AN ABSTRACT OF THE DISSERTATION OF

Kerri A. Stanley for the degree of Doctor of Philosophy in Toxicology presented on December 12, 2008.

Title: Semi-Volatile Organic Compounds and Developing Organisms: Accumulation in California Mountain Tadpoles in the Field and Fish Embryo Exposures in the Laboratory

Abstract approved:

Staci L. Massey Simonich Lawrence R. Curtis

The atmospheric transport and deposition of semi-volatile organic compounds (SOCs), including current and historic use pesticides, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), to mountain ecosystems may result in the exposure of tadpoles to these SOCs. This exposure has been implicated in amphibian population declines in California. Tadpoles encounter sediment during burrowing and feeding, making sediment a potential route of SOC exposure. Little is known about the potential adverse effects of SOCs on developing tadpoles at the relatively low concentrations measured in mountain ecosystems. A matrix solid phase dispersion (MSPD) method was developed and validated to measure over 70 SOCs in tadpole tissue. The MSPD method was used to analyze tadpole samples collected from 81 sites throughout the Cascade and Sierra Nevada Mountains in California. Sediment samples from these sites were also analyzed and the tadpole and sediment SOC concentrations were investigated with respect to regional pesticide use. The tadpole and sediment concentrations of current use pesticides, including dacthal, endosulfan II, endosulfan sulfate, and total endosulfans, were significantly negatively correlated with site distance from pesticide use areas. Tadpole and sediment concentrations were not significantly positively correlated within regions indicating possible differences in food web exposure and tadpole metabolism of the SOCs between ecosystems. However, tadpole and sediment concentrations of several SOCs were significantly correlated on a statewide basis, indicating regional differences, i.e. low SOC concentrations in the Cascades and high concentrations in the SEKI tadpoles and sediment. Endosulfan sulfate was the most frequently detected SOC and its developmental toxicity, along with endosulfan I was investigated using the zebrafish model. An abnormal response of embryos and larvae to touch, indicating neurotoxicity, was the most sensitive endpoint for endosulfan I and the sulfate, with EC_{50}s of 2.2 µg/L and 23 µg/L, corresponding to tissue EC_{50}s of 367 ng/g and 4552 ng/g wet weight, respectively. However, NOAEC and tissue EC_{50}s were above those measured in the tadpoles collected from mountain ecosystems for which the maximum measurement of total endosulfans was 1.62 ng/g wet weight. Finally, endosulfan I was approximately ten times more toxic than endosulfan sulfate in developing zebrafish.

Semi-Volatile Organic Compounds and Developing Organisms: Accumulation in California Mountain Tadpoles in the Field and Fish Embryo Exposures in the Laboratory

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Kerri A. Stanley, Author

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CONTRIBUTION OF AUTHORS

Dr. Staci L. Massey Simonich assisted with experimental design and writing for Chapter 2. Dr. Carlos Davidson, Dr. David F. Bradford, and Dr. Nita Tallent-Halsell provided samples for use in method development and assisted with writing for Chapter 2. Dr. Simonich provided guidance and assisted with the writing of Chapter 3. Dr. Davidson was responsible for the study design and sample collection for the Cascades 2005 and Sierra Nevada Mountains 2006 portion of the project. Dr. Bradford and Dr. Tallent-Halsell were responsible for the study design and sample collection for the Sequoia and Kings Canyon National Parks 2005 and Yosemite National Park 2006 portion of the project as well as the total organic carbon analysis for all sediment samples. Dr. Bradford provided the 2005 and 2006 CA DPR pesticide data for importation into ARC GIS. Rachel Huber was responsible for most of the sediment sample preparation for chemical analysis for Chapter 3. Dr. Robert Tanguay, Dr. Lawrence R. Curtis, and Dr. Simonich provided guidance and assisted with writing for Chapter 4.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (continued)

Semi-Volatile Organic Compounds and Developing Organisms: Accumulation in California Mountain Tadpoles in the Field and Fish Embryo Exposures in the Laboratory

1. Introduction

1.1 Objectives

The purpose of this research was to assess the accumulation of semi-volatile organic compounds (SOCs), including current and historic use pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs), in tadpoles and sediment collected from ecosystems throughout the Cascade and Sierra Nevada Mountains of California, U.S.A where some amphibian species are in decline. Additionally, in order to better understand the measured tadpole tissue concentrations of endosulfan sulfate, the most frequently detected SOC in tadpole tissue and sediment samples, toxicity tests were conducted in the laboratory using the embryonic zebrafish model.

1.2 Atmospheric Transport and Deposition of SOCs to the Cascade and Sierra Nevada Mountains

Long range and regional transport of SOCs, including transport to mountain ecosystems [1, 2], has been observed around the globe in temperate and tropical areas [3-18]. Recently it has been suggested that regional atmospheric transport is particularly important when considering SOC transport to high elevation ecosystems [12, 14, 16]. Upslope mountain winds transport SOCs from their sources at lower elevations to high elevation ecosystems [10]. SOC deposition in mountainous sites depends on their location relative to predominant wind direction, as well as source locations and topography [16].

The Central Valley of California lies south of the Cascades Mountains and adjacent to the Sierra Nevada Mountains and is compromised of the Sacramento Valley in the north and the San Joaquin Valley in the south. The valley is one of the most productive agricultural regions in the world [19], and large amounts of pesticides are applied there. The Central Valley also includes large populated areas such as

Sacramento and Fresno, which may be a source of polycyclic aromatic hydrocarbons (PAHs), formed during incomplete combustion, and polychlorinated biphenyls (PCBs), historically use in many industrial processes [20, 21]. The predominant wind direction patterns results in atmospheric transport of agrochemicals and anthropogenic chemicals from the valley to the Cascades and Sierra Nevada Mountains [22].

In recent years, the incidence of forest fires in the Cascade and Sierra Nevada Mountains has increased [23]. In addition to agricultural and urban sources of SOCs, forest fires may result in the revolatilization of pesticides, used in forestry or previously deposited as a result of atmospheric transport, and the formation of PAHs as a result of wood combustion [24-27].

Most of the research on atmospheric transport and deposition of SOCs in California mountains has been conducted in the Sierra Nevada Mountains [5-9, 14, 17, 28-32]. Limited data exists on atmospheric transport to the Cascade Mountains [15, 29, 32]. SOC measurements have been made in several environmental matrices, including precipitation [5, 7, 9, 14], lake water [5, 6, 15, 30], sediment[15], vegetation [8, 15], fish [5, 17, 32], tadpoles [29, 31, 32], and frogs [28-30].

Once deposited to high elevation aquatic ecosystems, SOCs may persist for hours to years depending on their environmental half-lives [33]. Depending on their physical-chemical properties, SOCs may remain in the water column or accumulate in the sediment. Organisms, including tadpoles, may accumulate SOCs directly through the water column, through interactions with the sediment, or through the food web.

Sediment may be a particularly important accumulation route for tadpoles due to their behavior, including burrowing to hide from predators and feeding on detritus [34, 35]. Some frog species, such as the mountain yellow-legged frog, take more than one summer to metamorphose and overwinter underwater [36]. Both water and sediment are important SOC exposure routes for these species due to the long time period they spend in the aquatic environment.

Several previous studies have investigated amphibian accumulation of some SOCs in mountain ecosystems. The first to do so was Cory et al. in 1970 in which they measured DDE in frogs collected throughout the Sierra Nevada Mountains [28]. This study was also likely the first to report SOC accumulation in remote ecosystems as a result of regional atmospheric transport [28]. Studies in the 1990s examined the accumulation of some current and historic use pesticides, as well as PCBs, in tadpoles and frogs at different locations throughout California, with an emphasis on the Sierra Nevada Mountains [29-32]. These studies measured only a limited number of SOCs and did not considered sediment as a potential exposure route in these mountain ecosystems.

1.3 Background on Amphibian Declines

Amphibian population declines have been reported around the world and have received considerable attention since the 1990s [37-41]. At least one third of amphibian species are currently in danger of becoming extinct [41, 42]. Many studies have investigated potential causes of decline and several contributing factors have been suggested, including habitat alterations, ultraviolet radiation, climate change, disease, introduced predators, and anthropogenic chemicals [38, 43, 44]. The synergistic interaction of these factors likely plays a role in amphibian declines with populations differentially influenced by the causative agents [45-52].

In California, several amphibian species are declining. Among them are the Cascades frog (*Rana cascadae*) and the mountain yellow-legged frog (*Rana muscosa*). The Cascades frog has disappeared from parts of its range in the California Cascades and the mountain yellow-legged frog has disappeared from the majority of its range in Southern California and the Sierra Nevada Mountains [53-56]. Cascade frog declines have been suggested to be a result of many synergistic factors; nonnative trout, disease, and contaminants have been suggested to have the greatest impact [57]. The presence of nonnative trout has been associated with mountain yellow-legged frog declines in parts of the Sierra Nevada Mountains [58-61]. Recently chytridiomycosis (*Batrachochytrium dendrobatidis*), a fungal pathogen, has been associated with the disappearance of several populations of the mountain yellow-legged frog in the Sierra Nevada [62, 63]. Contaminant exposure, among other causes, has been implicated in the Cascades frog and the mountain yellow-legged frog declines due to the close proximity of the Sierra Nevada and Cascades Mountains to the Central Valley [29, 30, 64].

1.4 Developmental Toxicity of SOCs and the Embryonic Zebrafish Model

Vertebrates, including amphibians, are particularly sensitive to contaminant exposure during development [65, 66]. In addition, it has been shown that maternal transfer of organic compounds occurs in frogs [67]. Exposure to SOCs via maternal transfer, waterborne exposure, or sediment has the potential to adversely affect developing eggs and tadpoles.

In order to investigate the developmental toxicity of endosulfan, the embryonic zebrafish model was chosen [68] and, with caveats, these results were extrapolated to amphibians. Zebrafish are a model organism for toxicological studies [69]. The benefits of the model include transparent embryos and larvae, large numbers of organisms available year round, and the small amounts of chemicals and other materials necessary to conduct toxicity tests due to the small size of embryos and larvae. The embryonic zebrafish model was chosen over the use of tadpoles because of the increased availability of organisms year-round; the short time period to assess developmental toxicity (5 days compared to several weeks for tadpoles); and the reduced cost required for animal husbandry and exposure studies (zebrafish embryos are smaller in size than tadpole embryos and larvae). Also, zebrafish and amphibians share developmental similarities, including fate maps, nervous system and muscle development, and early motility and behaviors [70, 71].

1.5 Data Gaps

Studies conducted to date on amphibian accumulation of SOCs have analyzed only a small number of compounds or chemical classes. The potential for amphibian exposure to many SOCs belonging to several chemical classes exists and thus, methods capable of detecting trace amounts of a wide range of SOCs are necessary to better characterize exposure in mountain ecosystems.

Our understanding of amphibian SOC exposure pathways in mountain ecosystems is limited [30]. Sediment has been suggested as an important route, however studies taking place in mountain ecosystems have not measured SOCs in tadpoles and sediment simultaneously. Although tissue measurements of SOCs in amphibians from the field have been made, these concentrations have not been compared to tissue measurements associated with toxic endpoints.

1.6 Studies Conducted

The research described in this dissertation presents an analytical method developed and validated to measure over 70 SOCs, including current and historic use pesticides, PCBs and PAHs, in tadpole tissue in Chapter 2. The method used a matrix solid phase dispersion (MSPD) extraction technique and is compared to a method previously developed for the analysis of SOCs in fish tissue, which used pressurized liquid extraction (PLE). The goal of the MSPD method was to improve the recoveries of the current-use pesticides relative to the PLE method.

Next, in Chapter 3, the analytical method is applied to tadpole samples collected throughout the California Cascades and Sierra Nevada Mountains, including Sequoia and Kings Canyon National Parks and Yosemite National Park, in 2005 and 2006. The analysis of sediment samples collected from the same lakes is also presented. Samples were collected from a total of 81 lakes, ponds, and wetlands throughout California. Pacific chorus frog tadpoles were collected from all regions. This species is not in decline and was used as a surrogate species for the Cascades frog and the mountain yellow-legged frog which are in decline. At some sites in the Cascades where the Cascades frog is still abundant, tadpoles were collected. The primary objectives included assessing the relationship of SOC accumulation in tadpoles and sediment samples with the site distance from regional sources, as well as the relationship between SOC accumulation in tadpoles and sediment. Biota sediment accumulation factors (BSAFs) for tadpoles are also presented.

Lastly, in Chapter 4, the developmental toxicity of endosulfan I and endosulfan sulfate, a metabolite of endosulfan I and II, is investigated using the embryonic zebrafish model. Endosulfan sulfate was the most frequently detected current use pesticide in California tadpole and sediment samples and was also detected at the highest concentrations. The objectives were to determine the most sensitive endpoint of endosulfan I and endosulfan sulfate toxicity in zebrafish, to measure the associated tissue concentrations, and to compare to the corresponding tissue concentrations of organisms in the field. The relative developmental toxicity of endosulfan sulfate and endosulfan I was also determined.

1.7 References

[1] Carrera G, Fernandez P, Vilanova RM, Grimalt JO. 2001. Persistent organic pollutants in snow from European high mountain areas. *Atmospheric Environment* 35:245-254.

[2] Grimalt JO, Fernandez P, Berdie L, Vilanova RM, Catalan J, Psenner R, Hofer R, Appleby P, Rosseland BO, Lien L, Massabuau JC, Battarbee RW. 2001. Selective trapping of organochlorine compounds in mountain lakes of temperate areas. *Environ Sci Technol* 35:2690-2697.

[3] Simonich S, Hites R. 1995. Global distribution of persistent organochlorine compounds. *Science* 269:1851-1854.

[4] Blais JM, Schindler DW, Muir DCG, Kimpe LE, Donald DB, Rosenberg B. 1998. Accumulation of persistent organochlorine compounds in mountains of western Canada. *Nature* 395:585-588.

[5] Datta S, McConnell LL, Baker JE, LeNoir J, Seiber JN. 1998. Evidence for atmospheric transport and deposition of polychlorinated biphenyls to the Lake Tahoe Basin, California-Nevada. *Environ Sci Technol* 32:1378-1385.

[6] LeNoir JS, McConnell LL, Fellers GM, Cahill TM, Seiber JN. 1999. Summertime transport of current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry* 18:2715-2722.

[7] McConnell LL, LeNoir JS, Datta S, Seiber JN. 1998. Wet deposition of current-use pesticides in the Sierra Nevada Mountain Range, California, USA. *Environmental Toxicology and Chemistry* 17:1908-1916.

[8] Aston LS, Seiber JN. 1997. Fate of summertime airborne organophosphate pesticide residues in the Sierra Nevada Mountains. *Journal of Enviornmental Quality* 26:1483-1492.

[9] Zabik JM, Seiber, J.N. 1993. Atmospheric transport of organophosphate pesticides from California's Central Valley to the Sierra Nevada Mountains. *Journal of Enviornmental Quality* 22:80-90.

[10] Daly GL, Wania F. 2005. Organic contaminants in mountains. *Environ Sci Technol* 39:385-398.

[11] Daly GL, Lei YD, Teixeira C, Muir DCG, Castillo LE, Jantunen LMM, Wania F. 2007. Organochlorine Pesticides in the Soils and Atmosphere of Costa Rica. *Environ Sci Technol* 41:1124-1130.

[12] Daly GL, Lei YD, Teixeira C, Muir DCG, Castillo LE, Wania F. 2007. Accumulation of current-use pesticides in neotropical montane forests. *Environ Sci Technol* 41:1118-1123.

[13] Daly GL, Lei YD, Teixeira C, Muir DCG, Wania F. 2007. Pesticides in Western Canadian mountain air and soil. *Environ Sci Technol* 41:6020-6025.
[14] Hageman KJ, Simonich SL, Campbell DH, Wilson GR, Landers DH. 2006. Atmospheric deposition of current-use and historic-use pesticides in snow at national parks in the Western United States. *Environ Sci Technol* 40:3174-3180.
[15] Landers DH, Simonich SL, Jaffe DA, Geiser LH, Cambell DH, Schwindt AR, Schreck CB, Kent ML, Hafner WD, Taylor HE, Hageman KJ, Usenko S, Ackerman LA, Schrlau JE, Rose NL, Blett TF, Erway MM. 2008. The fate, transport, and ecological impacts of airborne contaminants in western national parks (USA). Corvallis, OR.
[16] Usenko S, Landers DH, Appleby PG, Simonich SL. 2007. Current and historical deposition of PBDEs, pesticides, PCBs, and PAHs to Rocky Mountain National Park. *Environ Sci Technol* 41:7235-7241.
[17] Ackerman LK, Schwindt AR, Massey Simonich SL, Koch DC, Blett TF, Schreck CB, Kent ML, Landers DH. 2008. Atmospherically deposited PBDEs, pesticides, PCBs, and PAHs in Western U.S. National Park fish: Concentrations and consumption guidelines. *Environ Sci Technol* 42:2334-2341.
[18] Carrera G, Fernandez P, Grimalt JO, Ventura M, Camarero L, Catalan J, Nickus U, Thies H, Psenner R. 2002. Atmospheric deposition of organochlorine compounds to remote high mountain lakes of Europe. *Environ Sci Technol* 36:2581-2588.
[19] USGS. 2008. USGS Ground-Water Information http://water.usgs.gov/ogw/gwrp/activities/gw-avail.html. Vol 2008.
[20] Van Metre PC, Mahler BJ, Furlong ET. 2000. Urban sprawl leaves its PAH signature. *Environ Sci Technol* 34:4064-4070.
[21] Brevik K, Sweetman A, Pacyna JM, Jones KC. 2002. Towards a global historical emission inventory for selected PCB congeners -a mass balance approach: 2. Emissions. *The Science of the Total Environment* 290:199-224.
[22] Hayes TP, Kinney JJR, Wheeler NJM. 1984. California surface wind climatology. California Air Resources Board, Aerometric Data Division, Aerometric Projects and Laboratory Branch, Meteorology Section, Sacramento, CA, USA.
[23] Westerling AL, Hidalgo HG, Cayan DR, Swetnam TW. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. *Science* 313:940-943.
[24] Nelson GL. 2000. Fire and Pesticides, A Review and Analysis of Recent Work. *Fire Technology* 36:163-183.
[25] McMahon CK, Clements, H.B., Bush, P.B., Neary, D.G., Taylor, J.W. . 1985. Pesticides released from burning treated wood. In Donoghue LR, Martin, R.E., ed, *Proceedings of the eight conference on fire and forest meteorology*. Society of American Foresters, Bethesda, MD, pp 145-152.
[26] Gabos S, Ikonomou MG, Schopflocher D, Fowler BR, White J, Prepas E, Prince D, Chen W. 2001. Characteristics of PAHs, PCDD/Fs and PCBs in sediment following forest fires in northern Alberta. *Chemosphere* 43:709-719.
[27] Kim EJ, Oh JE, Chang YS. 2003. Effects of forest fire on the level and distribution of PCDD/Fs and PAHs in soil. *Sci Total Environ* 311:177-189.
[28] Cory L, Fjeld, P., Serat, W. 1970. Distribution patterns of DDT residues in the Sierra Nevada Mountains. *Pesticides Monitoring Journal* 3:204-211.

[29] Sparling DW, Fellers GM, McConnell LL. 2001. Pesticides and amphibian population declines in California, USA. *Environmental Toxicology and Chemistry* 20:1591-1595.
[30] Fellers GM, McConnell LL, Pratt D, Datta S. 2004. Pesticides in mountain yellow-legged frogs (*Rana muscosa*) from the Sierra Nevada Mountains of California, USA. *Environmental Toxicology and Chemistry* 23:2170-2177.
[31] Angermann JE, Fellers GM, Matsumura F. 2002. Polychlorinated biphenyls and toxaphene in pacific tree frog tadpoles (*Hyla regilla*) from the California Sierra Nevada, USA. *Environmental Toxicology and Chemistry* 21:2209-2215.
[32] Datta S, Hansen L, McConnell L, Baker J, LeNoir J, Seiber JN. 1998. Pesticides and PCB contaminants in fish and tadpoles from the Kaweah River Basin, California. *Bulletin of Environmental Contamination and Toxicology* 60:829-836.
[33] Webster E, Mackay D, Wania F. 1998. Evaluating environmental persistence. *Environmental Toxicology and Chemistry* 17:2148-2158.
[34] Sparling DW, Krest S, Ortiz-Santaliestra M. 2006. Effects of lead-contaminated sediment on Rana sphenocephala tadpoles. *Arch Environ Contam Toxicol* 51:458-466.
[35] Wassersug RJ. 1975. Tetrapod Gait Patterns. *Science* 188:1256-1258.
[36] Bradford DF. 1983. Winterkill, oxygen relations, and energy metabolism of a submerged dormant amphibian, *Rana muscosa*. *Ecology* 64:1171-1183.
[37] Barinaga M. 1990. Where have all the froggies gone? *Science* 247:1033-1034.
[38] Blaustein AR, and Wake, D. B. 1990. Declining amphibian populations: A global phenomenon? *Trends in Ecology & Evolution* 5:203-204.
[39] Wake DB. 1991. Declining amphibian populations. *Science* 253:860-.
[40] Houlahan JE, Findlay CS, Schmidt BR, Mayer AH, Kuzmin SL. 2000. Quantitative evidence for global amphibian population declines *Nature* 404:752-755.
[41] Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischmann DL, Waller RW. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science* 306:1783-1786.
[42] Wake DB, Vredenburg VT. 2008. Colloquium paper: are we in the midst of the sixth mass extinction? A view from the world of amphibians. *Proc Natl Acad Sci U S A* 105 Suppl 1:11466-11473.
[43] Alford RA, Richards SJ. 1999. Global amphibian declines: A problem in applied ecology. *Annual Review of Ecology and Systematics* 30:133-165.
[44] Beebee TJC, Griffiths RA. 2005. The amphibian decline crisis: A watershed for conservation biology? *Biological Conservation* 125:271-285.
[45] Blaustein AR, Kiesecker JM. 2002. Complexity in conservation: lessons from the global decline of amphibian populations. *Ecology Letters* 5:597-608.
[46] Davidson C, Bradley Shaffer H, Jennings MR. 2001. Declines of the California red-legged frog: Climate, UV-B, habitat, and pesticides hypotheses. *Ecological Applications* 11:464-479.
[47] Davidson C, Shaffer HB, Jennings MR. 2002. Spatial tests of the pesticide drift, habitat destruction, UV-B, and climate-change hypotheses for California amphibian declines. *Conservation Biology* 16:1588-1601.

[48] Blaustein AR, Romansic JM, Kiesecker JM, Hatch AC. 2003. Ultraviolet radiation, toxic chemicals and amphibian population declines. *Diversity & Distributions* 9:123-140.
[49] Kiesecker JM, Blaustein AR, Miller CL. 2001. Transfer of a pathogen from fish to amphibians. *Conservation Biology* 15:1064-1070.
[50] Davidson C, Knapp, R.A. 2007. Multiple stressors and amphibian declines: dual impacts of pesticides and fish on yellow-legged frogs *Ecological Applications* 17:587-597.
[51] Pounds JA, Bustamante MR, Coloma LA, Consuegra JA, Fogden MPL, Foster PN, La Marca E, Masters KL, Merino-Viteri A, Puschendorf R, Ron SR, Sanchez-Azofeifa GA, Still CJ, Young BE. 2006. Widespread amphibian extinctions from epidemic disease driven by global warming. *Nature* 439:161-167.
[52] Linder G, Krest SK, Sparling DW. 2003. Amphibian decline: an integrated analysis of multiple stressor effects. United States, pp 368 pages.
[53] Jennings MR, Hayes MP. 1994. Amphibian and reptile species of special concern in California. California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA, USA.
[54] Drost CA, Fellers GM. 1996. Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA. *Conservation Biology* 10:414-425.
[55] Bradford DF, Graber DM, Tabatabai F. 1994. Population declines of the native frog, *Rana muscosa*, in Sequoia and Kings Canyon National Parks, California. *Southwestern Naturalist* 39:323-327.
[56] Fellers GM, Drost, C.A. 1993. Disappearance of the cascades frog *Rana cascadae* at the southern end of its range, California, USA. *Biological Conservation* 65:177-181.
[57] Fellers GM, Pope, K.L., Stead, J.E., Koo, M.S., Welsh, H.H. 2008. Turning population trend monitoring into active conservation: Can we save the Cascades frog (*Rana cascadae*) in the Lassen region of California? *Herpetological Conservation and Biology* 3:28-39.
[58] Vredenburg VT. 2004. Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog. *Proc Natl Acad Sci U S A* 101:7646-7650.
[59] Knapp RA, Matthews KR. 2000. Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas. *Conservation Biology* 14:428-438.
[60] Bradford DF. 1989. Allotropic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: Implications of the negative effect of fish introductions. *Copeia* 1989:775-778.
[61] Bradford DF, Tabatabai, F., Graber, D. M. 1993. Isolation of remaining populations of the native frog, *Rana muscosa*, by introduced fishes in Sequoia and Kings Canyon National Parks, California. *Conservation Biology* 7:882-888.
[62] Rachowicz LJ, Knapp RA, Morgan JA, Stice MJ, Vredenburg VT, Parker JM, Briggs CJ. 2006. Emerging infectious disease as a proximate cause of amphibian mass mortality. *Ecology* 87:1671-1683.

[63] Fellers GM, Green DE, Longcore JE. 2001. Oral chytridiomycosis in the mountain yellow-legged frog (*Rana muscosa*). *Copeia* 2001:945-953.
[64] Davidson C. 2004. Declining downwind: amphibian population declines in California and historical pesticide use. *Ecological Applications* 14:1892-1902.
[65] Lele Z, Krone PH. 1996. The zebrafish as a model system in developmental, toxicological and transgenic research. *Biotechnology Advances* 14:57-72.
[66] Hopkins WA, DuRant SE, Staub BP, Rowe CL, Jackson BP. 2006. Reproduction, embryonic development, and maternal transfer of contaminants in the amphibian Gastrophryne carolinensis. *Environ Health Perspect* 114:661-666.
[67] Kadokami K, Takeishi M, Kuramoto M, Ono Y. 2004. Maternal transfer of organochlorine pesticides, polychlorinated dibenzo-p-dioxins, dibenzofurans, and coplanar polychlorinated biphenyls in frogs to their eggs. *Chemosphere* 57:383-389.
[68] Granato M, van Eeden FJ, Schach U, Trowe T, Brand M, Furutani-Seiki M, Haffter P, Hammerschmidt M, Heisenberg CP, Jiang YJ, Kane DA, Kelsh RN, Mullins MC, Odenthal J, Nusslein-Volhard C. 1996. Genes controlling and mediating locomotion behavior of the zebrafish embryo and larva. *Development* 123:399-413.
[69] Spitsbergen JM, Kent ML. 2003. The State of the Art of the Zebrafish Model for Toxicology and Toxicologic Pathology Research—Advantages and Current Limitations. *Toxicologic Pathology* 31:62 - 87.
[70] Eisen JS. 1991. Developmental neurobiology of the zebrafish. *J Neurosci* 11:311-317.
[71] Drapeau P, Saint-Amant L, Buss RR, Chong M, McDearmid JR, Brustein E. 2002. Development of the locomotor network in zebrafish. *Prog Neurobiol* 68:85-111.

Comparison of Pressurized Liquid Extraction and Matrix Solid Phase Dispersion for the Measurement of Semi-Volatile Organic Compound Accumulation in Tadpoles

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2. Comparison of Pressurized Liquid Extraction and Matrix Solid Phase Dispersion for the Measurement of Semi-Volatile Organic Compound Accumulation in Tadpoles

2.1 Abstract

Analytical methods capable of trace measurement of semi-volatile organic compounds (SOCs) are necessary to assess the exposure of tadpoles to contaminants as a result of long-range and regional atmospheric transport and deposition. The following study compares the results of two analytical methods, one using pressurized liquid extraction (PLE) and the other using matrix solid phase dispersion (MSPD), for the trace measurement of over 70 SOCs, including current-use pesticides, in tadpole tissue. The MSPD method resulted in improved SOC recoveries and precision compared to the PLE method. The MSPD method also required less time, consumed less solvent, and resulted in the measurement of a greater number of SOCs than the PLE method.

2.2 Introduction

Declines in amphibian species have been reported worldwide [1-4]. Several factors have been suggested to be responsible for these declines, including climate change, ultraviolet radiation, habitat destruction, introduced species, disease, and contaminants [5-9]. While multiple factors are likely responsible for the declines, among contaminants, pesticide exposure has been suggested to be important [5, 10-20].

Many pesticides are semi-volatile organic compounds (SOCs), and undergo both long-range and regional atmospheric transport and deposition to remote ecosystems [21-26]. Recently, Hageman et al. and Usenko et al. have shown that regional agricultural sources are responsible for a significant portion of the pesticide deposition in remote U.S. mountain ecosystems [22, 25]. Previous studies have linked atmospheric transport and deposition of pesticides in remote areas of the Sierra Nevada Mountains to their proximity to the intensely agricultural Central Valley of California [19, 20, 22, 26-29].

Exposure of amphibians to pesticides and other SOCs occurs in low elevation ecosystems near sources, in high elevation ecosystems, and in other remote ecosystems. Previous studies on amphibian SOC body burdens have focused on measuring a fairly limited number of pesticides in tadpole or frog tissue [17, 19, 20, 27-34]. However, amphibians are likely exposed to a far greater array of pesticides. For example, over 500 different pesticides were applied in 2006 in California alone [35].

In this research, two analytical methods were compared for the trace measurement of over 70 SOCs, including current-use pesticides and their degradation products, in tadpole tissue. One method used pressurized liquid extraction (PLE) (referred to as the "PLE Method") and was similar to a PLE method developed for measuring SOCs in fish with a moderate to high lipid content (0.71 – 18 %) [36]. The second method used matrix solid phase dispersion (MSPD) (referred to as the "MSPD Method"). MSPD has been used for the measurement of SOCs in food products, as well as animal samples, including tadpoles and frogs, and is a relatively simple method for the extraction of SOCs from samples with a low to moderate fat content [32, 37, 38]. Because tadpoles have a relatively low lipid content (0.01 – 3.3 %) (unpublished data), MSPD was evaluated as a potential extraction method. The objectives included developing a method capable of identifying and quantifying current-use pesticides, to allow for the assessment of tadpole exposure to pesticides that are currently being applied in agricultural areas, and developing a method capable of trace measurement, because the concentrations of pesticides that have accumulated in high elevation biota (including amphibians) are generally low.

2.3 Materials and Methods

2.3.1 Chemicals and materials

In the summer of 1999, Pacific chorus frog (*Pseudacris regilla*) and Cascades frog (*Rana cascadae*) tadpoles were collected from lakes, ponds, and creeks in the Cascade Mountain Range in Northern California. In the summer of 2003, *P. regilla* tadpoles were collected from several lakes in Sequoia and Kings Canyon National

Park. Tadpoles from both regions were pooled and used for analytical method development and validation.

Tadpoles were placed in cryovials and in liquid nitrogen or on dry ice after collection and during shipment and were stored at -20ºC to -80ºC until analysis. A liquid nitrogen – cooled mortar, CoorsTek 99.5% alumina pestles (100 mm) and sodium sulfate (Na_2SO_4) was purchased from VWR (West Chester, PA, USA). Octadecylsilyl (C_{18}) (bulk sorbent), empty 60 ml solid phase extraction (SPE) columns, and silica SPE columns (Mega Bond-elut 20 g) were purchased from Varian, Inc. (Palo Alto, CA, USA). Non-labeled SOC standards (Table 1) were purchased from Chemical Services (West Chester, PA, USA), Restek (Bellefonte, PA, USA), Sigma-Aldrich (St. Louis, MO, USA), and AccuStandard (New Haven, CT, USA), or obtained from the U.S. Environmental Protection Agency repository [39]. Isotopically labeled chemical standards, including 24 surrogate standards: d_{10}-Fluorene, d_{10}-Phenanthrene, d_{10}-Pyrene, d_{12}-Triphenylene, d_{12}-Benzo[a]pyrene, d_{12}-Benzo[ghi]perylene, d_{14}-EPTC, d_5-Atrazine, d_{10}-Diazinon, d_7-Malathion, d_{10}-Parathion, d_8-p,p'-DDE, d_8-p,p'-DDT, d_6-Methyl Parathion, d_{13}-Alachlor, d_{11}-Acetochlor, $^{13}C_{12}$ PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl), $^{13}C_{12}$ PCB 180 (2,2', 3,4,4',5,5'-Heptachlorobiphenyl), d_{10} - Chlorpyrifos, $^{13}C_6$-HCB, d_6-γ-HCH, d_4-Endosulfan I, d_4-Endosulfan II, d_{14}-Trifluralin, and 4 internal standards: d_{10}-Acenaphthene, d_{10}-Fluoranthene, d_{12}-Benzo[k]fluoranthene, $^{13}C_{12}$ PCB 138 (2,2',3,4,4',4',5'-Hexachlorobiphenyl), were purchased from CDN Isotopes (Pointe-Claire, QC, Canada) and Cambridge Isotope Laboratories (Andover, MA, USA) [39]. All chemical standards were stored at 4°C until use. Optima grade solvents (acetonitrile, dichloromethane, hexane, and ethyl acetate) were purchased from Fisher Scientific (Fairlawn, NJ, USA).

2.3.2 Grinding of tadpoles

Frozen tadpole samples were ground in a liquid nitrogen mortar. The mortar base was filled with liquid nitrogen and the stainless steel mortar was added to the base. Tadpoles were added to the mortar and covered with liquid nitrogen. While covered with liquid nitrogen, the tadpoles were gently broken apart with the pestle and, when the liquid nitrogen evaporated from the mortar, the tadpole tissue was ground into a sand-like consistency.

2.3.3 PLE Method

The PLE method was used to extract SOCs from tadpole tissue as described in Ackerman et al. 2008 for extracting SOCs from fish tissue [36]. Two grams of tadpole tissue was ground with 65 g Na_2SO_4 and the mixture was packed into a 66 ml PLE cell (Dionex, Salt Lake City, UT, USA). In the case of SOC spike and recovery experiments, non-labeled SOC standards (Table 2.1) were added to the ground sample at the top of the PLE cell prior to extraction to assess SOC recoveries over the entire analytical method. In order to measure and subtract the background SOC concentration in the tadpole tissue (tissue blanks) used in the spike and recovery experiments, the 24 isotopically labeled surrogates were added to the ground sample at the top of the PLE cell prior to extraction. Lab blank experiments consisted of 65 g Na_2SO_4 without tadpole tissue packed into the PLE cell and spiked with the 24 isotopically labeled surrogates at the top of the PLE cell prior to extraction. The standards, both non-labeled and labeled, were spiked at approximately 150 ng and the PLE conditions used dichloromethane (DCM) at 100ºC, 1500 psi, 2 cycles of 5 minutes, and 150% flush volume [36] (see Table 2.2 for PLE method details). Additional Na_2SO_4 was added to the extracts to remove any remaining water.

The PLE DCM extract was reduced to 1 ml using a TurboVap II (Caliper Life Sciences, Hopkinton, MA, USA) (12 psi, 30 ˚ C) and solvent exchanged to hexane by adding 10 ml of hexane to the 1 ml DCM extract and reducing it to 1ml. This was repeated a total of 4 times to successfully exchange the DCM to hexane. Extract purification was performed using a 20 g silica SPE column preconditioned with 50 ml hexane, 40 ml ethyl acetate, 25 ml dichloromethane, and 25 ml hexane. The SOCs were eluted from the silica column using 25 ml hexane, 25 ml 60:40 hexane:DCM, and 75 ml 70:30 DCM:hexane. The silica fractions were combined, reduced to 1 ml, and solvent exchanged to DCM using 4 subsequent 10 ml DCM rinses and reductions. Further extract purification was performed using gel permeation chromatography (GPC) (Waters, Milford, MA, USA) [36].

2.3.4 MSPD Method

The ground tadpole tissue (2 g) was further ground with C_{18} and Na_2SO_4 in proportions of 1:5:17.5 by weight, respectively. This tadpole mixture was packed into a 60 ml SPE column containing 30 g Na_2SO_4. In the case of SOC spike and recovery experiments, non-labeled SOC standards (Table 2.1) were added to the tadpole mixture on the top of the MSPD column to assess SOC recoveries over the entire analytical method. Tissue blanks and lab blanks were analyzed as described in the PLE method, by spiking the isotopically labeled surrogates on the top of the MSPD column prior to extraction. The standards, both non-labeled and labeled, were spiked at approximately 150 ng. The MSPD column containing the ground tadpole sample, was placed on a vacuum manifold (Supelco, Bellefonte, PA, USA), a vacuum was applied, and the sample was eluted with 300 ml acetonitrile (MeCN), followed by 100 ml DCM at a flow rate of approximately 25 ml/min (see Table 2.2 for MSPD method details). The DCM fraction was reduced and stored as an archive fraction. To determine if additional SOCs were eluted from the MSPD column with the DCM, this fraction was analyzed and contained no spiked SOCs. MeCN was chosen as the MSPD column elution solvent because of its ability to simultaneously elute SOCs with a wide range of polarities. The MeCN fraction was reduced to 0.5 ml using a TurboVap II (12 psi, 30 ˚ C), approximately 1.0 ml hexane was added, and silica cleanup was performed. The 20 g silica SPE column was preconditioned as described in the PLE method and the SOCs were eluted from the column using 100 ml ethyl acetate. Different silica column elution solvents were tested and it was determined that ethyl acetate successfully eluted the target SOCs without eluting matrix interferences.

2.3.5 Instrumental Analysis

Just prior to instrumental analysis, the triplicate recovery extracts were reduced to 240 µl and spiked with the 28 isotopically labeled surrogates and internal standards to assess spiked SOC recoveries over the entire method. In the case of the tissue and lab blanks, the 4 internal standards were spiked into the extract just prior to instrumental analysis.

SOCs were identified and quantified using an Agilent 6890 gas chromatograph (Santa Clara, USA) coupled to an Agilent 5973N mass selective detector. Briefly, 1 μl of the extract was injected using an HP 7683 autosampler, a pulsed splitless injection was performed, and 30 m x 0.25 mm inner diameter x 0.25 um film thickness DB-5 column (J&W Scientific, Palo Alto, CA, USA) was used for separation of the SOCs [39]. Solvent-based calibration curves were prepared prior to instrumental analysis of samples. Selective ion monitoring (SIM) mode was used to identify and quantify the SOCs. Either electron impact ionization (EI) or electron capture negative ionization (ECNI) was used based on the mode of ionization with the lowest instrumental detection limit for a given SOC [39]. For quality assurance and quality control, one lab blank was included with each batch of samples. Calibration curves were monitored throughout using check standards. One check standard was run for every 3 to 4 samples and ion abundances were considered a match if they were within ± 20% of the standard or NIST mass spectra library. A signal to noise ratio of 3:1 was used in identification of target analytes and retention times were monitored such that identified target analytes matched check standards within ± 0.05 minutes. Estimated detection limits (EDLs) were calculated using EPA method 8280A [40] (Table 2.3). The limits of detection, ions monitored, and GC oven parameters for electron impact mode and negative chemical ionization mode have previously been published [39].

2.3.6 Statistical Analysis

Average recoveries were compared using a two sided, two-samples t-test in SPLUS (version 8.0). A p-value of less than 0.01 was considered significant. Individual SOC average recoveries over 180 % or less than 20 % were excluded from statistical analysis and average and standard deviation calculations as these values were outside the range determined acceptable.

2.4 Results and Discussion

2.4.1 Comparison of PLE Method for Fish and Tadpoles

The PLE method resulted in higher SOC recoveries with fish tissue than with tadpole tissue (ref. [36] and Table 2.1). Considering all SOCs, the average recoveries were significantly higher for fish tissue (54.8 ± 15.5 % [standard deviation]) than tadpole tissue (46.8 ± 15.3 %) ($p < 0.01$). Fish tissue recoveries were significantly higher for the DDXs (DDTs, DDDs, and DDEs), and PCBs ($p < 0.01$). The additional

SOC losses using tadpole tissue may have been due to higher SOC losses during extract evaporation and solvent exchanges. In addition, the precision for the PLE method, as indicated by the percent relative standard deviations of the SOC recoveries, was much better with the fish tissue (ranged from 0.46 to 21.6 with an average of 5.88) than with the tadpole tissue (ranged from 17.4 to 96.9 with an average of 34.1) (ref. [36] and Table 2.1). This may be due to the additional SOC losses during extract evaporation and solvent exchange.

2.4.2 Comparison of PLE and MSPD Methods for Tadpoles

The MSPD method showed significantly higher average recoveries (80.6 ± 25.9 %) over the PLE method (46.8 ± 15.3 %) for measuring SOCs in tadpole tissue (Table 2.1) ($p < 0.01$). The MSPD method also showed much better precision (ranged from 0.86 to 40.7, with an average of 11.3), as indicated by the percent relative standard deviation of the SOC recoveries, than the PLE method (ranged from 17.4 to 96.9 with an average of 34.1) for tadpole tissue (Table 2.1). MSPD average recoveries were significantly higher for organochlorine pesticides, organophosphorous pesticides, PCBs, and PAHs ($p < 0.01$). Both the PLE and the MSPD methods were capable of detecting, but not quantifying, carbaryl and carbofuran. However, only the MSPD method was capable of detecting cyanazine. The MSPD method was capable of detecting 15 additional SOCs than the PLE method, all current-use pesticides and their degradation products, including the triazine herbicides (Table 2.1). The ability to measure current-use pesticides in tadpole tissue is particularly important because some have been reported to cause sublethal effects in amphibians at low concentrations and are among the pesticides implicated in population declines [16, 18, 20, 41]. The PLE and MSPD estimated detection limits, as calculated using EPA method 8280A [40], were compared and the results were not significantly different when considering all SOCs and SOCs by class ($p > 0.1$) and ranged from 0.19 to 2900 pg/g wet weight (Table 2.3).

The MSPD average recoveries for dieldrin and endrin were above the acceptable range. Recoveries were over 200% and may be a result of these target analytes not behaving in the same manner as their labeled surrogate standards. The PLE average recoveries for acenaphthylene, acenaphthene, parathion, and endrin aldehyde were below the acceptable range. This may be a result of large losses during evaporation.

In addition to significantly higher recoveries for several SOC classes, better precision, and detection of more SOCs, the MSPD method resulted in shorter extract preparation time and less solvent consumption (Table 2.2). The MSPD method also resulted in reduced use of dichloromethane, a chlorinated solvent and probable human carcinogen (Table 2.2) [42].

The PLE method was adequate for measuring many of the historic use pesticides in tadpole tissue (Table 2.1) and proved a very good method for measuring SOCs in fish tissue, with good recoveries and precision as shown in Ackerman et al. 2008 [36]. However, the MSPD method proved to be the best method for measuring a wide range of SOCs in tadpole tissue, including current-use pesticides.

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2.6 References

[1] Wake DB. 1991. Declining amphibian populations. *Science* 253:860-.
[2] Blaustein AR, and Wake, D. B. 1990. Declining amphibian populations: A global phenomenon? *Trends in Ecology & Evolution* 5:203-204.

[3] Houlahan JE, Findlay CS, Schmidt BR, Mayer AH, Kuzmin SL. 2000. Quantitative evidence for global amphibian population declines *Nature* 404:752-755.
[4] Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischmann DL, Waller RW. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science* 306:1783-1786.
[5] Alford RA, Richards SJ. 1999. Global amphibian declines: A problem in applied ecology. *Annual Review of Ecology and Systematics* 30:133-165.
[6] Beebee TJC, Griffiths RA. 2005. The amphibian decline crisis: A watershed for conservation biology? *Biological Conservation* 125:271-285.
[7] Carey C, Cohen N, Rollins-Smith L. 1999. Amphibian declines: An immunological perspective. *Developmental & Comparative Immunology* 23:459-472.
[8] Rachowicz LJ, Knapp RA, Morgan JA, Stice MJ, Vredenburg VT, Parker JM, Briggs CJ. 2006. Emerging infectious disease as a proximate cause of amphibian mass mortality. *Ecology* 87.
[9] Pounds JA, Bustamante MR, Coloma LA, Consuegra JA, Fogden MPL, Foster PN, La Marca E, Masters KL, Merino-Viteri A, Puschendorf R, Ron SR, Sanchez-Azofeifa GA, Still CJ, Young BE. 2006. Widespread amphibian extinctions from epidemic disease driven by global warming. *Nature* 439:161-167.
[10] Carey C, Bryant CJ. 1995. Possible interrelations among environmental toxicants, amphibian development, and decline of amphibian populations. *Environmental Health Perspectives Supplements* 103:13.
[11] Blaustein AR, Wake DB. 1995. The puzzle of declining amphibian populations. *Scientific American* 272:52.
[12] Blaustein AR, Romansic JM, Kiesecker JM, Hatch AC. 2003. Ultraviolet radiation, toxic chemicals and amphibian population declines. *Diversity & Distributions* 9:123-140.
[13] Davidson C, Bradley Shaffer H, Jennings MR. 2001. Declines of the California red-legged frog: Climate, UV-B, habitat, and pesticides hypotheses. *Ecological Applications* 11:464-479.
[14] Davidson C, Shaffer HB, Jennings MR. 2002. Spatial tests of the pesticide drift, habitat destruction, UV-B, and climate-change hypotheses for California amphibian declines
. *Conservation Biology* 16:1588-1601.
[15] Davidson C, Knapp, R.A. 2007. Multiple stressors and amphibian declines: dual impacts of pesticides and fish on yellow-legged frogs *Ecological Applications* 17:587-597.
[16] Davidson C. 2004. Declining downwind: amphibian population declines in California and historical pesticide use. *Ecological Applications* 14:1892-1902.
[17] Russell RW, Hecnar SJ, Haffner GD. 1995. Organochlorine pesticide residues in Southern Ontario spring peepers. *Environmental Toxicology and Chemistry* 14:815-817.
[18] Hayes TB, Case, P., Chui, S., Chung, D., Haeffele, C., Haston, K., Lee, M., Mai, V.P., Marjuoa, Y., Parker, J., Tsui, M. 2006. Pesticide mixtures, endocrine disruption, and amphibian declines: Are we underestimating the impact? *Environmental Health Perspectives Supplements* 114:40-50.

[19] Fellers GM, McConnell LL, Pratt D, Datta S. 2004. Pesticides in mountain yellow-legged frogs (*Rana muscosa*) from the Sierra Nevada Mountains of California, USA. *Environmental Toxicology and Chemistry* 23:2170-2177.
[20] Sparling DW, Fellers GM, McConnell LL. 2001. Pesticides and amphibian population declines in California, USA. *Environmental Toxicology and Chemistry* 20:1591-1595.
[21] Simonich S, Hites R. 1995. Global distribution of persistent organochlorine compounds. *Science* 269:1851-1854.
[22] Hageman KJ, Simonich SL, Campbell DH, Wilson GR, Landers DH. 2006. Atmospheric deposition of current-use and historic-use pesticides in snow at national parks in the Western United States. *Environ Sci Technol* 40:3174-3180.
[23] Daly GL, Lei YD, Teixeira C, Muir DCG, Castillo LE, Wania F. 2007. Accumulation of current-use pesticides in neotropical montane forests. *Environ Sci Technol* 41:1118-1123.
[24] Daly GL, Lei YD, Teixeira C, Muir DCG, Wania F. 2007. Pesticides in Western Canadian mountain air and soil. *Environ Sci Technol* 41:6020-6025.
[25] Usenko S, Landers DH, Appleby PG, Simonich SL. 2007. Current and historical deposition of PBDEs, pesticides, PCBs, and PAHs to Rocky Mountain National Park. *Environ Sci Technol* 41:7235-7241.
[26] Daly GL, Wania F. 2005. Organic contaminants in mountains. *Environ Sci Technol* 39:385-398.
[27] Cory L, Fjeld, P., Serat, W. 1970. Distribution patterns of DDT residues in the Sierra Nevada Mountains. *Pesticides Monitoring Journal* 3:204-211.
[28] Datta S, Hansen L, McConnell L, Baker J, LeNoir J, Seiber JN. 1998. Pesticides and PCB contaminants in fish and tadpoles from the Kaweah River Basin, California. *Bulletin of Environmental Contamination and Toxicology* 60:829-836.
[29] Angermann JE, Fellers GM, Matsumura F. 2002. Polychlorinated biphenyls and toxaphene in pacific tree frog tadpoles (*Hyla regilla*) from the California Sierra Nevada, USA. *Environmental Toxicology and Chemistry* 21:2209-2215.
[30] Loveridge AR, Bishop, C. A., Elliot, J. E., Kennedy, C. J. 2007. Polychlorinated biphenyls and organochlorine pesticides bioaccumulated in green frogs, *Rana clamitans*, from the Lower Fraser Valley, British Columbia, Canada. *Bull Environ Contam Toxicol* 79:315-318.
[31] Hofer R, Lackner R, Lorbeer G. 2005. Accumulation of toxicants in tadpoles of the common frog (*Rana temporaria*) in high mountains. *Archives of Environmental Contamination and Toxicology* 49:192-199.
[32] Fagotti A, Morosi L, Di Rosa I, Clarioni R, Simoncelli F, Pascolini R, Pellegrino R, Guex G-D, Hotz Hr. 2005. Bioaccumulation of organochlorine pesticides in frogs of the *Rana esculenta* complex in central Italy. *Amphibia-Reptilia* 26:93-104.
[33] Russell RW, Gillan KA, Haffner GD. 1997. Polychlorinated biphenyls and chlorinated pesticides in Southern Ontario, Canada, green frogs. *Environmental Toxicology and Chemistry* 16:2258-2263.
[34] Ter Schure AFH, Larsson P, Merila J, Jonsson KI. 2002. Latitudinal fractionation of polybrominated diphenyl ethers and polychlorinated biphenyls in frogs (*Rana temporaria*). *Environ Sci Technol* 36:5057-5061.

[35] CADPR. 2007. Pesticide Use Reporting - 2006 Summary Data. Sacramento, CA

[36] Ackerman LK, Schwindt AR, Massey Simonich SL, Koch DC, Blett TF, Schreck CB, Kent ML, Landers DH. 2008. Atmospherically deposited PBDEs, pesticides, PCBs, and PAHs in Western U.S. National Park fish: Concentrations and consumption guidelines. *Environ Sci Technol* 42:2334-2341.

[37] Walker CC, Lott HM, Barker SA. 1993. Matrix solid-phase dispersion extraction and the analysis of drugs and environmental pollutants in aquatic species. *Journal of Chromatography A* 642:225-242.

[38] Lehotay SJ, Mastovska K. 2005. Evaluation of two fast and easy methods for pesticide residue analysis in fatty food matrices. *Journal of AOAC International* 88:630-638.

[39] Usenko S, Hageman KJ, Schmedding DW, Wilson GR, Simonich SL. 2005. Trace analysis of semivolatile organic compounds in large volume samples of snow, lake water, and groundwater. *Environ Sci Technol* 39:6006-6015.

[40] EPA. 1996. Method 8280A: The analysis of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans by high-resolution gas chromatography / low resolution mass spectrometry (HRGC/LRMS).

[41] Sparling DW, Fellers G. 2007. Comparative toxicity of chlorpyrifos, diazinon, malathion and their oxon derivatives to larval *Rana boylii*. *Environmental Pollution* 147:535-539.

[42] EPA. 1995. IRIS Dichloromethane. Retrieved 6/30/2008 from, http://www.epa.gov/iris/subst/0070.htm

Table 2.1: Average SOC recoveries over the entire PLE and MSPD methods for tadpoles (RSD = relative standard deviation, NR = not recovered)

	Log Kow	PLE Average Recovery (% RSD)	MSPD Average Recovery (%RSD)		Log Kow	PLE Average Recovery (% RSD)	MSPD Average Recovery (%RSD)
Amide Pesticides				**Thiocarbamate Pesticides**			
Alachlor	2.6	NR	76.3 (8.6)	EPTC	3.2	NR	56.5 (8.1)
Acetochlor	3.0	NR	60.7 (9.7)	Pebulate	3.8	NR	65.3 (4.9)
Metolachlor	3.1	NR	120 (9.2)	Triallate	4.6	61.3 (40.9)	142 (12.2)
Propachlor	2.4	NR	174 (12.3)	**Triazine Herbicides and Metabolites**			
Organochlorines Pesticides and Metabolites				Atrazine desisopropyl	1.4	NR	91.2 (0.9)
HCH, gamma	3.8	35.0 (49.3)	76.8 (8.2)	Atrazine desethyl	1.8	NR	58.8 (40.7)
HCH, alpha	3.8	28.0 (64.4)	71.0 (8.6)	Atrazine	2.3	NR	84.4 (9.6)
HCH, beta	4.0	48.4 (25.8)	87.0 (10.1)	Simazine	2.2	NR	103 (3.2)
HCH, delta	4.1	47.8 (25.6)	84.6 (8.4)	Metribuzin	1.7	NR	103 (13.7)
Methoxychlor	4.5	55.9 (27.3)	92.8 (14.6)	**Miscellaneous Pesticides**			
Heptachlor	5.2	44.0 (47.4)	106 (6.5)	Etridiazole	2.6	NR	71.7 (5.9)
Heptachlor epoxide	4.6	27.0 (32.9)	48.7 (10.1)	Dacthal	4.3	70.5 (34.7)	152 (3.5)
Hexachlorobenzene	5.5	26.2 (70.8)	64.5 (9.6)	Trifluralin	5.3	38.0 (58.3)	75.9 (9.0)
Endrin	5.2	75.3 (24.2)	224 (8.0)	**Polycyclic Aromatic Hydrocarbons**			
Endrin aldehyde	4.8	13.9 (35.9)	84.6 (14.2)	Acenaphthylene	3.9	14.6 (102)	64.8 (4.9)
Chlordane, trans	6.1	26.4 (30.1)	33.1 (12.5)	Acenaphthene	4.0	21.0 (93.6)	65.1 (6.9)
Chlordane, cis	5.9	27.7 (29.1)	35.8 (13.1)	Fluorene	4.2	19.6 (91.8)	60.0 (8.5)
Nonachlor, trans	6.1	26.5 (29.8)	33.1 (12.7)	Anthracene	4.5	33.2 (49.0)	76.4 (8.2)
Nonachlor, cis	6.1	41.5 (26.9)	50.3 (14.6)	Phenanthrene	4.5	23.9 (96.9)	50.4 (15.8)
Chlordane, oxy	5.5	27.3 (32.3)	43.4 (11.2)	Pyrene	5.1	48.7 (20.4)	79.3 (10.5)
Dieldrin	5.5	114 (25.4)	236 (8.4)	Fluoranthene	5.2	48.4 (21.6)	79.4 (12.0)
Aldrin	6.4	37.5 (43.3)	76.6 (8.7)	Chrysene + Triphenylene	5.7	51.4 (24.5)	106 (17.6)
o,p'-DDT	6.5	40.6 (21.4)	56.4 (11.7)	Benzo(a)anthracene	5.9	61.3 (22.8)	100 (13.4)
o,p'-DDD	6.1	49.4 (25.5)	98.6 (18.1)	Retene	6.4	63.3 (20.4)	94.0 (11.6)
o,p'-DDE	5.5	45.4 (23.7)	83.7 (9.3)	Benzo(k)fluoranthene	6.5	54.5 (24.6)	104 (16.5)
p,p'-DDT	6.9	43.6 (26.4)	69.6 (11.8)	Benzo(a)pyrene	6.5	46.1 (17.4)	73.1 (11.0)
p,p'-DDD	5.9	54.2 (19.5)	116 (9.2)	Benzo(b)fluoranthene	6.6	58.5 (24.6)	113 (17.6)
p,p'-DDE	6.8	46.4 (23.8)	67.2 (10.5)	Benzo(e)pyrene	6.9	57.6 (24.4)	108 (17.5)
Mirex	6.9	51.1 (26.0)	89.5 (14.2)	Indeno(1,2,3-cd)pyrene	6.7	57.2 (24.2)	83.5 (10.6)
Organochlorine Sulfide Pesticides and Metabolites				Dibenz(a,h)anthracene	6.8	55.2 (25.5)	91.0 (9.7)
Endosulfan I	4.7	32.7 (30.2)	46.0 (12.7)	Benzo(ghi)perylene	7.0	51.9 (24.2)	77.5 (9.6)
Endosulfan II	4.8	49.7 (26.3)	73.2 (13.3)	**Polychlorinated Biphenyls**			
Endosulfan sulfate	3.7	53.1 (27.4)	58.5 (9.1)	PCB 74	6.3	45.8 (32.5)	101 (10.5)
Phosphorothioate Pesticides				PCB 101	6.4	47.4 (33.9)	87.3 (12.3)
Methyl parathion	2.7	36.2 (40.6)	63.5 (7.9)	PCB 118	7.0	47.7 (35.6)	75.0 (15.3)
Malathion	2.9	NR	59.9 (18.7)	PCB 153	6.9	50.1 (34.2)	96.4 (9.4)
Diazinon	3.7	NR	70.1 (6.0)	PCB 138	6.7	51.8 (34.1)	99.1 (10.2)
Parathion	3.8	19.4 (75.2)	81.6 (12.0)	PCB 187	7.2	49.7 (36.1)	86.3 (10.4)
Ethion	5.1	38.3 (41.4)	46.6 (17.8)	PCB 183	8.3	49.8 (35.8)	86.2 (10.8)
Chlorpyrifos	5.1	55.0 (36.2)	87.6 (9.5)	**Ave, Min, and Max Recoveries, % RSD**			
				ave		46.8 (34.1)	80.6 (11.3)
				max		114	236
				min		14.6	33.1

Table 2.2: PLE and MSPD method conditions (DCM = dichlormethane, MeCN = acetonitrile, HEX = hexane, EA = ethyl acetate, SPE = solid phase extraction)

	PLE method	**MSPD method**
Sample Mass	2 g	2 g
Grinding Agent	Na_2SO_4	Na_2SO_4, C_{18}
Mass	65 g	35 g, 10 g
Extraction		
Pressure / Flow	1500 psi	25 ml/min
Temperature	100ºC	25ºC
Solvent	DCM	MeCN, DCM
Solvent Volume	200 ml	300ml, 100 ml
Solvent Exchanges	2	0
HEX	4 X 10 ml	
DCM	4 X 10 ml	
Extract Purification	**Silica SPE**	**Silica SPE**
Conditioning Solvent	HEX, EA, DCM	HEX, EA, DCM
Solvent Volume	75 ml, 40 ml, 25 ml	75 ml, 40 ml, 25 ml
SPE Solvent	HEX, DCM	EA
Solvent Volume	62.5 ml, 62.5 ml	100 ml
	Gel Permeation Chromatography	
Elution Solvent	DCM	
Solvent Volume	200 ml	
Total Solvent Volume	745 ml	640 ml
Total DCM Volume	528 ml	125 ml
Extract Preparation Time (Set of 4 Samples)	12 hours	9.3 hours

Table 2.3: Tadpole SOC estimated method detection limits in pg/g wet weight (NR = not recovered)

	Log Kow	PLE Estimated Method Detection Limit (pg/g ww)	MSPD Estimated Method Detection Limit (pg/g ww)
Amide Pesticides			
Alachlor	2.6	NR	620
Acetochlor	3.0	NR	320
Metolachlor	3.1	NR	240
Propachlor	2.4	NR	210
Organochlorines Pesticides and Metabolites			
HCH, gamma	3.8	24	26
HCH, alpha	3.8	21	19
HCH, beta	4.0	29	71
HCH, delta	4.1	17	44
Methoxychlor	4.5	17	150
Heptachlor	5.2	108	240
Heptachlor epoxide	4.6	68	48
Hexachlorobenzene	5.5	0.19	1.4
Endrin	5.2	800	400
Endrin aldehyde	4.8	140	48
Chlordane, trans	6.1	2.7	1.1
Chlordane, cis	5.9	69	44
Nonachlor, trans	6.1	2.7	1.2
Nonachlor, cis	6.1	5.3	6.0
Chlordane, oxy	5.5	56	80
Dieldrin	5.5	260	260
Aldrin	6.4	44	160
o,p'-DDT	6.5	270	240
o,p'-DDD	6.1	190	270
o,p'-DDE	5.5	400	170
p,p'-DDT	6.9	63	310
p,p'-DDD	5.9	93	260
p,p'-DDE	6.8	110	250
Mirex	6.9	12	84
Organochlorine Sulfide Pesticides and Metabolites			
Endosulfan I	4.7	13	16
Endosulfan II	4.8	34	7.6
Endosulfan sulfate	3.7	2.7	9.7
Phosphorothioate Pesticides			
Methyl parathion	2.7	1100	310
Malathion	2.9	NR	260
Diazinon	3.7	NR	120
Parathion	3.8	1600	230
Ethion	5.1	390	210
Chlorpyrifos	5.1	6.9	22

	Log Kow	PLE Estimated Method Detection Limit (pg/g ww)	MSPD Estimated Method Detection Limit (pg/g ww)
Thiocarbamate Pesticides			
EPTC	3.2	NR	710
Pebulate	3.8	NR	150
Triallate	4.6	36	39
Triazine Herbicides and Metabolites			
Atrazine desisopropyl	1.4	NR	2900
Atrazine desethyl	1.8	NR	390
Atrazine	2.3	NR	300
Simazine	2.2	NR	830
Metribuzin	1.7	NR	44
Miscellaneous Pesticides			
Etridiazole	2.6	NR	620
Dacthal	4.3	32	7.5
Trifluralin	5.3	4.1	11
Polycyclic Aromatic Hydrocarbons			
Acenaphthylene	3.9	230	160
Acenaphthene	4.0	290	730
Fluorene	4.2	68	360
Anthracene	4.5	130	520
Phenanthrene	4.5	50	290
Pyrene	5.1	66	33
Fluoranthene	5.2	130	120
Chrysene + Triphenylene	5.7	24	41
Benzo(a)anthracene	5.9	26	68
Retene	6.4	93	160
Benzo(k)fluoranthene	6.5	320	110
Benzo(a)pyrene	6.5	180	190
Benzo(b)fluoranthene	6.6	220	74
Benzo(e)pyrene	6.9	170	130
Indeno(1,2,3-cd)pyrene	6.7	95	210
Dibenz(a,h)anthracene	6.8	120	160
Benzo(ghi)perylene	7.0	77	110
Polychlorinated Biphenyls			
PCB 74	6.3	730	250
PCB 101	6.4	180	710
PCB 118	7.0	12	23
PCB 153	6.9	11	19
PCB 138	6.7	26	98
PCB 187	7.2	5	3.2
PCB 183	8.3	4.7	2.8
Ave, Min, and Max Recoveries, % RSD			
ave		160	230
max		1600	2900
min		0.19	1.1

Regional Atmospheric Transport and Accumulation of Semi-Volatile Organic Compounds in California Mountain Tadpoles and Sediment

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3. Regional Atmospheric Transport and Accumulation of Semi-Volatile Organic Compounds in California Mountain Tadpoles and Sediment

3.1 Abstract

The atmospheric transport and accumulation of semi-volatile organic compounds (SOCs), including regionally used pesticides, was studied in California mountain ecosystems inhabited by amphibian species in decline. Tadpole and surficial sediment samples were collected from 81 sites located throughout the California Cascades, Sequoia and Kings Canyon National Parks (SEKI), along a north to south transect through the Sierra Nevada Mountains (Sierras transect), and in Yosemite National Park (YOSE) in the summer of 2005 and 2006 and measured for a wide range of SOCs. The site distance from regional pesticide use areas was inversely correlated with the dacthal, endosulfan II, endosulfan sulfate, and total endosulfan concentration in tadpoles and sediment, indicating the importance of regional sources in the atmospheric transport of SOCs to these mountain ecosystems. The tadpole-sediment relationship was assessed on a regional and statewide basis using a multiple linear regression model approach. After accounting for tadpole Gosner stage, percent lipid, and distance to regional sources, a significant positive correlation was observed only for PCB 187 in *Rana cascadae* tadpoles from the Cascades on a regional basis. However significant positive correlations were observed for dacthal, endosulfan II, endosulfan sulfate, trans-nonachlor, cis-nonachlor, and p,p'-DDE on a statewide basis. The correlations observed on the statewide level are a result of regional differences in SOC concentrations, i.e higher SOC concentrations were measured in the SEKI samples and lower SOC concentrations were measured in the Cascades samples. Tadpole biota-sediment accumulation factors (BSAFs) were calculated and it was determined that BSAFs varied largely within regions and that average BSAFs were similar between regions.

3.2 Introduction

The atmospheric transport and deposition of semi-volatile organic compounds (SOCs), including pesticides, to the Cascade and Sierra Nevada Mountains of

California has been documented [1-10]. In addition, studies have suggested the proximity of the Central Valley to the Sierra Nevada Mountains as a source of pesticides deposited to these mountains [7-9, 11, 12] and recent studies have documented the importance of regional sources in the transport of SOCs to mountain ecosystems in the western U.S. [3, 13]. The Central Valley of California, located within 40 to 50 km of the Cascade and Sierra Nevada Mountains, is one of the most intensely cultivated areas in the world and approximately one-fifth of annual U.S. pesticide use is applied there [14]. Forest fires may be a source of pesticides, as a result of revolatilization, and polycyclic aromatic hydrocarbons (PAHs) formed during wood combustion [15-18]. In addition, large cities, including Sacramento and Fresno, are located within approximately 110 km of these mountains and diurnal and seasonal winds likely transport and concentrate pesticides and other SOCs in these mountain ecosystems [13, 19].

Worldwide, amphibian populations are declining as a result of a combination of factors, including habitat destruction, climate change, disease, introduction of nonnative species and exposure to contaminants [20-22]. The Cascades frog (*Rana cascadae*) and the mountain yellow-legged frog (*Rana muscosa*) are amphibian species with historical ranges in the Cascade and Sierra Nevada Mountains of California and exposure to pesticides, along with disease and nonnative trout [23-29], has been implicated in their population declines [1, 2, 23, 30].

The routes of tadpole exposure to and accumulation of SOCs in mountain ecosystems is not well understood [2]. Tadpoles have the potential to be exposed to SOCs via maternal transfer, the water column, food web and surficial sediment. Hydrophobic SOCs accumulate in mountain ecosystem food webs [10, 31-33] and sediment [13, 33, 34]. However, water column SOC concentrations in mountain lakes are very low [35]. Tadpoles feed on algae, bacteria, diatoms, and organic and inorganic debris [36] and may be exposed to SOCs in sediment during feeding on detritus and burrowing to hide from predators [37]. SOCs partition to the organic carbon portion of the sediment and may be bioavailable [38]. In addition, biota sediment accumulation factors (BSAFs), defined as the lipid normalized SOC concentration in an organism divided by the organic carbon normalized SOC concentration in the sediment, has been used to better understand the accumulation of lipophilic SOCs in invertebrates and fish in freshwater ecosystems [39-41]. However, field derived tadpole-sediment SOC BSAFs have not been reported.

This research included the collection of tadpole and sediment samples from ecosystems in California where *R. cascadae* and *R. muscosa* are and are not declining (or declines are less severe in the case of *R. muscosa*) with respect to their historical ranges [2, 30, 42, 43]. In order to characterize SOC accumulation in tadpoles from these ecosystems the Pacific tree frog (*Pseudacris regilla*), a species not in decline, was used as a surrogate species. The hypotheses were 1) tadpole and sediment SOC concentrations are significantly correlated with distance to regional sources and 2) tadpole and sediment concentrations are significantly correlated. In order to investigate these hypotheses, the objectives of this research were to 1) determine the SOC concentrations in tadpoles and sediment collected from 81 lakes, ponds, and wetlands located throughout the California Cascades (Cascades), Sequoia and Kings Canyon National Parks (SEKI), the Sierra Nevada (Sierras transect), and Yosemite National Park (YOSE); 2) investigate factors governing the SOC accumulation in tadpoles and sediment collected from these ecosystems, including associations with regional sources and between tadpole and sediment concentrations, and 3) calculate the tadpole-sediment SOC BSAFs for each ecosystem and investigate regional differences.

3.3 Experimental Section

3.3.1 Sites and sample collection

Tadpole and sediment samples were collected in the summer of 2005 from 33 lakes, ponds, and wetlands in the California Cascades (Cascades) (elevation range: 1145-2916 m) and 32 lakes in Sequoia and Kings Canyon National Parks (SEKI) (elevation range: 2754-3375 m) (Figure 3.1). In the summer of 2006, tadpole and sediment samples were collected from 11 lakes along a north to south transect through the Sierra Nevada Mountains (Sierras transect) (elevation range: 1734-2915 m) and 5 lakes in Yosemite National Park (YOSE) (elevation range: 2471-3176 m) (Figure 3.1). Tadpoles were collected at random with dip nets and stored in glass jars or Ziploc bags full of water until they were transferred to 2.0 ml cryovials or 25 ml glass jars with Teflon-lined caps. Tadpoles were pooled to obtain a single sample for chemical analysis, and composites contained anywhere from 2 to 70. Vials were then stored in liquid nitrogen, on dry ice, or at -20 ° C until shipment to Oregon State University. Samples were shipped on dry ice and stored at -20 ° C until analysis. Primarily Pacific tree frog (*Pseudacris regilla*) tadpoles were collected at the Cascades sites and only *P. regilla* tadpoles were collected from the SEKI, Sierras transect, and YOSE lakes (Table 3.1). Cascades frog (*Rana cascadae*) tadpoles were also collected from some sites in the California Cascades (Table 3.1). Surficial sediment (the top 2.5 cm) was collected using a hand corer or by taking hand grabs. Samples collected from SEKI, YOSE and some of the Cascades sites were obtained using a 2424-A series hand coring device (Wildlife Supply Co., Buffalo, NY). In SEKI and YOSE samples were taken at a depth of approximately one meter. One sample was obtained by collecting the top 2.5 cm of sediment from 2 different areas of the lake. In the Cascades and Sierras transect, surficial cores (2.5 cm) were collected at a depth where tadpoles were observed. Two, 2.5 cm cores were combined from a site to obtain a single sediment sample. Hand grabs were obtained by scooping surficial sediment from 2 locations in the same water body and combining them. Sediment cores were stored in Teflon or glass jars with a Teflon-lined caps and stored on dry ice or at -20 ° C until shipment to Oregon State University. Samples were shipped on dry ice and stored at -20 ° C until analysis. Sampling dates and site location information are shown in Tables 3.1 and 3.2.

3.3.2 Analytical method

The analytical methods for the measurement of SOCs in tadpoles [41] and sediment [13] are reported elsewhere. The number of tadpoles pooled per sample ranged from 2 to 60, and a 2 g subsample of the pooled, ground tadpoles was used in analysis. Briefly, tadpoles were ground to a sand-like consistency using a liquid nitrogen mortar and matrix solid phase dispersion (MSPD) was performed by further grinding 2 g of ground tadpoles with 10 g octadecylsilyl (C_{18}) and 35 g of sodium sulfate (Na_2SO_4). This tadpole mixture was packed into an empty 60 ml solid phase extraction (SPE) column on top of 30 g Na_2SO_4, spiked with isotopically labeled recovery surrogates and eluted with 300 ml of acetonitrile (MeCN). The tadpole extract was reduced in volume using N_2, 1.0 ml of hexane was added and a 20 g silica SPE column was used to clean-up the extract. For sediment, approximately 12 g of wet sediment was ground with 120 g of Na_2SO_4 and packed into 66 ml accelerated solvent extraction (ASE) cells. The sediment mixture were spiked with isotopically labeled recovery surrogates and pressurized liquid extraction (PLE) was performed with dichloromethane (DCM). Sediment extract cleanup was performed using silica gel and gel permeation chromatography. After cleanup, the sediment extract was reduced in volume with N_2, and spiked with isotopically labeled internal standards.

Moisture content was determined in tadpole and sediment samples by weighing a subsample (at least 10 % of the wet weight sample size used for the analytical method) before and after drying samples at a 105 °C. Tadpole samples were dried for 24 hours and sediment samples were dried for 48 hours prior to reweighing. Lipid content in tadpole samples was determined by gravimetric analysis. Lipids were extracted from a 0.5 g subsample of tadpole tissue by grinding the subsample with Na_2SO_4 and performing an on column extraction with 100 ml of DCM. Total organic carbon (TOC) was determined by drying 0.2 g subsamples and analyzing for TOC using a CNS-2000 Element Analyzer (LECO Corp., St. Joseph Michigan).

SOCs were identified and quantified using an Agilent 6890N gas chromatograph (GC), with a DB-5MS 30 m x 0.25 mm x 0.25 μm column, coupled to an Agilent 5973N mass spectrometer (MS) (Pal Alto, CA). The tadpole and sediment extracts were analyzed using both electron impact ionization (EI) and electron capture negative ionization (ECNI) and selected ion monitoring (SIM). Instrumental temperature programs and the ions monitored in EI and ECNI modes have been reported elsewhere [44]. SOCs measured in tadpoles and sediment are listed in Table 3.3.

The GC/MS calibration curve was verified by analyzing a calibration standard every 3 to 4 samples and new calibration curves and calibration standards were prepared as necessary. A signal to noise ratio of 3 to 1, retention time (± 0.05 minutes) and 3 ion ratios matching those in the NIST mass spectrometry library (EI) or standards library (CI) were used for positive identification of SOCs. Estimated method detection limits (EDLs) were calculated as described previously [13, 44, 45]. The EDLs for tadpoles, on a dry weight basis, and sediment, on a total organic carbon basis, are shown in Tables 3.4 and 3.5

3.3.3 Site distance from use areas

The distance between each sampling site and the closest upwind current-use pesticide (CUPs – including dacthal, chlorpyrifos, and endosulfan) use areas in 2005 was calculated using ArcGIS. The California Department of Pesticide Regulation (DPR) 2005 pesticide use data was imported into ArcGIS on a township basis (~ 6 x 6 mile polygons) and the Euclidean Distance toolbox tool in ArcGIS was used to calculate the distance from 2005 pesticide application to the site (Figure 3.2). For the historic-use pesticides (trans-chlordane, trans-nonachlor, cis-nonachlor, p,p'-DDE) and PCBs (congeners 153, 187, 138, and 183), the distance from each site to the closest point of the Central Valley was determined in ArcGIS by drawing the nominal boundary of the Central Valley (Figure 3.1) and using the measure tool. The site distances from pesticide use areas and the Central Valley are given in Table 3.2.

3.3.4 Statistical analysis

All statistical analyses were conducted using SPLUS (Version 8.0). SOC concentrations below the estimated detection limit (EDL) were substituted with a value equal to one-half the EDL, on a wet weight, dry weight, lipid, and organic carbon basis [35, 46]. The average tadpole and sediment concentration was calculated for sites at which more than one sample was collected at a given time point. The Kruskal-Wallis rank test was used to compare tadpole and sediment SOC concentrations between the four regions, when detections frequencies were greater than 40 % in all regions, due non-normal distribution of the data. Tadpole SOC concentrations are reported on a dry weight basis. Although the lipid content of the tadpole samples were measured, the tadpole SOC concentrations are not reported on a lipid basis because the tadpole lipid content was very low and moisture explained more of the variability, in the majority of tadpole SOC concentrations, than lipid. Most sediment SOC concentrations were significantly correlated with sediment organic carbon content and thus the sediment SOC concentrations were normalized to total organic carbon content. The tadpole and sediment SOC concentrations were log transformed to satisfy the normality assumption for regression analyses. Only SOCs with at least 40 % detections in tadpoles or sediments were included in the SOC regression analyses and BSAF determinations. Simple linear regression was used to investigate the correlation between site distance from pesticide use areas and the Central Valley. A multiple linear regression model was developed to study the explanatory variables governing SOC accumulation in tadpoles on a regional and statewide basis. Pearson's correlations and the variance inflation factor (VIF) for multicollinearity were used to determine if an explanatory variable should be removed from the model. A Pearson's correlation coefficient (r) ≥ 0.70 resulted in the removal of one of the correlated explanatory variables from the model. VIF was tested to assure multicollinearity between explanatory variables was not present in the model. A VIF ≥ 10 was used to indicate multicollinearity between variables.

3.4 Results and Discussion

3.4.1 Tadpole stage

The tadpole development stage ranged from approximately Gosner stage 25 to 41 [47]. Tadpole Gosner stage was generally similar (within a few stage numbers) between samples pooled for analysis. However, in a few cases tadpoles ranged by as many as 10 Gosner stages. Tadpoles with an average stage of 42 and above were excluded from statistical analysis because they were undergoing metamorphosis [47]. Tadpole average Gosner stage and average tadpole weight were highly positively correlated for both *P. regilla* and *R. cascadae* (Figure 3.3) (r2 ≥ 0.60, p ≤ 0.02).

3.4.2 Tadpole and sediment SOC concentrations by region

The tadpole and sediment SOC concentration profiles and frequency of detection for the Cascades, SEKI, the Sierras transect, and YOSE are shown in Figures 3.4 and 3.5. The concentrations are shown on a dry weight basis in these figures for direct comparison between SOC accumulation in tadpoles and surficial sediment. The frequency of detection was similar between the tadpole and sediment samples for most current-use pesticides, including dacthal, endosulfan I, II and endosulfan sulfate, a degradation product of endosulfan I and II (Figures 3.4 and 3.5). The deposition of

CUPs, including dacthal, chlorpyrifos, and endosulfan, in 2003 snow samples collected from Sequoia National Park has been reported [3, 7]. Thus, the measurement of these CUPs in SEKI tadpole and sediment samples is consistent with deposition to this region in recent years. The detection frequencies of trans-chlordane, trans-nonachlor, and cis-nonachlor in all regions except SEKI, and the detection frequencies of PCBs in sediment from all regions, were generally higher in sediment samples than in tadpoles (Figures 3.4 and 3.5). This may be a result of the deposition of SOCs into the sediment over decades where tadpoles are less than a few months in age. The concentrations of dacthal (tadpoles and sediment), chlorpyrifos (sediment), endosulfan II (tadpoles and sediment), endosulfan sulfate (tadpoles and sediment), trans-chlordane (tadpoles), trans-nonachlor (sediment), cis-nonachlor (sediment), and p,p'-DDE (sediment) were significantly higher in SEKI samples compared to the Cascades (Wilcox rank test, $p < 0.01$). The concentrations of dacthal in SEKI sediment were higher than YOSE, endosulfan sulfate in SEKI tadpoles were higher than other regions and SEKI sediment was higher than YOSE, and trans-chlordane in SEKI tadpoles were higher than YOSE (Kruskal Wallis and Wilcox rank test, $p < 0.01$). Tadpole and sediment PCB concentrations were not significantly different between regions. This may be a result of their widespread use in urban areas.

Several PAH concentrations, including acenapthylene, acenapthene, fluorine, anthracene, fluoranthene, benzo(a)anthracene, chrysene + triphenylene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(e)pyrene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(ghi)perylene in sediment samples (from sites dom, gum, tng, fry (Table 3.1)) were higher in the Cascades sediment than in tadpoles from the same sites or sediment from other regions (Figures 3.4 and 3.5). PAH sources were investigated using previously published ratios indicating petrogenic and pyrogenic sources, as well as more specific combustion sources [48, 49]. PAH ratios indicate the sources are pyrogenic, and further comparisons indicate that PAH contamination at the Cascades sites may be a result of engine combustion of kerosene (site: dom (Table3.1)), or diesel (sites: dom, fry, gum, tng (Table 3.1)), or wood combustion (sites: fry, gum, tng (Table 3.1)) (Table 3.6). Thus motorboat usage on the lakes and/or nearby forest fires may play a role in the deposition of PAHs to these sites. Tadpoles from these same lakes did not have detectable concentrations of these PAHs even though these compounds have relatively high octanol-water partition coefficients. PAHs have similar physical -chemical properties to other SOCs measured in both tadpoles and sediment (Tables 3.4 and 3.5). Because of this, they were expected to be bioavailable in the surficial sediment, and it was expected that the high sediment concentrations at these sites would correspond to high tissue concentrations in the tadpoles if they were not readily metabolized. Because of the lack of PAHs in tadpoles, we hypothesize that tadpoles as young as Gosner stage 33 have the ability to metabolize PAHs through cytochrome P450 xenobiotic metabolizing enzymes. Cytochrome P450 development has been studied in Xenopus laevis and it was determined that activity was not present in early development of premetamorphs [50]. However, developing vertebrates have been noted to have high levels of some cytochrome P450 isoforms [51, 52], so it is possible that young tadpoles have the systems in place to metabolize some SOCs. However, this hypothesis does not hold if the PAHs in these ecosystems were sediment bound and not readily available for uptake by the tadpoles.

Because of the likelihood that some of the lakes were contaminated from PAH emissions from motorboats and/or nearby forest fires and not atmospheric deposition, PAHs were excluded from further statistical analysis.

3.4.3 SOC accumulation and site distance from regional sources

The relationship between the tadpole and sediment SOC concentrations and the site distance from regional sources on a statewide basis was investigated. When considering distance to regional sources, all sites statewide were considered because the topography of these mountains is very complex and statewide relationships to source locations give a better picture than considering relatively small regional areas.

For the current-use pesticides dacthal, chlorpyrifos and endosulfan, site distance from 2005 pesticide use areas were compared to the concentrations of these pesticides in tadpoles and sediment using simple linear regression (Figure 3.6). The data for California locations of pesticide application in 2005 and 2006 were compared visually in ArcGIS and were very similar (Figure 3.7). The 2005 data was chosen for calculating site distance to applications. Dacthal, endosulfan II, endosulfan sulfate, and total endosulfan concentrations in sediment and tadpoles were significantly negatively correlated ($p < 0.05$) with site distance from 2005 pesticide use areas (Figure 2). These statistically significant correlations indicate that regional pesticide use plays an important role in the atmospheric transport and deposition of CUPs to these remote ecosystems. The atmospheric half-lives of endosulfan II (1.3 days calculated using EPI Suite [53]) and dacthal (24 days (EPI Suite)) appear to be sufficiently long to result in regional atmospheric transport to these ecosystems.

The negative correlations were expected for endosulfan sulfate in addition to endosulfan II and total endosulfans because the sulfate is formed through biodegradation of both endosulfan I and II [54] and may be formed in the tadpoles through metabolism or the sediment through microbial degradation. As discussed above, the presence of PAHs in the sediment but not the corresponding tadpole samples, led us to hypothesize that the tadpoles have the capability to metabolize some SOCs by Gosner stage 33 and may also be able to metabolize endosulfan I and II to endosulfan sulfate. The concentrations of endosulfan sulfate in these mountain ecosystems was expected to reflect the transport of endosulfan I and II to the sites.

Chlorpyrifos concentrations in sediment and tadpoles were not correlated with site distance from pesticide use areas (Figure 3.6). Chlorpyrifos is widely used in the Central Valley [55] (Figure 3.7). Its widespread use may result in a more uniform distribution and, therefore, account for the lack of an observed correlation. Chlorpyrifos degrades more quickly in the environment than the other CUPs, with an environmental half-life on the order of days to weeks [56, 57] as compared to days to years for endosulfan [54, 58, 59]. This may also explain the lack of correlation between application location and concentration at mountain sites.

The sediment concentrations of trans-chlordane, trans-nonachlor, and cis-nonachlor, and PCBs 153, 138, 183 and 187 in sediment, were significantly negatively correlated with site distance from the Central Valley ($p < 0.05$) (Figure 3.8). PCBs were historically used in industry and in transformers and other electronic components [60]. Chlordane was historically used as a termiticide around house foundations in urban areas [61] and chlordane sources are also associated with populated areas. The continued presence of these SOCs in remote mountain ecosystems may result from historic regional application, their continued persistence in soils, and revolatilization. The concentrations of p,p'-DDE in sediment and tadpoles were not correlated with site distance from the Central Valley. Historically, DDT was applied in forests in several parts of the Sierra Nevada Mountains [11, 62] and its use in mountains, as well as the Central Valley, may result in a more uniform distribution of DDE at the sites. Of the historically used SOCs, only the PCB 153 tadpole concentration was significantly correlated with site distance from the Central Valley. For other historic-use SOCs, concentrations in tadpoles were often near the detection limit, in the Cascades, the Sierras and YOSE samples, and detection frequencies were lower in tadpoles than sediment. This may have affected the comparison of these compounds to regional sources.

3.4.4 Correlations between tadpole and sediment accumulation of SOCs

A multiple linear regression (MLR) model was used to determine some of the factors, in addition to site distance from regional use areas, which influenced tadpole SOC concentrations on a regional and statewide basis.

Sediment SOC concentration, average tadpole stage, tadpole percent lipid, and site distance from current-use pesticide application areas, or site distance from the Central Valley for historic-use SOCs, were included in the MLR model. Average tadpole stage and average tadpole weight were correlated; therefore average tadpole weight was excluded from the model (Figure 3.3). After accounting for site distance to regional sources, lipid and stage, only the Cascades *R. cascadae* tadpole PCB 187 concentration was significantly positively correlated with the corresponding sediment SOC concentrations ($p < 0.05$). The lack of a significant correlation between tadpole and sediment SOC concentrations may suggest that sediment is not the main exposure route of tadpoles to SOCs. Also if tadpoles are capable of metabolizing these SOCs this may have an effect on the tadpole-sediment correlation, and metabolism may differ between Gosner stages and populations of tadpoles, thus differing in collected tadpoles.

At the statewide level, significant positive correlations were observed for dacthal, endosulfan II, endosulfan sulfate, trans-nonachlor, cis-nonachlor, and p,p'-

DDE (Table 3.7). The tadpole-sediment relationship was driven by lower SOC concentrations in the Cascades and significantly higher SOC concentrations in SEKI because the dataset was composed primarily of samples taken from these regions (Figure 3.9). No significant relationship was apparent between the Sierras transect and YOSE tadpole and sediment SOC concentrations, which accounted ≤ 18 of the data points (Figure 3.9). The low concentrations in tadpole and sediment samples in the Cascades and high concentrations in tadpole and sediment samples in SEKI are likely a result of differences in regional sources.

3.4.5 Tadpole-sediment bioaccumulation factors

Field derived biota-sediment bioaccumulation factors (BSAFs) incorporate all exposure routes, including water, sediment, and the food web, into the value [40]. To investigate the (BSAFs), the tadpole SOC concentrations were compared on a dry weight basis ($BSAF_{dryweight}$) and on a lipid weight basis ($BSAF_{lipid}$), with sediment SOC concentrations on an organic carbon basis. The BSAF is commonly reported on a lipid weight basis in organisms and on an organic carbon weight basis for sediment [63]. However, because the tadpole lipid content was not correlated with tadpole SOC body burden, $BSAF_{dryweight}$ was calculated in addition to $BSAF_{lipid}$.

$BSAF_{dryweight}$ and $BSAF_{lipid}$ were calculated on an individual site basis, for each SOC, and values for all sites combined were compared to log K_{ow} and log K_{oc} (Figure 3.10) to determine if there were trends between SOC BSAFs and these physical-chemical properties. A significant, negative correlation existed between both $BSAF_{dryweight}$ and $BSAF_{lipid}$ and SOC log K_{ow} and log K_{oc} (Figure 3.10). However, these physical-chemical properties only explained at a maximum 13 % of the variation in BSAFs. The $BSAF_{dryweight}$ and $BSAF_{lipid}$ results were similar (Figure 3.10) and were highly variable within regions. The variability of $BSAF_{dryweight}$ and $BSAF_{lipid}$ may be due to differences in the mountain ecosystem food webs and the metabolism capabilities of tadpoles of different stages and different populations [40, 64, 65].

$BSAF_{dryweight}$ and $BSAF_{lipid}$ were also investigated by calculating the slope of the correlation between the SOC concentration in the tadpole and the SOC concentration in the sediment. Results did not show trends with log K_{ow} and log K_{oc}

properties. Values for the individual site calculation BSAFs, the slope method BSAFs, and some fish SOC BSAFs from the literature, are shown in Table 3.6.

Average $BSAF_{dryweight}$ and $BSAF_{lipid}$ are generally similar between regions for individual SOCs (Table 3.6). In comparison to the median fish BSAFs for dacthal, trans-chlordane, trans-nonachlor, and cis-nonachlor from Wong et al. 2001 [65] the tadpole $BSAF_{lipid}$ were higher in all cases. The bioaccumulation potential for the current-use pesticides, as determined from $BSAF_{dryweight}$ and $BSAF_{lipid}$, is generally higher than historic-use SOCs in California mountain tadpoles (Table 3.6). However it is important to note that the variability in BSAFs calculated from field measurements has been suggested to limit the use of BSAF as a predictor of the bioaccumulative potential of organic compounds [65].

3.5 Acknowledgement

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3.6 References

[1] Sparling DW, Fellers GM, McConnell LL. 2001. Pesticides and amphibian population declines in California, USA. *Environmental Toxicology and Chemistry* 20:1591-1595.

[2] Fellers GM, McConnell LL, Pratt D, Datta S. 2004. Pesticides in mountain yellow-legged frogs (*Rana muscosa*) from the Sierra Nevada Mountains of California, USA. *Environmental Toxicology and Chemistry* 23:2170-2177.
[3] Hageman KJ, Simonich SL, Campbell DH, Wilson GR, Landers DH. 2006. Atmospheric deposition of current-use and historic-use pesticides in snow at national parks in the Western United States. *Environ Sci Technol* 40:3174-3180.
[4] Datta S, Hansen L, McConnell L, Baker J, LeNoir J, Seiber JN. 1998. Pesticides and PCB contaminants in fish and tadpoles from the Kaweah River Basin, California. *Bulletin of Environmental Contamination and Toxicology* 60:829-836.
[5] Datta S, McConnell LL, Baker JE, LeNoir J, Seiber JN. 1998. Evidence for atmospheric transport and deposition of polychlorinated biphenyls to the Lake Tahoe Basin, California-Nevada. *Environ Sci Technol* 32:1378-1385.
[6] Angermann JE, Fellers GM, Matsumura F. 2002. Polychlorinated biphenyls and toxaphene in pacific tree frog tadpoles (*Hyla regilla*) from the California Sierra Nevada, USA. *Environmental Toxicology and Chemistry* 21:2209-2215.
[7] McConnell LL, LeNoir JS, Datta S, Seiber JN. 1998. Wet deposition of current-use pesticides in the Sierra Nevada Mountain Range, California, USA. *Environmental Toxicology and Chemistry* 17:1908-1916.
[8] LeNoir JS, McConnell LL, Fellers GM, Cahill TM, Seiber JN. 1999. Summertime transport of current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry* 18:2715-2722.
[9] Aston LS, Seiber JN. 1997. Fate of summertime airborne organophosphate pesticide residues in the Sierra Nevada Mountains. *Journal of Enviornmental Quality* 26:1483-1492.
[10] Ackerman LK, Schwindt AR, Massey Simonich SL, Koch DC, Blett TF, Schreck CB, Kent ML, Landers DH. 2008. Atmospherically deposited PBDEs, pesticides, PCBs, and PAHs in Western U.S. National Park fish: Concentrations and consumption guidelines. *Environ Sci Technol* 42:2334-2341.
[11] Cory L, Fjeld, P., Serat, W. 1970. Distribution patterns of DDT residues in the Sierra Nevada Mountains. *Pesticides Monitoring Journal* 3:204-211.
[12] Zabik JM, Seiber, J.N. 1993. Atmospheric transport of organophosphate pesticides from California's Central Valley to the Sierra Nevada Mountains. *Journal of Enviornmental Quality* 22:80-90.
[13] Usenko S, Landers DH, Appleby PG, Simonich SL. 2007. Current and historical deposition of PBDEs, pesticides, PCBs, and PAHs to Rocky Mountain National Park. *Environ Sci Technol* 41:7235-7241.
[14] Gunier RB, Harnly ME, Reynolds P, Hertz A, Von Behren J. 2001. Agricultural pesticide use in California: pesticide prioritization, use densities, and population distributions for a childhood cancer study. *Environ Health Perspect* 109:1071-1078.
[15] Nelson GL. 2000. Fire and Pesticides, A Review and Analysis of Recent Work. *Fire Technology* 36:163-183.
[16] McMahon CK, Clements, H.B., Bush, P.B., Neary, D.G., Taylor, J.W. . 1985. Pesticides released from burning treated wood. In Donoghue LR, Martin, R.E., ed,

Proceedings of the eight conference on fire and forest meteorology. Society of American Foresters, Bethesda, MD, pp 145-152.
[17] Gabos S, Ikonomou MG, Schopflocher D, Fowler BR, White J, Prepas E, Prince D, Chen W. 2001. Characteristics of PAHs, PCDD/Fs and PCBs in sediment following forest fires in northern Alberta. *Chemosphere* 43:709-719.
[18] Kim EJ, Oh JE, Chang YS. 2003. Effects of forest fire on the level and distribution of PCDD/Fs and PAHs in soil. *Sci Total Environ* 311:177-189.
[19] Daly GL, Wania F. 2005. Organic contaminants in mountains. *Environ Sci Technol* 39:385-398.
[20] Alford RA, Richards SJ. 1999. Global amphibian declines: A problem in applied ecology. *Annual Review of Ecology and Systematics* 30:133-165.
[21] Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischmann DL, Waller RW. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science* 306:1783-1786.
[22] Davidson C, Bradley Shaffer H, Jennings MR. 2001. Declines of the California red-legged frog: Climate, UV-B, habitat, and pesticides hypotheses. *Ecological Applications* 11:464-479.
[23] Fellers GM, Pope, K.L., Stead, J.E., Koo, M.S., Welsh, H.H. 2008. Turning population trend monitoring into active conservation: Can we save the Cascades frog (*Rana cascadae*) in the Lassen region of California? *Herpetological Conservation and Biology* 3:28-39.
[24] Vredenburg VT. 2004. Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog. *Proc Natl Acad Sci U S A* 101:7646-7650.
[25] Knapp RA, Matthews KR. 2000. Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas. *Conservation Biology* 14:428-438.
[26] Bradford DF. 1989. Allotropic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: Implications of the negative effect of fish introductions. *Copeia* 1989:775-778.
[27] Bradford DF, Tabatabai, F., Graber, D. M. 1993. Isolation of remaining populations of the native frog, *Rana muscosa*, by introduced fishes in Sequoia and Kings Canyon National Parks, California. *Conservation Biology* 7:882-888.
[28] Rachowicz LJ, Knapp RA, Morgan JA, Stice MJ, Vredenburg VT, Parker JM, Briggs CJ. 2006. Emerging infectious disease as a proximate cause of amphibian mass mortality. *Ecology* 87.
[29] Fellers GM, Green DE, Longcore JE. 2001. Oral chytridiomycosis in the mountain yellow-legged frog (*Rana muscosa*). *Copeia* 2001:945-953.
[30] Davidson C. 2004. Declining downwind: amphibian population declines in California and historical pesticide use. *Ecological Applications* 14:1892-1902.
[31] Demers MJ, Kelly EN, Blais JM, Pick FR, St.Louis VL, Schindler DW. 2007. Organochlorine Compounds in Trout from Lakes over a 1600 Meter Elevation Gradient in the Canadian Rocky Mountains. *Environ Sci Technol* 41:2723-2729.
[32] Blais JM, Schindler DW, Muir DCG, Kimpe LE, Donald DB, Rosenberg B. 1998. Accumulation of persistent organochlorine compounds in mountains of western Canada. *Nature* 395:585-588.

[33] Grimalt JO, Fernandez P, Vilanova RM. 2001. Trapping of organochlorine compounds in high mountain lakes. *ScientificWorldJournal* 1:609-611.
[34] Grimalt JO, Borghini F, Sanchez-Hernandez JC, Barra R, Garcia CJ, Focardi S. 2004. Temperature dependence of the distribution of organochlorine compounds in the mosses of the Andean mountains. *Environ Sci Technol* 38:5386-5392.
[35] Landers DH, Simonich SL, Jaffe DA, Geiser LH, Cambell DH, Schwindt AR, Schreck CB, Kent ML, Hafner WD, Taylor HE, Hageman KJ, Usenko S, Ackerman LA, Schrlau JE, Rose NL, Blett TF, Erway MM. 2008. The fate, transport, and ecological impacts of airborne contaminants in western national parks (USA). Corvallis, OR.
[36] Wassersug RJ. 1975. The adaptive significance of the tadpole stage with comments on the maintenance of complex life cycles in anurans. *J Amer Zool* 15:405-417.
[37] Sparling DW, Krest S, Ortiz-Santaliestra M. 2006. Effects of lead-contaminated sediment on Rana sphenocephala tadpoles. *Arch Environ Contam Toxicol* 51:458-466.
[38] Landrum PF, Robbins JA. 1990. Bioavailabilty of sediment-associated contaminants to benthic invertebrates. In Baudo R, Geisy JP, Muntau H, eds, *Sediments: Chemistry and toxicity of in-place pollutants*. CRC Press, p. 405.
[39] Landrum PF, Robinson SD, Gossiaux DC, You J, Lydy MJ, Mitra S, Ten Hulscher TE. 2007. Predicting bioavailability of sediment-associated organic contaminants for Diporeia spp. and oligochaetes. *Environ Sci Technol* 41:6442-6447.
[40] Burkhard LP, Cook PM, Lukasewycz MT. 2005. Comparison of biota-sediment accumulation factors across ecosystems. *Environ Sci Technol* 39:5716-5721.
[41] van der Oost R, Beyer J, Vermeulen NPE. 2002. Fish bioaccumulation and biomarkers in environmental risk assessment: a review. *Environmental Toxicology and Pharmacology* 13:57-149.
[42] Fellers GM, Drost, C.A. 1993. Disappearance of the cascades frog *Rana cascadae* at the southern end of its range, California, USA. *Biological Conservation* 65:177-181.
[43] Bradford DF, Graber DM, Tabatabai F. 1994. Population declines of the native frog, *Rana muscosa*, in Sequoia and Kings Canyon National Parks, California. *Southwestern Naturalist* 39:323-327.
[44] Usenko S, Hageman KJ, Schmedding DW, Wilson GR, Simonich SL. 2005. Trace analysis of semivolatile organic compounds in large volume samples of snow, lake water, and groundwater. *Environ Sci Technol* 39:6006-6015.
[45] Stanley KA, Davidson C, Bradford DF, Tallent-Halsell N, Massey Simonich SL. Submitted. Comparison of Pressurized Liquid Extraction and Matrix Solid Phase Dispersion for the Measurement of Semi-Volatile Organic Compound Accumulation in Tadpoles.
[46] Antweiler RC, Taylor HE. 2008. Evaluation of statistical treatments of left-censored environmental data using coincident uncensored data sets: I. Summary statistics. *Environ Sci Technol* 42:3732-3738.
[47] Gosner KL. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica* 16:183-190.

[48] Yunker MB, Cretney WJ, Ikonomou MG. 2002. Assessment of chlorinated dibenzo-p-dioxin and dibenzofuran trends in sediment and crab hepatopancreas from pulp mill and harbor sites using multivariate- and index-based approaches. *Environ Sci Technol* 36:1869-1878.
[49] Readman JW, Fillmann G, Tolosa I, Bartocci J, Villeneuve JP, Catinni C, Mee LD. 2002. Petroleum and PAH contamination of the Black Sea. *Mar Pollut Bull* 44:48-62.
[50] Courchesne CL, Bantle JA. 1985. Analysis of the activity of DNA, RNA, and protein synthesis inhibitors on Xenopus embryo development. *Teratog Carcinog Mutagen* 5:177-193.
[51] Stoilov I. 2001. Cytochrome P450s: coupling development and environment. *Trends Genet* 17:629-632.
[52] Juchau MR, Lee QP, Fantel AG. 1992. Xenobiotic biotransformation/bioactivation in organogenesis-stage conceptual tissues: implications for embryotoxicity and teratogenesis. *Drug Metab Rev* 24:195-238.
[53] EPA. 2007. Estimation Programs InterfaceSuite. Washington, DC, USA.
[54] Leonard AW, Hyne RV, Lim RP, Leigh KA, Le J, Beckett R. 2001. Fate and Toxicity of Endosulfan in Namoi River Water and Bottom Sediment. *J Environ Qual* 30:750-759.
[55] CADPR. 2006. Pesticide Use Reporting - 2005 Summary Data, Sacramento, CA.
[56] Racke KD. 1993. Environmental fate of chlorpyrifos. *Rev Environ Contam Toxicol* 131:1-150.
[57] Smith AG. 1991. Chlorpyrifos. In Hayes WJJ, Laws ERJ, eds, *Handbook of Pesticide Toxicology*. Academic, New York, NY, USA.
[58] Wan MT, Kuo J-n, Buday C, Schroeder G, Aggelen GV, Pasternak J. 2005. Toxicity of *alpha-, beta-, and (alpha + beta)*-endosulfan and their formulated and degredation products to Daphnia magna, Hyalella azteca, Oncorhynchus mykiss, Oncorhynchus kisutch, and biological implications in streams. *Environmental Toxicology and Chemistry* 24:1146-1154.
[59] Hose GC, Lim RP, Hyne RV. 2003. The transport, fate and effects of endosulfan in the Australian freshwater environment. *Australasian Journal of Ecotoxicology* 9:101-111.
[60] Brevik K, Sweetman A, Pacyna JM, Jones KC. 2002. Towards a global historical emission inventory for selected PCB congeners -a mass balance approach: 2. Emissions. *The Science of the Total Environment* 290:199-224.
[61] Leone AD, Ulrich EM, Bodnar CE, Falconer RL, Hites RA. 2000. Organochlorine pesticide concentrations and enantiomer fractions for chlordane in indoor air form the US cornbelt. *Atmospheric Environment* 34:4131-4138.
[62] Wickman BE, Mason RR, Thompson CG. 1973. Major outbreaks of the Douglas-fir tussock moth in Oregon and California, Portland, OR.
[63] Burkhard LP. 2003. Factors influencing the design of bioaccumulation factor and biota-sediment accumulation factor field studies. *Environmental Toxicology and Chemistry* 22:351-360.
[64] Burkhard LP, Cook PM, Lukasewycz MT. 2004. Biota--sediment accumulation factors for polychlorinated biphenyls, dibenzo-p-dioxins, and

dibenzofurans in southern Lake Michigan lake trout (Salvelinus namaycush). *Environ Sci Technol* 38:5297-5305.
[65] Wong CS, Capel PD, Nowell LH. 2001. National-scale, field-based evaluation of the biota-sediment accumulation factor model. *Environ Sci Technol* 35:1709-1715.

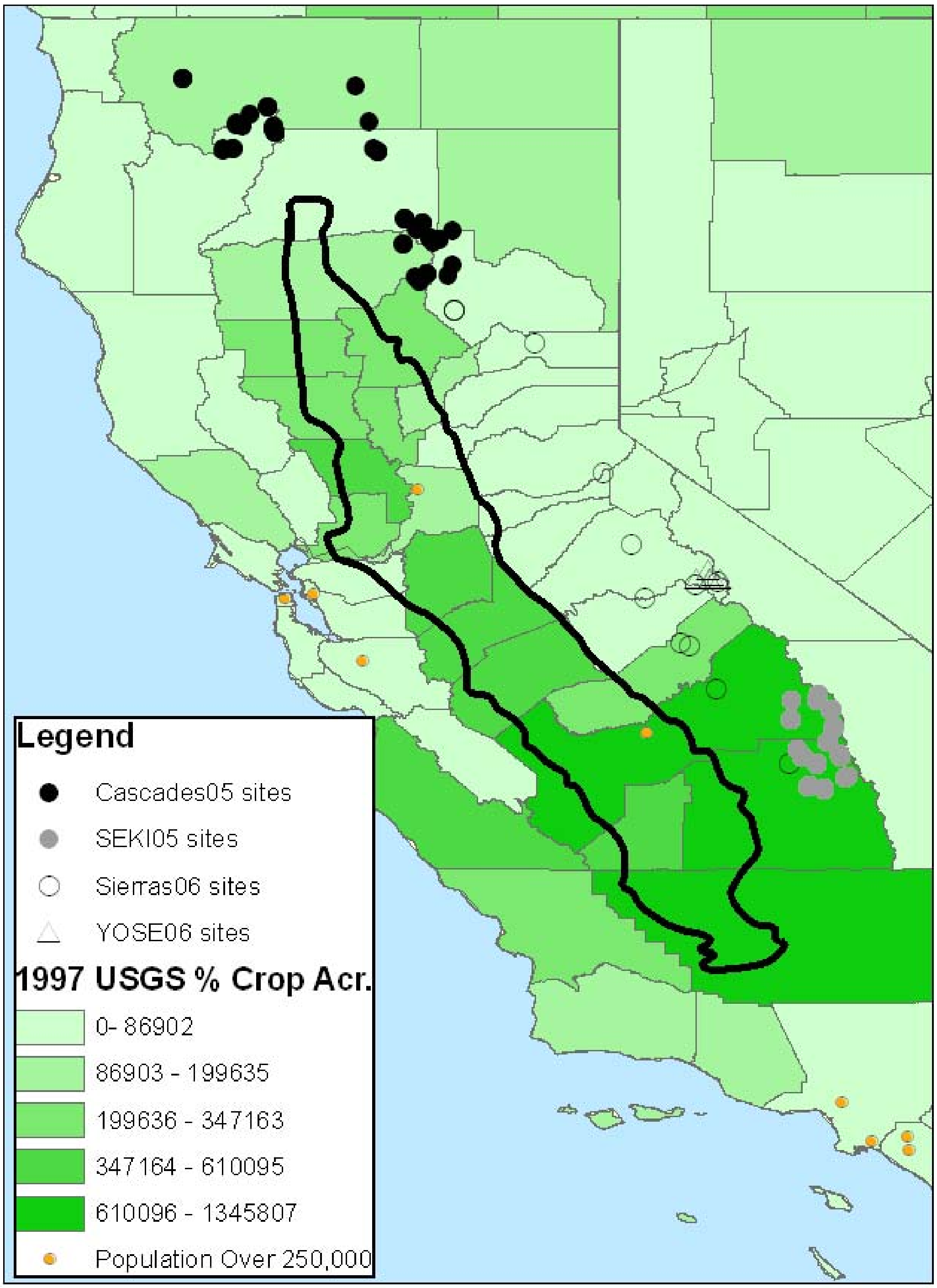


Figure 3.1. Location of sites sampled in the Cascade Mountains (Cascades) and Sequoia and Kings Canyon National Parks (SEKI) in 2005 and the Sierra Nevada Mountains (Sierras) and Yosemite National Park (YOSE) in 2006, cropland intensity by county, and cities with population greater than 250,000. The black line indicates the nominal boundary of the Central Valley.

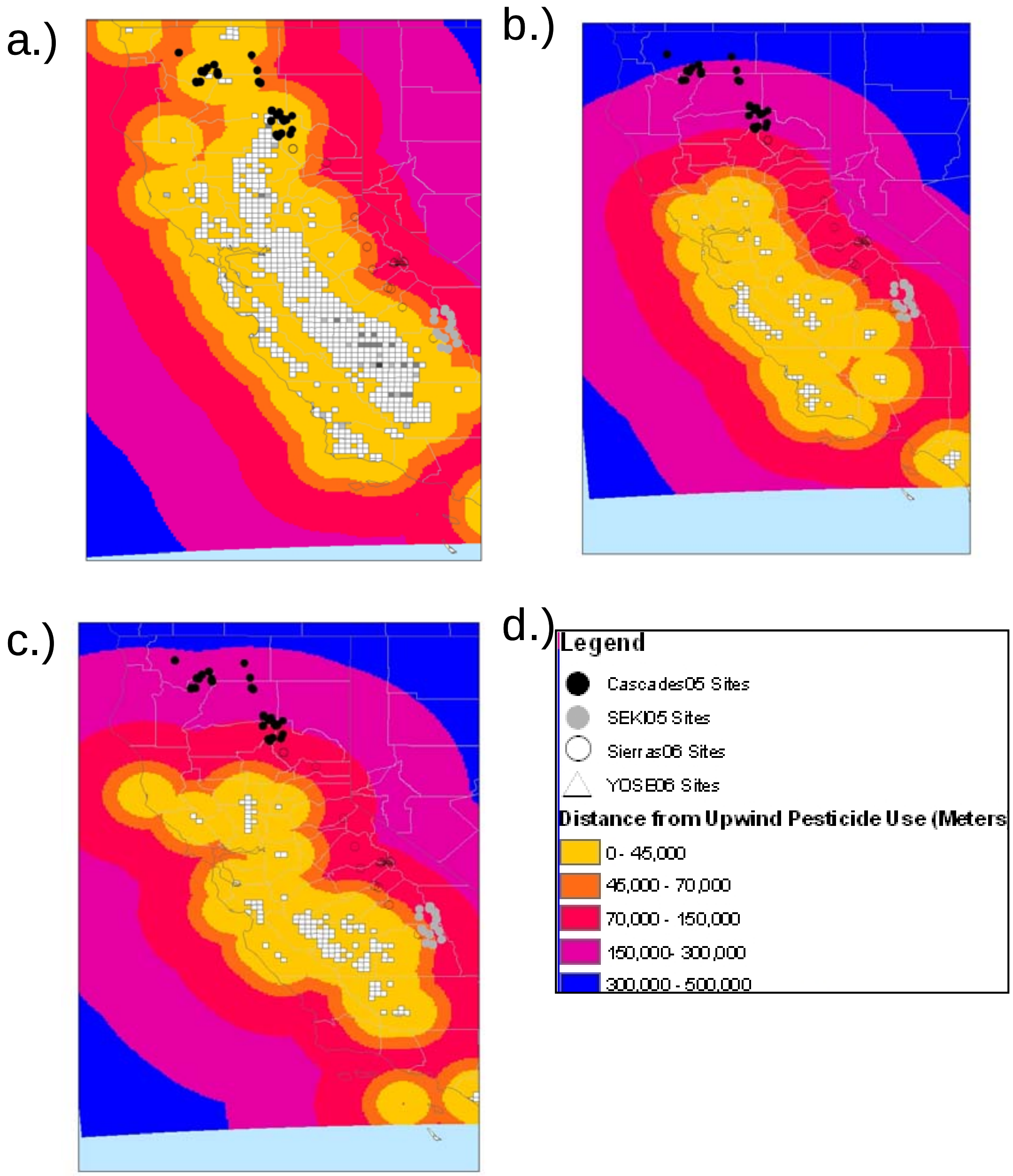


Figure 3.2. Maps indicating location of California pesticide applications in 2005 for a.) chlorpyrifos, b.) dacthal and c.) endosulfan (squares represent location of applications) and distance from pesticide application (euclidean distance in meters shown by colored rings extending from pesticide use locations). Site symbols and distance from upwind pesticide use in meters shown in d.) legend.

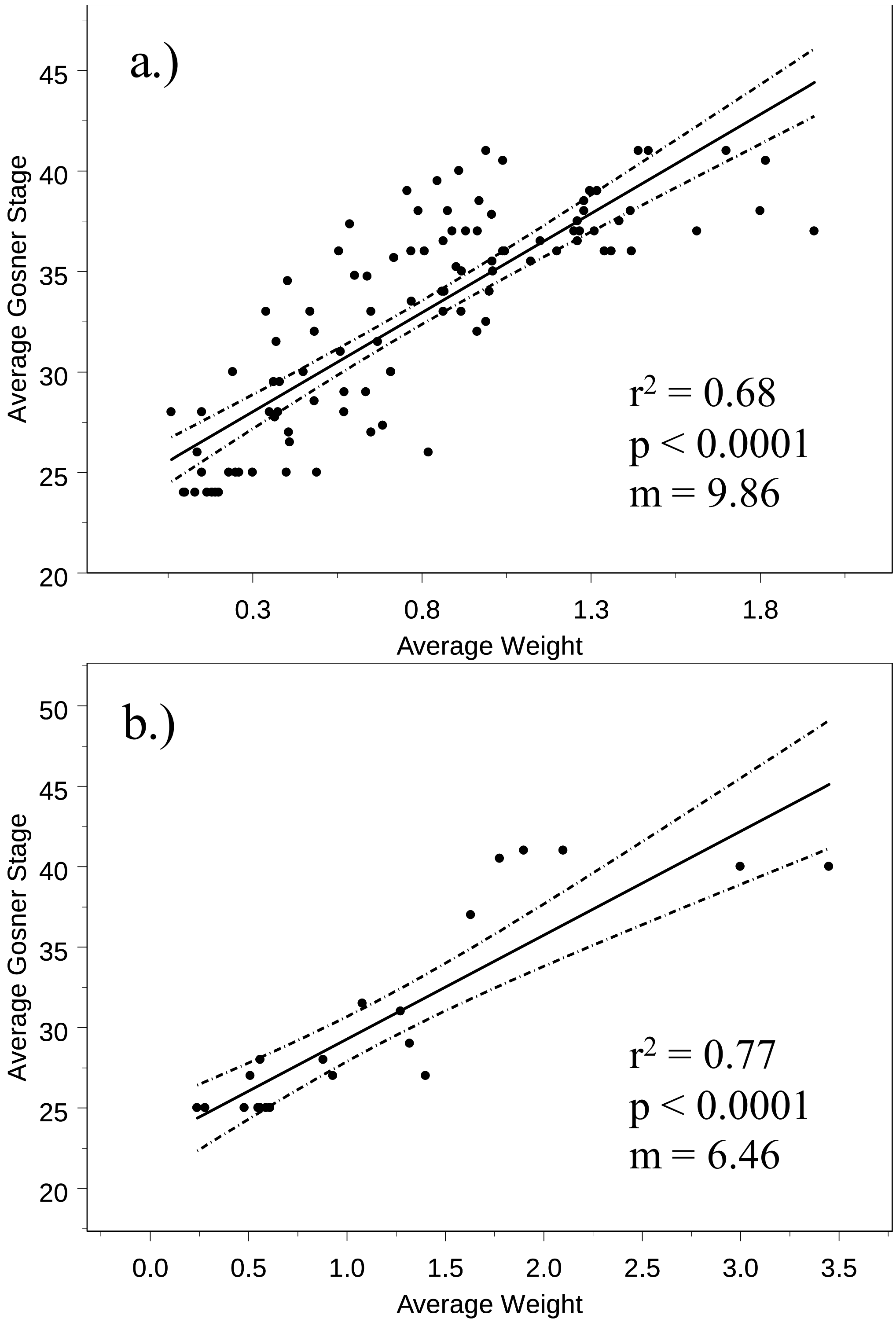


Figure 3.3. Correlation between average tadpole Gosner stage of development and average weight of tadpoles for a.) *Pseudacris regilla* from all regions and b.) *Rana cascadae* from the Cascades. Dotted line represents the 95 % confidence interval.

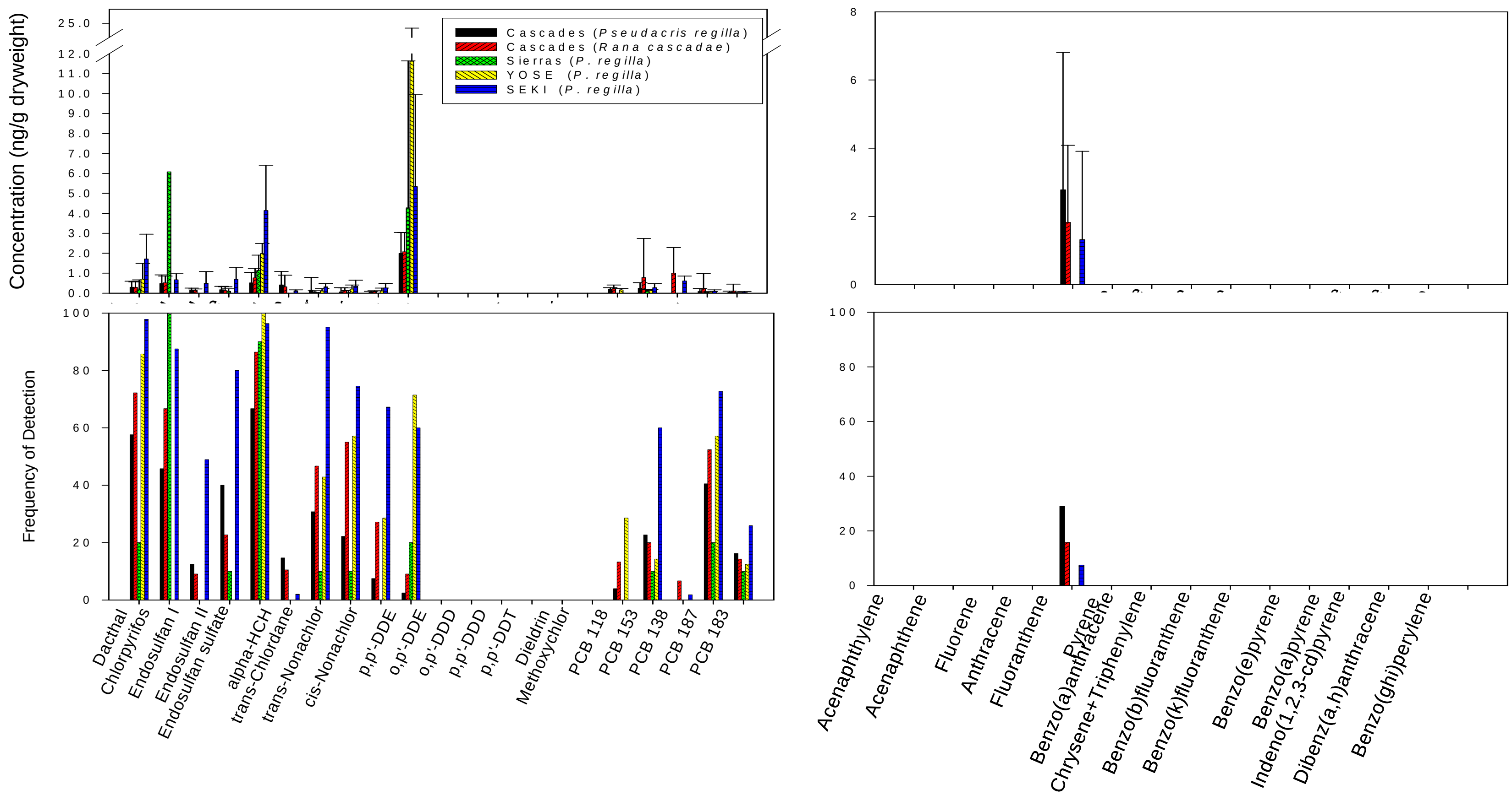


Figure 3.4. Pesticide, PCB, and PAH percent detections and concentrations in tadpoles from the Cascades (*Pseudacris regilla and Rana cascadae*), SEKI, the Sierras, and YOSE (*P. regilla*) on a ng/g dry weight basis. Note: scales differ for concentration bar graphs. Error bars indicate standard deviation; a missing error bar indicates the SOC was detected in one sample only. A missing bar indicates the SOC was not detected in any samples above the estimated detection limit (EDL).

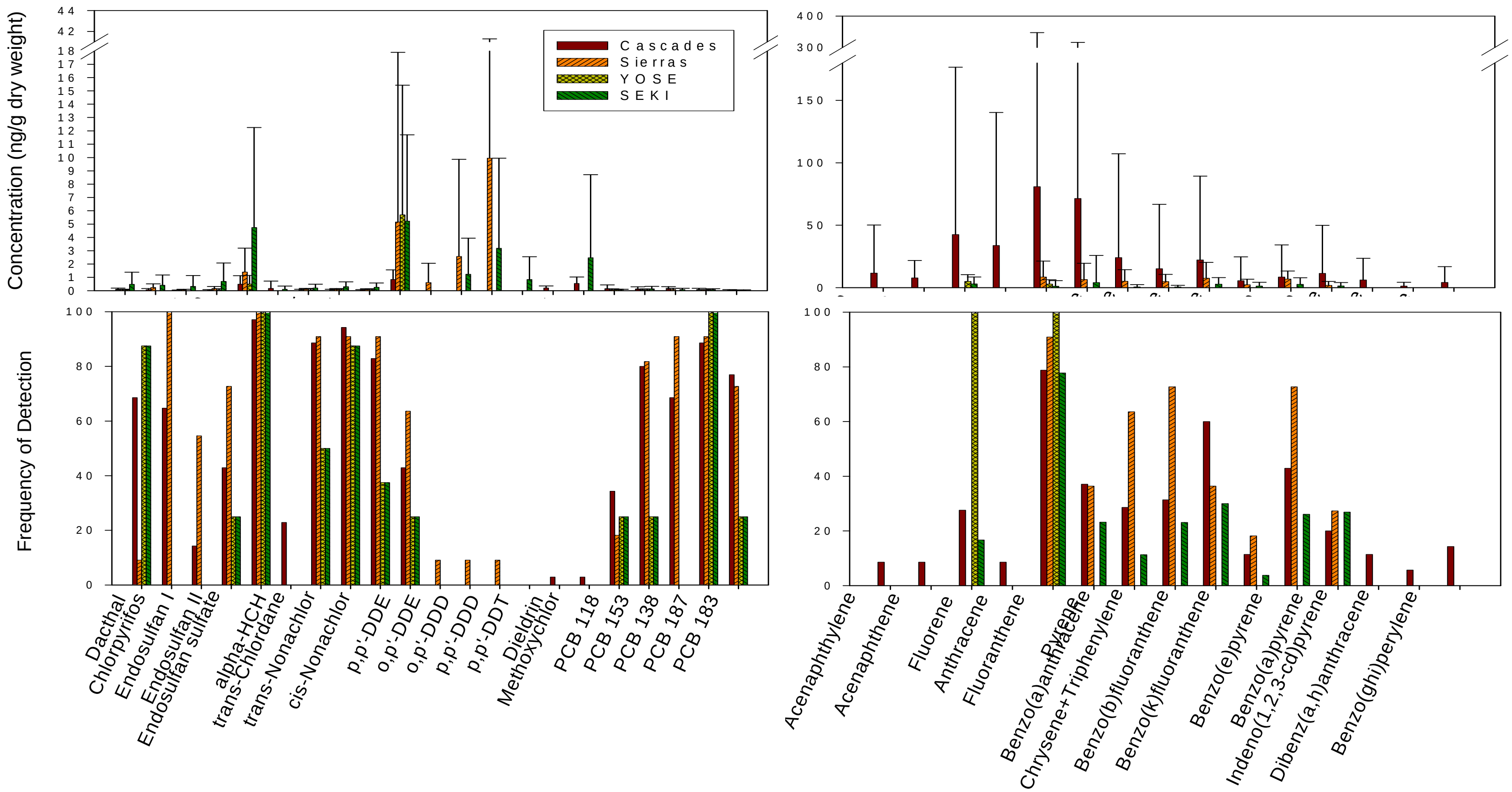


Figure 3.5. Pesticide, PCB, and PAH percent detections and concentrations in sediment from the Cascades, SEKI, the Sierras, and YOSE on a ng/g dry weight basis. Note: scales differ for concentration bar graphs. Error bars indicate standard deviation; a missing error bar indicates the SOC was detected in one sample only. A missing bar indicates the SOC was not detected in any samples above the estimated detection limit (EDL).

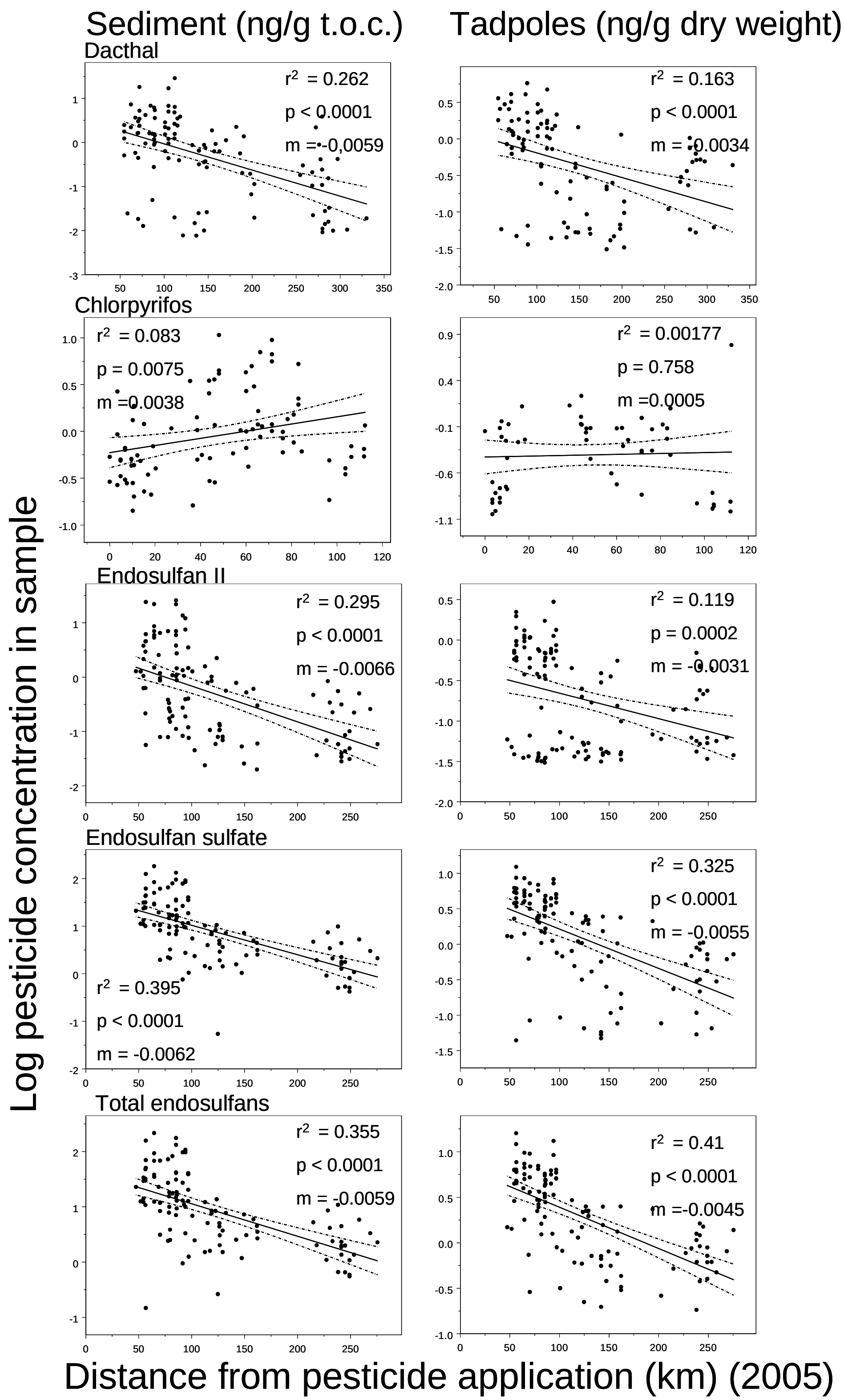
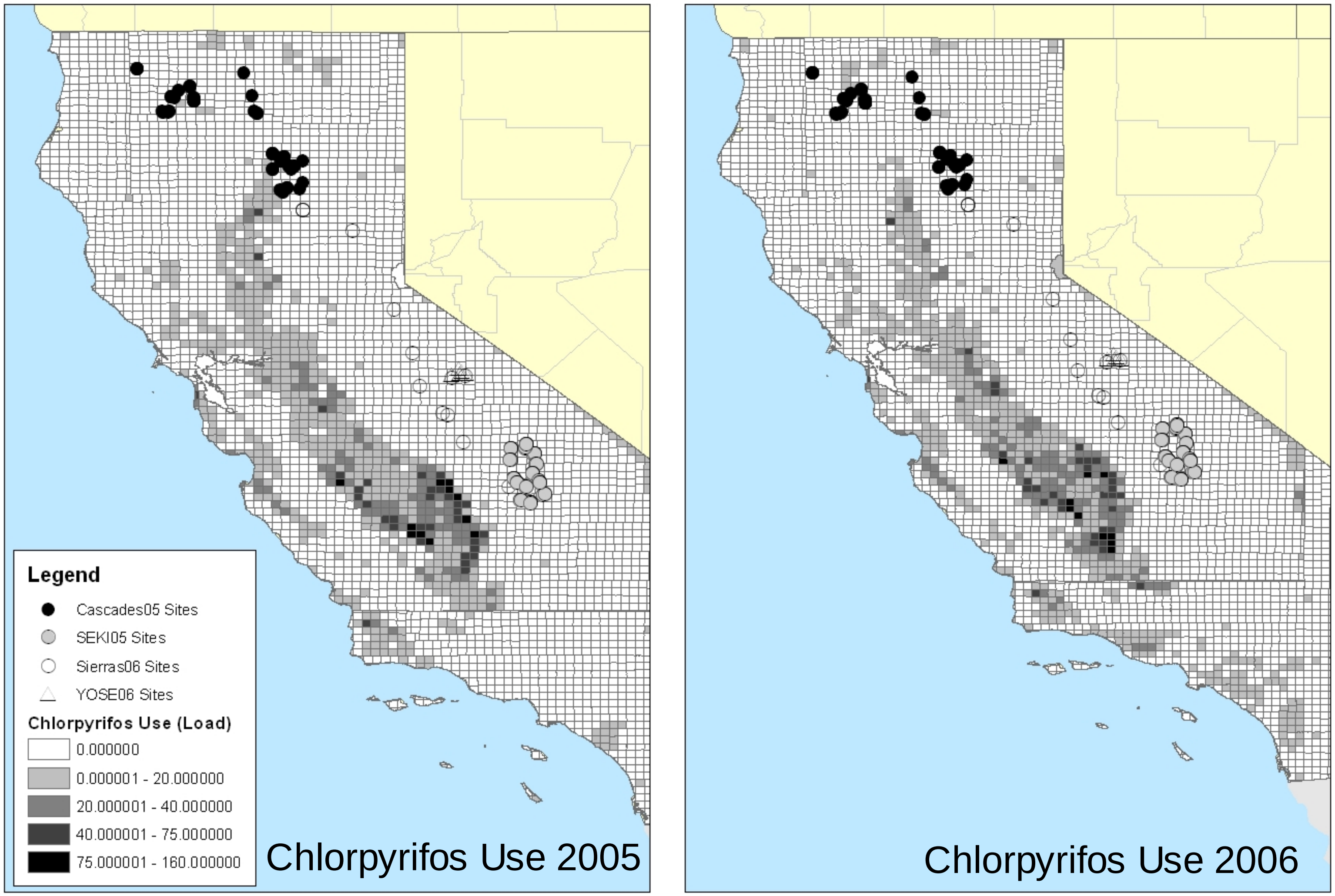
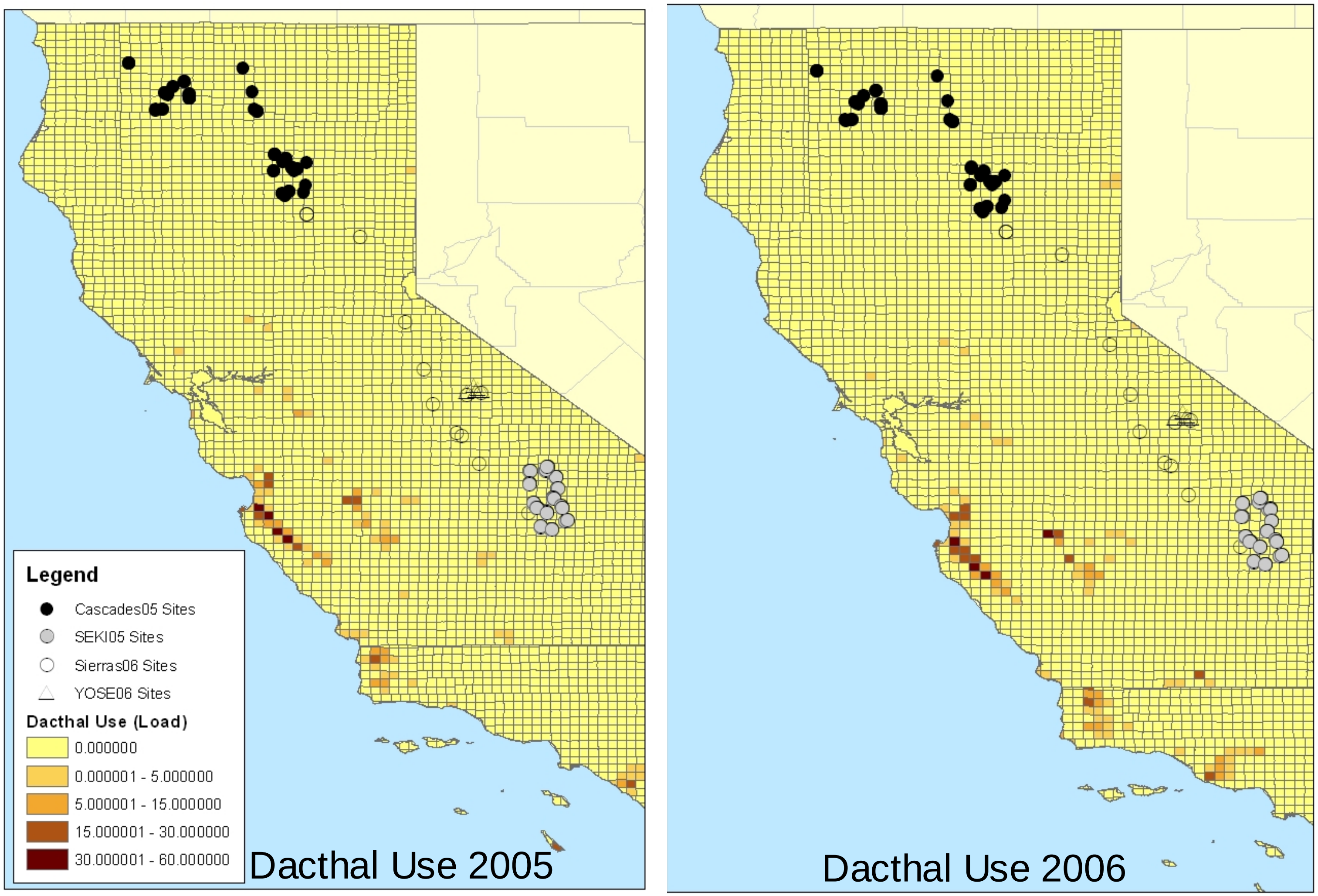


Figure 3.6. Correlation between log current use pesticide concentration in sediment (ng/g toc) and tadpoles (ng/g dw) and site distance from application areas. The dotted lines represent the 95% confidence interval of the regression.

a.)


Legend
Cascades05 Sites
SEKI05 Sites
Sierras06 Sites
YOSE06 Sites
Chlorpyrifos Use (Load)
0.000000
0.000001 - 20.000000
20.000001 - 40.000000
40.000001 - 75.000000
75.000001 - 160.000000
Chlorpyrifos Use 2005
Chlorpyrifos Use 2006

b.)


Legend
Cascades05 Sites
SEKI05 Sites
Sierras06 Sites
YOSE06 Sites
Dacthal Use (Load)
0.000000
0.000001 - 5.000000
5.000001 - 15.000000
15.000001 - 30.000000
30.000001 - 60.000000
Dacthal Use 2005
Dacthal Use 2006

c.)

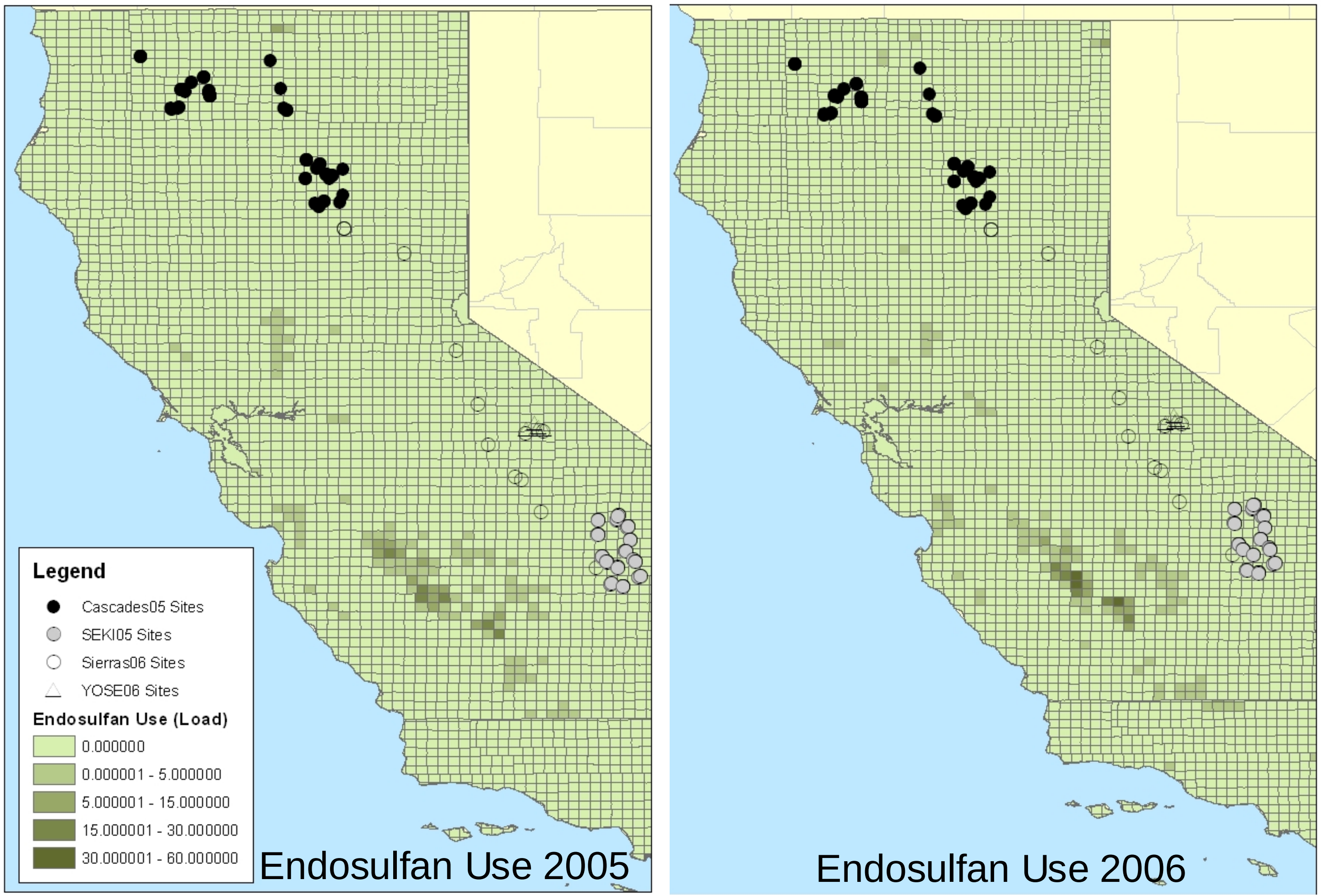


Figure 3.7. Current-use pesticide application comparisons (load (kg applied / square kilometer) for 2005 and 2006, on a township basis, for (a) chlorpyrifos, (b) dacthal, and (c) endosulfan.

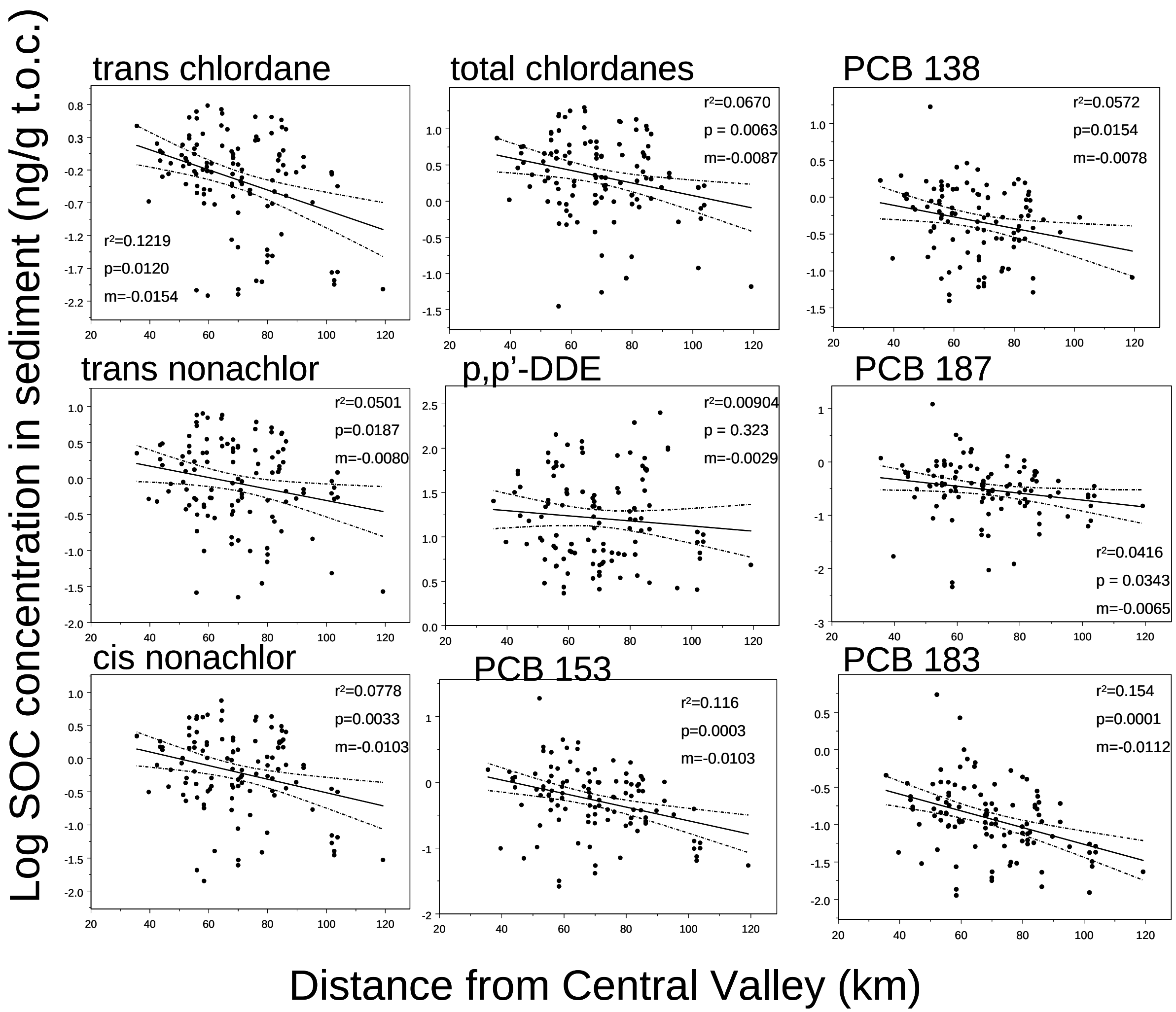


Figure 3.8. Correlation between SOC concentrations in sediment and distance to the Central Valley (km).

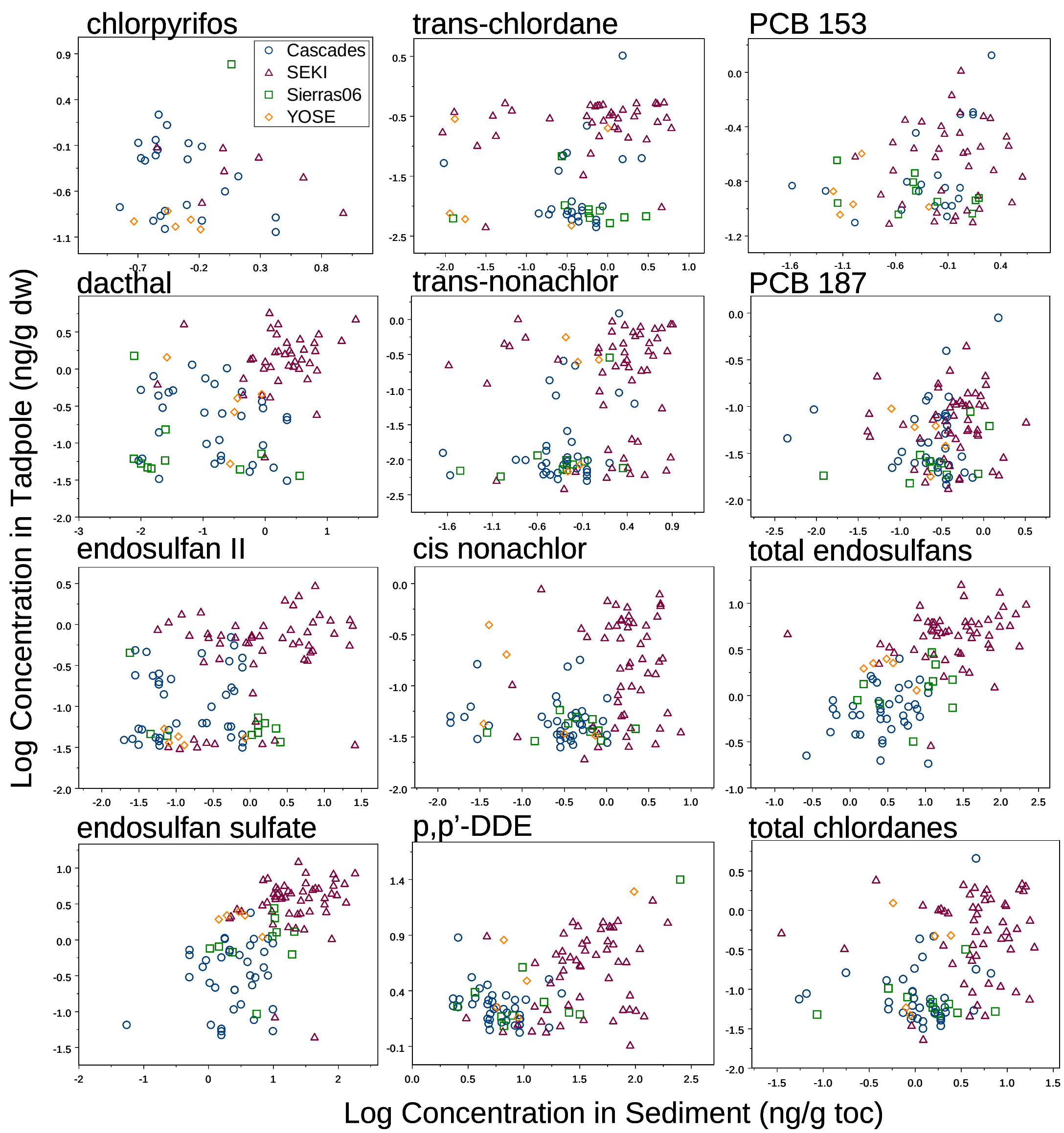


Figure 3.9. Scatter plot of SOC concentrations in sediment (organic carbon normalized) and tadpoles (dry weight normalized). The different symbols indicate the region of sample collection.

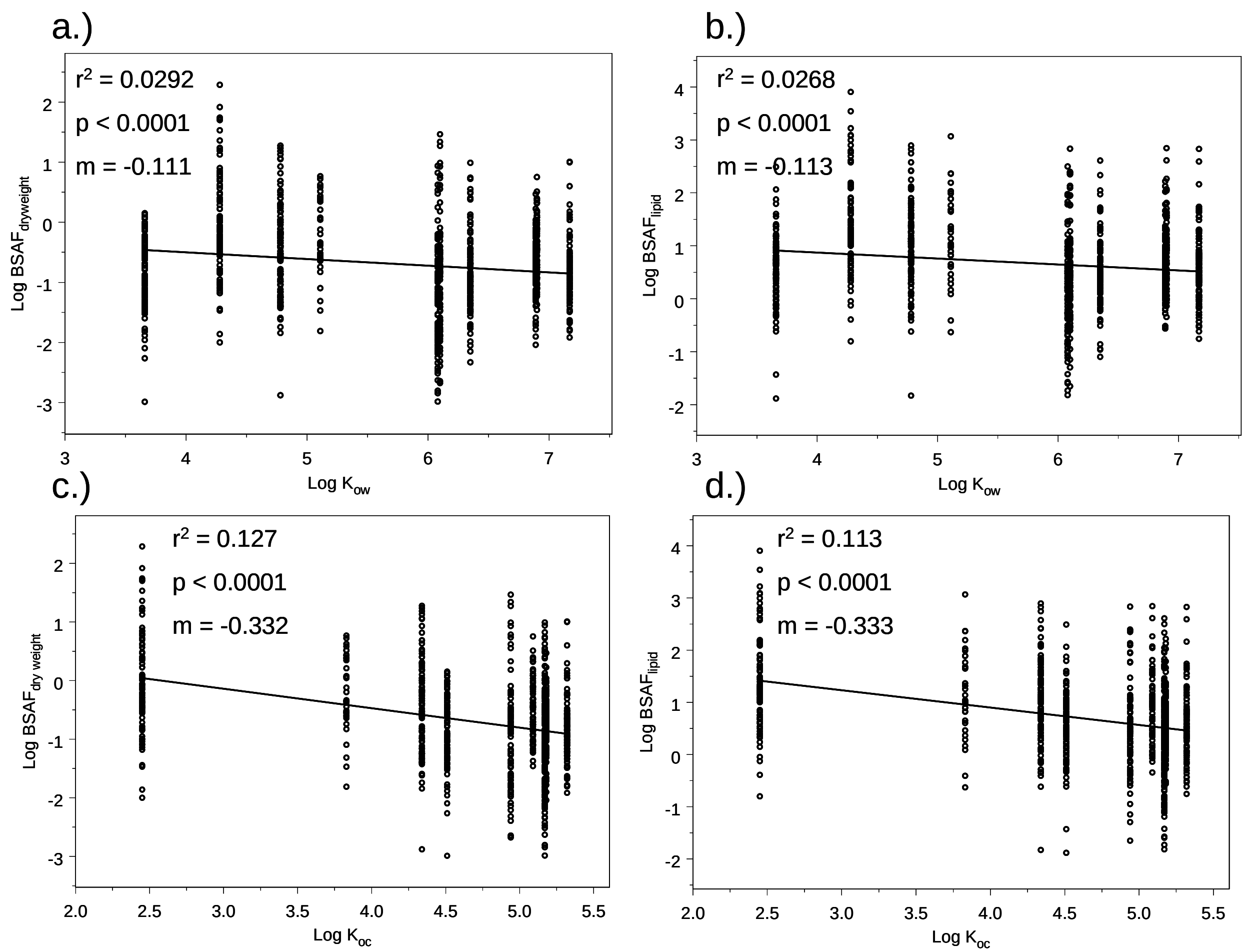


Figure 3.10. BSAF versus log Kow and log Koc. BSAF versus log K_{ow} determined on a site basis (a.) for tadpole dry weight versus sediment organic carbon (toc) and (b.) for tadpole lipid weight versus sediment toc; and BSAF versus log K_{oc} (c.) for tadpole dry weight versus sediment organic carbon (toc) and (d.) for tadpole lipid weight versus sediment toc.

Table 3.1. Sites, date of sample collection, types of samples collected.

Site Name	Region	Year	Sample Type (PR = *Pseudacris regilla*, RC = *Rana cascadae*)	Tadpole Sample Date(s)	Sediment Sample Date(s)
ant	Cascades	2005	tadpoles (PR), sediment	7/7	7/7
bat	Cascades	2005	tadpoles (PR), sediment	6/8,7/11,7/30,8/20	6/8
bcl	Cascades	2005	tadpoles (PR, RC), sediment	7/28	7/28
bdr	Cascades	2005	tadpoles (PR, RC), sediment	8/1	8/1
blf	Cascades	2005	tadpoles (PR, RC), sediment	7/10	7/10
bty	Cascades	2005	tadpoles (PR), sediment	8/3	8/3
but	Cascades	2005	tadpoles (PR), sediment	7/12	7/12
cby	Cascades	2005	Sediment		7/14
dch	Cascades	2005	tadpoles (PR), sediment	7/10,7/29,8/20	7/10
dlp	Cascades	2005	tadpoles (PR), sediment	7/30	7/30
dom	Cascades	2005	tadpoles (PR), sediment	6/6	6/6
fnd	Cascades	2005	tadpoles (RC), sediment	8/1	8/1
fry	Cascades	2005	tadpoles (PR, RC), sediment	7/28	7/28
gum	Cascades	2005	tadpoles (PR, RC), sediment	7/26	7/06, 7/26
kng	Cascades	2005	tadpoles (PR)	7/29	
lly	Cascades	2005	tadpoles (PR)	7/9, 8/21	
lml	Cascades	2005	tadpoles (PR, RC), sediment	7/12,7/29,823	7/12, 7/29
lst	Cascades	2005	tadpoles (PR), sediment	7/13,8/2,8/19	7/13
mbp	Cascades	2005	tadpoles (PR, RC), sediment	7/8,7/27,8/22	7/8
mcc	Cascades	2005	tadpoles (PR), sediment	7/7	7/7
meb	Cascades	2005	tadpoles (PR, RC), sediment	7/29	7/29
mum	Cascades	2005	tadpoles (PR, RC), sediment	7/6,7/27,8/22 (RC only)	7/06, 8/22
nel	Cascades	2005	tadpoles (RC), sediment	7/8	7/8
skw	Cascades	2005	tadpoles (PR, RC), sediment	7/8	7/8
sng	Cascades	2005	tadpoles (PR), sediment	7/13	7/13
snw	Cascades	2005	tadpoles (PR), sediment	6/7,7/13,7/29	6/7, 8/21
tng	Cascades	2005	tadpoles (RC), sediment	7/12	7/12
ueb	Cascades	2005	tadpoles (PR, RC), sediment	7/29	7/29
ugb	Cascades	2005	tadpoles (PR), sediment	7/26	7/26
ulc	Cascades	2005	tadpoles (PR, RC), sediment	7/31	7/31
unl	Cascades	2005	tadpoles (RC), sediment	7/31	7/31
wcp	Cascades	2005	tadpoles (PR), sediment	7/30	7/30
Yel	Cascades	2005	tadpoles (PR), sediment	7/13	7/13
1168X	SEKI	2005	tadpoles (PR), sediment	8/7, 9/4	8/7, 9/4
2310X	SEKI	2005	tadpoles (PR), sediment	8/4, 9/3	8/4, 9/3
10249	SEKI	2005	tadpoles (PR), sediment	8/8, 9/6	8/8, 9/6
10310	SEKI	2005	tadpoles (PR), sediment	9/11	9/11
10594	SEKI	2005	tadpoles (PR), sediment	8/12	8/12
11087	SEKI	2005	tadpoles (PR), sediment	7/31, 8/30	7/31, 8/30
11089	SEKI	2005	tadpoles (PR), sediment	7/31, 8/30	7/31, 8/30
11281	SEKI	2005	tadpoles (PR), sediment	8/11	8/11
11474	SEKI	2005	tadpoles (PR), sediment	8/7, 9/5	8/7, 9/5
11475	SEKI	2005	tadpoles (PR), sediment	8/6, 9/5	8/6, 9/5
11685	SEKI	2005	tadpoles (PR), sediment	8/6, 9/4	8/6, 9/4
12154	SEKI	2005	tadpoles (PR), sediment	8/2, 8/31	8/2, 8/31

12155	SEKI	2005	tadpoles (PR), sediment	8/1, 8/31	8/1, 8/31
12338	SEKI	2005	tadpoles (PR), sediment	8/12, 9/12	8/12, 9/12
12457	SEKI	2005	tadpoles (PR), sediment	7/30, 8/29	7/30, 8/29
12461	SEKI	2005	tadpoles (PR), sediment	7/30, 8/29	7/30, 8/29
20027	SEKI	2005	tadpoles (PR), sediment	8/10, 9/10	8/10, 9/10
20037	SEKI	2005	tadpoles (PR), sediment	8/2, 9/2	8/2, 9/2
20062	SEKI	2005	tadpoles (PR), sediment	8/3, 9/4	8/3, 9/4
20135	SEKI	2005	tadpoles (PR), sediment	8/10, 9/9	8/10, 9/9
21317	SEKI	2005	tadpoles (PR), sediment	8/1, 9/2	8/1, 9/2
21329	SEKI	2005	tadpoles (PR), sediment	8/8, 9/7	8/8, 9/7
21390	SEKI	2005	tadpoles (PR), sediment	8/3, 9/3	8/3, 9/3
21397	SEKI	2005	tadpoles (PR), sediment	8/3, 9/3	8/3, 9/3
21522	SEKI	2005	tadpoles (PR), sediment	8/9, 9/8	8/9, 9/8
21559	SEKI	2005	tadpoles (PR), sediment	8/8, 9/7	8/8, 9/7
23058	SEKI	2005	tadpoles (PR), sediment	8/10, 9/10	8/10, 9/10
10311	SEKI	2005	tadpoles (PR), sediment	8/11, 9/11	8/11, 9/11
10525	SEKI	2005	tadpoles (PR), sediment	8/8, 9/6	8/8, 9/7
12337	SEKI	2005	tadpoles (PR), sediment	9/13	9/13
12459	SEKI	2005	tadpoles (PR), sediment	8/29	
20305	SEKI	2005	tadpoles (PR), sediment	9/3	
chi	Sierras	2006	Sediment		7/18
cnt	Sierras	2006	tadpoles (PR), sediment	7/1	7/1
cnf	Sierras	2006	tadpoles (PR), sediment	7/6	7/6
dan	Sierras	2006	tadpoles (PR), sediment	7/7	7/7
tlp	Sierras	2006	tadpoles (PR), sediment	7/7	7/7
slv	Sierras	2006	tadpoles (PR), sediment	7/9	7/9
srd	Sierras	2006	tadpoles (PR), sediment	7/9	7/9
swa	Sierras	2006	tadpoles (PR), sediment	7/17	7/17
kel	Sierras	2006	tadpoles (PR), sediment	7/19	7/19
mud	Sierras	2006	tadpoles (PR), sediment	7/21	7/21
dar	Sierras	2006	tadpoles (PR), sediment	7/24	7/24
70550	YOSE	2006	sediment		8/2, 8/31
70134	YOSE	2006	tadpoles (PR), sediment	7/29, 8/30	7/29, 8/30
70414	YOSE	2006	tadpoles (PR), sediment	7/30, 8/29	7/30, 8/29
72403	YOSE	2006	tadpoles (PR)	8/2, 8/31	
72996	YOSE	2006	tadpoles (PR), sediment	7/31, 8/31	7/31, 8/31

Table 3.2. Site locations and distances to the Central Valley and current use pesticide applications.

Site Name	Region	elevation (meters (m))	latitude	longitude	distance to Central Valley (m)	distance to dacthal use 2005 (m)	distance to chlorpyrifos use 2005 (m)	distance to endosulfan use 2005 (m)
ant	Cascades	1736	41.503	-121.914	95253	308026	36574	268659
bat	Cascades	1513	40.355	-121.571	51348	181924	3381	142015
bcl	Cascades	1690	41.292	-122.687	73996	292092	13525	253360
bdr	Cascades	1851	41.049	-122.807	55986	268390	9564	233019
blf	Cascades	1922	41.347	-122.559	76756	297203	18209	258217

bty	Cascades	2083	40.454	-121.210	81596	199058	15122	161618
but	Cascades	1371	40.202	-121.212	69971	170317	19127	132281
cby	Cascades	1507	40.114	-121.480	39639	156767	0	117227
dch	Cascades	2030	40.499	-121.429	71279	197846	7561	158331
dlp	Cascades	1798	40.398	-121.368	68297	188782	0	149469
dom	Cascades	1556	40.362	-121.346	66356	186401	3381	147288
fnd	Cascades	2096	41.042	-122.818	64460	268390	12191	228562
fry	Cascades	1778	41.552	-123.179	119184	330048	57581	275456
gum	Cascades	1859	41.212	-122.509	60915	279551	10693	241448
kng	Cascades	2231	40.460	-121.467	66158	154189	3381	193811
lly	Cascades	1805	40.540	-121.562	67895	162082	6763	202508
lml	Cascades	1869	41.221	-122.758	69977	286710	4782	249012
lst	Cascades	1970	40.136	-121.396	51148	158511	10144	122576
mbp	Cascades	1793	41.167	-122.503	56081	276192	6763	238097
mcc	Cascades	1209	41.239	-121.815	70066	277825	43957	238364
meb	Cascades	2083	41.228	-122.781	71278	287408	9564	249012
mum	Cascades	1858	41.191	-122.509	58423	279980	10144	241448
nel	Cascades	1490	41.044	-121.788	49662	257746	40575	218003
skw	Cascades	1145	41.025	-121.757	52480	254617	44087	214852
sng	Cascades	1726	40.082	-121.446	46365	154338	3381	115037
snw	Cascades	1805	40.539	-121.562	67895	202508	6763	162082
tng	Cascades	1752	41.207	-122.743	66217	282728	4782	244893
ueb	Cascades	2067	41.225	-122.782	71278	282728	9564	244893
ugb	Cascades	1898	41.209	-122.514	60440	279551	10693	241448
ulc	Cascades	2058	41.032	-122.879	58383	269221	16906	227269
unl	Cascades	1838	41.044	-122.883	65937	272497	15122	230426
wcp	Cascades	1541	40.388	-121.309	70864	190593	6763	151619
Yel	Cascades	1309	40.126	-121.246	61984	162788	20288	124680
1168X	SEKI	3241	37.020	-118.729	68303	104961	71375	85195
2310X	SEKI	3176	36.377	-118.487	53359	104961	71375	85195
10249	SEKI	3207	37.025	-118.546	81356	112084	80945	94030
10310	SEKI	3299	36.959	-118.435	87098	111726	84505	91475
10594	SEKI	3045	36.884	-118.738	59621	89342	60061	70086
11087	SEKI	3224	36.832	-118.423	83595	100957	76166	85803
11089	SEKI	3232	36.833	-118.419	83989	100957	76166	85803
11281	SEKI	3291	36.951	-118.452	84892	111726	84505	91475
11474	SEKI	3260	37.070	-118.534	85298	118055	83011	96636
11475	SEKI	3329	37.066	-118.539	84699	115059	83011	96636
11685	SEKI	3240	37.020	-118.727	68303	104961	71375	85195
12154	SEKI	3338	36.722	-118.467	75834	104961	71375	85195
12155	SEKI	3304	36.719	-118.464	76162	88570	62934	77599
12338	SEKI	3188	36.878	-118.733	59362	89342	60061	70086
12457	SEKI	2786	36.661	-118.689	55832	70418	46206	56582
12461	SEKI	2754	36.668	-118.690	55142	70418	46206	56582
20027	SEKI	3189	36.562	-118.545	64307	71947	48080	64504
20037	SEKI	3120	36.399	-118.612	43527	54567	38563	54395
20062	SEKI	3262	36.463	-118.337	67795	78712	62465	78487
20135	SEKI	3375	36.636	-118.384	79851	86675	65232	79584
21317	SEKI	3241	36.404	-118.604	44249	54567	38563	54395
21329	SEKI	3242	36.610	-118.645	57976	67172	43750	56274

21390	SEKI	3232	36.371	-118.488	53359	62216	46046	64594
21397	SEKI	3213	36.473	-118.317	69908	83237	66240	78854
21522	SEKI	3364	36.613	-118.372	79995	84602	63516	81733
21559	SEKI	3186	36.613	-118.650	55956	69765	43750	56274
23058	SEKI	3239	36.559	-118.541	64549	71947	48080	64504
10311	SEKI	3343	36.956	-118.437	86248	111726	84505	91475
10525	SEKI	3202	37.030	-118.549	81623	112084	80945	94030
12337	SEKI	3234	36.879	-118.729	59490	89342	60061	70086
12459	SEKI	2796	36.665	-118.691	54821	56582	43413	70418
20305	SEKI	3180	36.377	-118.489	53359	64594	46046	63581
chi	Sierras	2263	37.412	-119.481	52275	88246	60989	70086
cnt	Sierras	2048	36.559	-118.747	47109	58222	35377	47352
cnf	Sierras	1905	37.759	-119.805	55132	116837	67013	92793
dan	Sierras	2916	37.886	-119.270	101742	145319	112331	123609
tlp	Sierras	2609	37.864	-119.432	89712	136417	97149	112549
slv	Sierras	2206	38.672	-120.116	82311	131979	65345	100678
srd	Sierras	1755	39.618	-120.616	78069	139118	78263	97233
swa	Sierras	1734	37.097	-119.290	101742	76048	38372	51782
kel	Sierras	1782	37.441	-119.543	50784	89406	59938	68838
mud	Sierras	2142	38.151	-119.903	74065	121309	54266	112395
dar	Sierras	1575	39.866	-121.201	42442	134727	27133	102780
70550	YOSE	3206	37.931	-119.306	101784	146808	106308	126200
70134	YOSE	3018	37.908	-119.257	103726	145319	111872	126520
70414	YOSE	2471	37.903	-119.428	92243	139529	96617	118745
72403	YOSE	2957	37.909	-119.326	99466	123188	104241	143774
72996	YOSE	3176	37.971	-119.345	102617	148437	103675	129232

Table 3.3. SOCs monitored in tadpole and sediment samples.

	Sample Matrix Monitored		Sample Matrix Monitored
Amide Pesticides		**Thiocarbamate Pesticides**	
Alachlor	Tadpole, Sediment	EPTC	Tadpole
Acetochlor	Tadpole, Sediment	Pebulate	Tadpole
Metolachlor	Tadpole, Sediment	Triallate	Tadpole, Sediment
Propachlor	Tadpole, Sediment	**Triazine Herbicides and Metabolites**	
Organochlorine Pesticides and Metabolites		Atrazine desisopropyl	Tadpole
HCH, gamma	Tadpole, Sediment	Atrazine desethyl	Tadpole
HCH, alpha	Tadpole, Sediment	Atrazine	Tadpole, Sediment
HCH, beta	Tadpole, Sediment	Simazine	Tadpole, Sediment
HCH, delta	Tadpole, Sediment	Cyanazine	Sediment
Methoxychlor	Tadpole, Sediment	Metribuzin	Tadpole, Sediment
Heptachlor	Tadpole, Sediment	**Miscellaneous Pesticides**	
Heptachlor epoxide	Tadpole, Sediment	Etridiazole	Tadpole, Sediment
Hexachlorobenzene	Tadpole, Sediment	Dacthal	Tadpole, Sediment
Endrin	Tadpole, Sediment	Trifluralin	Tadpole, Sediment
Endrin aldehyde	Tadpole, Sediment	**Polycyclic Aromatic Hydrocarbons**	
Chlordane, trans	Tadpole, Sediment	Acenaphthylene	Tadpole, Sediment
Chlordane, cis	Tadpole, Sediment	Acenaphthene	Tadpole, Sediment
Nonachlor, trans	Tadpole, Sediment	Fluorene	Tadpole, Sediment
Nonachlor, cis	Tadpole, Sediment	Anthracene	Tadpole, Sediment
Chlordane, oxy	Tadpole, Sediment	Phenanthrene	Tadpole, Sediment
Dieldrin	Tadpole, Sediment	Pyrene	Tadpole, Sediment
Aldrin	Tadpole, Sediment	Fluoranthene	Tadpole, Sediment
o,p'-DDT	Tadpole, Sediment	Chrysene + Triphenylene	Tadpole, Sediment
o,p'-DDD	Tadpole, Sediment	Benzo(a)anthracene	Tadpole, Sediment
o,p'-DDE	Tadpole, Sediment	Retene	Tadpole, Sediment
p,p'-DDT	Tadpole, Sediment	Benzo(k)fluoranthene	Tadpole, Sediment
p,p'-DDD	Tadpole, Sediment	Benzo(a)pyrene	Tadpole, Sediment
p,p'-DDE	Tadpole, Sediment	Benzo(b)fluoranthene	Tadpole, Sediment
Mirex	Tadpole, Sediment	Benzo(e)pyrene	Tadpole, Sediment
Organochlorine Sulfide Pesticides and Metabolites		Indeno(1,2,3-cd)pyrene	Tadpole, Sediment
Endosulfan I	Tadpole, Sediment	Dibenz(a,h)anthracene	Tadpole, Sediment
Endosulfan II	Tadpole, Sediment	Benzo(ghi)perylene	Tadpole, Sediment
Endosulfan sulfate	Tadpole, Sediment	**Polychlorinated Biphenyls**	
Phosphorothioate Pesticides		PCB 74	Tadpole
Methyl parathion	Tadpole, Sediment	PCB 101	Tadpole, Sediment
Malathion	Tadpole, Sediment	PCB 118	Tadpole, Sediment
Diazinon	Tadpole, Sediment	PCB 153	Tadpole, Sediment
Parathion	Tadpole, Sediment	PCB 138	Tadpole, Sediment
Ethion	Tadpole, Sediment	PCB 187	Tadpole, Sediment
Chlorpyrifos	Tadpole, Sediment	PCB 183	Tadpole, Sediment

Table 3.4. EDLs for tadpole samples from the Cascades, SEKI, Sierras transect, and YOSE on a ng/g dry weight basis.

	Log Kow	Tadpole Estimated Method Detection Limit (ng/g dw)
Amide Pesticides		
Alachlor	2.6	9.0
Acetochlor	3.0	4.6
Metolachlor	3.1	3.5
Propachlor	2.4	3.1
Organochlorines Pesticides and Metabolites		
HCH, gamma	3.8	0.38
HCH, alpha	3.8	0.27
HCH, beta	4.0	1.0
HCH, delta	4.1	0.65
Methoxychlor	4.5	2.1
Heptachlor	5.2	3.5
Heptachlor epoxide	4.6	0.70
Hexachlorobenzene	5.5	0.020
Endrin	5.2	5.8
Endrin aldehyde	4.8	0.71
Chlordane, trans	6.1	0.016
Chlordane, cis	5.9	0.64
Nonachlor, trans	6.1	0.018
Nonachlor, cis	6.1	0.088
Chlordane, oxy	5.5	1.2
Dieldrin	5.5	3.8
Aldrin	6.4	2.3
o,p'-DDT	6.5	3.5
o,p'-DDD	6.1	4.0
o,p'-DDE	5.5	2.5
p,p'-DDT	6.9	4.5
p,p'-DDD	5.9	3.8
p,p'-DDE	6.8	3.7
Mirex	6.9	1.2
Organochlorine Sulfide Pesticides and Metabolites		
Endosulfan I	4.7	0.23
Endosulfan II	4.8	0.11
Endosulfan sulfate	3.7	0.14
Phosphorothioate Pesticides		
Methyl parathion	2.7	4.6
Malathion	2.9	3.8
Diazinon	3.7	1.8
Parathion	3.8	3.3
Ethion	5.1	3.0
Chlorpyrifos	5.1	0.32
Thiocarbamate Pesticides		
EPTC	3.2	10
Pebulate	3.8	2.2
Triallate	4.6	0.56
Triazine Herbicides and Metabolites		
Atrazine desisopropyl	1.4	42
Atrazine desethyl	1.8	5.6
Atrazine	2.3	4.3
Simazine	2.2	12
Metribuzin	1.7	0.64
Miscellaneous Pesticides		
Etridiazole	2.6	9.1
Dacthal	4.3	0.11
Trifluralin	5.3	0.15
Polycyclic Aromatic Hydrocarbons		
Acenaphthylene	3.9	2.3
Acenaphthene	4.0	11
Fluorene	4.2	5.2
Anthracene	4.5	7.6
Phenanthrene	4.5	4.2
Pyrene	5.1	0.48
Fluoranthene	5.2	1.8
Chrysene + Triphenylene	5.7	0.60
Benzo(a)anthracene	5.9	0.98
Retene	6.4	2.3
Benzo(k)fluoranthene	6.5	1.5
Benzo(a)pyrene	6.5	2.8
Benzo(b)fluoranthene	6.6	1.1
Benzo(e)pyrene	6.9	1.9
Indeno(1,2,3-cd)pyrene	6.7	3.1
Dibenz(a,h)anthracene	6.8	2.3
Benzo(ghi)perylene	7.0	1.6
Polychlorinated Biphenyls		
PCB 74	6.3	3.5
PCB 101	6.4	10
PCB 118	7.0	0.34
PCB 153	6.9	0.28
PCB 138	6.7	1.4
PCB 187	7.2	0.046
PCB 183	8.3	0.041
Ave, Min, and Max Recoveries, % RSD		
ave		3.3
max		42
min		0.016

Table 3.5. EDLs for sediment samples from the Cascades, SEKI, Sierras transect, and YOSE on a ng/g dry weight basis.

	Log Koc	Sediment Estimated Method Detection Limit (ng/g dw)		Log Koc	Sediment Estimated Method Detection Limit (ng/g dw)
Amide Pesticides			**Thiocarbamate Pesticides**		
Alachlor	2.3	2.6	Triallate	3.2	0.16
Acetochlor	2.3	11	**Triazine Herbicides and Metabolites**		
Metolachlor	2.5	5.4	Cyanazine	2.1	12
Propachlor	2.5	2.0	Prometon	2.2	7.5
Organochlorines Pesticides and Metabolites			Atrazine	2.4	6.9
HCH, gamma	3.5	0.24	Simazine	2.2	20
HCH, alpha	3.5	0.30	Metribuzin	3.1	0.40
HCH, beta	3.5	0.46	**Miscellaneous Pesticides**		
HCH, delta	3.5	0.64	Etridiazole	2.0	9.4
Methoxychlor	4.6	7.0	Dacthal	2.5	0.027
Heptachlor	4.7	2.8	Trifluralin	4.0	0.024
Heptachlor epoxide	3.7	0.64	**Polycyclic Aromatic Hydrocarbons**		
Hexachlorobenzene	3.5	0.0031	Acenaphthylene	3.8	8.6
Endrin	4.0	2.6	Acenaphthene	3.8	53
Endrin aldehyde	4.0	0.21	Fluorene	4.1	9.7
Chlordane, trans	4.9	0.013	Anthracene	4.3	39
Chlordane, cis	4.9	0.28	Phenanthrene	4.3	20
Nonachlor, trans	5.2	0.037	Pyrene	4.8	0.12
Nonachlor, cis	5.2	0.041	Fluoranthene	4.9	2.7
Chlordane, oxy	3.9	0.39	Chrysene + Triphenylene	5.4	0.67
Dieldrin	4.0	2.8	Benzo(a)anthracene	5.4	1.2
Aldrin	5.0	0.67	Retene	5.2	13
o,p'-DDT	5.4	3.5	Benzo(k)fluoranthene	5.9	3.7
o,p'-DDD	5.2	5.1	Benzo(a)pyrene	5.9	2.5
o,p'-DDE	5.2	2.4	Benzo(b)fluoranthene	5.9	7.0
p,p'-DDT	5.3	3.2	Benzo(e)pyrene	5.9	9.0
p,p'-DDD	5.2	6.7	Indeno(1,2,3-cd)pyrene	6.4	16
p,p'-DDE	5.2	6.7	Dibenz(a,h)anthracene	6.4	6.8
Mirex	5.7	0.12	Benzo(ghi)perylene	6.4	1.3
Organochlorine Sulfide Pesticides and Metabolites			**Polychlorinated Biphenyls**		
Endosulfan I	4.3	0.13	PCB 101	4.9	1.7
Endosulfan II	4.3	0.081	PCB 118	4.9	0.085
Endosulfan sulfate	4.5	0.056	PCB 153	5.1	0.075
Phosphorothioate Pesticides			PCB 138	5.1	0.11
Methyl parathion	2.7	6.4	PCB 187	5.3	0.013
Malathion	1.5	20	PCB 183	5.3	0.032
Diazinon	3.1	3.3	**Ave, Min, and Max Recoveries, % RSD**		
Parathion	3.3	19	ave		5.5
Ethion	4.1	3.6	max		53
Chlorpyrifos	3.8	0.41	min		0.0031

Table3.6. Polycyclic aromatic hydrocarbon (PAH) ratios and corresponding sources. phen = phenanthrene, anth = anthracene, fl = flouranthene, pyr = pyrene, baA = benzo(a)anthracene, chry = chrysene, tri = triphenylene, ip = indeno(1,2,3-cd)pyrene, bghi = benzo(ghi)pyrelene. [1] chry is actually chry+tri because these peaks showed little chromatographic resolution in gas chromatography / mass spectrometry analysis.

	Ratios to determine if source was pyrogenic/petrogenic				Ratios to determine pyrogenic source				
Sediment Sample: site code and date	phen/ anth	fl/pyr	baA/ chry[1]	(phen/ anth) / (fl/pyr)	anth/ anth+ phen	fl/fl+ pyr	baA/ baA+tri+ chry	ip/ip+ bghi	Potential Source
DOM 06JUN05	4.9	1.0	0.57	4.8	0.17	0.51	0.36	0.35	pyrogenic: kerosene/diesel
FRY 28JUL05	5.8	1.1	1.57	5.5	0.15	0.51	0.61	0.64	pyrogenic: diesel/wood
GUM 06JUL05	4.8	1.1	1.62	4.5	0.17	0.52	0.62	0.58	pyrogenic: diesel/wood
GUM 26JUL05	-	1.4	1.72	-	-	0.59	0.63	0.93	pyrogenic: diesel/wood
TNG 12JUL05	6.0	1.0	1.63	5.9	0.14	0.50	0.62	0.52	pyrogenic: diesel/wood

Table3.7. MLR results on a statewide basis.

SOC	explanatory variable	coefficient ± SE	partial p value	r^2	SEest	p value
log dacthal	Intercept	-0.24 ± 0.52	0.65			
	log concentration in sediment	0.20 ± 0.075	0.0083			
	average stage of tadpoles	0.0018 ± 0.015	0.91			
	percent lipid	0.45 ± 0.17	0.0084			
	distance from dacthal application (km)	-0.0025 ± 0.0010	0.014	0.34	0.53	<0.0001
log chlorpyrifos	Intercept	0.10 ± 0.49	0.83			
	log concentration in sediment	-0.15 ± 0.20	0.44			
	average stage of tadpoles	-0.019 ± 0.017	0.29			
	percent lipid	-0.060 ± 0.19	0.76			
	distance from chlorpyrifos application (km)	0.0000 ± 0.0022	1.0	0.10	0.45	0.53
log endosulfan II	Intercept	0.087 ± 0.47	0.85			
	log concentration in sediment	0.22 ± 0.082	0.009			
	average stage of tadpoles	-0.016 ± 0.014	0.26			
	percent lipid	0.016 ± 0.15	0.92			
	distance from endosulfan application (km)	-0.0018 ± 0.0011	0.085	0.20	0.55	0.0002
log endosulfan sulfate	Intercept	-0.021 ± 0.44	0.96			
	log concentration in sediment	0.39 ± 0.096	0.0001			
	average stage of tadpoles	0.0022 ± 0.013	0.86			
	percent lipid	0.18 ± 0.14	0.20			
	distance from endosulfan application (km)	-0.0034 ± 0.0010	0.0009	0.43	0.49	<0.0001
log total endosulfans	Intercept	0.30 ± 0.30	0.33			
	log concentration in sediment	0.28 ± 0.063	<0.0001			
	average stage of tadpoles	0.0008 ± 0.0085	0.93			
	percent lipid	0.12 ± 0.093	0.21			
	distance from endosulfan application (km)	-0.0030 ± 0.0007	<0.0001	0.50	0.34	<0.0001
log trans-chlordane	Intercept	-2.2 ± 0.71	0.0025			
	log concentration in sediment	0.25 ± 0.13	0.067			
	average stage of tadpoles	0.032 ± 0.021	0.14			
	percent lipid	0.35 ± 0.23	0.13			
	distance from Central Valley (km)	-0.0023 ± 0.0055	0.68	0.16	0.75	0.012
log trans-nonachlor	Intercept	-0.27 ± 0.63	0.0005			
	log concentration in sediment	0.50 ± 0.14	0.0003			
	average stage of tadpoles	0.037 ± 0.019	0.059			
	percent lipid	0.073 ± 0.20	0.72			
	distance from Central Valley (km)	-0.0038 ± 0.0049	0.45	0.19	0.77	<0.0001
log cis-nonachlor	Intercept	-0.95 ± 0.34	0.0064			
	log concentration in sediment	0.25 ± 0.074	0.0009			
	average stage of tadpoles	-0.0056 ± 0.011	0.61			
	percent lipid	0.23 ± 0.12	0.051			
	distance from Central Valley (km)	-0.0003 ± 0.0028	0.92	0.15	0.44	0.0037
log total chlordanes	Intercept	-1.7 ± 0.41	0.0001			
	log concentration in sediment	0.38 ± 0.099	0.0002			
	average stage of tadpoles	0.028 ± 0.013	0.028			
	percent lipid	0.091 ± 0.14	0.52			
	distance from Central Valley (km)	-0.0020 ± 0.0035	0.57	0.23	0.53	<0.0001
log p,p'-dde	Intercept	0.16 ± 0.23	0.47			
	log concentration in sediment	0.36 ± 0.061	<0.0001			
	average stage of tadpoles	-0.0064 ± 0.0072	0.37			

	percent lipid	0.090 ± 0.078	0.25			
	distance from Central Valley (km)	0.0002 ± 0.0019	0.92	0.27	0.29	<0.0001
log PCB 153	Intercept	-0.22 ± 0.32	0.50			
	log concentration in sediment	0.13 ± 0.080	0.11			
	average stage of tadpoles	-0.0085± 0.0092	0.36			
	percent lipid	0.031 ± 0.085	0.71			
	distance from Central Valley (km)	-0.0030 ± 0.0022	0.17	0.11	0.28	0.12
log PCB 187	Intercept	-1.1 ± 0.30	0.0007			
	log concentration in sediment	0.11 ± 0.086	0.23			
	average stage of tadpoles	-0.0037 ± 0.0092	0.69			
	percent lipid	0.15 ± 0.098	0.14			
	distance from Central Valley (km)	-0.0022 ± 0.0024	0.37	0.054	0.37	0.26

Table3.8. BSAFs for tadpoles from California and comparison to median BSAFs for fish collected throughout the US (Wong et al. 2001). All values were calculated as the ratio of the tadpoles SOC concentration to the sediment SOC concentration ± standard deviation. If noted with a * the value is the slope of the regression line for sediment SOC concentration versus tadpole SOC concentration (standard error of the slope).

		Region	Cascades	Cascades	Sierras	YOSE	SEKI	All	All	Fish BSAFs from Wong et al. 2001
		Species	*Pseudacris regilla (PR)*	*Rana cascadae*	*PR*	*PR*	*PR*	*PR*	*PR*	median from 7 benthic fish and 5 pelagic fish sampled at 485 sites throughout the US
SOC	dacthal	BSAFdryweight	7.3 (±13.0)	9.9 (±17.7)		11.5 (±24.3)	3.9 (±14.0)	6.6 (±22.6)	0.14 (0.029)*	
		BSAFlipid	79.4 (±133)	110 (±167)		139 (±272)	82.3 (±266)	221 (±895)	3.8 (0.68)*	0.1
	chlorpyrifos	BSAFdryweight	1.6 (±1.6)	1.0 (±0.53)			0.65 (±0.93)	1.3 (±1.6)	-0.039 (0.10)*	
		BSAFlipid	42.8 (±67.0)	21.3 (±17.2)			43.8 (±59.0)	69.9 (±200)	0.10 (22.9)*	
	endosulfan I	BSAFdryweight					1.9 (±3.7)			
		BSAFlipid					41.6 (±89.9)			
	endosulfan II	BSAFdryweight	2.0 (±3.5)				1.4 (±3.2)	1.6 (±3.5)	0.033 (0.0098)*	
		BSAFlipid	31.7 (±64.5)				40.7 (±119)	44.9 (±121)	0.74 (0.39)*	
	endosulfan sulfate	BSAFdryweight	0.27 (±0.35)	0.52 (±0.49)	0.24 (±0.23)	0.82 (±0.46)	0.27 (±0.28)	0.29 (±0.33)	0.041 (0.0065)*	
		BSAFlipid	5.4 (±10.7)	6.9 (±6.5)	59.6 (±95.1)	18.7 (±14.4)	5.4 (±5.1)	11.2 (±33.2)	0.77 (0.45)*	
	trans-chlordane	BSAFdryweight		0.76 (±2.5)		4.6 (±9.6)	2.3 (±5.7)	1.6 (±4.8)	0.051 (0.033)*	
		BSAFlipid		10.6 (±33)		54.8 (±108)	39.8 (±116)	28.6 (±90.1)	1.0 (0.47)*	1.1
	trans-nonachlor	BSAFdryweight				0.33 (±0.44)	0.63 (±1.6)	0.37 (±1.2)	0.057 (0.014)*	
		BSAFlipid				3.9 (±14.0)	13.3 (±45.7)	8.6 (±33.7)	1.1 (0.27)*	4.5
	cis-nonachlor	BSAFdryweight					0.28 (±0.74)	0.51 (±1.3)	0.043 (0.013)*	
		BSAFlipid					4.3 (±7.2)	14.7 (±47.1)	0.57 (0.30)*	2.1
	p,p'-DDE	BSAFdryweight				0.41 (±0.38)	0.17 (±0.23)	0.28 (±0.37)	0.064 (0.0072)*	
		BSAFlipid				7.1 (±3.6)	6.5 (±19.6)	11.5 (±26.3)	15.0 (2.3)*	8.6
	PCB153	BSAFdryweight					0.44 (±0.48)	0.61 (±0.88)	0.062 (0.031)*	
		BSAFlipid					9.0 (±11.9)	31.8 (±96.8)	-0.58 (2.1)*	
	PCB187	BSAFdryweight	0.79 (±2.3)	0.55 (±1.0)		0.41 (±0.47)	0.33 (±0.63)	0.48 (±1.5)	0.057 (0.024)*	
		BSAFlipid	19.3 (±69.0)	11.6 (±30.2)		6.0 (±4.6)	7.4 (±11.6)	18.9 (±77.9)	2.7 (1.1)*	

66

Endosulfan I and Endosulfan Sulfate are Developmentally Toxic to Zebrafish

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4. Endosulfan I and Endosulfan Sulfate are Developmentally Toxic to Zebrafish

4.1 Abstract

Fish in agricultural and remote areas may be exposed to endosulfan and its degradation products as a result of direct runoff, atmospheric transport and deposition. The following study used the zebrafish developmental model to investigate the adverse effects of endosulfan I and endosulfan sulfate, the major degradation product of endosulfan I and II. Embryos were dechorionated and waterborne exposed to the endosulfans from 6 to 120 hours post fertilization (hpf). Endosulfan I exposure concentrations ranged from 0.01 to 10 µg/L and endosulfan sulfate from 1 to 100 µg/L. Water solutions were renewed every 24 hours and fish were scored for overt developmental and behavioral abnormalities. Chemical analysis was performed on water samples, whole embryo and larvae samples to determine exposure concentrations and tissue concentrations throughout the 5 day exposure period. The most sensitive toxicity endpoint for both endosulfan I and endosulfan sulfate was an abnormal response of the embryo/larvae to touch, suggesting that endosulfan I and sulfate are developmental neurotoxins. The touch response EC_{50}s for endosulfan I and endosulfan sulfate were 2.2 µg/L and 23 µg/L, respectively. The endosulfans were highly concentrated by the organisms, the tissue EC_{50}, determined from the measured tissue concentrations, was 367 ng/g for endosulfan I and 4552 ng/g for endosulfan sulfate.

4.2 Introduction

Endosulfan (6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,3,4-benzodioxathiepin-3-oxide) is a cyclodiene insecticide currently used in many countries throughout the world. It is applied as a technical mixture of the I (α) and II (β) isomers in the ratios of 2:1 to 7:3 on a wide variety of crops [1]. It may enter the environment surrounding agricultural areas as a result of atmospheric transport and field runoff with concentrations ranging in the low part per billion measured in streams and rivers bordering these areas [1-3]. Endosulfans have also been measured in fish from remote lakes throughout the U.S., Canada, and Europe where atmospheric transport and deposition accounts for its presence [4-11]. Upon entering the environment endosulfan I and II are primarily converted to the diol form in water and the sulfate form in soil and sediment [2]. The endosulfan sulfate and diol further break down to the ether, hydroxyl ether, lactone, and alcohol forms [2]. Endosulfan sulfate is the only breakdown product considered to be toxic [12]. The half lives of endosulfan I and II in water are on the order of days to months, whereas endosulfan sulfate is on the order of weeks to years [1, 13]. In sediment, both forms are more persistent [1, 13]. Although fish tissue half-lives are on the order of days, potential exists for aquatic organisms to be impacted by endosulfan exposure, especially in agricultural areas where organisms are exposed to the highest environmental levels of endosulfan [2, 3, 14].

Endosulfan I and II are highly toxic to aquatic organisms, including fish. In laboratory studies, fish LC_{50}s in the range of 1 to 100 μg/L for endosulfan I, II, and the technical product have been reported [2, 15]. In some fish species, endosulfan I is more toxic than endosulfan II and the technical product [1, 16]. Based on acute studies, endosulfan sulfate appears to be as toxic as the parent isomers [13]. However, its toxicity is not well-characterized.

Endosulfan I and II are neurotoxic, thought to act through inhibition of the gamma-aminobutyric acid (GABA)-gated chloride channels [17, 18] and endosulfan inhibits ATPases [14, 19]. Symptoms of neurotoxicity, including hyperactivity, erratic swimming, and convulsions, have been reported in adult fish [15]. Development is a particularly sensitive life stage, and fish are more vulnerable to the adverse effects of chemicals during this period [20, 21]. Only one study, conducted in rodents, has investigated the developmental neurotoxicity of endosulfan and reported possible neurotoxic effects as a result of alterations in brain measurements in developing pups of rats exposed to 400 ppm endosulfan during pregnancy [22].

Zebrafish (*Danio rerio*) are a model organism [23] and are useful for studying developmental toxicity because of their quick time to complete organogenesis, which is largely complete by 48 hours post fertilization (hpf) [24]. Other benefits of using zebrafish in developmental studies include their transparency during early development, allowing for direct viewing of toxicological endpoints, large clutch sizes and their small size which reduces the supplies required and costs required to conduct experiments [25]. The sequencing of the zebrafish genome is nearly complete and thus it is a particularly useful tool to study the mechanisms of developmental processes and how toxicants interfere with these processes [23, 25].

Relatively few studies have investigated the toxicity of endosulfan sulfate despite its environmental persistence. In particular, information gaps exist regarding the potential developmental or developmental neutoxicity of endosulfan. Endosulfan I was chosen in this study because it has been reported in some cases to be more toxic than endosulfan II. The objectives of this study were to determine if early zebrafish life stages were sensitive to endosulfan I or endosulfan sulfate, to determine the most sensitive endpoint of toxicity, and to define the relative developmental toxicity of endosulfan sulfate to endosulfan I.

4.3 Materials and methods

4.3.1 Fish care and husbandry

Adult zebrafish wild-type (*Danio rerio*) of the strains AB and 5D Tropical (5D) were reared at the Sinnhuber Aquatic Research Laboratory (SARL) at Oregon State University. Fish were housed in 2.0 L polycarbonate tanks filled with reverse osmosis (RO) treated water (containing 0.6% instant ocean (Aquarium Systems, Inc., Mentor, Ohio)) in a recirculating system. The water temperature was held at 28 °C (±1 °C), with a pH of 7.2 (±0.2), and the fish were kept on a 14 hour light / 10 hour dark photoperiod. Fish were group spawned and embryos were collected at 2 to 3 hours post fertilization (hpf) and rinsed with water. They were dechorionated in a glass petri dish at 5 hpf using pronase (50 mg/ ml), rinsed thoroughly with water, and allowed to recover 0.5 to 1 hour before they were placed into exposure solutions. Extensive comparative studies were completed between the AB and 5D and there were no significant differences in the dose response to endosulfan I and endosulfan sulfate (data not shown).

4.3.2 Waterborne exposures

Endosulfan I (99.5%) and sulfate (98.9%) were purchased from ChemService (West Chester, PA). A master stock solution of each chemical was prepared by dissolving the crystalline solids into ethyl acetate to obtain a concentration of 1 mg/ml. The solutions were stored at 4 °C. A stock solution in DMSO was prepared for each experiment by reducing the ethyl acetate solution to dryness and immediately adding DMSO to the vial. Using the DMSO stocks a serial dilution was prepared to obtain endosulfan I and endosulfan sulfate DMSO solutions of varying concentrations. One microliter of the solution was added to each 999 µl of water for a final percentage of DMSO in the water solutions of 0.1 %. Experiments were conducted in 96-well styrene divinylbenzene plates, with 100 µL of exposure solution and one organism per well. Zebrafish embryos were staged using the methods described in Kimmel et al. 1995 [24] and exposed to the chemicals from 6 hpf to 120 hpf. Exposure solutions were renewed with freshly prepared water solutions at 24, 48, 72, and 96 hpf.

4.3.3 Range finding experiments

Experiments were conducted to determine the waterborne concentration that produced mortality in 50 % of the embryos (LC_{50}) and to determine the embryonic response most sensitive to endosulfan I and endosulfan sulfate using a large range of concentrations. Concentrations between 0.01 and 1000 µg/L were tested for endosulfan I and between 1 and 10,000 µg/L were tested for endosulfan sulfate. The results from these experiments were used to determine a dose response curve for the most sensitive endpoint, neurotoxicity, of endosulfan I and endosulfan sulfate exposure in the embryos and larvae. Once an appropriate range for the dose response curve was determined the experiment was repeated on three separate occasions. Final nominal concentrations were 0.01, 0.1, 0.5, 1, 5, and 10 μg/L for endosulfan I and 1, 10, 20, 40, 80, and 100 μg/L for endosulfan sulfate.

4.3.4 Abnormality scoring and behavioral scoring system

Embryos and larvae were scored for developmental abnormalities at 24, 48, 72, 96, and 120 hpf. Behavioral abnormalities were scored at 48, 72, 96, and 120 hpf by using a touch response scoring system, which was developed during the initial range finding experiments. The touch response was conducted by touching a thin needle head to the tip of the tail of the embryo or larvae and the resulting behavior of the zebrafish was recorded using a score of 1 through 5. The behaviors associated with each score are detailed in Table 4.1.

4.3.5 Chemical analysis

All solvents used in analysis were of Optima grade (Fisher Scientific, Pittsburgh, PA). Water samples and embryo and larvae tissue samples were analyzed using isotope dilution gas chromatography (GC) / mass spectrometry (MS). In order to determine the average concentrations of endosulfan I and endosulfan sulfate in the organisms over the course of the 5-day, static renewal (every 24 hours) exposure, a time course study was designed and fish were exposed in groups of 12-24, repeated in triplicate, in individual wells of a 24-well styrene divinylbenzene plate. The total amount of endosulfan I and sulfate exposure was kept consistent with the dose response studies by adding/ renewing exposure solutions such that 100 μl of solution was added per embryo/larvae.

The water and tissue extraction procedures were based on the method developed by Isaacson et al. 2007 [26]. The recovery of the water and tissue method were determined by adding a known concentration of endosulfan I and endosulfan sulfate (10 ng) to the samples (triplicate) and then the samples were extracted and analyzed as follows. Water samples were collected (0.5 ml) and added to a 2.0 ml centrifuge tube. Embryos and larvae were rinsed thoroughly with water and anesthetized with tricaine amide methylsulfonate. Next fish were added to a pre-weighed 2.0 ml centrifuge tube (approximately 12 to 24 organisms pooled per sample), all water was removed with a 10 µl pipette, and the tube was reweighed (Mettler B6 Analytical Balance, Hightstown, NJ). Both water and tissue samples were stored at -20 °C until analysis. Samples were thawed and spiked with 5 µl of isotopically labeled surrogate standards. In the case of water samples, 0.5 ml of hexane was added to each sample. In the case of embryo and larvae samples, 0.1 ml of glacial acetic acid was added to each sample, the tube was vortexed for 30 seconds, 0.25 ml of ethyl acetate and 0.25ml of hexane was added to the sample. The water and fish samples were vortexed for 1 minute and centrifuged for 10 min at 14,000 rpm. One half of the top layer of solvent (0.25 ml) was removed and added to a 2.0 ml amber glass GC vial. The samples were solvent exchanged to ethyl acetate by reducing the solvent under a steady stream of nitrogen gas to approximately 0.1 ml and adding 10 times the amount of ethyl acetate and this was repeated 3 times. The samples were then reduced to 95 µl, spiked with 5 µl of internal standards and run on an Agilent 6890 gas chromatograph coupled to an Agilent 5973N mass selective detector in electron capture negative ionization mode using selected ion monitoring (SIM). The GC / MS temperature method and SIM details are reported elsewhere [27]. In the case of the triplicate spike and recovery experiment both isotopically labeled surrogates and internal standards were added to the sample just prior to instrumental analysis to determine the loss of endosulfan I and endosulfan sulfate over the method.

4.3.6 Statistical analysis

A one-way ANOVA was performed in S-PLUS (version 8.0) to determine if there was a significant relationship between the dose and the response. Linear regression, using indicator variables for endosulfan I and endosulfan sulfate, was used to determine if there was a significant difference between the dose response curves of the two compounds (log-log transformed) (S-PLUS). Sigmoidal regression analysis was performed for endosulfan I and endosulfan sulfate dose response curves using sigmastat (version 8.0) and the resulting equation for the curve was used to calculate the EC_{50}. Fisher's exact test was used to determine if there was a significant difference between the exposure groups and the control (S-PLUS). For all analyses, a p-value ≤ 0.05 was considered significant.

4.4 Results

4.4.1 Abnormal touch response is the most sensitive endpoint following endosulfan I and endosulfan sulfate exposure

Endosulfan I and endosulfan sulfate, even at relatively high concentrations did not produce visible or overt toxicity. No physical abnormalities were observed in larvae exposed to nominal concentrations of 5 µg/L or less of endosulfan I. Pericardial and yolk sac edema was observed in less than 20 % of larvae exposed to endosulfan I concentrations of 10 µg/L at 120 hpf. At the highest concentrations tested, 100 and 1000 µg/L, pericardial and yolk sac edema was visible in at least 80 % of larvae, a curved body axis in at least 40 % of larvae, and a wavy notochord in at least 66 % of larvae. Larvae exposed to the highest concentrations of endosulfan I also showed a less sensitive response to touch, reduced movement, and in some cases paralysis. No physical abnormalities were observed in larvae exposed to nominal concentrations of 40 µg/L or less of endouslfan sulfate at 120 hpf. Pericardial and yolk sac edema were observed in 20 to 50 % of larvae exposed to 80 and 100 µg/L and 80 to 100 % of larvae exposed to 1000 and 10000 µg/L of endosulfan sulfate (the highest concentrations tested). A curved body axis was visible in 33 to 80 % of larvae exposed to the highest concentrations of endosulfan sulfate and in 33 to 60 % of larvae wavy notochords were also apparent. Like larvae exposed to the highest concentrations of endosulfan I, those exposed to the highest concentrations of endosulfan sulfate showed a less sensitive response to touch, reduced movement, and in some cases paralysis. Mortality occurred in less than 20 % of the larvae exposed to the highest concentrations of endosulfan I and endosulfan sulfate.

Preliminary range finding experiments indicated that endosulfan I and endosulfan sulfate induced abnormal behavior and reduced touch response in larval zebrafish. The abnormal touch response was the most sensitive toxicity endpoint, that is, it is the response that was observed at the earliest developmental time point and at the lowest concentration, in zebrafish exposed to endosulfan I or endosulfan sulfate. Further dose response tests more accurately determined the nominal exposure concentration and time point at which the abnormal touch response were produced (Figure 4.1). An abnormal touch response was recorded in 100% of tested individuals exposed to a nominal concentration of 5 μg/L of endosulfan I and 40 μg/L of endosulfan sulfate at 72 hpf and there were no overt developmental abnormalities in the larvae from these exposure groups through 120 hpf (Figure 4.2). The dose was significantly related to the abnormal touch response and the y-intercepts for endosulfan I and endosulfan sulfate curves were significantly different. The average abnormal touch response EC_{50} for endosulfan I and endosulfan sulfate were determined to be 2.2 ± 1.8 (standard deviation) and 23 ± 5.8, respectively (Figure 4.1). The no observable adverse effect concentration (NOAEC), determined from the highest concentration not significantly different from the control, was 0.5 μg/L for endosulfan I and 1 μg/L for endosulfan sulfate (Figure 4.1). The lowest observable adverse effect concentration (LOAEC), determined from the lowest concentration significantly different from the control, was 1 μg/L for endosulfan I and 10 μg/L for endosulfan sulfate (Figure 4.1). Observed abnormal behaviors included prolonged swimming and disoriented, spastic swimming behavior and in a few cases a slower response and shorter distance swam in response to touch (Figure 4.3). Endosulfan I and endosulfan sulfate showed the same progression of abnormal behaviors at the highest concentrations tested (100 and 1000 μg/L of endosulfan I and 1000 and 10,000 μg/L of endosulfan sulfate), that is, fish first exhibited symptoms with a score of 2 followed by more severe symptoms with a score of 3, 4, and 5 as time progressed.

4.4.2 Concentrations of endouslfan I and endosulfan sulfate in exposure water and zebrafish tissue

The analytical methods for measuring endosulfan I and endosulfan sulfate in water and tissue showed good accuracy and precision as determined by the average recovery and relative standard deviation (RSD) from the triplicate spike and recovery experiment. Spiked water samples had an average recovery of 87 % (± 2.3 RSD) for endosulfan I and 105 % (± 3.6) and fish samples had an average recovery of 91 % (± 7.8) for endosulfan I and 56 % (± 3.0) for endosulfan sulfate.

The endosulfan I and endosulfan sulfate water exposure solutions were measured 3 times over the course of the 5 day exposure by collecting water samples immediately following their preparation (0hpf, 48hpf, and 96hpf). The measured concentrations for the nominally prepared exposure concentrations of 0.1 µg/L, 2µg/L, and 10 µg/L endosulfan I were 0.12 µg/L (± 0.044 standard deviation), 1.7 µg/L (± 0.75), and 7.0 µg/L (± 4.0). The measured concentrations for the nominally prepared exposure concentrations of 1 µg/L, 20µg/L, and 40 µg/L endosulfan sulfate were 1.6 µg/L (± 0.60), 18 µg/L (± 7.3), and 51 µg/L (± 19).

The embryos and larvae accumulated high concentrations of endosulfan I and endosulfan sulfate 30 to 5300 and 7 to 160 times the exposure concentrations, respectively, over the course of the 5 day exposure (Figure 4.4). The concentrations appeared to stabilize in water and fish by 120 hpf (Figures 4.4 and 4.5), and thus the BCF for endosulfan I was calculated to be 94 (± 9.9) and for endosulfan sulfate was 69 (± 5.4). The estimated EC_{50} for abnormal touch response in larvae (72 hpf), determined from the measured tissue concentrations, was 370 (± 54.6) for endosulfan I and 4600 (± 1300) ng/g wet weight (w.w.) for endosulfan sulfate. The estimated NOAEC, determined from the measured tissue concentrations in the low exposure groups, was 38 (± 5.2) for endosulfan I and 210 (± 60) ng/g w.w. for endosulfan sulfate. The embryos at 36 hpf and larvae at 72 hpf and 120 hpf appear to be capable of metabolizing endosulfan I. Endosulfan II was measured in fish exposed to 7.0 µg/L at 36 hpf, in fish exposed to 1.7 and 7.0 µg/L at 72 hpf and in fish exposed to 7.0 µg/L at 120 hpf (Figure 4.6). Endosulfan sulfate was measured in fish exposed to 1.7 µg/L at 72 hpf and fish exposed to 1.7 and 7.0 µg/L at 120 hpf (Figure 4.6). Endosulfan I concentrations were less than exposure water concentrations at all time points in wells with and without fish (Figure 4.5). Endosulfan sulfate concentrations in the wells with and without the zebrafish present were lower than the exposure water concentrations during the first 72 hpf of the endosulfan sulfate experiment (Figure 4.5). The concentrations in the water appeared to stabilize by 120 hpf and reach concentrations closer to exposure water concentrations (Figure 4.5). In addition to uptake by the organisms, some of the loss of endosulfan I and sulfate in the water may be attributed to loss by sorption to the polypropylene wells and/or hydrolysis [26, 28]. The stabilization of the endosulfan I and endosulfan sulfate concentrations in exposure wells with fish by 120 hpf may be due to equilibrium being achieved between the fish concentrations and the water concentrations (Figures 4.4 and 4.5).

4.5 Discussion

These studies were aimed at determining if endosulfan I and II were developmentally toxic to zebrafish. The results indicate that neurotoxicity is the most sensitive endpoint as indicated from the abnormal touch response resulting from endosulfan I and endosulfan sulfate exposure. This is the first study, to our knowledge, to investigate developmental neurotoxicity of these compounds in fish. Behavioral abnormalities, associated with neurotoxicity, resulting from endosulfan I and sulfate included extended periods of swimming and spastic behavior at the lower concentrations and reduced motility and paralysis at the highest concentrations tested.

Adult zebrafish exposed to endosulfan have been reported have an LC_{50} of 1.6 μg/L comparable to the LC_{50}s observed in other fish species used for toxicity testing which range from 0.8 μg/L for rainbow trout (*Oncorhychus mykiss*) to 1.7 μg/L for the bluegill sunfish (*Lepomis macrochirus*) [15, 29]. At the highest concentrations tested in this study, 1000 μg/L of endosulfan I and 10,000 μg/L of endosulfan sulfate, some larvae were paralyzed as a result of exposure. However, the occurrence of mortality was low. The lack of mortality in the developing zebrafish is likely due to the ability of the developing zebrafish to obtain oxygen through cutaneous respiration [30] even after paralysis results in the prevention of gill respiration.

Endosulfan, like other cyclodiene insecticides, has been reported to cause neurotoxicity through GABA-gated chloride channel inhibition [14, 17, 18].

Inhibition of these channels results in excitation because the neuron is not able to repolarize [18]. Associated symptoms of neurotoxicity include convulsions and eventual paralysis. Studies in rats have shown that endosulfan I and II inhibit the influx of chloride and GABA-induced chloride influx across rat brain membranes, with endosulfan I being a more potent inhibitor than endosulfan II [31, 32]. A mutation in GABA receptor subunits has been shown to provide resistance to endosulfan toxicity in insects [33].

Although GABA-gated inhibition has been widely suggested as the molecular endpoints underlying endosulfan neurotoxicity, the molecular mechanism has yet to be confirmed. This work provides a basis to begin investigations to elucidate the mechanism of endosulfan I and endosulfan sulfate neurotoxicity in developing zebrafish.

Endosulfan I is 10 times more toxic than endosulfan sulfate to zebrafish. For endosulfan I the BCF was calculated to be 94 (± 9.9) and for endosulfan sulfate was calculated to be 69 (± 5.4). In comparison to the BCF for the technical mixture of endosulfan in adult zebrafish, 2650 [34], the measured BCF for endosulfan I and endosulfan sulfate is low, this may be a result of less uptake from the gills in developing zebrafish, as little is known about the time of gill development in zebrafish [30, 35].

Developing zebrafish appear to have the ability to metabolize endosulfan I to endosulfan II beginning at 36 hpf and to endosulfan sulfate beginning at 72 hpf (Figure 4.6). The sulfate is formed through oxidation by Phase I cytochrome P450s [36], thus these systems may be inducible in larvae. In humans this conversion has been reported to occur via enzyme isoforms CYP3A4 and CYP2B6 [36]. Developing organisms have large numbers of P450s [37, 38]. In zebrafish it has been reported that CYP1A1 is present in developing zebrafish as early as 36 hpf [39], consistent with our findings that some metabolism of endosulfan I is occurring at 36 hpf.

Total endosulfan (I, II, and sulfate) concentrations in fish from agricultural areas have been measured up to 310 ng/g w.w. and in remote areas concentrations <

10 ng/g w.w. have been measured [4, 40]. The tissue NOAEC and EC_{50} for developmental toxicity for endosulfan I is within the range measured in fish from agricultural areas and, at a minimum, 4 (NOAEC) and 37 (EC_{50}) times higher than concentrations measured in remote ecosystems. The tissue NOAEC for endosulfan sulfate is within the range measured in fish from agricultural areas and 20 times higher than measured concentrations in fish from remote ecosystems. The EC_{50} for endosulfan sulfate is, at a minimum 15 times higher than fish tissue concentrations measured in agricultural areas and 450 times higher than measured concentrations in fish from remote ecosystems. The endosulfan I NOAEC and EC_{50} and the endosulfan sulfate NOAEC in this study are within the range of endosulfan concentrations measured in fish from agricultural areas. Thus, there is the potential for behavioral effects to result from exposure to endosulfan in the environment. Endosulfan I and endosulfan sulfate exposure cause the same behavioral abnormalities in developing zebrafish. In addition, it has been reported that synergistic effects occur as a result of exposure to endosulfan I + II + sulfate [1]. Therefore, the potential synergistic behavioral effects (potential neurotoxic) of endosulfan I + II + sulfate should be considered when assessing risk to organisms.

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4.7 References

[1] Wan MT, Kuo J-n, Buday C, Schroeder G, Aggelen GV, Pasternak J. 2005. Toxicity of *alpha-, beta-, and (alpha + beta)*-endosulfan and their formulated and degredation products to Daphnia magna, Hyalella azteca, Oncorhynchus mykiss, Oncorhynchus kisutch, and biological implications in streams. *Environ Toxicol Chem* 24:1146-1154.

[2] Hose GC, Lim RP, Hyne RV. 2003. The transport, fate and effects of endosulfan in the Australian freshwater environment. *Australasian Journal of Ecotoxicology* 9:101-111.
[3] Wan MT, Kuo J-n, Pasternak J. 2005. Residues of Endosulfan and Other Selected Organochlorine Pesticides in Farm Areas of the Lower Fraser Valley, British Columbia, Canada. *J Environ Qual* 34:1186-1193.
[4] Ackerman LK, Schwindt AR, Massey Simonich SL, Koch DC, Blett TF, Schreck CB, Kent ML, Landers DH. 2008. Atmospherically deposited PBDEs, pesticides, PCBs, and PAHs in Western U.S. National Park fish: Concentrations and consumption guidelines. *Environ Sci Technol* 42:2334-2341.
[5] Carrera G, Fernandez P, Grimalt JO, Ventura M, Camarero L, Catalan J, Nickus U, Thies H, Psenner R. 2002. Atmospheric deposition of organochlorine compounds to remote high mountain lakes of Europe. *Environ Sci Technol* 36:2581-2588.
[6] LeNoir JS, McConnell LL, Fellers GM, Cahill TM, Seiber JN. 1999. Summertime transport of current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. *Environmental Toxicology and Chemistry* 18:2715-2722.
[7] McConnell LL, LeNoir JS, Datta S, Seiber JN. 1998. Wet deposition of current-use pesticides in the Sierra Nevada Mountain Range, California, USA. *Environmental Toxicology and Chemistry* 17:1908-1916.
[8] Simonich S, Hites R. 1995. Global distribution of persistent organochlorine compounds. *Science* 269:1851-1854.
[9] Usenko S, Landers DH, Appleby PG, Simonich SL. 2007. Current and historical deposition of PBDEs, pesticides, PCBs, and PAHs to Rocky Mountain National Park. *Environ Sci Technol* 41:7235-7241.
[10] Vilanova R, Fernandez P, Martinez C, Grimalt JO. 2001. Organochlorine Pollutants in Remote Mountain Lake Waters. *J Environ Qual* 30:1286-1295.
[11] Stern GA, Braekevelt E, Helm PA, Bidleman TF, Outridge PM, Lockhart WL, McNeeley R, Rosenberg B, Ikonomou MG, Hamilton P, Tomy GT, Wilkinson P. 2005. Modern and historical fluxes of halogenated organic contaminants to a lake in the Canadian arctic, as determined from annually laminated sediment cores. *Sci Total Environ* 342:223-243.
[12] Berntssen MHG, Glover CN, Robb DHF, Jakobsen J-V, Petri D. 2008. Accumulation and elimination kinetics of dietary endosulfan in Atlantic salmon (Salmo salar). *Aquatic Toxicology* 86:104-111.
[13] Leonard AW, Hyne RV, Lim RP, Leigh KA, Le J, Beckett R. 2001. Fate and Toxicity of Endosulfan in Namoi River Water and Bottom Sediment. *J Environ Qual* 30:750-759.
[14] Naqvi SM, Vaishnavi C. 1993. Bioaccumulative potential and toxicity of endosulfan insecticide to non-target animals. *Comp Biochem Physiol* 105C:347-361.
[15] Jonsson CM, Toledo MCF. 1993. Acute toxicity of endosulfan to the fish *Hyphessobrycon bifasciatus* and *Brachydanio rerio*. *Archives of Environmental Contamination and Toxicology* 24:151-155.

[16] Devi AP, Rato DMR, Tilak KS, Murty AS. 1981. Relative toxicity of the technical grade material, isomers, and formulations of endosulfan to the fishChanna punctata. *Bulletin of Environmental Contamination and Toxicology* 27:239-243.
[17] ATSDR. 2000. Toxicological Profile for Endosulfan. 2007. Retrieved 6/11/2007 from, http://www.atsdr.cdc.gov/toxprofiles/tp41.html
[18] Jia Z, Misra HP. 2007. Developmental exposure to pesticides zineb and/or endosulfan renders the nigrostriatal dopamine system more susceptible to these environmental chemicals later in life. *NeuroToxicology* 28:727-735.
[19] Glover CN, Petri D, Tollefsen K-E, Jorum N, Handy RD, Berntssen MHG. 2007. Assessing the sensitivity of Atlantic salmon (Salmo salar) to dietary endosulfan exposure using tissue biochemistry and histology. *Aquatic Toxicology* 84:346-355.
[20] Rosenthal H. 1976. Sublethal effects of environmental stressors, natural and pollution, on marine fish eggs and larvae. *J Fish Res Board Can* 33:2047-2065.
[21] Lele Z, Krone PH. 1996. The zebrafish as a model system in developmental, toxicological and transgenic research. *Biotechnology Advances* 14:57-72.
[22] EPA. 2007. Summary of "A Developmental Neurotoxicity Study with Technical Grade Endosulfan in Wistar Rats" by Gilmore et al. 2006 Bayer CropScience.
[23] Spitsbergen JM, Kent ML. 2003. The State of the Art of the Zebrafish Model for Toxicology and Toxicologic Pathology Research--Advantages and Current Limitations. *Toxicol Pathol* 31:62-87.
[24] Kimmel C.B. B, W.W., Kimmel, S.R., Ullmann, B., Schilling, T.F. 1995. Stages of embryonic development of the zebrafish. *Developmental Dynamics* 203:253-310.
[25] Hill AJ, Teraoka H, Heideman W, Peterson RE. 2005. Zebrafish as a Model Vertebrate for Investigating Chemical Toxicity. *Toxicol Sci* 86:6-19.
[26] Isaacson CW, Usenko CY, Tanguay RL, Field JA. 2007. Quantification of Fullerenes by LC/ESI-MS and Its Application to in Vivo Toxicity Assays. *Anal Chem* 79:9091-9097.
[27] Usenko S, Hageman KJ, Schmedding DW, Wilson GR, Simonich SL. 2005. Trace analysis of semivolatile organic compounds in large volume samples of snow, lake water, and groundwater. *Environ Sci Technol* 39:6006-6015.
[28] Guerin TF, I.R. K. 1992. Distribution and dissipation of endosulfan and related cyclodienes in sterile aqueous systems: Implications for studies on biodegredation. *Journal of Agricultural and Food Chemistry* 40:2315-2323.
[29] EPA US. 2001. Overview of Endosulfan Risk Assessment. Vol 2006.
[30] Rombough P. 2002. Gills are needed for ionoregulation before they are needed for O2 uptake in developing zebrafish, Danio rerio. *J Exp Biol* 205:1787-1794.
[31] Gant DB, Eldefrawi ME, Eldefrawi AT. 1987. Cyclodiene insecticides inhibit GABAA receptor-regulated chloride transport. *Toxicol Appl Pharmacol* 88:313-321.
[32] Abalis IM, Eldefrawi ME, Eldefrawi AT. 1986. Effects of insecticides on GABA-induced chloride influx into rat brain microsacs. *J Toxicol Environ Health* 18:13-23.

[33] Ffrench-Constant RH, Anthony N, Aronstein K, Rocheleau T, Stilwell G. 2000. Cyclodiene insecticide resistance: from molecular to population genetics. *Annu Rev Entomol* 45:449-466.
[34] Toldeo MCF, Jonsson CM. 1993. Bioaccumulation and elimination of endosulfan in Zebrafish (*Brachydanio rerio*). *Pesticide Science* 36:207-211.
[35] ZFIN. 2008. Zebrafish Information Network (ZFIN). Eugene, Oregon, Anatomical Development: Gills. Retrieved 10/29/2008 from, http://zfin.org/action/anatomy/term-detail?anatomyitem.zdbID=ZDB-ANAT-011113-279.
[36] Lee H-K, Moon J-K, Chang C-H, Choi H, Park H-W, Park B-S, Lee H-S, Hwang E-C, Lee Y-D, Liu K-H, Kim J-H. 2006. Stereoselective metabolism of endosulfan by human liver microsomes and human cytochrome P450 isoforms. *Drug Metab Dispos* 34:1090-1095.
[37] Stoilov I. 2001. Cytochrome P450s: coupling development and environment. *Trends Genet* 17:629-632.
[38] Juchau MR, Lee QP, Fantel AG. 1992. Xenobiotic biotransformation/bioactivation in organogenesis-stage conceptual tissues: implications for embryotoxicity and teratogenesis. *Drug Metab Rev* 24:195-238.
[39] Andreasen EA, Spitsbergen JM, Tanguay RL, Stegeman JJ, Heideman W, Peterson RE. 2002. Tissue-Specific Expression of AHR2, ARNT2, and CYP1A in Zebrafish Embryos and Larvae: Effects of Developmental Stage and 2,3,7,8-Tetrachlorodibenzo-p-dioxin Exposure. *Toxicol Sci* 68:403-419.
[40] Nowak B. 1990. Residues of endosulfan in the livers of wild catfish from a cotton growing area. *Environmental Monitoring and Assessment* 14:347-351.

Table 4.1. Associated behaviors for touch response scoring system.

Number	Behavior
1	Normal: fish quickly swim away from the source of the touch, move across the length of the well
2	Fish quickly respond to touch, includes prolonged periods of swimming and fish acting disoriented
3	Fish are slower to respond to touch and swim a shorter distance
4	Fish flick the tail in response to touch, but do not swim
5	Paralysis: fish do not move

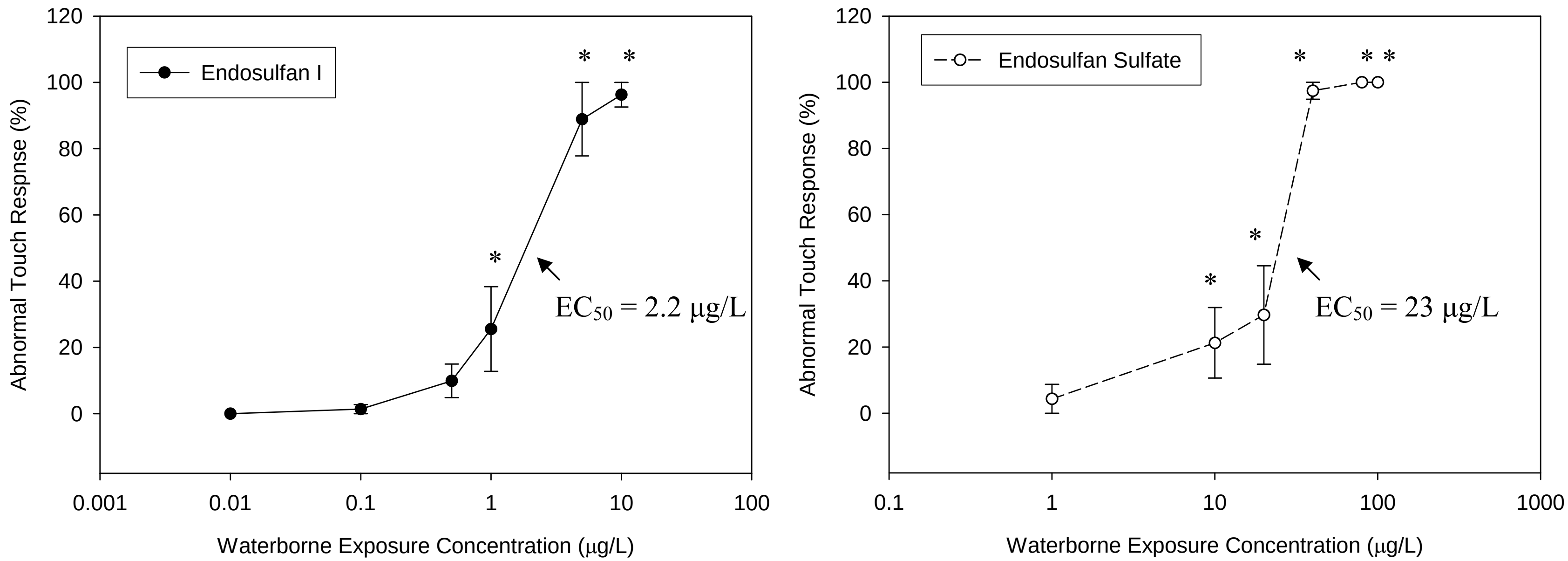

Figure 4.1. Concentration response curve for the nominal waterborne exposure concentration versus the % incidence of abnormal touch response at 72 hpf for endosulfan I and endosulfan sulfate averaged across 3 experiments. The error bars represent the standard error of the mean. * indicates significantly different from control group ($p \leq 0.01$).

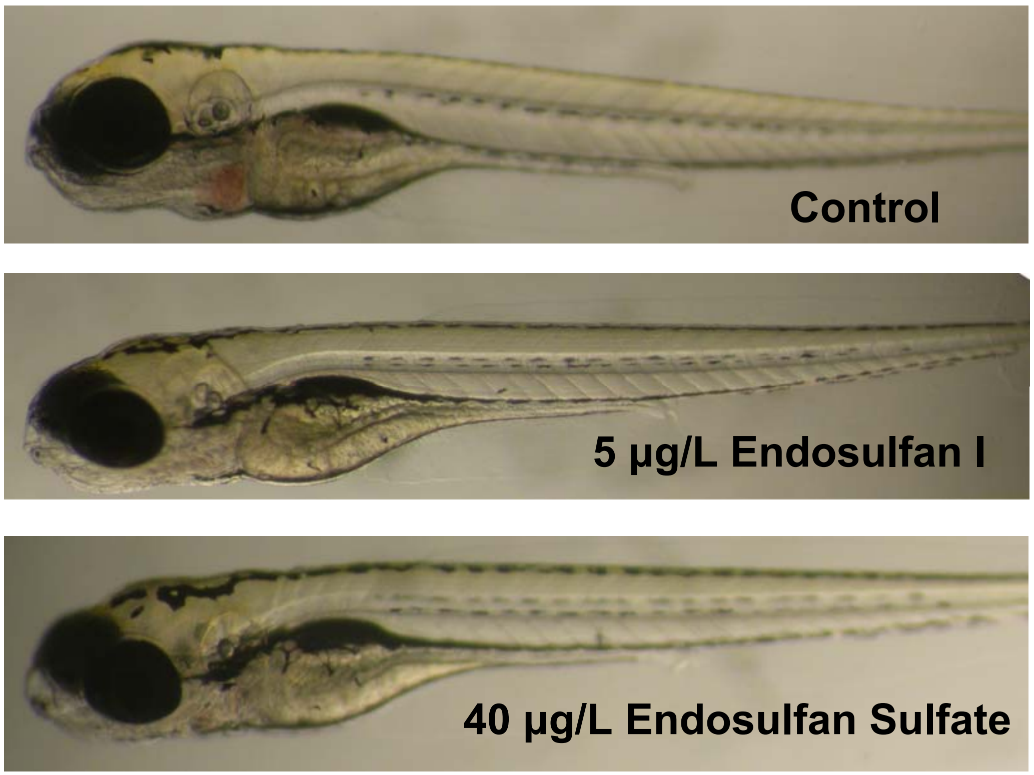

Figure 4.2. Examples of control and 5 µg/L endosulfan I and 40 µg/L endosulfan sulfate exposed zebrafish larvae at 120hpf. One hundred percent of these exposure groups exhibited symptoms of neurotoxicty, as indicated by abnormal touch response.

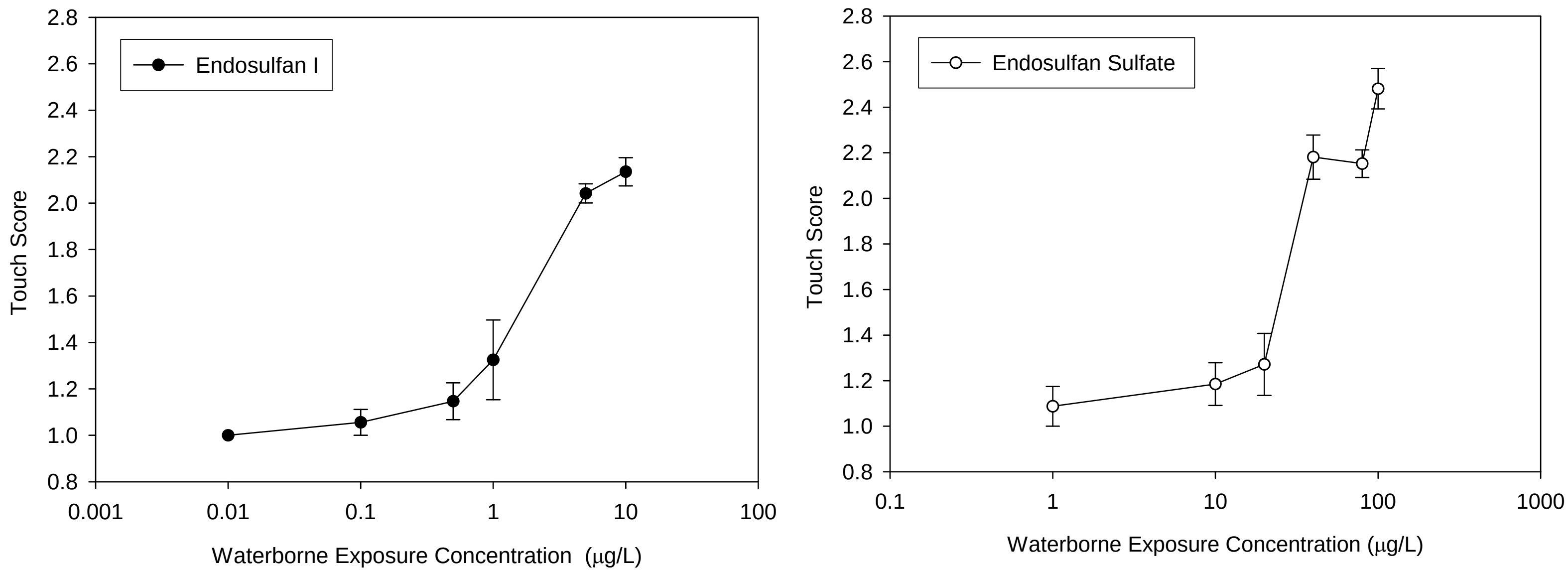

Figure 4.3. The nominal waterborne exposure concentration versus the touch score for abnormal touch response at 72 hpf for endosulfan I and endosulfan sulfate averaged across 3 experiments. The error bars represent the standard error of the mean.

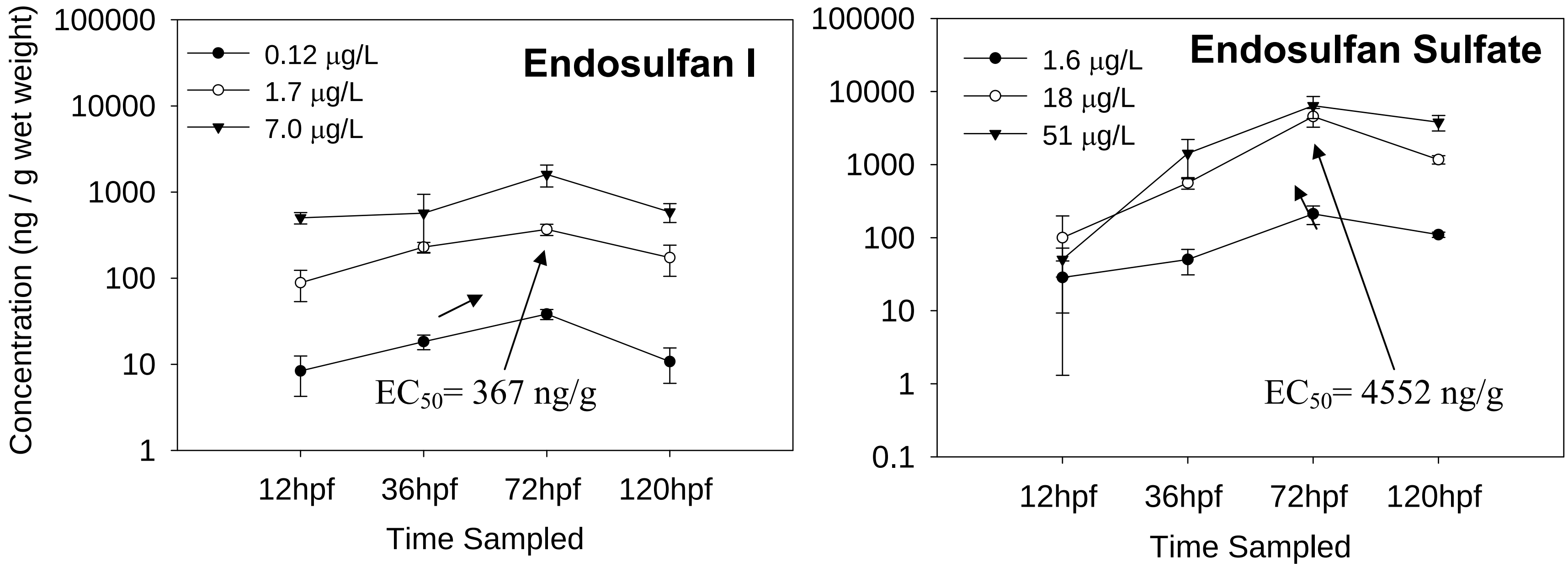

Figure 4.4. The average concentration (ng/g) in zebrafish embryos and larvae sampled over the course of a 5 day exposure to endosulfan I and endosulfan sulfate. The bars represent the standard deviation; $n = 3$. The tissue EC_{50} for abnormal touch response is shown.

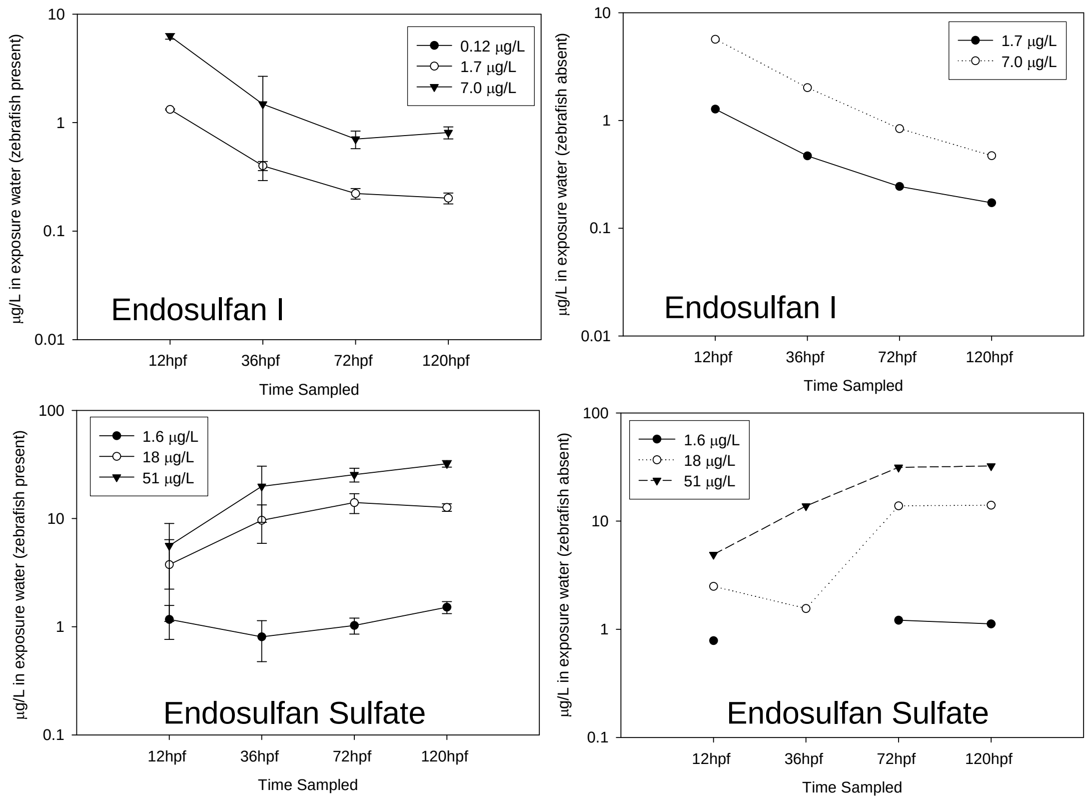

Figure 4.5. The average concentration (µg/L) in exposure water, with and without the embryos/larvae present, over the course of a 5 day exposure to endosulfan I and endosulfan sulfate. Zebrafish present: the bars in represent the standard deviation; *n* = 3, zebrafish absent: *n* = 1.

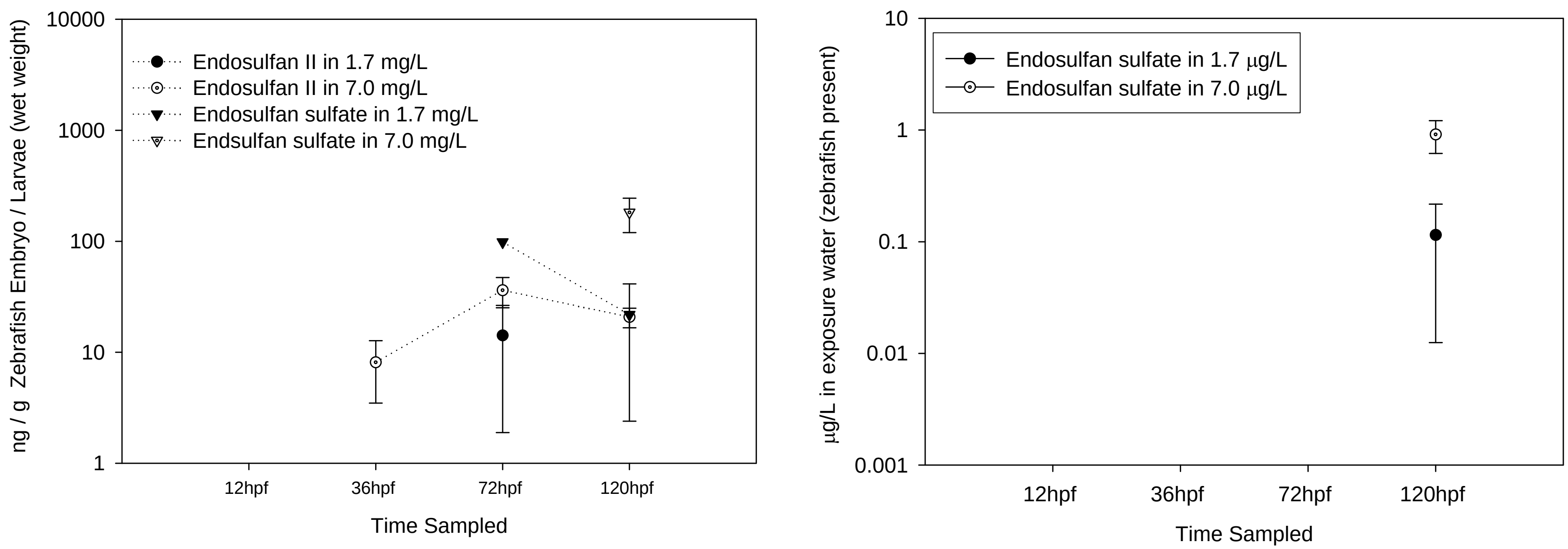

Figure 4.6. The average concentration of metabolites (endosulfan II and endosulfan sulfate) of endosulfan I in zebrafish embryos and larvae (ng/g) in exposure water (µg/L) over the course of a 5 day exposure to endosulfan I. The bars in represent the standard deviation; $n = 3$, no bars present $n = 1$.

5. Conclusions

Regional atmospheric transport has been documented previously and, in California, it has been suggested as an important transport route for SOC deposition to mountain ecosystems. Several amphibian populations are declining in California and there is a need to better understand the potential factors involved in these declines, including contaminants. In addition, relatively little is known about the routes by which amphibians can accumulate contaminants. Quantitative analytical methods, capable of measuring a large number of SOCs at low concentrations, are necessary to better assess amphibian accumulation of pesticides and other contaminants. Field-based tissue concentrations need to be compared to laboratory-based tissue concentrations that result in toxic effects in order to gain insight into the potential effects of low levels contaminants present in field.

An analytical method, capable of measuring over 70 SOCs, including many current and historic use pesticides, PCBs, and PAHs, in tadpole tissue was developed and validated. The method used a matrix phase solid dispersion (MSPD) extraction procedure, silica solid phase extraction to remove interfering compounds and isotope dilution GC/MS analysis. When compared to a pressurized liquid extraction (PLE) method for measuring SOCs in fish that required gel permeation chromatography, in addition to silica solid phase extraction and isotope dilution GC/MS, the MSPD method resulted in significantly higher recoveries for organochlorine pesticides, organophosphorous pesticides, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls, better precision and the detection of a larger number of current-use pesticides in tadpole tissue. The average recovery over the entire MSPD method for all SOCs was 80.6 (± 25.9) %. This method was also sensitive and estimated method detection limits ranged from 0.19 to 2900 pg/g wet weight tadpole.

The validated MSPD analytical method was used to measure SOCs in tadpole samples collected from mountains throughout California. Surficial sediment samples were also collected and analyzed from the same sites that the tadpoles were collected from, including 33 lakes, ponds and wetlands in the California Cascades, 11 lakes along a north to south transect in the Sierra Nevada Mountains, 5 high elevation lakes in Yosemite National Park and 32 high elevation lakes in Sequoia and Kings Canyon National Parks. A total of 17 SOCs were detected in tadpoles and 37 SOCs were detected in sediment. Across all regions, endosulfan sulfate and dacthal were the most frequently detected current-use pesticides in tadpole tissue and sediment samples. In general, SOCs were more frequently detected, in surficial sediment samples than in tadpole samples, likely as a result of longer accumulation periods in sediment (several years) compared to tadpoles (weeks to months). The relatively high PAH concentrations in several surficial sediment samples, attributed to pyrogenic sources, likely motorboat engines and/or forest fires, the absence of PAHs above the estimated method detection limit in tadpole samples taken from the same lakes, and the similarity between the physical-chemical properties of PAHs and some of the other SOCs measured in both tadpoles and sediment (i.e. PCBs), suggest that tadpoles of Gosner stage 33 and above have the ability to metabolize PAHs. This may also indicate that tadpoles have the ability to metabolize endosulfan I and II to endosulfan sulfate.

The impact of regional sources on tadpole and sediment SOC concentrations was also investigated. Site distance from regional endosulfan and dacthal use areas was significantly negatively correlated with tadpole and sediment concentrations. Site distance from the Central Valley was significantly negatively correlated with sediment concentrations of historic-use pesticides, including trans-chlordane, trans-nonachlor, and cis-nonachlor, and PCBs. This suggests that historic-use pesticides continue to be deposited to these high elevation ecosystems due to revolatilization from historically contaminated soils in the Central Valley, revolatilization as a result of forest fires, regional atmospheric transport, and deposition. These results indicate that regional sources located in the Central Valley are responsible for much of the SOC deposition in California mountain ecosystems.

Sediment is potentially an important SOC exposure route for tadpoles because of their close contact with the sediment during feeding and their use of sediment as a cover to hide from predators. The accumulation of SOCs in tadpoles as a result of exposure to sediment was investigated on a regional and statewide basis. A multiple linear regression model was developed to determine if there was a significant correlation between the surficial sediment and tadpole SOC concentrations after accounting for other potential explanatory factors, including average tadpole developmental stage, tadpole lipid content, and site distance from regional sources. Tadpole and sediment concentrations were not significantly correlated on a regional basis. Significant positive correlations between tadpole and sediment concentrations of dacthal, endosulfan II, endosulfan sulfate, trans-nonachlor, cis-nonachlor, and p,p'-DDE were observed on a statewide basis as a result of low concentrations in the Cascades and high concentrations in SEKI. These results indicate that regional sources are responsible for the observed trends and, in areas with high concentrations in the sediment, the tadpoles are also likely to have high tissue concentrations.

Tadpole BSAFs were also calculated. BSAFs were highly variable within regions and the average BSAFs were similar between the regions. BSAFs for current-use pesticides were generally higher than BSAFs for historic-use SOCs, indicating that there may be more potential for California mountain tadpoles to accumulate current-use pesticides than historic-use SOCs.

The zebrafish model was chosen to investigate the potential developmental effects of endosulfan I and endosulfan sulfate, the most frequently detected SOCs in tadpole and sediment samples, and the results were extrapolated to amphibians. The relative toxicity of endosulfan sulfate and endosulfan I was studied because tadpole exposure to endosulfan sulfate may occur in the sediment and/or tadpoles may be exposed to endosulfan I and II and subsequently metabolize these compounds to endosulfan sulfate. Endosulfan I was chosen for these studies because it is reported in the literature to be the more toxic of the two parent compounds. This study also determined the most sensitive toxicity endpoint and the tissue concentrations associated with the observed effects.

Preliminary toxicity range finding tests, conducted by exposing zebrafish embryos from 6 hours post fertilization (hpf) to 120 hpf, indicated that the most sensitive toxicity endpoint in zebrafish exposed to endosulfan I and endosulfan sulfate is an abnormal response to touch. This abnormal behavioral response is associated with neurotoxicity. Further studies demonstrated that endosulfan I is approximately ten times more toxic than endosulfan sulfate.

An analytical method, based on a method described by Isaacson et al. 2007, was developed and validated in order to measure endosulfan I and endosulfan sulfate concentrations in exposure water and embryo and larvae tissue throughout the five day exposures. The no observable adverse effect concentration (NOAEC) for tissue was 38 ng/g w.w, and the endosulfan I tissue concentrations at which fifty percent of the larvae exhibit adverse behavioral effects (tissue EC_{50}), was 367 ng/g w.w. These concentrations are within the range of concentrations measured in fish collected from agricultural areas but 4 and 30 times higher, respectively, than tissue concentrations in fish, tadpoles and frogs collected from mountain ecosystems. For endosulfan sulfate, the NOAEC for tissue was 210 ng/g w.w. and the tissue EC_{50} was 4552 ng/g w.w. The endosulfan sulfate NOAEC was within the range of concentrations measured in fish from agricultural areas but at least 20 times higher than concentrations measured in fish, tadpoles and frogs from mountain ecosystems. The EC_{50} was 15 times higher than concentrations measured in fish from agricultural areas and 450 times higher than fish, tadpoles, and frog concentrations measured in mountain ecosystems. These results indicate that there is a potential for endosulfan I and endosulfan sulfate to adversely affect organisms in agricultural regions, while in remote regions, adverse effects as a result of endosulfan I and sulfate exposure alone are unlikely. However, additive and synergistic effects of endosulfan I + II + sulfate and endosulfan, in combination with exposure to other SOCs, should be considered along with differences in sensitivity between species.

The research in this dissertation describes the development and validation of a method to measure a range of SOC classes in tadpoles, the assessment of SOC accumulation in tadpoles from mountain ecosystems, and identification of potential toxic effects associated with endosulfan I and endosulfan sulfate exposure using the zebrafish model and extrapolating to amphibians. Regional sources are particularly important when considering atmospheric transport and deposition to California mountain ecosystems, including areas where amphibian population declines have been observed. Tadpole accumulation of SOCs is likely a complex combination of exposure from the water column, sediment, and the food web, as well as potential metabolism of SOCs. Exposure of tadpoles to endosulfan I and endosulfan sulfate in these California ecosystems are unlikely to directly affect amphibians.

Additional studies are necessary in order to better characterize tadpole exposure in mountain ecosystems, including investigating additional exposure pathways and factors involved in accumulation because sediment SOC concentration, tadpole stage, lipid content, and site distance from regional sources accounted for 50 % or less of the variability in the tadpole SOC concentrations. Studies should focus on taking several measurements in one or a few ecosystems, over a short time period, and measure sediment, water and tissue concentrations. A site known to have higher levels of SOCs present would be useful in these studies so that measurements are consistently above detection limits. Laboratory studies should be conducted to study the metabolism of SOCs by tadpoles under controlled conditions. Future studies are also needed to better understand the field SOC tissue concentrations with respect to potential toxic effects, including the effects of combined exposure to multiple SOCs.

Bibliography

Abalis, I. M., M. E. Eldefrawi, et al. (1986). "Effects of insecticides on GABA-induced chloride influx into rat brain microsacs." J Toxicol Environ Health **18**(1): 13-23.

Ackerman, L. K., A. R. Schwindt, et al. (2008). "Atmospherically deposited PBDEs, pesticides, PCBs, and PAHs in Western U.S. National Park fish: Concentrations and consumption guidelines." Environ. Sci. Technol. **42**(7): 2334-2341.

Alford, R. A. and S. J. Richards (1999). "Global amphibian declines: A problem in applied ecology." Annual Review of Ecology and Systematics **30**: 133-165.

Andreasen, E. A., J. M. Spitsbergen, et al. (2002). "Tissue-Specific Expression of AHR2, ARNT2, and CYP1A in Zebrafish Embryos and Larvae: Effects of Developmental Stage and 2,3,7,8-Tetrachlorodibenzo-p-dioxin Exposure." Toxicol. Sci. **68**(2): 403-419.

Angermann, J. E., G. M. Fellers, et al. (2002). "Polychlorinated biphenyls and toxaphene in pacific tree frog tadpoles (*Hyla regilla*) from the California Sierra Nevada, USA." Environmental Toxicology and Chemistry **21**(10): 2209-2215.

Antweiler, R. C. and H. E. Taylor (2008). "Evaluation of statistical treatments of left-censored environmental data using coincident uncensored data sets: I. Summary statistics." Environ Sci Technol **42**(10): 3732-8.

Aston, L. S. and J. N. Seiber (1997). "Fate of summertime airborne organophosphate pesticide residues in the Sierra Nevada Mountains." Journal of Enviornmental Quality **26**: 1483-1492.

ATSDR. (2000). "Toxicological Profile for Endosulfan."   Retrieved June 11, 2007, from http://www.atsdr.cdc.gov/toxprofiles/tp41.html.

Barinaga, M. (1990). "Where have all the froggies gone?" Science **247**: 1033-1034.

Beebee, T. J. C. and R. A. Griffiths (2005). "The amphibian decline crisis: A watershed for conservation biology?" Biological Conservation **125**: 271-285.

Berntssen, M. H. G., C. N. Glover, et al. (2008). "Accumulation and elimination kinetics of dietary endosulfan in Atlantic salmon (Salmo salar)." Aquatic Toxicology **86**(1): 104-111.

Blais, J. M., D. W. Schindler, et al. (1998). "Accumulation of persistent organochlorine compounds in mountains of western Canada." Nature **395**(6702): 585-588.

Blaustein, A. R., and Wake, D. B. (1990). "Declining amphibian populations: A global phenomenon?" Trends in Ecology & Evolution **5**: 203-204.

Blaustein, A. R. and J. M. Kiesecker (2002). "Complexity in conservation: lessons from the global decline of amphibian populations." Ecology Letters **5**(4): 597-608.

Blaustein, A. R., J. M. Romansic, et al. (2003). "Ultraviolet radiation, toxic chemicals and amphibian population declines." Diversity & Distributions **9**(2): 123-140.

Blaustein, A. R. and D. B. Wake (1995). "The puzzle of declining amphibian populations." Scientific American **272**(4): 52.

Bradford, D. F. (1983). "Winterkill, oxygen relations, and energy metabolism of a submerged dormant amphibian, *Rana muscosa*." Ecology **64**: 1171-1183.

Bradford, D. F. (1989). "Allotropic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: Implications of the negative effect of fish introductions." Copeia **1989**(3): 775-778.

Bradford, D. F., D. M. Graber, et al. (1994). "Population declines of the native frog, *Rana muscosa*, in Sequoia and Kings Canyon National Parks, California." Southwestern Naturalist **39**: 323-327.

Bradford, D. F., Tabatabai, F., Graber, D. M. (1993). "Isolation of remaining populations of the native frog, *Rana muscosa*, by introduced fishes in Sequoia and Kings Canyon National Parks, California." Conservation Biology **7**(4): 882-888.

Brevik, K., A. Sweetman, et al. (2002). "Towards a global historical emission inventory for selected PCB congeners -a mass balance approach: 2. Emissions." The Science of the Total Environment **290**(1-3): 199-224.

Burkhard, L. P. (2003). "Factors influencing the design of bioaccumulation factor and biota-sediment accumulation factor field studies." Environmental Toxicology and Chemistry **22**(2): 351-360.

Burkhard, L. P., P. M. Cook, et al. (2004). "Biota--sediment accumulation factors for polychlorinated biphenyls, dibenzo-p-dioxins, and dibenzofurans in southern Lake Michigan lake trout (Salvelinus namaycush)." Environ Sci Technol **38**(20): 5297-305.

Burkhard, L. P., P. M. Cook, et al. (2005). "Comparison of biota-sediment accumulation factors across ecosystems." Environ Sci Technol **39**(15): 5716-21.

CADPR (2006). Pesticide Use Reporting - 2005 Summary Data. Sacramento, CA.

CADPR (2007). Pesticide Use Reporting - 2006 Summary Data.

Carey, C. and C. J. Bryant (1995). "Possible interrelations among environmental toxicants, amphibian development, and decline of amphibian populations." Environmental Health Perspectives Supplements **103**: 13.

Carey, C., N. Cohen, et al. (1999). "Amphibian declines: An immunological perspective." Developmental & Comparative Immunology **23**(6): 459-472.

Carrera, G., P. Fernandez, et al. (2002). "Atmospheric deposition of organochlorine compounds to remote high mountain lakes of Europe." Environ. Sci. Technol. **36**(12): 2581-2588.

Carrera, G., P. Fernandez, et al. (2001). "Persistent organic pollutants in snow from European high mountain areas." Atmospheric Environment **35**(2): 245-254.

Cory, L., Fjeld, P., Serat, W. (1970). "Distribution patterns of DDT residues in the Sierra Nevada Mountains." Pesticides Monitoring Journal **3**(4): 204-211.

Courchesne, C. L. and J. A. Bantle (1985). "Analysis of the activity of DNA, RNA, and protein synthesis inhibitors on Xenopus embryo development." Teratog Carcinog Mutagen **5**(3): 177-93.

Daly, G. L., Y. D. Lei, et al. (2007). "Organochlorine Pesticides in the Soils and Atmosphere of Costa Rica." Environ. Sci. Technol. **41**(4): 1124-1130.

Daly, G. L., Y. D. Lei, et al. (2007). "Accumulation of current-use pesticides in neotropical montane forests." Environ. Sci. Technol. **41**(4): 1118-1123.

Daly, G. L., Y. D. Lei, et al. (2007). "Pesticides in Western Canadian mountain air and soil." Environ. Sci. Technol. **41**(17): 6020-6025.

Daly, G. L. and F. Wania (2005). "Organic contaminants in mountains." Environ. Sci. Technol. **39**(2): 385-398.

Datta, S., L. Hansen, et al. (1998). "Pesticides and PCB contaminants in fish and tadpoles from the Kaweah River Basin, California." Bulletin of Environmental Contamination and Toxicology **60**: 829-836.

Datta, S., L. L. McConnell, et al. (1998). "Evidence for atmospheric transport and deposition of polychlorinated biphenyls to the Lake Tahoe Basin, California-Nevada." Environ. Sci. Technol. **32**(10): 1378-1385.

Davidson, C. (2004). "Declining downwind: amphibian population declines in California and historical pesticide use." Ecological Applications **14**(6): 1892-1902.

Davidson, C., H. Bradley Shaffer, et al. (2001). "Declines of the California red-legged frog: Climate, UV-B, habitat, and pesticides hypotheses." Ecological Applications **11**: 464-479.

Davidson, C., Knapp, R.A. (2007). "Multiple stressors and amphibian declines: dual impacts of pesticides and fish on yellow-legged frogs " Ecological Applications **17**(2): 587-597.

Davidson, C., H. B. Shaffer, et al. (2002). "Spatial tests of the pesticide drift, habitat destruction, UV-B, and climate-change hypotheses for California amphibian declines." Conservation Biology **16**(6): 1588-1601.

Demers, M. J., E. N. Kelly, et al. (2007). "Organochlorine Compounds in Trout from Lakes over a 1600 Meter Elevation Gradient in the Canadian Rocky Mountains." Environ. Sci. Technol. **41**(8): 2723-2729.

Devi, A. P., D. M. R. Rato, et al. (1981). "Relative toxicity of the technical grade material, isomers, and formulations of endosulfan to the fishChanna punctata." Bulletin of Environmental Contamination and Toxicology **27**(1): 239-243.

Drapeau, P., L. Saint-Amant, et al. (2002). "Development of the locomotor network in zebrafish." Prog Neurobiol **68**(2): 85-111.

Drost, C. A. and G. M. Fellers (1996). "Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA." Conservation Biology **10**(2): 414-425.

Eisen, J. S. (1991). "Developmental neurobiology of the zebrafish." J Neurosci **11**(2): 311-7.

EPA (2007). Estimation Programs InterfaceSuite. U. S. EPA. Washington, DC, USA.

EPA (2007). Summary of "A Developmental Neurotoxicity Study with Technical Grade Endosulfan in Wistar Rats" by Gilmore et al. 2006 Bayer CropScience. MRID#46968301.

EPA. (1995). IRIS Dichloromethane. Retrieved 6/30/2008, from http://www.epa.gov.iris/subst/0070.htm.

EPA. (1996). Method 8280A: The analysis of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans by high-resolution gas chromatography / low resolution mass spectrometry (HRGC/LRMS).

EPA, U. S. (2001, 10/11/2006). "Overview of Endosulfan Risk Assessment." Retrieved 11/13/2006, from http://www.epa.gov/oppsrrd1/reregistration/endosulfan/endosulfan_finaloverview.pdf.

Fagotti, A., L. Morosi, et al. (2005). "Bioaccumulation of organochlorine pesticides in frogs of the *Rana esculenta* complex in central Italy." Amphibia-Reptilia **26**(1): 93-104.

Fellers, G. M., Drost, C.A. (1993). "Disappearance of the cascades frog *Rana cascadae* at the southern end of its range, California, USA." Biological Conservation **65**(2): 177-181.

Fellers, G. M., D. E. Green, et al. (2001). "Oral chytridiomycosis in the mountain yellow-legged frog (*Rana muscosa*)." Copeia **2001**(4): 945-953.

Fellers, G. M., L. L. McConnell, et al. (2004). "Pesticides in mountain yellow-legged frogs (*Rana muscosa*) from the Sierra Nevada Mountains of California, USA." Environmental Toxicology and Chemistry **23**(9): 2170-2177.

Fellers, G. M., Pope, K.L., Stead, J.E., Koo, M.S., Welsh, H.H. (2008). "Turning population trend monitoring into active conservation: Can we save the Cascades frog (*Rana cascadae*) in the Lassen region of California?" Herpetological Conservation and Biology **3**(1): 28-39.

Ffrench-Constant, R. H., N. Anthony, et al. (2000). "Cyclodiene insecticide resistance: from molecular to population genetics." Annu Rev Entomol **45**: 449-66.

Gabos, S., M. G. Ikonomou, et al. (2001). "Characteristics of PAHs, PCDD/Fs and PCBs in sediment following forest fires in northern Alberta." Chemosphere **43**(4-7): 709-19.

Gant, D. B., M. E. Eldefrawi, et al. (1987). "Cyclodiene insecticides inhibit GABAA receptor-regulated chloride transport." Toxicol Appl Pharmacol **88**(3): 313-21.

Glover, C. N., D. Petri, et al. (2007). "Assessing the sensitivity of Atlantic salmon (Salmo salar) to dietary endosulfan exposure using tissue biochemistry and histology." Aquatic Toxicology **84**(3): 346-355.

Gosner, K. L. (1960). "A simplified table for staging anuran embryos and larvae with notes on identification." Herpetologica **16**: 183-190.

Granato, M., F. J. van Eeden, et al. (1996). "Genes controlling and mediating locomotion behavior of the zebrafish embryo and larva." Development **123**: 399-413.

Grimalt, J. O., F. Borghini, et al. (2004). "Temperature dependence of the distribution of organochlorine compounds in the mosses of the Andean mountains." Environ Sci Technol **38**(20): 5386-92.

Grimalt, J. O., P. Fernandez, et al. (2001). "Selective trapping of organochlorine compounds in mountain lakes of temperate areas." Environ. Sci. Technol. **35**(13): 2690-2697.

Grimalt, J. O., P. Fernandez, et al. (2001). "Trapping of organochlorine compounds in high mountain lakes." ScientificWorldJournal **1**: 609-11.

Guerin, T. F. and K. I.R. (1992). "Distribution and dissipation of endosulfan and related cyclodienes in sterile aqueous systems: Implications for studies on biodegredation." Journal of Agricultural and Food Chemistry **40**: 2315-2323.

Gunier, R. B., M. E. Harnly, et al. (2001). "Agricultural pesticide use in California: pesticide prioritization, use densities, and population distributions for a childhood cancer study." Environ Health Perspect **109**(10): 1071-8.

Hageman, K. J., S. L. Simonich, et al. (2006). "Atmospheric deposition of current-use and historic-use pesticides in snow at national parks in the Western United States." Environ. Sci. Technol. **40**(10): 3174-3180.

Hayes, T. B., Case, P., Chui, S., Chung, D., Haeffele, C., Haston, K., Lee, M., Mai, V.P., Marjuoa, Y., Parker, J., Tsui, M. (2006). "Pesticide mixtures, endocrine disruption, and amphibian declines: Are we underestimating the impact?" Environmental Health Perspectives Supplements **114**(1): 40-50.

Hayes, T. P., J. J. R. Kinney, et al. (1984). California surface wind climatology. Sacramento, CA, USA, California Air Resources Board, Aerometric Data Division, Aerometric Projects and Laboratory Branch, Meteorology Section.

Hill, A. J., H. Teraoka, et al. (2005). "Zebrafish as a Model Vertebrate for Investigating Chemical Toxicity." Toxicol. Sci. **86**(1): 6-19.

Hofer, R., R. Lackner, et al. (2005). "Accumulation of toxicants in tadpoles of the common frog (*Rana temporaria*) in high mountains." Archives of Environmental Contamination and Toxicology **49**: 192-199.

Hopkins, W. A., S. E. DuRant, et al. (2006). "Reproduction, embryonic development, and maternal transfer of contaminants in the amphibian Gastrophryne carolinensis." Environ Health Perspect **114**(5): 661-6.

Hose, G. C., R. P. Lim, et al. (2003). "The transport, fate and effects of endosulfan in the Australian freshwater environment." Australasian Journal of Ecotoxicology **9**: 101-111.

Houlahan, J. E., C. S. Findlay, et al. (2000). "Quantitative evidence for global amphibian population declines " Nature **404**: 752-755.

Isaacson, C. W., C. Y. Usenko, et al. (2007). "Quantification of Fullerenes by LC/ESI-MS and Its Application to in Vivo Toxicity Assays." Analytical Chemistry **79**(23): 9091-9097.

Jennings, M. R. and M. P. Hayes (1994). Amphibian and reptile species of special concern in California. Rancho Cordova, CA, USA, California Department of Fish and Game, Inland Fisheries Division.

Jia, Z. and H. P. Misra (2007). "Developmental exposure to pesticides zineb and/or endosulfan renders the nigrostriatal dopamine system more susceptible to these environmental chemicals later in life." NeuroToxicology **28**: 727-735.

Jonsson, C. M. and M. C. F. Toledo (1993). "Acute toxicity of endosulfan to the fish *Hyphessobrycon bifasciatus* and *Brachydanio rerio*." Archives of Environmental Contamination and Toxicology **24**(2): 151-155.

Juchau, M. R., Q. P. Lee, et al. (1992). "Xenobiotic biotransformation/bioactivation in organogenesis-stage conceptual tissues: implications for embryotoxicity and teratogenesis." Drug Metab Rev **24**(2): 195-238.

Kadokami, K., M. Takeishi, et al. (2004). "Maternal transfer of organochlorine pesticides, polychlorinated dibenzo-p-dioxins, dibenzofurans, and coplanar polychlorinated biphenyls in frogs to their eggs." Chemosphere **57**(5): 383-9.

Kiesecker, J. M., A. R. Blaustein, et al. (2001). "Transfer of a pathogen from fish to amphibians." Conservation Biology **15**(4): 1064-1070.

Kim, E. J., J. E. Oh, et al. (2003). "Effects of forest fire on the level and distribution of PCDD/Fs and PAHs in soil." Sci Total Environ **311**(1-3): 177-89.

Kimmel C.B., B., W.W., Kimmel, S.R., Ullmann, B., Schilling, T.F. (1995). "Stages of embryonic development of the zebrafish." Developmental Dynamics **203**(3): 253-310.

Knapp, R. A. and K. R. Matthews (2000). "Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas." Conservation Biology **14**(2): 428-438.

Landers, D. H., S. L. Simonich, et al. (2008). The fate, transport, and ecological impacts of airborne contaminants in western national parks (USA). O. o. R. a. D. U.S. Environmental Protection Agency. Corvallis, OR.

Landrum, P. F. and J. A. Robbins (1990). Bioavailabilty of sediment-associated contaminants to benthic invertebrates. Sediments: Chemistry and toxicity of in-place pollutants. R. Baudo, J. P. Geisy and H. Muntau, CRC Press**:** 405.

Landrum, P. F., S. D. Robinson, et al. (2007). "Predicting bioavailability of sediment-associated organic contaminants for Diporeia spp. and oligochaetes." Environ Sci Technol **41**(18): 6442-7.

Lee, H.-K., J.-K. Moon, et al. (2006). "Stereoselective metabolism of endosulfan by human liver microsomes and human cytochrome P450 isoforms." Drug Metab Dispos **34**(7): 1090-1095.

Lehotay, S. J. and K. Mastovska (2005). "Evaluation of two fast and easy methods for pesticide residue analysis in fatty food matrices." Journal of AOAC International **88**(2): 630-638.

Lele, Z. and P. H. Krone (1996). "The zebrafish as a model system in developmental, toxicological and transgenic research." Biotechnology Advances **14**(1): 57-72.

LeNoir, J. S., L. L. McConnell, et al. (1999). "Summertime transport of current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA." Environmental Toxicology and Chemistry **18**(12): 2715-2722.

Leonard, A. W., R. V. Hyne, et al. (2001). "Fate and Toxicity of Endosulfan in Namoi River Water and Bottom Sediment." J Environ Qual **30**(3): 750-759.

Leone, A. D., E. M. Ulrich, et al. (2000). "Organochlorine pesticide concentrations and enantiomer fractions for chlordane in indoor air form the US cornbelt." Atmospheric Environment **34**(24): 4131-4138.

Linder, G., S. K. Krest, et al. (2003). Amphibian decline: an integrated analysis of multiple stressor effects, United States, SETAC Press, Pensacola, FL (United States).

Loveridge, A. R., Bishop, C. A., Elliot, J. E., Kennedy, C. J. (2007). "Polychlorinated biphenyls and organochlorine pesticides bioaccumulated in green frogs, *Rana clamitans*, from the Lower Fraser Valley, British Columbia, Canada." Bull. Environ. Contam. Toxicol. **79**: 315-318.

McConnell, L. L., J. S. LeNoir, et al. (1998). "Wet deposition of current-use pesticides in the Sierra Nevada Mountain Range, California, USA." Environmental Toxicology and Chemistry **17**(10): 1908-1916.

McMahon, C. K., Clements, H.B., Bush, P.B., Neary, D.G., Taylor, J.W. (1985). Pesticides released from burning treated wood. Proceedings of the eight conference on fire and forest meteorology. L. R. Donoghue, Martin, R.E. Bethesda, MD, Society of American Foresters**:** 145-152.

Naqvi, S. M. and C. Vaishnavi (1993). "Bioaccumulative potential and toxicity of endosulfan insecticide to non-target animals." Comparative Biochemistry and Physiology **105C**: 347-361.

Nelson, G. L. (2000). "Fire and Pesticides, A Review and Analysis of Recent Work." Fire Technology **36**(3): 163-183.

Nowak, B. (1990). "Residues of endosulfan in the livers of wild catfish from a cotton growing area." Environmental Monitoring and Assessment **14**(2): 347-351.

Pounds, J. A., M. R. Bustamante, et al. (2006). "Widespread amphibian extinctions from epidemic disease driven by global warming." Nature **439**(7073): 161-167.

Rachowicz, L. J., R. A. Knapp, et al. (2006). "Emerging infectious disease as a proximate cause of amphibian mass mortality." Ecology **87**(7): 1671-83.

Racke, K. D. (1993). "Environmental fate of chlorpyrifos." Rev Environ Contam Toxicol **131**: 1-150.

Readman, J. W., G. Fillmann, et al. (2002). "Petroleum and PAH contamination of the Black Sea." Mar Pollut Bull **44**(1): 48-62.

Rombough, P. (2002). "Gills are needed for ionoregulation before they are needed for O2 uptake in developing zebrafish, Danio rerio." J Exp Biol **205**(12): 1787-1794.

Rosenthal, H. (1976). "Sublethal effects of environmental stressors, natural and pollution, on marine fish eggs and larvae." J. Fish Res Board Can **33**: 2047-2065.

Russell, R. W., K. A. Gillan, et al. (1997). "Polychlorinated biphenyls and chlorinated pesticides in Southern Ontario, Canada, green frogs." Environmental Toxicology and Chemistry **16**(11): 2258-2263.

Russell, R. W., S. J. Hecnar, et al. (1995). "Organochlorine pesticide residues in Southern Ontario spring peepers." Environmental Toxicology and Chemistry **14**(5): 815-817.

Simonich, S. and R. Hites (1995). "Global distribution of persistent organochlorine compounds." Science **269**(5232): 1851-1854.

Smith, A. G. (1991). Chlorpyrifos. Handbook of Pesticide Toxicology. W. J. J. Hayes and E. R. J. Laws. New York, NY, USA, Academic.

Sparling, D. W. and G. Fellers (2007). "Comparative toxicity of chlorpyrifos, diazinon, malathion and their oxon derivatives to larval *Rana boylii*." Environmental Pollution **147**(3): 535-539.

Sparling, D. W., G. M. Fellers, et al. (2001). "Pesticides and amphibian population declines in California, USA." Environmental Toxicology and Chemistry **20**(7): 1591-1595.

Sparling, D. W., S. Krest, et al. (2006). "Effects of lead-contaminated sediment on Rana sphenocephala tadpoles." Arch Environ Contam Toxicol **51**(3): 458-66.

Spitsbergen, J. M. and M. L. Kent (2003). "The State of the Art of the Zebrafish Model for Toxicology and Toxicologic Pathology Research--Advantages and Current Limitations." Toxicol Pathol **31**(1_suppl): 62-87.

Spitsbergen, J. M. and M. L. Kent (2003). "The State of the Art of the Zebrafish Model for Toxicology and Toxicologic Pathology Research—Advantages and Current Limitations." Toxicologic Pathology **31**(1 supp 1): 62 - 87.

Stanley, K. A., C. Davidson, et al. (Submitted). "Comparison of Pressurized Liquid Extraction and Matrix Solid Phase Dispersion for the Measurement of Semi-Volatile Organic Compound Accumulation in Tadpoles."

Stern, G. A., E. Braekevelt, et al. (2005). "Modern and historical fluxes of halogenated organic contaminants to a lake in the Canadian arctic, as determined from annually laminated sediment cores." Science of the Total Environment **342**(1-3): 223-243.

Stoilov, I. (2001). "Cytochrome P450s: coupling development and environment." Trends Genet **17**(11): 629-32.

Stuart, S. N., J. S. Chanson, et al. (2004). "Status and trends of amphibian declines and extinctions worldwide." Science **306**: 1783-1786.

Ter Schure, A. F. H., P. Larsson, et al. (2002). "Latitudinal fractionation of polybrominated diphenyl ethers and polychlorinated biphenyls in frogs (*Rana temporaria*)." Environ. Sci. Technol. **36**(23): 5057-5061.

Toldeo, M. C. F. and C. M. Jonsson (1993). "Bioaccumulation and elimination of endosulfan in Zebrafish (*Brachydanio rerio*)." Pesticide Science **36**: 207-211.

Usenko, S., K. J. Hageman, et al. (2005). "Trace analysis of semivolatile organic compounds in large volume samples of snow, lake water, and groundwater." Environ. Sci. Technol. **39**(16): 6006-6015.

Usenko, S., D. H. Landers, et al. (2007). "Current and historical deposition of PBDEs, pesticides, PCBs, and PAHs to Rocky Mountain National Park." Environ. Sci. Technol. **41**(21): 7235-7241.

USGS. (2008). "USGS Ground-Water Information http://water.usgs.gov/ogw/gwrp/activities/gw-avail.html." Retrieved 11/17/2008, 2008, from http://water.usgs.gov/ogw/gwrp/activities/gw-avail.html.

van der Oost, R., J. Beyer, et al. (2002). "Fish bioaccumulation and biomarkers in environmental risk assessment: a review." Environmental Toxicology and Pharmacology **13**(2): 57-149.
Van Metre, P. C., B. J. Mahler, et al. (2000). "Urban sprawl leaves its PAH signature." Environ Sci Technol **34**: 4064-4070.
Vilanova, R., P. Fernandez, et al. (2001). "Organochlorine Pollutants in Remote Mountain Lake Waters." J Environ Qual **30**(4): 1286-1295.
Vredenburg, V. T. (2004). "Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog." Proc Natl Acad Sci U S A **101**(20): 7646-50.
Wake, D. B. (1991). "Declining amphibian populations." Science **253**(5022): 860-.
Wake, D. B. and V. T. Vredenburg (2008). "Colloquium paper: are we in the midst of the sixth mass extinction? A view from the world of amphibians." Proc Natl Acad Sci U S A **105 Suppl 1**: 11466-73.
Walker, C. C., H. M. Lott, et al. (1993). "Matrix solid-phase dispersion extraction and the analysis of drugs and environmental pollutants in aquatic species." Journal of Chromatography A **642**(1-2): 225-242.
Wan, M. T., J.-n. Kuo, et al. (2005). "Toxicity of *alpha-, beta-, and (alpha + beta)*-endosulfan and their formulated and degredation products to Daphnia magna, Hyalella azteca, Oncorhynchus mykiss, Oncorhynchus kisutch, and biological implications in streams." Environmental Toxicology and Chemistry **24**(5): 1146-1154.
Wan, M. T., J.-n. Kuo, et al. (2005). "Residues of Endosulfan and Other Selected Organochlorine Pesticides in Farm Areas of the Lower Fraser Valley, British Columbia, Canada." J Environ Qual **34**(4): 1186-1193.
Wassersug, R. J. (1975). "Tetrapod Gait Patterns." Science **188**(4195): 1256-1258.
Wassersug, R. J. (1975). "The adaptive significance of the tadpole stage with comments on the maintenance of complex life cycles in anurans." J. Amer. Zool. **15**(2): 405-417.
Webster, E., D. Mackay, et al. (1998). "Evaluating environmental persistence." Environmental Toxicology and Chemistry **17**(11): 2148-2158.
Westerling, A. L., H. G. Hidalgo, et al. (2006). "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity." Science **313**(5789): 940-943.
Wickman, B. E., R. R. Mason, et al. (1973). Major outbreaks of the Douglas-fir tussock moth in Oregon and California. F. S. U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station. Portland, OR**:** 18 p.
Wong, C. S., P. D. Capel, et al. (2001). "National-scale, field-based evaluation of the biota-sediment accumulation factor model." Environ Sci Technol **35**(9): 1709-15.
Yunker, M. B., W. J. Cretney, et al. (2002). "Assessment of chlorinated dibenzo-p-dioxin and dibenzofuran trends in sediment and crab hepatopancreas from pulp mill and harbor sites using multivariate- and index-based approaches." Environ Sci Technol **36**(9): 1869-78.

Zabik, J. M., Seiber, J.N. (1993). "Atmospheric transport of organophosphate pesticides from California's Central Valley to the Sierra Nevada Mountains." Journal of Enviornmental Quality **22**: 80-90.

ZFIN. (2008). "Zebrafish Information Network (ZFIN)." Retrieved October 29, 2008, from http://zfin.org/action/anatomy/term-detail?anatomyItem.zdbID=ZDB-ANAT-011113-279.

APPENDIX

Appendix: Table of Semi-Volatile Organic Compound Concentrations in Tadpoles and Sediment

Abbreviation	Full name	Units	Description
Sample No			Site code followed by date, species indication letter (H or C;Cascades only), sample no., and analytical dup no. if applicable
Matrix			Tadpole or sediment
Region			Region code
Species			PR=*Pseudacris regilla* and RC = *Rana cascadae*
Stage			Average Gosner stage of Tadpoles in Sample
Tadpole Weight			Average Weight of Tadpoles in Sample
extracted g		g	mass extracted
moisture % ww (dry weight)		%	water in homogenate
lipid % ww		%	solvent extractable lipid
total organic carbon % dw		%	total organic carbon normalized on a dry weight basis
f	flag	a	Detected but below the quantification limit. The quantification limit equals the concentration of the lowest calibration standard used to make the calibration curve.
		b	Above the calibration range; i.e., greater than the concentration of the highest calibration standard used to make the calibration curve.
		c	Performance standard deviated by > 30%.
		d	Surrogate recovery <30% or >130%.
		G	No other flags necessary
		m	below estimated method detection limit, value = 1/2 estimated detection limit (EDL)
		X	Don't use because lab blank was >33% of the value.
		z	Don't use because of other reasons (I will make a note with the sample as to why we shouldn't use the sample if this occurs).
Chordcs	Chlordane, cis		
Nonatn	Nonachlor, trans		
Diel	Dieldrin		

Pcb118	PCB 118 (penta)
End2	Endosulfan II
Nonacs	Nonachlor, cis
Endsu	Endosulfan sulfate
Pcb153	PCB 153 (hexa)
Pcb138	PCB 138 (hexa)
Pcb187	PCB 187 (hepta)
Pcb183	PCB 183 (hepta)
Acenathyl	Acenaphthylene-L
Acena	Acenaphthene
Fluor	Fluorene-LA
Phenan	Phenanthrene-LA
Anthrc	Anthracene-L
Flrant	Fluoranthene-L
Pyr	Pyrene-LA
Retene	Retene-L
opDde	o,p'-DDE-L
Dde	p,p'-DDE-LA
opDdd	o,p'-DDD-L
Ddd	p,p'-DDD-L
Ddt	p,p'-DDT-L
methox	Methoxychlor-L
benzoaanth	Benzo(a)anthracene-L
Chrytri	Chrys-L +Triph-LA
benzobflur	Benzo(b)fluoranthene-L
benzokflur	Benzo(k)fluoranthene-L
benzoepyr	Benzo(e)pyrene-L
benzoapyr	Benzo(a)pyrene-LA
indenopyr	Indeno(1,2,3-cd)pyrene-L
dibenzanth	Dibenz(a,h)anthracene-L
benzopery	Benzo(ghi)perylene-LA

Sample No	Matrix	Region	Species	Stage	Tadpole Weight	g extracted	moisture % ww	lipid % ww
ANT 07JUL05 H	Tadpole	Cascades	PR	25	0.25	1.9	93.5	0.25
BAT 08JUN05 H	Tadpole	Cascades	PR	25	0.13	1.8	90.3	0.25
BAT 11JUL05 H	Tadpole	Cascades	PR	25	0.25	2.0	90.6	0.27
BAT 20AUG05 H	Tadpole	Cascades	PR	25	0.49	2.3	88.3	0.34
BAT 30JUL05 H	Tadpole	Cascades	PR	28	0.57	2.2	90.7	0.38
BCL 28JUL05 C	Tadpole	Cascades	RC	40	3.45	2.1	90.0	0.81
BCL 28JUL05 H	Tadpole	Cascades	PR	34	0.86	1.9	91.9	0.73
BDR 01AUG05 C	Tadpole	Cascades	RC	25	0.55	2.1	93.0	0.37
BDR 01AUG05 H	Tadpole	Cascades	PR	25	0.25	2.0	93.6	0.34
BLF 10JUL05 C 1	Tadpole	Cascades	RC	25	0.61	2.0	94.1	0.43
BLF 10JUL05 C 2 Analy dup 1	Tadpole	Cascades	RC	25	0.61	1.9	94.0	0.40
BLF 10JUL05 C 2 Analy dup 2	Tadpole	Cascades	RC	25	0.61	2.0	94.0	0.40
BLF 10JUL05 C 2 Analy dup 3	Tadpole	Cascades	RC	25	0.61	1.8	94.0	0.40
BLF 10JUL05 H	Tadpole	Cascades	PR	25	0.26	2.2	93.7	0.37
BTY 03AUG05 H	Tadpole	Cascades	PR	41	1.47	2.1	90.4	2.40
BUT 12JUL05 H	Tadpole	Cascades	PR	25	0.40	2.0	93.7	0.16
DCH 10JUL05 H	Tadpole	Cascades	PR	25	0.18	2.3	95.0	0.10
DCH 29JUL05 H 1	Tadpole	Cascades	PR	35	0.78	2.1	92.7	0.31
DCH 29JUL05 H 2	Tadpole	Cascades	PR	36	0.63	2.1	93.4	0.37
DCH 29JUL05 H 3	Tadpole	Cascades	PR	36	0.74	1.9	93.9	0.21
DLP 30JUL05 H 1 Analy dup 1	Tadpole	Cascades	PR	39	0.80	2.0	89.4	1.20
DLP 30JUL05 H 1 Analy dup 2	Tadpole	Cascades	PR	39	0.80	2.0	89.0	1.20
DLP 30JUL05 H 1 Analy dup 3	Tadpole	Cascades	PR	39	0.80	1.9	89.0	1.20
DLP 30JUL05 H 2 Analy dup 1	Tadpole	Cascades	PR	35	0.98	2.2	92.0	2.40
DLP 30JUL05 H 2 Analy dup 2	Tadpole	Cascades	PR	35	0.98	2.2	92.0	2.40
DLP 30JUL05 H 2 Analy dup 3	Tadpole	Cascades	PR	35	0.98	2.2	92.0	2.40
DOM 6JUN05 H	Tadpole	Cascades	PR	33	0.47	2.0	90.6	0.40
FND 01AUG05 C	Tadpole	Cascades	RC	25	0.24	1.9	94.9	0.27
FRY 28JUL05 C Analy dup 1	Tadpole	Cascades	RC	37	1.63	2.0	90.0	0.71
FRY 28JUL05 C Analy dup 2	Tadpole	Cascades	RC	37	1.63	2.0	90.0	0.71
FRY 28JUL05 C Analy dup 3	Tadpole	Cascades	RC	37	1.63	1.9	90.0	0.71
FRY 28JUL05 H Analy dup 1	Tadpole	Cascades	PR	40.5	1.04	2.1	89.8	0.62
FRY 28JUL05 H Analy dup 2	Tadpole	Cascades	PR	40.5	1.04	2.1	89.8	0.62
FRY 28JUL05 H Analy dup 3	Tadpole	Cascades	PR	40.5	1.04	2.0	89.8	0.62
GUM 26JUL05 C	Tadpole	Cascades	RC	41	2.10	1.9	90.9	0.76
GUM 26JUL05 H	Tadpole	Cascades	PR	37	0.93	2.0	92.5	0.95
KNG 29JUL05 H Analy dup 1	Tadpole	Cascades	PR	26.5	0.41	2.1	94.1	0.22
KNG 29JUL05 H Analy dup 2	Tadpole	Cascades	PR	26.5	0.41	2.0	94.1	0.22
KNG 29JUL05 H Analy dup 3	Tadpole	Cascades	PR	26.5	0.41	1.8	94.1	0.22
LLY 09JUL05 H 1	Tadpole	Cascades	PR	35	0.93	2.0	91.3	0.55
LLY 09JUL05 H 2	Tadpole	Cascades	PR	28	0.63	1.7	92.4	3.31
LLY 09JUL05 H 3	Tadpole	Cascades	PR	29	0.50	1.5	92.4	0.39
LML 12JUL05 C	Tadpole	Cascades	RC	25	0.48	2.2	95.0	0.67
LML 12JUL05 H	Tadpole	Cascades	PR	25	0.20	2.2	95.1	0.61
LML 23AUG05 C	Tadpole	Cascades	RC	40	3.00	2.2	89.3	1.04
LML 23AUG05 H	Tadpole	Cascades	PR	41	0.99	2.2	89.6	2.10
LML 29JUL05 C	Tadpole	Cascades	RC	27	0.93	2.2	92.5	0.51
LML 29JUL05 H	Tadpole	Cascades	PR	33	0.34	2.0	92.6	0.51
LST 13JUL05 H	Tadpole	Cascades	PR	25	0.23	2.0	95.9	0.30

Sample No	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthlf
ANT 07JUL05 H		aXm		Xm	0.010	m	0.004	m
BAT 08JUN05 H		aXm		X	0.18			aXm
BAT 11JUL05 H		aXm		Xm	0.010	m	0.019	a
BAT 20AUG05 H		aXm		Xm	0.28		0.004	m
BAT 30JUL05 H		aXm		Xm	0.0085	m	0.021	a
BCL 28JUL05 C		aXm		X	0.0092	m	0.048	
BCL 28JUL05 H		aXm		Xm	0.010	m	0.042	
BDR 01AUG05 C		aXm		X	0.0092	m	0.004	m
BDR 01AUG05 H		aXm		Xm	0.010	m	0.016	a
BLF 10JUL05 C 1		aXm		X	0.010	m	0.019	a
BLF 10JUL05 C 2 Analy dup 1		Xm		aXm	0.010	m	0.004	m
BLF 10JUL05 C 2 Analy dup 2		Xm		aXm	0.010	m	0.004	m
BLF 10JUL05 C 2 Analy dup 3		Xm		aXm	0.011	m	0.004	m
BLF 10JUL05 H		aXm		X		Xm	0.031	a
BTY 03AUG05 H		aX		X	0.0092	m	0.110	c
BUT 12JUL05 H		Xm		X	0.010	m		aXm
DCH 10JUL05 H		aXm		X	0.079		0.003	m
DCH 29JUL05 H 1		X		Xm	0.0094	m	0.004	m
DCH 29JUL05 H 2		dX		Xm	0.0094	m	0.004	m
DCH 29JUL05 H 3		dX		Xm	0.010	m	0.004	m
DLP 30JUL05 H 1 Analy dup 1		aXm		X	0.010	m	0.032	ac
DLP 30JUL05 H 1 Analy dup 2		aXdm		X	0.010	m	0.026	ac
DLP 30JUL05 H 1 Analy dup 3		aXdm		X	0.010	m	0.025	ac
DLP 30JUL05 H 2 Analy dup 1		aXm		X	0.0091	m	0.018	a
DLP 30JUL05 H 2 Analy dup 2		aXm		X	0.0091	m	0.014	a
DLP 30JUL05 H 2 Analy dup 3		aXm		X	0.0090	m	0.019	a
DOM 6JUN05 H		aXm		Xm	0.010	m	0.004	m
FND 01AUG05 C		aXm		Xm		X		aXm
FRY 28JUL05 C Analy dup 1		aXm		X		X	0.022	a
FRY 28JUL05 C Analy dup 2		aXm		X		X	0.015	a
FRY 28JUL05 C Analy dup 3		aXm		X		X	0.021	a
FRY 28JUL05 H Analy dup 1		aXm		Xm	0.010	m	0.023	a
FRY 28JUL05 H Analy dup 2		aXm		Xm	0.0095	m	0.052	
FRY 28JUL05 H Analy dup 3		aXm		Xm	0.010	m	0.059	
GUM 26JUL05 C		aXm		X	0.010	m	0.048	a
GUM 26JUL05 H		aX		X		Xm	0.056	
KNG 29JUL05 H Analy dup 1		aXm		X	0.010	m		aX
KNG 29JUL05 H Analy dup 2		aXm		X	0.010	m		aXm
KNG 29JUL05 H Analy dup 3		aXm		X	0.011	m		aX
LLY 09JUL05 H 1		aXm		Xm	0.010	m	0.004	am
LLY 09JUL05 H 2		aXm		Xm	0.012	m	0.005	m
LLY 09JUL05 H 3		aXm		Xm	0.013	m	0.005	m
LML 12JUL05 C		aX		X	0.12		0.050	
LML 12JUL05 H		aX		X	0.11		0.039	
LML 23AUG05 C		aXm		X	0.0088	m	0.031	a
LML 23AUG05 H		aX		X	0.0088	m	0.066	
LML 29JUL05 C		aXm		X	0.0091	m	0.004	m
LML 29JUL05 H		aXm		X	0.010	m	0.004	m
LST 13JUL05 H		aXm		Xm	0.010	m	0.004	m

Sample No	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chordtn ng/g ww	End1 ng/g ww	End1f	Nonatn ng/g ww	Nonatnf
ANT 07JUL05 H		X	0.00058	m	0.0086	m	0.00065	m
BAT 08JUN05 H	0.013	m		aX	0.0092	m	0.00070	m
BAT 11JUL05 H		Xm	0.00056	m	0.019	a	0.00063	m
BAT 20AUG05 H	0.010	m	0.00052	m	0.0077	m	0.00058	m
BAT 30JUL05 H		Xdm	0.00049	m	0.026	a	0.00055	m
BCL 28JUL05 C		Xm	0.00052	m	0.027	ad	0.017	ad
BCL 28JUL05 H		aXdm	0.00058	m	0.0086	m	0.011	a
BDR 01AUG05 C	0.058	ad	0.00053	m	0.0078	m	0.00059	m
BDR 01AUG05 H	0.011	m	0.0045	a	0.0083	m	0.00063	m
BLF 10JUL05 C 1	0.011	m	0.00056	m	0.0083	m	0.00063	m
BLF 10JUL05 C 2 Analy dup 1		Xm	0.00058	m	0.0086	m	0.00066	m
BLF 10JUL05 C 2 Analy dup 2		Xm	0.00058	m	0.0085	m	0.00065	m
BLF 10JUL05 C 2 Analy dup 3		Xm	0.00062	m	0.0092	m	0.00070	m
BLF 10JUL05 H	0.036	d		aXm	0.0075	m	0.00057	m
BTY 03AUG05 H	0.052	ad	0.00053	m	0.0078	m	0.00059	m
BUT 12JUL05 H		aXdm		aX	0.0085	m		aX
DCH 10JUL05 H	0.031	a	0.00049	m	0.0072	m	0.00055	m
DCH 29JUL05 H 1	0.063	ad	0.00054	m	0.0080	m	0.00061	m
DCH 29JUL05 H 2	0.058	ad	0.00054	m	0.0080	m	0.00061	m
DCH 29JUL05 H 3	0.060	ad	0.00059	m	0.0088	m	0.00067	m
DLP 30JUL05 H 1 Analy dup 1		aXdm	0.0015	a	0.0085	m	0.00065	m
DLP 30JUL05 H 1 Analy dup 2		aXdm	0.0030	a	0.0085	m	0.00064	m
DLP 30JUL05 H 1 Analy dup 3		aXdm	0.0077	a	0.0086	m	0.00065	m
DLP 30JUL05 H 2 Analy dup 1	0.12	ad		aX	0.0077	m		aXd
DLP 30JUL05 H 2 Analy dup 2	0.12	ad		aX	0.0077	m		aX
DLP 30JUL05 H 2 Analy dup 3	0.12	ad		aX	0.0077	m		aXd
DOM 6JUN05 H	0.011	m	0.0059	a	0.0082	m	0.0059	a
FND 01AUG05 C		aXm	0.00060	m	0.0089	m	0.0048	a
FRY 28JUL05 C Analy dup 1	0.046			aXm	0.0082	m	0.00062	m
FRY 28JUL05 C Analy dup 2	0.052			aXm	0.0082	m	0.00062	m
FRY 28JUL05 C Analy dup 3	0.058			Xm	0.0090	m	0.00068	m
FRY 28JUL05 H Analy dup 1	0.011	m	0.0044	a	0.017	a	0.00061	m
FRY 28JUL05 H Analy dup 2	0.011	m	0.0058	a	0.084		0.00061	m
FRY 28JUL05 H Analy dup 3	0.054	a	0.0059	a	0.090		0.00062	m
GUM 26JUL05 C		aXdm		aX	0.0086	m	0.025	a
GUM 26JUL05 H		Xdm		Xm	0.0081	m	0.00062	m
KNG 29JUL05 H Analy dup 1		aXm		aX		aXm	0.00061	m
KNG 29JUL05 H Analy dup 2	0.011	m	0.00055	m	0.0082	m	0.00062	m
KNG 29JUL05 H Analy dup 3	0.012	m	0.00061	m	0.0091	m	0.00069	m
LLY 09JUL05 H 1	0.012	adm		aXm	0.0085	m		aX
LLY 09JUL05 H 2	0.014	m	0.00067	m	0.010	m	0.00075	m
LLY 09JUL05 H 3	0.015	m	0.00076	m	0.011	m	0.00086	m
LML 12JUL05 C		Xd		Xm	0.0077	m		aXd
LML 12JUL05 H		Xdm		Xm	0.0081	m	0.00062	m
LML 23AUG05 C	0.010	m		aXm	0.0075	m	0.046	
LML 23AUG05 H	0.010	m		aXm	0.0074	m	0.027	a
LML 29JUL05 C	0.011	m	0.00052	m	0.0077	m	0.00059	m
LML 29JUL05 H	0.011	m	0.00055	m	0.0082	m	0.00062	m
LST 13JUL05 H		aXm	0.13	a	0.0081	m	0.050	

Sample No	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2f	Nonacs ng/g ww	Nonacsf	Endsu ng/g ww	Endsuf
ANT 07JUL05 H		aX	0.0041	m	0.0032	m	0.040	
BAT 08JUN05 H		aXm	0.0044	am	0.0035	m	0.006	m
BAT 11JUL05 H	0.012	am	0.028	a	0.0031	m	0.005	m
BAT 20AUG05 H	0.011	m	0.0037	m	0.0029	m	0.066	
BAT 30JUL05 H	0.011	m	0.036		0.0027	m	0.004	m
BCL 28JUL05 C	0.011	m	0.087		0.014	a	0.066	
BCL 28JUL05 H	0.013	m	0.036	a	0.0033	am	0.005	m
BDR 01AUG05 C	0.011	m	0.0037	m	0.0030	m	0.092	
BDR 01AUG05 H		aXm	0.0040	m	0.0032	m	0.043	
BLF 10JUL05 C 1		aXm	0.0040	m	0.0031	m	0.042	
BLF 10JUL05 C 2 Analy dup 1	0.013	am	0.0041	m	0.0033	m	0.005	m
BLF 10JUL05 C 2 Analy dup 2	0.013	am	0.0041	m	0.0032	m	0.005	m
BLF 10JUL05 C 2 Analy dup 3	0.030	a	0.0044	m	0.0035	m	0.006	m
BLF 10JUL05 H		aXm	0.0036	am	0.0028	m	0.019	a
BTY 03AUG05 H	0.011	m	0.0037	m	0.0030	m	0.230	
BUT 12JUL05 H	0.013	m	0.011	a	0.0032	m	0.026	a
DCH 10JUL05 H		aXm	0.0078	a	0.0027	m	0.052	
DCH 29JUL05 H 1	0.012	m	0.046	a	0.0030	m	0.005	m
DCH 29JUL05 H 2	0.012	m	0.063	a	0.0030	m	0.005	m
DCH 29JUL05 H 3	0.013	m	0.0042	m	0.0033	m	0.005	m
DLP 30JUL05 H 1 Analy dup 1	0.012	m	0.0041	m	0.0032	m	0.101	
DLP 30JUL05 H 1 Analy dup 2	0.012	m	0.0040	m	0.0032	m	0.061	
DLP 30JUL05 H 1 Analy dup 3		aXm	0.0041	m	0.0033	m	0.065	
DLP 30JUL05 H 2 Analy dup 1	0.011	m	0.0037	m	0.0029	m	0.052	
DLP 30JUL05 H 2 Analy dup 2	0.011	m	0.0037	m	0.0029	m	0.038	
DLP 30JUL05 H 2 Analy dup 3	0.011	m	0.0037	m	0.0029	m	0.043	
DOM 6JUN05 H	0.012	m	0.0039	m	0.0031	m	0.024	a
FND 01AUG05 C		aXm	0.0042	m	0.0034	m	0.083	
FRY 28JUL05 C Analy dup 1		aXm	0.0039	m	0.0031	m	0.058	
FRY 28JUL05 C Analy dup 2	0.012	m	0.0039	am	0.0031	m	0.053	
FRY 28JUL05 C Analy dup 3		aXm	0.0043	am	0.0034	m	0.050	
FRY 28JUL05 H Analy dup 1	0.012	m	0.0039	m	0.0031	m	0.073	
FRY 28JUL05 H Analy dup 2	0.012	m	0.0038	m	0.0031	m	0.071	
FRY 28JUL05 H Analy dup 3	0.012	m	0.0039	m	0.0031	m	0.078	
GUM 26JUL05 C		aX	0.0041	m	0.012	a	0.059	
GUM 26JUL05 H		aXm	0.0039	am	0.0031	m	0.016	a
KNG 29JUL05 H Analy dup 1	0.012	m	0.0039	m	0.0031	m	0.128	
KNG 29JUL05 H Analy dup 2	0.012	m	0.0039	m	0.0031	m	0.120	
KNG 29JUL05 H Analy dup 3	0.013	m	0.0044	m	0.0035	m	0.128	
LLY 09JUL05 H 1	0.012	m	0.0041	am	0.0032	m	0.005	am
LLY 09JUL05 H 2	0.015	m	0.0047	m	0.0038	m	0.006	m
LLY 09JUL05 H 3	0.017	m	0.0054	m	0.0043	m	0.007	m
LML 12JUL05 C		Xm	0.011	a	0.0029	m	0.024	a
LML 12JUL05 H		aXm	0.012	a	0.0031	m		aXm
LML 23AUG05 C	0.011	m	0.0036	m	0.016	a	0.065	
LML 23AUG05 H	0.011	m	0.0036	m	0.019	a	0.064	
LML 29JUL05 C	0.011	m	0.0037	m	0.0029	m	0.061	
LML 29JUL05 H	0.012	m	0.0039	m	0.0031	m	0.053	
LST 13JUL05 H		aXm	0.010	a	0.0031	m	0.043	

Sample No	Pcb153 ng/g ww	Pcb153f	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f
ANT 07JUL05 H	0.010	m	0.053	m	0.0017	m	0.0015	m
BAT 08JUN05 H		aXm		aXm	0.0050	a	0.0016	m
BAT 11JUL05 H		aXm	0.051	m	0.0074	a	0.0014	am
BAT 20AUG05 H	0.0092	m	0.047	m	0.0041	a	0.0013	m
BAT 30JUL05 H		aXm	0.044	m	0.0078	a	0.0026	a
BCL 28JUL05 C		aXm	0.048	m	0.010	a	0.0070	a
BCL 28JUL05 H		aXm	0.053	m	0.0093	a	0.0031	a
BDR 01AUG05 C	0.0094	m	0.048	m	0.0016	m	0.0014	m
BDR 01AUG05 H		aXm		aXm	0.0017	m	0.0015	m
BLF 10JUL05 C 1		aXm		aXm	0.0016	m	0.0015	m
BLF 10JUL05 C 2 Analy dup 1	0.010	m	0.053	m	0.0017	m	0.0015	m
BLF 10JUL05 C 2 Analy dup 2	0.010	am	0.053	m	0.0017	m	0.0015	m
BLF 10JUL05 C 2 Analy dup 3	0.011	m	0.057	m	0.0018	m	0.0016	m
BLF 10JUL05 H	0.0090	am	0.046	m	0.0015	m	0.0013	m
BTY 03AUG05 H	0.0094	m	0.048	m	0.0070	a	0.0014	m
BUT 12JUL05 H		aXm	0.053	m		aXm		aXm
DCH 10JUL05 H		aXm	0.044	m	0.0014	am	0.0013	m
DCH 29JUL05 H 1	0.010	m	0.049	m	0.0016	m	0.0014	m
DCH 29JUL05 H 2	0.010	m	0.049	m	0.0016	m	0.0014	m
DCH 29JUL05 H 3	0.010	m	0.054	m	0.0017	m	0.0015	m
DLP 30JUL05 H 1 Analy dup 1		aXm	0.053	m	0.0017	m	0.0015	m
DLP 30JUL05 H 1 Analy dup 2		aXm	0.052	m	0.0017	am	0.0015	m
DLP 30JUL05 H 1 Analy dup 3		aXm	0.053	m	0.0017	am	0.0015	am
DLP 30JUL05 H 2 Analy dup 1	0.0093	m	0.048	m	0.0015	m	0.0014	m
DLP 30JUL05 H 2 Analy dup 2	0.0093	m	0.048	m	0.0015	m	0.0014	m
DLP 30JUL05 H 2 Analy dup 3	0.0092	m	0.047	m	0.0015	m	0.0013	m
DOM 6JUN05 H	0.010	m	0.050	m	0.0016	am	0.0014	m
FND 01AUG05 C		aXm		aXm	0.0018	am	0.0016	m
FRY 28JUL05 C Analy dup 1	0.021	a	0.051	m	0.0059	a	0.0014	m
FRY 28JUL05 C Analy dup 2	0.010	am	0.051	am	0.0044	a	0.0014	m
FRY 28JUL05 C Analy dup 3		aXm	0.055	am	0.0081	a	0.0016	m
FRY 28JUL05 H Analy dup 1	0.010	am	0.050	m	0.0016	am	0.0014	m
FRY 28JUL05 H Analy dup 2	0.010	am	0.050	m	0.0016	am	0.0014	m
FRY 28JUL05 H Analy dup 3	0.022	a	0.050	m	0.0044	a	0.0014	m
GUM 26JUL05 C		aX		aXm	0.025	a	0.0093	a
GUM 26JUL05 H	0.037		0.050	m		aX	0.0014	m
KNG 29JUL05 H Analy dup 1	0.010	am		aXm	0.0016	am	0.0014	m
KNG 29JUL05 H Analy dup 2	0.010	m		aXm	0.0016	m	0.0014	m
KNG 29JUL05 H Analy dup 3	0.011	m		aXm	0.0018	am	0.0016	m
LLY 09JUL05 H 1		aXm	0.052	m	0.0017	am		aXm
LLY 09JUL05 H 2	0.012	m	0.061	m	0.0020	m	0.0017	m
LLY 09JUL05 H 3	0.014	m	0.070	m	0.0022	m	0.0020	m
LML 12JUL05 C		aXm		aXm	0.0042	a	0.0014	m
LML 12JUL05 H		aXm		Xm	0.0016	am	0.0014	m
LML 23AUG05 C		aXm	0.046	am	0.0094	a	0.0013	m
LML 23AUG05 H		aX	0.046	m	0.0080	a	0.0013	am
LML 29JUL05 C	0.0093	m	0.048	am	0.0042	a	0.0014	m
LML 29JUL05 H	0.010	m	0.051	m	0.0016	m	0.0014	m
LST 13JUL05 H		aX		aXm	0.016	a	0.0073	a

Sample No	Fluor ng/g ww	Fluorf	Phen an ng/g ww	Phen anf	Flrant ng/g ww	Flrantf	Retene ng/g ww	Reten ef	Dde ng/g ww	Dd ef
ANT 07JUL05 H		Xm		X	0.439		6.4		0.14	m
BAT 08JUN05 H		X		X		X	5.6		0.15	m
BAT 11JUL05 H	0.19	m	0.15	m	0.064	m	8.3		0.13	m
BAT 20AUG05 H		Xm		Xm	0.060	m	7.5		0.12	m
BAT 30JUL05 H		Xm		Xm	0.056	m	4.5		0.12	m
BCL 28JUL05 C		Xm		Xm	0.061	m	0.26	m	0.12	m
BCL 28JUL05 H		Xm		Xm	0.067	m	5.8		0.14	m
BDR 01AUG05 C		Xm		Xm	0.061	m	0.26	m	0.13	m
BDR 01AUG05 H		Xm		X	0.065	m	3.3		0.13	m
BLF 10JUL05 C 1	0.19	m		X	0.064	m	3.5		0.13	m
BLF 10JUL05 C 2 Analy dup 1		Xm		Xm	0.067	m	1.6		0.14	m
BLF 10JUL05 C 2 Analy dup 2		X		Xm	0.067	m	1.4		0.14	m
BLF 10JUL05 C 2 Analy dup 3		Xm		Xm	0.072	m	1.4		0.15	m
BLF 10JUL05 H		Xm		X		Xm	121		0.12	m
BTY 03AUG05 H		X		X	0.061	m	50		0.13	m
BUT 12JUL05 H		Xm		Xm		Xm	3.9		0.14	m
DCH 10JUL05 H		Xm		Xm	0.47		0.91		0.12	m
DCH 29JUL05 H 1	0.18	m		X	0.062	m	0.27	m	0.13	m
DCH 29JUL05 H 2	0.18	m		X	0.062	m	0.27	m	0.13	m
DCH 29JUL05 H 3	0.20	m		X	0.068	m	0.29	m	0.14	m
DLP 30JUL05 H 1 Analy dup 1		Xm		X	0.066	m	0.28	m	0.14	m
DLP 30JUL05 H 1 Analy dup 2		Xm		X	0.066	m	0.28	m	0.14	m
DLP 30JUL05 H 1 Analy dup 3		Xm		X	0.067	m	0.29	m	0.14	m
DLP 30JUL05 H 2 Analy dup 1		X		X		Xm	0.26	m	0.12	m
DLP 30JUL05 H 2 Analy dup 2		X		Xm		Xm	0.26	m	0.12	m
DLP 30JUL05 H 2 Analy dup 3		X		Xm		Xm	0.25	m	0.12	m
DOM 6JUN05 H		Xm		Xm	0.064	m	0.80		0.13	m
FND 01AUG05 C		Xm		Xm	0.069	m	0.69		0.14	m
FRY 28JUL05 C Analy dup 1		Xm		X		Xm		X	0.13	m
FRY 28JUL05 C Analy dup 2		Xm		X		Xm		X	0.13	m
FRY 28JUL05 C Analy dup 3		Xm		X		Xm		X	0.14	m
FRY 28JUL05 H Analy dup 1		Xm		Xm	0.063	m		Xm	0.13	m
FRY 28JUL05 H Analy dup 2		Xm		Xm	0.063	m		Xm	0.13	m
FRY 28JUL05 H Analy dup 3		Xm		X	0.064	m		Xm	0.13	m
GUM 26JUL05 C		X		Xm	0.067	m	0.28	m	0.43	G
GUM 26JUL05 H		Xm		X	0.36		0.27	m	0.13	m
KNG 29JUL05 H Analy dup 1		Xm		X	0.063	m	0.27	m	0.13	m
KNG 29JUL05 H Analy dup 2		Xm		X	0.39		0.27	m	0.13	m
KNG 29JUL05 H Analy dup 3		Xm		X	0.44		0.30	m	0.15	m
LLY 09JUL05 H 1		Xm		X	0.066	m	2.0		0.14	m
LLY 09JUL05 H 2	0.22	m	0.18	m	0.077	m	0.33	m	0.16	m
LLY 09JUL05 H 3	0.25	m		Xm	0.088	m	0.37	m	0.18	m
LML 12JUL05 C		Xm		X	0.060	m	7.3		0.12	m
LML 12JUL05 H		X		X		Xm	1.4		0.13	m
LML 23AUG05 C		Xm		X		Xm	11		0.61	
LML 23AUG05 H		Xm		X	0.058	m	8.0		0.79	
LML 29JUL05 C		X		X	0.44		8.3		0.12	m
LML 29JUL05 H		Xm		Xm	0.35		3.1		0.13	m
LST 13JUL05 H		Xm		X	0.80		0.27	m	0.13	m

Sample No	Matrix	Region	Species	Stage	Tadpole Weight	g extracted	moisture % ww	lipid % ww
LST 19AUG05 H 1	Tadpole	Cascades	PR	40.5	1.55	1.9	88.2	1.14
LST 19AUG05 H 2	Tadpole	Cascades	PR	40.5	2.05	2.0	88.8	0.55
LST 19AUG05 H 3	Tadpole	Cascades	PR	40.5	1.85	2.0	87.6	1.24
MBP 08JUL05 C Analy dup 1	Tadpole	Cascades	RC	25	0.59	2.1	94.1	0.16
MBP 08JUL05 C Analy dup 2	Tadpole	Cascades	RC	25	0.59	2.1	94.1	0.16
MBP 08JUL05 C Analy dup 3	Tadpole	Cascades	RC	25	0.59	1.9	94.1	0.16
MBP 08JUL05 H Analy dup 1	Tadpole	Cascades	PR	25	0.30	1.8	95.1	0.22
MBP 08JUL05 H Analy dup 2	Tadpole	Cascades	PR	25	0.30	2.0	95.1	0.22
MBP 08JUL05 H Analy dup 3	Tadpole	Cascades	PR	25	0.30	2.0	95.1	0.22
MBP 22AUG05 C	Tadpole	Cascades	RC	41	1.90	2.0	88.3	1.23
MBP 22AUG05 H	Tadpole	Cascades	PR	40	0.91	2.0	90.5	1.39
MBP 29JUL05 C	Tadpole	Cascades	RC	27	1.40	2.0	92.1	0.38
MBP 29JUL05 H	Tadpole	Cascades	PR	38	0.79	2.1	93.2	0.14
MCC 7JUL05 H	Tadpole	Cascades	PR	25	0.19	2.0	93.6	0.16
MEB 29JUL05 C	Tadpole	Cascades	RC	27	0.51	1.9	92.3	0.54
MEB 29JUL05 H	Tadpole	Cascades	PR	25	0.20	2.1	94.0	
MUM 06JUL05 C	Tadpole	Cascades	RC	25	0.55	2.3	94.6	0.54
MUM 06JUL05 H	Tadpole	Cascades	PR	25	0.20	2.2	94.2	0.79
MUM 22AUG05 C 1	Tadpole	Cascades	RC		1.13	2.2	89.1	1.93
MUM 22AUG05 C 2	Tadpole	Cascades	RC	40.5	2.00	2.1	90.3	0.53
MUM 22AUG05 C 3	Tadpole	Cascades	RC	40.5	2.20	1.5	87.5	0.83
MUM 27JUL05 C 1	Tadpole	Cascades	RC	25	1.07	1.9	91.7	0.52
MUM 27JUL05 C 2	Tadpole	Cascades	RC	34	1.45	1.8	90.4	0.93
MUM 27JUL05 C 3	Tadpole	Cascades	RC	34	1.30	2.3	91.4	0.14
MUM 27JUL05 H 1	Tadpole	Cascades	PR	25	0.67	2.1	91.9	0.71
MUM 27JUL05 H 2	Tadpole	Cascades	PR	31	0.56	1.9	92.9	0.48
MUM 27JUL05 H 3	Tadpole	Cascades	PR	31	0.48	1.8	92.2	0.32
NEL 08JUL05 C	Tadpole	Cascades	RC	25	0.56	2.0	92.9	0.45
SKW 08JUL05 C	Tadpole	Cascades	RC	29	1.32	2.0	94.2	0.46
SKW 08JUL05 H 1	Tadpole	Cascades	PR	25	0.58	1.9	94.1	0.04
SKW 08JUL05 H 2	Tadpole	Cascades	PR	29	0.66	1.7	91.4	0.68
SKW 08JUL05 H 3	Tadpole	Cascades	PR	29	0.66	1.7	94.4	0.16
SNG 13JUL05 H	Tadpole	Cascades	PR	33.5	0.77	2.1	89.6	0.36
SNW 07JUN05 H	Tadpole	Cascades	PR	25	0.10	2.0	95.9	0.25
SNW 09JUL05 H	Tadpole	Cascades	PR	37	1.31	2.0	90.5	0.99
SNW 29JUL05 H	Tadpole	Cascades	PR	41	1.70	2.2	89.0	1.79
TNG 12JUL05 C	Tadpole	Cascades	RC	25	0.28	2.0	94.9	0.35
UEB 29JUL05 C	Tadpole	Cascades	RC	31.5	1.08	1.8	91.6	0.88
UEB 29JUL05 H	Tadpole	Cascades	PR	31.5	0.37	1.9	91.2	1.23
UGB 27JUL05 H	Tadpole	Cascades	PR	27	0.65	2.0	94.1	0.52
ULC 31JUL05 C	Tadpole	Cascades	RC	28	0.56	2.0	92.9	0.44
ULC 31JUL05 H	Tadpole	Cascades	PR	25	0.49	2.4	93.7	0.54
UNL 31JUL05 C	Tadpole	Cascades	RC	28	0.88	2.0	94.1	0.44
WCP 30JUL05 H 1	Tadpole	Cascades	PR	35	0.87	1.9	90.8	0.88
WCP 30JUL05 H 2	Tadpole	Cascades	PR	37	1.12	2.1	91.0	0.41
WCP 30JUL05 H 3	Tadpole	Cascades	PR	36	1.15	2.1	92.6	0.34
YEL 13JUL05 H	Tadpole	Cascades	PR	31.5	0.67	2.1	92.4	0.15

Sample No	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthlf
LST 19AUG05 H 1		adXm		Xm	0.010	m	0.043	
LST 19AUG05 H 2		X		dXm	0.010	m	0.021	ad
LST 19AUG05 H 3		X		Xm	0.010	m	0.041	
MBP 08JUL05 C Analy dup 1		aXm		X	0.072			aXm
MBP 08JUL05 C Analy dup 2		aXm		X	0.065			aXm
MBP 08JUL05 C Analy dup 3		aXm		X	0.11			aXm
MBP 08JUL05 H Analy dup 1		aXm		X	0.011	m		aXm
MBP 08JUL05 H Analy dup 2		aXm		X	0.010	m		aXm
MBP 08JUL05 H Analy dup 3		aXm		X	0.010	m		aXm
MBP 22AUG05 C		aXm		X	0.010	m	0.038	
MBP 22AUG05 H		aXm		X	0.010	m	0.034	a
MBP 29JUL05 C		aXm		Xm	0.010	m	0.030	
MBP 29JUL05 H		aXm		X	0.010	m		aX
MCC 7JUL05 H		aX		X	0.010	m	0.015	a
MEB 29JUL05 C		aX		X		Xm	0.025	a
MEB 29JUL05 H		aXm		X		Xm	0.031	a
MUM 06JUL05 C		Xm		Xm	0.0087	m		aX
MUM 06JUL05 H		aXm		X	0.0091	m		aXm
MUM 22AUG05 C 1		aXm		X	0.0088	m		aX
MUM 22AUG05 C 2		Xm		Xm	0.0095	m	0.004	m
MUM 22AUG05 C 3		Xm		Xm	0.013	m	0.005	m
MUM 27JUL05 C 1		Xm		X	0.010	m		aX
MUM 27JUL05 C 2		aXm		Xm	0.011	m	0.004	m
MUM 27JUL05 C 3		adXm		Xm	0.0087	m	0.003	m
MUM 27JUL05 H 1		Xm		X	0.0093	m		aX
MUM 27JUL05 H 2		aXm		Xm	0.010	m	0.004	m
MUM 27JUL05 H 3		adXm		Xm	0.011	m	0.004	m
NEL 08JUL05 C		aXm		X	0.010	m	0.018	a
SKW 08JUL05 C		aXm		Xm	0.010	m	0.004	m
SKW 08JUL05 H 1		aXm		Xd	0.011	m	0.011	a
SKW 08JUL05 H 2		aXm		Xm	0.012	m	0.005	m
SKW 08JUL05 H 3		aXm		Xm	0.012	m	0.005	m
SNG 13JUL05 H		aXm		X	0.0093	m		aX
SNW 07JUN05 H		aXm		Xm	0.010	m	0.004	m
SNW 09JUL05 H		aXm		X		Xm	0.013	a
SNW 29JUL05 H		aXdm		X		Xm	0.004	m
TNG 12JUL05 C		aXm		Xm	0.010	m	0.004	m
UEB 29JUL05 C		aXm		X	0.011	m	0.056	
UEB 29JUL05 H		aXm		X		Xm	0.043	
UGB 27JUL05 H		X		aXm	0.010	m	0.060	ac
ULC 31JUL05 C		aXm		X	0.010	m		aX
ULC 31JUL05 H		aXm		X	0.0082	m	0.019	a
UNL 31JUL05 C		aXm		Xm	0.010	m	0.028	
WCP 30JUL05 H 1		Xm		X	0.010	m		aX
WCP 30JUL05 H 2		aXm		Xm	0.0095	m	0.004	m
WCP 30JUL05 H 3		adXm		Xm	0.0095	m	0.004	m
YEL 13JUL05 H		aX		X	0.15		0.004	m

Sample No	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chordtn ng/g ww	End1 ng/g ww	End1f	Nonatn ng/g ww	Nonatnf
LST 19AUG05 H 1	0.012	m	0.010	ad	0.0089	m	0.013	ad
LST 19AUG05 H 2	0.053	ad	0.0030	ad	0.0085	m	0.0046	ad
LST 19AUG05 H 3	0.064	ad	0.0091	ad	0.0084	m	0.015	ad
MBP 08JUL05 C Analy dup 1	0.056	d	0.00053	m	0.0078	m	0.00060	m
MBP 08JUL05 C Analy dup 2	0.057	d	0.00053	m	0.0079	m	0.00060	m
MBP 08JUL05 C Analy dup 3	0.057	d	0.00060	m	0.0088	m	0.00067	m
MBP 08JUL05 H Analy dup 1		aXdm	0.00061	m	0.029	a	0.00069	m
MBP 08JUL05 H Analy dup 2		aXdm	0.00057	m	0.0085	m	0.00064	m
MBP 08JUL05 H Analy dup 3		aXdm	0.00057	m	0.029	ad	0.00064	m
MBP 22AUG05 C	0.083	d	0.00057	m	0.0084	m	0.023	a
MBP 22AUG05 H	0.011	m	0.00056	m	0.0083	m	0.00063	m
MBP 29JUL05 C	0.063	ad	0.00057	m	0.0084	m	0.00064	m
MBP 29JUL05 H	0.052	ad	0.00055	m	0.0081	m	0.00062	m
MCC 7JUL05 H	0.11	ad		aX	0.0082	m		aX
MEB 29JUL05 C		Xm		Xm	0.0087	m	0.00066	m
MEB 29JUL05 H	0.034	ad		aXm	0.0078	m	0.00059	m
MUM 06JUL05 C		aXdm		aX	0.0073	m		aX
MUM 06JUL05 H		aXdm		aX	0.0077	m		aX
MUM 22AUG05 C 1		aXdm		aX	0.0075	m	0.022	a
MUM 22AUG05 C 2	0.052	ad	0.010	ad	0.0080	m	0.016	ad
MUM 22AUG05 C 3	0.059	ad	0.0081	ad	0.011	m	0.00086	m
MUM 27JUL05 C 1		aXdm		aX	0.0087	m		aX
MUM 27JUL05 C 2	0.013	m	0.00064	m	0.0094	m	0.00072	m
MUM 27JUL05 C 3	0.010	m	0.0066	ad	0.0074	m	0.011	ad
MUM 27JUL05 H 1		aXdm		aX	0.0079	m	0.018	a
MUM 27JUL05 H 2	0.012	m	0.00060	m	0.0089	m	0.00067	m
MUM 27JUL05 H 3	0.013	m	0.00063	m	0.0094	m	0.00071	m
NEL 08JUL05 C		Xdm	0.0015	ad	0.027	ad	0.022	a
SKW 08JUL05 C		aX	0.0088	a	0.0082	m	0.015	a
SKW 08JUL05 H 1	0.124	a		aX	0.0090	m		aX
SKW 08JUL05 H 2	0.014	m	0.00067	m	0.010	m	0.00075	m
SKW 08JUL05 H 3	0.014	m	0.00067	m	0.010	m	0.00075	m
SNG 13JUL05 H		aXm	0.023	a	0.0079	m	0.023	a
SNW 07JUN05 H		Xm		Xm	0.0085	am	0.00064	m
SNW 09JUL05 H		Xm		aXm	0.0082	m	0.00062	m
SNW 29JUL05 H		aXdm		Xdm	0.0077	m	0.00058	m
TNG 12JUL05 C		aXd	0.0073	a	0.0082	m	0.00062	m
UEB 29JUL05 C		aXm	0.019	a	0.0094	m	0.025	a
UEB 29JUL05 H		Xm		aXdm	0.020	ad	0.0016	ad
UGB 27JUL05 H	0.050	ad	0.0045	ad	0.008	m	0.0015	ad
ULC 31JUL05 C		aXm		aX	0.008	m	0.018	a
ULC 31JUL05 H	0.083	ad		aX	0.007	m		aX
UNL 31JUL05 C		aXdm	0.0044	a	0.008	m	0.00062	m
WCP 30JUL05 H 1		aXdm		aX	0.009	m		aX
WCP 30JUL05 H 2	0.011	m	0.00054	m	0.008	m	0.00061	m
WCP 30JUL05 H 3	0.011	m	0.00054	m	0.008	m	0.00061	m
YEL 13JUL05 H		Xm	0.00055	m	0.008	m	0.00061	m

Sample No	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2f	Nonacs ng/g ww	Nonacsf	Endsu ng/g ww	Endsuf
LST 19AUG05 H 1	0.013	m	0.062	a	0.0034	m	0.037	a
LST 19AUG05 H 2		Xm	0.0040	m	0.0032	m	0.020	ad
LST 19AUG05 H 3		aXm	0.0040	m	0.0032	m	0.058	
MBP 08JUL05 C Analy dup 1	0.024	a	0.0085	a	0.0030	m	0.016	a
MBP 08JUL05 C Analy dup 2	0.025	a	0.0038	am	0.0030	m	0.014	a
MBP 08JUL05 C Analy dup 3	0.013	am	0.011	a	0.0034	m	0.018	a
MBP 08JUL05 H Analy dup 1	0.013	m	0.028	a	0.0035	m	0.006	m
MBP 08JUL05 H Analy dup 2	0.012	m	0.031	a	0.0032	m	0.005	m
MBP 08JUL05 H Analy dup 3	0.012	m	0.044		0.0032	m	0.005	m
MBP 22AUG05 C	0.012	m	0.0040	m	0.0032	m	0.005	m
MBP 22AUG05 H	0.012	m	0.0040	m	0.0032	m	0.005	m
MBP 29JUL05 C	0.012	m	0.0040	m	0.0032	m	0.104	
MBP 29JUL05 H	0.012	m	0.0039	m	0.0031	m	0.061	
MCC 7JUL05 H	0.012	m	0.012	a	0.010	a	0.019	a
MEB 29JUL05 C		aXm	0.0041	m	0.003	m	0.020	a
MEB 29JUL05 H		aXm	0.0037	am	0.0030	m	0.025	a
MUM 06JUL05 C	0.011	m	0.013	a	0.0028	m	0.063	
MUM 06JUL05 H	0.011	m	0.014	a	0.0029	m	0.049	
MUM 22AUG05 C 1	0.011	m	0.016	a	0.0094	a	0.125	
MUM 22AUG05 C 2	0.012	m	0.0038	m	0.012	a	0.041	
MUM 22AUG05 C 3	0.017	m	0.0054	m	0.0043	m	0.043	a
MUM 27JUL05 C 1	0.013	m	0.011	a	0.0033	am	0.066	
MUM 27JUL05 C 2	0.014	m	0.0045	m	0.0036	m	0.006	m
MUM 27JUL05 C 3	0.011	m	0.0035	m	0.0028	m	0.025	a
MUM 27JUL05 H 1	0.012	m	0.020	a	0.0030	am	0.065	
MUM 27JUL05 H 2	0.013	m	0.0042	m	0.0034	m	0.005	m
MUM 27JUL05 H 3	0.014	m	0.090	a	0.0036	m	0.006	m
NEL 08JUL05 C	0.059	G	0.028	a	0.0088	a	0.106	
SKW 08JUL05 C		aXm	0.0039	m	0.0031	m	0.063	
SKW 08JUL05 H 1	0.013	m	0.016	a	0.0034	m	0.031	ac
SKW 08JUL05 H 2		aXm	0.0047	m	0.0038	m	0.006	m
SKW 08JUL05 H 3		Xm	0.0047	m	0.0038	m	0.006	m
SNG 13JUL05 H		aXm	0.0038	m	0.0030	am	0.051	
SNW 07JUN05 H		aXm	0.0040	am	0.0032	m	0.005	m
SNW 09JUL05 H		Xm	0.0039	am	0.0031	m	0.019	a
SNW 29JUL05 H		X	0.0037	adm	0.0029	m	0.022	ad
TNG 12JUL05 C	0.012	m	0.0039	m	0.0031	m	0.041	
UEB 29JUL05 C		aXm	0.0045	m	0.017	a	0.134	
UEB 29JUL05 H		aXm	0.019	a	0.0033	m	0.093	
UGB 27JUL05 H	0.012	am	0.027	a	0.0090	a	0.060	a
ULC 31JUL05 C	0.012	m	0.0040	m	0.0031	am	0.052	
ULC 31JUL05 H	0.010	m	0.0088	a	0.0026	am	0.033	
UNL 31JUL05 C	0.012	m	0.0039	adm	0.0031	m	0.005	m
WCP 30JUL05 H 1	0.013	m	0.017	a	0.0033	m	0.019	a
WCP 30JUL05 H 2	0.012	m	0.0038	m	0.0030	m	0.005	m
WCP 30JUL05 H 3	0.012	m	0.062	a	0.0030	m	0.005	m
YEL 13JUL05 H	0.047	a	0.0039	m	0.0031	m	0.005	m

Sample No	Pcb153 ng/g ww	Pcb153f	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f
LST 19AUG05 H 1	0.011	m	0.055	m	0.0018	m	0.0016	m
LST 19AUG05 H 2	0.010	m	0.052	m	0.0017	m	0.0015	m
LST 19AUG05 H 3	0.010	m	0.052	m	0.0017	m	0.0015	m
MBP 08JUL05 C Analy dup 1		aXm	0.048	am	0.0016	am	0.0014	m
MBP 08JUL05 C Analy dup 2	0.027		0.049	m	0.0099	a	0.0014	m
MBP 08JUL05 C Analy dup 3		aXm	0.055	am	0.0018	am	0.0016	m
MBP 08JUL05 H Analy dup 1		aXm	0.056	m	0.0049	a	0.0016	am
MBP 08JUL05 H Analy dup 2		aXm	0.052	m	0.0061	a	0.0015	m
MBP 08JUL05 H Analy dup 3		aXm	0.052	m	0.0076	a	0.0046	a
MBP 22AUG05 C	0.010	m	0.052	m	0.024	a	0.0015	m
MBP 22AUG05 H	0.010	m	0.051	m	0.0017	m	0.0015	m
MBP 29JUL05 C		aXm	0.052	m	0.0076	a	0.0015	m
MBP 29JUL05 H	0.010	m	0.050	m	0.0016	m	0.0014	m
MCC 7JUL05 H		aXm		aXm	0.0059	a	0.0044	a
MEB 29JUL05 C	0.025	a		aXm	0.0047	a	0.0015	m
MEB 29JUL05 H		aXm	0.048	m	0.0016	am	0.0014	m
MUM 06JUL05 C		aXm	0.045	m		aXm		aXm
MUM 06JUL05 H		aXm	0.048	m		aXm		aXm
MUM 22AUG05 C 1		aXm	0.046	m		aX		aX
MUM 22AUG05 C 2	0.010	m	0.050	m	0.0016	m	0.0014	m
MUM 22AUG05 C 3	0.013	m	0.070	m	0.0022	m	0.0020	m
MUM 27JUL05 C 1		aXm	0.054	m		aX		aXm
MUM 27JUL05 C 2	0.011	m	0.058	m	0.0019	m	0.0017	m
MUM 27JUL05 C 3	0.0088	m	0.045	m	0.0015	m	0.0013	m
MUM 27JUL05 H 1		aXm	0.049	m	0.0071	a		aX
MUM 27JUL05 H 2	0.011	m	0.055	m	0.0018	m	0.0016	m
MUM 27JUL05 H 3	0.011	m	0.058	m	0.0019	m	0.0016	m
NEL 08JUL05 C	0.45		0.40		0.25		0.116	
SKW 08JUL05 C		aXm		aXm	0.0016	am	0.0014	m
SKW 08JUL05 H 1		aXm	0.055	m		aXm		aXm
SKW 08JUL05 H 2	0.012	m	0.061	m	0.0020	m	0.0017	m
SKW 08JUL05 H 3	0.012	m	0.061	m	0.0020	m	0.0017	m
SNG 13JUL05 H		aXm		aXm	0.0043	a	0.0014	m
SNW 07JUN05 H		aXm		aXm	0.0017	m	0.0015	m
SNW 09JUL05 H	0.048		0.050	m	0.0073	a	0.0014	m
SNW 29JUL05 H	0.054		0.047	m	0.0069	a	0.0013	m
TNG 12JUL05 C	0.010	m	0.050	m	0.0016	m	0.0014	m
UEB 29JUL05 C		aXm		aXm	0.0019	am	0.0017	m
UEB 29JUL05 H		aXm		aXm	0.0017	am	0.0015	m
UGB 27JUL05 H	0.021	a	0.052	am	0.0075	a	0.0075	a
ULC 31JUL05 C		aXm		aXm	0.0016	am	0.0015	m
ULC 31JUL05 H		aXm	0.043	m	0.0014	am		aXm
UNL 31JUL05 C		aXm	0.050	m	0.0044	a	0.0014	am
WCP 30JUL05 H 1		aXm		Xm		aXm		aXm
WCP 30JUL05 H 2	0.010	m	0.050	m	0.0016	m	0.0014	m
WCP 30JUL05 H 3	0.010	m	0.050	m	0.0016	m	0.0014	m
YEL 13JUL05 H	0.10		0.050	m	0.067		0.023	a

Sample No	Fluor ng/g ww	Fluor f	Phenan ng/g ww	Phenanf	Flrant ng/g ww	Flrantf	Retene ng/g ww	Retenef	Dde ng/g ww	Ddef
LST 19AUG05 H 1	0.20	m		Xm	0.069	m	0.29	m	0.14	m
LST 19AUG05 H 2	0.19	m		dXm	0.066	m	0.28	m	0.14	m
LST 19AUG05 H 3	0.19	m		Xm	0.066	m	0.28	m	0.14	m
MBP 08JUL05 C Analy dup 1		Xm		Xm	0.061	m	24		0.13	m
MBP 08JUL05 C Analy dup 2		Xm		Xm	0.061	m	57		0.13	m
MBP 08JUL05 C Analy dup 3		Xm		Xm	0.069	m	26		0.14	m
MBP 08JUL05 H Analy dup 1		Xm		Xm	0.071	m	4.0		0.15	m
MBP 08JUL05 H Analy dup 2		Xm		Xm	0.066	m	4.3		0.14	m
MBP 08JUL05 H Analy dup 3		Xm		Xm	0.066	m	3.3		0.14	m
MBP 22AUG05 C	0.189	m		X	0.065	m	32		0.13	m
MBP 22AUG05 H		Xm		Xm	0.065	m	19		0.13	m
MBP 29JUL05 C		Xm		Xm	0.065	m	0.28	m	0.13	m
MBP 29JUL05 H		Xm		Xm	0.063	m	0.27	m	0.13	m
MCC 7JUL05 H		Xm		X		Xm	0.83		0.13	m
MEB 29JUL05 C		Xm		Xm	0.42		1.7		0.14	m
MEB 29JUL05 H		Xm		Xm		Xm		Xm	0.13	m
MUM 06JUL05 C		Xm		X		Xm	1.5		0.12	m
MUM 06JUL05 H		Xm		X		Xm	0.84		0.12	m
MUM 22AUG05 C 1		Xm		X		Xm	18		0.35	
MUM 22AUG05 C 2	0.18	m		Xm	0.063	m	27		0.13	m
MUM 22AUG05 C 3	0.25	m		Xm	0.088	m	10		0.18	m
MUM 27JUL05 C 1		Xm		Xm		Xm	1.1		0.14	m
MUM 27JUL05 C 2	0.21	m		Xm	0.073	m	0.31	m	0.15	m
MUM 27JUL05 C 3	0.17	m		Xm	0.057	m	0.24	m	0.12	m
MUM 27JUL05 H 1		Xm		Xm		Xm	0.68		0.13	m
MUM 27JUL05 H 2	0.20	m		Xm	0.069	m	0.29	m	0.14	m
MUM 27JUL05 H 3	0.21	m		Xm	0.073	m	0.31	m	0.15	m
NEL 08JUL05 C		Xm		Xm	0.064	m	5.0		0.17	m
SKW 08JUL05 C		Xm		Xm	0.064	m	0.27	m	0.13	m
SKW 08JUL05 H 1		Xm		X		Xm	0.30	m	0.14	m
SKW 08JUL05 H 2	0.22	m		Xm	0.077	m	0.33	m	0.16	m
SKW 08JUL05 H 3	0.22	m		Xm	0.077	m	0.33	m	0.16	m
SNG 13JUL05 H		Xm		X	0.64		9.8		0.13	m
SNW 07JUN05 H		Xm		Xm	0.36		0.88		0.14	m
SNW 09JUL05 H		Xm		Xm	0.32			X	0.13	m
SNW 29JUL05 H		Xm		Xm	0.060	m	2.8		0.12	m
TNG 12JUL05 C		Xm		X	0.44		0.78		0.13	m
UEB 29JUL05 C		Xm		Xm	0.073	m	1.2		0.15	m
UEB 29JUL05 H		Xm		Xm	0.068	m	1.3		0.14	m
UGB 27JUL05 H		Xm		Xm	0.065	m		Xm	0.13	m
ULC 31JUL05 C		Xm		X	0.065	m		X	0.13	m
ULC 31JUL05 H		Xm		Xm		Xm	6.4		0.11	m
UNL 31JUL05 C		X		Xm	0.064	m	71		0.13	m
WCP 30JUL05 H 1		Xm		Xm		Xm	67		0.14	m
WCP 30JUL05 H 2	0.18	m		Xm	0.063	m	28		0.13	m
WCP 30JUL05 H 3	0.18	m		Xm	0.063	m	113		0.13	m
YEL 13JUL05 H		X		X		Xm	1.8		0.13	m

Sample No	Matrix	Region	Species	Stage	Tadpole Weight	g extracted	moisture % ww	lipid % ww
1168X 07AUG05 1	Tadpole	SEKI	PR	28		2.0	91.8	0.02
2310X 04AUG05 1	Tadpole	SEKI	PR	33	0.86	2.1	92.6	0.49
10249 08AUG05 1	Tadpole	SEKI	PR	28	0.06	1.9	93.0	0.17
10249 08AUG05 2	Tadpole	SEKI	PR	28		1.8	94.0	0.25
10310 11AUG05 1	Tadpole	SEKI	PR	32		1.7	96.0	0.21
10594 12AUG05 1	Tadpole	SEKI	PR	28	0.35	2.0	91.3	0.21
11087 31JUL05 1	Tadpole	SEKI	PR	33	0.65	2.1	92.5	0.27
11089 31JUL05 1	Tadpole	SEKI	PR	35	1.01	2.0	90.3	0.27
11281 11AUG05 1	Tadpole	SEKI	PR	37		2.2	89.8	0.74
11474 07AUG05 1	Tadpole	SEKI	PR	33		2.1	92.3	0.17
11475 06AUG05 1	Tadpole	SEKI	PR	32	0.48	2.1	92.5	0.13
11685 06AUG05 1	Tadpole	SEKI	PR	26	0.14	2.1	93.0	0.17
12154 02AUG05 1	Tadpole	SEKI	PR	34	1.00	2.2	90.1	0.35
12155 01AUG05 1	Tadpole	SEKI	PR	35	0.92	2.0	91.8	0.53
12338 12AUG05 1	Tadpole	SEKI	PR	28	0.38	2.2	94.5	0.09
12457 30JUL05 1	Tadpole	SEKI	PR	35		2.0	91.5	0.24
12461 30JUL05 1	Tadpole	SEKI	PR	33	0.92	1.9	92.1	0.28
20027 10AUG05 1	Tadpole	SEKI	PR	29.5	0.36	2.0	91.9	0.21
20037 02AUG05 1	Tadpole	SEKI	PR	31	0.56	2.1	94.0	0.20
20062 03AUG05 1	Tadpole	SEKI	PR	34	0.87	2.0	89.5	0.38
20135 10AUG05 1	Tadpole	SEKI	PR	37	1.27	2.0	92.8	0.50
21317 01AUG05 1	Tadpole	SEKI	PR	27	0.41	2.1	95.7	0.07
21329 08AUG05 1	Tadpole	SEKI	PR	26	0.82	2.4	94.6	0.16
21390 03AUG05 1	Tadpole	SEKI	PR	30	0.24	2.2	92.5	0.18
21397 03AUG05 1	Tadpole	SEKI	PR	36	1.20	2.3	90.4	0.28
21522 09AUG05 1	Tadpole	SEKI	PR	32.5	0.99	2.1	84.4	0.33
21559 08AUG05 1	Tadpole	SEKI	PR	29.5	0.38	2.1	93.4	0.37
21559 09AUG05 2	Tadpole	SEKI	PR	29.5		1.9	94.9	0.35
23058 10AUG05 1	Tadpole	SEKI	PR	28	0.15	2.1	96.9	0.11
1168X 04SEP05 1	Tadpole	SEKI	PR	36	1.36	2.0	87.2	0.68
10249 06SEP05 1	Tadpole	SEKI	PR	36	0.77	2.1	89.1	0.53
10310 11SEP05 1	Tadpole	SEKI	PR	38.5	0.97	2.0	90.8	0.65
10311 11SEP05 1	Tadpole	SEKI	PR	45	0.40	2.0	89.6	0.53
10311 11SEP05 2	Tadpole	SEKI	PR	45		2.2	88.0	0.94
10525 06SEP05 1	Tadpole	SEKI	PR	35.5	1.01	2.3	90.5	0.77
11087 30AUG05 1	Tadpole	SEKI	PR	37.5	1.38	2.0	87.9	1.12
11089 30AUG05 1	Tadpole	SEKI	PR	39	0.76	2.1	89.4	1.05
11474 05SEP05 2	Tadpole	SEKI	PR	36	0.81	2.1	91.2	0.49
11474 05SEP05 3	Tadpole	SEKI	PR	45	0.29	2.2	88.9	0.68
11475 05SEP05 1	Tadpole	SEKI	PR	39.5	0.85	1.9	87.1	0.57
11685 04SEP05 1	Tadpole	SEKI	PR	32	0.96	2.0	87.2	0.69
12154 31AUG05 1	Tadpole	SEKI	PR	36.5	0.86	2.0	88.4	1.03
12154 31AUG05 3	Tadpole	SEKI	PR	44.5	0.44	2.1	87.9	1.21
12155 31AUG05 1	Tadpole	SEKI	PR	36	1.34	2.0	87.4	1.55
12155 31AUG05 3	Tadpole	SEKI	PR	42		2.1	85.3	2.02

Sample No	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthlf
1168X 07AUG05 1		aXm		X	0.026	a	0.035	a
2310X 04AUG05 1		aXm		Xm	0.0094	m	0.180	a
10249 08AUG05 1		aXm		X	0.010	m	0.209	
10249 08AUG05 2		aXm		Xm	0.011	m	0.418	
10310 11AUG05 1		aXm		X		Xm	0.065	
10594 12AUG05 1		aXm		X	0.010	m		X
11087 31JUL05 1		aXm		X	0.0093	m	0.081	
11089 31JUL05 1		aXm		X		Xm	0.136	
11281 11AUG05 1		aXm		X		Xm	0.075	
11474 07AUG05 1		aXm		X		Xm	0.105	
11475 06AUG05 1		aXm		X	0.0093	m		aX
11685 06AUG05 1		aXm		X	0.0093	m	0.107	
12154 02AUG05 1		aXm		X	0.0091	m	0.045	
12155 01AUG05 1		aXm		X		Xm	0.186	
12338 12AUG05 1		aXm		Xm	0.0090	m	0.004	m
12457 30JUL05 1		aXm		X	0.010	m	0.053	
12461 30JUL05 1		aXm		X		X	0.059	
20027 10AUG05 1		Xm		X	0.010	m	0.091	
20037 02AUG05 1		aXm		X	0.010	m		X
20062 03AUG05 1		aXm		X	0.010	m	0.107	
20135 10AUG05 1		aXm		X	0.010	m	0.293	
21317 01AUG05 1		aXm		X	0.0092	m		aX
21329 08AUG05 1		aXm		X	0.0081	m	0.073	
21390 03AUG05 1		aXm		X	0.0091	m		aX
21397 03AUG05 1		aXm		Xm	0.0085	m	0.067	
21522 09AUG05 1		aXm		X	0.0094	m	0.151	
21559 08AUG05 1		aXm		X	0.0094	m	0.254	
21559 09AUG05 2		aXm		Xm	0.010	m	0.223	
23058 10AUG05 1		aXm		X	0.0094	m		aXm
1168X 04SEP05 1		Xm		X	0.010	m	0.057	
10249 06SEP05 1		aXm		X	0.0094	m	0.193	
10310 11SEP05 1		Xm		X	0.010	m	0.099	
10311 11SEP05 1		aXm	0.041		0.010	m	0.004	m
10311 11SEP05 2		aXm		X	0.0088	m	0.003	m
10525 06SEP05 1		aXm		X	0.0087	m	0.133	
11087 30AUG05 1		Xm		X	0.010	m	0.277	
11089 30AUG05 1		aXm		X	0.0091	m	0.314	
11474 05SEP05 2		X		X	0.0093	m	0.064	
11474 05SEP05 3		aXm		X	0.0091	m	0.022	a
11475 05SEP05 1		aXm		X	0.010	m	0.131	
11685 04SEP05 1		aX		X	0.010	m		cz
12154 31AUG05 1		Xm		X	0.010	m	0.028	a
12154 31AUG05 3		aXm		X	0.0095	m	0.038	c
12155 31AUG05 1		aX		X	0.010	m	0.728	
12155 31AUG05 3		aXm		X	0.0095	m	0.281	a

Sample No	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chordtn ng/g ww	End1 ng/g ww	End1f	Nonatn ng/g ww	Nonatnf
1168X 07AUG05 1	0.035	a		aXm	0.0084	m	0.00063	m
2310X 04AUG05 1	0.011	am		aX	0.070		0.020	
10249 08AUG05 1	0.056	a	0.014	a	0.11		0.022	a
10249 08AUG05 2	0.058	a	0.037	a	0.15		0.040	a
10310 11AUG05 1	0.050			aXm	0.010	am	0.00072	m
10594 12AUG05 1	0.066	a	0.018	a		aXm	0.031	a
11087 31JUL05 1	0.056	a	0.0057	a	0.033	a	0.0071	a
11089 31JUL05 1	0.043			aXm	0.025	a	0.0059	a
11281 11AUG05 1	0.040			aXm	0.040	a	0.036	
11474 07AUG05 1	0.045			aXm	0.030	a	0.00060	m
11475 06AUG05 1	0.057	a		aX		aX	0.014	a
11685 06AUG05 1	0.066	a		aX		aXm	0.014	a
12154 02AUG05 1	0.043	a	0.014		0.036	a	0.027	a
12155 01AUG05 1	0.040			aXm	0.018	a	0.0045	a
12338 12AUG05 1	0.010	m		Xm	0.0076	am	0.0006	am
12457 30JUL05 1	0.065	a	0.015	a	0.035	a	0.019	a
12461 30JUL05 1	0.045			aXm	0.0086	m	0.014	a
20027 10AUG05 1	0.062	a	0.011	a	0.046	a	0.015	
20037 02AUG05 1	0.082			aX		aXm	0.013	a
20062 03AUG05 1	0.081		0.022	a		Xm	0.044	
20135 10AUG05 1	0.041	a	0.0074	a	0.063	a	0.0088	a
21317 01AUG05 1		Xm	0.0014			aXm	0.00060	m
21329 08AUG05 1	0.046	a	0.014	a	0.051	a	0.025	a
21390 03AUG05 1	0.051	a	0.011	a		aX	0.018	a
21397 03AUG05 1		aX	0.014	a	0.0072	m	0.013	a
21522 09AUG05 1		aXm		aX	0.0079	m	0.00060	m
21559 08AUG05 1		aXm	0.026	a	0.083		0.037	
21559 09AUG05 2	0.052	a	0.022	a	0.11		0.027	a
23058 10AUG05 1	0.011	m		aXm		aXm	0.00061	m
1168X 04SEP05 1		Xm	0.047	ad	0.0082	m	0.079	ad
10249 06SEP05 1		X	0.056	d	0.092	ad	0.081	d
10310 11SEP05 1		Xm	0.030	ad	0.102	ad	0.00062	m
10311 11SEP05 1		Xm	0.001		0.0084	m	0.00064	m
10311 11SEP05 2	0.010	m	0.025	a	0.0074	m	0.041	
10525 06SEP05 1		dX	0.028	ad	0.0074	m	0.037	d
11087 30AUG05 1		Xm	0.033	ad	0.087	ad	0.042	d
11089 30AUG05 1		dXm	0.035	d	0.0078	m	0.00059	m
11474 05SEP05 2		Xm	0.042		0.0078	m	0.059	
11474 05SEP05 3		dXm	0.032	ad	0.0077	m	0.079	d
11475 05SEP05 1		dXm	0.051	d	0.0086	m	0.072	d
11685 04SEP05 1		dX	0.062	d	0.095	ad	0.11	d
12154 31AUG05 1		Xm	0.030	ad	0.0082	m	0.036	ad
12154 31AUG05 3		X	0.041		0.0080	m	0.085	
12155 31AUG05 1		dX	0.047	d	0.0085	m	0.043	d
12155 31AUG05 3		Xm	0.054	d	0.0081	m	0.093	d

Sample No	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2f	Nonacs ng/g ww	Nonacsf	Endsu ng/g ww	Endsuf
1168X 07AUG05 1		aX	0.030	a	0.0032	m	0.12	
2310X 04AUG05 1		aXm	0.041	a	0.013		0.31	
10249 08AUG05 1	0.013	m	0.187		0.016	a	0.43	
10249 08AUG05 2	0.014	am	0.217		0.025	a	0.68	
10310 11AUG05 1		aXm	0.027	a	0.0036	m	0.14	
10594 12AUG05 1		aXm	0.040		0.016	a	0.27	
11087 31JUL05 1	0.012	m	0.051		0.0030	am	0.12	
11089 31JUL05 1		aXm	0.059		0.0031	am	0.38	
11281 11AUG05 1		aXm	0.079		0.019	a	0.45	
11474 07AUG05 1		aXm	0.066		0.0030	m	0.30	
11475 06AUG05 1	0.012	m	0.100		0.010	a	0.37	
11685 06AUG05 1	0.012	m	0.116		0.011	a	0.17	
12154 02AUG05 1	0.011	m	0.047		0.015	a	0.24	
12155 01AUG05 1		aXm	0.031	a	0.0031	am	0.19	
12338 12AUG05 1		aXm	0.004	m	0.0029	m	0.00	m
12457 30JUL05 1	0.012	m	0.074		0.010	a	0.29	
12461 30JUL05 1		aXm	0.048		0.0077	a	0.41	
20027 10AUG05 1		aXm	0.087		0.011		0.46	
20037 02AUG05 1	0.012	m	0.035		0.0031	am	0.14	
20062 03AUG05 1	0.012	m	0.081		0.031	a	0.60	
20135 10AUG05 1	0.012	m	0.053		0.0074	a	0.15	
21317 01AUG05 1		aXm	0.030	a	0.0030	m	0.16	
21329 08AUG05 1	0.010	m	0.052		0.021	a	0.24	
21390 03AUG05 1	0.011	m	0.072		0.011	a	0.30	
21397 03AUG05 1	0.011	m	0.003	m	0.0078	a	0.22	
21522 09AUG05 1		aXm	0.023	a	0.0030	m	0.16	
21559 08AUG05 1		aXm	0.129	a	0.020	a	0.80	
21559 09AUG05 2	0.013	am	0.103		0.011	a	0.64	
23058 10AUG05 1		aXm	0.012	a	0.0030	m	0.04	
1168X 04SEP05 1		aXm	0.004	m	0.053		0.39	
10249 06SEP05 1		aXm	0.123		0.066		0.79	
10310 11SEP05 1	0.012	m	0.066	a	0.0031	m	0.40	
10311 11SEP05 1		aXm	0.004	m	0.0032	m	0.01	m
10311 11SEP05 2		aXm	0.004	m	0.020	a	0.05	a
10525 06SEP05 1		aXm	0.056	a	0.035		0.26	
11087 30AUG05 1		aXm	0.040	a	0.036	a	0.41	
11089 30AUG05 1		Xm	0.004	m	0.045		0.51	
11474 05SEP05 2		Xm	0.042	a	0.040		0.39	
11474 05SEP05 3	0.011	m	0.004	m	0.032	a	0.18	
11475 05SEP05 1		Xm	0.095		0.0033	m	0.66	
11685 04SEP05 1		Xm	0.089		0.080		0.52	
12154 31AUG05 1	0.012	m	0.004	m	0.003	m	0.39	
12154 31AUG05 3		aXm	0.004	m	0.046		0.20	
12155 31AUG05 1	0.012	m	0.004	m	0.038		0.27	
12155 31AUG05 3		aXm	0.004	m	0.080		0.27	

Sample No	Pcb153 ng/g ww	Pcb153f	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f
1168X 07AUG05 1		aX	0.052	a	0.0017	a	0.0015	m
2310X 04AUG05 1		aXm	0.049	am	0.0016	am	0.0014	m
10249 08AUG05 1	0.033	a	0.054	m	0.011	a	0.0031	a
10249 08AUG05 2	0.011	am	0.057	am	0.0083	a	0.0016	am
10310 11AUG05 1		aXm	0.059	am	0.0019	am	0.0017	m
10594 12AUG05 1		aXm	0.050	m	0.0059	a	0.0014	am
11087 31JUL05 1	0.0095	m	0.049	m	0.0016	m	0.0014	m
11089 31JUL05 1		aXm	0.050	am	0.0044	a	0.0014	m
11281 11AUG05 1	0.027	a	0.046	m	0.011	a	0.0013	m
11474 07AUG05 1	0.020	a	0.049	m	0.0042	a	0.0014	m
11475 06AUG05 1		aXm	0.049	m	0.0043	a	0.0014	am
11685 06AUG05 1		aXm	0.048	m	0.0016	m	0.0014	m
12154 02AUG05 1	0.024	a	0.048	m	0.0070	a	0.0014	am
12155 01AUG05 1		aXm	0.051	am	0.0016	am	0.0014	m
12338 12AUG05 1		aXm	0.047	am	0.0015	am	0.0013	m
12457 30JUL05 1	0.031	a	0.051	m	0.0088	a	0.0029	a
12461 30JUL05 1	0.022	a	0.053	m	0.0077	a	0.0015	m
20027 10AUG05 1	0.010	m	0.052	m	0.0046	a	0.0015	m
20037 02AUG05 1		aXm	0.050	m	0.0044	a	0.0014	am
20062 03AUG05 1		aX	0.050	m	0.0088	a	0.0029	a
20135 10AUG05 1	0.010	am	0.051	m	0.0059	a	0.0014	am
21317 01AUG05 1		aXm	0.048	m	0.0016	am	0.0014	m
21329 08AUG05 1	0.024	a	0.043	m	0.0087	a	0.0025	a
21390 03AUG05 1		aXm	0.048	m	0.0042	a	0.0014	am
21397 03AUG05 1	0.018	a	0.045	am	0.0052	a	0.0013	m
21522 09AUG05 1		aXm		aXm	0.0071	a		aXm
21559 08AUG05 1		aXm		aXm	0.0043	a	0.0014	m
21559 09AUG05 2	0.011	am	0.054	am	0.0017	am	0.0015	m
23058 10AUG05 1		aXm	0.049	m	0.0016	am	0.0014	m
1168X 04SEP05 1	0.031	a	0.050	m	0.010	a	0.0014	m
10249 06SEP05 1	0.050		0.049	am	0.019	a	0.0130	a
10310 11SEP05 1	0.010	m	0.051	m	0.0059	a	0.0014	m
10311 11SEP05 1	0.010	m	0.052	m	0.014	a	0.0015	m
10311 11SEP05 2	0.032	a	0.046	m	0.012	a	0.0013	m
10525 06SEP05 1	0.0089	m	0.046	m	0.0015	m	0.0013	m
11087 30AUG05 1	0.010	m	0.051	m	0.0059	a	0.0014	m
11089 30AUG05 1	0.0093	m	0.048	m	0.011	a	0.0014	m
11474 05SEP05 2	0.031	a	0.048	m	0.010	a	0.010	a
11474 05SEP05 3	0.047	a	0.048	am	0.018	a	0.011	a
11475 05SEP05 1	0.036	a	0.053	am	0.014	a	0.011	a
11685 04SEP05 1	0.065		0.051	m	0.031	a	0.018	a
12154 31AUG05 1	0.022	a	0.051	m	0.0059	a	0.0014	m
12154 31AUG05 3	0.041		0.050	m	0.013	a	0.0087	a
12155 31AUG05 1	0.010	m	0.052	m	0.0092	a	0.0015	m
12155 31AUG05 3	0.036		0.050	m	0.016	a	0.012	a

Sample No	Acena ng/g ww	Acenaf	Fluor ng/g ww	Fluorf	Phenan ng/g ww	Phen anf	Flrant ng/g ww	Flran tf	Retene ng/g ww	Retenef	Dde ng/g ww	Ddef
1168X 07AUG05 1		X		X		X		X	1.7		0.37	
2310X 04AUG05 1	0.37	m	0.18	m	0.33		0.062	m	1.4		0.13	m
10249 08AUG05 1		X		X		X		X	1.5		0.33	
10249 08AUG05 2	0.43	m		Xm		Xm		Xm		Xm	0.15	m
10310 11AUG05 1		Xm		Xm		X		X	4.6		0.15	m
10594 12AUG05 1		Xm		Xm		X		Xm	3.4		0.52	
11087 31JUL05 1		X		Xm		X		Xm	1.0		0.13	m
11089 31JUL05 1		Xm		Xm		X	0.064	m	0.27	m	0.13	m
11281 11AUG05 1		Xm		Xm		X	0.058	m	6.4		0.97	
11474 07AUG05 1		Xm		Xm		X	0.061	m	10.0		0.25	
11475 06AUG05 1		Xm		Xm		Xm		Xm	1.3		0.13	m
11685 06AUG05 1		Xm		Xm		X	0.061	m		X	0.13	m
12154 02AUG05 1		Xm		Xm		X		Xm		Xm	0.58	
12155 01AUG05 1		Xm		Xm		Xm	0.064	m	3.6		0.35	
12338 12AUG05 1		X		Xm		X		X	2.9		0.12	m
12457 30JUL05 1		Xm		Xm		X		Xm	1.7		0.66	
12461 30JUL05 1		Xm		Xm		X	0.067	m	2.2		0.71	
20027 10AUG05 1		Xm		Xm		X		Xm		Xm	0.14	m
20037 02AUG05 1		Xm		Xm		X		Xm	2.2		0.36	
20062 03AUG05 1		Xm		Xm		X		X	0.97		0.60	
20135 10AUG05 1		Xm		Xm		X		Xm	2.4		0.13	m
21317 01AUG05 1		X		Xm		X	0.47			Xm	0.13	m
21329 08AUG05 1		Xm		Xm		X		Xm	0.52		0.45	
21390 03AUG05 1		Xm		Xm		X		Xm	5.7		0.38	
21397 03AUG05 1	0.33	m		Xm		Xm	0.056	m		Xm	0.12	m
21522 09AUG05 1	0.37	m		X		X	0.71			Xm	0.13	m
21559 08AUG05 1	0.37	m		X		X	0.062	m		X	0.80	
21559 09AUG05 2	0.40	m		Xm		Xm	0.068	m		Xm	0.48	
23058 10AUG05 1		X		Xm		X	0.40		0.93		0.13	m
1168X 04SEP05 1	0.38	m		Xm		Xm	0.064	m	0.27	m	0.61	
10249 06SEP05 1	0.37	m		Xm		Xm	0.062	m	0.27	m	1.1	
10310 11SEP05 1	0.38	m		Xm		X	0.064	m	1.8		0.13	m
10311 11SEP05 1	0.39	m	0.19	m		Xm	0.066	m	0.28	m	0.14	m
10311 11SEP05 2	0.34	m		Xm		X	0.058	m	0.25	m	0.67	
10525 06SEP05 1	0.34	m		Xm		X	0.058	m	2.7		0.12	m
11087 30AUG05 1	0.38	m		Xm		Xm	0.064	m	0.27	m	0.13	m
11089 30AUG05 1	0.36	m		Xm		X	0.060	m	1.3		0.56	
11474 05SEP05 2	0.36	m	0.18	m		Xm	0.061	m	1.7		0.62	
11474 05SEP05 3	0.36	m		X		X	0.060	m	0.26	m	1.2	
11475 05SEP05 1	0.40	m		Xm		X	0.067	m	1.3		0.86	
11685 04SEP05 1	0.38	m	0.51	X		X	0.064	m	0.27	m	0.60	
12154 31AUG05 1	0.38	m		Xm		Xm	0.064	m	0.27	m	0.53	
12154 31AUG05 3	0.37	m		Xm		X	0.063	m	0.27	m	1.1	
12155 31AUG05 1	0.39	m		Xm		X	0.066	m	0.28	m	0.14	m
12155 31AUG05 3	0.37	m		Xm		X	0.063	m	0.27	m	0.86	

Sample No	Matrix	Region	Species	Stage	Tadpole Weight	g extracted	moisture % ww	lipid % ww
12337 13SEP05 1	Tadpole	SEKI	PR	36.5	1.21	2.1	88.7	0.69
12337 13SEP05 2	Tadpole	SEKI	PR	36.5	1.09	2.1	88.6	0.78
12338 12SEP05 1	Tadpole	SEKI	PR	37	1.25	2.0	90.5	0.72
12457 29AUG05 1	Tadpole	SEKI	PR	38.5	1.28	1.9	88.4	1.05
12459 29AUG05 1	Tadpole	SEKI	PR	41	1.44	2.0	87.9	1.67
12461 29AUG05 2	Tadpole	SEKI	PR			2.1	91.1	0.69
20027 10SEP05 1	Tadpole	SEKI	PR	36	0.56	2.0	91.2	0.36
20037 02SEP05 1	Tadpole	SEKI	PR	37	1.96	2.3	90.7	1.10
20062 03SEP05 1	Tadpole	SEKI	PR	36.5	1.26	2.1	89.3	1.18
20135 09SEP05 1	Tadpole	SEKI	PR	38	1.80	2.2	88.4	1.70
20305 03SEP05 1	Tadpole	SEKI	PR	38	1.28	2.0	88.4	1.67
20305 03SEP05 2	Tadpole	SEKI	PR	46		2.0	85.4	2.12
20305 03SEP05 3	Tadpole	SEKI	PR	46		2.0	86.3	1.73
21317 02SEP05 1	Tadpole	SEKI	PR	35.5	1.12	2.1	90.1	0.26
21329 07SEP05 1	Tadpole	SEKI	PR	36	1.04	2.1	86.6	0.75
21390 03SEP05 1	Tadpole	SEKI	PR	36	1.42	2.1	90.3	0.82
21397 03SEP05 1	Tadpole	SEKI	PR	46		2.1	87.2	0.19
21397 03SEP05 2	Tadpole	SEKI	PR	37.5	1.26	2.2	90.7	0.82
21522 08SEP05 1	Tadpole	SEKI	PR	40	1.39	2.1	87.8	0.61
21522 08SEP05 2	Tadpole	SEKI	PR	38	1.25	2.1	88.0	0.67
21522 08SEP05 3	Tadpole	SEKI	PR	46	0.43	2.1	86.5	0.96
21559 07SEP05 1	Tadpole	SEKI	PR	37	0.89	2.1	88.9	0.87
21559 07SEP05 3	Tadpole	SEKI	PR	46	0.48	2.3	86.0	1.25
23058 10SEP05 1	Tadpole	SEKI	PR	30	0.45	2.0	94.1	0.55

Sample No	Matrix	Region	Species	Stage	Tadpole Weight	g extracted	moisture % ww	lipid % ww
CNT 01JUL06 1	Tadpole	Sierras transect	PR	25	0.24	2.0	93.5	0.02
CNT 01JUL06 2	Tadpole	Sierras transect	PR	31	0.49	2.1	93.1	0.16
CNF 06JUL06 1	Tadpole	Sierras transect	PR	35	1.05	2.0	90.5	0.19
CNF 06JUL06 2	Tadpole	Sierras transect	PR	35	0.75	2.0	91.4	0.21
DAN 07JUL06 1	Tadpole	Sierras transect	PR	24	0.17	2.1	93.0	0.03
DAN 07JUL06 2	Tadpole	Sierras transect	PR	24	0.16	2.2	92.9	0.05
TLP 07JUL06 1	Tadpole	Sierras transect	PR	24	0.09	2.0	94.0	0.01
TLP 07JUL06 2	Tadpole	Sierras transect	PR	24	0.10	2.0	92.8	0.03
SLV 08JUL06 1	Tadpole	Sierras transect	PR	27	0.27	2.1	94.8	0.01
SLV 07JUL06 2	Tadpole	Sierras transect	PR	30	0.70	2.1	94.6	0.04
SRD 07JUL06 1	Tadpole	Sierras transect	PR	32	0.54	2.1	92.3	0.01
SRD 07JUL06 2	Tadpole	Sierras transect	PR	37	0.67	2.1	90.1	0.05
SWA 17JUL06 1	Tadpole	Sierras transect	PR	35	0.41	2.0	91.1	0.06
SWA 17JUL06 2	Tadpole	Sierras transect	PR	34	0.40	2.1	92.3	0.06
KEL 19JUL06 1	Tadpole	Sierras transect	PR	37	0.60	2.3	89.6	0.10
KEL 19JUL06 2	Tadpole	Sierras transect	PR	38	0.58	2.1	90.4	0.12
MUD 21JUL06 1	Tadpole	Sierras transect	PR	36	0.91	2.3	90.2	0.22
MUD 21JUL06 2	Tadpole	Sierras transect	PR	40	1.10	2.1	89.5	0.27
DAR 24JUL06 1	Tadpole	Sierras transect	PR	34	0.46	2.0	91.0	0.04
DAR 24JUL06 2	Tadpole	Sierras transect	PR	36	0.81	2.0	91.5	0.03

Sample No	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthlf
12337 13SEP05 1		Xm		X	0.0093	m	0.205	
12337 13SEP05 2		aXm	0.025		0.010	m	0.183	c
12338 12SEP05 1		aXm		X	0.010	m	0.119	
12457 29AUG05 1		Xm		X	0.010	m	0.149	
12459 29AUG05 1		aX	0.105		0.010	m	0.311	
12461 29AUG05 2		aXm		X	0.010	m	0.156	
20027 10SEP05 1		aXm		X	0.010	m		cz
20037 02SEP05 1		aXm		X	0.0085	m	0.333	
20062 03SEP05 1		aXm		X	0.0092	m	0.197	
20135 09SEP05 1		aX		X	0.0088	m		cz
20305 03SEP05 1		aXm		X	0.010	m	0.098	
20305 03SEP05 2		aXm		X	0.010	m	0.044	
20305 03SEP05 3		aXm		X	0.010	m	0.004	m
21317 02SEP05 1		aXm	0.022		0.0095	m	0.178	
21329 07SEP05 1		aXm	0.024		0.0093	m	0.340	
21390 03SEP05 1		aXm		X	0.0092	m	0.289	
21397 03SEP05 1		aXm		X	0.010	m	0.004	m
21397 03SEP05 2		aXm	0.014		0.0091	m	0.080	c
21522 08SEP05 1		aXm	0.023		0.0095	m	0.109	
21522 08SEP05 2		aXm		X	0.010	m	0.077	
21522 08SEP05 3		aXm		X	0.010	m	0.004	m
21559 07SEP05 1		aX		X	0.010	m	0.357	
21559 07SEP05 3		aXm		X	0.0087	m	0.105	
23058 10SEP05 1		aXm	0.009		0.010	m	0.072	

Sample No	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf	Dacthl ng/g ww	Dacthlf	Chlrpy ng/g ww	Chlrpyf
CNT 01JUL06 1		aX		aXm	0.0040	m		dX
CNT 01JUL06 2		aXm		aX	0.0038	m		X
CNF 06JUL06 1		aXm		aX	0.0040	m		X
CNF 06JUL06 2		aXm		aX	0.0040	m		dX
DAN 07JUL06 1		aXm		aX	0.0038	m	0.424	
DAN 07JUL06 2		X		aX	0.0036	m		dX
TLP 07JUL06 1		aX		aX	0.0040	m		Xm
TLP 07JUL06 2		aX		aX	0.0040	m		X
SLV 08JUL06 1		aX		aXm	0.0038	m		Xm
SLV 07JUL06 2		aX		aX	0.0038	m		X
SRD 07JUL06 1		aX		aX	0.0038	m		dX
SRD 07JUL06 2		X		aX	0.025	a		dX
SWA 17JUL06 1		aXm		X	0.0040	m		dXm
SWA 17JUL06 2		X		aX	0.0038	m		dX
KEL 19JUL06 1		aXm		X	0.0034	m		Xm
KEL 19JUL06 2		aXm		X	0.0038	m		dXm
MUD 21JUL06 1		aXm		aX	0.13	G		dXm
MUD 21JUL06 2		aXm		aX	0.18	G		dXm
DAR 24JUL06 1		aXm		aX	0.0039	m		dX
DAR 24JUL06 2		aXm		aX	0.0039	m		dXm

Sample No	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chordtn ng/g ww	End1 ng/g ww	End1f	Nonatn ng/g ww	Nonatnf
12337 13SEP05 1		Xm	0.066		0.106	a	0.12	
12337 13SEP05 2		X	0.045	d	0.097	ad	0.090	d
12338 12SEP05 1		Xm	0.044	d	0.116	ad	0.075	d
12457 29AUG05 1		dXm	0.064	d	0.071	ad	0.088	d
12459 29AUG05 1		X	0.081	d	0.107	ad	0.11	d
12461 29AUG05 2		adXm	0.026	ad	0.0081	m	0.036	d
20027 10SEP05 1		dX	0.026	ad	0.0082	m	0.001	m
20037 02SEP05 1		dX	0.046	d	0.0072	m	0.062	d
20062 03SEP05 1		Xm	0.056	ad	0.0078	m	0.11	
20135 09SEP05 1		dX	0.038	d	0.0075	m	0.052	d
20305 03SEP05 1		X	0.032	ad	0.0085	m	0.052	d
20305 03SEP05 2		aXm	0.042	a	0.0081	m	0.083	
20305 03SEP05 3		adXm	0.034	ad	0.0085	m	0.069	d
21317 02SEP05 1		dXm	0.033	ad	0.0080	m	0.058	d
21329 07SEP05 1		dXm	0.071	d	0.27	d	0.11	d
21390 03SEP05 1		dX	0.031	ad	0.0078	m	0.00059	m
21397 03SEP05 1		adXm	0.022	ad	0.0081	m	0.035	ad
21397 03SEP05 2		Xm	0.018	d	0.0078	m	0.00059	m
21522 08SEP05 1		X	0.00054	m	0.0081	m	0.00061	m
21522 08SEP05 2		Xm	0.00054	m	0.0081	m	0.00061	m
21522 08SEP05 3	0.011	m	0.019	a	0.0081	m	0.035	a
21559 07SEP05 1		dX	0.060	d	0.282	d	0.096	d
21559 07SEP05 3		X	0.00050	m	0.0074	m	0.24	
23058 10SEP05 1		X	0.001	m	0.0085	m	0.001	m

Sample No	Chordtn ng/g ww	Chordtn ng/g ww	Nonatn ng/g ww	Nonatnf	ctEnd2mdw	End2f	Endsu ng/g ww	Endsuf
CNT 01JUL06 1	0.00057	m	0.001	m	0.004	m	0.074	
CNT 01JUL06 2	0.00054	m	0.001	m	0.004	m	0.10	
CNF 06JUL06 1	0.00057	m	0.001	m	0.004	m	0.11	
CNF 06JUL06 2	0.00057	m	0.001	m	0.004	m	0.094	
DAN 07JUL06 1	0.00055	m	0.001	m	0.004	m	0.15	
DAN 07JUL06 2	0.00052	m	0.001	m	0.004	m	0.13	
TLP 07JUL06 1	0.00057	m	0.001	m	0.004	m	0.18	
TLP 07JUL06 2	0.00058	m	0.001	m	0.004	m	0.18	
SLV 08JUL06 1	0.00055	m	0.001	m	0.004	m	0.005	m
SLV 07JUL06 2	0.00055	m	0.001	m	0.004	m	0.005	m
SRD 07JUL06 1	0.00055	m	0.001	m	0.004	m	0.061	a
SRD 07JUL06 2	0.00052	m	0.001	m	0.004	m	0.071	
SWA 17JUL06 1	0.00057	m	0.001	m	0.004	m	0.11	
SWA 17JUL06 2	0.00054	m	0.001	m	0.004	m	0.103	
KEL 19JUL06 1	0.00049	m	0.033		0.003	m	0.063	a
KEL 19JUL06 2	0.00054	m	0.025	a	0.004	m	0.062	a
MUD 21JUL06 1	0.0080	ad	0.001	m	0.040	a	0.082	
MUD 21JUL06 2	0.0058	ad	0.001	m	0.052	a	0.081	
DAR 24JUL06 1	0.00056	m	0.001	m	0.004	m	0.057	a
DAR 24JUL06 2	0.00057	m	0.001	m	0.004	m	0.061	a

Sample No	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2f	Nonacs ng/g ww	Nonacsf	Endsu ng/g ww	Endsuf
12337 13SEP05 1	0.011	m	0.068	a	0.082		0.47	
12337 13SEP05 2		aXm	0.067	a	0.073		0.38	
12338 12SEP05 1		Xm	0.101		0.056		0.68	
12457 29AUG05 1		X	0.113	d	0.056	d	0.71	d
12459 29AUG05 1		X	0.131		0.075		0.60	
12461 29AUG05 2		aXm	0.050	a	0.033	a	0.34	
20027 10SEP05 1		aXm	0.100		0.0031	m	0.75	
20037 02SEP05 1		Xm	0.068		0.045		0.50	
20062 03SEP05 1		aXm	0.004	m	0.094		0.73	
20135 09SEP05 1	0.011	m	0.040	a	0.044		0.29	
20305 03SEP05 1		aXm	0.004	m	0.043		0.45	
20305 03SEP05 2		aXm	0.004	m	0.051		0.25	a
20305 03SEP05 3		aXm	0.004	m	0.037	a	0.10	
21317 02SEP05 1		aXm	0.004	m	0.043		0.62	
21329 07SEP05 1		aXm	0.189		0.11		1.2	
21390 03SEP05 1		Xm	0.079		0.038		0.46	
21397 03SEP05 1		aXm	0.004	m	0.019	a	0.065	a
21397 03SEP05 2		aXm	0.004	m	0.0029	m	0.23	
21522 08SEP05 1		aXm	0.004	m	0.0031	m	0.21	
21522 08SEP05 2		aXm	0.004	m	0.0031	m	0.16	
21522 08SEP05 3		aXm	0.004	m	0.0031	m	0.051	a
21559 07SEP05 1		aXm	0.248		0.071	a	0.0049	m
21559 07SEP05 3		aXm	0.004	m	0.13		0.66	
23058 10SEP05 1		aXm	0.078		0.0032	m	0.31	

Sample No	Pcb153 ng/g ww	Pcb153f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f	Phenan ng/g ww	Phenanf
CNT 01JUL06 1	0.010	m	0.0017	m	0.0015	m		X
CNT 01JUL06 2	0.020	a	0.0016	m	0.0014	m		Xm
CNF 06JUL06 1	0.010	m	0.0017	m	0.0015	m		X
CNF 06JUL06 2	0.010	m	0.0017	m	0.0015	m		X
DAN 07JUL06 1	0.010	m	0.0016	m	0.0014	m		X
DAN 07JUL06 2	0.0093	m	0.0015	m	0.0014	m		X
TLP 07JUL06 1	0.010	m	0.0017	m	0.0015	m		X
TLP 07JUL06 2	0.010	m	0.0017	m	0.0015	m		X
SLV 08JUL06 1	0.010	m	0.0016	m	0.0014	m		X
SLV 07JUL06 2	0.010	m	0.0016	m	0.0014	m		X
SRD 07JUL06 1	0.010	m	0.0016	m	0.0014	m		X
SRD 07JUL06 2	0.0093	m	0.0015	m	0.0014	m		X
SWA 17JUL06 1	0.010	m	0.0091	a	0.0045	a		X
SWA 17JUL06 2	0.010	m	0.0016	m	0.0014	m		X
KEL 19JUL06 1	0.0088	m	0.011	a	0.0013	m		X
KEL 19JUL06 2	0.010	m	0.0072	a	0.0014	m		X
MUD 21JUL06 1	0.0088	m	0.0015	m	0.0013	m		X
MUD 21JUL06 2	0.010	m	0.0016	m	0.0014	m		Xm
DAR 24JUL06 1	0.010	m	0.0017	m	0.0015	m		X
DAR 24JUL06 2	0.010	m	0.0017	m	0.0015	m		X

Sample No	Pcb153 ng/g ww	Pcb153f	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f
12337 13SEP05 1	0.047		0.048	am	0.023	a	0.0014	m
12337 13SEP05 2	0.045		0.050	am	0.017	a	0.0014	m
12338 12SEP05 1	0.064		0.050	m	0.0016	m	0.0014	m
12457 29AUG05 1	0.056		0.053	am	0.025	a	0.012	a
12459 29AUG05 1	0.061		0.052	m	0.031	a	0.015	a
12461 29AUG05 2	0.032	a	0.050	m	0.010	a	0.0014	m
20027 10SEP05 1	0.010	m	0.051	m	0.0016	m	0.0014	m
20037 02SEP05 1	0.096		0.044	m	0.041		0.025	a
20062 03SEP05 1	0.048		0.048	am	0.023	a	0.013	a
20135 09SEP05 1	0.0090	m	0.046	m	0.016	a	0.0013	m
20305 03SEP05 1	0.010	m	0.053	m	0.0017	m	0.0015	m
20305 03SEP05 2	0.042		0.050	am	0.015	a	0.0088	a
20305 03SEP05 3	0.034	a	0.053	m	0.011	a	0.0092	a
21317 02SEP05 1	0.010	m	0.050	m	0.010	a	0.0014	m
21329 07SEP05 1	0.038		0.048	am	0.014	a	0.010	a
21390 03SEP05 1	0.028	a	0.048	m	0.010	a	0.0014	m
21397 03SEP05 1	0.031	a	0.050	m	0.012	a	0.0087	a
21397 03SEP05 2	0.0093	m	0.048	m	0.0015	m	0.0014	m
21522 08SEP05 1	0.010	m	0.050	m	0.0016	m	0.0014	m
21522 08SEP05 2	0.010	m	0.050	m	0.0016	m	0.0014	m
21522 08SEP05 3	0.028	a	0.050	m	0.0087	a	0.0044	a
21559 07SEP05 1	0.038		0.050	m	0.015	a	0.0014	m
21559 07SEP05 3	0.0088	m	0.046	m	0.0015	m	0.0013	m
23058 10SEP05 1	0.010	m	0.052	m	0.0017	m	0.0015	m

Sample No	Flrant ng/g ww	Flrantf	Retene ng/g ww	Retenef	Dde ng/g ww	Ddef
CNT 01JUL06 1	0.066	m	1.6		0.136	m
CNT 01JUL06 2	0.063	m	1.5		0.129	m
CNF 06JUL06 1	0.066	m	1.1		0.136	m
CNF 06JUL06 2	0.066	m	0.28	m	0.135	m
DAN 07JUL06 1	0.063	m	0.27	m	0.129	m
DAN 07JUL06 2	0.060	m	0.26	m	0.124	m
TLP 07JUL06 1	0.066	m	17		1.857	
TLP 07JUL06 2	0.067	m	6.3		1.380	
SLV 08JUL06 1	0.063	m	0.27	m	0.130	m
SLV 07JUL06 2	0.063	m	0.27	m	0.130	m
SRD 07JUL06 1		X	27		0.129	m
SRD 07JUL06 2		X	35		0.125	m
SWA 17JUL06 1	0.066	m	0.28	m	0.135	m
SWA 17JUL06 2	0.063	m	0.27	m	0.129	m
KEL 19JUL06 1	0.057	m	0.88		0.432	
KEL 19JUL06 2	0.062	m	0.27	m	0.387	
MUD 21JUL06 1	0.057	m	1.2		0.118	m
MUD 21JUL06 2	0.063	m	0.27	m	0.129	m
DAR 24JUL06 1	0.065	m	1.1		0.134	m
DAR 24JUL06 2	0.066	m	1.1		0.135	m

Sample No	Acena ng/g ww	Acen af	Fluor ng/g ww	Fluorf	Phen an ng/g ww	Phenanf	Flrant ng/g ww	Flrantf	Retene ng/g ww	Retenef	Dde ng/g ww	Ddef
12337 13SEP05 1	0.36	m		Xm		Xm	0.061	m	0.26	m	1.1	
12337 13SEP05 2	0.37	m	0.18	m		X	0.063	m	0.27	m	1.1	
12338 12SEP05 1	0.38	m		Xm		X	0.063	m	0.27	m	0.13	m
12457 29AUG05 1	0.40	m		Xm		Xm	0.067	m	2.5		1.9	
12459 29AUG05 1	0.39	m		Xm		X	0.066	m	1.8		3.4	
12461 29AUG05 2	0.37	m		Xm		X	0.063	m	0.27	m	0.83	
20027 10SEP05 1	0.38	m		Xm		X	0.064	m	0.27	m	0.13	m
20037 02SEP05 1	0.33	m		Xm		X	0.056	m	1.1		0.97	
20062 03SEP05 1	0.36	m	0.18	m		X	0.061	m	0.72		1.1	
20135 09SEP05 1	0.34	m		Xm		Xm	0.058	m	0.25	m	0.62	
20305 03SEP05 1	0.39	m		Xm		Xm	0.067	m	0.28	m	0.46	
20305 03SEP05 2	0.38	m		Xm		X	0.063	m	0.27	m	0.79	
20305 03SEP05 3	0.39	m		Xm		X	0.067	m	0.28	m	0.69	
21317 02SEP05 1	0.37	m		Xm		Xm	0.063	m	0.27	m	0.71	
21329 07SEP05 1	0.36	m	0.18	m		Xm	0.061	m	0.77		1.3	
21390 03SEP05 1	0.36	m		Xm		X	0.061	m	1.2		0.45	
21397 03SEP05 1	0.37	m		Xm		Xm	0.063	m	0.27	m	0.13	m
21397 03SEP05 2	0.36	m		Xm		Xm	0.060	m	0.26	m	0.12	m
21522 08SEP05 1	0.37	m		Xm		Xm	0.063	m	0.27	m	0.13	m
21522 08SEP05 2	0.37	m		Xm		X	0.063	m	0.27	m	0.13	m
21522 08SEP05 3	0.37	m	0.18	m		X	0.063	m	0.27	m	0.13	m
21559 07SEP05 1	0.37	m		Xm		Xm	0.063	m	0.27	m	0.74	
21559 07SEP05 3	0.34	m		Xm		X	0.057	m	0.24	m	2.0	
23058 10SEP05 1	0.39	m		Xm		Xm	0.066	m	0.28	m	0.14	m

Sample No	Matrix	Region	Species	Stage	Tadpole Weight	g extracted	moisture % ww	lipid % ww
CNT 01JUL06 1	Tadpole	Sierras transect	PR	25	0.24	2.0	93.5	0.02
CNT 01JUL06 2	Tadpole	Sierras transect	PR	31	0.49	2.1	93.1	0.16
CNF 06JUL06 1	Tadpole	Sierras transect	PR	35	1.05	2.0	90.5	0.19
CNF 06JUL06 2	Tadpole	Sierras transect	PR	35	0.75	2.0	91.4	0.21
DAN 07JUL06 1	Tadpole	Sierras transect	PR	24	0.17	2.1	93.0	0.03
DAN 07JUL06 2	Tadpole	Sierras transect	PR	24	0.16	2.2	92.9	0.05
TLP 07JUL06 1	Tadpole	Sierras transect	PR	24	0.09	2.0	94.0	0.01
TLP 07JUL06 2	Tadpole	Sierras transect	PR	24	0.10	2.0	92.8	0.03
SLV 08JUL06 1	Tadpole	Sierras transect	PR	27	0.27	2.1	94.8	0.01
SLV 07JUL06 2	Tadpole	Sierras transect	PR	30	0.70	2.1	94.6	0.04
SRD 07JUL06 1	Tadpole	Sierras transect	PR	32	0.54	2.1	92.3	0.01
SRD 07JUL06 2	Tadpole	Sierras transect	PR	37	0.67	2.1	90.1	0.05
SWA 17JUL06 1	Tadpole	Sierras transect	PR	35	0.41	2.0	91.1	0.06
SWA 17JUL06 2	Tadpole	Sierras transect	PR	34	0.40	2.1	92.3	0.06
KEL 19JUL06 1	Tadpole	Sierras transect	PR	37	0.60	2.3	89.6	0.10
KEL 19JUL06 2	Tadpole	Sierras transect	PR	38	0.58	2.1	90.4	0.12
MUD 21JUL06 1	Tadpole	Sierras transect	PR	36	0.91	2.3	90.2	0.22
MUD 21JUL06 2	Tadpole	Sierras transect	PR	40	1.10	2.1	89.5	0.27
DAR 24JUL06 1	Tadpole	Sierras transect	PR	34	0.46	2.0	91.0	0.04
DAR 24JUL06 2	Tadpole	Sierras transect	PR	36	0.81	2.0	91.5	0.03
Sample No	Matrix	Region	Species	Stage	Tadpole Weight	g extracted	moisture % ww	lipid % ww
70134 29JUL06 1	Tadpole	YOSE	PR	30	0.71	2.1	91.0	0.26
70134 30AUG06 1	Tadpole	YOSE	PR	37	0.97	2.3	89.6	0.35
70414 29AUG06 1	Tadpole	YOSE	PR	46	0.61	2.1	84.3	2.39
70414 30JUL06 1	Tadpole	YOSE	PR	39	1.30	2.1	90.6	0.63
72403 02AUG06 1	Tadpole	YOSE	PR	37	1.38	2.1	89.8	0.28
72403 02AUG06 2	Tadpole	YOSE	PR	39	1.45	2.1	90.0	0.22
72403 31AUG06 1	Tadpole	YOSE	PR	37	1.61	2.1	90.3	1.14
72996 30AUG06 1	Tadpole	YOSE	PR	38	0.88	2.1	89.3	0.94
72996 31JUL06 1	Tadpole	YOSE	PR	25	0.15	2.1	92.8	0.41

Sample No	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf	Dacthl ng/g ww	Dacthlf	Chlrpy ng/g ww	Chlrpyf
CNT 01JUL06 1		aX		aXm	0.0040	m		dX
CNT 01JUL06 2		aXm		aX	0.0038	m		X
CNF 06JUL06 1		aXm		aX	0.0040	m		X
CNF 06JUL06 2		aXm		aX	0.0040	m		dX
DAN 07JUL06 1		aXm		aX	0.0038	m	0.424	
DAN 07JUL06 2		X		aX	0.0036	m		dX
TLP 07JUL06 1		aX		aX	0.0040	m		Xm
TLP 07JUL06 2		aX		aX	0.0040	m		X
SLV 08JUL06 1		aX		aXm	0.0038	m		Xm
SLV 07JUL06 2		aX		aX	0.0038	m		X
SRD 07JUL06 1		aX		aX	0.0038	m		dX
SRD 07JUL06 2		X		aX	0.025	a		dX
SWA 17JUL06 1		aXm		X	0.0040	m		dXm
SWA 17JUL06 2		X		aX	0.0038	m		dX
KEL 19JUL06 1		aXm		X	0.0034	m		Xm
KEL 19JUL06 2		aXm		X	0.0038	m		dXm
MUD 21JUL06 1		aXm		aX	0.13	G		dXm
MUD 21JUL06 2		aXm		aX	0.18	G		dXm
DAR 24JUL06 1		aXm		aX	0.0039	m		dX
DAR 24JUL06 2		aXm		aX	0.0039	m		dXm

Sample No	Hexch ng/g ww	Hexchf	Dacthl ng/g ww	Dacthlf	Chordtn ng/g ww	Chordtn ng/g ww	Nonatn ng/g ww	Nonatnf
70134 29JUL06 1		X	0.036		0.00054	m	0.00060	m
70134 30AUG06 1		X	0.047		0.00049	m	0.027	a
70414 29AUG06 1	0.101		0.040		0.043		0.074	
70414 30JUL06 1		X	0.024	a	0.019	a	0.023	a
72403 02AUG06 1		X	0.0037	m	0.00054	m	0.00060	m
72403 02AUG06 2		X	0.033	a	0.00054	m	0.00060	m
72403 31AUG06 1		X	0.20		0.020	a	0.030	a
72996 30AUG06 1		X	0.15		0.030	a	0.059	
72996 31JUL06 1		X	0.0037	m	0.00054	m	0.00060	m

Sample No	Chordtn ng/g ww	Chordtn ng/g ww	Nonatn ng/g ww	Nonatnf	ctEnd2mdw	End2f	Endsu ng/g ww	Endsuf
CNT 01JUL06 1	0.00057	m	0.001	m	0.004	m	0.074	
CNT 01JUL06 2	0.00054	m	0.001	m	0.004	m	0.10	
CNF 06JUL06 1	0.00057	m	0.001	m	0.004	m	0.11	
CNF 06JUL06 2	0.00057	m	0.001	m	0.004	m	0.094	
DAN 07JUL06 1	0.00055	m	0.001	m	0.004	m	0.15	
DAN 07JUL06 2	0.00052	m	0.001	m	0.004	m	0.13	
TLP 07JUL06 1	0.00057	m	0.001	m	0.004	m	0.18	
TLP 07JUL06 2	0.00058	m	0.001	m	0.004	m	0.18	
SLV 08JUL06 1	0.00055	m	0.001	m	0.004	m	0.005	m
SLV 07JUL06 2	0.00055	m	0.001	m	0.004	m	0.005	m
SRD 07JUL06 1	0.00055	m	0.001	m	0.004	m	0.061	a
SRD 07JUL06 2	0.00052	m	0.001	m	0.004	m	0.071	
SWA 17JUL06 1	0.00057	m	0.001	m	0.004	m	0.11	
SWA 17JUL06 2	0.00054	m	0.001	m	0.004	m	0.103	
KEL 19JUL06 1	0.00049	m	0.033		0.003	m	0.063	a
KEL 19JUL06 2	0.00054	m	0.025	a	0.004	m	0.062	a
MUD 21JUL06 1	0.0080	ad	0.001	m	0.040	a	0.082	
MUD 21JUL06 2	0.0058	ad	0.001	m	0.052	a	0.081	
DAR 24JUL06 1	0.00056	m	0.001	m	0.004	m	0.057	a
DAR 24JUL06 2	0.00057	m	0.001	m	0.004	m	0.061	a

Sample No	Pcb118 ng/g ww	Pcb118f	Nonacs ng/g ww	Nonacsf	Endsu ng/g ww	Endsuf	Pcb153 ng/g ww	Pcb153f
70134 29JUL06 1	0.012	m	0.003	m	0.194		0.010	m
70134 30AUG06 1	0.011	m	0.021	a	0.254		0.026	a
70414 29AUG06 1	0.057		0.049		0.063		0.066	
70414 30JUL06 1	0.012	m	0.003	m	0.101		0.010	m
72403 02AUG06 1	0.012	m	0.003	m	0.159		0.010	m
72403 02AUG06 2	0.012	m	0.003	m	0.144		0.010	m
72403 31AUG06 1	0.024	a	0.003	m	0.233		0.010	m
72996 30AUG06 1	0.027	a	0.041		0.203		0.010	m
72996 31JUL06 1	0.012	m	0.003	m	0.156		0.010	m

Sample No	Pcb153 ng/g ww	Pcb153f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f	Phenan ng/g ww	Phenanf
CNT 01JUL06 1	0.010	m	0.0017	m	0.0015	m		X
CNT 01JUL06 2	0.020	a	0.0016	m	0.0014	m		Xm
CNF 06JUL06 1	0.010	m	0.0017	m	0.0015	m		X
CNF 06JUL06 2	0.010	m	0.0017	m	0.0015	m		X
DAN 07JUL06 1	0.010	m	0.0016	m	0.0014	m		X
DAN 07JUL06 2	0.0093	m	0.0015	m	0.0014	m		X
TLP 07JUL06 1	0.010	m	0.0017	m	0.0015	m		X
TLP 07JUL06 2	0.010	m	0.0017	m	0.0015	m		X
SLV 08JUL06 1	0.010	m	0.0016	m	0.0014	m		X
SLV 07JUL06 2	0.010	m	0.0016	m	0.0014	m		X
SRD 07JUL06 1	0.010	m	0.0016	m	0.0014	m		X
SRD 07JUL06 2	0.0093	m	0.0015	m	0.0014	m		X
SWA 17JUL06 1	0.010	m	0.0091	a	0.0045	a		X
SWA 17JUL06 2	0.010	m	0.0016	m	0.0014	m		X
KEL 19JUL06 1	0.0088	m	0.011	a	0.0013	m		X
KEL 19JUL06 2	0.010	m	0.0072	a	0.0014	m		X
MUD 21JUL06 1	0.0088	m	0.0015	m	0.0013	m		X
MUD 21JUL06 2	0.010	m	0.0016	m	0.0014	m		Xm
DAR 24JUL06 1	0.010	m	0.0017	m	0.0015	m		X
DAR 24JUL06 2	0.010	m	0.0017	m	0.0015	m		X

Sample No	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f	Fluor ng/g ww	Fluorf	Phenan ng/g ww	Phenanf
70134 29JUL06 1	0.0016	am	0.0014	m		Xm		X
70134 30AUG06 1	0.0039	a	0.0013	m		Xm		X
70414 29AUG06 1	0.030	a	0.013	a		X		X
70414 30JUL06 1	0.0057	a	0.0014	m		Xm		X
72403 02AUG06 1	0.0016	m	0.0014	m		Xm		X
72403 02AUG06 2	0.0016	m	0.0014	m		Xm		X
72403 31AUG06 1	0.0016	m	0.0014	m		Xm		X
72996 30AUG06 1	0.010	a	0.0014	m		Xm		X
72996 31JUL06 1	0.0043	a	0.0014	m		Xm		Xm

Sample No	Flrant ng/g ww	Flrantf	Retene ng/g ww	Retenef	Dde ng/g ww	Ddef
CNT 01JUL06 1	0.066	m	1.6		0.136	m
CNT 01JUL06 2	0.063	m	1.5		0.129	m
CNF 06JUL06 1	0.066	m	1.1		0.136	m
CNF 06JUL06 2	0.066	m	0.28	m	0.135	m
DAN 07JUL06 1	0.063	m	0.27	m	0.129	m
DAN 07JUL06 2	0.060	m	0.26	m	0.124	m
TLP 07JUL06 1	0.066	m	17		1.857	
TLP 07JUL06 2	0.067	m	6.3		1.380	
SLV 08JUL06 1	0.063	m	0.27	m	0.130	m
SLV 07JUL06 2	0.063	m	0.27	m	0.130	m
SRD 07JUL06 1		X	27		0.129	m
SRD 07JUL06 2		X	35		0.125	m
SWA 17JUL06 1	0.066	m	0.28	m	0.135	m
SWA 17JUL06 2	0.063	m	0.27	m	0.129	m
KEL 19JUL06 1	0.057	m	0.88		0.432	
KEL 19JUL06 2	0.062	m	0.27	m	0.387	
MUD 21JUL06 1	0.057	m	1.2		0.118	m
MUD 21JUL06 2	0.063	m	0.27	m	0.129	m
DAR 24JUL06 1	0.065	m	1.1		0.134	m
DAR 24JUL06 2	0.066	m	1.1		0.135	m

Sample No	Retene ng/g ww	Retenef	Dde ng/g ww	Ddef
70134 29JUL06 1	5.697		0.127	m
70134 30AUG06 1	0.240	m	0.318	
70414 29AUG06 1	0.263	m	9.161	
70414 30JUL06 1	8.483		1.810	
72403 02AUG06 1	0.263	m	0.904	
72403 02AUG06 2	0.263	m	1.254	
72403 31AUG06 1	0.263	m	3.547	
72996 30AUG06 1	0.263	m	0.757	
72996 31JUL06 1	0.263	m	0.127	m

Sample No	Matrix	Region	g extracted	moisture % ww	total organic carbon % dw	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf
ANT 07JUL05	Sediment	Cascades	12.6	28.4	5.3		X		X
BAT 08JUN05	Sediment	Cascades	12.0	91.5	13.5		aXm		X
BCL 28JUL05	Sediment	Cascades	12.4	55.8	9.1		X		X
BDR 01AUG05	Sediment	Cascades	12.1	81.7	16.8		X		X
BLF 10JUL05	Sediment	Cascades	15.0	60.9	6.2		X		X
BTY 03AUG05	Sediment	Cascades	13.2	70.0	19.3		dX	0.051	d
BUT 12JUL05	Sediment	Cascades	14.5	73.8	9.0		X		X
CBY 14JUL05	Sediment	Cascades	10.9	92.5	17.5		Xm		Xm
DCH 10JUL05	Sediment	Cascades	13.7	77.5	21.0		X		X
DLP 30JUL05	Sediment	Cascades	12.5	87.2	37.0		X	0.061	d
DOM 06JUN05	Sediment	Cascades	14.3	59.3	4.1		aX	0.057	
FND 01AUG05	Sediment	Cascades	13.2	84.6	32.8		X		X
FRY 28JUL05	Sediment	Cascades	13.3	79.0	9.3		X		X
GUM 06JUL05	Sediment	Cascades	14.4	47.8	6.9		X	3.2	
GUM 26JUL05	Sediment	Cascades	12.7	67.8	10.8		X	0.042	
LML 12JUL05	Sediment	Cascades	13.0	59.4	5.9		Xm		Xm
LML 29JUL05	Sediment	Cascades	13.8	74.1	13.6		X		Xm
LST 13JUL05	Sediment	Cascades	13.6	56.9	4.4		X		X
MBP 08JUL05	Sediment	Cascades	12.1	87.4	17.4		X		Xm
MCC 07JUL05	Sediment	Cascades	14.5	34.9	2.8		X		X
MEB 29JUL05	Sediment	Cascades	14.7	53.2	2.2	0.00031	m		X
MUM 06JUL05	Sediment	Cascades	14.2	76.1	16.0	0.00032	m	0.000041	m
MUM 22AUG05 1	Sediment	Cascades	13.0	87.0	23.8	0.0030			X
MUM 22AUG05 2	Sediment	Cascades	12.8	82.2	22.0		X		dX
NEL 08JUL05	Sediment	Cascades	15.4	51.2	5.6		X		X
SKW 08JUL05	Sediment	Cascades	13.8	71.9	13.9	0.0030			X
SNG 13JUL05	Sediment	Cascades	11.9	50.2	6.0		X	0.065	
SNW 07JUN05	Sediment	Cascades	13.2	89.5	26.5		X		X
SNW 21AUG05	Sediment	Cascades	13.2	88.7	17.0		Xm		X
TNG 12JUL05	Sediment	Cascades	14.5	75.0	9.7		X		X
UEB 29JUL05	Sediment	Cascades	13.1	77.7	6.1		X		X
UGB 26JUL05	Sediment	Cascades	14.6	74.1	10.1		Xm		X
ULC 31JUL05	Sediment	Cascades	13.2	80.8	8.8		Xm		Xm
UNL 31JUL05	Sediment	Cascades	11.8	91.2	31.4	0.019		0.70	
WCP 30JUL05	Sediment	Cascades	12.8	66.7	5.9		X		X
YEL 13JUL05	Sediment	Cascades	14.1	52.9	2.9		Xm		Xm

Sample No	Matrix	Region	g extracted	moisture % ww	total organic carbon % dw	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf
12457 30JUL05 1	Sediment	SEKI	16.2	89.0	15.2	0.00028	m		dX
12461 30JUL05 1	Sediment	SEKI	13.1	86.1	19.6		X		X
11087 31JUL05 1	Sediment	SEKI	14.5	95.4	11.6		Xm		Xm
11089 31JUL05 1	Sediment	SEKI	13.9	77.0	6.1		Xm		Xm
12155 01AUG05 1	Sediment	SEKI	11.0	98.1	18.8		X		X
21317 01AUG05 1	Sediment	SEKI	14.1	87.7	17.3		X		X
12154 02AUG05 1	Sediment	SEKI	12.7	88.6	14.8		Xm	0.033	
20037 02AUG05 1	Sediment	SEKI	12.2	93.6	13.1		aXm		Xm
20062 03AUG05 1	Sediment	SEKI	15.0	24.2	0.5		Xm		Xm
21390 03AUG05 1	Sediment	SEKI	15.2	94.7	12.8		aXm		Xm
21397 03AUG05 1	Sediment	SEKI	14.2	54.6	0.9		X		dX
2310X 04AUG05 1	Sediment	SEKI	12.1	99.8	28.7		X		X
2310X 04AUG05 2	Sediment	SEKI	8.3	97.7	27.2		X		X
11475 06AUG05 1	Sediment	SEKI	14.9	64.0	2.4		aXm		X
11685 06AUG05 1	Sediment	SEKI	12.8	71.1	7.2		aXm		X
11474 07AUG05 1	Sediment	SEKI	15.2	56.4	8.6		X		X
11474 07AUG05 2	Sediment	SEKI	13.4	94.0	15.5		X	0.044	
1168X 07AUG05 1	Sediment	SEKI	12.6	77.2	9.8		X		X
10249 08AUG05 1	Sediment	SEKI	12.9	92.6	6.2		aXm		Xm
21329 08AUG05 1	Sediment	SEKI	16.7	42.3	4.3		aXm		Xm
21559 08AUG05 1	Sediment	SEKI	13.0	75.9	7.2		X		dX
21522 09AUG05 1	Sediment	SEKI	14.7	90.4	1.0		X		X
10525 08AUG05 1	Sediment	SEKI	12.9	69.9	2.1		X		Xm
20027 10AUG05 1	Sediment	SEKI	13.6	91.7	13.2		aXm		Xm

Sample No	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthl f	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chor dtn ng/g ww	End1 ng/g ww	End1 f	Nonatn ng/g ww	Nonatnf
ANT 07JUL05	0.0045	m	0.00040	m	0.0061	am	0.0076		0.0020	m	0.0055	
BAT 08JUN05	0.0047	m	0.026		0.031	d	0.0083	d	0.0021	m	0.010	d
BCL 28JUL05	0.0046	m	0.00040	m	0.019	a	0.013	d	0.0020	m	0.014	d
BDR 01AUG05	0.0047	m	0.0032	a	0.015	a	0.0087	d	0.0020	m	0.0057	ad
BLF 10JUL05	0.0038	m	0.010		0.0051	m	0.044		0.0016	m	0.039	
BTY 03AUG05	0.079		0.0039	a	0.013	a	0.025		0.0019	m	0.017	
BUT 12JUL05	0.0039	m	0.026		0.016	a	0.018		0.0017	m	0.023	
CBY 14JUL05	0.0052	m	0.0083		0.0070	adm	0.0028	ad	0.0023	m	0.0069	d
DCH 10JUL05	0.062		0.0092		0.013	a	0.023		0.016	a	0.026	
DLP 30JUL05	0.0045	m	0.010	d	0.014	a	0.012		0.0020	m	0.017	
DOM 06JUN05	0.037	c	0.011		0.0054	m	0.053		0.0017	m	0.061	
FND 01AUG05	0.075		0.011		0.028		0.028	d	0.016	ad	0.026	d
FRY 28JUL05	0.0042	m	0.00037	m	0.020	a	0.00019	m	0.0019	m	0.00053	m
GUM 06JUL05	0.0039	m	0.14		0.067		0.029		0.0017	m	0.025	
GUM 26JUL05	0.0044	m	0.0038	a	0.015	a	0.020		0.0019	m	0.019	
LML 12JUL05	0.0043	m	0.00038	m	0.012	a	0.00019	m	0.0019	m	0.00054	m
LML 29JUL05	0.0041	m	0.0054		0.012	a	0.0050	a	0.0018	m	0.017	
LST 13JUL05	0.029	c	0.018		0.025	d	0.029	d	0.0018	m	0.039	d
MBP 08JUL05	0.085		0.020		0.015	a	0.0079		0.010	a	0.0069	
MCC 07JUL05	0.0039	m	0.007		0.0053	am	0.00017	m	0.0017	m	0.0025	a
MEB 29JUL05	0.0038	m	0.00034	m	0.0052	m	0.0065		0.0017	m	0.0094	
MUM 06JUL05	0.0040	m	0.00035	m	0.0054	m	0.012	d	0.0017	m	0.015	d
MUM 22AUG05 1	0.0043	m	0.00038	m	0.0059	m	0.0060		0.0019	m	0.00054	m
MUM 22AUG05 2	0.0044	m	0.00039	m	0.016	a	0.0077		0.0019	m	0.0070	
NEL 08JUL05	0.0037	m	0.0082		0.015	a	0.026		0.0016	m	0.034	
SKW 08JUL05	0.0041	m	0.0072		0.020	a	0.034		0.0018	m	0.028	
SNG 13JUL05	0.066		0.056		0.028	d	0.017	d	0.0088	ad	0.020	d
SNW 07JUN05	0.0043	m	0.0032	a	0.018	a	0.010		0.0019	m	0.0089	
SNW 21AUG05	0.0043	m	0.00038	m		aX	0.0075	d	0.0019	m	0.0082	d
TNG 12JUL05	0.0039	m	0.00034	m	0.012		0.013		0.0017	m	0.021	
UEB 29JUL05	0.0043	m	0.00038	m	0.0059	adm	0.0053	ad	0.0019	m	0.0082	d
UGB 26JUL05	0.0039	m	0.0064		0.0053	adm	0.0082	d	0.0017	m	0.014	d
ULC 31JUL05	0.0043	m	0.00038	m	0.0058	adm	0.0045	ad	0.0019	m	0.0073	d
UNL 31JUL05	0.284		0.061		0.033		0.00021	m	0.010	a	0.0084	
WCP 30JUL05	0.0044	m	0.027		0.0060	am	0.0084	a	0.0019	m	0.014	
YEL 13JUL05	0.0040	m	0.0085		0.0054	am	0.0026	a	0.0018	m	0.0038	a
Sample No	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthl f	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chor dtn ng/g ww	End1 ng/g ww	End1 f	Nonatn ng/g ww	Nonatnf
12457 30JUL05 1	0.0035	m	0.00031	m	0.0047	m	0.00015	m	0.0015	m	0.00043	m
12461 30JUL05 1	0.0043	m	0.012			X	0.030		0.049		0.036	
11087 31JUL05 1	0.0039	m	0.015		0.0053	am	0.0033	a	0.0017	m	0.0066	a
11089 31JUL05 1	0.0041	m	0.0088			Xm	0.015		0.0018	m	0.019	
12155 01AUG05 1	0.0051	m	0.022			Xm	0.0074		0.0022	m	0.022	
21317 01AUG05 1	0.0040	m	0.011			X	0.011		0.0018	m	0.033	
12154 02AUG05 1	0.0044	m	0.015			X	0.030		0.0019	m	0.042	
20037 02AUG05 1	0.0046	m	0.015			Xm	0.010		0.016	a	0.015	
20062 03AUG05 1	0.0038	m	0.0036	a		Xm	0.0046	a	0.0016	m	0.00047	m
21390 03AUG05 1	0.0037	m	0.015			Xm	0.0053		0.0016	m	0.016	
21397 03AUG05 1	0.0040	m	0.0068		0.029		0.00018	m	0.0017	m	0.012	
2310X 04AUG05 1	0.0047	m	0.023		0.013		0.0055	a	0.021	a	0.0006	m
2310X 04AUG05 2	0.0068	m	0.023		0.034		0.0094		0.0030	m	0.0008	m
11475 06AUG05 1	0.0038	m	0.021			Xm	0.032		0.0017	m	0.036	
11685 06AUG05 1	0.0044	m	0.044			Xm	0.021		0.021	a	0.055	
11474 07AUG05 1	0.0037	m	0.0085		0.0051	m	0.0083		0.0016	m	0.016	
11474 07AUG05 2	0.0042	m	0.070		0.035		0.021		0.0018	m	0.044	
1168X 07AUG05 1	0.0045	m	0.027		0.023		0.022		0.066		0.038	
10249 08AUG05 1	0.0044	m	0.13			Xm	0.011		0.020	a	0.020	
21329 08AUG05 1	0.0034	m	0.015			Xm	0.016		0.0015	m	0.057	
21559 08AUG05 1	0.0043	m	0.028			Xm	0.027		0.044		0.094	
21522 09AUG05 1	0.0038	m	0.0065			X	0.00017	m	0.0017	m	0.00048	m
10525 08AUG05 1	0.0044	m	0.010			Xm	0.00019	m	0.0019	m	0.012	
20027 10AUG05 1	0.0042	m	0.026			Xm	0.033	d	0.022	ad	0.039	d

Sample No	Diel ng/g ww	Dielf	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2 f	Nonacs ng/g ww	Non acsf	Endsu ng/g ww	Ends uf	Pcb153 ng/g ww	Pcb1 53f
ANT 07JUL05	0.041	m	0.0013	m	0.010	a	0.0064		0.11		0.012	
BAT 08JUN05	0.043	m	0.0013	m	0.0090	ad	0.0033	ad	0.018	d	0.0012	m
BCL 28JUL05	0.042	m	0.0013	m	0.0090	a	0.013		0.044		0.015	
BDR 01AUG05	0.043	m	0.0013	m	0.0069	a	0.00063	m	0.064		0.016	
BLF 10JUL05	0.034	m	0.054		0.012		0.022		0.13		0.025	
BTY 03AUG05	0.17	m	0.0012	m	0.0012	m	0.019		0.26		0.017	
BUT 12JUL05	0.036	m	0.0011	m	0.013		0.0091		0.17		0.0010	m
CBY 14JUL05	0.047	m	0.0015	m	0.0014	m	0.0041	a	0.017		0.0013	m
DCH 10JUL05	0.038	m	0.0012	m	0.029		0.020		0.24		0.021	
DLP 30JUL05	0.041	m	0.091	d	0.0012	m	0.018		0.34		0.028	d
DOM 06JUN05	0.036	m	0.021		0.0011	m	0.020		0.021		0.017	
FND 01AUG05	0.039	m	0.089		0.043		0.021		0.37		0.019	
FRY 28JUL05	0.039	m	0.0012	m	0.0011	m	0.00058	m	0.042		0.0011	m
GUM 06JUL05	0.036	m	0.197		0.011		0.014		0.058		0.12	
GUM 26JUL05	0.041	m	0.096		0.0012	m	0.018		0.044		0.036	
LML 12JUL05	0.040	m	0.0012	m	0.0012	m	0.00059	m	0.010	a	0.0078	
LML 29JUL05	0.037	m	0.0012	m	0.0011	m	0.017		0.018		0.015	
LST 13JUL05	0.038	m	0.0012	m	0.0011	m	0.019	d	0.16	d	0.015	
MBP 08JUL05	0.043	m	0.0013	m	0.012	a	0.0057	a	0.22		0.016	
MCC 07JUL05	0.036	m	0.0011	m	0.0011	m	0.00053	m	0.009	a	0.0010	m
MEB 29JUL05	0.035	m	0.0011	m	0.0010	m	0.0057		0.008		0.0055	
MUM 06JUL05	0.036	m	0.0011	m	0.0011	m	0.00054	m	0.17		0.0010	m
MUM 22AUG05 1	0.040	m	0.0012	m	0.0012	m	0.0065		0.077		0.0011	m
MUM 22AUG05 2	0.040	m	0.0013	m	0.0012	m	0.0059		0.078		0.0011	m
NEL 08JUL05	0.034	m	0.096		0.0010	m	0.012		0.052		0.511	
SKW 08JUL05	0.037	m	0.027		0.018		0.020		0.18		0.025	
SNG 13JUL05	0.11	ad	0.0014	m	0.024		0.011		0.12		0.014	
SNW 07JUN05	0.039	m	0.039		0.0084		0.0070		0.088		0.022	
SNW 21AUG05	0.039	m	0.105		0.0012	m	0.0077		0.049		0.026	
TNG 12JUL05	0.036	m	0.0011	m	0.0011	m	0.017		0.013		0.017	
UEB 29JUL05	0.039	m	0.0012	m	0.0012	m	0.0092		0.024		0.014	
UGB 26JUL05	0.035	m	0.017		0.0010	m	0.0090		0.047		0.010	
ULC 31JUL05	0.039	m	0.0012	m	0.0012	m	0.0034	ad	0.015	d	0.0045	a
UNL 31JUL05	0.044	m	0.107		0.0094	a	0.0089		0.095		0.027	
WCP 30JUL05	0.040	m	0.0013	m	0.010	a	0.010		0.048		0.020	
YEL 13JUL05	0.037	m	0.0011	m	0.0011	m	0.00054	m	0.00074	m	0.028	

Sample No	Pcb74 ng/g ww	Pcb74f	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2 f	Nonacs ng/g ww	Non acsf	Endsu ng/g ww	Ends uf	Pcb153 ng/g ww	Pcb1 53f
12457 30JUL05 1	0.14	m	0.0010	m	0.0009	m		dz		dz		dX
12461 30JUL05 1	0.17	m	0.0012	m	0.12		0.040		1.2		0.018	
11087 31JUL05 1	0.15	m	0.0011	m	0.015		0.0037	a	0.053		0.0010	m
11089 31JUL05 1	0.16	m	0.0012	m	0.012		0.024		0.21		0.010	a
12155 01AUG05 1	0.20	m	0.0015	m	0.0014	m	0.016		0.094		0.0013	m
21317 01AUG05 1	0.16	m	0.0011	m	0.013		0.029		0.28		0.018	
12154 02AUG05 1	0.17	m	0.0013	m	0.12		0.031		1.1		0.010	a
20037 02AUG05 1	0.18	m	0.0013	m	0.031		0.013		0.20		0.010	a
20062 03AUG05 1	0.15	m	0.0011	m	0.0010	m	0.0036	a	0.056		0.0009	m
21390 03AUG05 1	0.15	m	0.0011	m	0.010		0.010		0.072		0.0053	a
21397 03AUG05 1	0.16	m	0.0011	m	0.0011	m	0.0057		0.074		0.0010	m
2310X 04AUG05 1	0.18	m	0.0013	m	0.030		0.0057	a	0.13		0.0012	m
2310X 04AUG05 2	0.27	m	0.0019	m	0.037		0.011		0.17		0.0017	m
11475 06AUG05 1	0.15	m	0.0011	m	0.0010	m	0.027		0.35		0.011	
11685 06AUG05 1	0.17	m	0.0013	m	0.080		0.040		0.76		0.012	
11474 07AUG05 1	0.15	m	0.0011	m	0.012		0.010		0.15		0.0075	a
11474 07AUG05 2	14		0.0012	m	0.063		0.034		0.62		0.019	
1168X 07AUG05 1	0.18	m	0.0013	m	0.13		0.028		0.50		0.010	a
10249 08AUG05 1	3.6		0.0012	m	0.035		0.014		0.39		0.0011	m
21329 08AUG05 1	0.13	m	0.010	a	0.016		0.033		0.25		0.011	
21559 08AUG05 1	0.17	m	0.0012	m	0.051		0.044		0.42		0.022	
21522 09AUG05 1	0.15	m	0.0011	m	0.0010	m	0.00052	m	0.076		0.0010	m
10525 08AUG05 1	0.17	m	0.0012	m	0.0012	m	0.007		0.059		0.0058	a
20027 10AUG05 1	0.16	m	0.0012	m	0.077		0.042		0.92		0.017	

Sample No	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187 f	Pcb183 ng/g ww	Pcb183 f	Acenathyl ng/g ww	Acenathyl f	Acena ng/g ww	Acenaf	Fluor ng/g ww	Fluor f
ANT 07JUL05	0.013		0.0036	a	0.0019	a	0.13	m	0.79	m	0.77	d
BAT 08JUN05	0.0018	m	0.0040	a	0.0015	a	0.13	m	0.83	m		X
BCL 28JUL05	0.019		0.0082		0.0029	a	0.13	m	0.80	m		Xm
BDR 01AUG05	0.018		0.0072		0.0030		0.13	m	0.82	m	0.54	
BLF 10JUL05	0.027		0.0092		0.0044	a	0.11	m	0.66	m	0.12	M
BTY 03AUG05	0.023		0.0086		0.0032	a	0.12	m	0.75	m	0.14	M
BUT 12JUL05	0.0015	m	0.0060		0.00042	m	0.11	m	0.69	m	0.67	
CBY 14JUL05	0.0020	m	0.00022	m	0.00056	m	0.15	m	0.91	m	0.17	M
DCH 10JUL05	0.027		0.010		0.0048	a	0.12	m	0.73	m	0.13	M
DLP 30JUL05	0.051	d	0.017	d	0.0067	d	0.13	m	0.79	m	0.15	M
DOM 06JUN05	0.025		0.015		0.0050	a	0.11	m	0.69	m		Xm
FND 01AUG05	0.026		0.011		0.0048	a	0.12	m	0.75	m	0.14	M
FRY 28JUL05	0.0016	m	0.0029	a	0.00046	m	24		7.0		78	
GUM 06JUL05	0.091		0.098		0.0358		96	d	34	d	315	Bd
GUM 26JUL05	0.045		0.028		0.0106		0.13	m	0.78	m		Xm
LML 12JUL05	0.0016	m	0.0025	a	0.00047	m	0.12	m	0.76	m	0.14	M
LML 29JUL05	0.019		0.010		0.0067		0.12	m	0.72	m	0.13	M
LST 13JUL05	0.014		0.0068		0.0031	a	0.12	m	0.73	m	0.13	M
MBP 08JUL05	0.023		0.0084		0.0040	a	0.13	m	0.82	m	0.15	M
MCC 07JUL05	0.0015	m	0.00017	m	0.00042	m	0.11	m	0.69	m	0.13	M
MEB 29JUL05	0.010		0.0031	a	0.0016	a	0.11	m	0.68	m	0.12	M
MUM 06JUL05	0.0015	m	0.00017	m	0.00043	m	0.11	m	0.70	m	0.13	M
MUM 22AUG05 1	0.0016	m	0.00019	m	0.00047	m	0.12	m	0.76	m	0.58	
MUM 22AUG05 2	0.0017	m	0.00019	m	0.00048	m	0.13	m	0.78	m	1.1	D
NEL 08JUL05	0.456		0.33		0.15		0.10	m	0.65	m	0.40	
SKW 08JUL05	0.035		0.022		0.0087		0.12	m	0.72	m		dX
SNG 13JUL05	0.022		0.0066		0.0030	a	0.14	m	0.84	m	0.15	M
SNW 07JUN05	0.031		0.0050	a	0.0025	a	0.12	m	0.75	m		X
SNW 21AUG05	0.045		0.0070		0.0036	a	0.12	m	0.75	m	0.14	M
TNG 12JUL05	0.0015	m	0.0074		0.0033	a	22	b	13		57	
UEB 29JUL05	0.014		0.0039	a	0.0016	a	0.12	m	0.76	m	0.14	M
UGB 26JUL05	0.016		0.0058		0.0029	a	0.11	m	0.68	m	0.12	M
ULC 31JUL05	0.0016	m	0.0014	a	0.00046	m	0.12	m	0.75	m	0.14	M
UNL 31JUL05	0.035		0.018		0.016		0.14	m	0.84	m	0.15	M
WCP 30JUL05	0.029		0.012		0.0068		0.13	m	0.78	m	0.14	M
YEL 13JUL05	0.0015	m	0.020		0.010		0.11	m	0.70	m	0.13	M

Sample No	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187 f	Pcb183 ng/g ww	Pcb183 f	Fluor ng/g ww	Fluor f	Phenan ng/g ww	Phenanf	Flrant ng/g ww	Flrantf
12457 30JUL05 1	0.0013	m		dX		adXm	0.11	m		xdm	0.69	D
12461 30JUL05 1	0.017		0.011		0.0039	a	0.82			x	1.1	
11087 31JUL05 1	0.0015	m		aXm		aXm		xm		xm	0.04	M
11089 31JUL05 1	0.010		0.0065		0.0024	a	0.41			xm	0.52	
12155 01AUG05 1	0.0019	m	0.0046	a	0.0019	a	0.17	m		x	0.51	
21317 01AUG05 1	0.020		0.011		0.0034	a	0.13	m		xm	0.44	
12154 02AUG05 1	0.0017	m	0.0059		0.00048	m	0.14	m		x	0.49	
20037 02AUG05 1	0.0089		0.0054	a	0.0020	a	0.68			x		X
20062 03AUG05 1	0.0014	m	0.00016	m	0.00041	m	0.12	m		xm	0.03	M
21390 03AUG05 1	0.0014	m	0.0026	a	0.0010	a	0.38			x		X
21397 03AUG05 1	0.0015	m	0.00017	m	0.00043	m	0.13	m		xm	0.22	
2310X 04AUG05 1	0.0018	m	0.00020	m	0.00050	m	0.15	m	2.7		0.04	M
2310X 04AUG05 2	0.0026	m	0.0029	a	0.00073	m	0.22	m		xm	0.63	
11475 06AUG05 1	0.0093		0.0056		0.0024	a	0.12	m		x	0.49	
11685 06AUG05 1	0.015		0.0082		0.0028	a	0.14	m		x	0.90	
11474 07AUG05 1	0.0014	m	0.0039	a	0.0014	a		xdm		xm	0.28	
11474 07AUG05 2	0.017		0.011		0.0034	a	0.14	m		x	0.04	M
1168X 07AUG05 1	0.0017	m	0.0048	a	0.0017	a		xm		xm	0.65	
10249 08AUG05 1	0.0016	m	0.0037	a	0.00047	m	0.14	m		x	0.77	
21329 08AUG05 1	0.012		0.0072		0.0023	a	0.31			x	0.41	
21559 08AUG05 1	0.022		0.015		0.0046	a	0.14	m		x	0.77	
21522 09AUG05 1	0.0014	m	0.00017	m	0.00041	m	0.12	m		xm	0.03	M
10525 08AUG05 1	0.0016	m	0.0019	a	0.00047	m	0.14	m		x	0.40	
20027 10AUG05 1	0.017		0.0093		0.0035	a	0.70			x	0.59	

Sample No	Phenan ng/g ww	Phenanf	Anthrc ng/g ww	Anthrc f	Flrant ng/g ww	Flra ntf	Pyr ng/g ww	Pyrf	Retene ng/g ww	Reten ef	opDde ng/g ww	opDde f
ANT 07JUL05		X	0.58	m	1.213		0.002	m	524.696	b	0.035	M
BAT 08JUN05		X	0.61	m	0.75		0.0018	m	37.644	b	0.037	M
BCL 28JUL05		X	0.59	m	0.77		0.64		3.714		0.036	M
BDR 01AUG05		X	0.60	m	0.50		0.0018	m	1040.831	b	0.037	M
BLF 10JUL05		X	0.48	m	0.034	m	0.85		114.410	b	0.030	M
BTY 03AUG05		X	0.55	m	1.3		1.3		185.938	b	0.034	M
BUT 12JUL05	2.6		0.50	m	0.035	m	0.0015	m	428.426	b	0.031	M
CBY 14JUL05		X	0.67	m		X	0.0020	m	9.803		0.041	M
DCH 10JUL05		X	0.53	m	0.80		1.0		4.615		0.032	M
DLP 30JUL05	3.4	d	0.58	m	1.6		1.8			X	0.036	M
DOM 06JUN05	2.5		0.51	m	2.1		2.0		4.810		0.031	m
FND 01AUG05		X	0.55	m	0.039	m	0.0017	m	374.410	b	0.034	m
FRY 28JUL05	424	b	73		159		151		41.098		0.033	m
GUM 06JUL05	1231	b	255	b	657	b	613	b	256.498	b	0.031	m
GUM 26JUL05		X	0.57	m	0.59		0.41		95.361	b	0.035	m
LML 12JUL05		Xm	0.56	m	0.69		0.0017	m	170.225	b	0.034	m
LML 29JUL05		X	0.53	m	0.35		0.0016	m	14.606		0.032	m
LST 13JUL05		X	0.53	m	0.038	m	0.0016	m	16.059		0.033	m
MBP 08JUL05		Xm	0.60	m	0.042	m	0.0018	m	389.318	b	0.037	m
MCC 07JUL05		X	0.50	m		X	0.0015	m	29.866	b	0.031	m
MEB 29JUL05		Xm	0.49	m	0.28		0.0015	m	2.934		0.030	m
MUM 06JUL05		X	0.51	m	0.51		0.0016	m	3.138		0.031	m
MUM 22AUG05 1		X	0.56	m	0.47		0.0017	m	108.777	b	0.034	m
MUM 22AUG05 2		X	0.57	m	0.54		0.0017	m	253.796	b	0.035	m
NEL 08JUL05		X	0.47	m	0.59		0.0014	m	41.841	b	0.029	m
SKW 08JUL05		X	0.53	m	1.1		0.0016	m	3.485		0.032	m
SNG 13JUL05		X	0.61	m	0.043	m	0.0019	m	191.007	b	0.037	m
SNW 07JUN05		X	0.55	m	0.30		0.37		4.065		0.034	m
SNW 21AUG05		Xm	0.55	m	0.47		0.0017	m	48.584	b	0.034	m
TNG 12JUL05	384	b	64		141		139		165.756		0.031	m
UEB 29JUL05		Xm	0.55	m	0.34		0.0017	m		X	0.034	m
UGB 26JUL05		Xm	0.50	m	0.61		0.56		37.551	b	0.030	m
ULC 31JUL05		Xm	0.55	m	0.039	m	0.0017	m	122.525	b	0.034	m
UNL 31JUL05		X	0.62	m	1.1		0.89		1341.456	b	0.038	m
WCP 30JUL05		X	0.57	m	0.67		0.0017	m	462.028	b	0.035	m
YEL 13JUL05		X	0.52	m	0.20		0.0016	m	19.075		0.031	m

Sample No	Pyr ng/g ww	Pyrf	Retene ng/g ww	Reten ef	Dde ng/g ww	Ddef	opDdd ng/g ww	opDd df	Ddt ng/g ww	Ddtf	Ddd ng/g ww	Dddf
12457 30JUL05 1	0.62	d	0.48	d	0.078	m	0.059	m	0.037	m	0.078	m
12461 30JUL05 1	0.023	m	144	b	1.3		0.073	m	0.046	m	1.369	
11087 31JUL05 1	0.021		0.71		0.087	m	0.066	m	0.042	m	0.09	m
11089 31JUL05 1	0.0016	m	3.1		0.88		0.069	m	0.043	m	0.50	
12155 01AUG05 1	0.027	m	1.6		0.11	m	0.087	m	0.055	m	0.11	m
21317 01AUG05 1	0.0016	m	0.70		0.37		0.068	m	0.043	m	0.090	m
12154 02AUG05 1	0.024	m	7.4		0.60		0.075	m	0.047	m	0.71	
20037 02AUG05 1	0.025	m	103		0.46		0.078	m	0.049	m	0.10	m
20062 03AUG05 1	0.020	m	1.2		0.084	m	0.064	m	0.040	m	0.084	cm
21390 03AUG05 1	0.0014	m	1.5		0.18		0.063	m	0.040	m	0.083	m
21397 03AUG05 1	0.24		3.6		0.089	m	0.067	m	0.042	m	0.089	cm
2310X 04AUG05 1	0.0018	m	2.3		0.10	m	0.079	m	0.050	m	0.10	m
2310X 04AUG05 2	0.0027	m	3.5		0.15	m	0.11	m	0.073	m	0.15	m
11475 06AUG05 1	0.020	m	0.79		0.67		0.064	m	0.040	m	0.490	c
11685 06AUG05 1	0.023	m	0.91		0.52		0.075	m	0.047	m	0.099	cm
11474 07AUG05 1	0.0014	m	5.8		0.32		0.063	m	0.040	m	0.083	m
11474 07AUG05 2	0.0016	m	69		1.00		0.071	m	0.045	m	0.094	m
1168X 07AUG05 1	0.0017	m	1.6		0.28		0.076	m	0.048	m	0.10	m
10249 08AUG05 1	1.1		3.1		0.098	m	0.074	m	0.047	m	0.098	m
21329 08AUG05 1	0.018	m	0.34		0.57		0.057	m	0.35		0.076	m
21559 08AUG05 1	0.023		0.50		1.2		0.073	m	0.046	m	0.097	m
21522 09AUG05 1	0.0015	m	2.0		0.086	m	0.065	m	0.041	m	0.086	Cm
10525 08AUG05 1	0.023	m	3.6		0.098	m	0.074	m	0.047	m	0.098	M
20027 10AUG05 1	0.022	m	13		1.1		0.45		0.044	m	2.310	

Sample No	Dde ng/g ww	Ddef	opDdd ng/g ww	opDdd f	Ddd ng/g ww	Ddd f	methox ng/g ww	methox f	benzoaanth ng/g ww	benzo aanthf	ChryTri ng/g ww	ChryTri f
ANT 07JUL05	0.100	m	0.076	m	0.10	m	0.10	m	0.017	m	0.010	m
BAT 08JUN05	0.105	m	0.079	m	0.11	m	0.11	m	0.50		0.37	
BCL 28JUL05	0.216		0.077	m	0.10	m	0.11	m	0.28		0.27	
BDR 01AUG05	0.321		0.079	m	0.10	m	0.11	m	0.018	m	0.010	m
BLF 10JUL05	0.084	m	0.064	m	0.084	m	0.088	m	0.014	m	0.0084	m
BTY 03AUG05	0.367		0.072	m	0.096	m	0.71		0.016	m	0.010	m
BUT 12JUL05	0.087	m	0.066	m	0.087	m	0.091	m	0.015	m	0.0087	m
CBY 14JUL05	0.115	m	0.088	m	0.12	m	0.12	m	0.020	m	0.012	m
DCH 10JUL05	0.246		0.070	m	0.092	m	0.096	m	0.016	m	0.0092	m
DLP 30JUL05	0.329		0.076	m	0.10	m	0.11	m	0.017	m	0.010	m
DOM 06JUN05	0.187		0.067	m	0.088	m	0.092	m	0.66		1.166	
FND 01AUG05	0.379		0.072	m	0.096	m	0.10	m	0.016	m	0.010	m
FRY 28JUL05	0.095	m	0.072	m	0.095	m	0.099	m	53		34	
GUM 06JUL05	0.243		0.066	m	0.088	m	0.091	m	208		128	
GUM 26JUL05	0.289		0.075	m	0.099	m	0.10	m	0.017	m	0.010	m
LML 12JUL05	0.097	m	0.073	m	0.097	m	0.10	m	0.017	m	0.010	m
LML 29JUL05	0.091	m	0.069	m	0.092	m	0.095	m	0.109		0.13	
LST 13JUL05	0.321		0.070	m	0.093	m	0.097	m	0.016	m	0.0093	m
MBP 08JUL05	0.104	m	0.079	m	0.10	m	0.11	m	0.018	m	0.010	m
MCC 07JUL05	0.087	m	0.066	m	0.087	m	0.091	m	0.015	m	0.0087	m
MEB 29JUL05	0.086	m	0.065	m	0.086	m	0.090	m	0.25		0.168	
MUM 06JUL05	0.089	m	0.067	m	0.089	m	0.093	m	0.015	m	0.0089	m
MUM 22AUG05 1	0.097	m	0.073	m	0.097	m	0.10	m	0.017	m	0.010	m
MUM 22AUG05 2	0.098	m	0.075	m	0.099	m	0.10	m	0.017	m	0.010	m
NEL 08JUL05	0.082	m	0.062	m	0.082	m	0.086	m	0.32		0.87	
SKW 08JUL05	0.854		0.069	m	0.092	m	0.095	m	0.016	m	0.70	d
SNG 13JUL05	0.250		0.080	m	0.11	m	0.11	m	0.018	m	0.011	m
SNW 07JUN05	0.095	m	0.072	m	0.096	m	0.10	m	0.016	m	0.010	m
SNW 21AUG05	0.095	m	0.072	m	0.096	m	0.10	m	0.11		0.19	
TNG 12JUL05	0.410		0.066	m	0.087	m	0.091	m	44		27	
UEB 29JUL05	0.096	m	0.073	m	0.096	m	0.10	m	0.017	m	0.010	m
UGB 26JUL05	0.182		0.065	m	0.087	m	0.090	m	0.015	m	0.0086	m
ULC 31JUL05	0.095	m	0.072	m	0.096	m	0.10	m	0.016	m	0.010	m
UNL 31JUL05	0.107	m	0.081	m	0.11	m	0.11	m	0.018	m	0.011	m
WCP 30JUL05	0.098	m	0.075	m	0.099	m	0.10	m	0.017	m	0.010	m
YEL 13JUL05	0.089	m	0.068	m	0.090	m	0.093	m	0.015	m	0.0089	m

Sample No	methox ng/g ww	methoxf	benzoaanth ng/g ww	benzo aanthf	ChryTri ng/g ww	ChryTri f	benzobflur ng/g ww	benzob flurf	benzokflur ng/g ww	benzo kflurf	benzoepyr ng/g ww	benzoepyrf
12457 30JUL05 1	0.081	m	0.20	d	0.26	d	0.70	d	0.18	d	0.36	d
12461 30JUL05 1	5.264		0.059	m	0.010	m	0.57		0.052	m	0.48	a
11087 31JUL05 1	0.091	m	0.053	m	0.009	m	0.091	m	0.047	m	0.12	m
11089 31JUL05 1	0.095	m	0.186		0.17		0.39		0.049	m	0.12	m
12155 01AUG05 1	0.12	m	0.238		0.13			xm	0.062	m		xm
21317 01AUG05 1	0.093	cm	0.215		0.0089	m	0.45		0.049	m	0.30	
12154 02AUG05 1	1.5		0.061	m	0.010	m	0.38		0.054	m		xm
20037 02AUG05 1	0.11	m		xm		x		xm	0.056	m		xm
20062 03AUG05 1	0.088	cm	0.051	m	0.0084	m	0.088	m	0.046	m	0.11	m
21390 03AUG05 1	0.087	m	0.014	m		xm	0.087	m	0.045	m		xm
21397 03AUG05 1	0.093	m	0.054	m	0.0089	c m	0.093	m	0.048	m	0.12	m
2310X 04AUG05 1	0.11	cm	0.018	m	0.010	m	0.11	m	0.057	m	0.14	m
2310X 04AUG05 2	0.16	m	0.093	m	0.015	c m	0.52		0.083	m	0.20	m
11475 06AUG05 1	0.088	cm	0.052	m	0.0085	m	0.089	m	0.046	m		xm
11685 06AUG05 1	0.10	cm	0.060	m	0.010	m	0.10	m	0.054	m	0.51	
11474 07AUG05 1	0.087	m	0.051	m	0.0083	m	0.28		0.045	m	0.11	m
11474 07AUG05 2	0.098	m	0.058	m	0.0094	m	0.53		0.051	m	0.40	
1168X 07AUG05 1	0.10	m	0.061	m	0.010	m	0.60		0.054	m	0.32	
10249 08AUG05 1	0.10	m	0.017	m	0.010	m		xm		xm		xm
21329 08AUG05 1	0.079	m		xm		x		xm		xm		xm
21559 08AUG05 1	0.10	m	0.268		0.33		0.71		0.053	m	0.33	
21522 09AUG05 1	0.090	m	0.052	m	0.0086	c m	0.090	m	0.047	m	0.12	m
10525 08AUG05 1	0.10	m	0.060	m	0.17			x	0.053	m		xm
20027 10AUG05 1	0.097	m		xm		x		xm		xm	0.12	m

Sample No	benzobflur ng/g ww	benzobflurf	benzokflur ng/g ww	benzokflurf	benzoepyr ng/g ww	benzoepyrf	benzoapyr ng/g ww	benzoapyrf	indenopyr ng/g ww	indenopyrf	dibenzanth ng/g ww	dibenzanthf	benzopery ng/g ww	benzoperyf
ANT 07JUL05	1.1		0.054	m	0.51		0.038	m	0.23	m	0.10	m	0.019	m
BAT 08JUN05	1.2		0.057	m	0.14	m	0.42		0.25	m	0.11	m	0.020	m
BCL 28JUL05	0.70		0.055	m	0.40		0.038	m	0.24	m	0.10	m	0.019	m
BDR 01AUG05	0.11	m	0.057	m	0.14	m	0.039	m	0.24	m	0.11	m	0.020	m
BLF 10JUL05	0.088	m	0.046	m	0.37		0.68		0.20	m	0.085	m	0.016	m
BTY 03AUG05	1.5		0.052	m	0.82		0.036	m	0.22	m	0.097	m	0.018	m
BUT 12JUL05	0.091	m	0.047	m	0.12	m	0.033	m	0.20	m	0.088	m	0.016	m
CBY 14JUL05	0.12	m	0.063	m	0.16	m	0.044	m	0.27	m	0.12	m	0.022	m
DCH 10JUL05	0.097	m	0.050	m	0.12	m	0.035	m	0.22	m	0.093	m	2.1	
DLP 30JUL05	3.8	d	0.055	m	0.70	d	0.038	m	0.24	m	0.10	m	0.019	m
DOM 06JUN05	2.7		0.645		3.28		1.2		1.5	c	0.80	cz	2.8	
FND 01AUG05	0.10	m	0.052	m	0.13	m	0.036	m	0.22	m	0.097	m	0.018	m
FRY 28JUL05	43		11		14		24		11		0.096	m	6.4	
GUM 06JUL05	171		51		70		97		44		8.4	c	32	
GUM 26JUL05	0.90		0.054	m	0.33		0.037	m	0.23	m	0.10	m	0.019	m
LML 12JUL05	0.81		0.053	m	0.13	m	0.036	m	0.23	m	0.098	m	0.018	m
LML 29JUL05	0.37		0.050	m	0.12	m	0.034	m	0.21	m	0.092	m	0.017	m
LST 13JUL05	0.44		0.050	m	0.12	m	0.035	m	0.22	m	0.094	m	0.018	m
MBP 08JUL05	0.11	m	0.057	m	0.14	m	0.039	m	0.24	m	0.11	m	0.020	m
MCC 07JUL05	0.26		0.047	m	0.12	m	0.033	m	0.20	m	0.088	m	0.016	m
MEB 29JUL05	0.42		0.047	m	0.12	m	0.032	m	0.20	m	0.087	m	0.016	m
MUM 06JUL05	0.093	m	0.048	m	0.12	m	0.033	m	0.21	m	0.090	m	0.017	m
MUM 22AUG05 1	0.10	m	0.053	m	0.13	m	0.036	m	0.23	m	0.098	m	0.018	m
MUM 22AUG05 2	0.10	m	0.054	m	0.13	m	0.037	m	0.23	m	0.10	m	0.019	m
NEL 08JUL05	1.2		0.045	m	1.3		0.031	m	0.19	m	0.083	m	0.015	m
SKW 08JUL05	2.2	d	0.050	m	0.91	d	0.504		0.21	m	0.092	m	0.017	m
SNG 13JUL05	0.11	m	0.058	m	0.14	m	0.040	m	0.25	m	0.11	m	0.020	m
SNW 07JUN05	0.36		0.052	m	0.13	m	0.036	m	0.22	m	0.097	m	0.018	m
SNW 21AUG05	0.10	m	0.052	m	0.13	m	0.036	m	0.22	m	0.097	m	0.018	m
TNG 12JUL05	34		9.2		12		21		9.4	c	2.3	c	8.8	
UEB 29JUL05	0.10	m	0.052	m	0.13	m	0.036	m	0.23	m	0.097	m	0.018	m
UGB 26JUL05	0.65		0.047	m	0.34		0.032	m	0.20	m	0.087	m	0.016	m
ULC 31JUL05	0.10	m	0.052	m	0.13	m	0.036	m	0.22	m	0.097	m	0.018	m
UNL 31JUL05	0.95		0.058	m	0.41		0.040	m	0.25	m	0.11	m	0.020	m
WCP 30JUL05	0.75		0.054	m	0.74		0.037	m	0.23	m	0.10	m	0.019	m
YEL 13JUL05	0.094	m	0.049	m	0.12	m	0.034	m	0.21	m	0.090	m	0.017	m

Sample No	benzoapyr ng/g ww	benzoapyrf
12457 30JUL05 1	0.25	d
12461 30JUL05 1	0.41	
11087 31JUL05 1	0.033	m
11089 31JUL05 1	0.18	
12155 01AUG05 1	0.19	
21317 01AUG05 1	0.24	
12154 02AUG05 1	0.037	m
20037 02AUG05 1		xm
20062 03AUG05 1	0.032	m
21390 03AUG05 1		xm
21397 03AUG05 1	0.033	m
2310X 04AUG05 1	0.039	m
2310X 04AUG05 2	0.057	m
11475 06AUG05 1	0.032	m
11685 06AUG05 1	0.44	
11474 07AUG05 1	0.031	m
11474 07AUG05 2	0.035	m
1168X 07AUG05 1	0.038	m
10249 08AUG05 1		x
21329 08AUG05 1		xm
21559 08AUG05 1	0.33	
21522 09AUG05 1	0.032	m
10525 08AUG05 1	0.113	
20027 10AUG05 1	0.035	m

Sample No	Matrix	Region	g extracted	moisture % ww	total organic carbon % dw	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf
20135 10AUG05 1	Sediment	SEKI	14.1	89.6	6.9	0.00033	m		Xm
23058 10AUG05 1	Sediment	SEKI	13.5	96.4	24.9		X		X
10310 11AUG05 1	Sediment	SEKI	13.1	81.7	2.3		aXm		Xm
11281 11AUG05 1	Sediment	SEKI	12.0	87.9	20.7		X	0.071	
10594 12AUG05 1	Sediment	SEKI	13.9	65.0	1.6	0.013		0.034	
12338 12AUG05 1	Sediment	SEKI	13.9	83.6	15.0		X		X
12338 12AUG05 2	Sediment	SEKI	13.6	73.8	12.9		X	0.039	
12457 29AUG05 1	Sediment	SEKI	13.0	93.0	19.6		X	0.049	
12461 29AUG05 1	Sediment	SEKI	13.2	90.0	19.5		X	0.030	
11087 30AUG05 1	Sediment	SEKI	12.8	97.1	16.5		X	0.014	
11087 30AUG05 2	Sediment	SEKI	12.7	85.1	20.2		X		X
11089-30AUG05-1	Sediment	SEKI	13.9	84.2	12.0		X		X
12154 31AUG05 1	Sediment	SEKI	12.1	94.2	16.5		X	0.047	d
12154 31AUG05 2	Sediment	SEKI	11.6	97.2	17.9		dX	0.040	d
12155 31AUG05 1	Sediment	SEKI	12.3	87.0	12.1		X		X
20037 02SEP05 1	Sediment	SEKI	12.7	93.6	17.9		X		X
21317 02SEP05 1	Sediment	SEKI	12.2	88.0	10.7		X		dX
21390 03SEP05 1	Sediment	SEKI	13.7	97.3	14.9		X		X
21397 03SEP05 1	Sediment	SEKI	13.0	44.1	1.2		dX		dz
2310X 03SEP05 1	Sediment	SEKI	13.3	98.6	29.2		dX		dX
11685 04SEP05 1	Sediment	SEKI	13.7	69.2	3.6		X		X
1168X 04SEP05 1	Sediment	SEKI	12.1	71.1	3.9		Xm		Xm
20062 04SEP05 1	Sediment	SEKI	13.9	25.8	0.4		dX		dX
11474 05SEP05 1	Sediment	SEKI	12.8	85.0	10.5		X	0.031	
11475 05SEP05 1	Sediment	SEKI	16.0	45.1	0.4		dX		dX
10249 06SEP05 1	Sediment	SEKI	12.9	82.9	6.4		X	0.045	
10525 07SEP05 1	Sediment	SEKI	14.4	62.4	4.3		X		X
10525 07SEP05 2	Sediment	SEKI	14.5	71.0	2.5		aXm		dX
21329 07SEP05 1	Sediment	SEKI	14.2	75.2	2.0		X		X
21559 07SEP05 2	Sediment	SEKI	14.3	69.3	3.6		dX	0.027	d
21559 07SEP05 1	Sediment	SEKI	13.4	44.2	0.6	0.012	d		dX
21522 08SEP05 1	Sediment	SEKI	12.7	50.8	1.3		dX		dX
20135 09SEP05 1	Sediment	SEKI	14.5	61.3	1.2		aXm		X
20027 10SEP05 1	Sediment	SEKI	12.7	97.3	17.7		X	0.028	
20027 10SEP05 2	Sediment	SEKI	12.6	88.2	15.7		X		X
23058 10SEP05 1	Sediment	SEKI	13.5	97.8	21.2		dX	0.023	d
10310 11SEP05 1	Sediment	SEKI	11.1	82.9	21.7		X		X
10311 11SEP05 1	Sediment	SEKI	14.1	78.8	12.5		X	0.023	
10311 12SEP05 2	Sediment	SEKI	11.5	69.3	3.8		aX		X
12338 12SEP05 1	Sediment	SEKI	13.9	79.9	6.9		X		X
12337 13SEP05 1	Sediment	SEKI	14.3	85.1	7.8		X	0.016	
Sample No	Matrix	Region	g extracted	moisture % ww	total organic carbon % dw	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf
CHI 18JUL06	Sediment	Sierras transect	14.8	29.5	5.6		X	0.031	
CNF 06JUL06	Sediment	Sierras transect	12.6	87.0	34.3		Xm		X
CNT 01JUL06	Sediment	Sierras transect	11.9	94.0	28.2		Xm		X
DAN 07JUL06	Sediment	Sierras transect	13.0	75.2	15.4		dX		dX
DAR 24JUL06	Sediment	Sierras transect	14.1	52.4	5.0		Xm		X
KEL 19JUL06	Sediment	Sierras transect	14.0	64.0	2.6	0.0088		0.043	
MUD 21JUL06	Sediment	Sierras transect	14.4	75.4	18.0		Xm		Xm
SLV 09JUL06	Sediment	Sierras transect	12.9	85.3	18.1		Xm		X
SRD 09JUL06	Sediment	Sierras transect	12.3	70.9	5.6		Xm		Xm
SWA 17JUL06	Sediment	Sierras transect	13.3	52.1	6.1		Xm		X
TLP 07JUL06	Sediment	Sierras transect	13.9	73.0	17.2		Xm		X
Sample No	Matrix	Region	g extracted	moisture % ww	total organic carbon % dw	Trifl ng/g ww	Triflf	Hexch ng/g ww	Hexchf
70134 29JUL06 1	Sediment	YOSE	12.5	66.0	3.4		X		X
70134 30AUG06 1	Sediment	YOSE	12.7	87.1	11.7		dX		X
70134 30AUG06 2	Sediment	YOSE	13.2	95.0	12.9		X		X
70414 29AUG06 1	Sediment	YOSE	12.3	85.0	21.7		X		X
70414 30JUL06 1	Sediment	YOSE	12.8	94.1	21.5		Xm		X
70550 02AUG06 1	Sediment	YOSE	13.2	54.9	2.4		X		X
70550 31AUG06 1	Sediment	YOSE	12.8	66.7	2.6		Xm		X
72996 30AUG06 1	Sediment	YOSE	13.3	57.9	3.4		X		X

72996 31JUL06 1	Sediment		YOSE	12.9	66.5	5.1			X		X	

Sample No	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthlf	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chordtn ng/g ww	End1 ng/g ww	End1f	Nonatn ng/g ww	Nona tnf
20135 10AUG05 1	0.0040	M	0.00035	m		Xm	0.00018	m	0.0018	m	0.00050	m
23058 10AUG05 1	0.0042	M	0.030		0.040		0.013		0.026		0.025	
10310 11AUG05 1	0.0043	m	0.011			Xm	0.011		0.0019	m	0.014	
11281 11AUG05 1	0.123		0.12			Xm	0.072		0.11		0.11	
10594 12AUG05 1	0.0041	m	0.031			X	0.035		0.0018	m	0.040	
12338 12AUG05 1	0.0041	m	0.032		0.016		0.019		0.0018	m	0.051	
12338 12AUG05 2	0.0042	m	0.022			Xm	0.029		0.0018	m	0.086	
12457 29AUG05 1	0.070		0.042			X	0.068		0.12		0.084	
12461 29AUG05 1	0.0043	m	0.032		0.023		0.026		0.037		0.034	
11087 30AUG05 1	0.0044	m	0.017			Xm	0.0073		0.0019	m	0.019	
11087 30AUG05 2	0.0044	m	0.031		0.018		0.008		0.0019	m	0.021	
11089-30AUG05-1	0.0041	m	0.029		0.016		0.020		0.0018	m	0.028	
12154 31AUG05 1	0.0047	m	0.043	d		Xm	0.030		0.095		0.033	
12154 31AUG05 2	0.0049	m	0.046	d	0.028		0.025		0.13		0.032	
12155 31AUG05 1	0.0046	m	0.019		0.017		0.00020	m	0.0020	m	0.019	
20037 02SEP05 1	0.0044	m	0.015		0.0060	m	0.011		0.0019	m	0.035	
21317 02SEP05 1	0.0046	m	0.032		0.013		0.015		0.0020	m	0.040	
21390 03SEP05 1	0.0041	m	0.029		0.014		0.0085		0.0018	m	0.016	
21397 03SEP05 1	0.0043	m		dX	0.0059	m	0.0090		0.0019	m	0.018	
2310X 03SEP05 1	0.0042	m	0.020		0.027		0.0077		0.0019	m	0.011	
11685 04SEP05 1	0.0041	m	0.011		0.013		0.0088		0.0018	m	0.026	
1168X 04SEP05 1	0.0047	m	0.0050			Xm	0.012		0.0020	m	0.039	
20062 04SEP05 1	0.0041	m	0.014	d	0.016		0.00018	m	0.0018	m	0.00050	m
11474 05SEP05 1	0.0044	m		X	0.035		0.012		0.0019	m	0.026	
11475 05SEP05 1	0.0035	m	0.0083		0.012		0.00016	m	0.0015	m	0.00044	m
10249 06SEP05 1	0.0044	m	0.070		0.017		0.044		0.043		0.056	
10525 07SEP05 1	0.0039	m		X	0.013	d	0.0058		0.0017	m	0.016	
10525 07SEP05 2	0.0039	m		cz	0.0053	m	0.00017	m	0.0017	m	0.010	
21329 07SEP05 1	0.0040	m	0.018		0.013		0.011		0.0017	m	0.040	
21559 07SEP05 2	0.0042	m		cz	0.0057	m	0.028		0.0018	m	0.095	
21559 07SEP05 1	0.0039	m		X	0.021		0.018		0.0017	m	0.024	
21522 08SEP05 1	0.0044	m		X	0.019		0.00020	m	0.0019	m	0.00055	m
20135 09SEP05 1	0.0039	m	0.0070		0.005	m	0.00017	m	0.0017	m	0.00048	m
20027 10SEP05 1	0.0044	m	0.16	d	0.034		0.043		0.10		0.054	
20027 10SEP05 2	0.0045	m	0.046	d	0.023		0.031		0.051		0.042	
23058 10SEP05 1	0.0042	m	0.024	d	0.050		0.021		0.042		0.035	
10310 11SEP05 1	0.0051	m	0.046		0.023		0.021		0.0022	m	0.025	
10311 11SEP05 1	0.0040	m	0.018			X	0.022		0.025		0.018	
10311 12SEP05 2	0.0049	m		X		Xm	0.006	a	0.0021	m	0.011	a
12338 12SEP05 1	0.0041	m	0.014		0.014		0.010		0.0018	m	0.049	
12337 13SEP05 1	0.022		0.017		0.031	d	0.0071	d	0.0017	m	0.020	d

Sample No	Hch ng/g ww	Hchf	Dacthl ng/g ww	Dacthlf	Chlrpy ng/g ww	Chlrpyf	Chordtn ng/g ww	Chordtn ng/g ww	End1 ng/g ww	End1f	Nonatn ng/g ww	Nona tnf
CHI 18JUL06	0.074		0.011		0.017	a	0.015		0.012	a	0.015	
CNF 06JUL06	0.0045	m	0.018		0.050		0.027		0.012	a	0.024	
CNT 01JUL06	0.0047	m	0.00042	m	0.059	d	0.014	d	0.010	ad	0.014	d
DAN 07JUL06	0.0043	m	0.00038	m	0.044		0.022		0.032		0.024	
DAR 24JUL06	0.0040	m	0.00035	m	0.026		0.038		0.0018	m	0.011	
KEL 19JUL06	0.0040	m	0.033		0.039		0.010	d	0.0090	ad	0.015	d
MUD 21JUL06	0.0039	m	0.00035	m	0.026	d	0.012	d	0.0017	m	0.0044	ad
SLV 09JUL06	0.0044	m	0.023		0.044		0.0079		0.0019	m	0.0067	
SRD 09JUL06	0.0046	m	0.00040	m	0.022		0.00020	m	0.0020	m	0.00057	m
SWA 17JUL06	0.0042	m	0.00037	m	0.041	d	0.087	d	0.0019	m	0.066	d
TLP 07JUL06	0.0041	m	0.00036	m		dXm	0.027	d	0.013	ad	0.025	d

Sample No	Dacthl ng/g ww	Dacthlf	Chordtn ng/g ww	Chordtn ng/g ww	Nonatn ng/g ww	Nonatnf	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2f	Nonacs ng/g ww	Nona csf
70134 29JUL06 1	0.0041	a	0.00020	m	0.0062		0.0013	m	0.0012	m	0.0036	a
70134 30AUG06 1	0.0076		0.00020	m	0.014		0.0013	m	0.0012	m	0.00060	m
70134 30AUG06 2	0.0082		0.0045	a	0.010		0.0012	m	0.0012	m	0.00058	m
70414 29AUG06 1	0.0083		0.0090	d	0.0080	d	0.0013	m	0.013		0.010	
70414 30JUL06 1	0.010		0.032		0.023		0.019		0.028		0.024	
70550 02AUG06 1	0.0041	a	0.00019	m	0.0005	m	0.0012	m	0.0012	m	0.00058	m
70550 31AUG06 1	0.0066		0.0047	ad	0.0080	d	0.0013	m	0.0012	m	0.00060	m
72996 30AUG06 1	0.00037	m	0.00019	m	0.0074		0.0012	m	0.0011	m	0.00058	m
72996 31JUL06 1	0.0047	a	0.00019	m	0.013		0.064		0.0012	m	0.00060	m

Sample No	Pcb74 ng/g ww	Pcb74f	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2f	Nonacs ng/g ww	Nonacsf	Endsu ng/g ww	Endsuf	Pcb153 ng/g ww	Pcb153f
20135 10AUG05 1	0.16	m	0.0011	m	0.0011	m	0.00054	m	0.015		0.0049	a
23058 10AUG05 1	0.16	m	0.0012	m	0.048		0.018		0.26		0.0011	m
10310 11AUG05 1	0.17	m	0.0012	m	0.0012	m	0.011		0.11		0.0011	m
11281 11AUG05 1	0.18	m	0.0013	m	0.34		0.067		2.0		0.031	
10594 12AUG05 1	0.16	m	0.0012	m	0.037		0.027		0.35		0.025	
12338 12AUG05 1	0.16	m	0.0110		0.031		0.034		0.27		0.015	
12338 12AUG05 2	0.16	m	0.0012	m	0.038		0.063		0.34		0.018	
12457 29AUG05 1	0.17	m	0.0012	m	0.333		0.055		1.7		0.024	
12461 29AUG05 1	0.17	m	0.0012	m	0.121		0.035		1.2		0.020	
11087 30AUG05 1	0.17	m	0.0066	a	0.011	a	0.012		0.066		0.0070	a
11087 30AUG05 2	0.17	m	0.012	a	0.0012	m	0.014		0.072		0.010	a
11089-30AUG05-1	0.16	m	0.0012	m	0.028		0.034		0.32	c	0.018	
12154 31AUG05 1	0.18	m	0.0013	m	0.168		0.025		0.98		0.0092	a
12154 31AUG05 2	0.19	m	0.0014	m	0.171		0.025		0.82		0.017	
12155 31AUG05 1	0.18	m	0.0013	m	0.0012	m	0.0093		0.035		0.0093	a
20037 02SEP05 1	0.17	m	0.0013	m	0.013		0.022		0.13		0.013	
21317 02SEP05 1	0.18	m	0.0013	m	0.028		0.019		0.41		0.015	
21390 03SEP05 1	0.16	m	0.0012	m	0.024		0.012		0.12		0.012	
21397 03SEP05 1	0.17	m	0.0012	m	0.0012	m	0.00059	m	0.064		0.011	a
2310X 03SEP05 1	0.17	m	0.0012	m	0.028		0.0090		0.14		0.014	
11685 04SEP05 1	0.16	m	0.0012	m	0.012		0.014		0.15		0.011	
1168X 04SEP05 1	0.18	m	0.0013	m	0.0013	m	0.023		0.076		0.0012	m
20062 04SEP05 1	0.16	m	0.0012	m	0.0011	m	0.00055	m	0.023		0.0010	m
11474 05SEP05 1	0.17	m	0.0013	m	0.023		0.023		0.29		0.011	a
11475 05SEP05 1	0.14	m	0.0010	m	0.0010	m	0.0043	a	0.028		0.00089	m
10249 06SEP05 1	0.17	m	0.023	a	0.13		0.047		1.00		0.022	
10525 07SEP05 1	0.15	m	0.0088	a	0.010	a	0.0073		0.054		0.0069	a
10525 07SEP05 2	0.15	m	0.0011	m	0.0011	m	0.0039	a	0.015		0.0058	a
21329 07SEP05 1	0.16	m	0.0011	m	0.0011	m	0.021		0.16		0.0080	a
21559 07SEP05 2	0.17	m	0.0012	m	0.025		0.049		0.27		0.026	
21559 07SEP05 1	0.15	m	0.0011	m	0.023		0.015		0.21	c	0.011	
21522 08SEP05 1	0.17	m	0.0013	m	0.0012	m	0.0050	a	0.11		0.0085	a
20135 09SEP05 1	0.15	m	0.0011	m	0.0011	m	0.0048	a	0.014		0.00098	m
20027 10SEP05 1	0.17	m	0.022	a	0.18		0.062		1.4		0.026	
20027 10SEP05 2	0.18	m	0.0013	m	0.11		0.039		1.2		0.020	
23058 10SEP05 1	0.16	m	0.0012	m	0.040		0.024		0.23		0.019	d
10310 11SEP05 1	0.20	m	0.0014	m	0.050		0.030		0.43		0.011	a
10311 11SEP05 1	0.16	m	0.0011	m	0.047		0.023		0.11		0.0077	a
10311 12SEP05 2	0.19	m	0.0014	m	0.0013	m	0.008		0.016		0.0055	a
12338 12SEP05 1	0.16	m	0.0012	m	0.0011	m	0.024		0.11		0.012	
12337 13SEP05 1	0.15	m	0.011	ad	0.011		0.012		0.13		0.0080	ad

Sample No	Diel ng/g ww	Dielf	Pcb118 ng/g ww	Pcb118f	ctEnd2mdw	End2f	Nonacs ng/g ww	Nonacsf	Endsu ng/g ww	Endsuf	Pcb153 ng/g ww	Pcb153f
CHI 18JUL06	0.035	m	0.0011	m	0.034		0.0091		0.078		0.0087	
CNF 06JUL06	0.041	m	0.0013	m	0.047		0.029		0.43		0.028	
CNT 01JUL06	0.043	m	0.0014	m	0.022		0.012		0.36		0.0012	am
DAN 07JUL06	0.040	m	0.0012	m	0.085		0.013		0.40		0.015	
DAR 24JUL06	0.037	m	0.10		0.001	m	0.019		0.056		0.035	
KEL 19JUL06	0.037	m	0.0011	m	0.024		0.0079		0.18		0.012	
MUD 21JUL06	0.036	m	0.0011	m	0.0011	m	0.0063		0.064		0.012	
SLV 09JUL06	0.040	m	0.0012	m	0.034		0.0074		0.15		0.010	
SRD 09JUL06	0.042	m	0.0013	m	0.0012	m	0.0006	m	0.017		0.0012	m
SWA 17JUL06	0.039	m	0.112		0.037		0.065		0.33		0.046	
TLP 07JUL06	0.037	m	0.0012	m	0.074		0.021		0.48		0.017	

Sample No	Endsu ng/g ww	Endsuf	Pcb153 ng/g ww	Pcb153f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f	Fluor ng/g ww	Fluorf	Phenan ng/g ww	Phenanf
70134 29JUL06 1	0.022		0.0011	m	0.0026	a	0.00049	m	0.92			X
70134 30AUG06 1	0.022		0.0011	m	0.0043	a	0.00048	m	0.83	d		X
70134 30AUG06 2	0.028		0.0011	m	0.0027	a	0.00046	m	0.37			Xm
70414 29AUG06 1	0.095		0.013		0.0056	a	0.0024	a	0.93			X
70414 30JUL06 1	0.22		0.017		0.0087		0.0035	a	1.5			X
70550 02AUG06 1	0.054		0.0011	m	0.0007	a	0.00046	m	0.40			X
70550 31AUG06 1	0.037		0.0011	m	0.0019	a	0.00048	m	0.44			X
72996 30AUG06 1	0.021		0.0011	m	0.0011	a	0.00046	m	0.46			X
72996 31JUL06 1	0.062		0.0011	m	0.0026	a	0.00047	m	0.51			X

Sample No	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f	Fluor ng/g ww	Fluorf	Phenan ng/g ww	Phenanf	Flrant ng/g ww	Flrantf
20135 10AUG05 1	0.0015	m	0.0019	a	0.00043	m	0.13	m		xm	0.04	m
23058 10AUG05 1	0.0016	m	0.0036	a	0.00045	m	0.14	m		x	0.64	
10310 11AUG05 1	0.0016	m	0.00019	m	0.00046	m	0.14	m		xm	0.13	
11281 11AUG05 1	0.030		0.017		0.0060	a	0.15	m		x	0.04	m
10594 12AUG05 1	0.0015	m	0.019		0.0153		0.13	m		xm	0.45	
12338 12AUG05 1	0.016		0.0088		0.0030	a		xm		x	0.72	
12338 12AUG05 2	0.019		0.011		0.0035	a	0.13	m	3.7		0.93	
12457 29AUG05 1	0.022		0.015		0.0051	a	0.14	m		x	0.04	m
12461 29AUG05 1	0.017		0.010		0.0039	a	1.1			x	1.0	
11087 30AUG05 1	0.012		0.0023	a	0.00048	m	0.14	m		xm	0.46	
11087 30AUG05 2	0.018		0.0028	a	0.00048	m	0.14	m		x	0.40	
11089-30AUG05-1	0.017		0.0088		0.0035	a	0.13	m	5.2		0.68	
12154 31AUG05 1	0.0018	m	0.0047	a	0.00050	m	0.15	m	7.2		0.67	
12154 31AUG05 2	0.0018	m	0.0059	a	0.00052	m	0.16	m	3.1		0.55	
12155 31AUG05 1	0.0017	m	0.0039	a	0.00049	m	0.15	m		xm	0.35	
20037 02SEP05 1	0.013		0.0076		0.0026	a	0.14	m		x	0.04	m
21317 02SEP05 1	0.014		0.0079		0.0022	a	0.15	m		x	0.56	
21390 03SEP05 1	0.0016	m	0.0042	a	0.0022	a	0.13	m		x	0.04	m
21397 03SEP05 1	0.0016	m	0.0035	a	0.00047	m	0.14	m		xd	0.04	m
2310X 03SEP05 1	0.0016	m	0.0034	a	0.00046	m	0.14	m		x	0.04	m
11685 04SEP05 1	0.0016	m	0.0044	a	0.0015	a	0.71	d		x	0.46	
1168X 04SEP05 1	0.0018	m	0.0050	a	0.0017	a	0.15	m		xm	0.58	
20062 04SEP05 1	0.0015	m	0.00017	m	0.00044	m	0.13	m		xd	0.28	
11474 05SEP05 1	0.010		0.0068		0.0021	a	0.14	m	2.8		0.78	
11475 05SEP05 1	0.0013	m	0.0013	a	0.00038	m	0.11	m		xdm	0.20	
10249 06SEP05 1	0.019		0.012		0.0044	a	0.14	m	5.0		34	b
10525 07SEP05 1	0.0050	a	0.0027	a	0.0010	a	0.13	m		xm	0.39	
10525 07SEP05 2	0.0015	m	0.0017	a	0.00042	m	0.13	m		x	0.28	
21329 07SEP05 1	0.007		0.0044	a	0.0017	a	0.13	m		xm	0.57	
21559 07SEP05 2	0.028		0.011		0.0043	a	0.14	m		x	0.88	
21559 07SEP05 1	0.0015	m	0.0029	a	0.00043	m	0.13	m		x	0.62	
21522 08SEP05 1	0.0017	m	0.0024	a	0.00048	m	0.14	m		xm	0.04	m
20135 09SEP05 1	0.0015	m	0.0029	a	0.00042	m	0.13	m		xm	0.22	
20027 10SEP05 1	0.023		0.013		0.0050	a	0.14	m	4.1		1.1	
20027 10SEP05 2	0.017		0.0071		0.0029	a	0.14	m		x	0.84	
23058 10SEP05 1	0.0016	m	0.0080	d	0.0031	ad	0.14	m		xd	0.82	
10310 11SEP05 1	0.0019	m	0.0041	a	0.00055	m	0.16	m		x	0.05	m
10311 11SEP05 1	0.0015	m	0.0032	a	0.0011	a	1.34		3.7		0.62	
10311 12SEP05 2	0.0019	m	0.0016	a	0.00053	m	0.16	m		x	0.46	
12338 12SEP05 1	0.010		0.0071		0.0024	a	0.13	m		x	0.69	
12337 13SEP05 1	0.0071	d	0.0034	ad	0.0013	ad	0.13	m		x	0.64	

Sample No	Pcb138 ng/g ww	Pcb138f	Pcb187 ng/g ww	Pcb187f	Pcb183 ng/g ww	Pcb183f	Fluor ng/g ww	Fluorf	Phenan ng/g ww	Phenanf	Flrant ng/g ww	Flrantf
CHI 18JUL06	0.014		0.0034	a	0.0018	a	0.12	m	2.6		0.69	
CNF 06JUL06	0.036		0.016		0.0062		0.14	m		Xm	0.68	
CNT 01JUL06	0.012		0.0053	a	0.0005	m	0.15	m		Xm	0.043	m
DAN 07JUL06	0.020		0.0092		0.00047	m	0.14	m		dXm	0.70	d
DAR 24JUL06	0.047		0.021		0.0085			dXm		X	1.1	
KEL 19JUL06	0.015		0.0064		0.0032	a	0.13	m		X	0.39	
MUD 21JUL06	0.012		0.0058		0.0023	a	0.13	Xm		Xm	2.0	
SLV 09JUL06	0.015		0.0047	a	0.0021	a	0.14	m		Xm	0.90	
SRD 09JUL06	0.0017	m	0.00020	m	0.00049	m	0.15	Xm		Xm	6.4	
SWA 17JUL06	0.049		0.035		0.013		0.14	m		Xm	1.2	
TLP 07JUL06	0.023		0.011		0.0032	a		dXm		X	11	

Sample No	Flrant ng/g ww	Flrantf	Retene ng/g ww	Retenef	Dde ng/g ww	Ddef
70134 29JUL06 1	0.22		2.0		0.10	m
70134 30AUG06 1	0.39		0.99		0.099	m
70134 30AUG06 2	0.26		0.56		0.095	m
70414 29AUG06 1	0.62		129	b	1.3	
70414 30JUL06 1	0.57		461	b	3.1	
70550 02AUG06 1	0.27		15		0.095	m
70550 31AUG06 1	0.39		0.75		0.098	m
72996 30AUG06 1	0.21		0.46		0.095	m
72996 31JUL06 1	0.63		0.90		0.098	m

Sample No	Pyr ng/g ww	Pyrf	Retene ng/g ww	Reten ef	Dde ng/g ww	Ddef	opDdd ng/g ww	opDd df	Ddt ng/g ww	Ddtf	Ddd ng/g ww	Dddf
20135 10AUG05 1	0.0016	m	0.97		0.089	m	0.068	m	0.043	m	0.090	m
23058 10AUG05 1	0.0016	m	3.8		0.29		0.071	m	0.045	m	0.094	m
10310 11AUG05 1	0.023	m	0.18	m	0.096	m	0.073	m	0.046	m	0.096	m
11281 11AUG05 1	0.025	m	14		1.5		0.079	m	0.050	m	0.11	m
10594 12AUG05 1	0.022	m	133		0.63		0.069	m	0.043	m	0.79	
12338 12AUG05 1	0.0016	m	0.17	m	0.76		0.069	m	0.043	m	0.091	m
12338 12AUG05 2	1.040		4.5		1.1		0.070	m	1.0		0.093	m
12457 29AUG05 1	0.0017	m	18		2.0		0.073	m	0.046	m	0.097	m
12461 29AUG05 1	0.810		72	b	1.2		0.072	m	0.046	m	0.096	m
11087 30AUG05 1	0.0017	m	1.5		0.098	m	0.075	m	0.047	m	0.099	m
11087 30AUG05 2	0.0017	m	1.1		0.099	m	0.075	m	0.047	m	0.099	m
11089-30AUG05-1	0.590		17		0.84		0.069	m	0.043	m	0.091	m
12154 31AUG05 1	0.0018	m	3.8		0.71		0.079	m	0.050	m	0.10	m
12154 31AUG05 2	0.0019	m	2.5		0.46		0.082	m	0.052	m	0.11	m
12155 31AUG05 1	0.0018	m	0.8		0.10	m	0.078	m	0.049	m	0.10	m
20037 02SEP05 1	0.0017	m	7.5		0.62		0.075	m	0.047	m	0.099	m
21317 02SEP05 1	0.0018	m	3.8		0.47		0.078	m	0.049	m	0.10	m
21390 03SEP05 1	0.0016	m	43	b	0.28		0.070	m	0.044	m	0.092	cm
21397 03SEP05 1	0.0017	m	5.0		0.097	m	0.073	m	0.046	m	0.097	cm
2310X 03SEP05 1	0.0017	m	15		0.095	m	0.072	m	0.045	m	0.095	m
11685 04SEP05 1	0.0016	m	0.5		0.25		0.070	m	0.955		0.092	m
1168X 04SEP05 1	0.0018	m	0.6		0.33		0.079	m	0.050	m	0.10	m
20062 04SEP05 1	0.0016	m	0.7		0.091	m	0.069	m	0.043	m	0.091	cm
11474 05SEP05 1	0.871		14		0.88		0.075	m	0.047	m	0.099	m
11475 05SEP05 1	0.0014	m	0.15	m	0.079	m	0.060	m	0.038	m	0.079	m
10249 06SEP05 1	27.7		30	b	2.1		0.074	m	0.047	m	2.2	
10525 07SEP05 1	0.0015	m	1.8		0.09	m	0.066	m	0.77		0.088	m
10525 07SEP05 2	0.0015	m	2.0		0.09	m	0.066	m	0.042	m	0.087	cm
21329 07SEP05 1	0.0016	m	0.4		0.32		0.067	m	0.042	m	0.089	m
21559 07SEP05 2	0.65		0.6		1.2		0.071	m	0.045	m	0.094	cm
21559 07SEP05 1	0.0015	m	0.6		0.09	m	0.067	m	0.042	m	0.088	cm
21522 08SEP05 1	0.0017	m	2.9		0.10	m	0.075	m	0.047	m	0.099	m
20135 09SEP05 1	0.0015	m	0.5		0.09	m	0.066	m	0.042	m	0.087	m
20027 10SEP05 1	0.90		82	b	1.0		0.075	m	27	d	1.7	
20027 10SEP05 2	0.0017	m	3.5		0.41		0.076	m	0.048	m	0.10	m
23058 10SEP05 1	0.0016	m	5.4		0.41		0.071	m	0.045	m	0.09	m
10310 11SEP05 1	0.0020	m	1.6		0.11	m	0.086	m	0.054	m	0.114	m
10311 11SEP05 1	0.0016	m	5.9		0.09	m	0.068	m	0.043	m	0.090	m
10311 12SEP05 2	0.0019	m	2.7		0.25		0.083	m	0.052	m	0.11	cm
12338 12SEP05 1	0.0016	m	1.4		0.47		0.069	m	0.043	m	0.091	m
12337 13SEP05 1	0.62		2.0		0.36		0.067	m	0.042	m	0.088	m

Sample No	Pyr ng/g ww	Pyrf	Retene ng/g ww	Reten ef	opDde ng/g ww	opD def	Dde ng/g ww	Ddef	opDdd ng/g ww	opDdd f	Ddd ng/g ww	Dddf
CHI 18JUL06	0.0015	m	31	b	0.030	m	0.22		0.064	m	0.085	m
CNF 06JUL06	0.0017	m	3.0		0.035	m	0.35		0.076	m	0.100	m
CNT 01JUL06	0.0019	m	180	b	0.037	m	0.26		0.080	m	0.106	m
DAN 07JUL06	0.0017	m	8.5	d	0.034	m	0.097	m	0.073	m	0.097	m
DAR 24JUL06	0.0016	m	198	b	0.031	m	0.76		0.068	m	0.090	m
KEL 19JUL06	0.0016	m	12		0.032	m	0.090	m	0.068	m	0.090	m
MUD 21JUL06	1.0		38	b	0.031	m	0.30		0.066	m	0.088	m
SLV 09JUL06	0.0017	m	14		0.034	m	0.098	m	0.074	m	0.098	m
SRD 09JUL06	6.6		351	b	0.036	m	0.10	m	0.078	m	0.103	m
SWA 17JUL06	2.1		15		0.033	m	0.74		0.072	m	0.095	m
TLP 07JUL06	11		178	b	1.3		12		6.6		28	b

Sample No	methox ng/g ww	methoxf	benzoaanth ng/g ww	benzoaanthf	ChryTri ng/g ww	ChryTrif	benzobflur ng/g ww	benzobflurf	benzokflur ng/g ww	benzokflurf	benzoepyr ng/g ww	benzoepyrf
20135 10AUG05 1	0.093	m	0.015	m	0.064		0.094	m	0.049	m	0.12	m
23058 10AUG05 1	0.098	cm	0.057	m	0.0093	m	0.35		0.051	m	0.30	
10310 11AUG05 1	0.10	m	0.017	m	0.010	m	0.10	m	0.052	m	0.13	m
11281 11AUG05 1	0.11	m	0.064	m	0.010	m	0.11	m	0.057	m		xm
10594 12AUG05 1	0.095	m	0.055	m	0.0091	m	0.36		0.049	m		xm
12338 12AUG05 1	0.095	m	0.055	m	0.0091	m	0.67		0.049	m	0.48	
12338 12AUG05 2	0.097	cm	0.057	m	0.0093	m	0.097	m	0.050	m	0.12	m
12457 29AUG05 1	0.10	cm	0.059	m	0.010	m	0.10	m	0.053	m	0.13	m
12461 29AUG05 1	0.10	m	0.016	m	0.010	m	0.10	m	0.052	m	0.13	m
11087 30AUG05 1	0.10	m	0.017	m	0.010	m	0.10	m	0.054	m	0.13	m
11087 30AUG05 2	0.10	m	0.017	m	0.010	m	0.10	m	0.054	m	0.13	m
11089-30AUG05-1	0.095	cm	0.055	m	0.0091	m	0.095	m	0.049	m	0.12	m
12154 31AUG05 1	0.11	m	0.064	m	0.010	m	0.11	m	0.057	m	0.14	m
12154 31AUG05 2	0.11	m	0.019	m	0.011	m	0.11	m	0.059	m	0.15	m
12155 31AUG05 1	0.11	cm	0.063	m	0.010	m	0.11	m	0.056	m	0.14	m
20037 02SEP05 1	0.10	m	0.061	m	0.010	m	0.10	m	0.054	m	0.13	m
21317 02SEP05 1	0.11	m	0.063	m	0.010	m	0.11	m	0.056	m	0.14	m
21390 03SEP05 1	0.096	m	0.056	m	0.0092	c m	0.097	m	0.050	m	0.12	m
21397 03SEP05 1	0.10	m	0.017	m	0.010	cm	0.10	m	0.053	m	0.13	m
2310X 03SEP05 1	0.099	m	0.058	m	0.0095	m	0.099	m	0.052	m	0.13	m
11685 04SEP05 1	0.096	m	0.056	m	0.0092	m	0.097	m	0.050	m	0.12	m
1168X 04SEP05 1	0.11	m	0.198		0.21		0.42		0.057	m	0.14	m
20062 04SEP05 1	0.095	c m	0.016	m	0.0091	m	0.095	m	0.049	m	0.12	m
11474 05SEP05 1	0.10	cm	0.060	m	0.010	m	0.10	m	0.054	m	0.13	m
11475 05SEP05 1	0.082	m	0.014	m	0.0079	m	0.083	m	0.043	m	0.11	m
10249 06SEP05 1	0.10	cm	0.060	m	1.0		2.3		0.053	m	1.23	
10525 07SEP05 1	0.091	m	0.054	m	0.0087	m	0.092	m	0.048	m	0.12	m
10525 07SEP05 2	0.091	m	0.053	m	0.0087	c m	0.091	m	0.047	m	0.12	m
21329 07SEP05 1	0.093	m	0.054	m	0.23		0.093	m	0.048	m	0.12	m
21559 07SEP05 2	0.098	m	0.058	m	0.42	c	0.099	m	0.051	m	0.13	m
21559 07SEP05 1	0.092	m	0.054	m	0.0088	c m	0.092	m	0.048	m	0.12	m
21522 08SEP05 1	0.10	cm	0.017	m	0.010	m	0.10	m	0.054	m	0.13	m
20135 09SEP05 1	0.091	m	0.015	m	0.0087	m	0.091	m	0.047	m	0.12	m
20027 10SEP05 1	0.10	m	0.061	m	0.010	m	0.10	m	0.97		0.13	m
20027 10SEP05 2	0.10	m	0.061	m	0.010	m	0.10	m	0.054	m	0.13	m
23058 10SEP05 1	0.098	cm	0.057	m	0.0093	m	0.098	m	0.051	m	0.13	m
10310 11SEP05 1	0.12	cm	0.069	m	0.011	m	0.12	m	0.062	m	0.15	m
10311 11SEP05 1	0.093	cm	0.055	m	0.0089	m	0.094	m	0.049	m	0.12	m
10311 12SEP05 2	0.11	m	0.067	m	0.011	c m	0.12	m	0.060	m	0.15	m
12338 12SEP05 1	0.095	m	0.016	m	0.30		0.095	m	0.049	m	0.12	m
12337 13SEP05 1	0.092	cm	0.21		0.21		0.43		0.048	m	0.31	

Sample No	benzoaanth ng/g ww	benzoaanthf	ChryTri ng/g ww	ChryTrif	benzobflur ng/g ww	benzobflurf	benzokflur ng/g ww	benzokflurf	benzoepyr ng/g ww	benzoepyrf	benzoapyr ng/g ww	benzoapyrf
CHI 18JUL06	0.30		0.38		0.089	m	0.046	m	0.11	m	0.032	m
CNF 06JUL06	0.51		0.83		0.10	m	0.054	m	1.2		0.038	m
CNT 01JUL06	0.018	m	0.011	m	0.11	m	0.058	m	0.14	m	0.040	m
DAN 07JUL06	0.017	m	0.51	d	0.10	m	0.053	m	1.2	d	0.036	m
DAR 24JUL06	0.51		0.98		1.8		0.049	m	2.3		0.034	m
KEL 19JUL06	0.015	m	0.0090	m	0.094	m	0.049	m	0.98		0.034	m
MUD 21JUL06	0.37		0.90		0.092	m	0.048	m	0.12	m	0.033	m
SLV 09JUL06	0.017	m	0.010	m	0.10	m	0.053	m	0.37		0.037	m
SRD 09JUL06	5.1		3.1		8.8		2.7		3.5		1.3	
SWA 17JUL06	0.96		5.4		5.3		0.052	m	8.1		1.6	
TLP 07JUL06	7.8		4.6		9.2		3.5		5.0		2.8	

Sample No	benzoapyr ng/g ww	benzoapyrf
20135 10AUG05 1	0.096	
23058 10AUG05 1	0.21	
10310 11AUG05 1	0.036	m
11281 11AUG05 1	0.040	m
10594 12AUG05 1	0.034	m
12338 12AUG05 1	0.34	
12338 12AUG05 2	0.035	m
12457 29AUG05 1	0.036	m
12461 29AUG05 1	1.3	
11087 30AUG05 1	0.037	m
11087 30AUG05 2	0.037	m
11089-30AUG05-1	0.034	m
12154 31AUG05 1	0.039	m
12154 31AUG05 2	0.041	m
12155 31AUG05 1	0.039	m
20037 02SEP05 1	0.037	m
21317 02SEP05 1	0.039	m
21390 03SEP05 1	0.035	m
21397 03SEP05 1	0.036	m
2310X 03SEP05 1	0.036	m
11685 04SEP05 1	0.035	m
1168X 04SEP05 1	0.039	m
20062 04SEP05 1	0.034	m
11474 05SEP05 1	0.037	m
11475 05SEP05 1	0.030	m
10249 06SEP05 1	0.87	
10525 07SEP05 1	0.033	m
10525 07SEP05 2	0.033	m
21329 07SEP05 1	0.033	m
21559 07SEP05 2	0.035	m
21559 07SEP05 1	0.033	m
21522 08SEP05 1	0.037	m
20135 09SEP05 1	0.033	m
20027 10SEP05 1	0.037	m
20027 10SEP05 2	0.038	m
23058 10SEP05 1	0.035	m
10310 11SEP05 1	0.043	m
10311 11SEP05 1	0.034	m
10311 12SEP05 2	0.041	m
12338 12SEP05 1	0.034	m
12337 13SEP05 1	0.14	