# The Occurrence and Distribution of New Zealand Mud Snail (*Potamopyrgus antipodarum*) in Utah

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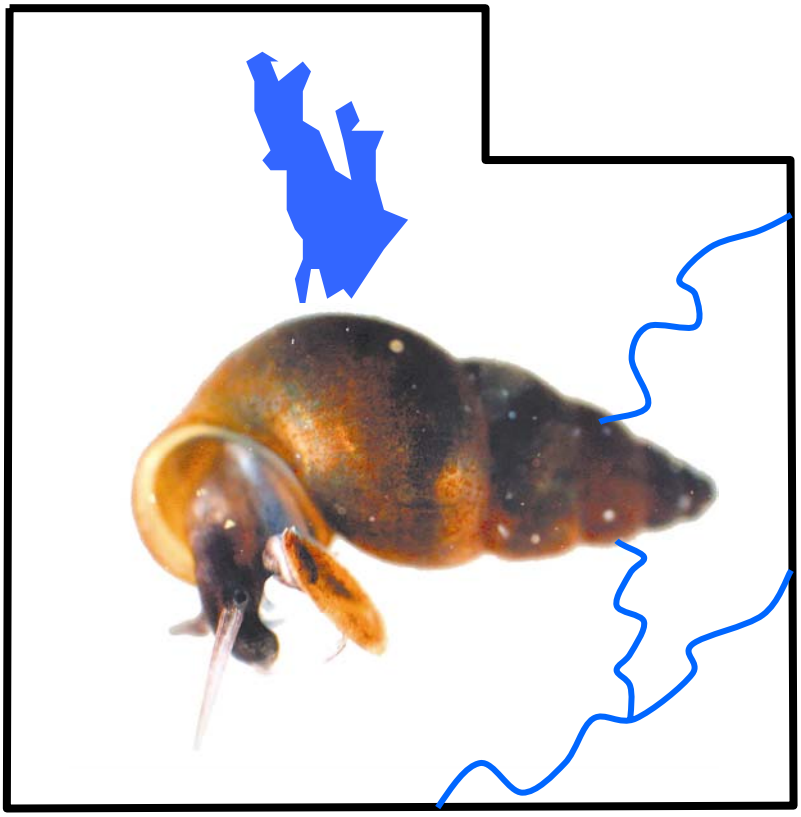

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Cover photograph: The beast that is *Potamopyrgus antipodarum*, the New Zealand mud snail. Photograph by Mark Vinson.

The work described in this report was conducted by the National Aquatic Monitoring Center, which is housed at Utah State University, Logan, Utah. Dave Axford, Dan Barnes, Laura Bennett, Nathan Etherington, Leslie Ogden, Matt Tagg, Erin Thompson, and Dan Zamecnik participated in the field collection of the samples, the identification of the invertebrates, and the writing of this report. I thank them for their help and good spirit.

**Summary**

The purpose of this project was to determine the occurrence of New Zealand mud snails in Utah. The NZMS is a small to medium sized Hydrobiid snail that is native to New Zealand. Since the mid 1800s and in particular during the last few years, the snail has spread from New Zealand to freshwater environments throughout the United States, Europe, Asia, and Australia. New Zealand mud snails were first collected in Utah on 18 September 2001 in the Green River downstream from Flaming Gorge Dam. Between September 2001 and May 2004, 477 locations were sampled in Utah. New Zealand mud snails were found at 28 locations within 16 stream basins. Their dispersal throughout Utah and in particular along the Wasatch Front appeared to be rapid. In 2001 they were found in 3 basins, in 2002 they were found in 8 basins, and in 2003 they were found in 16 basins. They can currently be found in many of the State's quality trout waters including the Green, Bear, Provo, Weber, Ogden, and Logan River Basins. At individual sites, population abundances were highest in stream habitats characterized by slower water velocities and abundant aquatic vegetation that were adjacent to higher water velocity run and riffle habitats.

**Introduction**

The New Zealand mud snail (NZMS, *Potamopyrgus antipodarum* Gastropoda: Hydrobiidae) is a small to medium sized snail that is native to New Zealand. Since the mid 1800s the snail has spread from New Zealand to freshwater environments throughout the world. It can currently be found in New Zealand, Australia, Europe, Asia, and North America. The snail was first found in the United States in the 1987 in the Snake River near Hagerman, Idaho (Bowler 1991). Since then the snail has move rapidly throughout the United States and in particular the western United States (Figure 1, also see http://www.esg.montana.edu/aim/mollusca/nzms/). The source of the original introduction in the Snake River and nearly all other locations is unknown. Speculated sources include aquaculture activities, recreationists, and in local introductions, fish and waterfowl have been suggested as potential sources.

*Potamopyrgus antipodarum* are typically 3-7 mm in length. Their shell is dextral (right opening) and moderately thick. The aperture is elliptical. There can be 5 to 8 whorls, with 5 to 6 seeming to be most common in Utah snails (Plate 1). The shell spire generally appears higher and narrower then other native Hydrobiidae in Utah. The operculum is ovate, thin, and paucispiral. The presence of immature snails within adults allows for the positive separation of NZMS from other native Hydrobiidae (Plate 1).

New Zealand mud snails possess several morphological and behavioral traits that make them well suited to both passive and active dispersal to local and distant environments. The snails are parthenogenic (egg development without fertilization), viviparous (bearing live young), and in the United States all snails are believed to be female and clones of one another (Dybdahl and Lively 1995, Hall et al. 2003). They can produce young throughout the year, though reproduction appears highest during the summer months, and they can produce up to 6 generations per year. Reproductively active snails typically contain between 10 and 90 embryos (Richards 2002). They possess an operculum, which allows them, if kept moist and not exposed to excessive heat, to live for several weeks out of the water; thus recreationists can unknowingly spread them. Fish and waterfowl can also transport them within and likely between

water bodies. Bondeson and Kaiser (1949) and Haynes et al. (1985) reported that *Potamopyrgus* were able to pass through the digestive tracts of trout (*Salmo trutta* and *Oncorhynchus mykiss*) and perch (*Perca fluviatilis*). Haynes et al. (1985) fed four 12 cm long rainbow trout *Potamopygrus jenkinsi* for three hours. The fish were then transferred to another aquarium where any snails were collected. On one occasion 49 snails were recovered; 35 were alive and within 24 hours of being voided 10 live young were recovered. These results are similar to that found by Vinson this past spring (unpublished data, Plate 2). We found that rainbow trout fed NZMS voided these snails within 6 hours (Figure 2). Of the snails that were voided and collected, about half of the snails were alive, 25% of the shells were empty, and the remaining snails were intact, but were dead. In addition to being able to drift downstream on aquatic vegetation and woody debris, the snails have also been observed to move upstream in rivers (Haynes et al. 1985). Adam (1942; cited in Zaranko et al. 1997) reported them moving as much as 60 m upstream over 3 months. Lassen (1975) predicted upstream movements of about 1 km per year for the related European species *Potamopyrgus jenkinsi*.

Like many exotic species, they appear able to out-compete native fauna. In Polecat Creek near Yellowstone National Park, New Zealand mud snail population densities exceeded 100,000 individuals per square meter and they comprised over 95% of the invertebrate biomass in some river sections (Hall et al. 2003). At these high population densities they may eliminate many native invertebrates and this has led to speculation that this will result in trout population decreases (Sacramento Bee, November 16, 2003 quoting David Richards, Montana State University). In addition direct ecological consequences, economic impacts may be felt as well, but they are not predicted to have as much of a biofouling potential as zebra mussels. However, they have been observed to pass through domestic water pipes (Ponder 1988).

New Zealand mud snails appear able to tolerate and flourish in a variety of aquatic habitats across a wide range of temperatures, substrates, salinities, and habitiat sizes (Cogerino et al. 1995, Zaranko, et al. 1997, Richards et al. 2001, Hall et al. 2003). They have been found in both streams and lakes, but in the western United States they

have been found much more often in streams then lakes. They have been found in water temperatures ranging from warm; springs near Yellowstone National Park (Hall et al. 2003) to cold; rivers like the Green (Vinson unpublished data) and Colorado (Shannon et al. 2003). They also occupy a variety of substrates including silt, sand, cobble, and aquatic vegetation (Richards 2002).

New Zealand mud snails were first collected in Utah on 18 September 2001 near Swallow Canyon on the Green River downstream from Flaming Gorge Dam. In spring 2002, this project was initiated to survey the state of Utah to determine the occurrence of New Zealand mud snails (Gastropoda: Hydrobiidae *Potamopyrgus antipodarum,* NZMS). The purpose of this project was to determine the occurrence of New Zealand mud snails in Utah. Some ancillary data were collected within stream habitat locations, but this was not the focus of this project, so its treatment here is light.

**Study area**

Aquatic habitats throughout the State of Utah were searched for the presence of New Zealand mud snails. An effort was made to sample waters throughout the state, but an emphasis was placed on collecting from high quality trout waters, regulated rivers, and cold springs. It was initially thought that the snail preferred these habitats.

**Methods**

Two data sets were used for this project. The first dataset was comprised of historical data from aquatic invertebrate collections that were associated with other projects conducted between 1993 and June 2004. The second data set was derived from aquatic invertebrate collections that were specifically done to determine if New Zealand mud snails were present at a site. All of these samples were collected in 2002.

*Location and habitat descriptions*

At each NZMS specific collection locations, the latitude and longitude was determined using hand held global positioning units (Datum = NAD 1983). Water temperature, specific conductance, digital images and basic descriptions of the

sampling locations were also recorded from each site. If New Zealand mud snails were found, a brief description of the habitat they occupied was made. Aquatic invertebrate assemblage data for all collections (historic and NZMS specific) are available from Mark Vinson or can be downloaded at: www.usu.edu/buglab.

*Aquatic invertebrates*

At the routine monitoring sites samples were typically collected with fixed area samplers, typically either a Hess or Surber sampler with 250 to 500 micron mesh nets. Samples were collected by disturbing the area within the square sampling frame with our hands and scrubbing individual substrate particles within the sampling area and allowing the invertebrates and detritus to wash downstream into the net. Usually multiple samples were collected at a site and composited. At many of these sites, qualitative collections of aquatic invertebrates were made as well. These samples were generally collected with a kicknet (457 x 229 mm) with a 500 micron mesh net and by hand picking invertebrates from woody debris and large boulders. All major habitat types (e.g., riffles, pools, back waters, macrophyte beds) were sampled and all samples were composited to form a single sample from each site on each sampling date

At New Zealand mud snail specific sites, the objective was to determine if NZMS were present. At each site, qualitative invertebrate collections were done to determine if mud snails were present and to collect as many different kinds of invertebrates living at a site as possible. Samples were collected with a kicknet (457 x 229 mm) with a 500 micron mesh net and by hand picking invertebrates from woody debris and large boulders. All major habitat types (e.g., riffles, pools, back waters, macrophyte beds) were sampled and all samples were composited to form a single sample from each site on each sampling date.

*Laboratory methods*—The general procedures followed for processing aquatic invertebrate samples from non-NZMS targeted sites were similar to those recommended by the United States Geological Survey (Cuffney et al. 1993) and are described in greater detail and rationalized in Vinson and Hawkins (1996). Samples

collected at NZMS specific collection sites were qualitative samples and were processed in their entirety, i.e., all the organisms were removed and identified. Quantitative samples were sub-sampled if the sample appeared to contain more than 500 organisms. Sub-samples were obtained by pouring the sample into an appropriate diameter 500 micron sieve, floating this material by placing the sieve within an enamel pan partially filled with water and leveling the material within the sieve. The sieve was then removed from the water pan and the material within the sieve was divided into equal parts. One side of the sieve was then randomly chosen to be processed and the other side was set aside. The sieve was then placed back in the enamel pan and the material in the sieve again leveled and split in half. This process was repeated until approximately 500 organisms remained in one-half of the sieve. This material was then placed into a petri dish and all organisms were removed under a dissecting microscope at 10-30 power. Additional sub-samples were taken until at least 500 organisms were removed. All organisms within a sub-sample were removed. During the sorting process the organisms were separated into Orders. When the sorting of the sub-samples was completed, the entire sample was spread throughout a large white enamel pan and searched for 10 minutes to remove any taxa that might not have been picked up during the initial sample sorting process. The objective of this "big/rare" search was to provide a more complete taxa list by finding rarer taxa that may have been excluded during the sub-sampling process. These rarer bugs were placed into a separate vial and tracked separately from the bugs removed during the sub-sampling process. All the organisms removed during the sorting process were then identified. Once the data had been entered into a computer and checked, the unsorted portion of the sample was discarded. The identified portion of the sample was placed in 70% ethanol, given a catalog number, and was retained.

**Results and discussion**

New Zealand mud snails were first collected in Utah on 18 September 2001 near Swallow Canyon on the Green River downstream from Flaming Gorge Dam. Between

1993 and September 2001, aquatic invertebrate assemblage data were available from our data base for 1,148 locations in Utah (Figure 2). No NZMS were collected at any of these sites. There were also no reports of NZMS being present in Utah prior to their collection in the Green River in September 2001. Since this date, 477 other locations throughout Utah were sampled (both data sets). New Zealand mud snails were found at 28 of these locations (ca. 6% of the sites) within 16 stream basins (Table 1, Figure 1). The date of the first collection within each stream basin is shown in Table 1. After their initial occurrence in the Green River, they were collected about one month later, in both Cache Valley and in the Provo River along the Wasatch Front.

Their dispersal throughout Utah and in particular along the Wasatch Front has been rapid. In 2001 they were found in 3 basins, in 2002 they were found in 8 basins, and in 2003 they were found in 16 basins. They can currently be found in many of the State's quality trout waters including the Green, Bear (Idaho), Provo, Weber, Ogden, and Logan River Basins (Table 1). Within individual stream basins, populations have appeared to generally expand their range over time. For example, in September 2001, they were found at a single site in the Green River, presently they can be found in fairly high densities from just downstream from Flaming Gorge Dam downstream to the Colorado State line, a distance of about 50 km. In the Bear River in Oneida Narrows, they can be found throughout the Oneida Narrows Canyon just upstream from the Utah State line.

Within individual streams, the snails appear to prefer habitats with lower then reach average velocities and aquatic vegetation. At locations where the snails were collected they could be found on both gravel and cobble substrates and aquatic vegetation, but abundances were always higher within aquatic vegetation as compared to mineral substrates. In the Green River, local population densities are highest within beds of sago pondweed (*Potamogeton pectinatus*, Plates 3 and 4). Population abundances in riffle habitats have generally been observed to be much lower then that observed in aquatic plant beds.

Population abundance trends at individual sites have tended to fluctuate seasonally. Data available to evaluate this question comes from the Bear River in Onieda Narrows, Idaho and from the Green River near Little Hole downstream from Flaming Gorge Dam. Quantitative samples were collected monthly from the Bear River from November 2002 through April 2004 and seasonally (January, April, July, and September) in the Green River from January 1993 through April 2004 (note - NZMS were not found near Little Hole until April 2002). At both locations, populations appear to peak in the fall and early winter (Figures 3 and 4). In the Bear River, populations in 2004 were generally higher than in 2003, whereas, in the Green River there was no clear trend in abundance over time. It should be noted though that in the Green River, these data were collected in a cobble-dominated riffle and the snails in this river appear to prefer aquatic vegetation beds, where we have not collected quantitative samples, but gross estimates of abundance are likely greater then 100,000 per square meter (Plate 4).

Table 1. The location of New Zealand mud snail collections within or near Utah between September 2001 and June 2004. * Denotes collections made by Dr. Dan Gustafson, Montana State University. All other collections were made by M. Vinson. Collection dates were the date they were first collect at that site.

| Drainage Basin, location | Collection date | Relative abundance |
|---|---|---|
| Bear River Basin | | |
| Bear River within Oneida Narrows, Franklin County, Idaho | 09/08/2002 | Abundant |
| Clarkston Creek upstream from Newton, Cache County, Utah | 09/24/2002 | Abundant |
| Springs near Paradise, Cache County, Utah | 01/15/2002 | Abundant |
| Little Bear River west of Avon, Cache County, Utah | 10/17/2001 | Few |
| Logan River ponds near 3rd Dam, north side of Hwy 89, Cache County, Utah | 07/16/2002 | Few |
| Colorado River | | |
| Colorado River at Lee's Ferry, Coconino County, Arizona | 06/19/2002 | Abundant |
| Green River | | |
| Green River at Swallow Rapid, Daggett County, Utah | 09/18/2001 | Few |
| Green River near Little Hole in trout stomach, Daggett County, Utah | 09/18/2001 | Few |
| Green River at Grasshopper Island, Daggett County, Utah | 07/17/2002 | Few |
| Green River just downstream from Taylor Flat Bridge, Daggett County, Utah | 07/17/2002 | Few |
| Green River just upstream from Caddis Wall, Daggett County, Utah | 04/22/2003 | Few |
| Green River near FGD tailrace boat ramp, Daggett County, Utah | 09/20/2003 | Few |
| Green River, eddy 1, Daggett County, Utah | 09/20/2003 | Few |
| Green River at Swinging Bridge,, Daggett County, Utah | 01/08/2004 | Few |
| Green River just upstream from Green River, Sweetwater County, Wyoming | 04/21/2004 | Few |
| Great Salt Lake Basin | | |
| Provo River at Utah Highway 114 crossing | 10/18/2001 | Abundant |
| East Canyon Creek downstream from Jeremy | 10/01/2002 | Few |
| Ogden River at mouth of canyon | 01/31/2003 | Few |
| Provo River at mouth of South Fork | 03/12/2003 | Few |
| Weber River above East Canyon Creek | 04/01/2003 | Abundant |
| Kays Creek pond | 07/16/2003 | Few |
| *Spanish Fork River at Camp | 08/26/2003 | Few |
| *Lost Creek near Weber River | 08/29/2003 | Moderate |
| *Ogden River at Wildwood | 08/29/2003 | Moderate |
| *Weber River near Henefer | 08/29/2003 | Moderate |
| Weber River at Mountain View Exit | 09/25/2003 | Few |
| Jordan River at Jordan River Parkway | 05/02/2004 | abundant |
| Strawberry River | | |
| Strawberry River at Highway 40 | 09/25/2003 | Few |

Future Recommendations

These data will provide excellent baseline information on the occurrence and distribution of the New Zealand mud snails prior to 2004. I believe a moderate level of surveying should be continued in Utah. While there is no immediate remedy for habitats occupied by NZMS, knowledge of their occurrence, posting of information at recreation access points, and public education seems to be the best defenses currently available to limiting their dispersal. A specific study of the habitat preferences of the snails in high value fishery habitats should also be conducted. The long-term aquatic invertebrate assemblage monitoring that has and is being done in the Green River downstream from Flaming Gorge Dam should be continued. These data will be invaluable in assessing the long-term effects of this species on other invertebrates and trout and also the effects of high flows on New Zealand mud snail populations. It is thought, but it an untested hypothesis, that the release of high flows may be a way of managing this species in regulated rivers. Conversely, Haynes et al (1985) found that a related species *Potamopyrgus jenkinsi* was positively rheotactic and at water velocities of 30 cm $sec^{-1}$ moved upstream.

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Project accomplishments that can be attributed to this grant

Television appearances

1. New Zealand mud snails and fishery issues in the Green River downstream from Flaming Gorge Dam – 1 interview in 2002 and 2 interviews during 2003 with Doug Miller - Outdoors with Doug Miller, KSL Salt Lake City.

Newspaper stories

1. On the trail of the snail, Salt Lake Tribune 15 July 2004.
2. Polluted waters, Intermountain Angler April 2004
3. Tiny snails are big problem, Deseret Morning News 29 March 2004.
4. Invasion of the mud snails. The Herald Journal 5 March 2004.
5. New Zealand mud snails in the Green River, Salt Lake Tribune on 24 April 2002.

Outreach and education

1. Training course on exotic species identification at the annual meeting of the Utah Division of Parks and Recreation, Spring 2003.
2. Invited lecture on New Zealand mud snails given to the Utah Fish Health Board on aquatic invasive species, Spring 2003.
3. Mark Vinson led a river trip for the Utah Division of Wildlife Resources on the Green River for a group of fishing guides who were concerned about the health of the river due to forest fires and intense thunderstorms.
4. Mark Vinson went on 2 river trips on the Green River through Dinosaur National Monument in 2003 on behalf of the National Park Service to talk about potential effects of New Zealand mud snails on Park resources.
5. I taught an aquatic invertebrate invasive species identification short course at the Colorado, Utah, and Wyoming AFS meeting in Grand Junction, April 2003.
6. A Nuisance Aquatic Species poster was prepared and disseminated to natural resource education groups around the western U.S. to use at local and regional outreach and extension events.

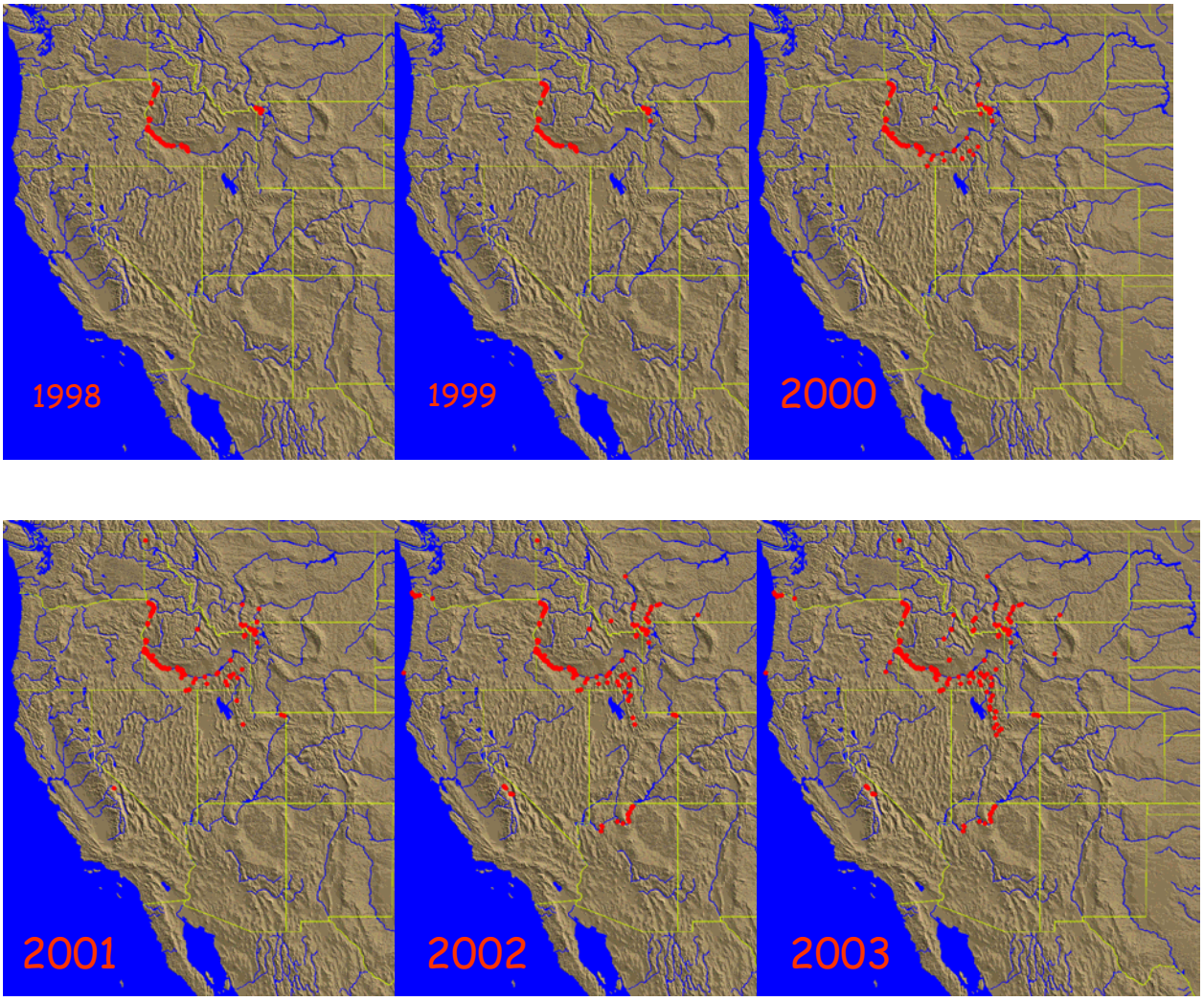


Figure 1. Occurrences of New Zealand mud snails in the western United States from January 1998 through July 2004. Data from: http://www.esg.montana.edu/aim/mollusca/nzms/ Downloaded 9 August 2004.

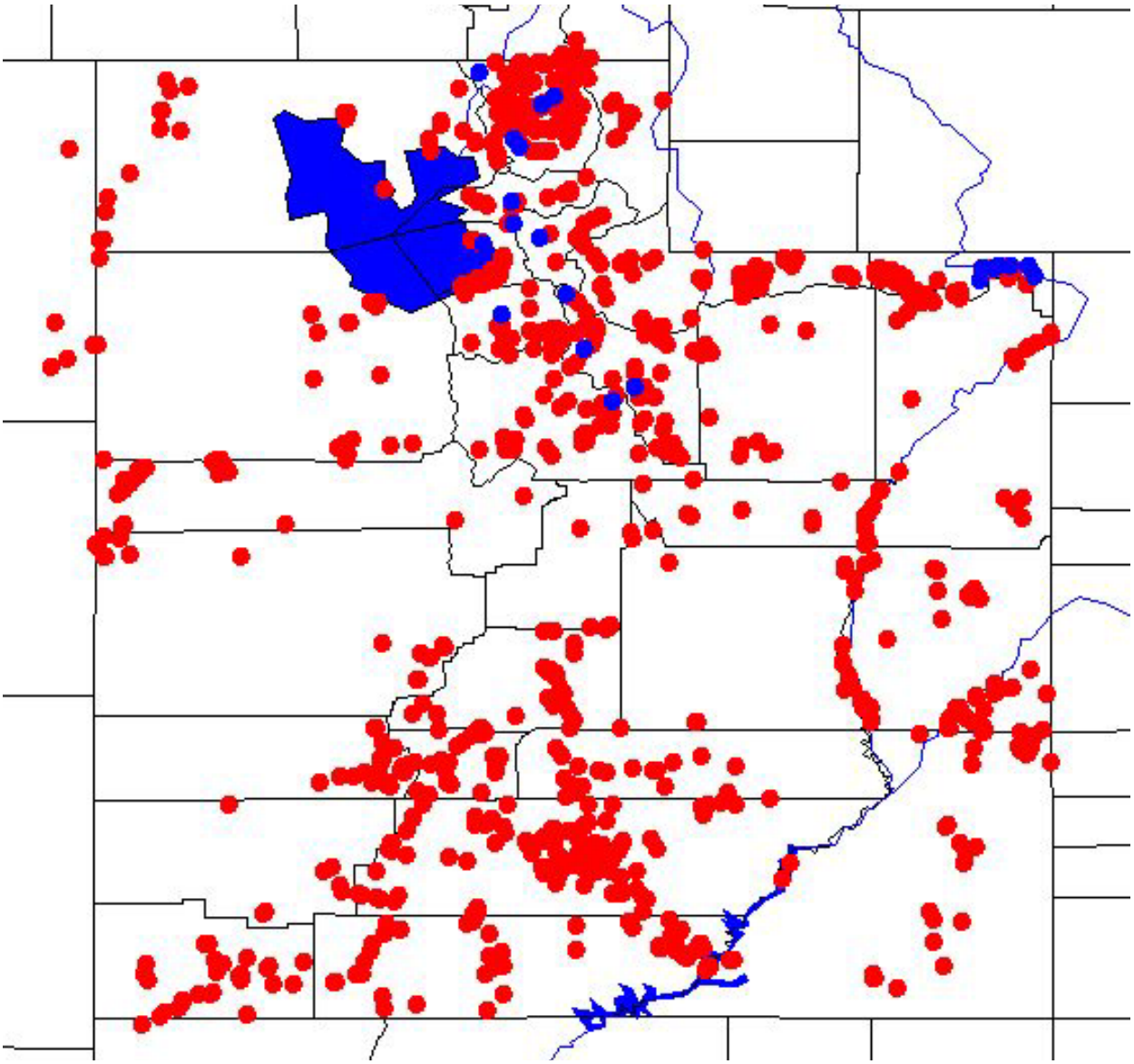

Figure 2. Location of sampling sites that were evaluated for the occurrence of New Zealand mud snails between 1993 and 2004. Data for individual sampling locations are available at http://www.usu.edu/buglab. Red dots were negative and blue dots were locations where New Zealand mud snails were found.

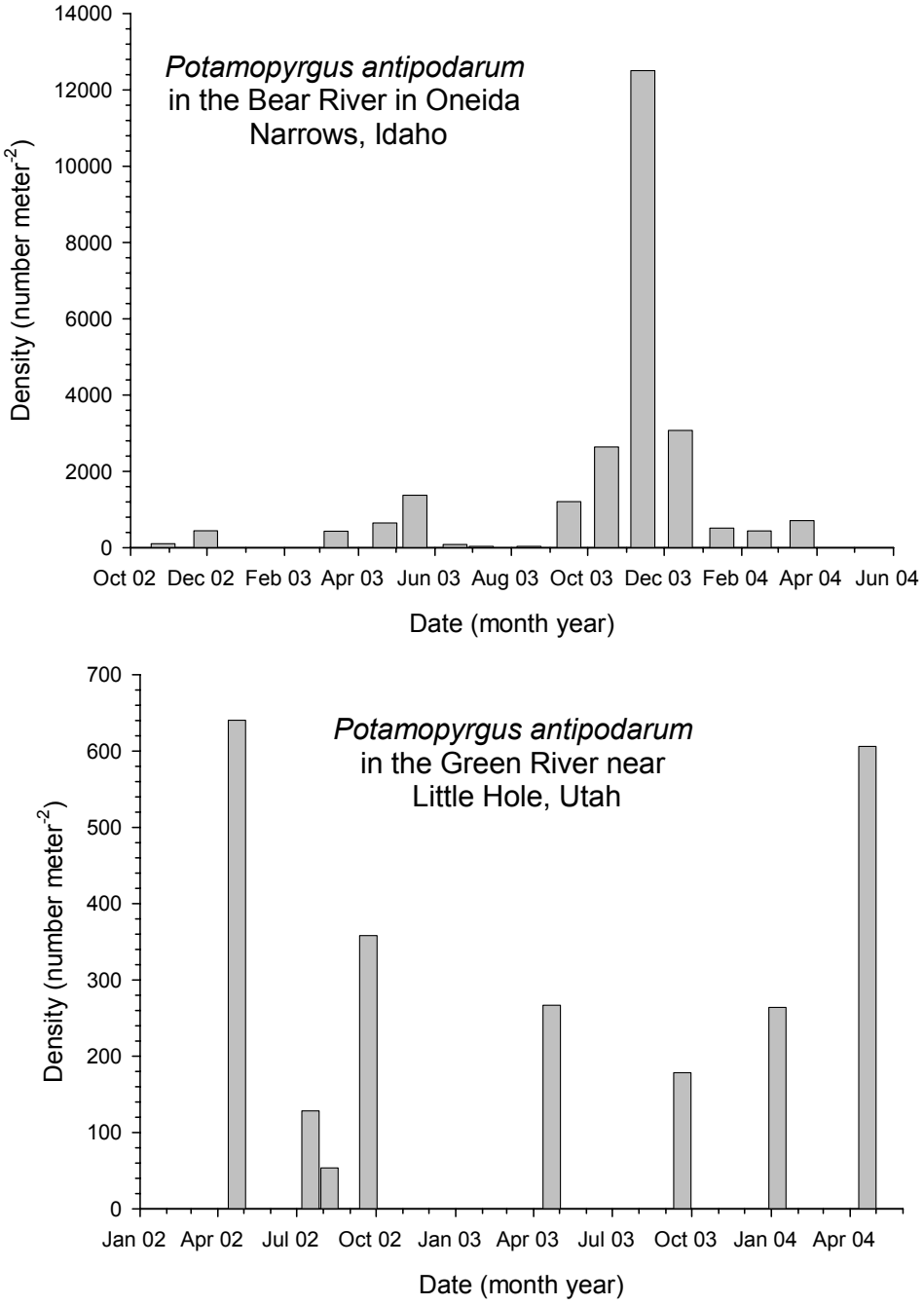


Figure 3. New Zealand mud snails abundances (number $m^{-2}$) in the Bear River (upper) and the Green River (lower) between 2002 and 2004.

Plate 1. New Zealand mud snails (*Potamopyrgus antipodarum*, right) and embryos found in a mature specimen (below).

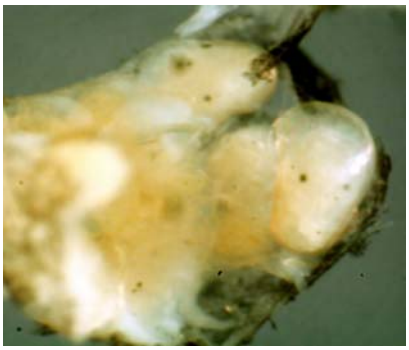

Plate 2. New Zealand mud snails that were ingested and then passed through the intestinal tract of rainbow trout in the laboratory. Several of these snails were still living.

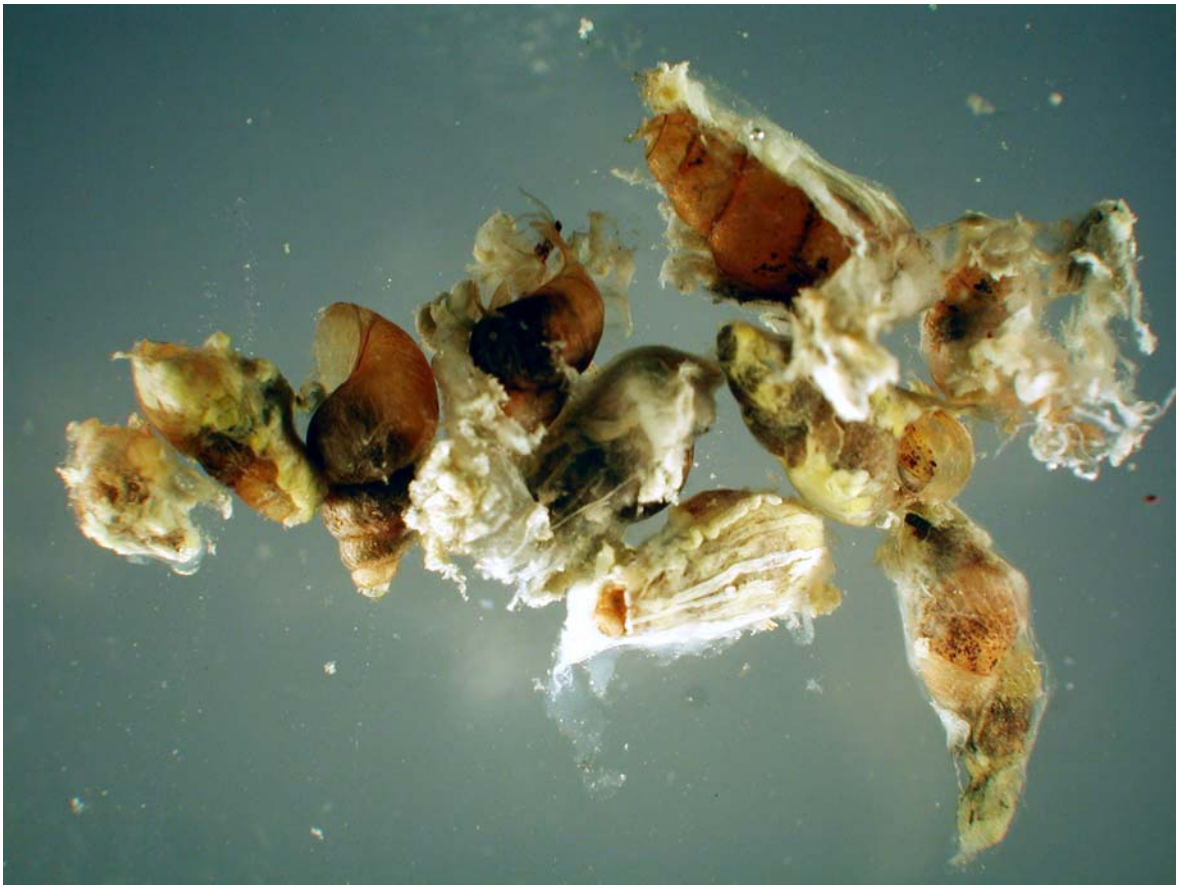

Plate 3. Sago pondweed, the preferred habitat of New Zealand mud snails in the Green River downstream from Flaming Gorge Dam.

Plate 4. Hundreds of thousands of New Zealand mud snails – all of the black particles in the net - collected with little effort from the Green River downstream from Flaming Gorge Dam near Little Hole, September 2003.