PHASE I FOLLOW-UP WATER QUALITY MONITORING: ORGANOPHOSPHATE PESTICIDE SAMPLING FINAL DATA REPORT

Central Coast Region Conditional Waiver Cooperative Monitoring Program

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Executive Summary

Organophosphate pesticides were measured at 23 Cooperative Monitoring Program (CMP) sites in the Lower Salinas and Santa Maria watersheds in August and September, 2006 and again in February and March, 2007 to address Ag Waiver requirements for "Follow-up" monitoring and further explore the link between organophosphate (OP) pesticides and toxicity.

During each sampling event, water samples from each site were collected for laboratory analysis of 19 OP compounds via gas chromatography/mass spectrometry. Samples were also collected for laboratory tests of toxicity to aquatic invertebrates (*Ceriodaphnia dubia*), fish (*Pimephales*, or fathead minnow), and algae (*Selenastrum*, or green algae). This report focuses on toxicity to invertebrates, which was assessed using 3-brood tests to evaluate *C. dubia* survival and reproduction rates in sample water relative to rates in laboratory controls. Fewer significantly toxic results were observed for algae and fish than for invertebrates during this study, and a relationship between invertebrate toxicity and OP concentrations is perhaps more readily inferred because pesticides are crop protection products designed to cause mortality to invertebrates which damage crops in fields.

It should be understood that this study addressed only one of many potential sources of toxicity – OP pesticides – and that this study was observational, rather than experimental in nature, such that a *causal* relationship between the OP's and toxicity observed cannot be statistically confirmed by these results. That said, results from this study show a strong and readily observable relationship between OP concentrations above published LC50 values and acute toxicity to invertebrates.

Organophosphates were detected at every site during at least 1 of the 4 sampling events. Detections occurred at 16 of the 23 sites on all four sampling dates, and at 20 of the 23 sites on at least two of the sampling dates. Of the 19 OP's tested, the following 7 were detected at least once: chlorpyrifos, diazinon, dichlorvos, dimethoate, ethoprop, fenchlorphos, and malathion. Of these, only chlorpyrifos and diazinon were detected at concentrations likely to cause acute toxicity. Survival rates for *C. dubia* were significantly lower than the control in 50 of the 94 samples, or 53% of samples. Significant toxicity was observed at least once at 19 of the 23 sites.

It is common to evaluate toxicity, and especially additive toxicity, in terms of *toxic units* (TUs) such that for each compound, 1 TU = median lethal concentration (LC50). Samples containing at least 1 TU of chlorpyrifos, diazinon, or both comprised 40% (38 samples) of the total OP samples collected for this study. The only other OP detected at a concentration > 0.2 TUs was malathion, which was detected in 1 sample at 0.26 TUs (the sample also contained chlorpyrifos and diazinon). The number of OP-related TUs detected in samples from this study ranged from 0 to 19, excluding one outlier.

A large subset of the samples with ≥ 1 OP-related TU exhibited 100% *mortality* in corresponding invertebrate toxicity tests. Another large subset of samples with ≤ 1 OP-related TU showed 100% or near 100% *survival* in corresponding toxicity tests. Only 3 samples showed high survival rates despite ≥ 1 calculated TU, however a subset of 15 samples showed significantly lowered survival rates despite ≤ 1 OP-related TU, suggesting possible additional sources of toxicity. For the protection of aquatic life, Central Coast Water Quality Control Board (RWQCB) staff have adopted "303(d)-listing" criteria of one-half the LC50s for chlorpyrifos and diazinon (the criteria are 0.025 μg/L and 0.16 μg/L, respectively). 42 samples from this study exceeded this guideline for chlorpyrifos; 27 exceeded the diazinon guideline.

A substantial amount of pesticide sampling has also been conducted by the California Department of Pesticide Regulation (DPR), and by private industry in the pest control field. The DPR is also a source of information on pesticide applications, as are the county Agricultural Commissioners' offices. As a part of ongoing efforts to understand and manage agricultural pesticides, data from this study should also be examined in light of these other monitoring datasets, and the discussion of results expanded to include available pesticide application data.

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1 INTRODUCTION

The Cooperative Monitoring Program (CMP) Phase I began monthly surface water grab sampling in 25 water bodies in the Lower Salinas and Santa Maria watersheds in January, 2005. The Salinas and Santa Maria Rivers are major coastal rivers and both are primary migration corridors for endangered steelhead trout (*Onchorhyncus mykiss*). Large areas of the lower watersheds in each of these systems are agricultural, some of them cultivated year-round. The CMP measures basic physical and chemical water quality parameters, as well as in-stream flows and nutrient-related parameters. Water column toxicity to invertebrates, fish, and algae is measured 4 times per year, and sediment toxicity to invertebrates is measured once a year. Annual assessments of benthic invertebrate communities and habitat are also performed. In 2006, Phase II began with the addition to the CMP of 25 sites in other agricultural areas of California's Central Coast.

During the 2005 sampling events, several of the 25 Phase I sites showed significant, repeated toxicity to invertebrates. By that time, several studies had been published linking toxicity observed on the Central Coast to the organophosphate (OP) pesticides chlorpyrifos and diazinon (e.g. Anderson et al. 2003a and b; Hunt et al. 1999; Hunt et al. 2003; Koslowski et al. 2004; Phillips et al. 2004). Both chemicals are commonly applied to crops grown in the Phase I monitoring areas.

To address Ag Waiver requirements for "Follow-up" monitoring and further explore the link between OP pesticides and toxicity, OP pesticides were measured in the Phase I monitoring areas concurrently with regularly scheduled CMP water toxicity sampling in August and September, 2006 and again in February and March, 2007. Measured OP concentrations were compared to published median lethal concentrations (LC50s) for test invertebrates, and then with toxicity observed in concurrently collected water samples. Other relevant metrics are the Central Coast RWQCB "303d-listing" criteria for the protection of aquatic life - 0.025 µg/L and 0.16 µg/L for chlorpyrifos and diazinon, respectively. Results have also been used in ongoing outreach efforts to inform the agricultural community about the presence of pesticides and toxicity in surface waters in agricultural areas of the Central Coast.

It should be understood that this study addressed only one of many potential sources of toxicity – OP pesticides – and that this study was observational, rather than experimental in nature, such that a *causal* relationship between the OP's and toxicity observed cannot be statistically confirmed. That said, results from this study show a strong and readily observable relationship between OP concentrations above published LC50 values and acute toxicity to invertebrates.

2 METHODS

2.1 Monitoring Approach & Sites

Sample collection for the study was planned for 15 CMP sites in an agricultural region of northern Monterey County draining to the Salinas River and at 10 sites in an agricultural region on either side of the Santa Maria River near the coast (Table 1; Figure 1). Samples were collected during four regularly scheduled CMP events (August, 2006; September, 2006; February, 2007; March, 2007). The August and September events are representative of Central Coast late summer or "dry season" conditions, with substantial contribution to in-stream flows from irrigation. The February and March sampling events took place during the winter or "wet season." Total accumulated precipitation in the northern study area during the week prior to sampling was approximately 0.9 inches in February and 0.26 to 0.58 inches in March (data from South Salinas and North Salinas CIMIS stations; CIMIS 2008). In the southern study area, total accumulated precipitation in the week prior to sampling was 0.36 to 0.61 inches in February and 0.19 to 0.25 inches in March (data from Nipomo and Sisquoc CIMIS stations; CIMIS 2008).

Though some irrigation occurs during the winter/wet season, in-stream flows are also expected to be influenced by precipitation runoff during sampling which immediately follows a rain event, provided the rainfall is adequate to create saturated conditions in area soils. (Saturated conditions were not necessarily present in all locations during both "wet season" sampling events for this study.)

The 15 sites in the northern study area were distributed as follows: 3 sites in the mainstem Salinas River, 8 in creeks or sloughs receiving agricultural drainage, 1 in an agricultural drain, 2 in the Salinas Reclamation Canal, and 1 site in a slough receiving tidal inputs influenced by water from the Salinas River. The 10 sites in the southern study area were distributed as follows: 2 sites in the mainstem Santa Maria River, 2 sites in a creek tributary to the Santa Maria River receiving agricultural drainage, 2 sites in agricultural drains tributary to the Santa Maria River, and 2 sites in creeks tributary to Oso Flaco Lake, which drains to the Pacific Ocean.

Water samples for toxicity and organophosphate (OP) pesticide analyses were collected from each site on all four sampling dates. Toxicity of water samples to aquatic invertebrates was assessed using 3-brood tests for survival and reproduction rates of *Ceriodaphnia dubia*. Toxicity to fish (test organism: *Pimephales*) and aquatic algae (test organism: *Selenastrum*) were also assessed, however this report will focus on toxicity to aquatic invertebrates. This focus is due in part to the fact that toxicity to algae is more likely to be tied to the presence of herbicides in the water, and results are also confounded by nutrient enrichment in many samples. Also, though toxicity to fish may be caused by pesticides, almost no acute toxicity to fish was observed during this study period. A mechanistic relationship between observed invertebrate toxicity and OP concentrations is perhaps more readily inferred because pesticides are crop protection products designed to cause mortality to invertebrates which damage crops in fields. Organophosphate compounds were measured by EPA method 625m, gas chromatograpy/mass spectrometry.

2.2 Sample Collection Methods

Ambient water samples were collected for toxicity and OP pesticide analyses as described in the CMP Quality Assurance Project Plan, pages 15 through 23 and Appendix A attachments 1 (Pacific EcoRisk Ambient Water Sampling SOP) and 4 (CCAMP Sampling SOP) (QAPP 2006; Table 2). Briefly, ambient water samples were collected from mid-channel at mid-depth by bucket grab. Samples for toxicity analysis were immediately transferred into appropriately cleaned 1-gallon amber glass bottles. Samples for pesticide analysis were immediately transferred into appropriately cleaned 1-liter unpreserved amber glass bottles.

Within 24 hours of collection, water samples for toxicity analysis were transported on ice and under chain-of-custody to the Pacific EcoRisk laboratory facility in Martinez, CA. Upon receipt at the laboratory, an aliquot of each water sample was removed for analysis of initial water quality characteristics. The remainders of each sample were stored at $4^{o}C$, and were used to initiate testing within 36 hours of collection. Water samples for OP analysis were transported on ice and under chain-of-custody to CRG Marine Labs in Torrance, CA, generally within 6 days of collection. Upon receipt by the laboratory, samples were extracted and analyzed within the 7 day EPA-specified hold time.

All sample collections took place concurrently with regularly scheduled CMP sampling for which basic physical and chemical parameters were measured as well, using a Hydrolab® multi-parameter sonde (Table 2). Water samples for laboratory analysis of nitrate, orthophosphate, and total ammonia were also collected (Table 2).

2.3 Analytical Methods

2.3.1 Organophosphate analysis

Organophosphate compounds were measured by EPA method 625m, gas chromatography/mass spectrometry. Briefly, compounds were serially extracted from the sample solution with an organic solvent at high and low pH, separated using a gas chromatographic column, and quantified according to mass:charge ratio by a mass spectrometer. Analyte-specific method detection limits (MDL) ranged from 0.001 to 0.008 µg/L, with reporting limits from 0.002 to 0.016 µg/L (Table 2). Results below the MDL were reported as "not detected," and results above the MDL but below the laboratory reporting limit were indicated by a "J-flag" qualifier. A detailed description of the analytical method can be found in the QAPP Appendix C, Attachment 5 (QAPP 2006).

2.3.2 Toxicity analysis

Toxicity analyses were conducted according to US Environmental Protection Agency methods (USEPA 2002). Toxicity testing with *Ceriodaphnia dubia* (*C. dubia*) consisted of exposing individual females to ambient waters for the length of time required for control treatment females to produce three broods (typically 6-8 days). The control treatments consisted of a mixture of commercially available spring waters, and experimental treatments were full strength (i.e. undiluted) water samples from each monitoring site. All treatments consisted of 200 mL of test solution, plus food additions for the test organisms consisting of Yeast-Cerophyll Trout Food and the alga *Selenastrum capriconutum*.

One *C. dubia* neonate (<24 hours old) was introduced into each of ten 15 mL replicates which were placed in a temperature-controlled environment at 25^{o}C, with a photoperiod of 16 hours light to 8 hours dark. Each day of the tests, fresh test solutions and new sets of replicate cups were prepared. The number of offspring produced in each cup were counted, and surviving organisms were counted and transferred into the new cups. Water quality characteristics (pH, dissolved oxygen, and conductivity) were measured in all solutions prior to use in tests, and in one randomly selected replicate following each treatment. For samples where ambient conductivity levels were >3000 µS, the amphipod *Hyallela azteca* was used as an alternative test species more tolerant of the higher conductivities. For very high conductivities (salinity > 15 ppt), the mysid *Americamysis bahia* was used as an alternative test species.

After it was determined that ≥60% of *C. dubia* in the control treatments had produced their third brood of offspring, the tests were terminated. Data from the full strength water samples were analyzed and compared to data from the control treatments to evaluate any reductions in survival or reproduction rates attributable to the samples. Data management and statistical analyses were accomplished using CETIS® software. Supporting documentation for toxicity testing procedures is given in QAPP Appendix B, with information specific to aquatic invertebrate testing in Attachments 3 and 4 (QAPP 2006).

2.4 Quality Assurance

Water quality data collected by this monitoring program are compatible with State of California Surface Water Ambient Monitoring Program (SWAMP) data quality objectives. The CMP also generally follows informal guidance provided by the US EPA regarding data verification and validation.

Quality assurance protocols are described in detail in the QAPP, pages 29 – 44 (QAPP 2006). Briefly, field blank and duplicate samples were collected regularly to identify any contamination and demonstrate precision of sampling procedures. Laboratory method blanks, duplicates, and matrix spikes were also analyzed to identify any contamination and demonstrate precision and accuracy of analytical procedures. Additional details regarding quality control for toxicity tests are given in QAPP Appendix B (QAPP 2006). Both field and laboratory instruments were calibrated according to a regular schedule and user manuals where applicable. Data generated by analytical laboratories were reviewed and qualified as necessary.

3 RESULTS

3.1 Organophosphate Pesticides

A total of 94 samples were collected for OP analysis from 23 sites during 4 sampling events between August, 2006 and March, 2007. Sampling was planned for 25 sites, but 2 of the Salinas area sites – Chualar and Gabilan Creeks – did not have flowing water during any sampling event. Organophosphates were detected at every site during at least 1 of the 4 sampling events. Detections occurred at 16 of the 23 sites on all four sampling dates, and at 20 of the 23 sites on at least two of the sampling dates (Table 3). Of the 19 OP's for which we tested (Table 2), the following 7 were detected at least once: chlorpyrifos, diazinon, dichlorvos, dimethoate, ethoprop, fenchlorphos, and malathion. Of these, only chlorpyrifos and diazinon were detected at concentrations likely to cause acute toxicity (discussed further in Section 3.3). Site-specific concentrations of each organophosphate compound detected during each sampling event are provided in Appendix Table A-1.

As a group, the OP detections were relatively evenly distributed among sampling events, with the most detections (55) in March, 2007. There were 49 detections in August, 2006 and 43 detections each in September, 2006 and February, 2007. Temporal patterns are discussed by compound for each of the two monitoring areas in Sections 3.1.1 and 3.1.2 below. The concentrations of OP's detected in relation to toxicity observed in concurrently collected samples are discussed in Section 3.3, below.

3.1.1 Santa Maria watershed organophosphate results

The following OP's were detected at the 10 Santa Maria watershed monitoring sites during this study: chlorpyrifos (31 samples, 8 sites), malathion (26 samples, all sites), diazinon (18 samples, 7 sites), dimethoate (15 samples, 9 sites), dichlorvos (1 sample, 1 site). All 10 sites sampled had at least 1 OP detection, however it is of note that Little Oso Flaco Creek (312OFN) had only 1 detection (malathion, 0.0175 ug/L), at a concentration 3 orders of magnitude below the suggested LC50 (5 to 40 ug/L; Table 2).

Diazinon, chlorpyrifos, dimethoate, and malathion were detected during both wet and dry season events. About twice as many diazinon detections occurred in wet season events than in dry events, while chlropyrifos detections were more evenly distributed. Dichlorvos was detected only in March, 2007. The range of concentrations over which these compounds were detected during each event is given in Table 4, and concentrations of chlorpyrifos and diazinon specific to each sampling event are shown in Figures 2 and 3.

Temporal patterns should be interpreted with caution, especially in the absence of data on pesticide use and cropping systems at the time of sample collection. Classification of the sampling events as "dry" and "wet" suggests influence by irrigation-related discharges versus storm runoff. However, the events are probably more accurately characterized as "late summer" versus "late winter." Other seasonal variables such as planted commodities and current portion of the crop cycle impact pesticide use, irrigation practices, and runoff control measures.

3.1.2 Salinas watershed organophosphate results

The following OP's were detected at Salinas watershed monitoring sites during this study: chlorpyrifos (14 samples, 8 of 13 sites), malathion (7 samples, 5 sites), diazinon (48 samples, all sites), dimethoate (22 samples, 8 sites), ethoprop (7 samples, 4 sites), fenchlorphos (1 sample, 1 site). All 13 sites sampled had at least 1 OP detection, however it is of note that the Salinas River at the Chualar Bridge on River Rd. had only 1 detection (diazinon, 0.0085 ug/L), at a concentration 2 orders of magnitude below the suggested LC50 (0.32 ug/L; Table 4).

Diazinon, chlorpyrifos, dimethoate, and malathion were detected during both wet and dry season events. Twice as many chlorpyrifos detections occurred in wet season events than in dry events, while diazinon detections were more evenly distributed. Ethoprop and fenchlorphos were detected only during wet season events. The range of concentrations over which these compounds were detected during each event is given in Table 4, and concentrations of chlorpyrifos and diazinon specific to each sampling event are shown in Figures 2 and 3. Temporal patterns should be interpreted with caution, for reasons discussed in Section 3.1.1 above.

3.2 Toxicity

C. dubia 3-brood toxicity tests were conducted on samples collected concurrently with each sample for OP analysis (i.e. 94 samples from 23 sites during 4 sampling events between August, 2006 and March, 2007). Survival rates for test organisms were significantly lower than the control in 50 of the 94 samples, or 53% of samples. Statistically significant acute toxicity (i.e. lower survival rates for test organisms in sample water than in laboratory control) was observed at least once at 19 of the 23 sites. Significant acute toxicity was observed during all 4 sampling events at 4 sites, and during at least 2 sampling events at 15 sites. Twenty-seven of the 50 toxic results occurred during dry season events, with 18 of these occurring in August, 2006. Site-specific invertebrate survival rates during each sampling event are provided in Table 3 and Appendix Table A-2.

Reproduction rates for test organisms in sample water relative to controls were assessed in 50 samples. Rates could not be assessed in all 94 samples due to some cases of early mortality (i.e. 0% survival rate, with all mortality occurring early in the test), and because reproductive endpoints were not assessed when alternative test species were used in high conductivity samples. Reproduction was significantly lower than the control in 25 of these, or 50% of samples. The low reproduction rates were observed at least once at 16 of the 23 sites. Fifteen of the 25 low reproduction rates were observed in September, 2006. Site-specific results for invertebrate reproduction rates during each sampling event are provided in Appendix Table A-3.

3.2.1 Santa Maria watershed toxicity results

Statistically significant toxicity was observed at least once at 8 of the 10 Santa Maria watershed sampling sites. No acute toxicity to invertebrates was observed in Little Oso Flaco Creek (312OFN) or the Santa Maria River at Highway 1 (312SMI) during this study (Table 3). Significant, acute toxicity was observed during all 4 sampling events in the Bradley Channel at Jones St. (312BCJ), and during 3 of the events in Orcutt-Solomon Creek near the mouth (312ORC) and in the Santa Maria River at the estuary (312SMA) (Table 3).

The greatest number of significantly toxic results were obtained during August, 2006 (Table 3), when all sites that were not dry exhibited significant, acute toxicity, with the exception of Little Oso Flaco Creek. The fewest significantly toxic results were obtained during September, 2006 and February, 2007, when only 3 sites exhibited significant, acute toxicity.

3.2.2 Salinas watershed toxicity results

Statistically significant, acute toxicity was observed at least once at 11 of the 13 lower Salinas River watershed sampling sites. No acute toxicity was observed in Moro Coho Slough (306MOR) or the Blanco Drain (309BLA) during this study (Table 3). Significant, acute toxicity was observed during all 4 sampling events in the Salinas Reclamation Canal at the airport (309ALG) at San Jon Rd. (309JON), and in Quail Creek (309QUI) (Table 3). It was observed during 3 of the events in Espinosa (309ESP) and Tembladero (309TEH) Sloughs (Table 3).

As in Santa Maria, the greatest number of significantly toxic results were obtained during August, 2006 (Table 3), when 9 of the 13 sites sampled exhibited significant, acute toxicity. Sites not exhibiting toxicity were: Moro Coho Slough, Alisal Slough at the White Barn (309ASB), Blanco Drain, and Merrit Ditch (309MER). The fewest significantly toxic results were obtained during February, 2007, when only 5 sites exhibited significant, acute toxicity.

3.2.3 Toxicity results elsewhere on the Central Coast

Though OP sampling was restricted to the Lower Salinas and Santa Maria hydrologic areas, toxicity tests were performed at 23 additional sites in other agricultural areas of the Central Coast, as part of routine CMP monitoring. The additional sites were distributed as follows: 10 sites on the Pajaro River and tributary creeks, 2 sites on the mainstem Salinas River upstream of Chualar, 5 sites in San Luis Obispo area creeks, 2 sites on the Santa Ynez River near Lompoc, and 4 sites in Santa Barbara area creeks. Site-specific invertebrate survival rates at these sites for each sampling event are provided in Appendix Table A-4. Of the 87 samples collected from these sites during the 4 sampling events and analyzed for toxicity to *C. dubia*, test organisms in 8 samples (9%) exhibited significantly lower survival rates than the controls (Appendix Table A-4). The significantly toxic results came from 7 different sites, 3 of which are on the Pajaro River or tributaries, 2 on the mainstem Salinas River, and 2 in Santa Barbara area creeks. Seven of the 8 toxic results occurred during the dry season sampling events (August and September, 2006), and no significantly toxic results were obtained from any of these sites during March, 2007 (Appendix Table A-4).

3.3 Relationship Between Organophosphates and Toxicity

Chlorpyrifos and diazinon have been found to exhibit additive joint acute toxicity to aquatic invertebrates when both are present in water (Bailey et al. 1997). Other OP compounds may behave similarly. It is common to evaluate toxicity, and especially additive toxicity, in terms of *toxic units* (TUs) such that for each compound, 1 TU = median lethal concentration (LC50). Suggested LC50s for each OP detected are given in Table 2; TUs calculated from each OP detection are given with corresponding invertebrate toxicity results in Table 4 and shown in Figures 4a through 4c. In this study, samples containing at least 1 toxic unit (TU) of chlorpyrifos, diazinon, or both comprised 40% of the total OP samples collected (38 samples; Table 5). The only other OP detected at a concentration > 0.2 TUs was malathion, which was detected in 1 sample at 0.4-1.2 TUs (the sample also contained >1 TU of chlorpyrifos and diazinon).

The number of OP-related TUs detected in samples from this study ranged from undetected (10 samples, several stations and events) to 19 (Orcutt-Solomon Creek near mouth – 312ORC, September 2007), excluding one outlier (Table 4). The outlier (105 TUs at Quail Creek – 309QUI, March 2007) resulted from high concentrations of both chlorpyrifos and diazinon, which were validated by the analytical laboratory. Thirty-five of 38 samples with ≥ 1 TU corresponded to results of 100% mortality of invertebrate toxicity test organisms (Table 5). Three other samples with ≥ 1 TU did not show significant mortality (Table 5). Of 56 samples with ≤ 1 TU, 14 had corresponding significant mortality in toxicity test invertebrates (only 2 of these had no OP-related TUs, however).

Un-ionized ammonia from both natural and anthropogenic sources (e.g. fertilizer) is also toxic to aquatic invertebrates (Bailey et al. 2006). Concentrations of un-ionized ammonia depend on total ammonia concentration, pH, and temperature of the water, and published LC50s for *C. dubia* include 1.04 mg/L as N (Ankley et al. 1990) and 1.35 mg/L (Bailey et al. 1996). Only one sample collected during this study had a calculated un-ionized ammonia concentration high enough to suggest ammonia-related toxicity: Bradley Channel at Jones St. (312BCJ) in March, 2007. The un-ionized ammonia concentration was 8.26 mg/L as N; corresponding pH was 9.73. (This is, coincidentally, the highest un-ionized ammonia concentration in the entire CMP dataset to date.) There were also 2.6 OP-related TUs in the sample, with the corresponding toxicity test showing 100% mortality.

3.3.1 Organophosphate-Toxicity relationship for Santa Maria watershed

Results of TU calculations and corresponding toxicity test results for the Santa Maria study area are given in Table 5 and Figures 4a through 4c. Toxic units calculated for Santa Maria study area sites ranged from 0 (4 samples, all from Little Oso Flaco Creek) to 19 (1 sample, Orcutt-Solomon Creek near mouth). Corresponding invertebrate toxicity results were ≥100% survival in the Little Oso Flaco Creek samples, and 100% mortality in the Orcutt-Solomon Creek sample. Twenty of 39 samples from this study area had ≥ 1 TU, and all but 3 of those showed significant mortality in corresponding toxicity tests. Of the 19 samples with ≤ 1 OP-related TU, 3 showed significant toxicity (100% mortality in each case).

All but one sample from August, 2006 had ≥ 1 OP-related TU and significant mortality in corresponding invertebrate toxicity tests. In September, 2006, 6 of 10 samples had had ≥ 1 OP-related TU, but only 3 of those showed significant toxicity to invertebrates. All samples with ≤ 1 OP-related TU had corresponding 100% invertebrate survival rates. In February, 2007, only 2 of 10 samples had ≥ 1 OP-related TU. Both had corresponding toxicity test results of 100% mortality. Of the 7 samples with ≤ 1 OP-related TU, 1 had significant corresponding toxicity (100% mortality, Oso Flaco Creek – 312OFC). Four of 10 samples from March, 2007 had ≥ 1 OP-related TU; all had corresponding 100% invertebrate mortality rates. Of the 6 samples with ≤ 1 OP-related TU, 2 showed significant toxicity to invertebrates (0.8 TUs and 100% mortality in both cases).

3.3.2 Organophosphate-Toxicity relationship for Salinas watershed

Results of TU calculations and corresponding toxicity test results for the Salinas study area are given in Table 5 and Figures 4a through 4c. Toxic units calculated for the Salinas study area sites ranged from undetected (6 samples, from Moro Coho Slough, Salinas River at Spreckles (309SSP), Salinas River at Chualar Bridge (309SAC), and Old Salinas River at Monterey Dunes Way (309OLD)) to 105 (1 sample, Quail Creek). The next highest TU calculation was for Natividad Creek (309NAD), at 16 OP-related TUs. Corresponding invertebrate toxicity results ranged from 0% to >100% survival in the 0 TU samples, and were 0% survival in both the 105 and 15 TU samples. Eighteen of 55 samples from this study area had ≥ 1 TU, all of which showed 100% mortality in corresponding toxicity tests. Of the 37 samples with ≤ 1 OP-related TU, 11 showed significant toxicity (0 to 77% survival rates).

Six of 14 samples from August, 2006 had ≥ 1 OP-related TU (all had corresponding 100% invertebrate mortality). Four of the 8 samples with ≤ 1 OP-related TU had significant corresponding toxicity (0 to 77% invertebrate survival rates). Only 2 of 13 samples from September, 2006 had ≥ 1 OP-related TU (both had corresponding 100% invertebrate mortality). Four of the 11 samples with ≤ 1 OP-related TU had significant corresponding toxicity (100% mortality in each). In February, 2007, 4 of 14 samples had ≥ 1 OP-related TU (all had corresponding 100% invertebrate mortality). Significant toxicity was observed in 2 of the 10 samples with ≤ 1 OP-related TU (0% and 48% survival rates). Six of 14 samples from March, 2007 had ≥ 1 OP-related TU (all had corresponding 100% invertebrate mortality). One of the samples with ≤ 1 OP-related TU showed corresponding toxicity (0.5 TUs, 100% mortality).

4 DISCUSSION & CONCLUSIONS

4.1 Organophosphates and Toxicity

This study addressed OP pesticide concentrations and toxicity levels in corresponding water samples at 25 sites in agricultural areas of the Lower Salinas and Santa Maria watersheds during August and September, 2006 and February and March, 2007. Two sites did not have enough flow to be sampled at all during the study period. Measurable OP concentrations were common throughout both study areas during the four sampling events, with OP's detected in 89% of all samples collected. However, samples containing sufficient OP's to cause acute toxicity to aquatic invertebrates based on published LC50 values comprised only 39% of the samples collected. Significant, acute toxicity to invertebrates was observed in 53% of all samples collected. In general, results from this study showed a readily observable relationship between OP concentrations above published LC50 values and acute toxicity to aquatic invertebrates.

Following calculation of TUs based on the observed OP concentrations, a strong (though non-linear) relationship between OP's and acute invertebrate toxicity emerged. A large subset of the samples with ≥ 1 OP-related TU exhibited 100% mortality in corresponding toxicity tests (Figure 5). Another large subset of samples with ≤ 1 OP-related TU showed 100% or near 100% survival in corresponding toxicity tests (Figure 5). Only 3 samples showed high survival rates despite ≥ 1 calculated TU, however a subset of 15 samples showed significantly lowered survival rates despite ≤ 1 OP-related TU (Figure 5), suggesting possible additional sources of toxicity.

The Central Coast RWQCB has adopted the following criteria for protection of aquatic life, used in determining which waterbodies will go onto the EPA's 303d list of impaired waters: chlorpyrifos < 0.025 µg/L and diazinon < 0.16 µg/L. In this study, 45% of samples (42 samples) exceeded the 303(d) listing criterion for chlorpyrifos, and 29% (27 samples) exceeded the criterion for diazinon (Table 6). Of the 54 samples exceeding 303(d) listing criteria for chlorpyrifos, diazinon or both, 40 (74%) showed significant acute toxicity to aquatic invertebrates (as compared with controls; Table 6). Comparatively, 34 (92%) of the 37 samples exceeding published LC50 values were significantly toxic to test invertebrates. (Suggested LC50s, or median lethal concentrations, for chlorpyrifos and diazinon are 0.053 µg/L and 0.32 µg/L respectively.)

4.2 Other Studies

In another recent Salinas watershed study in which 61 samples were analyzed for 78 different compounds, 5 samples had concentrations of compounds other than chlorpyrifos and diazinon above published LC50 values – zinc, chromium, DDT, endrin, and carbofuran (Hunt et al. 2003). Strong conclusions were not drawn identifying any of these compounds as clear sources of toxicity, however (Hunt et al. 2003). At least three local studies have examined the relationship between suspended solids and *C. dubia* mortality, one of which did not determine a strong relationship (Hunt et al. 2003), another concluded that the positive relationship was due to the positive correlation between turbidity and TUs in field samples (Anderson et al. 2003b), and the third concluded that turbidities up to 1000 NTU's are not acute stressors of invertebrate test species (Anderson et al. 2006). It is also of note that the Hunt et al. study (2003) did not identify un-ionized ammonia as a source of toxicity. Un-ionized ammonia levels calculated from total ammonia concentrations measured in our study are also not believed to have contributed to the observed toxicity in a significant way. Finally and on a different note, it is also important to bear in mind the limitations of laboratory toxicity measurements in accurately characterizing in-stream invertebrate community health. Recent studies involving both laboratory and *in situ* toxicity experiments indicate that while pesticides are often the likely cause of laboratory-measured toxicity, other physical and biological factors (e.g. bank vegetation) also influence the in-stream macroinvertebrate community (e.g. Anderson et al. 2003b).

The relationships between OP pesticides, particularly chlorpyrifos and diazinon, observed in this and other studies are compelling. However, it is also important to place these results in a regional context, especially with respect to the regional CMP. Over half of the CMP sites (27 of 50), and all of the sites sampled for this study, are located in the Lower Salinas and Santa Maria watersheds. This sampling distribution emphasizes areas of intensive agricultural land use, rather than distributing sites uniformly throughout Central Coast agricultural waterways.

5 PROJECT OUTREACH & FUTURE EFFORTS

Selected results from this study were presented at 11 grower and/or PCA meetings, 2 ag interest group meetings, and 2 Farm Bureau meetings between June and December, 2007. Additional presentations are planned for several grower meetings and 1 water quality training workshop, to take place in the spring and summer of 2008. Communication of these results to the agricultural community is expected to continue as part of ongoing outreach efforts by CCWQP staff, and future presentations are expected to be enhanced by the data summaries discussed in this report. For example, chlorpyrifos and diazinon concentrations are being presented to growers for monitoring sites in their areas, together with corresponding toxicity data and in comparison to published LC50 values and RWQCB 303d-listing criteria for the protection of aquatic life. Emphasis is placed on presenting locally relevant data and highlighting the apparent relationship between OP concentrations and toxicity.

The overwhelming majority of CMP outreach is conducted in collaboration with the many partner organizations on the Central Coast, which means that most presentations occur in tandem with discussions of related management practices. For example, two meetings in the Santa Maria and Salinas area watersheds were conducted at the end of April, 2008. At each, thorough discussions of pesticide and toxicity monitoring results were provided to growers, followed by information on how to determine whether discharge from one's own operation may be contributing to the observed toxicity. Follow-up with growers who requested assistance with discharge analysis as a result of these meetings is currently underway, and more meetings are planned for the 2008 season.

Beyond the literature cited in this report, a substantial amount of pesticide sampling has been conducted by the California Department of Pesticide Regulation (DPR), and by private industry in the pest control field. The DPR is also a source of information on pesticide applications, as are the county Agricultural Commissioners' offices. As a part of ongoing efforts to understand and manage agricultural pesticides, data from this study should also be examined in light of these other monitoring datasets, and the discussion of results expanded to include available pesticide application data.

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Tables

Table 1. Station names and locations for organophosphate pesticide sampling.

Site Description	Site ID	Longitude	Latitude	Site Type
LOWER SALINAS WATERSHED				
Moro Cojo Slough at Highway 1	306MOR	-121.78328	36.79646	Tributary Creek
Old Salinas River at Monterey Dunes Way	309OLD	-121.787855	36.772291	River
Tembladero Slough at Haro	309TEH	-121.75445	36.75952	Tributary Creek
Merritt Ditch u/s Highway 183	309MER	-121.74168	36.75158	Drain
Espinosa Slough u/s Alisal Slough	309ESP	-121.73372	36.73675	Tributary Creek
Alisal Slough at White Barn	309ASB	-121.72968	36.72482	Tributary Creek
Blanco Drain Below Pump	309BLA	-121.74393	36.71060	Drain
Salinas Reclamation Canal at San Jon Road	309JON	121.70496	36.70493	Canal
Gabilan Creek at Boronda Road	309GAB	-121.61641	36.71548	Tributary Creek
Natividad Creek u/s Salinas Reclamation Canal	309NAD	-121.60197	36.70254	Tributary Creek
Salinas Reclamation Canal at La Guardia	309ALG	-121.61297	36.65697	Canal
Salinas River at Spreckels Gauge	309SSP	-121.67339	36.62967	River
Quail Creek at Highway 101	309QUI	-121.56211	36.60943	Tributary Creek
Salinas River at Chualar Bridge on River Road	309SAC	-121.547737	36.553757	River
Chualar Creek at Chualar River Road	309CRR	-121.50995	36.56142	Tributary Creek
SANTA MARIA WATERSHED				
Bradley Channel at Culvert	312BCC	-120.37399	34.94507	Canal
Bradley Channel at Jones Street	312BCJ	-120.41679	34.94544	Canal
Santa Maria River at Estuary	312SMA	-120.641796	34.963774	River
Orcutt Solomon Creek u/s Santa Maria River	312ORC	-120.631454	34.957554	Tributary Creek
Little Oso Flaco Creek	312OFN	-120.586157	35.022795	Tributary Creek
Oso Flaco Creek at Oso Flaco Lake Road	312OFC	-120.586259	35.016388	Tributary Creek
Santa Maria River at Highway 1	312SM1	-120.569832	34.977207	River
Orcutt Solomon Creek at Highway 1	312OR1	-120.572882	34.941374	Tributary Creek
Main Street Canal u/s Ray Road at Highway 166	312MSD	-120.486578	34.955227	Canal
Green Valley at Simas	312GVS	-120.556457	34.942280	Tributary Creek

Table 2. Specific OPs analyzed and concurrently sampled CMP parameters. Method detection and reporting limits are also provided. Units for organophosphates are µg/L and for nutrient-related parameters are mg/L. Median lethal concentrations (LC50) are given for 6 of the 7 organophosphates detected in this study (in µg/L, except for unionized ammonia, in mg/L).

Water Quality Parameter	Method Detection Limit	Reporting Limit	LC50's, *303d Criteria*
ORGANOPHOSPHATES			
Chlorpyrifos*	0.001	0.002	0.053 [1], *0.025*
Demeton	0.001	0.002	--
Diazinon*	0.002	0.004	0.32 [1], *0.16*
Dichlorvos*	0.003	0.006	0.149 [2]
Dimethoate*	0.003	0.006	600 [3]
Disulfoton	0.001	0.002	--
Ethoprop*	0.001	0.002	--
Fenchlorphos*	0.002	0.004	1.8 [4]
Fensulfothion	0.001	0.002	--
Fenthion	0.002	0.004	--
Malathion*	0.003	0.006	1.1 to 3.2 [5]
Merphos	0.001	0.002	--
Methyl Parathion	0.001	0.002	--
Mevinphos	0.008	0.016	--
Phorate	0.006	0.012	--
Sulprofos	0.002	0.004	--
Tetrachlorvinphos	0.002	0.004	--
Tokuthion	0.003	0.006	--
Trichloronate	0.001	0.002	--
TOXICITY-RELATED PARAMETERS			
Algae Toxicity, Cell Growth	Results reported as survival, growth, or reproduction rates as % of control (0 to >100%). Minimum reportable result = 0%, regardless of actual toxic strength of sample.		
Invertebrate Toxicity, Survival			
Invertebrate Toxicity, Reproduction			
Fish Toxicity, Survival			
Fish Toxicity, Growth			
BASIC PARAMETERS			
Flow	calculated parameter		--
Air Temperature	-5°C	0°C	--
Water Temperature	-5°C	0°C	--
Turbidity	0 NTU	0.5 NTU	--
Conductivity	0 µS	0.1 µS	--
Solids, Total Dissolved (TDS)	3.8 mg/L	40 mg/L	--
pH	0 s.u.	0 s.u.	--
Dissolved Oxygen	0 mg/L	0 mg/L	--
Chlorophyll a	0.02 µg/L	2 µg/L	--
NUTRIENT-RELATED PARAMETERS			
Nitrate as N	0.014	0.1	--
Orthophosphate as P	0.0075	0.01	--
Ammonia as N	0.042	0.2	--
Unionized Ammonia as N	calculated parameter		1.04 [6]

Notes:
- * Denotes OP detected in this study
- 1 LC50 ref., chlorpyrifos and diazinon: Bailey et al. 1997
- 2 LC50 ref., dichlorvos: Brooke 1991
- 3 LC50 ref. (*Daphnia magna*), dimethoate: Beusen and Neven 1989
- 4 LC50 ref. (Daphnia magna), fenchlorphos: Frear and Boyd 1967
- 5 LC50 ref., malathion: Nelson and Roline 1998
- 6 LC50 ref., unionized ammonia: Ankley et al. 1990

Table 3. Organophosphates detected during each sampling event. Bold red text indicates that the concentration was greater than the LC50 for that compound (see Table 2 for LC50s). Survival rates for *C. dubia* in concurrently collected toxicity samples are given below each list of detected organophosphates. Bold red text indicates statistically significant toxicity.

Site ID	Site Description	Organophosphate Pesticides Detected (invertebrate survival rates shown below as % of control)			
		2006		2007	
		August	September	February	March
306MOR	Moro Cojo Slough at Highway 1	no detections 100%	no detections 103%	Diazinon 103%	Diazinon 97%
309ALG	Salinas Reclamation Canal at La Guardia	***Diazinon*** Dimethoate ***0%***	Diazinon Dimethoate ***0%***	***Chlorpyrifos*** Diazinon Dimethoate Ethoprop ***0%***	***Chlorpyrifos*** ***Diazinon*** Dimethoate Malathion ***0%***
309ASB	Alisal Slough at White Barn	Diazinon Dimethoate 80%	Diazinon 90%	Dimethoate 80%	Diazinon ***0%***
309BLA	Blanco Drain below Pump	Diazinon 100%	Diazinon Dimethoate 90%	Chlorpyrifos Diazinon Dimethoate 100%	Diazinon 100%
309ESP	Espinosa Slough upstream from Alisal Slough	***Diazinon*** Dimethoate Malathion ***0%***	***Diazinon*** Dimethoate ***0%***	Diazinon Dimethoate Ethoprop 100%	***Chlorpyrifos*** ***Diazinon*** Ethoprop Malathion ***0%***
309JON	Salinas Reclamation Canal at San Jon Road	***Diazinon*** Dimethoate ***0%***	Diazinon Dimethoate ***0%***	***Chlorpyrifos*** Diazinon Malathion ***0%***	***Diazinon*** Ethoprop Fenchlorphos ***0%***
309MER	Merrit Ditch upstream from Highway 183	Diazinon 100%	Diazinon 90%	Diazinon 100%	Diazinon ***56%***
309NAD	Natividad Creek upstream from Salinas Reclamation Canal	***Chlorpyrifos*** ***Diazinon*** Dimethoate Malathion ***0%***	***Diazinon*** Dimethoate ***0%***	Diazinon 100%	Diazinon 100%
309OLD	Old Salinas River at Monterey Dunes Way	no detections ***77%***	Diazinon Dimethoate 100%	Diazinon ***48%***	Diazinon 105%
309QUI	Quail Creek at Highway 101	***Chlorpyrifos*** Diazinon Dimethoate ***0%***	***Chlorpyrifos*** Diazinon Dimethoate ***0%***	***Chlorpyrifos*** Diazinon ***0%***	***Chlorpyrifos*** ***Diazinon*** ***0%***
309SAC	Salinas River at Chualar Bridge	no detections ***0%***	NS	no detections 80%	Diazinon 111%

Table 4. Continued from previous page.

Site ID	Site Description	Organophosphate Pesticides Detected (invertebrate survival rates shown below as % of control)			
		2006		2007	
		August	September	February	March
309SSP	Salinas River at Spreckels Gage	Diazinon ***20%***	no detections 111%	Diazinon 100%	Chlorpyrifos Diazinon ***0%***
309TEH	Tembladero Slough at Haro	Diazinon Dimethoate ***0%***	Diazinon Dimethoate 100%	Chlorpyrifos Diazinon Ethoprop ***0%***	***Chlorpyrifos*** ***Diazinon*** Ethoprop Malathion ***0%***
312BCC	Bradley Channel at Culvert	NS	NS	***Chlorpyrifos*** ***0%***	***Chlorpyrifos*** Diazinon Dichlorvos Dimethoate Malathion ***0%***
312BCJ	Bradley Channel at Jones Street	***Chlorpyrifos*** Dimethoate Malathion ***0%***	***Chlorpyrifos*** Dimethoate Malathion ***0%***	***Chlorpyrifos*** Diazinon ***0%***	***Chlorpyrifos*** Diazinon ***0%***
312GVS	Green Valley at Simas	***Chlorpyrifos*** Dimethoate Malathion ***0%***	Chlorpyrifos Dimethoate Malathion 100%	Chlorpyrifos Diazinon 80%	Chlorpyrifos Diazinon Malathion 90%
312MSD	Main Street Canal u/s Ray Road at Highway 166	***Chlorpyrifos*** Malathion ***0%***	***Chlorpyrifos*** Malathion 95%	***Chlorpyrifos*** Malathion 90%	Chlorpyrifos Diazinon Dimethoate Malathion ***0%***
312OFC	Oso Flaco Creek at Oso Flaco Lake Road	***Chlorpyrifos*** Malathion ***0%***	Malathion 100%	Malathion ***0%***	Chlorpyrifos Dimethoate Malathion 90%
312OFN	Little Oso Flaco Creek	Malathion 100%	no detections 100%	no detections 100%	no detections 106%
312OR1	Orcutt Solomon Creek at Highway 1	***Chlorpyrifos*** Diazinon Dimethoate Malathion ***42%***	***Chlorpyrifos*** Dimethoate 100%	Chlorpyrifos Diazinon Malathion 89%	Chlorpyrifos Diazinon Malathion ***0%***
312ORC	Orcutt Solomon Creek u/s Santa Maria River	***Chlorpyrifos*** Diazinon Dimethoate Malathion ***0%***	***Chlorpyrifos*** Diazinon Dimethoate Malathion ***0%***	Chlorpyrifos Diazinon 95%	***Chlorpyrifos*** Diazinon Dimethoate Malathion ***0%***
312SM1	Santa Maria River at Highway 1	NS	Dimethoate Malathion 100%	NS	NS
312SMA	Santa Maria River at Estuary	***Chlorpyrifos*** ***Diazinon*** Dimethoate Malathion ***0%***	***Chlorpyrifos*** Diazinon Malathion ***0%***	Chlorpyrifos Diazinon 80%	***Chlorpyrifos*** Diazinon Dimethoate Malathion ***0%***

Table 5. Range of organophosphate concentrations observed in samples from each study area during the four sampling events. All concentrations are given in µg/L.

		2006		2007	
		August	September	February	March
Lower Salinas Watershed	Chlorpyrifos (0.053)[1]	ND – 0.245	ND – 0.054	ND – 0.463	ND – 1.494
	Diazinon (0.32)	ND – 3.9	ND – 1.59	ND – 0.683	0.009 – 24.47
	Dichlorvos (0.149)	ND	ND	ND	ND
	Dimethoate (600)	ND – 1.34	ND – 0.935	ND – 0.152	ND – 0.242
	Ethoprop	ND	ND	ND – 0.636	ND – 5.41
	Fenchlorphos (1.8)	ND	ND	ND	ND – 0.361
	Malathion (1.1 - 3.2)	ND – 0.329	ND	ND – 0.032	ND – 1.29
Santa Maria Watershed	Chlorpyrifos (0.053)	ND – 0.421	ND – 0.978	ND – 0.211	ND – 0.355
	Diazinon (0.32)	ND – 0.414	ND – 0.074	ND – 0.102	ND – 0.085
	Dichlorvos (0.149)	ND	ND	ND	ND – 0.005
	Dimethoate (600)	ND – 0.002	ND – 0.001	ND	ND – 0.0002
	Ethoprop	ND	ND	ND	ND
	Fenchlorphos (1.8)	ND	ND	ND	ND
	Malathion (1.1-3.2)	ND – 0.515	ND – 0.267	ND – 0.095	ND – 0.855

Notes:

1 LC50s are given in parentheses following each compound name. Rreferences for LC50s are provided in footnotes to Table 2. Laboratory detection limits are also given in Table 2.

2 ND = "not detected"

Table 5. "Total OP-related TUs" detected at each site for each sampling event, corresponding invertebrate survival rates, and flows. "ND" = no OP's detected.

Site Description	Site ID	Sampling Date	Joint OP Toxic Units	Invertebrate Survival Rate (%)	Discharge (CFS)	Discharge Qualifier
Moro Coho Slough at Hwy 1	306MOR	August '06	ND	100	7.9	1
		September '06	ND	103	10.4	1
		February '07	0.1	103	8.1	1
		March '07	0.1	97	12.7	--
Salinas Reclamation Canal at La Guardia	309ALG	August '06	***3.1***	***0***	4.3	1,2
		September '06	0.5	***0***	5.3	2
		September dup.	0.5	***0***	5.3	2
		February '07	***4.0***	***0***	0.5	1
		March '07	***7.0***	***0***	0.3	1
Alisal Slough at White Barn	309ASB	August '06	0.2	80	1.2	--
		September '06	0.3	90	1.1	1
		February '07	<0.05	80	0.3	1
		March '07	0.5	***0***	3.6	--
Blanco Drain below Pump	309BLA	August '06	0.2	100	8.4	1,2
		September '06	0.5	90	15.8	1,2
		February '07	0.6	100	4.6	1
		March '07	0.4	100	5.2	1
Espinosa Slough upstream from Alisal	309ESP	August '06	***1.3***	***0***	0.8	1
		September '06	***5.0***	***0***	0.7	1
		February '07	0.5	100	3.0	--
		March '07	***7.5***	***0***	0.9	1
Salinas Reclamation Canal at San Jon Road	309JON	August '06	***9.9***	***0***	33.5	--
		September '06	0.7	***0***	15.2	--
		February '07	***1.6***	***0***	3.4	--
		March '07	***1.8***	***0***	1.4	--
Merrit Ditch upstream from Highway 183	309MER	August '06	0.4	100	5.1	1
		September '06	0.1	90	2.1	1
		February '07	0.1	100	7.4	3
		March '07	0.1	***11***	1.8	1
		March dup.	0.1	100	1.8	1
Natividad Creek upstream from Salinas Reclamation	309NAD	August '06	***14.1***	***0***	0.3	1
		August dup.	***15.7***	***0***	0.3	1
		September '06	0.4	***0***	0.1	1
		February '07	0.1	100	0.2	1
		March '07	0.5	100	0.2	1
Old Salinas River at Monterey Dunes Way	309OLD	August '06	ND	***77***	2.9	1
		September '06	0.6	100	4.3	1
		February '07	0.1	***48***	47.1	--
		March '07	0.2	105	16.0	--
Quail Creek at Highway 101	309QUI	August '06	***5.1***	***0***	3.9	1
		September '06	***1.9***	***0***	3.5	1
		February '07	***9.3***	***0***	2.3	1
		March '07	***104.6***	***0***	1.2	1
Salinas R. at Chualar bridge on River Road	309SAC	August '06	ND	***0***	81.2	--
		September '06	NS	--	0.0	--
		February '07	ND	80	52.9	--
		March '07	<0.05	111	100.9	--

Discharge qualifiers: 1 = "High biased" – Velocimeter detection limit used in calculations for which water velocity was below instrument detection limit; 2 = One or more *transect points* were estimated; 3 = Discharge too high to allow safe access to stream, so result is estimate.

Table 5. Continued from previous page. "Total OP toxic units" > 1 and significantly toxic results are in bold red text. Discharge qualifiers are given on previous page.

Site Description	Site ID	Sampling Date	Joint OP Toxic Units	Invertebrate Survival Rate (%)	Discharge (CFS)	Discharge Qualifier
Salinas River at Spreckels Gage	309SSP	August '06	0.1	***20***	2.5	1
		September '06	ND	111	1.1	1
		February '07	<0.05	100	22.2	3
		March '07	***1.2***	***0***	28.5	3
Tembladero Slough at Haro	309TEH	August '06	0.8	***0***	13.7	1
		September '06	0.4	100	17.9	1
		February '07	***1.0***	***0***	18.1	1
		February dup.	0.4	***0***	18.1	1
		March '07	***3.0***	***0***	17.3	1
Bradley Channel at Culvert	312BCC	August '06	NS	--	0.0	--
		September '06	NS	--	0.0	--
		February '07	***4.0***	***0***	0.5	--
		March '07	***2.0***	***0***	0.9	--
Bradley Channel at Jones Street	312BCJ	August '06	***6.8***	***0***	2.5	--
		September '06	***2.8***	***0***	0.9	--
		February '07	***2.4***	***0***	0.0	1,2
		March '07	***2.6***	***0***	0.0	1
Green Valley at Simas	312GVS	August '06	***2.4***	***0***	2.3	--
		September '06	0.8	100	2.0	--
		February '07	0.8	80	2.4	--
		March '07	0.5	90	1.1	1
Main Street Canal u/s Ray Road at Highway 166	312MSD	August '06	***7.9***	***0***	1.1	--
		September '06	***1.4***	90	0.6	--
		September dup.	***1.2***	100	0.6	--
		February '07	0.6	90	0.4	--
		March '07	0.8	***0***	1.8	--
Oso Flaco Creek at Oso Flaco Lake Road	312OFC	August '06	***3.5***	***0***	4.6	--
		August dup.	***3.2***	***0***	4.6	--
		September '06	<0.05	100	2.7	--
		February '07	<0.05	***0***	1.2	--
		March '07	0.9	90	4.1	--
Little Oso Flaco Creek	312OFN	August '06	<0.05	100	1.2	--
		September '06	ND	100	2.0	--
		February '07	ND	100	0.5	--
		March '07	ND	100	0.7	--
		March dup.	ND	111	0.7	--
Orcutt Solomon Creek at Highway 1	312ORI	August '06	***2.2***	***42***	6.4	--
		September '06	***1.3***	100	5.2	--
		February '07	0.5	89	2.0	--
		March '07	0.8	***0***	2.3	--
Orcutt Solomon Creek u/s Santa Maria River	312ORC	August '06	***8.5***	***0***	11.6	--
		September '06	***18.7***	***0***	8.2	--
		February '07	0.7	90	11.2	3
		Februrary dup.	0.8	100	11.2	3
		March '07	***5.0***	***0***	5.7	--
Santa Maria River at Highway 1	312SMI	August '06	NS	--	0.0	--
		September '06	<0.05	100	0.3	1
		February '07	NS	--	0.0	--
		March '07	NS	--	0.0	--
Santa Maria River at Estuary	312SMA	August '06	***4.8***	***0***	12.0	--
		September '06	***13.4***	***0***	10.7	--
		February '07	0.7	80	8.8	--
		March '07	***6.9***	***0***	11.9	--

Table 6. Chlorpyrifos, diazinon, and corresponding acute toxicity to invertebrates. Significantly toxic results are in bold red text. OP concentrations above the 303(d) criteria are in bold red text; concentrations above the LC50s are in bold red text and shaded.

Site ID	Month	Chlorpyrifos Conc. (ppb)	Diazinon Conc. (ppb)	Invertebrate Survival (%)	Significant Toxic Effect
306MOR	August '06	ND	ND	100	NO
	September '06	ND	ND	103	NO
	February '07	ND	0.043	103	NO
	March '07	ND	0.040	97	NO
309ALG	August '06	ND	***1.000***	***0***	***YES***
	September '06	ND	0.159	***0***	***YES***
	September dup.	ND	***0.163***	***0***	***YES***
	February '07	***0.099***	***0.683***	***0***	***YES***
	March '07	***0.070***	***1.677***	***0***	***YES***
309ASB	August '06	ND	0.058	80	NO
	September '06	ND	0.110	90	NO
	February '07	ND	ND	80	NO
	March '07	ND	***0.162***	***0***	***YES***
309BLA	August '06	ND	0.071	100	NO
	September '06	ND	***0.166***	90	NO
	February '07	0.018	0.097	100	NO
	March '07	ND	0.124	100	NO
309ESP	August '06	ND	***0.414***	***0***	***YES***
	September '06	ND	***1.590***	***0***	***YES***
	February '07	ND	***0.161***	100	NO
	March '07	***0.068***	***1.957***	***0***	***YES***
309JON	August '06	ND	***3.160***	***0***	***YES***
	September '06	ND	***0.236***	***0***	***YES***
	February '07	***0.055***	***0.169***	***0***	***YES***
	March '07	ND	***0.514***	***0***	***YES***
309MER	August '06	ND	0.133	100	NO
	September '06	ND	0.031	90	NO
	February '07	ND	0.026	100	NO
	March '07	ND	0.041	***11***	***YES***
	March dup.	ND	0.033	100	NO
309NAD	August '06	***0.155***	***3.550***	***0***	***YES***
	August dup.	***0.184***	***3.900***	***0***	***YES***
	September '06	ND	0.128	***0***	***YES***
	February '07	ND	0.018	100	NO
	March '07	ND	***0.163***	100	NO
309OLD	August '06	ND	ND	***77***	***YES***
	September '06	ND	***0.206***	100	NO
	February '07	ND	0.036	***48***	***YES***
	March '07	ND	0.069	105	NO
309QUI	August '06	***0.245***	***0.163***	***0***	***YES***
	September '06	***0.054***	***0.296***	***0***	***YES***
	February '07	***0.463***	***0.196***	***0***	***YES***
	March '07	***1.494***	***24.465***	***0***	***YES***
309SAC	August '06	ND	ND	***0***	***YES***
	September '06	NS	NS	NS	--
	February '07	ND	ND	80	NO
	March '07	ND	0.009	111	NO

Table 6. Continued from previous page.

Site ID	Month	Chlorpyrifos	Diazinon	Invertebrate Survival (%)	Significant Toxic Effect
309SSP	August '06	ND	0.027	***20***	***YES***
	September '06	ND	ND	111	NO
	February '07	ND	0.005	100	NO
	March '07	***0.029***	***0.221***	***0***	***YES***
309TEH	August '06	ND	***0.248***	***0***	***YES***
	September '06	ND	0.118	100	NO
	February '07	***0.029***	0.131	***0***	***YES***
	February dup.	ND	0.137	***0***	***YES***
	March '07	***0.070***	***0.516***	***0***	***YES***
312BCC	August '06	NS	NS	NS	--
	September '06	NS	NS	NS	--
	February '07	***0.211***	ND	***0***	***YES***
	March '07	***0.100***	0.036	***0***	***YES***
312BCJ	August '06	***0.356***	ND	***0***	***YES***
	September '06	***0.144***	ND	***0***	***YES***
	February '07	***0.113***	0.102	***0***	***YES***
	March '07	***0.129***	0.069	***0***	***YES***
312GVS	August '06	***0.127***	ND	***0***	***YES***
	September '06	***0.043***	ND	100	NO
	February '07	***0.038***	0.025	80	NO
	March '07	0.022	0.008	90	NO
312MSD	August '06	***0.421***	ND	***0***	***YES***
	September '06	***0.071***	ND	90	NO
	September dup.	***0.064***	ND	100	NO
	February '07	***0.031***	ND	90	NO
	March '07	***0.033***	0.011	***0***	***YES***
312OFC	August '06	***0.183***	ND	***0***	***YES***
	August dup.	***0.167***	ND	***0***	***YES***
	September '06	ND	ND	100	NO
	February '07	ND	ND	***0***	***YES***
	March '07	***0.046***	ND	90	NO
312OFN	August '06	ND	ND	100	NO
	September '06	ND	ND	100	NO
	February '07	ND	ND	100	NO
	March '07	ND	ND	100	NO
	March dup.	ND	ND	111	NO
312OR1	August '06	***0.110***	0.046	***42***	***YES***
	September '06	***0.070***	ND	100	NO
	February '07	0.024	0.011	89	NO
	March '07	***0.031***	0.023	***0***	***YES***
312ORC	August '06	***0.400***	***0.304***	***0***	***YES***
	September '06	***0.978***	0.053	***0***	***YES***
	February '07	***0.036***	0.012	90	NO
	February dup.	***0.041***	0.011	100	NO
	March '07	***0.253***	0.085	***0***	***YES***
312SM1	August '06	NS	NS	NS	--
	September '06	ND	ND	100	NO
	February '07	NS	NS	NS	--
	March '07	NS	NS	NS	--
312SMA	August '06	***0.187***	***0.414***	***0***	***YES***
	September '06	***0.697***	0.074	***0***	***YES***
	February '07	***0.033***	0.011	80	NO
	March '07	***0.355***	0.077	***0***	***YES***

Figures

Figure 1. Phase I Follow-up sites in the lower Salinas (a) and Santa Maria (b) watersheds, Central Coast, California.

a)

b)

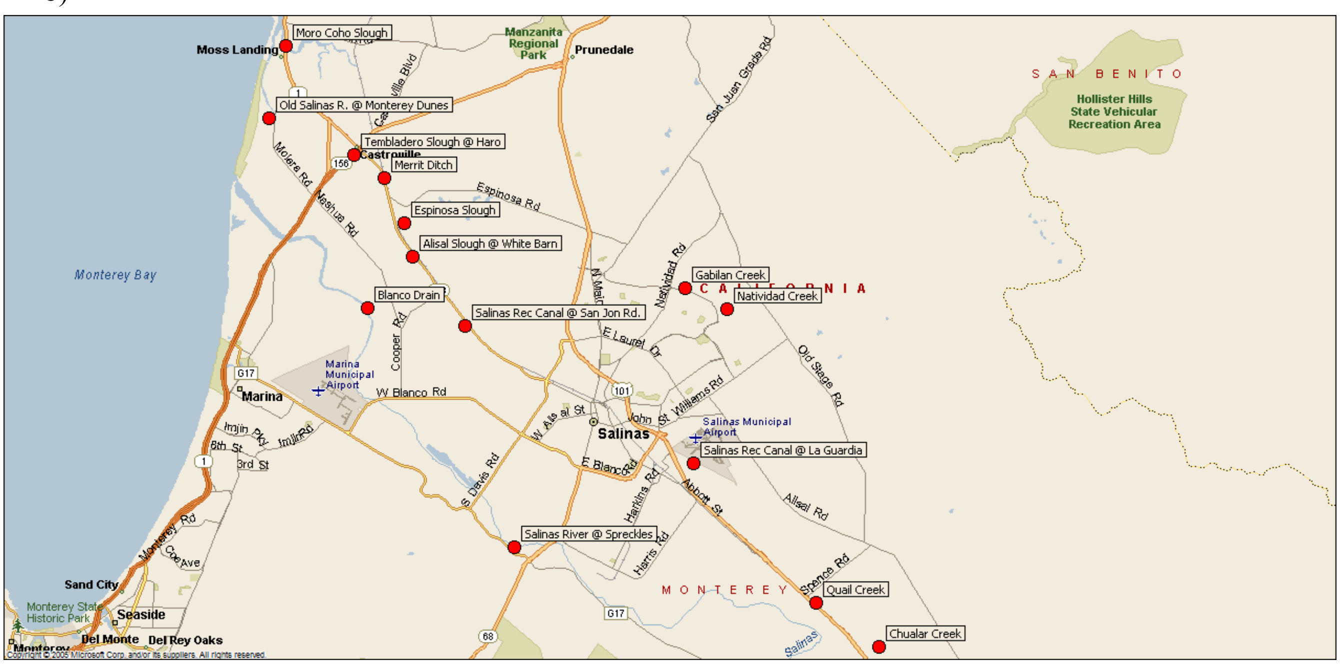


Figure 2. Flows (a) and concentrations of chlorpyrifos (b) and diazinon (c) measured in the Santa Maria Watershed study area, August, 2006 through March, 2007. LC50s are marked by dashed lines on the two OP graphs (Bailey et al. 1997).

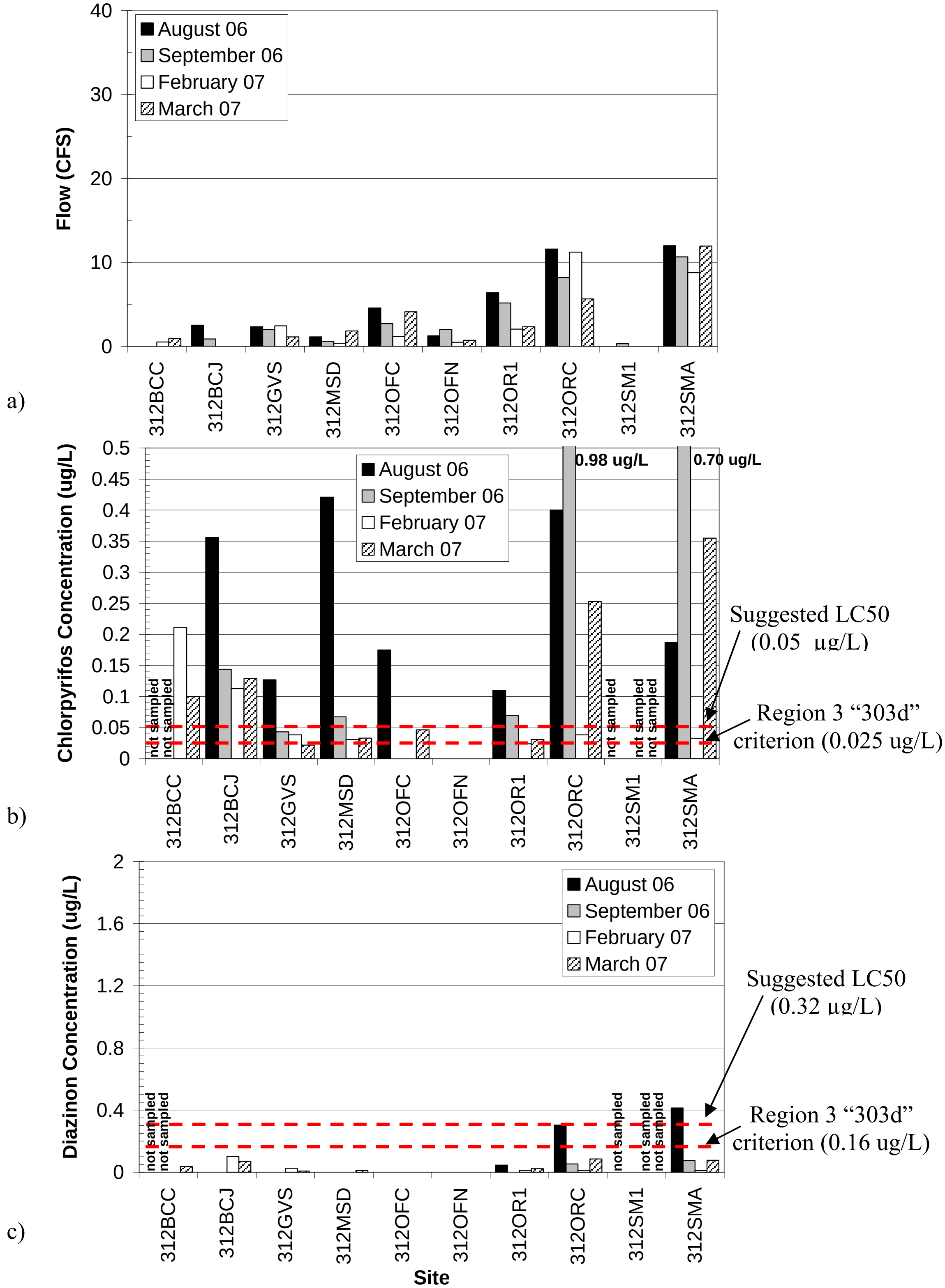


Figure 3. Flows (a) and concentrations of chlorpyrifos (b) and diazinon (c) measured in the Lower Salinas Watershed study area, August, 2006 through March, 2007. LC50s are marked by dashed lines on the two OP graphs (Bailey et al. 1997).

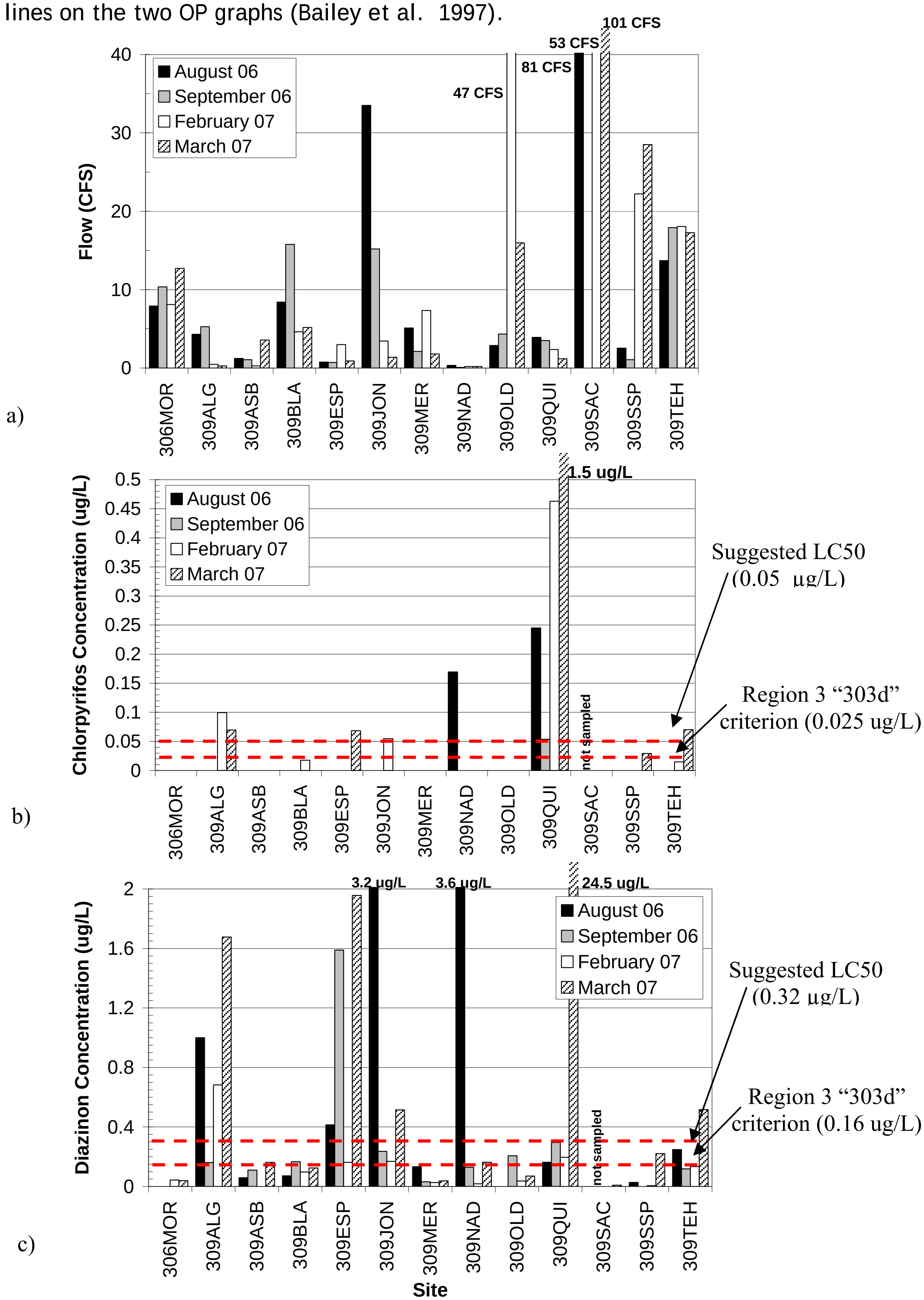
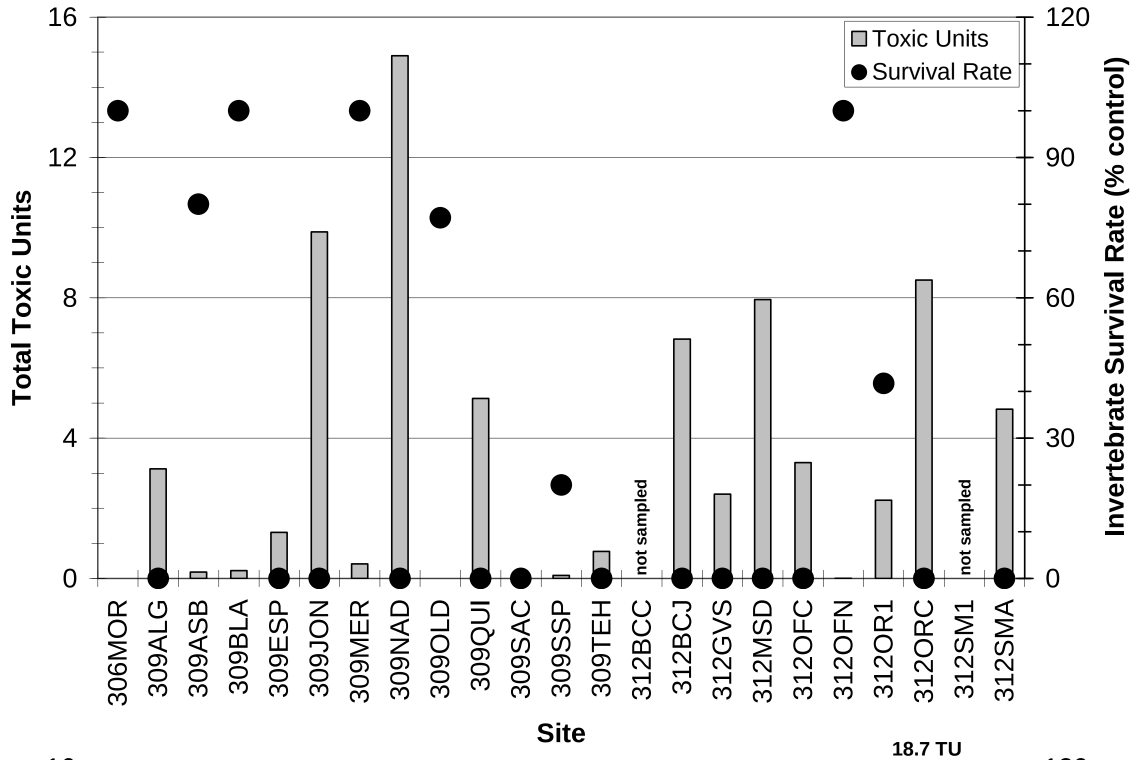
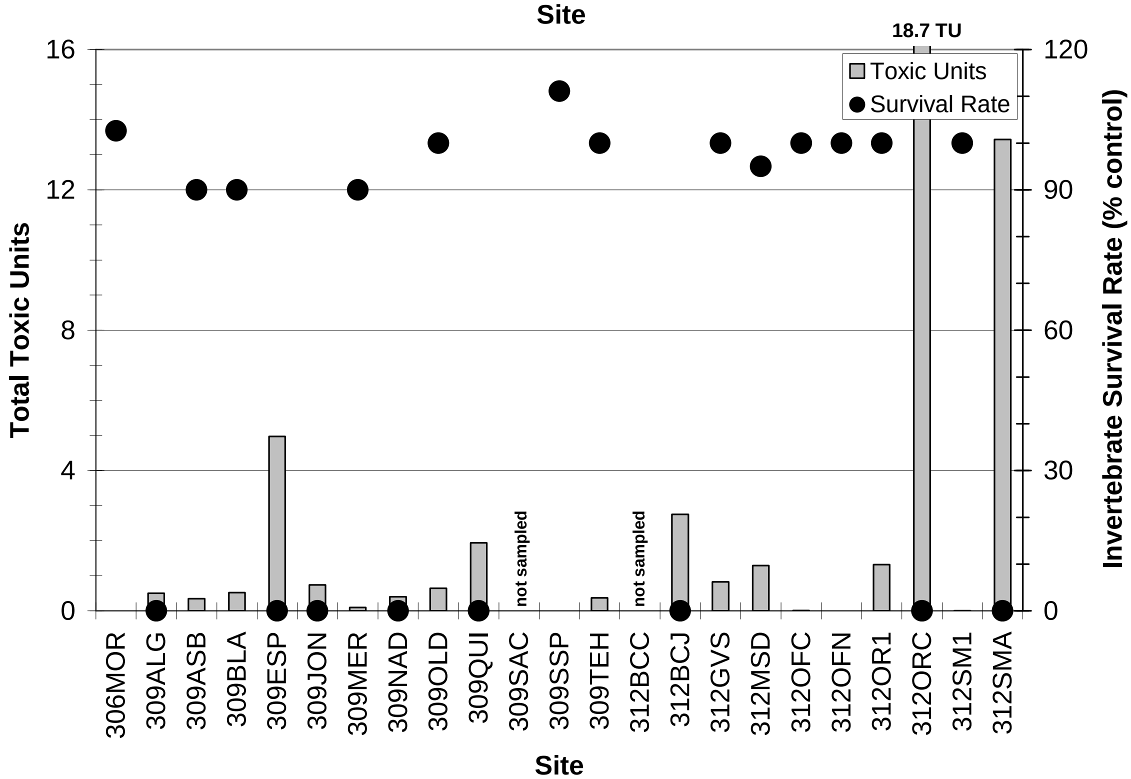


Figure 4. Toxic units and invertebrate toxicity test results from the Santa Maria and Salinas watershed study areas in August (a) and September (b) of 2006 and February (c) and March (d) of 2007. Toxic units were calculated from observed OP concentrations and suggested LC50s (given in Table 2), and summed for all OP's detected in each sample.

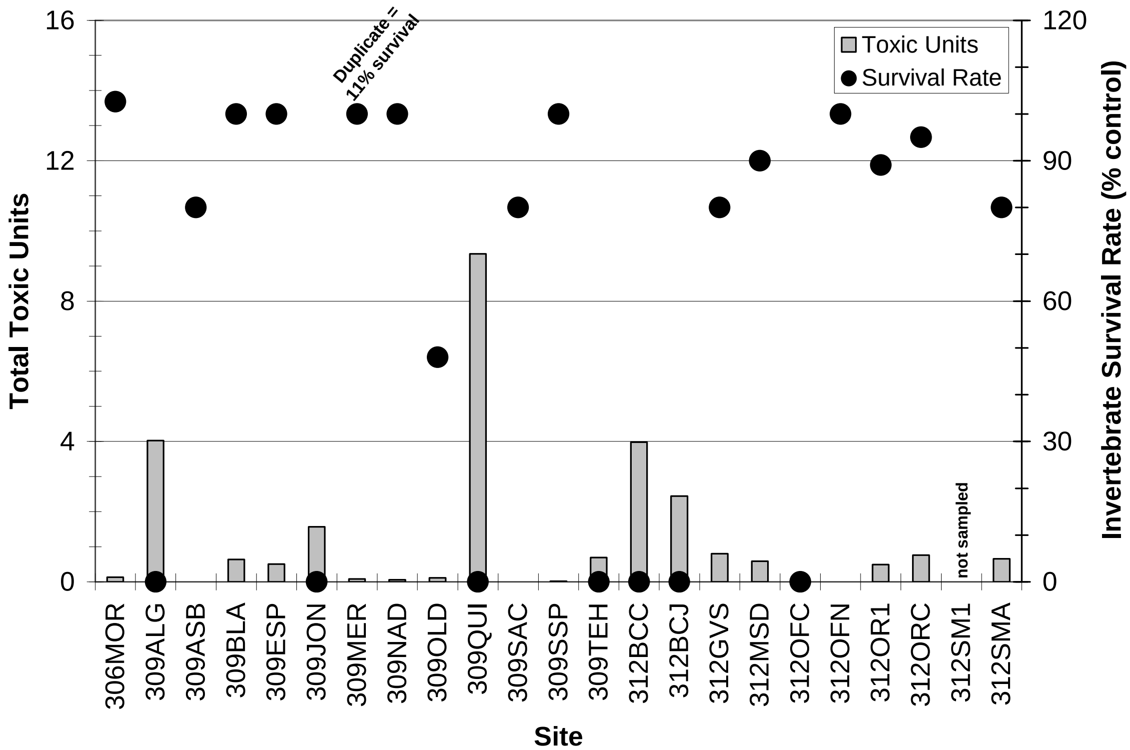


a)

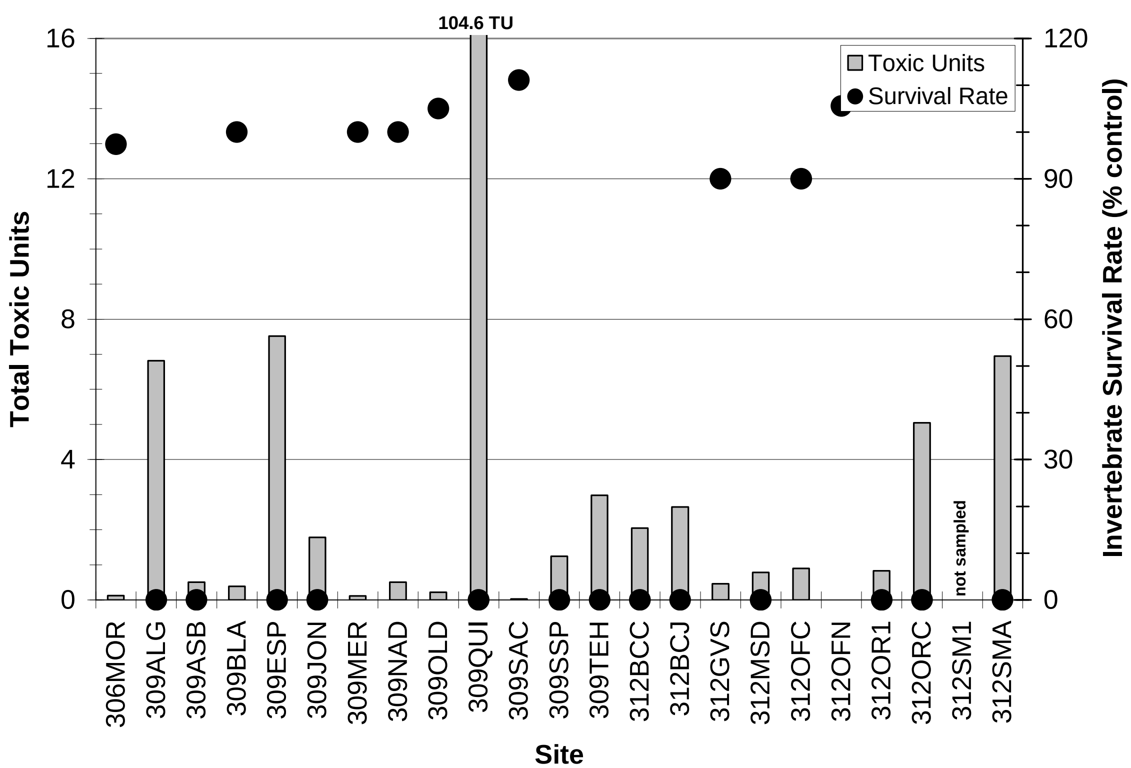


b)

Figure 4. Continued from previous page.

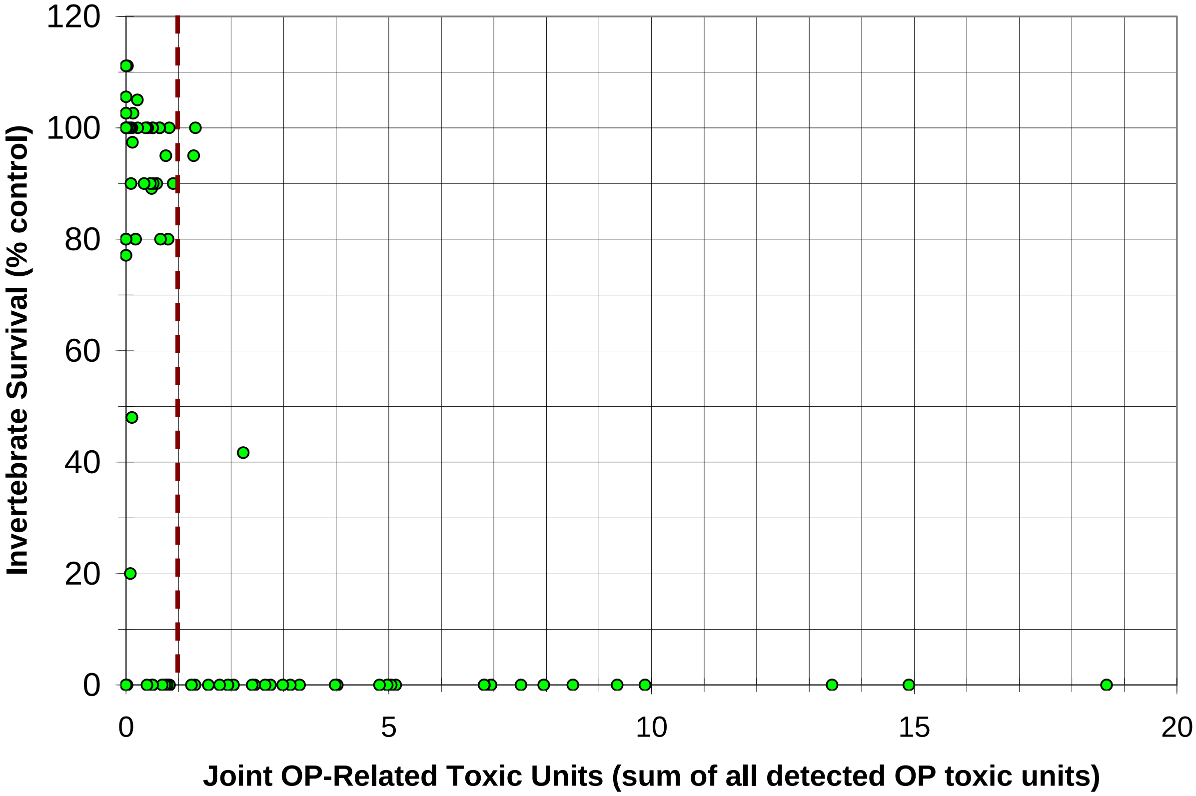


c)



d)

Figure 5. Relationship between joint OP toxic units and observed toxicity to invertebrates. (Toxic units were derived from OP concentrations given in Table A-1 and the published LC50 values given in Table 2.) One outlier (105 OP-related TU's and 0% survival) has been omitted to improve readability of the graph. The dashed line delineates results greater and less than 1 OP-related TU.



Appendix

Table A-1. Results from OP sampling for all sites during all sampling events. Site descriptions corresponding to Site ID's are given in Table 1. ND = not detected; NS = not sampled

Site ID	Month	Chlorpyrifos	Diazinon	Dichlorvos	Dimethoate	Ethoprop	Fenchlorphos	Malathion
312BCC	August '06	NS	NS	NS	NS	NS	NS	NS
	September '06	NS	NS	NS	NS	NS	NS	NS
	February '07	0.211	ND	ND	ND	ND	ND	ND
	March '07	0.100	0.036	0.005	0.075	ND	ND	0.044
312BCJ	August '06	0.356	ND	ND	1.760	ND	ND	0.515
	September '06	0.144	ND	ND	0.232	ND	ND	0.167
	February '07	0.113	0.102	ND	ND	ND	ND	ND
	March '07	0.129	0.069	ND	ND	ND	ND	ND
312GVS	August '06	0.127	ND	ND	0.058	ND	ND	0.028
	September '06	0.043	ND	ND	0.478	ND	ND	0.027
	February '07	0.038	0.025	ND	ND	ND	ND	ND
	March '07	0.022	0.008	ND	ND	ND	ND	0.133
312MSD	August '06	0.421	ND	ND	ND	ND	ND	0.032
	September '06	0.071	ND	ND	ND	ND	ND	0.087
	September dup.	0.064	ND	ND	ND	ND	ND	0.080
	February '07	0.031	ND	ND	ND	ND	ND	0.011
	March '07	0.033	0.011	ND	0.027	ND	ND	0.639
312OFC	August '06	0.183	ND	ND	ND	ND	ND	0.019
	August dup.	0.167	ND	ND	ND	ND	ND	ND
	September '06	ND	ND	ND	ND	ND	ND	0.063
	February '07	ND	ND	ND	ND	ND	ND	0.095
	March '07	0.046	ND	ND	0.194	ND	ND	0.110
312OFN	August '06	ND	ND	ND	ND	ND	ND	0.018
	September '06	ND	ND	ND	ND	ND	ND	ND
	February '07	ND	ND	ND	ND	ND	ND	ND
	March '07	ND	ND	ND	ND	ND	ND	ND
	March dup.	ND	ND	ND	ND	ND	ND	ND
312OR1	August '06	0.110	0.046	ND	0.075	ND	ND	0.049
	September '06	0.070	ND	ND	1.440	ND	ND	ND
	February '07	0.024	0.011	ND	ND	ND	ND	0.012
	March '07	0.031	0.023	ND	ND	ND	ND	0.855
312ORC	August '06	0.400	0.304	ND	0.134	ND	ND	0.035
	September '06	0.978	0.053	ND	0.115	ND	ND	0.210
	February '07	0.036	0.012	ND	ND	ND	ND	ND
	February dup.	0.041	0.011	ND	ND	ND	ND	ND
	March '07	0.253	0.085	ND	0.008	ND	ND	0.042
312SM1	August '06	NS	NS	NS	NS	NS	NS	NS
	September '06	ND	ND	ND	1.480	ND	ND	0.016
	February '07	NS	NS	NS	NS	NS	NS	NS
	March '07	NS	NS	NS	NS	NS	NS	NS
312SMA	August '06	0.187	0.414	ND	0.051	ND	ND	0.014
	September '06	0.697	0.074	ND	ND	ND	ND	0.267
	February '07	0.033	0.011	ND	ND	ND	ND	ND
	March '07	0.355	0.077	ND	0.013	ND	ND	0.055

Table A-1. Continued from previous page.

Site ID	Month	Chlorpyrifos	Diazinon	Dichlorvos	Dimethoate	Ethoprop	Fenchlorphos	Malathion
306MOR	August '06	ND	ND	ND	ND	ND	ND	ND
	September '06	ND	ND	ND	ND	ND	ND	ND
	February '07	ND	0.043	ND	ND	ND	ND	ND
	March '07	ND	0.040	ND	ND	ND	ND	ND
309ALG	August '06	ND	1.000	ND	1.340	ND	ND	ND
	September '06	ND	0.159	ND	0.338	ND	ND	ND
	September dup.	ND	0.163	ND	0.302	ND	ND	ND
	February '07	0.099	0.683	ND	0.017	0.636	ND	ND
	March '07	0.070	1.677	ND	0.242	ND	ND	1.293
309ASB	August '06	ND	0.058	ND	0.077	ND	ND	ND
	September '06	ND	0.110	ND	ND	ND	ND	ND
	February '07	ND	ND	ND	0.060	ND	ND	ND
	March '07	ND	0.162	ND	ND	ND	ND	ND
309BLA	August '06	ND	0.071	ND	ND	ND	ND	ND
	September '06	ND	0.166	ND	0.090	ND	ND	ND
	February '07	0.018	0.097	ND	0.152	ND	ND	ND
	March '07	ND	0.124	ND	ND	ND	ND	ND
309ESP	August '06	ND	0.414	ND	0.028	ND	ND	0.098
	September '06	ND	1.590	ND	0.856	ND	ND	ND
	February '07	ND	0.161	ND	0.065	0.174	ND	ND
	March '07	0.068	1.957	ND	ND	5.409	ND	0.021
309JON	August '06	ND	3.160	ND	0.830	ND	ND	ND
	September '06	ND	0.236	ND	0.153	ND	ND	ND
	February '07	0.055	0.169	ND	ND	ND	ND	0.032
	March '07	ND	0.514	ND	ND	0.260	0.307	ND
309MER	August '06	ND	0.133	ND	ND	ND	ND	ND
	September '06	ND	0.031	ND	ND	ND	ND	ND
	February '07	ND	0.026	ND	ND	ND	ND	ND
	March '07	ND	0.041	ND	ND	ND	ND	ND
	March dup.	ND	0.033	ND	ND	ND	ND	ND
309NAD	August '06	0.155	3.550	ND	0.459	ND	ND	0.253
	August dup.	0.184	3.900	ND	0.459	ND	ND	0.329
	September '06	ND	0.128	ND	0.636	ND	ND	ND
	February '07	ND	0.018	ND	ND	ND	ND	ND
	March '07	ND	0.163	ND	ND	ND	ND	ND
309OLD	August '06	ND	ND	ND	ND	ND	ND	ND
	September '06	ND	0.206	ND	0.488	ND	ND	ND
	February '07	ND	0.036	ND	ND	ND	ND	ND
	March '07	ND	0.069	ND	ND	ND	ND	ND
309QUI	August '06	0.245	0.163	ND	0.079	ND	ND	ND
	September '06	0.054	0.296	ND	0.667	ND	ND	ND
	February '07	0.463	0.196	ND	ND	ND	ND	ND
	March '07	1.494	24.465	ND	ND	ND	ND	ND
309SAC	August '06	ND	ND	ND	ND	ND	ND	ND
	September '06	NS	NS	NS	NS	NS	NS	NS
	February '07	ND	ND	ND	ND	ND	ND	ND
	March '07	ND	0.009	ND	ND	ND	ND	ND
309SSP	August '06	ND	0.027	ND	ND	ND	ND	ND
	September '06	ND	ND	ND	ND	ND	ND	ND
	February '07	ND	0.005	ND	ND	ND	ND	ND
	March '07	0.029	0.221	ND	ND	ND	ND	ND
309TEH	August '06	ND	0.248	ND	0.158	ND	ND	ND
	September '06	ND	0.118	ND	0.935	ND	ND	ND
	February '07	0.029	0.131	ND	ND	0.049	ND	ND
	February dup.	ND	0.137	ND	ND	0.034	ND	ND
	March '07	0.070	0.516	ND	ND	0.318	ND	0.181

Table A-2. Results from invertebrate toxicity tests (survival endpoint) for all sites during all events. NS = not sampled. All results are "% of control." Significantly toxic results are in bold red text.

Site ID	Month	Invertebrate Survival (%)	Significant Toxic Effect
306MOR	August '06	100	NO
	September '06	103	NO
	February '07	103	NO
	March '07	97	NO
309ALG	August '06	**0**	**YES**
	September '06	**0**	**YES**
	September dup.	**0**	**YES**
	February '07	**0**	**YES**
	March '07	**0**	**YES**
309ASB	August '06	80	NO
	September '06	90	NO
	February '07	80	NO
	March '07	**0**	**YES**
309BLA	August '06	100	NO
	September '06	90	NO
	February '07	100	NO
	March '07	100	NO
309ESP	August '06	**0**	**YES**
	September '06	**0**	**YES**
	February '07	100	NO
	March '07	**0**	**YES**
309JON	August '06	**0**	**YES**
	September '06	**0**	**YES**
	February '07	**0**	**YES**
	March '07	**0**	**YES**
309MER	August '06	100	NO
	September '06	90	NO
	February '07	100	NO
	March '07	**11**	**YES**
	March dup.	100	NO
309NAD	August '06	**0**	**YES**
	August dup.	**0**	**YES**
	September '06	**0**	**YES**
	February '07	100	NO
	March '07	100	NO
309OLD	August '06	**77**	**YES**
	September '06	100	NO
	February '07	**48**	**YES**
	March '07	105	NO
309QUI	August '06	**0**	**YES**
	September '06	**0**	**YES**
	February '07	**0**	**YES**
	March '07	**0**	**YES**
309SAC	August '06	**0**	**YES**
	September '06	NS	--
	February '07	80	NO
	March '07	111	NO
309SSP	August '06	**20**	**YES**
	September '06	111	NO
	February '07	100	NO
	March '07	**0**	**YES**
309TEH	August '06	**0**	**YES**
	September '06	100	NO
	February '07	**0**	**YES**
	February dup.	**0**	**YES**
	March '07	**0**	**YES**

Site ID	Month	Invertebrate Survival (%)	Significant Toxic Effect
312BCC	August '06	NS	--
	September '06	NS	--
	February '07	**0**	**YES**
	March '07	**0**	**YES**
312BCJ	August '06	**0**	**YES**
	September '06	**0**	**YES**
	February '07	**0**	**YES**
	March '07	**0**	**YES**
312GVS	August '06	**0**	**YES**
	September '06	100	NO
	February '07	80	NO
	March '07	90	NO
312MSD	August '06	**0**	**YES**
	September '06	90	NO
	September dup.	100	NO
	February '07	90	NO
	March '07	**0**	**YES**
312OFC	August '06	**0**	**YES**
	August dup.	**0**	**YES**
	September '06	100	NO
	February '07	**0**	**YES**
	March '07	90	NO
312OFN	August '06	100	NO
	September '06	100	NO
	February '07	100	NO
	March '07	100	NO
	March dup.	111	NO
312OR1	August '06	**42**	**YES**
	September '06	100	NO
	February '07	89	NO
	March '07	**0**	**YES**
312ORC	August '06	**0**	**YES**
	September '06	**0**	**YES**
	February '07	90	NO
	February dup.	100	NO
	March '07	**0**	**YES**
312SM1	August '06	NS	--
	September '06	100	NO
	February '07	NS	--
	March '07	NS	--
312SMA	August '06	**0**	**YES**
	September '06	**0**	**YES**
	February '07	80	NO
	March '07	**0**	**YES**

Table A-3. Results from invertebrate toxicity tests (reproduction endpoint) for all sites during all events. NS = not sampled. NA = not assessed (due to 100% mortality early in the test). All results are "% of control." Significantly toxic results are in bold red text.

Site ID	Month	Invertebrate Reproduction (%)	Significant Toxic Effect
306MOR	August '06	133	NO
	September '06	134	NO
	February '07	152	NO
	March '07	121	NO
309ALG	August '06	0	NA
	September '06	**35**	**YES**
	September dup.	**44**	**YES**
	February '07	0	NA
	March '07	0	NA
309ASB	August '06	**71**	**YES**
	September '06	**78**	**YES**
	February '07	76	NO
	March '07	48	NA
309BLA	August '06	**67**	**YES**
	September '06	**71**	**YES**
	February '07	93	NO
	March '07	**82**	**YES**
309ESP	August '06	0	NA
	September '06	**0**	**YES**
	February '07	110	NO
	March '07	0	NA
309JON	August '06	0	NA
	September '06	**10**	**YES**
	February '07	12	NA
	March '07	0	NA
309MER	August '06	101	NO
	September '06	118	NO
	February '07	86	NO
	March '07	5	NA
	March dup.	55	NO
309NAD	August '06	0	NA
	August dup.	0	NA
	September '06	**0**	**YES**
	February '07	125	NO
	March '07	**76**	**YES**
309OLD	August '06	NA	NA
	September '06	NA	NA
	February '07	NA	NA
	March '07	NA	NA
309QUI	August '06	0	NA
	September '06	**0**	**YES**
	February '07	0	NA
	March '07	0	NA
309SAC	August '06	0	NA
	September '06	NS	--
	February '07	101	NO
	March '07	102	NO
309SSP	August '06	28	NA
	September '06	125	NO
	February '07	127	NO
	March '07	3	NA
309TEH	August '06	5	NA
	September '06	**88**	**YES**
	February '07	52	NA
	February dup.	65	NA
	March '07	0	NA

Site ID	Month	Invertebrate Reproduction (%)	Significant Toxic Effect
312BCC	August '06	NS	--
	September '06	NS	--
	February '07	0	NA
	March '07	0	NA
312BCJ	August '06	0	NA
	September '06	**6**	**YES**
	February '07	0	NA
	March '07	1	NA
312GVS	August '06	0	NA
	September '06	**34**	**YES**
	February '07	**64**	**YES**
	March '07	94	NO
312MSD	August '06	0	NA
	September '06	82	NO
	September dup.	85	NO
	February '07	**54**	**YES**
	March '07	0	NA
312OFC	August '06	0	NA
	August dup.	0	NA
	September '06	91	NO
	February '07	0	NA
	March '07	90	NO
312OFN	August '06	**70**	**YES**
	September '06	111	NO
	February '07	98	NO
	March '07	94	NO
	March dup.	109	NO
312OR1	August '06	NA	NA
	September '06	**62**	**YES**
	February '07	NA	NA
	March '07	0	NA
312ORC	August '06	0	NA
	September '06	**0**	**YES**
	February '07	**63**	**YES**
	February dup.	**73**	**YES**
	March '07	0	NA
312SM1	August '06	NS	--
	September '06	**70**	**YES**
	February '07	NS	--
	March '07	NS	--
312SMA	August '06	0	NA
	September '06	**0**	**YES**
	February '07	**58**	**YES**
	March '07	0	NA

Table A-4. Results from invertebrate toxicity tests (survival endpoint) for CMP sites outside the study area. NS = not sampled. All results are "% of control." Significantly toxic results are in bold red text.

Site ID	Month	Invertebrate Survival (%)	Significant Toxic Effect
305CAN	August '06	100	NO
	September '06	100	NO
	February '07	100	NO
	March '07	100	NO
305CHI	August '06	100	NO
	September '06	***33***	***YES***
	February '07	90	NO
	March '07	63	NO
305COR	August '06	100	NO
	September '06	NS	--
	February '07	100	NO
	March '07	125	NO
305FRA	August '06	100	NO
	September '06	***0***	***YES***
	February '07	***60***	***YES***
	March '07	100	NO
305LCS	August '06	100	NO
	September '06	100	NO
	February '07	100	NO
	March '07	80	NO
305PJP	August '06	100	NO
	September '06	89	NO
	February '07	80	NO
	March '07	125	NO
305SJA	August '06	***0***	***YES***
	September '06	100	NO
	February '07	80	NO
	March '07	125	NO
305STL	August '06	100	NO
	September '06	100	NO
	February '07	100	NO
	March '07	125	NO
305TSR	August '06	90	NO
	September '06	90	NO
	February '07	100	NO
	March '07	90	NO
305WSA	August '06	80	NO
	September '06	100	NO
	February '07	100	NO
	March '07	125	NO
309GRN	August '06	***0***	***YES***
	September '06	NS	--
	February '07	100	NO
	March '07	80	NO
309SAG	August '06	***0***	***YES***
	September '06	NS	--
	February '07	90	NO
	March '07	111	NO

Site ID	Month	Invertebrate Survival (%)	Significant Toxic Effect
310CCC	August '06	90	NO
	September '06	90	NO
	February '07	100	NO
	March '07	111	NO
310LBC	August '06	100	NO
	September '06	88	NO
	February '07	100	NO
	March '07	100	NO
310PRE	August '06	90	NO
	September '06	100	NO
	February '07	90	NO
	March '07	100	NO
310USG	August '06	100	NO
	September '06	100	NO
	February '07	100	NO
	March '07	100	NO
310WRP	August '06	100	NO
	September '06	90	NO
	February '07	100	NO
	March '07	111	NO
314FYF	August '06	100	NO
	September '06	100	NO
	February '07	100	NO
	March '07	111	NO
314SYL	August '06	NS	--
	September '06	NS	--
	February '07	100	NO
	March '07	100	NO
315APF	August '06	100	NO
	September '06	***11***	***YES***
	February '07	90	NO
	March '07	111	NO
315BEF	August '06	80	NO
	September '06	67	NA
	February '07	100	NO
	March '07	105	NO
315FMV	August '06	***50***	***YES***
	September '06	67	NA
	February '07	90	NO
	March '07	111	NO
315GAN	August '06	90	NO
	September '06	89	NO
	February '07	90	NO
	March '07	111	NO