VISUAL IMPACTS OF STALK FORMING DIATOMS IN GRAND TETON NATIONAL PARK

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✦ ABSTRACT

A survey was conducted in August 2008 to determine the distribution and extent of stalked diatoms in major rivers and streams in Grand Teton National Park (GTNP). We determined that a nuisance bloom of the diatom *Didymosphenia geminata* was present in Lake Creek from the outlet of Phelps Lake to approximately 1 km downstream of the Rockefeller Preserve. This bloom was considered "excessive" because the coverage of the stream substrate was 70% or above for greater than 1 km. This diatom species is able to survive out of water in damp conditions, and it may be transported on the gear of recreationalists. In GTNP, this diatom was found in a high visitor use area, with concomitant potential for the species to be spread by anglers to other sites within the national park. Although there are several factors that appear to influence its distribution, recent nuisance blooms of this species suggest popular angling sites are often sites of nuisance blooms. Decontamination of aquatic gear by recreationalists may be appropriate to limit the spread of nuisance blooms within the national park system and adjacent public and private water bodies.

✦ INTRODUCTION

This research presents a collaborative effort between the US Geological Survey, National Park Service, and US Environmental Protection Agency to address an issue of concern within Grand Teton National Park (GTNP). Park managers have determined detecting the presence, abundance, and potential impacts of *Didymosphenia geminata* as a research goal.

The diatom *Didymosphenia geminata* (Lyngbye) Schmidt is emerging as an organism with an extraordinary capacity to impact stream ecosystems on a global scale. In recent years, streams in New Zealand, North America, Europe, and Asia have been colonized by unprecedented masses of "didymo" and its extracellular stalks. This diatom is able to dominate stream surfaces by covering up to 100% of substrate with thicknesses of greater than 20 cm, greatly altering physical and biological conditions within streams. Although it is considered native to North America, this species is believed to be expanding its geographic range. Two other species of concern, *Cymbella mexicana* (Ehrenberg) Cleve and *C. janischii* A. Schmidt historically inhabit western streams and rivers (Patrick & Reimer 1966, Wellnitz et al. 1996, Bahls 2004). The typical growth habit of all these species includes the episodic formation of large masses (Cleve 1894-1896, Skvortzow 1935, Skulberg 1982) and the rate that nuisance blooms are reported by the public and local media are increasing.

Although *D. geminata* occurs in both lakes and flowing waters, nuisance blooms are only known in streams and rivers. For the purposes of this study, "excessive growth" is defined as masses of cells and stalks that extend for greater than 1 km. The masses may persist for several months of the year, as with several sites in North America (Spaulding & Elwell 2007). By the use of this term "excessive", we have a working understanding that some aspect of these growths are unusual, and we consider them to be the result of a combination of biological and environmental factors.

Prior to 2007, there were no confirmed reports of *D. geminata* from Grand Teton National Park, although macroscopic clumps of the diatom *Cymbella mexicana* and *C. janischii* were documented in the rivers of Grand Teton National Park (K. Hermann, personal observations). These cymbelloid diatoms produce stalks that are close in chemical composition to *D. geminata* and may produce excessive amounts of stalks, leading to nuisance growths (Spaulding & Elwell 2007). In the Snake River watershed, these masses occur during periods of low flow in August and September. Furthermore, the species *C. mexicana* and *D. geminata* are cymbelloid diatoms that are suggested to be sister taxa (Kociolek & Stoermer 1993). That is, they are more closely related to one another than to members of either gomphonemoid or cymbelloid lineages.

The goal of this study is to determine the distribution and extent of stalked diatoms in Grand Teton National Park. The objectives are to:

- *Develop an assessment of the occurrence of masses of stalked diatoms in Grand Teton National Park using a survey design that will allow estimation of extent and areal coverage.*
- *Evaluate survey results to determine if masses of diatoms are considered "excessive" and suggest management response.*
- *Assess the degree to which stalked diatoms are correlated to human impact.*
- *Determine if decontamination of aquatic gear by recreationalists is appropriate to contain the spread of blooms within Grand Teton National Park.*

✦ METHODS AND MATERIALS

Field surveys. Fieldwork was completed over 17-22 August 2008 on several tributaries and main stem of the Snake River. GIS maps with high resolution imagery and site locations (transects) were provided to field crews for location of selected sites (Figure 1). At each site, beginning with the upstream transect, three crews performed sampling activities. One crew was assigned to the left bank, one crew assigned to the right bank, and one crew assigned to cover the transect distance between the two banks (center). The center crew anchored their craft for sampling (where conditions permitted) and relocated to new positions along the transect to complete sampling activities. The bank crews secured at shore sites and accessed the transect location at the bank, wading into the stream as much as possible. Once transect sampling activities were completed, the crews moved downstream to the next transect, maintaining their respective positions (left bank, right bank, and center). At the upstream transect of each site, GPS coordinates were obtained and recorded.

Figure1. An example of site selection design, consisting of a series of 11 transects placed at 250 m separation. The site (11 transects) covers a distance of approximately 40 times the river width, based on EPA EMAP sampling protocol.

At each transect, the following activities were completed: Each crew was issued an aerial photograph with marked, numbered transects for the site. Crews recorded site and transect number on field data sheets. Each crew recorded parameters for the transect area (10 x 10 m) on the field data sheet. One person used the underwater viewing box (Nuova Rade viewer) to determine if stalked diatoms appeared to be present in the transect area and results were recorded on field data sheets. For qualitative samples, a small area from the most dominant type of stream substrate (cobble, boulder) was scraped and placed in a sample vial. For quantitative samples, a tooth brush was used to scrape an area (20 cm^2) and collected. Quantitative measures of organic matter were estimated from 31 sites on Lake Creek and the Snake River. Samples were collected by scraping 20 cm^2 of benthic cobble surfaces within the survey site and preserved in 70% ETOH. Crews estimated the percent cover of stalked diatoms over the transect area and recorded on field data sheets. Where possible, the underwater camera was used to record appearance of benthic algal mats at each site and reference numbers for photos were recorded on field data sheets. Several hundred images were taken to document benthic coverage.

Sites on Lake Creek, where macroscopic stalked diatoms were present, were rated using a modification of the Kilroy Visual Index (Larned et al. 2006). The KVI combines a measure of the average thickness of diatom stalks and the percent areal coverage on a given stream transect. We report the percent cover, because thickness was difficult to access for a large number of sites in fast flowing water. Continuous visual qualitative observations were made by two members of the field crew from Jackson Lake Dam to Dead Man's Bar. Crew members (equipped with wetsuit, mask, snorkel, fins) checked for macroscopic growths along entire reach (except in sites of water hazards). The observations confirmed that transect sites were representative of each sub-reach of the river.

Laboratory processing. Samples were processed following established methods to remove organic matter and produce permanent microslides. Organic material was oxidized using 15 ml of 30% H_2O_2 in a digestion over 6 days (Renberg 1990). Following the digestion, deionized water was added to bring the total volume to 50 ml. The samples were allowed to settle for 8 hours, decanted, and rinsed with deionized water 6 times to remove H_2O_2. The cleaned sediments were well mixed by shaking and 0.500 ml was placed on glass cover slips. Two replicate cover slips were made for each of the 170 samples collected. The cover slips were allowed to dry and were mounted on glass microslides using a high refractive mounting medium (Zrax). Ash-free dry mass (AFDM) was measured on quantitative samples based on standard methods (Steinman and Lamberti, 1996).

Microscope analysis. Slides were examined under high magnification for diatom species identification using an Olympus VANOX microscope using a 100x oil objective (NA = 1.4) and DIC. Only large stalked diatoms were included in this survey, although archiving of samples allows for future, more complete community analysis. Estimates of abundance were made at lower power (40x) to determine presence of large, stalk-forming species.

Permanent archives. Permanent slides and cleaned material are archived in the University of Colorado INSTAAR Diatom Database (INSTAAR Accession 10836-10999). One set of slides will be provided to Grand Teton National Park for permanent records.

Data analysis, GIS, and final report. The geographic distribution of sites, their percentage cover of stalked diatom species, and species identification were used to produce a distribution map for Grand Teton National Park using ARC GIS.

✦ RESULTS

Visual field surveys showed a bloom of *D. geminata* present on Lake Creek during the survey period in August 2008. Coverage of *D. geminata* ranged from 20% of the stream transect at the outlet of Phelps Lake to 100% coverage at several sites downstream (Figure 2). Sites were surveyed in detail above and below the bridge crossing Lake Creek, showing that high coverage (> 60%) of the substrate occurred at both high and lower survey resolution. The bloom appeared to decline at the lowest site below Rockefeller Preserve, although we were not able to follow it to its decline, because of concern over crossing into private property.

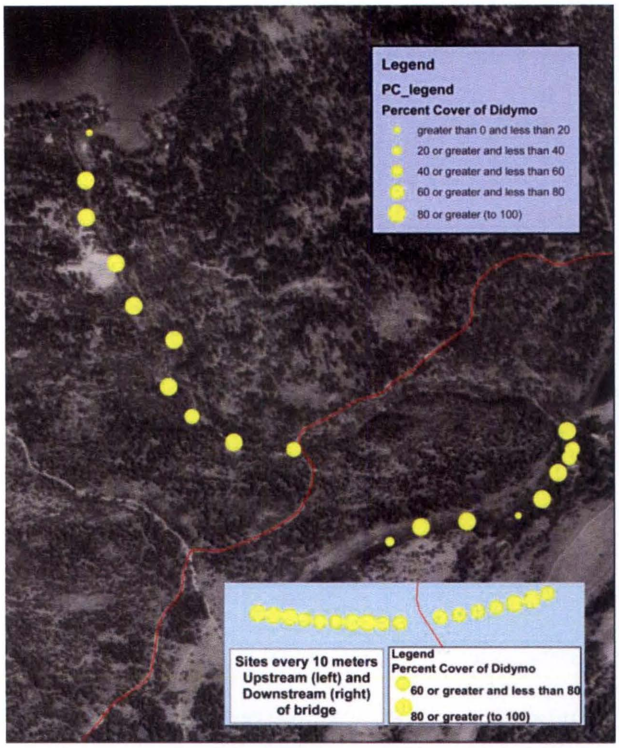

Figure 2. Image of the section of Lake Creek from Phelps Lake to below the Rockefeller Preserve. Macroscopic growths of *D. geminata* were present at all sites surveyed and the percent cover is indicated by the size of the solid circles. The inset shows the results from the detailed survey above and below the road and bridge crossing Lake Creek (red line).

The bloom of *D. geminata* in Lake Creek was typical of blooms from other sites in North America (Figure 3). Furthermore, many of the stalks were above water level, indicating that streamflow had declined since the period of growth (stalks are not formed above water level, but may persist there). Growths of this diatom may not be as visible under periods of high flow, but they can form large amounts of biomass which is later exposed by declining water levels. In contrast to other blooms in North America, a large number of Trichoptera (aquatic caddis fly larvae, likely of the genus *Brachycentrus*) were present in many survey sites, particularly below Rockefeller Preserve. The caddis fly larvae were apparently grazing on *D. geminata* cells and stalks with much of the biomass removed from the cobbles. This observation suggests that blooms of *D. geminata* may be moderated by these grazing macroinvertebrates.

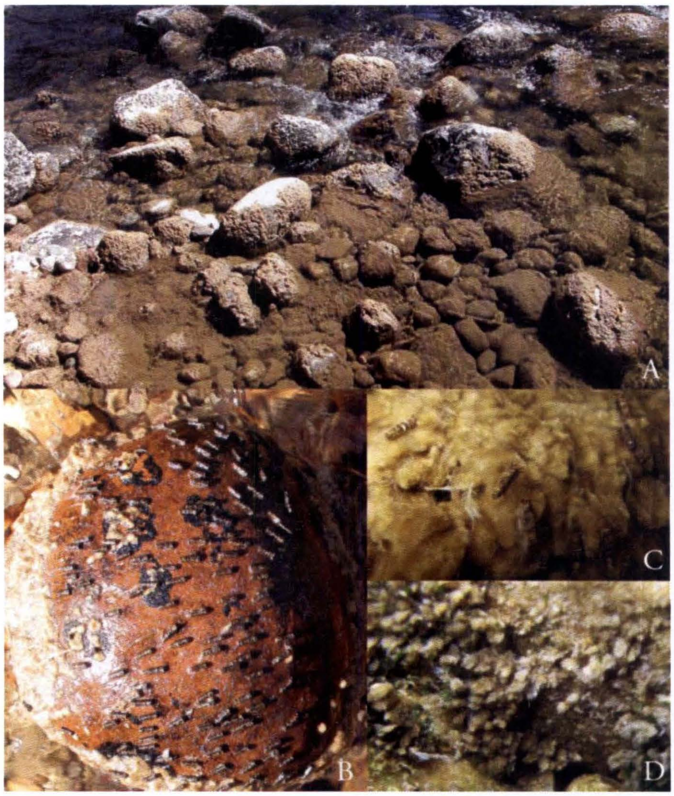

Figure 3. Images of the bloom of *Didymosphenia geminata* on Lake Creek in August 2008. A) Site at Lake Creek, near the Rockefeller Preserve with 80% coverage of the streambed by diatoms and their stalks. Note that some of the stalks are above water level, indicating that streamflow had declined since the period of growth (stalks are not formed above water level, but may persist there), B) Large number of Trichoptera (aquatic caddis fly larvae) apparently grazing on *D. geminata* cells and stalks, C) Underwater image diatoms, their stalks and caddis fly larvae and D) Underwater image diatoms, their stalks and caddis fly larvae.

One hundred and seventy samples (Appendix 1) were collected for microscopic analysis of cells. Slides were scanned for the presence of stalk forming diatoms, including several species of *Gomphoneis, Cymbella mexicana, C. janischii*, and *Gomphonema olivaceum*. These taxa are capable of forming macroscopic growths in streams, rivers and lakes. There were no large growths, however, observed of these taxa. The microscopic presence of *D. geminata* was confirmed in several Lake Creek sites, including Lake Creek above Phelps Lake, as well as in Kaufmann Creek and Taggart Creek. Surveys of the coverage and extent of cells at these sites, however, were not initiated.

An extensive survey of the Snake River was completed below Jackson Dam. No blooms or excessive growths were observed. Microscopic examination of slides from over 100 samples resulted in the confirmation of one cell of *D. geminata*. That sample (#10859), however, contained a silica frustule (cell wall) was rather degraded and likely does not represent a population in the Snake River itself. Permanent mounts of these samples and the raw material are archived at the INSTAAR Diatom Collection and serve as a resource to determine future expansion in range of *D. geminata*.

Thirty-one samples were analyzed for ash-free dry mass (AFDM) from Lake Creek and the Snake River (Figure 4). Sample values ranged from detection limits to 0.87 (grams/20 cm^2). While the samples that lack *D. geminata* were all below 0.2 grams/20 cm^2, samples with *D. geminata* present ranged up to several fold that concentration at 0.9 grams/20 cm^2. In other words, in sites with a bloom of *D. geminata*, the biomass produced reached greater values than at sites without *D. geminata*. The presence of this diatom is associated with high amounts of organic material produced in streams.

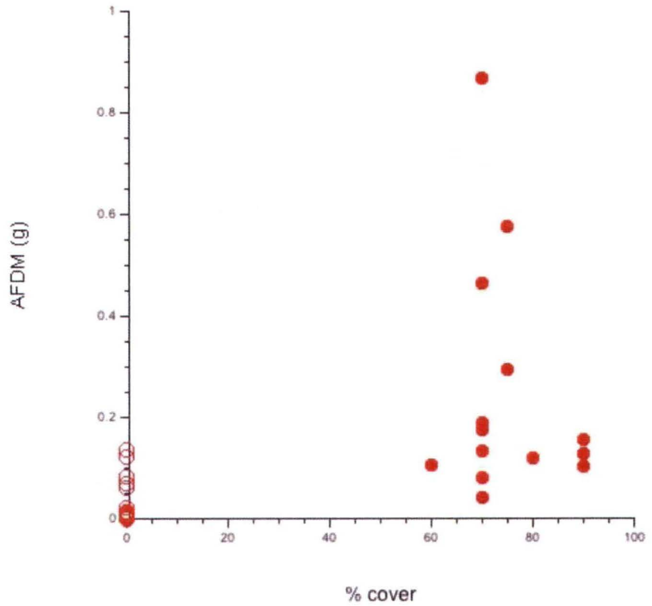

Figure 4. Plot of AFDM (grams/20 cm^2) against % cover of stalked diatoms from the Snake River (open circles) and Lake Creek (closed circles).

In addition to Lake Creek, other streams (Kaufmann Creek and Taggart Creek) had visible masses of *D. geminata*, but the stream extent and coverage was not quantified. Species identification was confirmed based on microscopic examination at those sites. The diatom was also confirmed in Fish Creek by microscopic examination; no visible masses were observed. Sites without both visible blooms and microscopic occurrences were at Arizona Creek, Spread Creek, Buffalo Fork, Cottonwood Creek, Snake River (with except of a single degraded cell) and the Gros Ventre River.

Although there have been attempts to relate the occurrence of *D. geminata* to specific water chemistry and geologic influence, chemical and physical factors seem to represent only a portion of the control on growth and distribution (Lindstrom 1991, Sherbot & Bothwell 1993, Jónsson et al. 2000, Kilroy 2004). Therefore, it is difficult to state whether water chemistry is controlling the formation of the blooms in GTNP. However, there is indication that these species may be favored under some conditions of increased human impact. Types of human influence that are associated with *D. geminata* blooms include increased nutrient concentration (Kara, & Şahin 2001, Kawecka & Sanecki 2003, Noga 2003, Subakov-Simić & Cvijan 2004), stable flow below impoundments (Dufford et al. 1987, Holderman & Hardy 2004, Shelby 2006), low flows (Kilroy et al. 2005a), and spread by aquatic

✦ CONCLUSIONS

We determined that a nuisance bloom of the diatom *Didymosphenia geminata* was present in Lake Creek from the outlet of Phelps Lake to approximately 1 km downstream of the Rockefeller Preserve. This bloom was considered "excessive" because the coverage of the stream substrate was 70% or above for greater than 1 km. At these sites the total amount of biomass (measured as AFDM) was up to six-fold the biomass found at sites without *D. geminata*.

recreationalists (Kilroy et al. 2005b, Kilroy et al. 2006, Larned et al. 2006). In particular, recent blooms on the east coast of the US in sites with heavy fishing pressure point to the role humans may play in spreading the diatom. The relationship, however, has not been fully documented (Bothwell, personal communication).

We know that *D. geminata* is able to survive out of water, and it may be transported on the gear of recreationalists (Kilroy et al. 2005b). In GTNP, this diatom was found in a high visitor use area, and there is the potential for the species to spread by anglers to other sites within the national park and other public and private lands. Although there are several factors that appear to influence its distribution, recent nuisance blooms of this species suggest popular angling sites are often sites of nuisance blooms. Decontamination of aquatic gear used by recreationalists should reduce the spread of *D. geminata* and the frequency of nuisance blooms within the national park system and adjacent public and private water bodies

✦ ACKNOWLEDGEMENTS

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APPENDIX 1. Sample site location and confirmation of *D. geminata* with microscopic examination.

INSTAAR accessnum	latitude	longitude	water body	site name	notes	date
10836	43.84455588	-110.517538	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 0 right bank		08/20/2008
10837	43.84035691	-110.515488	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 2 right bank		08/20/2008
10838	43.83605913	-110.5144012	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 4 right bank	Gomphoneis spp.	08/20/2008
10839	43.83232945	-110.5162783	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 6 right bank		08/20/2008
10840	43.83067456	-110.5218358	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 8 right bank		08/20/2008
10841	43.81513835	-110.5357418	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 10 right bank	Gomphoneis spp.	08/20/2008
10842	43.84455588	-110.517538	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 0 left bank	Gomphoneis spp.	08/20/2008
10843	43.84035691	-110.515488	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 2 left bank		08/20/2008
10844	43.83605913	-110.5144012	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 4 left bank		08/20/2008
10845	43.83232945	-110.5162783	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 6 left bank		08/20/2008
10846	43.83067456	-110.5218358	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 8 left bank		08/20/2008
10847	43.82835278	-110.5270475	Snake River	Pacific Landing to Deadman's Bar reach PLDB A 10 left bank		08/20/2008
10848	43.82738327	-110.530191	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 0 right bank		08/20/2008
10849	43.8242773	-110.5334694	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 2 right bank		08/20/2008
10850	43.81993012	-110.5333212	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 4 right bank		08/20/2008
10851	43.81647214	-110.5295916	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 6 right bank		08/20/2008
10852	43.81513835	-110.5357418	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 10 right bank		08/20/2008
10853	43.82738327	-110.530191	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 0 left bank		08/20/2008
10854	43.8242773	-110.5334694	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 2 left bank		08/20/2008
10855	43.81993012	-110.5333212	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 4 left bank		08/20/2008
10856	43.81647214	-110.5295916	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 6 left bank		08/20/2008
10857	43.81326116	-110.5320863	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 8 left bank		08/20/2008
10858	43.80901278	-110.5625906	Snake River	Pacific Landing to Deadman's Bar reach PLDB B 10 left bank	One cell – D. geminata	08/20/2008
10859	43.81444675	-110.5427566	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 2 right bank		08/20/2008
10860	43.81190267	-110.5477213	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 4 right bank		08/20/2008
10861	43.81064298	-110.5586633	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 8 right bank		08/20/2008
10862	43.80901278	-110.5625906	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 10 right bank		08/20/2008
10863	43.81646817	-110.5374271	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 0 left bank		08/20/2008
10864	43.81444675	-110.5427566	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 2 left bank		08/20/2008
10865	43.81190267	-110.5477213	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 4 left bank		08/20/2008
10866	43.80990198	-110.5533528	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 6 left bank		08/20/2008
10867	43.80901278	-110.5625906	Snake River	Pacific Landing to Deadman's Bar reach PLDB C 10 left bank		08/20/2008

10868	43.80652546	-110.5617988	Snake River	Pacific Landing to Deadman's Bar reach PLDB D 0 right bank	08/20/2008
10869	43.79972564	-110.5653076	Snake River	Pacific Landing to Deadman's Bar reach PLDB D 5 right bank	08/20/2008
10870	43.80652546	-110.5617988	Snake River	Pacific Landing to Deadman's Bar reach PLDB D 0 left bank	08/20/2008
10871	43.79972564	-110.5653076	Snake River	Pacific Landing to Deadman's Bar reach PLDB D 5 left bank	08/20/2008
10872	43.80006302	-110.5741966	Snake River	Pacific Landing to Deadman's Bar reach PLDB D 10 left bank	08/20/2008
10873	43.79814517	-110.5783102	Snake River	Pacific Landing to Deadman's Bar reach PLDB E 0 right bank	08/20/2008
10874	43.78572082	-110.5828692	Snake River	Pacific Landing to Deadman's Bar reach PLDB E 5 right bank	08/20/2008
10875	43.79814517	-110.5783102	Snake River	Pacific Landing to Deadman's Bar reach PLDB E 0 left bank	08/20/2008
10876	43.78572082	-110.5828692	Snake River	Pacific Landing to Deadman's Bar reach PLDB E 5 left bank	08/20/2008
10876	43.77690297	-110.5833632	Snake River	Pacific Landing to Deadman's Bar reach PLDB E 10 left bank	08/20/2008
10877	43.77657385	-110.5858459	Snake River	Pacific Landing to Deadman's Bar reach PLDB F 0 right bank	08/20/2008
10878	43.7704316	-110.5949721	Snake River	Pacific Landing to Deadman's Bar reach PLDB F 5 right bank	08/20/2008
10879	43.7704316	-110.5949721	Snake River	Pacific Landing to Deadman's Bar reach PLDB F 5 left bank	08/20/2008
10880	43.76131735	-110.6006531	Snake River	Pacific Landing to Deadman's Bar reach PLDB F 10 left bank	08/20/2008
10881	43.76025713	-110.6035316	Snake River	Pacific Landing to Deadman's Bar reach PLDB G 0 right bank	08/20/2008
10882	43.86153733	-110.5740036	Snake River	Jackson Dam to Pacific Landing reach JDPL A 5 left bank	08/20/2008
10883	43.86163161	-110.5653294	Snake River	Jackson Dam to Pacific Landing reach JDPL A 8 left bank	08/20/2008
10884	43.86034305	-110.5629094	Snake River	Jackson Dam to Pacific Landing reach JDPL A 9 left bank	08/20/2008
10885	43.8561945	-110.555178	Snake River	Jackson Dam to Pacific Landing reach JDPL B 1 left bank	08/20/2008
10886	43.85654022	-110.5522552	Snake River	Jackson Dam to Pacific Landing reach JDPL B 2 left bank	08/20/2008
10887	43.85823735	-110.5499609	Snake River	Jackson Dam to Pacific Landing reach JDPL B 3 left bank	08/20/2008
10888	43.84934312	-110.5375782	Snake River	Jackson Dam to Pacific Landing reach JDPL B 10 left bank - sample #1	08/20/2008
10889	43.84934312	-110.5375782	Snake River	Jackson Dam to Pacific Landing reach JDPL B 10 left bank - sample #2	08/20/2008
10890	43.84807404	-110.5347935	Snake River	Jackson Dam to Pacific Landing reach JDPL C 0 left bank	08/20/2008
10891	43.84871455	-110.5313868	Snake River	Jackson Dam to Pacific Landing reach JDPL C 1 left bank	08/20/2008
10892	43.84880884	-110.5281811	Snake River	Jackson Dam to Pacific Landing reach JDPL C 2 left bank	08/20/2008
10893	43.84846313	-110.5249125	Snake River	Jackson Dam to Pacific Landing reach JDPL C 3 left bank	08/20/2008
10894	43.84783456	-110.5218325	Snake River	Jackson Dam to Pacific Landing reach JDPL C 4 left bank	08/20/2008
10895	43.85690028	-110.5584696	Snake River	Jackson Dam to Pacific Landing reach JDPL B 0 right bank	08/20/2008
10896	43.8561945	-110.555178	Snake River	Jackson Dam to Pacific Landing reach JDPL B 1 right bank	08/20/2008
10897	43.85823735	-110.5499609	Snake River	Jackson Dam to Pacific Landing reach JDPL B 3 right bank	08/20/2008
10898	43.85999734	-110.5483267	Snake River	Jackson Dam to Pacific Landing reach JDPL B 4 right bank	08/20/2008
10899	43.8587402	-110.5456238	Snake River	Jackson Dam to Pacific Landing reach JDPL B 5 right bank	08/20/2008
10900	43.85635165	-110.5452467	Snake River	Jackson Dam to Pacific Landing reach JDPL B 6 right bank	08/20/2008
10901	43.85415166	-110.5444924	Snake River	Jackson Dam to Pacific Landing reach JDPL B 7 right bank	08/20/2008
10902	43.85236024	-110.542261	Snake River	Jackson Dam to Pacific Landing reach JDPL B 8 right bank	08/20/2008

10903	43.8509774	-110.540061	Snake River	Jackson Dam to Pacific Landing reach JDPL B 9 right bank		08/20/2008
10904	43.84934312	-110.5375782	Snake River	Jackson Dam to Pacific Landing reach JDPL B 10 right bank		08/20/2008
10904	43.84934312	-110.5375782	Snake River	Jackson Dam to Pacific Landing reach JDPL B 10 right bank		08/20/2008
10905	43.85826377	-110.5859682	Snake River	Jackson Dam to Pacific Landing reach JDPL A 0 left bank		08/20/2008
10906	43.85795449	-110.5827093	Snake River	Jackson Dam to Pacific Landing reach JDPL A 1 left bank		08/20/2008
10907	43.85720021	-110.5799436	Snake River	Jackson Dam to Pacific Landing reach JDPL A 2 left bank		08/20/2008
10908	43.86012305	-110.5760151	Snake River	Jackson Dam to Pacific Landing reach JDPL A 4 left bank		08/20/2008
10909	43.86087733	-110.5712065	Snake River	Jackson Dam to Pacific Landing reach JDPL A 6 left bank		08/20/2008
10910	43.86163161	-110.5684408	Snake River	Jackson Dam to Pacific Landing reach JDPL A 7 left bank		08/20/2008
10911	43.85839449	-110.560898	Snake River	Jackson Dam to Pacific Landing reach JDPL A 10 left bank		08/20/2008
10912	43.7602494	-110.6276562	Snake River	DB to Moose reach DBMO A 0 left bank		08/20/2008
10913	43.75625323	-110.6282153	Snake River	DB to Moose reach DBMO A 2 left bank		08/20/2008
10914	43.75625323	-110.6282153	Snake River	DB to Moose reach DBMO A 2 right bank		08/20/2008
10915	43.75294252	-110.6296835	Snake River	DB to Moose reach DBMO A 4 left bank		08/20/2008
10916	43.75294252	-110.6296835	Snake River	DB to Moose reach DBMO A 4 right bank		08/20/2008
10917	43.75346072	-110.635758	Snake River	DB to Moose reach DBMO A 6 left bank		08/20/2008
10918	43.75346072	-110.635758	Snake River	DB to Moose reach DBMO A 6 right bank		08/20/2008
10919	43.7542668	-110.6418324	Snake River	DB to Moose reach DBMO A 8 left bank		08/20/2008
10920	43.7542668	-110.6418324	Snake River	DB to Moose reachDBMO A 8 right bank		08/20/2008
10921	43.79064468	-110.538105	Spread Creek			08/20/2008
10922	43.83818272	-110.5122158	Buffalo Fork			08/20/2008
10923	43.69306121	-110.7313942	Cottonwood Creek			08/20/2008
10924	43.58409465	-110.7129389	Gros Ventre	side channel		08/20/2008
10927	43.75219401	-110.6472159	Snake River	DB to Moose reach DBMO A 10 left bank		08/20/2008
10928			Lake Creek	Lake Creek down from bridge 01 quant.	D. geminata	08/18/2008
10929			Lake Creek	Lake Creek down from bridge 02 quantitative	D. geminata	08/18/2008
10930			Lake Creek	Lake Creek down from bridge 03 quantitative	D. geminata	08/18/2008
10931			Lake Creek	Lake Creek down from bridge 04 quantitative	D. geminata	08/18/2008
10932			Lake Creek	Lake Creek down from bridge 05 quant.	D. geminata	08/18/2008
10933			Lake Creek	Lake Creek down from bridge 06 quant.	D. geminata	08/18/2008
10934			Lake Creek	Lake Creek down from bridge 07 quant.	D. geminata	08/18/2008
10935			Snake River	PLDB D 5 C qualitative sample		08/20/2008
10936	43.62610846	-110.7857077	Lake Creek	Lake Creek up from bridge A quant.	D. geminata	08/20/2008
10937	43.62678509	-110.786796	Lake Creek	Lake Creek up from bridge B quant.	D. geminata	08/20/2008
10938	43.62755324	-110.7874092	Lake Creek	Lake Creek up from bridge C quant.	D. geminata	08/20/2008
10939	43.62877504	-110.7872648	Lake Creek	Lake Creek up from bridge D quant.	D. geminata	08/20/2008
10940	43.62966231	-110.7883079	Lake Creek	Lake Creek up from bridge E quant.	D. geminata	08/20/2008
10941	43.63077242	-110.7887709	Lake Creek	Lake Creek up from bridge F quant.	D. geminata	08/20/2008
10942	43.63416222	-110.7894559	Lake Creek	Lake Creek up from bridge H		08/20/2008
10943	43.85795449	-110.5827093	Snake River	JDLP A 1 L quant.		08/19/2008
10944	43.84880884	-110.5281811	Snake River	JDLP C 2 L quant.		08/19/2008
10945	43.86034305	-110.5629094	Snake River	JDLP A 9 L quant.		08/19/2008
10946	43.85720021	-110.5799436	Snake River	JDLP A 2 L quant.		08/19/2008
10948	43.86012305	-110.5760151	Snake River	JDLP A 4 L quant.		08/19/2008
10949			Snake River	JDLP A 0 L quant.		08/19/2008
10950	43.86163161	-110.5684408	Snake River	JDLP A 7 L quant.		08/19/2008
10951	43.85789164	-110.5768636	Snake River	JDLP A 3 L quant.		08/19/2008
10951	43.85789164	-110.5768636	Snake River	JDLP A 3 L quant.		08/19/2008
10952	43.86087733	-110.5712065	Snake River	JDLP A 6 L quant.		08/19/2008

10953	43.85823735	-110.5499609	Snake River	JDLP B 3 L quant.		08/19/2008
10954	43.85690028	-110.5584696	Snake River	JDLP B 0 L quant.		08/19/2008
10954	43.85690028	-110.5584696	Snake River	JDLP B 0 L quant.		08/19/2008
10955	43.8587402	-110.5456238	Snake River	JDLP B 5 L quant.		08/19/2008
10956	43.86163161	-110.5653294	Snake River	JDLP A 8 L quant.		08/19/2008
10957	43.84783456	-110.5218325	Snake River	JDLP C 4 L quant.		08/19/2008
10958	43.84846313	-110.5249125	Snake River	JDLP C 3 L quant.		08/19/2008
10959	44.10212638	-110.6726082	Snake River	Snake River above Jackson Lake FRJL A 2		08/17/2008
10960	44.10348869	-110.6822655	Snake River	Snake River above Jackson Lake FRJL A 5-6		08/17/2008
10961	43.8587402	-110.5456238	Snake River	Jackson Dam to Pacific Landing JDPL B 5 center		08/17/2008
10962	43.62640	110.77702	Lake Creek	Lake Creek at Rockefeller Preserve Trailhead #6	D. geminata	08/17/2008
10963	43.8587402	-110.5456238	Snake River	Jackson Dam to Pacific Landing JDPL B 5 center		08/20/2008
10964			Snake River	Jackson Dam to Pacific Landing JDPL A 0 right		08/20/2008
10965	43.85795449	-110.5827093	Snake River	Jackson Dam to Pacific Landing JDPL A 1 right		08/20/2008
10966	43.85720021	-110.5799436	Snake River	Jackson Dam to Pacific Landing JDPL A 2 right		08/20/2008
10967	43.85789164	-110.5768636	Snake River	Jackson Dam to Pacific Landing JDPL A 3 right		08/20/2008
10968	43.85789164	-110.5768636	Snake River	Jackson Dam to Pacific Landing JDPL A 3 right		08/17/2008
10969	43.86012305	-110.5760151	Snake River	Jackson Dam to Pacific Landing JDPL A 4 right		08/17/2008
10970	43.86087733	-110.5712065	Snake River	Jackson Dam to Pacific Landing JDPL A 6 right		08/17/2008
10971	43.86163161	-110.5684408	Snake River	Jackson Dam to Pacific Landing JDPL A 7 right		08/17/2008
10972	43.86163161	-110.5653294	Snake River	Jackson Dam to Pacific Landing JDPL A 8 right		08/17/2008
10973	43.86034305	-110.5629094	Snake River	Jackson Dam to Pacific Landing JDPL A 9 right		08/17/2008
10974	43.85839449	-110.560898	Snake River	Jackson Dam to Pacific Landing JDPL A 10 right		08/17/2008
10975	43.7602494	-110.6276562	Snake River	Deadman's Bar to Moose DBMO A 0 right		08/17/2008
10975	43.7602494	-110.6276562	Snake River	Deadman's Bar to Moose DBMO A 0 right		08/17/2008
10976	43.75113826	-110.649403	Snake River	Deadman's Bar to Moose DBMO B 0 right		08/17/2008
10977	43.75113826	-110.649403	Snake River	Deadman's Bar to Moose DBMO B 0 left		08/17/2008
10978	43.74318351	-110.6559907	Snake River	Deadman's Bar to Moose DBMO B 4 right		08/17/2008
10979	43.74704081	-110.6523115	Snake River	Deadman's Bar to Moose DBMO B 2 left		08/17/2008
10979	43.74704081	-110.6523115	Snake River	Deadman's Bar to Moose DBMO B 2 left		08/17/2008
10980	43.74704081	-110.6523115	Snake River	Deadman's Bar to Moose DBMO B 2 lright		08/17/2008
10981	43.73334449	-110.6621454	Snake River	Deadman's Bar to Moose DBMO C 0 left		08/17/2008
10983	43.84871455	-110.5313868	Snake River	Jackson Dam to Pacific Landing JDPL C 1 right		08/17/2008
10984	43.84880884	-110.5281811	Snake River	Jackson Dam to Pacific Landing JDPL C 2 right		08/17/2008
10985	43.84846313	-110.5249125	Snake River	Jackson Dam to Pacific Landing JDPL C 3 right		08/17/2008
10985	43.84846313	-110.5249125	Snake River	Jackson Dam to Pacific Landing JDPL C 3 right		08/17/2008
10986	43.84783456	-110.5218325	Snake River	Jackson Dam to Pacific Landing JDPL C 4 right		08/17/2008
10987	43.84635743	-110.5193497	Snake River	Jackson Dam to Pacific Landing JDPL C 5 right		08/17/2008
10988	43.97339183	-110.645612	Arizona Creek	Arizona 2		08/17/2008
10989	43.97339183	-110.645612	Chris Creek	Arizona 2		08/17/2008
10990			Snake River	Snake River below Jackson Dam		08/17/2008
10991			Snake River	Snake River below Jackson Dam		08/21/2008
10992	43.60477	110.79350	Lake Creek	5 Lake Creek at Granite Trailhead	D. geminata	08/21/2008
10993	43.49794	110.87268	Fish Creek	1 Fish Creek at Teton Village		08/21/2008
10994	43.54662	100.82227	Fish Creek	2 Fish Creek	D. geminata	08/21/2008
10995	43.61884466	-110.7892574	Kaufmann Creek		D. geminata	08/22/2008
10996	43.69679273	-110.7360295	Taggart Creek 300 m upstream of bridge		D. geminata	08/22/2008
10997	43.650095	-110.806122	Phelps Lake			08/22/2008
10998			Phelps Lake	Lake Creek above Phelps Lake	D. geminata	08/22/2008
10999	43.58467	110.82468	Fish Creek	3 Fish Creek at Teton Village		08/22/2008