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*METHYLMERCURY TRANSPORT DOWN THE SACRAMENTO RIVER: IN A REGION OF DECREASING METHYLMERCURY CONCENTRATIONS*

The Sacramento River is a major source of methylmercury to the San Francisco Bay-Delta (Bay-Delta). Methylmercury originating in sediments and upstream tributaries is transported down the Sacramento River and out to San Francisco Bay. In this study methylmercury concentrations were measured during two field events along a 24 km transect of the Sacramento River starting at Sherman Lake. On December 16, 2003, during high river flow conditions (991 $m^3$/sec) both unfiltered and filtered methylmercury concentrations decreased at the confluence of the Sacramento River and the deep water shipping channel. On April 27, 2004, during low river flow conditions (340 $m^3$/sec) unfiltered methylmercury concentrations increased, while filtered methylmercury concentrations decreased. This continuing study seeks to identify the processes responsible for methylmercury loss in this vicinity. The following processes are being investigated: dilution, hydraulic residence time, particle settling, increasing salinity, photo degradation and bioaccumulation. A geo-referenced flow-through sensor package (Conductivity, Temperature, Transmissometry, and Fluorescence) has been developed to map total suspended solids, salinity, temperature, and chlorophyll a during transects planned in the Sacramento River for the summer and winter of 2004. Bottle incubation experiments will be used to estimate photo demethylation rates. Biological uptake rates by plankton will be estimated from previous lab experiments. Statistical analysis (linear regressions and principle component analysis) will be performed to quantify the significance of these processes in potentially controlling methylmercury transport and cycling. These factors should provide for a greater quantitative understanding of the processes controlling methylmercury cycling in surface waters and help to mitigate elevated mercury levels in Bay-Delta fish species.

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*SCIENCE TO SUPPORT RESTORATION PLANNING IN A SEVERELY DEGRADED ENVIRONMENT: THE MERCED RIVER DREDGER TAILINGS REACH*

Adaptive management approaches to river restoration are highly demanding of baseline scientific data. These support the generation of specific project objectives from which to derive testable hypotheses that explore project uncertainties, and the selection of performance criteria that form the basis of monitoring and evaluation. Conversely, 'predictive' river management generally required only hydrological data and construction of flow simulation models prior to project implementation, instead using factors-of-safety to buffer project uncertainties rather than extensive data collection. As a result, restoration projects are frequently lacking in pertinent data, requiring the rapid generation, integration and historical contextualization of data during project inception. Data deficiencies are especially acute in highly disturbed environments that have few reference counterparts, such as the Dredger Tailings Reach of the Merced River. Here, restoration planning must contend with significant flow regulation, a lack of coarse sediment supply, and the consequences of gold dredging that has produced a floodplain of tailing piles. Baseline data collection has included detailed topographic surveys, investigation of the dredger tailings' volume and texture, estimates of flood flow inundation levels, estimates of sediment transport potential, assessment of mercury content in tailings and surrounding waters, and periodic surveys to establish an empirical geomorphic and biological baseline. Results indicate that the contemporary floodplain is largely inaccessible to flood flows, that the channel sediment is frequently too coarse for spawning habitat, that very little sediment transport occurs other than re-distribution of gravels at augmentation sites, that the coarse floodplain sediment has little stratigraphic differentiation above the water table, and that levels of mercury are mostly very low. These results, while mostly anticipated, provide a rigorous (and potentially transferable) scientific basis to the restoration of functional channel and floodplain habitats in the reach, using process- and form-based rehabilitation techniques to improve the prospects for native fish and riparian vegetation.

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*TRANSPLANT STUDIES WITH THE INTRODUCED ASIATIC CLAM TO MEASURE METHYLMERCURY ACCUMULATION IN THE SACRAMENTO-SAN JOAQUIN DELTA*

A series of clam transplant studies were conducted with the Introduced Asiatic clam, Corbicula fluminea, to determine the temporal and spatial pattern of methylmercury uptake in the Estuary and the primary factor(s) controlling it. Four thousand clams were transplanted into replicate cages at six locations and change in body burden, tissue weight, and a suite of water quality parameters measured monthly at each site. Most of the methylmercury uptake and tissue growth occurred between March-June. The rate of methylmercury uptake was more variable (0.6 to 4.5-fold increase) than was tissue growth (1.3 to 1.8-fold increase) demonstrating that site-specific tissue concentrations are primarily determined by changes in methylmercury. The rate of change of methylmercury body burden in clams (ng-methylmercury per clam per month) was positively correlated to aqueous unfiltered methylmercury divided by chlorophyll concentration. Change in tissue weight (gms per clam per month) was positively correlated with chlorophyll concentration. Therefore, site-specific changes in methylmercury tissue concentration (ng-methylmercury per gm- dry tissue weight) are predicted to be a function of unfiltered aqueous methylmercury divided by chlorophyll concentration squared.

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*MERCURY METHYLATION AND DEMETHYLATION RATES IN SALTMARSHES BORDERING THE HAMILTON ARMY AIRFIELD ON SAN PABLO BAY*

The re-establishment of wetlands in the San Francisco Bay/Delta System using dredged material has the potential for mobilizing mercury present in the sediments. The origin of this contamination in the Bay System is largely from the historic mining of mercury in the nearby coastal mountains. Inorganic mercury can be methylated by certain bacteria in anoxic sediments to methylmercury (MeHg). MeHg is highly toxic and can accumulate in food webs. To estimate standing pool sizes of MeHg in coastal marshes this study evaluated the methylation and demethylation potential in two wetlands near the Hamilton Army Air Field (HAAF) on San Pablo Bay, using a stable isotope approach. Mean sediment concentrations ranged from 0.79 to 1.80 ng MeHg/g DW, i.e. from 0.11 to 2.58 % THg. MeHg concentrations in the macrophytes usually exceeded those in the sediments. Mean MeHg concentrations in macrophytes varied from 1.08 ng/g DW in Spartina stems to 5.59 ng/g DW in roots. The MeHg concentrations in macrophytes found in this study are in the same range as published for other saltmarshes, and greatly exceed those published for another freshwater wetland. Overall, rates of mercury methylation in sediments showed large variability within and among sites. Methylation rates decreased in the order epipelon>macrophyte-vegetated >non-vegetated, and mean values varied between 0.22 and 4.61 % Hg/12 h in the light and between 0.12 and 6.01 % in darkness. Daily MeHg degradation rates varied between 15 and 80 % of MeHg (administered as the Mz 200 isotope). This study will provide site-specific information, needed as a basis for wetland design and management in the San Francisco Bay area.

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*METHYL MERCURY ACCUMULATION IN CHINOOK SALMON REARING IN THE SACRAMENTO RIVER AND THE YOLO BYPASS*

In its methyl form, mercury has been shown to be damaging to several species of fish as well as to humans. The literature indicates a strong correlation between inundation of previously oxidized soils, such as that which can accompany flood plain or wetland inundation, and increased microbial methylation of mercury. As a consequence, there is concern over the potential for proposed wetland restoration in and around the San Francisco estuary to result in a significant increase in methyl mercury levels. Concern is perhaps greatest in locations such as the Yolo Bypass, a 59,000 acre floodplain that receives inflow from Cache Creek, the source of approximately 50% of the total methyl mercury load to the San Francisco estuary. Methyl mercury has been shown to bioaccumulate at higher trophic levels, creating the potential for higher body burden in predatory fish species such as Chinook salmon that use the Yolo Bypass as a primary rearing area. Our study builds on this research, through a comparison of methyl mercury accumulation in juvenile hatchery Chinook salmon placed in enclosures in the Sacramento River and in the Yolo Bypass during a winter 2004 flood event. For each of the study 2004 groups, we examine methyl mercury content and growth rate To provide an indication of temporal variability in bioaccumulation in floodplain salmon, we analyzed methyl mercury levels of Coded Wire Tagged (CWT) released in Yolo Bypass each year during 2001-2004.

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*DOES SHREDDING WATER HYACINTHS AFFECT MERCURY SPECIATION?*

*Eichhornia crassipes* (water hyacinth) is a non-native plant species found in abundance in the San Francisco Delta. Water hyacinths have become a problem by clogging the waterways and wetlands of the delta. They are also known to accumulate mercury, especially in the root system. Previous attempts to curb their proliferation have centered on the use of herbicides which subsequently pose environmental concerns. Current methods include shredding the water hyacinths with specialized boats. This research is to better understand the ability of water hyacinths to phytoremediate mercury, and to determine the effect of shredding on mercury speciation in the hyacinths.

Plant samples were collected from the Dow Wetlands and grown in 1ppm $HgCl_2$ under (1) aerobic conditions, (2) anaerobic conditions, and (3) with shredded plant material only. Water hyacinth roots and shoots samples were analyzed for mercury using CVAA. Plants were also analyzed at Stanford Synchrotron Radiation Lab using X-ray absorption spectroscopy (XAS), a method to examine speciation that is element-specific and non-invasive.

As expected the roots had a greater concentration of mercury than the shoots, and shredded hyacinths had a lower mercury uptake than live hyacinths. XAS data revealed that roots undergo speciation changes from a more ionic form in aerobic live plants, becoming more covalent in anaerobic conditions, and more so in shredded plants. During the summer of 2004 these data will be compared with concurrently collected XAS data on known inorganic and methylmercury forms, to complete the speciation process and determine whether shredding is affecting the degree of mercury methylation. This is strongly relevant to the CALFED goal of minimizing mercury methylation in the Delta.

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*ELEMENTAL MERCURY, CAN IT BE RECOVERED EFFICIENTLY BY GOLD SUCTION DREDGES?*

By now everyone knows that millions of pounds of elemental mercury were lost during California's Gold Rush and as a result, mercury is still found in California's rivers and streams today. Although normally dispursed in sediment, mercury occasionally concentrates in streams, usually on bedrock, in amounts that are visible to the naked eye (i.e., hotspots). A current urban legend purports that recreational gold miners using suction dredges recover substantial amounts of mercury from such hotspots in their pursuit of gold. The legend and the fact that there are several thousand recreational dredgers in California, led state and federal agencies to consider offering incentives to encourage recreational dredgers to recover and turn in mercury. Unfortunately, no one knew if "off the shelf" gold dredging equipment would recover mercury efficiently.

In October 2003, United States forest Service, Department of Fish and Game, and State Water Resource Control Board staff dredged a mercury hotspot in the South Fork of the American River at Lotus California. The recovery results indicated that "off the shelf" suction dredges are not efficient at recovering liquid elemental mercury.

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*SEDIMENT GEOCHEMISTRY AND MERCURY IN BIOTA AT HAAF AND CHINA CAMP, SAN PABLO BAY, CA*

Clean dredged material from San Francisco Bay harbors and channels will be used to restore nearly 1000 acres of lost wetlands at the Hamilton Army Airfield (HAAF) site. Wetlands tend to produce the conditions for methylation of mercury when other forms of mercury are present, as they are in most of the sediments of San Francisco Bay. Analysis of surficial soils/sediments at HAAF and China Camp showed mobilization of mercury as MeHg. Management of mercury methylation in reconstruction of the HAAF salt marsh will require knowledge of characteristics of the sediments that relate to mercury methylation and the uptake of mercury in resident biota. We took soil/sediment cores at the intertidal zones and selected upper marsh sites at HAAF and China Camp, sectioned them by depth, and analyzed the geochemical constituents. Analytes were THg and MeHg, PSD, AVS, TOC, Fe, Al, selected trace elements, and mineralogy. Eh/pH measurements on depth sections were made in situ. Clams, snails, and mussels were collected as found at the sample sites and were analyzed for THg and MeHg. Sulfide and redox potential in intertidal sediments were inversely related to depth, the redox cline occurred within 2-5 cm of the surface, and MeHg concentrations were highest at the surface and declined with increasing Eh negativity. THg increased with depth and was inversely related to MeHg (rho = -0.60 to -0.89). Bioaccumulation was evidenced by all organisms with THg in mussels and crabs averaging 15-30 ng/g ww and snails averaging 100 ng/g. Biota MeHg in THg ranged 10-90%. Bioaccumulation factors (BAF, dw basis) were 12 for the snails and 1-4 for the crabs and mussels. Results will be used in parameterization of QnD:HAAF, a testable and iterative site-specific model for management of mercury in wetlands restoration at HAAF.

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*EFFECTS OF METHYLMERCURY ON GREEN STURGEON, ACINPENSER MEDIROSTRIS, BIOENERGETICS AT VARIOUS LIFE STAGES*

Restoration projects in California may accelerate the methylation of mercury (Hg), increasing related risks to wildlife and human health. Green sturgeon are considered a species of special concern In California, and nothing is known regarding the effects of this toxicant on its lifestages' bioenergetic parameters essential for efficiently using resources and survival. Spawning and development of this species is limited to two watersheds in California, Klamath/Trinity and Sacramento river systems. Both of these watersheds are known to be contaminated with mercury and methylmercury. Three experiments were conducted to determine the effects of methylmercury on green sturgeon bioenergetics. Green sturgeon eggs, larvae, and juveniles were exposed to methylmercury via three routes: egg immersion, larval injection, and dietary exposure. We investigated the effects of methylmercury on embryonic development, hatching success, and growth following exposure to aqueous concentrations of methylmercury during the water hardening phase of the egg chorion post fertilization. Newly hatched, exposure naive, sturgeon larvae were injected with one of four dose regimes of methylmercury into the yolk sac. We examined the effects of methylmercury, administered by injection, on larval growth, oxygen consumption, swimming performed and survival. Juvenile green sturgeon were exposed for 40 days to four different dietary concentrations of methylmercury. Measured parameters include growth, swimming performance, oxygen consumption and survival. Our developmental and bioenergetic data will assess the risks of physiological compromise in green sturgeon embryos, larvae and juveniles exposed to methylmercury, assisting ecologists in evaluating risks and benefits of proposed restoration efforts slated for the Sacramento, Klamath and Trinity River watersheds.

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*APPLICATION OF A SPATIALLY-EXPLICIT ECOSYSTEM MODEL FOR REDUCING METHYLMERCURY RELEASES FROM RESTORED WETLAND AREAS*

The restoration effort of the former Hamilton Army Air Field (HAAF) presents significant questions on strategies to limit the production of methylmercury (meHg). These questions include the temporal and spatial-scale of meHg production as well as the dynamics of its trophic transfer through the food chain. The Questions and Decisions™ (QnD™) screening model system was created to provide an effective and efficient tool to incorporate ecosystem, management, economics and socio-political issues into a user-friendly modeling framework. The model is written in object-oriented Java and can be deployed as a stand-alone program or as a web-based (browser-accessed) tool. The QnD model links the spatial components within geographic information system (GIS) files to the abiotic (climatic), biotic and chemical/contaminant interactions that exist in an environmental system. The model development is iterative and can be initiated through conversations with scientists, potential model users or stake-holders.

An initial version of the QnD model for the Hamilton site (QnD:HAAF) was designed to use experimental results from current and on-going US Army Corps of Engineers research at the HAAF site. The prototype model was constructed with four idealized marsh habitats (Salicornia-dominated marsh, Spartina-dominated marsh, Mudflats and SubTidal areas) with representative plant, invertebrate and higher trophic-level species. Simplified methylation/demethylation relationships were combined with bioaccumulation factors to simulate elementary uptake/release dynamics. Two, 14-day scenarios were simulated at an hourly time step to represent seasonal dry and wet periods. Results from simulations indicate a significant seasonal meHg production/export potential along with related trophic transfer levels. An important aspect of this meHg production/transfer is the elevation of the different habitats and their oxic/anoxic status in relation to other influences such as light conditions. The model results and design are iterative so that both scientific and management issues can be modified and tested adaptively for further collective learning.

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*MODELING UNCERTAINTY USING BAYESIAN NETWORKS FOR MERCURY TMDL DECISION ANALYTICAL SUPPORT*

Problem Statement: Water quality impairment due to high mercury fish tissue concentrations (Hg-fish) and elevated mercury aqueous concentrations is a widespread problem in several sub-watersheds that are major sources of mercury to the San Francisco Bay. Several mercury Total Maximum Daily Load regulations are currently being developed to address this problem. Decisions about control strategies are being made despite very large uncertainties about current mercury loadings, relationships between total mercury ($Hg_T$) loading and methyl mercury (MeHg) formation, and relationships between control efforts and Hg-fish.

Approach: This work proposes a novel decision analytical alternative to the current use of safety factors and deterministic models for mercury TMDL decision support, one that is fully compatible with an adaptive management approach. The approach uses a probabilistic (Bayesian) network (BN) model of the relationships between potential mercury control efforts, $Hg_T$ loadings, MeHg concentrations, and Hg-fish in the Cache Creek watershed, a major source of mercury to the Bay Delta. The stochastic empirical models used to generate the needed probability distributions are based on the same empirical models currently being used by the Cache Creek mercury TMDL workgroup. The significant difference is that model input uncertainty and model error are explicitly included and propagated throughout the model using BN algorithms.

Results: Model results include 1) probabilistic estimates of $Hg_T$ loads and MeHg concentrations within watershed segments; 2) probabilistic estimates of the downstream effects of various control strategies on $Hg_T$ loadings, MeHg concentrations, and Hg-fish; and 3) probabilistic inferences about unmonitored total mercury sources given observations from monitored sources.

Relevance: This work demonstrates an approach to handling uncertainty in a complex and highly uncertain TMDL decision process. The various sources of uncertainty are integrated and propagated as decision risk, allowing decision makers to simultaneously consider uncertainties in mitigation/implementation costs and in meeting various environmental/ecological targets.

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*METHYLMERCURY PRODUCTION IN EXPERIMENTAL RESERVOIRS INUNDATING BOREAL FORESTS: SENSITIVITY TO LAND COVER AND FLOODING*

Hydroelectric reservoir creation increases mercury content in piscivorous fish, which can remain elevated for decades after the initial inundation. We examined the dependence of methylmercury (MeHg) production on storage of organic carbon (OC) in upland soils of three hectare-scale experimental reservoirs of varying OC content (the FLUDEX Experiment). Three years of results indicate that the overall rate of MeHg production is positively correlated with soil OC storage, and that most of the production occurs in the surficial sediments. Methylmercury production increased greatly after inundation, and was particularly stimulated in areas containing specific vegetation types. The medium-OC site exported the most MeHg throughout the study, while the high-OC site retained the majority in its sediments. The low-OC produced and exported the least MeHg at all times. Reservoirs were drawn down each winter, during which the soil MeHg remained stable until the following spring. Methylmercury production rates were greatest in year two, and significantly decreased in all sites in year three. While OC content appears to control the total amount of MeHg formed, most of it was retained within the system in surficial soils. Export fluxes observed from the poor upland soils of FLUDEX were similar in magnitude (27-122 ng MeHg $m^{-2}$ $d^{-1}$) to those observed in a nearby flooded peatland (5-15 ng $m^{-2}$ $d^{-1}$), and the Everglades (22-192 ng $m^{-2}$ $d^{-1}$), suggesting that in the short term, export and subsequent exposure is more a function of specific vegetation type, labile carbon content, and sulfate availability than of total OC stores in soil. Further, rapid increases in porewater MeHg at the onset of each inundation period suggest that the re-oxidation of sulfide through drawdown likely provides a new source of sulfate for subsequent MeHg production. The MeHg content in reservoir food webs generally increased over time, but not in a predictable fashion.

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*DOES DIETARY METHYLMERCURY ALTER FISH REPRODUCTION?*

Little is known of the effects of environmentally realistic concentrations of methylmercury on wild populations of fish. We conducted a series of laboratory experiments with fish to (1) assess the effects of dietary methylmercury on reproduction and (2) to establish the relationship between methylmercury, altered reproduction, and biomarkers that could also be measured in wild populations. We fed juvenile fathead minnows diets contaminated with methylmercury (0.06 to 8.46 (Mu)g Hg $g^{-1}$ dry weight). At sexual maturity, fish were paired, allowed to reproduce and then analyzed for total mercury, plasma testosterone (T), and 17(Beta)-estradiol (E2). Dietary methylmercury reduced reproductive success and delayed spawning, altered spawning behavior, and reduced egg production. Moreover, dietary methylmercury suppressed levels of T in males and E2 in females. It also inhibited gonadal development of females; gonadal development was positively related to plasma levels of T in males and E2 in females. We subsequently quantified sex hormones (T and 11-ketotestosterone) in adult male northern pike from semi-pristine drainage lakes in Voyageurs National Park, USA. The lakes span a narrow range in pH, but vary more than 8-fold in methylmercury concentrations in resident northern pike and have some of the highest concentrations of methylmercury in fish within Minnesota. Fish were sampled shortly before active spawning in early May 2002. Concentrations of reproductive hormones varied greatly among individual fish within each lake. However, mean hormone concentrations decreased markedly with increasing methylmercury exposure among lakes, as reflected by the concentration of total mercury in axial muscle tissue of the fish. Reproduction of wild fishes may be adversely affected by methylmercury, and suppressed hormone levels can be used to indicate diminished reproduction of fish.

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*METHYL MERCURY EXPORT FROM TWO PONDS ON TWITCHELL ISLAND: HABITAT MAKES A DIFFERENCE*

Wetlands are known to be major contributors of methyl mercury to the Bay-Delta system. Considering 5,504 hectares of wetland restoration is planned for the Bay-Delta, it is important to evaluate which aspects of wetland design affect methyl mercury production. The sediment-water flux of methyl mercury in two 270-hectare experimental ponds on Twitchell Island was examined from June to December 2003. The ponds had different depths, vegetation densities, water flow patterns, and methyl mercury production rates. The flux of methyl mercury was calculated from water budgets, methyl mercury concentration of import and export waters, and the surface area of the ponds. In June, the flux of methyl mercury from the west pond was 41 ng $m^{-2}$ $d^{-1}$ while the flux from the east pond was 3 ng $m^{-2}$ $d^{-1}$. In October, the flux from both ponds leveled off to 3 ng $m^{-2}$ $d^{-1}$. If the planned wetlands are similar to the west pond with respect to methyl mercury production, they could contribute an additional 2.25 g $d^{-1}$ of methyl mercury to the delta. Conversely, wetlands that are similar to the east pond could contribute far less methyl mercury. Investigations to determine why these two similar ponds are producing different amounts of methyl mercury are critical for making restoration decisions.

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*TRENDS IN METHYLMERCURY EXPOSURE ASSOCIATED WITH A GRAVEL PIT LAKES WETLAND RESTORATION AT CACHE CREEK*

Lower Cache Creek in Yolo County is a primary source of gravel used in construction throughout the surrounding region. Gravel mining has been discontinued within the flow channel, with current mining consisting of shallow to deep pit operations in the adjacent floodplain. As these pit regions are exhausted of target rock, long range planning proposes converting them into wetland habitats, resulting ultimately in a series of approximately 17 substantial constructed wetlands along the Capay-Woodland Cache Creek corridor. The concern, in this documented high mercury watershed, is that the habitat and recreational benefits of these new wetlands may be compromised by enhanced methylmercury exposure and export.

Mercury bioaccumulation was investigated over a three year period at a newly constructed pit lakes wetland restoration, the Cache Creek Nature Preserve, as well as in the Gordon Slough inflow and Cache Creek upstream and downstream of the wetlands.

A distinctive spatial pattern of bioaccumulation was found, with identical small fish biosentinels in the constructed wetlands accumulating to more than double the concentrations of methylmercury seen in the inflowing slough habitat, statistically significant at the 95% confidence level. Methylmercury in outflowing water was also elevated. No discernible bioaccumulation increases generally resulted in downstream Cache Creek, possibly due to the relatively low concentrations in Gordon Slough source water. Large, statistically significant seasonal cycles were found in mercury bioaccumulation in both wetland and creek environments, with minimum concentrations in the late winter and spring and maximum concentrations (as much as 5-fold greater) in summer and fall.

This type of converted, vegetated wetlands habitat can be expected to enhance localized methylmercury production and exposure, relative to slough inflow habitats. The magnitude of this effect may be minimized by utilizing low-mercury source water and low-mercury surficial sediments. Export of methylmercury may be minimized by minimizing warm season outflows.

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*BIOACCUMULATION OF GOLD-RUSH MERCURY IN REACHES OF THE YUBA RIVER WATERSHED PROPOSED FOR ANADROMOUS FISH REINTRODUCTION*

The Middle Yuba and South Yuba rivers are being considered as sites of renewed spawning access for anadromous salmonids, including steelhead and spring-run Chinook salmon. This would require fish passage at Englebright Dam (79 m high), which is being considered for decommissioning or modification. The potential for juvenile anadromous salmonids to be exposed to elevated methylmercury (MeHg) in the upper watershed is of concern.

Biotic mercury was sampled at 13 sites, 10 upstream and 3 downstream of Englebright Lake. Sites spanned the zone of historical gold-mining activity (200-900 m elevation), with additional sites upstream and downstream (30-1,700 m elevation). Adult and juvenile trout, hydropsychid caddisflies, and perlid stoneflies were utilized as biosentinels of relative MeHg exposure. Non-anadromous rainbow trout were sampled from upstream sites as surrogates for potentially reintroduced anadromous salmonids.

All biotic samples showed consistent, statistically significant increases in MeHg and total mercury (THg) within the historical gold mining zone: 4- to 6-fold increases of MeHg in invertebrates, 2- to 4-fold increases of THg in juvenile trout, and 2- to 3-fold increases of THg in adult trout. Mercury bioaccumulation was significantly lower immediately downstream from Englebright Lake, although some higher values were noted further downstream in the lower Yuba River, the site of large-scale historical and ongoing dredging activity. MeHg concentrations in aquatic insects and juvenile trout correlated strongly with each other and with THg concentrations in adult trout, all exhibiting system-wide $R^2$ correlation coefficients greater than 0.90.

Significant mercury bioaccumulation was found within the historical gold-mining region in the upper Yuba River watershed. If mercury-contaminated stream reaches are re-opened for migration and rearing of anadromous salmonids, juveniles are likely to be exposed to elevated MeHg, with possible adverse effects. This study confirms the utility of young-of-year fish and aquatic insects as biosentinels for MeHg exposure and bioaccumulation.

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*METHYLMERCURY EXPORTS FROM WETLANDS IN THE SAN FRANCISCO BAY DELTA--PRELIMINARY DATA*

The California Bay-Delta Authority plans to convert large amounts of San Francisco Bay-Delta agricultural land to wetlands. Studies conducted in numerous estuaries including the Bay-Delta have shown wetlands to be major methylmercury production sites. Mass balance calculations suggest that in low flow conditions about 40 percent of the aqueous methylmercury present in the Bay-Delta estuary at any time is produced in situ and an unknown fraction originates from Delta marshes. A concern, expressed by the Authors of the Mercury Strategy for the Bay-Delta Ecosystem, is that the conversion of large tracts of Bay-Delta agricultural land to marsh habitat may exacerbate methylmercury exposure and concentrations in aquatic resources. Several studies were conducted in the Bay-Delta to quantify methyl mercury export from marsh habitat. Methylmercury concentration data from Browns Island indicate methyl mercury is exported from the marsh during the latter half of the ebbing tide cycle. Other studies are ongoing in Suisun Slough and Twitchell Island to determine water and methylmercury exports/imports for the determination of mass loading estimates. The wetlands mass loads are compared to mass loads from riverine inputs for a better understanding of the relative importance of each habitat within the overall Bay-Delta methylmercury budget. Data from several wetland areas are presented.

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*EFFECTS OF MERCURY ON BIRD REPRODUCTION IN THE SAN FRANCISCO BAY-DELTA ECOSYSTEM*

The legacy of mining in California, resulting in mercury (Hg) accumulation in the Bay/Delta Ecosystem has resulted in potential Hg bioaccumulation and adverse effects on listed and non-listed wildlife species. A three-year joint U.S. Fish and Wildlife Service and U.S. Geological Survey project is being initiated with funding from CALFED to evaluate the potential effects of Hg on three foraging guilds of birds in the Bay-Delta ecosystem. A field component will build on existing data to evaluate reproduction in diving ducks (surf scoters), recurvirostrids (stilts, avocets) and terns (Caspian and Forsters). We will identify trophic pathways for each foraging guild (using diet, stable isotopes and telemetry), quantify Hg concentrations in adults, eggs and chicks of selected species, and evaluate reproductive success for each foraging guild by quantifying hatchability and chick survival. Laboratory studies will: (1) establish and refine Hg dose-response relationships and threshold concentrations of methyl Hg associated with embryo toxicity to various avian taxa using egg injection studies, and (2) use mallards to conduct a feeding study designed to establish a true NOAEL (No Observed Adverse Effects Level) to which egg injection studies may calibrated.