CACHE CREEK NATURE PRESERVE
MERCURY MONITORING PROGRAM

YOLO COUNTY, CALIFORNIA

FOURTH SEMI-ANNUAL DATA REPORT
(SPRING – SUMMER 2002)

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prepared for

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Study and Report by

Darell G. Slotton, Ph.D. *

and

Shaun M. Ayers

* *(530) 756-1001 dgslotton@ucdavis.edu*

EXECUTIVE SUMMARY

This fourth semi-annual report marks the completion of two years of this three year mercury study at the Cache Creek Nature Preserve and environs. In this work, which began in the fall of 2000, mercury bioaccumulation has been characterized within the Nature Preserve wetlands in eight quarterly samplings to date. A more extensive additional series of collections was made semi-annually at strategically located adjacent sites (four events to date). The data collected thus far indicate that Gordon Slough is typically a significantly lower mercury environment than adjacent Cache Creek. Mercury bioaccumulation in the Nature Preserve has been substantially elevated over that in its source water environment (Gordon Slough), bringing it to a level similar to that found in Cache Creek. Water samples showed an approximate 30% elevation in methylmercury in Preserve wetlands outflow vs inflow. The Nature Preserve has thus functioned to some extent as a source of methylmercury. This is consistent with most wetland environments. A localized elevation in invertebrate mercury bioaccumulation has been occasionally noted in Cache Creek immediately downstream of the Nature Preserve outlet. However, a short distance downstream of that location, in Cache Creek below Gordon Slough, mercury bioaccumulation in both invertebrates and fish has consistently been similar to or lower than corresponding levels in Cache Creek upstream of the project.

A fascinating seasonal trend is becoming apparent in the long-term data. The small fish exhibited a pronounced drop in their mercury levels in both spring samplings to date, relative to preceding fall collections. The fall concentrations were generally between 50% and over 400% greater than corresponding spring levels. We believe that these trends in the fish data are actually offset by a period of one to several months from the underlying cycles of mercury methylation and bioavailability. Other project data are consistent with these cycles being maximal in the mid-summer and lowest in the winter. The invertebrate data did not consistently capture these apparent seasonal trends. This may be due to a more rapid equilibration between mercury exposure conditions and bioaccumulation in these organisms.

As initiated in the previous semi-annual period, organic (methyl) mercury analyses have been added to the standard total mercury assays for biological samples. As seen in the last report, these additional data again closely followed the total mercury values, at high percentages of the total mercury concentrations. Data interpretation would be very similar using either mercury parameter as a monitoring tool. However, we felt that it was important, for this demonstration wetland effects study, to obtain a solid set of representative methyl vs total mercury data.

Also because of the likely future importance of this demonstration project, we continued to conduct substantially increased numbers of some of the analyses relative to the numbers required (282 mercury analyses this period vs the contracted 75), in order to obtain tighter confidence intervals, facilitating the statistical differentiation of mercury exposure conditions between individual sites and dates.

BACKGROUND AND INTRODUCTION

The Cache Creek Nature Preserve is a constructed wetland reserve in Yolo County, built in 1999-2000 at the site of a former gravel mining operation. It is located between Gordon Slough and Cache Creek, just west of County Road 94B and the Gordon Slough-Cache Creek confluence, on the north side of Cache Creek. The Preserve was built to provide new habitat for wildlife and recreational and educational opportunities for the public. A contoured pond system with several islands was created and landscaped with native vegetation. A visitor's center and a system of walkways and overlooks were built. The Preserve has attracted numerous wildlife species and is becoming a popular educational and recreational destination.

As constructed, the wetland is intended to occasionally have its water exchanged between the months of approximately April and September (irrigation season). During these months, water is periodically diverted from Gordon Slough to the wetland, exiting the wetland to Cache Creek approximately 0.5 km upstream of the Gordon Slough - Cache Creek confluence. Gordon Slough is a seasonally operated irrigation drainage canal, which contains agricultural return flows of water that originates from upstream Cache Creek. Wetland water exchanges typically occur for 1/2 – 2 days and are conducted one or two times per month during irrigation season. It is notable that this year, following an initial flushing of the system in the spring of 2002, no further water exchanges were conducted.

Cache Creek is known to transport seasonally elevated loads of mercury (Hg) from historic mining districts in the upper watershed (Slotton et al. 1997, Foe and Croyle 1998). Consequently, there is a general interest in mercury and mercury bioaccumulation throughout the watershed. Because wetland habitats have been demonstrated to enhance the conversion of inorganic mercury to bioaccumulating methylmercury in certain environments (Rudd 1995), it was felt that the issues of mercury and mercury bioaccumulation should be investigated at the Cache Creek Nature Preserve, both within the Preserve wetlands and in adjacent Cache Creek upstream and downstream of the Nature Preserve outlet. Mercury dynamics in this wetland are additionally of interest as a model that may help in the planning of potential future wetland preserves at other sites in the region.

A three-year mercury monitoring study was initiated in the fall of 2000. The primary purpose of this monitoring program is to indicate the potential role, if any, that Nature Preserve water discharges may have on mercury levels in adjacent Cache Creek. Secondarily, the study seeks to quantify the relative changes, if any, in mercury bioaccumulation within the constructed wetland system itself, relative to conditions in both its source waters and adjacent Cache Creek. The monitoring includes a series of quarterly collections, with data reports issued semi-annually. This is the fourth of these reports. In it, we discuss findings from collections made in Spring and Summer 2002, and compare to results from previous sampling for the project (Fall 2000 through Winter 2002).

METHODS

As designed, the monitoring program focuses on mercury levels in selected types of localized aquatic biota as the primary indicators of relative mercury conditions at several key locations. These locations are:

- Cache Creek upstream of the Preserve and the Preserve water outlet.
- Gordon Slough, near the Preserve intake and the confluence with Cache Creek.
- The Nature Preserve wetlands.
- Cache Creek downstream of Gordon Slough and the Preserve.

The Cache Creek sites for invertebrate collections are located approximately 1 km upstream of the Preserve and 1 km downstream (~0.7 km downstream of the Cache Creek - Gordon Slough confluence). Small fish are taken along the Creek from these points and continuing away from the Preserve for a further 0.3-0.7 km. An additional site was added for invertebrate sampling only at:

- Cache Creek between the Preserve outlet and the Gordon-Cache confluence.

Fish cannot be effectively sampled from this intermediate site because (a) the reach between the Preserve outlet and the Cache-Gordon confluence is too small to contain sufficient, reliable samples and (b) due to fish movement, it is not possible to ensure that samples taken in this location are not derived from adjacent sites upstream and downstream. However, with some effort, it has been possible to collect adequate samples of invertebrate bioindicators that we believe are representative of mercury exposure conditions at the intermediate stretch of Cache Creek just downstream of the Preserve outlet.

By comparing mercury concentrations in similar local biota taken at the different sites, it can be determined whether statistically significant differences exist among the sites. The potential role of Nature Preserve water discharges on mercury levels in Cache Creek can also be assessed.

All of the sites are scheduled for sampling on a semi-annual basis, once in the fall and once in the spring. Because aquatic organisms accumulate their mercury burdens over time, biotic sampling can provide information on average conditions throughout the previous months. The fall samplings are intended to integrate relative mercury bioaccumulation throughout the warm season period of irrigation flows and maximal biological activity . The spring collections monitor conditions during the previous cool season, when the Preserve is not designed to exchange water. Supplementing the primary multi-site, semi-annual collections are additional quarterly samplings from the Nature Preserve wetlands site alone, conducted in summer and winter.

The target biota for use as mercury bioindicators in this project are small or juvenile fishes and aquatic insects that tend to remain within fairly localized ranges. These organisms have been found to be ideal monitoring tools to indicate relative mercury bioaccumulation between locations, in numerous research studies by the authors throughout California and by other researchers elsewhere. Because these organisms are generally well under a year old when collected, they can also reflect potential seasonal changes in mercury exposure more directly than large fish. In contrast, large fish mercury burdens represent the combined mercury accumulations of several years time. Large fish are also far less likely to have remained in the immediate sampling region throughout their lives.

The localized availability of potential mercury bioindicator species was determined at each of the sites in the initial Fall 2000 work. Sampling was directed at taxa that were prevalent and would not be impacted by collections. Efforts have been made to collect similar sample types from the different sites and between collection dates. Whenever possible, composite samples of multiple individuals were collected. For the samples that were most inter-comparable between sites and/or dates, replicate composites were taken when possible. When three or more identical composites could be taken, each containing multiple small individual fish or invertebrates, statistical confidence intervals of the mean mercury levels were determined.

Benthic aquatic insects were collected with research kick screens and various nets. Small fishes were taken using a backpack electro-shock unit, beach seines, and other nets. Samples were identified, measured, cleaned, and sorted using well-established laboratory protocols. Composite samples were prepared and analyzed for both total and methyl mercury at the UC Davis Environmental Mercury Laboratory. Research-level Quality Assurance / Quality Control (QA/QC) was employed throughout.

Following the first year of the project, in which we analyzed strictly for total mercury according to the monitoring protocol, the concern was raised that tracking of total mercury alone in project bioindicator samples might not provide an accurate measure of methylmercury trends. We have therefore conducted double analyses of all samples since that time, generating both organic (methyl) and total mercury data. Using our extensively tested procedures, we run both total and methyl fractions for each sample within the same analytical run, thereby further reducing potential laboratory-based variability. Additionally, because of high levels of natural variability seen occasionally in the creek invertebrate samples, all of the invertebrate analyses were further done in duplicate, using laboratory split samples. This doubled the analytical load but improved the statistical confidence intervals for each sample.

RESULTS AND DISCUSSION

This fourth semi-annual data report discusses samples taken in the spring (May 15-17 plus April 18 for water only) and summer (August 20) of 2002. A total of 75 composite fish samples, each consisting of multiple similar individual small fish, were prepared and analyzed from the four fish sampling locations in Spring 2002. Thirty-three composite samples of aquatic insects were assembled from the spring collections as well. Summer 2002 collections at the Nature Preserve site alone included 33 composite samples of fish. Samples analyzed for both total and methyl mercury during this reporting period are summarized in Table 1 (below). Additional data tables and associated figures are presented together following the text. Figures 6(a-e) and 7(a-c) compare selected parameters seasonally across the entire monitoring project to-date.

Table 1. Summary of Biological Samples Analyzed for Mercury in This Six Month Period (Spring and Summer 2002 Collections).

Site	Small Fish Composites	Aquatic Insect Composites	**Totals**
SPRING 2002			
Cache Ck upstream of Preserve	15	11	**26**
Gordon Slough	16		**16**
Nature Preserve Wetlands	31		**31**
Cache Ck btw. Preserve & Gordon Sl.		11	**11**
Cache Ck downstream of Gordon Sl.	13	11	**24**
TOT. SPRING 2002 SAMPLES (108 total):	**75**	**33**	**108**
SUMMER 2002			
Nature Preserve Wetlands	33		**33**
TOT. SUMMER 2002 SAMPLES (33 total):	**33**		**33**
TOTAL SAMPLES FOR THg (141 total):	**108**	**33**	**141**
TOTAL SAMPLES FOR MeHg (141 total):	**108**	**33**	**141**

These 141 total mercury and 141 methylmercury samples were prepared and analyzed using research levels of QA/QC. Associated QA/QC data are presented in Table 2(a-b). No problems were encountered in the analyses and the associated data for the last two quarters of sampling, as those from the preceding quarters, can be treated as very reliable.

SITE TO SITE (SPATIAL) VARIATION IN MERCURY

Mercury in Small/Juvenile Fishes

The new multi-site fish mercury data from Spring 2002 are presented in Tables 3-7 and are shown graphically in Figures 1-4. In fish sampling since Year 1, we are focusing our efforts on non-native species that can be obtained in replicate composites from the maximum number of sites. While the composite samples were all powdered and analyzed on a dry weight basis for consistency, the values as presented have been converted to wet (fresh) weight concentrations so as to be comparable to various guidelines. Moisture percentage was determined for each individual sample to convert the consistent data from the dry, powdered samples to a fresh/wet weight basis. Replicate composite samples were generally similar in mercury concentration. The data are displayed so as to allow inter-comparison of the sites and dates, for each sample type. The added parameter of methylmercury will be additionally discussed in a following section, though it can be summarized as having virtually mirrored the total mercury data, at a consistent high percentage of corresponding total mercury. Identical mercury trends were described by both data sets and either would lead to the same conclusions. Below, we discuss the data trends relative to total mercury, corresponding to the previous three reports.

Red shiners (Table 3, Figure 1) were initially the most readily available of the fish species present at all of the fish sampling locations. And, being an invasive, non-native species, we could sample intensively without impacting the local aquatic environment. This species thus provided the strongest measure of inter-site variability in fish mercury bioaccumulation. Red shiners have remained abundant at the Gordon Slough and Cache Creek sites but, over the course of the project, shiners in the Nature Preserve itself have declined to low densities. They were initially largely displaced by fathead minnows as the new wetlands evolved. Parallel sampling has been conducted with both species to the extent possible during the period of overlap. It appears now that both of these indicator species may be disappearing at the Preserve site, which continues to evolve. Red shiners remain an excellent indicator species at the Gordon Slough and Cache Creek sites.

In the Spring 2002 sampling, it was possible to obtain 4-5 multi-individual composite samples of the same 36-50 mm size class of red shiners at each of the creek and slough sites, each consisting of 10-15 individual small fish. Similarly, 3-5 composites of the larger size class (51-65 mm) were taken, also relative to availability. Spring 2002 data are shown in Table 3 and are plotted in Figure 1. Mercury concentrations ranged between 0.04 and 0.09 ppm among all 33 of the red shiner multi-individual composite samples. Following the evolving pattern of the last two years of sampling, this was dramatically lower than the results from Fall 2002, which were approximately three fold greater at 0.08-0.30 ppm. Within the low and narrow range of Spring 2002 red shiner concentrations, replication was generally excellent between replicate composites, providing statistical confidence intervals with precision relatively proportional to number of replicate composites and number of individuals per composite.

The larger size class (51-65 mm, Class 3) exhibited slightly higher concentrations than the mid-size class (36-50 mm, Class 2) at all of the sites. The elevation was statistically significant at the Nature Preserve and Cache below Gordon Slough sites. Between sites for same size classes, the Spring 2002 data set also exhibited some statistical differences. Most notably, shiners of both size classes from the Nature Preserve site were statistically elevated relative to identical samples from Gordon Slough and both Cache Creek sites. This elevation ranged from 34-64%. Methylmercury spatial trends followed those seen for total mercury and were also statistically significant.

Fathead minnow data from the Spring 2002 collections are displayed in Table 4 and are shown graphically in Figure 2. This species was primarily available from the Nature Preserve wetlands, where it was possible to obtain triplicate composite samples for both mid and large size classes (15 individuals per composite). Concentrations were extremely similar among all of the composites, ranging from 0.05-0.06 ppm. The larger size class was somewhat higher in mercury concentration than the mid size class, though the difference was not statistically significant. As compared to Nature Preserve red shiners of the same sizes, the Spring 2002 fathead minnows were approximately 32% lower in overall mercury levels (0.05-0.06 vs. 0.08-0.09 ppm). The same trends were apparent in the methylmercury data.

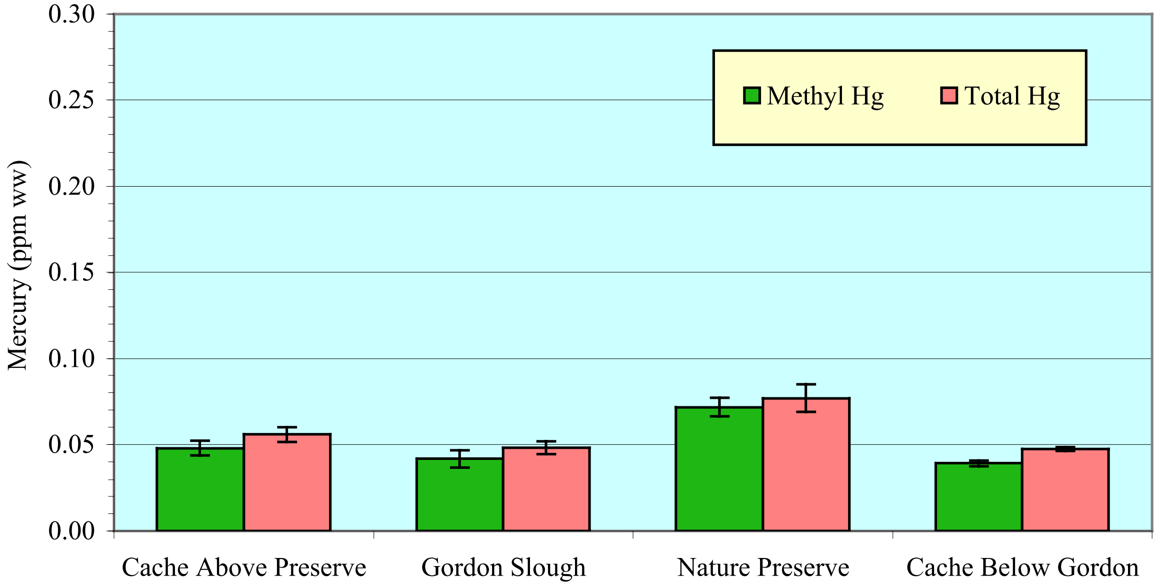
Juvenile green sunfish (Table 5, Figure 3) were taken at all four of the fish sampling sites in the Spring 2002 sampling. This species was collected in numbers sufficient to provide statistical confidence intervals for two of four sites among the smaller size class (25-50 mm) and at all four of the sites for the larger class (51-80 mm). Mercury concentrations from Spring 2002 ranged between 0.05 and 0.09 ppm and were fairly consistent between these two size classes at each site. Within this relatively low range of concentrations, similar mercury levels were found at Gordon Slough, Cache Creek below Gordon Slough, and the Nature Preserve. The Cache Creek site above the Preserve was relatively elevated, with the difference being significant vs the Gordon Slough and Nature Preserve samples in the Class 2 fish for which confidence intervals could be calculated. Methylmercury trends followed those of total mercury, continuing at a high percentage of total mercury (81-98%).

Mosquitofish (Table 6, Figure 4) remained very difficult to obtain in the spring season, particularly at the Cache Creek and Gordon Slough sites. Only single composites of relatively low numbers of individuals (2-8) were obtainable from the upper Cache Creek and Gordon Slough sites at this time. No mosquitofish could be found from Cache Creek downstream of Gordon Slough. Within the Nature Preserve itself, it was possible to collect excellent, triplicate composites of 15-18 individuals each for both Size Class 1 (20-30 mm) and 2 (31-40 mm), allowing construction of 95% statistical confidence intervals. Concentrations in the Spring 2002 samplings ranged between 0.04 and 0.10 ppm across the three sites where samples were collected. Among this relatively low range of overall concentrations, mosquitofish from Gordon Slough uncharacteristically exhibited the highest levels for both Size Class 1 and 2. Also interesting was the presence of greater mercury concentrations in the smaller Class 1 fish, relative to Class 2, at both the Nature Preserve and Gordon Slough. For the sets which could be statistically compared (Nature Preserve), the relative elevation in the small class was statistically significant. This is evidence for a recent relative increase in methylmercury exposure, which will be most dramatic in the smallest sizes. The divergence from larger fish occurs because the tiny fish, by virtue of their short lives to-date, have received most or all of their mercury bioaccumulation under the recent exposure conditions. For the larger fish, which have accumulated mercury over an extended time, recent conditions can only partially determine their overall concentrations. If exposure conditions change dramatically, either up or down, the smallest/youngest fish will show the most dramatic corresponding change, while larger fish will typically exhibit a more muted response. Mosquitofish methylmercury trends were identical to those seen for total mercury, continuing at a high percentage of total mercury (87-96%).

Inland Silversides (Table 7) have been increasing gradually in the Nature Preserve environment, though they continued to occur in numbers too few for adequate sampling at the stream sites. Like the other species utilized in this project for long-term bioindicator monitoring, silversides are a non-native, introduced fish species. Silversides were sampled in the Nature Preserve during this Spring 2002 collection to obtain some comparative mercury information within the wetland environment. Triplicate, multi-individual composite samples were obtainable for the medium size class present (51-65 mm), with single composite samples of multiple individuals from smaller (41-50 mm) and larger (66-80 mm) sizes. The 41-50 mm silversides had 0.04 ppm mercury, the 51-65 mm size class averaged 0.05 ppm, and the 66-80 mm fish contained 0.07 ppm. These relatively low concentrations were comparable to those from most of the other fish samples taken from the Nature Preserve in the Spring 2002 sampling. Also as in the other samples, methylmercury was found at a high percentage of total mercury (91-97%).

Fig. 1. FISH Composite Hg (wet wt ppm) VS LOCATION
Red Shiner (*Notropis lutrensis*)
(mean values plotted for replicate composites)
(95% confidence intervals shown for samples with ≥3 replicates)

1(a). Red Shiner 36-50 mm size class.



1(b). Red Shiner 51-65 mm size class.

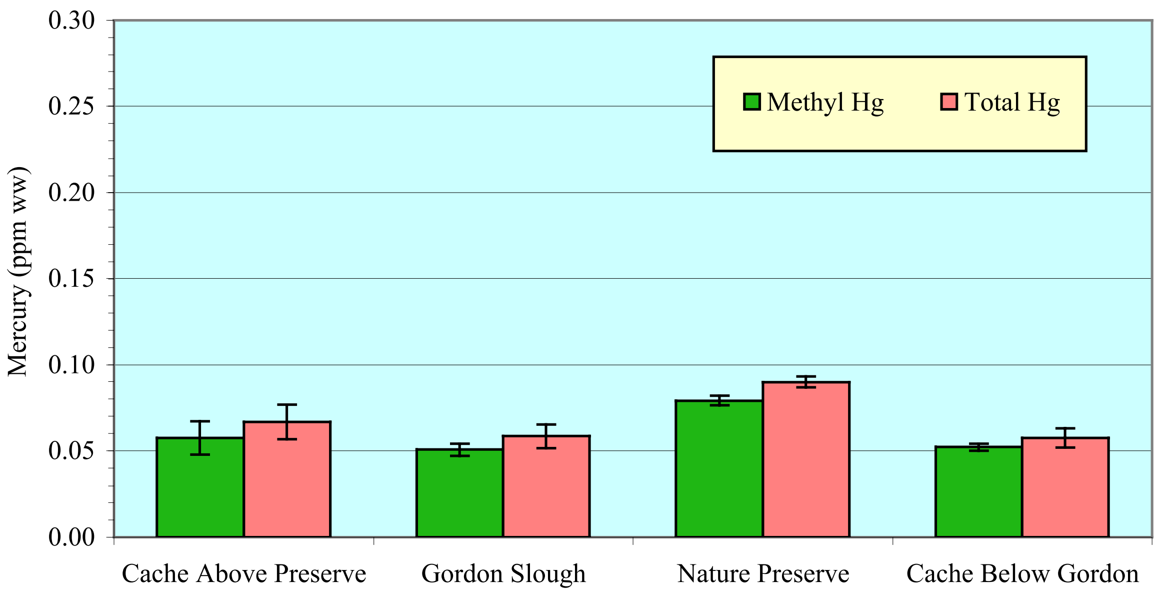
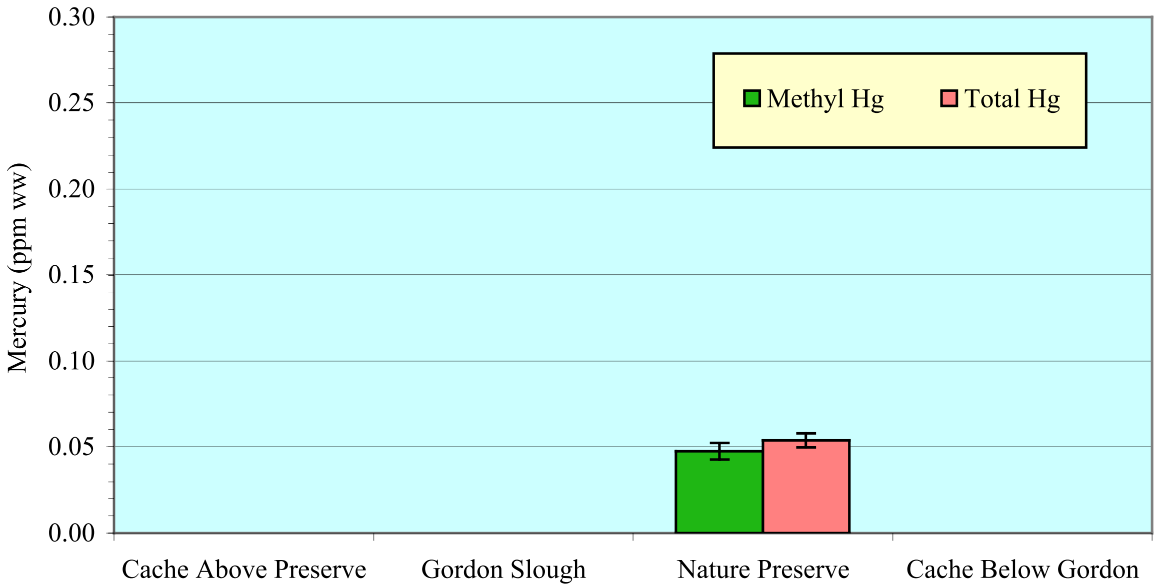


Fig. 2. FISH Composite Hg (wet wt ppm) VS LOCATION
<u>Fathead Minnow</u> (*Pimephales promelas*)
(mean values plotted for replicate composites)
(95% confidence intervals shown for samples with ≥3 replicates)

2(a). Fathead Minnow 36-50 mm size class.



2(b). Fathead Minnow 51-65 mm size class.

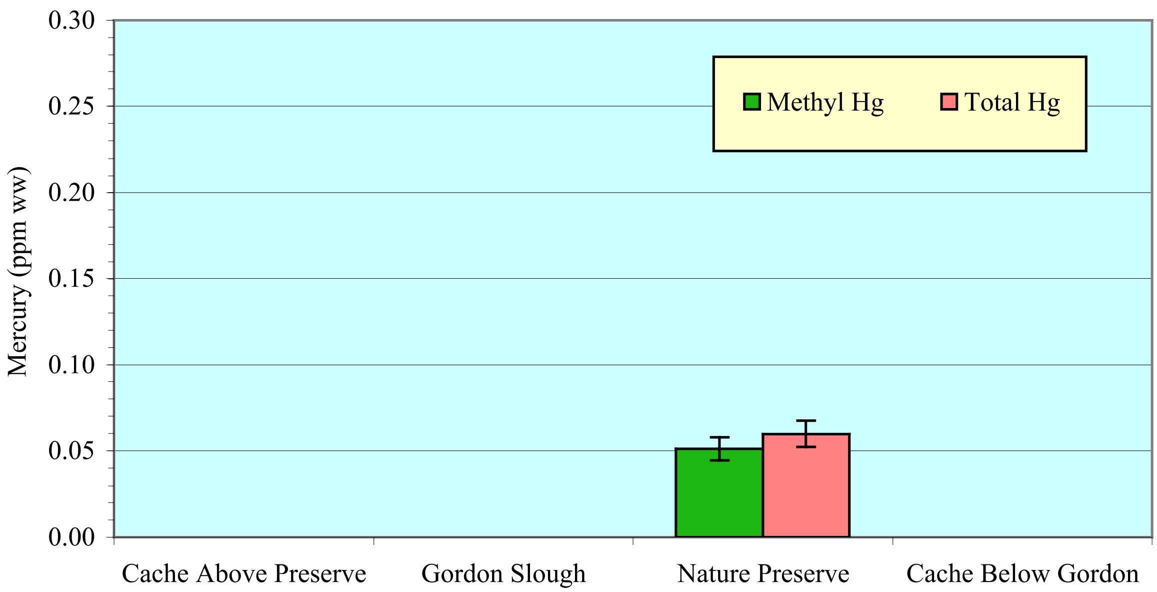
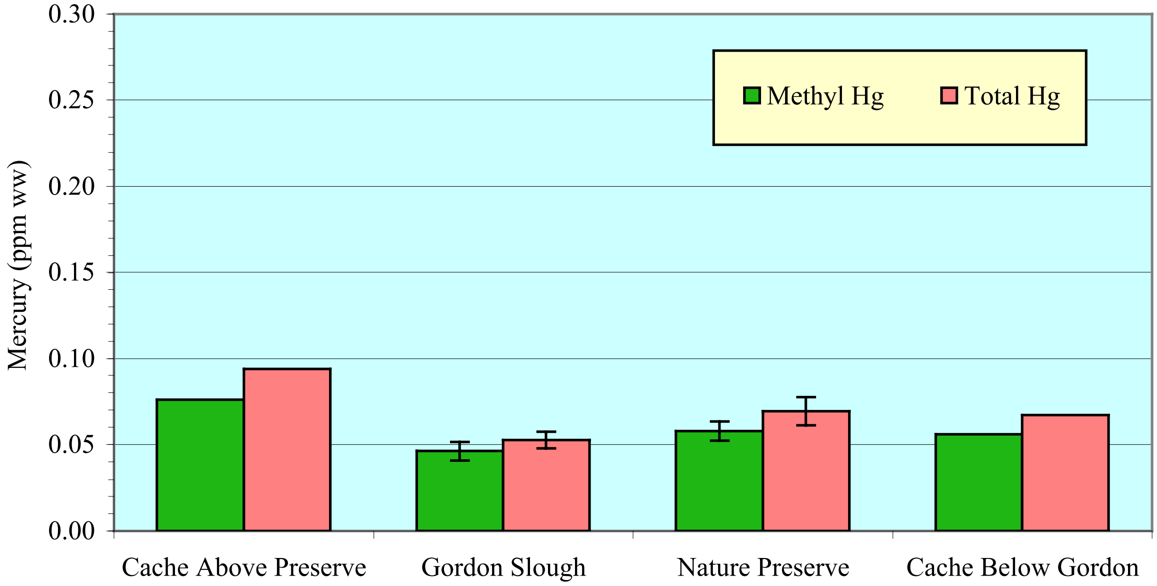


Fig. 3. FISH Composite Hg (wet wt ppm) VS LOCATION
<u>Green Sunfish</u> (*Lepomis cyanellus*)
(mean values plotted for replicate composites)
(95% confidence intervals shown for samples with ≥3 replicates)

3(a). Green Sunfish 25-50 mm size class.



3(b). Green Sunfish 51-80 mm size class.

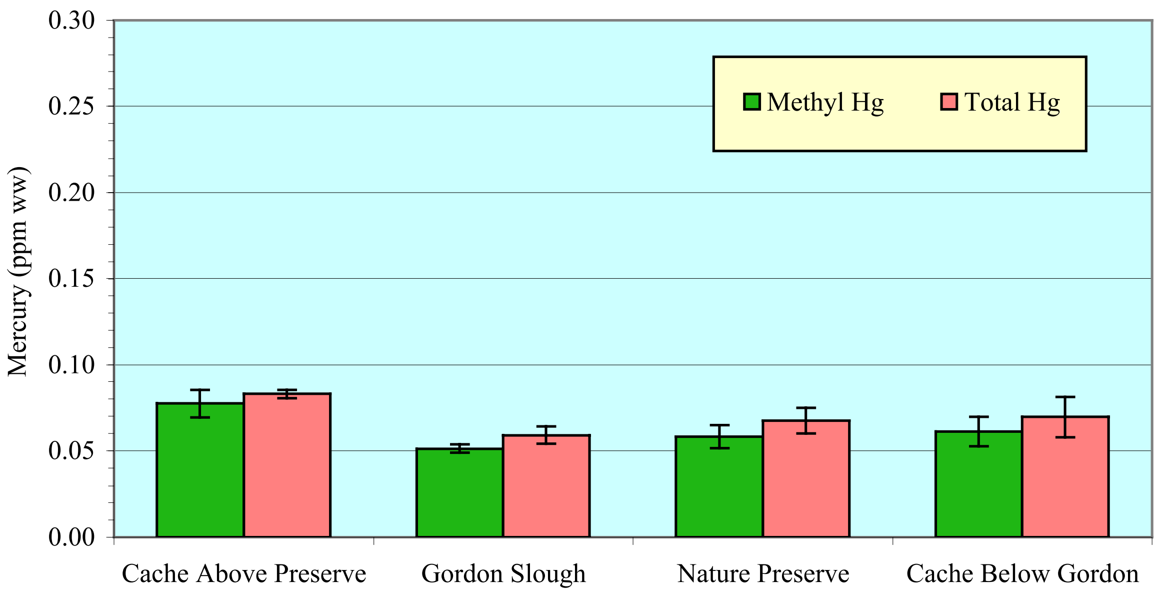
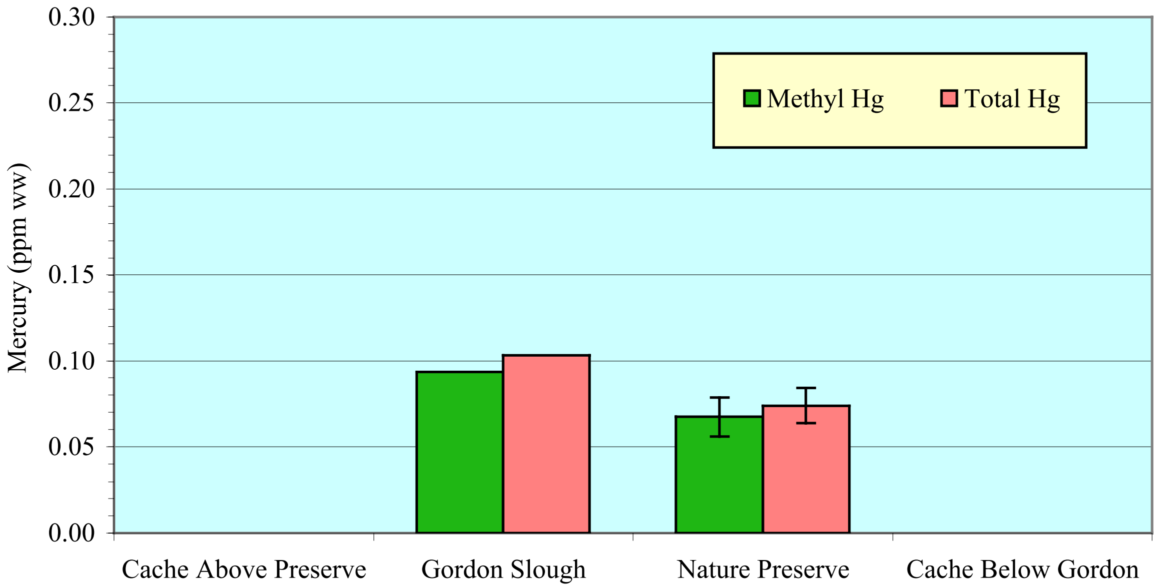
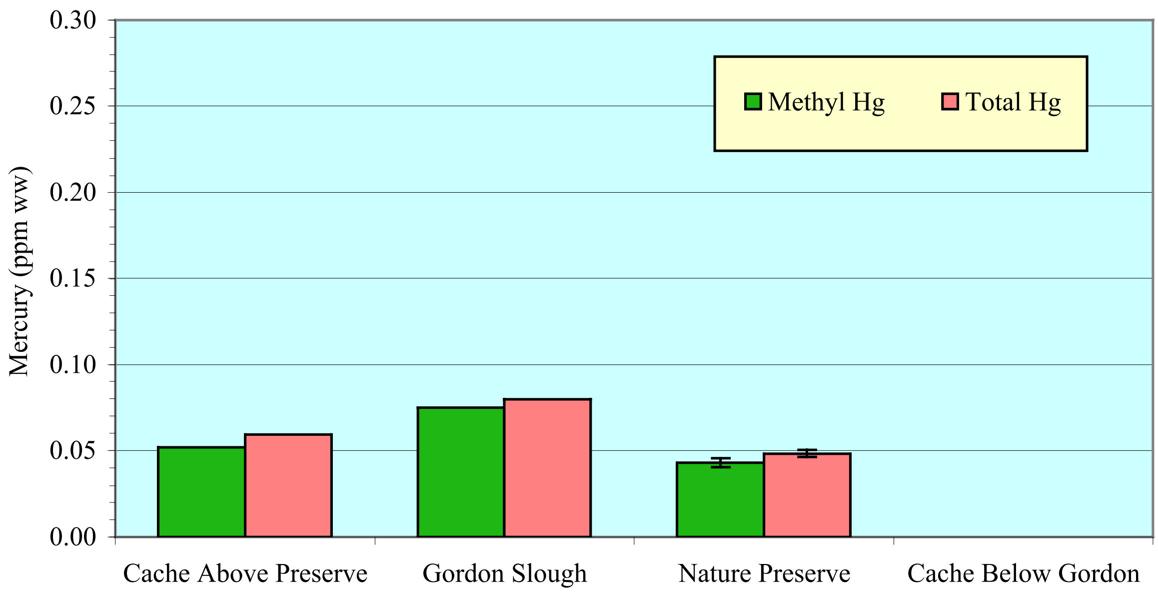


Fig. 4. FISH Composite Hg (wet wt ppm) VS LOCATION
<u>Mosquitofish</u> (*Gambusia affinis*)
(mean values plotted for replicate composites)
(95% confidence intervals shown for samples with ≥3 replicates)

4(a). Mosquitofish 20-30 mm size class.



4(b). Mosquitofish 31-40 mm size class.



Mercury in Aquatic Insects

Aquatic insect mercury data from the Spring 2002 collections are presented in Tables 8-10 and Figures 5(a-e). These data, as initiated in the last report, are displayed in units of *fresh/wet weight* parts per million total or methyl mercury, corresponding to the fish data. A sufficient data base of species-specific moisture percentage information was available, allowing the invertebrate mercury dry weight, powdered concentrations, as analyzed, to be converted to a wet weight basis, for comparability with the fish. Because of the generally lower range of mercury concentrations in the invertebrate samples relative to the fish, the invertebrate data are graphically plotted with 0.00-0.10 ppm axes rather than the 0.00-0.30 range used for the fish figures, and the data are discussed at the 0.001 ppm level.

As in previous samplings, aquatic insects were not available from the Nature Preserve or Gordon Slough in sufficient numbers for meaningful comparative analysis. Spring 2002 aquatic insect data therefore all come from the strategic series of Cache Creek sites including: Cache Creek above the Nature Preserve, Cache Creek between the Nature Preserve outlet and Gordon Slough, and Cache Creek below Gordon Slough.

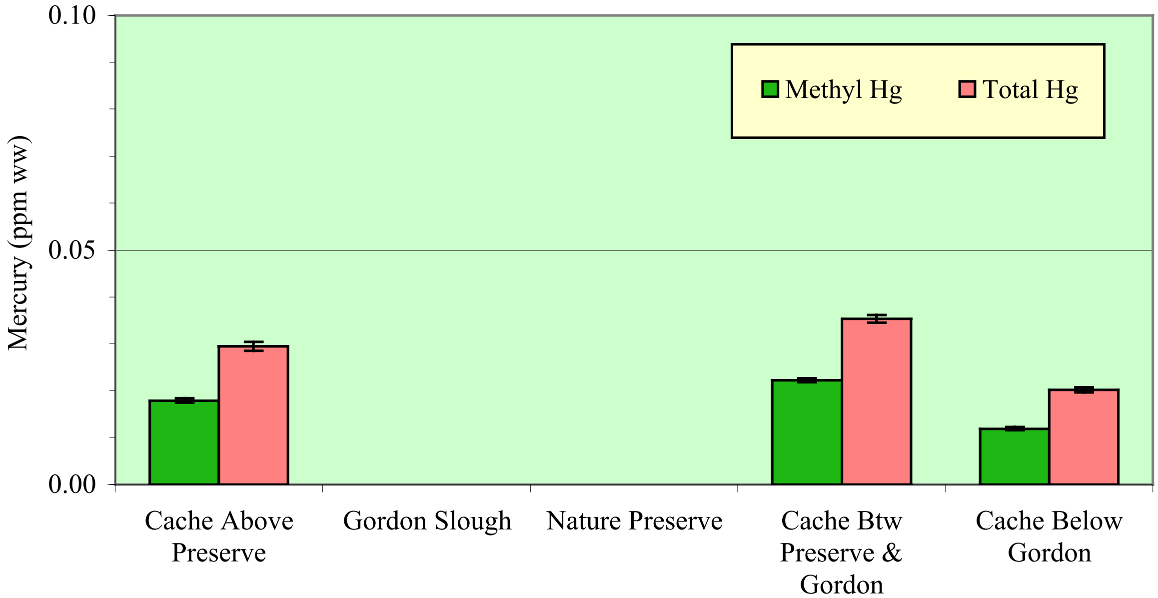
Hydropsychid caddisfly larvae (Table 8, Figure 5a) were taken in four replicate composite samples, each consisting of 42-50 similar individuals, from each of the three Cache Creek sites. Because of occasional anomalously high variation in some previous invertebrate samples, we further analyzed each of the composites in duplicate. These intensive analyses resulted in very good accuracy and precision in the statistics generated. Spring 2002 caddisfly mercury ranged between 0.020 and 0.035 ppm among all 9 of the composites. These are relatively low levels, as compared to other data we have collected at numerous sites for this organism. However, the site data were extremely consistent among replicates and the mean concentrations were found to differ significantly, at the 95% confidence level, between each of the three sites. Concentrations increased by approximately 21% between the Cache Creek site located above the Preserve (0.029 ppm) and the site located downstream of the Preserve outflow and upstream of Gordon Slough (0.035 ppm). At the site downstream of Gordon Slough (0.020 ppm), levels were 31% lower than at the most upstream Cache Creek site and 43% lower than at the site located between the Preserve outlet and the Gordon Slough confluence. The caddisfly methylmercury data showed matching trends at 58-64% of corresponding total mercury levels (mean = 61%).

Calopterygid damselfly nymphs (Table 9, Figure 5b) were also taken from each of the three Cache Creek invertebrate sampling locations, with four replicate composites of multiple individuals (7-11 each) collected at each of the sites. These composites were also analyzed in duplicate to lessen potential variability. Though samples consisted of considerably fewer individuals per composite, as compared to the Hydropsyche samples, the approach again generated quite good precision and accuracy. Spring 2002 Calopterygid mercury ranged between 0.014 and 0.022 ppm. Similar to the caddisfly data, concentrations were lowest at the downstream Cache Creek site, located below both the Preserve and the Gordon Slough confluence (0.014 ppm) and were greater at the site upstream of the Preserve (0.017 ppm). This 18% relative decline was on the edge of being statistically significant. Again similar to the caddisfly data, the samples from the intermediate site, located downstream of the Preserve outflow and upstream of Gordon Slough, were elevated over both other sites, at 0.22 ppm. The differences were statistically significant. On a percentage basis, the intermediate location damselfly Hg was 29% greater than corresponding data from the upstream site, and 57% greater than the downstream site below the Gordon Slough confluence. Methylmercury trends generally tracked those seen for total mercury, at 60-100% of total mercury (mean = 83%).

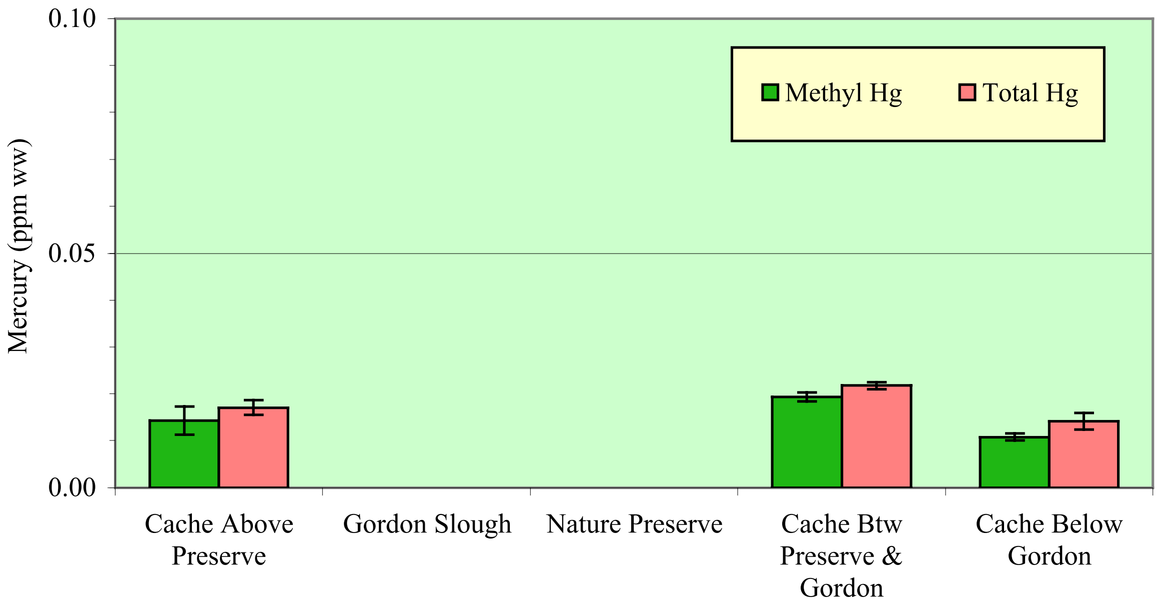
Data from additional aquatic insect samples (Table 10, Figures 5c-e) were generally consistent with those noted above. Because these less readily available invertebrate taxa each needed to be assembled into single multi-individual composites, statistical comparisons cannot be made. These data sets were less differentiated, spatially, than the intensive composite data assembled for the two main monitoring species. For two of the additional taxa (Coenagrionid damselfly nymphs and Libellulid dragonfly nymphs), comparisons among corresponding composites indicated lowest mercury bioaccumulation at the downstream site below Gordon Slough and somewhat higher concentrations at the intermediate and upstream sites, which were similar to each other. The third additional invertebrate group, Naucoridae, exhibited greatest overall invertebrate mercury levels at 0.040-0.046 ppm, with similar concentrations at each of the sites at this time. Methylmercury was found at 66-85% of total mercury in these additional invertebrate samples.

Fig. 5. INVERTEBRATE Composite Hg (WET wt ppm) VS LOCATION
(mean values plotted for replicate composites)
(95% confidence intervals shown for samples with ≥3 replicates)

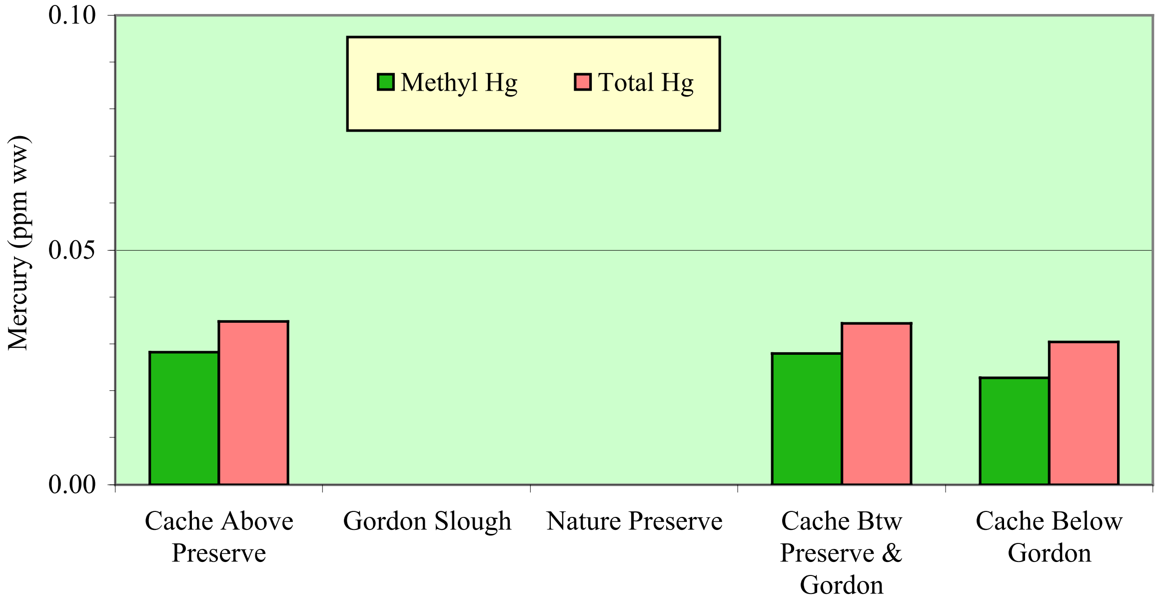
5(a). Hydropsychidae (caddisfly larvae, omnivores).



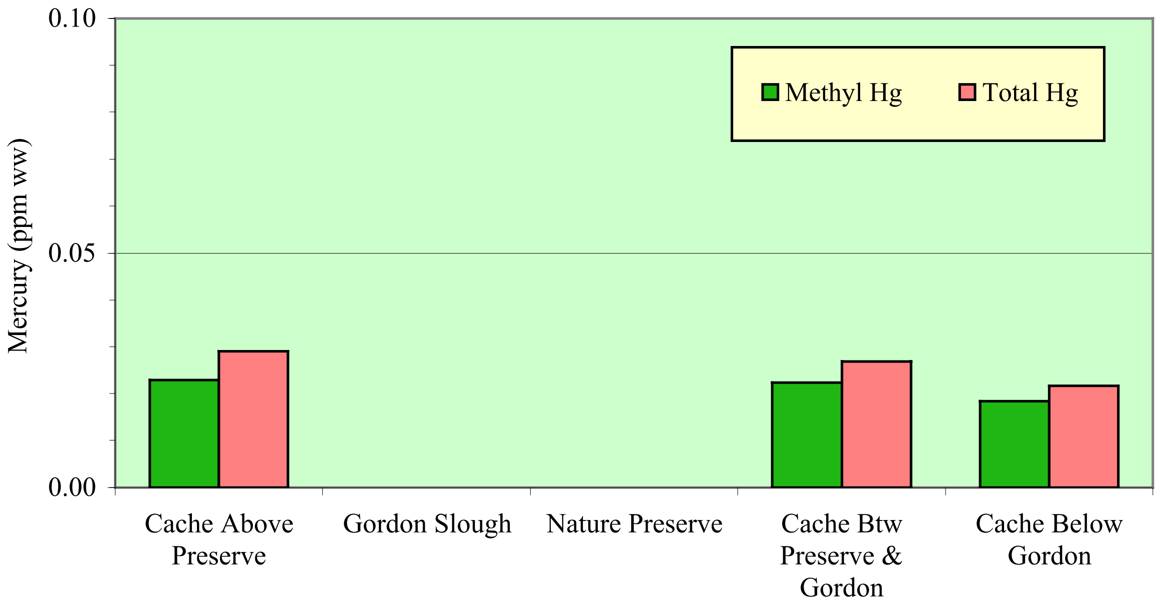
5(b). Calopterygidae (damselfly nymphs, omnivorous type).



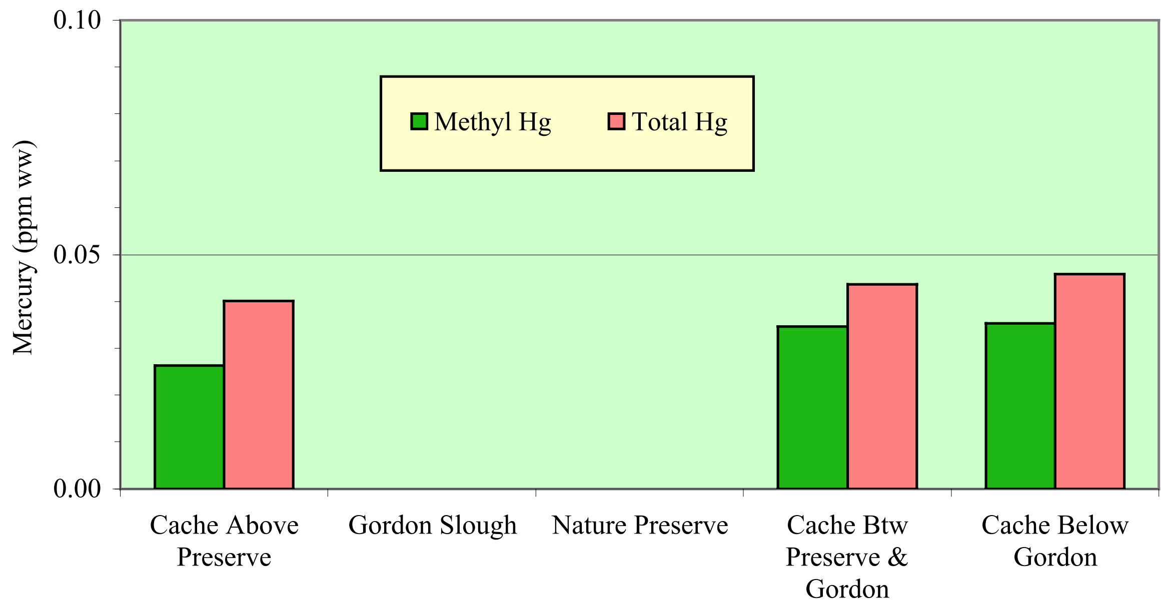
5(c). Coenagrionidae (predatory damselfly nymphs).



5(d). Libellulidae (predatory dragonfly nymphs).



5(e). Naucoridae (predaceous creeping water bugs).

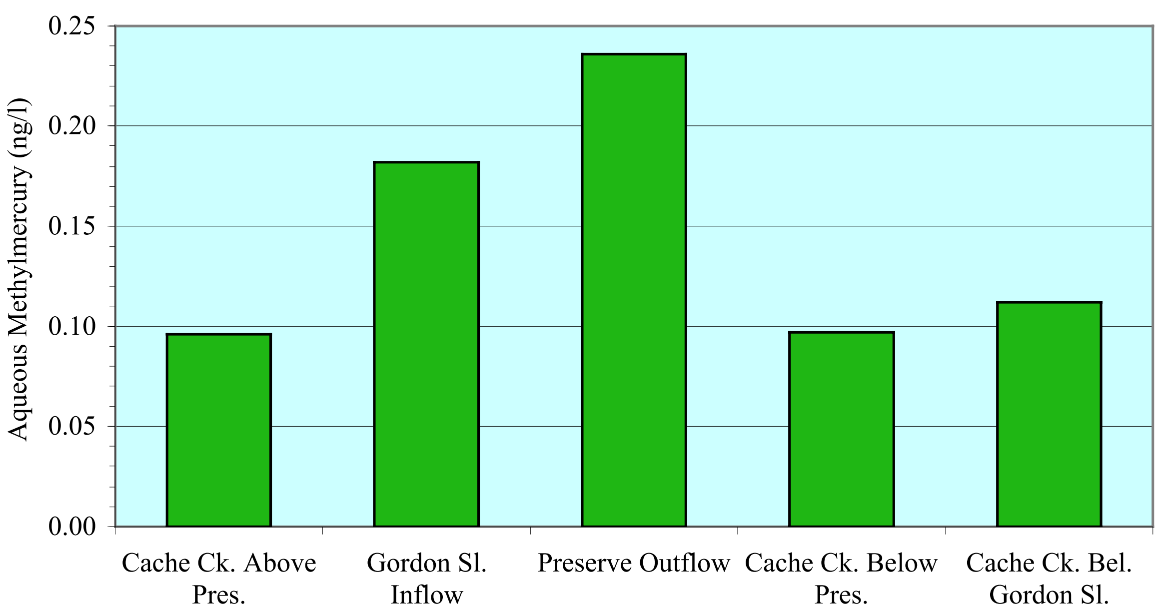


Aqueous (Water) Sampling of Methylmercury in Spring 2002

Water was investigated at five strategically located sites in the system on April 18, 2002, during a brief period of flushing flows through the Nature Preserve wetlands. A variety of aqueous parameters were measured in the field. Laboratory samples were collected for analysis of methylmercury (Battelle Laboratories) and total suspended solids (UC Davis). Data are reported in Table 11, with relative aqueous methylmercury levels graphically shown in Figure 6.

Interestingly, on this date, Gordon Slough water contained approximately twice as much methylmercury as upstream Cache Creek, though this could likely be attributed to 14 fold greater suspended solids in the Gordon Slough water. Most importantly, aqueous methylmercury in the Nature Preserve wetlands increased by approximately 30% between the Gordon Slough inflow and the wetlands outflow. This increase could not be attributed to changes in suspended solids, which remained steady. Methylmercury levels in Cache Creek below the Preserve outflow showed no substantial change, consistent with the small proportional input relative to the flow in Cache Creek. Gordon Slough inputs resulted in roughly proportional increases. Preserve-flushing flows occurred for two days and then were discontinued through the remainder of 2002, during which time herbicide was used to kill off pond macrophytes (large aquatic weeds).

Fig. 6. Water Sampling Data: April 18, 2002 Methylmercury
(Methylmercury analyzed by Battelle Labs, Sequim, WA)



SEASONAL VARIATION IN MERCURY LEVELS

In addition to the multi-site primary sampling of May 2002, a summer sampling of biota was made at the Nature Preserve wetlands site in August 2002. Data from that sampling are presented in Table 12. At this point in the project, we now have four semi-annual data sets from the Cache Creek and Gordon Slough sites (Fall 2000, Spring and Fall 2001, and Spring 2002) and eight quarterly collections from the Nature Preserve (Fall 2000, Winter, Spring, Summer, and Fall 2001, and Winter, Spring, and Summer 2002). Graphic comparisons of selected, sequential, semi-annual fish data from Cache Creek and Gordon Slough are shown in Figures 7a, 7b, and 7e. Graphic comparisons of selected Nature Preserve fish data from all ten seasonal samplings to date are displayed in Figures 7c and 7d. The seasonal trends for invertebrates from the series of Cache Creek sampling locations are plotted in Figures 8(a-c).

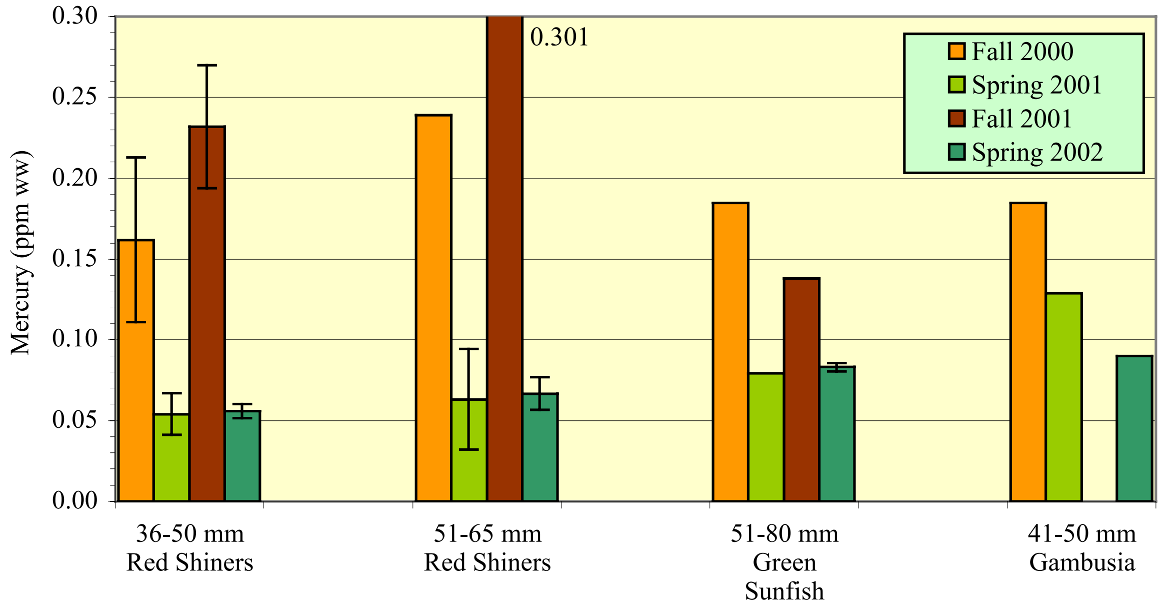
The fish data from all of the sites now clearly demonstrate a strong seasonal pattern. This cycle includes a maximum in the fall, and a distinctive minimum level of fish mercury concentrations in the spring samplings. Where sufficient numbers of replicate composites have been available for statistical comparison, this fall high vs. spring low phenomenon was significant at the 95% confidence level. The single exception was the fathead minnow data, which exhibited the smallest relative seasonal changes. But among the other species, the seasonal fluctuation in mercury content was relatively enormous, with fall levels typically ranging from 50% to over 400% greater than corresponding concentrations measured in the spring. Both fall samplings to date (2000 and 2001) exhibited this distinctive elevation over the subsequent spring data. The most recent contrast between Fall 2001 and Spring 2002 concentrations are discussed above within the spatial treatment of individual species. The higher resolution quarterly data from the Nature Preserve wetlands provide additional information, also describing an annual pattern of minimal fish mercury concentrations in spring, increasing toward maximal concentrations in fall, with transitions between the spring low and fall high levels generally present in the winter and summer.

As fish mercury accumulates over time, it is likely that these peaks and lows exhibited in their concentrations are not precisely matched with the underlying seasonal cycles in methylmercury production and bioavailability. It is likely that those processes somewhat precede their appearance in the fish tissue record; i.e. lowest in the winter and highest in the summer. This would be consistent with the data set we have to-date for methylmercury in water.

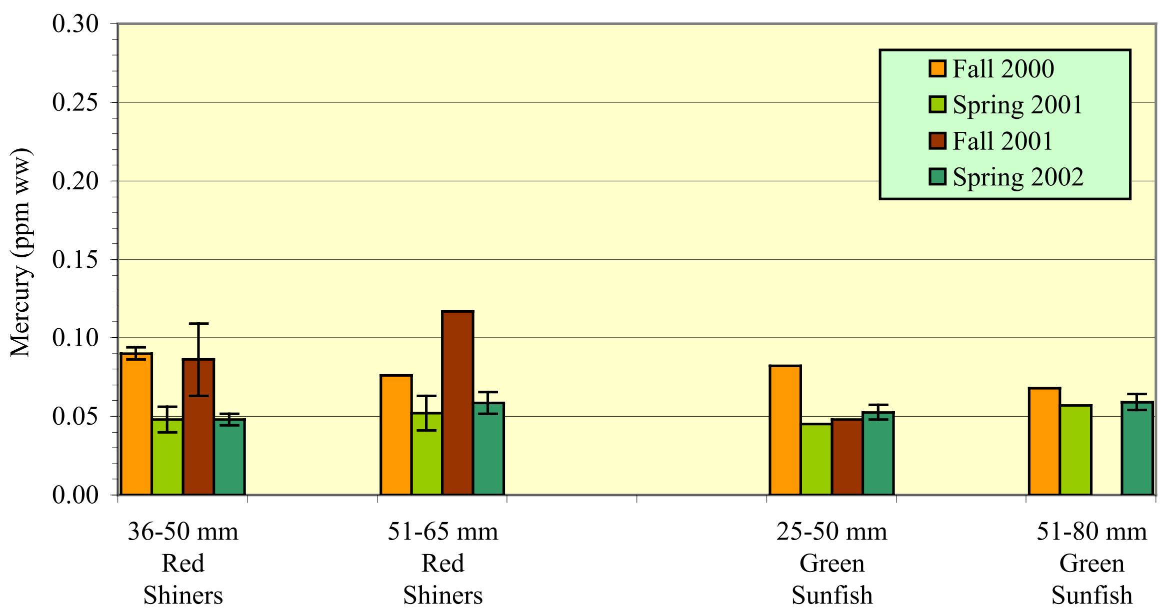
In contrast to the dramatic seasonal trends noted nearly uniformly for fish, the invertebrate seasonal data (Figures 8a-c) exhibited no consistent seasonal trend of any kind. For some sites and/or organisms, spring data were lower than corresponding fall values. For others, spring levels were higher. In the case of Spring 2001 Hydropsychidae (caddisfly larvae) at the upstream Cache Creek site, this apparent spring increase was statistically significant. Interestingly, while little or no statistical difference was recorded between the most recent fall and spring invertebrate data sets, a significant inter-annual decline in concentrations was seen in all but one of the comparisons where statistics were available, between Spring 2001 and Spring 2002. While suggesting a relative decline in mercury exposure levels between the two years, this trend was not seen in the small fish data. The invertebrate mercury concentrations were generally far more consistent than the fish across seasons. This is nearly the reverse of what we would intuitively expect. The apparent lack of a seasonal pattern in the Cache Creek invertebrate data may be due to a different invertebrate response to changes in localized methylmercury exposure, relative to the small fishes. Some of our other recent research in the watershed and elsewhere suggests that this difference is related to a more rapid invertebrate response to changing exposure conditions. Under this scenario, methylmercury production and exposure may indeed be maximal in the summer and at lowest levels in the winter. The fish may be taking a period of one to several months for their accumulated mercury burdens to reflect recent conditions, while the invertebrates may change more rapidly. This could be due to physiological differences or simply greater relative growth rates and turnover in the seasonal invertebrates as compared to the fish. Exposure and rapid equilibration in mercury accumulations may be fairly similar for the invertebrates in the beginning of the warm season in the spring and at the end of the warm season in the fall.

Fig. 7 (a-e). FISH Composite Hg VS SEASON
(mean values plotted for replicate composites)
(95% confidence intervals shown for samples with ≥3 replicates)

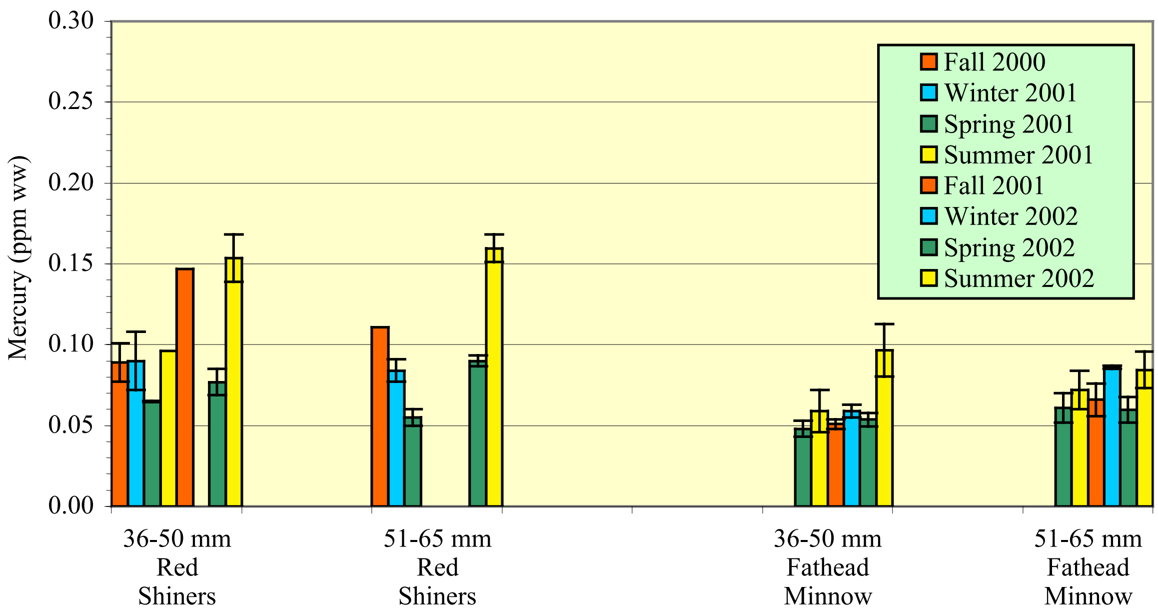
7(a). Cache Creek above Nature Preserve.



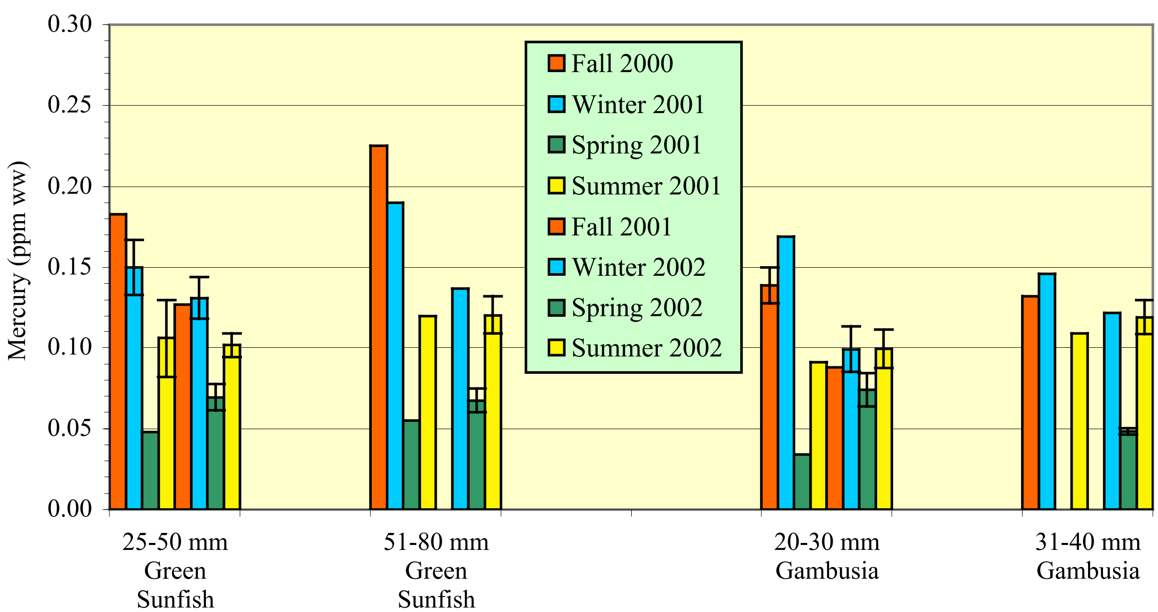
7(b). Gordon Slough.



7(c). Nature Preserve: Red Shiners and Fathead Minnows.



7(d). Nature Preserve: Green Sunfish and Mosquitofish.



7(e). Cache Creek below Gordon Slough.

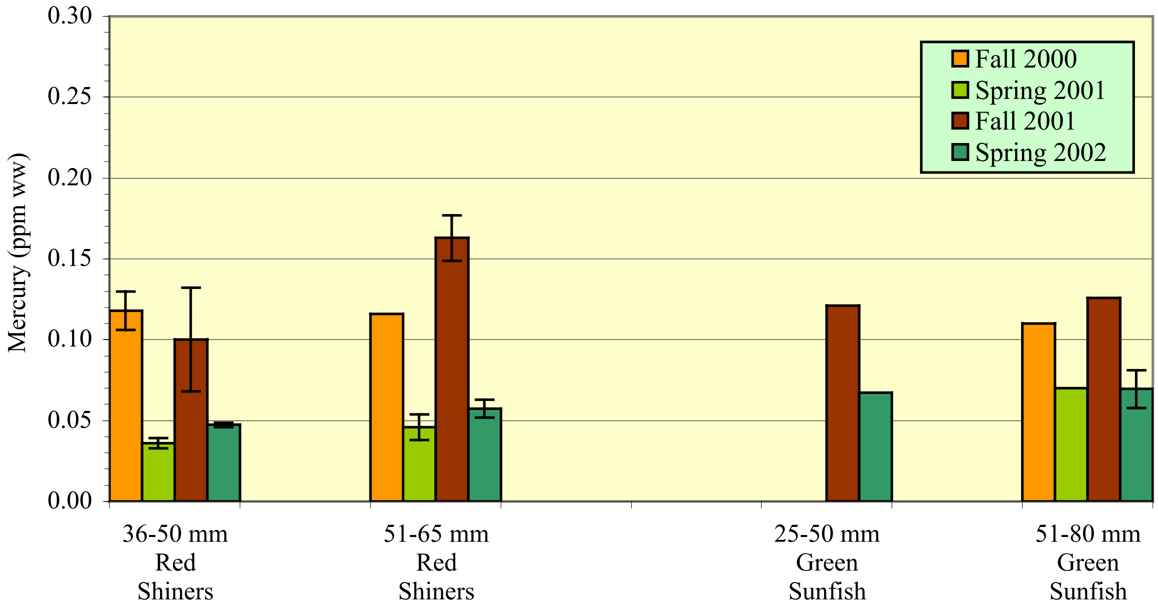
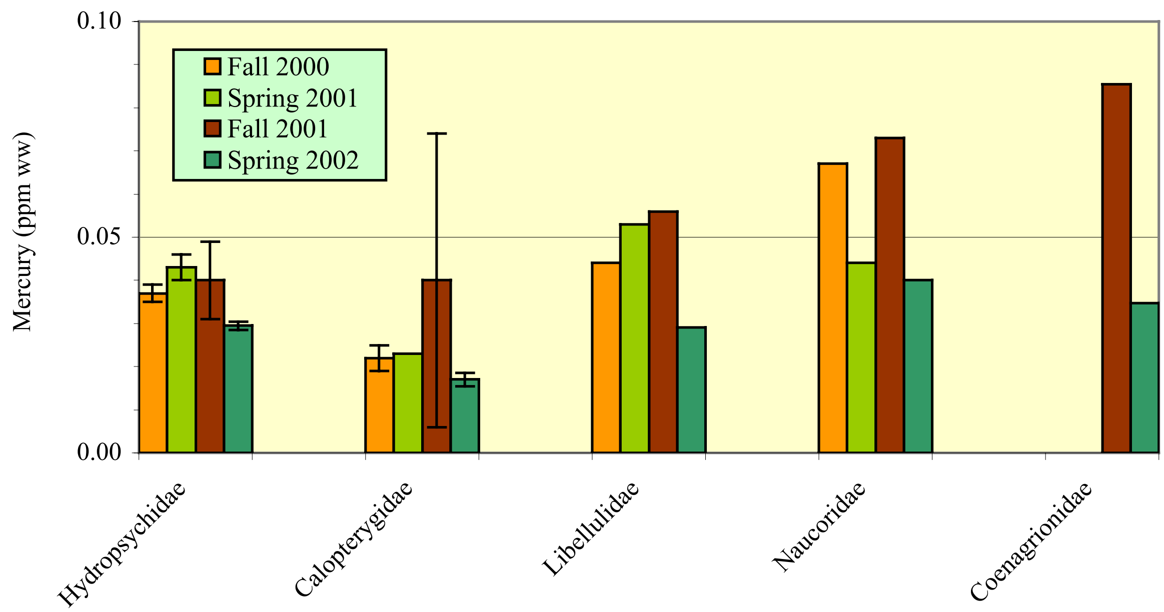


Fig. 8 (a-c). INVERTEBRATE Composite Hg VS SEASON

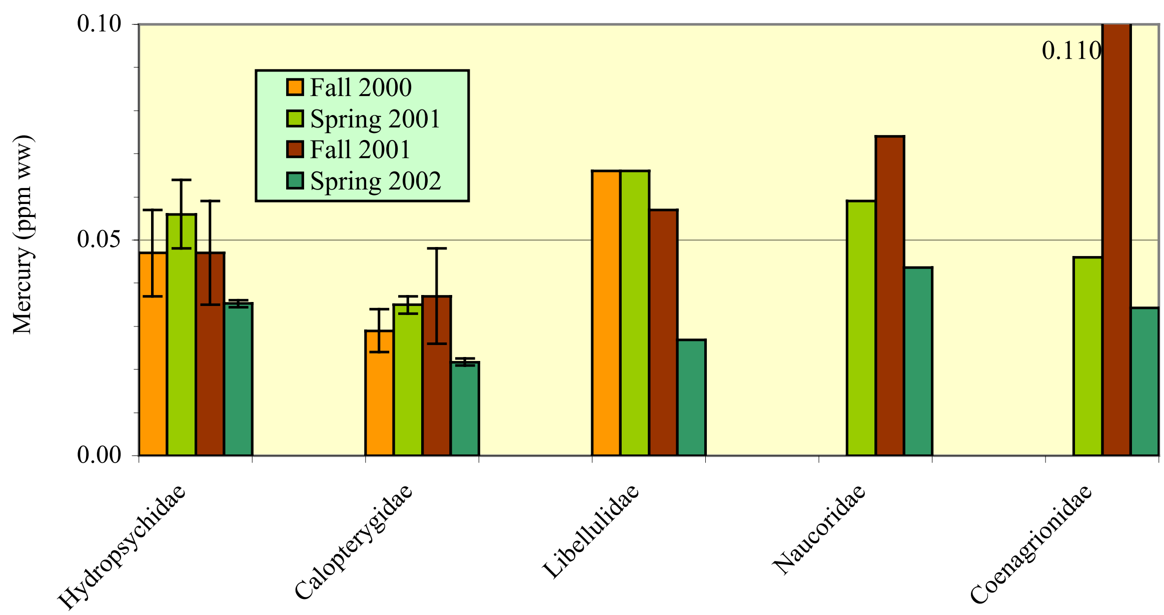
(mean values plotted for replicate composites)

(95% confidence intervals shown for samples with ≥3 replicates)

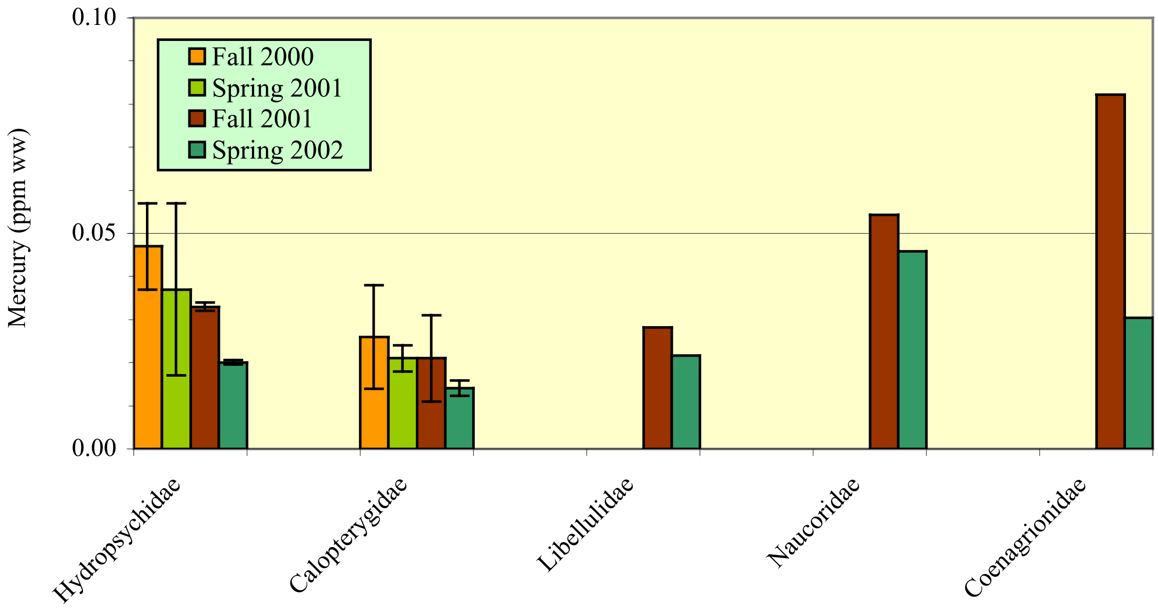
8(a). Cache Creek above Nature Preserve.



8(b). Cache Creek between Nature Preserve and Gordon Slough.



8(c). Cache Creek below Gordon Slough.



Organic (Methyl) Mercury vs. Total Mercury in Spring-Summer 2002 Biotic Samples

As already noted, the methylmercury data closely followed the corresponding total mercury values in nearly all paired comparisons, with the methylmercury concentration almost uniformly a high percentage proportion of the total mercury. Among the 108 fish samples analyzed for both parameters, methylmercury ranged from 78 to 100% of total mercury, with a mean of 89% ± 4% (standard deviation). The 33 invertebrate composites demonstrated methylmercury proportions that ranged from 58 to 101%, with a mean percentage of 74% ± 12%. Thus, the total mercury for these samples was primarily organic. The trends and conclusions to be drawn from these data would continue to be very similar using either parameter as a monitoring tool. However, we felt that it would be valuable to develop a baseline database of methyl vs total mercury information in bioindicator organisms for these types of wetland/creek systems.

CONCLUSIONS--FOURTH SEMI-ANNUAL REPORT

With the completion of two full years of seasonal sampling in this three-year mercury monitoring program, we are accumulating a sizeable database of inter-comparable mercury bioaccumulation information from the Cache Creek Nature Preserve and related adjacent sites. With some difficulty, it has been possible to collect a series of closely corresponding fish samples from the Preserve and three additional fish locations. No corresponding aquatic insects were obtainable among all of the sites, although two types (Hydropsychid caddisfly larvae and Calopterygid damselfly nymphs) were taken in excellent numbers at a series of three Cache Creek locations, and three additional invertebrate taxa were obtainable in lower numbers from all three of these creek sites.

The following points can be made about the data collected in the past semi-annual period:

- Of the sites sampled throughout the project area, Gordon Slough continued to exhibit the lowest overall levels of mercury bioaccumulation in most fish samples. However, mosquitofish were relatively elevated at this site in the Spring 2002 sampling.

- Fish taken within the Nature Preserve generally contained mercury at levels similar to those seen at the upstream Cache Creek site. Red shiners exhibited their highest relative concentrations at this site. In previous samplings, Nature Preserve wetlands fish and water mercury concentrations were substantially elevated over corresponding samples from Gordon Slough, which provides the source water for the Nature Preserve. However, in the Spring 2002 samplings, results were mixed.

- Spring 2002 invertebrates collected at the intermediate Cache Creek site, located between the Nature Preserve outflow and Gordon Slough, demonstrated a localized mercury elevation of 21-29% relative to upstream in the two primary indicator species. These differences were statistically significant at the 95% level of confidence. The Spring 2002 data thus provide some new evidence that the intermediate site, located immediately downstream of the Nature Preserve outflow, may constitute a relatively elevated mercury exposure location. This may be due to changing environmental conditions within the creek between upstream and this reach. Substantial changes in fish populations between these sections suggests that this may be at least partially the case. Alternatively, the apparent elevations in bioaccumulation at this site may be linked to elevated methylmercury in Nature Preserve outflow water.

- The phenomenon of occasional increases in Cache Creek biotic mercury downstream of the Preserve continued to be highly localized. Throughout the project to date, Cache Creek below Gordon Slough contained biotic mercury at levels similar to and in most cases lower than corresponding samples from Cache Creek above the Preserve.

- Mercury in small fish bioindicators exhibited a strong seasonal pattern, with minimum concentrations in the spring and maximum concentrations in the fall. We believe that this actually represents a delayed measure of underlying cycles of mercury methylation and methylmercury bioavailability, which likely peak in the summer and decline in the winter. Invertebrate bioindicators, as sampled, did not consistently demonstrate this pattern; related data from other research suggests that this may be due to different accumulation dynamics in the invertebrates (more rapid equilibration) and not to a different underlying trend in seasonal biological mercury exposure. The invertebrate bioindicators, however, can be used as highly accurate measures of fine scale spatial differences in relative mercury exposure, as well as short-term changes over time.

- The organic (methyl) mercury analyses conducted during this most recent semi-annual period again indicate that methylmercury constituted the majority of the mercury measured in fish (89±4%) and invertebrates (74±12%) from the project region. The methylmercury data generally mirrored the total mercury results, at a high proportion of the corresponding total mercury levels. At this point in the analytical cross-comparison, identical or very similar trends and conclusions would be supported by either parameter.

LITERATURE CITED

Foe, C., and W. Croyle. 1998. Mercury concentrations and loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta estuary. *Central Valley Regional Water Quality Control Board staff report*, 101 pp.

Rudd, J.W.M. 1995. Sources of methyl mercury to freshwater ecosystems: A review. *Water, Air and Soil Pollution*, 80:697-713.

Slotton, D.G., S.M. Ayers, J.E. Reuter, and C.R. Goldman. 1997. Cache Creek watershed preliminary mercury assessment, using benthic macro-invertebrates. *Final Report for the Central Valley Regional Water Quality Control Board and the National Science Foundation*, June 1997, 36 pp.

Table 2a. Laboratory QA/QC Summary for UC Davis Total Mercury Analyses Used in This Data Report.

Method Detection Limit (MDL) = 0.005 µg THg/g (ppm)

	Std Curve R^2	Lab Split RPD	Spike Recoveries	Lab Cont. Std. Recoveries	Cont. Calibration Validation
Ideal Recovery	1.000	(0%)	(100%)	(100%)	(100%)
Control Range (%)	≥ 0.975	≤ 25%	75-125%	75-125%	75-125%
Tracking Method		Control Chart	Control Chart	Control Chart	Control Chart
Recoveries (%)	0.9993-0.9999	0.3%-7.4%	92%-99%	96%-102%	97%-102%
(n)	n=8	n=12	n=24	n=18	n=26
Mean Recoveries (%)	0.9996	2.5%	95.7%	100.0%	99.0%

Standard Reference Materials

	TORT-2 Lobster	DOLT-2 Dogfish
Certified Level (ppm THg)	0.27±0.02	2.14±0.28
Ideal Recovery	(100%)	(100%)
Control Range (%)	75-125%	75-125%
Tracking Method	Control Chart	Control Chart
Control Range (ppm)	0.20-0.34	1.61-2.68
Recoveries (%)	95%-111%	95%-103%
Recoveries (ppm)	0.26-0.30	2.03-2.20
(n)	n=18	n=8
Mean Recoveries (%)	100.5%	98.9%
Mean Recoveries (ppm)	0.27	2.12

Table 2b. Laboratory QA/QC Summary for UC Davis Methyl Mercury Analyses Used in This Data Report.

Method Detection Limit (MDL) = 0.005 µg MeHg/g (ppm)

	Std Curve R^2	Lab Split RPD	Spike Recoveries	Lab Cont. Std. Recoveries	Cont. Calibration Validation
Ideal Recovery	1.000	(0%)	(100%)	(100%)	(100%)
Control Range (%)	≥ 0.975	≤ 25%	75-125%	75-125%	75-125%
Tracking Method		Control Chart	Control Chart	Control Chart	Control Chart
Recoveries (%)	0.9993-0.9999	0.7%-13.9%	91%-115%	96%-102%	93%-104%
(n)	n=8	n=12	n=24	n=18	n=26
Mean Recoveries (%)	0.9996	3.8%	102.0%	100.0%	99.3%

Standard Reference Materials

	TORT-2 Lobster	DOLT-2 Dogfish
Certified Level (ppm THg)	0.152±0.013	0.693±0.053
Ideal Recovery	(100%)	(100%)
Control Range (%)	75-125%	75-125%
Tracking Method	Control Chart	Control Chart
Control Range (ppm)	0.114-0.190	0.520-0.866
Recoveries (%)	93%-105%	97%-105%
Recoveries (ppm)	0.14-0.16	0.67-0.73
(n)	n=18	n=8
Mean Recoveries (%)	99.0%	102.0%
Mean Recoveries (ppm)	0.15	0.71

Table 3. May 2002 Fish Mercury:
RED SHINER (*Notropis lutrensis*).

(composite samples of multiple (n) whole individuals)
(wet weight = fresh weight, µg mercury per gram = parts per million)

Size Class	(n)	Mean Fish Size wt (g)	Mean Fish Size lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
			Cache Creek Above Preserve			
2 (36-50 mm)	(15)	1.2	46	0.056	0.063	88%
2 (36-50 mm)	(15)	1.2	46	0.045	0.052	87%
2 (36-50 mm)	(15)	1.2	46	0.047	0.056	84%
2 (36-50 mm)	(15)	1.2	46	0.042	0.051	84%
2 (36-50 mm)	(15)	1.2	46	0.049	0.057	86%
			Means:	**0.048**	**0.056**	**86%**
		95% Conf. Intervals:		± 0.004	± 0.004	±2%
3 (51-65 mm)	(13)	2.1	58	0.063	0.070	90%
3 (51-65 mm)	(13)	2.2	58	0.052	0.057	90%
3 (51-65 mm)	(13)	2.2	58	0.047	0.059	79%
3 (51-65 mm)	(13)	2.2	58	0.068	0.079	85%
			Means:	**0.057**	**0.067**	**86%**
		95% Conf. Intervals:		± 0.010	± 0.010	±5%
			Gordon Slough			
2 (36-50 mm)	(15)	1.1	46	0.044	0.052	85%
2 (36-50 mm)	(15)	1.2	46	0.040	0.047	85%
2 (36-50 mm)	(15)	1.2	46	0.047	0.050	94%
2 (36-50 mm)	(15)	1.2	46	0.036	0.043	82%
			Means:	**0.042**	**0.048**	**87%**
		95% Conf. Intervals:		± 0.005	± 0.004	±5%
3 (51-65 mm)	(15)	2.0	58	0.049	0.055	88%
3 (51-65 mm)	(15)	2.1	58	0.051	0.063	81%
3 (51-65 mm)	(15)	2.2	58	0.056	0.065	85%
3 (51-65 mm)	(15)	2.0	58	0.047	0.050	94%
			Means:	**0.051**	**0.058**	**87%**
		95% Conf. Intervals:		± 0.004	± 0.007	±6%

(continued)

Table 3. (Continued).

Size Class	(n)	Mean Fish Size wt (g)	lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
			Nature Preserve Wetlands			
2 (36-50 mm)	(15)	1.0	45	0.072	0.075	96%
2 (36-50 mm)	(15)	1.1	45	0.064	0.067	96%
2 (36-50 mm)	(15)	1.0	45	0.077	0.086	89%
2 (36-50 mm)	(15)	1.0	45	0.074	0.080	93%
			Means:	**0.072**	**0.077**	**93%**
		95% Conf. Intervals:		± 0.006	± 0.008	±3%
3 (51-65 mm)	(10)	1.8	56	0.080	0.093	85%
3 (51-65 mm)	(10)	1.9	56	0.081	0.089	92%
3 (51-65 mm)	(10)	2.0	56	0.077	0.088	87%
			Means:	**0.079**	**0.090**	**88%**
		95% Conf. Intervals:		± 0.003	± 0.003	±4%
			Cache Creek Below Gordon Slough			
2 (36-50 mm)	(15)	1.1	45	0.041	0.048	84%
2 (36-50 mm)	(15)	1.1	45	0.038	0.049	78%
2 (36-50 mm)	(15)	1.1	45	0.038	0.046	83%
2 (36-50 mm)	(15)	1.1	45	0.040	0.046	86%
			Means:	**0.039**	**0.047**	**83%**
		95% Conf. Intervals:		± 0.001	± 0.001	±4%
3 (51-65 mm)	(15)	2.3	57	0.051	0.060	85%
3 (51-65 mm)	(15)	2.4	57	0.050	0.050	100%
3 (51-65 mm)	(15)	2.4	57	0.055	0.066	83%
3 (51-65 mm)	(15)	2.4	57	0.053	0.055	96%
3 (51-65 mm)	(15)	2.3	57	0.050	0.055	91%
			Means:	**0.052**	**0.057**	**91%**
		95% Conf. Intervals:		± 0.002	± 0.006	±6%

Table 4. **May 2002 Fish Mercury:**
FATHEAD MINNOW (*Pimephales promelas*).

(composite samples of multiple (n) whole individuals)
(wet weight = fresh weight, µg mercury per gram = parts per million)

Size Class	(n)	Mean Fish Size wt (g)	Mean Fish Size lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
			Nature Preserve Wetlands			
2 (36-50 mm)	(15)	0.7	44	0.049	0.056	87%
2 (36-50 mm)	(15)	0.7	44	0.051	0.056	92%
2 (36-50 mm)	(15)	0.6	44	0.042	0.050	86%
			Means:	**0.047**	**0.054**	**88%**
			95% Conf. Intervals:	± 0.005	± 0.004	±4%
3 (51-70 mm)	(15)	2.2	58	0.052	0.058	89%
3 (51-70 mm)	(15)	2.3	58	0.057	0.067	84%
3 (51-70 mm)	(15)	2.4	58	0.045	0.054	83%
			Means:	**0.051**	**0.060**	**86%**
			95% Conf. Intervals:	± 0.007	± 0.008	±4%

Table 5. **May 2002 Fish Mercury:**
GREEN SUNFISH (*Lepomis cyanellus*).

(composite samples of multiple (n) whole individuals)
(wet weight = fresh weight, µg mercury per gram = parts per million)

Size Class	(n)	Mean Fish Size wt (g)	Mean Fish Size lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
			Cache Creek Above Preserve			
1 (25-50 mm)	(5)	3.3	57	**0.076**	**0.094**	**81%**
2 (51-80 mm)	(4)	6.2	66	0.069	0.080	86%
2 (51-80 mm)	(4)	5.9	66	0.081	0.084	96%
2 (51-80 mm)	(4)	6.3	66	0.082	0.084	98%
			Means:	**0.077**	**0.083**	**93%**
			95% Conf. Intervals:	± 0.008	± 0.003	±7%
			Gordon Slough			
1 (25-50 mm)	(2)	2.5	49	0.049	0.056	87%
1 (25-50 mm)	(2)	2.3	49	0.049	0.054	91%
1 (25-50 mm)	(2)	2.4	49	0.041	0.048	85%
			Means:	**0.046**	**0.053**	**88%**
			95% Conf. Intervals:	± 0.005	± 0.005	±4%
2 (51-80 mm)	(4)	6.8	66	0.049	0.054	91%
2 (51-80 mm)	(4)	6.9	66	0.052	0.062	83%
2 (51-80 mm)	(4)	6.5	66	0.053	0.061	87%
			Means:	**0.051**	**0.059**	**87%**
			95% Conf. Intervals:	± 0.002	± 0.005	±4%

(continued)

Table 5. (Continued).

Size Class	(n)	Mean Fish Size wt (g)	Mean Fish Size lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
			Nature Preserve Wetlands			
1 (25-50 mm)	(2)	1.3	41	0.053	0.064	83%
1 (25-50 mm)	(2)	1.1	41	0.063	0.077	81%
1 (25-50 mm)	(2)	1.1	41	0.058	0.067	86%
			Means:	**0.058**	**0.069**	**83%**
		95% Conf. Intervals:		± 0.006	± 0.008	±2%
2 (51-80 mm)	(3)	3.3	57	0.052	0.061	85%
2 (51-80 mm)	(3)	3.3	57	0.064	0.074	86%
2 (51-80 mm)	(3)	3.6	57	0.059	0.067	88%
			Means:	**0.058**	**0.067**	**86%**
		95% Conf. Intervals:		± 0.007	± 0.007	±2%
			Cache Creek Below Gordon Slough			
1 (25-50 mm)	(4)	3.2	55	**0.056**	**0.067**	**83%**
2 (51-80 mm)	(2)	6.4	68	0.068	0.079	86%
2 (51-80 mm)	(2)	6.3	68	0.062	0.072	87%
2 (51-80 mm)	(2)	5.8	68	0.053	0.058	91%
			Means:	**0.061**	**0.070**	**88%**
		95% Conf. Intervals:		± 0.009	± 0.012	±3%

**Table 6. May 2002 Fish Mercury:
MOSQUITOFISH (*Gambusia affinis*).**

(composite samples of multiple (n) whole individuals)
(wet weight = fresh weight, µg mercury per gram = parts per million)

Size Class	(n)	Mean Fish Size wt (g)	Mean Fish Size lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
			Cache Creek Above Preserve			
2 (31-40 mm)	(2)	0.6	36	**0.052**	**0.059**	**87%**
3 (41-50 mm)	(2)	1.4	46	**0.083**	**0.090**	**92%**
			Gordon Slough			
1 (20-30 mm)	(7)	0.2	25	**0.094**	**0.103**	**91%**
2 (31-40 mm)	(8)	0.7	37	**0.075**	**0.080**	**94%**
3 (41-50 mm)	(3)	1.0	42	**0.068**	**0.074**	**92%**
			Nature Preserve Wetlands			
1 (20-30 mm)	(18)	0.2	26	0.077	0.080	96%
1 (20-30 mm)	(18)	0.2	26	0.068	0.078	87%
1 (20-30 mm)	(18)	0.2	26	0.057	0.064	90%
			Means:	**0.067**	**0.074**	**91%**
		95% Conf. Intervals:		± 0.011	± 0.010	±5%
2 (31-40 mm)	(15)	0.5	36	0.042	0.047	88%
2 (31-40 mm)	(15)	0.5	36	0.046	0.050	91%
2 (31-40 mm)	(15)	0.5	36	0.041	0.047	88%
			Means:	**0.043**	**0.048**	**89%**
		95% Conf. Intervals:		± 0.003	± 0.002	±2%
3 (41-50 mm)	(3)	1.0	43	**0.052**	**0.058**	**90%**

Table 7. May 2002 Fish Mercury:
INLAND SILVERSIDES (*Menidia beryllina*).

(composite samples of multiple (n) whole individuals)
(wet weight = fresh weight, µg mercury per gram = parts per million)

Size Class	(n)	Mean Fish Size wt (g)	Mean Fish Size lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
			Nature Preserve Wetlands			
1 (41-50 mm)	(6)	0.6	46	**0.035**	**0.037**	**95%**
2 (51-65 mm)	(12)	1.0	58	0.047	0.049	97%
2 (51-65 mm)	(12)	1.0	58	0.045	0.049	91%
2 (51-65 mm)	(12)	1.0	58	0.044	0.048	92%
			Means:	**0.045**	**0.049**	**93%**
			95% Conf. Intervals:	± 0.002	± 0.001	±4%
3 (66-80 mm)	(5)	2.1	72	**0.066**	**0.071**	**92%**

**Table 8. May 2002 Invertebrate Mercury:
Primary Indicator Samples From Cache Creek Transect;
HYDROPSYCHIDAE (Caddisfly Larvae, Omnivores).**

(composite samples of multiple (n) whole individuals)
(WET weight µg mercury per gram = parts per million)

(n)	Size (mean mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
		Cache Creek Above Preserve		
(42)	11	0.018	0.031	60%
(42)	11	0.018	0.029	62%
(42)	11	0.017	0.030	58%
(42)	11	0.017	0.028	62%
	Means:	**0.018**	**0.029**	**61%**
	95% Conf. Intervals:	± 0.001	± 0.001	±2%
		Cache Creek Between Nature Preserve and Gordon Slough		
(47)	12	0.022	0.035	63%
(47)	12	0.023	0.034	66%
(47)	12	0.022	0.036	60%
(47)	12	0.022	0.035	64%
	Means:	**0.022**	**0.035**	**63%**
	95% Conf. Intervals:	± 0.000	± 0.001	±3%
		Cache Creek Below Gordon Slough		
(50)	12	0.012	0.020	60%
(50)	12	0.012	0.020	60%
(50)	12	0.012	0.021	58%
(50)	12	0.012	0.020	58%
	Means:	**0.012**	**0.020**	**59%**
	95% Conf. Intervals:	± 0.000	± 0.001	±1%

**Table 9. May 2002 Invertebrate Mercury:
Primary Indicator Samples From Cache Creek Transect;
CALOPTERYGIDAE (Damselfly Nymphs, Omnivorous Type).**

(composite samples of multiple (n) whole individuals)
(WET weight μg mercury per gram = parts per million)

(n)	Size (mean mm)	μg/g METHYL Hg in WET Sample	μg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
		Cache Creek Above Preserve		
(8)	26	0.014	0.018	78%
(8)	26	0.012	0.016	73%
(8)	26	0.012	0.015	81%
(8)	26	0.019	0.018	101%
	Means:	**0.014**	**0.017**	**83%**
	95% Conf. Intervals:	± 0.003	± 0.002	±12%
		Cache Creek Between Nature Preserve and Gordon Slough		
(11)	30	0.018	0.021	87%
(11)	30	0.020	0.022	93%
(11)	30	0.018	0.021	87%
(11)	30	0.020	0.023	88%
	Means:	**0.019**	**0.022**	**89%**
	95% Conf. Intervals:	± 0.001	± 0.001	±3%
		Cache Creek Below Gordon Slough		
(7)	27	0.012	0.014	85%
(7)	27	0.010	0.012	82%
(7)	27	0.011	0.014	81%
(7)	27	0.010	0.017	60%
	Means:	**0.011**	**0.014**	**77%**
	95% Conf. Intervals:	± 0.001	± 0.002	±11%

Table 10. May 2002 Invertebrate Mercury: Additional Samples from Cache Creek Sites.

(composite samples of multiple (n) whole individuals)
(WET weight µg mercury per gram = parts per million)

Insect Family	Description	Trophic Level	(n)	Size (mm)	Wet ppm Hg METHYL	Wet ppm Hg TOTAL	Percent Methyl
			Cache Creek Above Preserve				
Coenagrionidae	damselfly nymph	predator	(25)	19	**0.028**	**0.035**	81%
Libellulidae	dragonfly nymph	lg predator	(14)	18	**0.023**	**0.029**	79%
Naucoridae	water bug	lg predator	(47)	10	**0.026**	**0.040**	66%
			Cache Creek Between Nature Preserve and Gordon Slough				
Coenagrionidae	damselfly nymph	predator	(30)	16	**0.028**	**0.034**	81%
Libellulidae	dragonfly nymph	lg predator	(7)	19	**0.022**	**0.027**	83%
Naucoridae	water bug	lg predator	(65)	11	**0.035**	**0.044**	79%
			Cache Creek Below Gordon Slough				
Coenagrionidae	damselfly nymph	predator	(14)	17	**0.023**	**0.030**	75%
Libellulidae	dragonfly nymph	lg predator	(5)	18	**0.018**	**0.022**	85%
Naucoridae	water bug	lg predator	(11)	11	**0.035**	**0.046**	77%

Table 11. Spring 2002 Water Sampling Data.

(First flush through Nature Preserve in 2002: samples collected April 18, 2002)
(NOTE: No additional Year 2002 flushes, due to invasive weeds in Preserve)

(Methylmercury analyzed by Battelle Labs, Sequim, WA)
(TSS analyzed by DG Slotton Lab)
(Peripheral analyses measured directly in field with YSI meters)

WATER PARAMETER	Cache Ck Above Pres.	Gordon Sl. Inflow	Preserve Outflow	Cache Ck Below Pres.	Cache Ck Bel. Gordon Sl.
			April 18, 2002		
Raw Methylmercury (ng/L)	**0.096**	**0.182**	**0.236**	**0.097**	**0.112**
TSS (mg/L)	1.9	26.2	27.5	4.1	4.7
Temperature (°C)	17.04	12.47	15.05	17.41	18.4
Dissolved Oxygen (mg/L)	12.8	10.5	10.1	11.8	11.8
D.O. (% of saturation)	132%	99%	100%	125%	125%
Conductivity (mS/cm)	0.589	0.392	0.460	0.581	0.567
Tot. Diss. Solids (g/L)	0.383	0.255	0.299	0.378	0.370
pH	8.17	7.91	8.37	8.21	8.29
Oxid./Red. Potential	-200	-201	-206	-191	-146
Turbidity (NTU)					
Chlorophyll (µg/L)					

Table 12. Summer 2002 Fish Mercury:
Nature Preserve Wetlands Only

(composite samples of multiple (n) whole individuals)
(wet weight = fresh weight, µg mercury per gram = parts per million)

Size Class	(n)	Mean Fish Size wt (g)	Mean Fish Size lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
FATHEAD MINNOW (*Pimephales promelas*)						
2 (36-50 mm)	10	1.0	45	0.092	0.100	92%
2 (36-50 mm)	10	0.9	45	0.101	0.109	93%
2 (36-50 mm)	10	1.0	45	0.074	0.081	91%
			Means:	**0.089**	**0.097**	**92%**
			95% Conf. Intervals:	± 0.016	± 0.016	±1%
3 (51-70 mm)	15	2.0	58	0.074	0.081	91%
3 (51-70 mm)	15	2.2	58	0.081	0.096	85%
3 (51-70 mm)	15	2.1	58	0.073	0.077	95%
			Means:	**0.076**	**0.084**	**90%**
			95% Conf. Intervals:	± 0.005	± 0.011	±6%
RED SHINER (*Notropis lutrensis*)						
2 (36-50 mm)	15	0.9	48	0.120	0.132	91%
2 (36-50 mm)	15	0.7	48	0.146	0.159	91%
2 (36-50 mm)	15	0.9	48	0.147	0.165	89%
2 (36-50 mm)	15	0.8	48	0.142	0.159	90%
			Means:	**0.139**	**0.154**	**90%**
			95% Conf. Intervals:	± 0.012	± 0.015	±1%
3 (51-70 mm)	10	1.4	52	0.158	0.168	94%
3 (51-70 mm)	10	1.2	52	0.142	0.156	91%
3 (51-70 mm)	10	1.2	52	0.141	0.155	91%
			Means:	**0.147**	**0.160**	**92%**
			95% Conf. Intervals:	± 0.011	± 0.009	±2%

(continued)

Table 12. (Continued).

Size Class	(n)	Mean Fish Size wt (g)	lgth (mm)	µg/g METHYL Hg in WET Sample	µg/g TOTAL Hg in WET Sample	% Methyl Hg of Total Hg
				GREEN SUNFISH (*Lepomis cyanellus*)		
1 (25-50 mm)	12	0.9	40	0.098	0.106	92%
1 (25-50 mm)	12	0.9	40	0.082	0.094	86%
1 (25-50 mm)	12	0.9	40	0.091	0.104	88%
			Means:	**0.090**	**0.102**	**89%**
		95% Conf. Intervals:		± 0.009	± 0.007	±3%
2 (51-80 mm)	6	4.2	64	0.108	0.125	87%
2 (51-80 mm)	6	4.7	64	0.101	0.108	93%
2 (51-80 mm)	6	4.7	64	0.104	0.127	82%
			Means:	**0.104**	**0.120**	**87%**
		95% Conf. Intervals:		± 0.004	± 0.012	±6%
				MOSQUITOFISH (*Gambusia affinis*)		
1 (20-30 mm)	20	0.1	26	0.092	0.100	92%
1 (20-30 mm)	20	0.2	26	0.079	0.089	90%
1 (20-30 mm)	20	0.2	26	0.093	0.109	85%
			Means:	**0.088**	**0.099**	**89%**
		95% Conf. Intervals:		± 0.008	± 0.012	±4%
2 (31-40 mm)	15	0.5	36	0.105	0.113	93%
2 (31-40 mm)	15	0.4	36	0.121	0.130	93%
2 (31-40 mm)	15	0.5	36	0.107	0.115	93%
			Means:	**0.111**	**0.119**	**93%**
		95% Conf. Intervals:		± 0.009	± 0.011	±0%
3 (41-50 mm)	15	1.0	46	**0.150**	**0.169**	**89%**
				INLAND SILVERSIDE (*Menidia beryllina*)		
2 (51-65 mm)	15	1.0	60	0.156	0.181	86%
2 (51-65 mm)	15	0.9	60	0.135	0.143	94%
2 (51-65 mm)	15	1.0	60	0.137	0.147	93%
			Means:	**0.142**	**0.157**	**91%**
		95% Conf. Intervals:		± 0.013	± 0.023	±5%
3 (66-80 mm)	12	1.4	67	0.232	0.242	96%
3 (66-80 mm)	12	1.5	67	0.238	0.253	94%
3 (66-80 mm)	12	1.3	67	0.236	0.260	91%
			Means:	**0.235**	**0.252**	**93%**
		95% Conf. Intervals:		± 0.004	± 0.010	±3%