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Bruneau Hot-spring Springsnail (*Pyrgulopsis bruneauensis*)

by

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SUMMARY

This report presents the 1999 monitoring results from four sites near Indian Bathtub in southwestern Idaho that contain, or have contained, populations of the Bruneau Hot-spring Springsnail (*Pyrgulopsis bruneauensis*) and compares them with results from previous years. Three of these sites were monitored in 1990 and 1991 by Mladenka (1992), in 1992 by Robinson et al. (1992), in 1993 by Royer and Minshall (1993), in 1994, 1995, 1997 by Varricchione and Minshall (1995a, 1996, 1997, 1998) and in 1998 by Myler and Minshall (1999). An additional seep at Site 3 (New Seep) was included in the 1994, 1995, 1997, 1998, and 1999 Springsnail monitoring efforts.

Springsnails have recolonized Hot Creek from the relict population found within a 1.80 m seep that drained into Hot Creek (Site 1). Experiments conducted in 1999 by Cary Myler (MS thesis) bipassed the thermal barrier (Myler and Minshall 1999) with a segment of pipe which acted as a bridge for snail movement. Once Springsnails regained their presence in Hot Creek, large stable substrate were added near the small seep (Myler, unpublished data). A fish exclosure was constructed to eliminate possible predation from *Tilapia* (Myler, unpublished data). As of November 1999, 300-400 Springsnails were found upstream and downstream of the confluence of the small seep but within the boundaries of the fish exclosure (Myler, unpublished data).

In 1999, the U.S. Fish and Wildlife Service (USFWS) recognized that present monitoring locations were not providing a representative overview of the status of the Bruneau Springsnail over its entire range. A cooperative effort between the USFWS, Idaho State University (ISU), and the Bureau of Land Management (BLM) was initiated. Twenty-one sites, which include the five monitoring sites in this report, were established over the 4 km range of present spring locations. Factors included in site selection included location, Springsnail density, accessibility, and discharge monitoring.

INTRODUCTION

The snail *Pyrgulopsis bruneauensis* is an endemic species inhabiting a complex of related hot springs near the Bruneau River south of Mountain Home, Idaho. Hershler (1990) provided a complete taxonomic description of *P. bruneauensis*. Mladenka (1992) focused on the life history of *P. bruneauensis*, providing the groundwork on which this monitoring study is based. Mladenka (1992) found only two studies addressing the biology of *P. bruneauensis*: Taylor (1982) described the taxonomy of the snail and Fritchman (1985) studied its reproduction in the laboratory.

Mladenka (1992) found temperature to be the most important factor affecting the distribution of *P. bruneauensis*. Experiments showed the thermal tolerance range for the snails to be 11-35°C. Reproduction occurred between 20°C and 35°C. Snail growth and reproduction were retarded at temperatures <24°C. The study also showed that under suitable conditions, recruitment and growth may occur at all times of the year, sexual maturity could occur within two months of hatching, maximum size could be reached within four months (both under suitable temperature conditions), and the sex ratio of Springsnails was 1:1. In laboratory experiments, Springsnails were found to survive on all types of substrate, although higher numbers were found on gravel and silt than on sand (Mladenka 1992). Rockface seeps had highly variable temperatures, but never exceeded thermal maximum temperatures. Hot Creek maintained temperatures that were less variable, but often above the Springsnail thermal maximum temperature (35°C) (Mladenka 1992).

A flood in the summer of 1991 contributed much silt, sand, and gravel to Hot Creek. In particular, Indian Bathtub was reduced to less than one-half its size before the flood because of sediment addition. Available habitat in the immediate vicinity of Indian Bathtub was reduced because of this and other sedimentation events (Mladenka 1992). The Springsnail's habitat throughout its known range along the Bruneau River has diminished considerably in recent years because of agriculture-related groundwater mining in the area (Berenbrock 1993). The Indian Bathtub population has been reduced to zero as a result of reduction of hot water inputs and other habitat alterations (Myler and Minshall 1999). Hot Creek re-surfaces over 450 m from Indian Bathtub (Myler and Minshall 1999).

Springsnail populations were reduced drastically in Hot Creek (Site 1) by a major runoff event in July 1992 (Royer and Minshall 1993) and failed to recover until June of 1999. Experiments conducted in 1998 identified a thermal barrier to potential recolonists that exceeded the thermal maximum of the Springsnail (Myler and Minshall 1999). Myler and Minshall (1999) postulated that temperatures (>35°C) reduced Springsnail survival in Hot Creek. Addition of protruding substrate, bypass of the thermal barrier and a fish exclosure have enabled the Springsnail to recolonize Hot Creek proper (Myler, unpublished data).

Gut analyses performed on two exotic fish occupying Hot Creek, *Gambusia* and *Tilapia*, showed that their diets consisted of organic matter and insects, but not of *P. bruneauensis.* However, these analyses were performed in 1995, a year when Springsnails were apparently absent from Hot Creek (Varricchione and Minshall 1995b). In 1998, Myler and Minshall performed a controlled fish feeding experiment using *Tilapia zilli* taken from Hot Creek and *P. bruneauensis* taken from Site 2. The fish were shown to recognize the Springsnail as food, both when the fish were starved and when they were fed generously. Experiments indicate that *Tilapia* do negatively impact Springsnail populations in Hot Creek (Myler and Minshall 1999).

This report presents the continued biomonitoring of Mladenka's (1992) study sites through November 1999.

METHODS

Site Description

Mladenka (1992) described in detail the three original Springsnail study sites (1, 2, and 3 Original Seep). Figure 1 shows the locations of the three study sites with respect to the Bruneau River. Figure 2a shows a map view of Site 1 at Hot Creek and an adjacent rockface seep. Figures 2b and 2c show front views of the hot-spring study areas (Sites 2 and 3 respectively). These sites have been continuously monitored (January-November) from 1990-1999 with the exception of January-May 1996 when monitoring was not performed. Royer and Minshall (1993) recommended that Site 3 be divided into two sub-sites: the Original Seep (right side) and a New Seep (left side) (Fig. 2c). These two seeps are approximately 4 m apart from each other and each "seep" has a distinct spring-flow. Their populations have been monitored separately from 1994 through 1999. In 1994, Springsnail size distributions, densities, and eventually temperatures (beginning November 1996) at Site 3-New Seep began to be monitored. This data was kept separate from Site 3-Original Seep, so that it could be determined if its snail population is under different constraints and behaving differently than the population at Site 3-OS. Size distribution data, life history patterns, densities, and habitat conditions have since been found to be noticeably different between the two sites. Therefore, the data continue to be kept separate. Site 2 also is comprised of two "seeps", but their population data have been combined since the first monitoring year. The purpose of the division of Site 3 was to allow the 1994-1999 Original Seep data to remain consistent with data from previous years and to allow for the inclusion of a recently discovered Springsnail population and habitat into monitoring efforts. The remainder of this report will refer to Site 3 (Original Seep) as Site 3-OS and Site 3 (New Seep) as Site 3-NS.

Both spring-rockface and stream habitats were examined for *P. bruneauensis* at Site 1. Spring-rockface habitats were monitored at Sites 2, 3-OS and 3-NS. "Spring-flow-covered rockface", or "SFC rockface", was defined as madicolous habitat (rockface covered by a thin layer of running water). "Rockface wetted but lacking flow", or "rockface W/LF", was defined as moist rockface adjacent to spring-flow-covered rockface. Springsnails occur in both types of habitats.

Study quadrats (Appendix A) were established at each site for monitoring purposes. To estimate *P. bruneauensis* size-distribution and density-fluctuation inside a study quadrat, a meter stick (baseline) was positioned flush against the rockface and parallel to the direction of spring-flow. Ten transects, each perpendicular to the meter stick, were established at 10-cm intervals along the baseline. Random number lists were used to determine rockface-sampling locations for Springsnail size and density monitoring. The random numbers were used to determine the distance across a transect each sample would be taken or monitored.

Environmental conditions were monitored at the study quadrat ($\pm$ 1 m) of each site on a monthly basis. These parameters included discharge and stream habitat at Hot Creek (Site 1), amount of flow-covered and wetted-rockface (Sites 2, 3-OS, and 3-NS), water chemistry, water temperature, and food availability (periphyton abundance).

Springsnail Size Distribution

To determine if the Site 1 Springsnail population was recovering from previous flood events, arbitrary creek substrate and spring-rockface locations within a 50-m reach of Hot Creek (Site 1 $\pm$ 25 m) were examined, without magnification, for the presence of *P. bruneauensis*.

Within the sampling quadrats at Sites 2, 3-OS, 3-NS, Springsnails were washed from random locations into a standard petri dish using streams of water from a squirt bottle. The sizes of the snails were determined on site using a Bausch and Lomb dissecting microscope. The microscope ocular was marked with 0.14 mm units (under 7x magnification). Snail lengths were rounded to the nearest 0.14 mm unit (i.e., a snail whose length was 8.8 units long was noted as being in the 9-unit, or 1.26 mm, size class). Sample size was 100 for both Sites 2 and 3. Beginning in 1994, population censusing at Site 3 was partitioned between the Original Seep (n=50) and the New Seep (n=50).

Springsnail Population Fluctuations

Although Springsnails recently have recolonized Hot Creek, density was not measured routinely at Site 1 because the snail occurs in low numbers (300-400). Springsnail density was measured at the rockface sites (Sites 2, 3-OS, and 3-NS). Densities were estimated as the number of Springsnails present within the circumference of a petri dish (8.5 cm diameter) at ten random locations within the sampling quadrat. Densities were reported as the number of snails per m^2. A small Garrity flashlight (2 AA batteries, PR 104 bulb) was used to help distinguish the snails from the dark rockface.

Discharge, Temperature, and Water Chemistry Fluctuations

Stream water velocities were measured across a permanent transect at Site 1 (Hot Creek) using a small Ott C-2 current meter. This transect was moved slightly upstream or downstream (1 or 2 m) if instream vegetation was too thick to allow proper operation of the current meter. Stream discharge (calculated from the measured velocities) was determined using the methods described in Platts et al. (1983). Spring-flow and wetted-rockface area estimates at the rockface study quadrats adjacent to Site 1 were not possible, in general, because of the large amount of vegetation (primarily sedges) obscuring the rockface.

In 1994, maximum/minimum recording thermometers were replaced with miniature temperature data loggers at all sites. Internal sensor loggers (Onset Hobo-Temp HTI-05+37) were used from 18 February 1994 to 26 September 1994 and then replaced with external sensor data loggers (Onset StowAway-Temp STEB02-05+37) on 26 September 1994 at Sites 1, 2, and 3-OS. Beginning in November 1996, an additional logger was installed at Site 3-NS. Data loggers were downloaded and relaunched approximately every two months, in the laboratory, using Boxcar Pro for Windows v.4.0 software (Onset Instrument Corp.).

Figure 2a shows the location of the temperature data logger submersed in Hot Creek. The logger was located 2 m upstream of the regularly-examined section at Site 1. Figures 2b and 2c show the locations of the temperature data loggers at Site 2 and Site 3, respectively. Water depth at the seep study sites was quite shallow. Therefore, small pits were excavated immediately below the seep outflows in order to submerge the loggers in hot-spring water. The loggers were covered by cobble substrate or hillside talus. Data from temperature loggers in 1997, 1998, and 1999 were used to calculate average daily temperatures for each site. 1997 was used as a starting point since it was the first year that temperature loggers monitored Site 3-NS.

Water chemistry parameters were measured for all the study sites. pH was measured in the field using an Orion pH meter (Model 290A). The pH meter was calibrated in the field to standard buffer solutions (Orion pH 7.00 and 10.01) during each monitoring visit. Specific conductance (µS/cm) standardized to 25°C was measured in the field using an Orion conductivity meter (Model 126). Water samples, for all sites, were collected in 250-ml plastic bottles, kept on ice until returned to the laboratory, and then frozen until processed. In the laboratory, samples were thawed at room temperature and shaken by hand (approximately 5 sec) to re-dissolve solids. Alkalinity and hardness were determined using procedures described in Standard Methods for the Examination of Water and Wastewater (APHA, 1992).

Periphyton

Periphyton samples were taken from rock substrata collected within 1 m of the study quadrats. For each sample, a modified syringe tube (3.14 cm^2) was placed on top of the substrate. Closed-cell foam, attached to the base of the modified syringe tube, formed a seal between the tube and the substrate to prevent the loss of periphyton sample. Approximately 5 ml of spring or creek water was added to the tube. A modified toothbrush was used to dislodge periphyton from the rock and a dropper was used to extract the periphyton slurry from the tube. The periphyton slurry was concentrated onto Whatman GF/F glass microfibre filters held in a Nalgene filter holder (Nalge No. 310-4000). A Nalgene hand vacuum pump (Nalge No. 6131-0010) was used to create the suction necessary to remove the water from the slurry. For each sample, this procedure was repeated three times to remove all periphyton from the substrate. Periphyton samples were placed on ice, returned to the laboratory, and kept frozen until processed. In the laboratory, periphyton filters were analyzed for the presence of chlorophyll a (corrected for the presence of phaeophytin) on a Gilford Instruments spectrophotometer (Model 2600) using procedures described in Standard Methods for the Examination of Water and Wastewater (APHA, 1992). Methanol was substituted for acetone as the solvent used in the analyses (Marker et al. 1980). Chlorophyll a, an indicator of the presence of algal organisms, was expressed as mg chlorophyll a per m^2.

The remaining periphyton material from each sample was used in the determination of algal biomass (expressed as g ash-free dry mass (AFDM) per m^2). The material was dried at 50°C for 24 h, cooled to ambient temperature in a desiccator, weighed on a Sauter balance (Model AR1014) to the nearest 10^{-4}g, combusted in a muffle furnace at 550°C for a minimum of 3 h, rehydrated, redried at 50°C, cooled to ambient temperature in a desiccator, and then reweighed. The difference in weights equaled the AFDM of the sample.

Habitat Assessment at Hot Creek

From March 1995 to November 1996, stream habitat assessment at Hot Creek (Site 1) was conducted monthly using the Idaho Department of Health and Welfare's

Habitat Assessment Field Data Sheet for lowland streams (Appendix B; Robinson and Minshall 1995). In 1997-1999 habitat features were censused once a year. The parameters assessed included bottom substrate/instream cover, pool substrate characterization, pool variability, canopy covering, channel alteration, deposition, channel sinuosity, lower bank channel capacity, upper bank stability, bank vegetation protection, streamside cover, and riparian vegetative zone width.

Discharge monitoring at the rockface seeps

The water emerging from these seeps is diffuse, making it difficult to monitor flow. Small 90° V-notch weirs were installed approximately 1 m from the rockface seeps on 17 October 1997. The weirs collected diffuse runoff coming from the rockface to permit estimation of spring-flow discharge. The approximate location of the weirs is shown in Figure 2. Volume (liters) per minute was determined for each of the weirs on a monthly basis through November 1999. Stage height (cm) also was recorded monthly from a metal staff gauge permanently attached to the side of each weir.

Intensive search for relict populations of P. bruneauensis in and around Hot Creek

Since *P. bruneauensis* has not been found at the Hot Creek study site for the past several years (Myler and Minshall 1999; Varricchione and Minshall 1998, 1997, 1996, 1995a; Royer and Minshall 1993), it is important to determine if potential recolonists for Site 1 occur anywhere in, or adjacent to, the stream between Indian Bathtub and the Bruneau River. Robinson and others (1992) had described a small stream-side refugium that had retained <10 Springsnails after flooding and scouring events in the same year. As grazing pressure was lifted from the Hot Creek area, the growth of thick riparian vegetation near the creek and the seep made observation of this population difficult (Royer and Minshall 1993, Varricchione and Minshall 1997). An intensive search for relict populations of *P. bruneauensis* was conducted June 1998 and May 1999 in and immediately adjacent to Hot Creek (between Indian Bathtub and the Bruneau River). The search was completed by examining (without magnification) Hot Creek sediments, emergent vegetation, and nearby rockface seeps for *P. bruneauensis.* Where Springsnails were found, temperatures were recorded using a Reotemp digital thermometer (model TM99A).

RESULTS

Springsnail Size Distribution

Site 1 (Hot Creek)

Site 1 (Hot Creek) population density was reduced to zero from a flood in July 1992, but snails recolonized the stream in June 1999 and populations have increased each month. As of November 1999 total Springsnail population is estimated at 300-400 individuals. Size distribution was not conducted in 1999 due to low population densities. The flood in July 1992 probably resulted in the death of younger snails and skewed the size distributions in July and September 1992 (Fig. 3c). Mean size distribution data suggest that when the Springsnails were present (1990-1992), life histories were correlated with season and a single cohort of individuals moved from juvenile classes in the winter to mature classes in the summer.

Site 2 (Upper Spring Rockface)

The Springsnail population at Site 2 maintained a size distribution that was relatively even across size classes between February and November 1999 (Fig. 3j). This trend agreed with monitoring results from previous years. Mean size distribution data (Fig. 5a) showed juveniles to be prevalent at all times of the year.

Site 3-OS (Lower Spring Rockface)

There were no clear size distribution trends between January and November 1999 (Fig. 3j). Mean size distribution data for the Springsnail population at Site 3-OS did not show clear trends associated with season over the past eight years. Individuals appeared to be dispersed fairly evenly across the size classes each month.

Site 3-NS

Between January and November 1999, the Springsnail population at Site 3-NS also lacked any clear trends in size distribution (Fig. 4b), consistent with earlier surveys (Figs. 4a, 4b). Mean size distribution data (Fig. 5b) suggested that the New Seep population maintained a fairly even distribution of individuals across the different size classes during all seasons and that the development of cohorts at both Site 3 seeps might not be a frequent occurrence. During the 1999 monitoring season, site 3-NS had fewer snails than monitoring Sites 2 and 3. In April, July, and November, size measurements were not taken due to the lack of individuals at this location.

Comparison of Average Monthly Snail Sizes Among Sites

An analysis of the average monthly snail sizes, based upon data collected between 1990 and 1999, revealed distinct differences in population life histories among the study sites. The slopes of the linear regressions calculated in Figure 6 were used as estimates of site-specific population growth rates. Snails at Site 1 appeared to grow as a distinct cohort. The water temperatures at Site 1 were the warmest (often above the thermal maximum temperature of 35°C (Fig. 10; Mladenka 1992)). Recruitment probably only occurred in the cooler winter months, based upon the small average snail sizes found between January and March. The slope of the regression line for Site 1 (0.244; $p < 0.005$) (Fig. 6) was strongly positive and appeared to represent a gradual aging of the population between January and August. September was the month when another cohort appeared to begin its development in Hot Creek (Fig. 5a), so Figure 6 does not take the months of September through December into account. Site 1 also had the largest average snail size of all the study sites (Fig. 6). The populations at the other sites (2, 3-OS, and 3-NS) did not exhibit trends seen at Site 1 (analyzed between January and August for comparative purposes). Both Site 2 and Site 3-NS had significant regression lines ($p < 0.005$) with slightly positive slopes (0.044 and 0.069, respectively). Site 3-OS data were very scattered and even exhibited a slightly negative trend between January and August (slope = 0.008, $p = 0.972$).

Springsnail Population Fluctuations

Site 1 (Hot Creek).

Storm flow in Hot Creek during July 1992 resulted in major channel scouring and sediment loading. As a result, Indian Bathtub was filled with sediment and the Hot Creek (Site 1) population of *P. bruneauensis* was reduced to zero (Robinson et al. 1992). Snails were not found in Hot Creek from 1993 until June 1999. Robinson et al. (1992) and Royer and Minshall (1993) observed a streamside refugium that had retained snails (<10 individuals). Royer and Minshall (1993) noted that in May 1993, this refugium became overgrown with dense terrestrial vegetation. These conditions have persisted, inhibiting observations, since that time. A more intensive search of this area on 22 June 1998 revealed, again, a small population of Springsnails along the path of the small seep that drains 1.8 m into Hot Creek (Myler and Minshall 1999). Also, about 20 Springsnails were found in the Bruneau River - Hot Creek interface during the spring survey which was conducted in September of 1998 (Myler and Minshall 1999). However, in an October 1999 survey no Springsnails were found in the interface. Observations made in 1999 revealed a thermal barrier that blocked movement into Hot Creek. A bypass for the thermal barrier, large protruding substrate, and a fish exclosure have enabled colonization in Hot Creek proper as well as recruitment (Myler, unpublished data). The population in Hot Creek has shown monthly growth and the total population is estimated between 300-400 individuals (Myler, unpublished data).

Site 2 (Upper Spring Rockface).

In 1999 Springsnail density at Site 2 ranged from 5,033 snails/m^2 in April to 1,532 snails/m^2 in January. These numbers fell within the range set by previous monitoring years; however, 1999 appears to have some of the lowest densities found in the last decade (Fig. 7). Densities at Site 2, between 1990 and 1999, have generally been higher than those at the other study sites, although monthly estimates have exhibited great variability (Fig. 7). Typically, lower densities at Site 2 were found during colder months (September through February) (Fig. 7).

Site 3-OS (Lower spring rockface).

In 1999, the Site 3-OS Springsnail population maintained fairly constant densities between the months of January and November. With the exception of 1992 and 1996, densities were within the range of data from previous monitoring years. (Fig 7). In 1999, the highest snail density at this site was 3708 snails/m^2 in August while the lowest density was 1415 snails/m^2 in January (Fig. 7).

Site 3-NS.

Snail densities at Site 3-NS were generally lower than those at Sites 2 and 3-OS (Fig. 7). In 1999, the highest density, 2936 snails/m^2, was recorded in April and the lowest density, 771 snails/m^2, was recorded in November. Densities in 1999 were among the lowest since 1994 (Fig. 7). Currently, Site 3-NS does not provide a habitat suitable for large populations of Springsnails because of its small rockface area, large amount of shading, and diffuse groundwater flow. Still, this seep does support a viable population.

Discharge, Temperature, and Water Chemistry Fluctuations

Site 1 (Hot Creek).

Hot Creek discharge dropped after channel scouring and sediment loading in July 1992. Discharge after the start of 1993 fluctuated greatly, probably as a result of precipitation (Fig. 8). Reduced discharge in Hot Creek resulted in higher maximum water temperatures for 1992 (Mladenka 1992). This relationship did not hold as strongly between 1993 and 1996 (Fig. 8). Extreme temperatures at Site 1 prior to September 1994 (date when minimum-maximum thermometers were replaced with submersible temperature data loggers) may have been the result of thermometer exposure to air (Figs. 8, 9; Royer and Minshall 1993, Varricchione and Minshall 1997). Water temperatures in 1999 ranged from 32.6 to 35.2°C, which is consistent with trends after September 1994 (click here to view Fig. 9). Mean temperatures appeared to remain constant in 1999 (Fig. 10). There was no apparent change in water chemistry at Site 1 during 1999.

Site 2.

At the left seep in 1999, the percent springflow-covered (SFC) rockface ranged from 5 to 30% (Fig. 12 top). The percent rockface-wetted-but-lacking flow (W/LF) in 1999 ranged from 80 to 100%, which was consistent with previous years (Fig. 12 bottom). At the right seep, the percent SFC rockface in 1999 fluctuated between 10 and 60%, which was higher than previous years (Fig. 12 top). In 1999, percent rockface W/LF at the right seep ranged between 95 and 100%, which was generally higher than previous years (Fig. 12 bottom). Very low water temperatures at Site 2 in 1993 were probably the result of thermometer exposure to air (Royer and Minshall 1993). Site 2 maintained relatively constant Min/Max temperatures during 1999 (Fig. 9). However, there were small intervals (less than 8 hours) in the data where the minimum temperatures fell below the apparent range of the last decade. Minimum temperatures (24.9°C) were recorded in March and maximum temperatures (34.64°C) were recorded in October (Fig. 9). Site 2 maintained relatively constant daily average temperatures throughout 1997, 1998, and 1999 (Fig. 10). The sudden drops shown in Figure 10 are results of temperature data not being collected in December 1997 and 1998. Water chemistry for 1999 was similar to values from previous years (Fig. 11).

Site 3.

The percent SFC rockface for Site 3-OS in 1999 ranged from 30% in January to 50% in November, and was slightly higher than in previous years (Fig. 12 top). The percent rockface W/LF in 1999 ranged between 90 and 100%, which also agreed with data from previous years (Fig. 12 bottom). Very low water temperatures at Site 3-OS in 1993 were probably the result of thermometer exposure to air (Royer and Minshall 1993). In 1999, temperatures varied widely, as in other years, from 10.7 to 31.2°C (Fig. 9). However, average daily temperatures were relatively constant throughout 1997, 1998, and 1999 (Fig. 10). The sharp drops shown between 1997, 1998, and 1999 are due to lack of data recorded in December 1997 and 1998 (Fig. 10). Water chemistry for 1999 was similar to values from other years (Fig. 11).

Site 3-NS.

In 1999, the percent SFC at Site 3-NS ranged from 10 to 15% (Fig. 12) which was consistent with previous years. Percent rockface W/LF ranged from 80 to 100% (Fig. 12). Water temperatures at Site 3-NS were the most variable of all the study sites, ranging from 11.3 to 34.6°C (Fig. 9). Average daily temperatures remained constant throughout the year (Fig. 10). Slight drops in temperature between 1997, 1998, and 1999 are due to data not being collected in December 1997 and 1998 (Fig. 10). Water chemistry remained consistent with data from previous years (Fig. 11).

Periphyton

Site 1 (Hot Creek).

In 1999, the highest value for chlorophyll a, 98.7 mg/m^2, was obtained in August, and the lowest value, 19.5 mg/m^2, was obtained in May. The highest value for AFDM, 40 g/m^2, was obtained in March, and the lowest value, 4.2 g/m^2 was obtained in October . These values are within the range from previous monitoring years. Chlorophyll a and AFDM values tended to be higher and much more variable at Site 1 than at any other study site (Figs. 13, 14).

Site 2 (Upper Spring Rockface).

In 1999, the highest value for chlorophyll a at Site 2, 27.4 mg/m^2, was obtained in January and the lowest value, 5.5 mg/m^2, in March (Fig. 13). The highest value for AFDM, 19.0 g/m^2, occurred in March, while the lowest value, 6.0 g/m^2 was obtained in June (Fig. 14). These values fell within the range of measurements from previous years.

Site 3-OS (Lower Spring Rockface).

Chlorophyll a values for Site 3-OS were highest in October (32.5 mg/m^2) and lowest in March (3.8 mg/m^2) in 1999, and generally were lower than values from previous years (Fig. 13). The highest value for AFDM, 14.1 g/m^2, was obtained in March and the lowest value, 2.3 g/m^2 was obtained in November (Fig. 14). These values fell within the range of measurements from previous years, but were on the lower end of the range.

Site 3-NS.

The highest value for chlorophyll a, 66.4 mg/m^2, was obtained in November and the lowest value, 8.2 mg/m^2, was in October (Fig. 13). The highest value for AFDM, 16.2 g/m^2, was obtained in March and the lowest value, 3.0 g/m^2 was found in November (Fig. 14). In general, these measurements were slightly lower than those from previous years.

Habitat Assessment at Hot Creek

Using the Idaho Division of Environmental Quality Habitat Assessment Field Data Sheet for lowland streams (Appendix B), habitat assessment scores were obtained on a monthly basis for Hot Creek beginning in 1995. At the recommendation of Varricchione and Minshall (1997), habitat scoring was only once each year, midsummer, beginning in July 1997. Conditions remained fairly constant between 1995 and 1999, with only seasonal changes in vegetation (in 1995 and 1996) being apparent. Overall, scores for the riparian community were intermediate to high, while substrate scores were low (Table 1).

Discharge monitoring at the rockface seeps

Discharge measurements at all of the weirs were made between October 1997 and November 1999. In 1999, weir discharge at Site 3-NS ranged between 0.5 in January to 0.9 L/min in May, Site 3-OS ranged between 3.6 in August to 6.6 L/min in January, and Site 2 Right Seep ranged between 3.00 in November to 8.4 L/min in April. The drop that occurred in June 1998 was due to breakdown of plastic sheeting at Site 2. The plastic was in poor condition and an unknown quantity of water flowed through the plastic and under the weir. The plastic was replaced in June of 1998. Weirs located at Sites 3-OS and 3-NS should be accurate since no plastic was used in these locations. In the 25 months that discharge in the weirs was measured, expected highs in spring (January - March) were shown (Fig. 15) as well as a gradual dropping that occurred April through

November (Fig. 15). Although less than three years of data exist at the weirs, 1999 was shown to contain the lowest values recorded. Additional weir measurements in future years are needed to see if seasonal trends exists.

Intensive search for relict populations of P. bruneauensis in and around Hot Creek.

An intensive search along the length of Hot Creek (May 1999) revealed that there was still an apparent absence of Springsnails in Hot Creek. A small rockface seep, approximately 1.80 m out from Hot Creek and approximately 2.00 m in the downstream direction from Site 1 on Hot Creek, is in the same location as that described by Robinson et al. (1992). Less than 50 Springsnails were found on this rockface in 1997 (Varricchione and Minshall 1998). In January 1998, less than 30 Springsnails were found. In February through November of 1999, this rockface was dry and no Springsnails were found. However, less than 20 Springsnails were found along the path of the small seep which emerged below the rockface and trickled to Hot Creek. Due to thick vegetation along the path of the seep and little Springsnail abundance, density sampling of the seep was not done.

DISCUSSION

Conditions at Indian Bathtub and Hot Creek

The Indian Bathtub and Hot Creek areas have been greatly impacted in recent years. A flood in the summer of 1991 contributed much silt, sand, and gravel to Hot Creek. In particular, Indian Bathtub was reduced to less than one-half its size before the flood because of sediment. Available habitat in the immediate vicinity of Indian Bathtub was reduced because of this and other sedimentation events (Mladenka 1992). Furthermore, Springsnail habitat has diminished considerably in recent years because of agriculture-related groundwater mining in the area (Berenbrock 1993). As a result of these changes the Indian Bathtub population has been eliminated (Myler and Minshall 1999). Hot Creek re-surfaces over 450 m from Indian Bathtub. Springsnail populations downstream of the Bathtub were reduced drastically in Hot Creek (Site 1) following a major runoff event in July 1992 (Royer and Minshall 1993) but have recently recovered in small numbers (300-400 individuals).

Other habitat parameters measured at Hot Creek (Site 1) (stream temperature, discharge, periphyton chlorophyll a and biomass, and riparian habitat quality) in 1999 remained fairly consistent with data collected in previous years (at least after sedimentation events in 1991 and 1992). The lack of grazing in the area has led to a rapid recovery of riparian vegetation over the past few years.

The recolonization of *P. bruneauensis* in Hot Creek demonstrates this Springsnails resilience to disturbance. Since Hot Creek is a geothermally heated stream, apparently no natural aquatic predators were present. Therefore, Springsnails probably did not evolve in the presence of significant predators and competitors. Anthropogenic disturbances have placed this species in danger of possible extinction. The most significant threat to this species remains the reduction of available habitat as a result of extensive groundwater mining. This has caused the once plentiful rockface habitat near Hot Creek to become virtually eliminated. Since complete restoration of habitat might take hundreds to thousands of years, more realistic goals of stabilizing the thermal aquifer at 1999 levels should be established.

Conditions at the Rockface Seeps

Springsnail size-distribution and density measurements, along with rockface habitat parameters (periphyton chlorophyll a and biomass, water temperature and chemistry, and rockface flow and moisture conditions) all were within a range set by previous years. However, Springsnail densities at Sites 2 and 3 (OS, NS) were among the lowest of the past decade. In particular at Site 3 NS, densities were such that 50 snails could not be found to conduct size distribution analysis. The rockface seeps had water temperatures that were consistently lower than those in Hot Creek (Site 1) and rarely exceeded the thermal tolerance temperature (35°C) (Mladenka 1992). This most likely explains the higher amounts of year-round recruitment at the rockface seep sites (2, 3-OS, and 3-NS) compared with those formerly found in Hot Creek. Temperature variations clearly affect the *P. bruneauensis* populations. Average size and growth rates were smaller, but densities were greater at the rockface seeps than found in Hot Creek during 1990-1992. The rockface sites are probably more suitable for Springsnail success than Hot Creek (Varricchione and Minshall 1998) because they provide a refuge from temperature extremes, predation, and flooding events and provide stable habitat for egg-laying (Myler and Minshall 1999). Historically, the highest densities of Springsnails probably occurred on wetted rockfaces on Indian Bathtub.

Although discharge measurements have only been recorded at the rockface seep sites (2, 3-OS, and 3-NS) for 25 months, it appears that there may be extensive variability. The lowest discharge measurement (June-November) appear to coincide with the groundwater extraction for agriculture. Continued monitoring of spring flows should provide useful insight into the status of the local groundwater situation.

The current monitoring program examines the habitat, food resources, size, and density of the Bruneau Springsnail at locations which are not representative of the entire population over the present Springsnail range. We feel that the present monitoring efforts should continue but that other sites, which are distributed across the native range, should be added to current monitoring protocols. A cooperative effort between the USFWS, ISU, and the BLM has been established to modify existing protocols to include a more representative number of monitoring locations. Twenty-one sites including the five sites included in this report (BHSS sites 1, 2A, 2B, 3-OS, and 3-NS) were established in October 1999. Photographs, site sketches, and initial reconnaissance findings are on file at the U.S. Fish and Wildlife Service in Boise, Idaho. Monitoring will continue at present sites but will be restricted to monthly sampling from May through October. Measurements at remaining sites will focus on wetted and flowing spring area, discharge, relative Springsnail density, specific conductance, and water temperature.

RECOMMENDATIONS

To properly manage *P. bruneauensis* populations in the Bruneau River drainage, the biology of these Springsnails must be well understood. Mladenka (1992), Taylor (1982), and Fritchman (1985) made significant contributions to knowledge of the biology of *P. bruneauensis*. Recent population and habitat monitoring done by Idaho State University (Myler and Minshall 1999; Varricchione and Minshall 1998, 1997, 1996, 1995a, 1995b; Royer and Minshall 1993; Robinson et al. 1992) have made additional contributions. Still, many questions remain unanswered. The most pressing question regards the uniqueness of the Springsnail populations at the different thermal streams and spring flows along the Bruneau River. Because of the different temperature regimes and the spatial separation of the populations, there is a good probability for the existence of unique gene pools and thus, different species or subspecies of the Bruneau Hot-spring Springsnail at the various locations within the drainage. Experiments such as controlled growth-rate studies and population genetics studies would provide insight into whether these populations are closely related or not. This insight is needed before experiments or large-scale re-introductions in Hot Creek can be performed using *P. bruneauensis* from other locations.

Exotic fish have been shown to recognize the Springsnails as food in the laboratory. Further experiments have determined that *Tilapia* is a significant predator and competitor to the Bruneau Springsnail in Hot Creek (Myler, unpublished data). Individuals have recolonized Hot Creek only within the boundaries of the fish exclosure. These exotic fish have been seen along the entire 4 km reach of the Bruneau River where the hot springs occur. We recommend that these fish be removed from Hot Creek. A fish barrier would need to be constructed near the confluence with the Bruneau River to prevent reentry of fish from the Bruneau River. Since Springsnails are once again found in the upstream portion of this stream, removal of these fish will be complicated if immediate action is not taken.

The Bruneau Springsnail is dependant upon the thermal aquifer for its survival. The spring survey conducted in September 1998 shows that the number of thermal springs is rapidly declining (Myler and Minshall 1998). Managers must take action to stabilize the thermal aquifer at present levels. Habitat improvement techniques can utilize existing habitat to stabilize Springsnail populations. Again, the most significant threat to the endangerment of this species is the reduction of habitat as a result of ground water mining for agriculture. This Springsnail has demonstrated high potential to rebound from anthropogenic disturbance. However, if thermal groundwater levels are not stabilized, this species is likely to become extinct.

ACKNOWLEDGMENTS

Many thanks to Aaron Prussian, Chris Seeley, Dawn Schmidli, and Jeff Varricchione for their assistance with field work in the 1999 field season.

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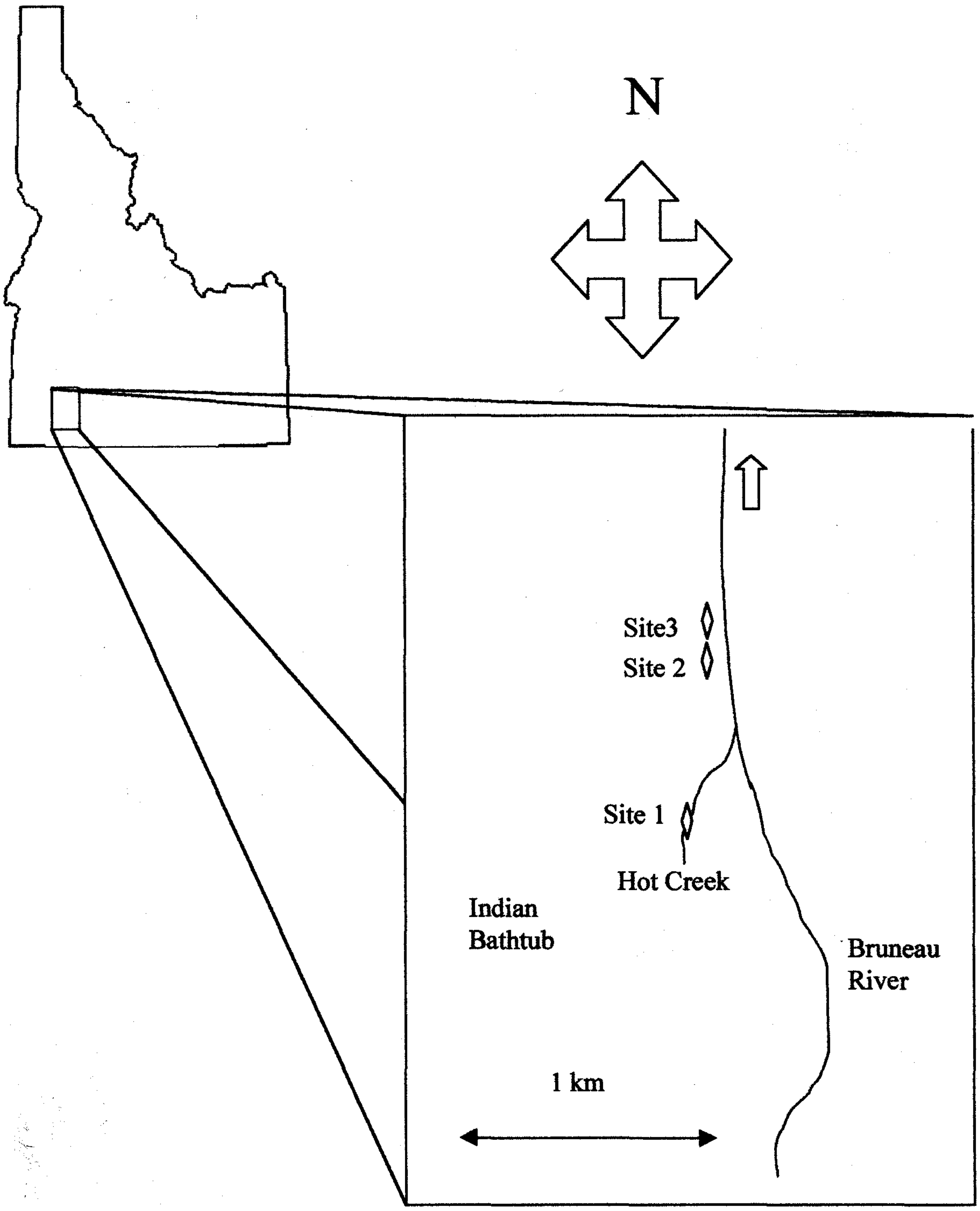


Figure 1. Map showing the locations of the Bruneau Hot-spring Springsnail study sites. Hot Creek is shown as it exists in 1998, emerging over 400 m downstream of Indian Bathtub.

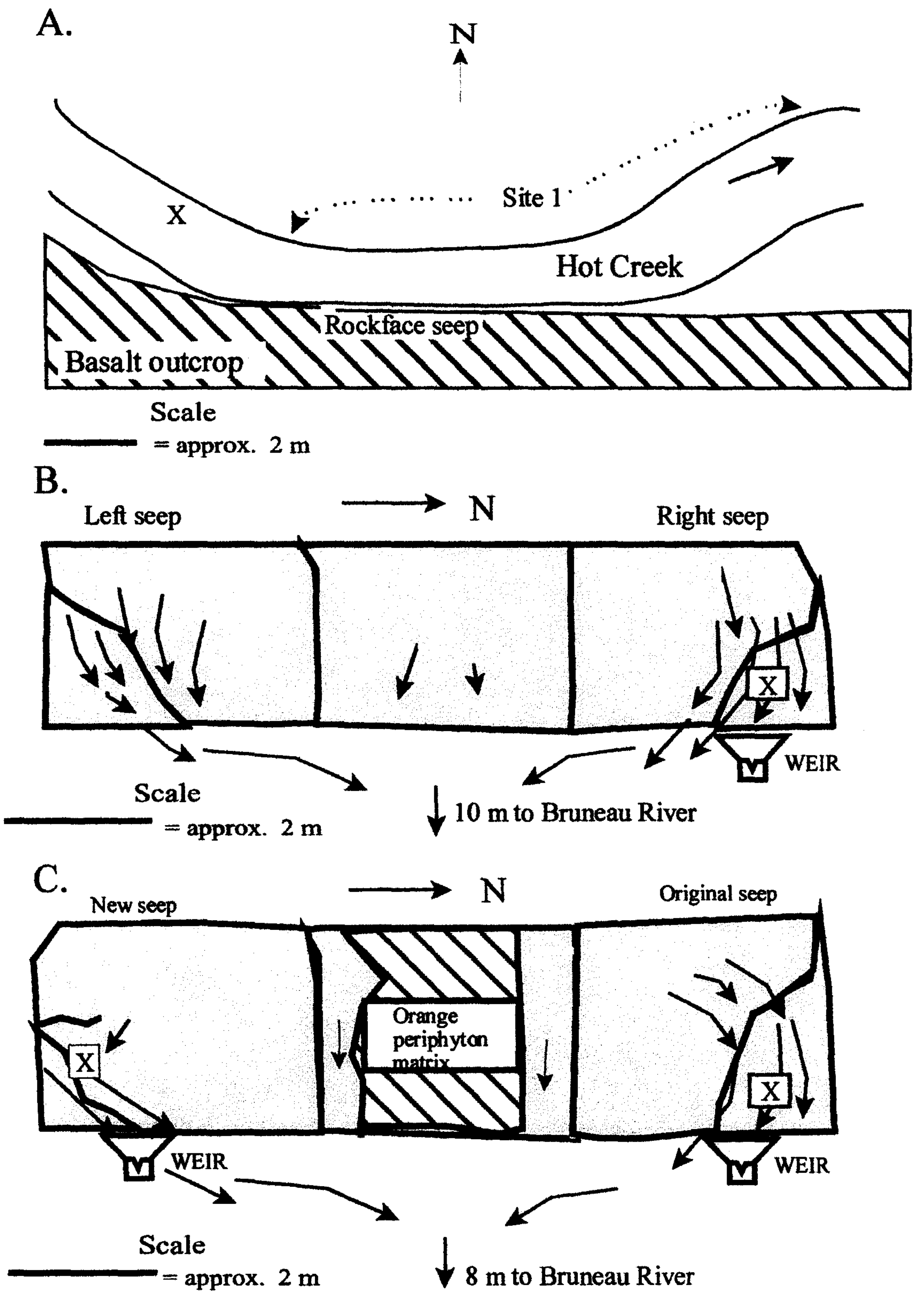


Figure 2. Temperature data logger locations for each of the study sites. Data loggers are represented by "x". A. Map view of Site 1 (Hot Creek). B. Front view of Site 2 rockface. C. Front view of Site 3 rockface (Original and New Seeps).

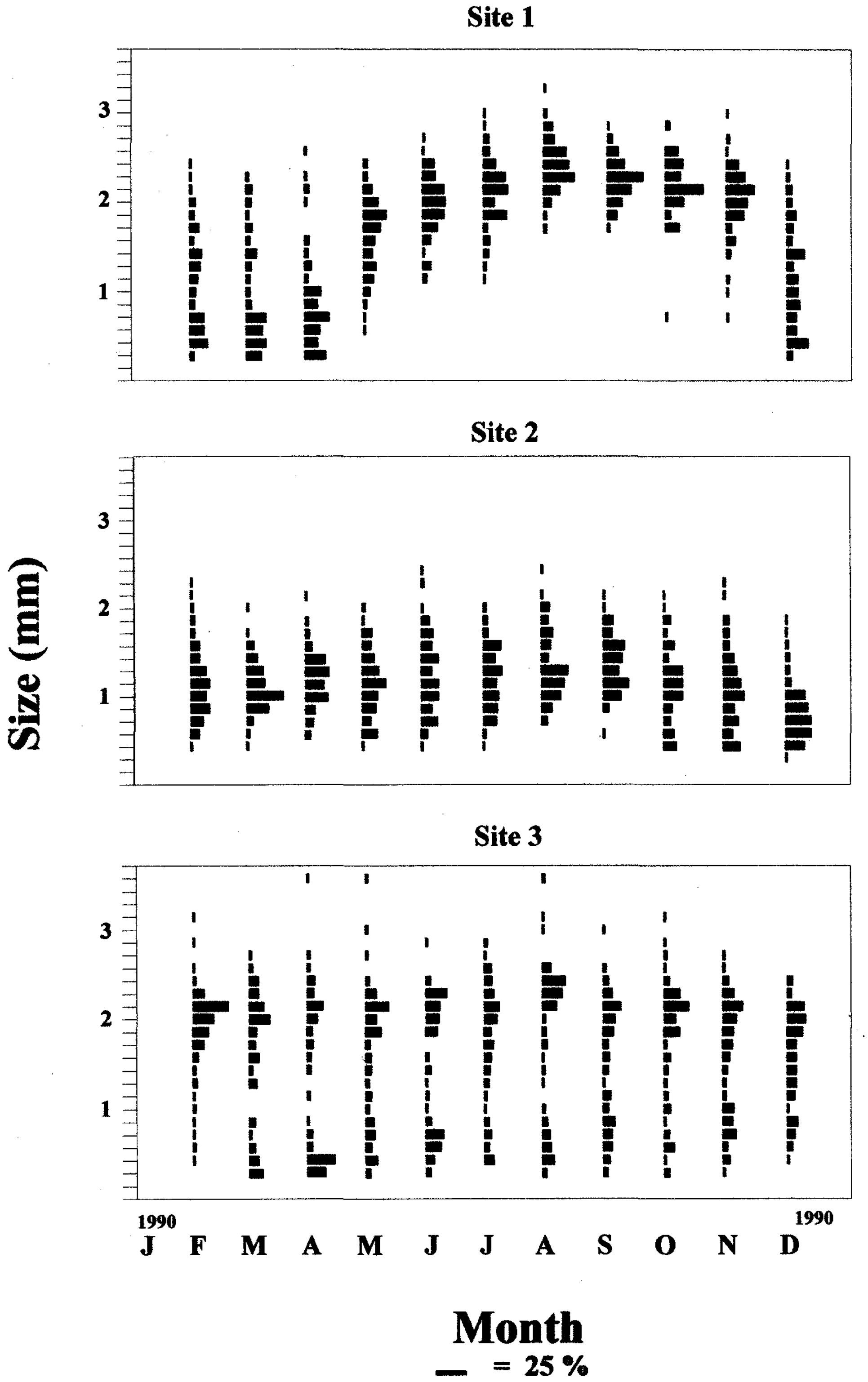


Figure 3a. **Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for each sample).**

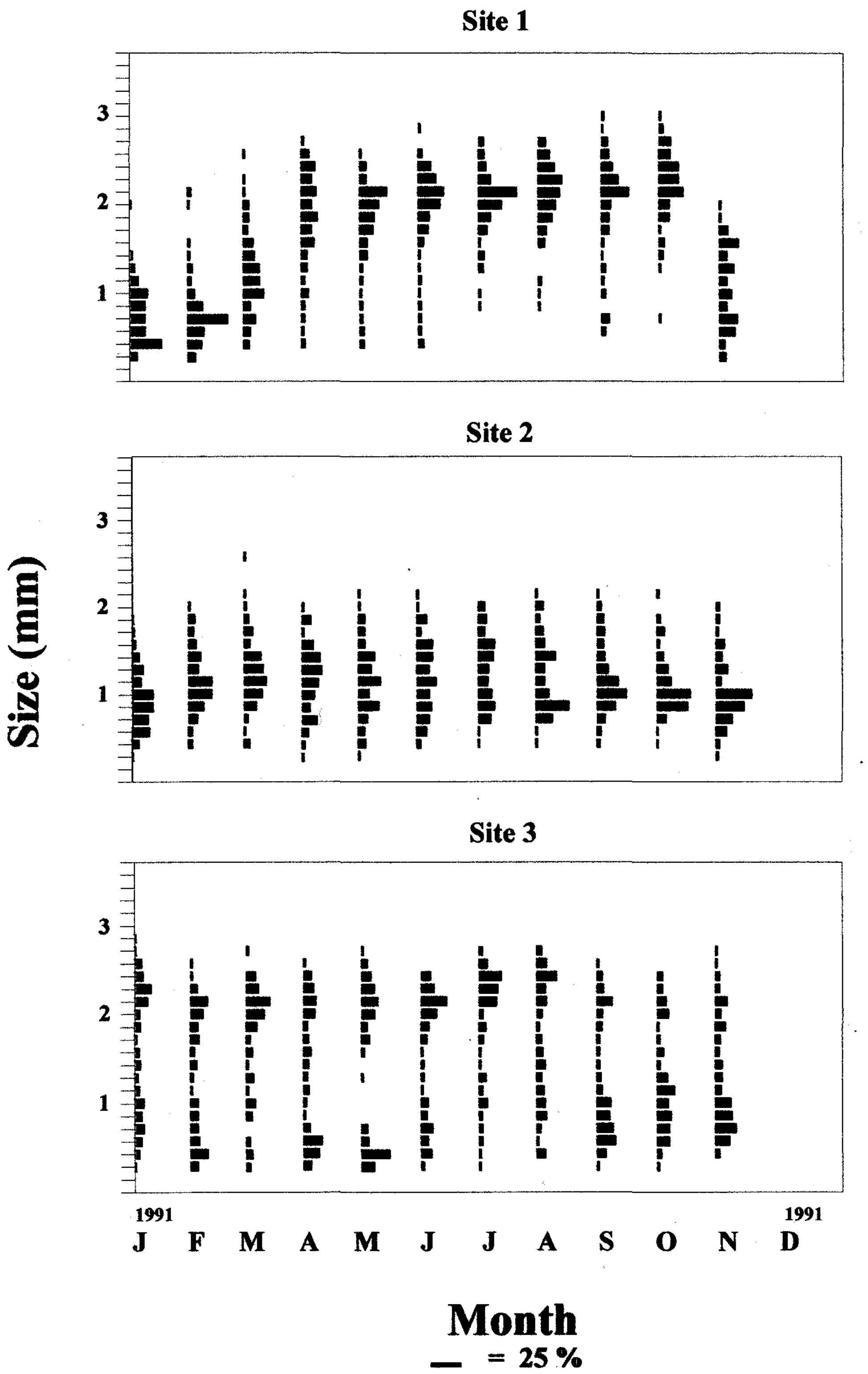


Figure 3b. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for each sample).

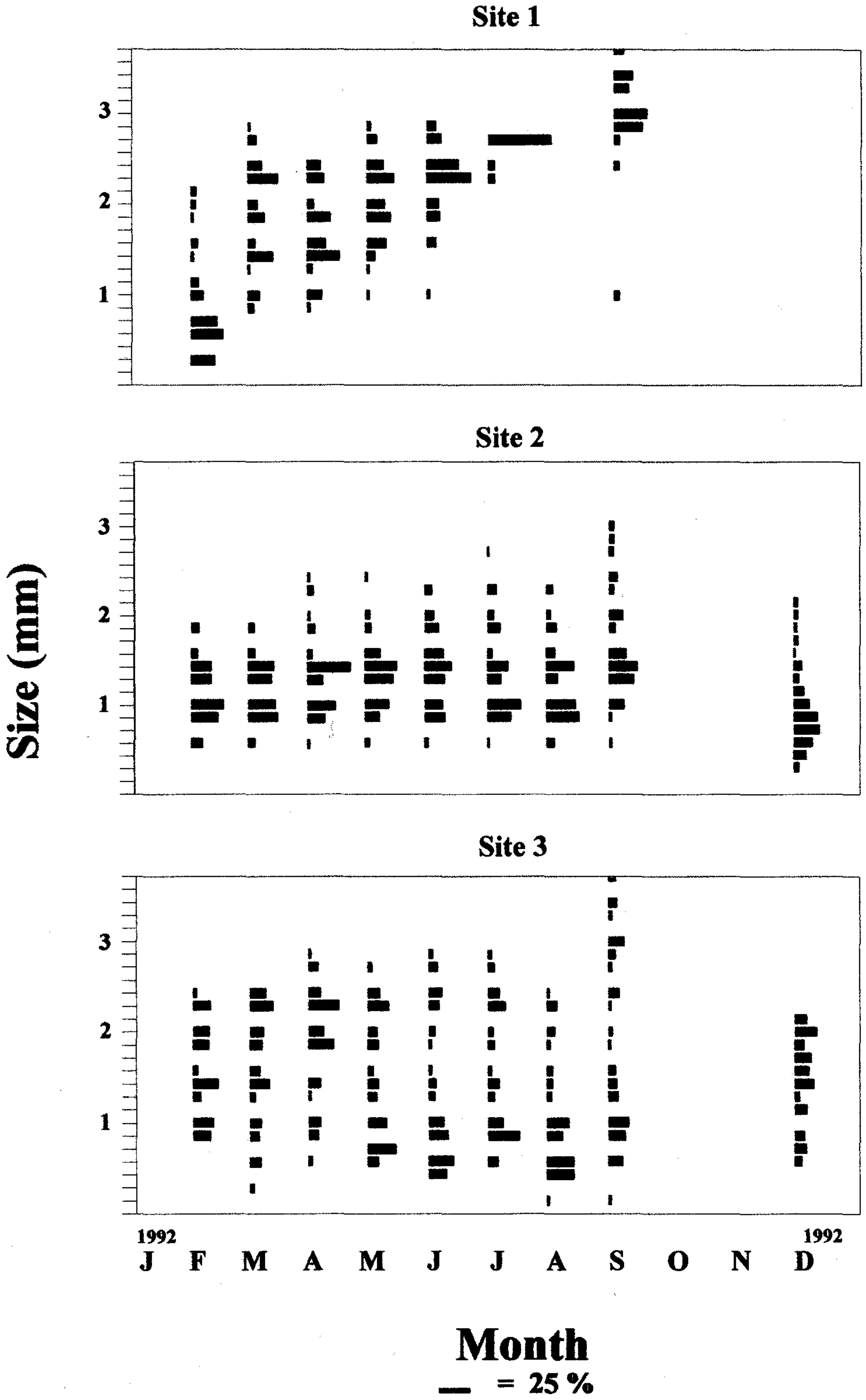


Figure 3c. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for each sample). In July, 92% of the snails at Site 1 were found in the 2.66 mm size class (an out of range value for this figure).

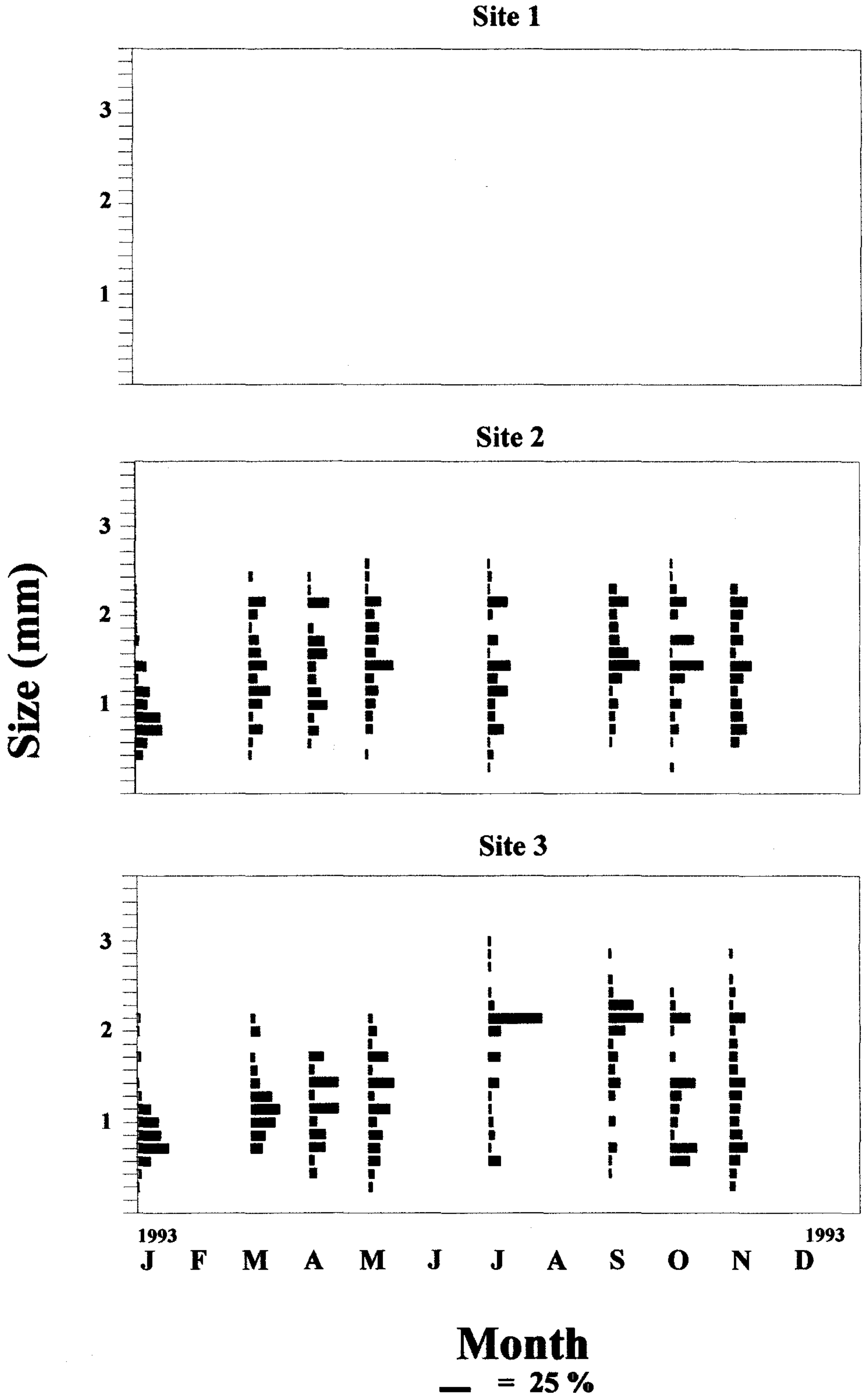


Figure 3d. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for each sample).

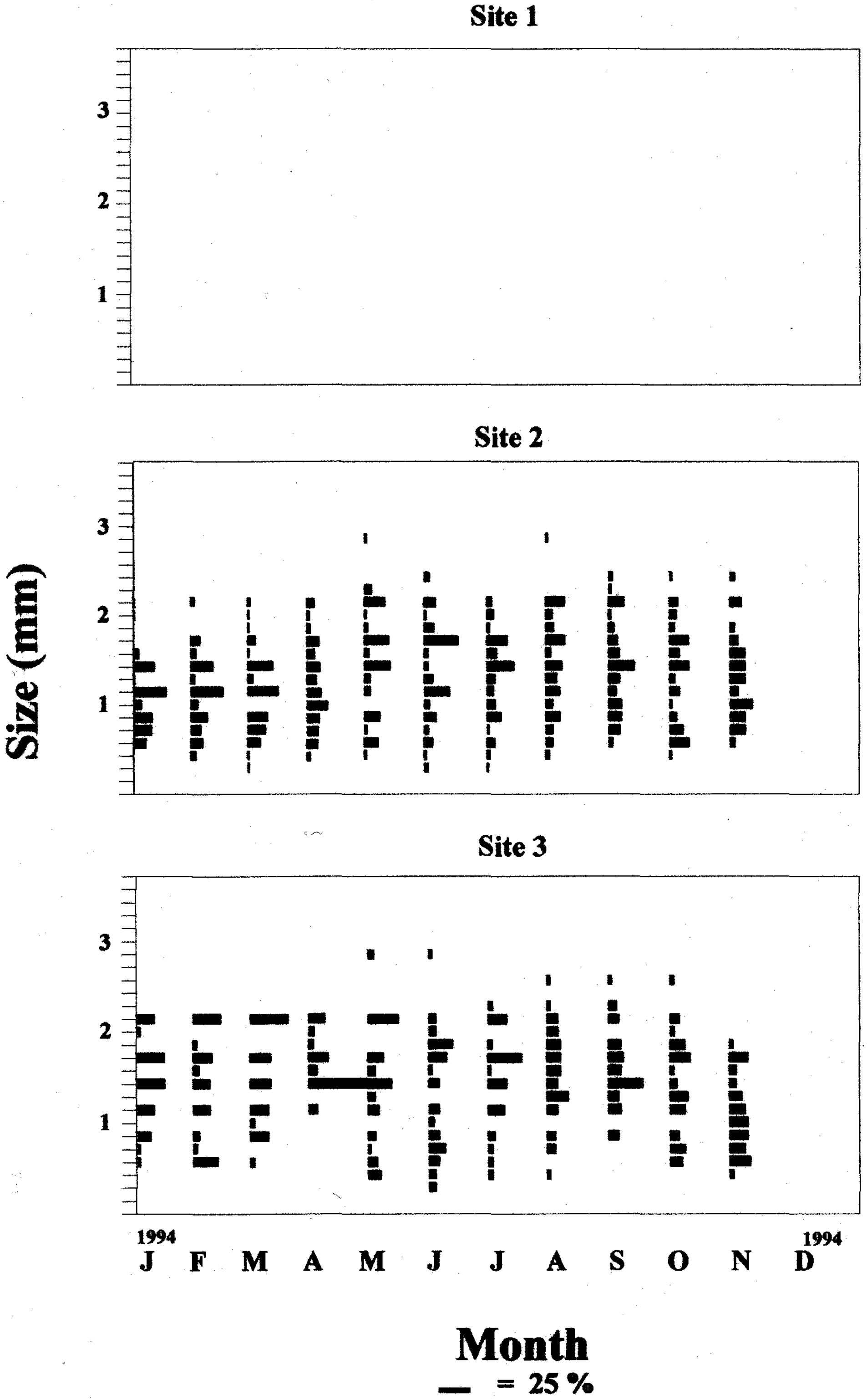


Figure 3e. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular class (n=100 for Site 2; n=50 for Site 3).

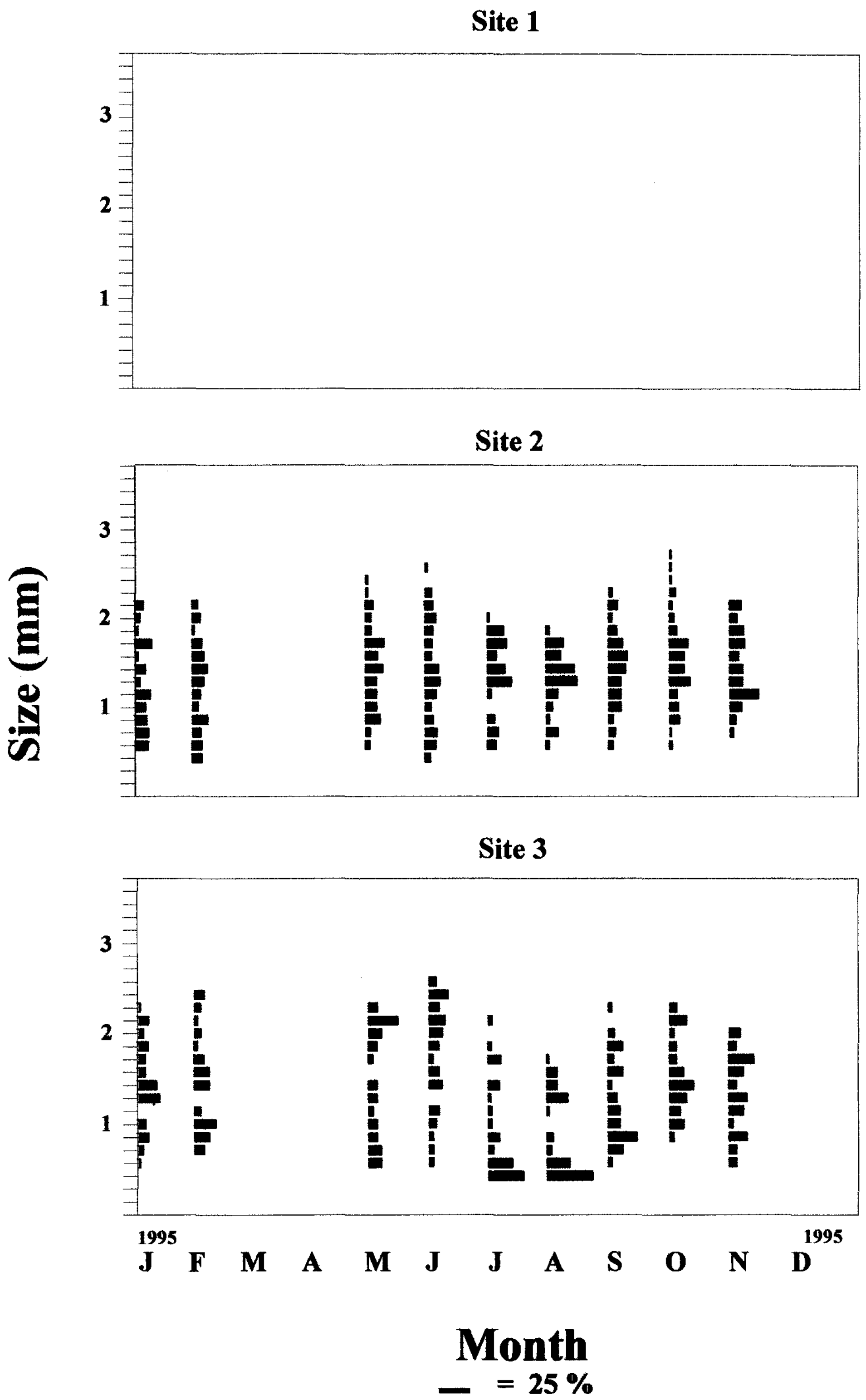


Figure 3f. **Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).**

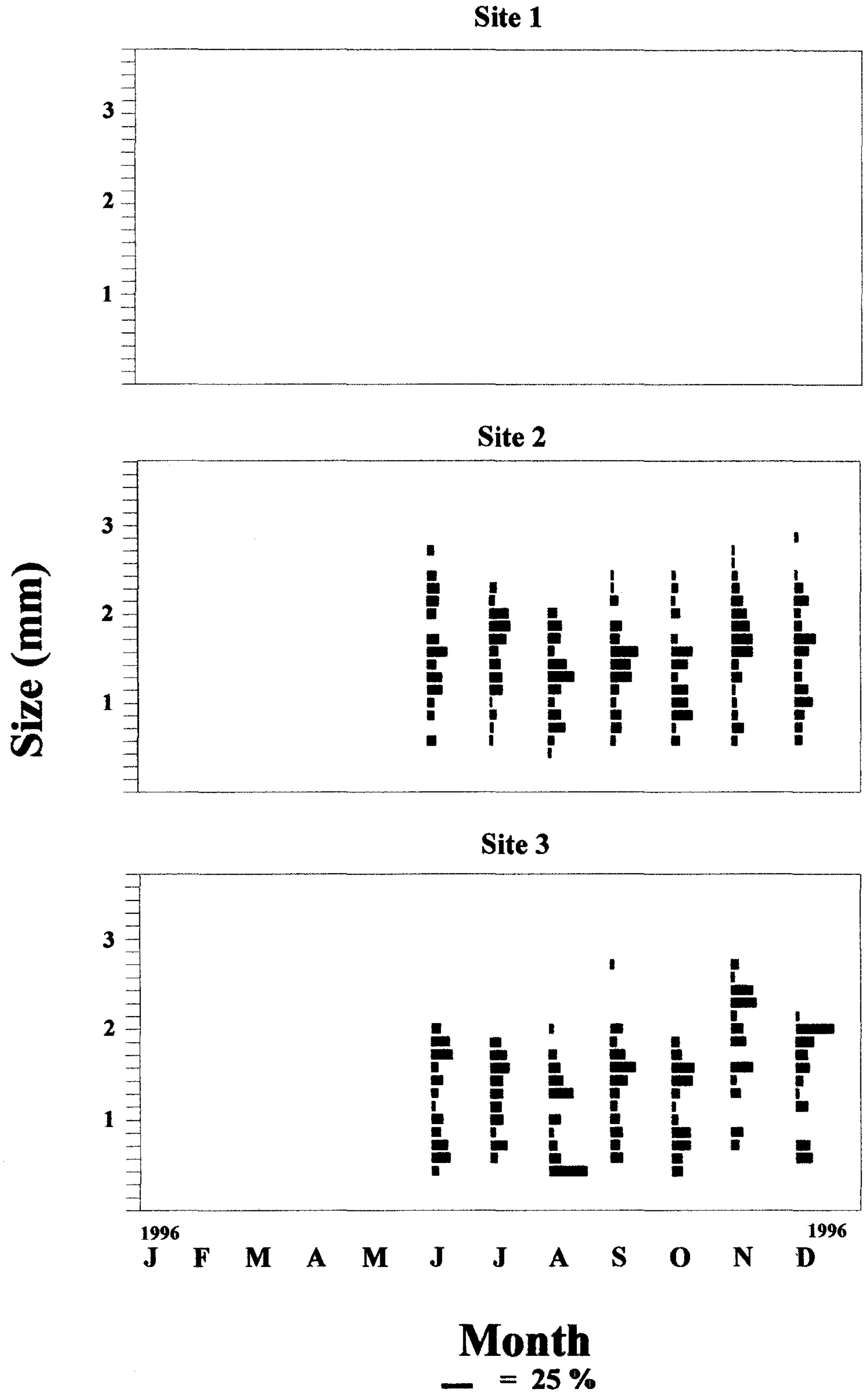


Figure 3g. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

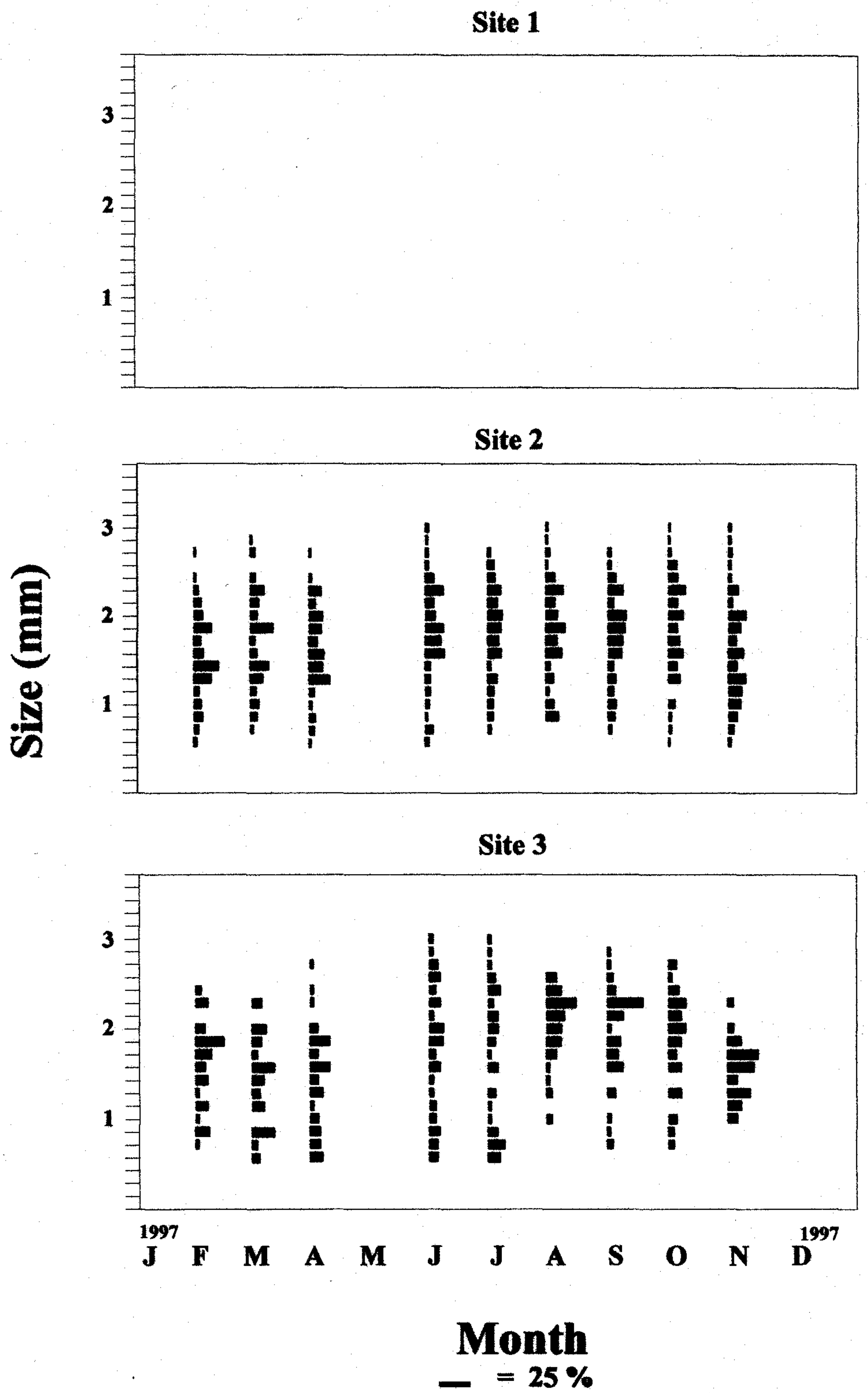


Figure 3h. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

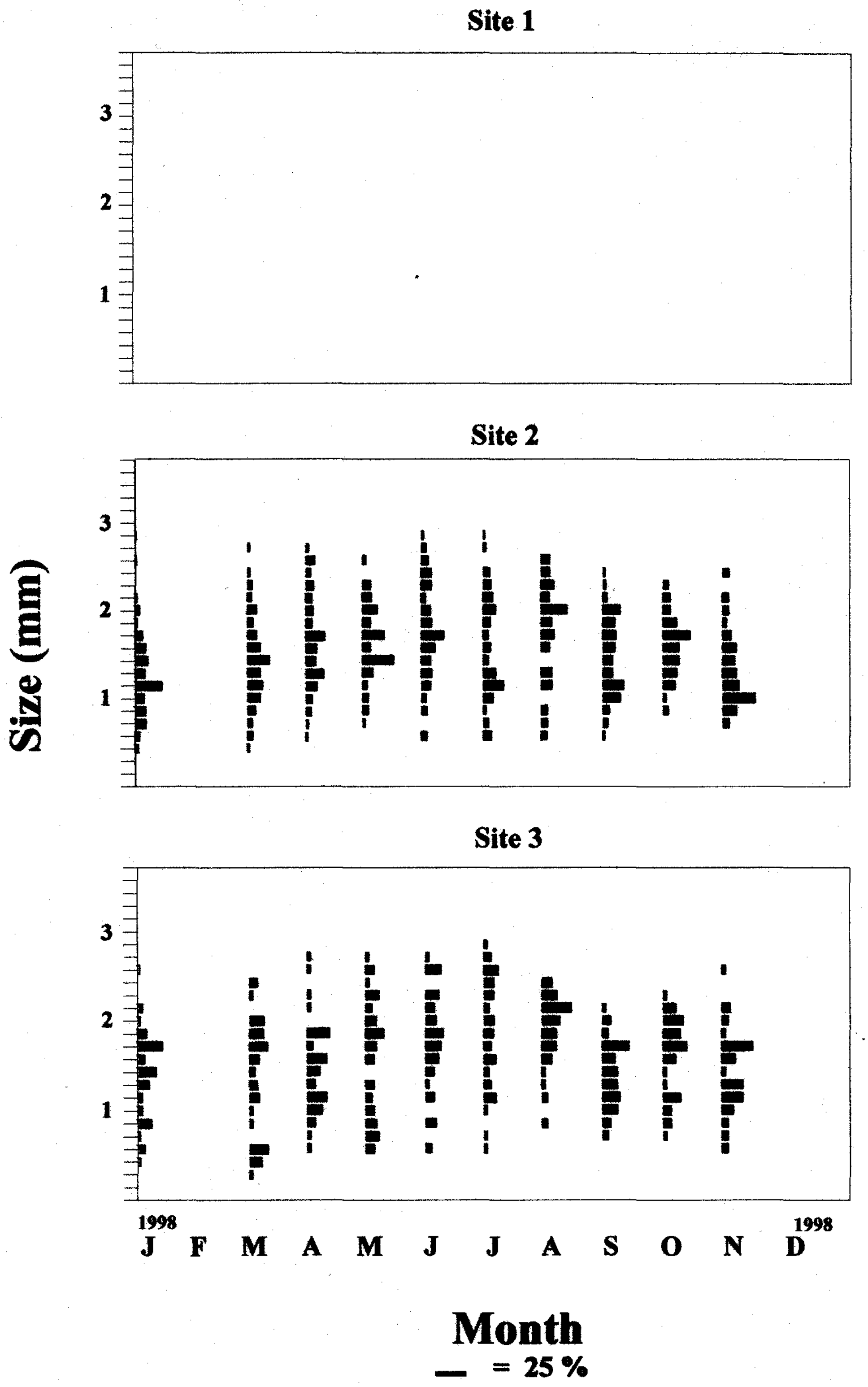


Figure 3i. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

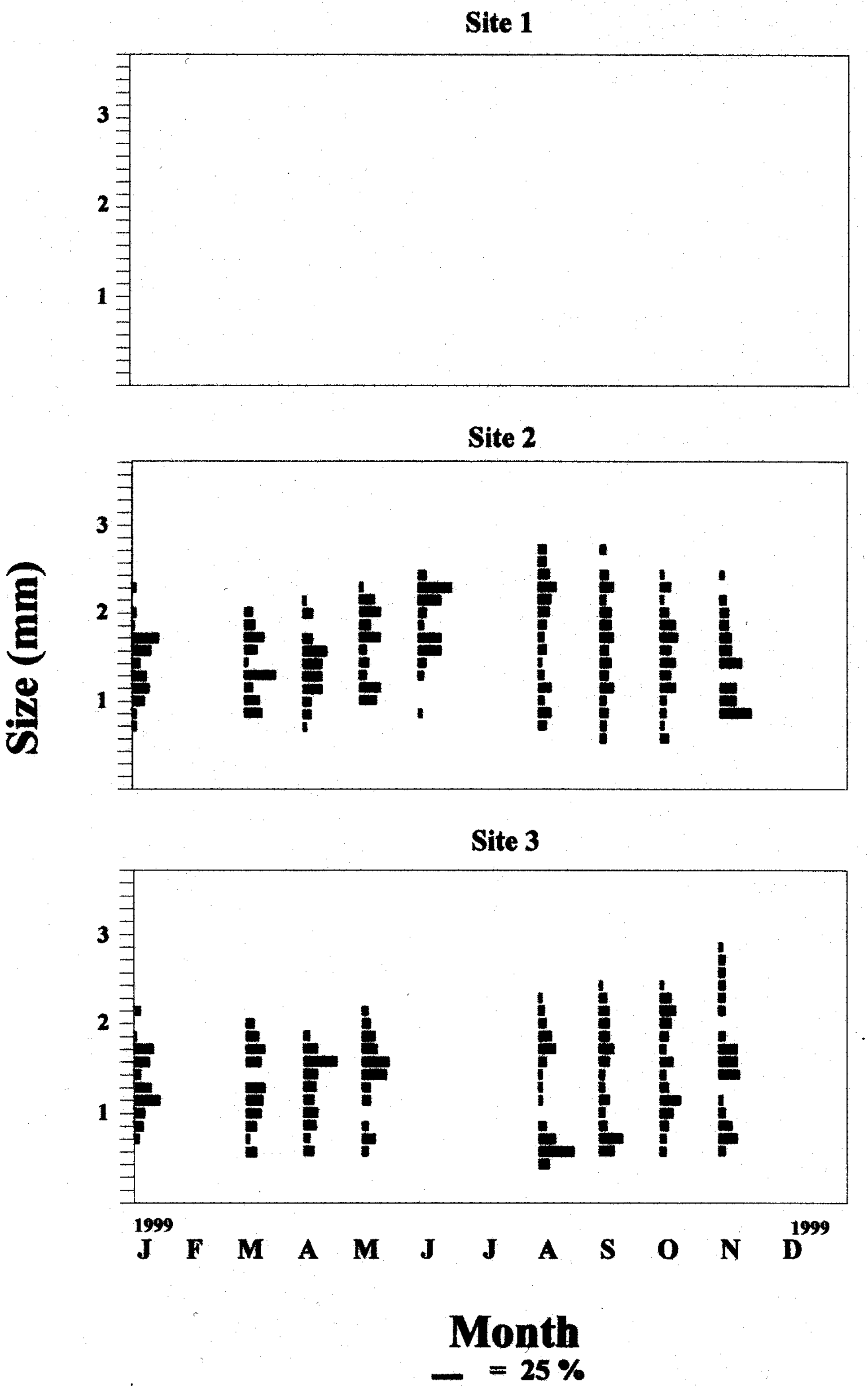


Figure 3j. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=100 for Site 2; n=50 for Site 3).

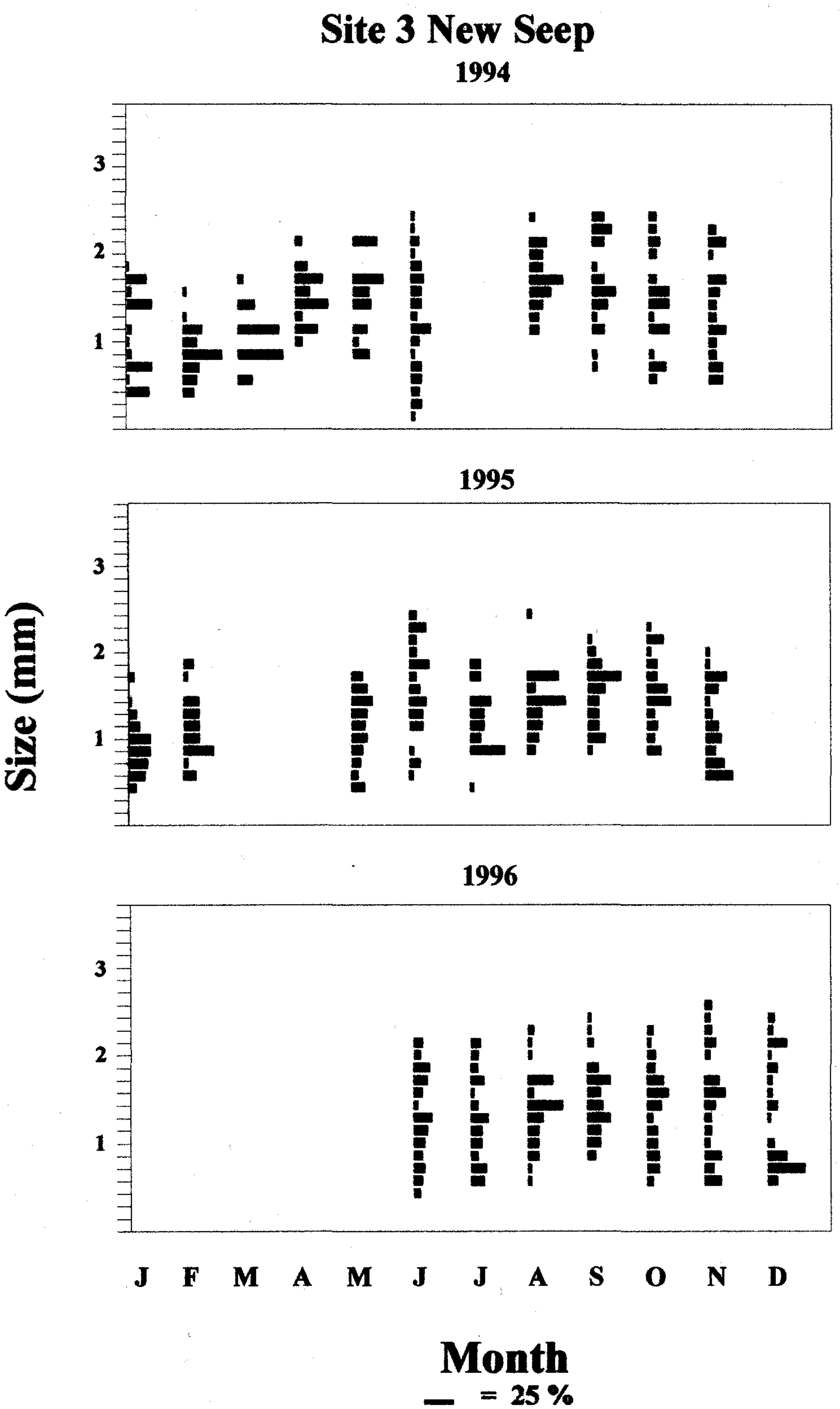


Figure 4a. **Size histograms for the Bruneau Springsnail study site 3 New Seep. Horizontal tick marks represent 0.14 mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=50 for each sample).**

Site 3 New Seep

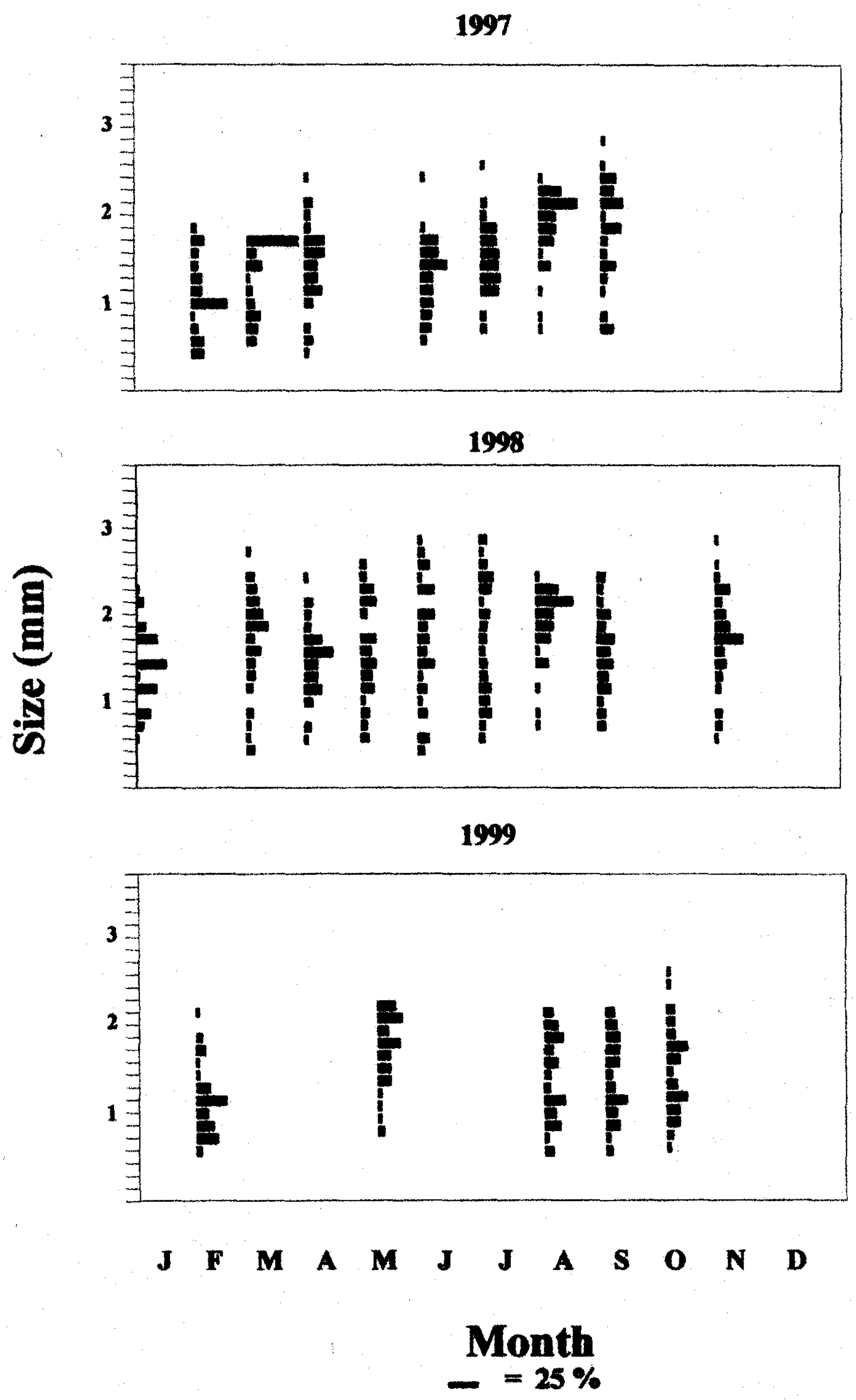


Figure 4b. Size histograms for the Bruneau Springsnail study sites 3 New Seep. Horizontal tick marks represent 0.14 mm size classes. Solid bars represent relative abundance of snails for a particular size class (n=50 for each sample).

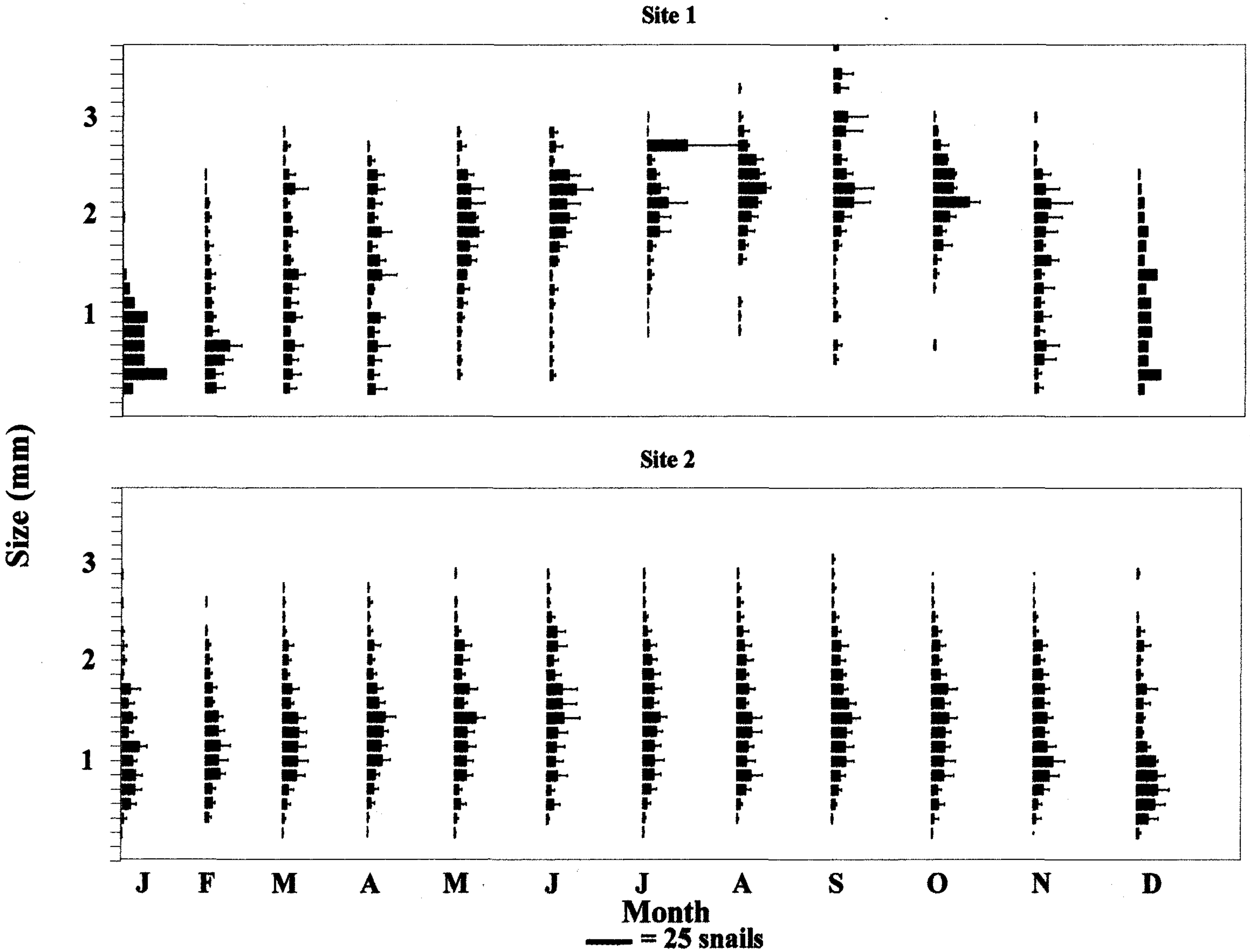


Figure 5a. Size histograms for Bruneau Springsnail study sites 1 and 2 based upon data from 1990-1999. Horizontal tick marks represent 0.14 mm size classes. Error bars represent one standard deviation from the mean. Figures lacking error bars did not have enough sets of data to determine standard deviations.

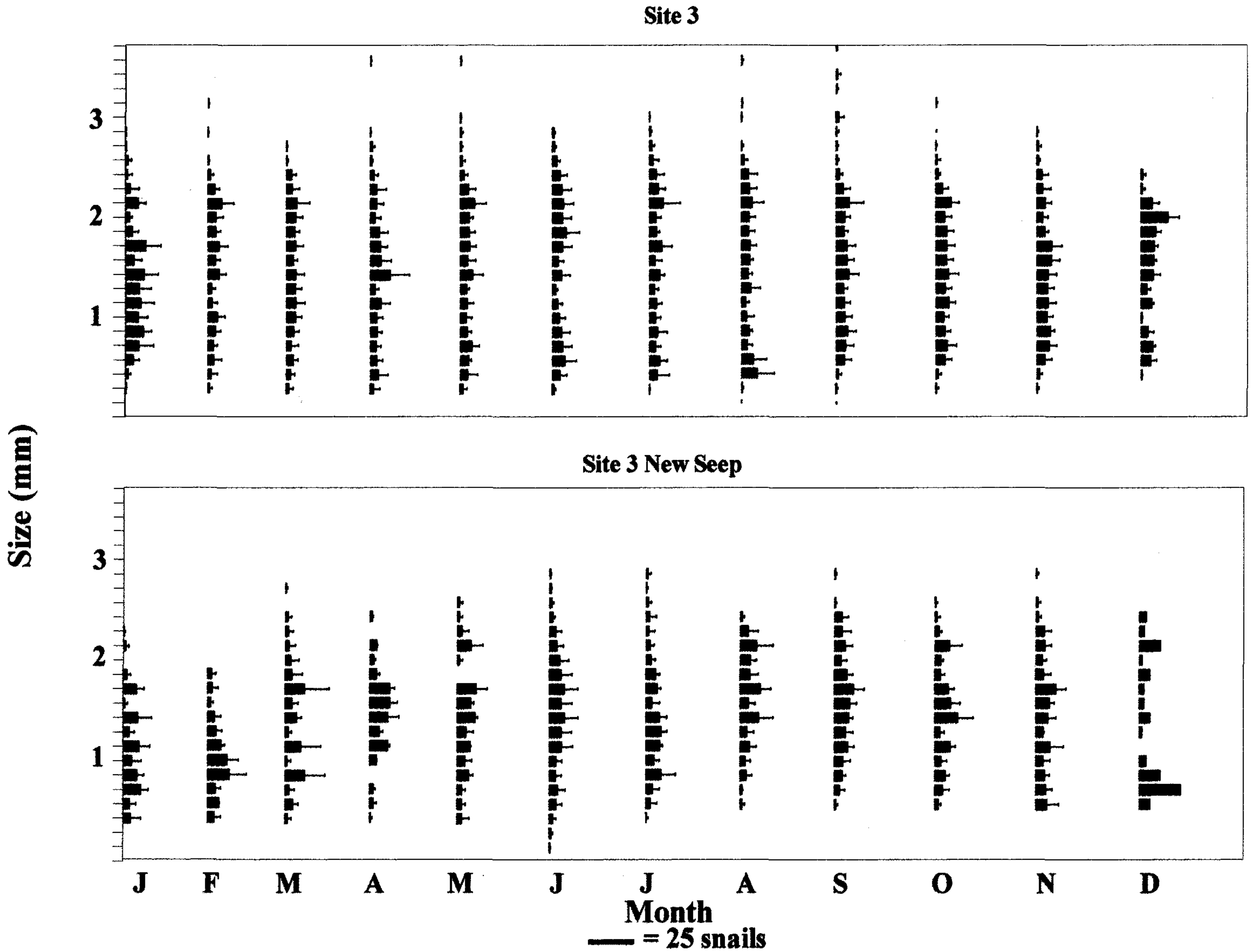


Figure 5b. Size histograms for Bruneau Springsnail study sites 3 and 3 New Seep based upon data from 1990-1999. Horizontal tick marks represent 0.14-mm size classes. Error bars represent one standard deviation from the mean. Figures lacking error bars did not have enough sets of data to determine standard deviations.

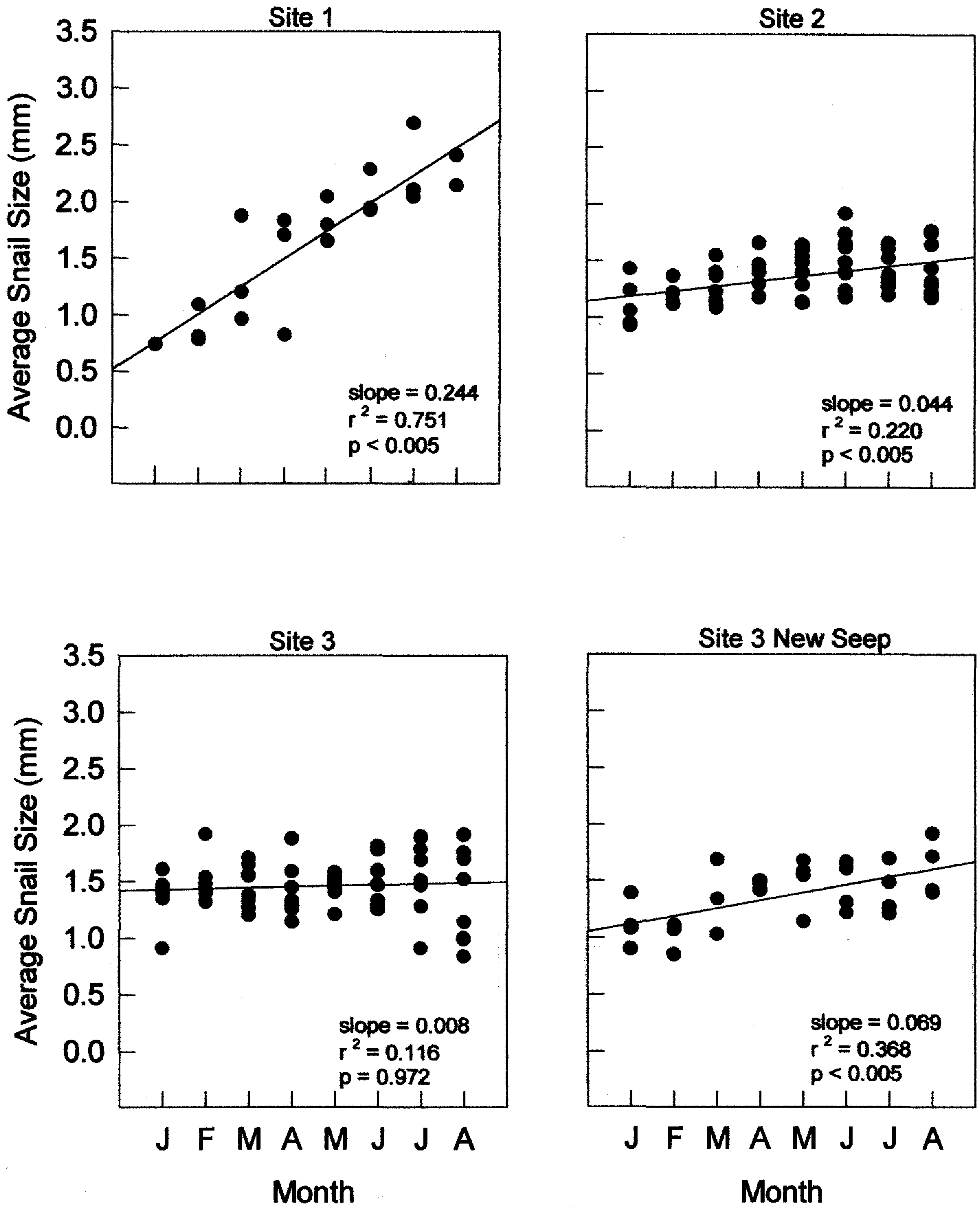


Figure 6. Estimated Springsnail growth rates based upon average monthly size (mm) at study sites 1, 2, 3-OS, and 3-NS. See text for explanation of months chosen for analyses. Years included in the analyses were 1990 - 1992 (Site 1), 1990 - 1999 (Sites 2 and 3-OS), and 1994 - 1999 (Site 3-NS).

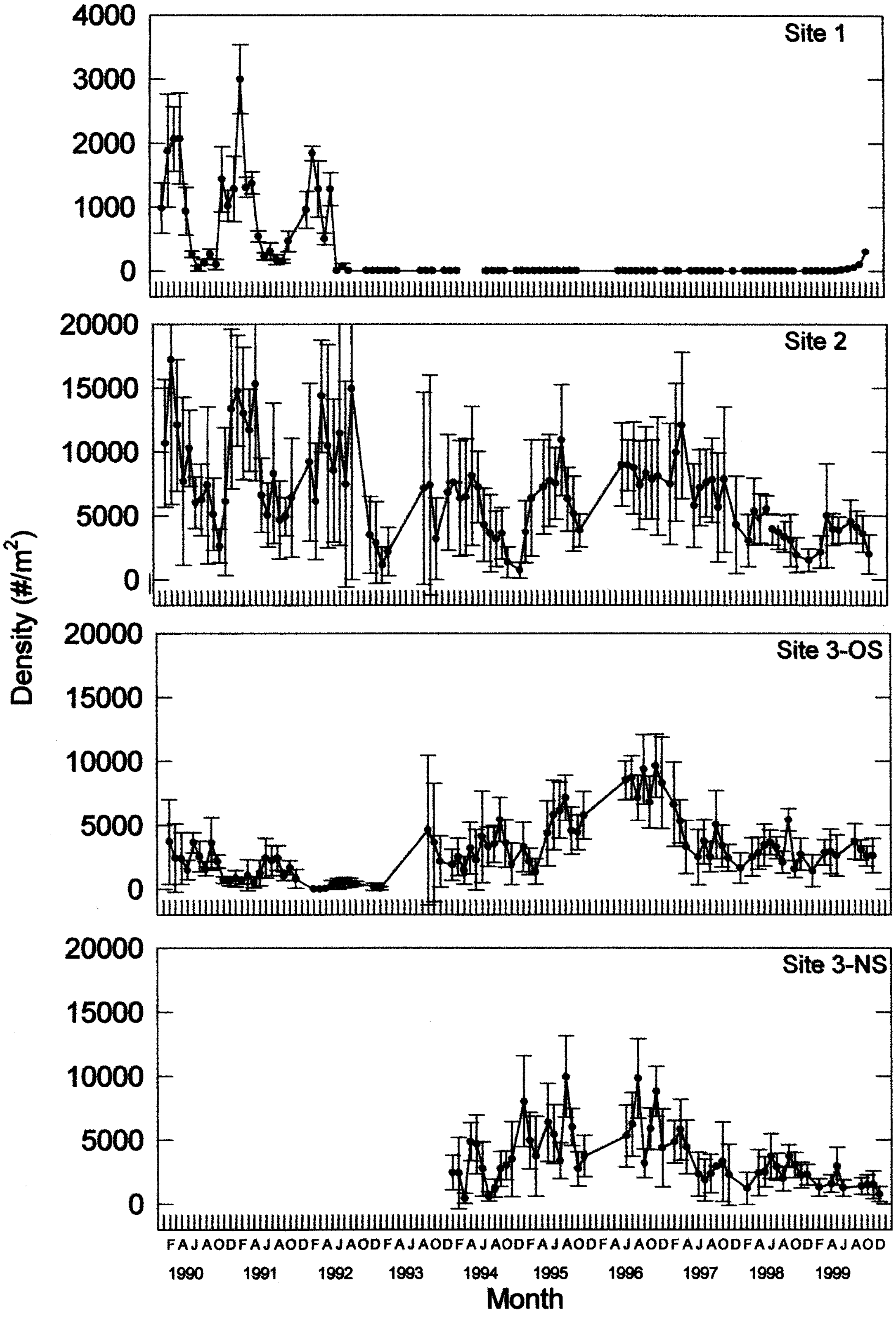


Figure 7. Mean density of the Bruneau Springsnail at the four study sites. Error bars represent one standard deviation from the mean. Note the different Y-axis for Site 1.

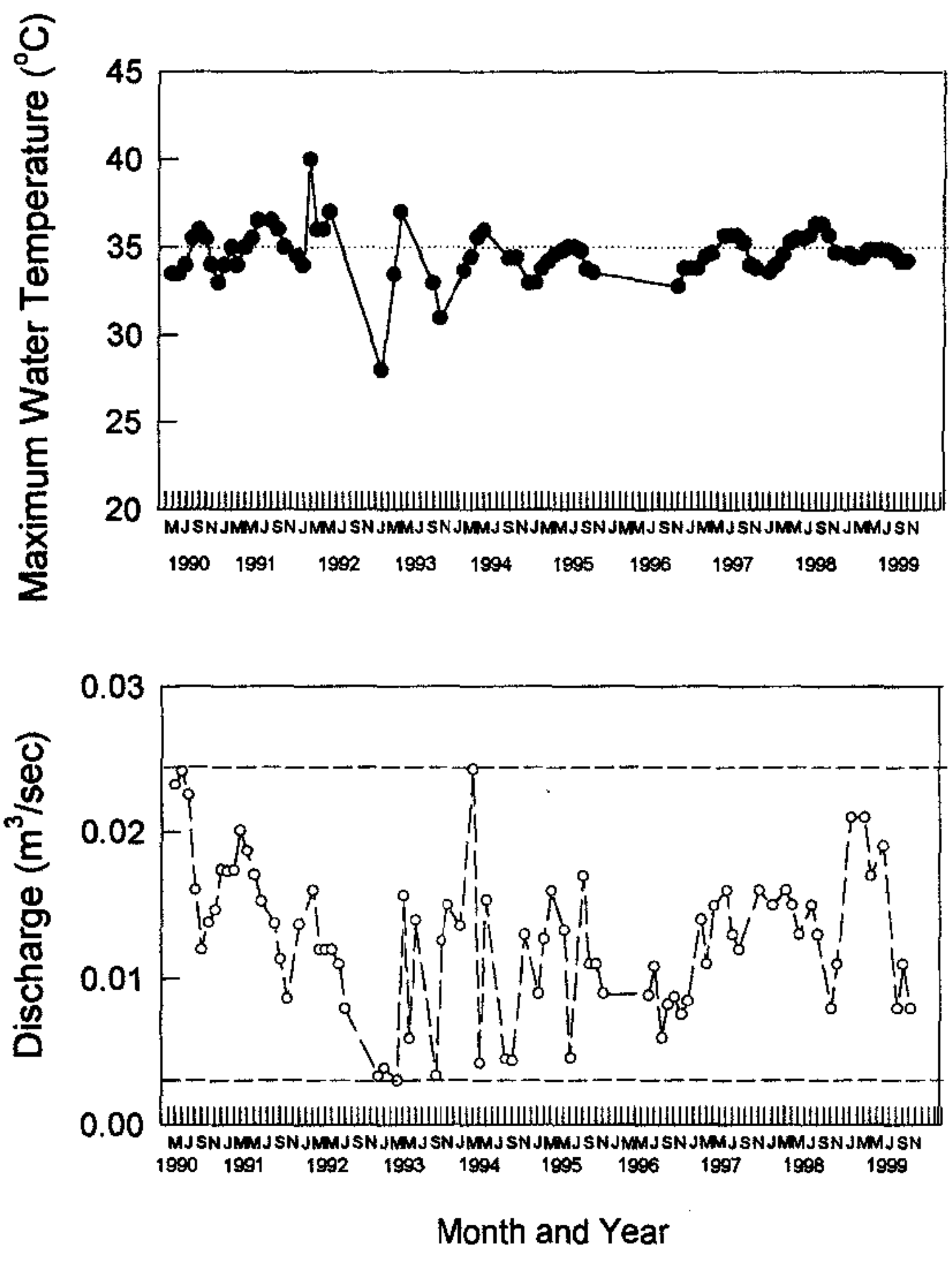


Figure 8. Discharge and maximum water temperatures for Site 1 (Hot Creek). Dashed horizontal lines indicate the maximum and minimum discharges measured at Hot Creek. Dotted horizontal line indicates thermal maximum temperature for *P. bruneauensis*.

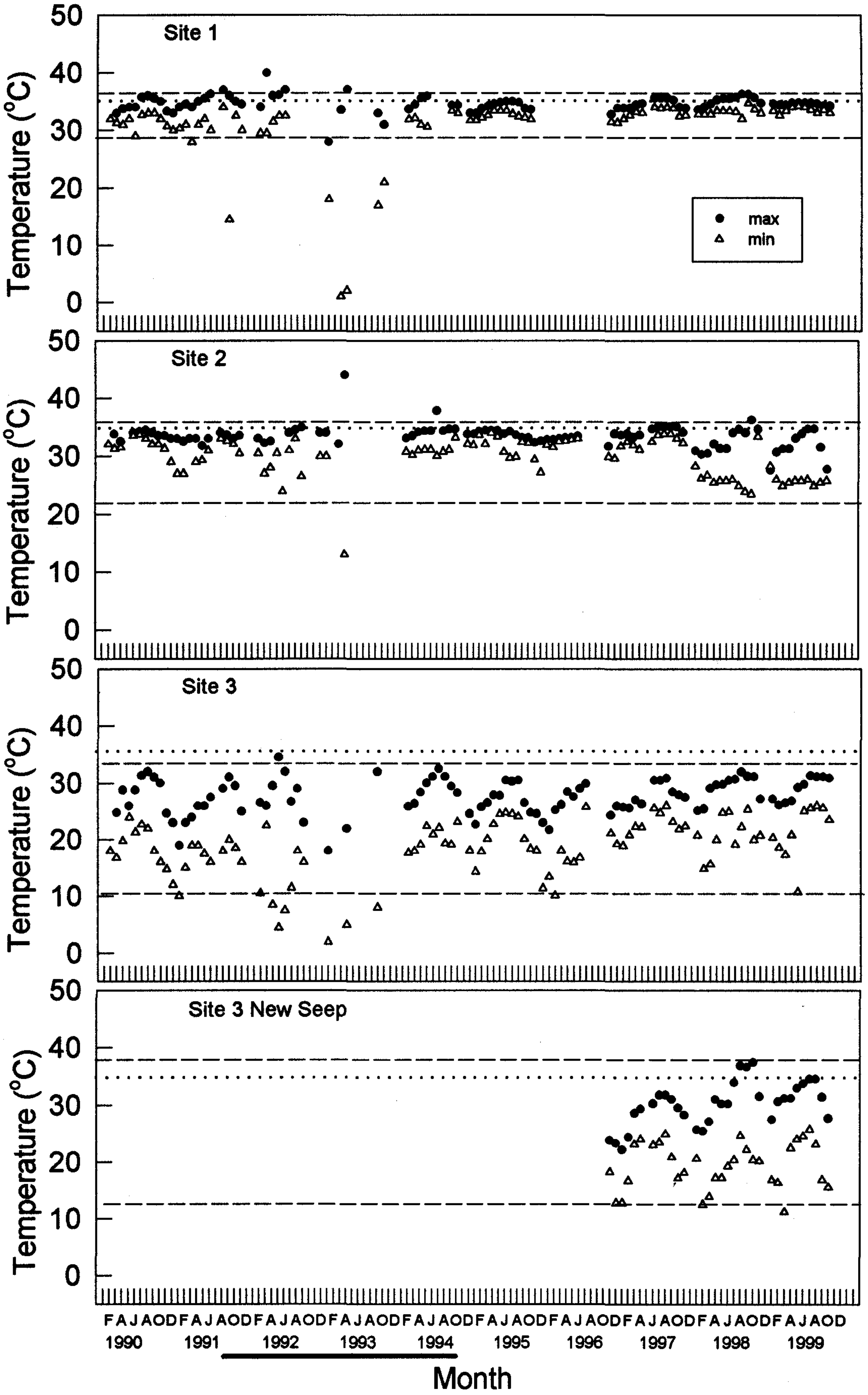


Figure 9. Maximum and minimum water temperatures for the Bruneau Springsnail study sites. Dashed horizontal lines indicate maximum and minimum for each site as inferred from logger data. Dotted horizontal lines indicate thermal maximum temperature for *P. bruneauensis*. Dark bar under x-axis represents probable outlier period. See text for additional comments.

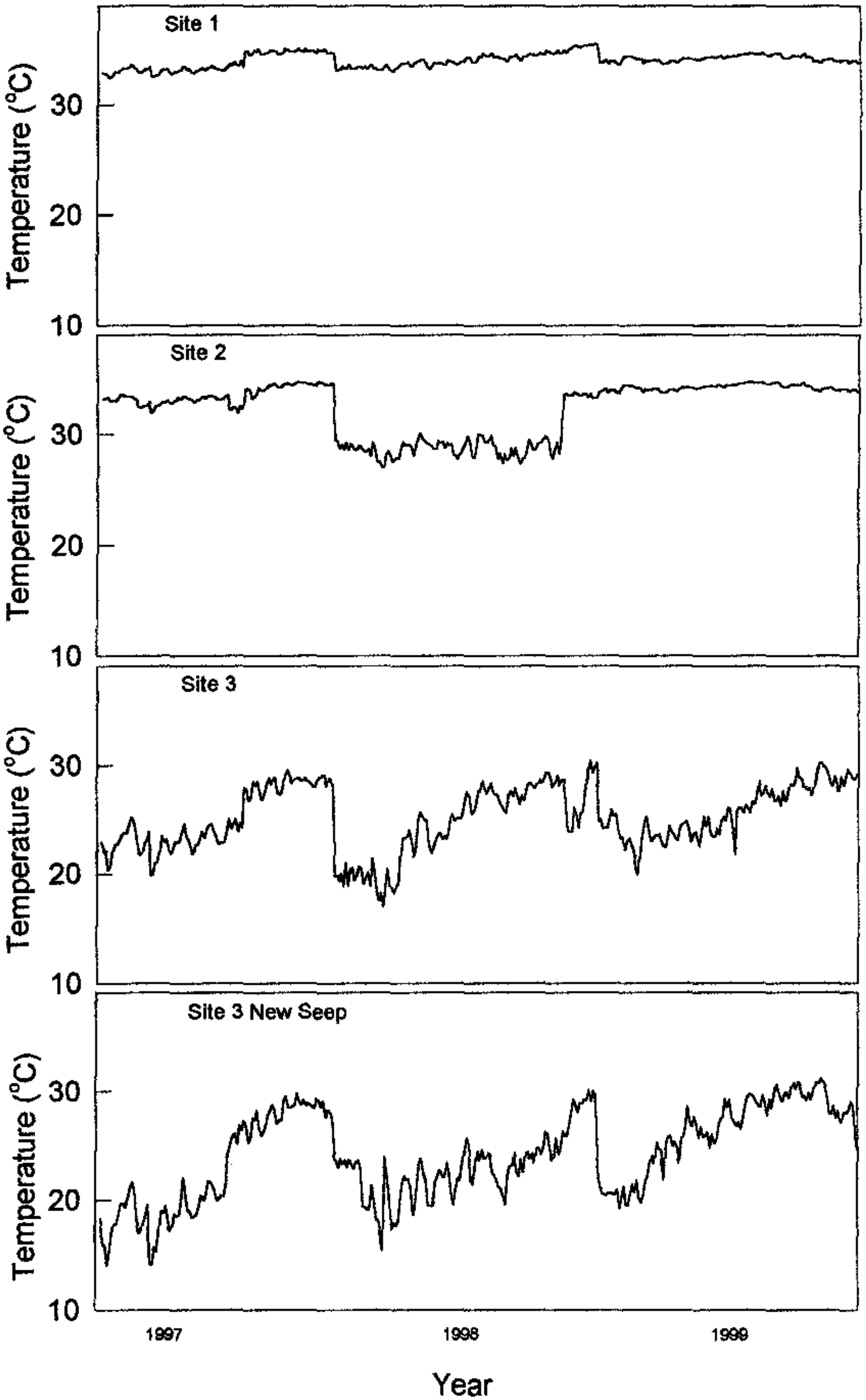


Figure 10. Daily mean temperatures for the Bruneau Springsnail study sites. The average daily temperatures collected from data loggers is plotted from 1997-1999 data. Data was not collected for December 1997and 1998.

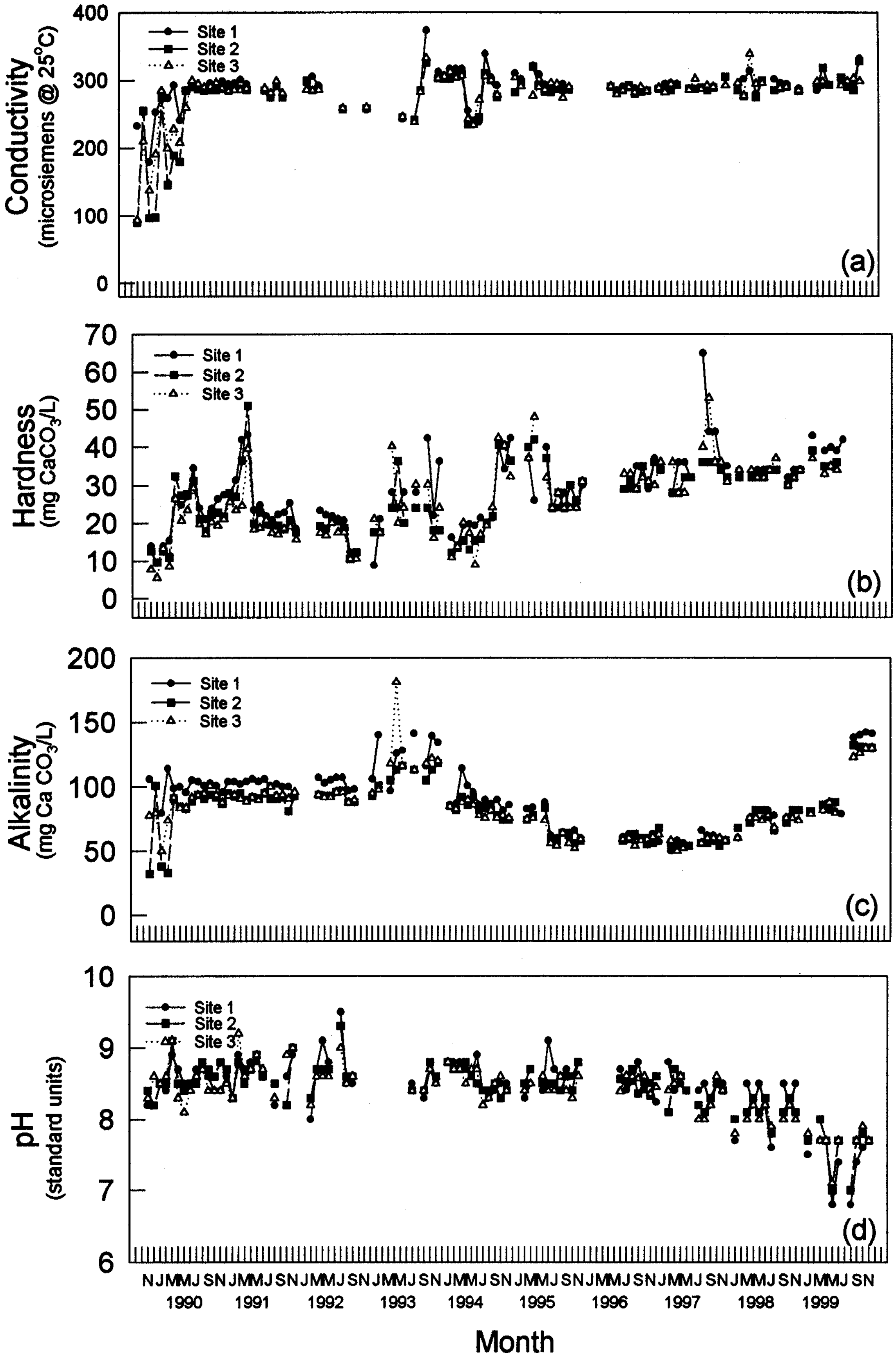


Figure 11. Conductivity (a), hardness (b), alkalinity (c), and pH (d) for the Bruneau Springsnail study sites.

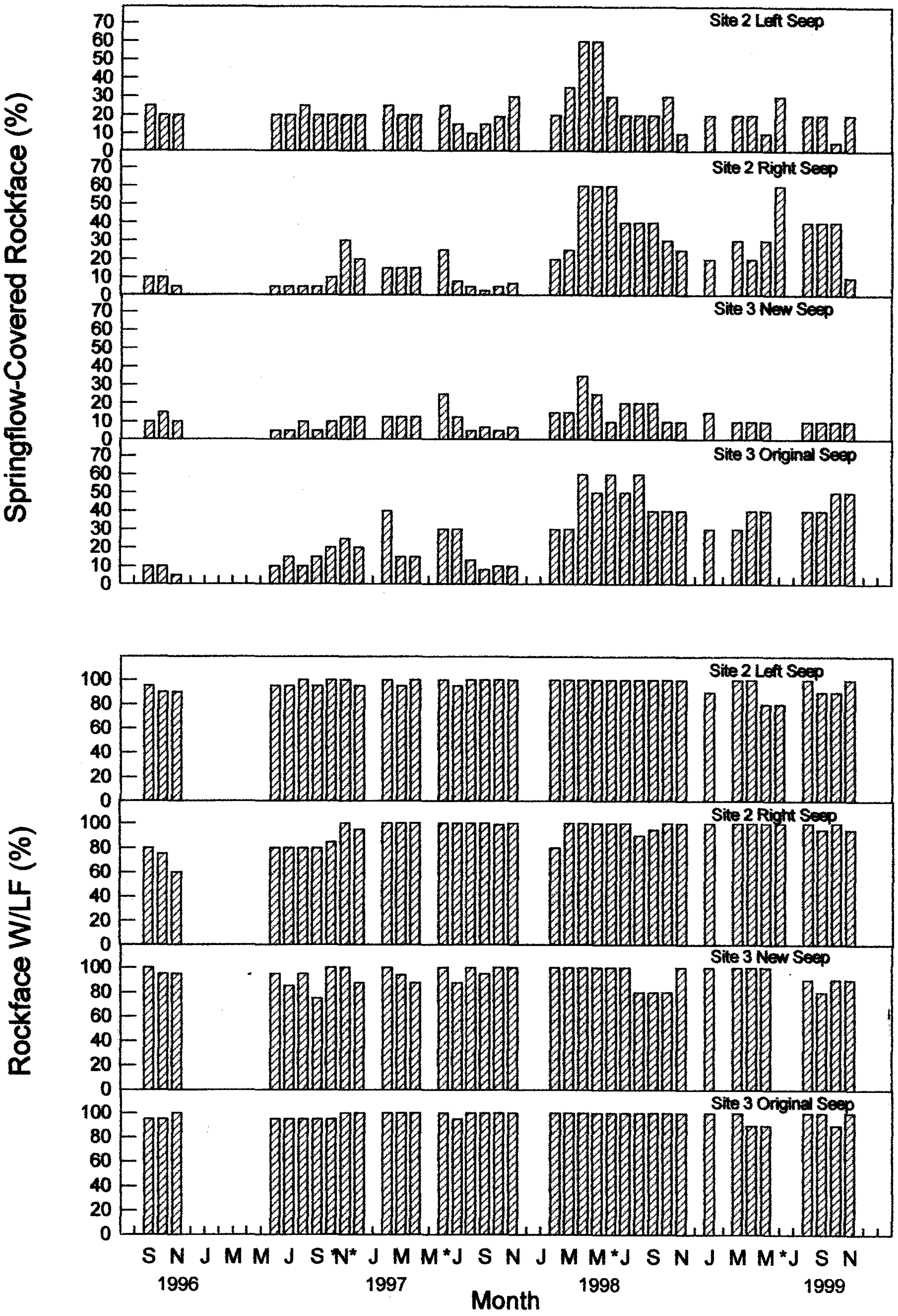


Figure 12. (Top) Percent springflow-covered rockface (SFC rockface) and (bottom) percent rockface, wetted, but lacking flow (rockface W/LF) for the Bruneau Springsnail study sites. Asterisks indicate that sampling occurred during rain events.

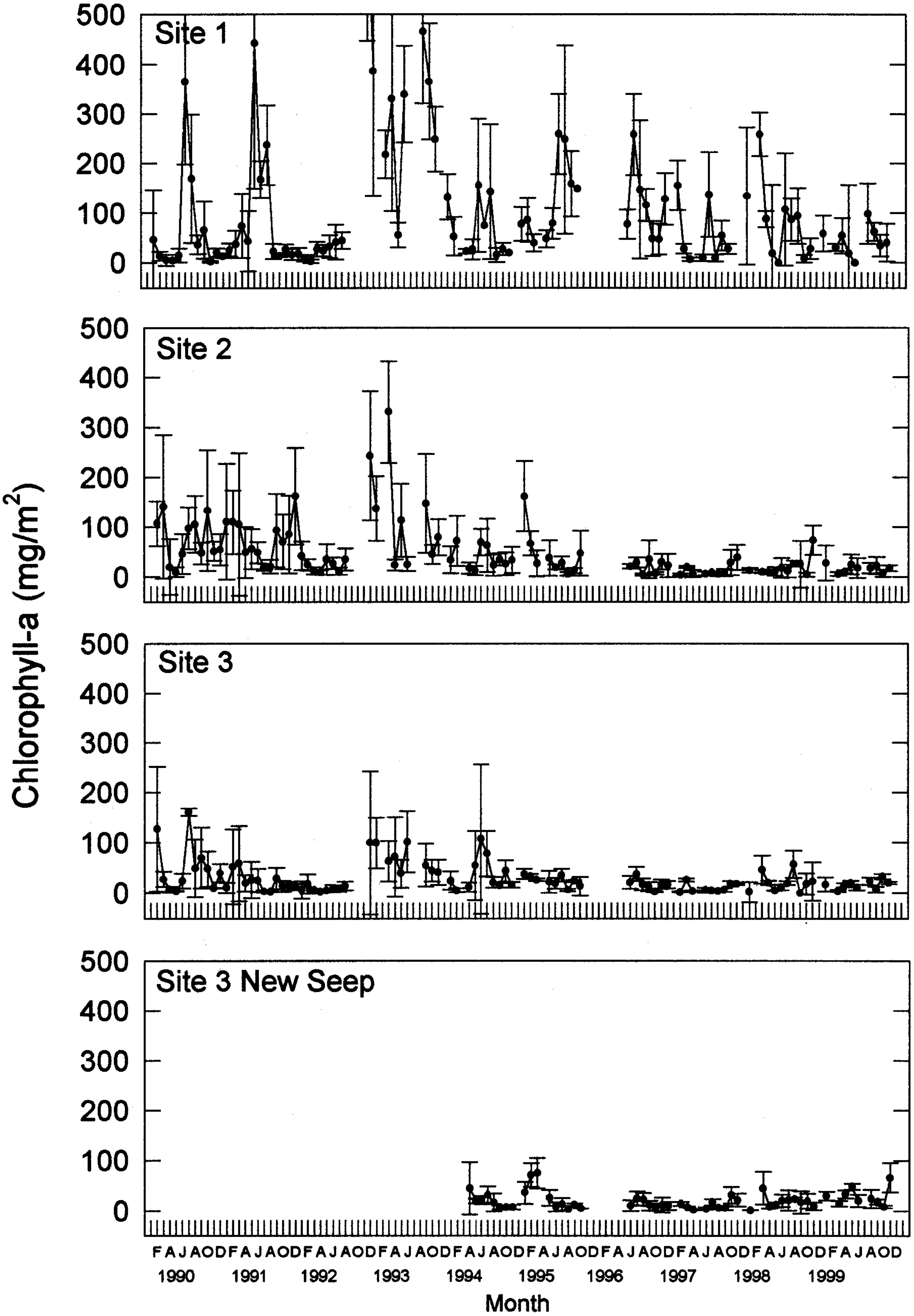


Figure 13. Periphyton chlorophyll-a values for the Bruneau Springsnail study sites. The value for Site 1 in December 1992 was 742.7 mg/m^2. Error bars represent one standard deviation from the mean. (n = 5 for Sites 1 and 2; n = 3 for Site 3 and 3 New Seep).

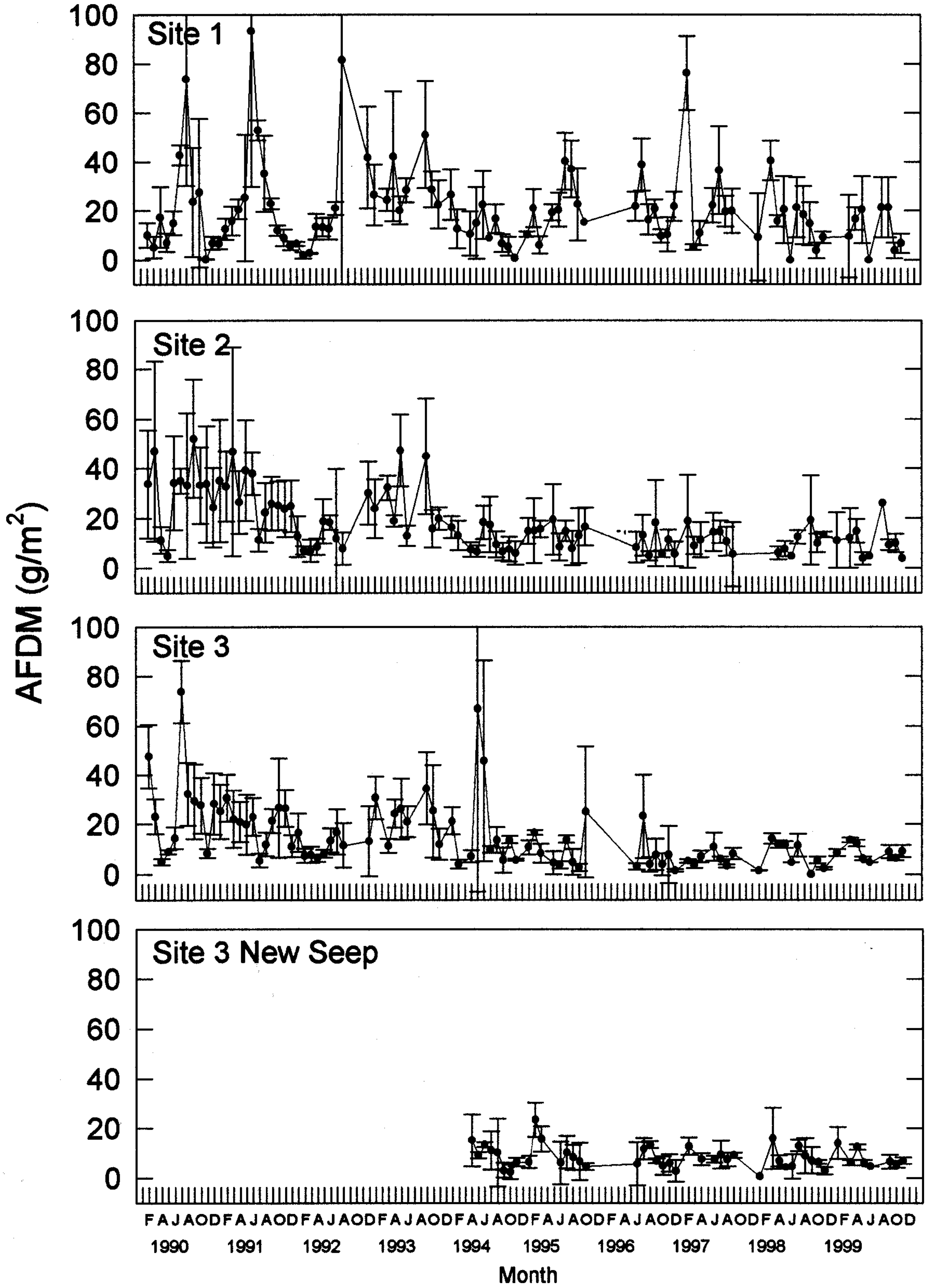


Figure 14. Periphyton ash-free dry mass (AFDM) values for the Bruneau Springsnail study sites. Error bars represent one standard deviation from the mean. (n=5 for Sites 1 and 2; n=3 for Site 3 and Site 3 New Seep).

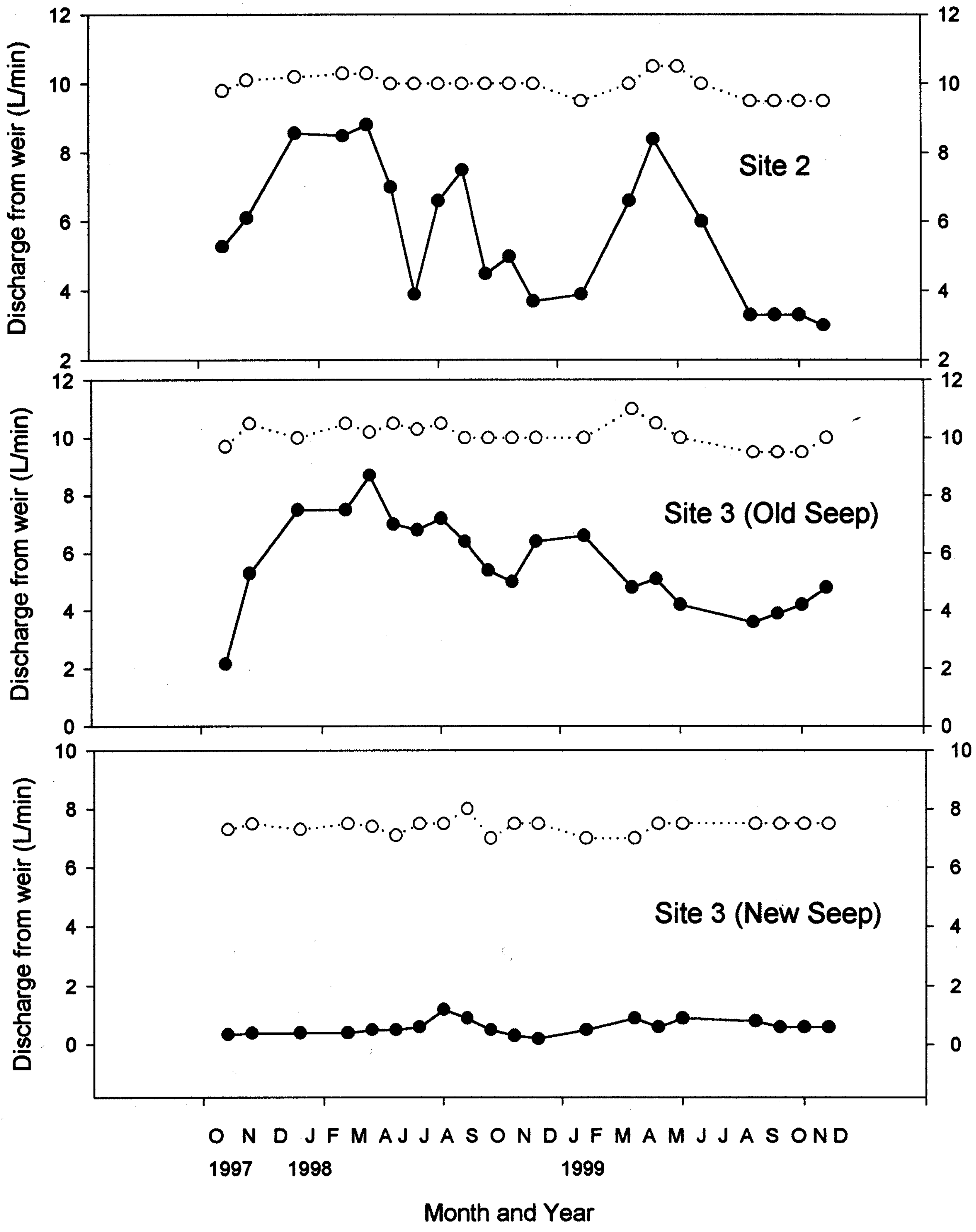
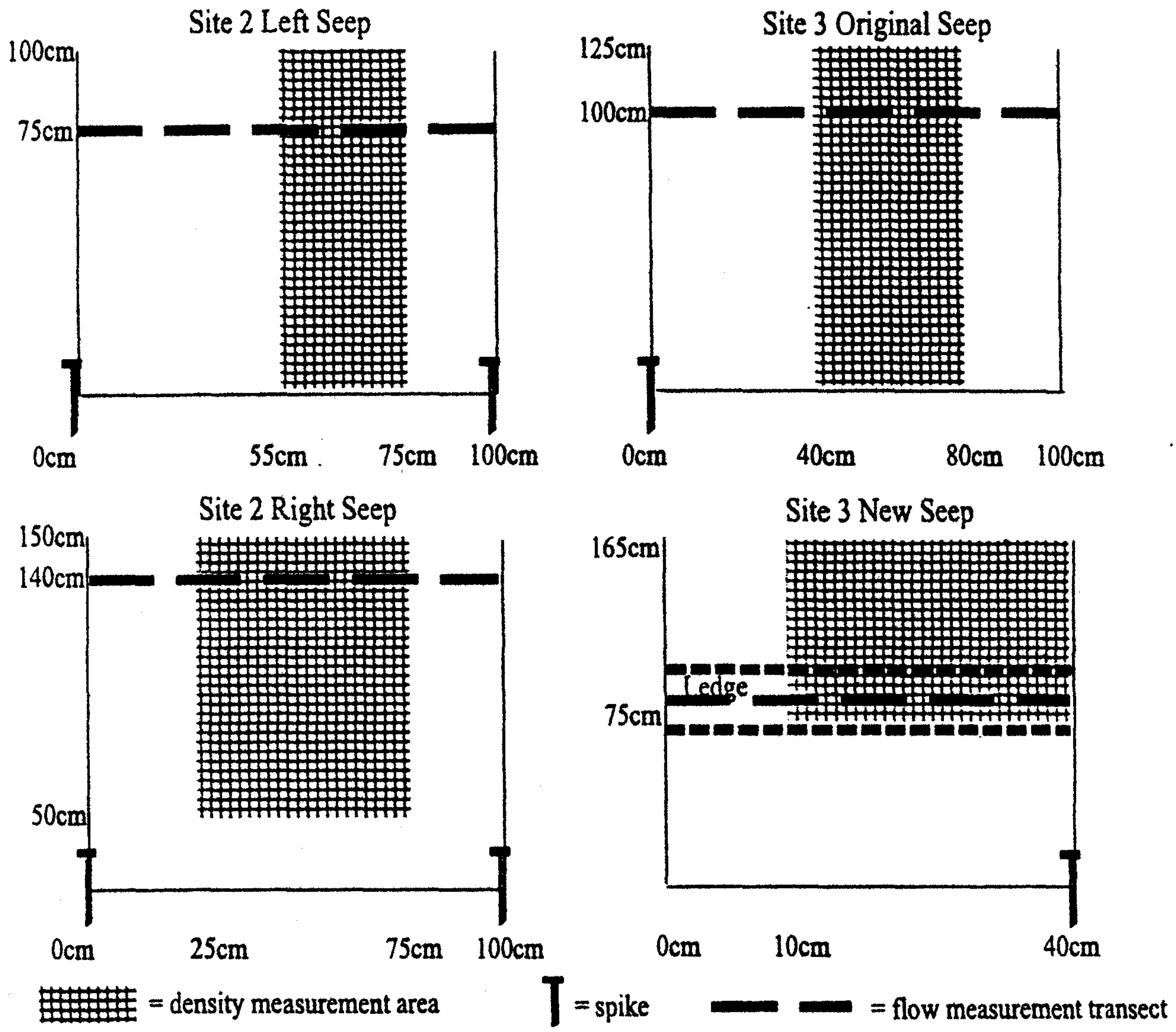


Figure 15. Discharge from the weirs placed approximately 1 m below rockface seeps at site 2a, 3OS, and 3NS. Solid circles represent weir discharge (L/min) and open circles represent weir stage height.

Table 1. Habitat assessment scores for Site 1 (Hot Creek).

Year	Month	Bottom Substrate	Pool Substrate	Pool Variability	Canopy Cover	Channel Alteration	Deposition	Channel Sinuosity	Channel Capacity	Bank Stability	Bank Vegetation	Streamside Cover	Riparian Width	Total Score	Percent of Maximum
Maximum score possible:		20	20	20	20	15	15	15	15	10	10	10	10	180	100
1995	March	4	5	5	16	12	2	10	9	8	8	6	5	90	50
	May	4	5	5	16	12	2	10	9	8	8	8	5	92	51
	June	4	5	5	15	12	2	10	9	9	9	5	5	90	50
	July	4	5	5	14	12	2	10	9	9	10	5	5	90	50
	August	4	5	5	14	12	2	10	9	9	10	5	5	90	50
	September	4	5	5	14	12	2	10	9	9	10	5	5	90	50
	October	4	5	5	15	12	2	10	9	9	10	5	5	91	51
	November	4	5	5	15	12	2	10	9	9	9	6	5	91	51
1996	June	4	5	5	15	12	2	10	9	8	9	5	5	89	49
	July	4	5	5	14	12	2	10	9	8	10	5	5	89	49
	August	4	5	5	14	12	2	10	9	8	10	5	5	89	49
	September	4	5	5	14	12	2	10	9	8	10	5	5	89	49
	October	4	5	5	15	12	2	10	9	8	10	5	5	90	50
	November	4	5	5	15	12	2	10	9	8	10	6	5	91	51
	December	4	5	5	16	12	2	10	9	8	9	6	5	91	51
1997	July	4	5	5	15	12	2	10	9	8	10	5	5	90	50
1998	June	4	6	5	15	12	2	10	9	8	10	5	5	91	51
1999	June	4	6	5	15	12	2	10	9	8	10	5	5	91	51



Appendix A. Springsnail density, wetted rockface, and springflow measurement locations at the rockface seeps. Maps are not drawn to scale.

Habitat Assessment, Glide/Pool Prevalence (modified after Plafkin et al., 1989).

Stream Name: ____________ Station ____________ Date ____________ Location Description ____________

Idaho Department of Health and Welfare - Division of Environmental Quality
HABITAT ASSESSMENT FIELD DATA SHEET
GLIDE/POOL PREVALENCE

	CATEGORY			
HABITAT PARAMETER	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
1. Bottom substrate/ instream cover	Greater that 50% mix of rubble, gravel, submerged logs, undercut banks, or other stable habitat. 16-20 ____	30-50% mix of rubble, gravel, or other stable habitat. Adequate habitat. 11-15 ____	10-30% mix of rubble, gravel, or other stable habitat. Habitat availability less than desirable. 6-10 ____	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 0-5 ____
2. Pool substrate characterization	Mixture of substrate materials with gravel and firm sand prevalent, root mats and submerged vegetation common. 16-20 ____	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present. 11-15 ____	All mud or clay or channelized with sand bottom; little or no root mat; no submerged vegetation. 6-10 ____	Hard-pan clay or bedrock; no root mat or vegetation. 0-5 ____
3. Pool variability	Even mix of deep/shallow/ large/small pools present. 16-20 ____	Majority of pools large and deep; very few shallow. 11-15 ____	Shallow pools much more prevalent than deep pools. 6-10____	Majority of pools small and shallow or pools absent. 0-5 ____
4. Canopy cover (shading)	A mixture of conditions where some areas of water surface fully exposed to sunlight, and other receiving various degrees of filtered light. 16-20 ____	Covered by sparse canopy; entire water surface receiving filtered light. 11-15 ____	Completely covered by dense canopy; water surface completely shaded. OR nearly full sunlight reaching water surface. Shading limited to < 3 hours per day. 6-10 ____	Lack of canopy, full sunlight reaching water surface. 0-5 ____

Habitat Assessment, Glide/Pool Prevalence (modified after Plafkin et al., 1989).

Stream Name: ____________________ Station ________________ Date ________________ Location Description ______________

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HABITAT PARAMETER	CATEGORY: OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
5. Channel alteration	Little or no enlargement of islands or point bars, add/or no channelization. 12-15 ____	Some new increase in bar formation, mostly from coarse gravel; and/or some channelization present. 8-11 ____	Moderate deposition of new gravel, coarse sand on old and new bars; and/or embankments on both banks. 6-10 ____	Heavy deposits of fine material. Increased bar development; and/or extensive channelization. 0-3 ____
6. Deposition	Less than 5% of bottom affected; minor accumulation of coarse sand and pebbles as snags and submerged vegetation. 12-15 ____	5-30% affected; moderate accumulation of sand at snags and submerged vegetation. 8-11 ____	30-50% affected; major deposition of sand at snags and submerged vegetation; pools shallow, heavily silted. 4-7 ____	Channelized; mud, silt and/or sand in braided or nonbraided channels; pools almost absent due to deposition. 0-3 ____
7. Channel sinuosity	Instream channel length 3 to 4 times straight line distance. 12-15 ____	Instream channel length 2 to 3 times straight line distance. 8-11 ____	Instream channel length 1 to 2 times straight line distance. 4-7 ____	Channel straight; channelized waterway. 0-3 ____
8. Lower bank channel capacity	Overbank (lower) flows rare. Lower bank W/D ratio < 7. (Channel width divided by depth or height of lower bank.) 12-15 ____	Overbank (lower) flows occasional. W/D ratio: 8-15 8-11 ____	Overbank (lower) flows occasional. W/D ratio: 15-25. 4-7 ____	Peak flows not contained or contained through channelization. W/D ratio > 25 0-3 ____

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9. Upper bank stability	Upper bank stable. No evidence of erosion or bank failures. Side slopes generally < 30°. Little potential for future problems. 9-10 ____	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40° on one bank. Slight potential in extreme floods. 6-8 ____	Moderately stable. Moderate frequency and size of erosional areas. Side slopes up to 60° on some banks. High erosion potential during extreme high flow. 3-5 ____	Unstable. Many eroded areas. "Raw" areas frequent along straight sections and bends. Side slopes 60° common. 0-2 ____
10. Bank vegetation protection	Over 90% of the streambank surfaces covered by vegetation. 9-10 ____	70-89% of the streambank surfaces covered by vegetation. 6-8 ____	50-79% of the streambank surfaces covered by vegetation. 3-5 ____	Less than 50% of the streambank surfaces covered by vegetation. 0-2 ____
OR Grazing or other disruptive pressure	Vegetative disruption minimal or not efficient. Almost all potential plant biomass in present stage of development remains. 9-10 ____	Disruption evident but not affecting community vigor. Vegetative use is moderate, and at least one-half of the potential plant biomass remains. 6-8 ____	Disruption obvious; some patches of bare soil or closely cropped vegetation present. Less than one half of the potential plant biomass remains. 3-5 ____	Disruption of streambank vegetation is very high. Vegegation has been removed to 2 inches or less in average stubble height. 0-2 ____

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11. Streamside cover	Dominant vegetation is shrub. 9-10 ____	Dominant vegetation is of tree form. 6-8 ____	Dominant vegetation is grass or forbes. 3-5 ____	Over 50% of the stream bank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 0-2 ____
12. Riparian vegetative zone width (least buffered side)	> 18 meters 9-10 ____	Between 12 and 18 meters. 6-8 ____	Between 6 and 12 meters. 3-5 ____	< 6 meters 0-2 ____
Column Totals	____	____	____	____
Score				