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Characterization of Benthic Communities and Physical Habitat in Agricultural Streams in California's San Joaquin Valley in 2005

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ABSTRACT

This study was designed to characterize physical habitat and benthic communities (macroinvertebrates) in three agricultural streams in California's San Joaquin Valley in 2005. These streams have been listed as impaired water bodies (303 (d) list) by the State of California due to the presence of organophosphate insecticides (OP) chlorpyrifos and diazinon. A secondary goal of this study was to qualitatively compare the presence of OP-sensitive benthic species in these streams with available OP toxicity and exposure data to determine if these benthic species are present. Habitat requirements and to a lesser degree sampling gear limitations were considered in this comparison.

Based on 10 instream and riparian physical habitat metrics, total physical habitat scores in Del Puerto Creek ranged from 15 to 135 (maximum possible total score is 200). Most habitat metrics were highly variable among Del Puerto Creek sites and there appears to be no spatial trends. Orestimba Creek physical habitat scores ranged from 84 to 128. The lowest habitat score was reported at one of the most downstream sites. Salt Slough physical habitat scores ranged from 24 to 109 and the upstream site had the lowest habitat score. Salt Slough appears to have the strongest gradient of physical habitat metrics as bank vegetation, bend/riffle frequency, channel flow, epifaunal substrate, and sediment deposition declined significantly from downstream to upstream.

Abundance measures of macroinvertebrates were generally similar among the three streams considering that nine sites were sampled in Orestimba Creek while five sites were sampled in both Del Puerto Creek and Salt Slough. The most common dominant taxa in Del Puerto Creek and Salt Slough was the tolerant gastropod *Physa sp.* as this taxa was either the second or third most dominant taxa by stream. The most

dominant taxa found in Orestimba Creek was the caddisfly, *Hydropsyche californica*. The caddisfly is generally considered sensitive to environmental stressors.

Bend/riffle frequency, sediment deposition, and embeddedness were the most important physical habitat metrics influencing the various benthic metrics for these three streams. For the non-continuous habitat metrics, percent fines and percent gravel had the highest number of significant relationships with the various benthic metrics.

A qualitative comparison of OP-sensitives species in the three agricultural streams based on single species toxicity data was limited due to the lack of data. Species most sensitive to chlorpyrifos (*Chironomus sp.* and *Gammarus lacustris*) were generally found in all three streams except *G. lacustris* was absent for Del Puerto Creek. Species most sensitive to diazinon were the amphipod *Hyalella sp.* and the mayfly *Baetis sp. Hyalella* was more abundant in both Orestimba Creek and Salt Slough than Del Puerto Creek. *Baetis sp.* was only collected at upstream sites in both Del Puerto Creek and Orestimba Creek.

The presence of 86 taxa in Del Puerto Creek, 93 taxa in Orestimba Creek and 73 taxa in Salt Slough implies that the benthic communities in these streams are fairly diverse, considering their ephemeral environments, but without a clear definition of benthic community expectations it is unknown if these water bodies are actually impaired. Potential reference sites should be identified in agricultural streams in California's Central Valley in order to identify the range of benthic community taxa expected in non or minimally stressed environments. Extensive spatial and temporal assessments of benthic communities in concert with physical habitat assessments will be needed to accomplish this task.

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INTRODUCTION

Abundant water and long growing seasons are two important factors responsible for the highly productive agricultural economy of California's San Joaquin Valley (Dubrovsky et al. 1998). Approximately 10.2% of the total value of agricultural production in the United States originated from California in 1987 – approximately half of this total valued at $6.82 billion came from the San Joaquin Valley (Dubrovsky et al. 1998). Intense agricultural development in the San Joaquin Valley has modified many of the natural lotic systems in this area (May and Brown, 2000). The changing landscape coupled with various other anthropogenic factors has created stressful conditions for resident aquatic biological communities. Foe (1995) has reported that the following factors may have contributed to the decline of aquatic resources in California's Central Valley: water diversion, changes in basin hydrology, loss of habitat, introduction of exotic species and contaminants (e.g., organophosphate insecticides). Activities such as diking, dredging, filling of wetlands and significant diversion of freshwater flows for irrigated agriculture and urban use have also altered fish habitat and resulted in adverse impacts on fish populations (Moyle et al, 1992).

Assessments of benthic invertebrate assemblages and physical habitat (bioassessments) have been initiated in wadeable streams in California's Central Valley (Bacey, 2005; Brown and May, 2004; Hall and Killen, 2001; Hall and Killen, 2002; Hall and Killen, 2003; Hall and Killen, 2004; Hall and Killen 2005a, Hall and Killen 2005b; Jim Harrington, personal communication; Tetra Tech, 2003). Bioassessments provide a useful approach for integrating effects from physical, chemical, and biological stressors on aquatic organisms. Bioassessments are based upon the premise that the structure and function of an aquatic biological community can provide critical information about the quality of the surface water. These efforts are valuable for determining the status of aquatic biological communities across large spatial scales and land use types (agricultural and urban). Information on the status of resident biological communities is particularly useful for determining impaired water bodies, developing Total Maximum Daily Loads (TMDLs), and measuring success of voluntary or regulatory actions. Bioassessments serve monitoring needs through three primary functions: (1) screening or initial assessment of conditions; (2) characterization of impairment and diagnosis; and (3) trend monitoring to evaluate improvements from mitigation practices or further degradation.

The primary goal of this study was to characterize physical habitat and benthic communities in three representative agricultural streams in California's San Joaquin Valley in 2005. All of these streams have been listed as impaired water bodies (303 (d) list) due to the presence of OP insecticides diazinon and chlorpyrifos (www.swrcb.ca.gov). The benthic community data was interpreted in the context of recent ecological risk assessments for the OP insecticides chlorpyrifos and diazinon which have identified OP-sensitive benthic species.

METHODS

Site Selection

The three second to fourth order wadeable streams sampled during this study were Del Puerto Creek (Figures 1 and 2), Orestimba Creek (Figures 1 and 3) and Salt Slough (Figures 1 and 4). The sites sampled covered approximately 8, 12 and 14 miles in Del Puerto Creek, Orestimba Creek and Salt Slough, respectively. The predominate land use type in all of these water bodies is agriculture. The upstream sites in Del Puerto Creek (DLP5) and Orestimba Creek (ORE10) were above agricultural activity but all the other sites were in areas dominated by agriculture. Downstream Salt Slough sites SSL1, SSL2 and SSL3 were located within the San Luis Wildlife Refuge and the Los Banos State Wildlife area; upstream sites SSL4 and SSL5 were in agricultural areas.

Five sample sites in both Del Puerto Creek and Salt Slough and ten sites in Orestimba Creek were selected for sampling using a stratified random design with approximate equal spacing among sample sites (Table 1; Figures 2-4). The Del Puerto Creek and Salt Slough sites were previously sampled in similar bioassessment studies in the late spring/early summer of 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004) and 2004 (Hall and Killen, 2005b). It should be noted however, that an abundance of beaver activity in Del Puerto Creek may have been a factor influencing elevated water levels at various sites when compared with previous years (William Killen, personal communication). The ten sites in Orestimba Creek were also previously sampled in similar bioassessment studies conducted in the late spring/early summer of 2000 (Hall and Killen, 2001), 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004) and 2004 (Hall and Killen, 2005b).

Extensive beaver activity affected some of the sample sites used in previous years as the sampling locations for Orestimba Creek 3, 5, and 8 were moved approximately 150-100 meters from the locations previously sampled annually from in 2000 to 2004. Initial site visits were conducted for all streams in April of 2000 and 2001. Exact sample stations were determined in each stream and landowner contacts were made to access the sample sites for the late spring/early summer sampling.

Physical Habitat Assessments

Physical habitat was evaluated at each site concurrently with benthic collections and water quality evaluations. The physical habitat evaluation methods followed protocols described in Harrington and Born (2000). The physical habitat metrics used for this study are based on nationally standardized protocols described in Barbour et al. (1999). A total of 10 continuous metrics scored on a 0-20 scale were evaluated (Appendix A). Other non-continuous metrics including percent canopy, percent gradient, and substrate composition that were also measured are described in Appendix A.

Benthic Macroinvertebrate Sampling

Benthic macroinvertebrates were collected in the late spring of 2005 from three replicate samples at sample sites in the three streams. The sample site selections and sampling procedures were conducted in accordance with methods described in Harrington and Born (2000). Sampling reaches were approximately equally spaced along the stream starting at the confluence. Within each of these sample reaches, a riffle was located (if possible) for the collection of benthic macroinvertebrates. A tape measure was placed along the riffle and potential sampling transects were located at each meter interval of the tape. Using a random numbers table, three transects were randomly selected for sampling from among those available within the riffle. Benthic samples were taken using a standard D-net with 0.5 mm mesh starting with the most downstream portion of the riffle. A 1x2 foot section of the riffle immediately upstream of the net was disturbed to a depth of 4-6 inches to dislodge and collect the benthic macroinvertebrates. Large rocks and woody debris were scrubbed and leaves were examined to dislodge organisms clinging to these substrates. Within each of the randomly chosen transects, three replicate samples were collected to reflect the structure and complexity of the habitat within the transect. If habitat complexity was lacking, samples were taken near the side margins and thalweg of the transect and the procedures described above were followed. All samples were preserved with 95% ethanol.

Due to the physical nature of these agricultural streams, it was often difficult to locate a substantial number of riffles to sample. In various cases, there was only a single section of riffle available within a selected reach to sample and in some instances there were no riffles present. In cases where riffles were lacking, alternative sampling methods for non-riffle areas were used as outlined in Harrington and Born (2000). This involved sampling the best available 1x2 foot sections of habitat throughout the reach using the same procedures described above. Nine 1x2 foot sections were randomly selected for sampling. Groups of three 1x2 foot sections were composited for each replicate for a total of three replicates per site.

Taxonomy of Benthic Macroinvertebrates

The goal of this study was to identify all benthic samples to the species level if possible. Species level identifications will be particularly useful if and when Indices of Biotic Integrity (IBIs) are developed for wadeable streams in California's Central Valley.

For taxa such as oligochaetes and chironomids, family and genus level, respectively, were often the lowest level of identification possible.

The benthic macroinvertebrate subsampling (resulting in a maximum of 300 individuals) and identifications were supervised by Angie Montalvo of California's Department of Fish and Game (CDFG) in Rancho Cordova, California. The benthic macroinvertebrate samples were subsampled and sorted by personnel at the CDFG Laboratory located at Chico State University campus. Level 3 identifications (species level identifications) followed protocols outlined in Harrington and Born (2000). Mr. Dan Pickard of CDFG conducted the taxonomic identifications. Slide preparations and mounting for species such as midges and oligochaetes followed protocols from the United States Geological Survey National Quality Control Laboratory described in Moulton et al. 2000.

Water Quality Measurements

The following water quality parameters were measured at each stream site using procedures described in Kazyak (1997): temperature, pH, salinity, specific conductivity, dissolved oxygen, and turbidity.

Statistical Analysis

Principal components analysis (PCA) was used to determine the relationship among the various physical habitat and benthic metrics to identify groups of metrics that covary. Spatial trends (upstream to downstream) of both physical habitat and benthic metrics within each stream were examined using Spearmans Rank Correlation Coefficients and significance levels. The relationship among physical habitat and benthic metrics was also determined by using Spearmans Rank Correlation Analysis. The

Wilcoxon Rank-Sum Test and Kruskal-Wallis test were used to compare habitat and benthic metrics among the three streams. The Wilcoxon signed rank test and the Friedman test were used to compare among years within a stream.

RESULTS

Physical Habitat

Del Puerto Creek

The total physical habitat scores in Del Puerto Creek ranged from 15 to 135 for the ten metrics that were scored on a 0 to 20 scale (Table 2). Most of the metrics were highly variable across the five stations within Del Puerto Creek indicating diverse physical habitat conditions in this waterbody. For example, embeddedness ranged from 0 to 16, channel flow status ranged from 4 to 20, and frequency of bend/riffles ranged from 0 to 13. The total physical habitat score at DLP4 was particularly low as this site was drastically altered. The most upstream site in Del Puerto Creek (DLP5) – located above agricultural activity - had the highest total physical habitat score.

Other descriptive physical habitat metrics that were not scored on a 0-20 scale are presented in Table 3. These metrics are not scored on a 0-20 scale because some are bimodal (too much or too little canopy can be advantageous) and others are just descriptive. Mean flow by site ranged from 0 m/s at DLP4 to 0.42 m/s at DLP3. The mean value across all five sites was 0.23 m/s. The percent canopy for the five Del Puerto Creek sites ranged from 0% at DLP4 and DLP5 to 71% at downstream site DLP1. Gradient was consistent at all sties (1%). The percent fines for substrate percentages ranged from 15% DLP5 to 100% at DLP4.

Orestimba Creek

Orestimba Creek total physical habitat scores for the 10 metrics that were scored on a 0 to 20 scale ranged from 84 to 128 (Table 2). ORE9 was not evaluated for physical habitat because the site was completely dry. The lowest total habitat score (84) was reported for downstream site ORE2 (Figure 3). This site had particularly low scores for embeddedness, velocity/depth/diversity, and various riparian zone metrics. The highest total habitat score (128) was reported at upstream site (ORE7). The following metrics were reasonably high at this site: sediment deposition, channel flow status, channel alteration and frequency of bends/riffles. Other descriptive habitat metrics for the 10 Orestimba Creek sties in Table 3 showed that mean site flow ranged from 0 to 0.51 m/s (mean stream value of 0.22 m/s), % canopy ranged from 0 to 92%, % gradient was consistently 1%, and % fines ranged from 20% to 100%.

Salt Slough

The total physical habitat scores in Salt Slough ranged from 24 to 109 for the 10 metrics that were scored on a 0 to 20 scale (Table 2). The lowest total physical habitat score (24) was reported at the most upstream site (SSL5). This site had particularly low scores for embeddedness, velocity/depth/diversity, sediment deposition, channel alteration, frequency of bends/riffles, bank stability, vegetative protection, and riparian vegetation. The highest total physical habitat score (109) was reported at the downstream site SSL2. Channel flow status, and channel alteration were optimal (a high rating) at this site. The embeddedness metric, which is a rough measure of sediment loading, was particularly low (0) at all sites in this stream when compared with either Del Puerto Creek or Orestimba Creek as presented above.

Other descriptive physical habitat metrics for the five Salt Slough sites in Table 3 showed that mean site flow ranged from 0 to 0.30 m/s (mean stream value was 0.20 m/s), 0% canopy at all sties, % gradient was consistently 1% and % fines were 100% at all sites. The low flow conditions, lack of canopy, and dominance of substrate by % fines clearly shows different physical features for this stream when compared with either Del Puerto Creek or Orestimba Creek.

Summary Statistical Analysis for All Creeks

Principal Components Analysis (PCA) was used to determine the relationship among habitat metrics and identify metrics that covary (i.e., increase or decrease together). The 10 habitat metrics that were scored on a 0 to 20 scale had two eigenvalues that were greater than 1 (Table 4). The significance of this finding is that 10 habitat metrics contain two important factors which explained 76% of the variance in the data set. The metrics important to each factor are presented in Table 5. Bank stability, channel alteration, velocity/depth, epifaunal substrate, and bank vegetation were heavily loaded on factor 1. Factor 2 is comprised of sediment deposition, embeddedness, riparian buffer, bend/riffle frequency and channel flow. Metrics loaded on both Factors 1 and 2 include both instream as well as riparian metrics.

Correlations among raw physical habitat metrics grouped by factors and identified by PCA showed the following significant correlations for Factor 1: bank stability and channel alteration, velocity/depth, and bank vegetation; channel alteration and velocity/depth, epifaunal substrate, and bank vegetation; and velocity/depth and bank vegetation (Table 6). In factor 2, significant correlations were found between sediment deposition and both embeddedness and bend/riffle frequency and embeddedness and bend/riffle frequency.

The correlation matrix in Table 7 showed significant correlations among stream characteristics that were not scored on a 0 to 20 scale (i.e., width, depth) and some metrics that were scored on a 0 to 20 scale. The largest number of significant correlations occurred for width, mean flow, fines, and gravel. Width was negatively correlated with bend/riffle frequency, sediment deposition, and embeddedness. Width was positively correlated with riparian buffer and channel flow. Mean flow was positively correlated with bank stability, bank vegetation, bend/riffle frequency, sediment deposition, velocity/depth, embeddedness, and total score. Fines were negatively correlated with bend riffle frequency, epifaunal substrate, sediment deposition, embeddedness and total score. Gravel was positively correlated with bend riffle frequency, epifaunal substrate, sediment deposition, embeddedness, and total score.

The Spearman rank test for trends was conducted for each physical habitat metric in each stream to examine trends that might be associated with changing morphology of the stream between upstream and downstream (Table 8). Salt Slough appears to have the strongest gradient from upstream to downstream in physical habitat metrics. Bank vegetation, bend/riffle frequency, channel flow, epifaunal substrate, and sediment deposition showed a negative correlation with site indicating a decrease in values moving upstream. In Orestimba Creek, there was a significant positive correlation for bend/riffle frequency, embeddedness, and sediment deposition, i.e. increasing values moving upstream. There were no significant spatial trends among habitat metrics in Del Puerto Creek.

Sediment deposition and embeddedness were significantly greater in both Del Puerto Creek and Orestimba Creek when compared with Salt Slough (Table 9). Pairwise regression also showed that epifaunal substrate and bend/riffle frequency were greater in Orestimba Creek when compared to Salt Slough. Channel flow was significantly lower in Orestimba Creek when compared to Salt Slough.

Benthic Macroinvertebrates

Del Puerto Creek

Approximately 4,300 individual macroinvertebrates were picked and identified from 86 taxa collected from five Del Puerto Creek sites (Table 10; Appendix B). The five most abundant taxa - *Simulium sp., Nais communis/variabilis, Physa sp., Chircotopus sp.* and *Cyprididae* comprised ~ 62% of the total individuals collected (Table 10). These five taxa are generally considered tolerant to moderately tolerant (i.e., *Simulium sp.*) of environmental stressors (Harrington and Born, 2000; Stribling et al., 1998). Pollution sensitive species such as Ephemeroptera (mayflies), Plecoptera (stoneflies) and Tricoptera (caddisflies), i.e. EPT taxa, were found in very low numbers at most of the sites.

Total taxa richness ranged from 28 at upstream site (DLP4) to 45 at downstream site (DLP1) (Table 11). Taxa richness was reasonably consistent among the three transects at each site (Figure 5). The number of individuals collected at each site (total abundance) was higher at the upstream site (DLP5) and midstream site (DLP3) (Table 11). Lowest abundance was reported at DLP2 (Table 11). Macroinvertebrate abundance was variable among the three transects at each site (Figure 6).

Most of the other benthic metrics summarized in Table 11 were consistent among sites with a few exceptions. EPT taxa (pollution sensitive taxa) were higher at DLP5, a site above agricultural activity. The % chironomidae (tolerant taxa) were greater at downstream site (DLP1). Percent collectors/gatherers – a feeding guild that is dominant in stressed environments (Harrington and Born, 2000) – was lower at downstream site

DLP2. However, % filterers – a feeding guild that dominates in stressed environments – were higher at DLP2. It is also important to note that % shredders – a feeding guild that decreases in stressed environments – were not reported at any site.

Orestimba Creek

Approximately 6,200 individual macroinvertebrates were picked and identified from 93 taxa collected from nine sites in Orestimba Creek (Table 12; Appendix C). Orestimba Creek site 9 could not be sampled due to lack of water. The following taxa comprised ~ 53% of the total number of individuals collected: *Hydropsyche californica*, *Cricotopus bicinctus* group, *Cricotopus sp.*, *Nais communis/variabilis*, and *Polypedilum sp.* These taxa are generally tolerant of environmental degradation, with the exception of the most dominant taxa (the caddisfly, *H. californica*), which is generally considered sensitive to environmental stressors (Harrington and Born, 2000; Stribling et al., 1998).

Total taxa richness ranged from 22 at ORE8 to 41 at ORE1 and ORE10 (Table 13). Taxa richness was fairly consistent among the three transects at each site (Figure 7). The total number of individuals per site (total abundance) was much higher at upstream sites ORE8 and ORE10 when compared with the other sites (Table 13). Macroinvertebrate abundance was fairly consistent among the three transects for only the three downstream sites (Figure 8).

Various benthic metrics for the Orestimba Creek sites summarized in Table 13 showed the following: (1) percent dominant taxa were higher at ORE4: (2) EPT taxa (taxa associated with non-stressed environments) was higher at upstream site ORE10 above agricultural activity; (3) percent chironomidae were higher at the upstream site ORE8 and most downstream sites (ORE1); (4) percent hydropsychidae (caddisflies) were higher at ORE4; (5) percent collectors/gatherers – a feeding guild that dominates in stressed environments - were higher at upstream site ORE8 and (6) percent collectors/filterers – a feeding guild that dominates in stressed environments - were higher at ORE4.

Salt Slough

Approximately 4,100 individual macroinvertebrates were picked and identified from 73 taxa in five Salt Slough sites (Table 14, Appendix D). *Americorophium spinicorne*, *Physa sp.*, *Cricotopus sp.*, *Paratanytarus sp.*, and *Americorophium sp.* comprised ~55% of the individuals collected. The most dominant species (A. *spinicorne*) and the fifth most dominant species (*Americorophium sp.*) are amphipods. Amphipods are generally considered sensitive to OP insecticides (Giesy et al., 1999; Giddings et al., 2000) as well as other stressors (Harrington and Born, 2000). The second most dominant species (*Physa sp.*) is a gastropod; a taxa generally considered to be fairly tolerant of pollutant stress (Harrington and Born, 2000). The third and fourth most sensitive taxa are chironomids, which are taxa generally considered to be either tolerant or sensitive to environmental stressors (Harrington and Born, 2000).

Total taxa richness ranged from 32 at SSL3 to 40 at SSL4 (Table 15). Richness was fairly consistent among the transects by site (Figure 9). Total abundance by site was generally higher at SSL2 (Table 15). Macroinvertebrate abundance was generally variable among the transects at each site (Figure 10).

The other benthic metrics in Table 15 were generally consistent among the five Salt Slough sites with the following exceptions: (1) percent dominant taxa were higher at SSL3; (2) percent chironomidae were higher at upstream site SSL5; (3) percent collectors/gatherers (a feeding guild that dominates in stressed environments) were higher at SSL5; and (4) percent collectors/filterers (a feeding guild that dominates in stressed environments) were lower at SSL5.

Summary Statistical Analysis for All Creeks

PCA was used to determine the relationship among the benthic metrics and identify metrics that covary (Table 16). Five eigenvalues exceeded 1 indicating that there were five important factors in these data. Percent dominant taxa, percent collectors/filterers, Shannon diversity, and tolerance value were heavily loaded on factor 1 (Table 17). Factor 2 was composed of EPT taxa, percent Baetidae, percent intolerant taxa, sensitive EPT index, and percent tolerant taxa. Percent scrapers, percent shredders, percent chironomidae, and percent collectors/gatherers were dominant metrics in Factor 3. Factor 4 was composed of percent predators, number of trichoptera, and taxonomic richness. EPT index (%) was the dominant metric in Factor 5.

Spearmans Rank Correlation Analysis showed a significant ($p<0.05$) spatial trend for percent predators in Del Puerto Creek; EPT taxa, percent Baetidae and percent tolerant taxa in Orestimba Creek; and percent collectors/gatherers in Salt Slough (Table 18). The percent predators decreased from downstream to upstream in Del Puerto Creek. EPT taxa and percent Baetidae increased from downstream to upstream in Orestimba Creek while the percent tolerant taxa decreased from downstream to upstream. The percent collectors/gatherers increased from downstream to upstream in Salt Slough.

A comparison among benthic metrics in Del Puerto Creek, Orestimba Creek and Salt Slough in Table 19 showed that the percent scrapers – a feeding guild with a variable response to environmental stressors – were significantly higher in Del Puerto Creek when compared with Orestimba Creek. There were no significant differences among the other benthic metrics for these three streams using a p value of 0.05.

Relationship of Physical Habitat and Benthos

Spearman's Rank Correlation Analysis showed that bend/riffle frequency, sediment deposition, and embeddedness were the most important physical habitat metrics influencing the various benthic metrics (Table 20). Bend/riffle frequency was positively correlated with EPT index, EPT taxa, and percent Baetidae and negatively correlated with percent tolerant taxa. Sediment deposition was positively correlated with EPT index, EPT taxa, percent Baetidae and sensitive EPT index and negatively correlated with percent tolerant taxa. Embeddedness was positively correlated with EPT index, EPT taxa, percent Baetidae, and sensitive EPT index and negatively correlated with percent tolerant taxa. The total habitat score was positively correlated with EPT index, EPT taxa, percent Baetidae, percent intolerant taxa, and taxonomic richness. Total physical habitat score was negatively correlated with percent tolerant taxa.

The correlation matrix in Table 21 for habitat metrics not scored on a 0-20 scale shows that % fines and % gravel have the highest number of significant relationships with the various benthic metrics. Percent fines were negatively correlated with EPT index, EPT taxa, number of Trichoptera taxa, percent Baetidae, percent Hydropsychidae, and sensitive EPT taxa. Percent fines were positively correlated with percent tolerant taxa. Percent gravel was positively correlated with EPT index, EPT taxa, number of Trichoptera taxa, percent Baetidae, percent Hydropsychidae, and sensitive EPT index. Percent gravel was negatively correlated with tolerant taxa.

Water Quality

Del Puerto Creek

The only consistent water quality condition at all five sample sites in Del Puerto Creek in 2005 was salinity (Table 1). Parameters such as temperature (15 to 26.3 C), conductivity (397 to 940 umhos/L), pH (7.5 to 9.3), dissolved oxygen (9.1 to 14.9 mg/L) and turbidity (0.6 to 116 NTU) were variable across the various study sites. Spatial patterns showed: (1) temperature was lower at downstream sites; (2) conductivity was higher at the most upstream site; (3) pH was lower at downstream sites; (4) dissolved oxygen was greater at upstream site DLP4; and (5) turbidity was much lower at the upstream site DLP5.

A comparison of water quality measurements in Table 22 for the five Del Puerto Creek sites sampled in 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004), 2004 (Hall and Killen, 2005b) and 2005 showed the following: (1) temperature was more variable across the five years at DLP3; (2) conductivity was generally lower at DLP4 for all years; (3) pH was fairly consistent at all sites among the five years; (4) dissolved oxygen was consistently lower at four of the five sites in 2001; (5) salinity was consistent among sites by year; and (5) turbidity was consistently lower at the most upstream site (DLP5) for all years.

Orestimba Creek

The pH was fairly consistent among all nine sites in Orestimba Creek in 2005 (Table 1). Temperature ranged from 18.3 to 21.4 C with the lowest value at ORE6. Conductivity ranged from 485 to 830 umhos/L. Dissolved oxygen varied from 8.1 to 10.0 mg/L at all sites. There were no dissolved oxygen values below 5.0 mg/L in Orestimba Creek in 2005 - a concentration likely to be stressful to aquatic life (Lee and

Jones-Lee, 2000). Salinity ranged from 0.1 to 0.5 ppt across all sites. Turbidity was much lower at the upstream site (ORE10) when compared with the eight downstream sites. The lower turbidity at this upstream site likely occurs because there is no suspended sediment coming from eroded soil in irrigated agricultural fields (sites ORE 1-9).

A comparison of water quality data in Table 22 for the 10 Orestimba Creek sites sampled in 2000 (Hall and Killen, 2001), 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004), 2004 (Hall and Killen, 2005b) and 2005 showed the following: (1) temperature was generally lower at downstream site ORE1 and higher at ORE9 for all six years (2) specific conductance was higher for three of the six years at upstream site ORE10; (3) pH was fairly consistent among all sites for the six years; (4) dissolved oxygen was lower at most of the sites in 2001 except ORE1; (5) salinity was consistent among sites by year; and (5) turbidity was consistently lower at upstream site ORE10 for all years.

Salt Slough

The following ranges of water quality conditions were reported in Salt Slough in 2005: temperature (19.2 to 26.4 C), conductivity (990 to 2490 umhos/L), pH (7.5 to 8.0), dissolved oxygen (6.6 to 10.4 mg/L), salinity (0.2 to 1.3 ppt) and turbidity (48.5 to 90.2 NTU) (Table 1). Temperature, conductivity, pH and dissolved oxygen were generally higher at the upstream site (SSL5).

A comparison of water quality data in Table 22 for the five Salt Slough sites sampled in 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004), 2004 (Hall and Killen, 2005b) and 2005 showed the following: (1)

temperature was more variable at the most upstream and downstream sites across the five years; (2) conductivity was consistently lower at all sites in 2001 (3) dissolved oxygen was consistently lower at all sites in 2001; (4) pH was consistent among sites for all five years; (5) salinity was higher at upstream site SSL5 in 2005 and 2004; and (6) turbidity was lower at four sites in 2002.

DISCUSSION

Physical Habitat

Physical habitat in streams is the place where organisms such as benthic macroinvertebrates live. In streams, habitat structure generally means the physical structure of the channel and near channel environments. However, riparian areas along stream banks are also critical for determining the instream habitat structure (i.e., vegatation along stream banks can reduce sediment load). The habitat assessments conducted during this study were used to determine the suitability of the physical environment for aquatic biota such as benthic macroinvertebrates.

Impaired physical habitat (including sediment loading) has been identified as a major stressor to aquatic life in California streams (Jim Harrington, California Department of Fish and Game, personal communication). Altered physical habitat structure is also considered one of the major stressors of aquatic systems throughout the United States resulting in extinctions, local expirations and population reductions of aquatic fauna (Karr et al., 1986; Rankin, 1995). Identifying degraded physical habitat in streams is particularly critical for bioassessments as failure to do so can sometimes hinder investigations on the effects of toxic chemicals or other water quality related stressors. Rankin (1995) has reported that there is a small but still significant risk of reporting a water quality related impact when one does not exist (false positive) when habitat assessments are insufficient or absent. Physical habitat evaluations are not intended to replace biological assessments but rather to add an additional line of evidence about the status of lotic systems when conducted in concert with biological assessments. Evaluation of physical habitat in agricultural streams in California's Central Valley is particularly important due to the intensive development and landscape modifications in these areas.

Due to the limited number of sites sampled in the three agricultural streams in the present study, an extensive discussion or comparison of these physical habitat data across large spatial scales is problematic. Based on our limited sampling during 2005, the mean total physical habitat scores were not significantly different among the three streams using a p-value of < 0.05 (Table 9). Although Salt Slough did have significantly lower values for various metrics (i.e., epifaunal substrate, bend/riffle frequency, sediment deposition, and embeddedness) when compared with Del Puerto or Orestimba Creek (Table 9).

An exact historical comparison of total physical habitat scores (maximum of 200) for Del Puerto Creek (15 to 135), Orestimba Creek (84 to 128) and Salt Slough (24 to 109) as presented in Table 2 is not possible because historical physical habitat data for California's Central Valley streams has not been summarized in a published format. However, based on best professional judgement from other physical habitat assessments in the area, the range of physical habitat scores reported for the three streams in our study is generally considered low (Peter Ode, California Department of Fish and Game, personal communication).

Physical habitat scores for the 10 Orestimba Creek sites sampled in 2005 can be cautiously compared with same type of assessments conducted in 2000 (Hall and Killen, 2001), 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004) and 2004 (Hall and Killen, 2005b) with the caveat that these are only six temporally limited evaluations (Table 23). Total physical habitat scores across the six years were variable for all sites with somewhat more variability for ORE1 and ORE9. The qualitative habitat metrics that showed the highest number of significant changes for year-to-year comparisons were embeddedness and channel alteration (Table 24a). Total physical habitat scores in Orestimba Creek were greater in 2000 than in 2003 and 2004 and greater in 2001 than 2002, 2003, and 2004.

A comparison of physical habitat metrics in Table 23, Table 24b and Table 24c among the five Del Puerto Creek and Salt Slough sites sampled in 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004), and 2004 (Hall and Killen, 2005b) is also possible with the caveat that these are only five temporally limited evaluations. The final habitat scores among years in Del Puerto Creek site DLP2 were more consistent than the other four sites (Table 23). The only mean metric to show significant differences among years in Del Puerto Creek was epifaunal substrate (Table 24b). Due to the limited power with this statistical analysis, the only conclusion that can be stated is that epifaunal substrate was higher in 2003 than in 2001. The mean total physical habitat scores in Del Puerto Creek were consistent among the five years (Table 24b).

A comparison of total physical habitat scores among the five Salt Slough sites in 2001, 2002, 2003, 2004 and 2005 shows higher variability at SSL1 when compared with the other sites (Table 23). Mean channel flow, channel alteration, bend/riffle frequency, bank stability, and width were significantly different among years in Salt Slough (Table 24c). The mean total physical habitat scores were higher in 2001 when compared to 2002 (Table 24c).

<u>Presence of OP-Sensitive Species</u>

A secondary goal of this study was to compare the presence of benthic macroinvertebrates in all three agricultural streams with available organophosphate (OP) single-species toxicity data. The intent of this qualitative comparison is to determine if OP-sensitive benthic species are present in these streams. In order to conduct a valid comparison, the following issues must be addressed: (1) Are the OP-sensitive benthic species determined from single species toxicity tests expected to be found in these systems based on their habitat requirements? and (2) Are the sampling techniques used in our study (D-net sampling with 0.5 mm mesh) appropriate for collecting all OP-sensitive benthic species? Ranges of chlorpyrifos and diazinon concentrations presented in Table 25 have been reported during high use periods for the various streams (Poletika et al., 2002; Poletika and Robb, 1998; Waterborne Environmental Inc., 2002). These exposure data are used in a comparative analysis with the OP toxicity data presented below.

Chlorpyrifos acute toxicity data were available for 12 different taxa collected in the three streams sampled during our study (Table 26). The most sensitive taxa to chlorpyrifos that could be affected at environmentally realistic concentrations in any stream (concentrations < 2,282 ng/L based on the highest concentration in any stream) were *Chironomus sp.* (LC50 = 70 ng/L), *Gammarus sp.* (LC50 = 110 ng/L), *Hyalella sp.*, (LC50 = 1,300 ng/L), *Tanypus sp.* (LC50 = 1,500 ng/L), *Paratanytarsus sp.* (LC50 < 1,600 ng/L), and *Dugesia tigrina* (LC50 = 2,000 – 4,300 ng/L). The species most sensitive to chlorpyrifos (*Chironomus sp.*) was found in all three streams. *Gammarus sp.* are also predicted to be sensitive to chlorpyrifos based on single species toxicity tests and the effect concentrations are environmentally realistic. This amphipod was found in Orestimba Creek and Salt Slough but was absent from Del Puerto Creek

The amphipod, *Hyalella sp.,* was collected in all three streams. The chironomid, *Tanypus sp.* (one organism) was only collected in Salt Slough. The chironomid, *Paratanytarsus sp.*, was collected in all three streams but was less abundant in Del Puerto Creek. The flatworm, *Dugesia tigrina* was only found in Del Puerto Creek.

Diazinon acute toxicity data were available for five different taxa collected in either Del Puerto Creek, Orestimba Creek, or Salt Slough (Table 27). The most sensitive taxa to diazinon that could be affected at environmentally realistic concentrations in any stream (concentrations < 29,371 ng/L based on the highest value in any stream) were: *Hyalella sp.* (LC50 = 22,000 ng/L) and *Baetis adonis* (LC50 = 24,000 ng/L). The amphipod, *Hyalella sp.,* was more abundant in both Orestimba Creek and Salt Slough than Del Puerto Creek. The mayfly *Baetis adonis* - a species potentially sensitive to maximum reported environmental concentrations of diazinon - was collected at the most upstream sites in both Del Puerto Creek and Orestimba Creek.

<u>Historical Comparisons of Benthic Data</u>

Historical comparisons of our data with other benthic data from these three streams were limited. In 1993, the U.S. Geological Survey collected benthic macroinvertebrates at one site in Orestimba Creek that was approximately half way between our stations ORE2 and ORE3 (Larry Brown, personal communication). Dominant taxa reported by these investigators were mayflies, oligochaetes and gastropods. The dominant taxa we collected at ORE2 and ORE3 were amphipods, tricoptera (caddisflies) and chironomids.

Mayflies were not collected during our 2005 sampling at these two sites and gastropods were collected in low numbers. Due to the eleven year time period between the two sampling events, it is difficult to explain possible factors contributing to the differences in dominant taxa.

Benthic community assessments conducted during the present 2005 study at the 10 Orestimba Creek sties can be compared with similar studies conducted at the same sites in 2000 (Hall and Killen, 2001), 2001 (Hall and Killen, 2002), 2002 (Hall and Killen, 2003), 2003 (Hall and Killen, 2004), and 2004 (Hall and Killen, 2005b) . A comparison of mean benthic metrics across all sites for 2000, 2001, 2002, 2003, 2004, and 2005 showed that percent collectors, taxonomic richness, and percent shredders showed the highest number of significant differences for between year comparisons (Table 28a). Taxonomic richness – a common metric used in IBI development – was lower in 2000 than 2001, 2003 and 2004, and lower in 2001 than 2004. In general, most of the metrics did not show any significant differences over the six-year period thus suggesting that dramatic changes in benthic communities were not evident. However, it should be noted that percent composition of *H. californica* – a caddisfly considered sensitive to environmental stressors – has more than doubled between 2004 and 2005. An increase in the presence of an environmentally sensitive species suggests improved water quality conditions may be present in Orestimba Creek.

A comparison of mean benthic metrics reported for the five Del Puerto Creek sites in 2001, 2002, 2003, 2004 and 2005 showed significant differences ($p<0.05$) among years for percent shredders (Table 28b). Percent shredders – a feeding guild that decreases in stressed environments - were higher in 2001 and 2002 than 2003, 2004 and

2005. There were no significant annual differences for 17 of the 18 benthic metrics in Del Puerto Creek during the five year period (Table 28b). These data suggest that benthic communities in Del Puerto Creek have been fairly stable in recent years.

A comparison of mean benthic metrics in Salt Slough for 2001, 2002, 2003, 2004, and 2005 showed significant differences among years for percent collectors, percent dominant taxa, percent predators, percent shredders, Shannon Diversity, and taxonomic richness. Table 28c shows the following: (1) percent collectors were higher in 2001 than 2002; (2) percent dominant taxa were higher in 2003 than 2001; (3) percent predators were higher in 2002 than 2003; (4) percent shredders were higher 2002 than the other four years; (5) Shannon Diversity was higher in 2004 than 2003 and (6) taxonomic richness was higher in 2004 than 2003. Approximately one third of the benthic metrics showed significant annual differences in Salt Slough which suggests a moderate level of variability in benthic communities during five years.

Regulatory and Ecological Implications

The state of California has classified Del Puerto Creek, Orestimba Creek and Salt Slough as impaired water bodies (303 (d) list) due to the presence of chlorpyrifos and diazinon (www.swrcb.ca.gov). These water bodies were listed as impaired based on either OP concentrations exceeding a threshold (water quality criteria or target) or toxicity reported from single species toxicity tests (i.e., *Ceriodaphnia dubia* toxicity tests). Unfortunately, both the chemical monitoring and toxicity data used for these listings were based on data collected prior to 2001 and may not reflect the present use patterns of these OP insecticides. For example, in a recent analysis of diazinon and chlorpyrifos monitoring data (2001 to 2004) from the Sacramento and San Joaquin River watershed, target concentrations of these two OP insecticides were rarely exceeded (L. W. Hall, personnel communication).

Unfortunately, the status of resident biological communities was not considered when these water bodies were classified as impaired because these data were not available. The benthic community data generated from these three streams in 2005 as well as previous bioassessment efforts in these streams (Hall and Killen, 2001; Hall and Killen, 2002; Hall and Killen, 2003; Hall and Killen, 2004; Hall and Killen, 2005b) is therefore useful for providing another line of evidence for determining the biological condition of these water bodies. A recent report by the NRC (National Research Council, 2001), addressing various issues associated with TMDLs and impaired water bodies, stated that biological criteria should be used in conjunction with physical and chemical criteria to determine whether a water body is meeting its designated use. This NRC report further supports the use of biological data for determining the status (or potential impairment) of water bodies by stating that biological criteria are more closely related to designated uses of a waterbody than are chemical or physical measurements. A recent EPA report entitled "*Consolidated Assessment and Listing Methodology*" (CALM document) clearly supports the use of bioassessments for determining attainment of aquatic life based water quality standards by stating that bioassessment data are core indicators (critical or essential indicators) (U.S. EPA, 2002). This CALM document also endorses the use of multiple lines of evidence (chemical, toxicity and bioassessment data) for making valid designations of impaired water bodies (U.S. EPA, 2002).

Benthic communities in all three agricultural streams were generally comprised of tolerant species with the exception of Salt Slough where amphipods (an OP sensitive taxa) were dominant and Orestimba Creek where caddisflies (Trichoptera) were dominant. The dominant presence of the OP sensitive amphipod (i.e., *Americorophium spinicorne* comprised ~25% of the taxa collected in 2005) suggests that the laboratory toxicity data used to generate the "effects benchmarks" for OPs may not accurately predict the status of resident biota in Salt Slough. In addition, dominance by the caddisfly (Trichoptera) – an EPT taxa generally considered sensitive to environmental stressors – would suggest that the biological communities in Orestimba Creek may not be as degraded as the 303 (d) listing would suggest.

From an ecological perspective, dominance by tolerant species is expected in these streams due to generally poor physical habitat conditions, fluctuating flow conditions and stressful water quality conditions such elevated temperature and low dissolved oxygen. For example, historical data from permanent gauging stations near ORE10 (USGS) and ORE8 (CA DWR) shows that in most years Orestimba Creek is ephemeral in the reach with no commercial agriculture but generally has continuous low flow (in non-drought years) in most of the lower reach which receives irrigation return water (Poletika and Robb, 1998).

Critical issues to address with the benthic community data from these streams are: (1) What are the biological (benthic) expectations for these agricultural streams? and (2) Do these streams meet these biological expectations and are they impaired based on the status of resident benthic communities? Unfortunately, an agricultural reference stream is not available for this watershed to compare benthic communities for each stream although progress is being made with the development of reference streams in the Central Valley of California (Jim Harrington, personal communication). Therefore, the traditional reference stream approach often used to interpret the status of benthic communities is not feasible. The presence of 86 taxa in Del Puerto Creek, 93 taxa in Orestimiba Creek, and 73 taxa in Salt Slough implies that the benthic communities in these streams are fairly diverse, considering their ephemeral environments, but without a clear definition of benthic community expectations it is unknown if these water bodies are actually impaired. We therefore recommend extensive spatial and temporal assessments of benthic communities in concert with physical habitat assessments in agricultural streams of California's Central Valley in order to identify the range of benthic community taxa assemblages by stream orders and identify potential reference sites.

REFERENCES

Bacey, J. 2005. Biological assessment of urban and agricultural streams in the California Central Valley (Fall 2002 through Spring 2004). California Environmental Protection Agency, California Department of Pesticide Regulation, Sacramento, CA.

Barbour, M.T., J. Gerritson, B.D. Snyder, and S. Stribling. 1999. Rapid Bioassessment protocols for use in wadeable streams and rivers. EPA-841-B-99-002. Washington D.C.

Barron, M. G. and K. B. Woodburn. 1995. Ecotoxicology of chlorpyrifos. Reviews of Environmental Contamination and Toxicology 144: 1-93.

Brown, L. and J. May. 2004. Periphyton and macroinvertebrate communities at five sites in the San Joaquin river basin, California during June and September 2001. U. S. Geological Survey Report No. 2004-5098, Sacramento, CA.

Dubrovsky, N. M., C. R. Kratzer, L. R. Brown, J. M. Gronberg, and K. R. Burow. 1998. Water quality in the San Joaquin-Tulare basins, California, 1992-1995. U.S. Geological Survey Circular 1159, Sacramento, CA.

Foe, C. 1995. Evaluation of the potential impact of contaminants on aquatic resources in the Central Valley and Sacramento-San Joaquin Delta estuary. Report. Central Valley Regional Water Quality Control Board, Sacarmento, CA.

Giddings, J. M., L. W. Hall, Jr. and K. R. Solomon. 2000. Ecological risks of diazinon from agricultural use in the Sacramento – San Joaquin river basins, California. Risk Analysis 20: 545-572.

Giesy, J. P., K. R. Solomon, J. R. Coats, K. R. Dixon, J. M. Giddings and E. Kenaga. 1999. Chlorpyrifos: Ecological risk assessment in North American aquatic environments. Rev. Environ. Contam. Toxicol. 160: 1-129.

Hall, L. W. Jr. and W. D. Killen. 2001. Characterization of benthic communities and physical habitat in an agricultural and urban stream in California's Central Valley. Final report prepared by the University of Maryland, Wye Research and Education Center, Queenstown, MD.

Hall, L. W. Jr. and W. D. Killen. 2002. Characterization of benthic communities and physical habitat in agricultural streams in California's San Joaquin Valley. Final report prepared by University of Maryland, Wye Research and Education Center, Queenstown, MD.

Hall, L. W. Jr. and W. D. Killen. 2003. Characterization of benthic communities and physical habitat in agricultural streams in California's San Joaquin Valley in 2002. Final Report prepared by the University of Maryland, Wye Research and Education Center, Queenstown, MD.

Hall, L. W., Jr. and W. D. Killen. 2004. Characterization of benthic communities and physical habitat in agricultural streams in California's San Joaquin Valley in 2003. Final Report prepared by the University of Maryland, Wye Research and Education Center, Queenstown, MD.

Hall, L. W. Jr. and W. D. Killen. 2005a. Temporal and spatial assessment of water quality, physical habitat and benthic communities in an impaired stream in California's San Joaquin Valley. J. Environ. Sci. Hlth. 40:959-989.

Hall, L. W., Jr. and W. D. Killen. 2005b. Characterization of benthic communities and physical habitat in agricultural streams in California's San Joaquin Valley in 2004. Final Report prepared by the University of Maryland, Wye Research and Education Center, Queenstown, MD.

Harrington, J. and M. Born. 2000. Measuring the health of California streams and rivers. – A methods manual for water resource professionals, citizen monitors and natural resource students. Report. Sustainable Land Stewardship International Institute, Sacramento, CA.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant and I. J. Schlosser. 1986. Assessing biological integrity in running waters: A method and its rationale. Illinois Natural History Survey Special Publication 5, Champaign, IL.

Kazyak, P. F. 1997. Maryland Biological Stream Survey Sampling Manual. Maryland Department of Natural Resources, Chesapeake Bay Research and Monitoring Division, Annapolis, MD.

Lee, G. F. and Jones-Lee, A. 2000. Synopsis of issues in developing the San Joaquin River deep Water ship channel DO TMDL. Report. G. Fred Lee and Associates, El Macero, CA.

May, J. T. and L. R. Brown. 2000. Fish community structure in relation to environmental variables within the Sacramento River basin and implications for the greater Central Valley, California. Report 00-247, U.S. Geological Survey, Sacramento, CA.

Moyle, P. B., B. Herbold, D. E. Stevens and L. W. Miller. 1992. Life history and status of the delta smelt in the Sacramento-San Joaquin estuary in California. Trans. Am. Fish. Soc. 121: 67-77.

Moulton, S. R. II, J. L. Carter, S. A. Grotheer, T. F. Cuffney, and T. M. Short. 2000. Methods of analysis by the U. S. Geological Survey National Water Quality Laboratory – Processing, taxonomy and quality control of benthic macroinvertebrate samples. Report 00-212, U. S. Geological Survey, Sacramento, CA.

National Research Council. 2001. Assessing the TMDL Approach to Water Quality Management. National Academy Press, Washington, DC.

Poletika, N. N. and C. K. Robb. 1998. A monitoring study to characterize chlorpyrifos concentration patterns and ecological risk in an agricultural dominated tributary of the San Joaquin River. Report GH-C 4854. Dow Agro-Sciences LLC, Indianpolis, IN.

Poletika, N., K. B. Woodburn, and K. S. Henry. 2002. A ecological risk assessment for chlorpyrifos in an agriculturally dominated tributary of the San Joaquin River. Risk Analysis 22: 291-308.

Rankin, E. T. 1995. Habitat indices in water resource quality assessments. Pages 181-208 In W. S. Davis and T. P. Simon editors. *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making.* Lewis Publishers, Boca Raton, FL.

Stribling, J. B., J. S. White, B. J. Jessup, D. Boward, and M. Hurd. 1998. Development of a benthic index of biotic integrity for Maryland streams. Report. Tetra Tech Incorporated, Owings, MD.

Tetra Tech Inc. 2003. The status and future of biological assessment for California Streams. Prepared for the California State Water Resources Control Board Division of Water Quality, Sacramento, CA.

U. S. EPA (United States Environmental Protection Agency). 2002. Consolidated Assessment and Listing Methodology – Towards a Compendium of Best Practices. Report. USEPA Office of Wetlands, Oceans, and Watersheds, Washington, DC.

Waterborne Environmental, Inc. 2002. Surface water monitoring information on selected insecticides in the San Joaquin River and Sacramento/San Joaquin River Delta watersheds correlated with pesticide use data, 1990-1998. Report. Waterborne Environmental Inc., Leesburg, VA.

Table 1. Sample site names, coordinates and water quality parameters measured during late spring 2005 in Del Puerto Creek, Orestimba Creek and Salt Slough.

Site	Latitude	Longitude	Water Temperature (C)	Specific Conductivity (μmhos/L)	pH	Dissolved Oxygen (mg/L)	Salinity (ppt)	Turbidity (NTU)
DLP1	37 32 25	121 07 07	15.0	396.7	7.46	9.81	0.2	116
DLP2	37 32 03	121 07 46	17.3	426.4	7.74	9.48	0.2	109
DLP3	37 31 20	121 08 54	18.8	446.5	8.58	10.47	0.2	80.5
DLP4[a]	37 30 43	121 09 38	26.3	489	9.29	14.9	0.3	70.2
DLP5	37 28 59	121 12 41	22.9	940	8.65	9.10	0.2	0.56
ORE1	37 25 10	121 00 09	18.9	560	7.80	8.81	0.2	45.4
ORE2	37 25 12	121 00 21	20.6	550	7.91	8.55	0.2	85.6
ORE3	37 24 47	121 00 59	18.7	510	7.89	9.17	0.1	134
ORE4	37 24 19	121 01 28	18.8	485	7.91	9.09	0.1	137
ORE5	37 23 54	121 02 02	18.8	510	7.92	8.54	0.1	123
ORE6	37 23 21	121 02 34	18.3	810	8.05	8.19	0.4	152
ORE7	37 22 59	121 03 00	19.5	830	8.02	8.52	0.5	116
ORE8	37 22 37	121 03 31	20.6	780	8.01	8.28	0.3	110
ORE9[b]	37 21 53	121 03 45	-	-	-	-	-	-
ORE10	37 19 08	121 07 18	21.4	670	8.41	10.0	0.2	0.44
SSL1	37 14 54	120 51 12	19.2	1270	7.64	7.12	0.9	68.4
SSL2	37 11 59	120 49 33	20.4	1190	7.51	6.62	0.9	74.3
SSL3	37 09 33	120 48 44	21.8	1160	7.56	7.17	0.4	90.2
SSL4	37 08 21	120 46 04	21.9	990	7.59	7.57	0.2	70.3
SSL5[a]	37 07 45	120 42 28	26.4	2490	8.04	10.41	1.3	48.5

[a]stagnant pool, no flow.
[b]Not sampled, dewatered.

Table 2. Scoring of individual physical habitat metrics (0-20 scale) and final habitat score (maximum of 200) for sites in Del Puerto Creek, Orestimba Creek and Salt Slough in 2005.

Site	Epi Subs	Embedd	Veloc Depth Divers	Sedim Depos	Chan Flow Status	Chan Alt	Freq Bends Riffles	Left Bank Stab	Right Bank Stab	L Bank Veget. Protect	R Bank Veget. Protect	L Bank Ripar Zone	R Bank Ripar Zone	Total
DPL1	12	10	11	10	20	14	11	7	7	7	7	4	4	124
DPL2	11	11	15	15	19	11	11	7	0	6	0	3	0	109
DPL3	11	13	15	13	18	11	13	6	6	6	6	3	3	124
DPL4	1	0	0	5	4	0	0	0	1	1	1	1	1	15
DPL5	12	16	10	15	20	20	10	7	7	4	4	5	5	135
ORE1	11	1	6	6	19	14	6	5	1	5	4	5	4	87
ORE2	13	3	6	5	19	15	0	3	3	5	5	4	3	84
ORE3	11	6	15	8	13	9	11	3	2	5	3	3	3	92
ORE4	10	8	9	10	9	11	12	6	4	6	6	5	3	99
ORE5	10	10	10	12	9	13	11	6	5	7	8	5	4	110
ORE6	11	10	10	13	15	15	13	4	7	4	6	3	3	114
ORE7	13	10	10	12	14	15	14	8	7	6	8	5	6	128
ORE8	8	8	10	10	14	14	10	5	5	6	6	3	3	102
ORE9	-[a]	-	-	-	-	-	-	-	-	-	-	-	-	-
ORE10	12	13	10	14	17	16	16	4	4	4	4	5	5	124
SSL1	7	0	11	5	20	17	5	5	6	7	7	8	7	105
SSL2	5	0	11	4	20	18	4	9	8	8	6	8	8	109
SSL3	3	0	13	3	20	14	4	8	7	7	6	3	5	93
SSL4	4	0	14	1	18	15	2	2	6	6	7	3	5	83
SSL5	2	0	0	0	16	6	0	0	0	0	0	0	0	24

[a]Not sampled, site dewatered.

Table 3. Physical habitat characteristics for Del Puerto Creek, Orestimba Creek and Salt Slough that were not scored on a 0 - 20 scale.

Site	Mean Flow m/s	Ave. Width m	Ave. Depth cm	Canopy Cover %	Gradient %	Fines %	Gravel %	Cobble %	Boulder %	Bedrock %
DLP 1	0.24	4.7	18.7	71	1	70	20	5	5	0
DLP 2	0.24	3.7	24.9	17	1	60	30	0	10	0
DLP 3	0.42	2.0	17.4	4	1	60	30	10	0	0
DLP 4	0[a]	2.0	20.0	0	1	100	0	0	0	0
DLP 5	0.26	3.3	10.5	0	1	15	80	5	0	0
ORE 1	0[b]	>10	>1.5	12	1	100	0	0	0	0
ORE 2	0[b]	>15	>1.5	72	1	100	0	0	0	0
ORE 3	0.19	8.6	9.1	92	1	50	35	10	5	0
ORE 4	0.20	3.6	14.9	61	1	25	60	5	0	10[c]
ORE 5	0.28	6.8	7.4	53	1	30	70	0	0	0
ORE 6	0.51	3.6	10.4	17	1	30	40	30	0	0
ORE 7	0.51	2.8	7.0	32	1	20	30	47	3	0
ORE 8	0.36	2.5	7.0	0	1	50	45	5	0	0
ORE 9[d]	-	-	-	-	-	-	-	-	-	-
ORE 10	0.14	8.9	8.9	0	1	20	75	5	0	0
SSL 1	0.26	23.6	56.8	0	1	100	0	0	0	0
SSL 2	0.24	28.5	61.5	0	1	100	0	0	0	0
SSL 3	0.30	24.5	46.9	0	1	100	0	0	0	0
SSL 4	0.18	16.3	43.8	0	1	100	0	0	0	0
SSL 5	0[a]	8	>.50	0	1	100	0	0	0	0

[a] No flow, stagnant pool.
[b] Too deep to measure.
[c] Marl.
[d] Dewatered.

Table 4. Eigenvalues and proportion of variance explained for the correlation matrix of the ten habitat metrics.

	Eigenvalue	Proportion	Cumulative
Factor 1 *	4.922851	0.4923	0.4923
Factor 2 *	2.631338	0.2631	0.7554
Factor 3	0.918154	0.0918	0.8472
Factor 4	0.64812	0.0648	0.912
Factor 5	0.36306	0.0363	0.9484
Factor 6	0.221914	0.0222	0.9705
Factor 7	0.12009	0.012	0.9826
Factor 8	0.097414	0.0097	0.9923
Factor 9	0.039739	0.004	0.9963
Factor 10	0.037321	0.0037	1.0000

*eigenvalue > 1.0

Table 5. Eigenvectors for the two dominant factors of the correlation matrix of habitat metrics.

Metric	Factor 1	Factor 2
Factor 1		
BANKSTAB	0.364664*	0.229973
CHAN ALT	0.355318*	0.278108
VEL DPTH	0.329956*	0.067775
EPI SUB	0.329214*	-0.25835
BANKVEG	0.322362*	0.287037
Factor 2		
SED DEP	0.309627+	-0.42296*
EMBEDDED	0.306088+	-0.41995*
RIPBUFF	0.280103	0.373845*
BENRIFF	0.340965+	-0.34523*
CH FLOW	0.187952	0.319123*

* largest coefficient for each metric
\+ coefficient > 0.30 less than largest

Table 6. Correlation matrix for raw physical habitat metrics grouped by factors identified by the PCA. In the body of the table the correlation coefficients (top) are paired with the p-value (bottom) for the null hypothesis that the correlation is 0.0.

	BAN STAB	CHAN ALT	VEL DPTH	EPI SUB	BANK VEG	SED DEP	EMBEDD	RIP BUFF	BEN RIFF	CHAN FLOW	TOTAL
BANKSTAB	1.0000*	0.7314*	0.5793*	0.2908	0.8105*	0.3293	0.3293	0.7184*	0.4188	0.4028	0.7954*
	_	0.0004	0.0093	0.2271	0.0000	0.1686	0.1687	0.0005	0.0743	0.0873	0.0000
CHAN ALT	0.7314*	1.0000*	0.4895*	0.4582*	0.6522*	0.2499	0.2733	0.7703*	0.2929	0.6803*	0.7860*
	0.0004	_	0.0334	0.0485	0.0025	0.3021	0.2576	0.0001	0.2237	0.0013	0.0001
VEL DPTH	0.5793*	0.4895*	1.0000*	0.3726	0.6064*	0.3834	0.3773	0.3608	0.5250*	0.4085	0.7305*
	0.0093	0.0334	_	0.1161	0.0059	0.1052	0.1113	0.1292	0.0210	0.0825	0.0004
EPI SUB	0.2908	0.4582*	0.3726	1.0000*	0.3036	0.7511*	0.7396*	0.2194	0.7138*	0.2021	0.7378*
	0.2271	0.0485	0.1161	_	0.2063	0.0002	0.0003	0.3667	0.0006	0.4067	0.0003
BANKVEG	0.8105*	0.6522*	0.6064*	0.3036	1.0000*	0.1349	0.1166	0.7301*	0.3168	0.2514	0.6830*
	0.0000	0.0025	0.0059	0.2063	_	0.5819	0.6346	0.0004	0.1864	0.2991	0.0013
SED DEP	0.3293	0.2499	0.3834	0.7511*	0.1349	1.0000*	0.9474*	0.0446	0.8767*	-0.0689	0.7019*
	0.1686	0.3021	0.1052	0.0002	0.5819	_	0.0000	0.8562	0.0000	0.7794	0.0008
EMBEDD	0.3293	0.2733	0.3773	0.7396*	0.1166	0.9474*	1.0000*	-0.0206	0.8543*	-0.0044	0.6994*
	0.1687	0.2576	0.1113	0.0003	0.6346	0.0000	_	0.9332	0.0000	0.9857	0.0009
RIPBUFF	0.7184*	0.7703*	0.3608	0.2194	0.7301*	0.0446	-0.0206	1.0000*	0.1685	0.3807	0.5970*
	0.0005	0.0001	0.1292	0.3667	0.0004	0.8562	0.9332	_	0.4904	0.1079	0.0070
BENRIFF	0.4188	0.2929	0.5250*	0.7138*	0.3168	0.8767*	0.8543*	0.1685	1.0000*	-0.0516	0.7630*
	0.0743	0.2237	0.0210	0.0006	0.1864	0.0000	0.0000	0.4904	_	0.8337	0.0001
CHANFLOW	0.4028	0.6803*	0.4085	0.2021	0.2514	-0.0689	-0.0044	0.3807	-0.0516	1.0000*	0.4420
	0.0873	0.0013	0.0825	0.4067	0.2991	0.7794	0.9857	0.1079	0.8337	_	0.0581
TOTAL	0.7954*	0.7860*	0.7305*	0.7378*	0.6830*	0.7019*	0.6994*	0.5970*	0.7630*	0.4420	1.0000*
	0.0000	0.0001	0.0004	0.0003	0.0013	0.0008	0.0009	0.0070	0.0001	0.0581	_

* $p < 0.05$

Table 7. Correlation matrix for stream measurements against raw physical habitat metrics and the total habitat metric score. In the body of the table are the correlation coefficient (top) and the p-value (bottom) for the null hypothesis that the correlation is 0.0.

Metric	Width	Depth	Mean Flow	Canopy	Fines	Gravel	Cobble
BANKSTAB	0.2704	0.4299	0.7126*	-0.0467	-0.3041	0.2311	0.318
	0.2628	0.0662	0.0006	0.8493	0.2055	0.3412	0.1846
BANKVEG	0.3393	0.3988	0.5742*	0.1955	-0.1524	0.0996	0.2008
	0.1552	0.0908	0.0101	0.4226	0.5333	0.6851	0.4099
CHAN ALT	0.3851	0.2621	0.3985	-0.0917	-0.2424	0.2533	0.1399
	0.1035	0.2784	0.091	0.709	0.3174	0.2955	0.5679
BENRIFF	-0.5118*	-0.306	0.6469*	0.2142	-0.8729*	0.7772*	0.5308*
	0.0251	0.2027	0.0028	0.3786	0	0.0001	0.0194
EPI SUB	-0.4079	-0.4939*	0.3195	0.5137*	-0.6423*	0.5546*	0.42
	0.083	0.0316	0.1823	0.0245	0.003	0.0137	0.0734
RIPBUFF	0.5791*	0.5278*	0.2817	-0.0606	-0.0674	0.0645	0.0901
	0.0094	0.0202	0.2427	0.8055	0.7841	0.7931	0.7137
SED DEP	-0.6320*	-0.3861	0.5344*	0.1447	-0.8541*	0.8113*	0.4085
	0.0037	0.1025	0.0184	0.5544	0	0	0.0825
VEL DPTH	0.1564	0.3792	0.6002*	0.1373	-0.2817	0.2464	0.1333
	0.5225	0.1093	0.0066	0.5751	0.2426	0.3093	0.5863
CH FLOW	0.4874*	0.3421	0.0836	-0.2202	0.2692	-0.2483	-0.1342
	0.0343	0.1517	0.7337	0.3651	0.2651	0.3054	0.5838
EMBEDD	-0.6663*	-0.4580*	0.5137*	0.1758	-0.8787*	0.8541*	0.3923
	0.0018	0.0486	0.0245	0.4717	0	0	0.0967
TOTAL	-0.043	0.0702	0.6814*	0.1363	-0.6113*	0.5558*	0.3718
	0.8612	0.7751	0.0013	0.578	0.0054	0.0135	0.117

Number of observations = 19

* p-value < 0.05

Table 8. Spearman rank correlation coefficients (top) and significance levels (bottom) upstream-downstream trend in the physical habitat metrics and the total physical habitat index.

Physical Habitat metric	Del Puerto	Orestimba	Salt Slough
BANKSTAB	-0.1026 0.8696	0.557 0.1193	-0.7 0.1881
BANKVEG	-0.5 0.391	0.1857 0.6325	-0.9487* 0.0138
BENRIFF	-0.5643 0.3217	0.7029* 0.0347	-0.9747* 0.0048
CHAN ALT	0.0513 0.9347	0.4682 0.2037	-0.8 0.1041
CHAN FLOW	-0.2052 0.7406	-0.1772 0.6483	-0.8944* 0.0405
EMBEDD	0.4 0.5046	0.8513* 0.0036	. * .
EPI SUB	-0.1581 0.7995	-0.0855 0.8269	-0.9000* 0.0374
RIPBUFF	0.1 0.8729	0.1873 0.6295	-0.8721 0.0539
SED DEP	0.1539 0.8048	0.8236* 0.0064	-1.0000* 0
VEL DPTH	-0.5643 0.3217	0.523 0.1486	-0.0513 0.9347
TOTAL	0.2052 0.7406	0.8500* 0.0037	-0.9000* 0.0374
sample size	5	9	5

* P-value < 0.05

Table 9. Mean scores for each physical habitat metric and the total for each creek with the p- values for comparing the means among creeks based on the Kruskal-Wallis test. Pairwise comparisons between creeks are based on the Wilcoxon rank-sum test.

	Mean for each Creek				Pairwise Comparisons		
Physical Habitat Metric	Del Puerto	Orestimba	Salt Slough	Kruskal Wallace p-value	DO	DS	OS
VEL DPTH	10.2	9.6	9.8	0.36			
EPI SUB	9.4	11	4.2	0.01			*
BENRIFF	9	10.3	3	0.04			*
CHAN ALT	11.2	13.6	14	0.53			
BANKVEG	8.4	10.9	10.8	0.43			
RIPBUFF	5.8	8	9.4	0.43			
SED DEP	11.6	10	2.6	0.001		*	*
EMBEDD	10	7.7	0	0.002		*	*
BANKSTAB	9.6	9.1	10.2	0.71			
CHAN FLOW	16.2	14.3	18.8	0.05			*
Total	101.4	104.4	82.8	0.24			

DO – Del Puerto vs Orestimba
DS – Del Puerto vs Salt Slough
OS – Orestimba vs Salt Slough
* - p-value < 0.05

Table 10. Total and taxon abundance for benthic macroinvertebrates in Del Puerto Creek.

Lowest Taxa	Higher Taxa	Total N	Total %	Cumulative %
Simulium sp.	Simuliidae/Diptera	775	18.192	18.192
Nais communis/ variabilis	Naididae/Oligochaeta	772	18.122	36.315
Physa sp.	Physidae/Gastropoda	467	10.962	47.277
Cricotopus sp.	Chironomidae/Diptera	311	7.300	54.577
Cyprididae	Malacostraca	305	7.160	61.737
Chironomus sp.	Chironomidae/Diptera	179	4.202	65.939
Enchytraeidae	Oligochaeta	129	3.028	68.967
Cricotopus bicinctus group	Chironomidae/Diptera	125	2.934	71.901
Tubificidae unid. imm.	Tubificida/Oligochaeta	119	2.793	74.695
Gyraulus sp.	Planorbidae/Gastropoda	118	2.770	77.465
Eukiefferiella sp.	Chironomidae/Diptera	113	2.653	80.117
Baetis adonis	Baetidae/Ephemeroptera	85	1.995	82.113
Turbellaria	Platyhelminthes	67	1.573	83.685
Micropsectra sp.	Chironomidae/Diptera	53	1.244	84.930
Nanocladius sp.	Chironomidae/Diptera	43	1.009	85.939
Dicrotendipes sp.	Chironomidae/Diptera	39	0.915	86.854
Parachironomus sp.	Chironomidae/Diptera	38	0.892	87.746
Tanytarsus sp.	Chironomidae/Diptera	38	0.892	88.638
Rheotanytarsus sp.	Chironomidae/Diptera	33	0.775	89.413
Baetis tricaudatus	Baetidae/Ephemeroptera	32	0.751	90.164
Hyalella sp.	Hyalellidae/Malacostraca	32	0.751	90.915
Prostoma sp.	Tertastemmatidae/Nemertea	29	0.681	91.596
Fallceon quilleri	Baetidae/Ephemeroptera	21	0.493	92.089
Corixidae	Hemiptera	21	0.493	92.582
Cladotanytarsus sp.	Chironomidae/Diptera	20	0.469	93.052
Paratanytarsus sp.	Chironomidae/Diptera	19	0.446	93.498
Erpobdellidae	Hirudinea	18	0.423	93.920
Cricotopus trifascia group	Chironomidae/Diptera	17	0.399	94.319
Phaenopsectra sp.	Chironomidae/Diptera	14	0.329	94.648
Polypedilum sp.	Chironomidae/Diptera	13	0.305	94.953
Slavina appendiculata	Naididae/Oligochaeta	13	0.305	95.258
Centroptilum sp.	Baetidae/Ephemeroptera	12	0.282	95.540
Procladius sp.	Chironomidae/Diptera	12	0.282	95.822
Corbicula fluminea	Corbiculidae/Bivalvia	12	0.282	96.103
Hydra sp.	Hydridae/Coelenterata	11	0.258	96.362
Chaetogaster diaphanus	Naididae/Oligochaeta	11	0.258	96.620
Apedilum sp.	Chironomidae/Diptera	10	0.235	96.854
Menetus sp.	Planorbidae/Gastropoda	9	0.211	97.066
Paracladopelma sp.	Chironomidae/Diptera	8	0.188	97.254
Quistadrilus multisetosus	Tubificida/Oligochaeta	7	0.164	97.418
Tubificidae w/hair chaetae	Tubificida/Oligochaeta	7	0.164	97.582

Table 10. – continued.

Atractides sp.	Hygrobatidae/Chelicerata	6	0.141	97.723
Sphaeriidae	Bivalvia	6	0.141	97.864
Mooreobdella sp.	Erpobdellidae/Hirudinea	5	0.117	97.981
Peltodytes sp.	Haliplidae/Coleoptera	5	0.117	98.099
Tricorythodes sp.	Leptohyphidae/Ephemeroptera	5	0.117	98.216
Planorbella sp.	Planorbidae/Gastropoda	5	0.117	98.333
Cryptochironomus sp.	Chironomidae/Diptera	4	0.094	98.427
Thienemannimyia group	Chironomidae/Diptera	4	0.094	98.521
Lumbricina	Glossiphoniidae/Hirudinea	4	0.094	98.615
Hydrobiidae	Neotaenioglassa/Gastropoda	4	0.094	98.709
Fossaria sp.	Lymnaeidae/Gastropoda	4	0.094	98.803
Thienemanniella sp.	Chironomidae/Diptera	3	0.070	98.873
Corisella decolor	Corixidae/Hemiptera	3	0.070	98.944
Hydropsyche californica	Hydropsychidae/Trichoptera	3	0.070	99.014
Ophidonais serpentina	Naididae/Oligochaeta	3	0.070	99.085
Planorbidae	Planorbidae/Gastropoda	3	0.070	99.155
Sphaerium sp.	Sphaeriidae/Bivalvia	3	0.070	99.225
Pseudochironomus sp.	Chironomidae/Diptera	2	0.047	99.272
Rheocricotopus sp.	Chironomidae/Diptera	2	0.047	99.319
Ischnura sp.	Coenagrionidae/Odonata	2	0.047	99.366
Zoniagrion exlcamationis	Coenagrionidae/Odonata	2	0.047	99.413
Dugesia tigrina	Planariidae/Platyhelminthes	2	0.047	99.460
Corynoneura sp.	Chironomidae/Diptera	1	0.023	99.484
Microtendipes pedellus group	Chironomidae/Diptera	1	0.023	99.507
Parametriocnemus sp.	Chironomidae/Diptera	1	0.023	99.531
Paraphaenocladius sp.	Chironomidae/Diptera	1	0.023	99.554
Pentaneura sp.	Chironomidae/Diptera	1	0.023	99.577
Synorthocladius sp.	Chironomidae/Diptera	1	0.023	99.601
Coenagrionidae	Odonata	1	0.023	99.624
Corisella sp.	Corixidae/Hemiptera	1	0.023	99.648
Stictotarsus sp.	Dytiscidae/Coleoptera	1	0.023	99.671
Ephydridae	Diptera	1	0.023	99.695
Glossiphoniidae	Rhynchobdellida/Hirudinea	1	0.023	99.718
Bivalvia	Mollusca	1	0.023	99.742
Hydropsychidae	Trichoptera	1	0.023	99.765
Lebertia sp.	Lebertiidae/Arachnida	1	0.023	99.789
Mideopsis sp.	Mideopsidae/Arachnida	1	0.023	99.812
Muscidae	Diptera	1	0.023	99.836
Ambrysus sp.	Naucoridae/Hemiptera	1	0.023	99.859
Sciomyzidae	Diptera	1	0.023	99.883
Sperchon sp.	Sperchontidae/Arachnida	1	0.023	99.906
Pisidium sp.	Sphaeriidae/Bivalvia	1	0.023	99.930
Branchiura sowerbyi	Tubificida/Oligochaeta	1	0.023	99.953
Limnodrilus hoffmeisteri	Tubificida/Oligochaeta	1	0.023	99.977
Unionicola sp.	Unionicolidae/Arachnida	1	0.023	100.000
	Total	4260		

Table 11. Benthic metrics by site for the five Del Puerto Creek sites.

Metric	DLP 1	DLP 2	DLP 3	DLP 4	DLP 5
Taxonomic Richness	45	30	34	28	40
Percent Dominant Taxon	0.16	0.49	0.35	0.22	0.22
Number Plecoptera Taxa	0	0	0	0	0
Number Trichoptera Taxa	0	0	0	0	2
EPT Taxa	1	1	0	1	7
EPT Index (%)	0.00	0.00	0.00	0.00	0.17
Sensitive EPT Index (%)	0.00	0.00	0.00	0.00	0.01
Shannon Diversity	3.0	1.9	2.1	2.1	2.6
Tolerance Value	7.5	6.6	7.5	8.2	6.8
Percent Intolerant Taxa (0-2)	0.00	0.00	0.03	0.00	0.03
Percent Tolerant Taxa (8-10)	0.47	0.56	0.48	0.56	0.34
Percent Baetidae	0.00	0.00	0.00	0.00	0.17
Percent Chironomidae	0.61	0.16	0.11	0.35	0.12
Percent Hydropsychidae	0.00	0.00	0.00	0.00	0.00
Percent Collectors-Gatherers	0.72	0.26	0.60	0.75	0.51
Percent Collector-Filterers	0.04	0.52	0.25	0.02	0.19
Percent Scrapers	0.12	0.05	0.06	0.21	0.28
Percent Predators	0.11	0.09	0.06	0.01	0.02
Percent Shredders	0.00	0.00	0.00	0.00	0.00
Total Abundance (#/sample)	7890	3936	10227	6294	10144

Table 12. Total and taxon abundance for benthic macroinvertebrates in Orestimba Creek.

Lowest Taxa	Higher Taxa	Total N	Total %	Cumulative %
Hydropsyche californica	Hydropsychidae/Trichoptera	1192	19.158	19.158
Cricotopus bicinctus group	Chironomidae/Diptera	890	14.304	33.462
Cricotopus sp.	Chironomidae/Diptera	646	10.383	43.844
Nais communis/ variabilis	Naididae/Oligochaeta	300	4.822	48.666
Polypedilum sp.	Chironomidae/Diptera	282	4.532	53.198
Tubificidae unid. imm.	Tubificida/Oligochaeta	232	3.729	56.927
Paratanytarsus sp.	Chironomidae/Diptera	171	2.748	59.675
Eukiefferiella sp.	Chironomidae/Diptera	164	2.636	62.311
Torrenticola sp.	Torrenticolidae/Arachnida	159	2.555	64.867
Prostoma sp.	Tertastemmatidae/Nemertea	152	2.443	67.310
Ophidonais serpentina	Naididae/Oligochaeta	151	2.427	69.736
Centroptilum sp.	Baetidae/Ephemeroptera	146	2.347	72.083
Slavina appendiculata	Naididae/Oligochaeta	116	1.864	73.947
Sperchon sp.	Sperchontidae/Arachnida	108	1.736	75.683
Corbicula fluminea	Corbiculidae/Bivalvia	103	1.655	77.338
Physa sp.	Physidae/Gastropoda	103	1.655	78.994
Simulium sp.	Simuliidae/Diptera	102	1.639	80.633
Cricotopus trifascia group	Chironomidae/Diptera	90	1.446	82.080
Chironomus sp.	Chironomidae/Diptera	89	1.430	83.510
Hyalella sp.	Hyalellidae/Malacostraca	87	1.398	84.908
Corixidae	Hemiptera	68	1.093	86.001
Dicrotendipes sp.	Chironomidae/Diptera	60	0.964	86.966
Nereis limnicola	Nereididae/Polychaeta	55	0.884	87.850
Odontomyia/ Hedriodiscus	Stratiomyidae/Diptera	50	0.804	88.653
Gammarus sp.	Gammaridae/Malacostraca	43	0.691	89.344
Turbellaria	Platyhelminthes	41	0.659	90.003
Rheocricotopus sp.	Chironomidae/Diptera	36	0.579	90.582
Stictotarsus striatellus	Dytiscidae/Coleoptera	35	0.563	91.144
Hexatoma sp.	Tipulidae/Diptera	35	0.563	91.707
Ablabesmyia sp.	Chironomidae/Diptera	32	0.514	92.221
Eudistylia vancouveri	Sabellidae/Polychaeta	32	0.514	92.735
Fallceon quilleri	Baetidae/Ephemeroptera	31	0.498	93.234
Gyraulus sp.	Planorbidae/Gastropoda	29	0.466	93.700
Procladius sp.	Chironomidae/Diptera	28	0.450	94.150
Harnischia sp.	Chironomidae/Diptera	24	0.386	94.536
Lumbricina	Oligochaeta	23	0.370	94.905
Ormosia sp.	Tipulidae/Diptera	20	0.321	95.227
Thienemanniella sp.	Chironomidae/Diptera	19	0.305	95.532
Rheotanytarsus sp.	Chironomidae/Diptera	17	0.273	95.805
Fossaria sp.	Lymnaeidae/Gastropoda	14	0.225	96.030
Phaenopsectra sp.	Chironomidae/Diptera	13	0.209	96.239
Cyprididae	Ostracoda/Malacostraca	13	0.209	96.448
Americorophium spinicorne	Corophiidae/Malacostraca	12	0.193	96.641
Ephydridae	Diptera	12	0.193	96.834
Caloparyphus/ Euparyphus	Stratiomyidae/Diptera	12	0.193	97.027
Orthocladius complex	Chironomidae/Diptera	11	0.177	97.203

Table 12. - continued

Tanytarsus sp.	Chironomidae/Diptera	11	0.177	97.380
Palmacorixa sp.	Corixidae/Hemiptera	10	0.161	97.541
Cladotanytarsus sp.	Chironomidae/Diptera	9	0.145	97.686
Pristina leidyi	Naididae/Oligochaeta	9	0.145	97.830
Caenis sp.	Caenidae/Ephemeroptera	8	0.129	97.959
Nanocladius sp.	Chironomidae/Diptera	8	0.129	98.087
Lebertia sp.	Lebertiidae/Arachnida	8	0.129	98.216
Limnophyes sp.	Chironomidae/Diptera	7	0.113	98.329
Erpobdellidae	Hirudinea	7	0.113	98.441
Branchiura sowerbyi	Tubificida/Oligochaeta	7	0.113	98.554
Enchytraeidae	Tubificida/Oligochaeta	6	0.096	98.650
Atractides sp.	Hygrobatidae/Arachnida	6	0.096	98.746
Limnodrilus hoffmeisteri	Tubificida/Oligochaeta	6	0.096	98.843
Baetis adonis	Baetidae/Ephemeroptera	5	0.080	98.923
Parachironomus sp.	Chironomidae/Diptera	5	0.080	99.004
Corisella decolor	Corixidae/Hemiptera	5	0.080	99.084
Coenagrionidae	Odonata	4	0.064	99.148
Acari	Arachnida	4	0.064	99.212
Euparyphus sp.	Stratiomyidae/Diptera	4	0.064	99.277
Corynoneura sp.	Chironomidae/Diptera	3	0.048	99.325
Microchironomus sp.	Chironomidae/Diptera	3	0.048	99.373
Trichocorixa sp.	Corixidae/Hemiptera	3	0.048	99.421
Paranais litoralis	Naididae/Oligochaeta	3	0.048	99.470
Menetus sp.	Planorbidae/Gastropoda	3	0.048	99.518
Pseudochironomus sp.	Chironomidae/Diptera	2	0.032	99.550
Ischnura sp.	Coenagrionidae/Odonata	2	0.032	99.582
Trichocorixa calva	Corixidae/Hemiptera	2	0.032	99.614
Agabus sp.	Dytiscidae/Coleoptera	2	0.032	99.646
Oxyethira sp.	Hydroptilidae/Trichoptera	2	0.032	99.679
Chaetogaster diaphanus	Naididae/Oligochaeta	2	0.032	99.711
Caloparyphus sp.	Stratiomyidae/Diptera	2	0.032	99.743
Belostoma flumineum	Belostomatidae/Hemiptera	1	0.016	99.759
Procambarus clarkii	Cambaridae/Decapoda	1	0.016	99.775
Apedilum sp.	Chironomidae/Diptera	1	0.016	99.791
Micropsectra sp.	Chironomidae/Diptera	1	0.016	99.807
Smittia sp.	Chironomidae/Diptera	1	0.016	99.823
Thienemannimyia group	Chironomidae/Diptera	1	0.016	99.839
Sigara sp.	Corixidae/Hemiptera	1	0.016	99.855
Stictotarsus sp.	Dytiscidae/Coleoptera	1	0.016	99.871
Ephemerella maculata	Ephemerellidae/Ephemeroptera	1	0.016	99.887
Mooreobdella sp.	Erpobdellidae/Hirudinea	1	0.016	99.904
Hydrobiidae	Gastropoda	1	0.016	99.920
Mideopsis sp.	Mideopsidae/Arachnida	1	0.016	99.936
Stylaria lacustris	Naididae/Oligochaeta	1	0.016	99.952
Psychoda sp.	Psychodidae/Diptera	1	0.016	99.968
Manayunkia speciosa	Sabellidae/Polychaeta	1	0.016	99.984
Nemotelus sp.	Stratiomyidae/Diptera	1	0.016	100.000
	Total	6222		

Table 13. Benthic metrics by site for the 10 Orestimba Creek sites.*

Metric	ORE 1	ORE 2	ORE 3	ORE 4	ORE 5	ORE 6	ORE 7	ORE 8	ORE 10
Taxonomic Richness	41	28	30	26	34	30	31	22	41
Percent Dominant Taxon	0.23	0.17	0.25	0.73	0.53	0.26	0.27	0.38	0.18
Number Plecoptera Taxa	0	0	0	0	0	0	0	0	0
Number Trichoptera Taxa	0	0	1	1	1	1	1	1	1
EPT Taxa	1	0	1	2	1	2	2	2	6
EPT Index (%)	0.00	0.00	0.25	0.74	0.53	0.13	0.07	0.02	0.19
Sensitive EPT Index (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Shannon Diversity	2.7	2.7	2.9	1.3	2.0	2.4	2.3	1.8	2.9
Tolerance Value	7.4	7.3	6.7	4.6	5.8	7.1	6.8	7.0	5.5
Percent Intolerant Taxa (0-2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Percent Tolerant Taxa (8-10)	0.55	0.65	0.52	0.43	0.48	0.46	0.48	0.44	0.41
Percent Baetidae	0.00	0.00	0.00	0.01	0.00	0.02	0.01	0.00	0.18
Percent Chironomidae	0.66	0.40	0.20	0.08	0.08	0.50	0.63	0.72	0.29
Percent Hydropsychidae	0.00	0.00	0.25	0.73	0.53	0.11	0.06	0.02	0.00
Percent Collectors-Gatherers	0.63	0.69	0.39	0.10	0.25	0.73	0.66	0.87	0.58
Percent Collector-Filterers	0.22	0.08	0.41	0.80	0.63	0.13	0.14	0.05	0.04
Percent Scrapers	0.04	0.11	0.05	0.00	0.01	0.01	0.02	0.00	0.08
Percent Predators	0.10	0.13	0.13	0.07	0.09	0.09	0.09	0.04	0.28
Percent Shredders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Abundance (#/sample)	1082	226	161	3858	2039	2972	5004	6097	6294

*Site 9 was dewatered, not sampled.

Table 14. Total and taxon abundance for benthic macroinvertebrates in Salt Slough.

Lowest Taxa	Higher Taxa	Total N	Total %	Cumulative %
Americorophium spinicorne	Corophiidae/Malacostraca	1044	25.383	25.383
Physa sp.	Physidae/Gastropoda	502	12.205	37.588
Cricotopus sp.	Chironomidae/Diptera	245	5.957	43.545
Paratanytarsus sp.	Chironomidae/Diptera	242	5.884	49.429
Americorophium sp.	Corophiidae/Malacostraca	222	5.398	54.826
Chironomus sp.	Chironomidae/Diptera	211	5.130	59.956
Gammarus sp.	Gammaridae/Malacostraca	183	4.449	64.406
Nais communis/ variabilis	Naididae/Oligochaeta	167	4.060	68.466
Corixidae	Corixidae/Hemiptera	160	3.890	72.356
Eudistylia vancouveri	Sabellidae/Polychaeta	108	2.626	74.982
Ophidonais diaphanous	Naididae/Oligochaeta	106	2.577	77.559
Tubificidae unid. imm.	Tubificida/Oligochaeta	105	2.553	80.112
Hyalella sp.	Hyalellidae/Malacostraca	104	2.529	82.640
Cricotopus bicinctus group	Chironomidae/Diptera	100	2.431	85.072
Corbicula fluminea	Corbiculidae/Bivalvia	94	2.285	87.357
Prostoma sp.	Tertastemmatidae/Nemertea	60	1.459	88.816
Trichocorixa calva	Corixidae/Hemiptera	46	1.118	89.934
Paranais litoralis	Naididae/Oligochaeta	38	0.924	90.858
Hydropsyche californica	Hydropsychidae/Trichoptera	26	0.632	91.490
Branchiura sowerbyi	Tubificida/Oligochaeta	24	0.584	92.074
Slavina appendiculata	Naididae/Oligochaeta	23	0.559	92.633
Manayunkia speciosa	Sabellidae/Polychaeta	23	0.559	93.192
Limnophyes sp.	Chironomidae/Diptera	22	0.535	93.727
Simulium sp.	Simuliidae/Diptera	18	0.438	94.165
Limnodrilus hoffmeisteri	Tubificida/Diptera	18	0.438	94.602
Apedilum sp.	Chironomidae/Diptera	17	0.413	95.016
Ferrissia sp.	Ancylidae/Gastropoda	16	0.389	95.405
Dicrotendipes sp.	Chironomidae/Diptera	15	0.365	95.770
Corisella decolor	Corixidae/Hemiptera	15	0.365	96.134
Fossaria sp.	Lymnaeidae/Gastropoda	15	0.365	96.499
Coenagrionidae	Odonata	14	0.340	96.839
Corynoneura sp.	Chironomidae/Diptera	11	0.267	97.107
Eukiefferiella sp.	Chironomidae/Diptera	9	0.219	97.326
Parachironomus sp.	Chironomidae/Diptera	9	0.219	97.544
Rheotanytarsus sp.	Chironomidae/Diptera	9	0.219	97.763
Cyprididae	Ostracoda/Malacostraca	9	0.219	97.982
Procladius sp.	Chironomidae/Diptera	8	0.195	98.177
Hydropsyche sp.	Hydropsychidae/Trichoptera	6	0.146	98.322
Turbellaria	Platyhelminthes	6	0.146	98.468
Cladotanytarsus sp.	Chironomidae/Diptera	4	0.097	98.566
Nereis limnicola	Nereididae/Polychaeta	4	0.097	98.663
Paracladopelma sp.	Chironomidae/Diptera	3	0.073	98.736
Phaenopsectra sp.	Chironomidae/Diptera	3	0.073	98.809
Palmacorixa sp.	Corixidae/Hemiptera	3	0.073	98.882
Liodessus obscurellus	Dytiscidae/Coleoptera	3	0.073	98.955
Procambarus clarkii	Cambaridae/Decapoda	2	0.049	99.003
Endotribelos sp.	Chironomidae/Diptera	2	0.049	99.052

Table 14. – continued.

Glyptotendipes sp.	Chironomidae/Diptera	2	0.049	99.100
Nanocladius sp.	Chironomidae/Diptera	2	0.049	99.149
Parametriocnemus sp.	Chironomidae/Diptera	2	0.049	99.198
Polypedilum sp.	Chironomidae/Diptera	2	0.049	99.246
Psectrocladius sp.	Chironomidae/Diptera	2	0.049	99.295
Tanytarsus sp.	Chironomidae/Diptera	2	0.049	99.344
Thienemanniella sp.	Chironomidae/Diptera	2	0.049	99.392
Ischnura sp.	Coenagrionidae/Odonata	2	0.049	99.441
Trichocorixa sp.	Corixidae/Hemiptera	2	0.049	99.489
Lebertia sp.	Lebertiidae/Arachnida	2	0.049	99.538
Chaetogaster diaphanous	Naididae/Oligochaeta	2	0.049	99.587
Pristina leidyi	Naididae/Oligochaeta	2	0.049	99.635
Menetus sp.	Planorbidae/Gastropoda	2	0.049	99.684
Callibaetis sp.	Baetidae/Ephemeroptera	1	0.024	99.708
Cryptochironomus sp.	Chironomidae/Diptera	1	0.024	99.733
Tanypus sp.	Chironomidae/Diptera	1	0.024	99.757
Dixa sp.	Dixidae/Diptera	1	0.024	99.781
Ephydridae	Diptera	1	0.024	99.805
Hydroptila sp.	Hydroptilidae/Trichoptera	1	0.024	99.830
Gyraulus sp.	Planorbidae/Gastropoda	1	0.024	99.854
Sciomyzidae	Diptera	1	0.024	99.878
Staphylinidae	Staphylinidae/Coleoptera	1	0.024	99.903
Ormosia sp.	Tipulidae/Diptera	1	0.024	99.927
Aulodrilus pigueti	Tubificida/Oligochaeta	1	0.024	99.951
Quistadrilus multisetosus	Tubificida/Oligochaeta	1	0.024	99.976
Veliidae	Hemiptera	1	0.024	100.000
	Total	4113		

Table 15. Benthic metrics by site for the Five Salt Slough sites.

Metric	SSL 1	SSL 2	SSL 3	SSL 4	SSL 5
Taxonomic Richness	33	34	32	40	34
Percent Dominant Taxon	0.27	0.29	0.58	0.18	0.24
Number Plecoptera Taxa	0	0	0	0	0
Number Trichoptera Taxa	2	2	1	0	0
EPT Taxa	2	2	1	0	1
EPT Index (%)	0.00	0.02	0.02	0.00	0.00
Sensitive EPT Index (%)	0.00	0.00	0.00	0.00	0.00
Shannon Diversity	2.3	2.2	1.6	2.7	2.3
Tolerance Value	7.3	5.3	4.9	7.8	7.5
Percent Intolerant Taxa (0-2)	0.04	0.00	0.00	0.00	0.00
Percent Tolerant Taxa (8-10)	0.52	0.62	0.40	0.55	0.56
Percent Baetidae	0.00	0.00	0.00	0.00	0.00
Percent Chironomidae	0.08	0.05	0.07	0.29	0.64
Percent Hydropsychidae	0.00	0.02	0.02	0.00	0.00
Percent Collectors-Gatherers	0.16	0.25	0.29	0.39	0.60
Percent Collector-Filterers	0.35	0.66	0.68	0.27	0.24
Percent Scrapers	0.32	0.06	0.01	0.22	0.11
Percent Predators	0.16	0.03	0.02	0.11	0.04
Percent Shredders	0.00	0.00	0.00	0.00	0.00
Total Abundance (#/sample)	2078	6553	1829	1044	4424

Table 16. Eigenvalues and proportion of variance explained for the correlation matrix of the benthic metrics.

Factor	Eigenvalue	Proportion	Cumulative
Factor 1	6.0514	0.3362	0.3362
Factor 2	4.9330	0.2741	0.6102
Factor 3	2.1520	0.1196	0.7298
Factor 4	1.2453	0.0692	0.7990
Factor 5	1.0322	0.0573	0.8563
Factor 6	0.8500	0.0472	0.9035
Factor 7	0.7121	0.0396	0.9431
Factor 8	0.4545	0.0252	0.9684
Factor 9	0.2043	0.0113	0.9797
Factor10	0.1403	0.0078	0.9875
Factor11	0.0940	0.0052	0.9927
Factor12	0.0668	0.0037	0.9964
Factor13	0.0467	0.0026	0.9990
Factor14	0.0117	0.0007	0.9997
Factor15	0.0050	0.0003	0.9999
Factor16	0.0010	0.0001	1.0000
Factor17	0.0000	0.0000	1.0000
Factor18	0.0000	0.0000	1.0000

Table 17. Eigenvectors for the five dominant factors of the correlation matrix of benthic metrics.

Metric	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1					
Percent Dominant Taxon	-0.3728*	-0.0355	-0.0655	-0.0034	-0.2563
Percent Collector-Filterers	-0.3692*	-0.0372	-0.1881	0.1070*	-0.0122
Shannon Diversity	0.3368*	0.1263	-0.0239	0.2290	0.2429
Tolerance Value	0.3202*	-0.2010	0.0083	-0.0741	0.2660
Factor 2					
EPT Taxa	-0.0046	0.4042*	0.0870	-0.3329+	0.0748
Percent Baetidae	0.0975	0.4023*	-0.1032	-0.2476	-0.0354
Percent Intolerant Taxa (0-2)	0.1092	0.3920*	-0.2007	-0.0619	-0.1121
Sensitive EPT Index (%)	0.0970	0.3745*	-0.0859	0.1757	-0.2690
Percent Tolerant Taxa (8-10)	0.1528	-0.3222*	-0.3031+	0.1303	0.0904
Factor 3					
Percent Scrapers	0.1730	0.0043	-0.4508*	-0.3044+	0.4394+
Percent Shredders	0.0314	0.0423	0.4202*	-0.0176	0.4177+
Percent Chironomidae	0.2518	-0.0842	0.4152*	0.1373	-0.1819
Percent Collectors Gatherers	0.2994	-0.0377	0.3666*	-0.1367	-0.2162
Factor 4					
Percent Predators	0.1389	0.2604	-0.0164	0.5350*	0.1607
Number Trichoptera Taxa	-0.2191	0.2105	0.2675	-0.2932*	0.1928
Taxonomic Richness	0.1538	0.2458	-0.1244	0.2901*	-0.1063
Factor 5					
EPT Index (%)	-0.2853	0.1772	0.1033	0.2102	0.2978*

* Largest factor loading
+ loading >= 0.30

Table 18. Spearman rank correlation coefficients(top) and p-values (bottom) for upstream-downstream trend in the benthic metrics.

Benthic Habitat Metric	Del Puerto	Orestimba	Salt Slough
EPT Index (%)	0.11 0.8660	0.21 0.5890	-0.34 0.5810
EPT Taxa	0.36 0.5528	0.8* 0.0099	-0.56 0.3217
Number Trichoptera Taxa	0.71 0.1817	0.42 0.2625	-0.63 0.2522
Percent Baetidae	0.45 0.4502	0.81* 0.0077	. .
Percent Chironomidae	-0.5 0.3910	0.13 0.7324	0.7 0.1881
Percent Collector-Filterers	-0.2 0.7471	-0.53 0.1392	-0.6 0.2848
Percent Collectors Gatherers	0 1.000	0.18 0.6368	1* <0.0001
Percent Dominant Taxon	0.05 0.9347	0.18 0.6354	-0.3 0.6238
Percent Hydropsychidae	0.71 0.1817	-0.02 0.9655	-0.34 0.5811
Percent Intolerant Taxa (0-2)	0.67 0.2152	0.55 0.1269	-0.71 0.1817
Percent Predators	-0.9* 0.0374	0.01 0.9830	-0.2 0.7471
Percent Scrapers	0.7 0.1881	-0.28 0.4581	-0.2 0.7471
Percent Shredders	. .	0.14 0.7254	. .
Percent Tolerant Taxa (8-10)	0 1.0000	-0.75* 0.0199	-0.15 0.8048

Table 18. – continued.

Benthic Habitat Metric	Del Puerto	Orestimba	Salt Slough
Sensitive EPT Index (%)	0.71 0.1817	0.55 0.1269	. .
Shannon Diversity	-0.05 0.9347	-0.18 0.6368	0.31 0.6144
Taxonomic Richness	-0.3 0.6238	0.24 0.5292	0.6 0.2848
Tolerance Value	0.2 0.7471	-0.43 0.2440	0.5 0.3910

* $p <= 0.05$

Table 19. Mean scores for each benthic metric for each creek with the p-values for comparing the means among creeks based on the Kruskal-Wallis test. Pairwise comparisons between creeks are based on the Wilcoxon rank-sum test.

	Mean for each Creek				Pairwise Comparisons		
Benthic Metric	Del Puerto	Orestimba	Salt Slough	Kruskal-Wallace p-value	DO	DS	OS
Number Trichoptera Taxa	0.6	2.2	1.4	0.1274			
EPT Index (%)	3.7	20.8	0.7	0.0935			
Percent Hydropsychidae	0.1	18.4	0.7	0.0955			
Percent Chironomidae	27.6	39.3	21.5	0.2368			
Percent Collectors Gatherers	56.2	54.6	32.8	0.1638			
Percent Intolerant Taxa (0-2)	1.1	0.9	0.4	0.7291			
Percent Tolerant Taxa (8-10)	50.5	47.1	54.9	0.3270			
Shannon Diversity	2.2	2.1	1.9	0.5289			
Percent Dominant Taxon	33.9	35.8	40.7	0.4896			
Percent Predators	6.1	11.5	7.1	0.2901			
EPT Taxa	1.2	1.4	0.5	0.2143			
Percent Baetidae	3.4	2.3	0.0	0.1547			
Percent Scrapers	14.7	3.6	14.5	0.0263	*		
Percent Collector-Filterers	20.3	27.3	45.2	0.1541			
Tolerance Value	7.4	6.5	6.5	0.2563			
Taxonomic Richness	22.7	20.7	20.7	0.7474			
Percent Shredders	0.0	0.0	0.0	1.0000			
Sensitive EPT Index (%)	0.3	1.9	0.0	1.0000			

DO – Del Puerto vs Orestimba
DS – Del Puerto vs Salt Slough
OS – Orestimba vs Salt Slough
* p-value <= 0.05

Table 20. Spearman rank correlation coefficients (top) and p-values (bottom) for benthic metrics versus habitat metrics.

	BANK STAB	BANK VEG	CHAN ALT	BEN RIFF	EPI SUB	RIP BUFF	SED DEP	VEL DPTH	CH FLOW	EMBE DDED	TOTAL
EPT Index (%)	0.311	0.152	0.113	0.610*	0.27	0.29	0.490*	0.076	-0.335	0.461*	0.474*
	0.196	0.535	0.644	0.006	0.264	0.229	0.033	0.758	0.161	0.047	0.04
EPT Taxa	0.332	-0.008	0.318	0.568*	0.253	0.323	0.547*	-0.066	-0.193	0.457*	0.538*
	0.165	0.974	0.185	0.011	0.296	0.177	0.015	0.788	0.429	0.049	0.017
Number Trichoptera Taxa	0.436	0.285	0.222	0.417	0.085	0.312	0.284	0.059	-0.265	0.219	0.373
	0.062	0.237	0.36	0.076	0.73	0.194	0.238	0.811	0.273	0.367	0.116
Percent Baetidae	0.177	-0.229	0.349	0.621*	0.467*	0.141	0.725*	-0.114	-0.152	0.663*	0.581*
	0.469	0.347	0.144	0.005	0.044	0.565	0	0.644	0.535	0.002	0.009
Percent Chironomidae	-0.44	-0.352	-0.18	-0.002	0.26	-0.384	0.019	-0.473*	-0.251	0.073	-0.159
	0.059	0.139	0.461	0.994	0.282	0.105	0.937	0.041	0.299	0.768	0.515
Percent Collector-Filterers	0.238	0.313	-0.111	-0.045	-0.345	0.189	-0.211	0.418	0.136	-0.239	-0.099
	0.327	0.191	0.651	0.856	0.148	0.438	0.385	0.075	0.578	0.324	0.688
Percent Collectors-Gatherers	-0.23	-0.291	-0.112	-0.058	0.274	-0.416	0.065	-0.391	-0.185	0.118	-0.059
	0.344	0.227	0.649	0.812	0.256	0.076	0.791	0.098	0.448	0.629	0.809
Percent Dominant Taxon	0.416	0.444	0.019	-0.015	-0.363	0.129	-0.056	0.246	-0.007	-0.115	0.018
	0.077	0.057	0.938	0.95	0.126	0.599	0.82	0.309	0.977	0.64	0.94
Percent Hydropsychidae	0.354	0.333	-0.01	0.374	0.012	0.185	0.173	0.034	-0.428	0.119	0.222
	0.137	0.164	0.969	0.114	0.961	0.447	0.48	0.89	0.068	0.628	0.361
Percent Intolerant Taxa (0-2)	0.191	-0.096	0.445	0.295	0.264	0.376	0.42	0.149	0.314	0.437	0.503*
	0.433	0.697	0.056	0.22	0.275	0.112	0.073	0.542	0.191	0.061	0.028

* p-value <= 0.05

Table 20. - continued.

	BANK STAB	BANK VEG	CHAN ALT	BEN RIFF	EPI SUB	RIP BUFF	SED DEP	VEL DPTH	CH FLOW	EMBE DDED	TOTAL
Percent Predators	-0.14	0.136	0.28	0.407	0.467*	0.21	0.184	0.19	0.064	0.186	0.182
	0.567	0.579	0.245	0.084	0.044	0.389	0.45	0.436	0.795	0.445	0.456
Percent Scrapers	-0.191	-0.201	0.201	-0.417	-0.02	0.072	-0.211	0.05	0.396	-0.15	-0.1
	0.434	0.409	0.41	0.075	0.937	0.77	0.386	0.838	0.093	0.539	0.683
Percent Shredders	0.086	-0.065	0.152	0.282	0.087	-0.196	0.238	-0.066	-0.131	0.154	0.173
	0.725	0.791	0.534	0.242	0.723	0.422	0.327	0.789	0.594	0.53	0.48
Percent Tolerant Taxa (8-10)	-0.433	-0.06	-0.165	-0.702*	-0.297	-0.183	-0.610*	-0.094	0.159	-0.621*	-0.621*
	0.064	0.808	0.499	0.001	0.216	0.453	0.006	0.7	0.514	0.005	0.005
Sensitive EPT Index (%)	0.081	-0.315	0.469*	0.283	0.38	0.347	0.484*	-0.096	0.177	0.524*	0.465*
	0.742	0.188	0.043	0.24	0.109	0.145	0.036	0.697	0.47	0.021	0.045
Shannon Diversity	-0.224	-0.224	0.312	0.088	0.592*	0.157	0.164	-0.125	0.226	0.251	0.156
	0.357	0.355	0.194	0.721	0.008	0.522	0.504	0.611	0.353	0.301	0.522
Taxonomic Richness	0.255	0.107	0.37	0.344	0.4	0.394	0.312	-0.001	0.333	0.427	0.509*
	0.293	0.663	0.119	0.149	0.09	0.096	0.193	0.996	0.164	0.068	0.026
Tolerance Value	-0.347	-0.171	-0.19	-0.351	-0.113	-0.374	-0.251	-0.142	0.005	-0.199	-0.292
	0.145	0.483	0.435	0.14	0.645	0.114	0.299	0.561	0.984	0.415	0.225

* p-value <= 0.05

Table 21. Spearman Rank Correlation coefficients (top) and p-values (bottom) for benthic metrics versus physical habitat measurements (not scored on a 0-20 scale).

Benthic Metric	Width	Depth	Mean Flow	Canopy	Fines	Gravel
EPT Index (%)	-0.125	-0.081	0.34	0.306	-0.790*	0.794*
	0.6094	0.7427	0.1543	0.2023	0.0001	<0.0001
EPT Taxa	-0.212	-0.105	0.444	-0.041	-0.799*	0.755*
	0.3836	0.6698	0.0571	0.8669	<0.0001	0.0002
Number Trichoptera Taxa	-0.115	-0.063	0.596*	0.089	-0.638*	0.610*
	0.6384	0.7981	0.0071	0.7183	0.0033	0.0055
Percent Baetidae	-0.422	-0.196	0.34	-0.063	-0.811*	0.730*
	0.0719	0.4207	0.1541	0.7965	<0.0001	0.0004
Percent Chironomidae	-0.349	-0.691*	-0.227	0.13	-0.022	-0.033
	0.1436	0.0011	0.3499	0.5961	0.929	0.8937
Percent Collector-Filterers	0.427	0.4	0.14	0.102	0.122	-0.085
	0.068	0.09	0.5673	0.6775	0.6202	0.7281
Percent Collectors-Gatherers	-0.476*	-0.494*	-0.046	0.061	0.024	-0.07
	0.0395	0.0316	0.8503	0.8046	0.9216	0.7761
Percent Dominant Taxon	0.072	0.419	0.42	-0.131	0.033	0.005
	0.768	0.0744	0.0737	0.5931	0.8922	0.9852
Percent Hydropsychidae	-0.118	-0.067	0.476*	0.344	-0.526*	0.501*
	0.6311	0.7853	0.0392	0.1495	0.0207	0.0288
Percent Intolerant Taxa (0-2)	-0.054	0.135	0.12	-0.39	-0.325	0.349
	0.8257	0.5805	0.6242	0.0986	0.1743	0.1425
Percent Predators	0.281	-0.119	-0.065	0.379	-0.136	0.1
	0.2437	0.6287	0.793	0.1098	0.5785	0.6823

Table 21. - continued.

Benthic Metric	Width	Depth	Mean Flow	Canopy	Fines	Gravel
Percent Scrapers	0.17	0.251	-0.425	-0.301	0.331	-0.34
	0.4863	0.3	0.0693	0.2097	0.1657	0.1542
Percent Shredders	-0.151	-0.043	0.368	0.114	-0.202	0.179
	0.5379	0.861	0.1207	0.6428	0.4079	0.4629
Percent Tolerant Taxa (8-10)	0.302	0.05	-0.492*	-0.045	0.824*	-0.799*
	0.2087	0.8387	0.0324	0.8563	<0.0001	<0.0001
Sensitive EPT Index (%)	-0.049	-0.099	-0.091	-0.331	-0.534*	0.552*
	0.8408	0.6873	0.7106	0.1667	0.0184	0.0144
Shannon Diversity	0.107	-0.338	-0.356	0.197	-0.097	0.039
	0.6643	0.1575	0.1346	0.4184	0.6927	0.8743
Taxonomic Richness	0.011	-0.121	0.009	-0.103	-0.236	0.156
	0.9629	0.6219	0.9713	0.6743	0.3317	0.5225
Tolerance Value	-0.247	-0.082	-0.241	-0.13	0.442	-0.453
	0.3084	0.7382	0.3197	0.5959	0.0583	0.0514

* p-value <= 0.05

Table 22. Comparison of individual water quality measurements for sites sampled over the last five (Del Puerto Creek and Salt Slough) and six (Orestimba Creek) years.

	Temperature (C)						Specific Conductance (µmhos/L)						pH					
Site	2005	2004	2003	2002	2001	2000	2005	2004	2003	2002	2001	2000	2005	2004	2003	2002	2001	2000
DLP1	15.0	23.2	22.9	15.6	20.2	n/a	396.7	1179	1199	704	910	n/a	7.46	8.44	8.62	8.06	8.17	n/a
DLP2	17.3	25.6	25.6	20.6	23.7	n/a	426.4	1165	1336	709	900	n/a	7.74	8.53	8.82	8.58	-	n/a
DLP3	18.8	25.3	24.1	22.2	30.5	n/a	446.5	1254	1143	742	1086	n/a	8.58	8.53	8.12	8.34	8.51	n/a
DLP4	26.3	23.2	31.4	28.3	18.2	n/a	489	649	564	520	628	n/a	9.29	8.47	8.50	7.55	8.05	n/a
DLP5	22.9	20.6	18.7	22.7	22.1	n/a	940	1738	1287	1689	992	n/a	8.65	8.10	8.30	8.51	8.32	n/a
ORE1	18.9	17.0	18.7	18.1	18.8	21.5	560	761	659	663	648	754	7.80	7.86	7.28	7.80	7.96	8.01
ORE2	20.6	17.0	20.3	19.9	20.3	22.5	550	717	644	605	662	744	7.91	7.92	8.01	8.01	8.12	8.23
ORE3	18.7	21.9	22.7	21.1	20.3	23.0	510	824	672	653	675	739	7.89	7.93	8.10	8.12	7.86	8.18
ORE4	18.8	20.9	22.1	21.0	21.4	21.4	485	806	653	640	334	683	7.91	7.96	7.98	8.09	8.17	8.01
ORE5	18.8	17.0	20.4	18.8	22.8	22.0	510	712	596	656	636	654	7.92	7.81	7.15	8.06	8.08	8.1
ORE6	18.3	18.7	21.8	18.7	24.7	22.9	810	689	681	696	584	644	8.05	7.80	7.01	8.21	7.8	8.25
ORE7	19.5	18.2	24.4	20.1	19.5	29.5	830	892	745	711	663	620	8.02	7.62	7.73	8.14	8.04	8.48
ORE8	20.6	26.9	25.0	22.6	21.6	22.9	780	901	755	763	695	840	8.01	7.79	7.89	8.08	7.87	8.21
ORE9	-	20.1	28.5	23.1	30.3	27.7	-	937	933	697	1000	857	-	8.22	7.91	8.13	8.59	8.4
ORE10	21.4	21.6	21.9	18.1	27.1	27.4	670	798	780	825	1044	878	8.41	7.76	7.88	8.25	8.37	8.37
SSL1	19.2	24.6	28.6	18.5	22.1	n/a	1270	1606	1957	1885	989	n/a	7.64	7.73	7.68	7.69	7.62	n/a
SSL2	20.4	21.9	26.1	19.3	22.1	n/a	1190	1450	1844	1339	1011	n/a	7.51	7.60	7.37	7.43	7.73	n/a
SSL3	21.8	23.2	27.4	20.8	24.5	n/a	1160	1435	1616	1256	495	n/a	7.56	7.56	7.51	7.56	7.74	n/a
SSL4	21.9	18.9	24.6	23.5	20.6	n/a	990	951	1139	1073	542	n/a	7.59	7.59	7.35	7.75	7.30	n/a
SSL5	26.4	15.9	22.6	18.0	23.2	n/a	2490	2148	956	1473	552	n/a	8.04	7.39	6.96	7.37	7.37	n/a

Table 22. - continued.

	Dissolved Oxygen (mg/L)						Salinity (ppt)						Turbidity (NTU)					
Site	2005	2004	2003	2002	2001	2000	2005	2004	2003	2002	2001	2000	2005	2004	2003	2002	2001	2000
DLP1	9.81	8.28	9.19	9.5	9	n/a	0.2	0.6	-	0.4	0.4	-	116	81.3	3.33	84	103	n/a
DLP2	9.48	7.93	9.19	8.8	5.9	n/a	0.2	0.6	-	0.4	0.5	-	109	135	1.70	130	59	n/a
DLP3	10.47	7.43	8.06	9.1	4.7	n/a	0.2	0.6	-	0.4	0.5	-	80.5	64.5	1.93	112	25	n/a
DLP4	14.9	9.91	6.35	5.4	4.5	n/a	0.3	0.3	-	0.2	0.4	-	70.2	13.5	6.5	20	56	n/a
DLP5	9.10	10.06	8.24	12.2	4.0	n/a	0.2	0.9	-	0.9	0.5	-	0.56	1.13	1.53	1.1	0.64	n/a
ORE1	8.81	7.33	6.92	7.6	8.4	6.7	0.2	0.4	-	0.4	0.4	-	45.4	213	109.7	376	142	115
ORE2	8.55	7.91	7.90	7.8	5.0	8.2	0.2	0.4	-	0.3	0.4	-	85.6	249	102.8	207	126	158
ORE3	9.17	6.97	7.70	8.1	4.9	7.5	0.1	0.4	-	0.3	0.4	-	134	215	119	153	142	156
ORE4	9.09	7.48	7.72	8.3	4.2	7.8	0.1	0.4	-	0.3	0.2	-	137	267	135.6	226	104	107
ORE5	8.54	7.48	6.86	7.6	4.3	8.1	0.1	0.4	-	0.4	0.3	-	123	254	130	201	110	107
ORE6	8.19	7.58	7.14	8.1	4.0	8.9	0.4	0.4	-	0.4	0.3	-	152	270	99.7	178	128	131
ORE7	8.52	7.24	7.99	8.4	4.2	8.9	0.5	0.5	-	0.4	0.4	-	116	384	71.2	166	136	153
ORE8	8.28	6.46	7.07	7.9	3.3	8.2	0.3	0.4	-	0.4	0.4	-	110	656	116	150	92	80
ORE9	-	8.18	5.78	8.0	4.0	7.8	-	0.5	-	0.4	0.4	-	-	18.6	144	236	108	213
ORE10	10.0	6.52	7.18	3.2	4.8	13.0	0.2	0.2	-	0.1	0.5	-	0.44	0.26	0.07	0.88	0.82	0.51
SSL1	7.12	7.26	5.37	6.4	2.8	n/a	0.9	0.8	-	0.9	0.5	-	68.4	36.3	43.1	46	61	n/a
SSL2	6.62	7.07	5.12	6.0	3.2	n/a	0.9	0.8	-	0.8	0.5	-	74.3	49.7	80.1	41	78	n/a
SSL3	7.17	7.88	5.25	6.7	2.8	n/a	0.4	0.7	-	0.7	0.3	-	90.2	58.4	66.4	52	68	n/a
SSL4	7.57	6.81	5.44	7.4	2.9	n/a	0.2	0.5	-	0.6	0.3	-	70.3	56.1	60.3	52	65	n/a
SSL5	10.41	6.08	4.06	4.8	2.7	n/a	1.3	1.3	-	0.7	0.3	-	48.5	13.1	78.6	37	80	n/a

Table 23. Comparison of individual physical habitat metrics (0-20 scale) and total scores for sites sampled over the last five (Del Puerto Creek and Salt Slough) or six (Orestimba Creek) years.

Site & Date	Epifaunal Substrate						Embeddedness						Velocity Depth/Diversity						Sediment Deposition					
	00	01	02	03	04	05	00	01	02	03	04	05	00	01	02	03	04	05	00	01	02	03	04	05
DLP1	n/a	9	10	13	15	12	n/a	7	8	12	13	10	n/a	16	17	16	11	11	n/a	14	12	15	14	10
DLP2	n/a	7	11	13	11	11	n/a	7	7	12	10	11	n/a	14	10	15	15	15	n/a	16	12	14	10	15
DLP3	n/a	6	10	12	10	11	n/a	5	4	6	9	13	n/a	7	10	9	10	15	n/a	7	12	11	10	13
DLP4	n/a	2	9	10	11	1	n/a	10	4	8	7	0	n/a	5	10	10	5	0	n/a	6	6	10	11	5
DLP5	n/a	10	3	13	6	12	n/a	11	16	13	5	16	n/a	13	3	9	5	10	n/a	11	13	11	11	15
ORE1	6	13	9	15	6	11	4	6	0	1	2	1	7	13	6	6	14	6	4	6	1	5	1	6
ORE2	10	14	10	7	11	13	13	11	13	10	4	3	10	16	9	10	13	6	5	10	14	9	3	5
ORE3	14	15	11	10	11	11	14	16	15	13	13	6	10	18	10	9	10	15	15	16	10	10	10	8
ORE4	15	12	8	11	12	10	14	16	14	8	13	8	17	19	10	10	10	9	16	15	16	13	14	10
ORE5	17	16	10	10	10	10	13	15	7	8	9	10	19	19	17	8	10	10	15	9	14	12	13	12
ORE6	10	13	7	6	12	11	11	16	9	8	12	10	13	16	5	9	10	10	10	13	16	11	13	13
ORE7	8	10	8	12	13	13	13	16	10	8	12	10	12	18	10	10	10	10	14	16	17	15	13	12
ORE8	13	11	9	9	11	8	11	15	7	7	9	8	10	15	16	14	10	10	14	15	16	12	12	10
ORE9	14	10	11	10	2	-	14	12	9	6	13	-	10	14	10	6	10	-	14	5	16	8	16	-
ORE10	10	7	8	10	6	12	7	6	14	10	8	13	13	7	3	10	4	10	12	5	8	13	11	14
SSL1	n/a	8	2	5	6	7	n/a	1	0	0	0	0	n/a	11	11	9	16	11	n/a	4	2	1	2	5
SSL2	n/a	5	1	6	6	5	n/a	1	0	0	1	0	n/a	12	13	6	6	11	n/a	5	2	6	2	4
SSL3	n/a	2	1	6	7	3	n/a	1	0	0	0	0	n/a	11	9	9	9	13	n/a	4	2	4	3	3
SSL4	n/a	6	6	8	7	4	n/a	0	0	0	1	0	n/a	12	6	7	6	14	n/a	2	3	5	1	1
SSL5	n/a	2	6	2	7	2	n/a	0	0	0	0	0	n/a	2	0	1	0	0	n/a	1	3	1	0	0

Table 23. - continued.

Site & Date	Channel Flow Status						Channel Alteration						Frequency Bends/Riffles						Left Bank Stability					
	00	01	02	03	04	05	00	01	02	03	04	05	00	01	02	03	04	05	00	01	02	03	04	05
DLP1	n/a	19	14	16	15	20	n/a	15	14	15	15	14	n/a	18	15	15	13	11	n/a	7	5	5	6	7
DLP2	n/a	16	15	16	15	19	n/a	12	8	10	13	11	n/a	7	12	10	7	11	n/a	2	3	4	6	7
DLP3	n/a	15	16	14	15	18	n/a	13	14	14	11	11	n/a	7	14	11	10	13	n/a	6	7	8	6	6
DLP4	n/a	8	8	6	11	4	n/a	2	11	6	11	0	n/a	2	8	6	8	0	n/a	5	6	5	7	0
DLP5	n/a	9	7	14	8	20	n/a	17	16	17	16	20	n/a	15	9	11	11	10	n/a	7	7	8	6	7
ORE1	16	17	14	14	8	19	18	16	14	16	15	14	5	15	4	5	7	6	1	8	6	5	5	5
ORE2	15	20	16	14	16	19	18	15	15	13	13	15	17	12	11	8	10	0	1	5	6	6	5	3
ORE3	19	20	14	16	16	13	15	15	8	7	13	9	18	15	7	6	7	11	7	3	3	3	5	3
ORE4	15	20	10	16	10	9	15	14	14	16	13	11	10	11	6	10	9	12	5	4	4	6	6	6
ORE5	15	15	15	16	16	9	15	15	14	14	14	13	18	16	16	11	15	11	7	6	7	6	6	6
ORE6	15	15	19	16	13	15	14	14	13	11	12	15	8	15	15	9	11	13	8	8	8	8	7	4
ORE7	11	20	18	16	16	14	15	15	14	15	15	15	10	16	7	12	13	14	4	8	7	7	8	8
ORE8	10	20	19	13	15	14	13	13	14	13	15	14	15	10	11	13	11	10	7	8	4	5	2	5
ORE9	15	20	9	9	6	-	15	15	15	13	11	-	10	15	9	10	4	-	9	8	7	3	6	-
ORE10	9	6	6	14	7	17	19	15	13	12	12	16	16	13	11	12	8	16	7	5	4	3	4	4
SSL1	n/a	20	13	14	16	20	n/a	15	14	16	16	17	n/a	15	7	4	7	5	n/a	7	5	3	2	5
SSL2	n/a	19	14	19	18	20	n/a	16	15	16	16	18	n/a	7	1	5	4	4	n/a	9	8	10	7	9
SSL3	n/a	19	11	15	16	20	n/a	14	14	15	14	14	n/a	8	2	5	2	4	n/a	8	6	6	6	8
SSL4	n/a	20	13	19	16	18	n/a	15	13	13	12	15	n/a	11	5	6	2	2	n/a	5	2	0	1	2
SSL5	n/a	18	9	15	16	16	n/a	6	0	2	2	6	n/a	6	0	0	0	0	n/a	1	0	0	1	0

Table 23. - continued.

Site & Date	Right Bank Stability						Left Bank Veget. Protect						Right Bank Veget. Protect.						Left Bank Ripar. Zone					
	00	01	02	03	04	05	00	01	02	03	04	05	00	01	02	03	04	05	00	01	02	03	04	05
DLP1	n/a	8	5	6	7	7	n/a	7	3	5	8	7	n/a	8	4	5	8	7	n/a	5	1	2	5	4
DLP2	n/a	2	3	2	4	0	n/a	2	3	4	7	6	n/a	2	3	1	3	0	n/a	1	1	3	3	3
DLP3	n/a	4	7	6	6	6	n/a	6	7	5	5	6	n/a	6	7	3	5	6	n/a	3	4	3	2	3
DLP4	n/a	3	7	4	7	1	n/a	5	4	3	6	1	n/a	3	4	3	6	1	n/a	4	1	2	1	1
DLP5	n/a	9	7	8	4	7	n/a	7	5	5	3	4	n/a	7	5	4	3	4	n/a	8	6	6	7	5
ORE1	1	2	3	4	2	1	2	9	6	6	6	5	2	7	6	6	4	4	5	8	4	6	6	5
ORE2	1	6	6	6	5	3	2	9	6	6	6	5	2	9	6	6	6	5	5	8	5	5	6	4
ORE3	7	6	7	3	5	2	6	6	4	3	7	5	6	4	7	6	6	3	3	3	1	2	5	3
ORE4	5	2	2	3	4	4	4	5	3	4	6	6	4	3	3	4	6	6	4	3	2	3	6	5
ORE5	6	5	7	6	5	5	9	8	7	6	6	7	8	8	7	6	6	8	8	5	4	6	5	5
ORE6	8	8	8	7	7	7	9	6	6	6	6	4	8	5	6	6	6	6	6	3	5	5	5	3
ORE7	5	6	6	6	6	7	6	6	7	6	3	6	9	9	7	8	4	8	3	3	4	4	3	5
ORE8	9	8	6	7	5	5	7	6	7	5	5	6	7	6	7	6	5	6	6	3	4	2	2	3
ORE9	9	8	8	3	6	-	8	7	7	3	4	-	8	7	7	3	4	-	7	5	3	3	4	-
ORE10	7	6	4	2	4	4	3	4	4	1	2	4	3	3	4	1	2	4	3	3	6	3	3	5
SSL1	n/a	6	3	3	6	6	n/a	8	6	3	3	7	n/a	6	6	3	6	7	n/a	9	8	6	6	8
SSL2	n/a	9	8	6	7	8	n/a	7	7	8	8	8	n/a	7	7	6	4	6	n/a	9	8	10	8	8
SSL3	n/a	8	6	7	6	7	n/a	6	7	6	7	7	n/a	6	7	6	7	6	n/a	8	4	3	2	3
SSL4	n/a	6	7	6	6	6	n/a	4	4	3	3	6	n/a	4	6	7	4	7	n/a	3	4	1	1	3
SSL5	n/a	1	0	0	1	0	n/a	1	0	0	1	0	n/a	1	0	0	1	0	n/a	0	0	1	1	0

Table 23. - continued.

Site & Date	Right Bank Ripar. Zone						Total Score					
	00	01	02	03	04	05	00	01	02	03	04	05
DLP1	n/a	7	3	3	5	4	n/a	140	111	128	136	124
DLP2	n/a	1	1	3	3	0	n/a	89	89	107	105	109
DLP3	n/a	4	4	4	2	3	n/a	89	116	106	101	124
DLP4	n/a	4	1	2	1	1	n/a	59	79	75	91	15
DLP5	n/a	8	6	5	7	5	n/a	132	103	124	90	135
ORE1	3	8	4	3	6	4	74	128	77	92	80	87
ORE2	5	6	3	3	6	3	104	141	120	103	101	84
ORE3	3	3	4	4	5	3	137	140	101	92	113	92
ORE4	5	3	2	5	6	3	129	127	94	109	114	99
ORE5	8	5	3	5	5	4	158	142	128	114	119	110
ORE6	4	2	4	3	5	3	124	134	121	105	119	114
ORE7	6	6	4	5	3	6	116	149	119	124	119	128
ORE8	6	3	5	4	2	3	128	133	125	110	105	102
ORE9	8	5	5	3	4	-	141	131	116	80	90	-
ORE10	3	3	6	3	3	5	112	83	91	94	74	124
SSL1	n/a	9	8	3	6	7	n/a	119	85	70	93	105
SSL2	n/a	9	8	8	8	8	n/a	115	92	106	93	109
SSL3	n/a	5	5	5	2	5	n/a	100	74	87	84	93
SSL4	n/a	3	4	6	1	5	n/a	91	73	81	64	83
SSL5	n/a	0	0	1	1	0	n/a	39	18	23	31	24

Table 24a. Mean scores for each physical habitat metric, total score, and stream measurement for years 2000 through 2005 for Orestimba Creek. The p-value is based on Friedman's test and the pairwise comparisons are based on the Wilcoxon signed rank test.

Habitat Metric	2000	2001	2002	2003	2004	2005	Friedman p-value	00 vs 01	00 vs 02	00 vs 03	00 vs 04	00 vs 05	01 vs 02	01 vs 03	01 vs 04	01 vs 05	02 vs 03	02 vs 04	02 vs 05	03 vs 04	03 vs 05	04 vs 05
EPI SUB	11.7	12.1	9.1	10.0	9.4	11.0	0.1140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EMBEDD	11.4	12.9	9.8	7.9	9.5	7.7	0.0017*	-	-	*	*	*	-	*	*	*	*	-	-	-	-	-
VEL DPTH	12.1	15.5	9.6	9.2	10.1	9.6	0.0009*	-	-	-	-	-	*	*	*	*	-	-	-	-	-	-
SED DEP	11.9	11.0	12.8	10.8	10.6	10.0	0.1970	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CH FLOW	14.0	17.3	14.0	14.4	12.3	14.3	0.2071	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHAN ALT	15.7	14.7	13.4	13.0	13.3	13.6	0.0245*	-	*	*	*	*	-	-	*	-	-	-	-	-	-	-
BEN RIFF	12.7	13.8	9.7	9.6	9.5	10.3	0.0414*	-	-	-	-	-	*	*	*	-	-	-	-	-	-	-
BANK STAB	11.4	12.0	11.3	9.9	10.3	9.1	0.3553	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BANK VEG	11.3	12.7	11.7	9.8	10.0	10.9	0.2388	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RIP BUFF	10.1	8.8	7.8	7.7	8.4	8.0	0.3486	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	122.3	130.8	109.2	102.3	103.4	104.4	0.0047*	-	-	*	*	-	*	*	*	-	-	-	-	-	-	-
WIDTH	3.9	6.2	4.6	4.5	4.4	6.9	0.0603	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DEPTH	0.2	0.5	0.2	0.2	0.2	0.1	0.0022*	*	-	-	-	*	*	*	*	*	-	-	*	-	*	*
CANOPY	32.9	28.9	50.1	31.2	26.2	37.7	0.4658	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* p-value <= 0.05
- p-value > 0.05

Table 24b. Mean scores for each physical habitat metric, total score, and stream measurement for years 2001 through 2005 for Del Puerto Creek. The p-value is based on Friedman's test and the pairwise comparisons are based on the Wilcoxon signed rank test.

Habitat Metric	2001	2002	2003	2004	2005	Friedman p-value	01 vs 02	01 vs 03	01 vs 04	01 vs 05	02 vs 03	02 vs 04	02 vs 05	03 vs 04	03 vs 05	04 vs 05
EPI SUB	6.8	8.6	12.2	10.6	9.4	0.0257*	-	-	-	-	-	-	-	-	-	-
EMBEDD	8.0	7.8	10.2	8.8	10.0	0.3791	-	-	-	-	-	-	-	-	-	-
VEL DPTH	11.0	10.0	11.8	9.2	10.2	0.9562	-	-	-	-	-	-	-	-	-	-
SED DEP	10.8	11.0	12.2	11.2	11.6	0.9484	-	-	-	-	-	-	-	-	-	-
CH FLOW	13.4	12.0	13.2	12.8	16.2	0.2830	-	-	-	-	-	-	-	-	-	-
CHAN ALT	11.8	12.6	12.4	13.2	11.2	0.7521	-	-	-	-	-	-	-	-	-	-
BEN RIFF	9.8	11.6	10.6	9.8	9.0	0.6671	-	-	-	-	-	-	-	-	-	-
BANK STAB	10.6	11.4	11.2	11.8	9.6	0.9545	-	-	-	-	-	-	-	-	-	-
BANK VEG	10.6	9.0	7.6	10.8	8.4	0.4346	-	-	-	-	-	-	-	-	-	-
RIP BUFF	9.0	5.6	6.6	6.4	5.8	0.4530	-	-	-	-	-	-	-	-	-	-
TOTAL	101.8	99.6	108.0	104.6	101.4	0.8275	-	-	-	-	-	-	-	-	-	-
WIDTH	2.2	2.9	2.3	2.9	3.1	0.3413	-	-	-	-	-	-	-	-	-	-
DEPTH	0.4	0.1	0.2	0.2	0.2	0.1187	-	-	-	-	-	-	-	-	-	-
CANOPY	15.2	24.8	26.4	14.6	18.4	0.4637	-	-	-	-	-	-	-	-	-	-

* p-value <= 0.05
- p-value > 0.05

Table 24c. Mean scores for each physical habitat metric, total score, and stream measurement for years 2001 through 2005 for Salt Slough Creek. The p-value is based on Friedman's test and the pairwise comparisons are based on the Wilcoxon signed rank test.

Habitat Metric	2001	2002	2003	2004	2005	Friedman p-value	01 vs 02	01 vs 03	01 vs 04	01 vs 05	02 vs 03	02 vs 04	02 vs 05	03 vs 04	03 vs 05	04 vs 05
EPI SUB	4.6	3.2	5.4	6.6	4.2	0.1163	-	-	-	-	-	-	-	-	-	-
EMBEDD	0.6	0.0	0.0	0.4	0.0	0.0639	-	-	-	-	-	-	-	-	-	-
VEL DPTH	9.6	7.8	6.4	7.4	9.8	0.2533	-	-	-	-	-	-	-	-	-	-
SED DEP	3.2	2.4	3.4	1.6	2.6	0.2282	-	-	-	-	-	-	-	-	-	-
CH FLOW	19.2	12.0	16.4	16.4	18.8	0.0036*	-	-	-	-	-	-	-	-	-	-
CHAN ALT	13.2	11.2	12.4	12.0	14.0	0.0392*	-	-	-	-	-	-	-	-	-	-
BEN RIFF	9.4	3.0	4.0	3.0	3.0	0.0126*	-	-	-	-	-	-	-	-	-	-
BANK STAB	12.0	9.0	8.2	8.6	10.2	0.0144*	-	-	-	-	-	-	-	-	-	-
BANK VEG	10.0	10.0	8.4	8.8	10.8	0.5893	-	-	-	-	-	-	-	-	-	-
RIP BUFF	11.0	9.8	8.8	8.2	9.4	0.3885	-	-	-	-	-	-	-	-	-	-
TOTAL	92.8	68.4	73.4	73.0	82.8	0.0032*	-	-	-	-	-	-	-	-	-	-
WIDTH	20.8	19.0	17.9	17.0	20.2	0.0436*	-	-	-	-	-	-	-	-	-	-
DEPTH	0.8	0.6	0.5	0.4	0.4	0.0510	-	-	-	-	-	-	-	-	-	-
CANOPY	0.2	0.0	0.0	1.8	0.0	0.5578	-	-	-	-	-	-	-	-	-	-

* p-value <= 0.05
- p-value > 0.05

Table 25. Range of chlorpyrifos and diazinon concentrations measured historically in Del Puerto Creek, Orestimba Creek and Salt Slough.

OP Pesticide	Location	Range Conc (ng/L)	Years	Reference
Chlorpyrifos	Del Puerto Creek	0 - 120	1991/93	Poletika, 2001
Chlorpyrifos	Orestimba Creek	0 - 2,282	1996/97	Poletika and Robb, 1998
Chlorpyrifos	Salt Slough	0 - 120	1991/93	Poletika, 2001
Diazinon	Del Puerto Creek	0 - 2,600	1991/93	Poletika, 2001
Diazinon	Orestimba Creek	0 - 29,371	1996/97	Poletika and Robb, 1998
Diazinon	Salt Slough	0 - 330	1991/93	Poletika, 2001

Table 26. Comparison of resident benthic species by site in Del Puerto Creek, Orestimba Creek and Salt Slough with acute chlorpyrifos toxicity data from Giesy et al. 1999 and Barron and Woodburn 1995.

Species	Collection Site	Abundance	EC or LC50 Values (μg/L)
Hydropsyche californica	DLP 5	3	30.6[A]
Hydropsyche californica	ORE 3	39	30.6[A]
Hydropsyche californica	ORE 4	567	30.6[A]
Hydropsyche californica	ORE 5	439	30.6[A]
Hydropsyche californica	ORE 6	78	30.6[A]
Hydropsyche californica	ORE 7	54	30.6[A]
Hydropsyche californica	ORE 8	15	30.6[A]
Hydropsyche californica	SSL 2	12	30.6[A]
Hydropsyche californica	SSL 3	14	30.6[A]
Chironomus sp.	DLP 1	62	0.07[B]
Chironomus sp.	DLP 2	2	0.07[B]
Chironomus sp.	DLP 3	4	0.07[B]
Chironomus sp.	DLP 4	111	0.07[B]
Chironomus sp.	ORE 1	89	0.07[B]
Chironomus sp.	SSL 1	4	0.07[B]
Chironomus sp.	SSL 2	1	0.07[B]
Chironomus sp.	SSL 3	1	0.07[B]
Chironomus sp.	SSL 4	131	0.07[B]
Chironomus sp.	SSL 5	74	0.07[B]
Cricotopus sp.	DLP 1	153	3.5-90
Cricotopus sp.	DLP 2	45	3.5-90
Cricotopus sp.	DLP 3	41	3.5-90
Cricotopus sp.	DLP 4	173	3.5-90
Cricotopus sp.	DLP 5	41	3.5-90
Cricotopus sp.	ORE 1	16	3.5-90
Cricotopus sp.	ORE 2	23	3.5-90

Table 26. - continued.

Cricotopus sp.	ORE 3	13	3.5-90
Cricotopus sp.	ORE 4	14	3.5-90
Cricotopus sp.	ORE 5	39	3.5-90
Cricotopus sp.	ORE 6	289	3.5-90
Cricotopus sp.	ORE 7	465	3.5-90
Cricotopus sp.	ORE 8	603	3.5-90
Cricotopus sp.	ORE 10	164	3.5-90
Cricotopus sp.	SSL 1	27	3.5-90
Cricotopus sp.	SSL 2	27	3.5-90
Cricotopus sp.	SSL 3	45	3.5-90
Cricotopus sp.	SSL 4	52	3.5-90
Cricotopus sp.	SSL 5	194	3.5-90
Dicrotendipes sp.	DLP 1	19	7-40[C]
Dicrotendipes sp.	DLP 2	1	7-40[C]
Dicrotendipes sp.	DLP 3	17	7-40[C]
Dicrotendipes sp.	DLP 4	2	7-40[C]
Dicrotendipes sp.	ORE 1	19	7-40[C]
Dicrotendipes sp.	ORE 2	7	7-40[C]
Dicrotendipes sp.	ORE 3	1	7-40[C]
Dicrotendipes sp.	ORE 6	2	7-40[C]
Dicrotendipes sp.	ORE 7	1	7-40[C]
Dicrotendipes sp.	ORE 8	1	7-40[C]
Dicrotendipes sp.	ORE 10	29	7-40[C]
Dicrotendipes sp.	SSL 2	1	7-40[C]
Dicrotendipes sp.	SSL 3	1	7-40[C]
Dicrotendipes sp.	SSL 4	3	7-40[C]
Dicrotendipes sp.	SSL 5	10	7-40[C]
Dugesia tigrina	DLP 3	2	2.0-4.3[D]

Table 26. - continued.

Gammarus sp.	ORE 1	2	0.11^{E}
Gammarus sp.	ORE 3	13	0.11^{E}
Gammarus sp.	ORE 4	9	0.11^{E}
Gammarus sp.	ORE 5	17	0.11^{E}
Gammarus sp.	ORE 6	2	0.11^{E}
Gammarus sp.	SSL 1	13	0.11^{E}
Gammarus sp.	SSL 2	43	0.11^{E}
Gammarus sp.	SSL 3	127	0.11^{E}
Hyalella sp.	DLP 1	2	1.3
Hyalella sp.	DLP 2	1	1.3
Hyalella sp.	DLP 5	29	1.3
Hyalella sp.	ORE 1	36	1.3
Hyalella sp.	ORE 2	39	1.3
Hyalella sp.	ORE 5	9	1.3
Hyalella sp.	ORE 6	1	1.3
Hyalella sp.	ORE 7	2	1.3
Hyalella sp.	SSL 2	102	1.3
Hyalella sp.	SSL 4	1	1.3
Hyalella sp.	SSL 5	1	1.3
Ischnura sp.	DLP 1	2	11.4^{F}
Ischnura sp.	ORE 1	1	11.4^{F}
Ischnura sp.	ORE 2	1	11.4^{F}
Ischnura sp.	SSL 2	1	11.4^{F}
Ischnura sp.	SSL 5	1	11.4^{F}
Limnodrilus hoffmeisteri	DLP 4	1	>36
Limnodrilus hoffmeisteri	ORE 1	5	>36
Limnodrilus hoffmeisteri	ORE 5	1	>36
Limnodrilus hoffmeisteri	SSL 1	7	>36

Table 26. - continued.

Limnodrilus hoffmeisteri	SSL 2	2	>36
Limnodrilus hoffmeisteri	SSL 3	4	>36
Limnodrilus hoffmeisteri	SSL 5	5	>36
Paratanytarsus sp.	DLP 1	1	<1.6
Paratanytarsus sp.	DLP 2	1	<1.6
Paratanytarsus sp.	DLP 4	16	<1.6
Paratanytarsus sp.	DLP 5	1	<1.6
Paratanytarsus sp.	ORE 1	154	<1.6
Paratanytarsus sp.	ORE 2	14	<1.6
Paratanytarsus sp.	ORE 3	2	<1.6
Paratanytarsus sp.	ORE 4	1	<1.6
Paratanytarsus sp.	SSL 1	11	<1.6
Paratanytarsus sp.	SSL 2	18	<1.6
Paratanytarsus sp.	SSL 3	1	<1.6
Paratanytarsus sp.	SSL 4	6	<1.6
Paratanytarsus sp.	SSL 5	205	<1.6
Simulium sp.	DLP 1	17	27[G]
Simulium sp.	DLP 2	439	27[G]
Simulium sp.	DLP 3	206	27[G]
Simulium sp.	DLP 5	113	27[G]
Simulium sp.	ORE 2		27[G]
Simulium sp.	ORE 3	8	27[G]
Simulium sp.	ORE 4	5	27[G]
Simulium sp.	ORE 5	18	27[G]
Simulium sp.	ORE 6		27[G]
Simulium sp.	ORE 7	48	27[G]
Simulium sp.	ORE 8	7	27[G]
Simulium sp.	ORE 10	16	27[G]

Table 26. - continued.

Simulium sp.	SSL 3	6	27[G]
Simulium sp.	SSL 4	12	27[G]
Tanypus sp.	SSL 4	1	1.5[H]

[A] Listed toxicity value was for *Hydropsyche/Cheumatopsyche sp.*
[B] Listed toxicity value was for *Chironomus tentans.*
[C] Listed toxicity value was for *Dicrotendipes californicus.*
[D] Listed toxicity value was for *Dugesia dorotocephala.*
[E] Listed toxicity value was for *Gammarus lacustris*. Two values listed for this species. Used conservative value, other value = 0.76 µg/L.
[F] Listed toxicity value was for *Enallagma/Ischnura sp.*
[G] Listed toxicity value was for *Simulium vitattum.*
[H] Listed toxicity value was for *Tanypus grodhaus*

Table 27. Comparison of resident benthic species by site in Del Puerto Creek, Orestimba Creek and Salt Slough with acute diazinon toxicity data from Giddings et al. 2000.

Species	Collection Site	Abundance	EC or LC50 Values (µg/L)
Baetis adonis	DLP 5	85	24[A]
Baetis adonis	ORE 10	5	24[A]
Gammarus sp.	ORE 1	2	184[B]
Gammarus sp.	ORE 3	13	184[B]
Gammarus sp.	ORE 4	9	184[B]
Gammarus sp.	ORE 5	17	184[B]
Gammarus sp.	ORE 6	2	184[B]
Gammarus sp.	SSL 1	13	184[B]
Gammarus sp.	SSL 2	43	184[B]
Gammarus sp.	SSL 3	127	184[B]
Hyalella sp.	DLP 1	2	22[C]
Hyalella sp.	DLP 2	1	22[C]
Hyalella sp.	DLP 5	29	22[C]
Hyalella sp.	ORE 1	36	22[C]
Hyalella sp.	ORE 2	39	22[C]
Hyalella sp.	ORE 5	9	22[C]
Hyalella sp.	ORE 6	1	22[C]
Hyalella sp.	ORE 7	2	22[C]
Hyalella sp.	SSL 2	102	22[C]
Hyalella sp.	SSL 4	1	22[C]
Hyalella sp.	SSL 5	1	22[C]
Physa sp.	DLP 1	24	48[D]
Physa sp.	DLP 2	38	48[D]
Physa sp.	DLP 3	27	48[D]
Physa sp.	DLP 4	184	48[D]
Physa sp.	DLP 5	194	48[D]
Physa sp.	ORE 1	19	48[D]
Physa sp.	ORE 2	19	48[D]
Physa sp.	ORE 3	7	48[D]

Table 27. - continued.

Physa sp.	ORE 4		48[D]
Physa sp.	ORE 5	9	48[D]
Physa sp.	ORE 6	6	48[D]
Physa sp.	ORE 7	13	48[D]
Physa sp.	ORE 10	30	48[D]
Physa sp.	SSL 1	234	48[D]
Physa sp.	SSL 2	41	48[D]
Physa sp.	SSL 3	6	48[D]
Physa sp.	SSL 4	129	48[D]
Physa sp.	SSL 5	92	4800[E]
Undetermined Tubificidae	DLP 1	4	3160[F]
Undetermined Tubificidae	DLP 2	36	3160[F]
Undetermined Tubificidae	DLP 3	20	3160[F]
Undetermined Tubificidae	DLP 4	59	3160[F]
Undetermined Tubificidae	DLP 5	7	3160[F]
Undetermined Tubificidae	ORE 1	27	3160[F]
Undetermined Tubificidae	ORE 2	5	3160[F]
Undetermined Tubificidae	ORE 3	8	3160[F]
Undetermined Tubificidae	ORE 4	7	3160[F]
Undetermined Tubificidae	ORE 5	83	3160[F]
Undetermined Tubificidae	ORE 6	80	3160[F]
Undetermined Tubificidae	ORE 7	18	3160[F]
Undetermined Tubificidae	ORE 8	4	3160[F]
Undetermined Tubificidae	SSL 1	38	3160[F]
Undetermined Tubificidae	SSL 2	3	3160[F]
Undetermined Tubificidae	SSL 3	4	3160[F]
Undetermined Tubificidae	SSL 4	14	3160[F]
Undetermined Tubificidae	SSL 5	46	3160[F]

[A] Listed toxicity value was for *Baetis intermedius.*
[B] Listed toxicity value was for *Gammarus lacustris.*
[C] Listed toxicity value was for *Hyalella azteca.*
[D] Listed toxicity value was for *Physa gyrina.*
[E] Listed toxicity value was for *Physa acuta.*
[F] Listed toxicity value was for *Tubifex* species.

Table 28a. Mean scores for each benthic metric by year for Orestimba Creek with p-values for among years means comparison and pairwise comparisons between years.

Benthic Metric	2000	2001	2002	2003	2004	2005	Friedman p-value	00 vs 01	00 vs 02	00 vs 03	00 vs 04	00 vs 05	01 vs 02	01 vs 03	01 vs 04
EPT Index (%)	2	4.2	1.4	2.8	8.3	20.8	0.0726	-	-	-	-	-	-	-	-
EPT Taxa	0.9	1	0.9	1.3	1.9	1.4	0.039	-	-	-	-	-	-	-	-
Percent Baetidae	.	2.3	0.2	0.6	0.1	2.3	0.1822	-	-	-	-	-	-	-	-
Percent Chironomidae	.	18.4	34.4	40.6	31.1	39.3	0.0711	-	-	-	-	-	-	-	-
Percent Collectors	75.8	56.6	35.4	69.6	54.1	54.6	0.0001	*	*	-	*	*	*	-	-
Percent Dominant Taxon	44.2	32.1	35.1	24.8	30.2	35.8	0.0114	-	-	*	-	-	-	-	-
Percent Filterers	7.1	16.4	30.9	10.5	17.1	27.3	0.0065	*	*	-	-	*	-	-	-
Percent Hydropsychidae	.	0.1	0.5	0.9	7.8	18.4	0.0207	-	-	-	-	-	-	-	-
Percent Intolerant Taxa (0-2)	0.3	0.2	0	0.3	0.7	0.9	0.2359	-	-	-	-	-	-	-	-
Percent Predators	7.1	10.4	13.8	4.3	14.1	11.5	0.4447	-	-	-	-	-	-	-	-
Percent Scrapers	.	.	.	11.1	12.4	3.6	0.1245	-	-	-	-	-	-	-	-
Percent Shredders	6.1	6.7	11.8	0	0	0	0	-	-	*	*	*	-	*	*
Percent Tolerant Taxa (8-10)	52.6	52.7	30.9	35.9	41.7	47.1	0.0392	-	-	-	-	-	-	*	-
Sensitive EPT Index (%)	0.4	0	0.2	0.9	0	1.9	0.4159	-	-	-	-	-	-	-	-
Shannon Diversity	1.8	2.3	2.2	2.4	2.6	2.1	0.0043	-	-	*	-	-	-	-	-
Taxonomic Richness	17.3	22.4	21.9	23.1	35.2	20.7	0.0027	*	-	*	*	-	-	-	*
Tolerance Value	6.8	6.8	6.7	7.1	6.7	6.5	0.4716	-	-	-	-	-	-	-	-
Trichoptera Taxa	0.3	0.4	0.5	0.6	1.3	2.2	0.0014	-	-	-	*	*	-	-	*

*p<0.05

Table 28a. – continued.

Benthic Metric	2000	2001	2002	2003	2004	2005	Friedman p-value	01 vs 05	02 vs 03	02 vs 04	02 vs 05	03 vs 04	03 vs 05	04 vs 05
EPT Index (%)	2	4.2	1.4	2.8	8.3	20.8	0.0726	-	-	-	-	-	-	-
EPT Taxa	0.9	1	0.9	1.3	1.9	1.4	0.039	-	-	-	-	-	-	-
Percent Baetidae	.	2.3	0.2	0.6	0.1	2.3	0.1822	-	-	-	-	-	-	-
Percent Chironomidae	.	18.4	34.4	40.6	31.1	39.3	0.0711	-	-	-	-	-	-	-
Percent Collectors	75.8	56.6	35.4	69.6	54.1	54.6	0.0001	-	*	*	*	-	*	-
Percent Dominant Taxon	44.2	32.1	35.1	24.8	30.2	35.8	0.0114	-	*	-	-	-	*	-
Percent Filterers	7.1	16.4	30.9	10.5	17.1	27.3	0.0065	-	*	*	-	-	-	-
Percent Hydropsychidae	.	0.1	0.5	0.9	7.8	18.4	0.0207	*	-	-	-	-	*	-
Percent Intolerant Taxa (0-2)	0.3	0.2	0	0.3	0.7	0.9	0.2359	-	-	-	-	-	-	-
Percent Predators	7.1	10.4	13.8	4.3	14.1	11.5	0.4447	-	-	-	-	-	-	-
Percent Scrapers	.	.	.	11.1	12.4	3.6	0.1245	-	-	-	-	-	-	-
Percent Shredders	6.1	6.7	11.8	0	0	0	0	*	*	*	*	-	-	-
Percent Tolerant Taxa (8-10)	52.6	52.7	30.9	35.9	41.7	47.1	0.0392	-	-	-	-	-	*	-
Sensitive EPT Index (%)	0.4	0	0.2	0.9	0	1.9	0.4159	-	-	-	-	-	-	-
Shannon Diversity	1.8	2.3	2.2	2.4	2.6	2.1	0.0043	-	*	-	-	-	*	-
Taxonomic Richness	17.3	22.4	21.9	23.1	35.2	20.7	0.0027	-	-	*	-	*	-	*
Tolerance Value	6.8	6.8	6.7	7.1	6.7	6.5	0.4716	-	-	-	-	-	-	-
Trichoptera Taxa	0.3	0.4	0.5	0.6	1.3	2.2	0.0014	*	-	-	*	-	*	-

*p<0.05

Table 28b. Mean scores for each benthic metric by year for Del Puerto Creek with p-values for among years means comparison and pairwise comparisons between years.

Benthic Metric	2001	2002	2003	2004	2005	Friedman p-value	01 vs 02	01 vs 03	01 vs 04	01 vs 05	02 vs 03	02 vs 04	02 vs 05	03 vs 04	03 vs 05	04 vs 05
EPT Index (%)	6.3	1.1	1.9	0.8	3.7	0.5865	-	-	-	-	-	-	-	-	-	-
EPT Taxa	1.1	0.8	1.4	1.2	1.2	0.2655	-	-	-	-	-	-	-	-	-	-
Percent Baetidae	5.0	0.6	1.5	0.8	3.4	0.5632	-	-	-	-	-	-	-	-	-	-
Percent Chironomidae	36.3	25.1	30.2	11.4	27.6	0.2052	-	-	-	-	-	-	-	-	-	-
Percent Collectors	38.5	38.7	50.7	43.6	56.2	0.4995	-	-	-	-	-	-	-	-	-	-
Percent Dominant Taxon	29.9	38.1	43.7	53.0	33.9	0.2311	-	-	-	-	-	-	-	-	-	-
Percent Filterers	16.6	7.6	30.7	27.2	20.3	0.6057	-	-	-	-	-	-	-	-	-	-
Percent Hydropsychidae	1.1	0.0	0.0	0.0	0.1	0.4060	-	-	-	-	-	-	-	-	-	-
Percent Intolerant Taxa (0-2)	0.0	0.1	0.1	0.0	1.1	0.1436	-	-	-	-	-	-	-	-	-	-
Percent Predators	14.8	22.5	4.5	7.2	6.1	0.0916	-	-	-	-	-	-	-	-	-	-
Percent Scrapers	.	.	6.9	20.4	14.7	0.6918	-	-	-	-	-	-	-	-	-	-
Percent Shredders	16.1	15.1	0.1	0.0	0.0	0.0009*	-	-	-	-	-	-	-	-	-	-
Percent Tolerant Taxa (8-10)	41.7	45.2	32.1	45.6	50.5	0.2598	-	-	-	-	-	-	-	-	-	-
Sensitive EPT Index (%)	0.0	0.4	0.2	0.0	0.3	0.4060	-	-	-	-	-	-	-	-	-	-
Shannon Diversity	2.2	2.0	1.8	1.8	2.2	0.3294	-	-	-	-	-	-	-	-	-	-
Taxonomic Richness	21.8	21.5	18.8	28.4	22.7	0.2598	-	-	-	-	-	-	-	-	-	-
Tolerance Value	6.5	7.2	6.9	7.2	7.4	0.1917	-	-	-	-	-	-	-	-	-	-
Trichoptera Taxa	0.3	0.3	0.5	0.0	0.6	0.4060	-	-	-	-	-	-	-	-	-	-

*p<0.05

Table 28c. Mean scores for each benthic metric by year for Salt Slough with p-values for among years means comparison and pairwise comparisons between years.

Benthic Metric	2001	2002	2003	2004	2005	Friedman p-value	01 vs 02	01 vs 03	01 vs 04	01 vs 05	02 vs 03	02 vs 04	02 vs 05	03 vs 04	03 vs 05	04 vs 05
EPT Index (%)	2.9	2.5	3.4	4.0	0.7	0.2209	-	-	-	-	-	-	-	-	-	-
EPT Taxa	1.0	0.7	0.9	1.0	0.5	0.3637	-	-	-	-	-	-	-	-	-	-
Percent Baetidae	0.0	0.0	0.0	0.4	0.0	0.4060	-	-	-	-	-	-	-	-	-	-
Percent Chironomidae	35.1	33.3	20.4	20.2	21.5	0.3076	-	-	-	-	-	-	-	-	-	-
Percent Collectors	48.4	17.3	28.7	29.8	32.8	0.0320*	-	-	-	-	-	-	-	-	-	-
Percent Dominant Taxon	33.4	42.3	53.1	34.4	40.7	0.0192*	-	-	-	-	-	-	-	-	-	-
Percent Filterers	12.1	25.7	46.8	37.4	45.2	0.0766	-	-	-	-	-	-	-	-	-	-
Percent Hydropsychidae	2.7	2.5	3.1	3.6	0.7	0.3400	-	-	-	-	-	-	-	-	-	-
Percent Intolerant Taxa (0-2)	0.0	0.0	0.0	0.0	0.4	0.4060	-	-	-	-	-	-	-	-	-	-
Percent Predators	17.1	17.8	4.5	15.4	7.1	0.0118*	-	-	-	-	-	-	-	-	-	-
Percent Scrapers	.	.	19.5	17.0	14.5	1.0000	-	-	-	-	-	-	-	-	-	-
Percent Shredders	0.8	24.7	0.0	0.0	0.0	0.0005*	-	-	-	-	-	-	-	-	-	-
Percent Tolerant Taxa (8-10)	71.9	43.7	32.2	51.6	54.9	0.0755	-	-	-	-	-	-	-	-	-	-
Sensitive EPT Index (%)	0.0	0.0	0.0	0.0	0.0	.	-	-	-	-	-	-	-	-	-	-
Shannon Diversity	2.2	1.9	1.6	2.4	1.9	0.0058*	-	-	-	-	-	-	-	-	-	-
Taxonomic Richness	22.1	21.5	16.7	32.4	20.7	0.0047*	-	-	-	-	-	-	-	-	-	-
Tolerance Value	7.8	7.4	6.1	6.5	6.5	0.4756	-	-	-	-	-	-	-	-	-	-
Trichoptera Taxa	0.9	0.5	0.9	0.8	1.4	0.1257	-	-	-	-	-	-	-	-	-	-

*p<0.05

Figure 1. San Joaquin River Basin showing relative locations of Del Puerto Creek, Orestimba Creek and Salt Slough.

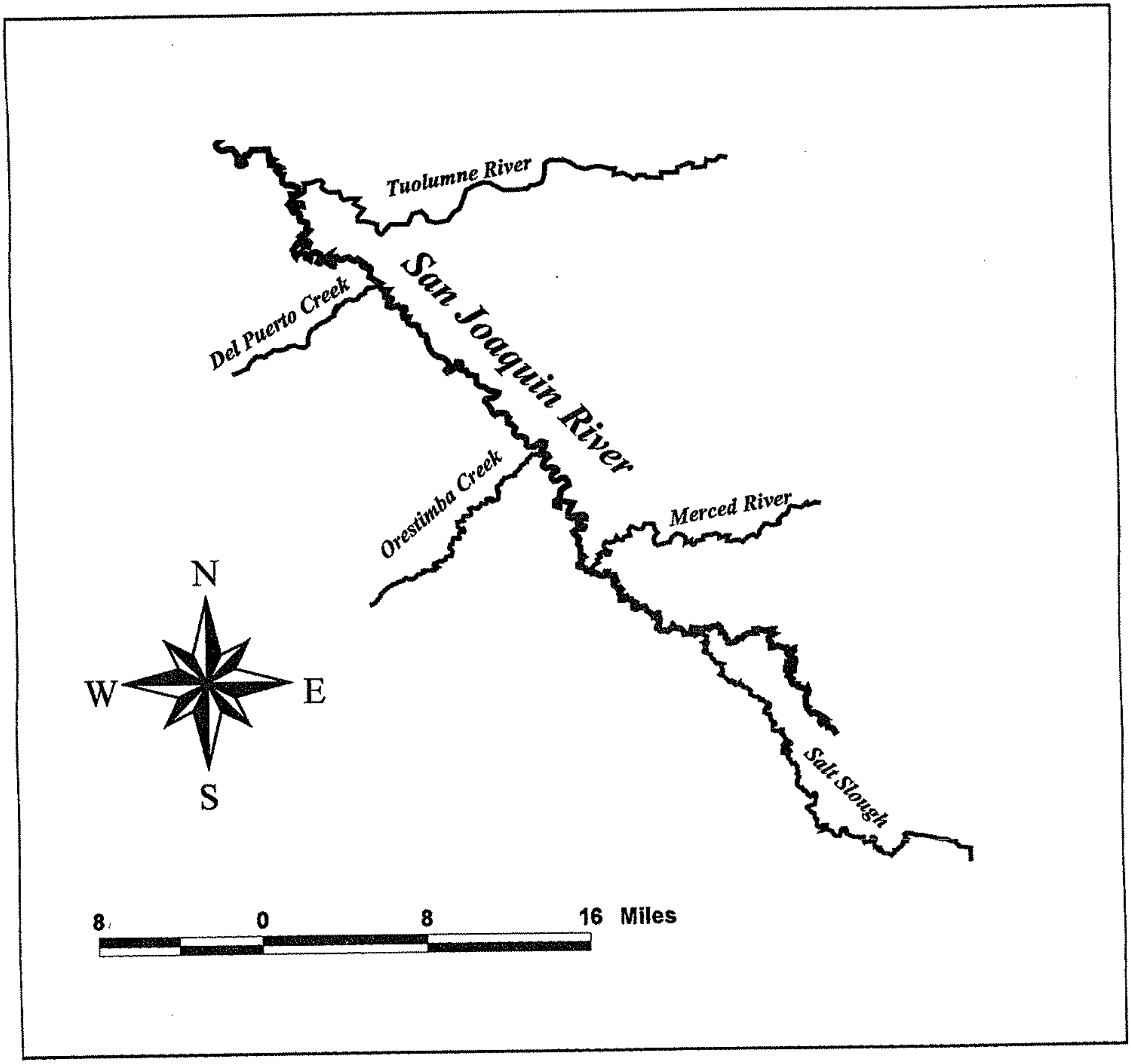
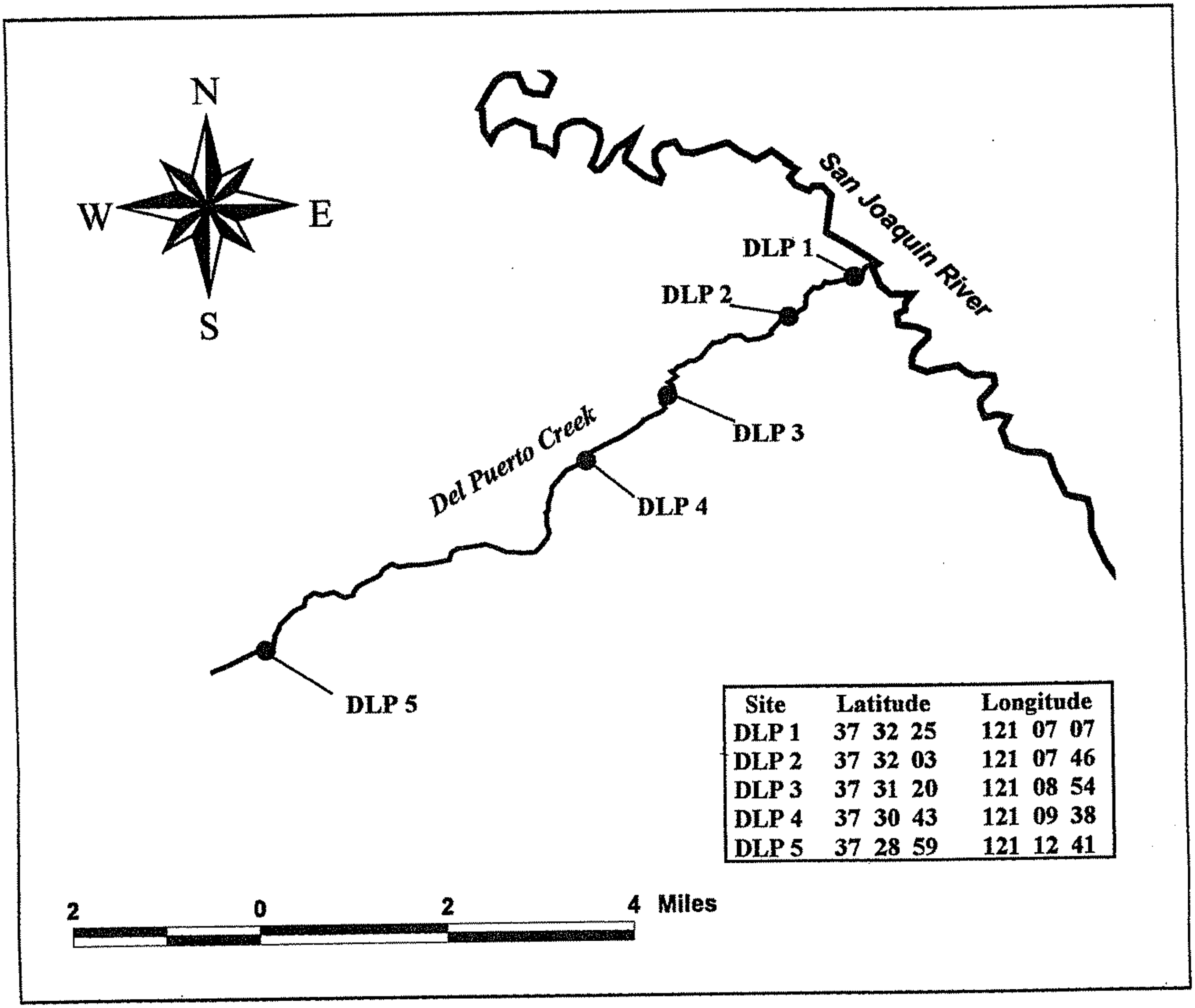
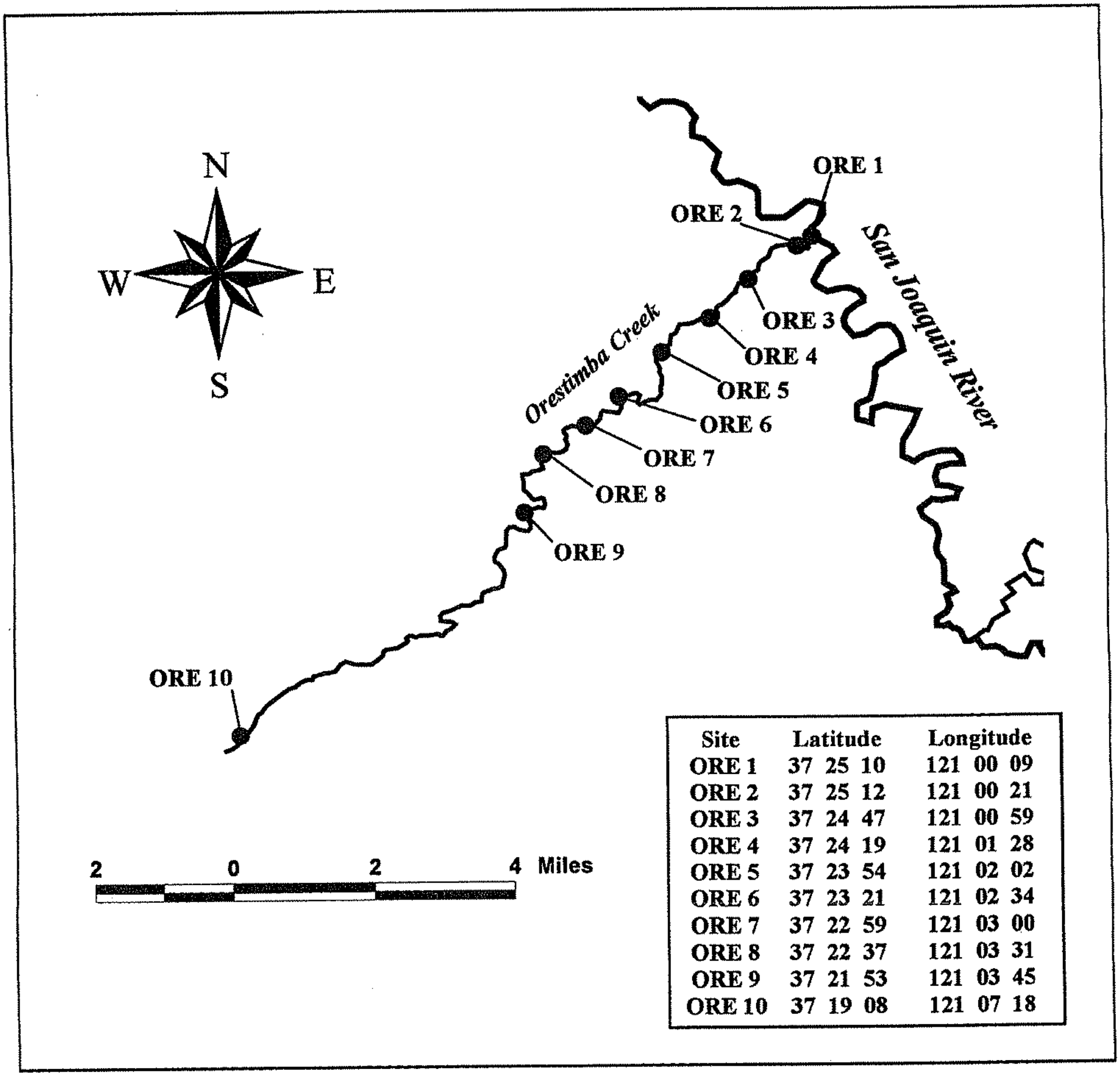


Figure 2. Del Puerto Creek sample sites.



Site	Latitude	Longitude
DLP 1	37 32 25	121 07 07
DLP 2	37 32 03	121 07 46
DLP 3	37 31 20	121 08 54
DLP 4	37 30 43	121 09 38
DLP 5	37 28 59	121 12 41

Figure 3. Orestimba Creek sample sites.



Site	Latitude	Longitude
ORE 1	37 25 10	121 00 09
ORE 2	37 25 12	121 00 21
ORE 3	37 24 47	121 00 59
ORE 4	37 24 19	121 01 28
ORE 5	37 23 54	121 02 02
ORE 6	37 23 21	121 02 34
ORE 7	37 22 59	121 03 00
ORE 8	37 22 37	121 03 31
ORE 9	37 21 53	121 03 45
ORE 10	37 19 08	121 07 18

Figure 4. Salt Slough sample sites.

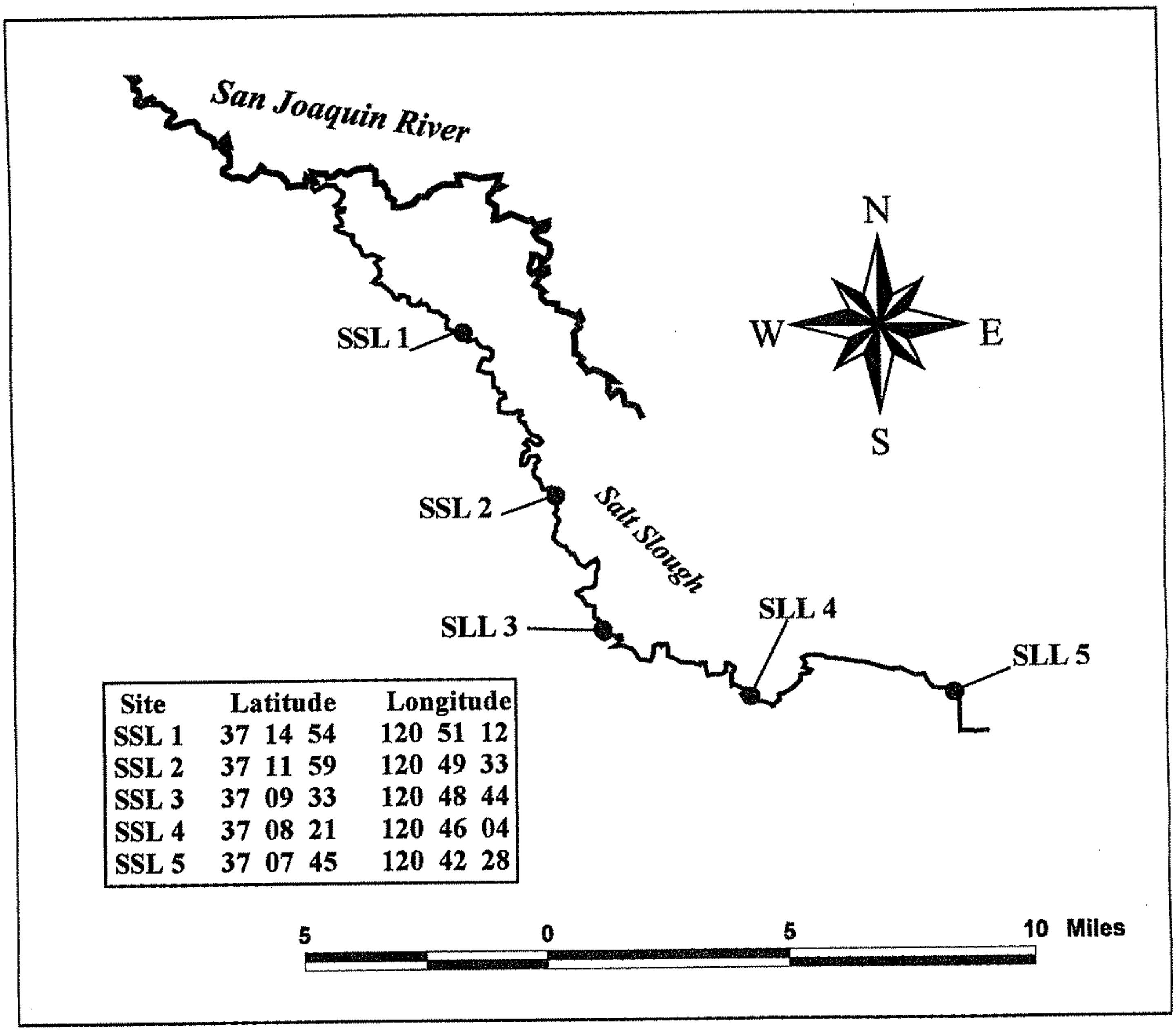


Figure 5. Macroinvertebrate richness for each transect and site total for the five Del Puerto Creek sites.

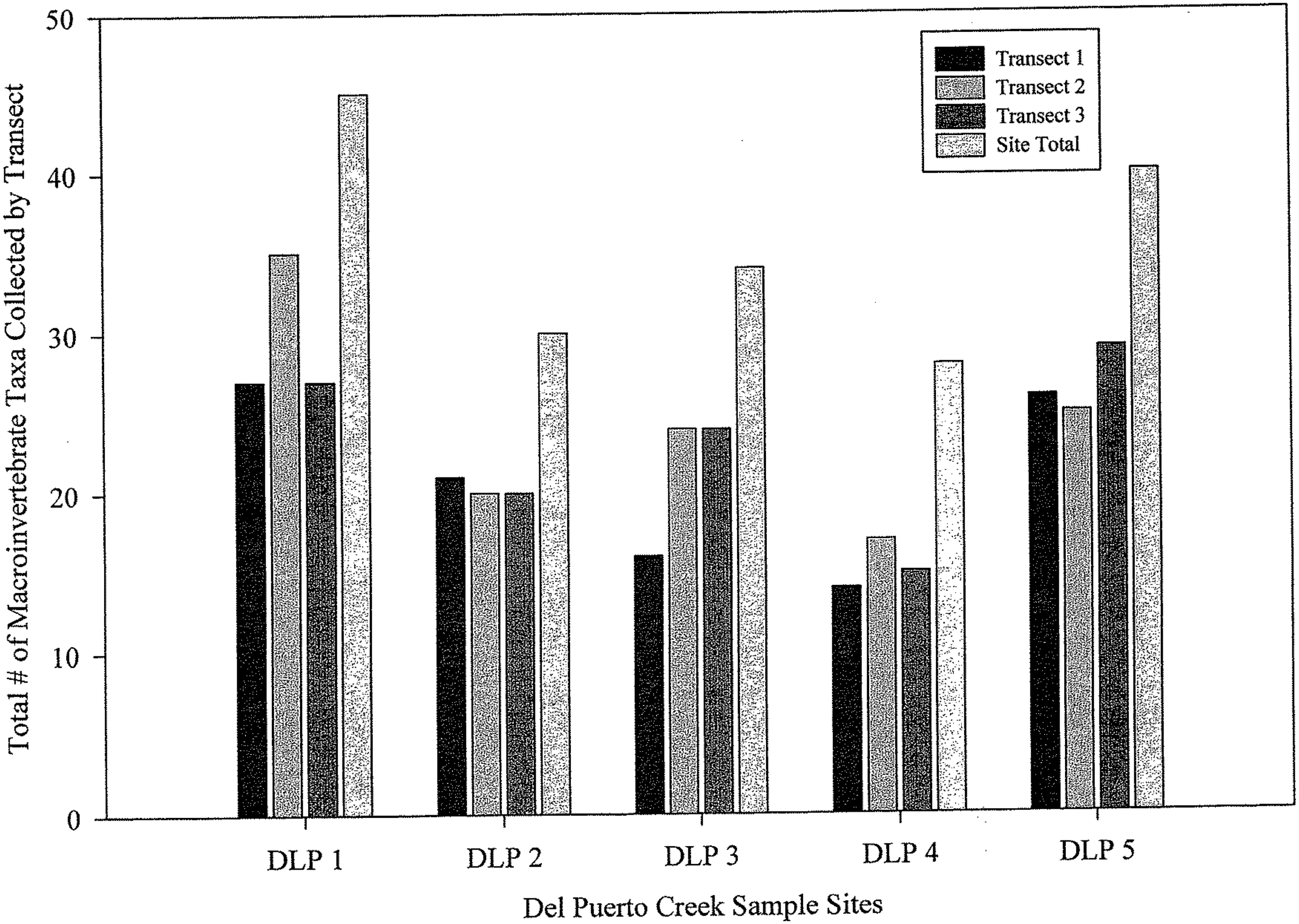


Figure 6. Macroinvertebrate abundance for each transect and site total for the five Del Puerto Creek sites.

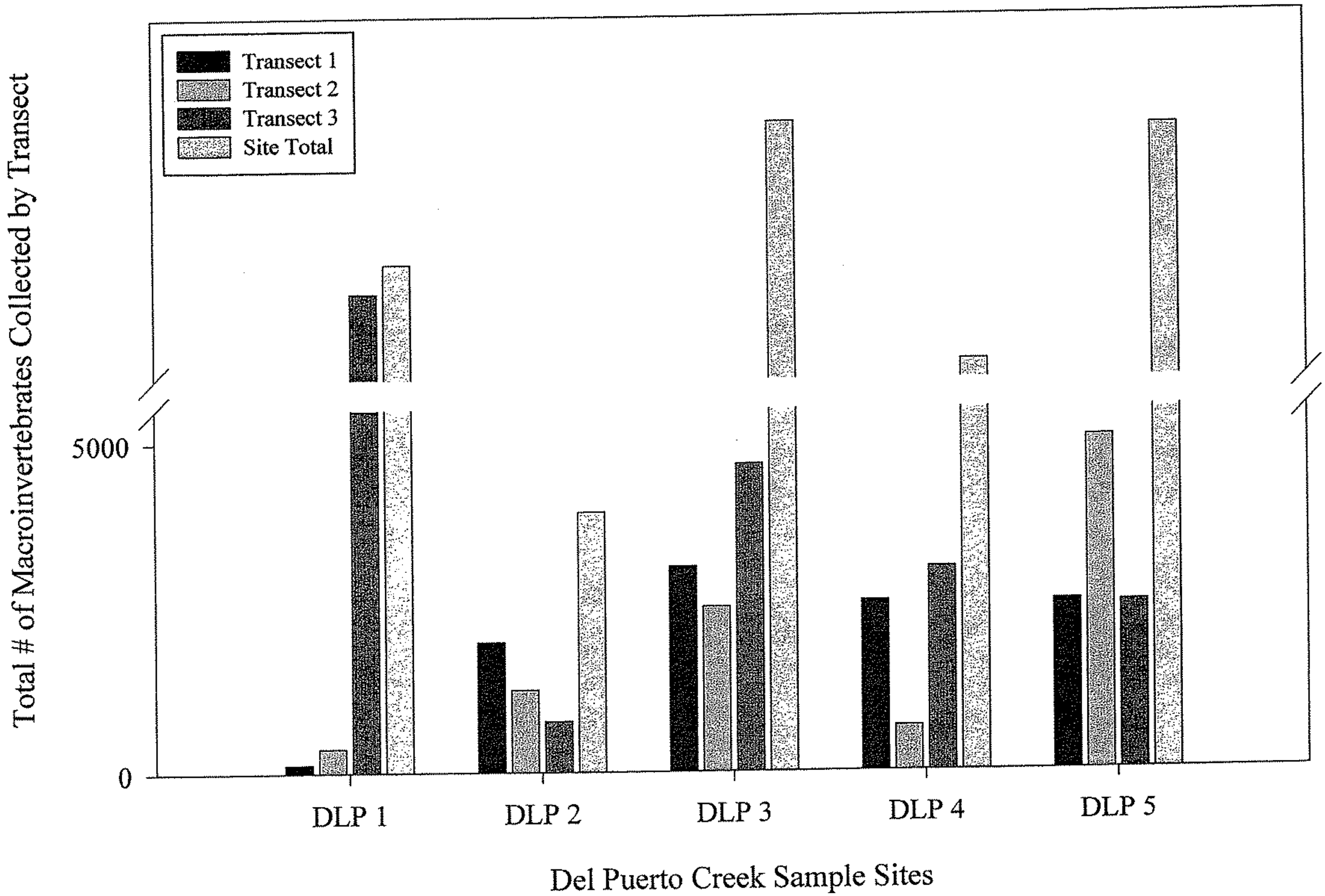


Figure 7. Macroinvertebrate richness for each transect and site total for the 10 Orestimba Creek sites.

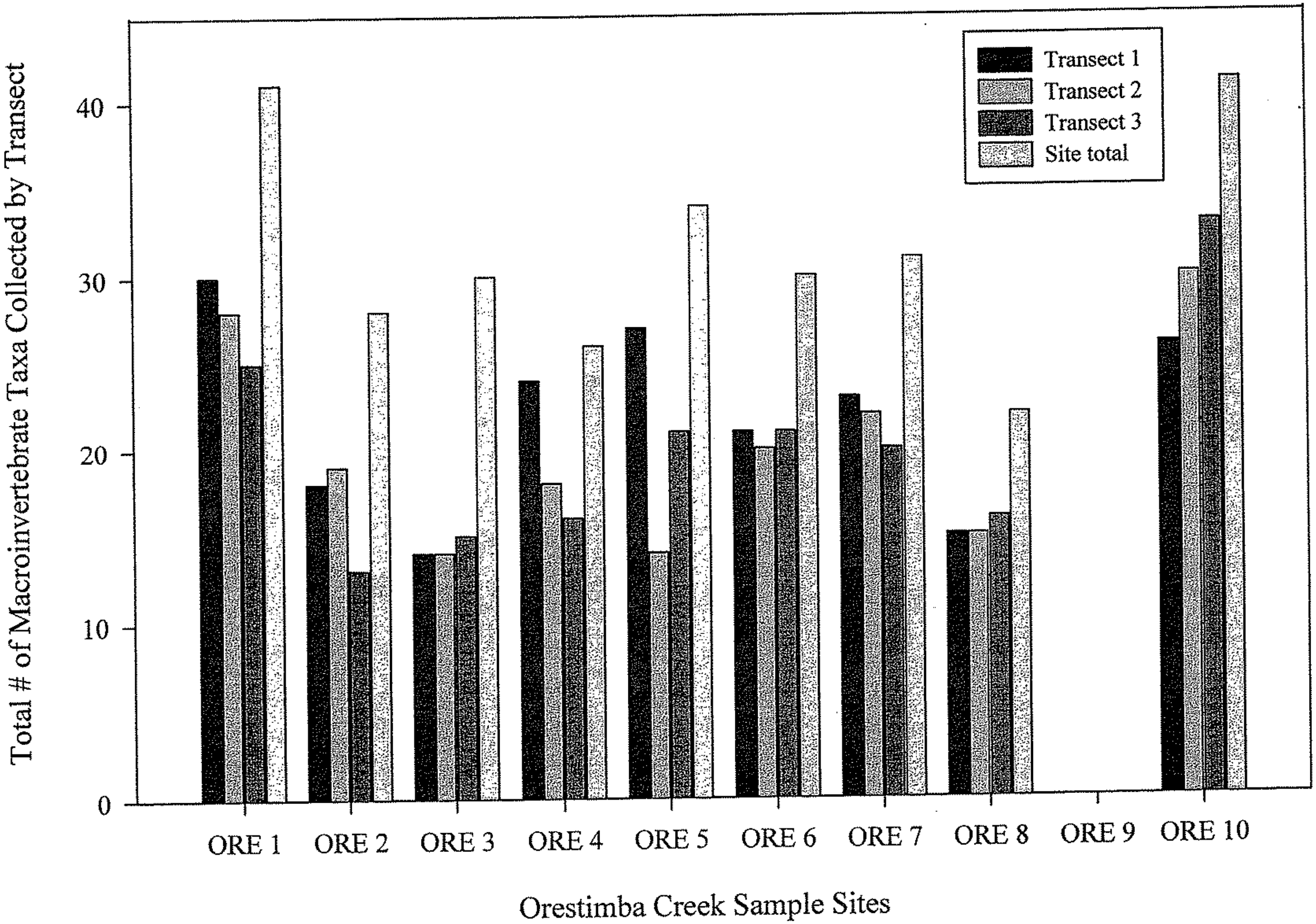


Figure 8. Macroinvertebrate abundance for each transect and site total for the 10 Orestimba Creek sites.

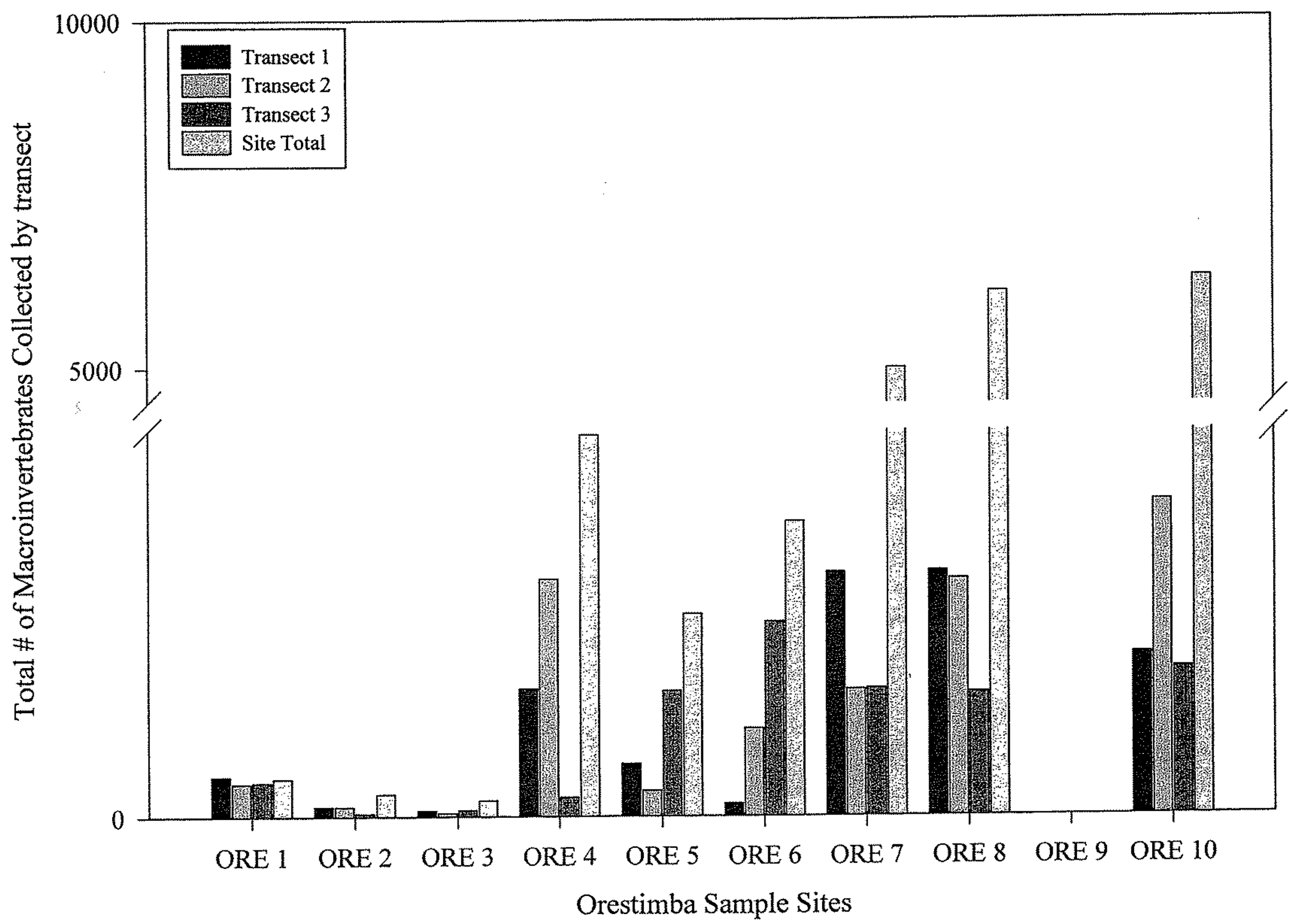


Figure 9. Macroinvertebrate richness for each transect and site total for the five Salt Slough sites.

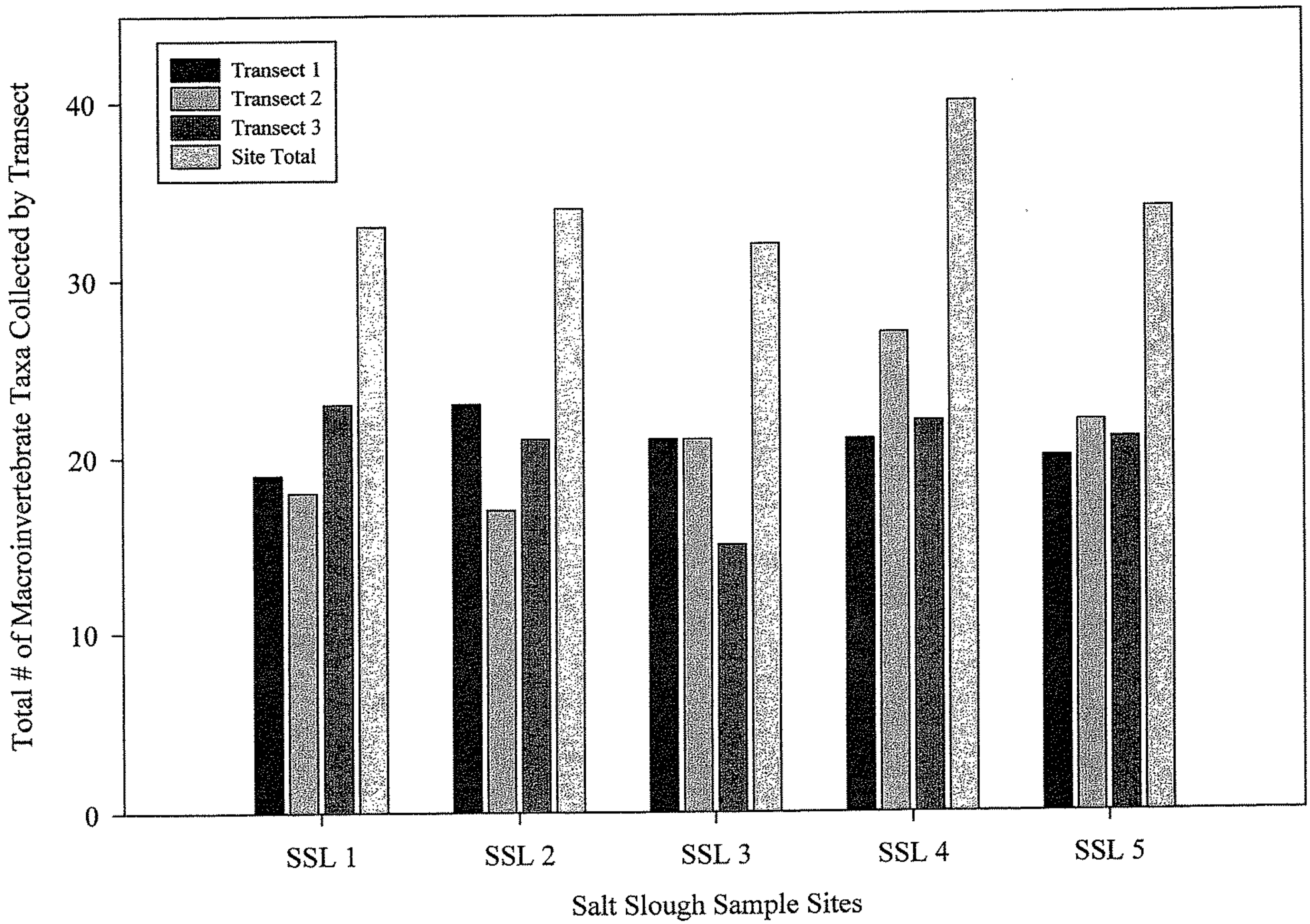
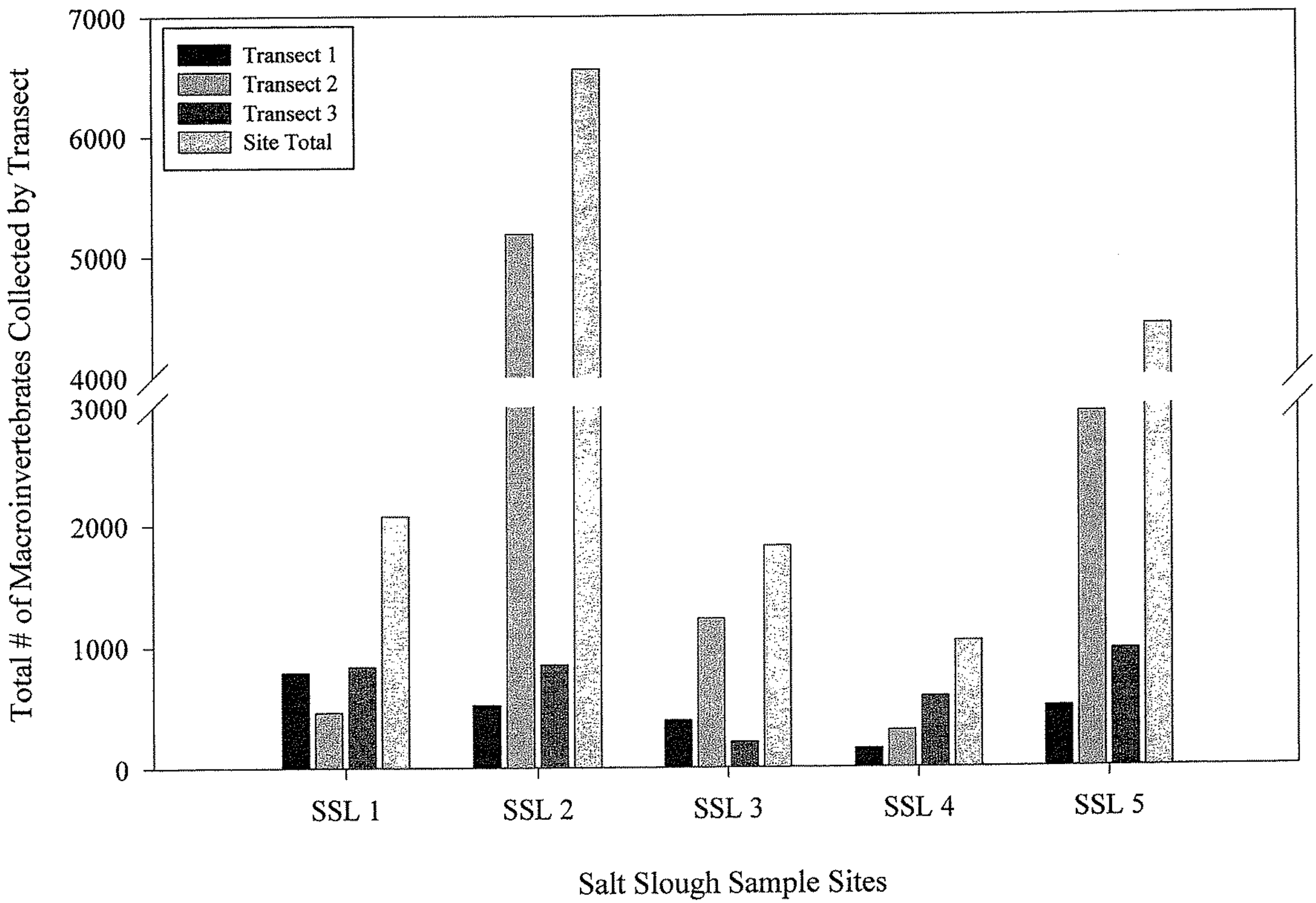


Figure 10. Macroinvertebrate abundance for each transect and site total for the five Salt Slough sites.



Appendix A

California bioassessment worksheets icluding specific descriptions of the various physical habitat metrics.

CALIFORNIA BIOASSESSMENT WORKSHEET

WATERSHED/ STREAM: ______________________ DATE/ TIME: ______________________

COMPANY/ AGENCY: ______________________ SAMPLE ID #: ______________________

SITE DESCRIPTION: ____

SAMPLING CREW

____
____
____

SITE INFORMATION

GPS Coordinates:

Latitude: ______________
Longitude: ______________

Elevation: ______________

Ecoregion: ______________

COMMENTS:

____
____
____
____
____

CHEMICAL CHARACTERISTICS

Water Temperature: __________
Specific Conductance: __________
pH: __________
Dissolved Oxygen: __________

Bioassessment Laboratory Information:

____
____
____
____
____

SEND A COPY OF THIS FORM TO:
DFG/ WPCL
2005 Nimbus Road
Rancho Cordova, CA 95670
(916) 358-2858
website: www.dfg.ca.gov/cabw/cabwhome.html

RIFFLE/ REACH CHARACTERISTICS

Point Source Sampling Design

Riffle Length: ______
Transect 1: ______
Transect 2: ______
Transect 3: ______

(record Physical/ Habitat Characteristics in Riffle 1 column)

Non-Point Source Sampling Design

Reach Length: ______
Physical Habitat Quality Score: ______

Physical/ Habitat Characteristics

	Riffle 1	Riffle 2	Riffle 3
Riffle Length:			
Transect Location:			
Avg. Riffle Width:			
Avg. Riffle Depth:			
Riffle Velocity:			
% Canopy Cover:			
Substrate Complexity:			
Embeddedness:			
Substrate Composition:			
Fines (<0.1"):			
Gravel (0.1-2"):			
Cobble (2-10"):			
Boulder (>10"):			
Bedrock (solid):			
Substrate Consolidation:			
Percent Gradient:			

CALIFORNIA STREAM BIOASSESSMENT PROCEDURE
CHAIN OF CUSTODY (COC) RECORD

Project Name: ______________________ Date/ Time: ______________________

Watershed Name: ______________________ Boiassessment Lab: ______________________

Sample Number	Lab Number	Sample Date	Sample Description

Sampled by: (sign and date)	Relinquished by: (sign and date)	Received by: (sign and date)
Received by: (sign and date)	Received by: (sign and date)	Received by: (sign and date)

Address of Sampler: ______________________

Address of Project Advisor: ______________________

BIOLOGICAL METRICS USED TO DESCRIBE BENTHIC MACROINVERTEBRATE (BMI) SAMPLES COLLECTED FOLLOWING THE CALIFORNIA STREAM BIOASSESSMENT PROCEDURE (CSBP)

Biological Metrics	Description	Response to Impairment
Richness Measures		
Taxa Richness	Total number of individual taxa	decrease
EPT Taxa	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	decrease
Ephemeroptera Taxa	Number of mayfly taxa (genus or species)	decrease
Plecoptera Taxa	Number of stonefly taxa (genus or species)	decrease
Trichoptera Taxa	Number of caddisfly taxa (genus or species)	decrease
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	decrease
Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with Tolerance Values of 0 through 3	decrease
Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963)	decrease
Tolerance/Intolerance Measures		
Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) and intolerant (lower values)	increase
Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	decrease
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	increase
Percent Hydropsychidae	Percent of organisms in the caddisfly family Hydropsychidae	increase
Percent Baetidae	Percent of organisms in the mayfly family Baetidae	increase
Percent Dominant Taxa	Percent composition of the single most abundant taxon	increase
Functional Feeding Groups		
Percent Collectors	Percent of macrobenthos that collect or gather fine particulate matter	increase
Percent Filterers	Percent of macrobenthos that filter fine particulate matter	increase
Percent Scrapers (Grazers)	Percent of macrobenthos that graze upon periphyton	variable
Percent Predators	Percent of macrobenthos that feed on other organisms	variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	decrease

PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)

Watershed/ Stream: ______________________ Date/ Time: ______________________

Company/ Agency: ______________________ Sample ID Number: ______________________

Site Description: ______________________

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

Parameters to be evaluated within the sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes *(deep<0.5 m, slow<0.3 m/s)*	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated in an area longer than the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities haveimpacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Appendix B

Number of lowest identified taxa by transect and combined transects including tolerance values (TV) and feeding guilds (FFG) for Del Puerto Creek sites. Tolerance values for taxa range from 1 to 10 with 10 being the most tolerant value. Feeding guilds are defined as follows:

CG = collector-gatherer; CF = collector-filterer; SC = scraper;
SH = shredder; P = predator; MH = macrophyte herbivore;
OM = omnivore; PA = parasite; XY = Xylophage.

Del Puerto 1	T1
Cricotopus sp.	26
Parachironomus sp.	15
Chironomus sp.	11
Gyraulus sp.	9
Cricotopus bicinctus group	8
Tanytarsus sp.	7
Physa sp.	6
Dicrotendipes sp.	5
Nanocladius sp.	5
Cyprididae	4
Paracladopelma sp.	3
Cryptochironomus sp.	2
Cladotanytarsus sp.	2
Corixidae	2
Hyalella sp.	2
Erpobdellidae	2
Enchytraeidae	2
Nais communis/ variabilis	2
Corbicula fluminea	2
Apedilum sp.	1
Phaenopsectra sp.	1
Polypedilum sp.	1
Eukiefferiella sp.	1
Thienemannimyia group	1
Ephydridae	1
Simulium sp.	1
Tricorythodes sp.	1
	123

	T2
Nais communis/ variabilis	45
Cricotopus bicinctus group	32
Nanocladius sp.	29
Chironomus sp.	24
Parachironomus sp.	23
Micropsectra sp.	18
Cricotopus sp.	17
Physa sp.	15
Gyraulus sp.	11
Cyprididae	10
Slavina appendiculata	6
Apedilum sp.	5
Dicrotendipes sp.	5
Phaenopsectra sp.	5
Procladius sp.	5
Erpobdellidae	4
Menetus sp.	4
Turbellaria	4
Cladotanytarsus sp.	3
Simulium sp.	3
Corixidae	3
Tubificidae unid. imm.	3
Planorbidae	3
Paracladopelma sp.	2
Eukiefferiella sp.	2
Ischnura sp.	2
Prostoma sp.	2
Cryptochironomus sp.	1
Paratanytarsus sp.	1
Tanytarsus sp.	1
Rheocricotopus sp.	1
Thienemanniella sp.	1
Thienemannimyia group	1
Corisella decolor	1
Coenagrionidae	1
Unionicola sp.	1
Sphaeriidae	1
Planorbella sp.	1
	296

	T3
Nais communis/ variabilis	64
Cricotopus bicinctus group	37
Micropsectra sp.	34
Cricotopus sp.	33
Chironomus sp.	27
Gyraulus sp.	21
Simulium sp.	13
Dicrotendipes sp.	9
Cladotanytarsus sp.	8
Nanocladius sp.	8
Cyprididae	8
Phaenopsectra sp.	5
Corixidae	5
Physa sp.	3
Apedilum sp.	2
Paracladopelma sp.	2
Procladius sp.	2
Zoniagrion exlcamationis	2
Cryptochironomus sp.	1
Eukiefferiella sp.	1
Paraphaenocladius sp.	1
Corynoneura sp.	1
Enchytraeidae	1
Slavina appendiculata	1
Tubificidae unid. imm.	1
Corbicula fluminea	1
Turbellaria	1
	292

	Tol Val	FFG	Total
Nais communis/ variabilis	--	CG	111
Cricotopus bicinctus group	7	CG	77
Cricotopus sp.	7	CG	76
Chironomus sp.	10	CG	62
Micropsectra sp.	7	CG	52
Nanocladius sp.	3	CG	42
Gyraulus sp.	8	SC	41
Parachironomus sp.	10	P	38
Physa sp.	8	SC	24
Cyprididae	8	CG	22
Dicrotendipes sp.	8	CG	19
Simulium sp.	6	CF	17
Phaenopsectra sp.	7	SC	11
Cladotanytarsus sp.	7	CG	10
Apedilum sp.	6	CG	8
Tanytarsus sp.	6	CF	8
Paracladopelma sp.	7	--	7
Procladius sp.	9	P	7
Corixidae	10	P	7
Slavina appendiculata	--	CG	7
Erpobdellidae	8	P	6
Turbellaria	4	P	5
Cryptochironomus sp.	8	P	4
Eukiefferiella sp.	8	OM	4
Tubificidae unid. imm.	10	CG	4
Menetus sp.	6	SC	4
Cladotanytarsus sp.	--	--	3
Corixidae	10	P	3
Enchytraeidae	10	CG	3
Corbicula fluminea	10	CF	3
Planorbidae	7	SC	3
Thienemannimyia group	6	P	2
Ischnura sp.	9	P	2
Zoniagrion exlcamationis	9	P	2
Hyalella sp.	8	CG	2
Prostoma sp.	8	P	2
Polypedilum sp.	6	CG	1
Paratanytarsus sp.	6	CF	1
Paraphaenocladius sp.	4	CG	1
Rheocricotopus sp.	6	OM	1
Thienemanniella sp.	6	CG	1
Corynoneura sp.	--	–	1
Ephydridae	6	--	1
Tricorythodes sp.	4	CG	1
Corisella decolor	--	–	1
Coenagrionidae	--	P	1
Unionicola sp.	5	P	1
Sphaeriidae	8	CG	1
Planorbella sp.	6	SC	1
			711

Del Puerto 2	T1
Simulium sp.	139
Nais communis/ variabilis	46
Eukiefferiella sp.	27
Turbellaria	23
Cricotopus sp.	17
Physa sp.	12
Cricotopus bicinctus group	7
Tubificidae unid. imm.	5
Prostoma sp.	5
Chironomus sp.	2
Polypedilum sp.	2
Tanytarsus sp.	2
Cyprididae	2
Sphaerium sp.	2
Cladotanytarsus sp.	1
Paratanytarsus sp.	1
Fallceon quilleri	1
Corixidae	1
Glossiphoniidae	1
Gyraulus sp.	1
Planorbella sp.	1
	298

	T2
Simulium sp.	97
Nais communis/ variabilis	68
Eukiefferiella sp.	26
Tubificidae unid. imm.	23
Physa sp.	22
Turbellaria	19
Cricotopus sp.	8
Corbicula fluminea	5
Tanytarsus sp.	3
Cricotopus bicinctus group	3
Enchytraeidae	3
Gyraulus sp.	3
Erpobdellidae	2
Prostoma sp.	2
Polypedilum sp.	1
Cladotanytarsus sp.	1
Cricotopus trifascia group	1
Corixidae	1
Hyalella sp.	1
Mooreobdella sp.	1
Planorbella sp.	1
	291

	T3
Simulium sp.	203
Eukiefferiella sp.	25
Turbellaria	13
Nais communis/ variabilis	9
Tubificidae unid. imm.	8
Tanytarsus sp.	6
Cricotopus sp.	6
Corixidae	5
Enchytraeidae	4
Physa sp.	4
Fallceon quilleri	3
Ophidonais serpentina	3
Corbicula fluminea	3
Phaenopsectra sp.	2
Cricotopus bicinctus group	2
Erpobdellidae	2
Mooreobdella sp.	2
Planorbella sp.	2
Dicrotendipes sp.	1
Cricotopus trifascia group	1
Lumbricina	1
	305

	Tol Val	FFG	Total
Simulium sp.	6	CF	439
Nais communis/ variabilis	--	CG	123
Eukiefferiella sp.	8	OM	78
Turbellaria	4	P	55
Physa sp.	8	SC	38
Tubificidae unid. imm.	10	CG	36
Cricotopus sp.	7	CG	31
Cricotopus bicinctus group	7	CG	12
Tanytarsus sp.	6	CF	11
Corbicula fluminea	10	CF	8
Corixidae	10	P	7
Enchytraeidae	10	CG	7
Prostoma sp.	8	P	7
Fallceon quilleri	4	CG	4
Erpobdellidae	8	P	4
Gyraulus sp.	8	SC	4
Planorbella sp.	6	SC	4
Polypedilum sp.	6	CG	3
Mooreobdella sp.	8	P	3
Ophidonais serpentina	--	--	3
Chironomus sp.	10	CG	2
Phaenopsectra sp.	7	SC	2
Cladotanytarsus sp.	7	CG	2
Cricotopus trifascia group	7	CG	2
Cyprididae	8	CG	2
Sphaerium sp.	8	CG	2
Dicrotendipes sp.	8	CG	1
Paratanytarsus sp.	6	CF	1
Hyalella sp.	8	CG	1
Glossiphoniidae	8	P	1
Lumbricina	--	CG	1
			894

Del Puerto 3	T1		T2		T3
Simulium sp.	139	Nais communis/ variabilis	93	Nais communis/ variabilis	181
Nais communis/ variabilis	34	Simulium sp.	61	Enchytraeidae	35
Enchytraeidae	31	Enchytraeidae	48	Chaetogaster diaphanus	10
Eukiefferiella sp.	23	Gyraulus sp.	23	Hydra sp.	10
Cricotopus sp.	15	Physa sp.	21	Tubificidae unid. imm.	7
Dicrotendipes sp.	14	Cricotopus sp.	10	Simulium sp.	6
Tubificidae unid. imm.	11	Prostoma sp.	9	Cricotopus sp.	5
Cricotopus bicinctus group	6	Turbellaria	6	Prostoma sp.	5
Prostoma sp.	6	Eukiefferiella sp.	3	Physa sp.	4
Corixidae	2	Dicrotendipes sp.	2	Menetus sp.	4
Physa sp.	2	Cricotopus bicinctus group	2	Chironomus sp.	3
Corisella sp.	1	Corixidae	2	Tanytarsus sp.	3
Cyprididae	1	Cyprididae	2	Cricotopus bicinctus group	3
Lumbricina	1	Lumbricina	2	Erpobdellidae	3
Slavina appendiculata	1	Tubificidae unid. imm.	2	Eukiefferiella sp.	2
Menetus sp.	1	Apedilum sp.	1	Dugesia tigrina	2
Turbellaria	1	Chironomus sp.	1	Dicrotendipes sp.	1
	289	Microtendipes pedellus group	1	Paracladopelma sp.	1
		Micropsectra sp.	1	Rheocricotopus sp.	1
		Thienemanniella sp.	1	Synorthocladius sp.	1
		Chaetogaster diaphanus	1	Sciomyzidae	1
		Slavina appendiculata	1	Cyprididae	1
		Hydra sp.	1	Slavina appendiculata	1
		Corbicula fluminea	1	Bivalvia	1
			295		291

	Tol Val	FFG	Total
Nais communis/ variabilis	--	CG	308
Simulium sp.	6	CF	206
Enchytraeidae	10	CG	114
Cricotopus sp.	7	CG	30
Physa sp.	8	SC	27
Eukiefferiella sp.	8	OM	26
Gyraulus sp.	8	SC	23
Tubificidae unid. imm.	10	CG	20
Prostoma sp.	8	P	20
Dicrotendipes sp.	8	CG	17
Cricotopus bicinctus group	7	CG	11
Chaetogaster diaphanus	--	--	11
Hydra sp.	5	P	11
Turbellaria	4	P	7
Menetus sp.	6	SC	5
Chironomus sp.	10	CG	4
Cyprididae	8	CG	4
Tanytarsus sp.	6	CF	3
Erpobdellidae	8	P	3
Lumbricina	--	CG	3
Slavina appendiculata	--	CG	3
Eukiefferiella sp.	--	--	2
Corixidae	10	P	2
Corixidae	10	P	2
Dugesia tigrina	4	P	2
Apedilum sp.	6	CG	1
Paracladopelma sp.	7	--	1
Microtendipes pedellus group	6	CF	1
Micropsectra sp.	7	CG	1
Rheocricotopus sp.	6	OM	1
Synorthocladius sp.	2	CG	1
Thienemanniella sp.	6	CG	1
Sciomyzidae	6	P	1
Corisella sp.	--	--	1
Bivalvia	--	CF	1
Corbicula fluminea	10	CF	1
			875

Del Puerto 4	T1
Cyprididae	90
Physa sp.	75
Cricotopus sp.	58
Nais communis/ variabilis	38
Paratanytarsus sp.	10
Chironomus sp.	4
Tubificidae unid. imm.	4
Gyraulus sp.	4
Erpobdellidae	3
Fossaria sp.	3
Dicrotendipes sp.	2
Cricotopus bicinctus group	2
Nanocladius sp.	1
Tricorythodes sp.	1
	295

	T2
Cyprididae	72
Physa sp.	63
Cricotopus sp.	57
Tubificidae unid. imm.	31
Nais communis/ variabilis	30
Chironomus sp.	26
Procladius sp.	5
Sphaeriidae	5
Paratanytarsus sp.	2
Tanytarsus sp.	2
Quistadrilus multisetosus	2
Apedilum sp.	1
Thienemannimyia group	1
Slavina appendiculata	1
Branchiura sowerbyi	1
Limnodrilus hoffmeisteri	1
Pisidium sp.	1
Fossaria sp.	1
	302

	T3
Chironomus sp.	81
Cricotopus sp.	56
Physa sp.	46
Nais communis/ variabilis	40
Cyprididae	37
Tubificidae unid. imm.	24
Cladotanytarsus sp.	5
Quistadrilus multisetosus	5
Paratanytarsus sp.	4
Tanytarsus sp.	2
Corisella decolor	2
Peltodytes sp.	1
Peltodytes sp.	1
Muscidae	1
Slavina appendiculata	1
Sphaerium sp.	1
	307

	Tol Val	FFG	Total
Cyprididae	8	CG	199
Physa sp.	8	SC	184
Cricotopus sp.	7	CG	171
Chironomus sp.	10	CG	111
Nais communis/ variabilis	--	CG	108
Tubificidae unid. imm.	10	CG	59
Paratanytarsus sp.	6	CF	16
Quistadrilus multisetosus	10	CG	7
Cladotanytarsus sp.	7	CG	5
Procladius sp.	9	P	5
Sphaeriidae	8	CG	5
Tanytarsus sp.	6	CF	4
Fossaria sp.	8	SC	4
Gyraulus sp.	8	SC	4
Erpobdellidae	8	P	3
Dicrotendipes sp.	8	CG	2
Cricotopus bicinctus group	7	CG	2
Corisella decolor	8	P	2
Slavina appendiculata	--	CG	2
Peltodytes sp.	5	MH	1
Peltodytes sp.	5	MH	1
Apedilum sp.	6	CG	1
Nanocladius sp.	3	CG	1
Thienemannimyia group	6	P	1
Muscidae	6	P	1
Tricorythodes sp.	4	CG	1
Branchiura sowerbyi	10	CG	1
Limnodrilus hoffmeisteri	--	CG	1
Pisidium sp.	8	CF	1
Sphaerium sp.	8	CG	1
			904

Del Puerto 5

Taxon	T1
Physa sp.	89
Cyprididae	46
Simulium sp.	32
Baetis tricaudatus	32
Nais communis/ variabilis	29
Hyalella sp.	17
Gyraulus sp.	9
Rheotanytarsus sp.	8
Centroptilum sp.	6
Tanytarsus sp.	4
Cricotopus bicinctus group	4
Cricotopus trifascia group	3
Baetis adonis	3
Pseudochironomus sp.	2
Tricorythodes sp.	2
Tubificidae w/hair chaetae	2
Stictotarsus sp.	1
Peltodytes sp.	1
Polypedilum sp.	1
Paratanytarsus sp.	1
Eukiefferiella sp.	1
Hydropsychidae	1
Atractides sp.	1
Sperchon sp.	1
Enchytraeidae	1
Hydrobiidae	1
	298

Taxon	T2
Simulium sp.	72
Physa sp.	57
Baetis adonis	45
Nais communis/ variabilis	19
Rheotanytarsus sp.	17
Cyprididae	15
Fallceon quilleri	9
Hyalella sp.	9
Gyraulus sp.	8
Polypedilum sp.	5
Cricotopus bicinctus group	5
Centroptilum sp.	5
Cricotopus trifascia group	3
Atractides sp.	3
Tanytarsus sp.	2
Cricotopus sp.	2
Mooreobdella sp.	2
Enchytraeidae	2
Tubificidae w/hair chaetae	2
Eukiefferiella sp.	1
Tricorythodes sp.	1
Ambrysus sp.	1
Hydropsyche californica	1
Lebertia sp.	1
Mideopsis sp.	1
	288

Taxon	T3
Nais communis/ variabilis	74
Physa sp.	48
Baetis adonis	37
Gyraulus sp.	29
Cyprididae	17
Cricotopus bicinctus group	14
Cricotopus trifascia group	9
Simulium sp.	9
Rheotanytarsus sp.	8
Fallceon quilleri	8
Tanytarsus sp.	6
Polypedilum sp.	3
Hyalella sp.	3
Tubificidae w/hair chaetae	3
Hydrobiidae	3
Peltodytes sp.	2
Hydropsyche californica	2
Atractides sp.	2
Erpobdellidae	2
Enchytraeidae	2
Phaenopsectra sp.	1
Cricotopus sp.	1
Eukiefferiella sp.	1
Parametriocnemus sp.	1
Thienemanniella sp.	1
Thienemannimyia group	1
Pentaneura sp.	1
Centroptilum sp.	1
Slavina appendiculata	1
	290

Taxon	Tol Val	FFG	Total
Physa sp.	8	SC	194
Nais communis/ variabilis	--	CG	122
Simulium sp.	6	CF	113
Baetis adonis	5	CG	85
Cyprididae	8	CG	78
Gyraulus sp.	8	SC	46
Rheotanytarsus sp.	6	CF	33
Baetis tricaudatus	6	CG	32
Hyalella sp.	8	CG	29
Cricotopus bicinctus group	7	CG	23
Fallceon quilleri	4	CG	17
Cricotopus trifascia group	7	CG	15
Tanytarsus sp.	6	CF	12
Centroptilum sp.	2	CG	12
Polypedilum sp.	6	CG	9
Tubificidae w/hair chaetae	10	CG	7
Atractides sp.	8	P	6
Enchytraeidae	10	CG	5
Hydrobiidae	8	SC	4
Peltodytes sp.	5	MH	3
Cricotopus sp.	7	CG	3
Eukiefferiella sp.	8	OM	3
Tricorythodes sp.	4	CG	3
Hydropsyche californica	4	CF	3
Pseudochironomus sp.	5	CG	2
Erpobdellidae	8	P	2
Mooreobdella sp.	8	P	2
Stictotarsus sp.	5	P	1
Phaenopsectra sp.	7	SC	1
Paratanytarsus sp.	6	CF	1
Parametriocnemus sp.	5	CG	1
Thienemanniella sp.	6	CG	1
Thienemannimyia group	6	P	1
Pentaneura sp.	6	P	1
Ambrysus sp.	5	P	1
Hydropsychidae	4	CF	1
Lebertia sp.	8	P	1
Mideopsis sp.	5	P	1
Sperchon sp.	8	P	1
Slavina appendiculata	--	CG	1
			876

Appendix C

Number of lowest identified taxa by transect and combined transects including tolerance values (TV) and feeding guilds (FFG) for Orestimba Creek sites. Tolerance values for taxa range from 1 to 10 with 10 being the most tolerant value. Feeding guilds are defined as follows:

CG = collector-gatherer; CF = collector-filterer; SC = scraper; SH = shredder; P = predator; MH = macrophyte herbivore; OM = omnivore; PA = parasite; XY = Xylophage.

Orestimba 1	T1		T2		T3
Chironomus sp.	52	Paratanytarsus sp.	56	Polypedilum sp.	107
Polypedilum sp.	50	Polypedilum sp.	46	Paratanytarsus sp.	65
Paratanytarsus sp.	33	Hyalella sp.	33	Ophidonais serpentina	24
Harnischia sp.	24	Chironomus sp.	27	Corixidae	20
Procladius sp.	23	Tubificidae unid. imm.	18	Chironomus sp.	10
Ophidonais serpentina	15	Corixidae	13	Dicrotendipes sp.	10
Corixidae	14	Ophidonais serpentina	13	Ormosia sp.	8
Corbicula fluminea	12	Ablabesmyia sp.	10	Nais communis/ variabilis	8
Tubificidae unid. imm.	9	Nais communis/ variabilis	10	Physa sp.	7
Dicrotendipes sp.	7	Physa sp.	10	Cricotopus sp.	5
Phaenopsectra sp.	5	Slavina appendiculata	7	Limnophyes sp.	5
Cricotopus sp.	4	Corbicula fluminea	7	Ablabesmyia sp.	5
Nereis limnicola	4	Phaenopsectra sp.	5	Corbicula fluminea	4
Microchironomus sp.	3	Cladotanytarsus sp.	3	Trichocorixa calva	2
Cricotopus bicinctus group	3	Cricotopus sp.	3	Coenagrionidae	2
Ephydridae	3	Procladius sp.	3	Slavina appendiculata	2
Palmacorixa sp.	3	Dicrotendipes sp.	2	Limnodrilus hoffmeisteri	2
Enchytraeidae	3	Palmacorixa sp.	2	Phaenopsectra sp.	1
Nais communis/ variabilis	3	Gammarus sp.	2	Cricotopus bicinctus group	1
Prostoma sp.	3	Paranais litoralis	2	Procladius sp.	1
Hyalella sp.	2	Limnodrilus hoffmeisteri	2	Palmacorixa sp.	1
Cyprididae	2	Corynoneura sp.	1	Hyalella sp.	1
Physa sp.	2	Fallceon quilleri	1	Cyprididae	1
Cladotanytarsus sp.	1	Coenagrionidae	1	Nereis limnicola	1
Limnophyes sp.	1	Enchytraeidae	1	Paranais litoralis	1
Ablabesmyia sp.	1	Pristina leidyi	1	Prostoma sp.	1
Sigara sp.	1	Stylaria lacustris	1		295
Ischnura sp.	1	Menetus sp.	1		
Eudistylia vancouveri	1	Prostoma sp.	1		
Manayunkia speciosa	1		282		
Limnodrilus hoffmeisteri	1				
	287				

	Tol Val	FFG	Total
Polypedilum sp.	6	CG	203
Paratanytarsus sp.	6	CF	154
Chironomus sp.	10	CG	89
Ophidonais serpentina	--	--	52
Corixidae	10	P	47
Hyalella sp.	8	CG	36
Tubificidae unid. imm.	10	CG	27
Procladius sp.	9	P	26
Harnischia sp.	6	CG	24
Corbicula fluminea	10	CF	23
Nais communis/ variabilis	--	CG	21
Dicrotendipes sp.	8	CG	19
Physa sp.	8	SC	19
Ablabesmyia sp.	8	CG	16
Cricotopus sp.	7	CG	12
Phaenopsectra sp.	7	SC	11
Slavina appendiculata	--	CG	9
Ormosia sp.	3	CG	8
Limnophyes sp.	8	CG	6
Palmacorixa sp.	--	--	6
Nereis limnicola	--	--	5
Limnodrilus hoffmeisteri	--	CG	5
Prostoma sp.	8	P	5
Cladotanytarsus sp.	7	CG	4
Cricotopus bicinctus group	7	CG	4
Enchytraeidae	10	CG	4
Microchironomus sp.	6	CG	3
Ephydridae	6	--	3
Coenagrionidae	--	P	3
Cyprididae	8	CG	3
Paranais litoralis	--	CG	3
Trichocorixa calva	--	--	2
Gammarus sp.	6	CG	2
Corynoneura sp.	7	CG	1
Procladius sp.	--	--	1
Fallceon quilleri	4	CG	1
Sigara sp.	--	--	1
Ischnura sp.	9	P	1
Eudistylia vancouveri	--	--	1
Manayunkia speciosa	--	CF	1
Pristina leidyi	--	CG	1
Stylaria lacustris	--	CG	1
Menetus sp.	6	SC	1
			864

Orestimba 2	T1		T2		T3
Hyalella sp.	28	Polypedilum sp.	28	Ophidonais serpentina	8
Corixidae	13	Cricotopus bicinctus group	16	Polypedilum sp.	4
Physa sp.	10	Hyalella sp.	11	Cladotanytarsus sp.	3
Ormosia sp.	8	Physa sp.	8	Ormosia sp.	3
Paratanytarsus sp.	6	Paratanytarsus sp.	7	Tubificidae unid. imm.	2
Polypedilum sp.	5	Corixidae	6	Apedilum sp.	1
Cricotopus bicinctus group	5	Corisella decolor	4	Dicrotendipes sp.	1
Ophidonais serpentina	4	Dicrotendipes sp.	3	Paratanytarsus sp.	1
Dicrotendipes sp.	3	Cricotopus sp.	2	Ablabesmyia sp.	1
Palmacorixa sp.	3	Trichocorixa sp.	2	Corixidae	1
Cyprididae	3	Nais communis/ variabilis	2	Trichocorixa sp.	1
Tubificidae unid. imm.	3	Nanocladius sp.	1	Cyprididae	1
Cladotanytarsus sp.	1	Belostoma flumineum	1	Physa sp.	1
Ablabesmyia sp.	1	Palmacorixa sp.	1	Gyraulus sp.	1
Procladius sp.	1	Ischnura sp.	1		29
Corisella decolor	1	Cyprididae	1		
Coenagrionidae	1	Ophidonais serpentina	1		
Corbicula fluminea	1	Slavina appendiculata	1		
Prostoma sp.	1	Fossaria sp.	1		
	98	Prostoma sp.	1		
			98		

	Tol Val	FFG	Total
Hyalella sp.	8	CG	39
Polypedilum sp.	6	CG	37
Cricotopus bicinctus group	7	CG	21
Corixidae	10	P	20
Physa sp.	8	SC	19
Paratanytarsus sp.	6	CF	14
Ophidonais serpentina	--	--	13
Ormosia sp.	3	CG	11
Dicrotendipes sp.	8	CG	7
Corisella decolor	--	--	5
Cyprididae	8	CG	5
Tubificidae unid. imm.	10	CG	5
Cladotanytarsus sp.	7	CG	4
Palmacorixa sp.	--	--	4
Trichocorixa sp.	--	--	3
Cricotopus sp.	7	CG	2
Ablabesmyia sp.	8	CG	2
Nais communis/ variabilis	--	CG	2
Prostoma sp.	8	P	2
Apedilum sp.	6	CG	1
Nanocladius sp.	3	CG	1
Procladius sp.	9	P	1
Belostoma flumineum	--	--	1
Coenagrionidae	--	P	1
Ischnura sp.	9	P	1
Slavina appendiculata	--	CG	1
Corbicula fluminea	10	CF	1
Fossaria sp.	8	SC	1
Gyraulus sp.	8	SC	1
			225

Orestimba 3	T1		T2		T3
Hydropsyche californica	13	Gammarus sp.	5	Hydropsyche californica	22
Cricotopus bicinctus group	10	Tubificidae unid. imm.	5	Sperchon sp.	7
Simulium sp.	8	Hydropsyche californica	4	Prostoma sp.	6
Corbicula fluminea	8	Corbicula fluminea	3	Physa sp.	5
Gammarus sp.	5	Paratanytarsus sp.	2	Ophidonais serpentina	4
Polypedilum sp.	3	Rheocricotopus sp.	2	Branchiura sowerbyi	4
Cricotopus sp.	3	Ablabesmyia sp.	2	Gammarus sp.	3
Tubificidae unid. imm.	3	Nais communis/ variabilis	2	Lumbricina	3
Lumbricina	2	Chaetogaster diaphanus	2	Parachironomus sp.	2
Prostoma sp.	2	Physa sp.	2	Nais communis/ variabilis	2
Dicrotendipes sp.	1	Thienemanniella sp.	1	Phaenopsectra sp.	1
Parachironomus sp.	1	Corixidae	1	Cladotanytarsus sp.	1
Eukiefferiella sp.	1	Cyprididae	1	Nereis limnicola	1
Rheocricotopus sp.	1	Eudistylia vancouveri	1	Eudistylia vancouveri	1
				Slavina appendiculata	1
	61		33		63

	Tol Val	FFG	Total
Hydropsyche californica	4	CF	39
Gammarus sp.	6	CG	13
Corbicula fluminea	10	CF	11
Cricotopus bicinctus group	7	CG	10
Simulium sp.	6	CF	8
Tubificidae unid. imm.	10	CG	8
Prostoma sp.	8	P	8
Sperchon sp.	8	P	7
Physa sp.	8	SC	7
Lumbricina	--	CG	5
Nais communis/ variabilis	--	CG	4
Ophidonais serpentina	--	--	4
Branchiura sowerbyi	10	CG	4
Parachironomus sp.	10	P	3
Polypedilum sp.	6	CG	3
Cricotopus sp.	7	CG	3
Rheocricotopus sp.	6	OM	3
Paratanytarsus sp.	6	CF	2
Ablabesmyia sp.	8	CG	2
Eudistylia vancouveri	--	--	2
Chaetogaster diaphanus	--	--	2
Phaenopsectra sp.	7	SC	1
Cladotanytarsus sp.	7	CG	1
Eukiefferiella sp.	8	OM	1
Thienemanniella sp.	6	CG	1
Corixidae	10	P	1
Cyprididae	8	CG	1
Nereis limnicola	--	--	1
Slavina appendiculata	--	CG	1
			156

Orestimba 4	T1		T2		T3
Hydropsyche californica	205	Hydropsyche californica	244	Hydropsyche californica	118
Sperchon sp.	18	Sperchon sp.	10	Nereis limnicola	18
Ophidonais serpentina	13	Rheocricotopus sp.	6	Sperchon sp.	12
Rheocricotopus sp.	9	Eukiefferiella sp.	4	Ophidonais serpentina	8
Polypedilum sp.	8	Simulium sp.	4	Ablabesmyia sp.	5
Nais communis/ variabilis	8	Tubificidae unid. imm.	4	Gammarus sp.	4
Ablabesmyia sp.	4	Polypedilum sp.	3	Acari	4
Cricotopus sp.	3	Fallceon quilleri	3	Prostoma sp.	4
Cricotopus bicinctus group	3	Gammarus sp.	3	Cricotopus sp.	3
Tanytarsus sp.	2	Cricotopus sp.	2	Rheocricotopus sp.	3
Eukiefferiella sp.	2	Cricotopus bicinctus group	2	Corbicula fluminea	2
Gammarus sp.	2	Ophidonais serpentina	2	Paratanytarsus sp.	1
Nereis limnicola	2	Tanytarsus sp.	1	Tanytarsus sp.	1
Slavina appendiculata	2	Nereis limnicola	1	Cricotopus bicinctus group	1
Tubificidae unid. imm.	2	Lumbricina	1	Nais communis/ variabilis	1
Turbellaria	2	Nais communis/ variabilis	1	Tubificidae unid. imm.	1
Simulium sp.	1	Slavina appendiculata	1		186
Fallceon quilleri	1	Corbicula fluminea	1		
Erpobdellidae	1		293		
Lumbricina	1				
Branchiura sowerbyi	1				
Corbicula fluminea	1				
Menetus sp.	1				
Prostoma sp.	1				
	293				

	Tol Val	FFG	Total
Hydropsyche californica	4	CF	567
Sperchon sp.	8	P	40
Ophidonais serpentina	--	--	23
Nereis limnicola	--	--	21
Rheocricotopus sp.	6	OM	18
Polypedilum sp.	6	CG	11
Nais communis/ variabilis	--	CG	10
Ablabesmyia sp.	8	CG	9
Gammarus sp.	6	CG	9
Cricotopus sp.	7	CG	8
Tubificidae unid. imm.	10	CG	7
Eukiefferiella sp.	8	OM	6
Cricotopus bicinctus group	7	CG	6
Simulium sp.	6	CF	5
Prostoma sp.	8	P	5
Tanytarsus sp.	6	CF	4
Fallceon quilleri	4	CG	4
Acari	5	PA	4
Corbicula fluminea	10	CF	4
Lumbricina	--	CG	2
Turbellaria	4	P	2
Paratanytarsus sp.	6	CF	1
Erpobdellidae	8	P	1
Branchiura sowerbyi	10	CG	1
Menetus sp.	6	SC	1
			769

Orestimba 5

Orestimba 5	T1
Hydropsyche californica	123
Tubificidae unid. imm.	31
Cricotopus bicinctus group	23
Sperchon sp.	17
Nereis limnicola	12
Ophidonais serpentina	12
Corbicula fluminea	10
Ephydridae	9
Hyalella sp.	9
Eukiefferiella sp.	5
Physa sp.	5
Polypedilum sp.	4
Cricotopus sp.	3
Nais communis/ variabilis	3
Slavina appendiculata	2
Micropsectra sp.	1
Rheocricotopus sp.	1
Smittia sp.	1
Thienemanniella sp.	1
Psychoda sp.	1
Simulium sp.	1
Nemotelus sp.	1
Cyprididae	1
Enchytraeidae	1
Limnodrilus hoffmeisteri	1
Prostoma sp.	1
Turbellaria	1
	280

	T2
Hydropsyche californica	144
Corbicula fluminea	20
Simulium sp.	15
Sperchon sp.	15
Tubificidae unid. imm.	15
Gammarus sp.	9
Slavina appendiculata	7
Cricotopus sp.	5
Cricotopus bicinctus group	5
Nereis limnicola	5
Eukiefferiella sp.	4
Polypedilum sp.	3
Physa sp.	2
Lumbricina	1
	250

	T3
Hydropsyche californica	172
Tubificidae unid. imm.	37
Sperchon sp.	27
Nais communis/ variabilis	14
Gammarus sp.	8
Ophidonais serpentina	8
Nereis limnicola	7
Slavina appendiculata	4
Prostoma sp.	4
Corbicula fluminea	3
Rheocricotopus sp.	2
Cricotopus bicinctus group	2
Simulium sp.	2
Physa sp.	2
Polypedilum sp.	1
Tanytarsus sp.	1
Cricotopus sp.	1
Limnophyes sp.	1
Lebertia sp.	1
Eudistylia vancouveri	1
Menetus sp.	1
	299

	Tol Val	FFG	Total
Hydropsyche californica	4	CF	439
Tubificidae unid. imm.	10	CG	83
Sperchon sp.	8	P	59
Corbicula fluminea	10	CF	33
Cricotopus bicinctus group	7	CG	30
Nereis limnicola	--	--	24
Ophidonais serpentina	--	--	20
Simulium sp.	6	CF	18
Gammarus sp.	6	CG	17
Nais communis/ variabilis	--	CG	17
Slavina appendiculata	--	CG	13
Cricotopus sp.	7	CG	9
Eukiefferiella sp.	8	OM	9
Ephydridae	--	--	9
Hyalella sp.	8	CG	9
Physa sp.	8	SC	9
Polypedilum sp.	6	CG	8
Prostoma sp.	8	P	5
Rheocricotopus sp.	6	OM	3
Micropsectra sp.	7	CG	1
Tanytarsus sp.	6	CF	1
Limnophyes sp.	8	CG	1
Smittia sp.	6	CG	1
Thienemanniella sp.	6	CG	1
Psychoda sp.	10	CG	1
Nemotelus sp.	8	CG	1
Cyprididae	8	CG	1
Lebertia sp.	8	P	1
Eudistylia vancouveri	--	--	1
Lumbricina	--	CG	1
Enchytraeidae	10	CG	1
Limnodrilus hoffmeisteri	--	CG	1
Menetus sp.	6	SC	1
Turbellaria	4	P	1
			829

Orestimba 6	T1		T2		T3
Cricotopus bicinctus group	34	Cricotopus bicinctus group	64	Cricotopus bicinctus group	84
Prostoma sp.	26	Tubificidae unid. imm.	60	Cricotopus sp.	61
Cricotopus sp.	5	Hydropsyche californica	43	Hydropsyche californica	30
Hydropsyche californica	5	Cricotopus sp.	41	Prostoma sp.	21
Ophidonais serpentina	5	Nais communis/ variabilis	24	Slavina appendiculata	20
Nereis limnicola	4	Eukiefferiella sp.	16	Tubificidae unid. imm.	16
Tubificidae unid. imm.	4	Slavina appendiculata	13	Nais communis/ variabilis	14
Polypedilum sp.	3	Fallceon quilleri	7	Thienemanniella sp.	8
Eudistylia vancouveri	3	Prostoma sp.	7	Eukiefferiella sp.	7
Eukiefferiella sp.	2	Physa sp.	6	Fallceon quilleri	5
Branchiura sowerbyi	2	Lumbricina	5	Lumbricina	5
Dicrotendipes sp.	1	Rheocricotopus sp.	3	Corbicula fluminea	5
Orthocladius complex	1	Corbicula fluminea	2	Orthocladius complex	4
Nanocladius sp.	1	Turbellaria	2	Rheocricotopus sp.	4
Thienemanniella sp.	1	Polypedilum sp.	1	Erpobdellidae	2
Fallceon quilleri	1	Nanocladius sp.	1	Ophidonais serpentina	2
Americorophium spinicorne	1	Thienemanniella sp.	1	Turbellaria	2
Hyalella sp.	1	Ablabesmyia sp.	1	Dicrotendipes sp.	1
Procambarus clarkii	1	Gammarus sp.	1	Thienemannimyia group	1
Slavina appendiculata	1		298	Ablabesmyia sp.	1
Turbellaria	1			Gammarus sp.	1
	103				294

	Tol Val	FFG	Total
Cricotopus bicinctus group	7	CG	182
Cricotopus sp.	7	CG	107
Tubificidae unid. imm.	10	CG	80
Hydropsyche californica	4	CF	78
Prostoma sp.	8	P	54
Nais communis/ variabilis	--	CG	38
Slavina appendiculata	--	CG	34
Eukiefferiella sp.	8	OM	25
Fallceon quilleri	4	CG	13
Thienemanniella sp.	6	CG	10
Lumbricina	--	CG	10
Rheocricotopus sp.	6	OM	7
Ophidonais serpentina	--	--	7
Corbicula fluminea	10	CF	7
Physa sp.	8	SC	6
Orthocladius complex	6	CG	5
Turbellaria	4	P	5
Polypedilum sp.	6	CG	4
Nereis limnicola	--	--	4
Eudistylia vancouveri	--	--	3
Dicrotendipes sp.	8	CG	2
Ablabesmyia sp.	8	CG	2
Gammarus sp.	6	CG	2
Erpobdellidae	8	P	2
Branchiura sowerbyi	10	CG	2
Nanocladius sp.	3	CG	1
Thienemannimyia group	6	P	1
Americorophium spinicorne	4	CF	1
Hyalella sp.	8	CG	1
Procambarus clarkii	8	SH	1
			694

Orestimba 7

Taxon	T1
Cricotopus bicinctus group	91
Cricotopus sp.	59
Eukiefferiella sp.	31
Simulium sp.	16
Slavina appendiculata	15
Prostoma sp.	15
Nais communis/ variabilis	11
Hydropsyche californica	10
Tubificidae unid. imm.	10
Physa sp.	8
Turbellaria	8
Orthocladius complex	6
Corbicula fluminea	5
Eudistylia vancouveri	3
Parachironomus sp.	2
Ophidonais serpentina	2
Nanocladius sp.	1
Americorophium spinicorne	1
Hyalella sp.	1
Cyprididae	1
Sperchon sp.	1
Mooreobdella sp.	1
Pristina leidyi	1
	299

Taxon	T2
Cricotopus bicinctus group	111
Cricotopus sp.	102
Eukiefferiella sp.	14
Prostoma sp.	11
Turbellaria	11
Hydropsyche californica	8
Simulium sp.	6
Nais communis/ variabilis	5
Physa sp.	5
Ophidonais serpentina	4
Fallceon quilleri	3
Eudistylia vancouveri	3
Americorophium spinicorne	2
Lumbricina	2
Slavina appendiculata	2
Corbicula fluminea	2
Dicrotendipes sp.	1
Nanocladius sp.	1
Rheocricotopus sp.	1
Hyalella sp.	1
Tubificidae unid. imm.	1
Gyraulus sp.	1
	297

Taxon	T3
Cricotopus sp.	64
Cricotopus bicinctus group	36
Hydropsyche californica	36
Eukiefferiella sp.	30
Simulium sp.	26
Eudistylia vancouveri	19
Prostoma sp.	19
Ophidonais serpentina	15
Slavina appendiculata	10
Turbellaria	10
Nais communis/ variabilis	9
Tubificidae unid. imm.	7
Corbicula fluminea	4
Nanocladius sp.	3
Fallceon quilleri	3
Rheocricotopus sp.	2
Cricotopus trifascia group	2
Polypedilum sp.	1
Thienemanniella sp.	1
Lumbricina	1
	298

Taxon	Tol Val	FFG	Total
Cricotopus bicinctus group	7	CG	238
Cricotopus sp.	7	CG	225
Eukiefferiella sp.	8	OM	75
Hydropsyche californica	4	CF	54
Simulium sp.	6	CF	48
Prostoma sp.	8	P	45
Turbellaria	4	P	29
Slavina appendiculata	--	CG	27
Eudistylia vancouveri	--	--	25
Nais communis/ variabilis	--	CG	25
Ophidonais serpentina	--	--	21
Tubificidae unid. imm.	10	CG	18
Physa sp.	8	SC	13
Corbicula fluminea	10	CF	11
Orthocladius complex	6	CG	6
Fallceon quilleri	4	CG	6
Nanocladius sp.	--	--	4
Rheocricotopus sp.	6	OM	3
Americorophium spinicorne	4	CF	3
Lumbricina	--	CG	3
Parachironomus sp.	10	P	2
Cricotopus trifascia group	7	CG	2
Hyalella sp.	8	CG	2
Dicrotendipes sp.	8	CG	1
Polypedilum sp.	6	CG	1
Nanocladius sp.	3	CG	1
Thienemanniella sp.	6	CG	1
Cyprididae	8	CG	1
Sperchon sp.	8	P	1
Mooreobdella sp.	8	P	1
Pristina leidyi	--	CG	1
Gyraulus sp.	8	SC	1
			894

Orestimba 8	T1		T2		T3
Cricotopus bicinctus group	135	Cricotopus bicinctus group	107	Cricotopus bicinctus group	103
Cricotopus sp.	63	Cricotopus sp.	94	Cricotopus sp.	101
Nais communis/ variabilis	57	Nais communis/ variabilis	26	Nais communis/ variabilis	45
Eukiefferiella sp.	12	Prostoma sp.	20	Eukiefferiella sp.	8
Prostoma sp.	6	Eukiefferiella sp.	16	Ophidonais serpentina	8
Hydropsyche californica	5	Slavina appendiculata	15	Slavina appendiculata	8
Slavina appendiculata	5	Hydropsyche californica	9	Americorophium spinicorne	4
Ophidonais serpentina	3	Corbicula fluminea	9	Tubificidae unid. imm.	3
Corbicula fluminea	3	Simulium sp.	5	Rheocricotopus sp.	2
Fallceon quilleri	2	Americorophium spinicorne	2	Simulium sp.	2
Americorophium spinicorne	2	Erpobdellidae	2	Prostoma sp.	2
Sperchon sp.	1	Turbellaria	2	Dicrotendipes sp.	1
Lumbricina	1	Thienemanniella sp.	1	Ormosia sp.	1
Tubificidae unid. imm.	1	Lumbricina	1	Hydropsyche californica	1
Turbellaria	1	Hydrobiidae	1	Erpobdellidae	1
				Corbicula fluminea	1
	297		310		291

	Tol Val	FFG	Total
Cricotopus bicinctus group	7	CG	345
Cricotopus sp.	7	CG	258
Nais communis/ variabilis	--	CG	128
Eukiefferiella sp.	8	OM	36
Slavina appendiculata	--	CG	28
Prostoma sp.	8	P	28
Hydropsyche californica	4	CF	15
Corbicula fluminea	10	CF	13
Ophidonais serpentina	--	--	11
Americorophium spinicorne	4	CF	8
Simulium sp.	6	CF	7
Tubificidae unid. imm.	10	CG	4
Erpobdellidae	8	P	3
Turbellaria	4	P	3
Rheocricotopus sp.	6	OM	2
Fallceon quilleri	4	CG	2
Lumbricina	--	CG	2
Dicrotendipes sp.	8	CG	1
Thienemanniella sp.	6	CG	1
Ormosia sp.	3	CG	1
Sperchon sp.	8	P	1
Hydrobiidae	8	SC	1
			898

Orestimba 10	T1
Cricotopus trifascia group	71
Cricotopus bicinctus group	30
Torrenticola sp.	30
Stictotarsus striatellus	24
Centroptilum sp.	21
Cricotopus sp.	12
Simulium sp.	12
Eukiefferiella sp.	11
Caloparyphus/ Euparyphus	11
Nais communis/ variabilis	10
Dicrotendipes sp.	8
Rheotanytarsus sp.	8
Physa sp.	8
Polypedilum sp.	7
Hexatoma sp.	7
Baetis adonis	5
Thienemanniella sp.	3
Caloparyphus sp.	2
Fallceon quilleri	2
Atractides sp.	2
Lebertia sp.	2
Fossaria sp.	2
Phaenopsectra sp.	1
Pseudochironomus sp.	1
Tanytarsus sp.	1
Euparyphus sp.	1
	292

	T2
Centroptilum sp.	62
Torrenticola sp.	43
Odontomyia/ Hedriodiscus	32
Nais communis/ variabilis	32
Hexatoma sp.	15
Physa sp.	15
Dicrotendipes sp.	12
Gyraulus sp.	12
Fossaria sp.	8
Stictotarsus striatellus	7
Cricotopus bicinctus group	7
Cricotopus trifascia group	7
Polypedilum sp.	5
Cricotopus sp.	5
Caenis sp.	4
Pristina leidyi	4
Rheotanytarsus sp.	3
Tanytarsus sp.	3
Lebertia sp.	3
Agabus sp.	2
Simulium sp.	2
Euparyphus sp.	2
Fallceon quilleri	2
Atractides sp.	2
Stictotarsus sp.	1
Eukiefferiella sp.	1
Thienemanniella sp.	1
Caloparyphus/ Euparyphus	1
Ephemerella maculata	1
Oxyethira sp.	1
	295

	T3
Torrenticola sp.	86
Centroptilum sp.	63
Odontomyia/ Hedriodiscus	18
Cricotopus bicinctus group	17
Gyraulus sp.	15
Hexatoma sp.	13
Nais communis/ variabilis	13
Cricotopus trifascia group	10
Dicrotendipes sp.	9
Physa sp.	7
Rheotanytarsus sp.	6
Cricotopus sp.	5
Stictotarsus striatellus	4
Caenis sp.	4
Polypedilum sp.	3
Pristina leidyi	3
Fossaria sp.	3
Tanytarsus sp.	2
Corynoneura sp.	2
Simulium sp.	2
Cyprididae	2
Atractides sp.	2
Lebertia sp.	2
Pseudochironomus sp.	1
Thienemanniella sp.	1
Ablabesmyia sp.	1
Euparyphus sp.	1
Fallceon quilleri	1
Oxyethira sp.	1
Mideopsis sp.	1
Erpobdellidae	1
Enchytraeidae	1
Turbellaria	1
	301

	Tol Val	FFG	Total
Torrenticola sp.	5	P	159
Centroptilum sp.	2	CG	146
Cricotopus trifascia group	7	CG	88
Nais communis/ variabilis	--	CG	55
Cricotopus bicinctus group	7	CG	54
Odontomyia/ Hedriodiscus	8	CG	50
Stictotarsus striatellus	5	P	35
Hexatoma sp.	2	P	35
Physa sp.	8	SC	30
Dicrotendipes sp.	8	CG	29
Gyraulus sp.	8	SC	27
Cricotopus sp.	7	CG	22
Rheotanytarsus sp.	6	CF	17
Simulium sp.	6	CF	16
Polypedilum sp.	6	CG	15
Fossaria sp.	8	SC	13
Caloparyphus/ Euparyphus	8	CG	12
Eukiefferiella sp.	8	OM	11
Caenis sp.	7	CG	8
Lebertia sp.	8	P	7
Pristina leidyi	--	CG	7
Tanytarsus sp.	6	CF	6
Atractides sp.	8	P	6
Baetis adonis	5	CG	5
Fallceon quilleri	4	CG	5
Thienemanniella sp.	6	CG	4
Euparyphus sp.	8	CG	4
Agabus sp.	8	P	2
Pseudochironomus sp.	5	CG	2
Corynoneura sp.	--	--	2
Caloparyphus sp.	7	CG	2
Oxyethira sp.	3	PH	2
Cyprididae	8	CG	2
Stictotarsus sp.	5	P	1
Phaenopsectra sp.	7	SC	1
Eukiefferiella sp.	--	--	1
Thienemanniella sp.	--	--	1
Ablabesmyia sp.	8	CG	1
Ephemerella maculata	1	CG	1
Mideopsis sp.	5	P	1
Erpobdellidae	8	P	1
Enchytraeidae	10	CG	1
Turbellaria	4	P	1
			888

Appendix D

Number of lowest identified taxa by transect and combined transects including tolerance values (TV) and feeding guilds (FFG) for Salt Slough sites. Tolerance values for taxa range from 1 to 10 with 10 being the most tolerant value. Feeding guilds are defined as follows:

CG = collector-gatherer; CF = collector-filterer; SC = scraper;
SH = shredder; P = predator; MH = macrophyte herbivore;
OM = omnivore; PA = parasite; XY = Xylophage.

Salt Slough 1	T1
Physa sp.	99
Americorophium spinicorne	72
Corixidae	58
Cricotopus bicinctus group	10
Paratanytarsus sp.	7
Trichocorixa calva	6
Eukiefferiella sp.	5
Corbicula fluminea	4
Tubificidae unid. imm.	3
Cricotopus sp.	2
Corisella decolor	2
Eudistylia vancouveri	2
Ophidonais serpentina	2
Chironomus sp.	1
Paratanytarsus sp.	1
Psectrocladius sp.	1
Cricotopus sp.	1
Sciomyzidae	1
Palmacorixa sp.	1
Procambarus clarkii	1
Nais communis/ variabilis	1
Branchiura sowerbyi	1
	281

	T2
Americorophium spinicorne	89
Physa sp.	55
Eudistylia vancouveri	34
Corixidae	26
Trichocorixa calva	23
Corbicula fluminea	11
Gammarus sp.	10
Cricotopus bicinctus group	9
Tubificidae unid. imm.	9
Ferrissia sp.	5
Paratanytarsus sp.	4
Ophidonais serpentina	4
Limnophyes sp.	2
Corisella decolor	2
Branchiura sowerbyi	2
Chironomus sp.	1
Dixa sp.	1
Hydropsyche sp.	1
Cyprididae	1
	289

	T3
Physa sp.	80
Americorophium spinicorne	48
Corixidae	31
Tubificidae unid. imm.	26
Manayunkia speciosa	20
Trichocorixa calva	16
Branchiura sowerbyi	13
Rheotanytarsus sp.	8
Paranais litoralis	8
Limnodrilus hoffmeisteri	7
Eukiefferiella sp.	4
Cricotopus bicinctus group	4
Gammarus sp.	3
Ophidonais serpentina	3
Chironomus sp.	2
Palmacorixa sp.	2
Cricotopus sp.	1
Psectrocladius sp.	1
Procladius sp.	1
Ephydridae	1
Corisella decolor	1
Coenagrionidae	1
Hydroptila sp.	1
Corbicula fluminea	1
	283

	Tol Val	FFG	Total
Physa sp.	8	SC	234
Americorophium spinicorne	4	CF	209
Corixidae	10	P	115
Trichocorixa calva	--	--	45
Tubificidae unid. imm.	10	CG	38
Eudistylia vancouveri	--	--	36
Cricotopus bicinctus group	7	CG	23
Manayunkia speciosa	--	CF	20
Branchiura sowerbyi	10	CG	16
Corbicula fluminea	10	CF	16
Gammarus sp.	6	CG	13
Paratanytarsus sp.	6	CF	11
Eukiefferiella sp.	8	OM	9
Ophidonais serpentina	--	--	9
Rheotanytarsus sp.	6	CF	8
Paranais litoralis	--	CG	8
Limnodrilus hoffmeisteri	--	CG	7
Corisella decolor	--	--	5
Ferrissia sp.	6	SC	5
Chironomus sp.	10	CG	4
Cricotopus sp.	7	CG	3
Limnophyes sp.	8	CG	2
Psectrocladius sp.	8	CG	2
Palmacorixa sp.	--	P	2
Paratanytarsus sp.	--	--	1
Cricotopus sp.	--	--	1
Procladius sp.	9	P	1
Dixa sp.	2	CG	1
Ephydridae	6	--	1
Sciomyzidae	6	P	1
Palmacorixa sp.	--	--	1
Coenagrionidae	--	P	1
Hydropsyche sp.	4	CF	1
Hydroptila sp.	6	PH	1
Procambarus clarkii	8	SH	1
Cyprididae	8	CG	1
Nais communis/ variabilis	--	CG	1
			853

Salt Slough 2	T1		T2		T3
Americorophium spinicorne	120	Americorophium sp.	222	Americorophium spinicorne	134
Ophidonais serpentina	49	Hyalella sp.	19	Hyalella sp.	49
Hyalella sp.	34	Gammarus sp.	8	Gammarus sp.	21
Cricotopus bicinctus group	15	Physa sp.	6	Physa sp.	20
Physa sp.	15	Hydropsyche sp.	5	Ophidonais serpentina	13
Gammarus sp.	14	Ophidonais serpentina	5	Paratanytarsus sp.	12
Hydropsyche californica	12	Eudistylia vancouveri	4	Cricotopus bicinctus group	8
Corbicula fluminea	8	Cyprididae	2	Corixidae	8
Eudistylia vancouveri	7	Fossaria sp.	2	Slavina appendiculata	7
Paratanytarsus sp.	5	Staphylinidae	1	Corbicula fluminea	5
Nais communis/ variabilis	4	Paratanytarsus sp.	1	Nais communis/ variabilis	3
Prostoma sp.	3	Cricotopus bicinctus group	1	Trichocorixa sp.	2
Liodessus obscurellus	2	Nais communis/ variabilis	1	Chironomus sp.	1
Cricotopus sp.	2	Slavina appendiculata	1	Cricotopus sp.	1
Coenagrionidae	2	Tubificidae unid. imm.	1	Trichocorixa calva	1
Limnodrilus hoffmeisteri	2	Gyraulus sp.	1	Veliidae	1
Turbellaria	2	Turbellaria	1	Coenagrionidae	1
Dicrotendipes sp.	1		281	Ischnura sp.	1
Limnophyes sp.	1			Cyprididae	1
Corixidae	1			Eudistylia vancouveri	1
Cyprididae	1			Tubificidae unid. imm.	1
Tubificidae unid. imm.	1			Fossaria sp.	1
Branchiura sowerbyi	1			Turbellaria	1
	302				293

	Tol Val	FFG	Total
Americorophium spinicorne	4	CF	254
Americorophium sp.	4	cf	222
Hyalella sp.	8	CG	102
Ophidonais serpentina	--	--	67
Gammarus sp.	6	CG	43
Physa sp.	8	SC	41
Cricotopus bicinctus group	7	CG	24
Paratanytarsus sp.	6	CF	18
Corbicula fluminea	10	CF	13
Hydropsyche californica	4	CF	12
Eudistylia vancouveri	--	--	12
Corixidae	10	P	8
Nais communis/ variabilis	--	CG	8
Slavina appendiculata	--	CG	8
Hydropsyche sp.	4	CF	5
Cyprididae	8	CG	4
Turbellaria	4	P	4
Cricotopus sp.	7	CG	3
Tubificidae unid. imm.	10	CG	3
Fossaria sp.	8	SC	3
Prostoma sp.	8	P	3
Liodessus obscurellus	5	P	2
Trichocorixa sp.	--	--	2
Coenagrionidae	--	P	2
Limnodrilus hoffmeisteri	--	CG	2
Staphylinidae	--	P	1
Chironomus sp.	10	CG	1
Dicrotendipes sp.	8	CG	1
Limnophyes sp.	8	CG	1
Trichocorixa calva	--	--	1
Veliidae	--	--	1
Coenagrionidae	--	P	1
Ischnura sp.	9	P	1
Branchiura sowerbyi	10	CG	1
Gyraulus sp.	8	SC	1
			875

Salt Slough 3	T1
Americorophium spinicorne	161
Gammarus sp.	77
Cricotopus bicinctus group	25
Corbicula fluminea	11
Nais communis/ variabilis	6
Ophidonais serpentina	6
Hydropsyche californica	4
Eudistylia vancouveri	3
Simulium sp.	2
Chironomus sp.	1
Dicrotendipes sp.	1
Polypedilum sp.	1
Paratanytarsus sp.	1
Tanytarsus sp.	1
Nanocladius sp.	1
Parametriocnemus sp.	1
Thienemanniella sp.	1
Ormosia sp.	1
Corisella decolor	1
Ferrissia sp.	1
Prostoma sp.	1
	307

	T2
Americorophium spinicorne	185
Gammarus sp.	38
Cricotopus bicinctus group	18
Hydropsyche californica	8
Nais communis/ variabilis	6
Ophidonais serpentina	6
Corbicula fluminea	5
Tubificidae unid. imm.	4
Prostoma sp.	4
Simulium sp.	3
Cricotopus sp.	2
Limnophyes sp.	2
Corixidae	2
Eudistylia vancouveri	2
Limnodrilus hoffmeisteri	2
Ferrissia sp.	2
Physa sp.	2
Nanocladius sp.	1
Corynoneura sp.	1
Coenagrionidae	1
Paranais litoralis	1
	295

	T3
Americorophium spinicorne	119
Eudistylia vancouveri	31
Gammarus sp.	12
Paranais litoralis	7
Nais communis/ variabilis	5
Physa sp.	4
Prostoma sp.	4
Hydropsyche californica	2
Limnodrilus hoffmeisteri	2
Simulium sp.	1
Corixidae	1
Corisella decolor	1
Manayunkia speciosa	1
Ophidonais serpentina	1
Quistadrilus multisetosus	1
Corbicula fluminea	1
	193

	Tol Val	FFG	Total
Americorophium spinicorne	4	CF	465
Gammarus sp.	6	CG	127
Cricotopus bicinctus group	7	CG	43
Eudistylia vancouveri	--	--	36
Nais communis/ variabilis	--	CG	17
Corbicula fluminea	10	CF	17
Hydropsyche californica	4	CF	14
Ophidonais serpentina	--	--	13
Prostoma sp.	8	P	9
Paranais litoralis	--	CG	8
Simulium sp.	6	CF	6
Physa sp.	8	SC	6
Tubificidae unid. imm.	10	CG	4
Limnodrilus hoffmeisteri	--	CG	4
Ferrissia sp.	6	SC	3
Cricotopus sp.	7	CG	2
Limnophyes sp.	8	CG	2
Nanocladius sp.	3	CG	2
Corixidae	10	P	2
Corisella decolor	--	--	2
Chironomus sp.	10	CG	1
Dicrotendipes sp.	8	CG	1
Polypedilum sp.	6	CG	1
Paratanytarsus sp.	6	CF	1
Tanytarsus sp.	6	CF	1
Parametriocnemus sp.	5	CG	1
Corynoneura sp.	7	CG	1
Thienemanniella sp.	6	CG	1
Ormosia sp.	3	CG	1
Corixidae	10	P	1
Coenagrionidae	--	P	1
Manayunkia speciosa	--	CF	1
Quistadrilus multisetosus	10	CG	1
			795

Salt Slough 4	T1
Corbicula fluminea	28
Physa sp.	26
Americorophium spinicorne	22
Simulium sp.	12
Prostoma sp.	10
Slavina appendiculata	9
Ophidonais serpentina	8
Eudistylia vancouveri	7
Paranais litoralis	5
Branchiura sowerbyi	5
Tubificidae unid. imm.	4
Nereis limnicola	3
Nais communis/ variabilis	3
Cyprididae	2
Ferrissia sp.	2
Rheotanytarsus sp.	1
Cricotopus sp.	1
Parametriocnemus sp.	1
Corixidae	1
Manayunkia speciosa	1
Fossaria sp.	1
	152

	T2
Chironomus sp.	131
Cricotopus sp.	41
Physa sp.	19
Prostoma sp.	14
Eudistylia vancouveri	9
Fossaria sp.	9
Nais communis/ variabilis	8
Corbicula fluminea	8
Procladius sp.	7
Tubificidae unid. imm.	7
Corixidae	6
Paratanytarsus sp.	5
Dicrotendipes sp.	3
Paracladopelma sp.	3
Corisella decolor	3
Paranais litoralis	3
Cladotanytarsus sp.	2
Cricotopus bicinctus group	2
Americorophium spinicorne	2
Cyprididae	2
Liodessus obscurellus	1
Thienemanniella sp.	1
Tanypus sp.	1
Hyalella sp.	1
Nereis limnicola	1
Branchiura sowerbyi	1
Menetus sp.	1
Turbellaria	1
	292

	T3
Americorophium spinicorne	92
Physa sp.	84
Prostoma sp.	24
Nais communis/ variabilis	14
Corbicula fluminea	12
Corixidae	9
Ophidonais serpentina	8
Cricotopus bicinctus group	7
Slavina appendiculata	6
Ferrissia sp.	6
Eudistylia vancouveri	4
Paranais litoralis	4
Tubificidae unid. imm.	3
Lebertia sp.	2
Chaetogaster diaphanus	2
Fossaria sp.	2
Parachironomus sp.	1
Paratanytarsus sp.	1
Cricotopus sp.	1
Corisella decolor	1
Coenagrionidae	1
Procambarus clarkii	1
Menetus sp.	1
	286

	Tol Val	FFG	Total
Chironomus sp.	10	CG	131
Physa sp.	8	SC	129
Americorophium spinicorne	4	CF	116
Corbicula fluminea	10	CF	48
Prostoma sp.	8	P	48
Cricotopus sp.	7	CG	42
Nais communis/ variabilis	--	CG	25
Eudistylia vancouveri	--	--	20
Ophidonais serpentina	--	--	16
Corixidae	10	P	15
Slavina appendiculata	--	CG	15
Tubificidae unid. imm.	10	CG	14
Simulium sp.	6	CF	12
Paranais litoralis	--	CG	12
Fossaria sp.	8	SC	12
Cricotopus bicinctus group	7	CG	9
Ferrissia sp.	6	SC	8
Procladius sp.	9	P	7
Paratanytarsus sp.	6	CF	6
Branchiura sowerbyi	10	CG	6
Corisella decolor	--	--	4
Cyprididae	8	CG	4
Nereis limnicola	--	--	4
Dicrotendipes sp.	8	CG	3
Paracladopelma sp.	7	--	3
Cladotanytarsus sp.	7	CG	2
Lebertia sp.	8	P	2
Chaetogaster diaphanus	--	--	2
Menetus sp.	6	SC	2
Liodessus obscurellus	5	P	1
Parachironomus sp.	10	P	1
Rheotanytarsus sp.	6	CF	1
Cricotopus sp.	--	--	1
Parametriocnemus sp.	--	--	1
Thienemanniella sp.	6	CG	1
Tanypus sp.	10	P	1
Corixidae	10	P	1
Coenagrionidae	--	P	1
Hyalella sp.	8	CG	1
Procambarus clarkii	8	SH	1
Manayunkia speciosa	--	CF	1
Turbellaria	4	P	1
			730

Salt Slough 5	T1		T2		T3
Cricotopus sp.	82	Paratanytarsus sp.	51	Paratanytarsus sp.	93
Paratanytarsus sp.	61	Physa sp.	50	Cricotopus sp.	70
Physa sp.	39	Nais communis/ variabilis	48	Nais communis/ variabilis	56
Chironomus sp.	20	Cricotopus sp.	41	Chironomus sp.	21
Tubificidae unid. imm.	17	Chironomus sp.	33	Tubificidae unid. imm.	16
Nais communis/ variabilis	12	Tubificidae unid. imm.	13	Paranais litoralis	7
Apedilum sp.	7	Corixidae	9	Apedilum sp.	6
Parachironomus sp.	6	Limnophyes sp.	8	Limnophyes sp.	5
Coenagrionidae	6	Dicrotendipes sp.	6	Corynoneura sp.	5
Limnophyes sp.	4	Apedilum sp.	4	Dicrotendipes sp.	4
Corixidae	4	Corynoneura sp.	4	Corixidae	4
Eudistylia vancouveri	2	Corisella decolor	3	Physa sp.	3
Paranais litoralis	2	Limnodrilus hoffmeisteri	3	Phaenopsectra sp.	2
Limnodrilus hoffmeisteri	2	Endotribelos sp.	2	Cladotanytarsus sp.	2
Glyptotendipes sp.	1	Coenagrionidae	2	Pristina leidyi	2
Phaenopsectra sp.	1	Cryptochironomus sp.	1	Parachironomus sp.	1
Polypedilum sp.	1	Glyptotendipes sp.	1	Tanytarsus sp.	1
Corynoneura sp.	1	Parachironomus sp.	1	Cricotopus bicinctus group	1
Corisella decolor	1	Ischnura sp.	1	Callibaetis sp.	1
Hyalella sp.	1	Eudistylia vancouveri	1	Eudistylia vancouveri	1
Branchiura sowerbyi	1	Manayunkia speciosa	1	Turbellaria	1
	271	Ophidonais serpentina	1		302
		Paranais litoralis	1		
		Aulodrilus pigueti	1		
			286		

	Tol Val	FFG	Total
Paratanytarsus sp.	6	CF	205
Cricotopus sp.	7	CG	193
Nais communis/ variabilis	--	CG	116
Physa sp.	8	SC	92
Chironomus sp.	10	CG	74
Tubificidae unid. imm.	10	CG	46
Apedilum sp.	6	CG	17
Limnophyes sp.	8	CG	17
Corixidae	10	P	13
Dicrotendipes sp.	8	CG	10
Corynoneura sp.	7	CG	10
Paranais litoralis	--	CG	10
Parachironomus sp.	10	P	8
Coenagrionidae	--	P	6
Limnodrilus hoffmeisteri	--	CG	5
Corixidae	10	P	4
Corisella decolor	--	--	4
Eudistylia vancouveri	--	--	4
Phaenopsectra sp.	7	SC	3
Endotribelos sp.	6	CG	2
Glyptotendipes sp.	10	SH	2
Cladotanytarsus sp.	7	CG	2
Coenagrionidae	--	P	2
Pristina leidyi	--	CG	2
Cryptochironomus sp.	8	P	1
Polypedilum sp.	6	CG	1
Tanytarsus sp.	6	CF	1
Cricotopus bicinctus group	7	CG	1
Callibaetis sp.	9	CG	1
Ischnura sp.	9	P	1
Hyalella sp.	8	CG	1
Manayunkia speciosa	--	CF	1
Ophidonais serpentina	--	--	1
Aulodrilus pigueti	--	CG	1
Turbellaria	4	P	1
			858