., K.A. Wilson, J.M. Casselman, N.D. Yan. 2004. Species introductions and their impacts in North American Shield lakes. Boreal Shield Watersheds: Lake Trout Ecosystems in a Changing Environment. 13:239-263.

Vanni M.J., C.D. Layne, S.E. Arnott. 1997. "Top-Down" Trophic Interactions in Lakes: Effects of Fish on Nutrient Dynamics. Ecology. 78(1):1-20.

Vanni M.J., C.D. Layne. 1997. Nutrient Recycling and Herbivory as Mechanisms in the "Top-Down" Effect of Fish on Algae in Lakes. Ecology 78(1):21-40.

Wathen, G., S.M Coghlan, J.G. Trial. 2011. Habitat Selection and Overlap of Atlantic Salmon and Smallmouth Bass Juveniles in Nursery Streams. American Fisheries Society. 140(5): 1145-1157.

Weidel, B.C., D.C. Josephson, C.E. Kraft. 2007. Littoral Fish Community Response to Smallmouth Bass Removal from an Adirondack Lake. Transactions of the American Fisheries Society. 136:778-789.

Appendix A: Creel Survey Form (Front and Back)

Wachusett Reservoir 2017 Creel Survey Form

Time started fishing:_______ AM/PM Interview Time:________ AM/PM Fishing trip completed? Y /N

 # anglers in party:___ # lines in water:___ Primary Fishing Type: Baitfish/Bait /Lures /Flies/ Bait and Lures

Target species (*choose one*):__________________ Surveyed before in 2017? Y /N Home zip code(s)? _________

Please list the fish species caught, their length, and whether kept or released:

	Fish Species	Length (inches)	
1			Kept / Released
2			Kept / Released
3			Kept / Released
4			Kept / Released
5			Kept / Released
6			Kept / Released
7			Kept / Released
8			Kept / Released
9			Kept / Released
10			Kept / Released

If fish were kept, do you plan to eat the fish that you kept? Y /N

Prevent aquatic hitchhikers! Don't dump bait buckets!

Date: __________ Day of the week: MO TU WE TH FR SA SU Location: ________________________________

Survey #: 2500 Survey agent: _______________________

MA DCR and MA Fish and Wildlife are cooperating on a creel survey to learn more about the fish in the Wachusett Reservoir. Do you mind answering a few quick questions about your fishing today?

Game Fish likely to be found in the Wachusett Reservoir:

Brown Trout (BT)
Rainbow Trout (RT)
Lake Trout (LT)
Brook Trout (BkT)
Landlocked Salmon (LLS)
Largemouth Bass (LMB)
Smallmouth Bass (SMB)
Yellow Perch (YP)
White Perch (WP)
Chain Pickerel (CP)
Rock Bass (RB)
Black Crappie (Calico Bass) (BC)
Brown Bullhead (BB)
Yellow Bullhead (YB)
Catfish/horned pout
Pumpkinseed Sunfish (PS)
Bluegill Sunfish (BG)
Sunfish

	Fish Species (cont'd)	Length (inches)	
11			Kept / Released
12			Kept / Released
13			Kept / Released
14			Kept / Released
15			Kept / Released
16			Kept / Released
17			Kept / Released
18			Kept / Released
19			Kept / Released
20			Kept / Released
21			Kept / Released
22			Kept / Released
23			Kept / Released
24			Kept / Released
25			Kept / Released

Survey Notes: ____

Appendix B: Wachusett Reservoir Creel Survey Form Explanation of Fields

Time started fishing:_______ AM/PM The time the angler or party started fishing.

Interview Time:________ AM/PM The time the creel survey interview is conducted. The interview time needs to be at least 30 minutes after the time started fishing for the survey to be valid. If the fishing time is less than 30 minutes, do not fill out the survey. You could come back to that fisherman at a later time. If you are coming back to an angler you surveyed earlier in the day who is still fishing, you can update the interview time, update any new fish caught since the last survey, and leave the rest of the survey the same.

Fishing trip completed? Y /N It is important to get completed fishing trips in order to get an estimate of the average length of time that trips last to make total fishing time estimates at the end of the year. You can survey anglers who are walking out, or arriving at their vehicles after a fishing trip. These surveys will be helpful to capture completed fishing trips.

 # anglers in party:___ This can allow multiple anglers to be included in one survey. However, if anglers started fishing at different times, or are using different fishing methods, a separate survey needs to be completed for that angler.

 # lines in water:___ This would be the total number of lines in the water for the angler or party the survey covers. It is legal for each angler to have up to two lines in the water at one time.

Primary Fishing Type: Baitfish/Bait /Lures /Flies/ Bait and Lures Baitfish includes live or dead fish. Bait includes worms, nightcrawlers, dough, corn, in general anything natural that can be put on a bare hook to catch fish. A lure is something artificial, usually made of wood, plastic, or metal. A rubber or plastic worm is considered a lure. Flies should represent people fly fishing with a fly rod and fly line using an artificial "fly", however if they are doing something odd and have a fly rod and are using bait then it should be counted as "bait". If they use two different types of fishing during one trip, ask for the one they spent the most time using. Bait and lures can be circled if their method of fishing is two methods at once- i.e. a shiner cast out to sit while casting with a lure on a second rod.

Target species (choose one):__________ This is the primary fish species that that person is trying to catch on that fishing trip. If they use two different types of fishing to target different species, ask for the one they spent the most time using. If there is confusion about what fish name the angler uses please use the freshwater fish of MA pamphlet to point to a picture or agree upon an accepted name for that species. Please try to be as specific, i.e. record "Largemouth bass" and not "bass."

Surveyed before in 2012? Y /N

Home zip code? ______ The home zip code for each angler surveyed, including one for each angler in a group.

Prevent aquatic hitchhikers Don't dump bait buckets Just a reminder to the survey agent to remind or educate anglers about preventing the spread of aquatic invasive species.

Date: __________

Day of the week: MO TU WE TH FR SA SU

Location: __________________________________ Please describe the general location where the survey took place or the person has fished, as appropriate. Sample descriptions might include: "Greenhalge Point", “Rainbow Cove”, “RR trestle in Oakdale Basin”, “Old Stone Church”, “near Gate 17 in South Basin”, or “ shore east of Gates Cove”. <u>Anyone fishing the Lilly ponds is not considered to be fishing the reservoir and should not be surveyed.</u>

Survey #: 124 This will be a unique number for each survey automatically filled in for each survey when it is printed out.

Survey agent: _______________________ The person who is completing the creel survey.

Please list the fish species you have caught today, their length, and whether kept or released: The goal of this question/chart is to record information to represent each fish caught by the angler or anglers on the day of the survey and the approximate length in inches of each fish. “Caught” means they brought the fish in to

shore and released it. If there is confusion about what fish name the angler uses please use the freshwater fish of MA pamphlet to point to a picture or agree upon an accepted name for that species. If the angler says “

I’ve caught 4 smallies that were 7-10 inches, I let them all go” Then write down Smallmouth Bass for lines 1-4, and tell him “Ok, I’m going to write down one 7 inch fish, one 8 inch, one 9 inch, and one 10 inch fish. Does that sound about right?” Also, if an angler gives length estimates for fish that are kept and are easily visible, use your own size estimate as opposed to the angler size estimate if there is a disparity. If the best you can get is something general like “catfish” then that is what will have to be recorded.

	Fish Species	Length (inches)	
1			Kept / Released
2			Kept / Released
3			Kept / Released
4			Kept / Released

If fish were kept, do you plan to eat the fish that you kept? Y /N

Survey Notes: This section is for any additional notes the creel survey agent may have that make that survey unique, or adds additional information that may be useful.

Other survey issues:

Language Barrier: If the survey is attempted but cannot be completed due to a language barrier, then note information such as the number of anglers and lines and complete as much of the survey as possible. Make a note in the survey notes section that some/all fields could not be completed due to a language barrier.

Appendix C: Creel Survey Agent Sheet

Wachusett Reservoir Creel Survey Agent Sheet

This form should be completed by each survey agent for each survey loop around the reservoir.

Survey agent:______________________ Date: __________ Day of the week: MO TU WE TH FR SA SU

Reservoir Loop started looking/surveying at: _______ AM/PM Finished: _______ AM/PM

Weather ________________________ Loop Direction: Clockwise/Counterclockwise/Two Ranger split

Were there any areas of the reservoir open to fishing that you did not cover? Y /N
If so, where? ____

How many anglers did you survey? ___________________

How many anglers did you see? ______________________ Loop: #

Reasons Anglers Not Surveyed	Count
I saw them fishing but they were not there when I reached their location	
I saw them fishing but I did not go to their location	
The angler would not cooperate with the survey	
They had been fishing for less than 1 hour	
Fishing Illegally/Violation of DCR rules	
There were too many anglers to survey every one	

Notes: ____

____

Appendix D: Additional Plots

The estimated yield reported in section 4.6 was recalculated for the 2011 and 2012 survey years based on results of fish sampling in the reservoir conducted during 2014-2017. This is an improvement over previous estimates because no length or weight information were available for Smallmouth Bass and only a limited number of Lake Trout measurements were available at the time of the 2015 report.

FIGURE 16: WACHUSETT RESERVOIR LAKE TROUT LENGTH AND WEIGHT

THESE DATA ARE THE RESULT OF THE WACHUSETT LAKE TROUT TAGGING PROGRAM WHICH BEGAN IN 2014. POINTS ARE INDIVIDUAL FISH.

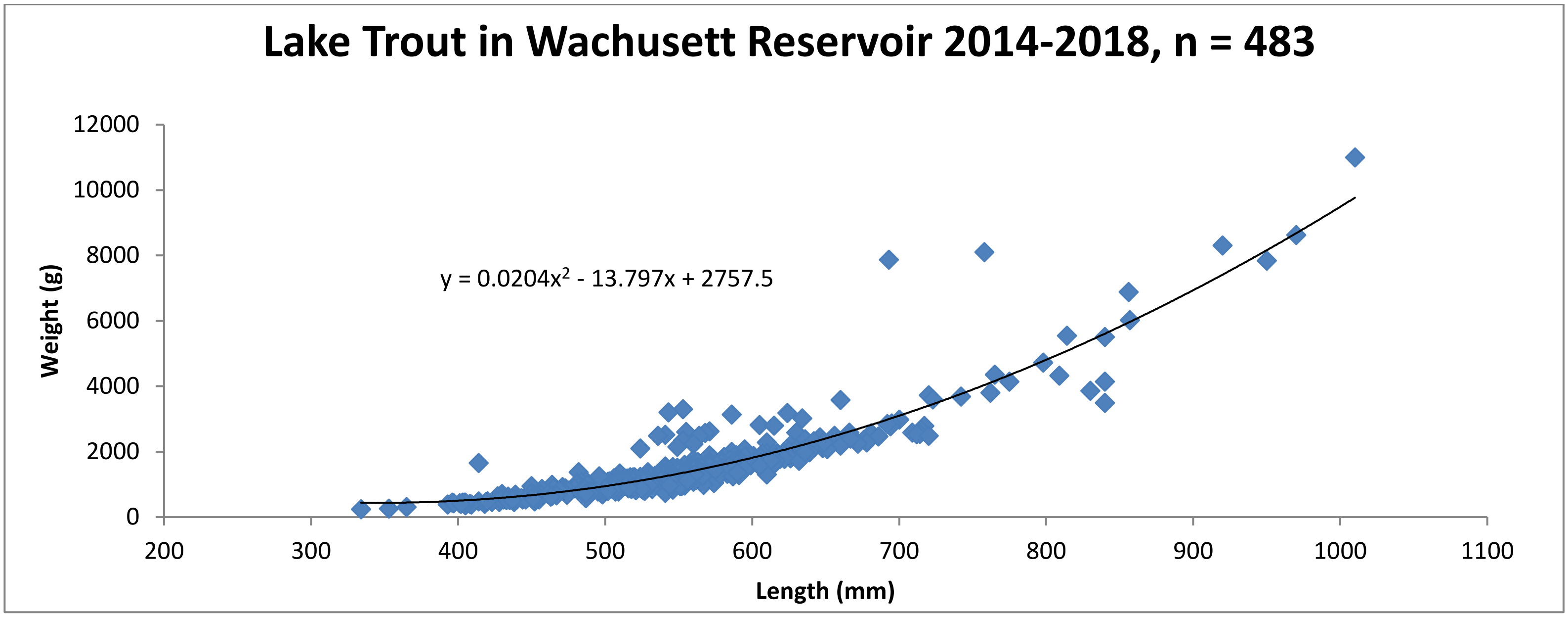


FIGURE 17: WACHUSETT RESERVOIR SMALLMOUTH BASS LENGTH AND WEIGHT

THESE DATA ARE THE RESULT OF THE WACHUSETT LAKE TROUT TAGGING PROGRAM WHICH BEGAN IN 2014. POINTS ARE INDIVIDUAL FISH. SMALLMOUTH BASS ARE CONSIDERED BYCATCH DURING SAMPLING. THEY HAVE BEEN REPORTED HERE DUE TO THEIR POPULARITY AS A GAME SPECIES.

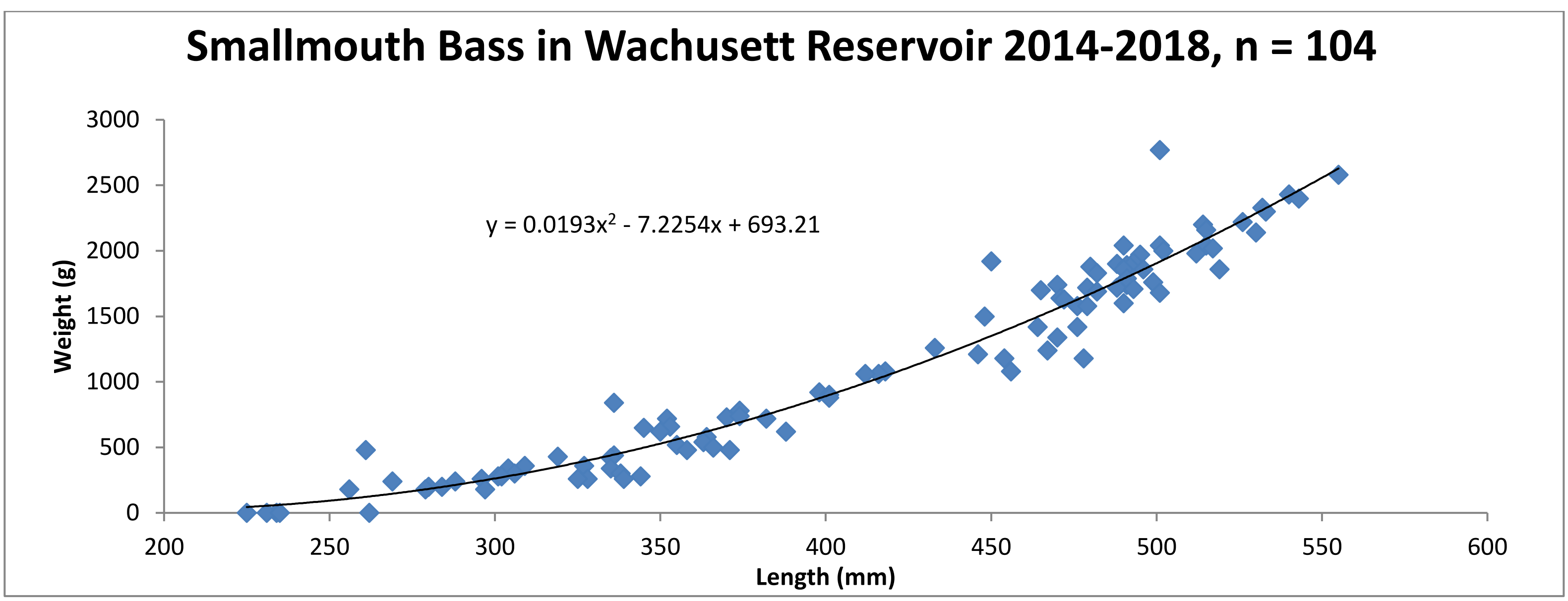


FIGURE 18: HISTOGRAM OF WACHUSETT LAKE TROUT LENGTH FROM MARK AND RECAPTURE STUDY
HISTOGRAM SHOWS FREQUENCY OF INDIVIDUAL FISH AT RESPECTIVE TOTAL LENGTH. BLACK REPRESENTS QUANTILE 1, GRAY REPRESENTS QUANTILE 2, AND WHITE IS QUANTILE 3.