Benthic Macroinvertebrate Analysis of Twelve Sites in Point Reyes National Seashore Using the California Stream Bioassessment Procedure

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ABSTRACT

Thirty-six benthic macroinvertebrate samples were collected from twelve stream sites in Point Reyes National Seashore. Sample collection, laboratory processing, and taxa determination followed the California Stream Bioassessment Procedure for Point Source Pollution. Six biological metrics (Taxa Richness, EFT Taxa Richness, Modified EPT Index, Percent Dominant Taxon, Tolerance Value, Shannon's Diversity Index) were used for analysis. Metric scores from Olema Creek sample sites were compared individually while metric scores from the remaining sample sites were compared in pairs, above and below a disturbance. Metric scores were moderate to low for the sample sites evaluated. Metric scores suggest greater impairment at many of the downstream sites in comparison to upstream sites.

Aquatic Bioassessment Program

Aquatic biomonitoring or bioassessment employs aquatic organism communities to evaluate the relative condition of an aquatic habitat Benthic macroinvertebrates (invertebrates that inhabit the bottom substrate of freshwater habitats for at least part of their life-cycle and are retained by a 500 micron mesh size) are one of the most promising groups of aquatic organisms being used (Rosenberg and Resh 1993). The advantages of using benthic macroinvertebrates for bioassessment are well documented (Plafkin et al. 1989; Rosenberg and Resh 1993; Wisseman 1996). These advantages include:

- macroinvertebrates are common and abundant in most aquatic habitats;
- the sessile nature of aquatic macroinvertebrates allows effective spatial analysis of disturbance;
- relatively long life-cycles (often more than one year) allow for temporal monitoring for disturbance;
- adequate taxonomic keys exist for most groups allowing for generic determinations; and
- benthic macroinvertebrates communities are a direct measure of biotic integrity.

A primary problem in the use of benthic macroinvertebrates for bioassessment is the difficulty of quantitative sampling techniques (Rosenberg and Resh 1993). A large number of samples are required to achieve accurate quantitative results. The high number of samples translates to time-consuming and costly laboratory sample processing and taxa determination. Rapid assessment approaches help make bioassessment more economically feasible. A Rapid Bioassessment Protocol published by the United States Environmental Protection Agency (Plafkin et al. 1989) has been adapted and modified for use in California by the California Department of Fish and Game (1999). The California Stream Bioassessment Procedure (CSBP) outlines protocols for benthic macroinvertebrate sample collection, laboratory sample processing, and sample analysis.

Methods

The Seashore collected benthic macroinvertebrates from 12 locations within Point Reyes National Seashore. Staff followed CSBP collection protocols for point source pollution. For each location, a riffle was identified, and three transects were performed across the riffle. Each transect is evaluated individually, with results grouped by location. Samples were collected in spring 1999, fall 1999, and spring 2000. This last set of samples was collected because the spring 1999 samples were not adequately preserved and could not be used for the macroinvertebrate sample evaluation.

Upstream/downstream pairs were selected for sample collection on Schooner Creek, Home Ranch Creek, and Muddy Hollow. Six sites along the mainstem of Olema Creek were also sampled. At each site, PORE staff used the CSBP protocol for transect selection, sample processing, and the visual habitat survey. Three transects were selected randomly for each riffle. For each transect, the composite sample includes benthic macroinvertebrates from three sample sites along the transect Consistent sampling effort (i.e. the same person to wash the bugs into the net) was used for the spring and fall samples. The samples were processed and preserved in the field.

The Seashore committed to randomly pick 300 bugs from each integrated transect, and has contracted with a consultant to perform the Biological Data Analysis. The complete sampling protocol is included as Attachment C to the Water Quality Monitoring Study Plan.

Bioassessment Sample Site Descriptions

Olema Creek

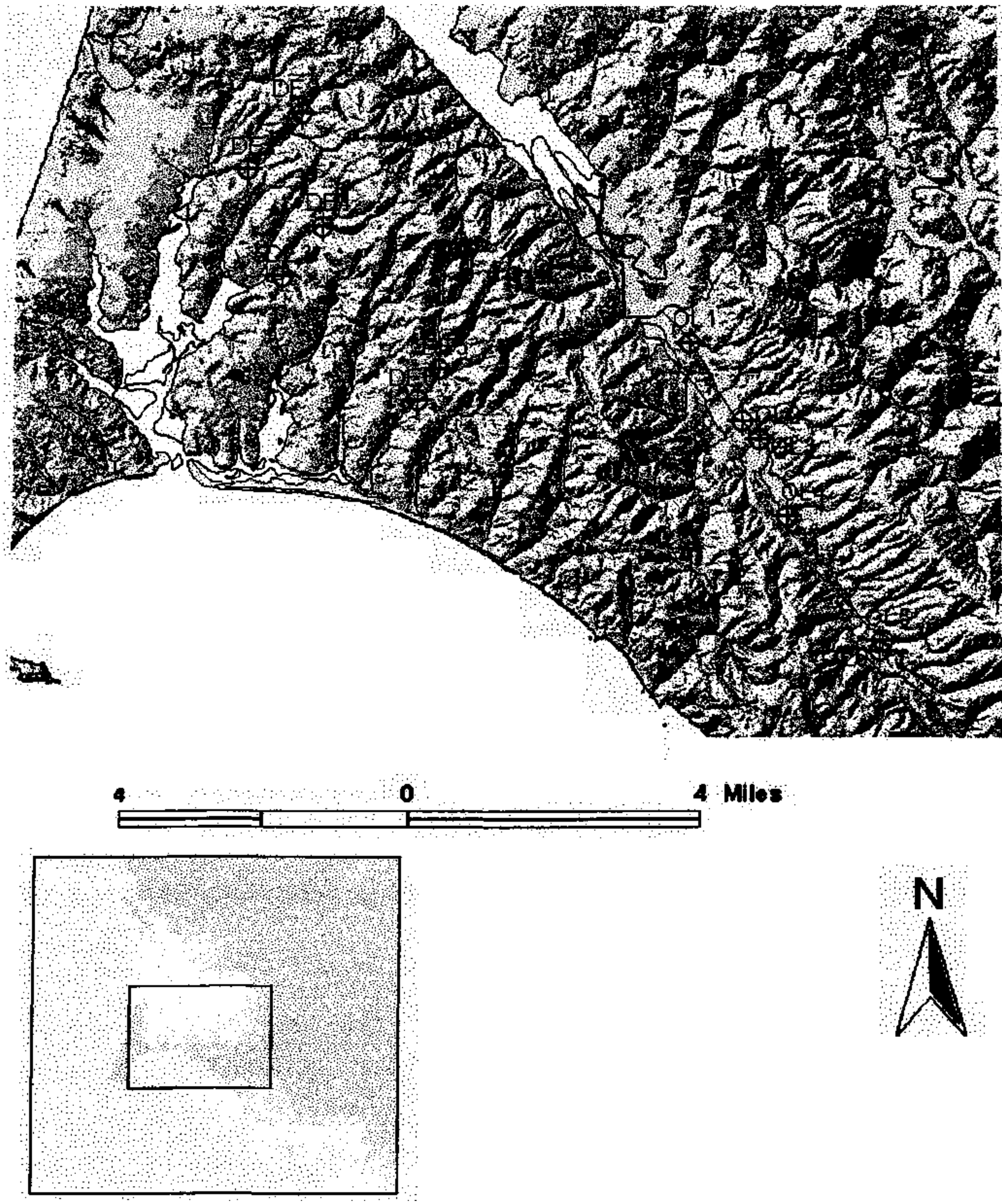
Olema Creek is the largest undammed tributary of Lagunitas Creek. The 14.5 square mile watershed flows north through the Olema Valley, the landward expression of the San Andreas Fault Zone (SFZ). It's confluence with Lagunitas Creek lies at the head of the ecologically significant Tomales Bay. The watershed is significant as it supports viable populations of federally threatened coho salmon *(Oncorhynchus kisutch)* and steelhead trout *(Oncorhynchus mykiss)*. Other threatened and endangered (T&E) aquatic and terrestrial species including California red-legged frog *(Rana aurora draytonii)* and the California freshwater shrimp *(Syncharis pacifica)* occur in the watershed. Because it is the centerpiece of fisheries management within Point Reyes National Seashore, Olema Creek is the subject of extensive monitoring to determine the effectiveness of various stream protection measures - including exclusion fencing and habitat restoration.

Currently, 35% of the Olema Creek watershed is within the designated Pastoral Zone and managed for beef cattle. The only confined animal facility in the valley at this time is the Stewart Horse stable, located in the central portion of the watershed.

Point Reyes National Seashore

Macroinvertebrate Sampling Program

Sample Location Map



The Seashore is interested in determining the impacts of ongoing beef operations within the watershed on the condition of threatened anadromous fish populations. Sample sites for aquatic invertebrates were selected based upon their location in the watershed and different intensity of land use. The six sites within the Olema Creek watershed cover the major area of agricultural use. All six sites are also sampled as part of the ambient stream sampling sites, and three (OL1, OL3, and OL4) are within fish index reach monitoring sites.

Beginning upstream at OL6, the sample point above the Blueline Creek confluence is primarily a gravel bed with alder and bay making up the broad riparian zone. Upstream there are significant sources of fine sediment as the channel meanders and cuts through the San Andreas Fault zone. Much of the watershed above this point is intermittent, with large reaches of the stream drying in the late summer. Nearly all of the agricultural uses occur in tributaries that tend to be characterized as intermittent. The Seashore has worked to address riparian fencing on all perennial streams on Olema Creek. North and 500 meters downstream of this site is OL5, at the north Five Brooks Bridge.

The channel is stable with the sampled riffle comprised of gravel. The riparian zone is limited by development with some cover provided by alder and bay trees. This area was accessible to cattle until 1999, a riparian exclusion fence was constructed as part of an Eagle Scout project. Fall 1999 sample collection would reflect the impacts of summer access to the channel by livestock.

Inputs to the channel between OL5 and OL6 are Blueline and Giacomini Creeks. Grazing impacts are noticeable from both watersheds, though actions were taken on Blueline to exclude cattle (a one kilometer riparian exclosure completed 1998).

Site OL4 is located below Truttman Gulch, nearly three miles downstream. The site is tucked away from most impacts and is considered a very stable and highly productive section of the stream. The bed is comprised of gravel to small gravel, with alder and some douglas fir providing cover. Inputs to Olema between OL5 and OL4 come from agricultural operations to the east, and the wilderness to the west The Stewart horse stables are located approximately 2 miles upstream of the site. This study was not designed to assess potential impacts from this facility.

OL3 is located above the Vedanta bridge. The reach between OL4 and OL3 is protected from direct access by cattle, but the riparian zone is limited to the edge of the stream terrace. At the sample site, the bed is primarily gravel with some small gravel, and riparian cover is comprised by bay and alder. Below this point the stream flows through the developed section of Olema, to site OL2 at the Bear Valley Bridge. Inputs from urban runoff and septic sources are likely, with the heaviest human impact to this reach of the channel.

Site OL2 is comprised of the gravel riffle 20 meters downstream of the hydrologic monitoring station. The channel is relatively stable, though a good volume of sand moves through the channel in most years. Alder squeezed along the stream banks comprise the riparian cover. The terrace is used for grazing to the west and is impacted by development on the east.

Site OL1 is located downstream of the Stewart Flat, 1.5 miles downstream of the Bear Valley Bridge. The substrate is primarily small gravel and sand, and riparian cover is provided by willow. Between OL2 and OL1, cattle grazing and the Olema Campground are the primary influences to the condition of the stream. Until the mid-1980s, this reach of Olema Creek was severely degraded with little to no riparian cover. In cooperation with the Seashore, volunteers from the Tomales Bay Association constructed a fence to protect nearly one kilometer of stream for summer rearing habitat

Sample Locations

- OL6 - mainstem above Blueline Creek confluence
- OL5 - mainstem just above Five Brooks Bridge (north)
- OL4 - mainstem @Truttman Gulch
- OL3 - mainstem above Vedanta Bridge
- OL2 - mainstem just below Bear Valley Road Bridge
- OL1 - mainstem, below Stewart flat

Schooner Creek

From its headwaters to the discharge into Schooner Bay, East Schooner Creek runs along Sir Francis Drake Boulevard. Through the gulch, the road and stream are squeezed into a narrow bottom, with little room for the stream to meander. Habitat is limited in this incised system, but the stream is perennial and quite productive. There has been ambient water quality monitoring performed in Schooner Creek at the lower site (DES2). There have also been anecdotal reports of ocean run steelhead migrating upstream.

The upper sample site just above the Mt Vision Road crossing is made up of fresh gravel and sand. Angular granitic substrate material is very common, and in spring sampling, the bed was highly turned over indicating a mobile bed. The lower site is below the Sir Francis Drake Road crossing, and is located in the depositional reach of the stream. The bed is highly mobile with sand and small gravel the dominant substrate material. Impacts to the stream include alteration to hydrology because of the road and increased sedimentation.

- DEI - below Sir Francis Drake Blvd Crossing (Rogers Ranch) {downstream}
- DE2 - Mt Vision Road Crossing {upstream}

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We will attempt to rectify this problem.

- DE5 - Muddy Hollow Creek - 500 meters above road crossing ^upstream}
- DE6 - Muddy Hollow Creek - adjacent to pumphouse {downstream}

Taxonomic Determination

Specimens were determined to the lowest practical taxonomic level with the aid of a stereomicroscope (8-50X magnification) or when necessary a compound microscope (400X magnification). A standard taxonomic level (CAMLnet Short List of Taxonomic Effort) was followed with the following exceptions: very early instars and some pupae, the dipteran family Ceratopogonidae, and the stonefly families Capniidae and Leuctridae. The following taxonomic keys were used: Usinger 1956; Cook 1974; Lauck 1979; Wiederholm 1983; Brinkhurst 1986; Stewart and Stark 1988; Pennak 1989; Merritt and Cummins 19%; Wiggens 19%. Within each sample discrete taxa were enumerated, placed in a vial containing 70% ethanol, and labeled with the sample date, sample I.D., taxa name, and determiners initials.

Analysis

The Rapid Bioassessment Protocol uses a multi-metric approach to bioassessment data analysis. Metrics are numerical measures which attempt to characterize the macroinvertebrate community sampled. The metrics are then compared to a reference site (if one has been determined) in a non-point source sample design (Plafkin et al. 1989) or, to control and test sites in a point source sample design. Primary metrics include Richness Measures, Composition Measures, Tolerance/Intolerance Measures, and Functional Feeding Group Measures. Following is a brief description of metrics calculated for the Point Reyes samples which have proven to be useful in the Pacific Northwest (Fore et al. 19%; Karr and Chu 1999) and Northern California (Harrington et al. 1999).

Taxa Richness

A richness measure. The total number of distinct taxa in a sample. Reflects health of the community through measurement of the variety of taxa present Generally increases with increasing water quality, habitat diversity, and/or habitat suitability (Plafkin et al. 1989).

EPT Richness

A richness measure. The total number of Ephemeroptera, Plecoptera and Trichoptera taxa present. Generally sensitive to disturbance. Expected to decrease with human induced disturbance.

Modified EPT Index

A composition measure. Proportion of sample composed of Ephemeroptera, Plecoptera and Trichoptera taxa minus the families Baetidae (Ephemeroptera) and Hydropsychidae (Trichoptera). For this index the genera Arctopsyche and Parapsyche will be considered to belong to the family Arctopsychidae. Baetids and hydropsychids are considered more tolerant of human induced disturbance than other families within these groups (Harrington et al. 1999). Expected to decrease with degraded habitat

Percent Dominant Taxon

A Tolerance/Intolerance measure. Percent contribution of the most numerous taxon present in a sample. A community dominated by relatively few taxa would indicate environmental stress (Plafldn et al. 1989). Expected to increase with stress.

Tolerance Value

A tolerance/Intolerance measure. A biotic index which evaluates tolerance of benthic macroinvertebrates to organic enrichment Taxa tolerant of organic enrichment are also generally tolerant of warm water, fine sediment, and heavy filamentous algal growth (Wisseman 19%). Scale is 0 through 10. 0 being highly intolerant and 10 being highly tolerant of organic enrichment The tolerance value is calculated as:

$$TV=\sum(n_i t_i)/N$$

where n_i is the number of individuals in a taxon, t_i is the tolerance value for that taxon, and N is the total number of individuals in the sample. Value expected to increase with stressed environment. Tolerance values are from California Department of Fish and Game (2000) listed values, however are subject to modification as more data is gathered.

Shannon's Diversity Index (H)

A diversity index is a mathematical measure of taxa diversity in a community. Shannon's index accounts for both abundance and evenness of the taxa present. The proportion of taxa *i* relative to the total number of taxa (pj) is calculated, and then multiplied by the natural log of this proportion

(Inpi). The resulting product is summed across taxa, and multiplied by -1:

$$H = \sum p_i \ln p_i$$

Diversity is expected to decrease with disturbance.

In addition to the metrics, relative abundance was estimated for each sample based on the subsampling data. The number of specimens picked from each grid in the subsampling tray was used to get an estimate of relative abundance of macroinvertebrates in the sample.

Metrics were calculated for each macroinvertebrate sample. A mean for each metric at each sample site was calculated from the samples at each site. Metric means were compared across sites (Olema Creek) and between upstream and downstream sites (Schooner, Muddy Hollow, and Home Ranch Creeks).

For a regional comparison metric scores were compared with the Russian River Index of Biological Integrity (RRIBI) (Harrington et al. 1999). The RRIBI scoring criteria is based on a visual examination of values for the six biological metrics described above based on samples collected from the Russian River Watershed, California (Harrington et al. 1999). The visual distribution scoring system uses three categories for the metric values: 5 (low impairment level), 3 (moderately impaired), and 1 (highly impaired). The RRIBI allows for a quick visual comparison of scores among sites. Harrington et al. (1999) recommend using the RRIBI in other central California coastal streams to test its usefulness outside of the Russian River Watershed.

RESULTS

A total of 94 taxa were determined from the 36 samples (subsamples) collected. Taxa lists, with number of each taxon found in samples, are included for each sample in Appendix B. The insects showed the greatest diversity with 76 taxa represented. The Diptera (true flies) displayed the greatest diversity within the insect orders with 26 taxa represented (including 8 cranefly (Tipulidae) genera). Water mites (Acarina or Hydracarina) were also well represented with 8 families determined.

Taxa Richness

Taxa richness ranged from a high of 36 in sample DE2-T3, to a low of 16 in sample DE3-T3 (Table Ib). Mean taxa richness for the samples from each site ranged from a high of 30 at site OL4 to a low of 18 at site DE3 (Table 1; Figure 1).

EPT Taxa Richness

EFT taxa richness ranged from a high of 16 in samples OL4-T2 and OL4-T3 to a low of 5 in samples DE1-T2 and DE3-T1 (Table 1). Mean EFT taxa richness was highest at site OL4 (15.7) and lowest at site DE3 (5.7) (Table 1; Figure 2).

Modified EPT Index

The modified EPT index ranged from a high of 74 in sample OL5-T3 to a low of 1.4 in sample DE1-T2 (Table 1). The mean modified EPT index value was highest at site OL5 (52.3) and lowest at site DE3 (11.2) (Table 1; Figure 3).

Percent Dominant Taxon

The percent dominant taxon ranged from a low of 16 in sample OL3-T1 to a high of 70.7 in sample OL5-T3 (Table la). The mean percent dominant taxon was lowest at site OL4 (20.7) and highest at site OL5 (49.8) followed closely by site DE3 (49.3) (Table 1; Figure 4).

Tolerance Value

Tolerance value ranged from a low of 2.17 in sample OL5-T3 to a high of 6.51 in sample

DE3-T1 (Table 1). The lowest mean tolerance value occurred at site OL5 (3.1) while the highest mean tolerance value was recorded at site DE3 (6.0) (Table 1; Figure 5).

Shannon's Diversity Index

Shannon's diversity index values ranged from a high of 2.7 in samples DE5-T2, OL3 Tl and T2, and OL4-T1, to a low of 1.3 in sample DE3-T1 (Table 1). The highest mean Shannon's diversity value was recorded at site OL3 (2.7) and the lowest value was recorded at site DE3 (1.6) (Table 1; Figure 6).

Estimated Relative Abundance

Estimated relative abundance ranged from 610 macroinvertebrates in sample DE5-T3 to 19440 macroinvertebrates in sample OL2-T3. Relative abundance would be estimated at several thousand individuals for a majority of the samples while the only sample (besides DE5-T3) with less than an estimated one thousand individuals was DE1-T2 (888). Estimated relative abundance values are given in Figure 7.

Sample I.D.	Taxa Richness	EPT Taxa Richness	Modified EPT Index	% Taxon	Tolerance Value	Shannon's D.I.
OL1-0999-T1	26	9	19.9	25	3.7	2.4
OL1-0999-T2	23	7	16.8	23.1	4	2.4
OL1-0999-T3	30	12	23.7	38	3.7	2.4
OL1 MEAN	**26.3**	**9.3**	**20.1**	**28.7**	**3.8**	**2.4**
OL2-0999-T1	25	11	35.9	29.9	3.9	2.2
OL2-0999-T2	26	14	26.6	41.5	4.3	2.3
OL2-0999-T3	25	11	27.3	38.3	4.2	2.2
OL2 MEAN	**25.3**	**12**	**29.9**	**36.6**	**4.2**	**2.2**
OL3-0999-T1	27	14	29.7	16	3.9	2.7
OL3-0999-T2	27	12	20.3	19.9	4.3	2.7
OL3-0999-T3	31	15	12.5	32.5	4.7	2.6
OL3 MEAN	**28.3**	**13.7**	**20.8**	**22.8**	**4.3**	**2.7**
OL4-0999-T1	31	15	50.7	17.2	2.8	2.7
OL4-0999-T2	28	16	34.7	21.1	3.6	2.5
OL4-0999-T3	31	16	39.1	23.8	3.3	2.6
OL4 MEAN	**30**	**15.7**	**41.5**	**20.7**	**3.2**	**2.6**
OLS-0999-T1	24	14	20.6	28.7	4.4	2.3
OL5-0999-T2	27	14	62.4	50	2.7	1.9
OL5-0999-T3	21	12	74	70.7	2.2	1.2
OL5 MEAN	**24**	**13.3**	**52.3**	**49.8**	**3.1**	**1.8**
OL6-0999-T1	26	12	52.2	43	3.1	2
OL6-0999-T2	30	15	25.9	36.5	4.3	2.4
OL6-0999-T3	29	15	26.5	29	4.5	2.6
OL6 MEAN	**28.3**	**14**	**34.9**	**36.2**	**4**	**2.3**

Table 1a.. Metric scores for Olema Creek samples.

Sample I.D.	Taxa	EPT Taxa	Modified	% Dominant	Tolerance	Shannon's
	Richness	Richness	EPT Index	Taxon	Value	D.I.
DE1-0999-T1	21	9	23.2	20.8	5.1	2.5
DE1-0999-T2	25	5	1.4	27.5	5.9	2.2
DE1-0999-T3	22	8	12.4	28.1	5.3	2.3
DEI MEAN	**22.7**	**7.3**	**12.3**	**25.5**	**5.5**	**2.3**
DE2-0999-T1	19	8	12	48.5	5.8	1.8
DE2-0999-T2	29	14	11.6	32.1	5.8	2.1
DE2-0999-T3	36	14	14.8	32.1	5.5	1.8
DE2 MEAN	**28**	**12**	**12.8**	**37.6**	**5.7**	**2.2**
DE3-0999-T1	17	5	6.3	60.9	6.5	1.3
DE3-0999-T2	21	6	12.1	50	6.1	1.6
DE3-0999-T3	16	6	15.1	36.9	5.5	1.8
DE3 MEAN	**18**	**5.7**	**11.2**	**49.3**	**6**	**1.6**
DE4-0999-T1	26	12	21.5	31.5	4.1	2.3
DE4-0999-T2	22	11	20.6	32.2	4.1	2.1
DE4-0999-T3	19	10	22	27.1	4.1	2.2
DE4 MEAN	**22.3**	**11**	**21.4**	**30.5**	**4.1**	**2.2**
DE5-0999-T1	27	14	30.6	25.9	4.5	2.5
DE5-0999-T2	28	12	35.9	16.6	4.3	2.7
DE5-0999-T3	24	11	17.5	33.9	4.8	2.2
DE5 MEAN	**26.3**	**12.3**	**28**	**25.5**	**4.5**	**2.5**
DE6-0999-T1	23	11	28.8	32.4	4.2	2.2
DE6-0999-T2	20	11	22.3	34.9	4.1	2.1
DE6-0999-T3	23	12	27.6	31.2	4.1	2.1
DE6 MEAN	**22**	**11.3**	**26.2**	**32.8**	**4.1**	**2.1**

Table 1b. Metric scores for Schooner, Home Ranch, and Muddy Hollow Creek samples.

Figure 1. Mean Taxa Richness Scores.

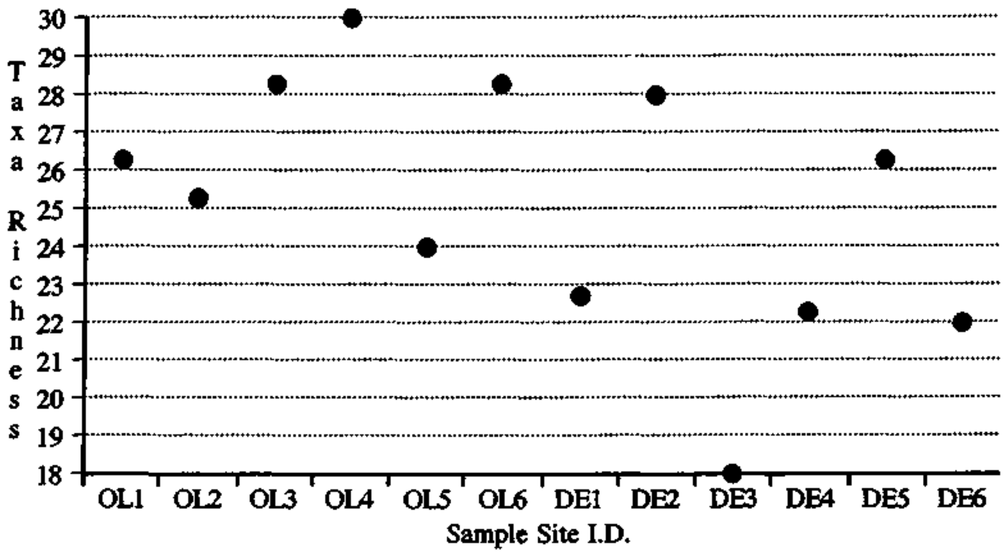
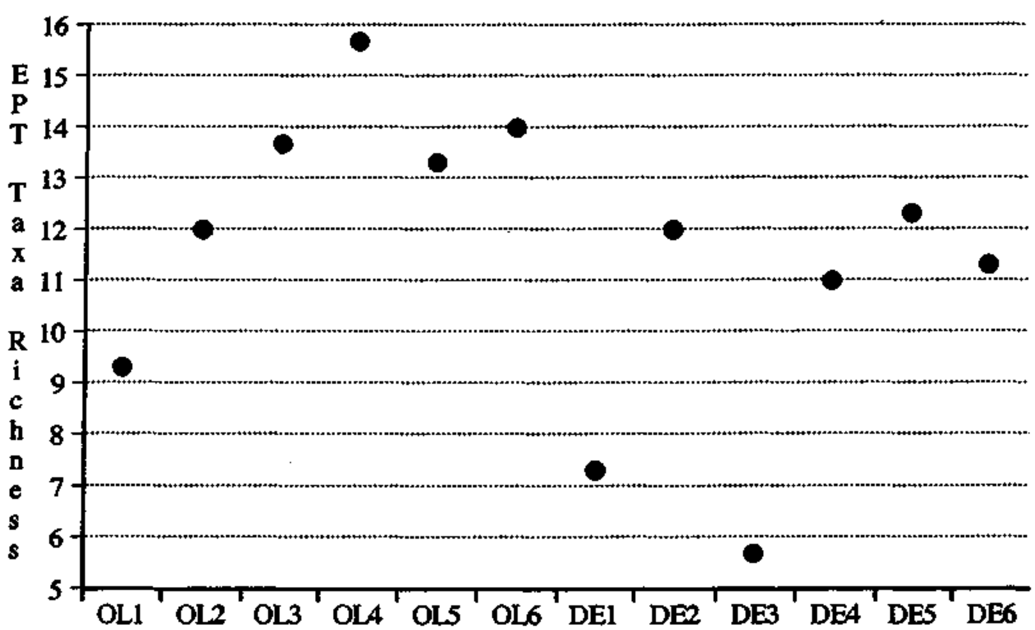


Figure 2. Mean EPT Richness Scores.



Sample Site I.D.

Figure 3. Mean Modified EPT Index Scores.

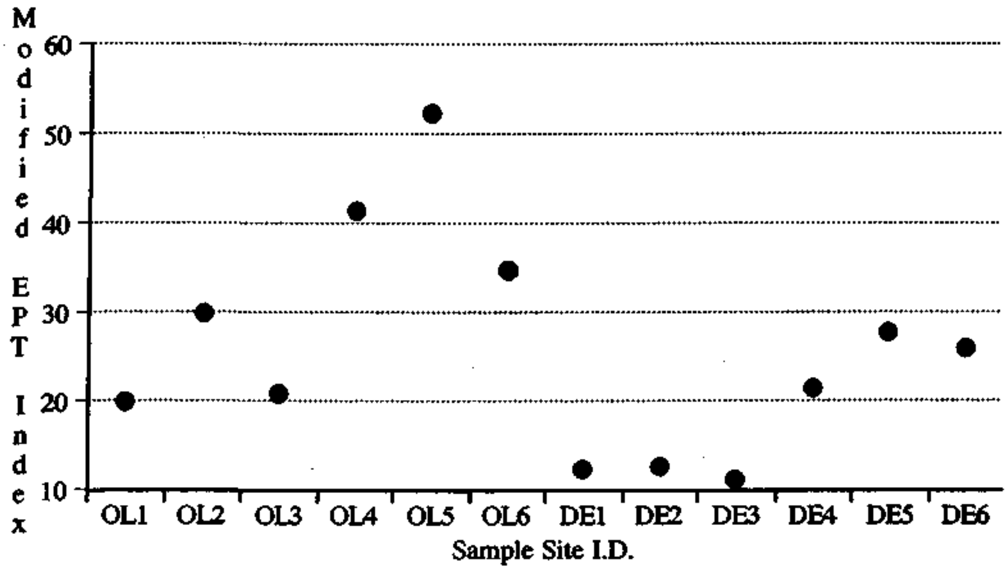


Figure 4. Mean % Dominant Taxon Scores.

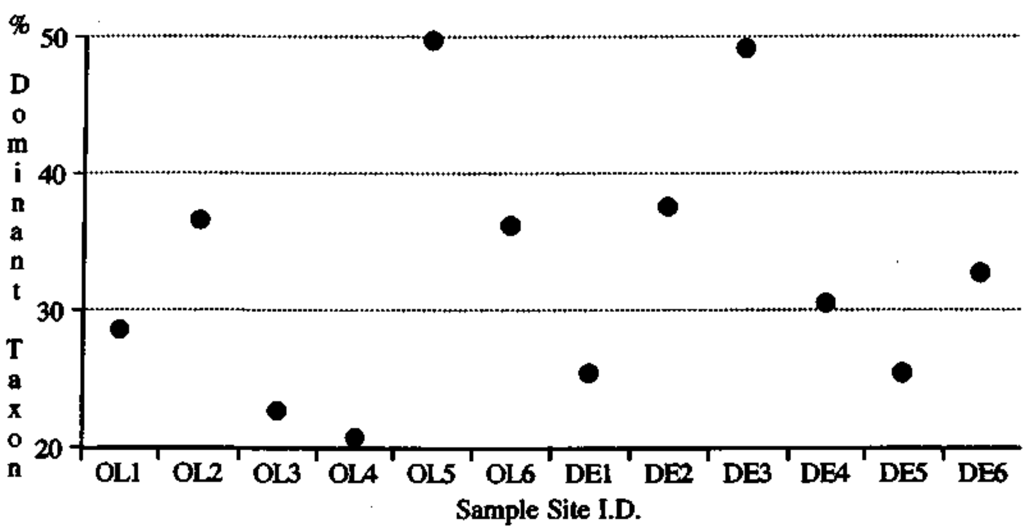


Figure 5. Mean Tolerance Value Scores.

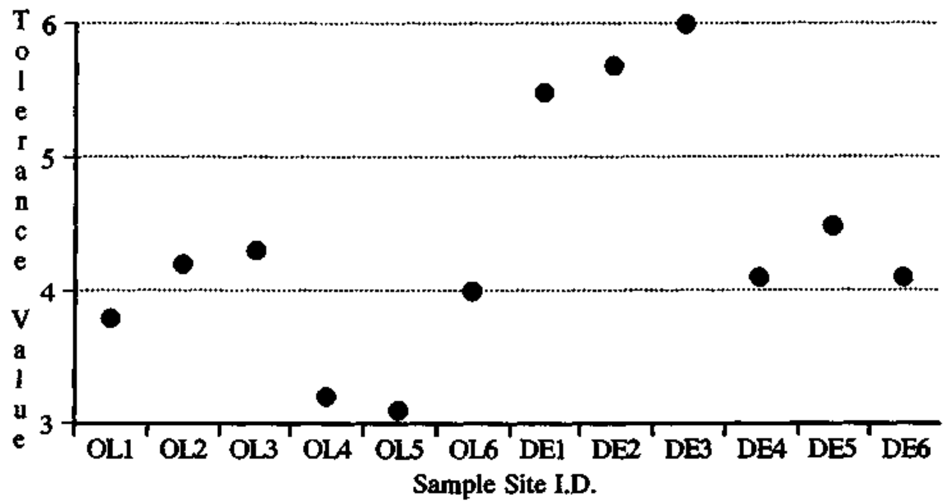


Figure 6. Mean Shannon's D.I. Scores.

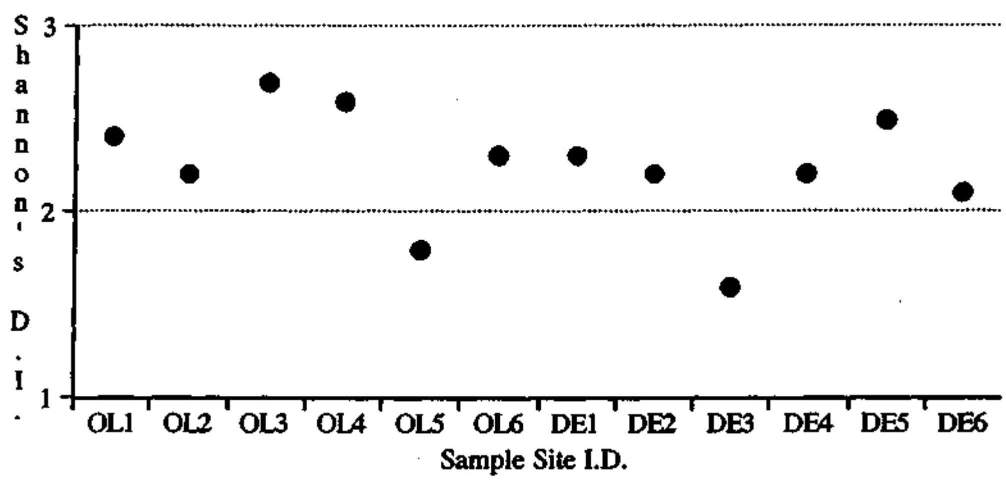
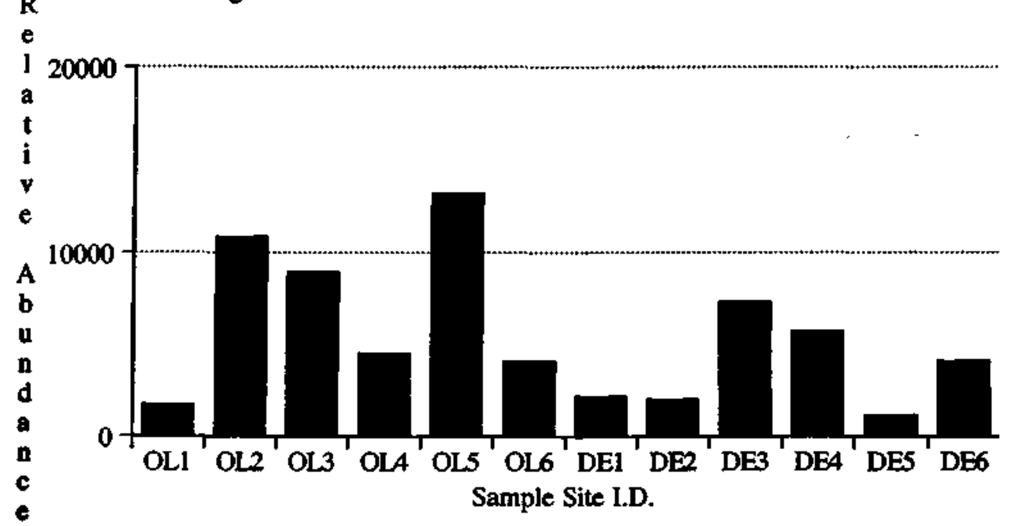


Figure 7. Mean Estimated Relative Abundance.



Russian River Index of Biological Integrity

The RRIBI assigns a score to the metric values and sums them for each sample to give a numeric rating of stream sites. Ratings can range from a high of 30 to a low of 6. RRIBI scores listed in Table 2 are based on the mean metric values for macroinvertebrate samples collected at each site (one sample at each of 3 transects). The high score for any of the sites was 18 (DE5, OL3, OL4, and OL6). The lowest score was 6 at site DE3. A score of 5 was not received for a metric at any site. Several scores of 1 were received, primarily at sites DEI, DE2, and DE3.

	SAMPLE SITE											
	DEI	DE2	DE3	DE4	DE5	DE6	OL1	OL2	OL3	OL4	OL5	OL6
Biological Metric												
Taxa Richness	1	3	1	1	3	1	3	1	3	3	1	3
EPT Taxa	1	3	1	1	3	1	1	3	3	3	3	3
Modified EPT Index	1	1	1	3	3	3	3	3	3	3	3	3
% Dominant Taxon	3	3	1	3	3	3	3	3	3	3	1	3
Tolerance Value	1	1	1	3	3	3	3	3	3	3	3	3
Shannon's D.I.	3	1	1	1	3	1	3	3	3	3	1	3
Total Score	**10**	**12**	**6**	**12**	**18**	**12**	**16**	**16**	**18**	**18**	**12**	**18**

Table 2. RRIBI scores for biological metrics at each sample site (based on mean scores from 3 macroinvertebrate samples at each site).

DISCUSSION

Site Comparisons: Olema Creek

OL4

The metric scores suggest that site OL4 has the highest quality macroinvertebrate habitat of the sites sampled, as would be expected from the site description. Relatively intolerant taxa which are common in samples from this site include the mayfly *Rhithrogena* ((Heptageniidae) at OL4-T1), the stonefly *Sweltsa* (Chloroperlidae) and the caddisfly *Rhyacophila* (Rhyacophilidae). The most abundant taxon was the relatively intolerant caddisfly Lepidostoma followed by the relatively tolerant chironomid tribe Tanytarsini (Diptera). Relatively tolerant taxa in moderate abundance include the riffle beetles *Optioservus* and *Zaitzevia* (Elmidae), and the net-spinning caddis *Hydropsyche* (Hydropsychidae). Site OL4 apparently has the best habitat of the sites surveyed however the number of tolerant taxa common in the samples suggests less than optimum macroinvertebrate habitat

OL5 and OL6

OL5 and OL6 displayed similar metric scores. Scores for taxa richness, EFT taxa richness, % dominant taxon, and Shannon's D.I. were slightly better at site OL6. High scores for modified EFT taxa and tolerance value, and low scores for % dominant taxon and Shannon's D.I. at site OL5, can be attributed to large numbers of early instars of the trichopteran *Lepidostoma* (Lepidostomatidae) at this site. Dominant taxa at both sites include the shredder *Lepidostoma* and the collector Tanytarsini (Chironomidae). The dominant taxon in sample OL5-0999-T1 was the chironomid subfamily Orthocladiinae (Diptera). High numbers of *Lepidostoma* suggest adequate riparian input while high numbers of Tanytarsini may indicate high sediment amounts at these sites.

Site OL3

Site OL3 appears to be slightly more impacted than Site OL4. All of the metrics except Shannon's D.I. have marginally better scores at Site OL4. The chironomid tribe Tanytarsini is the dominant taxon in the samples from OL3. Also abundant within the samples are the following relatively tolerant groups: the mayflies *Baetis* and *Diphetor* (Baetidae), the blackfly *Simulium* (Simuliidae), and *Zaitzevia. Lepidostoma* is also common but less abundant than at the three upstream sites.

Site OL2

The dominant taxa at Site OL2 are, once again, Tanytarsini and *Lepidostoma.* A moderately high number of *Optioservus* also occur at this site. Site OL2 has the highest % dominant taxon of a tolerant group (Tanytarsini) of the sites collected within Olema Creek. EFT taxa richness is also lower than at the upstream sites however the remaining metric values are not dissimilar to sites OL5 and OL6. The high number of *Lepidostoma* suggest at least a moderate amount of riparian input to the stream.

Site OL1

Site OL1 has the lowest EPT richness and modified EPT index values of the Olema Creek sites. The dominant taxa at this site include *Optioservus* and the dipteran subfamily Orthocladiinae (Chironomidae). The elmid *Zaitzevia* is also fairly common as are Tanytarsini, *Sweltsa, Hydropsyche,* and *Lepidostoma.* Apart from EPT taxa richness and modified EPT index the metric values do not vary considerably from the upstream sites.

The metrics suggest that Site OL4 has the highest quality macroinvertebrate habitat among the sites sampled. EPT taxa richness suggest sites OL2 and OL1 have the most highly impacted habitat among the sites collected. The remaining metrics do not suggest a direct upstream to downstream decline in habitat quality.

OL3, OL4, and OL6 share the highest RRIBI score (18) among the Olema Creek sites. Sites OL1 and OL2 follow with a score of 16 and site OL5 received a score of 12. Lowest taxa richness among the Olema Creek sites and high number *of Lepidostoma* at site OL5, assuring low scores for % dominant taxon and Shannon's D.I., contribute to the low score. Based on the site descriptions, the RRIBI may be a valuable index for detecting disturbance within Olema Creek. The RRIBI scoring criteria may be too rigorous for this small watershed, however, in view of the fact that no sites received a low impairment (5) score.

Schooner Creek

DEI and DE2

Site DEI displays low EPT taxa richness and modified EPT index scores and high tolerance value scores. Dominant taxa within the samples are all considered tolerant of disturbance and suggest an impaired habitat. These include *Optioservus,* Tanytarsini, *Diphetor,* the ubiquitous amphipod *Hyalella* (Hyalellidae), and the estuarine isopod *Gnorimosphaeroma* (Sphaeromaridae). Although aJist of sediment tolerant taxa is wanting for north coastal California, these taxa could probably all be considered sediment tolerant Interestingly the nemourid stonefly *Zapada cinctipes* (a shredder) is also common at this site suggesting some riparian input to the stream. Hawkins et al. (2000) note however, that *ZopodalMalenka,* Tanytarsini, and *Baetis* have been observed in light- or nutrient-enriched streams, which may be a factor at this site.

The taxa richness and EPT taxa richness metric values at the upstream site, DE2, suggest better overall habitat than at DEL Modified EPT index and tolerance value scores suggest disturbed habitat, however. Dominant taxa include Tanytarsini and *Gnorimosphaeroma. Optioservus, Diphetor,* and *Zapada cinctipes* are also common taxa in the samples. Several macroinvertebrates considered intolerant were also collected at Site DE2, though none were common. Included are the dipteran *Glutops* (Pelecorhynchidae), and the trichopterans *Cryptochia* (Limnephilidae) and *Fonda* (Uenoidae). Other taxa typical of small, cool streams collected at DE2 are the dipteran *Boreochlus* (Chironomidae) and the stonefly *Soyedina* (Nemouridae). The inclusion of these taxa in the samples and the relatively high number of taxa collected (particularly in sample DE2-0999-T3) suggest a small cool stream. The large number of tolerant taxa, however, suggest some form of perturbation.

It should be noted that they latest edition of Pennak (1989) does not include *Gnorimosphaeroma* in the taxonomic key. This estuarine isopod was determined using an earlier edition. It may be common in lower sections of streams near marine waters (abundant here and in Mendocino County, CA). A literature search found little information on it. It would be interesting to gather more information on this critter and determine whether it can be a confounding influence on metrics or is indeed indicative of impaired habitat

Home Ranch Creek

Sites DE3 and DE4

Metric scores from site DE3 were the poorest from any site sampled. Taxa richness and EFT taxa richness were much lower than at any other site. A total of 8 EFT taxa were found in the three samples, easily the lowest number among the sites. The dominant taxon is the very tolerant amphipod *Hyalella. Hyalella* accounts for almost half (49.3%) of the specimens in the three samples. The second most dominant taxon is *Optioservus.* Together these taxa account for over 77% of the macroinvertebrates in the DE3 subsamples. The metric scores suggest that DE3 to be the most highly impaired site within this survey.

Metric scores for site DE4 suggest a less impaired site than metric scores for site DE3. Each metric score suggests greater impairment at DE3 giving the strongest evidence of greater habitat disturbance at a downstream site compared to an upstream site of any pair of sites in this survey. The metric scores do, however, suggest an impaired habitat Dominant taxa include the disturbance tolerant *Optioservus* , *Baetis* and *Hydropsyche. A* facultative mayfly shredder *Paraleptophlebia* (Leptophlebiidae) and the stonefly family Nemouridae are also present suggesting some riparian input

Muddy Hollow Creek

Sites DE5 and DE6

Sites DE5 and DE6 have metric scores which are similar, scores at DE5 suggesting somewhat better habitat The dominant taxon in samples from both sites is the elmid beetle *Optioservus.* The next dominant taxon from site DE5 samples is *Gnorimosphaeroma* and from site DE6 samples, *Baetis.* Each of these taxa is considered tolerant of disturbance, suggesting impairment at both sites. The shredder functional feeding group is relatively well represented in samples from both sites suggesting some riparian input Although displaying overall metric scores suggesting higher quality habitat than the other DE sites the macroinvertebrate assemblage suggests impairment at sites DE5 and DE6.

The high number of tolerant taxa suggest some form of perturbation at each of these sites.

Common, though not abundant at the sites, are taxa considered to be in the shredder functional feeding group suggesting some riparian input at each site, although as mentioned, *Malenka/Zapada* presence may also suggest enrichment in the streams. Also at each site (except DE3) are taxa generally considered to be representative of small cool creeks. The macroinvertebrate data suggest high temperatures or poor riparian cover may not be an impairment at these sites. Past and present land use practices suggest sedimentation may be the primary negative impact at these sites.

RRIBI scores were lower at the downstream sites at Schooner, Home Ranch, and Muddy Hollow Creeks. Scores for DE3 are the lowest scores given and are in line with the site description which indicates a highly impacted site. The RRIBI score (18) at site DE5 was the highest of the sample sites among these three creeks suggesting streambed stabilization may be occurring at this site as referred to in the site description.

CONCLUSIONS

The metrics suggest that sample site OL4 had the least disturbed habitat among the sites. All metric scores from this site ranked either number one or number two among all sites. The metrics did not suggest an upstream to downstream trend in degree of disturbance within Olema Creek. They did suggest that sites OL1, OL2, and OL5 were the most impaired of the sites sampled. Schooner, Home Ranch, and Muddy Hollow Creeks each displayed metrics suggesting greater impairment at downstream sample sites than at upstream sites.

The Russian River Index of Biological Integrity can apparently detect disturbance impacts to the benthic macroinvertebrate community within Point Reyes National Seashore when comparing sites. Habitat impairment or disturbance is suggested at all of the benthic macroinvertebrate sample sites when the biological metrics from these sites are compared to the RRIBI. Whether this phenomenon is attributable to past and present land use practices or to the possibility that small coastal streams in this region may be naturally taxa and EPT taxa poor is worth further research. If benthic macroinvertebrate communities in this area differ naturally from the Russian River watershed, development of an Index of Biological Integrity for Point Reyes National Seashore may be warranted.

It may be worth investigating whether a reference stream exists within Point Reyes National Seashore. A reference stream would be an effective comparison for metrics which were generated from samples collected within the Seashore.

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APPENDIX B
Taxa List for September 1999
Samples DE1-0999 to OL6-0999

	SAMPLE I.D.		
	DE1-0999-T1 IX-15-99	DE1-0999-T2 IX-15-99	DE1-0999-T3 IX-15-99
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes		1	
Elmidae			
Optioservus	23	71	47
Hydrophilidae			
Laccobius		1	
Diptera			
Chironomidae			
Chironominae			
Chironomini		4	8
Tanytarsini	15	45	84
Orthocladiinae	3	13	7
Tanypodinae		6	6
Dixidae			
Dixa		1	
Empididae			
Trichoclinocera		4	
Pelecorhynchidae			
Glutops		4	2
Psychodidae			
Pericoma		1	
Simuliidae			
Simulium	3	1	
Tipulidae			
Dicranota	6	11	4
Limnophila	3	2	1
Ephemeroptera			
Baetidae			
Baetis	3	4	9
Diphetor	62	2	30
Heptageniidae			
Ironodes	3		
Leptophlebiidae			
Paraleptophlebia	5		3
Plecoptera			
Capniidae	5	1	1
Nemouridae			
Malenka	14		2
Zapada cinctipes	35	2	29
Perlodidae			
Isoperla	1		
Trichoptera			
Arctopsychidae			
Parapsyche	6	1	1

	SAMPLE I.D.		
	DE1-0999-T1 **IX-15-99**	**DE1-0999-T2** **IX-15-99**	**DE1-0999-T3** **IX-15-99**
Uenoidae			
Neophylax			1
CRUSTACEA			
Amphipoda			
Hyalellidae			
Hyalella	36	23	11
Isopoda			
Sphaeromatidae			
Gnorimosphaeroma	51	81	42
ARACHNIDA			
Acarina			
Hygrobatidae	2	1	1
Lebertiidae	9	7	5
Sperchonidae	13	3	2
OLIGOCHAETA			
Lumbricina		5	3
Total number specimens:	298	295	299

	DE2-0999-T1 **IX-15-99**	**DE2-0999-T2** **IX-15-99**	**DE2-0999-T3** **IX-15-99**
INSECTA			
Coleoptera			
Elmidae			
Optioservus	12	25	21
Diptera			
Ceratopogonidae	1		3
Atrichopogon			1
Chironomidae			
Chironominae			
Chironomini	11	4	10
Tanytarsini	141	76	19
Orthocladiinae	5	11	13
Podonominae			
Boreochlus			6
Tanypodinae	4	7	5
Dixidae			
Dixa	1		7
Meringodixa		1	2
Empididae			
Chelifera		1	
Trichoclinocera	4	1	
Pelecorhynchidae			
Glutops		1	1
Psychodidae			
Pericoma			6
Ptychopteridae			
Ptychoptera		1	10
Simuliidae			
Simulium			1

	SAMPLE I.D.		
	DE2-0999-T1 IX-15-99	DE2-0999-T2 IX-15-99	DE2-0999-T3 IX-15-99
Thaumaleidae			
Thaumalea		1	
Tipulidae			
Dicranota			1
Tipula			3
Ephemeroptera			
Baetidae			
Baetis		3	1
Diphetor	18	29	35
Heptageniidae			
Cinygmula		1	
Ironodes			4
Leptophlebiidae			
Paraleptophlebia	6	7	1
Plecoptera			
Capniidae		1	
Chloroperlidae			
Sweltsa	1	3	2
Leuctridae		1	
Nemouridae			
Malenka		1	
Soyedina		3	17
Zapada cinctipes	20	11	8
Perlodidae			
Isoperla	3	1	2
Trichoptera			
Calamoceratidae			
Heteroplectron			1
Lepidostomatidae			
Lepidostoma	2		1
Limnephilidae			
Cryptochia			1
Psychoglypha	1	1	1
Rhyacophilidae			
Rhyacophila	2	1	3
Uenoidae			
Farula		3	2
CRUSTACEA			
Isopoda			
Sphaeromatidae			
Gnorimosphaeroma	57	94	93
ARACHNIDA			
Acarina			2
Anisitsiellidae	1		
Hygrobatidae		2	2
Lebertiidae		1	2
Sperchonidae		1	1
OLIGOCHAETA			
Lumbricina	1		2
Total number specimens:	291	293	290

	SAMPLE I.D.		
	DE3-0999-T1 IX-15-99	DE3-0999-T2 IX-15-99	DE3-0999-T3 IX-15-99
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes	1		
Elmidae			
Optioservus	71	80	101
Hydrophilidae	1	1	
Diptera			
Chironomidae			
Chironominae			
Tanytarsini		1	
Orthocladiinae		1	
Tanypodinae	3	2	6
Simuliidae			
Simulium	1	2	1
Tipulidae			
Dicranota	1	1	3
Ephemeroptera			
Baetidae			
Diphetor	1		5
Leptophlebiidae			
Paraleptophlebia	2	4	12
Hemiptera			
Corixidae			
Sigara	2		
Plecoptera			
Chloroperlidae			
Sweltsa			1
Nemouridae			
Malenka	5	10	19
Zapada cinctipes	4	8	9
Trichoptera			
Glossosomatidae (pupa)		1	
Lepidostomatidae			
Lepidostoma	7	12	4
Rhyacophilidae			
Rhyacophila		1	
CRUSTACEA			
Amphipoda			
Hyalellidae			
Hyalella	173	149	110
Isopoda			
Sphaeromatidae			
Gnorimosphaeroma	1	3	4
Ostracoda			
Cyprididae		5	
ARACHNIDA			
Acarina			
Lebertiidae		3	1
Sperchonidae	3	2	13

	SAMPLE I.D.		
	DE3-0999-T1 IX- 15-99	DE3-0999-T2 IX- 15-99	DE3-0999-T3 IX- 15-99
OLIGOCHAETA			
Haplotaxida			
Naididae		1	
Tubificidae	2	1	
Lumbricina	6	10	8
NEMATODA			
Mermithidae			1
Total number specimens:	**284**	**298**	**298**

	DE4-0999-T1 IX- 16-99	DE4-0999-T2 IX- 16-99	DE4-0999-T3 IX- 16-99
INSECTA			
Coleoptera			
Elmidae			
Optioservus	94	97	83
Diptera			
Ceratopogonidae	2	1	
Chironomidae			
Chironominae			
Chironomini	1		
Tanytarsini	11	4	7
Orthocladiinae	5	1	6
Tanypodinae	1	1	3
Dixidae			
Dixa		1	
Pelecorhynchidae			
Glutops	1		
Psychodidae			
Mariana			1
Simuliidae			
Simulium	3	1	2
Tipulidae			
Dicranota	2		1
Tipula	1		
Ephemeroptera			
Baetidae			
Baetis	51	78	63
Centroptilum			1
Diphetor	5	15	10
Heptageniidae			
Cinygmula	7	3	6
Ironodes	11	8	6
Leptophlebiidae			
Paraleptophlebia	13	13	16
Plecoptera			
Chloroperlidae			
Sweltsa	1		

	SAMPLE I.D.		
	DE4-0999-T1 IX-16-99	**DE4-0999-T2 IX-16-99**	**DE4-0999-T3 IX-16-99**
Nemouridae			
Malenka	6	8	1
Zapada cinctipes	21	21	18
Trichoptera			
Calamoceratidae			
Heteroplectron	1		
Glossosomatidae			
Glossosoma		1	
Hydropsychidae			
Hydropsyche	44	31	48
Odontoceridae			
Parthina	1	2	
Rhyacophilidae			
Rhyacophila	3	6	7
CRUSTACEA			
Isopoda			
Sphaeromatidae			
Gnorimosphaeroma	1	2	4
ARACHNIDA			
Acarina			
Sperchonidae	8	5	5
OLIGOCHAETA			
Haplotaxida			
Naididae		1	
Lumbricina	3	1	
TURBELLARIA			
Tricladida			
Planariidae			
Dugesia	1		
Total number specimens:	**298**	**301**	**300**

	DE5-0999-T1 IX-16-99	**DE5-0999-T2 IX-16-99**	**DE5-0999-T3 IX-16-99**
INSECTA			
Coleoptera			
Elmidae			
Optioservus	78	47	99
Diptera			
Chironomidae			
Chironominae			
Tanytarsini	26	49	16
Orthocladiinae	9	13	7
Tanypodinae	2	1	1
Dixidae			
Dixa	1	1	
Pelecorhynchidae			
Glutops		1	
Simuliidae			
Simulium	7	7	9

	SAMPLE I.D.		
	DE5-0999-T1 IX-16-99	DE5-0999-T2 IX-16-99	DE5-0999-T3 IX-16-99
Tipulidae			
Dicranota		1	1
Hexatoma			1
Limnophila		1	
Ephemeroptera			
Baetidae			
Baetis	11	6	9
Diphetor	11	9	
Heptageniidae			
Cinygmula	3	8	
Ironodes	14	18	2
Leptophlebiidae			
Paraleptophlebia	16	32	3
Plecoptera			
Leuctridae	1		
Nemouridae			
Malenka	1	7	
Zapada cinctipes	23	20	5
Perlodidae			
Isoperla	6	8	8
Trichoptera			
Arctopsychidae			
Parapsyche	2	1	4
Glossosomatidae			
Agapetus	16	4	10
Glossosoma	3		2
Hydropsychidae			
Hydropsyche	2	1	5
Odontoceridae			
Parthina			1
Rhyacophilidae			
Rhyacophila	7	8	16
CRUSTACEA			
Amphipoda			
Hyalellidae			
Hyalella	3	8	1
Isopoda			
Sphaeromatidae			
Gnorimosphaeroma	50	32	72
ARACHNIDA			
Acarina			
Aturidae	1		
Hygrobatidae	1	2	1
Lebertiidae	1	3	7
Sperchonidae	5	5	11
Torrenticolidae		1	
OLIGOCHAETA			
Haplotaxida			
Naididae		1	
Lumbricina	1		1
Total number specimens:	**301**	**295**	**292**

	SAMPLE I.D.		
	DE6-0999-T1 IX- 16-99	**DE6-0999-T2 IX- 16-99**	**DE6-0999-T3 IX- 16-99**
INSECTA			
Coleoptera			
Elmidae			
Optioservus	55	105	96
Diptera			
Ceratopogonidae	1		
Chironomidae			
Chironominae			
Tanytarsini	29	20	34
Orthocladiinae			4
Tanypodinae			1
Dixidae			
Dixa		1	
Empididae			
Trichoclinocera	1		
Muscidae			
Limnophora			1
Simuliidae			
Simulium	7	11	1
Tipulidae			
Dicranota	2	2	2
Limnophila	1		
Rhabdomastix	1		
Ephemeroptera			
Baetidae			
Baetis	97	73	68
Diphetor	7	4	6
Leptophlebiidae			
Paraleptophlebia	7	6	16
Plecoptera			
Nemouridae			
Malenka	30	16	25
Zapada cinctipes	29	29	26
Perlodidae			
Isoperla	13	7	11
Trichoptera			
Arctopsychidae			
Parapsyche	1	2	1
Glossosomatidae			
Agapetus	1	1	1
Hydropsychidae			
Hydropsyche	1	1	1
Hydroptilidae			
Hydroptila	3		2
Oxyethira			2
Lepidostomatidae			
Lepidostoma		1	
Rhyacophilidae			
Rhyacophila	2	5	1

	SAMPLE I.D.		
	DE6-0999-T1 IX-16-99	DE6-0999-T2 IX-16-99	DE6-0999-T3 IX-16-99
CRUSTACEA			
Amphipoda			
Hyalellidae			
Hyalella	3	5	4
ARACHNIDA			
Acarina			
Aturidae			1
Hygrobatidae		1	
Lebertiidae	3	6	3
Sperchonidae	2	5	
OLIGOCHAETA			
Lumbricina	3		1
Total number specimens:	**299**	**301**	**308**

	OL1-0999-T1 IX-9-99	OL1-0999-T2 IX-9-99	OL1-0999-T3 IX-9-99
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes	3	1	4
Elmidae			
Narpus	1		
Optioservus	74	66	114
Ordobrevia	1		1
Zaitzevia	34	21	7
Hydraenidae			
Hydraena		4	
Diptera			
Ceratopogonidae	4	1	2
Chironomidae			
Chironominae			
Chironomini	1	2	3
Tanytarsini	5	25	14
Orthocladiinae	61	65	27
Tanypodinae		1	
Empididae (pupa)			1
Psychodidae			
Pericoma		5	
Simuliidae			
Simulium	5	1	1
Tipulidae			
Dicranota		2	1
Hexatoma	15	5	2
Limnophila			7
Rhabdomastix			1
Ephemeroptera			
Baetidae			
Centroptilum			1
Diphetor	2		7

	SAMPLE I.D.		
	OL1-0999-T1 IX-9-99	OL1-0999-T2 IX-9-99	OL1-0999-T3 IX-9-99
Heptageniidae			
Leucrocuta			3
Leptophlebiidae			
Paraleptophlebia	1		2
Plecoptera			
Chloroperlidae			
Sweltsa	21	12	11
Nemouridae			
Malenka	5	7	21
Perlodidae			
Isoperla	6	1	2
Trichoptera			
Glossosomatidae			
Agapetus	7	4	14
Hydropsychidae			
Hydropsyche	22	17	13
Lepidostomatidae			
Lepidostoma	18	23	16
Philopotamidae			
Wormaldia		1	1
Sericostomatidae			
Gumaga	1		1
ARACHNIDA			
Acarina			
Arrenuridae	1		
Aturidae	1		
Hygrobatidae	1		11
Lebertiidae	2	13	2
Sperchonidae	1	1	1
Torrenticolidae	4	8	9
Total number specimens:	**297**	**286**	**300**

	OL2-0999-T1 IX-9-99	OL2-0999-T2 IX-9-99	OL2-0999-T3 IX-9-99
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes		1	1
Elmidae			
Narpus	4		
Optioservus	30	14	15
Ordobrevia		1	
Zaitzevia	8	6	10
Diptera			
Ceratopogonidae	6	2	3
Chironomidae			
Chironominae			
Chironomini	7	2	1
Tanytarsini	84	125	118

	SAMPLE I.D.		
	OL2-0999-T1	**OL2-0999-T2**	**OL2-0999-T3**
	IX-9-99	**IX-9-99**	**IX-9-99**
Orthocladiinae	8	13	23
Empididae (pupa)	1		
Psychodidae			
Pericoma			1
Simuliidae			
Simulium		14	21
Tipulidae			
Dicranota			1
Hesperocanopa			1
Hexatoma	2	1	6
Rhabdomastix	1		
Ephemeroptera			
Baetidae			
Baetis	1	14	9
Centroptilum	1		
Diphetor	4	8	6
Heptageniidae			
Cinygmula		1	1
Leucrocuta	5	2	1
Rhithrogena		4	
Leptophlebiidae			
Paraleptophlebia	16	4	
Megaloptera			
Sialidae			
Sialis	2		
Plecoptera			
Chloroperlidae			
Sweltsa	2	7	7
Nemouridae			
Malenka		7	19
Perlidae			
Calineuria		2	
Perlodidae			
Isoperla	1		
Trichoptera			
Glossosomatidae			
Agapetus	3	10	8
Glossosoma			1
Hydropsychidae			
Hydropsyche	1	7	2
Lepidostomatidae			
Lepidostoma	73	40	46
Odontoceridae			
Parthina		1	
Rhyacophilidae			
Rhyacophila		2	1
Sericostomatidae			
Gumaga	1		

	SAMPLE I.D.		
	OL2-0999-T1	**OL2-0999-T2**	**OL2-0999-T3**
	IX-9-99	**IX-9-99**	**IX-9-99**
ARACHNIDA			
Acarina			
Hygrobatidae	2		
Lebertiidae	2	2	1
Torrenticolidae	16	11	5
Total number specimens	**281**	**301**	**308**

	OL3-0999-T1	**OL3-0999-T2**	**OL3-0999-T3**
	IX-8-99	**IX-8-99**	**IX-8-99**
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes		2	1
Elmidae			
Narpus	1		
Optioservus	6	10	13
Ordobrevia	3	8	13
Zaitzevia	23	17	14
Diptera			
Ceratopogonidae	2		4
Chironomidae			
Chironominae			
Chironomini	1	1	6
Tanytarsini	47	26	99
Orthocladiinae	13	6	29
Tanypodinae		2	5
Dixidae			
Dixa		3	
Empididae			
Chelifera			2
Hemerodromia			1
Psychodidae			
Mariana		1	
Simuliidae			
Simulium	31	57	
Tipulidae			
Antocha	1		
Hexatoma	2	1	2
Rhabdomastix	2		2
Ephemeroptera			
Baetidae			
Baetis	33	39	9
Centroptilum			6
Diphetor	26	34	31
Heptageniidae			
Leucrocuta	1	4	2
Rhithrogena	9	18	2
Leptophlebiidae			
Paraleptophlebia	4	2	2

SAMPLE I.D.	OL3-0999-T1 IX-9-99	OL3-0999-T2 IX-9-99	OL3-0999-T3 IX-9-99
Plecoptera			
Chloroperlidae			
Sweltsa	7	4	6
Nemouridae			
Malenka	10	6	5
Zapada cinctipes	1		
Perlidae			
Calineuria	2		1
Perlodidae			
Isoperla	1		3
Trichoptera			
Glossosomatidae			
Agapetus	5	2	2
Hydropsychidae			
Hydropsyche	11	15	2
Lepidostomatidae			
Lepidostoma	48	17	7
Philopotamidae			
Wormaldia		3	
Rhyacophilidae			
Rhyacophila		2	4
Sericostomatidae			
Gumaga	1		4
ARACHNIDA			
Acarina			
Hygrobatidae		1	5
Lebertiidae			2
Torrenticolidae	9	3	21
OLIGOCHAETA			
Haplotaxida			
Naididae		2	
Total number specimens:	**300**	**286**	**305**

	OL4-0999-T1 IX-9-99	OL4-0999-T2 IX-9-99	OL4-0999-T3 IX-9-99
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes			2
Elmidae			
Narpus			2
Optioservus	17	11	57
Ordobrevia	4	3	9
Zaitzevia	5	5	10
Diptera			
Ceratopogonidae	2	3	7
Chironomidae			
Chironominae			
Chironomini	8	10	21
Tanytarsini	31	62	30

	SAMPLE I.D. OL4-0999-T1 IX-9-99	OL4-0999-T2 IX-9-99	OL4-0999-T3 IX-9-99
Orthocladiinae	19	34	8
Tanypodinae		7	5
Empididae			
Chelifera	1		1
Psychodidae			
Mariana	1		
Simuliidae			
Simulium	3	1	4
Tipulidae			
Dicranota	1		
Hexatoma	1	1	3
Limonia	1		
Ephemeroptera			
Baetidae			
Baetis	9	7	8
Diphetor	3	4	1
Heptageniidae			
Leucrocuta/Nixe	2		1
Rhithrogena	50	3	3
Leptophlebiidae			
Paraleptophlebia	6	1	
Plecoptera			
Chloroperlidae			
Paraperla	4		1
Sweltsa	9	11	13
Leuctridae			1
Nemouridae			
Malenka	17	2	
Perlidae			
Calineuria		1	
Hesperoperla pacifica		2	
Perlodidae			
Isoperla	3	2	1
Trichoptera			
Brachycentridae			
Micrasema	1	7	2
Glossosomatidae			
Agapetus	1	1	1
Glossosoma		1	1
Hydropsychidae			
Hydropsyche	30	42	2
Lepidostomatidae			
Lepidostoma	45	31	70
Philopotamidae			
Wormaldia	1	2	1
Rhyacophilidae			
Rhyacophila	8	38	16
Sericostomatidae			
Gumaga			4

	SAMPLE I.D.		
	OL4-0999-T1	OL4-0999-T2	OL4-0999-T3
	IX-9-99	IX-9-99	IX-9-99
ARACHNIDA			
Acarina			
Hydryphantidae	1		1
Lebertiidae	1	1	
Torrenticolidae	5	1	8
Total number specimens:	**290**	**294**	**294**

	OL5-0999-T1	OL5-0999-T2	OL5-0999-T3
	IX-8-99	IX-8-99	IX-8-99
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes			1
Elmidae			
Narpus	1		
Optioservus	7	17	5
Ordobrevia	10	14	
Zaitzevia			1
Psephenidae			
Eubrianax		2	
Diptera			
Ceratopogonidae	4	1	
Chironomidae			
Chironominae			
Chironomini	4	3	8
Tanytarsini	59	55	36
Orthocladiinae	85	3	7
Tanypodinae		2	
Empididae			
Chelifera	7		
Simuliidae			
Simulium	2		
Tipulidae			
Dicranota		1	
Hexatoma		1	
Ephemeroptera			
Baetidae			
Baetis	7	1	
Centroptilum			2
Diphetor	5	10	3
Ephemerellidae			
Ephemerella			1
Heptageniidae			
Cinygmula	4		
Leucrocuta		5	1
Rhithrogena	1		
Leptophlebiidae			
Paraleptophlebia	3	9	1

	SAMPLE I.D.		
	OL5-0999-T1	**OL5-0999-T2**	**OL5-0999-T3**
	IX-8-99	**IX-8-99**	**IX-8-99**
Megaloptera			
Sialidae			
Sialis			2
Plecoptera			
Chloroperlidae			
Sweltsa		2	
Nemouridae			
Malenka	16	5	2
Perlidae			
Calineuria	1		
Perlodidae			
Isoperla		1	
Trichoptera			
Arctopsychidae			
Parapsyche	1		
Brachycentridae			
Micrasema	3	2	1
Calamoceratidae			
Heteroplectron			1
Glossosomatidae			
Agapetus		3	1
Glossosoma	1	5	
Hydropsychidae			
Hydropsyche	36		
Lepidostomatidae			
Lepidostoma	29	153	212
Philopotamidae			
Wormaldia	1		
Polycentropodidae			
Polycentropus	'	1	
Rhyacophilidae			
Rhyacophila	1	3	
Sericostomatidae			
Gumaga			1
Uenoidae			
Neophylax		2	1
ARACHNIDA			
Acarina			
Lebertiidae		1	1
Torrenticolidae	8	3	12
GASTROPODA			
Pulmonata			
Physidae			
Physella		1	
Total number specimens:	**296**	**306**	**300**

	SAMPLE I.D.		
	OL6-0999-T1 IX-8-99	OL6-0999-T2 IX-8-99	OL6-0999-T3 IX-8-99
INSECTA			
Coleoptera			
Dytiscidae			
Oreodytes			3
Elmidae			
Narpus	1	1	
Optioservus	23	8	27
Ordobrevia	2	19	10
Diptera			
Ceratopogonidae		5	11
Chironomidae			
Chironominae			
Chironomini	7	21	20
Tanytarsini	64	103	90
Orthocladiinae	3	6	23
Tanypodinae	7	4	8
Dixidae			
Dixa	1		
Empididae (pupa)	1		
Pelecorhynchidae			
Glutops		1	1
Psychodidae			
Maruina	1	5	
Tipulidae			
Antocha		1	
Dicranota	1		1
Hexatoma	2		1
Ephemeroptera			
Baetidae			
Baetis		1	1
Centroptilum	1	6	11
Diphetor	12	12	12
Ephemerellidae			
Ephemerella		1	
Heptageniidae			
Leucrocuta	3	4	7
Rhithrogena	2		
Leptophlebiidae			
Paraleptophlebia	4	9	25
Megaloptera			
Sialidae			
Sialis		1	1
Odonata			
Gomphidae		1	
Plecoptera			
Chloroperlidae			
Paraperla			1
Sweltsa		1	
Nemouridae			
Malenka	8	16	11

	SAMPLE I.D.		
	OL6-0999-T1	**OL6-0999-T2**	**OL6-0999-T3**
	IX-8-99	**IX-8-99**	**IX-8-99**
Perlidae			
Calineuria	1		
Perlodidae			
Isoperla		1	1
Trichoptera			
Brachycentridae			
Micrasema	2	2	
Calamoceratidae			
Heteroplectron			2
Lepidostomatidae			
Lepidostoma	125	33	17
Odontoceridae			
Parthina	1	1	1
Polycentropodidae			
Polycentropus		1	5
Rhyacophilidae			
Rhyacophila	5	3	6
Sericostomatidae			
Gumaga			4
Uenoidae			
Neophylax	1	1	2
CRUSTACEA			
Amphipoda			
Crangonyctidae			
Stygobromus			1
ARACHNIDA			
Acarina			
Lebertiidae	3	1	
Torrenticolidae	10	13	7
Total number specimens:	**291**	**282**	**310**