

Immigration of Juvenile Bull Trout from the Metolius River to Lake Billy Chinook, 1996–2002

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ABSTRACT

Juvenile bull trout immigrating to Lake Billy Chinook from the Metolius River have been captured in a screw trap just upstream of the lake since 1996. During the last 4 years the trap has been operated at the same location which has allowed comparisons among several years to be made. The ages of juvenile bull trout most commonly captured appear to be ages 0, 1, and 2. Most bull trout were captured during March and April, and the peak catch usually occurred during the first part of April. During the periods the trap was operated, immigration estimates of ages 1, 2 and 3 bull trout ranged from a low of 1,251 in 2000 to a high of 6,354 in 1999. Density-dependent effects are emerging as the population continues to increase. Growth rates of ages 1 and 2 have been steadily decreasing for the last 6 years, during which time the number of spawning bull trout have been increasing. The 2002 year class was the result of a record number of adults, however, there was a dramatic decrease in the number of age 0 fry captured. The implications of a large juvenile bull trout population in the Metolius River for successful anadromous fish reintroduction should be addressed before it is actually attempted.

INTRODUCTION

Beginning in the mid-1980s, a greater awareness and appreciation of the ecological role that native trout have in the Metolius River system prompted numerous studies. These studies were conducted by various agencies to increase the knowledge of native species including bull trout (*Salvelinus confluentus*) (Ratliff et al. 1996). Given the possibility of anadromous fish reintroduction to the Metolius Basin (Ratliff et al. 2001), new information about the bull trout population will help in predicting what interactions will occur and the significance of those interactions.

In 1996, Portland General Electric contracted with the Oregon Department of Fish and Wildlife to conduct a comprehensive kokanee study on Lake Billy Chinook and the Metolius River (Thiesfeld et al. 1999; Thiede et al. 2002). As part of the study, kokanee fry immigration to Lake Billy Chinook was studied using a 2.4-m rotary screw trap operated at various locations within a 2-km reach at the Metolius River inflow. In June 1998, the listing of bull trout as a threatened species by the United States Fish and Wildlife Service prompted a more in-depth look at all available data, such as the incidental bull trout catch from this screw trap. Since 2001, the primary objective for operating this trap has been to collect bull trout that would help provide a better understanding of juvenile bull trout and their immigration to Lake Billy Chinook.

This report summarizes information concerning the sizes, timing, and numbers of juvenile bull trout immigrating to Lake Billy Chinook from the Metolius River during the sampling periods from 1996 through 2002.

METHODS

Screw Trap Operations

1996–1998

In 1996, the screw trap was operated approximately 100 m upstream of Lake Billy Chinook. The trap was operated 5 days per week from June 6 through October 4. It was normally set on Monday and checked for captured fish on Wednesday and Friday. Total and fork lengths (to the nearest 1 mm) were measured on all bull trout.

In 1997, the trap was operated at the same location as in 1996 but was checked daily from March 5 through October 1. Again, total and fork lengths were measured for all bull trout.

During 1998, the trap was operated from January 20 to June 30. Due to poor sampling results in 1996 and 1997, the trap was moved downstream approximately 100-400 m to an area that had lower water velocity. The trap was periodically moved short distances within this area to adjust for changes in reservoir elevation and associated water velocity. The trap was operated 5 days per week. Total length, fork length, weight (to the nearest 2 g), and scales were collected from all bull trout ≥ 75 mm. Only length was recorded for bull trout < 75 mm.

1999–2002

Starting with the 1999 sampling period, January 6 through June 6, the trap was move upstream and operated at Monty Campground, which is 1.8 km upstream of Lake Billy Chinook (Figure 1). This location was chosen to increase and improve trap efficiencies and to eliminate the need to move the trap due to reservoir level fluctuation. Also, the consistency of catch would make comparisons among subsequent years more meaningful. The trap was operated 7 days per week. In 1999, total length, weight, and scales were collected from all bull trout ≥ 75 mm. Bull trout < 75 mm only had total length recorded.

During the 2000 sampling period, the trap was operated daily from January 5 through June 16 at the Monty Campground site. Total length and weight (to the nearest 0.1 g) were measured for all bull trout ≥ 75 mm. Only length was measured for bull trout < 75 mm.

During the 2001 sampling period, the trap was operated from March 5 through June 22 five days per week. All bull trout ≥ 75 mm were measured for total length and weighed (to the nearest 0.1 g). Periodically, bull trout < 75 mm were weighed in groups and the weight was divided by the number of bull trout in the group to calculate a mean individual weight.

From October 18 to November 27, 2001, the trap was operated to capture juvenile chinook salmon for a study comparing hatchery and wild chinook (Reisenbichler and Drake 2001). There were 73 juvenile bull trout captured during this two-month period. In conjunction with this study, two additional 1.5-m screw traps were operated by the U.S. Geological Survey (USGS) at

the Gorge Campground at km 40.5 from January 22, 2001 to May 5, 2002. The bull trout data from these 2 traps are also summarized in this report.

During 2002, the screw trap was operated daily from February 7 to June 7 at the Monty Campground site. The trap was not operated for 7 days during a high water event from April 13 to the 19. Length and weight data were collected as before.

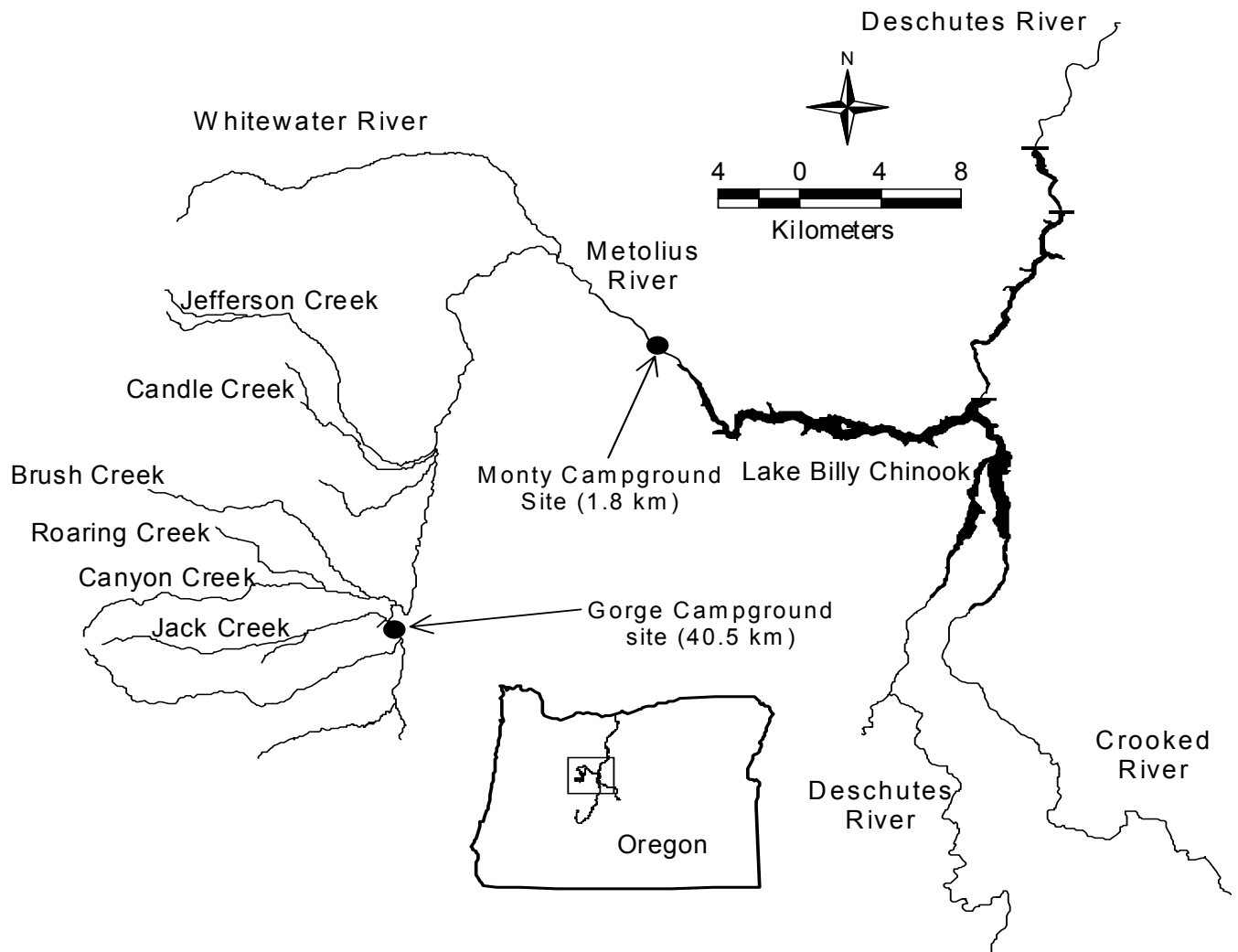


Figure 1. Locations of screw traps that were operated in the Metolius River to capture juvenile bull trout.

Immigration Estimates for 1999–2002

Immigration of age 1 and older bull trout was estimated during 1999 to 2002. Bull trout fry were not estimated because of the difficulty in marking large numbers. Trap efficiencies were estimated by marking, releasing, and later recapturing the marked fish in the trap. Bull trout were marked by partially clipping a fin, and a different fin clip was used each week. The fish were transported upstream of the trap approximately 400 m and released. Marked fish were noted on subsequent trap checks. Weekly trap efficiencies were calculated by dividing the number of recaptured fish by the number of marked fish. The weekly immigration estimate was calculated by taking the total number of bull trout for a week, minus the weekly recaptured fish, and dividing by the weekly trap efficiency. Weekly immigration estimates were expanded to include the days the trap was not operated. For weeks that a trap efficiency could not be calculated, the trap efficiency for the week before and after were averaged. If interpolation was not sufficient, than each year's mean trap efficiency was used. The total immigration during a trapping period was estimated by summing each week's estimate.

RESULTS

Immigration Timing

During 1996, high velocities through the trap were believed to allow bull trout to escape, and only 6 fish were captured between June and late October. The data for 1996 were omitted from all figures due to the small sample size and possible bias.

In 1997, bull trout catch steadily increased from mid-March to a peak in mid-April at 3.25 bull trout per day (Figure 2). The catch then slowly decreased until the end of May and leveled off at around 1 bull trout per day until trapping was completed in late September. In 1998, catch peaked at 5.6 bull trout per day during late March through early April (Figure 2). Catch rates declined throughout the summer. The last week before the trap was pulled, there was a slight increase of bull trout catch. In 1999, the trap catch increased steadily from mid-January, when trapping first began, to mid-March with a high of 11.7 bull trout per day (Figure 2). The peak continued through the first of May and then decreased to less than 4.4 fish per day for the remainder of the sampling period (Figure 2). During 2000, the catch increased from the middle

of March to the middle of April (Figure 2). The highest daily catch was 17.1 bull trout per day and was recorded in early April. The lowest catch per day was 0.75 bull trout in mid-June (Figure 2). In 2001, catch increased to over 20 bull trout per day from mid-March through April into the first week of May (Figure 2). For the remainder of the trapping period the catch remained below 10 fish per day. During 2002, the timing distribution was strongly bimodal with a peak about mid-March and mid-April (Figure 2). Overall, however, the general pattern of bull trout immigrating to Lake Billy Chinook was similar to previous year.

In 1996, age 0 bull trout were first captured in mid-August. In 1997, the age 0 bull trout were captured from May through August. The majority of age 1 and older bull trout were captured between early March through mid-May (Figure 3). During 1998, age 1 and older bull trout were captured from mid-January through April. From April through June all ages of immigrating bull trout were captured. In 1999 and 2000, all ages of immigrating bull trout were captured throughout the sampling period (Figure 3). The percent of age 0 has varied over the last several years. During 1999, 2000, 2001, and 2002, the percent of age 0 in the total catch was 31%, 54%, 87%, and 70%, respectively.

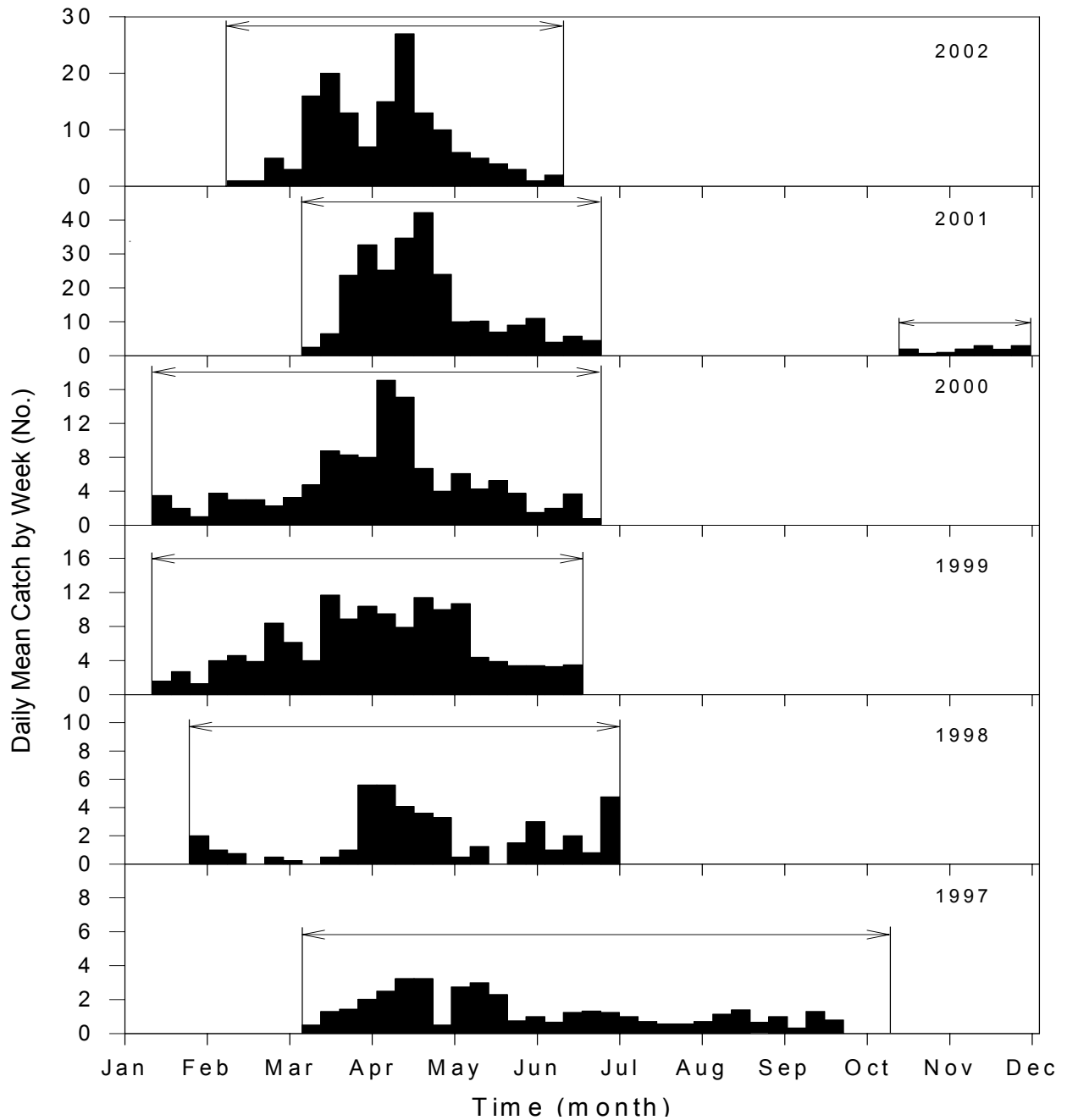


Figure 2. Estimated daily mean catch, by week, of all bull trout captured from the Metolius River 1997–2002. Arrowed lines indicate periods of trap operation.

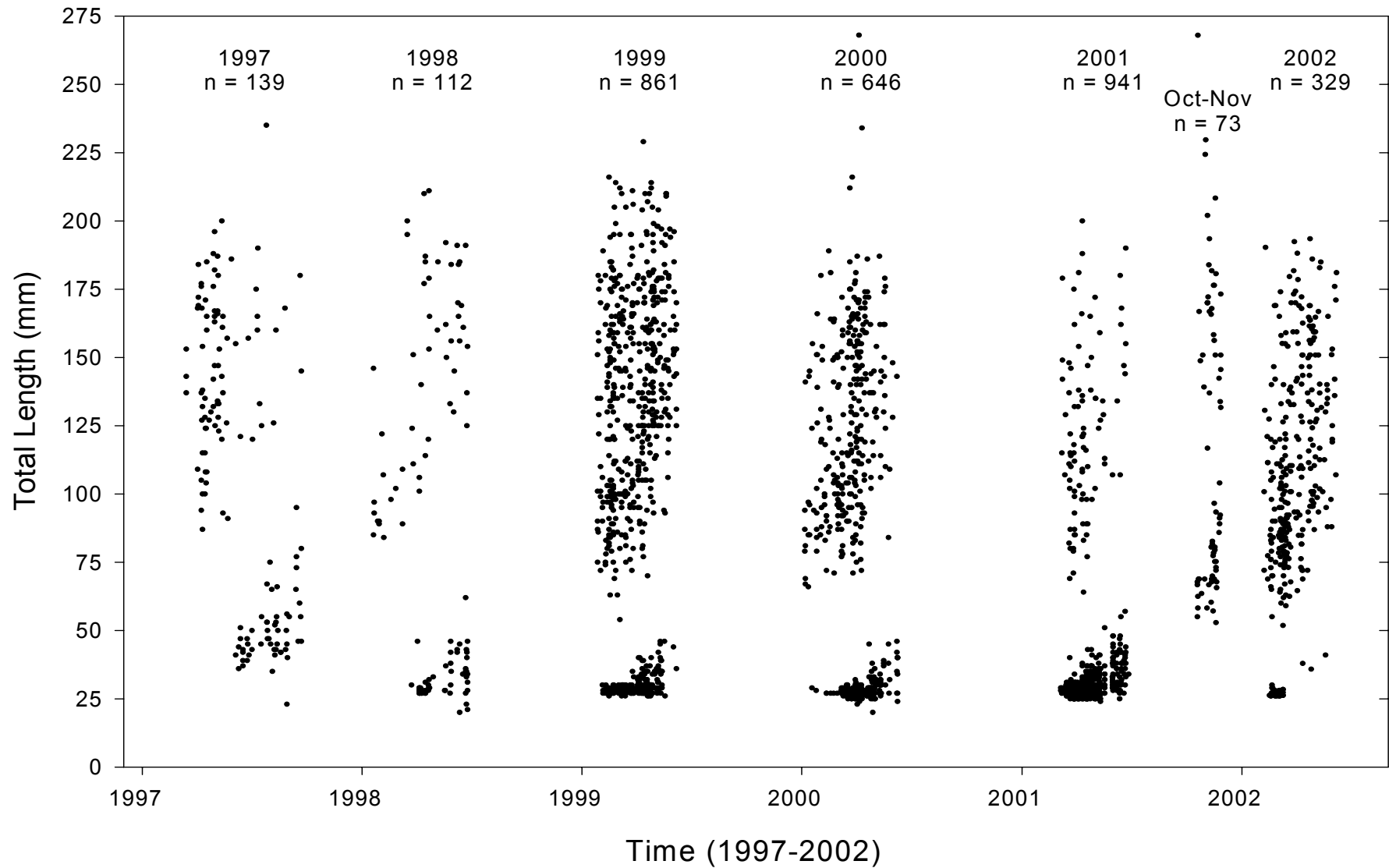


Figure 3. Total length of individual bull trout that were measured at time of capture in a screw trap from the Metolius River from 1997 to 2002.

Immigration Estimates for 1999–2002

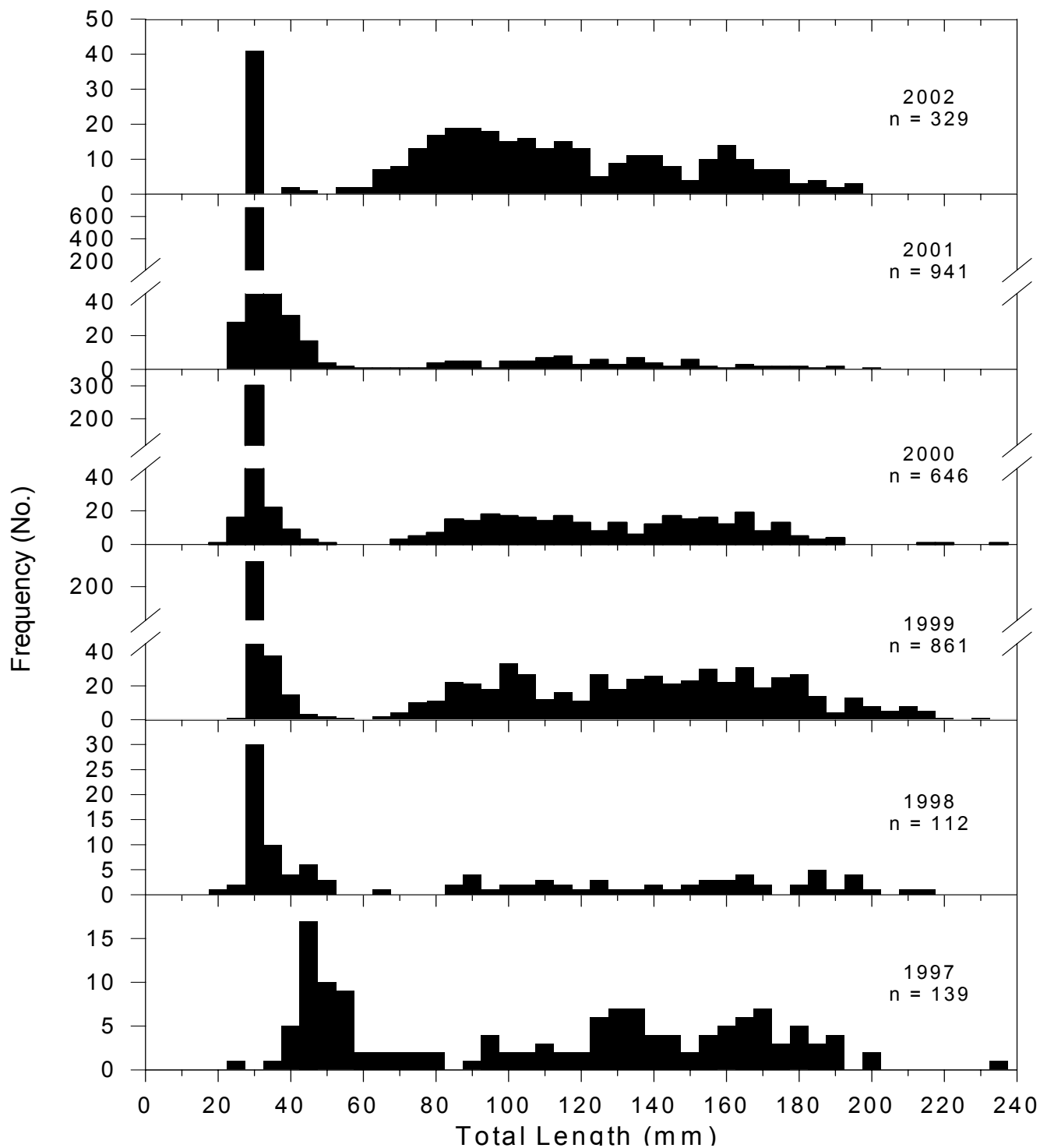
Total estimated bull trout immigration for 1999 bull trout ≥ 60 mm from January 11 through June 7 was 6,354. The highest trap efficiency during 1999 was for the week of March 8th at 16.7%, and the lowest was 4.5% during the week of February 22. The 1999 mean trap efficiency was 11.4%. During 2000, the immigration estimate of bull trout ≥ 60 mm from January 5 through June 16 was 2,824. Trap efficiencies could only be calculated for three separate weeks due to low a low number of bull trout marked and recaptured. The mean trap efficiency for 2000 was 15%. The immigration estimate for bull trout ≥ 60 mm from March 5th to June 24th was 1,251. During 2001, no reliable trap efficiencies could be obtained, so the mean trap efficiency of 13.2% for 1999 and 2000 was used. During the 2002 trapping period, February 7th to June 7th, the immigration estimate was 2,028 bull trout ≥ 60 mm. Only 4 weeks provided useable trap efficiencies, and the remaining weeks were estimated by using the 1999-2002 mean trap efficiency of 16%.

Length-Frequency Distributions

Ages of juvenile bull trout were estimated using length-frequency analysis (Figure 4). In 1996, the range of total lengths were from 45 to 170 mm. The size at age for bull trout captured in 1996 was not determined due to a small sample size. In 1997, the range for age 0 was 25 to 85 mm; age 1 was 90 to 150 mm; and age 2 and older was 151 mm and larger. In 1998, the range for age 0 was 20 to 65mm; age 1 was 85 to 135 mm; and age 2 and older was 136 mm and larger. In 1999, the range for age 0 was 25 to 55 mm; age 1 was 65 to 120 mm; and age 2 and older was 121 mm and larger. Some of the bull trout larger than about 190 mm were likely 3-year-old fish. For 2000 the age 0 ranged from 25 to 50 mm; age 1 was 70 to 135 mm; and age 2 and older was 136 mm and larger. During 2001, age 0 ranged from 25 to 60 mm; age 1 was 70 to 135 mm; and age 2 and older was 136 mm and larger. For 2002, age 0 ranged from 30 to 45 mm; age 1 ranged from 55 to 130 mm; and age 2 and older was 130 mm and larger. Laboratory analysis of scales collected during 1999 were conducted to support age class verification, but were inconclusive because of a small sample size of readable scales (Pratt 2000).

Weight-length data for the years 1998-2002 were combined for all bull trout (Figure 5). Total lengths ranged from 24 mm to 270 mm and weight from 0.2 g to 170 g.

Figure 4. Length-frequency distributions of bull trout captured in a screw trap from the Metolius River, 1997–2002.



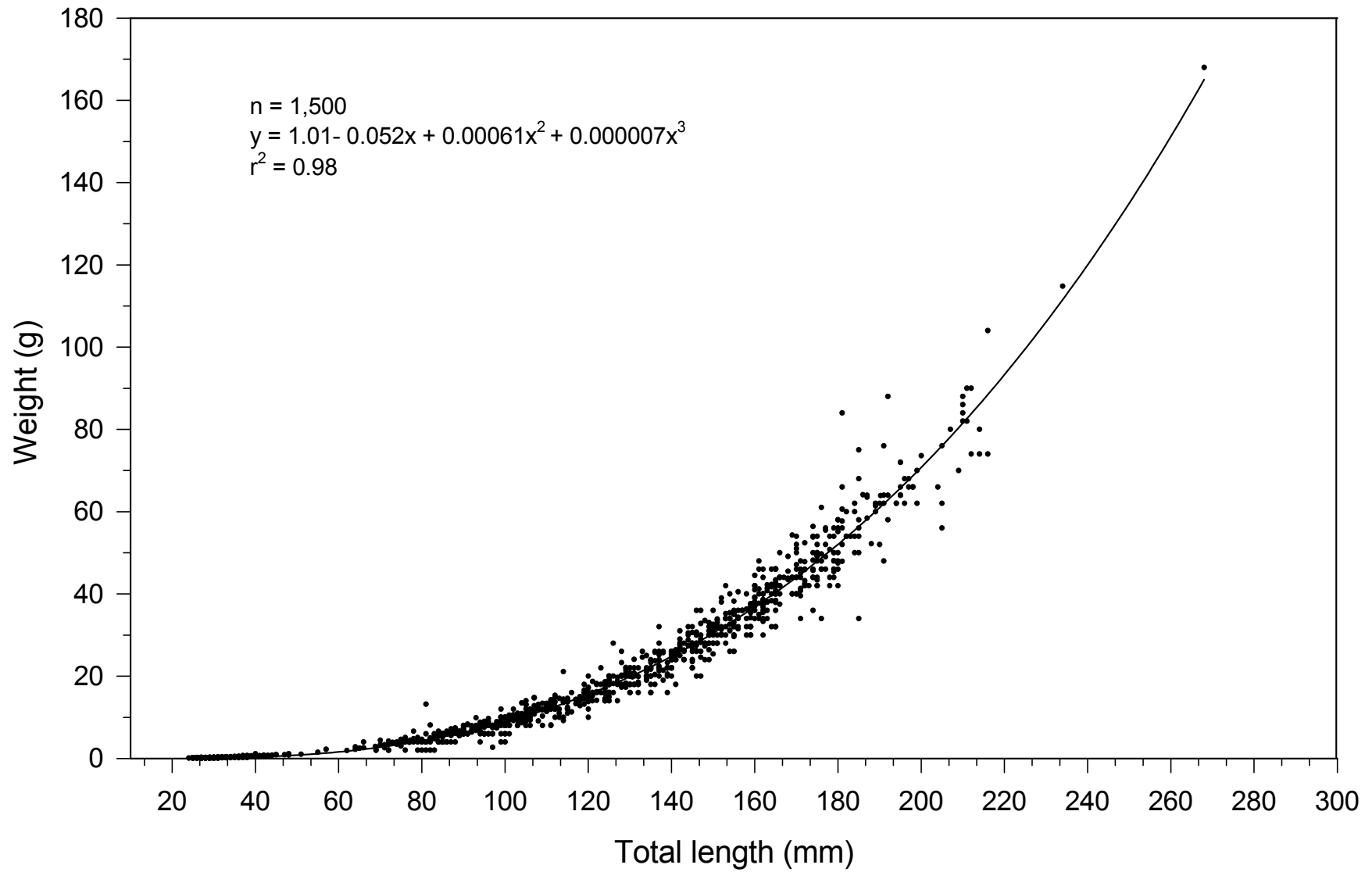


Figure 5. Weight-length relation of bull captured from a screw trap in the Metolius River, 1996–2002.

In-River Growth

The growth rates for the year classes 1996 through 2001 at first glance appeared to be very similar for the first three age classes (Figure 6). Mean length of age 1 bull trout was about 110 mm and 160 mm for age 2. Including all years, the mean growth rate during their first year is about 80 mm and about 50 mm during their second year. By looking at mean length of multiple age class among several years, some trends are evident (Figure 7). There has been a significant decrease in the mean length of age 1 and 2 bull trout immigrating to Lake Billy Chinook from 1997 to 2002. Age 1 bull trout mean length have decreased about 30 mm since 1997 ($p = 0.04$, $r^2 = 0.69$, linear regression). Age 2 bull trout have decreased about 20 mm in length over the same time period ($p = 0.01$, $r^2 = 0.81$, linear regression). Over the same time period the number of bull trout redds counted in the upper Metolius River has increased by about 600 (Wise 2002).

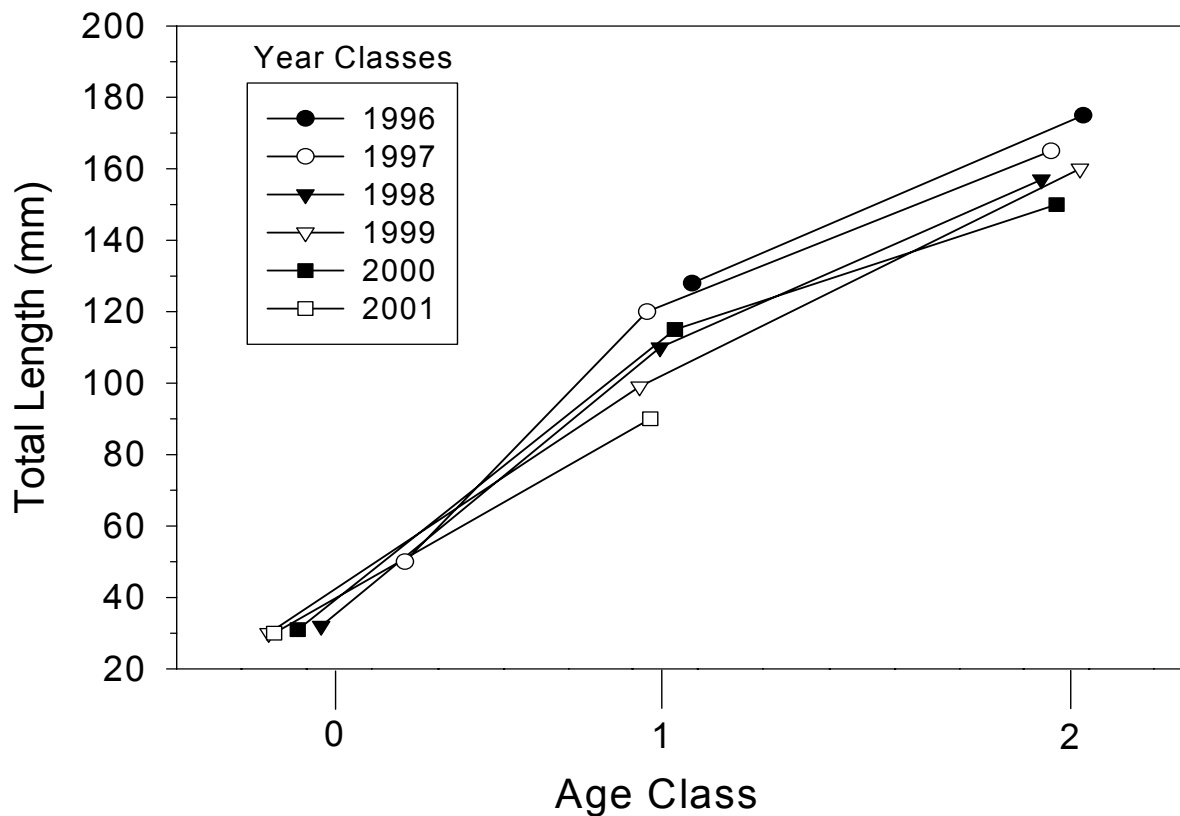


Figure 6. Growth of six year classes (1996–2001) for part or all of their first three years.

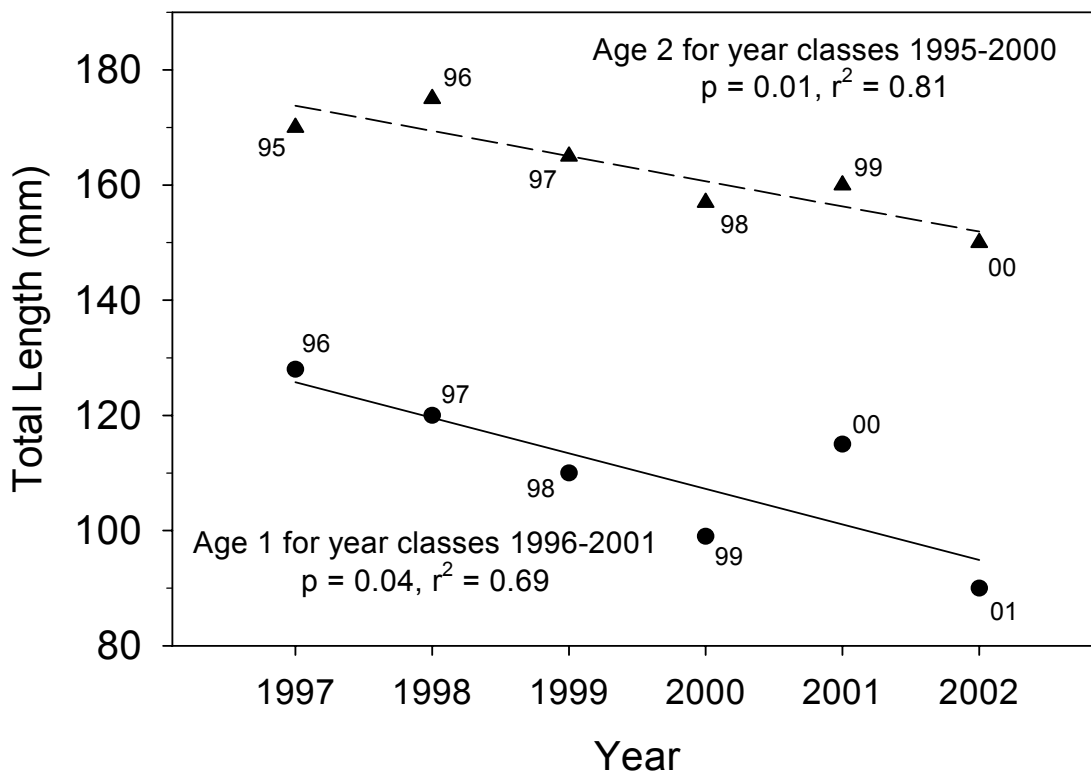


Figure 7. Mean total length of ages 1 and 2 bull trout captured in a screw trap from the lower Metolius River, 1997–2002.

Relation of Redd Numbers to Subsequent Fry Immigration

The estimated number of total age 0 bull trout captured during March and April was compared with each respective brood year for the year classes 1999 through 2002 (Figure 8). After the highest recorded number of redds in 2001 yielded a smaller number of age 0 bull trout in 2002, the pattern appeared to fit the classical Ricker stock-recruitment model. There was a decrease in age 0 immigration of about 50% from 2001 to 2002, however, there was an increase of about 40% in redd counts between the two respective brood years (Wise 2002).

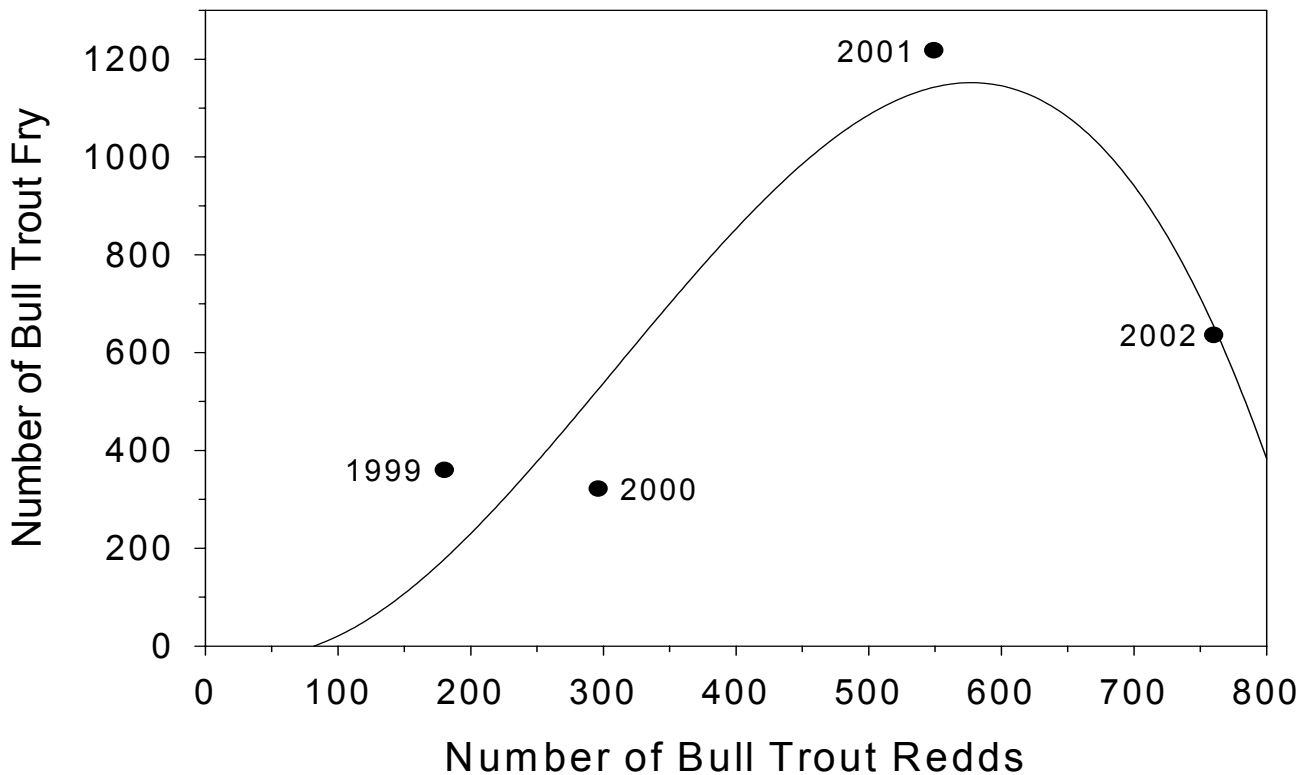


Figure 8 . Relation of bull trout fry captured in a screw trap in the lower Metolius River and the number of bull trout redds counted in the upper Metolius River.

Gorge Campground Catch

There were a total of 123 juvenile bull trout captured in the two screw at Gorge Campground during the approximately 15 months they operated (January 2001 – May 2003). From January through April 2001, bull trout primarily from 150 mm to 250 mm were captured (Figure 10). (All lengths of bull trout captured at Gorge Campground were measured as fork lengths. By using data from 1997 through 1999, a relation between total and fork length was developed (Figure 9), and all fork length measurements were converted accordingly.) Beginning in May, bull trout fry as small as 40 mm were captured. This cohort of bull trout appeared to be captured for the remainder of trapping period, as indicated by dashed lines in Figure 10. Another cohort began to be captured in March of 2002 and was evident into May when the traps were removed. Individuals from this cohort were first captured about 2 months earlier than the previous year and were about 10 mm shorter. There were 2 bull trout larger than 350 mm captured in mid-October of 2001 that could have been post-spawning fish moving back downstream.

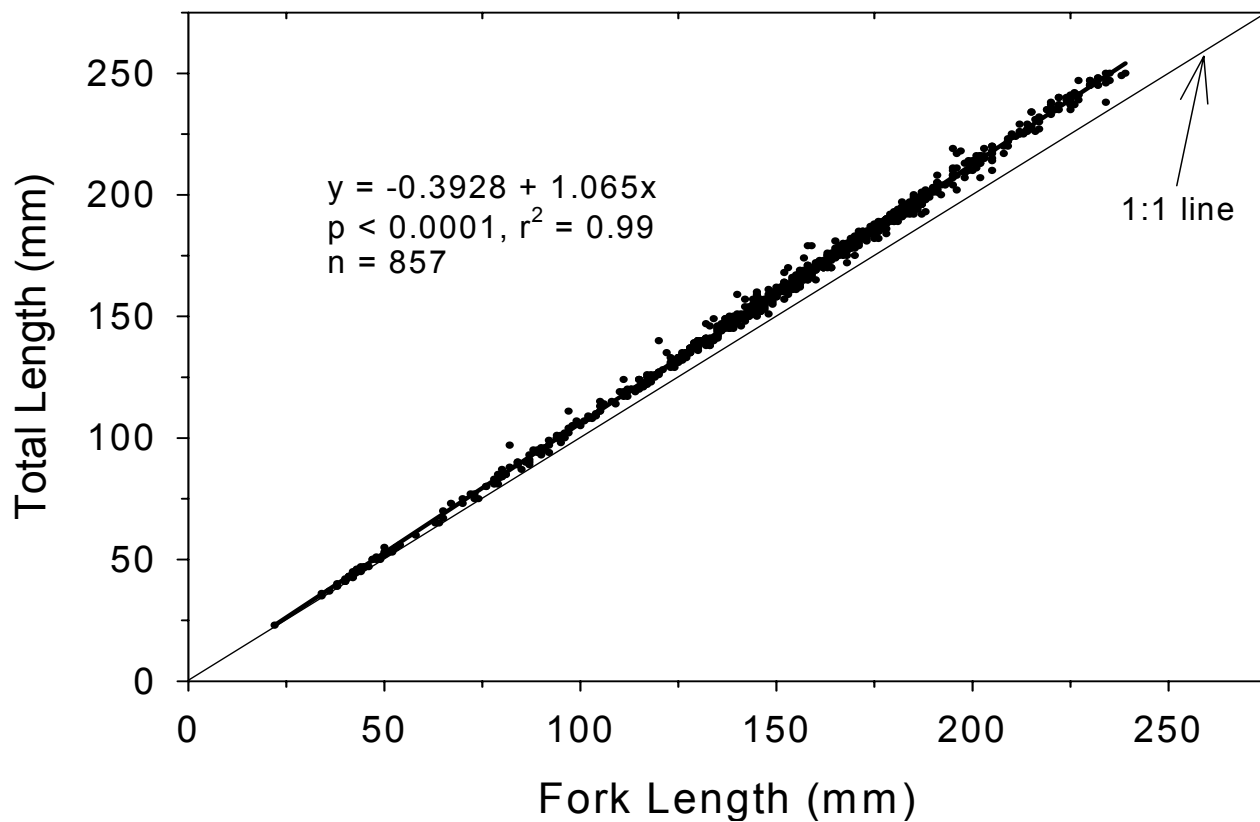


Figure 9. Linear regression of total length and fork length of bull trout captured in screw, Merwin or Humphrey traps in the Metolius River Basin, 1997-1999.

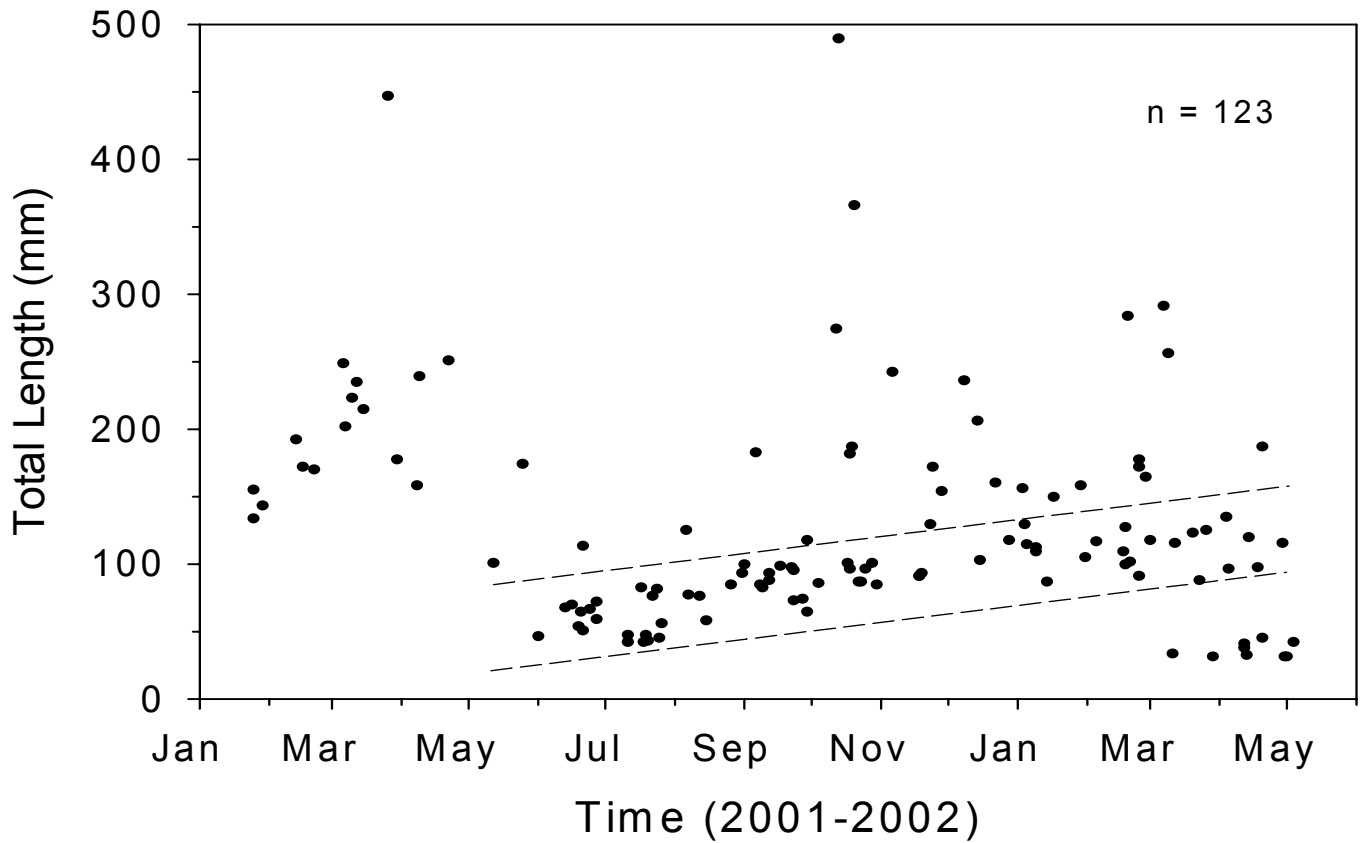


Figure 10. Total length of individual bull trout captured in screw traps at Gorge Campground on the Metolius River at km 40.5, 2001-2002. Diagonal dashed lines indicate generalized growth patterns of 2001 year class.

DISCUSSION

Immigration Timing

Ratliff et al. (1996) found that most juvenile bull trout appear to migrate from Jack Creek, in the upper Metolius River, during May and June. Results from this study indicate immigration to Lake Billy Chinook starts earlier. The primary immigration period can be best described as occurring from February through May. Most of the bull trout were captured during March and April, and the peak catch usually occurred during the first part of April (Figure 2). The difference in timing might be related to where the bull trout were emigrating. From. In other words, the bull trout captured from the mouth of Jack Creek were moving out of a spawning and rearing tributary and their destination was unknown. These fish could be residing in the Metolius River and rearing before ultimately immigrating to Lake Billy Chinook. The bull trout captured just upstream of Lake Billy Chinook represent fish that probably originated not only from spawning tributaries but also bull trout that had been rearing in the Metolius River. It appears that some bull trout immigrate to Lake Billy Chinook throughout the year. During the 7 years the screw trap has been operated, bull trout were captured January through November. December was the only month the screw trap has not been operated, and it seems likely that bull trout would be immigrating to Lake Billy Chinook during that month as well.

Length-Frequency Distributions

Bull trout size-at-age data presented in this report are slightly larger than what Ratliff et al. (1996) presented. Ratliff et al. (1996) captured bull trout in Jack Creek, which is approximately 36 km upstream of the screw trap location for this study. The differences can most likely be attributed to growth that occurred during rearing and movement down the Metolius River. The length data from the screw trap shows variation among years with respect to age class. The age classes undoubtedly overlap each other to some extent. The ages were to be verified with scale samples and back-calculated length during 1999; however, the sample size of readable scales was not large enough to be conclusive (Pratt 2000). Any future efforts to validate age using scales should increase the sample size so that more readable scales can be analyzed.

Traditional length-frequency analysis is of limited use in situations, such as this one, where the trapping period is long enough in duration so that significant growth of the target fish occurs. The growth of cohorts makes the already overlapping distributions even more difficult to identify. A slightly more sophisticated analysis could improve the discrimination of cohorts by fitting a line or curve between cohorts that maximizes the residuals. This was done for the cohort growth analysis, but discrimination lines were fitted by eye. Plans to develop a statistical method to maximize residuals are intended for future work of this nature.

Immigration Estimates for 1999–2002

The 1999 and 2000 juvenile immigration estimates of about 6,400 and 2,800 bull trout, respectively, seem reasonably accurate reflections of actual trends even after accounting for different trap efficiencies and the presence of 3-year-old bull trout during 1999. Ratliff et al. (1996) estimated approximately 2,000 age 1 and older bull trout emigrating from Jack Creek between April and October. Jack Creek represents about 24% of the total bull trout spawning in the upper Metolius River. Beauchamp and Van Tassell (2001) back calculated age-specific abundance for combined ages 1 and 2 bull trout based on 1993 and 1994 spawner surveys and estimated about 11,000 and 26,000 bull trout, respectively. If the 1999 and 2000 immigration estimates were extrapolated according to patterns observed among all 7 years, the annual immigration estimates could plausibly approach 10,000-15,000 per year. The substantially lower recruitment estimate of about 1,300 for 2001 does appear to be an actual decrease and not just the result of a short trapping period. The reduction is apparent in both the ages 1 and 2 bull trout. The 2002 immigration estimate of about 2,000 was up from 2001. There appears to be a cycle of ages 1 and 2 immigration that is not directly related to number of each respective brood size. There is probably a complex density-dependent interaction among the in-river cohorts with regard to cannibalism and competition for food and space that drives the observed immigration to Lake Billy Chinook.

Ratliff et al. (1996) estimated that 19% of the fish emigrating from Jack Creek were age 0; however, the percentage of age 0 bull trout captured in the lower Metolius River site ranged from 31 to 87%. The mesh size of the Jack Creek juvenile trap was about 6 mm (M. D. Riehle, US Forest Service, personal communication), and the mesh size on the screw trap on the lower

Metolius River was about 3 mm. The smaller mesh size likely accounts for some the proportional increase of age 0 bull trout catch. Their trapping period did not begin until April, which could also account for some of the difference since March is significant month during immigration. The recruitment of age 0 bull trout to Lake Billy Chinook appears to be larger than previously thought. It is generally believed that these fish have a higher mortality rate and contribute little, if any, to the spawning population. Analysis of scale and otolith growth patterns, to determine at what age the transition between slow and fast summer growth occurs (Stelfox 1997), would help determine the relative survival of all recruits that make it to Lake Billy Chinook.

The significant decrease in length of ages 1 and 2 bull trout captured in the screw trap seems to further support the conclusion that significant density-dependent effects are occurring as this bull trout population increases. This interaction is probably operating on a longer time scale than the cyclic immigration trends. For example, during 1990 and 2000 there were large numbers of ages 1 and 2 bull trout immigrating to Lake Billy Chinook (Figure 3). This large immigration probably made available more rearing habitat in the Metolius River, and as a result, the length of ages 1 and 2 fish showed a corresponding increase during 2001 (Figure 7). However, the 6-year decreasing trend of length continued during 2002. It was not until the highest recorded number of redds (i.e., highest number of spawning adults) in 2001 that density-dependent effects appeared (Figure 8). The typical reasons cited for such a stock-recruitment pattern are density-dependent transmission of diseases, decreased egg survival because of redd superimposition, and cannibalism by adults (Haddon 2001). Bull trout have a high degree of resistance to several diseases (Engelking 1999), so this density-dependent factor is probably not a primary regulator. Redd superimposition has not been implicated as a potential problem with bull trout in the Metolius River. The increasing number of adult spawners are probably expanding and spawning in less than optimal areas, which would just decrease the incremental increase of recruitment and not decrease the absolute recruitment. Cannibalism by older juveniles, but not by adults, would seem more likely to be primary regulator given bull trout piscivorous feeding habits. Cannibalism by ages 1 and 2 might be the primary in-river regulator of the age 0 bull trout at higher densities. The mechanism might be that as the in-river population increases over a period of years, the cannibalism also increases to the point that it actually decreases the recruitment.

Beauchamp and Van Tassel (2001) found that cannibalism and prey supply are potentially important factors that regulate the older bull trout in Lake Billy Chinook.

Prior to 2002, no bull trout redds had been documented upstream of the Gorge Campground. Even though no bull trout redds were observed upstream of Gorge Campground during 2000 or 2001, there was most likely at least one that went undiscovered each year as indicated by the length and growth pattern of age 0 bull trout captured at the Gorge Campground site. As the adult population has continued to increase, the spawning observed upstream of Gorge Campground is probably a result of population pressure causing adult bull trout to expand their range and find new spawning habitat.

Population data from juvenile bull trout captured emigrating from the Metolius River would suggest that the population has exceeded the carrying capacity. This could have implications with regard to anadromous fish reintroduction. If bull trout densities are high enough to regulate their own population through cannibalism, then these large numbers of juvenile bull trout might be a key factor controlling the ultimate success of reintroduction. The implications of bull trout adversely affecting anadromous reintroduction will also depend on the relative size of predator and prey, spatial and temporal overlap, and environmental conditions (Beauchamp and Van Tassel 2001). Further work to determine the overall significance of bull trout on anadromous reintroduction would be prudent considering the implications. A thorough survey of juvenile distribution in the Metolius River would identify areas of predator and prey overlap. Sampling of juvenile diet in the Metolius River could help understand potential predation rates (Beauchamp and Van Tassel 2001). Ultimately, the development of a population level model would be useful to incorporate key parameters and variables to better understand and describe the dynamics of this important bull trout population.

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