Riparian Aquatic Species Inventory
Pinnacles National Monument
2001-2005

(Sensitive Species Information Omitted)

Updated Report
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EXECUTIVE SUMMARY

The waters of Pinnacles National Monument were surveyed for an inventory of riparian aquatic vertebrate and invertebrate species in 2001-2005. Additional observations in 2006-7 have been incorporated in this updated report. Vertebrate surveys consisted of walking all stretches of appreciable streams and recording observations of fish, aquatic amphibians, and reptiles. Invertebrates were sampled using the California Rapid Bioassessment Protocol, kick nets, dip nets, aerial sweep nets, and black light traps. Invertebrate survey sites were selected to represent the range of riparian aquatic habitats found at Pinnacles. Species of concern include California red-legged frog (*Rana draytonii*), Western spadefoot (*Spea* hammondii), Southern Pacific pond turtle (*Clemmys marmorata pallida*), Pinnacles riffle beetle (*Optioservus canus*), and the exotic mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*) and bullfrog (*Rana catesbeiana*). The latter two species were successfully eradicated. For the Federally Threatened California red-legged frog, detailed habitat use and life history information was recorded. A total of twelve aquatic vertebrate species were recorded in the Monument, consisting of three fish, five amphibians, and four reptiles. A total of 250 aquatic macroinvertebrate taxa were collected and identified. This project more than doubled the number of dragonflies and damselflies known to occur in San Benito County, from 15 to 40. At least one aquatic macroinvertebrate species new to science was discovered, and several groups were found to be unusually diverse and/or abundant.

INTRODUCTION

Pinnacles National Monument is located in San Benito and Monterey Counties, at the southern end of the Gabilan Range in Central California's Inner Coast Ranges. It falls entirely within the Salinas River watershed. The vegetation is dominated by chaparral, with small areas of grassland, oak woodland, and riparian habitat. Although riparian habitat encompasses only a small percentage of the Pinnacles landscape, it is vital to the survival of many plant and animal species, both aquatic and terrestrial.

Because of the steep terrain of the Monument, most of the buildings, parking lots, roads, and trails are located in the flatter riparian areas. These structures, as well as bridges, culverts, and rock walls, have the potential to negatively impact natural stream processes. Furthermore, the concentration of visitor use in riparian areas increases the potential for pollution to enter the streams, and for direct visitor impacts such as road kills and trampling or collecting of aquatic wildlife and vegetation. Potential impacts on Pinnacles streams are not limited to sources within the Monument. The headwaters of most of Pinnacles' streams are located outside of the Monument's boundaries. Human activities and developments in these areas include cattle ranching, vineyards, a campground, and a reservoir which supports exotic invasive aquatic species.

Despite these factors, Pinnacles' aquatic ecosystems appear to be relatively healthy, and as such they may be useful as a baseline for comparison with other similar areas. The majority of Pinnacles streams are intermittent, so the fact that intermittent streams have not been examined as extensively as perennial

streams adds to the value of studying Pinnacles' aquatic ecosystems. And because aquatic organisms are excellent indicators of water quality and overall stream health, the information gathered from this study will form the baseline for future water quality and long-term stream ecosystem monitoring efforts.

Our historic knowledge of Pinnacles' fish and aquatic amphibians and reptiles is based on several resources, including a report by the Park Naturalist in the late 1950's (Wauer 1958), surveys by Morafka and Banta (1972, 1976), and NPS surveys conducted in the 1990's (Ely 1994; Johnson 1999 and 2001). These documented five fish, five amphibian, and three reptile species (Table 1). Our historic knowledge of Pinnacles' aquatic invertebrates is based mainly on limited published literature, surveys and observational reports. These sources documented 37 invertebrate species (Table 2).

Table 1. Historic records of riparian aquatic vertebrate species at Pinnacles National Monument.

Order	Scientific name	Common name	Comments	Reference
Gasterostei-formes	Gasterosteus aculeatus	threespine stickleback	native to PINN	Chandler 1954b
Gasterostei-formes	Gasterosteus aculeatus	threespine stickleback	in reservoir	Murray and Christiano 1976
Gasterostei-formes	Gasterosteus aculeatus	threespine stickleback	in reservoir, Chalone Creek	Chappell and Eimoto 1979
Perciformes	Lepomis cyanellus	green sunfish	widespread, abundant	Chappell and Eimoto 1979
Cyprinifor-mes	Pimephales promelas	fathead minnow	Chalone Creek	Chappell and Eimoto 1979
Perciformes	Archoplites interruptus	Sacramento perch	Chalone Creek, ID by Peter Moyle	Ely 1994
Cyprinodon-tiformes	Gambusia affinis	mosquitofish	abundant in S. Wilderness	Ely 1994
Anura	Bufo boreas	Western toad	Chalone Creek, rare	Banta and Morafka 1968
Anura	Hyla regilla	Pacific tree frog	widespread, abundant	Banta and Morafka 1968
Anura	Rana catesbeiana	Bullfrog	Adults and larvae common at reservoir	Wauer 1958
Anura	Rana draytonii	California red-legged frog	common at reservoir; Chalone Creek, Bear Gulch Cave	Banta and Morafka 1968
Anura	Rana draytonii	California red-legged frog	adults, tadpole in reservoir	Murray and Christiano 1976?
Anura	Rana boylii	Foothill yellow-legged frog	Present at Pinnacles as late as 1940's	Amy Lind, pers. comm.
Testudines	Clemmys marmorata pallida	Southern Pacific pond turtle	North Wilderness	Banta and Morafka 1968
Squamata	Thamnophis atratus zaxanthus	Diablo Range garter snake	Present at Pinnacles	Fitch 1940
Squamata	Thamnophis sirtalis	common garter snake	widespread, common	Banta and Morafka 1968

Table 2. Historic records of riparian aquatic invertebrate species at Pinnacles National Monument.

Order	Scientific name	Common name	Comments	Reference
Diptera	Simulium argus	black fly	Bear Creek, Chalone Creek	Coleman 1953
Diptera	Simulium piperi	black fly	Bear Gulch	Coleman 1953
Diptera	Simulium canadense	black fly	Chalone Creek	Coleman 1953
Diptera	Prosimulium dicum	black fly	Chalone Creek	Coleman 1953
Diptera	Lipoptena depressa		Chalone Creek	Coleman 1953
Hemiptera	Hebrus sobrinus			Chandler 1954b
Hemiptera	Merragata hebroides			Chandler 1954b
Hemiptera	Ambrysus californicus			Chandler 1954b
Hemiptera	Ranatra brevicollis	water scorpion		Chandler 1954b
Hemiptera	Sigara sp.			Chandler 1954b
Megaloptera	Neohermes sp.	dobsonfly		Chandler 1954b
Megaloptera	Sialis new sp.	alderfly		Chandler 1954b
Coleoptera	Peltodytes simplex			Chandler 1954b
Coleoptera	Hydroporus palliatus			Chandler 1954b
Coleoptera	Hydroporus villis			Chandler 1954b
Coleoptera	Hydroporus bidessoides			Chandler 1954b
Coleoptera	Deronectes striatellus			Chandler 1954b
Coleoptera	Agabus regularis			Chandler 1954b
Coleoptera	Agabus illybiiformis			Chandler 1954b
Coleoptera	Gyrinus plicifer	whirligig beetle		Chandler 1954b
Coleoptera	Hydraena vandykei			Chandler 1954b
Coleoptera	Limnebius piceus			Chandler 1954b
Coleoptera	Octhebius martini			Chandler 1954b
Coleoptera	Octhebius costipennis			Chandler 1954b
Coleoptera	Octhebius discretus			Chandler 1954b
Coleoptera	Tropisternus ellipticus			Chandler 1954b
Coleoptera	Anacaena signaticollis			Chandler 1954b
Coleoptera	Laccobius ellipticus			Chandler 1954b
Coleoptera	Laccobius californicus			Chandler 1954b
Coleoptera	Cymyiodyta dorsalis			Chandler 1954b
Coleoptera	Helochares normatus			Chandler 1954b
Coleoptera	Helichus productus			Chandler 1954b
Coleoptera	Helichus productus			Shepard 1990
Coleoptera	Helichus striatus			Shepard 1990
Coleoptera	Helichus suturalis			Chandler 1954b
Coleoptera	Helichus suturalis			Shepard 1990
Coleoptera	Optioservus canus	Pinnacles riffle beetle	Holotype Chalone Creek	Chandler 1954a
Coleoptera	Optioservus canus	Pinnacles riffle beetle	Chalone Creek, and elsewhere in San Benito and Monterey Co.	Shepard 1990
Coleoptera	Hydrocara lineata		Chalone Creek	De Foe 1963
Coleoptera	Eubrianax edwardsii	Water penny		Shepard 1990

The main objectives of this study were to:

- Produce a complete list and voucher collection of fish species.
- Create GIS coverages of distributions of fish and aquatic amphibian and reptile species.
- Create GIS coverages of California red-legged frog distribution by each life cycle component (eggs, tadpoles, and adults).
- Describe habitat preferences of the California red-legged frog.
- Produce a species list and voucher collection of aquatic invertebrates.
- Determine aquatic invertebrate community composition in relation to water quality conditions.
- Determine status and distribution of the endemic Pinnacles riffle beetle.

METHODS

--Vertebrates

Non-time-constrained visual encounter surveys for vertebrates (Ely 1994, Heyer et al. 1994) were conducted in stretches of stream with enough water to support amphibian breeding. Surveyors walked in or beside the stream, recording all reptile, amphibian, and fish species encountered. Surveyors gauged their effort level to find every species present, but not every individual present. In general, surveyors walked slowly enough to allow them to determine the numbers of individuals readily seen. A dip net was used to flush animals, and to sample a portion of areas not readily visible, such as beneath undercut banks or floating vegetation. An attempt was made to minimize habitat disturbance while walking and while flushing animals from within or beside the stream. If a section was completely covered with floating vegetation, a window was cleared in the vegetation and then an attempt was made to flush animals into view from obscured areas.

The primary goal was to establish presence/absence of species and their reproduction in reaches of creek. Information was also collected on numbers and life stages present. Only the number of individuals actually observed was recorded, along with proportions in each size/age class. Tadpoles and fish were generally too numerous to count individually, so numbers of these were estimated when necessary. However, total numbers were never inferred from a subsample observed. If it seemed that many more were present, surveyors continued surveying the area to get a better idea of what was there. If a section was too difficult to survey sufficiently, or if doing so would have significantly disturbed habitat, it was noted that many more were suspected to be present.

While walking along the creek, surveyors scanned from their feet to as far ahead as they could see. When they approached habitat that appeared to be prime for California red-legged frog or Southern Pacific pond turtle, they used binoculars to scan the area before approaching it. They also listened for the sounds of animals jumping into the creek, and identified them whenever possible. They did not make an effort to look for animals more than one meter away from the edges of the creek, but when their movement alerted the surveyor to their presence, they were recorded. For most species, observations were summarized for each

stream reach, following the morphological stream reach definitions created by Chad Moore, Park Physical Scientist. For the Southern Pacific pond turtle and the California red-legged frog, locations were recorded with a GPS unit.

Fish, amphibians, and lizards were generally not captured. Turtles and snakes were captured when possible for identification and measurement.

--Invertebrates

Aquatic macroinvertebrates were sampled using a variety of methods. The majority of samples were collected with a combination of techniques designed to sample all major microhabitats at each site. These sites were selected to represent the range of riparian aquatic habitats found at Pinnacles (Fig. 1). Kick nets were used to sample the substrate. Dip nets were used to sample within the water column, in aquatic vegetation, beneath undercut banks, and on the water surface. Forceps and aspirators were used to sample shorelines. At each site, invertebrates were placed into a flat, white plastic pan as they were collected. Sites were sampled until no obviously new morphospecies were collected. Because the primary limiting factor here was the cost of professional processing and identification of specimens, the contents of the pan were picked through to remove large debris and excessive multiples of the same morphospecies. Morphospecies in the pan believed to be present in other samples were also removed. The final sample containing several specimens of each morphospecies was then placed into a Whirlpak bag with 95% ethanol. The amount of water contained in the sample was enough to bring the alcohol concentration in the bag down to approximately 70%. These samples (64) were sent to Robert Wisseman at Aquatic Biology Associates, Inc. for identification, with the exception of a set of samples (18) collected in Summer, 2003 that were sent to Jon Lee. Robert Wisseman subsequently sent selected taxa to specialists for further identification. A complete list of taxonomists and the taxa they identified is presented in Appendix 1.

Another set of samples (39) was collected with kick nets following the California Rapid Bioassessment Protocol (RBP). The RBP applies only to riffles in the spring/summer of the year, and samples were not necessarily analyzed to inventory every species contained in them. However, they still provide valuable species presence and distribution data. RBP samples were preserved in ethyl alcohol and sent to Jon Lee for identification.

Aerial nets were used to collect winged adults of aquatic invertebrates, mainly dragonflies and damselflies (Odonates), at 41 sampling sites/dates. These were collected during trips targeted at specific times and habitats, as well as opportunistically while performing other tasks in the field. A few Odonates were also collected after they emerged as adults in pens used for rearing California red-legged frogs. Odonates were either pinned, or they were dried in acetone and placed in plastic envelopes with index cards. Odonates were sent to Andy Rehn for identification, except for *Tramea onusta* and *Libellula forensis* (photo) and *Libellula luctuosa* (sighting). Winged adults in other groups were either pinned or placed in 70% ethyl alcohol and sent to Robert Wisseman.

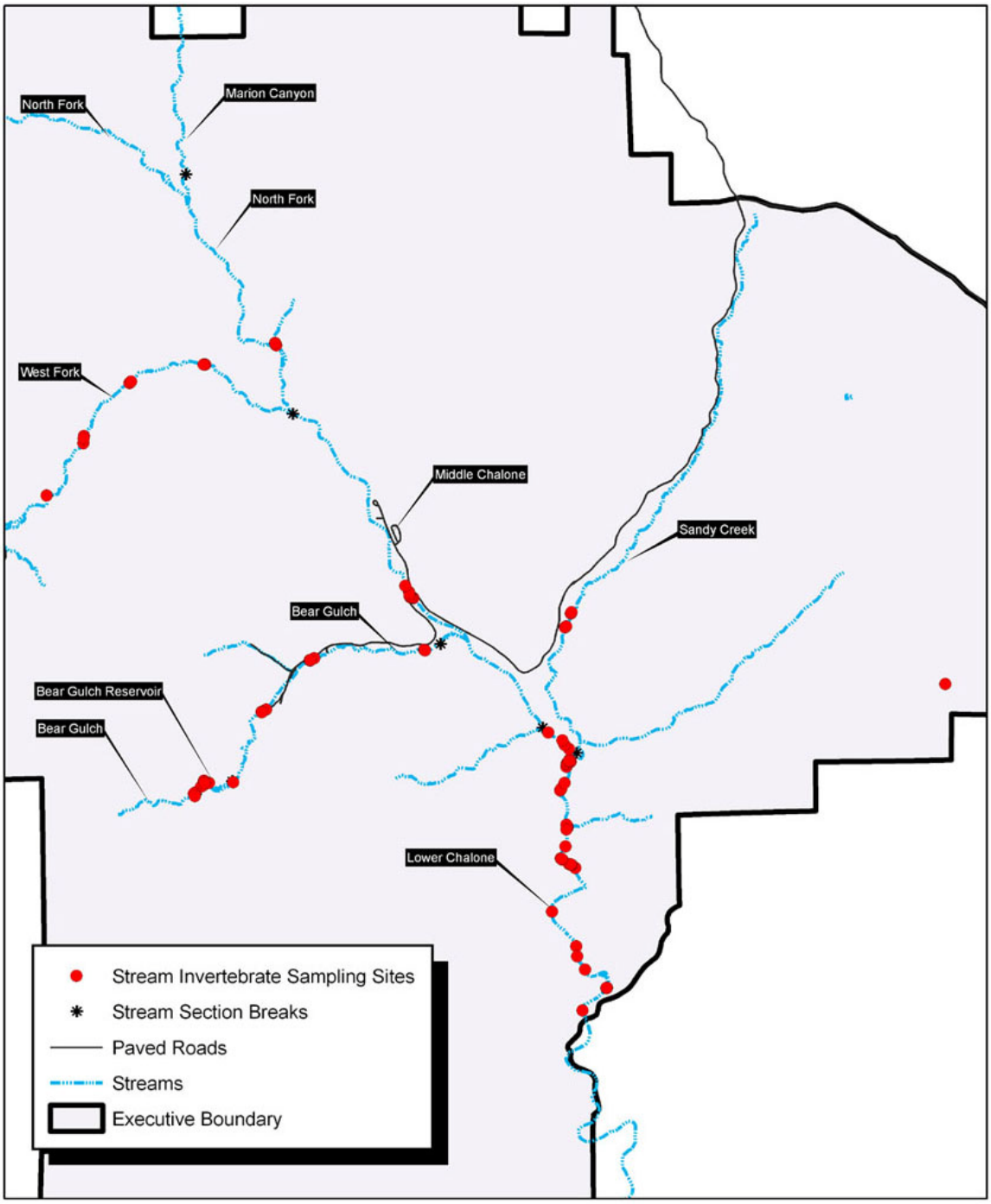

Fig. 1. Pinnacles National Monument aquatic invertebrate sampling sites (not including black light trap or aerial sampling sites) 2001-2004.

On the suggestion of Robert Wisseman, black light traps (Bioquip Products, catalog #2851) were also used to collect winged adults, especially caddisflies. A few winged adults were also collected at lights at buildings at Park Headquarters. Due to the abundance of insects in these samples, a subset of 32 samples were processed. These specimens were sent to Robert Wisseman and Steven Harris

for identification. Most of the specimens were preserved in ethyl alcohol, and a few were pinned.

RESULTS AND DISCUSSION

Vertebrates.--A total of twelve riparian aquatic vertebrate species were recorded in the Monument, consisting of three fish, five amphibians, and four reptiles (Table 3). Three of these species (Western toad, Western spadefoot, and Southern Pacific pond turtle) were not observed during stream surveys, but were observed at other times during the study period. Two exotic species (green sunfish and bullfrog) were observed in 2006 in Sandy Creek, and immediately eradicated. Western terrestrial gartersnakes were observed in 2006-7, although they had not been recorded historically. Additionally, several non-target riparian-inhabiting species were observed (Table 4). Table 5 summarizes vertebrate survey results by location.

Table 3. Riparian aquatic vertebrate species observed at Pinnacles National Monument historically and during 2001-2007. "()" indicates extirpated species.

Common Name	Scientific Name	Historic	Current
threespine stickleback	*Gasterosteus aculeatus*	X	X
green sunfish	*Lepomis cyanellus*	X	()
fathead minnow	*Pimephales promelas*	X	
Sacramento perch	*Archoplites interruptus*	X	
mosquitofish	*Gambusia affinis*	X	X
Foothill yellow-legged frog	*Rana boylii*	X	
bullfrog	*Rana catesbeiana*	X	()
California red-legged frog	*Rana draytonii*	X	X
Pacific tree frog	*Hyla regilla*	X	X
Western toad	*Bufo boreas*	X	X
Western spadefoot	*Spea hammondii*	X	X
Southern Pacific pond turtle	*Clemmys marmorata*	X	X
common garter snake	*Thamnophis sirtalis*	X	X
Diablo Range garter snake	*Thamnophis atratus zaxanthus*	X	X
Western terrestrial gartersnake	*Thamnophis elegans*	?	X

Table 4. Non-target vertebrate species observed at Pinnacles National Monument, 2001-2002.

Common name	Scientific name
common kingsnake	*Lampropeltis getula*
southern alligator lizard	*Elgaria multicarinata*
western whiptail lizard	*Cnemidophorus tigris*
mallard	*Anas platyrhynchos*
killdeer	*Charidrius vociferus*
green heron	*Butorides virescens*
common snipe	*Gallinago gallinago*
greater yellowlegs	*Tringa melanoleuca*
belted kingfisher	*Ceryle alcyon*
yellow-breasted chat	*Icteria virens*

Table 5. Summary of results of 2001-2002 aquatic vertebrate surveys. Values represent the sum per stream section of the highest number of individuals observed in each reach on any survey for each life stage of each species. Values do not include incidental observations, or observations made at the Bear Gulch Reservoir. Stream section names refer to Fig. 2.

		Stream Section						
Common Name	Life Stage	Lower Chalone	Middle Chalone	North Fork	West Fork	Bear Gulch	Sandy Creek	Marion Canyon
Threespine stickleback		12910	7000	490		1420	210	
Mosquitofish		13257						
Pacific tree frog	Egg							
	Tadpole	694	555	123	410	140	22	330
	Metamorph	7		2	3			
	Juvenile	1						
	Adult							
California red-legged frog	Egg							
	Tadpole		(total=64)					
	Metamorph		(total=4)					
	Juvenile		(total=10)					
	Adult		(total=15)					
	Undetermined		(total=8)					
Common gartersnake		12	5	2		2		2
Diablo Range gartersnake		1						
Unidentified gartersnake		2	1	1		1		

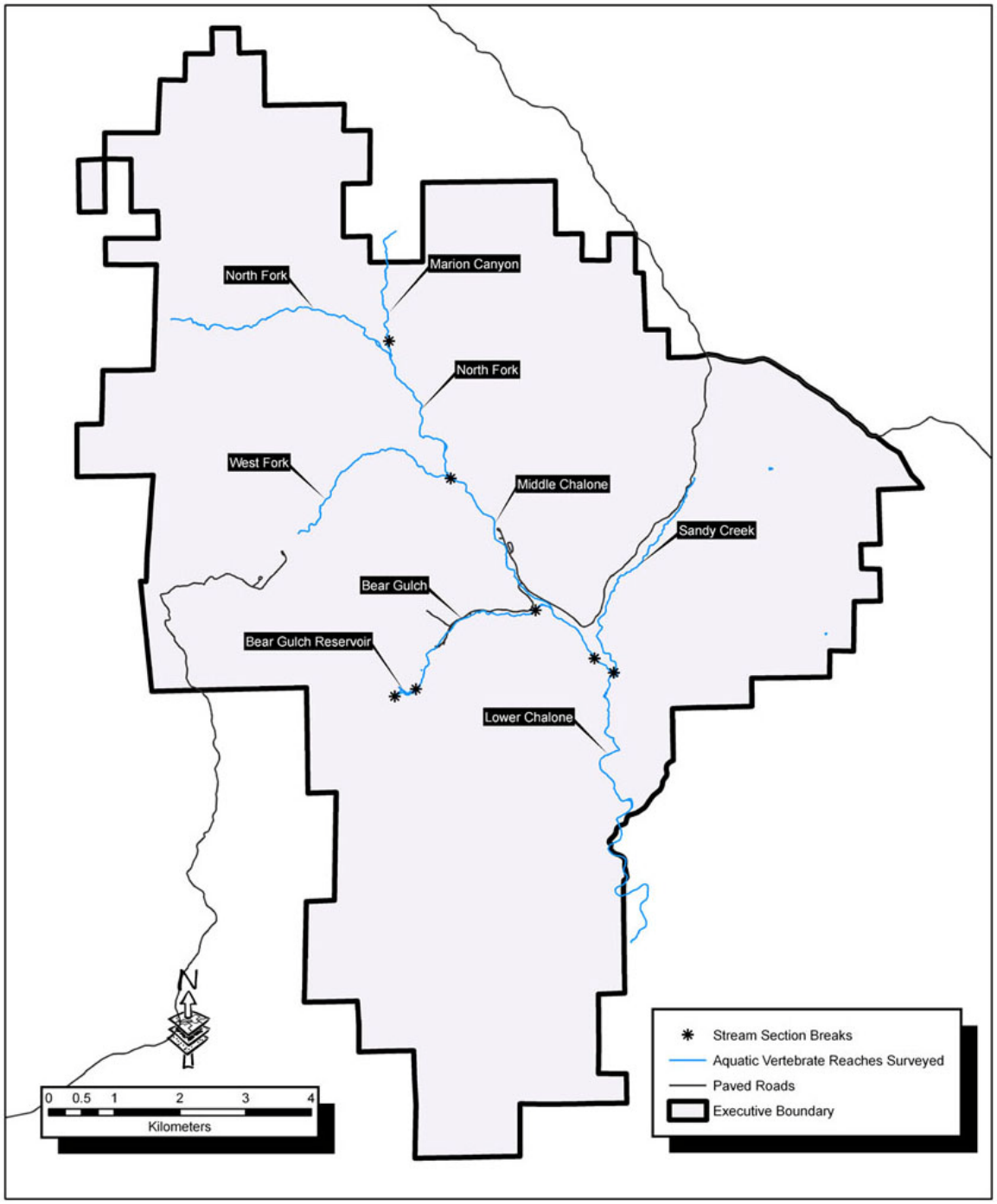

Fig. 2. Map of Pinnacles National Monument showing coverage of 2001-2002 aquatic vertebrate surveys. Stream section definitions are those used in Table 5.

Threespine sticklebacks (Fig. 3) and the invasive exotic mosquitofish (Fig. 4) were abundant in lower Chalone Creek. Threespine sticklebacks were common to uncommon in spotty locations in Bear Gulch and middle Chalone Creek. A yearly pattern was observed in which mosquitofish were present in spring in relatively small numbers in lower Chalone Creek, and by fall their numbers had increased and they had worked their way upstream.

An infestation of more than 3600 invasive exotic green sunfish was eradicated from the Monument in 1998-1999 (Johnson 1999). This species appeared in a single pool in Sandy Creek following flooding in 2006. They were eradicated.

No other fish species were observed, so fathead minnow and Sacramento perch were presumably extirpated naturally.

Foothill yellow-legged frogs were present in the Monument up until at least the 1940's. The cause of their extirpation is unknown. Suitable habitat appears to be present, and other anuran species appear to be doing well in the streams. A re-introduction project is scheduled to begin in 2005.

Bullfrogs were reportedly reproducing in the reservoir in the 1950's, but no longer exist there. While it is possible that this species was extirpated naturally, the fact that it is very difficult to eradicate makes this unlikely. It is possible that the 1950's observations may have actually been of large California red-legged frogs. Along with the green sunfish mentioned previously, in 2006 several bullfrog tadpoles were observed in Sandy Creek approximately 1.5 km downstream of Highway 25. An attempt was made to remove all the tadpoles present. On a subsequent visit the pool was dry.

California red-legged frog reproduction was documented and locations of all life stages were recorded. Populations were concentrated in the Bear Gulch Reservoir (as a result of re-establishment efforts) and in several kilometers of streams. Breeding most often occurred in slower, deeper stream sections, ranging in maximum depth from 0.2-0.75m, with an average depth of 0.45m. However, the eggs were laid near the stream margin where the average depth was approximately 0.2m. One egg mass was laid in such fast-flowing water that the current washed most of the eggs away before they hatched, and two were laid in pools that dried up before the tadpoles metamorphosed. Curiously, calmer, deeper pools often occur in the general vicinity of the breeding sites, but are not used.

The breeding period appeared to last less than a month each year. The one egg mass for which exact oviposition and hatching dates are known took 11 days to hatch. Egg masses contained approximately 500-2000 eggs, and were often laid near each other in the same pool. On several occasions one egg mass was laid directly on top of another. In some cases it was observed that egg masses laid later were significantly smaller than those laid earlier at the same site, suggesting that females may have laid a second mass. Egg masses were usually within 0.1m of the water surface, and sometimes enough of the surface of the mass

was exposed to the air that some of the eggs desiccated and died. Although many egg masses had up to nearly 100% hatching success, some inexplicably had a near 100% failure rate.

In summer, adult red-legged frogs tended to be found near deep stream pools, although they were occasionally found along shallow sections. They were often observed on a sunny spot of shoreline within one jump of the water. They tended to also be found near some sort of vegetative cover such as a willow thicket, blackberry tangle, or root wad. One was observed tucked in a recess in the bank below a culvert, and another under a large root. Young frogs tended to inhabit similar areas, although they rarely co-occurred with adults. In the fall, newly metamorphosed frogs were found in various types of stream habitat, presumably as they were dispersing away from their transformation site.

A California red-legged frog tadpole was observed being taken by either a belostomatid bug or dytiscid beetle. In 2006, while setting up bat monitoring equipment at the reservoir, Paul Heady observed a belted kingfisher with a California red-legged frog in its mouth. Also at the reservoir the same year, the author photographed a gartersnake in the last stages of swallowing a young California red-legged frog. Two observations of failed predation attempts by red-legged frogs were recorded. In the Bear Gulch Reservoir a frog swam up below a common garter snake, grabbed the snake in its mouth, and the two struggled until the snake escaped. In Sandy Creek a large frog jumped out from below a root and just missed a large Pacific spiketail dragonfly in mid-air as she was dipping up and down laying eggs in the stream bottom.

Pacific tree frogs were common throughout riparian areas of the park, with breeding abundant, widespread, and prolonged throughout much of the spring and summer (Fig. 7).

Western toads were not observed during surveys. Although 2001 and 2002 were only slightly drier than average, winter and spring weather patterns resulted in streams drying up at least a month ahead of the times they did in 1998-2000. The slow, shallow sections of Middle Chalone Creek and the North Fork where Western toads often breed were dry by the time of the spring surveys. However, Western toad reproduction was documented in 2001 prior to surveys in middle Chalone Creek and in a stock pond on the privately owned Pinnacles Ranch adjacent to the Monument. Estimated oviposition dates were 1 April and 10 March, respectively. Adults were seen opportunistically throughout the Monument, sometimes more than a kilometer from riparian areas.

Spadefoot toad reproduction was documented in a roadside puddle within the congressional boundary of the Monument, but on land which is currently privately owned (junction of Highway 25 and 146). This species breeds commonly within several miles of the Monument, and likely strays regularly within the boundary. Small seasonal ponds on the east and west sides of the Monument may serve as occasional breeding sites, although this has not been documented.

Like Western spadefoots, California tiger salamanders breed near the Monument, may stray within the boundary, and may even breed occasionally in temporary ponds. But their presence in the Monument has not been confirmed.

Southern Pacific pond turtles were not encountered on surveys. However, they were occasionally encountered opportunistically, always in areas with deep and/or year-round water.

One juvenile and two adult Diablo Range gartersnakes were seen in April and May in lower Chalone Creek. One of the adults was feeding on a large, flat, stiff, rubbery invertebrate egg mass. This species has only been found near perennial water (Fig. 8).

Common gartersnakes, as their name suggests, were commonly found in riparian areas, especially in combination with Pacific tree frog tadpoles. They were widespread throughout riparian areas, and likely range away from water (Fig. 8).

Western terrestrial gartersnakes superficially resemble common gartersnakes. Both have red blotches on the sides and yellow stripes on a black background. Due to the possibility of confusing these species, and the fact that published range maps suggest the Western terrestrial gartersnake might be found at Pinnacles even though it had not been recorded historically, the author captured every gartersnake he could for the first several years of this study. He finally convinced himself that only the common gartersnake was present. Then in 2006 he began observing Western terrestrial gartersnakes in the Monument. This situation requires further study.

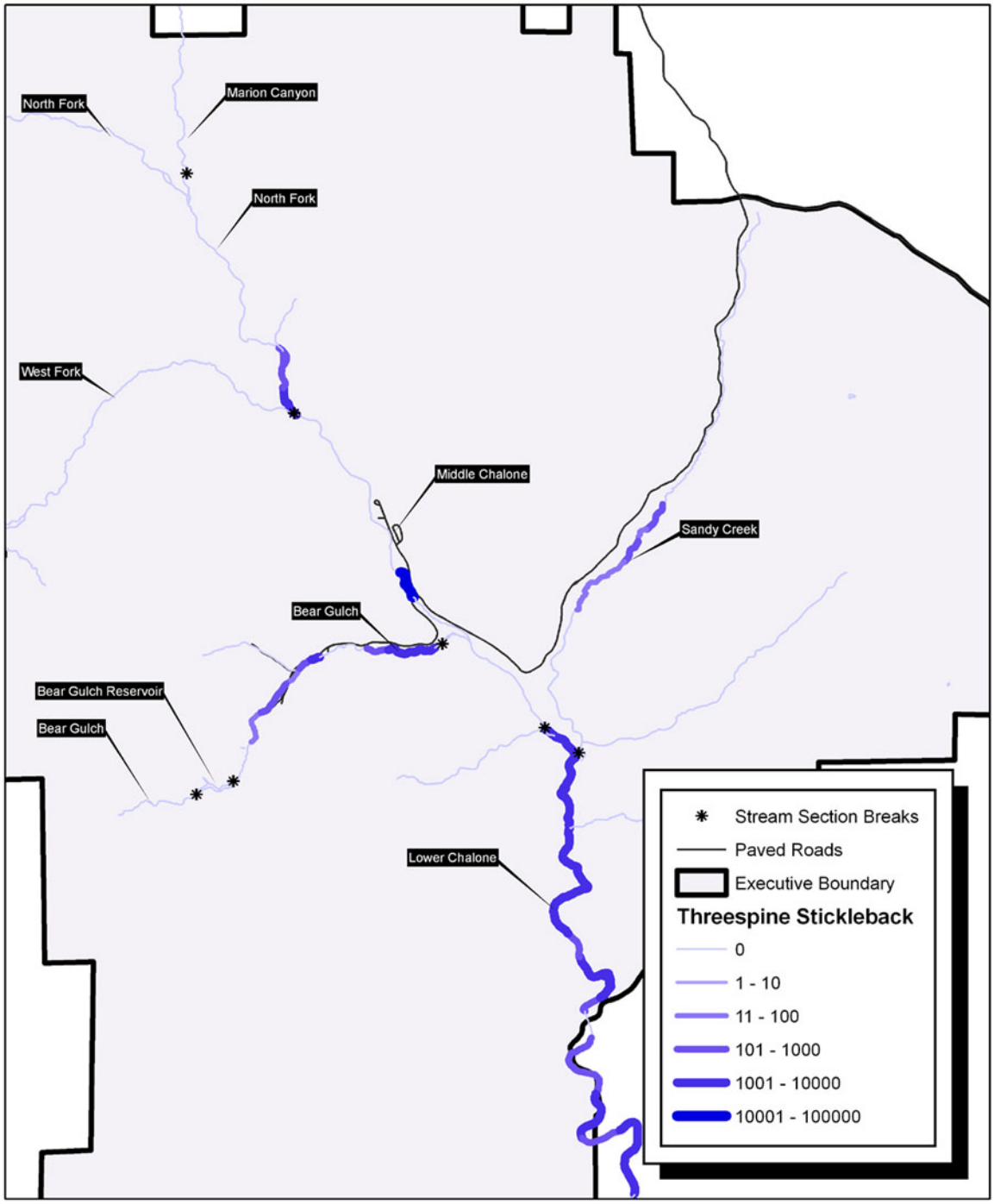

Fig. 3. Presence and abundance of threespine stickleback during stream surveys at Pinnacles National Monument, 2001-2002. Values for each stream reach represent the highest number of individuals observed on any survey, expressed in terms of number observed per kilometer.

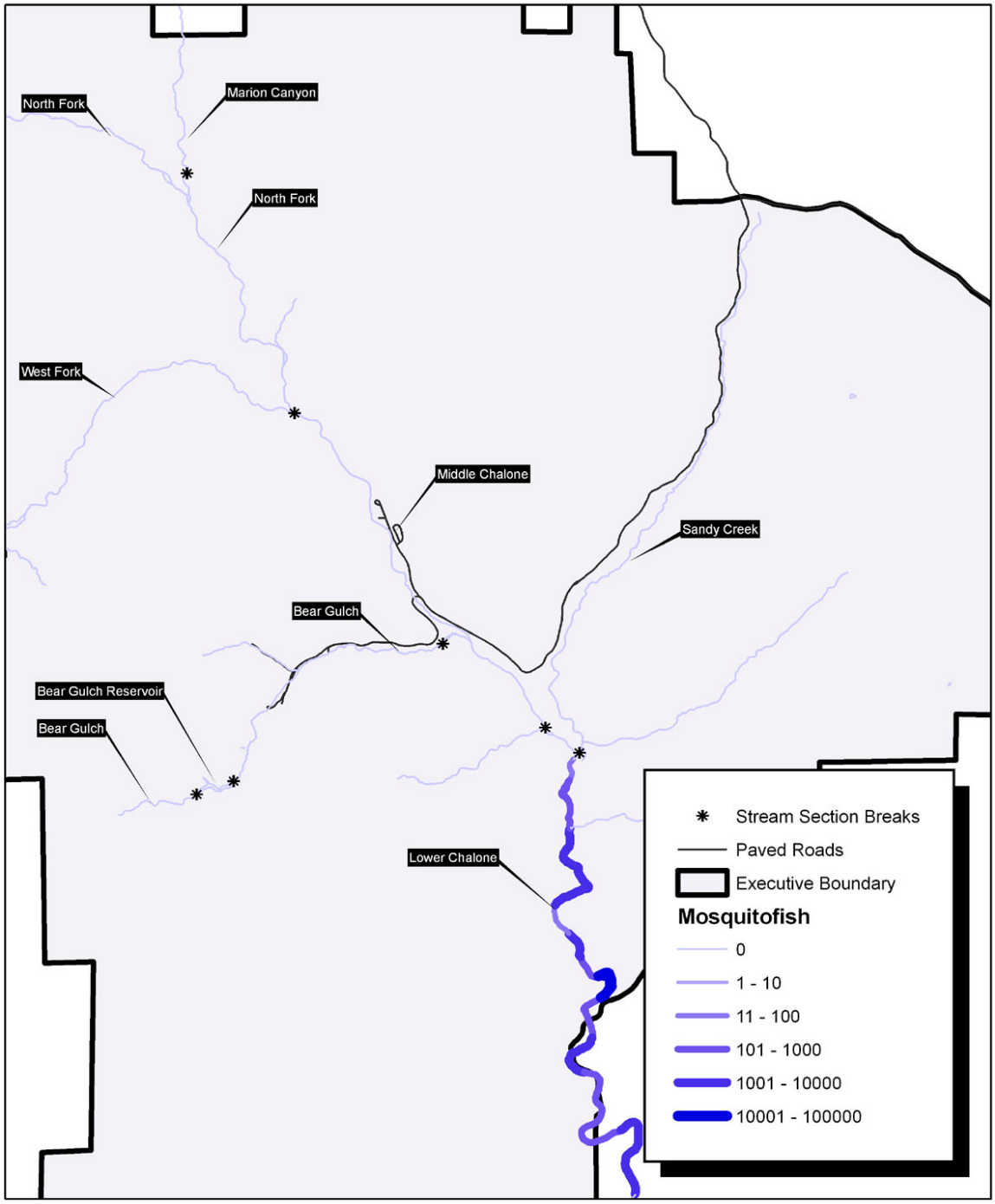

Fig. 4. Presence and abundance of mosquitofish during stream surveys at Pinnacles National Monument, 2001-2002. Values for each stream reach represent the highest number of individuals observed on any survey, expressed in terms of number per kilometer.

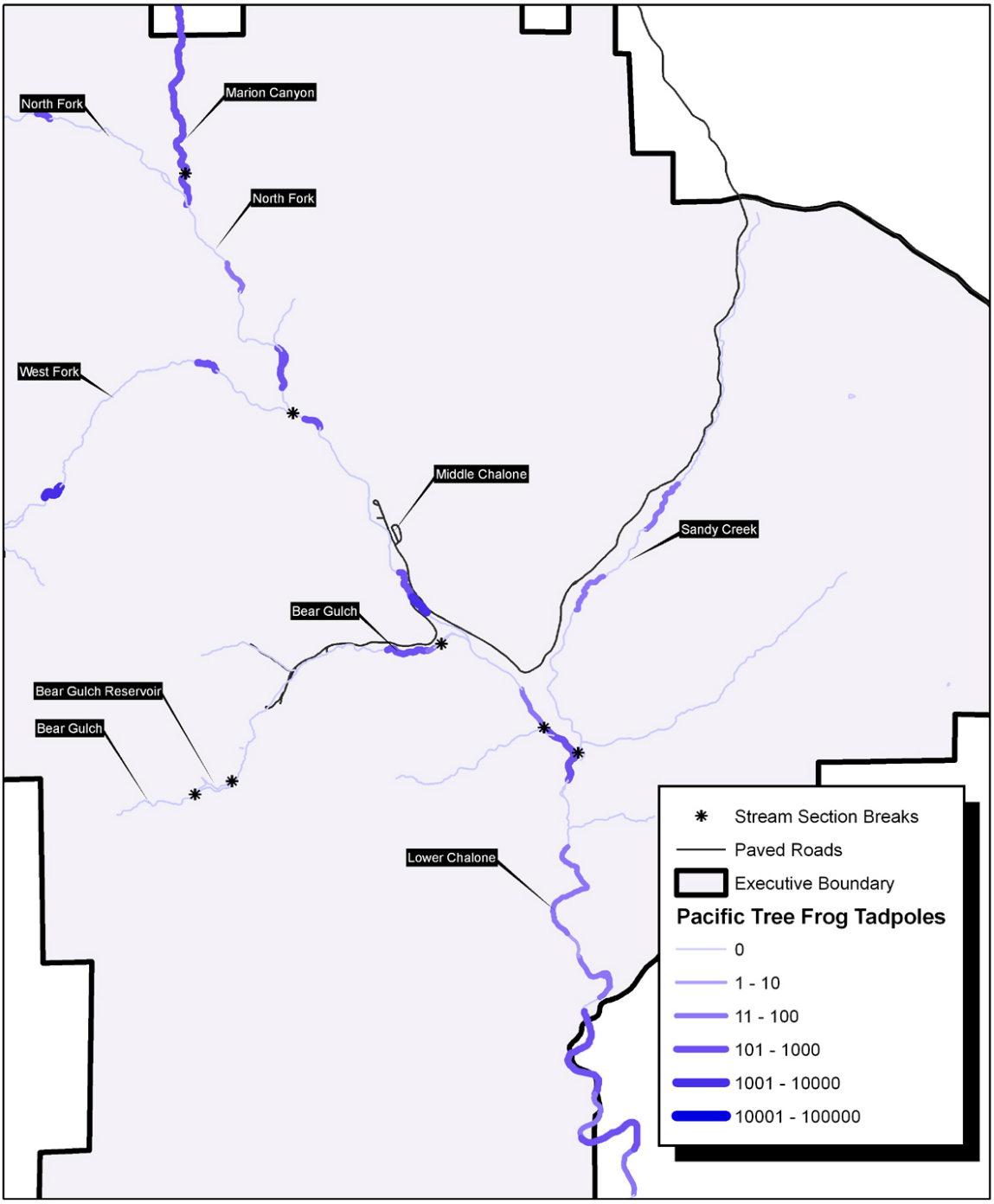

Fig. 7. Presence and abundance of Pacific tree frog tadpoles during stream surveys at Pinnacles National Monument, 2001-2002. Values for each stream reach represent the highest number of individuals observed on any survey, expressed in terms of number per kilometer. Note that because Marion Canyon was not divided into reaches, it appears as though this species was found along more of this section than it actually was.

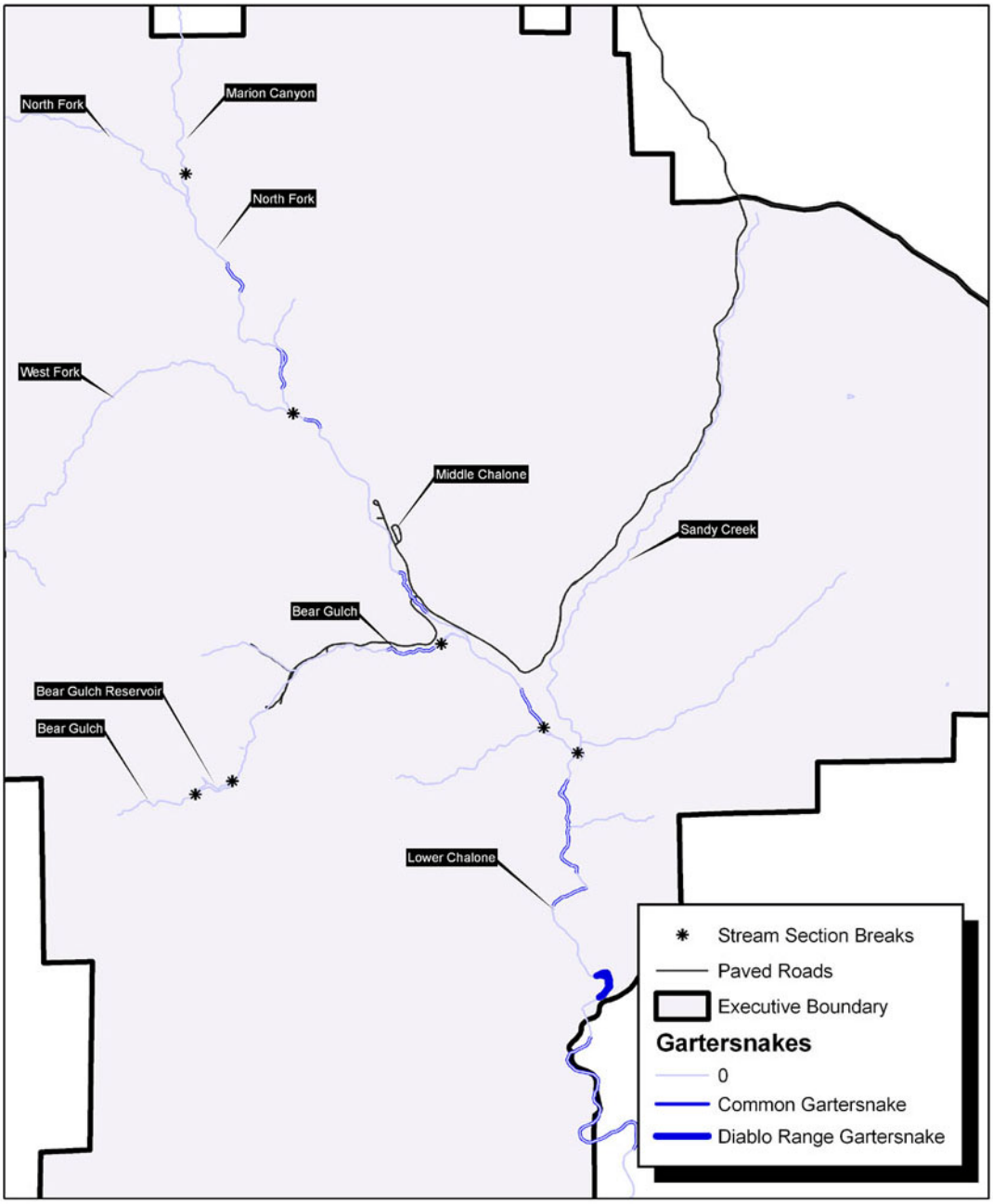

Fig. 8. Presence of common gartersnake and Diablo Range gartersnake during stream surveys at Pinnacles National Monument, 2001-2002.

Invertebrates.--In contrast to vertebrates, which are fairly easily identified with the help of commonly available field guides, many invertebrates can be identified to species by only a handful of specialists, and still others currently cannot be identified at all. In spite of the fact that the Pinnacles specimens were sent to 11 different specialists, many remain unidentified. Nevertheless, 201 insect and 49 non-insect taxa were identified, for a total of 250 aquatic macroinvertebrate taxa. Most of these were identified to the species level, and some which were not could be identified further with more funding. Findings are summarized in Tables 6 and 7, and a complete list is presented in Appendices 2 and 3.

Table 6. Summary of aquatic non-insect macroinvertebrate taxa collected at Pinnacles National Monument, 2001-2004. Numbers are minimum values.

Common Name	**Phylum**	**#Classes**	**#Orders**	**#Families**	**#Genera**	**#Species**
hydras	Hydrozoa	1	1	1	1	1
flat worms	Platyhelminthes	1	1	1	1	1
ribbon worms	Nemertea	1	1	1	1	1
round worms	Nematoda	1	1	1	1	1
horse hair worms	Nematomorpha	1	1	1	1	1
segmented worms	Annelida	2	8	9	15	22
molluscs	Mollusca	2	2	5	7	8
crustaceans/arachnids	Arthropoda	3	4	12	13	14
Total	**8**	**12**	**19**	**31**	**40**	**49**

Table 7. Summary of aquatic insect taxa collected at Pinnacles National Monument, 2001-2004. Numbers are minimum values.

Common Name	**Order**	**# Families**	**# Genera**	**# Species**
Mayflies	Ephemeroptera	5	8	8
Dragonflies and Damselflies	Odonata	7	22	40
Grasshoppers and Crickets	Orthoptera	2	2	2
Stoneflies	Plecoptera	5	8	8
True Bugs	Hemiptera	11	19	19
Alderflies and Dobsonflies	Megaloptera	2	2	2
Caddisflies	Trichoptera	11	20	27
Beetles	Coleoptera	8	22	24
True Flies	Diptera	14	67	71
Total	**9**	**65**	**170**	**201**

Odonates (dragonflies and damselflies) are the charismatic megafauna of the aquatic invertebrates. The existence of internet web sites and popular field guides for Odonates makes them ideal for interpreting riparian aquatic macroinvertebrates to the public. A web page describing the Odonata of Pinnacles, including a checklist, has been posted on the Pinnacles website.

For the aforementioned reasons, considerable effort was put into netting adult Odonates. In addition to forays targeting specific habitats and species, a net and binoculars were carried during most of the time spent in the field. Although it is

impossible to calculate the amount of extra effort, it surely amounts to hundreds of hours. This resulted in a list of 40 species of Odonates (Table 8).

Odonate larvae were sampled at the same effort level as other aquatic taxa. Thus, comparing the number of Odonate species detected as larvae and as adults allows for an estimate of the completeness of the invertebrate inventory. Only 12 Odonate species were found by aquatic sampling, while all 40 were found by aerial (including photo/visual) sampling (Table 8). Even considering that some Odonate species may be present only as stray adults (no aquatic stages present), and that other taxa may be more easily detected by aquatic sampling, this suggests that the aquatic macroinvertebrate inventory may be less than 50% complete.

Table 8. Dragonflies and Damselflies of Pinnacles National Monument, based on surveys in 2001-2005, with method of collection.

Family	Scientific Name	Common Name	Aquatic	Aerial	Photo/ Visual
Calopterygidae	*Hetaerina americana*	American Ruby-Spot	X	X	
Coenagrionidae	*Argia agrioides*	California Dancer		X	
Coenagrionidae	*Argia lugens*	Sooty Dancer		X	
Coenagrionidae	*Argia nahuana*	Aztec Dancer		X	
Coenagrionidae	*Argia vivida*	Vivid Dancer		X	
Coenagrionidae	*Enallagma carunculatum*	Tule Bluet		X	
Coenagrionidae	*Enallagma civile*	Familiar Bluet		X	
Coenagrionidae	*Enallagma cyathigerum*	Northern Bluet		X	
Coenagrionidae	*Enallagma praevarum*	Arroyo Bluet		X	
Coenagrionidae	*Ischnura cervula*	Pacific Forktail		X	
Coenagrionidae	*Ischnura denticollis*	Black-fronted Forktail		X	
Coenagrionidae	*Ischnura perparva*	Western Forktail		X	
Coenagrionidae	*Telebasis salva*	Desert Firetail		X	
Lestidae	*Archilestes californica*	California Spreadwing	X	X	
Lestidae	*Lestes congener*	Spotted Spreadwing		X	
Lestidae	*Lestes stultus*	Black Spreadwing		X	
Aeshnidae	*Aeshna californica*	California Darner		X	
Aeshnidae	*Aeshna multicolor*	Blue-Eyed Darner		X	
Aeshnidae	*Aeshna walkeri*	Walker's Darner	X	X	
Aeshnidae	*Anax junius*	Common Green Darner	X	X	
Aeshnidae	*Anax walsinghami*	Giant Darner		X	
Cordulegastridae	*Cordulegaster dorsalis*	Pacific Spiketail	X	X	
Gomphidae	*Erpetogomphus compositus*	White-Belted Ringtail	X	X	
Gomphidae	*Octogomphus specularis*	Grappletail	X	X	
Gomphidae	*Progomphus borealis*	Gray Sanddragon	X	X	
Libellulidae	*Libellula forensis*	Eight-spotted Skimmer			X
Libellulidae	*Libellula luctuosa*	Widow Skimmer			X
Libellulidae	*Libellula saturata*	Flame Skimmer	X	X	
Libellulidae	*Paltothemis lineatipes*	Red Rock Skimmer	X	X	
Libellulidae	*Plathemis lydia*	Common Whitetail	X	X	
Libellulidae	*Sympetrum corruptum*	Variegated Meadowhawk		X	
Libellulidae	*Sympetrum illotum*	Cardinal Meadowhawk	X	X	
Libellulidae	*Sympetrum pallipes*	Striped Meadowhawk		X	
Libellulidae	*Pachydiplax longipennis*	Blue Dasher		X	
Libellulidae	*Erythemis collocata*	Western Pondhawk		X	
Libellulidae	*Pantala flavescens*	Wandering Glider		X	
Libellulidae	*Pantala hymenaea*	Spot-Winged Glider		X	
Libellulidae	*Tramea lacerata*	Black Saddlebags		X	
Libellulidae	*Tramea onusta*	Red Saddlebags			X
Libellulidae	*Brechmorhoga mendax*	Pale-Faced Clubskimmer		X	

Another taxon for which additional effort was put toward sampling non-aquatic stages is the Trichoptera (caddisflies). Black light traps were used to sample Trichoptera (as well as moths for a separate moth inventory). Of the 160 samples, many collected more than 100 m from water, at least 32 contained Trichoptera. A total of 29 species were detected using this method. Unfortunately, because aquatic stages of Trichoptera could not be identified to species level, no estimate of completeness can be made by comparing the number of species detected by aquatic *vs.* black light sampling.

Dave Ruiter commented on two findings related to the Pinnacles caddisfly fauna involving the genus *Hydropsyche*. Several members of this genus were found in close proximity to each other. Generally, closely related species are so similar that they do not occupy the same habitat. When they do, it is often necessary for them to partition the habitat so as to minimize competition for the same resources. Thus, niche partitioning in *Hydropsyche* at Pinnacles is worthy of investigation. Also noteworthy is that *Hydropsyche philo* was found in larger numbers than it has been at other locations. The larva of this species has never been described, so Pinnacles offers a prime opportunity to do so.

When Steven Fend was sent our aquatic worm samples for identification, he noticed a specimen of *Eremidrilus*, his genus of specialization, that did not match any previously described species. He subsequently obtained a scientific collecting permit and made multiple visits to Chalone Creek. He was successful in obtaining more specimens of the new *Eremidrilus sp.*, as well as two other species in this genus. In his surveys of California streams, Chalone Creek is the only locality in which he has found more than two species of *Eremidrilus*.

The Pinnacles riffle beetle is endemic to Pinnacles and surrounding areas. The type specimen used for the original species description was collected from an unspecified site in Chalone Creek (Chandler 1954a). It was subsequently collected from a single site in Chalone Creek, as well as from nearby sites outside the Monument (Shepard 1990). During the present study it was recorded from 17 samples at 5 sites in a two-mile stretch of the middle and lower portions of Chalone Creek. The uppermost of these sites is likely in the vicinity of the sites from which the other collections were taken, but the rest appear to be new sites. Although the species is now known to be more widespread than was previously thought, most of its known population at Pinnacles is in Chalone Creek downstream of Bear Gulch and Sandy Creek. It may therefore be especially vulnerable to water pollution and disturbances to natural stream processes emanating from all of the developed areas of the Monument, as well as from many miles of Sandy Creek and the headwaters of Chalone Creek outside the Monument.

CONCLUSIONS AND RECOMMENDATIONS

The results of the inventory indicate that the aquatic vertebrates of Pinnacles have remained relatively unchanged over the last forty years, with the exception of the loss of some exotic fish species and the decline of the California red-legged frog. The re-establishment of the latter at the Bear Gulch Reservoir has

resulted in a moderate breeding population there, and frogs appear to be dispersing to streams. The planned re-introduction of the foothill yellow-legged frog will likely bring the fauna back to its historic complement. Larvae of this species are probably eaten by the Diablo Range gartersnake, so its population would likely benefit from this re-introduction. Similarly, the two-striped gartersnake has not been recorded at Pinnacles, but it often co-occurs with the foothill yellow-legged frog in this region. So re-introduction of the frog might increase the hospitability of Pinnacles for this snake. Continued monitoring of re-established species and the species that depend on them is recommended.

The aquatic vertebrate inventory is likely 100% complete for resident breeding species. As discussed previously, California tiger salamanders wander widely and may occasionally enter the Monument boundary or even breed here. A wet year would be the best time to find them. California newts are found within twenty miles of the Monument to the north, but it is unlikely that they breed here.

Comments from some of the taxonomists suggest that in general, the Pinnacles aquatic macroinvertebrate fauna is fairly representative of a Central California intermittent stream system. It lacks many of the indicators of good water quality found in cool, perennial streams. This is not unexpected for a relatively warm, primarily intermittent system, and should not be considered a sign of poor water quality. Indeed, the high diversity of groups such as *Eremidrilus* and *Hydropsyche* are an indication that the Pinnacles aquatic ecosystem is fairly healthy. As more is learned about intermittent stream faunas, we will be better able to gauge the health of the Pinnacles aquatic ecosystem.

While less than 50% completeness for a vertebrate inventory would be abominable, it is not unreasonable for invertebrates. This is especially true for such a diverse group as aquatic macroinvertebrates, which includes many unrelated taxa with highly diverse life histories and habitat preferences. Future efforts to improve the completeness of this inventory should follow these suggestions:

- Concentrate on life stages that can be identified to the species level.
- Concentrate on previously undersampled seasons (fall, winter).
- Concentrate on previously undersampled habitats (springs, seeps, intermittent stream sections, seasonal ponds).
- Enlist the assistance of experts to focus on particular taxa.

Exotic bullfrogs might one day invade the Monument, as might crayfish and green sunfish or other exotic fish species. (In fact, green sunfish and bullfrogs did to a small extent in 2006, but were eradicated.) These species could enter the Monument via floodwaters, visitor introductions, or overland migration in the case of the bullfrog. Regular surveys for exotic aquatic species should be conducted, and if infestations are detected they should be managed immediately.

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APPENDICES

Appendix 1. Taxonomists and the taxa they identified.

Name	Taxa	Affiliation/City
James DiGiulio	Diptera: Chironomidae	Valley Venoms and Allergens
Steve Fend	Oligochaete worms and general	USGS
Terrence Frest	Gastropod molluscs	Deixis Consultants
Steven Harris	Trichoptera: Hydroptilidae	Clarion University of PA
Peter Hovingh	Hirudinea	Salt Lake City, UT
Jon Lee	General	Jon Lee Consulting
Doug Post	Coleoptera: Elmidae & Dryopidae	CA Dept of Fish & Game
Andy Rehn	Odonata	CA Dept of Fish & Game
Dave Ruiter	Trichoptera	Centennial, CO
Robert Sites	Hemiptera: Naucoridae & Nepidae	University of Missouri-Columbia
Robert Wisseman	Trichoptera and general	Aquatic Biology Associates

Appendix 2. Aquatic non-insect macroinvertebrates collected at Pinnacles National Monument, 2001-2004.

Common Name	**Phylum**	**Class**	**Lowest Taxon**
hydras	Hydrozoa	Hydroida	*Hydra*
flat worms	Platyhelminthes	Tricladida	*Dugesia*
ribbon worms	Nemertea	Enopla	*Prostoma*
round worms	Nematoda		Mermithidae
horse hair worms	Nematomorpha		Nematomorpha
segmented worms	Annelida	Oligochaeta	*Chaetogaster diaphanus*
segmented worms	Annelida	Oligochaeta	*Chaetogaster diastrophus*
segmented worms	Annelida	Oligochaeta	*Dero nivea*
segmented worms	Annelida	Oligochaeta	*Nais communis/variabilis*
segmented worms	Annelida	Oligochaeta	*Pristina aequiseta*
segmented worms	Annelida	Oligochaeta	*Pristina leidyi*
segmented worms	Annelida	Oligochaeta	*Pristina jenkinae*
segmented worms	Annelida	Oligochaeta	*Pristinella cf osborni*
segmented worms	Annelida	Oligochaeta	*Limnodrilus*
segmented worms	Annelida	Oligochaeta	*Rhyacodrilus cf sodalis*
segmented worms	Annelida	Oligochaeta	*Eiseniella tetraedra*
segmented worms	Annelida	Oligochaeta	*Eremidrilus new sp.*
segmented worms	Annelida	Oligochaeta	*Eremidrilus cf. felini*
segmented worms	Annelida	Oligochaeta	*Eremidrilus cf. coyote*
segmented worms	Annelida	Oligochaeta	*Haplotaxis new sp?*
segmented worms	Annelida	Oligochaeta	*Enchytraeus sp.*
segmented worms	Annelida	Oligochaeta	*cf. Fridericia sp?*
segmented worms	Annelida	Oligochaeta	*Eukerria saltensis*
leeches	Annelida	Hirudinea	*Mooreobdella microstoma*
leeches	Annelida	Hirudinea	Glossiphoniidae
leeches	Annelida	Hirudinea	*Helobdella fusca*
leeches	Annelida	Hirudinea	*Helobdella triserialis*
snails	Mollusca	Gastropoda	*Ferissia*
snails	Mollusca	Gastropoda	*Fossaria bulimoides*
snails	Mollusca	Gastropoda	*Physella gyrina*
snails	Mollusca	Gastropoda	*Physella virgata*
snails	Mollusca	Gastropoda	*Gyraulus vermicularis*
snails	Mollusca	Gastropoda	*Helisoma*
snails	Mollusca	Gastropoda	*Planorbella subcrenata*
snails	Mollusca	Bivalvia	*Pisidium casertanum*
scuds	Arthropoda	Malacostraca	*Hyalella*
copepods	Arthropoda	Copepoda	Harpacticoida
seed shrimp	Arthropoda	Ostracoda	*Candona*
seed shrimp	Arthropoda	Ostracoda	Cyprinae
seed shrimp	Arthropoda	Ostracoda	*Eucypris*
seed shrimp	Arthropoda	Ostracoda	*Cypridopsis*
mites	Arthropoda	Arachnida	*Arrenurus*
mites	Arthropoda	Arachnida	*Atractides*
mites	Arthropoda	Arachnida	*Lebertia*
mites	Arthropoda	Arachnida	*Limnesia*
mites	Arthropoda	Arachnida	*Sperchon*
mites	Arthropoda	Arachnida	Thyadinae
mites	Arthropoda	Arachnida	*Torrenticola*
mites	Arthropoda	Arachnida	*Protzia*

Appendix 3. List of aquatic insects collected at Pinnacles National Monument, 2001-2004.

Common Name	**Order**	**Family**	**Lowest Taxon**
mayflies	Ephemeroptera	Ameletidae	*Ameletus*
mayflies	Ephemeroptera	Baetidae	*Baetis tricaudatus*
mayflies	Ephemeroptera	Baetidae	*Callibaetis*
mayflies	Ephemeroptera	Baetidae	*Centroptilum*
mayflies	Ephemeroptera	Baetidae	*Fallceon quilleri*
mayflies	Ephemeroptera	Caenidae	*Caenis bajaensis*
mayflies	Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*
mayflies	Ephemeroptera	Tricorythidae	*Tricorythodes*
American Ruby-Spot	Odonata	Calopterygidae	*Hetaerina americana*
California Dancer	Odonata	Coenagrionidae	*Argia agrioides*
Sooty Dancer	Odonata	Coenagrionidae	*Argia lugens*
Aztec Dancer	Odonata	Coenagrionidae	*Argia nahuana*
Vivid Dancer	Odonata	Coenagrionidae	*Argia vivida*
Tule Bluet	Odonata	Coenagrionidae	*Enallagma carunculatum*
Familiar Bluet	Odonata	Coenagrionidae	*Enallagma civile*
Northern Bluet	Odonata	Coenagrionidae	*Enallagma cyathigerum*
Arroyo Bluet	Odonata	Coenagrionidae	*Enallagma praevarum*
Pacific Forktail	Odonata	Coenagrionidae	*Ischnura cervula*
Black-fronted Forktail	Odonata	Coenagrionidae	*Ischnura denticollis*
Western Forktail	Odonata	Coenagrionidae	*Ischnura perparva*
Desert Firetail	Odonata	Coenagrionidae	*Telebasis salva*
California Spreadwing	Odonata	Lestidae	*Archilestes californica*
Spotted Spreadwing	Odonata	Lestidae	*Lestes congener*
Black Spreadwing	Odonata	Lestidae	*Lestes stultus*
California Darner	Odonata	Aeshnidae	*Aeshna californica*
Blue-Eyed Darner	Odonata	Aeshnidae	*Aeshna multicolor*
Walker's Darner	Odonata	Aeshnidae	*Aeshna walkeri*
Common Green Darner	Odonata	Aeshnidae	*Anax junius*
Giant Darner	Odonata	Aeshnidae	*Anax walsinghami*
Pacific Spiketail	Odonata	Cordulegastridae	*Cordulegaster dorsalis*
White-Belted Ringtail	Odonata	Gomphidae	*Erpetogomphus compositus*
Grappletail	Odonata	Gomphidae	*Octogomphus specularis*
Gray Sanddragon	Odonata	Gomphidae	*Progomphus borealis*
Eight-spotted Skimmer	Odonata	Libellulidae	*Libellula forensis*
Widow Skimmer	Odonata	Libellulidae	*Libellula luctuosa*
Flame Skimmer	Odonata	Libellulidae	*Libellula saturata*
Red Rock Skimmer	Odonata	Libellulidae	*Paltothemis lineatipes*
Common Whitetail	Odonata	Libellulidae	*Plathemis lydia*
Variegated Meadowhawk	Odonata	Libellulidae	*Sympetrum corruptum*
Cardinal Meadowhawk	Odonata	Libellulidae	*Sympetrum illotum*
Striped Meadowhawk	Odonata	Libellulidae	*Sympetrum pallipes*
Blue Dasher	Odonata	Libellulidae	*Pachydiplax longipennis*
Western Pondhawk	Odonata	Libellulidae	*Erythemis collocata*
Wandering Glider	Odonata	Libellulidae	*Pantala flavescens*
Spot-Winged Glider	Odonata	Libellulidae	*Pantala hymenaea*
Black Saddlebags	Odonata	Libellulidae	*Tramea lacerata*
Red Saddlebags	Odonata	Libellulidae	*Tramea onusta*
Pale-Faced Clubskimmer	Odonata	Libellulidae	*Brechmorhoga mendax*
grouse or pygmy locusts	Orthoptera	Tetrigidae	Tetrigidae

pygmy mole crickets	Orthoptera	Tridactylidae	Tridactylidae
small winter stoneflies	Plecoptera	Capniidae	*Capnura*
small winter stoneflies	Plecoptera	Capniidae	*?Capnia*
green stoneflies	Plecoptera	Chloroperlidae	*Sweltsa*
spring stoneflies	Plecoptera	Nemouoridae	*Malenka*
perlodid stoneflies	Plecoptera	Perlodidae	*Baumanella alameda*
perlodid stoneflies	Plecoptera	Perlodidae	*near Osobenus*
perlodid stoneflies	Plecoptera	Perlodidae	*near Isoperla*
winter stoneflies	Plecoptera	Taneniopterygidae	*?Oemopteryx*
giant water bugs	Hemiptera	Belostomatidae	*Abedus indentatus*
giant water bugs	Hemiptera	Belostomatidae	*Belostoma*
water boatmen	Hemiptera	Corixidae	*Graptocorixa*
water boatmen	Hemiptera	Corixidae	*Hesperocorixa laevigata*
water boatmen	Hemiptera	Corixidae	*Sigara mckinstryi*
toad bugs	Hemiptera	Gelastocoridae	*Gelastocoris*
water striders	Hemiptera	Gerridae	*Aquarius remigis*
water striders	Hemiptera	Gerridae	*Gerris*
water striders	Hemiptera	Gerridae	*Trepobates*
velvet water bugs	Hemiptera	Hebridae	*Merragata hebroides*
velvet water bugs	Hemiptera	Hebridae	*Hebrus*
water bugs	Hemiptera	Macroveliidae	*Macrovelia hornii*
creeping water bugs	Hemiptera	Naucoridae	*Ambrysus californicus*
water scorpions	Hemiptera	Nepidae	*Ranatra brevicollis*
backswimmers	Hemiptera	Notonectidae	*Buenoa*
backswimmers	Hemiptera	Notonectidae	*Notonecta kirbyi*
shore bugs	Hemiptera	Saldidae	*Saldula pexa*
broad-shouldered water striders	Hemiptera	Veliidae	*Microvelia*
broad-shouldered water striders	Hemiptera	Veliidae	*Rhagovelia*
dobsonflies/hellgrammites	Megaloptera	Corydalidae	*Neohermes*
alderflies	Megaloptera	Sialidae	*Sialis*
caddisflies	Trichoptera	Brachycentridae	*Micrasema diteris*
saddle-case caddisflies	Trichoptera	Glossosomatidae	*Agapetus celatus*
saddle-case caddisflies	Trichoptera	Glossosomatidae	*Agapetus marlo*
net-spinning caddisflies	Trichoptera	Hydropsychidae	*Hydropsyche californica*
net-spinning caddisflies	Trichoptera	Hydropsychidae	*Hydropsyche occidentalis*
net-spinning caddisflies	Trichoptera	Hydropsychidae	*Hydropsyche philo*
net-spinning caddisflies	Trichoptera	Hydropsychidae	*Parapsyche ?almota*
net-spinning caddisflies	Trichoptera	Hydropsychidae	*Rhyacophila neograndis*
net-spinning caddisflies	Trichoptera	Hydropsychidae	*Rhyacophila* nr. *rayneri*
microcaddisflies	Trichoptera	Hydroptilidae	*Hydroptila rono*
microcaddisflies	Trichoptera	Hydroptilidae	*Neotrichia new sp.?*
microcaddisflies	Trichoptera	Hydroptilidae	*Ochrotrichia lucia*
microcaddisflies	Trichoptera	Hydroptilidae	*Oxyethira pallida*
caddisflies	Trichoptera	Lepidostomatidae	*Lepidostoma canthum*
caddisflies	Trichoptera	Lepidostomatidae	*Lepidostoma cinereum*
long-horned caddisflies	Trichoptera	Leptoceridae	*Nectopsyche lahontanensis*
long-horned caddisflies	Trichoptera	Leptoceridae	*Nectopsyche sp. Muller*
long-horned caddisflies	Trichoptera	Leptoceridae	*Oecetis inconspicua*
long-horned caddisflies	Trichoptera	Leptoceridae	*Triaenodes tardus*
long-horned caddisflies	Trichoptera	Leptoceridae	*Ylodes frontalis*

northern caddisflies	Trichoptera	Limnephilidae	*Limnephilus frijole*
finger-net caddisflies	Trichoptera	Philopotamidae	*Dolophilodes*
finger-net caddisflies	Trichoptera	Philopotamidae	*Wormaldia gabriella*
tube-making caddisflies	Trichoptera	Polycentropodidae	*Polycentropus variegatus*
tube-making caddisflies	Trichoptera	Psychomyiidae	*Tinodes consueta*
tube-making caddisflies	Trichoptera	Psychomyiidae	*Tinodes sp. Curtis*
snail-case caddisflies	Trichoptera	Sericostomatidae	*Gumaga griseola*
long-toed water beetles	Coleoptera	Dryopidae	*Helichus suturalis*
long-toed water beetles	Coleoptera	Dryopidae	*Postelichus productus*
predaceous diving beetles	Coleoptera	Dytiscidae	*Agabus*
predaceous diving beetles	Coleoptera	Dytiscidae	*Dytiscus marginicollis*
predaceous diving beetles	Coleoptera	Dytiscidae	*Hydroporus fortis*
predaceous diving beetles	Coleoptera	Dytiscidae	*Laccophilus maculosus*
predaceous diving beetles	Coleoptera	Dytiscidae	*Rhantus gutticollis*
predaceous diving beetles	Coleoptera	Dytiscidae	*Sanfilippodytes*
predaceous diving beetles	Coleoptera	Dytiscidae	*Stictotarsus eximius*
predaceous diving beetles	Coleoptera	Dytiscidae	*Stictotarsus striatellus*
Pinnacles riffle beetle	Coleoptera	Elmidae	*Optioservus canus*
whirligig beetles	Coleoptera	Gyrinidae	*Gyrinus*
crawling water beetles	Coleoptera	Haliplidae	*Haliplus*
crawling water beetles	Coleoptera	Haliplidae	*Peltodytes callosus*
crawling water beetles	Coleoptera	Haliplidae	*Peltodytes simplex*
minute moss beetles	Coleoptera	Hydraenidae	*Hydraena*
water scavenger beetles	Coleoptera	Hydrophilidae	*Anacaena*
water scavenger beetles	Coleoptera	Hydrophilidae	*Berosus punctatissimus*
water scavenger beetles	Coleoptera	Hydrophilidae	*Cymbiodyta*
water scavenger beetles	Coleoptera	Hydrophilidae	*Helochares*
water scavenger beetles	Coleoptera	Hydrophilidae	*Laccobius*
water scavenger beetles	Coleoptera	Hydrophilidae	*Paracymus*
water scavenger beetles	Coleoptera	Hydrophilidae	*Tropisternus*
water penny beetles	Coleoptera	Psephenidae	*Psephenus*
no-see-ums	Diptera	Ceratopogonidae	*Atrichopogon*
no-see-ums	Diptera	Ceratopogonidae	*Bezzia/Palpomyia*
no-see-ums	Diptera	Ceratopogonidae	*Culicoides*
no-see-ums	Diptera	Ceratopogonidae	*Dasyhelea*
no-see-ums	Diptera	Ceratopogonidae	*Stilobezzia*
phantom midges	Diptera	Chaoboridae	*Chaoborus*
midges	Diptera	Chironomidae	*Apedilum*
midges	Diptera	Chironomidae	*Chironomus*
midges	Diptera	Chironomidae	*Dicrotendipes*
midges	Diptera	Chironomidae	*Micropsectra*
midges	Diptera	Chironomidae	*Microtendipes pedellus group*
midges	Diptera	Chironomidae	*Microtendipes rydalensis group*
midges	Diptera	Chironomidae	*Paracladopelma*
midges	Diptera	Chironomidae	*Paratanytarsus*
midges	Diptera	Chironomidae	*Phaenopsectra*
midges	Diptera	Chironomidae	*Polypedilum*
midges	Diptera	Chironomidae	*Pseudochironomus*
midges	Diptera	Chironomidae	*Rheotanytarsus*
midges	Diptera	Chironomidae	*Stempellinella*
midges	Diptera	Chironomidae	*Tanytarsus*

midges	Diptera	Chironomidae	*Corynoneura*
midges	Diptera	Chironomidae	*Cardiocladius*
midges	Diptera	Chironomidae	*Cricotopus bicinctus group*
midges	Diptera	Chironomidae	*Eukiefferiella*
midges	Diptera	Chironomidae	*Heterotrissocladius subpilosus group*
midges	Diptera	Chironomidae	*Hydrobaenus*
midges	Diptera	Chironomidae	*Nanocladius*
midges	Diptera	Chironomidae	*Parachaetocladius*
midges	Diptera	Chironomidae	*Parametriocnemus*
midges	Diptera	Chironomidae	*Paraphaenocladius*
midges	Diptera	Chironomidae	*Psectrocladius*
midges	Diptera	Chironomidae	*Rheocricotopus*
midges	Diptera	Chironomidae	*Thienemanniella fusca*
midges	Diptera	Chironomidae	*Tvetenia bavarica group*
midges	Diptera	Chironomidae	*Alotanypus*
midges	Diptera	Chironomidae	*Labrundinia*
midges	Diptera	Chironomidae	*Larsia*
midges	Diptera	Chironomidae	*Meropelopia*
midges	Diptera	Chironomidae	*Nilotanypus*
midges	Diptera	Chironomidae	*Paramerina*
midges	Diptera	Chironomidae	*Pentaneura*
midges	Diptera	Chironomidae	*Procladius*
midges	Diptera	Chironomidae	*Psectrotanypus*
midges	Diptera	Chironomidae	*Radotanypus*
midges	Diptera	Chironomidae	*Thienemannimyia group*
mosquitos	Diptera	Culicidae	*Anopheles*
dixid midges	Diptera	Dixidae	*Dixa*
dixid midges	Diptera	Dixidae	*Dixella*
dixid midges	Diptera	Dixidae	*Meringodixa*
dance flies	Diptera	Empididae	*Chelifera*
dance flies	Diptera	Empididae	*Hemerodromia*
dance flies	Diptera	Empididae	*cf. Clinocera*
dance flies	Diptera	Empididae	*Trichoclinocera*
shore flies	Diptera	Ephydridae	*Setacera*
house flies	Diptera	Muscidae	*Limnophora*
house flies	Diptera	Psychodidae	*Pericoma/Telmatoscopus*
marsh flies	Diptera	Sciomyzidae	Sciomyzidae
black flies	Diptera	Simuliidae	*Simulium aureum*
black flies	Diptera	Simuliidae	*Simulium piperi*
black flies	Diptera	Simuliidae	*Simulium cf. vittatum*
black flies	Diptera	Simuliidae	*Simulium cf. virgatum*
soldier flies	Diptera	Stratiomyidae	*Caloparyphus*
soldier flies	Diptera	Stratiomyidae	*Euparyphus*
soldier flies	Diptera	Stratiomyidae	*Odontomyia*
horse flies	Diptera	Tabanidae	*Chrysops*
crane flies	Diptera	Tipulidae	*Dicranota*
crane flies	Diptera	Tipulidae	*Hexatoma*
crane flies	Diptera	Tipulidae	*Holorusia hespera*
crane flies	Diptera	Tipulidae	*Limonia*
crane flies	Diptera	Tipulidae	*Tipula*
crane flies	Diptera	Tipulidae	*Ulomorpha*