MONITORING AMPHIBIAN POPULATIONS IN YELLOWSTONE AND GRAND TETON NATIONAL PARKS

Final Report to

University of Wyoming - National Park Service Research Center

Charles R. Peterson, Principal Investigator
Department of Biological Sciences, Idaho State University
Idaho Museum of Natural History

Edward D. Koch
U. S. Fish and Wildlife Service
Boise, Idaho

Paul Stephen Corn
U. S. Fish and Wildlife Service
National Ecology Research Center
Fort Collins, Colorado

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ABSTRACT

Recently, concern has increased over apparent declines in the populations of many amphibian species throughout the world. Consequently, studies are being undertaken to determine the extent of these declines and their causes. Studies of amphibian populations in the Greater Yellowstone Ecosystem are important for several reasons, including: (1) the amphibian species which occur there are experiencing problems elsewhere in their ranges, especially spotted frogs and western toads; (2) the region is relatively undisturbed and thus may provide comparisons valuable for testing hypotheses concerning the causes of declines (e.g., water pollution); and (3) it is relatively protected and will be available for long term studies. To determine the status of amphibian populations in Yellowstone and Grand Teton National Parks, we sampled eight sites several times during the spring and summer of 1991. Park personnel collaborated in the sampling and significantly increased the amount of data we were able to obtain. We gathered information on the physical and biological conditions at each site (elevation, water chemistry, weather, presence of fish, etc.). All of the sampled localities had intermediate pH values (6.8 - 8.5) and sufficient buffering capacity so that they are not at risk of acidification from acid precipitation. Our principal technique for sampling amphibians consisted of timed searches in which we counted or estimated the number of egg masses, larvae, juveniles, and adults seen or heard. Four species of amphibians were found. Western toads (*Bufo boreas*) were located at only three of the eight sites and at only one of five sites from where they were previously recorded. This species appears to be less widespread and less abundant than in the past. Spotted frogs (*Rana pretiosa*) were present, abundant, and reproducing at all eight sites. The widespread distribution (seven of eight sites) of western chorus frogs (*Pseudacris triseriata*) was easy to determine because of their spring calling behavior. However, relatively few adults, eggs, or tadpoles were observed. Tiger salamanders (*Ambystoma tigrinum*) were relatively difficult to sample and were found at only half of the sites. We did not find salamanders at sites with fish. Attempts to compare our results with previous studies from the 1950's by Frederick Turner and Charles Carpenter were confounded by developments at their sites (e.g., road construction).

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INTRODUCTION

During the past five years, biologists have become increasingly concerned about the health of amphibian populations because many of them appear to be declining throughout much of the world (Corn and Fogleman 1984, Beiswenger 1986, McAllister and Leonard 1990, National Research Council Workshop on Declining Amphibians 1990, Wake 1991). Declines appear to be particularly noticeable in the western United States in the true frogs and toads (families Ranidae and Bufonidae, respectively). For example, leopard frogs (*Rana pipiens*) and western toads (*Bufo boreas*) have disappeared from the majority of their historic ranges in Colorado (Corn et al. 1989) and populations of spotted frogs (*Rana pretiosa*) have gone extinct or declined on the periphery of their range in Washington, Oregon, California, Nevada, and Utah (McAllister and Leonard 1990). Amphibian declines in relatively undisturbed areas such as national parks are especially troubling.

Monitoring amphibian populations is important for several reasons. First and most obvious, we need to know if and why amphibian populations are fluctuating so we can effectively manage them and preserve biodiversity. Second, amphibians are important components of many ecosystems, both as prey and predators. Amphibians often make up a significant amount of a system's biomass (Pough 1983) and are an important source of food for a variety of animals, including insects, reptiles, birds, and mammals. Some amphibians, such as larval tiger salamanders, are high in the food chain and thus may play important roles in structuring their communities. Finally, amphibians are potentially sensitive indicators of environmental quality because of a unique combination of biological characteristics such as their permeable skins, biphasic life cycles, and aquatic reproduction and development (Wake and Morowitz - National

monitoring of amphibian populations has been recommended as an "early warning system" of environmental change (Beiswenger 1986, 1988, Wake 1991).

Two major questions need to be addressed to understand declines in amphibian populations: (1) *To what extent are amphibian populations actually declining?* The evidence for declining populations is largely anecdotal and there are few quantitative, long-term studies of amphibian populations (Wake 1991). We do not know what percentage of species are affected or to what extent their populations have declined. Therefore, to determine how widespread this problem is, top research priorities should include resurveying previously studied populations and initiating integrated, long-term studies of amphibian populations (Wake and Morowitz 1990, Pechmann et al. 1991).

(2) *If amphibian populations are decreasing, what are the causes of the declines?* A variety of factors may be involved with declines in amphibian populations, including temperature changes, increased ultraviolet radiation, air and water pollution, drought, habitat destruction and fragmentation, disease, and the introduction of exotic species. A key issue is the extent to which population fluctuations are the result of natural causes, such as drought, versus anthropogenic causes, such as pollution (Pechmann et al. 1991). The causes of declines which have occurred

1. Slide Lake is a small, permanent lake located several hundred meters east of the unpaved, Old Gardiner to Mammoth road, 1.6 km north of Mammoth, Wyoming in the northwestern portion of Yellowstone National Park. Slide Lake is our lowest elevation site (1722 m).

2. Slough Creek Pond (our name) is a small, glacial pothole located in the northeastern portion of Yellowstone National Park. It lies immediately on the east side of Slough Creek Road, 0.8 km north of its junction with the Northeast Entrance Road at an elevation of 1884 m.

3. Harlequin Lake is a permanent lake located in the west central portion of Yellowstone National Park. It lies 800 m north of the West Entrance Road, 2.4 km west of Madison Junction, at an elevation of 2128 m. The area surrounding this lake was burned during the 1988 fires.

4. Indian Pond (= Squaw Lake) is a small, permanent lake located in the central portion of Yellowstone National Park, just south of the highway 4.2 km east of Fishing Bridge at an elevation of approximately 2359 m. The southeast corner of the pond is geothermally influenced.

5. The Soldier (= Lodge) Creek site includes springs, a permanent stream, and several pools or ponds. This site is located just west of the Grand Loop Road, 1.6 km south of the junction with the East Entrance Road at an elevation of approximately 2371 m. This site was of particular interest because Frederick B. Turner conducted his classic demographic study of the spotted frog (*Rana pretiosa*) here. In 1991 we located the springs, the branches of the stream, and four of the six ponds described in Turner (1960); these ponds corresponded to Turner's pools 1, 2, 3, and 4. Unfortunately, this site has been considerably disturbed since the early 1950's by highway construction and by the development of the springs as a water supply for the Lake area complex.

6. The South Entrance Site (our name) is located just at the south entrance to Yellowstone National Park, immediately east of the Snake River but in the flood plain. The elevation is approximately 2094 m. This site includes a permanent pond, a smaller, temporary pond, and a stream that runs from near the temporary pond several hundred meters south to the Snake River. The stream and permanent pond are geothermally influenced. To our knowledge, this is our only site which had not been previously examined for amphibians.

7. The Togwotee Pass Pond (our name) is a small, permanent, glacial pond located in the Bridger Teton National Forest, within 10 m of the north side of Highway 287, approximately 4.6 km west of Togwotee Pass. Several other ponds and streams occur just to the north of this pond but we did not sample them. Based on our visit to this site with Charles C. Carpenter in June 1991, we believe that this is the same site described in Carpenter (1953b). This site is of particular interest because it is our highest elevation site (approximately 2804 m) and because Carpenter observed four species of amphibians in the Togwotee Pass area in 1951 (Carpenter 1953c).

8. Lower Moose Pond is a large, inactive beaver pond located at the base of Teewinot Mountain in Grand Teton National Park at an elevation of 2070 m. This pond is the southernmost and lowest of the three Moose Ponds located approximately 500 to 1000 km southwest of Jenny Lake. Charles C. Carpenter (pers. comm.) observed western toads and spotted frogs in this area in 1951.

METHODS

Sampling Schedule

We sampled each site at least once per month from May through August. Park personnel also sampled all of the sites except Togwotee Pass several times during June and August. The Soldier Creek site was sampled into September and the Harlequin Lake into October by Park personnel. The number of sampling visits per site ranged from 3 to 13 and averaged approximately eight times per site. The amount of time spent sampling a site varied from less than 30 minutes to several hours, depending on the size of the site, the number of amphibians observed, and a variety of other factors (the number of persons, water depth, amount of vegetation, etc.)

Site Descriptions and Environmental Measurements

During the first visit to an area, we described the site using a standard form developed by Paul Stephen Corn of the U.S. Fish and Wildlife Service (USFWS). The types of data collected included location, a description of the habitat, physical and chemical characteristics, and some of the plants and animals present (especially emergent vegetation and potential amphibian predators such as fish, snakes, and birds). See Figure 2 for an example of the form used and the site characteristics recorded.

Once in May and again in June, we collected a water sample at each site by filling a 250-ml opaque high density polyethylene bottle with water from the breeding habitat (if known) or from the north shore. Collection sites were within 2 m of the shoreline and the water depth was usually less than 0.5 m. At Soldier Creek, water samples were collected from Ponds 1 and 3, and at the South Entrance site only from the permanent pond. Unfiltered samples were

refrigerated and held until they were delivered for analysis to the Water Analysis Laboratory at the U.S. Forest Service Rocky Mountain Forest and Range Experiment Station in Ft. Collins, Colorado. Acid neutralizing capacity (ANC) was determined by Gran titration and pH was measured electrometrically with a glass electrode. Major anions and cations were measured following standard methods (U.S. Environmental Protection Agency, 1987).

During each sampling visit, we also recorded several types of weather data. We used a mercury thermometer to measure 1 m shaded air temperatures and 1 cm water temperatures at one or more locations (e.g., at the beginning of the sampling period and where we found eggs, larvae, and/or adults). Percent cloud cover, relative wind speed (calm, light, moderate, or strong), radiation (direct sunlight or blocked by clouds) and the occurrence of precipitation were also noted for each sampling period. These data were taken so that the influence of the physical environment could be considered when we were comparing our observations of amphibians among sites and through time at the same site.

Amphibian Sampling

Our principal sampling technique for amphibians consisted of timed searches. We walked in the water and/or along the shores of lakes and ponds and along the banks of streams. We counted the number of egg masses found and all the individuals seen and classified them as adults, juveniles, recently transformed (metamorphs), or larvae. In the case of large numbers of larvae or metamorphs, we only estimated their numbers. Dip nets were used to collect larvae and tadpoles for identification. We also listened for the advertisement calls of adult anurans. We experimented with the use of minnow traps at Harlequin Lake and Lower Moose Pond to sample for salamanders and tadpoles.

To obtain an indication of relative abundance, we noted beginning and ending times so that observation rates for each species could be calculated by dividing the number of observations by the total search time. We did not adjust for the number of observers but if we split into two groups (e.g., one group searching clockwise around a lake and the other group in a counter-clockwise direction), we doubled the search time. Because these calculated rates are subject to a variety of factors, they are only rough indicators of relative abundance.

To detect long-term changes in populations, we re-examined sites that had been studied in the early 1950's by Frederick B. Turner (1955, 1960) in Yellowstone National Park and Charles C. Carpenter (1953c, 1954) in the Jackson Hole area. We visited the site of Turner's spotted frog study (Soldier Creek) with Frederick Turner on 20-21 June 1991, as well as two areas where he had previously observed many spotted frogs (the Natural Bridge area and two small lakes several hundred meters southeast of Black Dragons Cauldron). During 24-26 June 1991, we visited several sites with Charles C. Carpenter, including Togwotee Pass, Lower Moose Pond, String Lake, and the former Jackson Hole Wildlife Park (Willow Creek and 3-Angle Pools).

To try to quantify long-term changes in the size of the spotted frog population at Soldier Creek, we conducted a mark/capture study during July and August of 1991 for comparison with 1953-1955 population estimates (Turner 1960). On 16-17 July 1991, we hand collected a total of 125 spotted frogs from the Soldier Creek Site (Pools 1-4, Springs 1 and 2, and the two stream branches from the springs east to the Grand Loop Road). We sexed each frog, measured its snout-urostyle length, weighed it, and freeze-branded 104 of them. This procedure (Clark 1971) was performed using liquid nitrogen and 12-gauge copper wire fashioned into numbers. The wire

was immersed into a flask of liquid nitrogen for at least 30 seconds, then the tip of the wire was touched lightly to the ventral surface of the frog and held for approximately four seconds. Marks made in this manner were immediately visible and were even more readable after 30 minutes. All of the frogs were released in the area in which they were collected within 10 hours of capture. On 24 August 1991 we resampled the population using the same techniques implemented during the original sampling. Individuals captured at this time were again sexed, measured, and weighed. Marked individuals were noted as the brands were easily readable. Thirty eight (37) of a total of 87 individuals captured had been branded.

RESULTS AND DISCUSSION

Site Descriptions and Environmental Measurements

The habitat data for each site are summarized in Table 1. The sites are also classified using the system of Cowardin et al. (1979) in Table 2. The elevations of the sites ranged from 1722 to 2804 m and are graphically represented in Figure 4.

Intersite and seasonal variation in water temperatures are shown in Figure 3. Visual inspection of these graphs indicates that Slide Lake, Harlequin Lake, and the permanent pond at the South Entrance sites were relatively warm and Soldier Creek Pond 3, Togwotee Pass, and Lower Moose Pond were cooler. The differences among sites are largely obscured by variation in the time of day that the measurements were made and by daily variation in weather conditions. It is clear from these data that continuous temperature measurements would be important for making accurate, quantitative comparisons of temperatures among the sites. Such data would be useful in interpreting activity periods, breeding times, times to metamorphosis, etc. The recent

development of relatively inexpensive ($100), single-channel dataloggers for measuring temperatures (Hobotemp, Onset Computer Corporation, N. Falmouth, MA) will make these data easier to obtain.

Water chemistry results are summarized in Table 3. Considerable variation existed among localities but much less difference occurred between the May and June samples within localities. Anions and cations tended to have slightly higher concentrations in June, and pH and acid neutralizing capacity (ANC) likewise tended to have higher values in the second samples. Variation among localities can be partly attributed to differences between vernal snowmelt ponds (e.g., Lodge Creek Ponds) that have low ion concentrations and moderate ANC, to ponds with geothermal influences (Slough Creek Pond, Indian Pond, and South Entrance Pond) that have high ion concentrations and large ANC.

All of the sampled localities have sufficient buffering capacity (ANC) so that they are not at risk of acidification from acid precipitation. Aquatic habitats are generally not susceptible to acidification unless ANC < 200 μeq/l and annual atmospheric deposition of sulfate exceeds 10 kg per ha (Schindler, 1988). Other habitats not sampled, such as high-elevation vernal ponds, may have lower ANC. However, Corn and Vertucci (in press) found that although montane amphibians may breed in water with low ANC, sulfate deposition was almost always < 10 kg per ha. They concluded that amphibian populations in the Rocky Mountains (including the Greater Yellowstone Ecosystem) were not in danger of damage from acidification. The chemistry data suggest additional questions, including whether the high concentrations of ions in some localities pose any problems for amphibians.

Temporal and Spatial Variation in the Occurrence of Amphibians

The historical and current occurrence of each species of amphibian is summarized by site in Table 4. This table also indicates which life stages (eggs, larvae/tadpoles, metamorphs, juveniles, and adults) were found at each site. We found three of the four species of amphibians present at six of the sites and two species at the other two sites. We did not find all four species at any of the sites although the historical records indicate that all four species used to be present at or nearby Slough Creek Pond, Harlequin Lake, and Togwotee Pass Pond. At each of these sites, the species we were unable to find was the western toad.

Tiger salamanders (*Ambystoma tigrinum*)

We found tiger salamander adults or larvae at four of our eight sampling sites. They had been previously recorded at or near five of the eight sites. We did not find this species at Indian Pond even though it was previously reported from there. The absence of tiger salamanders from some sites may be related to the presence of fish that may prey upon them. Fish and salamanders appear to be mutually exclusive at the eight sites we sampled (Table 5). This finding is consistent with studies by Carpenter (1953c) in the Jackson Hole area, Bradford (1989) in California, and Geraghty (1992). Although tiger salamanders and western toads used to occur together at some of our sites and continue to do so elsewhere in the Greater Yellowstone Ecosystem (C.R. Peterson, pers. observ.), we did not find them together at any of our sampling sites. It is also possible that we may have failed to detect the presence of this species at some sites because of sampling difficulties. Tiger salamanders (*Ambystoma tigrinum*) were relatively difficult to sample. They were most easily seen in the water, either as adults or larvae. We found eggs only at one site (Slide Lake). It was apparent that the probability of observing this

species was more affected by the experience of the observer than for the other species. We did not locate them consistently and typically detected this species on only one or two sampling dates at a given site. Our efforts to collect individuals with minnow traps at Harlequin Lake and Lower Moose Pond were unsuccessful but, given the success that Carpenter (1953a) had with this technique, we plan to try again next year, earlier in the season. Tiger salamanders have been found in pit traps placed out for sampling small mammal populations (Mary Harter, *pers. comm.*) but we did not use traps because of our limited sampling schedule and because many of the sites are visible to the public. Previous lake surveys for fish indicate that gill netting is effective (Fishery and Aquatic Management Program in Yellowstone National Park - Technical Reports for Calendar Years 1964-1982) but often results in the death of the salamanders. Although mass migrations of salamanders have been reported in Yellowstone National Park (Koch and Peterson 1989), we did not encounter or hear of any such migrations in 1991.

Based on the total number of adults observed (49), tiger salamanders were the second most abundant species of amphibian in our study (Table 6). About 32 larvae were observed. These numbers almost certainly do not reflect the number of salamanders at the sites and other techniques such as trapping would need to be used to measure actual population sizes.

Western Toads (*Bufo boreas*)

Western toads were found at only three of the eight sites. Although western toads were previously found at or near five of the sites (at Harlequin Lake, Soldier Creek, Lower Moose Pond, and within several miles of Slough Creek Pond and Togwotee Pass Pond), we only recorded a single juvenile at one of these sites (Soldier Creek). Based on the number of adults observed (10), western toads are the least abundant species of amphibian in the parks (Table 6).

In view of Carpenter's description of western toads as the most wide-spread amphibian in the Jackson Hole region (1953c), we find this apparent decrease in the distribution and abundance of western toads alarming and we consider it unlikely to be the result of ineffective sampling. Western toads are apparently relatively easy to observe if they are present. The timed searches were effective for sampling adults, larvae, and metamorphs at the South Entrance Pond site. Ten adults were seen at this site and thousands of tadpoles and recently transformed individuals were seen from June through August in the geothermally influenced stream. Toad tadpoles and juveniles also were easily observed at Indian Pond. It is interesting to note that both of these sites where the toads reproduced are geothermally influenced. We did not hear the toads calling for mates although individuals sometimes vocalized when captured. We also did not find any eggs.

Western chorus frogs (*Pseudacris triseriata*)

Because western chorus frogs were found at seven of the eight sites, we considered them to be widespread as did Turner (1955). They may also occur at the Indian Pond site but may simply have not been detected. The presence of chorus frogs at a site was most easily determined by listening for their calls in the spring. We encountered adults at a low rate (only 27 adults during the study). Eggs were hard to find and only seen at two sites. We saw fewer tadpoles than we expected to find on the basis of the amount of calling and number of adults seen. Tadpoles were only observed at one of the sites (South Entrance Pond).

Spotted Frogs (*Rana pretiosa*)

Spotted frogs were found at all eight sampling sites and thus were the most wide-spread species. Spotted frogs were the most easily sampled species. We found all stages (eggs,

tadpoles, metamorphs, juveniles, and adults) during the timed searches. We did not hear any calling. Eggs were found from mid May to mid June, depending on the location of the site. We captured many tadpoles in a minnow trap in Lower Moose Pond but were unsuccessful at Harlequin Lake, perhaps because of differences in the substrates, sizes of the water bodies, and times of development. Transforming individuals were observed from late to July to early September, depending on the location of the site.

Although spotted frogs appeared to be abundant and reproducing at all locations sampled, we do not know what the population trends are. Seasonal variation in the number and observation rates of spotted frogs was great (Figure 5). Turner's subjective impression from his 1991 visit was that there were fewer spotted frogs now than in the 1950's. We found very few spotted frogs during two visits to the Natural Bridge Area in Yellowstone National Park, even though Turner had observed that they were abundant there in the 1950's. Our preliminary analysis of 1991 mark/recapture data for spotted frogs at Lodge Creek suggests that, although many frogs are still present, a dramatic decline (about 60-80%) has occurred since the 1950's. On 16-17 July 1991 we captured, marked (freeze-branded), and released 104 spotted frogs in the upper portion of Lodge Creek. On August 24, we captured 87 frogs, 37 of which had been marked. This recapture ratio indicates a population size of about 245 frogs, compared to Turner's population estimates of 1000-1600 frogs in 1953-1955 (Turner 1960). Unfortunately, this site has been heavily disturbed by roads and a water well system and thus is probably not representative of the Park as a whole. The construction of roads and buildings in Grand Teton National Park also prevented comparisons of current and past abundances at Carpenter's best studied sites (Carpenter 1954).

Considerations for Monitoring Amphibians

Much of the difficulty in determining accurate distribution and population trends for amphibians is due to the variety of factors influencing their activity and abundance, including the species, life stage, sampling technique, weather, time, and location. We often failed to observe a given species at a particular site even though we found it there at another time. Because of the number of variables involved and their potential interactions, we feel that careful sampling using a variety of techniques at several times during the year is required. Once a general understanding of these effects is achieved, a more efficient sampling schedule can be developed. The participation of park personnel in the sampling greatly increased our understanding of temporal variation in the abundance of amphibians.

Based on the amount of temporal and intersite variation in the number of amphibians observed during our first year of sampling, we feel that mark/recapture studies will be required to obtain estimates of abundance that can be used for comparisons among sites or to determine population trends.

CONCLUSIONS

1. Western toads appeared to be less widespread and less abundant than in the past, especially in the southern portion of the Greater Yellowstone Ecosystem.

2. Spotted frogs were widespread, abundant, and successfully reproducing.

3. Western chorus frogs was widespread but relatively few adults, eggs, or tadpoles were observed, probably because of sampling difficulties.

4. Tiger salamanders were found at four of five sites where they were known to occur. Although somewhat difficult to sample, we encountered a moderate number of individuals.

5. It is difficult to determine population trends because of a lack of previous studies for comparisons. Unfortunately, those sites for which previous population data were available had been modified by developments so that meaningful comparisons could not be made. We recommend that the parks identify previous study areas and try to protect such sites from further development.

6. We recommend that a simple amphibian monitoring program be conducted on a long-term basis so that sufficient data will be available in the future to address questions concerning the population trends of amphibians in the Greater Yellowstone Ecosystem.

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TABLE CAPTIONS

Table 1. Physical characteristics of sampling sites.

Table 2. Wetland habitat classification of study sites (after Cowardin et al. 1979).

Table 3. Water chemistry data for May and June samples from 1991.

Table 4. Amphibian species and life stage occurrence at eight sampling sites in Yellowstone and Grand Teton National Parks during 1991. An asterisk indicates that a species was recorded at or near that site before 1991. A = adult. C = calling. E = eggs. J = juvenile. L = larva or tadpole. M = recently metamorphosed individual.

Table 5. Comparison of tiger salamander and fish occurrence at study sites.

Table 6. Summary of number of observations of each life stage for each species of amphibian at all sampling sites. Columns for those life stages with no observations at any of the sites are excluded. For egg masses, the first number indicates the actual number of egg masses; the number in parentheses includes repeated observations of the same egg masses.

Sampling Site	Elevation (m)	Origin	Status	Drainage	Primary Substrate	Silt Cover (%)	Emergent Vegetation (%)	North Shoreline Characteristics	Site Length (m)	Site Width (m)	Maximum Depth (m)
Slide Lake	1722	natural	permanent	permanent	sand/gravel	1-25	1-25	shallows present	400	200	> 2 m
Slough Creek Road Pond	1884	natural	permanent	none	silt/mud	> 50	1-25	shallows present	150	50	1-2
Harlequin Lake	2128	natural	permanent	occasional	silt/mud	> 50	1-25	shallows present	600	400	> 2 m
Slough Creek Road Pond	1884	natural	permanent	none	silt/mud	> 50	1-25	shallows present	150	50	1-2
Indian Pond	2359	natural	permanent	permanent	sand/gravel	1-25	1-25	shallows present	600	400	> 2
Soldier (= Lodge) Creek											
Pond #1	2388	natural	temporary	occasional	silt/mud	> 50	1-25	shallows present	15	10	< 1
Pond #3	2371	natural	permanent	occasional	silt/mud	> 50	1-25	shallows present	30	10	< 1
Stream	2371	natural	permanent	permanent	silt/mud	> 50	1-25	NA	200	1	< 1
South Entrance											
Permanent Pond	2094	natural	permanent	none	silt/mud	> 50	50-75	shallows present	200	200	1-2
Vernal Pond	2094	natural	temporary	occasional	silt/mud	> 50	50-75	shallows present	50	5	< 1
Stream	2094	natural	stream	permanent	silt/mud	> 50	1-25		50	3	< 1
Togwotee Pass Pond	2804	natural	permanent	occasional	silt/mud	> 50	1-25	shallows present	100	50	1-2
Lower Moose Pond	2070	natural	permanent	permanent	silt/mud	> 50	25-50	shallows present	250	50	1-2

Sampling Site	Habitat Classification
Slide Lake	Lacustrine, limnetic/littoral, unconsolidated bottom, permanently flooded
Slough Creek Pond	Palustrine, emergent, semipermanently flooded
Harlequin Lake	Lacustrine, limnetic/littoral, unconsolidated bottom, permanently flooded
Indian Pond	Lacustrine, limnetic/littoral, unconsolidated bottom, permanently flooded
Soldier Creek	
Pond #1	Palustrine, unconsolidated bottom, temporarily flooded
Pond #3	Palustrine, unconsolidated bottom, intermittently exposed
Creek	Riverine, upper perennial, unconsolidated bottom, permanently flooded
South Entrance	
Permanent Pond	Palustrine, emergent, intermittently exposed
Temporary Pond	Palustrine, emergent, seasonally flooded
Stream	Riverine, lower perennial, aquatic bed, permanently flooded
Togwotee Pass Pond	Palustrine, emergent, permanently flooded
Lower Moose Pond	Palustrine, emergent, permanently flooded

Location	Date	pH	Conductivity (µS/cm)	ANC (µeq/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	NH_4 (mg/l)	Cl (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)	SiO_2 (mg/l)	P (mg/l)	Al (µg/l)	Pb (µg/l)
Slide Lake	20 May	8.26	326.00	2188.20	29.37	7.69	10.82	2.42	0.09	1.90	0.00	16.73	30.62	0.04	16.99	<1.6
Slide Lake	21 June	8.31	324.38	2503.90	28.97	8.63	10.41	2.39	0.13	1.62	0.00	26.80	33.58	0.11	22.96	<1.6
Slough Creek Pond	21 May	8.47	561.00	3950.70	51.15	11.51	30.54	8.42	0.15	21.44	0.00	31.08	27.95	0.00	22.11	<1.6
Slough Creek Pond	22 June	8.18	688.48	NA	67.36	15.84	36.70	10.90	0.20	8.82	0.00	9.55	27.88	0.02	29.02	<1.6
Harlequin Lake	23 May	6.95	82.44	520.80	5.71	1.26	4.81	3.04	0.02	2.89	0.00	1.14	8.66	0.00	47.48	<1.6
Harlequin Lake	24 June	7.53	81.21	567.10	5.82	1.60	5.33	3.30	0.04	2.60	0.00	0.14	9.09	0.02	24.86	<1.6
Indian Pond	19 May	8.10	1234.00	1437.20	9.48	2.15	204.20	8.47	0.05	308.10	1.52	28.29	61.48	0.27	70.40	2.42
Indian Pond	22 June	8.11	1269.94	1765.30	10.93	3.47	191.80	10.06	0.03	356.70	0.26	10.07	69.24	0.17	62.22	<1.6
Soldier Creek Pond #1	23 May	6.84	58.38	364.40	4.12	1.61	1.29	2.60	0.28	1.56	1.97	1.23	8.24	0.00	115.00	<1.6
Soldier Creek Pond #1	23 June	7.55	121.48	895.90	9.36	4.00	5.39	6.70	0.37	4.09	0.00	1.84	0.52	0.05	239.10	2.02
Soldier Creek Pond #3	23 May	6.75	62.78	264.60	3.97	1.65	2.11	3.62	0.10	3.44	0.13	3.03	12.07	0.10	256.70	<1.6
Soldier Creek Pond #3	23 June	7.26	74.03	544.10	6.37	2.74	3.67	1.38	0.21	1.77	0.00	0.34	8.71	0.05	382.80	<1.6
South Entrance Pond (Permanent)	22 May	8.23	304.00	NA	31.53	4.69	7.29	3.93	0.08	8.58	0.00	9.25	9.75	0.03	32.05	<1.6
South Entrance Pond (Permanent)	23 June	8.29	957.70	NA	52.27	10.59	92.61	20.25	0.13	58.29	0.07	17.91	47.84	0.15	18.48	<1.6
Togwotee Pass Pond	25 June	7.39	43.69	400.90	3.36	1.25	1.90	0.71	0.20	1.19	0.00	0.00	1.06	0.01	54.67	<1.6
Lower Moose Pond	25 May	6.84	30.17	175.10	2.49	0.32	0.82	0.65	0.06	0.56	0.22	0.80	5.47	0.00	57.66	<1.6
Lower Moose Pond	26 June	7.07	18.34	181.20	2.32	0.41	0.92	0.53	0.03	0.31	0.00	0.14	17.52	0.01	29.46	<1.6

Sampling Site	Days Sampled	Tiger Salamander *Ambystoma tigrinum*	Western Toad *Bufo boreas*	Western Chorus Frog *Pseudacris triseriata*	Spotted Frog *Rana pretiosa*
Slide Lake	7	• E L		A C	A E J M
Slough Creek Pond	7	• A J L	•	A C	• A E J
Harlequin Lake	11	• L	•	A C	A E J L M
Indian Pond	4	•	J L	•	A E J L M
Soldier (= Lodge) Creek	13		• J	• A	• A E J L M
South Entrance	10		A L M	A C L	A E L
Togwotee Pass Pond	3	• A L	•	C	• A L M
Lower Moose Pond	7		•	C	• A E L

• = historic record at or near site A = adult C = calling E = eggs J = juvenile L = larva/tadpole M = metamorph

Sampling Site	Tiger Salamanders	Fish
Slide Lake	yes	no
Harlequin Lake	yes	no
Slough Creek Road Pond	yes	no
Indian Pond	no	yes
Lodge Creek (upper)	no	no
South Entrance Pond	no	no
Togwotee Pass Pond	yes	no
Lower Moose Pond	no	yes

Sampling Site	Days Sampled	Total Search Time (h)	Tiger Salamander Adults	Tiger Salamander Larvae	Tiger Salamander Egg Masses	Western Toad Adults	Western Toad Juveniles	Western Toad Metamorphs	Western Toad Tadpoles	Chorus Frog Adults	Chorus Frog Tadpoles	Chorus Frog Egg Masses	Spotted Frog Adults	Spotted Frog Juveniles	Spotted Frog Metamorphs	Spotted Frogs not aged	Spotted Frog Tadpoles	Spotted Frog Egg Masses
Slide Lake	7	10.40	0	2	3	0	0	0	0	4	0	0	90	17	3	0	0	12
Slough Creek Pond	7	7.82	34	10	0	0	0	0	0	2	0	0	21	27	0	125	0	1
Harlequin Lake	11	22.87	0	2	0	0	0	0	0	17	0	0	291	415	3	3	11	18
Indian Pond	4	7.22	0	0	0	0	1	2	> 100	0	0	0	4	24	28	0	> 100	1
Soldier Creek	13	16.92	0	0	0	0	1	0	0	1	0	0	166	131	2	175	> 500	15 (35)*
South Entrance	10	15.57	0	0	0	10	3	> 1,000	> 1,000	4	> 10	6	11	0	0	8	> 10	16 (28)*
Togwotee Pass Pond	3	2.20	15	18	0	0	0	0	0	0	0	0	8	0	1	0	> 10	0
Lower Moose Pond	7	6.15	0	0	0			0	0	0	0	0	3	0	0	0	> 50	34
TOTALS	62	89.13	49	32	3	10	5	> 1,000	> 1,000	28	> 10	6	594	614	37	311	> 700	97 (127)*

* the first number indicates the actual number of egg masses; the number in parentheses includes repeated observations of the same egg masses.

FIGURE CAPTIONS

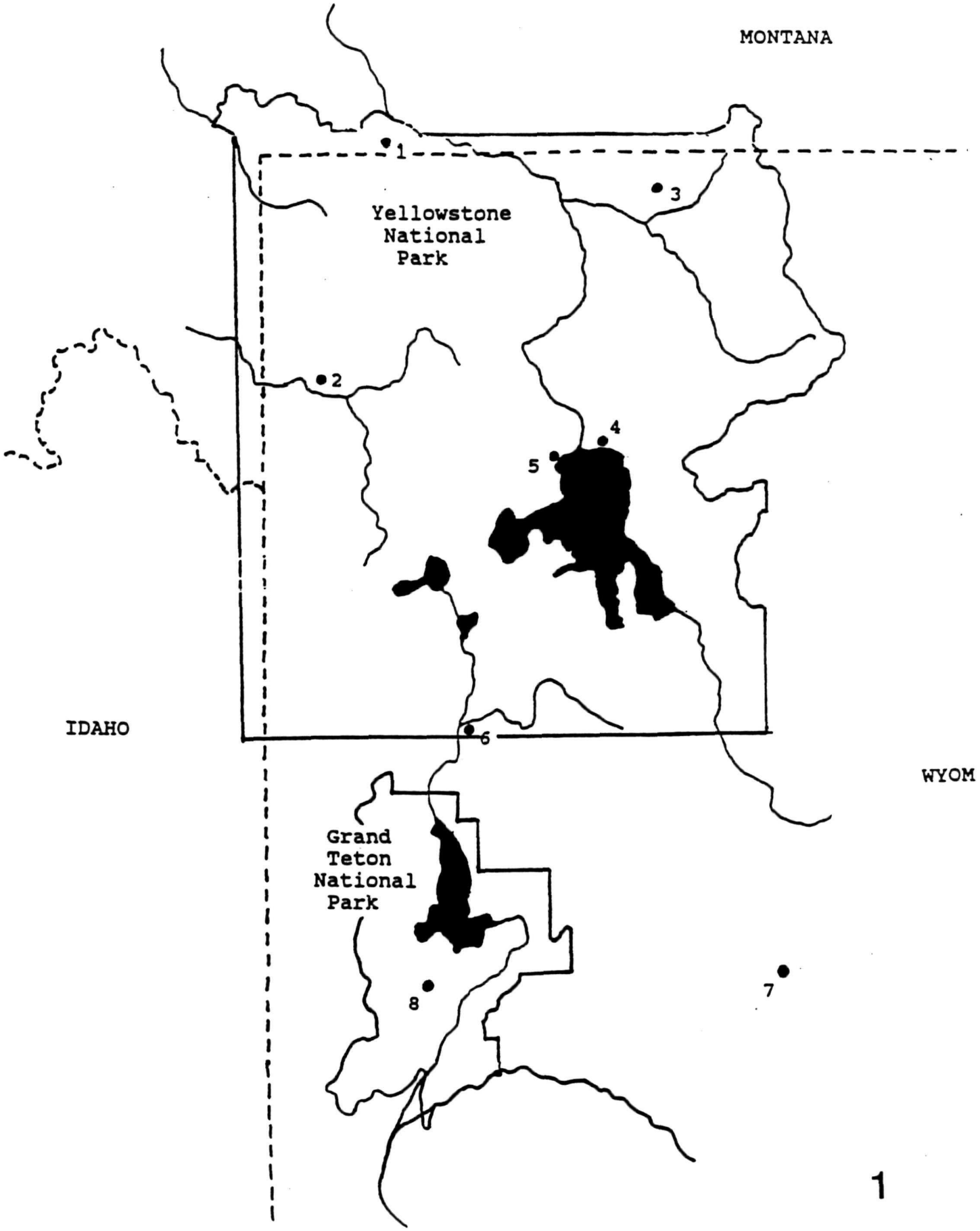
Figure 1. Location of amphibian sampling sites in the Greater Yellowstone Ecosystem. 1. Slide Lake. 2. Harlequin Lake. 3. Slough Creek Road Pond. 4. Indian Pond. 5. Soldier (Lodge) Creek. 6. South Entrance Pond. 7. Togwotee Pass Pond. 8. Lower Moose Pond.

Figure 2. 1991 USFWS amphibian survey data sheet.

Figure 3. Seasonal variation in 2 cm water temperatures at sampling sites.

Figure 4. Elevations of sampling sites and occurrence of amphibian species.

Figure 5. Observation rates of spotted frogs (*Rana pretiosa*) at Harlequin Lake during 1991. The juvenile category includes recently transformed individuals. The numbers above the bars indicate the total number of individuals observed on that day.


MONTANA
1
3
Yellowstone
National
Park
2
4
5
IDAHO
6
WYOM
Grand
Teton
National
Park
8
7

AMPHIBIAN SURVEY DATA SHEET (sketch site and put additional comments on back)

(ver. 5/9/91)

DATE	OBSERVERS
SITE NUMBER	SITE NAME

STATE	COUNTY	OWNER	ELEVATION

TOWN-SHIP	RANGE	SEC-TION	SECTION DESCRIPTION	LATI-TUDE	LONGI-TUDE

SITE DESCRIPTIONS - CIRCLE APPROPRIATE ANSWERS

ORIGIN:	NATURAL	MAN-MADE	STATUS:	PERMANENT LAKE/POND	TEMPORARY LAKE/POND	STREAM
DRAINAGE:	PERMANENT	OCCASIONAL	NONE	OTHER DESCRIPTION:	ACTIVE BEAVER POND	INACTIVE BEAVER POND / MARSH/BOG

PRIMARY SUBSTRATE:	SILT/MUD	SAND/GRAVEL	COBBLE	
IF PARTIAL SILT COVER, CIRCLE %:	1 - 25	25 - 50	> 50	
% EMERGENT VEGETATION:	0	1 - 25	25 - 50	50 - 75	> 75
NORTH SHORELINE CHARACTERS:	SHALLOWS PRESENT	SHALLOWS ABSENT	EMERGENT VEG PRESENT	EMERGENT VEG ABSENT	

SITE LENGTH (M)	SITE WIDTH (M)	MAXIMUM DEPTH:	< 1 M	1 - 2 M	> 2 M

EMERGENT VEGETATION SPECIES (LIST IN ORDER OF ABUNDANCE)			
DISTANCE (M) TO FOREST EDGE	FOREST TREE SPECIES		

PHYSICAL AND CHEMICAL ENVIRONMENT

WEATHER:	CLEAR	OVERCAST	RAIN	SNOW	WIND:	CALM	LIGHT / STRONG

AIR TEMP (°C)	WATER TEMP (°C)	pH

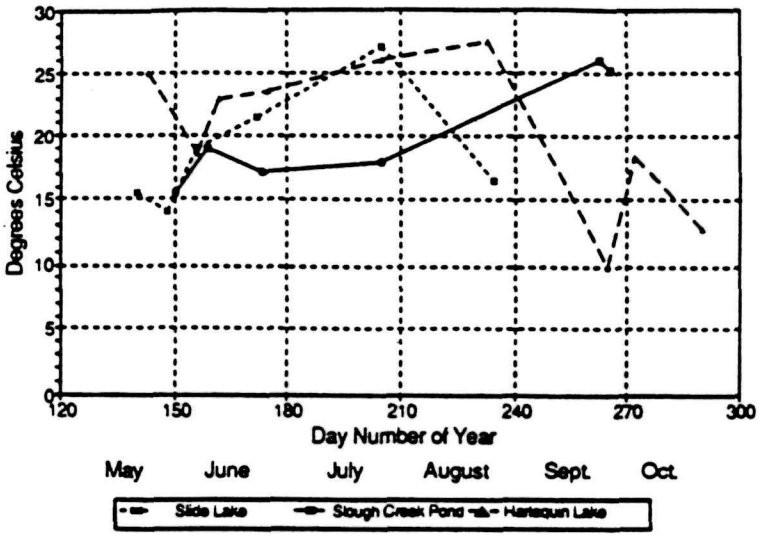
COLOR:	CLEAR	MODERATE	STAINED	TURBIDITY:	CLEAR	MODERATE / EXTREME

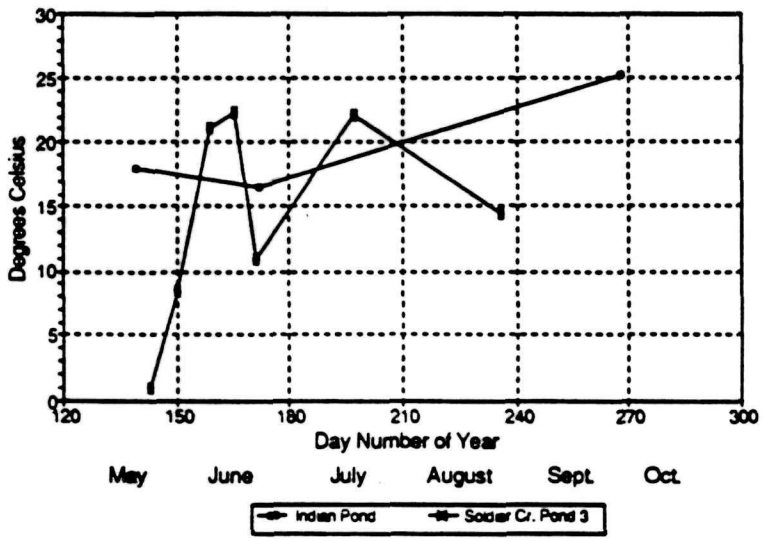
AMPHIBIAN SPECIES PRESENT (INDICATE NUMBERS IN CATEGORIES IF POSSIBLE)

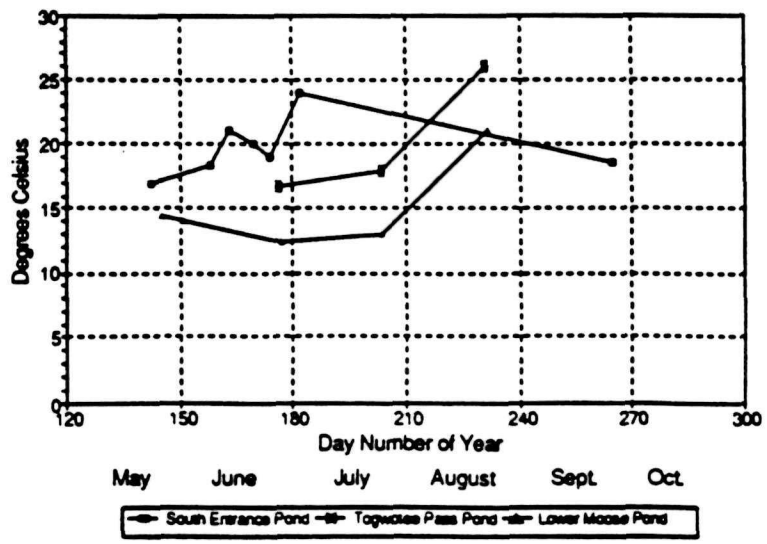
SPECIES	ADULTS/JUVENILES	BREEDING (Y/N)	TADPOLES/LARVAE	EGG MASSES

FISH PRESENT:	YES	NO	SPECIES:	

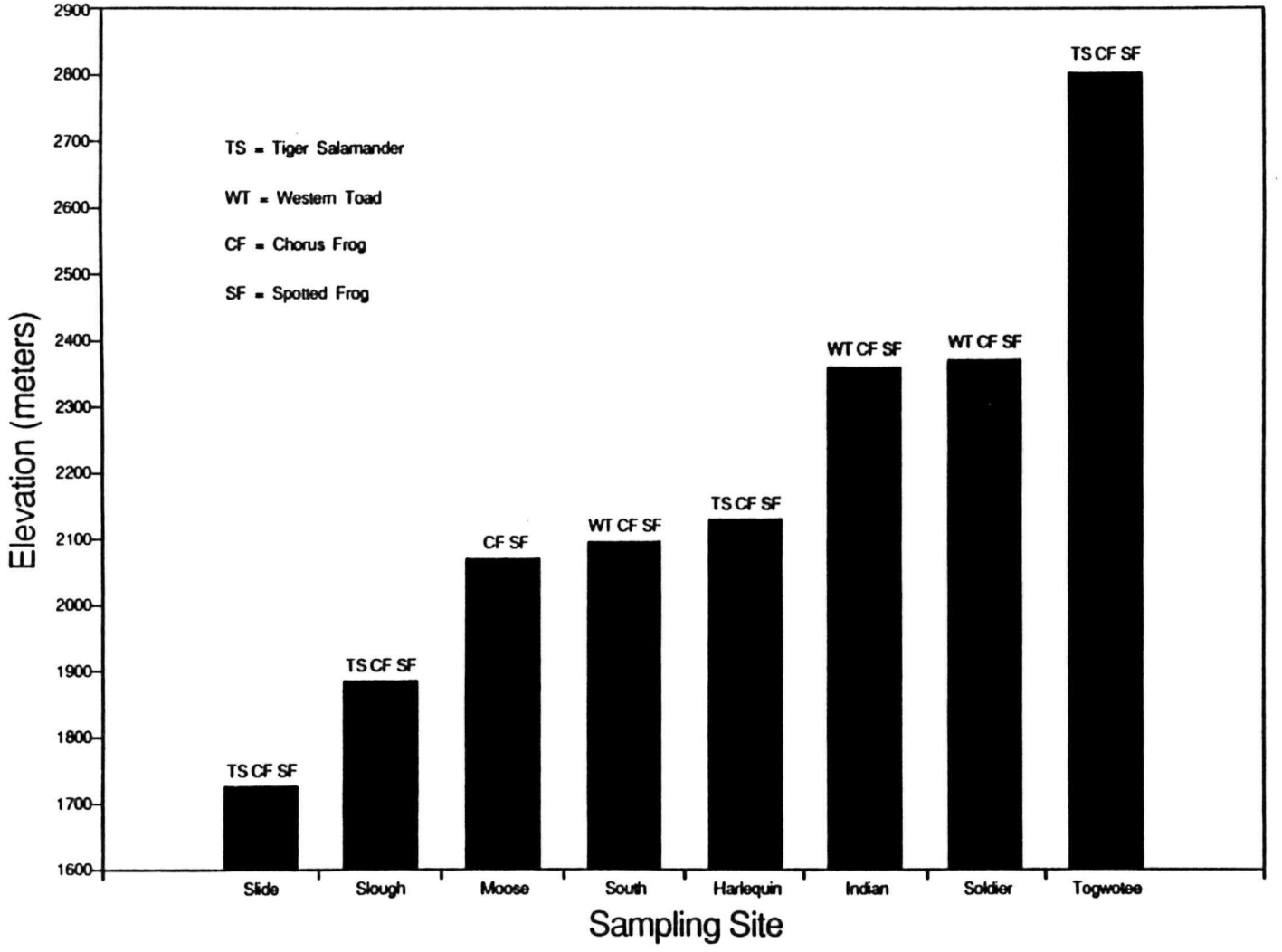
Water Temperature

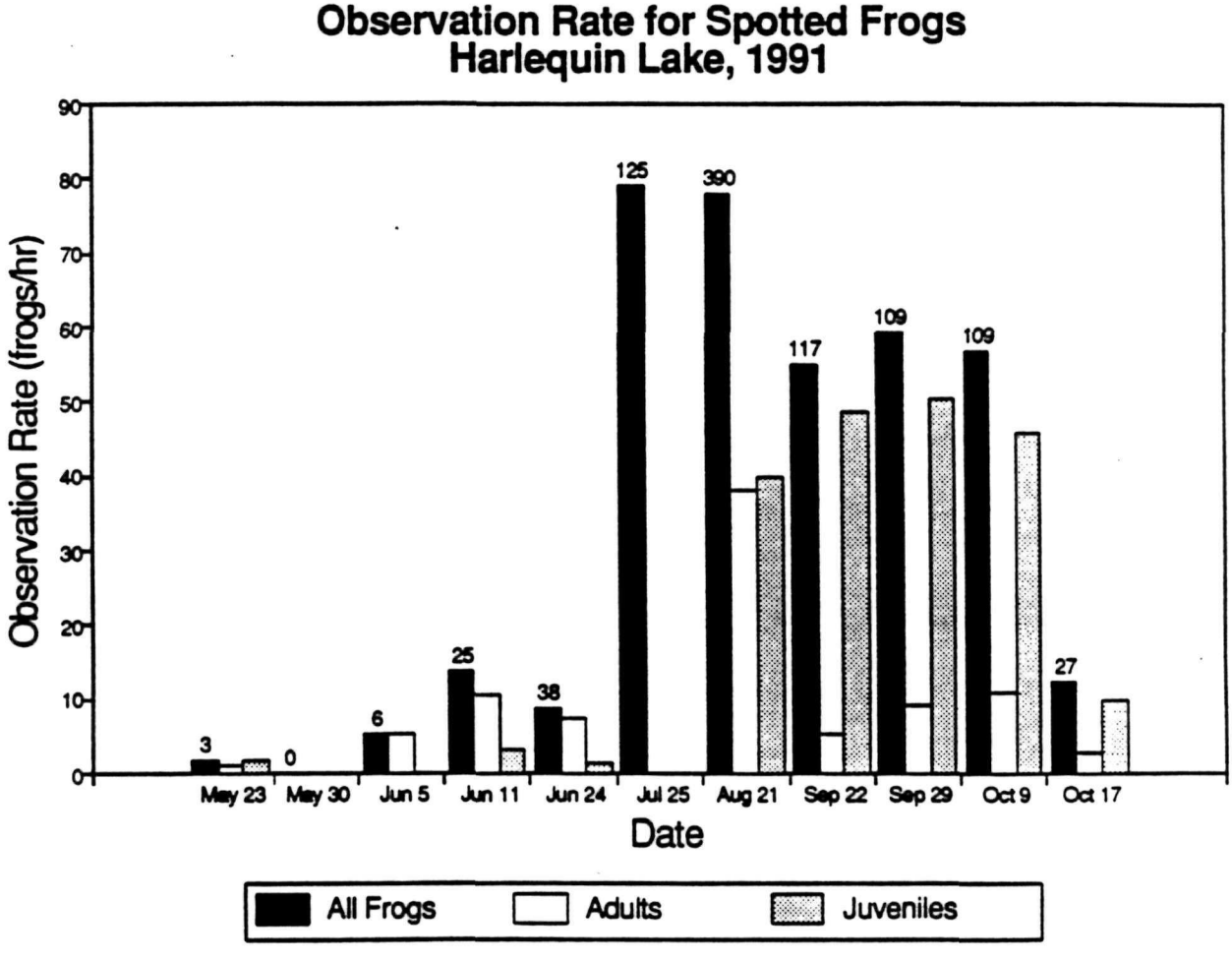






Elevations of Sampling Sites




Observation Rate for Spotted Frogs
Harlequin Lake, 1991
Observation Rate (frogs/hr)
90
80
70
60
50
40
30
20
10
0
3
0
6
25
38
125
390
117
109
109
27
May 23
May 30
Jun 5
Jun 11
Jun 24
Jul 25
Aug 21
Sep 22
Sep 29
Oct 9
Oct 17
Date
All Frogs
Adults
Juveniles