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Evaluation of Two Strains of Rainbow Trout Stocked into Inland Lakes in Michigan

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Abstract.–Equal numbers of Eagle Lake-strain rainbow trout (EL) and Michigan-strain steelhead (STT; anadromous form of rainbow trout) *Oncorhynchus mykiss* were given distinctive fin clips and stocked into seven experimental lakes each year from 2004 through 2008. Relative growth, survival, and return to creel of the strains were evaluated from samples collected by on-site angler survey, gill netting, electrofishing, and by volunteer anglers. Eagle Lake strain were smaller than STT at stocking but grew faster and erased the size deficit within six months of stocking. Size-at-capture differed between the study lakes, but overall size-at-age did not differ between the strains within each lake. Steelhead comprised 75% of the 590 stocked rainbow trout captured with survey gear. Return to anglers was poor for both strains in large inland lakes, but in smaller lakes 67% of rainbow trout caught by anglers were STT. Although EL may be more vulnerable to angling, their lower survival rate makes STT a more cost-effective fish to stock in small inland lakes. Stocking large inland lakes with either strain is not recommended as return rates to anglers were poor.

Introduction

The Michigan Department of Natural Resources (MDNR) has stocked many strains of rainbow trout *Oncorhynchus mykiss* since their original introduction in 1876. However, the current hatchery system only uses one resident form, Eagle Lake-strain (EL) rainbow trout, and one anadromous form, Michigan-strain steelhead (STT). The Little Manistee River, a tributary of Lake Michigan, has supported a naturalized population of anadromous rainbow trout since at least 1926. This river has not been stocked, with a few exceptions for research projects and has been used as a wild broodstock collection location since 1988 (Seelbach and Whelan 1988). The offspring of these fish constitute STT and are primarily used for stocking Great Lakes tributaries. Eagle Lake-strain rainbow trout originates from Eagle Lake, California and is unique enough to be classified as its own subspecies *Oncorhynchus mykiss aquilarum*. The Michigan Department of Natural Resources annually received EL eggs from the federal hatchery system beginning in 1988 until a captive broodstock based on the 2000 and 2001 year classes was established and able to meet the state's stocking requirements.

Natural reproduction of rainbow trout in Michigan's inland lakes is rare and insufficient to maintain high-quality fisheries. The primary objective of stocking rainbow trout into inland lakes is to provide more diverse sportfishing opportunities in areas where limnological and biological characteristics are conducive to good survival and growth of stocked trout (Dexter and O'Neal 2004). Since the late 1990s, MDNR Fisheries Division has annually stocked approximately 415,000 yearling EL rainbow trout into nearly 100 inland lakes (data on file).

The long-term cost of stocking lakes is high and deserving of evaluation. It can be logistically and fiscally challenging to obtain the angler effort and catch data that provide the best measures of the benefits of rainbow trout stocking programs. When angler-survey data are not available, fisheries managers must rely on voluntary reports from anglers or intermittent personal observations of the fishery, both of which have biases. Thus, snapshots of relative abundance and biological data such as growth rates and age composition are often obtained from netting and electrofishing surveys and compared to angler census data or volunteer angler reports.

Comparative evaluations of rainbow trout strain performance have been widely conducted. Strain characteristics, breeding history, rearing environment, and stocking location can all affect performance (Brauhn and Kincaid 1982; Hudy and Berry 1983; Dwyer and Piper 1984; Hume and Tsumura 1992; Wiley et al. 1993; Nuhfer 1996; Yule et al. 2000). In the early 1990s, the relative growth and survival of three strains of rainbow trout (EL, STT, and Shasta) were evaluated in small inland lakes in Michigan (Nuhfer 1996). Performance of the Shasta strain was poor. Although EL grew faster and larger, point estimates for survival and standing crop were consistently higher for STT in the small lakes. As a result of this study, interest increased in further evaluation of STT as a possible stocking alternative to domestic strains of rainbow trout in both small and large inland lakes in Michigan.

Past research has suggested that survival and return to the creel are positively correlated with the size of fish at stocking (Wiley et al. 1993; Yule et al. 2000; Dexter and O'Neal 2004). Nuhfer (1996) suggested a stocking size threshold of 167 mm for yearling rainbow trout, and that previous plants of steelhead in inland lakes were unsuccessful because they were small age-0 fish made available due to crowding at hatcheries. Eagle Lake-strain yearlings stocked into Michigan lakes averaged 167 mm between 2000 and 2011 while the standard STT yearling produced in Michigan hatcheries has averaged 188 mm over the same time period. We hypothesized that the larger STT presently reared in MDNR hatcheries would survive better, particularly in large lakes, and provide better returns to anglers than EL because they are less domesticated and well adapted to large-lake environments. Therefore, the objectives of our study were to determine the relative growth, survival, and return to anglers of STT and EL rainbow trout stocked into both small and large inland lakes.

Methods

Study Lakes

Fish were stocked into seven inland lakes of various sizes. Large lakes (>1,000 acres) stocked included Elk, Walloon, and Big Glen lakes. Maceday Lake was considered a medium-sized lake, and three small lakes were also stocked; Shupac, Big Chub, and Heart lakes. All study lakes had been stocked with salmonid species for many decades to generate put-grow-and-take trout angling opportunities. Trout species stocked into these lakes in the past include rainbow trout, lake trout *Salvelinus namaycush*, brown trout *Salmo trutta*, and splake hybrids (lake trout x brook trout *Salvelinus fontinalis*), with rainbow trout being the primary trout species stocked since 2000.

Stocking

An equal number of fin-clipped STT (right pectoral clip) and EL (left pectoral clip) rainbow trout were annually stocked into seven inland lakes each year from 2004 through 2008 (Table 1). All rainbow trout were reared at MDNR's Thompson State Fish Hatchery and transported to each stocking site on the same truck to minimize differences in handling stress among strains. Fish quality assessments were made each year at the hatchery several days before trout were stocked into the study lakes (Goede and Barton 1990; Goede 1993). Hatchery personnel examined a random sample of 60 fish of each strain to determine if eyes, gills, pseudobranchia, thymus, and opercles were normal. A subsample of 20 fish of each strain was examined to determine fat levels on pyloric caeca or in the body cavity; condition of the spleen, hind gut, kidney, and liver; and bile color. Fins were examined for erosion and fin clip quality was rated for a sample of 100 fish of each strain. Trout condition (K) immediately before stocking was determined each year from total length and weight measurements collected from a random sample of 60–100 fish of each strain (Table 1).

Creel Survey

We estimated creel catches from medium and large lakes using a stratified random design. Surveys followed an aerial-roving (aerial counts, roving interviews) or roving-roving/access (roving counts, roving and access site interviews) design. Counts of anglers and fishing boats progressed along a predefined path for each lake. Times of counts were randomized to cover the period sampled. Both weekend days and three randomly selected weekdays were selected for counting and interviewing during each week of the survey season; however, no holidays were sampled. Clerks worked one of two randomly selected shifts (morning or evening) each day. Large lakes were also sampled during the ice-cover period. Due to budgetary and staff limitations, creel surveys could not be implemented each year on each lake (Table 2). When rainbow trout were encountered by the creel clerk, biological data were recorded including length, fin clip, and a scale sample for aging purposes.

For medium and small lakes, return to the creel was assessed through volunteer angler reports. Local contacts and angler groups were approached about collecting harvest information on each of the strains. Volunteers were provided a diagram to distinguish between the fin clips of the two strains of rainbow trout and were asked to report the total number of rainbow trout caught as well as the individual length and fin clip of each fish captured. Reports returned from two angler groups on one lake appeared biased. The ratios of STT to EL reported to MDNR, although possible, were statistically highly unlikely ($P < 0.001$), so those reports were excluded from the analyses.

Fishery-independent Surveys

Fishery-independent surveys were conducted in small lakes where formal creel census did not occur as well as larger lakes to increase the sample size of both strains collected to provide clearer information regarding survival. Graded-mesh gill nets and/or boat-mounted electrofishing gear were used to target rainbow trout. The survey efforts in each lake were classified as discretionary surveys by MDNR Fisheries Division management units, thus, as other survey needs and requirements varied between the units, the amount of effort directed towards rainbow trout strain evaluations could not be consistent across all study lakes (Table 2). All rainbow trout collected were examined for a fin clip, measured for total length, and had a scale sample taken for analysis of growth and size-at-age for each strain. Because an insufficient number of fish was captured during most individual fishery-independent surveys, data were combined across years to obtain larger sample sizes for comparison of survival between the two strains in each lake, and data were combined across lakes to provide an overall comparison.

Statistical Methods

Analysis of variance was used to assess rainbow trout size and growth for each strain. Length at initial stocking, length-at-age of capture, and length in each lake were independent factors, with lake and strain as dependent variables. Analysis of variance was also used to evaluate rainbow trout condition at stocking by year and strain. Binomial tests were used to determine the probability of equal survival or catchability given the proportions of each strain observed. Relative survival (measured as return to gear) was assessed using proportional strain data collected from fishery-independent surveys and return to creel was assessed based on proportional strain data collected from volunteer anglers and MDNR creel clerks. Data were analyzed with R version 2.15. Differences were judged to be significantly different at $P < 0.05$.

Results

An average of 117,500 marked rainbow trout were annually stocked into the study lakes between 30 April and 8 May of 2004 through 2008 (Table 1). Stocking density averaged 5 fish/acre in the large lakes (Elk, Big Glen, and Walloon), 30/acre in medium-sized Maceday Lake, and 50-67/acre in the three smaller lakes (Shupac, Heart, and Big Chub). Michigan-strain steelhead were significantly longer than EL rainbow trout at stocking ($F = 145.9$; df = 1, 1,097; $P < 0.01$; Table 1); however, condition factors between the two strains were not significantly different ($F = 1.87$; df =1, 931; $P = 0.17$). Fish health inspections did not reveal substantial problems; however, in some cases the percentage of rainbow trout with a normal thymus, gills, and opercles, was lower for EL than STT (Table 3).

Growth

The EL grew significantly faster than STT during the first summer after stocking. Their size deficit at stocking was quickly erased by the first fall as there was no significant difference between the mean total lengths of the two strains six months following stocking ($F = 0.04$; df = 1, 226; $P = 0.85$; Table 4; Figure 1). Most rainbow trout that were aged came from fishery-independent surveys, but some were collected by creel clerks. On average, the month of capture did not differ between the two strains, and although EL were longer than STT at each age, the difference was not significant ($F = 0.9$; df = 3, 604; $P = 0.45$; Table 4; Figure 1). Although the mean size of rainbow trout differed between the lakes ($F = 116.1$; df = 5, 630; $P < 0.01$), there was no significant difference between the size of each strain within each lake ($F = 1.1$; df = 5, 630; $P = 0.38$; Figure 2).

Survival

Michigan-strain steelhead were captured three times more frequently than EL in pooled samples of rainbow trout collected with survey gear from the seven study lakes. Michigan-strain steelhead survived significantly better than EL rainbow trout in Big Glen, Shupac, Big Chub, and Heart lakes (all $P < 0.01$; Table 5). There was no significant difference in survival in Walloon Lake ($P = 1$) or Maceday Lake ($P = 0.77$), although only 16 fish were captured in Walloon Lake and 12 fish captured in Maceday Lake. In Elk Lake, only two STT were captured during three years of survey effort and no EL rainbow trout were captured. Eagle Lake-strain did not survive better than STT in any of the lakes examined, and STT represented 75% of all stocked rainbow trout caught in survey gear.

Big Glen Lake was the only large lake where a large sample of stocked STT and EL were captured with survey gear. In a spring 2007 gill-net survey 69 marked rainbow trout were caught, 84% of which were STT. A similar amount of netting effort in Walloon Lake in spring 2006 (1,000 feet of gill net fished for 4 nights) yielded only 8 STT and 8 EL rainbow trout. Only one wild rainbow trout was caught by the same amount of netting effort in Elk Lake during spring 2006. Two electrofishing surveys of Elk Lake conducted in fall 2005 captured a total of 18 rainbow trout but all appeared to be of wild origin because none had fin clips. Surveys of Elk Lake in 2008 resulted in the capture of the two STT; the remaining rainbow trout captured (21) were of natural origin (Table 5).

Return to Creel

Although creel surveys covered most of the fishing season, MDNR creel clerks did not observe large numbers of rainbow trout on any of the large lakes surveyed. Across all of the creel surveys conducted in each of the large lakes, no rainbow trout were observed in the creel in Elk Lake, only 10 were observed in Walloon Lake, and 13 were observed in Big Glen Lake. The Walloon Lake creel survey occurred in the fourth year of stocking, and the clerk observed 2 EL and 8 STT (Table 6), which provided expanded estimates (Lockwood et al. 1999) of 37 EL and 149 STT caught during the fishing season. The biological data containing the fin clip information of the Big Glen Lake fish were lost, so the ratio of EL to STT could not be determined, but the survey was conducted in the fifth year of stocking and the expanded estimate of rainbow trout catch was 166 fish. Maceday Lake had the highest number of rainbow trout observed by creel clerks. The creel survey occurred during the second year of stocking and the clerks observed 12 EL and 32 STT (Table 6), providing expanded estimates of 101 EL and 269 STT caught during the fishing season.

Volunteer angler information was relied upon for return to creel information in Maceday Lake and the small lakes. With all volunteer angler data pooled with the limited data collected by MDNR creel clerks, return to creel was significantly higher for STT than for EL rainbow trout ($P < 0.01$; Table 6). Significantly more STT returned to the creel in Maceday as well as each of the small lakes individually (all $P < 0.01$, Table 6). Across all lakes, 67% of all rainbow trout reported by volunteer anglers or observed by creel clerks were STT.

Discussion

The most important finding from this research was that STT survived three times better than EL; however, the exact mechanism is unclear. Yule et al. (2000) found that Kamloops strain (anadromous form) survived better than EL in reservoirs; however, size-at-stocking mattered more than strain and smaller stocked rainbow trout were consumed by walleye at a high rate. Even though EL grew faster than STT in the current study, the size difference at stocking could have made them more vulnerable to predation in the time period immediately following stocking, which is usually when predation of stocked fish is highest (Stein et al. 1981). However, results from Nuhfer (1996) suggest higher survival for STT compared to EL, even though STT were stocked at a smaller size, suggesting that factors other than size were playing a role in differential survival between these strains.

Domestication selection may also have contributed to the reduced survival of EL strain compared to STT. The EL strain is maintained as a captive broodstock in a state fish hatchery. This particular strain used to stock Michigan waters has been removed from natural selection for multiple generations, possibly allowing some combinations of alleles to persist in the hatchery fish that would not have allowed for survival in the wild. The STT are first generation offspring of adults naturally born in the wild. It is well known that hatchery fish tend to underperform compared to their wild counterparts; however, past research specific to steelhead has shown that even minimal time spent in a hatchery can reduce survival of stocked fish and their offspring (Miller et al. 2004, Caroffino et al. 2008, Araki et al. 2008).

Although there were differences in size at stocking, growth during the first year, and size between the lakes, overall size at capture did not favor one strain over another. The largest individual rainbow trout in most samples were usually STT because they more frequently survived to older ages, but older EL fish that survived were similar in size. Growth rates between the strains after the first year were not significantly different. The size differences observed between the lakes was partially due to non-uniform sampling through the years of the project. Collecting a large number of samples early in the study when most fish were age 1 or 2 would make the average size in that lake appear to be lower than in a lake that was sampled later in the study after multiple years of stocking. This study did not seek to evaluate total survival and compare it or growth rates between specific lakes. The intent was simply to evaluate relative differences between the strains.

This study relied on volunteer angler data to assess return to creel, as returns of stocked fish were poor in some lakes where creel surveys were conducted. Volunteer angler data will be biased if anglers have difficulty distinguishing different fin clips, or if an angler has enough information to desire a particular outcome from a given study. Reports from two angler groups had to be excluded from this study. The first angler group reported catching a high number of rainbow trout, but the ratio of EL:STT reported was statistically very unlikely given the observed survival differences from survey data, or even given equal survival of the two strains. If these anglers confused the right and left fin clip types, and their data were actually reversed, it would have been more consistent with that observed in the rest of this study. Another piece of volunteer angler data was excluded because an angler reported catching a high number of EL and no STT. While possible, this was extremely unlikely given the survival scenarios observed overall in this study.

Although STT clearly survived better than EL, it appeared that EL may be more susceptible to anglers. Three times as many STT were caught in survey gear than EL; however, STT were only twice as prevalent in the recreational catch as EL. This suggests that EL strain may be 33% more catchable than STT when stocked into inland lakes. Even though STT yearlings cost more to rear than EL yearlings ($1.45 vs. $1.07; data on file), the increased catchability of EL strain would not outweigh the disadvantage of reduced survival in terms of cost per fish caught by anglers unless angler effort expenditures offset the production cost differences (Table 7).

Vulnerability to angling can differ between genetic strains of a single species. Brauhn and Kincaid (1982) found that catchability among four rainbow trout strains differed depending on their rearing history and individual characteristics. Poor survival and susceptibility to anglers is why the Harrison Lake strain rainbow trout was discontinued from the Michigan hatchery system (G. E. Whelan, MDNR, personal communication). It wasn’t possible to identify why catchability differed between EL and STT in the present study. However, some genetic strains are more aggressive than others, or may inhabit different parts of a lake, making them more or less accessible by anglers.

This study examined overall survival and return to the creel as measures of stocking success, but total effort targeted towards a particular species can also be examined. This metric can be difficult to obtain where creel census surveys are not conducted, and as a result angler effort could not be described across all of the study lakes. However, it was estimated for the large lakes. The effort targeted towards rainbow trout in the large lakes was low, suggesting that the stocking events did not generate significant interest from anglers to cause an increase in fishing activity for this species. In the smaller lakes it appears that stocking generated angler effort, possibly due to the higher stocking density and smaller size of the lakes. However, total effort or amount of effort generated by stocking could not be estimated because the proportion of the total effort that was represented by the volunteer reports received was unknown.

Management Implications

This study examined the relative growth, survival, and catchability of the rainbow trout hatchery products currently produced by MDNR. If EL were stocked at a larger size, or if STT were stocked at a smaller size, the results may have been different. However, for best return to the creel from the current hatchery products available to managers for Michigan inland lakes, STT should be stocked rather than EL strain rainbow trout. Even though EL may have been more vulnerable to anglers, the survival difference between these two hatchery products outweighed any catchability advantage that EL may have. Although hatchery logistics and the high demand for STT by management units may preclude their use in all waters where rainbow trout are stocked, stocking STT into inland lakes rather than EL would result in a lower cost per fish caught by anglers.

The results from this study also demonstrated that stocking STT or EL strain rainbow trout in large lakes does not appear to be worth the investment unless offset by increased, although, unmeasured in the study, angler effort. Whether due to the lower stocking density, higher rates of predation, or lack of interest from anglers, return to creel of stocked fish in large lakes was poor. If it is assumed that one year of stocking was used to produce the catch estimated by creel surveys, the cost per fish caught was $190 in Walloon Lake and $152 in Big Glen Lake. Although still high, the cost per fish caught in the medium-sized Maceday Lake was four times lower at $41. Some large lakes (Elk) will support natural populations, but the dominant species in large inland lakes is rarely rainbow trout. Conversely, in smaller coldwater inland lakes, trout often survive well and are more concentrated and popular with anglers. Hatchery products should be focused on these smaller lakes where fish can be stocked at a higher density and lower cost, possibly generating more angler interest and targeting. To stock large lakes at the stocking densities used for the small lakes in this study would be cost prohibitive, take more STT than the hatchery system can produce, and ignore their Great Lakes use.

Given that some of the volunteer angler data appeared biased and needed to be discarded, future strain evaluations that utilize fin clips and volunteer angler reports should use clips that are less dependent on the orientation of the fish. For example, rather than using a right and left pectoral clip, an adipose clip or a ventral fin clip could be paired with a pectoral clip, eliminating the need for a right or left designation. Alternate tagging options could also be considered; perhaps those that use color rather than fin clips may be useful. Some bias is likely always going to be present when volunteer reports are considered, but reasonable steps should be taken during research planning to minimize it.

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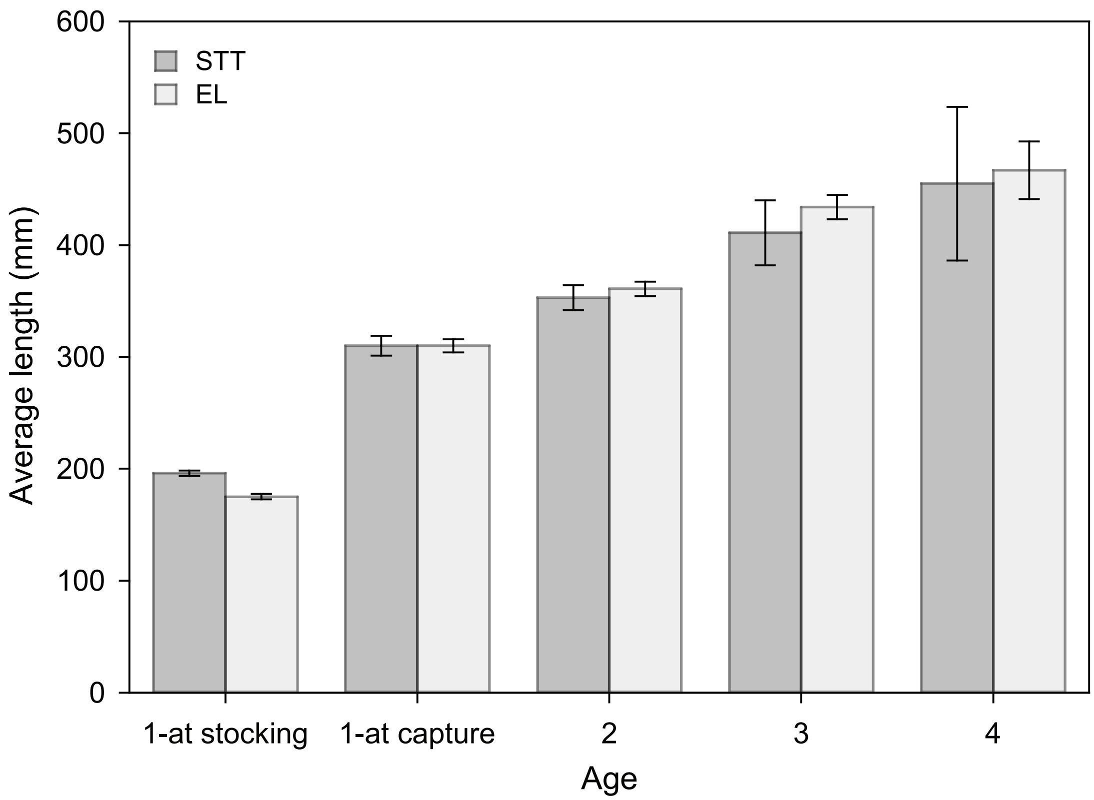

Figure 1.–Pooled length (mm)-at-age data for two rainbow trout strains from seven study lakes. Error bars represent two standard errors of the mean for each age/strain category. STT = Michigan-strain steelhead; EL = Eagle Lake strain.

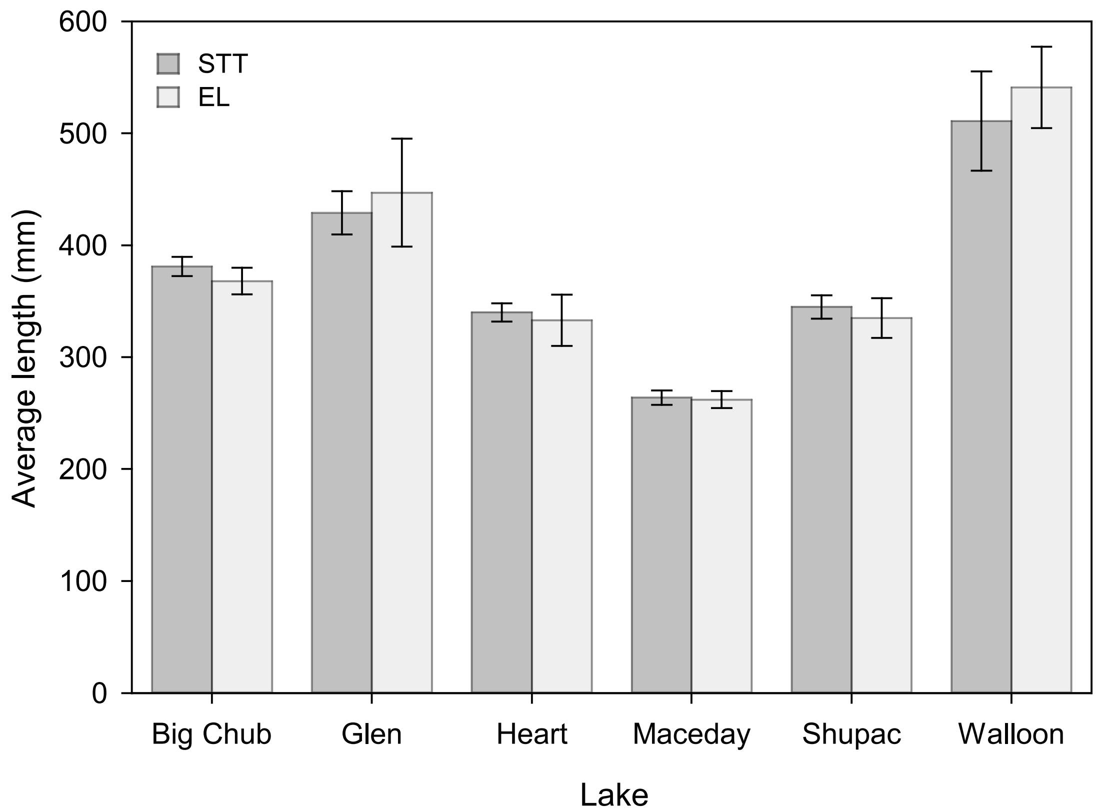

Figure 2.–Average length (mm) of rainbow trout by strain captured in each of the study lakes. Error bars represent two standard errors of the mean for each strain/lake category. STT = Michigan strain-steelhead; EL = Eagle Lake strain.

Table 1.–Number, mean length (mm), and condition (K) of Eagle Lake-strain rainbow trout (EL) and Michigan-strain steelhead (STT) stocked into experimental lakes.

		Number stocked		Mean length		Mean condition	
Lake information	Year	STT	EL	STT	EL	STT	EL
Elk Lake	2004	21,480	21,500	194	177	0.92	0.97
Antrim, Kalkaska, and	2005	21,500	21,500	203	170	0.93	0.95
Grand Traverse counties	2006	16,797	16,797	199	180	1.07	1.06
7,730 Acres	2007	18,700	18,700	192	175	0.96	1.09
	2008	21,000	21,000	192	175	0.93	0.93
Big Glen Lake	2004	10,000	10,000	194	177	0.92	0.97
Leelanau County	2005	13,279	13,116	203	170	0.93	0.95
4,865 Acres	2006	12,000	12,000	199	180	1.07	1.06
	2007	10,000	10,000	192	175	0.96	1.09
	2008	10,000	10,000	192	175	0.93	0.93
Walloon Lake	2004	14,000	14,000	194	177	0.92	0.97
Charlevoix County	2005	14,000	14,000	203	170	0.93	0.95
5,487 Acres	2006	15,000	15,000	199	180	1.07	1.06
	2007	14,000	14,000	192	175	0.96	1.09
	2008	14,000	14,000	192	175	0.93	0.93
Maceday Lake	2004	6,000	6,000	194	177	0.92	0.97
Oakland County	2005	6,000	6,000	203	170	0.93	0.95
419 Acres	2006	8,000	8,000	199	180	1.07	1.06
	2007	6,000	6,000	192	175	0.96	1.09
	2008	6,000	6,000	192	175	0.93	0.93
Shupac Lake	2004	2,700	2,700	194	177	0.92	0.97
Crawford County	2005	2,700	2,700	203	170	0.93	0.95
107 Acres	2006	2,700	2,700	199	180	1.07	1.06
	2007	2,700	2,700	192	175	0.96	1.09
	2008	2,700	2,700	192	175	0.93	0.93
Big Chub Lake	2004	2,500	2,500	194	177	0.92	0.97
Otsego County	2005	2,500	2,500	203	170	0.93	0.95
75 Acres	2006	2,500	2,500	199	180	1.07	1.06
	2007	2,500	2,500	192	175	0.96	1.09
	2008	2,500	2,500	192	175	0.93	0.93
Heart Lake	2004	2,000	2,000	194	177	0.92	0.97
Otsego County	2005	2,000	2,000	203	170	0.93	0.95
65 Acres	2006	2,000	2,000	199	180	1.07	1.06
	2007	2,000	2,000	192	175	0.96	1.09
	2008	2,000	2,000	192	175	0.93	0.93

Table 2.–Timing and method of sampling used to evaluate relative catches of Eagle Lake-strain rainbow trout and Michigan-strain steelhead in each study lake.

Lake (size class)	Electrofishing	Gill nets	On-site angler survey	Volunteer anglers
Elk Lake (large)	October 2005 April 2008	April 2006, 2008	October 2005 February to March 2006 May to October 2008 January to March 2009	None
Big Glen Lake (large)	October 2006 April 2008	April 2007	October 2005 February to March 2006 May to September 2008 January to March 2009	None
Walloon Lake (large)	April 2007	April 2006	October 2005 February–March 2006 May to October 2007	None
Maceday Lake (medium)	None	July 2005 August 2005	April to October 2005	2005–07
Shupac Lake (small)	October 2004–08 April 2005–08	None	None	2007
Big Chub Lake (small)	October 2004–07 April 2005–08	November 2004	None	2005–09
Heart Lake (small)	October 2005–07 April 2006–08	None	None	2005–07 2010

Table 3.–Percentage of rainbow trout examined during fish health inspections with normal organs by year and strain. EL = Eagle Lake-strain rainbow trout; STT = Michigan-strain steelhead.

	Year									
	2004		2005		2006		2007		2008	
Organ	EL	STT	EL	STT	EL	STT	EL	STT	EL	STT
Eyes	98	92	100	82	100	95	100	78	95	87
Gills	100	95	72	100	97	100	97	100	95	97
Pseudobranch	97	100	95	93	93	100	95	98	100	100
Thymus	98	90	98	98	68	88	68	95	80	82
Spleen	100	100	100	100	100	100	100	100	100	100
Hindgut	100	100	100	100	100	100	100	100	100	100
Kidney	100	100	100	100	100	100	100	100	100	100
Liver	100	100	100	100	100	100	100	100	100	100
Opercle	85	92	78	97	82	100	92	100	82	88

Table 4.–Length (mm)-at-age data for Eagle Lake-strain rainbow trout (EL) and Michigan-strain steelhead (STT); data are from fish caught in agency surveys or observed and measured by MDNR creel clerks.

	Size at age (mm)		Average month of capture		Sample size	
Age	STT	EL	STT	EL	STT	EL
1-at stocking	196	175				
1-at capture	310	310	Oct	Oct	156	72
2	353	361	May	May	170	52
3	411	434	May	May	94	18
4	455	467	Apr	Apr	43	7

Table 5.–Survey catches of Eagle Lake-strain rainbow trout (EL) and Michigan-strain steelhead (STT) in study lakes; data across years were combined for binomial tests of equal proportion of each strain in each lake and across all lakes.

Lake (size class)	Year	Rainbow trout strain			Binomial test of equal proportion
		EL	STT	No clip	
Elk Lake (large)	2005	0	0	18	
	2006	0	0	1	
	2008	0	2	21	
	All years	0	2	40	Not testable
Big Glen Lake (large)	2005	0	0	0	
	2006	0	1	0	
	2007	11	58	1	
	2008	1	4	2	
	All years	12	63	3	$P < 0.01$
Walloon Lake (large)	2005	0	0	0	
	2006	8	8	1	
	2007	0	0	0	
	All years	8	8	1	$P = 1.0$
Maceday Lake (medium)	2005	7	5	0	$P = 0.77$
Shupac Lake (small)	2004	8	3	0	
	2005	8	25	0	
	2006	7	38	0	
	2007	4	25	0	
	2008	7	29	1	
	All years	34	120	1	$P < 0.01$
Big Chub Lake (small)	2004	18	25	0	
	2005	6	23	0	
	2006	16	49	0	
	2007	23	41	0	
	2008	11	21	0	
	All years	74	159	0	$P < 0.01$
Heart Lake (small)	2005	2	23	0	
	2006	3	31	0	
	2007	6	28	0	
	2008	0	5	0	
	All years	11	87	0	$P < 0.01$
All Lakes	All years	146	444	45	$P < 0.01$

Table 6.–Catches of Eagle Lake-strain rainbow trout (EL) and Michigan-strain steelhead (STT) reported by volunteer anglers or observed by MDNR creel clerks; data across years were combined for binomial tests of equal proportion of each strain in each lake and across all lakes. Angler catch data were not available from Elk and Big Glen lakes.

Lake (size class)	Year	Rainbow trout strain EL	Rainbow trout strain STT	Binomial test of equal proportion
Walloon Lake (large)	2007	2	8	$P = 0.11$
Maceday Lake (medium)	2005	30	108	
	2006	29	48	
	2007	2	5	
	All years	61	161	$P < 0.01$
Shupac Lake (small)	2007	8	55	$P < 0.01$
Big Chub Lake (small)	2005	9	20	
	2006	62	80	
	2007	14	26	
	2008	15	16	
	2009	21	26	
	All years	121	168	$P < 0.01$
Heart Lake (small)	2005	2	2	
	2006	7	29	
	2007	25	42	
	2010	3	4	
	All years	37	77	$P < 0.01$
All Lakes	All years	229	469	$P < 0.01$

Table 7.–Relative cost of Michigan-strain steelhead (STT) and Eagle Lake-strain (EL) rainbow trout stocked and returned to the creel. Actual survival and exploitation rates were not estimated in this study; this is a hypothetical example based only on the relative availability to anglers and return rates observed in the present study.

	STT	EL
Initial Number Stocked	10,000	10,000
Initial Cost	$14,500	$10,700
Number available to anglers (STT 3x higher)	9,000	3,000
Return to Anglers (STT only 2x higher)	1,000	500
Cost per fish caught	$14.50	$21.40

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