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The response of a native brook trout (*Salvelinus fontinalis*) population to the removal of competing species in Little Moxie Pond

By

Timothy C. Obrey[1]

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[1] Maine Department of Inland Fisheries and Wildlife, Greenville, ME

Job F-011
Final Report No. 1

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Abstract

A study was conducted on Little Moxie Pond in Somerset Co., Maine to determine the effects of competition removal on the native brook trout population. Fall trapnetting was a very effective method to remove the majority of the white sucker population in each year of netting. Brook trout abundance and growth improved after two years of the removal of white suckers. The effects were still apparent five years after the competition removal had ceased. This study indicates that short-term, low effort removal of white suckers can have longer-term, but not permanent, benefits for native or wild brook trout in small homothermous headwater ponds.

KEY WORDS:BKT,WHS,AGE & GROWTH,COMPETITION,POPULATION STUDY

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Summary

Little Moxie Pond has been the subject of intense research over the past 19 years. The original objective of evaluating Little Moxie Pond in 1994 was for a comparative study of brook trout ponds with various regulations and access. The project was continued, however, when early results indicated that the removal of competing species was having a very positive impact on the native brook trout population and fishery. Therefore, the annual trapnetting and competition removal continued. The objective of this modified study was to determine the short and long term effects of white sucker removal on this native brook trout population.

Little Moxie Pond is a small homothermous pond located in northwestern Maine. It has a native population of brook trout. White suckers (*Catostomus commersoni*), creek chubs (*Semotilus atromaculatus*), and golden shiners (*Notemigonus crysoleucas*) are also present in varying densities. Little Moxie Pond was trapnetted annually in the fall from 1994-2001 and then again in 2006 and 2013 to determine the longevity of impacts. Annual population estimates were calculated for brook trout. All other species were removed from the pond. Annual pre-netting population estimates for white suckers were calculated from catch data.

The total number of brook trout greater than 4 inches ranged from 45 to 1,419 fish over the study period. The brook trout population declined in 2000 and 2001 to levels below 1994 and 1995 due to drought conditions. Total biomass of brook trout increased from 1.2 lbs/acre in the first 2 years of the study to a high of 6.4 lbs/acre in the third year. The number of larger brook trout also increased in the third year of the study. Over 18,000 white suckers were removed from Little Moxie Pond in 1994 and 1995. The total biomass of non-trout species removed was 3,622 lbs or 49.6 lbs/acre for the first two years of the project. After this initial removal, the total number of white suckers removed in any single year ranged from 25 to 300 fish from 1996 to 2006. All brook trout age classes showed improved growth after 2 years of competition removal. However after seven years with no removal, the white sucker population was much more abundant. Over 4,400 white suckers were captured and removed in the fall of 2013 and the mean length declined for age 2 and 3 brook trout.

The brook trout population responded dramatically to the removal of competing species. Brook trout density and growth rates improved after two years of removal. Trapnets were very efficient at capturing high percentages of the white sucker standing crop. The effects of the study were still apparent in 2006, despite a suspension of white sucker removal five years prior in 2001. However, with only one season of removal between 2001 and 2013 the white sucker population had become re-established at a level that caused a decline in brook trout growth and abundance compared to non-drought years.

Introduction

Chemical reclamation as a method of restoring or enhancing native or wild brook trout ponds is not always practical. In most cases, it is desirable to maintain the genetic integrity of the local self-sustaining brook trout population. Brood stock can be collected and transferred to a hatchery facility while chemical reclamation is conducted, but hatchery space if often limited and there is concern about the possible introduction of disease to the hatchery. Mechanical reclamation can be an option on these waters, where important species can be selected to remain in the pond, while undesirable species can be manually removed. However, this technique can be labor-intensive and the results are seldom permanent.

Little Moxie Pond has been the subject of intense research over the past 19 years. The original objective of evaluating Little Moxie Pond in 1994 was for a comparative study of brook trout ponds with various regulations and access. The project was continued, however, when early results indicated that the removal of competing species, primarily white suckers, was having a very positive impact on the native brook trout population and fishery. Therefore, the annual trapnetting and competition removal continued. The objective of this modified study was to determine the short and long term effects of white sucker removal on this native brook trout population. Data have been presented in several Interim Reports over the study period (Bonney 1998; Obrey 1999; Obrey 2002). The purpose of this report is to summarize the trapnetting data and results from this individual water into one document.

Study Area

Little Moxie Pond is a 73-acre headwater pond located in the Upper Piscataquis River drainage in East Moxie Twp, Somerset County, Maine. It is a homothermous pond with a mean depth of 5 feet and a maximum depth of 9 feet. Daily mean temperatures on the surface have exceeded 25^{o}C, the lethal limit for brook trout (Flick, 1991). One small tributary on the southwest shore contains a limited amount of brook trout spawning habitat. The majority of brook trout spawning occurs on gravelly areas along the shoreline of the pond. The outlet of the pond is very small and blocked with debris, including remnants of beaver activity. Fish passage can occur during periods of high water.

The forest surrounding the pond is typical northern Maine commercial timberlands with mixed hardwood and softwood stands. The area is relatively remote with little private camp development. Anglers can access the pond via a network of 2-wheel drive roads maintained for commercial forest management. An access trail and carry-in site were recently created through a cooperative effort between the Maine Department of Inland Fisheries and Wildlife and the landowner, International Paper, Inc. There are also two small private camps on the pond. The pond has had a variety of brook trout fishing regulations over the period of the study. Prior to 1996, Little Moxie Pond had a 10-inch minimum length limit and a daily bag limit of 5 fish. There were no gear restrictions. In 1996, as a result of the improvements in the brook trout population, a 2-fish bag limit was adopted with a minimum length of 10 inches and only one could exceed 12 inches. Gear was restricted to artificial lures only. This regulation was changed again in 1998 in an effort to maintain the quality fishery that had developed, which resulted in an increase in angler use. The pond has been managed with a 2-fish bag limit and a minimum length of 12 inches and only one may exceed 14 inches since 1998. Gear is restricted to artificial lures only. The pond is open to fishing from April 1st to September 30th; however, ice-out typically occurs in early May. Little Moxie Pond has never been open to ice fishing.

Methods

Trapnetting occurred after the conclusion of the open water fishing season. Sampling ranged from 4 to 13 consecutive days to reach the objective of a brook trout population estimate with a confidence interval of $\pm$ 20% ($p<0.05$). Population estimates of brook trout greater than 4 inches were calculated using Schnabel's method (Ricker, 1975). Fish smaller than 4 inches were eliminated from the estimate because these brook trout were typically young-of-the-year that were not totally vulnerable to trapnetting. Population estimates by inch class were calculated; these ratios were then applied to the total population estimate to determine size class strength. Mean weights by inch class were also applied to these estimates to determine brook trout biomass. Up to five fyke nets were used during the annual netting. From 1994-2001, the fyke nets were Johnson Pond style hoop nets with 3/8 inch stretch mesh. In 2006 and 2013, Maine Trout Trapnets were used. These nets are constructed of 3/8 inch or 1/4 inch stretch mesh, but do not contain any metal frames. All brook trout, except recaptures, were measured and weighed. Sex was determined by observation of secondary characteristics. A subsample of scales was taken to determine age composition and growth. A top caudal clip was applied to identify recaptures.

All non-trout species were weighed and removed and, in most cases, directly counted. A subsample of each species was measured to determine average size and to estimate total number removed when fish were not completed enumerated. Pre-sampling population estimates of white suckers were based on accumulated catches and catch per net-hour using Leslie's method (Ricker, 1975). This is the preferred method when CPUE varies over the study period. Upper and lower confidence limits were calculated using the following formula from Brower et al., (1990):

$$\bar{X} + b\ (Y - \bar{Y})/c\ \pm \sqrt{S^2 * \left(\underline{(Y - \bar{Y})^2} / SS_x + c\,(1 + 1/n) \right)}$$

In 1994, these non-target fish were moved to an off-site location. After 1994, the fish were placed in an area where the nutrients from decomposition would drain into the pond.

Surface water temperatures were recorded on dates of angler counts and during trapnetting in 1994 and 1995. A Stowaway recording thermometer was placed in the pond from May to October in 1998, 2000, and 2001.

Results

Fall Trapnetting

Post-season population estimates for brook trout are presented in Table 1. The total number of brook trout greater than 4 inches ranged from 45 to 1,419 fish over the study period. The brook trout population declined in 2000 and 2001 to levels below those estimated in 1994 and 1995.

Total biomass of brook trout increased from 1.2 lbs/acre in the first 2 years of the study to a high of 6.4 lbs/acre in the third year. The number of larger brook trout also increased in the third year of the study. There were an estimated 4 brook trout greater than 12 inches in 1994 and none were greater than 16 inches. By 1996, an estimated 228 fish exceeded 12 inches and 9 fish were greater than 16 inches. The number of age 1+ fish in the pond averaged 422 for the first two years of the project and increased to an average of 742 in years 3 and 4. Population estimates by age class are presented in Table 2. In 2000 and 2001 the population was in decline. In 2001, an estimated 45 brook trout were present in Little Moxie Pond after the open-water fishing season. No sampling occurred until the fall of 2006. The population estimate of brook trout had increased to 1079 fish. However, by 2013, with no additional sampling or competition removal, the brook trout population had declined to 598 fish.

Growth also improved after inception of the study. Mean lengths at age are presented in Table 3. All age classes showed improved growth after 2 years of competition removal. Tables 4-7 show the results of Tukey's multiple comparison tests for mean length at age over the study period. Age 1+ brook trout in 1996 to 1999 were significantly larger than in 1994 and 1995. Sample sizes of age 1+ brook trout were too small in 2000 and 2001 to detect any differences. However, by 2006, the average length of age 1+ brook trout had decreased and although it was significantly different from 1995, it was not significantly different from the first year of the study. Age 2+ brook trout showed significant increases in growth after the second year of competition removal. The mean lengths of age 2+ brook trout were significantly larger in all subsequent years up to 2013, except 2001 when sample sizes were very small. By 2013, the mean length had declined to 9.8 inches compared to the peak in 1996 of 11.4 inches. This was a significant decline. Mean length for age 3+ fish improved from 11.9 inches in the first year of removal to 13.5 inches, 14.3 inches, and 14.9 inches in years 2, 3, and 4 of the study, respectively. These were significantly larger than the first year. Mean lengths declined in the following years.

Over 18,000 white suckers were removed from Little Moxie Pond in 1994 and 1995. Creek chubs and golden shiners were also removed, but they were far less abundant (Table 8). The total biomass of non-trout species removed was 3,622 lbs or 49.6 lbs/acre for the first 2 years of the project. From 1996 to 2006, the total number of white suckers removed in any single year ranged from 25 to 300 fish. The total biomass of non-trout species removed in years 1996 to 2001 was 570 lbs or 7.8 lbs/acre. In 2006, five years since the previous sampling event, 258 white suckers weighing 232 lbs were removed. An additional 14 lbs of creek chubs and golden shiners were also removed for a combined weight of 246 lbs or 3.4 lbs/acre. No sampling or removal occurred until the fall of 2013. In October 2013, we removed 4,411 white suckers for a total of 1,120 lbs. We also removed another 17 lbs of other minnow species. Therefore, we were able to remove 15.6 lbs/ac of competing species.

Leslie population estimates and their associated confidence limits ($p=0.05$) indicate that trapnetting effectively captured white suckers. In 1994, the sucker population was estimated to be between 8,182 and 13,481 fish, and 11,003 were captured and removed. This represents a removal of between 82% and 100% of the population that was vulnerable to trapnetting. Pre-sampling population estimates, removal rates, sampling effort, and R^2 values for the regression line (accumulated catch vs. CPUE) are given in Table 9. By 1996, the third year of removal, the white sucker population was estimated to be between 72 and 648 fish.

Temperature Data

Surface water temperatures are presented in Figures 1-4. In 1994 and 1995, water temperatures were taken at the time of the angler counts. After 1998, recording thermometers were placed in the pond. There was a drought in the summer of 1995 and water temperatures exceeded 25^{o}C on 14 days from late June to mid August. The water level in the pond was very low during this time, resulting in stress and higher than normal mortality rates. Unpublished trapnetting results from Brown Pond, a similar brook trout pond in the area, also indicate higher mortalities in 1995. Before the thermometer failed in mid-June of 1999, it had already recorded temperatures in excess of 25°c for 13 days, including a period of 7 days in a row. Similarly, in August 2001, thirteen consecutive days with a high temperature in excess of 25°C were recorded. A recording thermometer was set in the summer of 2006; however, it was never recovered.

Discussion

The removal of competing species, especially white suckers, greatly enhanced the native brook trout population in Little Moxie Pond for 10 years. The estimated biomass (Figures 5 & 6) and population of brook trout (Table 1) increased after only 2 years of removal. Recruitment to age 1+ improved dramatically in the 3rd year of study from an average of 305 fish in the first two years to 887 fish in 1996. This correlates with other studies including Tremblay and Magnan (1991) and Magnan (1988), which demonstrated white suckers compete for food and habitat resulting in a reduction of brook trout density and growth rate. Venne and Magnan (1995) found that young-of-the-year brook trout were far less abundant in lakes containing white suckers than those without. Brodeur et al.(2001) documented an increase in catch per unit effort for age 1+ brook trout in 3 of 5 oligotrophic temperate lakes after 3 years of white sucker removal. Brodeur's study waters were larger and deeper than Little Moxie Pond and therefore he was not able to remove white suckers at the same level of efficiency. The total biomass removed in his 5 waters during the first 2 years of study ranged from a total of 10.4 lbs/acre to 21.3 lbs/acre, compared to 49.6 lbs/acre at Little Moxie Pond.

Growth improved across all age classes as a result of the reduction in competition from white suckers. Mean lengths increased significantly after the 2^{nd} year of removal for ages 1+, 2+, and 3+. This improvement in growth combined with improved survival created a noteworthy improvement in the quality of the fishery. Obrey (2002) documented the increase in fishing pressure as anglers targeted the quality fishery that developed in Little Moxie Pond. However, severe drought conditions in the latter years of the study reduced the brook trout abundance to extremely low levels in 2000 and 2001. In 2001, an estimated 45 brook trout were present in Little Moxie Pond at the close of the open-water fishing season. However, the population recovered quickly with no regulation changes. In 2006, the brook trout population had rebounded to an estimated 1,079 fish.

All trapnetting was completed in a maximum of two weeks at Little Moxie Pond using 3 to 5 trapnets. Total effort for the first 2 years ranged from 13.1 to 14.4 net-hours/acre (Table 9). An estimated 87%- 100% of the white sucker standing crop was removed in these 2 initial years.

Annual sampling and removal continued from 1996 to 2001 and the white sucker population estimates never exceeded 3% of the 1994 and 1995 estimates. Trapnetting ceased in 2001 after drought conditions caused the brook trout population to decline severely. This also provided an opportunity to evaluate longer term results from the removal of competing species. Five years later we documented a slight increase in white sucker abundance This indicates that short-term, low effort removal of white suckers can have longer-term benefits for native or wild brook trout in small homothermous headwater ponds. However, the effects were not permanent. In 2013, with no further sampling, the white sucker population had increased to its highest level since 1995. The increased number of white suckers is likely the cause of the decline in growth and abundance of brook trout also observed in 2013.

1. Recommendations

1. More frequent competition removal will be required to maintain the improvements documented in the native brook trout population and resulting fishery. A second consecutive year of removal should be conducted in 2014. Removal should occur every 5^{th} and 6^{th} year afterwards assuming there is sufficient staff time.
2. Develop a list of similar waters where competition removal will benefit native and wild brook trout populations and fisheries.
3. Regions should prioritize these types of projects with on-going fieldwork. Alternative staffing might be used in some cases.
4. The Department should consider a reclamation program to enhance native and wild brook trout populations. We could construct separate holding facilities at an existing hatchery or perhaps contract with a private hatchery to hold immature and adult native brook trout captured with trapnets in the early fall. The gametes of adult fish can be stripped in the hatchery as the adults become ripe. The pond can be chemically reclaimed in the late fall to permanently remove competing species. The original fish and resulting fry can be reintroduced the following spring. The overall winter holding capacity needed would likely be just a few thousand fish since reclamations would be limited to waters less than 200 acres. Funding could come from a number of sources including the EBTJV. Recently the legislature passed LD 213 which provided the Department with additional funds to increase stocking. The legislature has also recognized the importance of protecting wild and native brook trout populations in Maine. The Department could request future funding and use it for this purpose and to provide a match for federal

dollars and other grants. In years where the additional infrastructure is not needed to hold native or wild brook trout, it could be used to fulfill other Department objectives.

Acknowledgements

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Table 1. Post–season brook trout population and biomass estimates from Little Moxie Pond.

Year	Total Estimate (>4 in)	Total lbs	Lbs/acre	Number/acre	Number > 10 in	Number > 12 in	Number >16 in
1994	671	89	1.2	9.2	34	4	0
1995	416	89	1.2	5.7	86	40	1
1996	1343	470	6.4	18.4	431	228	9
1997	888	233	3.2	12.2	216	69	3
1998	1419	444	6.1	19.4	765	166	0
1999	893	245	3.4	12.2	344	42	0
2000	363	208	2.8	5.0	284	100	0
2001	45	26	0.4	0.6	41	14	0
2006	1079	199	2.7	14.8	211	80	2
2013	596	157	2.2	8.2	168	27	0

Table 2. Brook trout post-season population estimates by age class from Little Moxie Pond.

Year	Age 1+	Age 2+	Age 3+	Age 4+
1994	376	287	6	2
1995	234	148	33	1
1996	887	355	93	8
1997	596	262	30	0
1998	672	564	183	0
1999	506	322	65	0
2000	43	169	139	12
2001	2	21	17	5
2006	499	500	78	2
2013	241	333	22	0

Table 3. Brook trout growth data from fall trapnetting Little Moxie Pond.

Year	Age 1+		Age 2+		Age 3+		Age 4+		Age 5+	
	n	Mean Length (in)	n	Mean Length (in)	n	Mean Length (in)	n	Mean Length (in)	n	Mean Length (in)
1994	44	5.8	64	8.9	5	11.9	1	15.9		
1995	24	5.3	52	9.9	28	13.5			1	17.6
1996	81	7.8	51	11.4	25	14.3	6	16.9		
1997	67	7.9	24	10.6	7	14.9				
1998	37	8.4	49	10.9	14	13.0				
1999	34	8.1	36	10.7	27	12.6				
2000	7	7.2	49	10.6	39	12.6	6	14.3		
2001	2	6.7	11	10.2	9	12.0	4	13.5		
2006	33	6.5	53	10.5	9	12.8	1	17.0		
2013	43	8.3	59	9.9	3	12.0				

Table 4. Tukey's multiple comparison test for mean brook trout lengths at age 1 for Little Moxie Pond. An * indicates a significant difference in mean length (P=0.05).

Year	1994	1995	1996	1997	1998	1999	2000	2001	2006
1994			*	*	*	*			
1995			*	*	*	*			*
1996	*	*							*
1997	*	*							*
1998	*	*							*
1999	*	*							*
2000		*					*		
2001									
2006		*	*	*	*	*			
2013	*	*							*

Table 5. Tukey's multiple comparison test for mean brook trout lengths at age 2 for Little Moxie Pond. An * indicates a significant difference in mean length (P=0.05).

Year	1994	1995	1996	1997	1998	1999	2000	2001	2006
1994		*	*	*	*	*	*		*
1995	*		*		*	*			
1996	*	*					*		*
1997	*								
1998	*	*							
1999	*	*							
2000	*		*						
2001									
2006	*		*						
2013	*		*		*	*			

Table 6. Tukey's multiple comparison test for mean brook trout lengths at age 3 for Little Moxie Pond. An * indicates a significant difference in mean length (P=0.05).

Year	1994	1995	1996	1997	1998	1999	2000	2001	2006
1994		*	*	*					
1995	*		*	*		*	*	*	
1996	*	*			*	*	*	*	*
1997	*	*			*	*	*	*	*
1998			*	*					
1999		*	*	*					
2000		*	*	*					
2001		*	*	*					
2006			*	*					
2013			*	*					

Table 7. Tukey's multiple comparison test for mean brook trout lengths at age 4 for Little Moxie Pond. An * indicates a significant difference in mean length (P=0.05).

Year	1994	1995	1996	1997	1998	1999	2000	2001	2006
1994							*	*	
1995									
1996							*	*	
1997									
1998									
1999									
2000	*		*						*
2001	*		*						*
2006							*	*	
2013									

Table 8. Number and weight of competitors removed from Little Moxie Pond.

Year	Number white suckers	Lbs white suckers	Number creek chubs	Lbs creek chubs	Number golden shiners	Lbs golden shiners	Total Lbs (non-brook trout)	Lbs/acre (non-brook trout)
1994	11,003	2,082	119	12	3,439	77	2,171	29.7
1995	7,100	1,395	446	27	1,082	29	1,451	19.9
1996	188	99	121	5	439	7	111	1.5
1997	300	78	54	3	2,381	46	127	1.7
1998	25	8	121	10	394	8	27	0.4
1999	248	129	170	18	392	9	156	2.1
2000	31	37	48	6	1,848	14	57	0.8
2001	36	43	184	23	3,432	26	92	1.3
2006	258	232	--	--	--	14*	246	3.4
2013	4,411	1,120	244*	17*	--	--	1,137	15.6

* - All minnow species combined

Table 9. Pre-netting population estimates and removal estimates of white suckers in Little Moxie Pond.

Year	Population Estimate	Upper Limit	Lower Limit	Estimated Removal	Minimum Removal	Maximum Removal	Sampling Events	Net hours/acre	R^2
1994	10,707	13,481	8,182	100%	82%	100%	12	13.1	0.9162
1995	8,181	23,850	2,196	87%	30%	100%	9	14.4	0.6047
1996	196	648	72	96%	29%	100%	7	12.7	0.6787
1997	239	280	203	98%	83%	100%	7	9.0	0.9803
1998	46	--	--	54%	--	--	6	10.4	0.2086
1999	227	309	157	100%	80%	100%	6	13.2	0.9492
2000	31	39	25	100%	83%	100%	6	7.6	0.9738
2001	41	55	29	100%	83%	100%	8	20.9	0.9115
2006	537	--	--	48%	--	--	4	4.3	0.4613
2013	5,523	13,620	3,266	80%	32%	100%	4	5.0	0.9525

Figure 1. Maximum daily surface water temperatures at Little Moxie Pond – 1995.

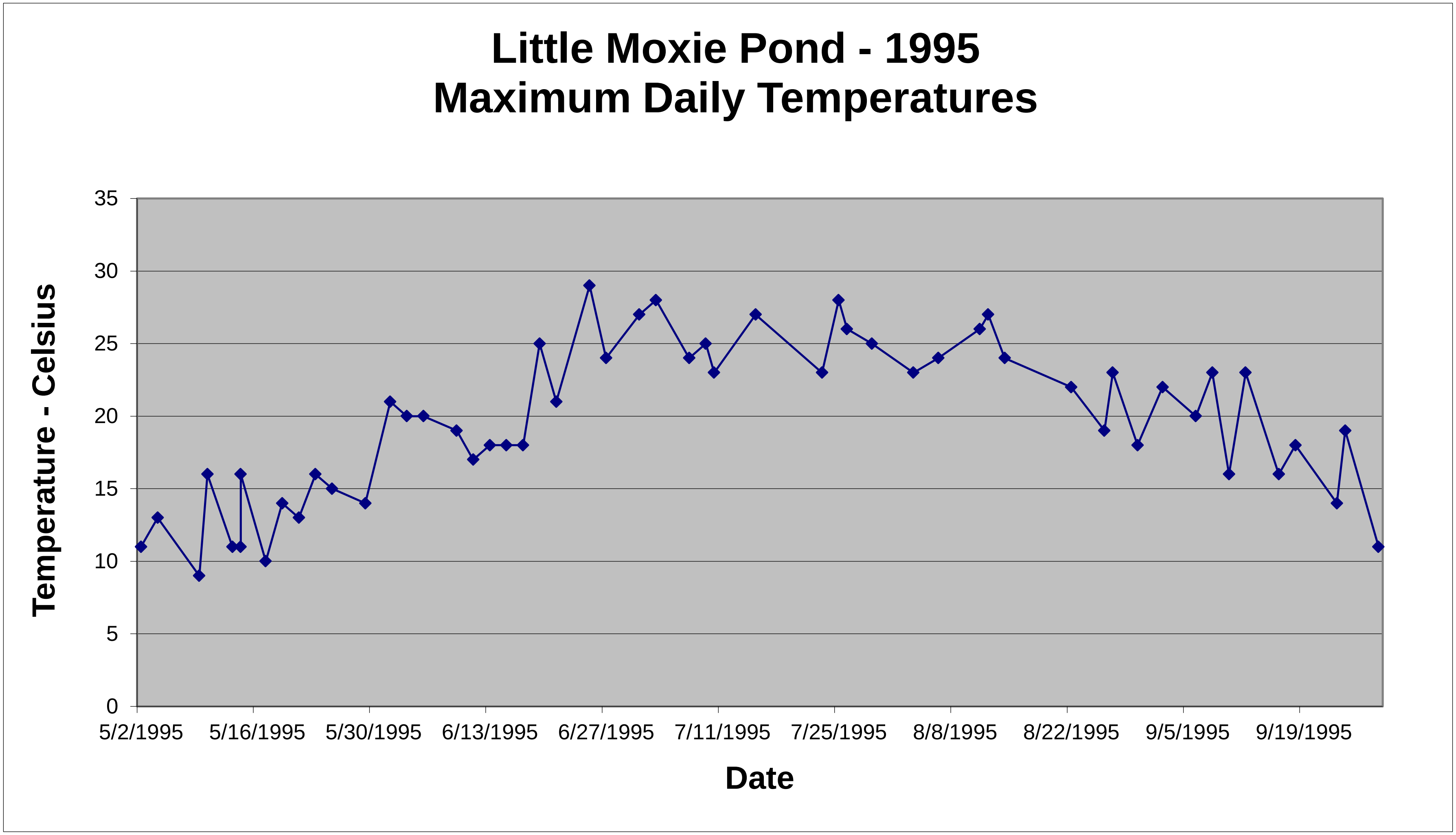
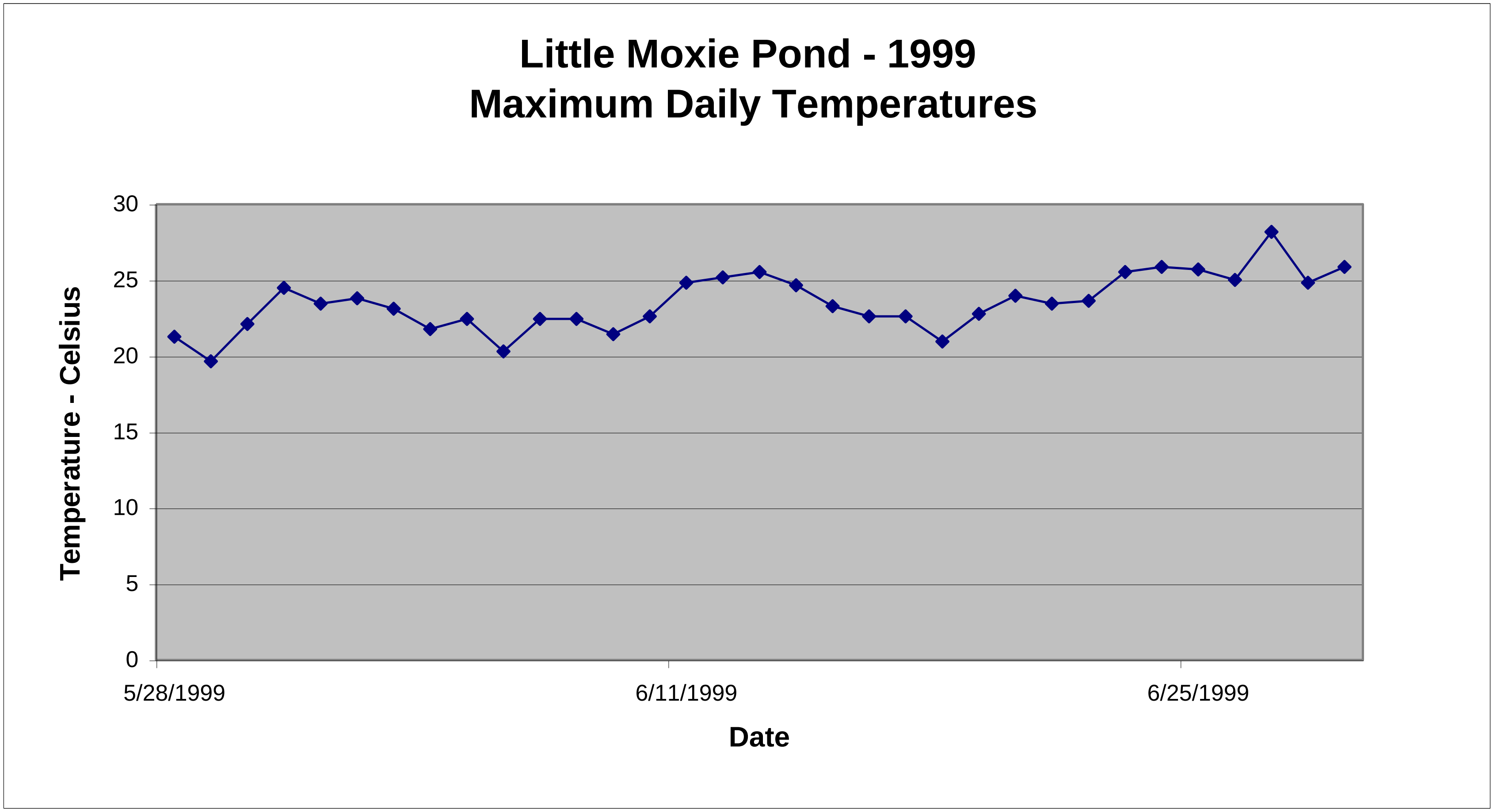


Figure 2. Maximum daily surface water temperatures at Little Moxie Pond – 1999.



· Note: Recording thermometer failed on June 29, 1999.

Figure 3. Maximum daily surface water temperatures at Little Moxie Pond – 2000.

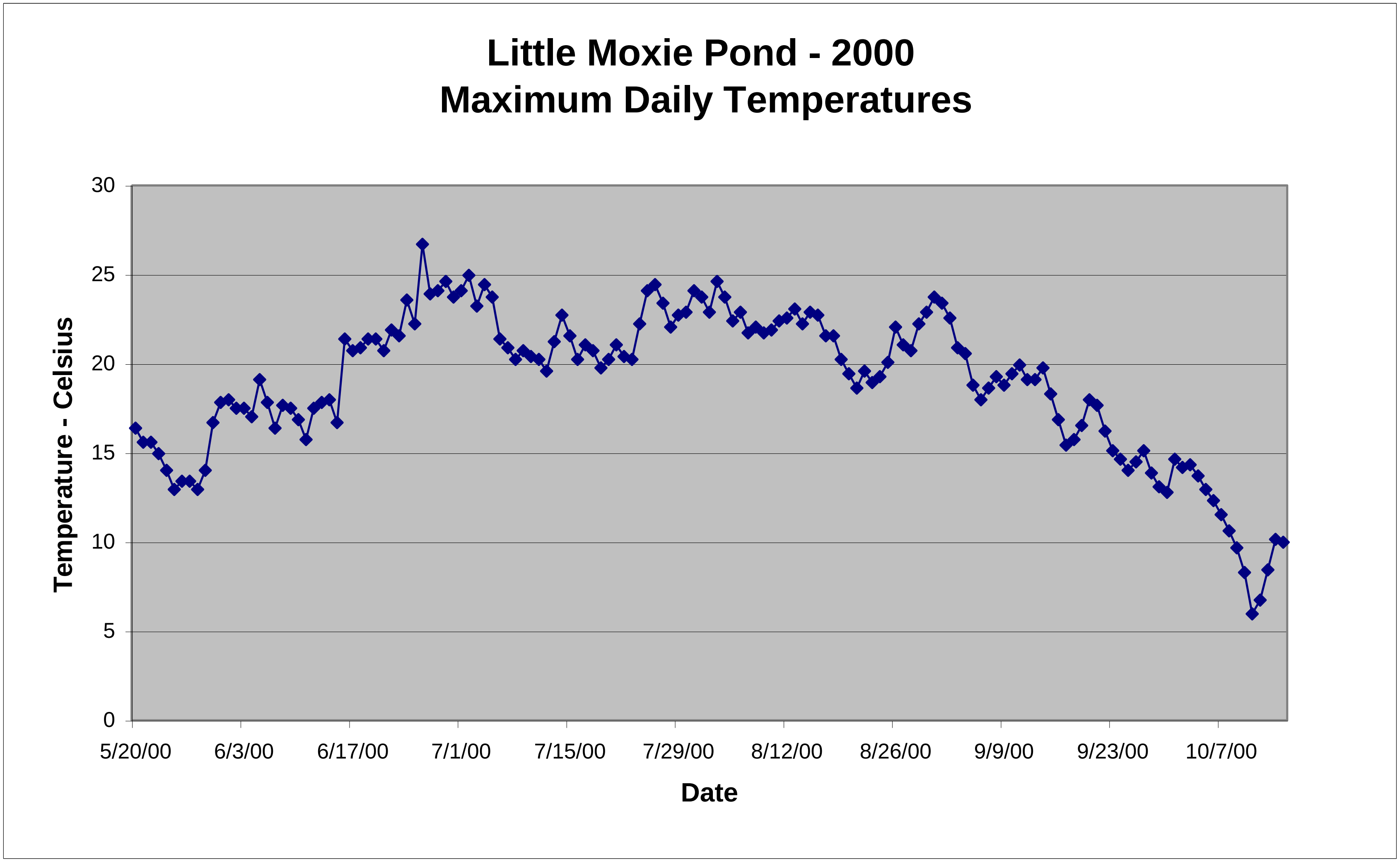


Figure 4. Maximum daily surface water temperatures at Little Moxie Pond – 2001.

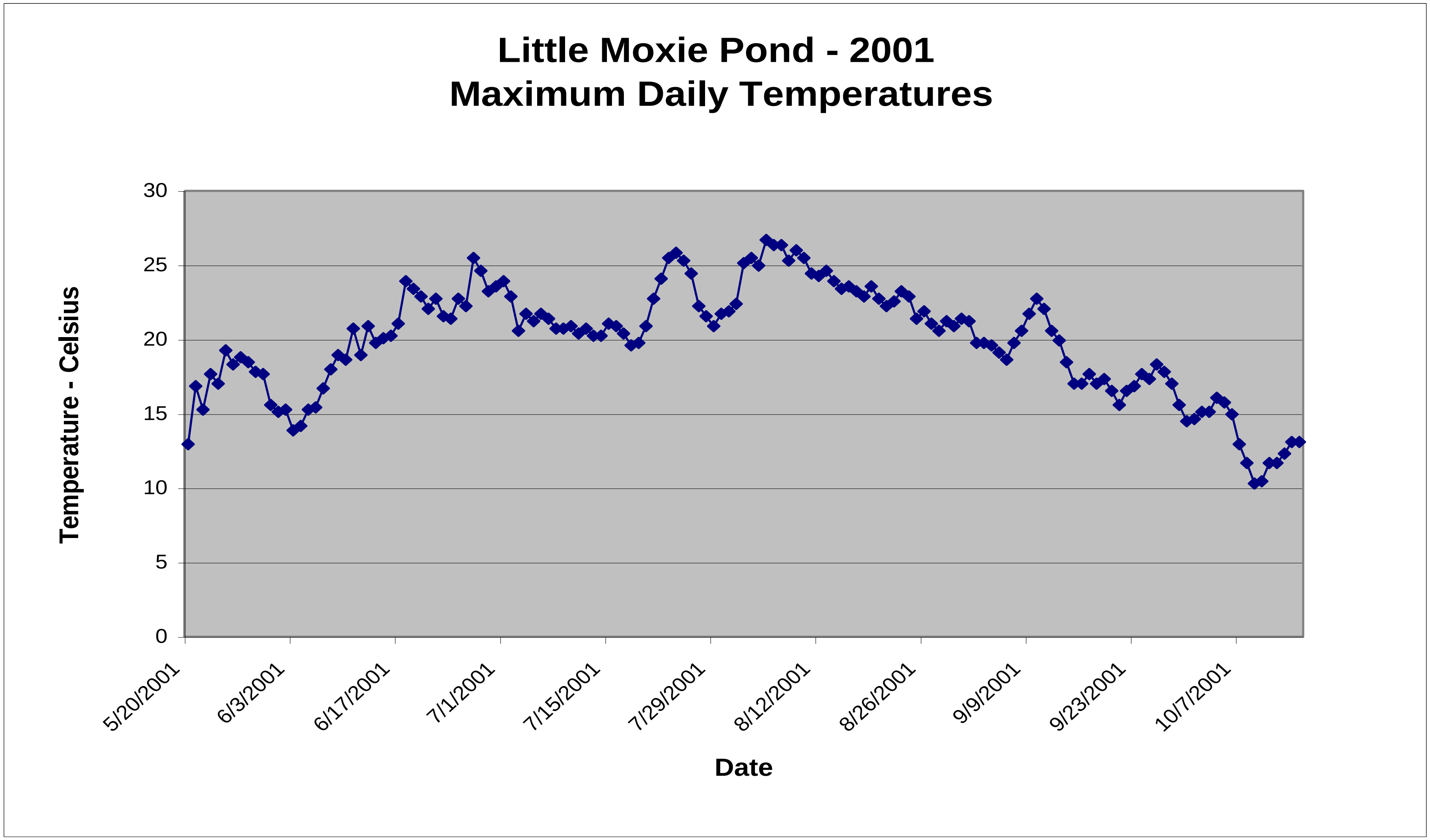


Figure 5. Percent of non-trout biomass removed and estimated biomass of brook trout from Little Moxie Pond.

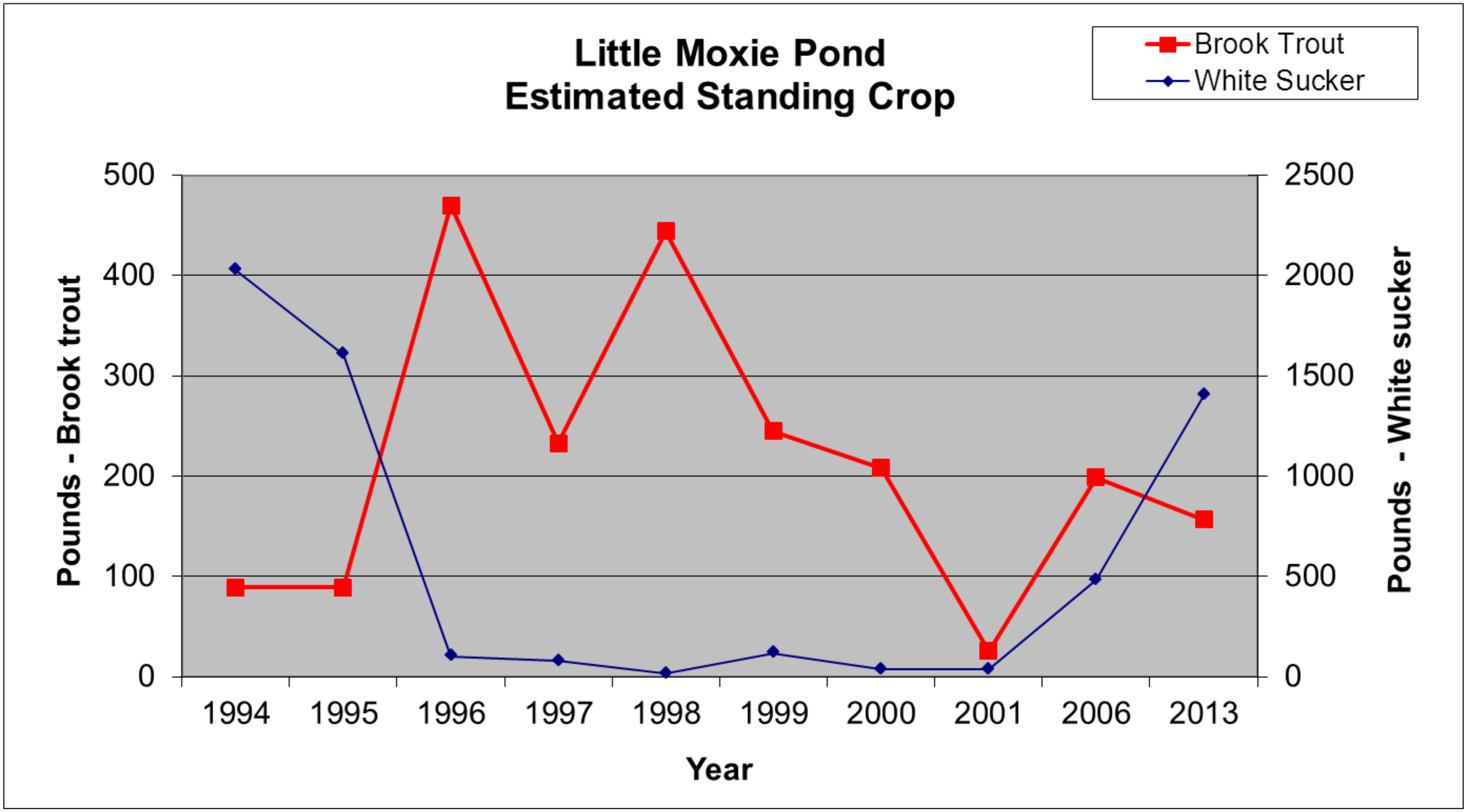


Figure 6. Percent of total biomass for white suckers and brook trout in Little Moxie Pond.