Population Characteristics of Jenny Creek Suckers (*Catostomus rimiculus*): Age-Size Relationships, Age Distribution, Apparent Densities, and Management Implications

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Abstract: Jenny Creek suckers (*Catostomus rimiculus*) are an isolated population of Klamath smallscale suckers, separated from the Klamath River by a large, natural waterfall. We compared growth rates between the Jenny Creek and Klamath River populations, ageing fish by counting opercle annuli. The growth rate of the Klamath River fish was slightly but significantly higher ($p<0.05$) than that of the Jenny Creek fish during the first year of growth. By age five, the growth rate of the Klamath fish was over three times faster than the Jenny Creek fish ($p<0.001$). Same-sized individuals of different ages indicated that growth rates varied for individuals within each population. Regardless, our length-age regressions for each population were strong ($R^2 = 0.8687$ for Klamath and 0.8061 for Jenny Creek, respectively). The oldest Klamath fish was aged at 17 years (391 mm SL). The largest Jenny Creek fish (141 mm SL) was aged at 5 years; however, fish > 141 mm SL were not sampled.

We then took our age-length regression and applied it to four summers of snorkeling population data for the Jenny Creek sucker. Larval recruitment was strong in three of the four sample years. Other population data were troubling: unlike 1992 and 1993, the 2003 and 2004 surveys found almost no adult Jenny Creek suckers. Our data do not explain why this pattern is present. Adult mortality, movement into non-sampled areas, or migration out of the system may all be causes. An isolated population like the Jenny Creek sucker depends entirely on larval recruitment to sustain densities. There is some potential that the Jenny Creek sucker population could suffer setbacks without thoughtful management of Jenny Creek watershed.

Introduction

Klamath smallscale suckers (*Catostomus rimiculus*) are widespread throughout the Rogue, Klamath and Smith River systems of southern Oregon and northern California. Jenny Creek suckers are a *C. rimiculus* population isolated in the 546 km^2 Jenny Creek watershed by a natural 10 m waterfall. Although not considered a subspecies (Harris and Currens 1993), the Jenny Creek sucker is a federal "special

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status" population and is classified as "sensitive" by the state of Oregon due to its limited distribution.

C. rimiculus is considered a "typical" sucker, with a life history most likely similar to other members of the genus (Moyle 2002). Moyle (2002), however, states that "this species is overdue for an extensive study of its life history, ecology, and taxonomy." The isolated Jenny Creek population has been described as dwarfed (Hohler 1981), although this was not confirmed by age and growth analysis. To date, there have been no detailed life history studies of *C. rimiculus* and specifically no analyses of the life history of the Jenny Creek population. Previous studies (Hohler 1981, Rossa 1999) suggest that this population may share certain life history traits with other *Catostomus* species inhabiting small streams in western North America, such as the Modoc (*C. microps*; Moyle and Marciochi 1975), Santa Ana (*C. santaanae*; Greenfield et al. 1970), and Salish (*C. sp*.; Pearson and Healey 2003) suckers. These traits include slow growth, small body size at maturity (e.g. <120mm SL), and a short life span.

Major portions of the Jenny Creek watershed are within, or adjacent to, the Cascade-Siskiyou National Monument (CSNM), established in 2000 by Presidential proclamation. The CSNM is managed by the Bureau of Land Management to conserve the "exceptional biological diversity" of the region. In particular, the Jenny Creek portion of the monument was recognized in part because it is home to three long-isolated endemic fishes (Office of White House Press Secretary 2000). The proclamation establishing the Monument charges the Bureau of Land Management to study impacts of livestock grazing on the CSNM's objects of biological interest. Although this paper does not address livestock grazing specifically, it provides crucial distribution and life history information necessary for investigating grazing impacts on one of the endemic fish. Both authors have been studying Jenny Creek sucker life history and ecology for some years, under a variety of cooperative and solo investigations. Here we report those results pertaining to the life history and population structure of the Jenny Creek sucker.

Study Site

Jenny Creek flows through a volcanic plateau in the southern Cascade Mountains. It empties into Irongate Reservoir, at river mile 190 on the upper Klamath River (Fig. 1). A natural waterfall approximately 2.5 miles from the mouth of Jenny Creek blocks upstream fish movement from the reservoir and river into the Jenny Creek basin. Three major tributaries, Keene, Corral, and Beaver Creeks, drain the west side of the watershed and one tributary, Johnson Creek, drains the east side. Other tributaries are either small, spring-fed systems or seasonally dry.

The native fish assemblage above the falls includes the Jenny Creek sucker, redband trout (*Oncorhynchus mykiss* ssp.), and speckled dace (*Rhinichthys osculus*). Four reservoirs in the Jenny Creek watershed contain exotic species, including golden shiners (*Notemigonus crysoleucas*) and bullhead (Ictaluridae). These fishes occasionally escape into Jenny Creek but stream population densities appear to be low (Rossa, unpublished data). State stocking programs have also introduced hatchery rainbow trout (*O. mykiss*).

Flows in the lower reaches of Jenny Creek typically range from 0.5 m^3/s in the summer to 23-30 m^3/s for bankfull flows (Rossa 1999). Precipitation ranges from over 100 cm per year in the upper watershed to approximately 57 cm per year in the lower watershed (USDI BLM 1995). Most of the precipitation falls as snow. The four reservoirs divert mainstem and tributary water into a canal system that removes approximately 30% of mean annual water yield from the basin (USDI BLM 1995). Water is only released over the dams when the reservoirs are full.

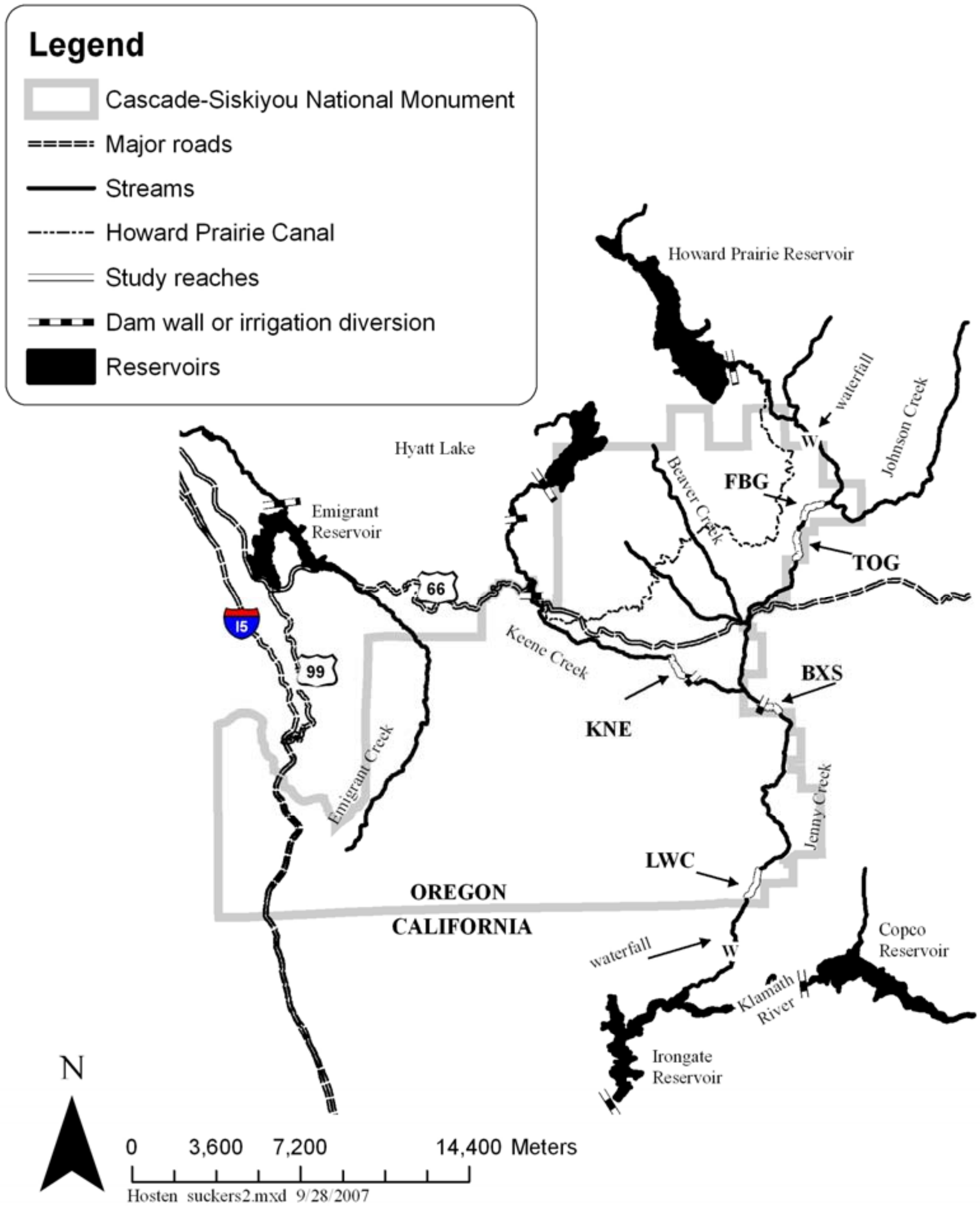

Figure 1: Map of Jenny Creek (with study reaches) in relation to the Klamath River, the Cascade-Siskiyou National Monument, and Interstate-5. The Klamath River flows east to west.

Jenny Creek flows through alternating wide, formerly beaver-dominated meadows and narrow, rocky canyons. Most of the riparian forests have been logged, and meadow habitat has been grazed since the 1850's (Hosten and Whitridge in prep.). One former ranch with a 2 ½ mile long stretch of mainstem Jenny Creek is now managed by the Bureau of Land Management and not currently grazed. Riparian areas in the upper half of the watershed are dominated by Douglas-fir (*Pseudotsuga mensezii*), red alder (*Alnus rubra*) and willow (*Salix spp*.). Riparian areas in the lower half are narrow and dominated by Ponderosa pine (*Pinus ponderosa*), Oregon ash (*Fraxinus latifolia*) and willow.

METHODS

Fish growth

Jenny Creek suckers used for growth and age analyses were collected from mainstem Jenny Creek on September 22, 2004 with a Smith Root Model 12A backpack electrofisher. By mid-October, water temperatures have cooled substantially and it is difficult to collect suckers (Rossa 1999); therefore, fish sampled in late September provide a fairly good approximation of the end of a year's growth. Due to the late sample date, fish were only collected from one site: the "south, or lower, crossing" located where Agate Flat road crosses Jenny Creek between Oregon Gulch and Skookum Creek (T41S-R4E-Sec.9NW). The Oregon Department of Fish and Wildlife (ODFW) collected the Klamath River *C. rimiculus* from the "peaking flow reach," approximately 25 miles above Irongate Reservoir, on July 21, 2004, using a Smith Root Drift Boat electrofisher. The two-mile sampling stretch (river mile 214 – 216) started at latitude 42.03358 and longitude 122.05311 and ended at latitude 42.02579 and longitude 122.10245. Suckers were euthanized using MS222 (tricaine) following ODFW euthanization protocol (S. Jacobs, Fish Biologist, ODFW, personal communication).

To examine growth patterns, we regressed fork length against annular count on opercle bones, following procedures described by Scoppettone (1988). Fish fork lengths (FL) and weights were measured in the field before transporting the fish on ice. Annuli were identified as bands of calcium-rich clear bone deposited during periods of slow winter growth, interspersed between bands of protein-rich opaque bone deposited during faster spring-summer growth. Measurements of annuli distances and opercle lengths (to nearest 0.01 mm) were taken directly from opercle bones using a dissecting microscope fitted with a calibrated ocular micrometer. Additional opercle processing and examination details can also be found in Parker and Call (2006).

Population distribution

Jenny Creek sucker population data were collected as part of a larger, multi-scale sucker habitat study (Rossa 1999, Rossa in prep.). Sampling was based on a hierarchical design in which five study reaches located in different parts of the watershed contained nested geomorphic habitat units (Fig. 1) (Frissell et al. 1986; Kershner and Snider 1992; Hawkins et al. 1993). This was done, in part, because preliminary data suggested that suckers were not evenly distributed throughout the watershed.

We selected the specific reaches (Fig. 1) to represent the range of gradients, geomorphologies and riparian area types found within the Jenny Creek basin, as follows:

1) Fredenberg Meadows (FBG): a low-gradient meadow with side channels and old beaver dam bed controls;
2) Turtle Old Growth (TOG): moderate-gradient, forested canyon with woody debris controls;
3) Box O – Box D (BXS): low-gradient, wide canyon with bedrock controls just upstream of 2 ½ mile meadow (the former "Box O Ranch");
4) Lower Canyon (LWC): high-gradient, narrow-walled canyon with bedrock and boulder controls and many cascades;
5) Keene Creek (KNE): moderate-gradient, wide, forested, tributary canyon with few bed controls.

Due to restricted access and limited resources, only one tributary (Keene Creek) was included as one of the five study reaches. The other four reaches were distributed along approximately 20 miles of mainstem Jenny Creek. The Lower Canyon and Box O to Box D reaches were 400 to 500 m long. The other three reaches were 800 to 1000 m long. More detailed reach descriptions can be found in Rossa (1999).

We estimated fish abundance by conducting visual counts while snorkeling. Each study reach was divided into smaller habitat units. We classified habitat units into six habitat types: alcoves, glides, pools, riffles, runs, and cascades (Bisson et al. 1982; Hawkins et al. 1993). Habitat types were differentiated primarily on physical attributes of bed dimensions (e.g. depth, bed shape) and flow (velocity). In order to reduce potential interference of the snorkelers on fish behavior, we snorkled units in each habitat type category at fixed intervals throughout the length of the reach after randomly selecting the first sampling unit. We sampled each habitat type in proportion to its abundance, sampling all units of rare habitat types. We counted all fish and visually estimated the standard length (SL) of each fish (sucker, trout, or dace) to the nearest 5 mm. We also estimated fish numbers in each size class for large schools of dace. All snorkeling data were collected between September 8-22 of 1992, August 23 – September 7 (with Keene Creek on July 26) of 1993, and August 9-26 of 2003 and 2004. All units were snorkled between 1000 and 1700 hours when visibility was good. Larval Jenny Creek suckers were easily distinguished from speckled dace. They were often mottled (dark blotches on light); fin position was different; and mouths were more subterminal even at small sizes (e.g. Greenfield et al. 1970; Fuiman and Witman 1979; Snyder and Muth 1988).

We used one or two snorkelers, depending on the width of the stream channel. Snorkelers moved slowly upstream, investigating nooks and crannies; peering under undercut banks, woody debris, large boulders, and grass clumps; and thoroughly searching mats of *Elodea canadensis* (which rarely contained fish). In the largest pools (e.g. 50m long, 8m wide, and 1.5m deep), two surveyors slowly moved up opposite sides of the pool to ensure that small fish in the margins were counted. The snorkeler with the least amount of margin habitat also counted the fish at the head of the pool and using open water.

Although many fish biologists express concern over the use of snorkeling as an accurate sampling method, due to variability in observer ability and inconsistencies in underwater visibility; snorkeling appears to be both efficient and accurate in Jenny Creek. Although each reach had different habitat characteristics, all were relatively free of instream cover and woody debris, compared to other streams in southwest Oregon. These conditions made it relatively easy to observe fish. The channel bottoms in four of the five reaches were dominated by smaller-sized substrates [sand (<0.25 mm) to small cobble (7.1 – 15.0 cm)] (Rossa, unpublished data). The only exception was the cascade-and-pool dominated Lower Canyon reach; however, even here, the boulders served as channel controls, but the actual substrate was usually gravel or small cobble. Snorkelers were all trained by the same person (J. Rossa), using underwater rulers to calibrate magnification error and ensure consistency among observers.

We did not use electroshocking to sample fish because many of the habitat units were too large to effectively sample with this technique (for example, 8m in width x 30 m long x 1.5m deep). In addition, suckers are known to be easily injured by electroshocking (Snyder, D.E. 2003).

Sampling effort varied among years due in part to vagaries of time and budget (Table 1). We also increased sampling effort in 2004 due to concerns that low numbers of medium- and large-sized fish observed in 2003 were a product of too few units snorkeled.

<u>Fork Lengths v. Standard Lengths</u>

The age-growth data are based on fork lengths but the population data are based on standard lengths. In addition, most key literature references used standard lengths. In order to compare the information, we converted our length data for the *C. rimiculus*

Table 1: Percentage of each study reach snorkeled, expressed as percent of total available habitat (m^2) in each study reach.

Reach	Summer 1992	Summer 1993	Summer 2003	Summer 2004
FBG	12%	44%	47%	46%
TOG	23%	21%	51%	56%
BXS	25%	65%	51%	69%
LWC	30%	52%	60%	77%
KNE	51%	22%	66%	47%
All Reaches Combined	**28%**	**39%**	**54%**	**59%**

collected for ageing from fork lengths to standard lengths. We chose to convert the age data because these measurements were taken from collected fish rather than visually estimated and are therefore, more accurate. To convert from fork length to standard length, we used the following formula provided by Dr. Douglas Markle of Oregon State University (personal communication): SL = (FL-1.76375)/1.14189. This formula was calculated from Klamath River and Rogue River *C. rimiculus*. There was no significant difference in the ratios of fork length to total length between those two populations.

RESULTS

Age-Size Relationships

The two *C. rimiculus* populations examined in this study showed marked differences in growth rates and possibly in longevity. The 22 fish from Jenny Creek ranged from 80 - 141 mm SL, all sizes commonly observed when snorkeling. The number of annuli counted ranged from 2 to 5, indicating that the oldest fish in this sample were in their sixth year (age 5+). The length – age regression shows that fish growth was fairly rapid during the first two years but slowed considerably after the second year (Fig. 2). Although the Jenny Creek length - age regression was strongly correlated ($R^2 = 0.8061$), there was considerable overlap in body size among some fish from age classes 2+ to 5+ (Fig. 2). For example: 117 mm, 118 mm, and 115 mm SL suckers were 3+, 4+, and 5+, respectively.

In contrast to the Jenny Creek population, the 61 fish from the upper Klamath River examined in this study ranged in size from 113 - 401 mm SL, with half >300 mm SL. They ranged in age from 2+ (121 mm SL) to 17+ (391 mm SL) years. In this river population, growth was rapid up to age 5+, very slow between 5+ and 10+, and by age

10+ most members of the population achieved maximum body size (Fig. 2). Like the Jenny Creek population, there was considerable overlap in body size despite a strong length – age relationship ($R^2 = 0.8687$). Three different 309 mm SL fish were 6+, 7+, and 9+ years old, respectively. Seven-year old fish ranged in size from 279 – 331 mm SL.

Three Klamath River fish exhibited exterior signs of spawning readiness or completion. A 248 mm SL fish (age 4) exhibited spawning colors and a 302 mm SL fish (age 8) had frayed caudal and dorsal fins, indicative of post-spawning females (Dauble 1980). In addition, a 314 mm SL fish sent to Oregon State University (and

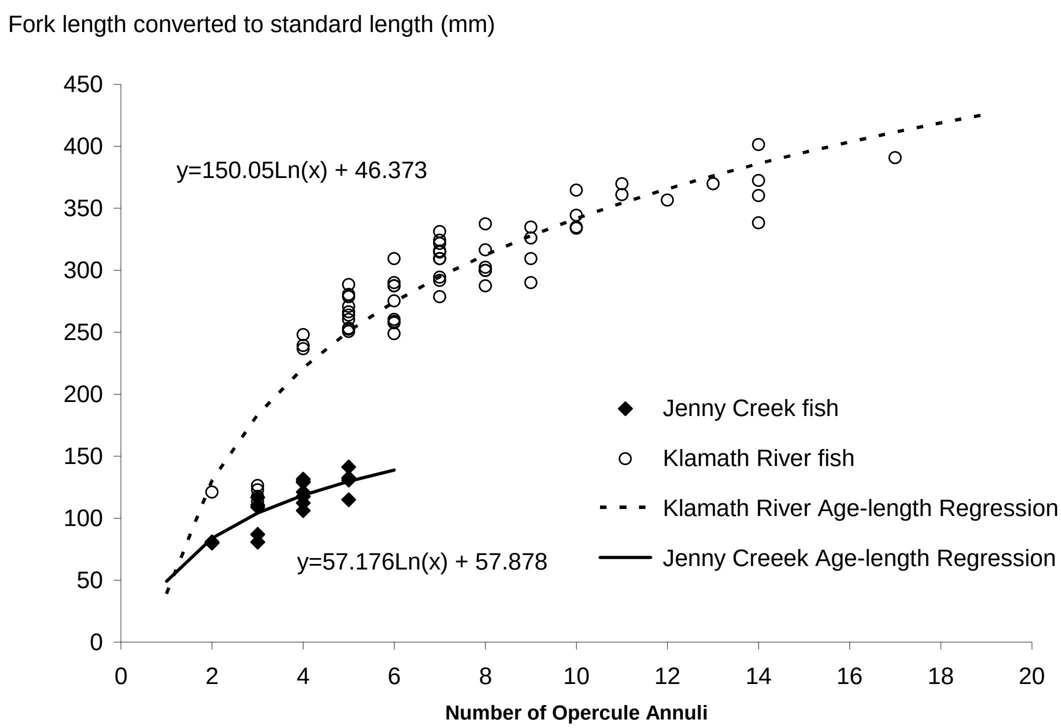

Figure 2: Length-age regression for *C. rimiculus* collected from Jenny Creek on September 22, 2004, and the upper Klamath River on July 21, 2004. Data point for annulus 1 estimated for Jenny Creek population using the Direct Proportion back calculation method (because the regression passed through the origin), and by the Fraser-Lee method for the Klamath population (because the regression had a y-intercept) (Devries and Frie 1986). Lengths originally measured in Fork Length and converted to Standard Length using the following formula from Dr. Douglas Markle, Oregon State University (personal communication): SL = (FL – 1.76375)/1.14189.

therefore, not part of our ageing sample) had some tubercles present. Although three fish do not provide a sufficient sample upon which to base population characteristics, it is apparent that at least some fish were mature by age four.

Comparing the Jenny Creek and Klamath River populations, we found that young-of-the-year growth up through deposition of the first annulus was slightly, but significantly (Mann-Whitney U; $p<0.05$), higher in the upper Klamath River population than in Jenny Creek. By age 5+, body size in the upper Klamath River population was over 3 times greater than that in the Jenny Creek population (Mann-Whitney U; $p<0.001$) (Fig. 3).

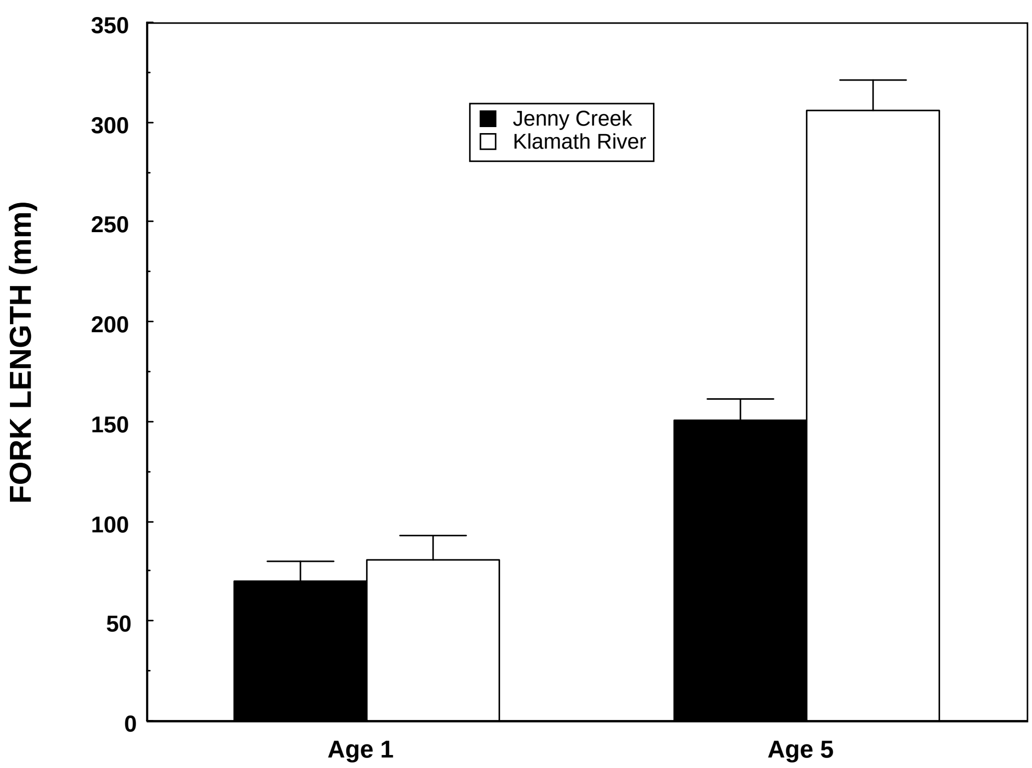

Figure 3: Differences between body size at ages 1 and 5 in the Jenny Creek and upper Klamath River *C. rimiculus* populations.

Table 2: Model predictions of size – age relationship of Jenny Creek suckers (*Catostomus rimiculus*) based on a size-age regression growth model developed from 22 fish, ages 2 – 5, collected September 22, 2004, in Jenny Creek, Jackson County, Oregon. Note that no Jenny Creek suckers have been aged beyond 5 years; however, >200 mm SL suckers have been observed (this paper) and collected (Hohler 1981).

Age at onset of winter	1	2	3	4	5	>5?
Predicted Size (mm SL) at onset of winter	49	84	104	118	130	>130

Using the length – age regression developed from the Jenny Creek fish, we classified each snorkel observation into age classes (Table 2). Note that our length – age data discerned overlap among sizes and age; therefore, these "age classes" are used ere to simplify the following discussion about Jenny Creek sucker population characteristics.

Population Age/Size Distribution and Dynamics

Over the course of four summers, Jenny Creek suckers were observed between the estimated standard lengths of 10 mm and 300 mm (Fig. 4). In 1992 and 1993, sizes were distributed more evenly throughout the population. In 2003 and 2004, the population was skewed heavily towards smaller fish. In 1992 and 1993, strong year classes seemed to occur about every 50 mm (Fig. 4). This pattern was less apparent in 2003 and 2004.

Jenny Creek sucker densities were low in most years, with the exception of 1993 (Table 3). In 1993, total sucker density was 2-3 times higher than the other years.

In 2003 and 2004, only 2% of the population was > 130 mm SL (Table 4). In comparison, 40% and 25% of the population was > 130 mm SL in 1992 and 1993, respectively. In 2003, only 23 fish over 60 mm SL were counted in the five study reaches – snorkeling over 15,000 square meters of stream.

Table 3: Jenny Creek sucker densities from daylight summer snorkel counts, in all habitat types, within five study reaches.

Year	Density (fish/100 m^2)	Area (m^2) Snorkeled
1992	1.99	16,660
1993	4.39	19,481
2003	1.55	15,206
2004	1.85	17,792

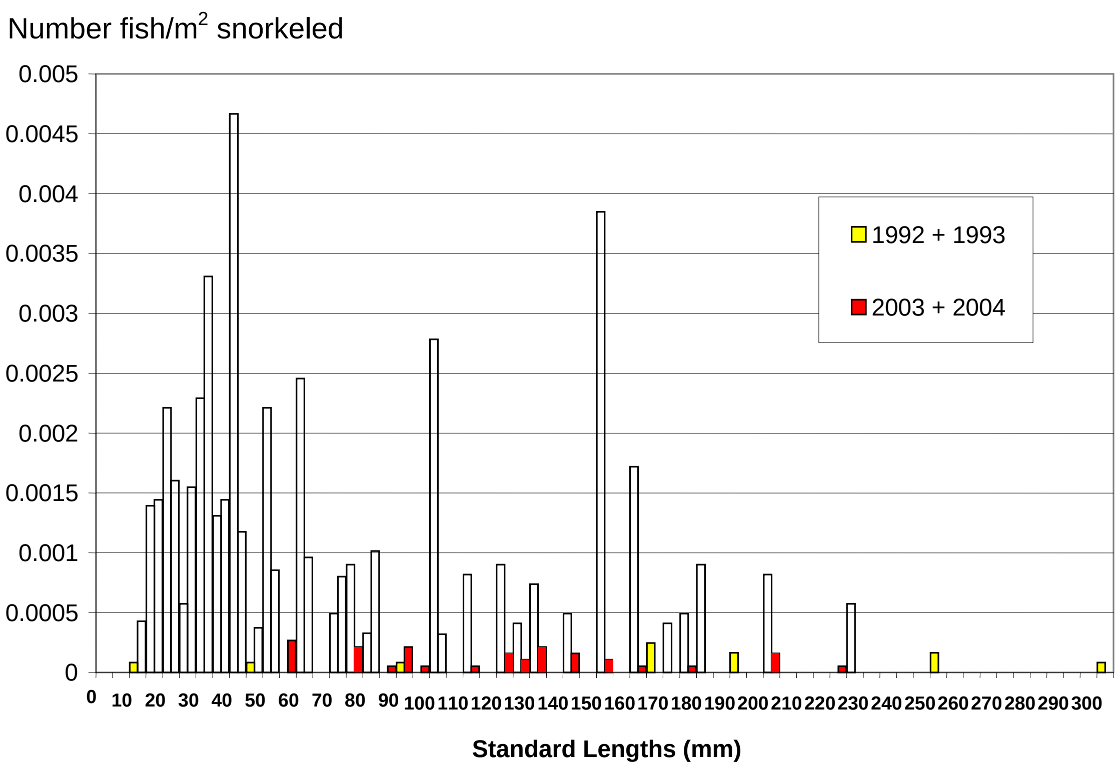

Figure 4: Jenny Creek sucker densities (number of fish/m^2) observed in summer daylight snorkel surveys. Data for 1992 and 1993, and 2003 and 2004 are combined to highlight the differences between the two periods.

Larval fish counts also varied among years. The lowest numbers of young-of-the-year fish (N = 16; total N = 94) were observed in 1992. In 1993, we counted the highest number of young-of-the-year (N = 138; total N = 329). In 2004, we observed more fish between 50 and 84 mm SL (age 1+) than we did in 2003 (Fig. 5), indicating that survival of the young-of-the-year age class may have improved as well. Note that the model predicts the limit of age 0+ fish to be 49 mm, whereas snorkel observations

Table 4: Percentage of each year's Jenny Creek sucker population found within age class increments, as estimated by length-age regression (this paper). Population size data are daylight summer snorkel estimates.

Size Class (mm SL)	Estimated Age	Percentage of the population within each 5-year age category			
		1992	1993	2003	2004
0-50	0+ (0 – 1)	17	42	82	55
51-85	1+	20	18	5	37
86-105	2+	10	8	3	4
106-120	3+	7	1	1	0
121-130	4+	5	6	4	2
>130	>5?	40	25	5	2

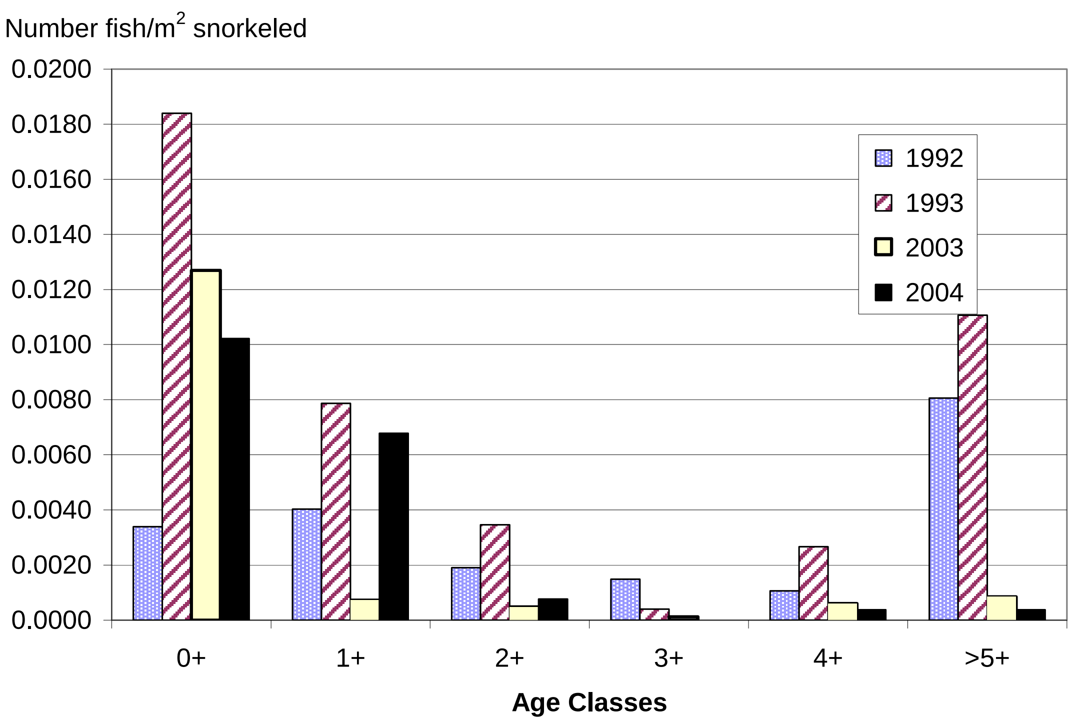

Figure 5: Jenny Creek sucker densities (number fish per m^2 snorkled) by age class, based on length-age regression of fishes ages 2 – 5 (this paper). Data from summer daylight snorkel surveys.

cannot be so exact. Given the size variability apparent within older age classes, it is probable that, each year, some 50 mm SL fish were age 1+ and not 0+.

In all years, we counted young-of-the-year late in the season. In three of the four years (1993, 2003, and 2004) we found young-of-the-year suckers in an almost continuous range of sizes from 10 mm SL to 45 mm SL.

DISCUSSION

Age-Size Relationships

Hohler (1981) and Rossa (1999) presented the most detailed studies, to date, of Jenny Creek sucker biology, focusing primarily on morphological characteristics, population structure, and habitat associations during summer low flow conditions. Using scale annuli, Hohler (1981) estimated that the largest fish (205 mm SL - 210 mm SL) in the population were age 4+ and that fish ranging from 153-204 mm SL were age 3+. Since then, scales have been shown to be unreliable for aging cypriniform fishes, particularly suckers (e.g., Scoppettone 1988; Thompson and Beckman 1995). Other hard parts, such as opercle bones, fin rays, and otoliths more accurately record growth history (Vondracek et al. 1982, Thompson and Beckman 1995; DeVries and Frie 1996). Rossa (1999) estimated age classes and time of maturity using a size-frequency distribution from two summers of snorkeling counts and comparing these data with life histories of other stream-dwelling suckers such as the Santa Ana. She estimated that fish ranging from 0 – 45 mm SL were age 0, 50 – 85 mm SL were age 1, 90 – 135 mm SL were age 2. Rossa (1999) did not presume to estimate age for suckers > 140 mm SL, because distinct cohorts were not discernable with the data. Rossa also assumed that Jenny Creek suckers did not mature until age 3, or >140 mm SL.

Using opercle bones, we show that both Hohler's (1981) earlier scale data and Rossa's (1999) size-frequency analysis underestimated Jenny Creek sucker ages. This may influence understanding of the population structure of other sucker species, such as the Modoc and Salish suckers. The life history literature for these two species (e.g. Moyle and Marchiochi 1975; and Pearson and Healey 2003, respectively) relies on scale analysis for age determinations, which could be underestimated. More accurate information on population age structure of these endangered species could help pinpoint factors limiting reproduction or adult survival.

Hohler (1981) collected a mature male as small as 115 mm SL and a mature female as small as 112 mm SL. In a separate investigation, an 84 mm SL fish collected from Johnson Creek showed the bright coloration and tuberculation common to mature spawners (Parker and Call 2006). Our results show that fish as small as 82-86 mm SL are likely in their third year of growth (age 2+) and 112 – 115 mm SL fish are in their fourth year of growth (Table 2). These observations indicate that Jenny Creek sucker mature at sizes similar to the Modoc (Martin 1972) and Salish suckers (Pearson and Healey 2003). Martin (1972) collected mature Modoc suckers as small as a 76 mm SL male and a 104 mm SL female. Pearson and Healey (2003) found that 50% of male Salish suckers in a British Columbia stream matured by 125 mm (90% at 140 mm SL) and 50% of females matured at 135 mm SL (90% at 155 mm SL). Jenny Creek suckers appear to mature at sizes larger than the Santa Ana, which matures in the spring following hatching at approximately 60 – 70 mm SL (Greenfield et al. 1970).

Jenny Creek sucker growth rates appear to be the most similar to Salish suckers. For fishes of the same sizes, growth rates were 0.13 – 0.07 mm/day for Jenny Creek suckers and 0.12 – 0.07 for Salish (Pearson and Healey 2003). Growth rates also appear to be similar to stream-dwelling Tahoe suckers *(C. tahoensis)* (Vondracek et al 1982*)*. Maximum size of Jenny Creek suckers appears greater than Santa Ana (154 mm; Greenfield et al. 1970), but similar to Salish (206 mm SL male and 287 mm SL female; Pearson and Healey 2003), Modoc (280 mm SL, Moyle and Marchiochi 1975), and Tahoe suckers (>200 mm; Vondracek et al. 1982). Hohler (1981) collected *C. rimiculus* from Spencer Creek, a nearby stream without a waterfall blocking access from the Klamath River, up to 270 mm SL.

Our aging and growth data showed that some fish within the Jenny Creek population reach age 5+. That may or may not be the maximum age attained within the population. The largest fish aged was 163 mm FL (141 mm SL). In snorkel counts, we counted fish with an estimated SL over 200 mm every year (Figure 4). Hohler (1981) also captured and measured larger fish (205-210 mm SL). Our regression model does not predict ages for fish this large. If our age-length regression was accurate for those sizes, a 200 mm SL fish would be 20 years old; a 210 mm SL fish would be 25. It is possible that Jenny Creek suckers are long-lived, especially since their conspecifics in the upper Klamath River are known to survive for 17 years. However, there is no evidence as yet to suggest that Jenny Creek suckers live beyond 5 years. Given the wide size distribution found among fish of the same age, it is likely that larger fishes enjoyed faster growth rates due to a combination of habitat, environmental conditions, genetics, skill, or luck.

In contrast to Jenny Creek, the Klamath River smallscale suckers experience a much higher growth rate, attain a body size several times larger, and may have much greater longevity than the Jenny Creek population. This result is not surprising; habitat-specific growth differences between populations are found among most fishes. A well-known example is the difference between stream-dwelling and anadromous *O. mykiss* (rainbow trout and steelhead, respectively). These differences have also been observed in *Catostomus* species. Reservoir-dwelling populations of Tahoe suckers have higher growth rates and larger body sizes than stream-dwelling populations of the same species (Vondracek et al. 1982). The Salish sucker exhibits differences in maximum size depending on geographic location (McPhail 1987).

Upper Klamath River sucker growth rate and size appear similar to Warner suckers (White et al. 1991). Other suckers from large river systems have been reported at much larger sizes (e.g. Dauble 1980, Villa 1985, Dauble 1986). Our largest fish (400 mm SL) is similar in size to *C. rimiculus* collected by Hohler (1981) in the Rogue and Applegate Rivers (380 mm SL and 400 mm SL, respectively). The only other age data that exist for upper Klamath River *C. rimiculus* are from Scoppettone (1988). He used opercle bones to estimate the ages of five smallscales from Copco Reservoir. The oldest fish had 15 annuli at a length of 397 mm SL. In this study, we estimated the oldest upper Klamath River fish to be 17 years at 398 mm SL. This age estimate is the oldest reported for *C. rimiculus*, although its age may be underestimated since there are often 2-3 annuli hidden within fenestrated bone near the base of opercles of suckers older than 6 or 7 years (Scoppetone 1988).

Population Age/Size Distribution and Dynamics

Sucker densities are not well reported in the literature. The Jenny Creek sucker densities we observed appear to be very low; however, they are within the range of western salmonid densities reported in the literature (Platts and McHenry 1988). Hohler (1981) sampled Jenny Creek suckers at twenty-eight 33 m stations throughout the drainage; however, such short lengths of stream would have included one or two habitat units at best. Jenny Creek suckers are not distributed evenly within each study reach (Rossa 1999); therefore Hohler could choose habitats with high sucker concentrations to sample. The data are not really comparable.

In August 1979, Hohler (1981) collected 394 Jenny Creek suckers ranging almost continuously from 15 to 210 mm SL. Similar to our combined 1992/1993 data, his length-frequency data show strong year classes moving through the population. The almost complete lack of adult fish in 2003 and 2004 sampling may be cause for concern. The waterfall near the mouth of Jenny Creek isolates the population from Irongate Reservoir and the Klamath River, precluding immigration. Spawning success is the only way individuals are recruited into the population. The lack of adults observed in 2003/2004 surveys could be due to several things: 1) sampling design or error, 2) many consecutive years of poor larval recruitment, 3) adult outmigration, 4) increased adult mortality, or 5) a combination of the above.

It is unlikely that the lack of adult observations in 2003 and 2004 was due to sampling error. In 2004, we increased our sampling effort in the two reaches where most adults were observed in 1992 and 1993, snorkeling almost 70% of the BXS study reach and almost 80% of the LWC study reach (Table 1). Even fewer large adults were observed in 2004, indicating that the low numbers were not due to our subsampling methods.

It is possible that sampling design could have been one of the reasons we saw few adults in 2003 and 2004. We only snorkled within our five study reaches, which comprised roughly 8 % of the estimated summer habitat available to Jenny Creek suckers. Larger fish could have concentrated in an unsampled part of the watershed. Torgersen et al. (1999) found that adult chinook salmon in the John Day River were distributed in a very spatially heterogeneous pattern, only detectable with continuous sampling over a large spatial scale. The 22 fish between 80 mm – 141mm SL collected in 2004 for the age-growth model were collected in mainstem Jenny Creek outside our study reaches. Similarly, Johnson and Corral Creeks appear to be important spawning areas (Parker et al. 2004; Parker and Ruhl 2005) and it is possible that adults could have concentrated and remained in these unsampled tributaries. However, it does seem unusual for adults to be distributed throughout the study reaches in some years but not in others.

Poor larval recruitment may be partially responsible for the low adult numbers in 2003 and 2004. The 1992/1993 data show a strong year class from approximately 1986. That corresponds with hydrologic data: 1987 – 1992 were all drought years (Rossa 1999). The low flows, warmer water temperatures and fine sediment build-up from the lack of flushing flows may have contributed to low recruitment during those years (Rossa 1999). In 2001 and 2002, Jenny Creek experienced severe drought (D. Squyres, Hydrologist, Bureau of Land Management, personal communication). Prior to 2001-2002, the stream experienced average flow years and an above-average flow year in 1998. It is unlikely that good water conditions would negatively affect larval recruitment. In addition, riparian condition is improving across the watershed, riparian grazing pressure is reduced (Hosten et al., in prep.), and we did not observe any introduced predatory fishes or evidence of an increase in terrestrial predators. Therefore, it does not seem likely that poor larval recruitment is to blame.

It is possible that large numbers of Jenny Creek sucker adults are outmigrating over Jenny Creek falls. For example, suckers may outmigrate to escape poor habitat conditions in Jenny Creek. The falls block any migration into the system, so suckers would not be able to return. In 2001 and 2002, Jenny Creek experienced drought (D. Squyres, Hydrologist, Bureau of Land Management, personal communication). Such poor conditions could have prompted adult suckers to outmigrate, resulting in fewer spawning adults available in study reaches. This would explain the low numbers of 1+ and 2+ fish in 2003. However, there were also low numbers of 4+ and >5+ fish observed in 2003, and those fish would have been spawned during normal (1999 – 2000) and one high water year (1998). More information is needed to determine whether migration out of Jenny Creek is occurring, and if so, when.

It is possible that the low numbers of Jenny Creek sucker adults are the result of increased adult mortality. Catostomids have high energy requirements in order to deal with the metabolic expense of gamete production (Andreason and Barnes 1975; Trippel and Harvey 1995; Pearson and Healey 2003). Pearson and Healey (2003) observed that the relative condition factor (K_n) of a population of Salish suckers declined significantly during the spawning season (April – July) and increased in September. However, one year, condition factor never recovered and remained significantly lower than the previous year's levels for the entire year. Pearson and Healey (2003) were unable to determine the cause of the population-wide condition decline, but presumed it was related to poor food availability. No studies of sucker feeding conditions have been conducted in Jenny Creek; however, there is an indication that food supplies may be an issue. Parker et al. (2002) found extremely high densities – $200/m^2$, among the highest reported for the species – of *Dicosmoecus gilvipes*, a limniphilid caddisfly, in a large, unshaded meadow downstream of the BXS study reach. At a density of only $50/m^2$, *Dicosmoecus* reduced algal standing crop and invertebrate abundance in instream enclosures by 80% and 60%, respectively (Parker and Power 1997). These food supply changes caused significant reductions in the growth and survival of juvenile steelhead trout (*O. mykiss*). Similar, or more severe, reduction of algal and insect crops could directly reduce local food supply for Jenny Creek suckers (Parker et al. 2002).

Dicosmoecus populations are susceptible to scouring floods, because they overwinter as early instar larvae (Parker and Power 1997). Jenny Creek experiences fewer than normal "bed-moving" flows as a result of upstream reservoir management (Rossa 1999); therefore, high *Dicosmoecus* densities could be a continuous problem. Parker collected his data in 1998 and 1999. As previously mentioned, Jenny Creek experienced drought in 2001 and 2002 (D. Squyres, Hydrologist, Bureau of Land Management, personal communication). It is possible that food supply issues reduced adult survival between 1998 and 2002. The relationship between winter streamflows and adult survival are not completely clear, however. Parker's (2000) high densities were counted after an above-normal water year (1998).

Water temperatures could also increase metabolic stress for suckers. Jenny Creek experiences a wide fluctuation in seasonal maximum and minimum temperatures. Parts of the stream are ice-bound in the winter and certain stream reaches experience maximum daily water temperatures of almost 80° F (Rossa 1999; Bureau of Land Management unpublished data). Highest water temperatures are generally during June and July – when adult sucker condition factor would be at its lowest. The combination could stress suckers and potentially contribute to increased mortality through disease or other factors.

In the Santa Ana River of southern California, high flows regularly contribute to adult mortality (Greenfield et al. 1970; USFWS 2000). However, since 1993, Jenny

Creek has only experienced one 10-20 year event (D. Squyres, Hydrologist, Bureau of Land Management, personal communication). It is unlikely that such a small event would disturb sucker overwintering habitat and cause excessive adult mortality. As previously mentioned, competition and predation are unlikely causes of increased adult mortality; and streamside logging and grazing have declined over the last two decades.

In summary, possible causes of low adult numbers are movement into non-sampled areas or adult mortality. However, there is not enough evidence to support a particular hypothesis.

As discussed above, the low numbers of young-of-the-year seen in 1992 were probably the result of poor recruitment due to low flow/high temperature water conditions. It is true that we sampled 1.5 – 3 times more habitat in three of the five study reaches; however, no young-of-the-year were counted in preliminary snorkeling work or during snorkel training sessions (Rossa, unpublished data). Therefore, the low counts were probably reflective of the year's recruitment in the study reaches.

In other investigations, we and others have found that Jenny Creek sucker larvae do not drift (Parker et al. 2004; Parker and Ruhl 2005). Johnson and Corral Creeks – both outside our study reaches – seem to be particularly important spawning and larval rearing areas, with high concentrations of larval fish. Conversely, White and Harvey (2003) captured Smith River *C. rimiculus* in drift nets. Many other papers have documented the nocturnal or crepuscular larval drift of other *Catostomus* species (e.g. Villa 1985; White et al. 1990; Johnston et al. 1995, White and Harvey 2003) – even *C. rimiculus* (White and Harvey 2003). But Kennedy and Vinyard (1997) discovered that Warner sucker larvae do not drift, ostensibly because the availability of downstream lake habitat is too unpredictable. The lack of sucker drift is important because it implies that the young-of-the-year counted in the study reaches are produced "on site." Our young-of-the-year data –although accurate for our study reaches – may not represent the population as a whole.

Management Implications and Opportunities

Regardless of reasons why, the management implications are serious: inconsistent spawning success in a small population of possibly short-lived fish with low densities means that the population could be set back considerably if the spawning adult numbers are reduced. This risk is offset somewhat by the assumption that Jenny Creek suckers are very fecund, like most Catostomids (Moyle 2002). The population could rebound from the successful spawning of a small number of adults. However, this scenario contains the potential for inbreeding problems which could potentially reduce the population's ability to withstand environmental changes (Moyle and Sato 1991).

Cascade – Siskiyou National Monument and private land managers should strive to increase Jenny Creek sucker densities and ensure year-to-year survival. Although our data do not explain the relationship between sucker density and management options, some practical opportunities include the following:

- Protect spawning and rearing areas. Because the falls block migration into Jenny Creek, larval recruitment is the only way to increase the numbers of fish.
- Restore yearly flushing (i.e. bankfull) flows over Howard Prairie dam. Our data indicate that larval recruitment may be higher in average water years following bankfull flow.
- Continue to reduce summer maximum temperatures where possible. Summer maximum daily water temperatures are still regularly above 70 degrees F in many places throughout the system, which could metabolically stress suckers.

- Encourage reintroduction of beaver (*Castor canadensis*). Beaver are potentially a critical tool to restore riparian areas, reduce water temperatures, and create slow-velocity complexes suitable for rearing young-of-the-year.

Additional information would help scientific investigators determine exactly which management actions are most appropriate for ensuring a self-sustaining Jenny Creek sucker population. Immediate information needs include the following:

- Larger (>170 mm SL) suckers should be collected and aged to determine whether Jenny Creek suckers are indeed long-lived, or whether growth rates within the population are extremely variable.
- The entire system should be surveyed to determine if adult densities are indeed low, or if adults are concentrating in a part of the drainage outside of our study reaches.
- The Johnson Creek drainage should be explored to determine how important it is relative to other larval production areas.
- Fish in Lower Jenny Creek (below the falls) should be examined to determine if "one-way outmigration" is taking place.
- Sucker movement patterns should be studied to determine whether they spend years in one place, or whether they move throughout the stream system.
- The relationship between sucker densities and environmental variables should be examined to determine whether flow regime, temperature, or other abiotic factors are influencing population trends.
- Population and habitat use information should be analyzed for Jenny Creek redband trout and speckled dace to determine whether all endemic fishes are experiencing the same population trends apparent in our sucker data.

Summary

We found that growth rates, size at maturation, and maximum size differed significantly between the Jenny Creek and upper Klamath River populations of *C.*

rimiculus. The river population grew faster, matured later, and grew larger than the stream population. We also recorded the age of the oldest Klamath River *C. rimiculus* to date: 17 years. Some of the stream population' life history characteristics were similar to those of other stream-dwelling Castotomids, specifically the Salish, Modoc, Tahoe, and Santa Ana suckers. However, ageing with otoliths or other bony structures must be completed on the Salish and Modoc suckers before growth rates and age at maturity can be compared with Jenny Creek suckers.

Applying our growth rate curve to Jenny Creek sucker population data from snorkel counts, we found that almost no adults were observed in 2003 and 2004. The most likely scenarios are increased adult mortality – cause unknown – or reach-scale movement of adults to locations outside our five long study reaches. We also found that larval recruitment was poor in 1992, probably the result of six consecutive years of drought, and that the spawning season appears to be longer than is usual for most Catostomids.

Rapid early growth, early maturation, a prolonged spawning season, and possibly a long lifespan certainly contribute to the Jenny Creek sucker's ability to recover from disturbances. However, the small number of adults in 2003 and 2004 highlights a problem common to isolated populations: without immigration opportunity, loss of adults could lead to a reduction in genetic variability potentially hindering long-term survival, or eventually resulting in extirpation. We urge private and federal land managers to take steps to conserve Jenny Creek suckers.

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APPENDIX: ADDITIONAL DATA TABLES

Table A-1: Length, mass, and age (opercle annuli count) for each individual *Catostomus rimiculus* collected from Jenny Creek, Jackson County, Oregon, and the upper Klamath River below J. C. Boyle Dam, Klamath County, CA. Fish lengths were measured as fork length (FL). Standard lengths (SL) are calculated using a conversion from Dr. Douglas Markle, Oregon State University (personal communication), based on Klamath River and Rogue River *C. rimiculus* [SL = (FL-1.76375)/1.14189].

I.D. #	FL (mm)	SL (mm)	Mass (g)	Annuli Count
		Jenny Creek		
JC01	93	80	10.4	2
JC02	94	81	9.8	2
JC03	94	81	8.7	3
JC04	94	81	9.3	2
JC05	94	81	9.2	2
JC06	101	87	11.7	3
JC07	123	106	23.0	4
JC08	126	109	27.5	3
JC09	128	111	23.7	3
JC10	130	112	23.9	4
JC11	133	115	28.2	5
JC12	135	117	29.7	3
JC13	136	118	30.4	4
JC14	136	118	30.1	4
JC15	140	121	31.6	4
JC16	149	129	34.0	4
JC17	150	130	41.3	4
JC18	151	131	43.7	5
JC19	152	132	44.5	4
JC20	153	132	45.1	5
JC21	153	132	51.1	5
JC22	163	141	47.9	5
		Klamath River		
CR37	131	113	31.0	3
CR28	136	118	33.0	3
CR40	140	121	35.8	2
CR31	142	123	37.9	3
CR27	146	126	39.7	3
CR35	272	237	276.7	4
CR7	275	239	276.0	4

I.D. #	FL (mm)	SL (mm)	Mass (g)	Annuli Count
CR33	285	248	280.3	4
CR15	286	249	343.0	6
CR6	288	251	310.0	5
CR51	290	252	329.1	5
CR21	291	253	335.6	5
CR14	296	258	319.0	6
CR16	297	259	290.0	6
CR41	299	260	343.4	5
CR53	299	260	359.0	6
CR36	303	264	358.0	5
CR48	306	266	434.0	5
CR25	311	271	405.2	5
CR2	316	275	411.0	6
CR50	320	279	396.0	5
CR54	320	279	431.0	7
CR49	322	280	441.0	5
CR9	330	287	464.0	6
CR32	330	287	458.0	6
CR43	330	287	521.0	8
CR42	331	288	465.0	5
CR38	333	290	475.0	6
CR13	333	290	495.0	9
CR45	335	292	494.0	7
CR56	338	294	505.0	7
CR24	344	300	597.0	8
CR60	344	300	595.0	8
CR57	347	302	589.3	8
CR47	355	309	644.0	6
CR58	355	309	605.6	7
CR20	355	309	568.0	7
CR61	355	309	576.0	9
CR46	361	315	654.1	7
CR8	362	315	660.0	7
CR34	362	315	661.0	7
CR29	363	316	614.0	8
CR3	369	322	684.0	7
CR4	372	324	706.0	7
CR39	374	326	739.0	9
CR1	380	331	765.0	7

I.D. #	FL (mm)	SL (mm)	Mass (g)	Annuli Count
CR26	383	334	739.0	10
CR12	384	335	859.0	9
CR5	384	335	772.0	10
CR52	387	337	736.0	8
CR11	388	338	942.0	14
CR17	395	344	762.0	10
CR18	409	357	879.0	12
CR23	413	360	957.0	14
CR30	414	361	978.0	11
CR59	418	365	901.0	10
CR19	424	370	1012.0	11
CR10	424	370	1004.0	13
CR22	427	372	1017.0	14
CR55	448	391	1347.0	17
CR44	460	401	1241.0	14

Data sources: Southern Oregon University, Ashland, OR (Jenny Creek, Klamath River); Oregon Department of Fish and Wildlife, Klamath Falls, OR (Klamath River).

Table A-2: Total number of Jenny Creek suckers (*C. rimiculus*) observed, by size, during late summer snorkeling surveys in all five study reaches combined, Jenny Creek, Jackson County, OR. SL = Standard Length.

SL (mm)	Year (m^2 snorkeled)			
	1992 (4716.23 m^2)	1993 (7502.56 m^2)	2003 (8271.60 m^2)	2004 (10,470.48 m^2)
0	0	0	0	0
5	0	0	0	0
10	0	1	1	7
15	0	17	9	18
20	0	27	13	17
25	0	7	17	12
30	5	23	26	36
35	0	16	22	5
40	11	46	13	9
45	0	1	4	3
50	7	20	2	14
55	0	0	0	5
60	6	24	0	18
65	0	0	0	0
70	0	6	2	13

SL (mm)	Year (m^2 snorkeled)			
	1992 (4716.23 m^2)	1993 (7502.56 m^2)	2003 (8271.60 m^2)	2004 (10,470.48 m^2)
75	6	5	0	4
80	0	4	2	17
85	0	0	0	1
90	0	1	3	1
95	0	0	0	1
100	9	25	1	5
105	0	0	0	0
110	7	3	1	0
115	0	0	0	0
120	1	10	1	2
125	4	1	0	2
130	0	9	4	0
135	0	0	0	0
140	0	6	3	0
145	0	0	0	0
150	17	30	2	0
155	0	0	0	0
160	0	21	1	0
165	0	3	0	0
170	0	5	0	0
175	2	4	0	1
180	0	11	0	0
185	0	0	0	0
190	0	2	0	0
195	0	0	0	0
200	9	1	0	3
205	0	0	0	0
210	0	0	0	0
215	0	0	0	0
220	0	0	1	0
225	7	0	0	0
230	0	0	0	0
235	0	0	0	0
240	0	0	0	0
245	0	0	0	0
250	2	0	0	0
255	0	0	0	0
260	0	0	0	0

SL (mm)	Year (m^2 snorkeled)			
	1992 ($4716.23\ m^2$)	1993 ($7502.56\ m^2$)	2003 ($8271.60\ m^2$)	2004 ($10,470.48\ m^2$)
265	0	0	0	0
270	0	0	0	0
275	0	0	0	0
280	0	0	0	0
285	0	0	0	0
290	0	0	0	0
295	0	0	0	0
300	1	0	0	0
Total	**94**	**329**	**128**	**194**

Data source: U. S. Bureau of Land Management, Ashland Field Office, Medford, OR.