Comparison of Three Methods for Surveying Amphibians in Forested Seep Habitats in Washington

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Abstract

This report compared the effectiveness of three amphibian survey methods (trapping, light-touch, and destructive sampling) in seeps. The study sites were located on managed forests in southwest Washington State. Trapping involved setting up an array of funnel traps across the seep, light-touch is a visual-encounter method facilitated by overturning and replacing moveable cover objects, and destructive sampling consisted of searching the seep surface by excavating the top 15 cm of soil and dismantling woody debris. Trapping and light-touch were compared through six, three-week periods, whereas the non-repeatable destructive sampling was compared with trapping and light-touch only during the final sampling period. Light-touch detected more species, more coastal tailed frogs, and similar numbers of Columbia torrent salamanders and western red-backed salamander compared to trapping.

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Running Footer: Surveying amphibians in seeps

2 tables, 4 figures.

Contains highlighted symbols.

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Abstract

We compared the effectiveness of three amphibian survey methods (trapping, light-touch, and destructive sampling) in seeps because the efficiency of these methods in this kind of habitat has not been evaluated previously. Our study sites were located on managed forests in southwest Washington State. Trapping involved setting up an array of funnel traps across the seep, light-touch is a visual-encounter method facilitated by overturning and replacing moveable cover objects, and destructive sampling consisted of searching the seep surface by excavating the top 15 cm of soil and dismantling woody debris. Trapping and light-touch were compared through six, three-week periods, whereas the non-repeatable destructive sampling was compared with trapping and light-touch only during the final sampling period. Light-touch detected more species ($P = 0.007$), more coastal tailed frogs (*Ascaphus truei*; $P < 0.001$), and similar numbers of Columbia torrent salamanders (*Rhyacotriton kezeri*; $P = 0.123$) and western red-backed salamanders (*Plethodon vehiculum*; $P = 0.152$) compared to trapping. When compared to other survey methods during the final sampling period, destructive sampling detected more species ($P = 0.001$) and more torrent salamanders ($P = 0.005$) than trapping, but detected similar numbers of species ($P = 0.15$) and torrent salamanders ($P = 0.21$) as light-touch. Light-touch was less expensive in material costs and required fewer visits, but more time (77 vs. 19 person-minutes) per survey session than trapping. Destructive sampling had the same material costs as light-touch, but required more time per survey session (690 person-minutes) than either of the other two methods. Where a repeatable method is required, light-touch seems preferable to trapping because it enumerates a higher percentage of species and individuals, has fewer potential survey biases, and can provide data on within-seep amphibian use.

Key words: Census, frogs, managed forests, northwest USA, salamanders, sampling, survey techniques, wetlands

Introduction

Many investigators have noted an association between amphibians and seeps (e.g., Stebbins and Lowe 1951, Nussbaum and Tait 1977, Welsh and Lind 1996, Diller and Wallace 1996, Bury and Adams 2000, Wilkins and Peterson 2000), but studies specifically quantifying this association are largely lacking. This dearth of studies may be related to the fact that seeps are relatively rare and occupy a small proportion of most landscapes, and that seeps have been difficult to define and thus are often lumped into broader hydrological groups that include springs (e.g., Bury and Adams 2000, but see Brooks et al. 1997).

Not surprisingly, development of amphibian sampling methods specific to seeps has rarely been addressed (but see Jones 1999). Traditional methods for sampling amphibians in aquatic habitats depend largely on the presence of a water column, a feature highly reduced or absent in seeps. For example, the most reliable sampling methods for small streams frequently depend on enough flowing water to move animals intentionally disturbed from the stream substrate into a net immediately downstream (e.g., Bury and Corn 1991) or to retrieve animals within a net-limited boundary (e.g., Wilkins and Peterson 2000). Similarly, the configuration of most traps used in lentic habitats requires a minimum water depth to allow aquatic animals to enter traps (e.g., Adams et al. 1997, Willson and Dorcas 2004). Conversely, some methods employed in terrestrial habitats intentionally attempt to eliminate problems resulting from a high water table. For example, pitfall traps may use drains to minimize water accumulation (e.g., Corn 1994), a condition unavoidable in seeps because, by definition, seeps are wetlands where the water table intercepts the surface.

In 2000, Washington State implemented new forest practice rules for the protection of seep-associated amphibians by prohibiting harvest activities within 15 m of certain types of seeps (WFPB 2000). We compared the logistics and effectiveness of amphibian sampling in seeps as the necessary first step of designing studies to evaluate the effectiveness of these seep buffer zones in protecting amphibians. We were primarily interested in comparing two methods, trapping versus light-touch, which are relatively nondestructive and thus appropriate for sampling seeps through time. These two methods are commonly used to sample other, typically terrestrial, habitat for amphibians (see Corn and Bury 1990, Greenberg et al. 1994). We used a third method, destructive sampling, to help gauge error associated with not detecting species when they are actually present (Type II or β error; Hayek 1994) because destructive sampling is the most exhaustive method available and thus represents the benchmark against which other methods could be compared at a single point in time (Quinn et al. 2007). Specifically, we asked three questions: 1) Which method detects the most amphibian species and individuals of each species? 2) Are methods life-stage biased? and 3) How do costs compare among methods?

Methods

We applied three amphibian survey methods – trapping, light-touch, and destructive sampling – to each of 10 seeps during 13 July to 18 November 2004. Trapping and light-touch were compared through six three-week periods, whereas the destructive sampling was compared with trapping and light-touch only during the final sampling period. Following Brooks et al. (1997), seeps were defined as wetlands where the water table intercepts the ground surface and discharge is too low to form a rivulet. All seeps were located in managed second-growth forest dominated by Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and red alder (*Alnus rubra*) in the Willapa Hills of southwest Washington State (N46° 30.06' - N46° 31.77', W123° 12.68' - W123° 13.37', elevation 255 - 691 m). We chose this area because of its high amphibian species richness relative to other areas in the state (Jones et al. 2005). Seeps were selected for size (≥5.2 m across in any direction by ≥4.5 m across in the perpendicular direction) and for easy access (within a 20-minute hike from a road). All amphibians detected by trapping or light-touch were weighed, measured (snout-to-vent length and tail length), assigned to life stage (larva or post-metamorph) and released at the point of capture. Salamanders were considered larvae if they had external gills. Frogs were considered larvae if they had fewer than four emerged limbs and a tail. Amphibians detected by the destructive method, at the end of the study, were processed similarly and then immersion-euthanized in MS-222, preserved in formalin, and deposited in the Burke Museum at the University of Washington.

Trapping

Trap arrays consisted of six funnel traps attached to three 3-m drift fences (Figure 1), a trigonal array (wings branching 120^{o} from a central point) modified from the design of Bury and Corn (1987). Fences, made from nylon window screen, had rebar supports at 1-m intervals, extended 30 cm above the ground and continued underground 15 cm. Fence material was doubled over the supporting rebar to prevent amphibians from using the rebar to climb the fences. At the end of each fence arm, we attached two horizontally aligned funnel traps ("collapsible minnow traps," Miller Net Company, Inc., Tennessee, USA), one on each side of the fence arm. Funnel traps consisted of 1.6-mm nylon screen on a collapsible metal frame (25.4 cm × 25.4 cm × 43.2 cm). Each end of the trap had an inverted lateral funnel with a 5.1-cm diameter circular opening. Only the funnels on the ends of traps facing the center of the array were kept open; the opposite ends were closed. Traps were partly buried (to a depth of 8 cm) to facilitate entry of amphibians into the sloped funnel opening. The entrance to each trap was located within the seep when the study period began, but during the study period, the hydrological footprint of several seeps contracted, sometimes leaving traps outside the seep margin. Traps were not moved during the course of this study.

The trap survey interval was one week, during which traps were opened on Monday and checked on Tuesday, Wednesday, and Thursday. After the Thursday check, traps were closed until the next survey cycle. Seeps were split into two groups of five for survey. We surveyed the first group of five traps during week 1 and the second group of five traps in week 2, and did not sample during week 3. This three-week cycle was repeated six consecutive times.

Light-touch

Light-touch consisted of searching an area by turning over, then replacing, all surface cover objects that could be moved by one person. We did not excavate the soil, search under cover objects too large for one person to move, or dismantle decaying woody debris. We applied light-touch by searching the area around the center of the seep extending out in a circle with an arbitrarily determined radius of 6 m (113 m^2; Figure 1). Light-touch surveys occurred on a three-week cycle corresponding with the trapping schedule except that surveys were done on Thursdays after the traps had been checked and closed. Amphibians found in a trap on a day when light-touch was conducted were not included in the light-touch tally. As for trapping, the three-week survey cycle was repeated six consecutive times.

Destructive Surveys

Destructive surveys were similar to light-touch surveys, but more exhaustive. Besides turning over small cover objects, we overturned all cover objects that could be moved by two people and excavated the substrate to a depth of 15 cm. We broke apart all large woody debris that could be dismantled with hand tools. The destructive (and therefore non-repeatable) nature of this survey limited its use to the final sampling period, after all trap arrays had been checked and all light-touch had been completed for the sixth and final time. Because of the greater amount of time required, destructive surveys were conducted 4 - 14 days following the last light-touch surveys. We applied this method to the same area that was searched in the light-touch method, a 6-m radius circle centered on the seep.

Statistical Analysis: Two-method Comparison

We used the following regression model to test for the effects of survey method (two method comparison: trapping vs. light-touch), time, and a method by time interaction on abundance/species richness,

$$\ln\left(\lambda_{ijk}\right) = \mu + \tau_j + \gamma_k + \left(\tau\gamma\right)_{jk} + \varepsilon_{ijk}, \tag{1}$$

where λ_{ijk} = the expected number of individuals/species enumerated in the k^{th} method ($k = 1,2$), at the j^{th} time ($j = 1,2,\ldots,6$), in the i^{th} site ($i = 1,2,\ldots,10$);

μ = the intercept;

τ_j = the effect of the j^{th} level of time;

γ_k = the effect of the k^{th} level of sample method (light-touch/trapping);

$\left(\tau\gamma\right)_{jk}$ = the time by method interaction effect;

ε_{ijk} = the error term that incorporates the within-site correlation of observations.

Where possible, we analyzed the data by use of generalized estimating equation (GEE) algorithms (Diggle et al. 1994, Littel et al. 2000) to account for correlation among observations within seeps and the Poisson error structure of the response variable. We used analysis of deviance (ANODEV) based on score statistics to test for significant interaction and main effects.

In situations where the GEE algorithm failed to converge because of sparse non-zero data, we analyzed the data by use of a generalized linear model (GLM) with a Poisson error structure, and log link (McCullagh and Nelder 1989). To account for site, we included it as a fixed main effect in the model as follows,

$$\ln(\lambda_{ijk}) = \mu + \delta_i + \tau_j + \gamma_k + (\tau\gamma)_{jk}, \quad (2)$$

where λ_{ijk} = the expected number of individuals/species enumerated using the k^{th} method

$(k = 1,2)$, at the j^{th} time $(j = 1,2,\ldots,6)$, in the i^{th} site $(i = 1,2,\ldots,10)$;

μ = the intercept;

δ_i = the effect of the i^{th} site;

τ_j = the effect of the j^{th} level of time;

γ_k = the effect of the k^{th} level of method (light-touch/trapping);

$(\tau\gamma)_{jk}$ = the time by method interaction effect.

The model in Eq. 2 is similar to the marginal model of Eq. 1 in that the interactions of fixed effects are averaged across seeps. We conducted tests for significant interaction and main effects using analysis of deviance (ANODEV) with F-tests where dispersion parameters were greater than one and with chi-square tests otherwise. We set $\alpha = 0.1$ for this and all subsequent tests. Because GLM analyses did not account for within site error structure, GLM results are less conservative, rejecting the null hypothesis more often, than analogous GEE analyses. Thus, significant results from the GLM should be interpreted cautiously. We only report results of GLM, where GEE results were unavailable (i.e., failed to converge), which included method by time interaction terms for all comparisons and for comparisons of coastal tailed frog (*Ascaphus truei*) abundance.

We compared species accumulation curves between trapping and light-touch to determine the amount of survey effort required to detect half (five) of the total number of species detected in the study. We pooled amphibian species richness data across sites and sample times for each method (n = 10 seeps * 6 sampling periods = 60 seep samples) and generated species accumulation curves using PC-ORD (version 4, MjM Software Design, Gleneden Beach, OR, U.S.). PC-ORD used 500 replicates drawn with replacement from each survey type pool to derive estimates of species richness as a function of sampling effort.

Statistical Analysis: Three-method Comparison

We used Friedman tests (non-parametric ANOVAs) to test whether the three methods differed in species richness and in the number of individual amphibians detected (for species with more than 15 captures) during the final survey cycle, the only period in which all three methods were used. Corrections were applied to χ^2 values to account for ties. Pairwise differences in ranked response variables were tested for significance after adjusting the critical P-value to 0.035 for three comparison, i.e., $1 - (1 - \alpha)^{1/k}$, where k is the number of comparisons (Sokal and Rohlf 1995).

We used Mantel-Haenszel tests to examine whether life stages (pre- vs. post-metamorphic) were detected in different proportions by light-touch and destructive surveys during the final survey period while controlling for potential variation between seeps. Trapping data were not included in life stage analyses because only one individual of each species analyzed was caught in this time period.

Effort

To describe the amount of effort required for each method, we determined the mean cost of materials and mean ± SE set-up time by method (n = 10). To assess whether survey time varied among methods, we first performed a linear regression with time as a response variable, number of amphibians detected as an explanatory variable, and site as a covariate. Survey time was defined as the number of person-minutes calculated between arrival at the site to departure from the site, including the time required to measure environmental conditions such as temperature and cloud cover. To test whether seeps varied in the amount of time to check the traps or to complete light-touch, we compared models with and without a site term using extra sum-of-squares *F*-tests. We then compared the three methods by performing a second linear regression with time as a response variable and the number of amphibians found and method used as explanatory variables. Using the y-intercepts of these regressions, we compared the amount of time each method took after removing the influence of the number of amphibians detected.

Results

We detected 406 amphibians of 10 species in the course of this study (Tables 1 and 2). Trapping caught 21 individuals of 8 species, including 1 species that was not detected by either of the other 2 methods, a Van Dyke's salamander (*Plethodon vandykei*). Using light-touch, we found 195 individuals of 9 species, including 1 not detected by either of the other 2 methods, a Cope's giant salamander (*Dicamptodon copei*). Using destructive surveys, we found 190 individuals of 6 species. No species were found in destructive surveys that were not found by at least one of the other two methods.

Two-method Comparison

Light-touch detected more amphibian species than trapping (GEE; $\chi^2_1 = 7.35$, $P = 0.007$, Figure 2) and there was no effect of time (GEE; $\chi^2_5 = 5.35$, $P = 0.374$) or method by time interaction on species richness (GLM; $\chi^2_5 = 8.25$, $P = 0.143$). Light-touch detected more individuals than trapping for 8 of 10 species, and for every species for which more than three individuals were detected in the course of the study. Three species were detected often enough to permit statistical analyses of detections ($n > 15$), including Columbia torrent salamanders (*Rhyacotriton kezeri*), coastal tailed frog, and western red-backed salamanders (*Plethodon vehiculum;* Figure 2). Detection rates of Columbia torrent salamander for light-touch and trapping were not significantly different (GEE; $\chi^2_1 = 2.38$, $P = 0.123$). In addition, there was neither a change in Columbia torrent salamander numbers through time (GEE; $\chi^2_5 = 5.55$, $P = 0.352$) nor a method by time interaction (GLM; $\chi^2_5 = 8.253$, $P = 0.143$). Detection rates of coastal tailed frog for light-touch and trapping were significantly different (GLM; $\chi^2_1 = 19.748$, $P < 0.001$), and changed through time (GLM; $\chi^2_5 = 45.709$, $P < 0.001$), but there was no method by time interaction (GLM; $\chi^2_5 = 6.287$, $P = 0.279$; Figure 2). Light-touch and trapping detected similar numbers of western red-backed salamanders (GEE; $\chi^2_1 = 2.05$, $P = 0.152$; Figure 2). Detection rates of western red-backed salamanders were consistent through time (GEE; $\chi^2_5 = 4.92$, $P = 0.436$) and there was no method by time interaction (GLM; $\chi^2_5 = 4.108$, $P = 0.534$).

We captured larvae of three species including Cope’s giant salamander, Coastal giant salamander (*Dicamptodon tenebrosus*), and Columbia torrent salamander (Table 1). However, no larvae were captured in traps. Larvae of Columbia torrent salamander averaged 23.7 mm SVL (SE = 0.3 mm) and ranged from 14 to 38 mm ($n = 228$), whereas post-metamorphs averaged 38.1 mm (SE = 0.6 mm) and ranged from 31 to 59 mm ($n = 138$). All 28 coastal tailed frogs were post-metamorphic. No eggs of any species were found by any method.

Visual inspection of the species accumulation curves suggested that, on average, trapping required nearly three times as many samples as light-touch (25 vs. 9, respectively) to detect half (five) of the total number of amphibian species (Figure 3).

Three-method Comparison

The three methods detected different numbers of species in the final period of the study (Friedman test, $\chi^2 = 7.7$, $P = 0.02$, Figure 4). On average, trapping detected only 38% as many species as light touch ($P = 0.06$) and only 26% as many species as destructive sampling ($P < 0.001$). Destructive sampling and light touch did not significantly differ in the number of species detected ($P = 0.15$)

Only one species, Columbia torrent salamander, was detected enough times in the final period of the study to permit statistical analyses of detections ($n > 15$). The three methods differed in the number of Columbia torrent salamander detected (Friedman test, $\chi^2 = 9.2$, $P = 0.01$, Figure 3); destructive surveys detected more Columbia torrent salamanders than trapping ($P = 0.005$); Columbia torrent salamander numbers did not differ between destructive surveys and light touch ($P = 0.21$) or between light touch and trapping ($P = 0.06$). Destructive sampling detected substantially more Columbia torrent salamanders than light-touch (169 vs. 15), but this difference was strongly influenced by one seep that contained most individuals. Thus, our statistical test likely had little statistical power to detect differences between sampling methods and failed to reject the null hypothesis (i.e., $P = 0.21$). Destructive surveys also detected a higher proportion of Columbia torrent salamander larvae to post metamorphs than light touch (Mantel-Haenszel test, $z = -1.6$, $P = 0.06$).

Effort

Trap arrays cost $71 USD each in materials and took 310 ± 73 person-minutes to construct. In contrast, light-touch and destructive surveys only required establishing a search perimeter, which took roughly 20 person-minutes per seep and cost less than $1 USD in materials to construct.

The 10 seeps did not vary in the amount of time they took to survey, after accounting for the number of amphibians found, when checking the traps ($F_{9,109} = 1.41$, $P = 0.19$), but did vary when using light-touch (extra sum-of-squares F-test, $F_{18,40} = 3.46$, $P < 0.001$). After accounting for variation among seeps, survey times were significantly different among methods ($F_{4,175}$ = 84.01, $P < 0.001$). Including time to process animals, trapping, light-touch, and destructive survey required 20 ± 1, 96 ± 5, and 929 ± 193 person-minutes per site, respectively. Excluding animal processing time, trapping, light-touch, and destructive survey required 19 ± 10, 77 ± 16, and 690 ± 37 person-minutes per site, per sampling period, respectively.

Discussion

The three methods we compared varied substantially in their ability to estimate species richness and amphibian abundance. Consequently, application of these methods represents tradeoffs that should be considered in future designs of seep surveys. Funnel trapping consistently detected fewer species and lower numbers of individuals than either of the active search methods, light-touch and destructive survey. We suspect that most species occupying seeps made few movements during our survey window and thus were not effectively surveyed by passive methods that rely on animals entering traps (Corn 1994, Brennan et al. 1999). Light-touch typically caught more species and more individuals than trapping per sample period. Moreover, our results probably underestimated the difference in performance between light-touch and trapping for two reasons. First, traps were checked daily and captured animals were released each day. Thus, it was possible to recapture individuals in traps within a three-day trapping session, although this may have been a rare occurrence based on the low proportion of animals (relative to light-touch) we trapped. We released amphibians daily because leaving animals in traps longer than one day could unnecessarily stress or kill them (Herpetological Animal Care and Use Committee 2004). Second, all animals caught in traps on day three were removed from the sampling pool for light-touch surveys, which were conducted immediately after the checking the traps. This reduced the total number of animals available to be caught during light-touch surveys.

Detection of different amphibian life stages also varied among methods. No larval stages were detected with trapping, likely because larvae (with exposed gills) would have had to briefly leave a wetted surface to climb into a trap. This issue could be addressed by submerging the trap entrance below the water level in a wetted portion of the seep. However, our observations suggested that because seep surface-moisture changed over the summer, we would have had to move our trapping array multiple times to address this issue. Moving trapping arrays would result in increased ground disturbance (obviating one advantage of this method) because drift fences are buried into the soil. It is important to note that we considered only one type of trap design (albeit one of the most widely used; see Corn 1994) and survey protocol on which to base our comparison, so our results should be considered working hypotheses. For example, we could have increased the number of days the traps were open, the number of fences used, the length of drift fences to cover more survey area, or the spatial extent of the light-touch and destructive surveys. All of these modifications could have altered our results. Nonetheless, our effort represents the first systematic attempt to compare survey effectiveness among diverse methods in seeps and underscores some basic considerations for surveying amphibians in seeps.

The three methods we tested varied in materials and set-up and survey costs. Trapping had high materials and set-up costs and was the least costly to administer, but required multiple trips to the site per survey session. In contrast, light-touch and destructive sampling had minimal materials and set-up costs but required more time than trapping. The time required for destructive surveys was nearly an order of magnitude larger than light-touch surveys.

We conclude that light-touch may be particularly useful in seeps because it consistently caught more individuals than trapping and appeared relatively unbiased to particular life stages. Trapping seemed to offer little advantage over light-touch and destructive sampling, underperforming these two methods in almost every measure. Light-touch is an effective method for detecting amphibians in seeps for a variety of purposes, such as mark-recapture population estimates, microhabitat associations, and presence/absence surveys. Perhaps the greatest advantage of light-touch over destructive surveys is that light-touch does not substantially disrupt habitat. Destructive sampling in other contexts has been shown to significantly decrease animal populations (e.g. Goode et al. 2004), and may be especially damaging in seeps, which often harbor unique and rare species. Destructive sampling may offer one advantage over light-touch in that it detected many more Columbia torrent salamander larvae in seeps where Columbia torrent salamander larvae were abundant, so destructive sampling may be warranted when detection of large numbers of Columbia torrent salamander larvae is a priority and seeps do not provide habitat for rare or sensitive species. However, until the relationship among trapping, light-touch, and destructive surveys and true abundance are known, e.g. by extensive mark-recapture studies to calculate accurate estimates of abundances, we encourage researchers to consider evaluating their survey methods as part of their work.

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Figure Captions

Figure 1. Overhead diagram of a trapping array centered over a circle of radius of 6 m. Each wing of the array measured 3 m with funnel traps located at the distal ends. The circle delineates the area sampled for light-touch and destructive surveys.

Figure 2. Mean ± one standard error (SE) of species richness (a), and mean numbers and SE of Columbia torrent salamanders (*Rhyacotriton kezeri*) (b), coastal tailed frogs (*Ascaphus truei*) (c), and western red-backed salamanders (*Plethodon vehiculum*) (d) detected per seep by light-touch (solid circles) and trapping (open circles) through the six, three-week survey periods in southwest Washington. Each seep was trapped during three consecutive days and searched by light touch methods on one day in each three-week period.

Figure 3. Mean ± one standard deviation of species richness for 500 bootstrap samples taken with replacement from the pool of 60 (10 seeps × 6 sampling periods) seep samples per survey method (light-touch and trapping).

Figure 4. Mean ± one standard error (SE) of species richness and mean number ± SE of Columbia torrent salamanders (*Rhyacotriton kezeri*) detected per seep by each of the three survey methods during the final sampling period of the study, November 2004, in southwestern Washington.

TABLE 1. Total numbers of amphibians by species and life stage in 10 seeps surveyed by light-touch and trapping methods during six sampling periods from July to November, 2004 (may include recaptures). No eggs were found. Species names follow Crother (2001) and its update (Crother et al. 2003).

		Life Stage	
Species	Survey Method	Larvae[1]	Post-metamorphs
Northwestern salamander	Trapping	0	1
(*Ambystoma gracile*)	Light-touch	0	2
Coastal tailed frog	Trapping	0	3
(*Ascaphus truei*)	Light-touch	0	25
Cope's giant salamander	Trapping	0	0
(*Dicamptodon copei*)	Light-touch	1	0
Coastal giant salamander	Trapping	0	2
(*Dicamptodon tenebrosus*)	Light-touch	6	2
Ensatina	Trapping	—	0
(*Ensatina eschscholtzii*)	Light-touch	—	6
Dunn's salamander	Trapping	—	2
(*Plethodon dunni*)	Light-touch	—	1
Van Dyke's salamander	Trapping	—	1

(*Plethodon vandykei*)	Light-touch	—	0
Western red-backed salamander	Trapping	—	3
(*Plethodon vehiculum*)	Light-touch	—	14
Northern red-legged frog	Trapping	0	1
(*Rana aurora*)	Light-touch	0	9
Columbia torrent salamander	Trapping	0	8
(*Rhyacotriton kezeri*)	Light-touch	39	90

[1] Dashes indicate species with no free-living larval stage.

TABLE 2. Counts of amphibians by species and life stages found during the last of six sampling periods in 10 seeps using three survey methods, November, 2004. No eggs were found.

		Life Stage	
Species	Sample Method	Larvae[1]	Post-metamorphs
Ambystoma gracile	Trapping	0	1
	Light-touch	0	0
	Destructive	0	0
Ascaphus truei	Trapping	0	0

	Light-touch	0	0
	Destructive	0	1
Dicamptodon copei	Trapping	0	0
	Light-touch	0	0
	Destructive	0	0
Dicamptodon tenebrosus	Trapping	0	1
	Light-touch	1	0
	Destructive	7	3
Ensatina eschscholtzii	Trapping	—	0
	Light-touch	—	2
	Destructive	—	5
Plethodon dunni	Trapping	—	1
	Light-touch	—	0
	Destructive	—	0
Plethodon vandykei	Trapping	—	1
	Light-touch	—	0
	Destructive	—	0
Plethodon vehiculum	Trapping	—	0
	Light-touch	—	3
	Destructive	—	1
Rana aurora	Trapping	0	0

	Light-touch	0	4
	Destructive	0	4
Rhyacotriton kezeri	Trapping	0	1
	Light-touch	6	9
	Destructive	139	30

[1] Dashes indicate species with no free-living larval stage.