of-year (<4 inches TL), I used total density as well as total biomass as metrics of performance. For all mixed-effect models, I treated river, year, and strain (or origin in the case of comparisons between stocked and unclipped resident brown trout) as fixed effects and site (nested within river) as a random effect. When appropriate, I transformed the data to meet the necessary distributional assumptions. I used Bonferroni-adjusted P-values for multiple comparisons and set rejection criterion at $\alpha = 0.05$ for all analyses. All data were analyzed with SPSS version 11.5 (SPSS 2002).

I did not conduct statistical analyses on the CPE data from the Muskegon River due to the difference in format (CPE versus population estimates) and relatively low brown trout catches compared to the other study rivers. Instead, I present a brief summary of the Muskegon River CPE data strictly for generalization and comparison purposes.

Angler data.—I used a paired t-test to determine if angler CPE of stocked brown trout varied as a function of strain in the Manistee River. Since no stocked brown trout were reported in 2002 or 2003, I excluded these years from subsequent analyses. I compared catch per 100 hours of all GC and SF brown trout, regardless of size, and of all GC and SF brown trout >8 inches. I also compared the catch per 100 hours of all stocked and unclipped resident brown trout, regardless of size, and of all stocked and unclipped resident brown trout >8 inches. I set rejection criterion at $\alpha = 0.05$ for all paired t-tests. All data were analyzed with SPSS version 11.5 (SPSS 2002).

Since creel clerks on the Muskegon River recorded relatively few brown trout, I did not conduct statistical analyses on the Muskegon River creel survey data. Similar to the electrofishing CPE, I present a brief summary of the Muskegon River creel data for generalization and comparison purposes.

Results

Population Assessment

Density of stocked trout.—Based on 96 separate population estimates (generated from a combination of rivers, sampling stations, and years), the total density of stocked brown trout varied significantly by strain (Table 5). Mean total density was significantly higher for GC brown trout than for either WR or SF brown trout (Table 6; Figure 2). No significant difference was detected between WR and SF strains. Mean total density of stocked trout also varied significantly by river, with the highest densities of stocked fish occurring in the Coldwater River, followed by Fish Creek, Paint Creek, the Rogue River, the Indian River, and the Manistee River (Figure 3). However, a significant river*year interaction was present, indicative of yearly variation in the total density of stocked trout across all study rivers, regardless of brown trout strain (Table 5; Appendix A).

Population estimates of stocked brown trout >8 inches also varied significantly by strain (Table 5). Mean density of fish >8 inches was significantly higher for GC brown trout when compared to SF brown trout, but not for GC brown trout compared to WR brown trout or WR brown trout compared to SF brown trout (Table 6; Figure 2). Population estimates of stocked trout >8 inches also varied significantly by river, with the highest densities occurring in the Coldwater River, followed by Fish Creek, the Indian River, the Manistee River, the Rogue River, and Paint Creek (Figure 3). Variability in the density of trout >8 inches occurred across strains and years as indicated by a significant strain*year interaction. Point estimates of the density of GC brown trout were less than the density of WR brown trout during the first and third years of the study, while in the second and fourth years of the study the density of GC brown trout was higher than WR brown trout (Figure 4). The density of SF brown trout >8 inches remained relatively stable through all years of study, and was lower than estimates of the densities of GC or WR brown trout >8 inches.

Survival of stocked trout.—Since the density of age-1 stocked brown trout at some study sites exceeded the prescribed stocking density (indicating uneven dispersal of stocked yearlings throughout the entire system 4–5 months after planting), I could not calculate meaningful survival estimates from the time of stocking to the time of sampling after the first summer in residence for age-1 fish. Therefore, I assumed

Schmutz (1999) observed a substantial decline in the survival of hatchery brown trout in comparison to wild fish after 1 year in an Austrian stream, while Berg and Jørgensen (1991) noted that post-stocking mortality of wild brown trout was lower than that of hatchery-origin brown trout in a Denmark river. Avery et al. (2001) documented much higher survival of a stocked wild brown trout strain compared to domesticated brown trout in two Wisconsin river systems. The survival of the wild strain was substantially greater than that of the domestic strains in all years of their study. Alexander (1987) found that the 2-year survival rates for wild brown trout strains were nearly twice those of a domesticated brown trout strain in four Michigan lakes. Alexander and Peterson (1983) documented that the survival rate of hatchery-reared brown trout was significantly lower for ages 1 to 3 than for wild brown trout in a Michigan stream. Similar to the results of these studies, I found that the wild GC brown trout demonstrated higher survival than both the domestic SF and WR strains. On average, survival of GC fish during the first year after stocking was more than 100 times higher than SF brown trout and more than 6 times higher than WR brown trout. In addition, some GC brown trout survived up to 3 years after stocking to ages 3 and 4, while few SF or WR brown trout survived past age 2. Accordingly, the densities of all GC fish, and in some years legal-sized GC fish, were noticeably higher than those of the SF and WR strains throughout the study.

The initial growth of GC strain brown trout during the first summer after stocking in my study was nearly 2 times that of SF brown trout and more than 1.5 times that of the WR brown trout strain when adjusted for initial length. Other studies have noted that wild brown trout strains exhibit higher growth rates than domestic strains. Avery et al. (2001) found that the growth of wild spring yearlings in a Wisconsin river exceeded the growth of domestic spring yearlings, thereby reducing the initial size advantage of the domestic strain over the 2 years of study. Alexander (1987) concluded that the GC strain brown trout displayed superior growth to other wild strains and a domestic strain in four Michigan lakes. In my study, the growth of GC fish also exceeded that of either domestic strain during the first year after stocking, up to a maximum of nearly twice that of SF brown trout. Although few SF or WR brown trout survived more than 2 years after stocking (i.e., to ages 3 and 4), the GC brown trout that did survive to these ages were usually larger than the minimum size limit in effect for the particular river of study.

The higher survival and growth displayed by the wild GC brown trout strain when compared to the domestic SF and WR brown trout strains are extremely relevant to stocking strategies and fisheries management. The minimum size limits in the majority of study rivers changed from 8 inches to 10 or 12 inches in 2000. The low survival and slow growth of the domestic brown trout strains may prohibit them from reaching the minimum size limit in these and similar systems, thereby decreasing the amount of fish available for angler harvest. Although the GC brown trout are far below the legal harvest size at the time of stocking, their high survival and growth rates afford them a chance to meet or exceed the minimum size limits in subsequent years. In addition, the presence of age 3 and 4 GC brown trout allows the chance for natural reproduction to occur; as such fish will probably be sexually mature.

In my study systems (with the exception of the Muskegon and Coldwater rivers), the densities of stocked brown trout on average were much lower than the densities of unclipped resident fish. Although some unclipped resident fish may have been carry-over of stocked fish from previous years, the low survival of the domestic strains in this study suggests that this may be minimal. Also, the presence of unclipped resident fish less than 4 inches TL indicates that natural reproduction is occurring. Fisheries managers should judge if such natural reproduction is enough to sustain the fishery, and if it is, consider making more efficient use of resources by reducing or discontinuing stocking.

The return of stocked fish to the angler should also be a consideration for fisheries managers. Avery et al. (2001) found that domestic brown trout provided a greater return to the angler during their second summer in a Wisconsin river because few of the wild brown trout had reached the 12-inch minimum size limit, but noted that the significantly higher survival of wild trout provided the opportunity

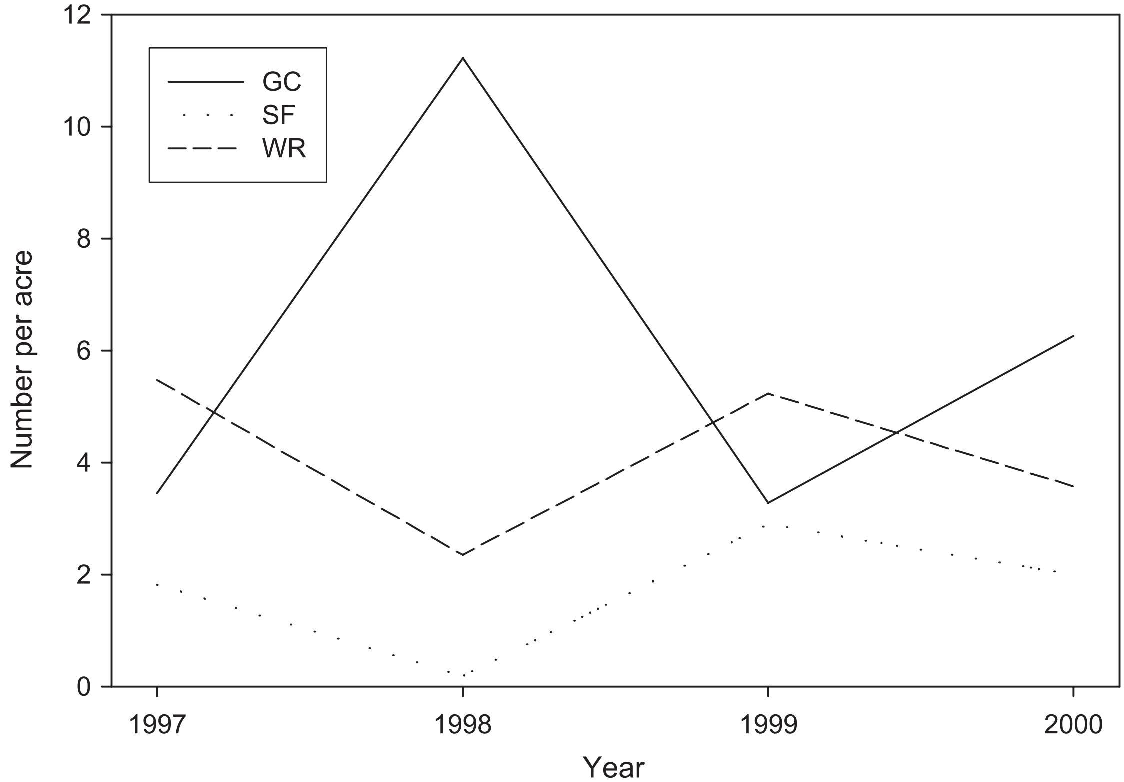

Figure 4.–Mean back-transformed density of stocked brown trout strains >8 in by strain and year for six rivers. Confidence intervals have been omitted for clarity. GC = Gilchrist Creek, SF = Seeforellen, WR = Wild Rose.

(Errata March 14, 2006