Using Macroinvertebrate Community Functional Organization to Predict Prey Base and Ecosystem Attributes Favorable to Juvenile Salmonid Growth and Survival in Freshwater Creek

Summary of Invertebrate Functional Feeding Group Composition
Freshwater Creek Basin
Summer 2004

n=317

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RCAA Contract #03-212-551-0
Pacific Lumber Contract # M6493
March 21, 2005
INVERTEBRATE FUNCTIONAL GROUP ANALYSIS
FOR THE
FRESHWATER CREEK WATERSHED

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Introduction

An invertebrate assessment using functional feeding group (FFG) classification (Cummins and Klug 1979; Merritt and Cummins 1996; Appendix I) was conducted in the Freshwater Creek Basin, Humboldt County, California in August and September 2004. Working in conjunction with the Institute for River Ecosystems (IRE), and California Department of Fish and Game (DFG) Anadromous Fisheries Research and Monitoring Program (AFRAMP) juvenile salmonid survey, an invertebrate survey crew from IRE sampled stream invertebrates at locations determined by a modified Hankin and Reeves (1988) protocol for the juvenile salmonid survey.

The juvenile salmonid survey crew followed a sequential protocol to monitor Freshwater Basin for juvenile salmonid species. First, habitat units were selected and flagged for later snorkel-dive, electrofishing, and invertebrate assessment surveys. With a few exceptions habitat units were classified as riffles (RI), shallow pools (SP), and deep pools (DP). Riffles were not snorkel-surveyed but one-tenth of all flagged riffles were selected for electrofishing. One-third of all shallow pools were selected for snorkel-surveying. One-fourth of the shallow pools that had been snorkel surveyed were selected for electrofishing. Thus, one-twelfth of all flagged shallow pools were selected for electrofishing. Invertebrates were sampled at every other electrofished unit. Because deep pools were snorkeled but not electrofished, no invertebrates were sampled at deep pool locations. The invertebrate survey crew worked up stream to the end of anadromy following the snorkel survey up. The electrofishing survey teams came up behind the invertebrate survey crew enumerating salmonid species. Salmonid stomach samples were taken from up to ten fish over one year old collected from those electrofishing sites where invertebrate samples were taken. This protocol allowed for a match between the juvenile salmonid stomach samples and invertebrate collections at all invertebrate sampling sites.
**Functional Groups**

The separation of stream invertebrates into functional feeding groups (FFG) is based on the mechanisms by which they acquire their food. Morphological and behavioral adaptations used in acquiring the food are generally easily observed in the field using live, freshly collected specimens. An example would be the large eyes, bright color patterns, and active movement that characterize the predaceous stonefly families. This combination of characters identifies these stoneflies as predators. The morphological characters used to place stream invertebrates into FFGs are given in the Key to FFGs in Appendix I. Feeding mechanisms, dominant food resources, and particle size ranges are summarized for each FFG in Table 1.

**Field Methods**

*Header Information*

At each unit, the Stream Name, Reach ID, and Drainage were recorded, as well as Habitat Unit Number and Type. Date, Water Temperature, and Time were also recorded. At every Unit where invertebrate sampling took place, stomach samples were collected by the electrofishing crew. The invertebrate crew left flagging to notify the electrofishing crew of the units where invertebrate sampling took place.

*Invertebrate Data*

In general, three samples were taken at every unit. Habitat sample type consisted of four categories; Cobble, Leaf Litter, Fine Sediments, and when available, Large Wood. For each sample, after the Header data were entered on the field form, individual invertebrates were field identified, sorted into functional feeding groups (FFG) and tallied. Field invertebrate taxonomy was generally to the family or genus level for insects and to the ordinal or class level for other invertebrates. In this method, separation of the invertebrates into functional feeding group was made in the field on fresh, live specimens. The FFGs used were: Shredders, Scrapers, Filtering Collectors, Gathering Collectors, and Predators (Cummins and Klug, 1979; Merritt and Cummins, 1996). The numbers of invertebrates contained in each FFG were tallied for every sample type. After FFG enumeration, the samples were labeled with data from the header of the field data form and preserved in 70% ethyl alcohol (ETOH) for return to the laboratory for analysis. In the laboratory, the invertebrates can be identified to a finer taxonomic level and the specimens measured to permit conversion of numbers to biomass using the software INVERTCALC (Cummins, Wilzbach, and Merritt, unpublished).
Invertebrate Sampling

Once the unit selection procedure and snorkel survey had taken place, units were sampled for invertebrates. The protocol (Figure 1) was to take one sample from each habitat type: leaf litter, cobble, fine sediment, and wood. Availability determined whether all habitat types could be sampled at each site. If leaf litter was abundant, it would be collected first, followed by cobble, and then fine sediments and large wood. If fine sediment depositional areas or large wood were absent, two cobble samples were taken.

A 250 µm mesh D-frame dip net was used to sample all four habitat types. This allowed for the separation of insects from fine sediment and particles of organic debris. All D-frame dip net collections were made for 40 seconds. Leaf Litter was collected for 40 seconds, and then the leaves were rinsed to separate insects from leaves. Water soaked logs or large woody debris were sampled for 40 seconds by rubbing the surface of the wood by hand to dislodge the invertebrates into the net. Invertebrates were removed by hand scrubbing the cobbles in the streambed into the net for 40 seconds. Fine sediments were sampled in pools or backwaters when they were present by skimming off the upper 1-2 cm for 40 seconds. An example field data sheet is given in Appendix II.

After collection, each sample was washed into a shallow white tray for taxonomic separation, functional group assignment, and enumeration. Functional group determinations were aided by a laminated FFG field key (Appendix 1; Cummins, Wilzbach, and Merritt, unpublished). Following enumeration and data entry on to the field form, each sample was washed onto a 250 µm sieve and into a whirl-pak® scientific collecting bag, and preserved with 70% ETOH for later lab analysis. Each bag was labeled with the Header information from the corresponding field data form.

Fish Stomachs

At every other electro-fishing unit where the invertebrate sampling was done, the invertebrate sampling crew left a flag marker to alert the fish sampling crew that fish stomach (lavage) samples were to be taken. At each of these sites, up to ten 1+ year old juvenile salmonids were stomach-pumped. Stomachs were flushed with a syringe into a tray and the material preserved in whirl-paks® with 70% ETOH. The tip of the syringe needle was protected with fine, flexible plastic tubing to prevent damage to the fish esophagus and stomach. Each sample was labeled with information corresponding to that recorded on the invertebrate field data form header from that site. Fish stomachs collected in Cloney Gulch were analyzed in the laboratory. Invertebrates were separated into taxa and converted to biomass using INVERTCALC, a software program that converts lengths of individuals into taxa-specific biomass estimates (Cummins and Wilzbach, unpublished).
Results

Invertebrates were collected, using methods described previously, from each stream in conjunction with the (AFRAMP) juvenile salmonid survey. In this manner samples were collected from ratio-generated locations (units) on the Mainstem. Using the same ratios and sampling protocol, the six tributary streams were sampled upstream until the end of anadromy (i.e. until no more juvenile coho were encountered).

A total of 317 samples was taken from six tributary streams and the two sections of the Mainstem in the Freshwater Creek Basin. Upper and Middle Mainstem were delineated as above and below the confluence with the South Fork of Freshwater Creek. The number of invertebrate sample locations for each stream and Upper and Middle Mainstem are summarized, along with the total number of samples taken in each habitat at each location, in Table 2. The taxa encountered during the survey (including all 317 samples) are summarized in Table 3. Stoneflies (Plecoptera), mayflies (Ephemeroptera) and caddisflies (Trichoptera) were well represented in all tributary streams and in both sections of the mainstem. The number of Ephemeroptera, Plecoptera, and Trichoptera relative to the total number of invertebrates present in a sample (EPT index) has been used to indicate stream health (e.g. Karr and Chu 1999). Based on this criterion alone, all six tributaries and the two sections of the mainstem that were surveyed for invertebrates were in acceptable condition. However, as indicated above (e.g. Table 3), these broad ordinal level taxonomic categories obscure within taxa functional relationships. For example, there are scrapers and gathering collectors in the order Ephemeroptera (Table 3) and these two groupings of mayflies have very different nutritional requirements (Table 1). Scrapers depend upon attached, non-filamentous algae as a food resource (autotrophic food chain) and the gathering collectors depend upon fine particulate organic matter (FPOM) (heterotrophically based food web).

A general overview of the invertebrate and juvenile salmonid surveys in the Freshwater Creek Basin is shown in Figure 2. The actual sampling locations for the invertebrate FFG data are depicted in Figure 3. From this figure it is clear that the basin coverage was quite broad and complete. The pie charts summarize relative percents of the functional groups averaged over all samples from each tributary and the mainstem sections. The estimated mean number of juvenile salmonids per running meter of stream length are also given for the study tributaries and mainstem reaches in Figure 2 and arranged by rank in Table 4. Using the autotrophy/heterotrophy index, or P/R ratio (Table 5), the tributaries and two mainstem reaches were classified as autotrophic or heterotrophic. As shown in Table 5, an FFG ratio is used as a surrogate for P/R with a threshold value of >0.75 indicating an autotrophic system with foodwebs based on in-stream algal primary production. Scrapers were the dominant FFG in four of the tributaries (Graham Gulch, Little Freshwater Creek, South Fork Freshwater Creek, and Falls Gulch). These four tributaries ranked 4th through 6th in terms of juvenile salmonid abundance. Heterotrophic based FFGs, shredders or collectors, were dominant in four tributaries and mainstem reaches (Middle and Upper Mainstem, Cloney Gulch, and McCready Gulch, Table 4). Shredders were dominant in Middle Mainstem and Cloney Gulch which were ranked 1st and 3rd in juvenile salmonid abundance (Table 4). Upper Mainstem, ranked 2nd for fish abundance, and McCready Gulch, ranked last for fish abundance, were both dominated by collectors (Table 4). Thus,
the general pattern was for heterotrophic tributaries and Mainstem reaches to support the highest juvenile salmonid densities. McCready Gulch, with its heavily silted substrates, constituted the exception (Table 4).

The results are summarized for all 317 tributary and mainstem samples combined and by each of the four habitats (cobble, litter, fines, and wood) in Figure 4 (i.e. a summary of all data shown in Figure 2). The average (by numbers) over all samples showed scrapers to be the dominant group (approx. 40%), followed by total collectors (approx. 30%), and then shredders (approx. 20%). The separation by habitat makes it clear that scrapers dominated cobble (riffle) samples, shredders dominated litter samples, and collectors made up half or more of the numbers collected from fine sediment and wood samples (Figure 3). Filtering collectors ranged from 0 (fine sediments) to 8% (cobbles), clearly reflecting the importance of surface attachment sites for this functional group. Gathering collectors accounted for over 60% of the invertebrates in fine sediment collections, indicating the abundance of their FPOM food resource in this habitat.

Examples of single Mainstem Reach or tributary analyses of FFG community organization are shown in Figure 5 (Upper Mainstem), Figure 6 (Cloney Gulch, and Figure 7 (McCready Gulch). Data for the remaining tributaries and the Middle Mainstem are presented in Appendix III. The average FFG composition for Upper Mainstem Freshwater Creek was approximately half collectors, including 10% filtering forms, a third scrapers, and about 10% shredders. The Upper Mainstem, cobble habitats averaged approximately half collectors and half scrapers, litter approximately 40% each collectors and shredders, and fine sediments and wood both had about 50% collectors (Figure 4). Cloney Gulch averaged half shredders and about a quarter each gathering collectors and scrapers, with filtering collectors essentially absent. Cobble habitats had 50% scrapers and approximately 20% each gathering collectors and shredders. Litter habitats had almost 90% shredders and fine sediments and wood with about half collectors (Figure 5). McCready Gulch samples averaged about 50% collectors and of that, about a third were filtering collectors. These were the largest filtering collector populations found anywhere in the Freshwater Creek Basin. This was reflected in the cobble samples with a third of the total being filtering collectors and about half scrapers; both these groups require the stable surfaces represented by cobble. Litter samples were about half collectors and a third shredders. Fine sediments and wood had 40 to 60% collectors. Filtering collectors were not found on fine sediments, reflecting the unstable surfaces characteristic of this habitat (Figure 6).

Fish stomach samples collected in Cloney Gulch were analyzed in the laboratory to determine the FFG composition of the diet and to convert invertebrate numbers to biomass estimates and categorize the invertebrates as either behavioral or accidental drifters. Cloney Gulch samples were selected as an example to illustrate the type of information that can be obtained from such analyses. The results of the analyses of the 35 juvenile salmonids are given in Table 6. Using the genetic analyses of juvenile salmonids collected in Cloney Gulch in 2003 as an indication of the accuracy with which field crews are able to correctly separate steelhead and cutthroat trout, an error of less than 20% would be expected in the data from 2004. Field crews made no errors in identifying coho juveniles. This was based on fish > 80 mm in length, which is the lower size limit suitable for stomach pumping. Therefore, because the field identification of juveniles is quite
The mean ratio of accidental to behavioral drifters (Table 5), an index of a reliable diurnal food supply of drift feeding juvenile salmonids, has been calculated for the fish stomachs collected in Cloney Gulch (Table 7). The ratios are above the threshold of 0.50, judged to indicate a suitable food supply for drift-feeding juvenile salmonids (Table 5), calculated using either invertebrate numbers or biomass (Table 7). The ratios could be calculated for only 17 of the 35 fish stomachs, because of zeros in either the numerator or denominator of the ratio. The heterotrophic streams (Middle and Upper Mainstem, Cloney Gulch, and McCready Gulch) had high shredder densities in late August - early September that were dominated by small, early instar lepidostomatid caddisflies. It is likely that very early instar caddis larvae that construct organic cases, such as Lepidostoma, have a much higher probability of exhibiting a diurnal pattern of entering the drift than their later instars which have much heavier wood cases. If Lepidostoma is included in the calculations of the behavioral to accidental drift ratio, 14 of the zeros are removed and the mean ratio, either by invertebrate number or biomass, is several orders of magnitude above the threshold (Table 7). However, the ratio calculated for each individual fish, rather than averaged over the entire sample, is only above the threshold in approximately 1/3 of the fish. That is, the phenomenon is discernable at the population level, but because many fish have little or no material in their guts, specific individual fish may not fit the average pattern.

Discussion

The invertebrate functional feeding group (FFG) analysis conducted in the Freshwater Creek demonstrated the utility of the method in providing a rapid, field-based evaluation of the composition of benthic invertebrate communities at the basin scale. A major advantage of the FFG procedure is that the sampling crew leaves the field with the data. This is in contrast to standard procedures which preserve samples for return to the laboratory where much more time consuming analysis is conducted. In the present investigation, the samples were preserved after the field enumerations and returned to the lab, so they are available for further analysis if desired.

Using the statistical sampling design established for juvenile salmonid survey work appears to be an optimal method for selecting sampling sites for the invertebrates. Invertebrate sampling need not be done at the same time as the fish surveys, but combining the two provided the opportunity to collect complementary fish stomach samples. Although there was complete correspondence between invertebrate and juvenile salmonid sample units,
the habitat survey data collected by CDFG did not match the locations. It should be noted that this was not as originally agreed upon between all the parties involved in the project.

The general picture for the Freshwater Creek Basin (all samples from all habitats from all tributaries and mainstem sections) is that at the basin is nearly in balance between heterotrophy (i.e., dependent upon riparian inputs) and autotrophy (i.e., dependent upon light-controlled in-stream primary production). Indeed, the tributaries and mainstem reaches sort out as half heterotrophic and half autotrophic (Table 4). Given that the three tributaries/mainstem reaches with the highest estimated fish densities (Upper and Middle Mainstem, and Cloney Gulch) were characterized as heterotrophic using the invertebrate surrogate P/R ratios (Table 4 and 5), protection of the riparian habitat along these channels would be recommended. The collector functional group (gathering and filtering) exhibited a rough correspondence with the density distribution of juvenile salmonids in the six tributaries and the two mainstem reaches (Figure 8). Cloney Gulch presents an interesting case, with gathering collectors most abundant above the point along the drainage where juvenile salmonid populations declined to near zero (unit 161, Figure 3). When the relative composition of FFGs are plotted for each sample unit separately for Cloney Gulch (Figure 9), a general shift from FFG composition with shredders most abundant to collectors and scrapers becoming more abundant can be seen. The most likely explanation is a change in habitat (both in-stream and riparian) near sample unit 161. Thus, it is likely that in some instances the invertebrate respond to different habitat features than do the fish. A case in point is McCready Gulch which is fine sediment enriched and had the lowest juvenile salmonid densities but the highest gathering collector percentages (Figure 8). Clearly, McCready Gulch habitat was adequate to support large collector populations, but was not suitable for juvenile salmonids. Further, McCready Gulch had significant populations of filtering collectors. At the basin scale, only McCready Gulch and the Upper Mainstem had significant populations of filtering collectors (Figure 2). These two tributary/mainstem reach systems apparently were the only ones with sufficient quantity and quality of suspended load to support notable populations of filtering collectors. This is of interest because many of the invertebrates that are behavioral drifters are filtering collectors.

**Recommendations**

The FFG assessment method applied at the basin scale is rapid, efficient, and informative and would be most valuable if it were repeated on a seasonal basis. One census period in August-September coupled with the juvenile salmonid survey and one in the spring, April-May, to correspond with the likely period of maximum growth for the juvenile salmonids are recommended. The first would adequately sample the summer generations and the second the winter generations of the macroinvertebrates. By such repeated annual sampling, trends in invertebrate communities related to land use and hydrologic year would be apparent and could be followed efficiently at the basin scale.

Habitat measurements should be made at the same time as the August-September fish/invertebrate survey work and match exactly the sites mapped out for the fish survey. Without this correspondence, direct interpretation of habitat effects will not be possible.
The field crew conducting the FFG survey should rate each unit sampled as to the % cover of each of the habitat types (Cobble/gravel riffles, depositional fine sediment/pools and backwaters, litter accumulations, and large woody debris) to allow appropriate weighting of the FFG collections.

Juvenile salmonid stomach samples should be collected at all the units where invertebrate FFG samples are taken. Laboratory analysis of these fish stomach samples is necessary in order to enumerate invertebrates consumed and to calculate invertebrate biomass.

Laboratory analysis of the FFG samples is advisable so that comparisons with the fish stomach data can be accomplished on a biomass basis.

References


FFG Methods

D-Frame, 250μm Mesh Net
30 s collection

Sample Each of 4 Habitats:
Cobbles (riffle/run), Litter Accumulations, Fine Sediments (pools, edges), Large Woody Debris

FOR EACH SAMPLE

Rinse Sample in Net in Stream

Wash Net Contents into Sorting Tray

Separate Invertebrates by Functional Feeding Group (FFG) into Compartmentalized Tray

OFFICE

Data Sheet: Enumerate each FFG and Record Recognizable Taxa

Calculate % FFGs & FGG Ratios for Ecosystem Attributes

LAB

Taxonomic Identifications & Measurements

Conversion to Biomass Estimates with INVERTCALC

Sample in Whirl-Pak

Label and Preserve (70% ETOH)
Weir

Salmonids/meter:

Invertebrate Functional Group
Community Organization and Salmonid Density
in the
Freshwater Creek Basin
during
Aug - Sept, 2004

Sources:
Data contact: Kenneth W. Cummins and Dana R. McCanne, Institute for River Ecosystems, Humboldt State University, Arcata, CA
Projection system: UTM Zone 10N, NAD 1927
Invertebrate Data: Developed using event methodology on the routed hydrography
Fish Data: Developed using event methodology on the routed hydrography. Electrofishing was used to acquire an estimated number of fish meter counted over several survey units on each stream.
Basin: California Watersheds (CALWATER 2.2) by the CDFFP (1999)
Map compiled by: Angie Brown, IRE, HSU, Arcata CA, November 2004
May contain errors of omission or commission
Figure 4
Invertebrate Functional Feeding Group (FFG)
Percent Composition, Freshwater Creek Basin (Summer 2004)

All Samples and Habitats

- Shredders: 22.1%
- Scrapers: 39.6%
- Filtering Collectors: 5.3%
- Gathering Collectors: 27.4%
- Predators: 5.5%

Cobble Samples
- Shredders: 4.6%
- Scrapers: 4.9%
- Filtering Collectors: 21.7%
- Gathering Collectors: 8.0%
- Predators: 60.8%

Fine Sediment Samples
- Shredders: 12.4%
- Scrapers: 9.9%
- Filtering Collectors: 15.7%
- Gathering Collectors: 0.0%
- Predators: 62.0%

Leaf Litter Samples
- Shredders: 3.4%
- Scrapers: 20.3%
- Filtering Collectors: 49.6%
- Gathering Collectors: 3.7%
- Predators: 23.1%

Wood Samples
- Shredders: 11.0%
- Scrapers: 11.7%
- Filtering Collectors: 4.2%
- Gathering Collectors: 45.0%
Figure 5
Invertebrate FFG Percent Composition
Upper Freshwater Creek, Freshwater Basin (Summer 2004)

All Samples and Habitats

- Shredders: 4.5%
- Scrapers: 33.1%
- Filtering Collectors: 39.0%
- Gathering Collectors: 10.2%
- Predators: 13.2%

- Cobble Samples: n=25
  - Shredders: 3.4%
  - Scrapers: 34.1%
  - Filtering Collectors: 14.3%
  - Gathering Collectors: 46.9%
  - Predators: 8.1%

- Fine Sediment Samples: n=3
  - Shredders: 1.8%
  - Scrapers: 59.4%
  - Gathering Collectors: 30.7%

- Leaf Litter Samples: n=13
  - Shredders: 6.8%
  - Scrapers: 11.9%
  - Filtering Collectors: 41.2%
  - Gathering Collectors: 36.3%
  - Predators: 3.8%

- Wood Samples: n=4
  - Shredders: 18.6%
  - Scrapers: 47.4%
  - Filtering Collectors: 11.1%
  - Gathering Collectors: 8.4%

Juvenile Salmonids per Meter: 3.01
Length of Upper Freshwater: 4.51 km
Figure 6
Invertebrate FFG Percent Composition
Cloney Gulch, Freshwater Basin (Summer 2004)

All Samples and Habitats

n=58

Cobble Samples
n=30

Fine Sediment Samples
n=10

Leaf Litter Samples
n=9

Wood Samples
n=9

Juvenile Salmonids per Meter: 2.58
Length of Cloney Gulch: 2.95 km
Figure 7
Invertebrate FFG Percent Composition
McCready Gulch, Freshwater Basin (Summer 2004)
All Samples and Habitats

- Shredders: 5.6%
- Scrapers: 22.9%
- Filtering Collectors: 36.5%
- Gathering Collectors: 18.5%
- Predators: 16.4%

n=42

Cobble Samples
- Shredders: 16.7%
- Scrapers: 3.6%
- Filtering Collectors: 3.2%
- Gathering Collectors: 44.2%

n=18

Fine Sediment Samples
- Shredders: 12.2%
- Scrapers: 15.9%
- Filtering Collectors: 65.3%

n=7

Leaf Litter Samples
- Shredders: 43.6%
- Scrapers: 4.5%
- Filtering Collectors: 9.82%
- Gathering Collectors: 31.4%

n=13

Wood Samples
- Shredders: 32.8%
- Scrapers: 8.4%
- Filtering Collectors: 38.9%
- Gathering Collectors: 5.34%

n=4

Juvenile Salmonids per Meter: 0.90
Length of McCready Gulch: 3.31 km
Figure 8
Freshwater Creek Basin
Gathering Collector Percentages and Juvenile Salmonids per Meter
Figure 8
Freshwater Creek Basin
Gathering Collector Percentages
and Juvenile Salmonids per Meter
Figure 9

Invertebrate Survey Units, Observed Salmonid Redds, and Invertebrate Functional Group Community Organization on Clooney Gulch during Aug - Sept, 2004

Invertebrate Functional Groups:
- Shredders
- Scrapers
- Filters
- Gatherers
- Predators

▲ Survey Locations (with unit number displayed)

Number of Observed Redds:
- 0
- 1 - 3
- 4 - 7

Streams in Survey

Streams
Table 1
Functional group categorization and food resources (from Merrit and Cummins 1996).
CPOM= Coarse Particulate Organic Matter; FPOM= Fine Particulate Organic Matter

<table>
<thead>
<tr>
<th>Functional Groups</th>
<th>Particle Size Feeding Mechanisms</th>
<th>Dominant Food Resources</th>
<th>Particle Size Range of Food (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>Chew conditioned litter or live vascular plant tissue, or gouge wood</td>
<td>CPOM-decomposing (or living hydrophyte) vascular plants</td>
<td>&gt; 1.0</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>Suspension feeders-filter particles from the water column</td>
<td>FPOM-decomposing detrital particles; algae, bacteria, and feces</td>
<td>0.01-1.0</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>Deposit feeders-ingest sediment or gather loose particles in depositional areas</td>
<td>FPOM-decomposing detrital particles; algae, bacteria, and feces</td>
<td>0.05-1.0</td>
</tr>
<tr>
<td>Scrapers</td>
<td>Graze rock and wood surfaces or stems of rooted aquatic plants</td>
<td>Periphyton-attached non-filamentous algae and associated detritus, microflora and fauna, and feces</td>
<td>0.01-1.0</td>
</tr>
<tr>
<td>Predators</td>
<td>Capture and engulf prey or tissue ingest body fluids</td>
<td>Prey-living animal</td>
<td>&gt;0.5</td>
</tr>
</tbody>
</table>
Table 2

Summary of the number of locations and invertebrate samples taken from the six tributaries and two Main-stem stream sections in the Freshwater Creek Basin.

<table>
<thead>
<tr>
<th>Stream ID Number</th>
<th>Steam Name</th>
<th>Sample Locations</th>
<th>Samples taken</th>
<th>Number of Samples Taken per Sample Type</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leaf Litter</td>
</tr>
<tr>
<td>198</td>
<td>Middle Main</td>
<td>9</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td>199</td>
<td>Upper Main</td>
<td>14</td>
<td>45</td>
<td>13</td>
</tr>
<tr>
<td>201</td>
<td>McCready Gulch</td>
<td>14</td>
<td>42</td>
<td>13</td>
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<tr>
<td>203</td>
<td>Little Freshwater</td>
<td>12</td>
<td>36</td>
<td>10</td>
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<td>204</td>
<td>Cloney Gulch</td>
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<td>58</td>
<td>9</td>
</tr>
<tr>
<td>205</td>
<td>Falls Gulch</td>
<td>14</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td>206</td>
<td>Graham Gulch</td>
<td>9</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>207</td>
<td>South Fork</td>
<td>14</td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>106</td>
<td>317</td>
<td>82</td>
</tr>
</tbody>
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Table 3
Taxa encountered in the FFG invertebrate survey in the Freshwater Creek Basin and the FFG assignments used for each.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mollusca</strong></td>
<td><strong>SCRAPERS</strong></td>
</tr>
<tr>
<td>Gastropoda (Snails)</td>
<td></td>
</tr>
<tr>
<td><strong>Crustacea</strong></td>
<td><strong>SHREDDERS</strong></td>
</tr>
<tr>
<td>Isopoda (Aquatic Pill Bugs)</td>
<td></td>
</tr>
<tr>
<td>Amphipoda (Side Swimmers)</td>
<td><strong>SHREDDERS</strong></td>
</tr>
<tr>
<td>Ostracoda (Seed Shrimp)</td>
<td><strong>GATHERING COLLECTORS</strong></td>
</tr>
<tr>
<td><strong>Arachnoidea</strong></td>
<td><strong>PREDATORS</strong></td>
</tr>
<tr>
<td>Hydracarina (Aquatic Mites)</td>
<td><strong>GATHERING COLLECTORS</strong></td>
</tr>
<tr>
<td>Oligochaeta</td>
<td></td>
</tr>
<tr>
<td><strong>Insecta</strong></td>
<td><strong>GATHERING COLLECTORS</strong></td>
</tr>
<tr>
<td>Odonata</td>
<td><strong>PREDATORS</strong></td>
</tr>
<tr>
<td>Anisoptera (Dragonflies)</td>
<td></td>
</tr>
<tr>
<td>Plecoptera (Stoneflies)</td>
<td></td>
</tr>
<tr>
<td><strong>Setipalpians</strong></td>
<td><strong>PREDATORS</strong></td>
</tr>
<tr>
<td>Perlidae</td>
<td></td>
</tr>
<tr>
<td>Chloroperlididae</td>
<td></td>
</tr>
<tr>
<td>Perlodidae</td>
<td></td>
</tr>
<tr>
<td><strong>Filipalpians</strong></td>
<td><strong>SHREDDERS</strong></td>
</tr>
<tr>
<td>Nemouridae</td>
<td></td>
</tr>
<tr>
<td>Peltoperlididae</td>
<td></td>
</tr>
<tr>
<td>Leuctridae</td>
<td></td>
</tr>
<tr>
<td><strong>Ephemeroptera (Mayflies)</strong></td>
<td><strong>GATHERING COLLECTORS</strong></td>
</tr>
<tr>
<td>Baetidae</td>
<td></td>
</tr>
<tr>
<td>Ameletiidae</td>
<td></td>
</tr>
<tr>
<td>Ephemerellidae</td>
<td></td>
</tr>
<tr>
<td><strong>Serratella</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Timpanoga</strong></td>
<td></td>
</tr>
<tr>
<td>Leptophlebiidae</td>
<td></td>
</tr>
<tr>
<td>Heptageniidae</td>
<td></td>
</tr>
<tr>
<td><strong>Trichoptera (Caddisflies)</strong></td>
<td><strong>SCRAPERS</strong></td>
</tr>
<tr>
<td>Glossosomatidae</td>
<td></td>
</tr>
<tr>
<td>Rhacophilidae</td>
<td></td>
</tr>
<tr>
<td>Hydropsychidae</td>
<td></td>
</tr>
<tr>
<td>Philopotamidae</td>
<td></td>
</tr>
<tr>
<td>Polycentropidae</td>
<td></td>
</tr>
<tr>
<td>Calamoceratidae</td>
<td></td>
</tr>
<tr>
<td><strong>Heteroplectron</strong></td>
<td><strong>SHREDDERS</strong></td>
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<tr>
<td>Limnephilidae</td>
<td>default [SHREDDERS]</td>
</tr>
<tr>
<td><strong>Hydatophylax</strong></td>
<td><strong>SHREDDERS</strong></td>
</tr>
<tr>
<td><strong>Ecclisomyia</strong></td>
<td><strong>SCRAPERS</strong></td>
</tr>
<tr>
<td>Apataniidae</td>
<td></td>
</tr>
<tr>
<td><strong>Apatania</strong></td>
<td></td>
</tr>
<tr>
<td>Sericostomatidae</td>
<td></td>
</tr>
</tbody>
</table>

21
Gumaga
Uenoidae

Neophylax
Neothremma

Lepidostomatidae
Brachycentridae

Micrasema

Trichoptera – undetermined
Megaloptera (Helgrammites)
Sialidae (Alderflies)

Coleoptera (Beetles)
Psephenidae
Elmidae (Larvae)

Optioservus
Lara

Dytiscidae (Adults)
Haliplidae (Adults)

Diptera (True Flies)
Tipulidae
Simuliidae (Black Flies)
Dixidae (Dixid Midges)
Psychodidae (Moth flies)
Chironomidae (Midges)

Orthocladinae
Chironominae

Tanytarsini
Tanypodinae

Ceratopogonidae (Biting Midge)
Athericidae (Snipe Flies)

SCRAPERS
SCRAPERS
SCRAPERS
SHREDDERS
SHREDDERS
default [SHREDDERS]
PREDATORS
SCRAPERS
SCRAPERS
SHREDDERS
PREDATORS
PREDATORS
PREDATORS
PREDATORS
FILTERING COLLECTORS
GATHERING COLLECTORS
GATHERING COLLECTORS
default [GATHERING COLL]
GATHERING COLLECTORS
default [GATHERING COLL]
PREDATORS
PREDATORS
PREDATORS

22
**Table 4**
Comparison of fish abundance ranking and FFG characteristics in six tributaries and two sections of the Mainstem of the Freshwater Creek basin*.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Fish per meter</th>
<th>Fish Rank</th>
<th>Dominant FFG (%)</th>
<th>P/R</th>
<th>Heterotrophy Vs Autotrophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Main Stem</td>
<td>73.4</td>
<td>1</td>
<td>Shredders (46)</td>
<td>0.39</td>
<td>Heterotrophic</td>
</tr>
<tr>
<td>Upper Main Stem</td>
<td>42.7</td>
<td>2</td>
<td>Total Collectors (48)</td>
<td>0.54</td>
<td>Heterotrophic</td>
</tr>
<tr>
<td>Cloney Gulch</td>
<td>32.0</td>
<td>3</td>
<td>Shredders (47)</td>
<td>0.31</td>
<td>Heterotrophic</td>
</tr>
<tr>
<td>Graham Gulch</td>
<td>28.8</td>
<td>4</td>
<td>Scrapers (53)</td>
<td>1.40</td>
<td>Autotrophic</td>
</tr>
<tr>
<td>Little Freshwater</td>
<td>16.3</td>
<td>5</td>
<td>Scrapers (71)</td>
<td>2.70</td>
<td>Autotrophic</td>
</tr>
<tr>
<td>South Fork</td>
<td>12.9</td>
<td>6</td>
<td>Scrapers (46)</td>
<td>0.93</td>
<td>Autotrophic</td>
</tr>
<tr>
<td>Falls Gulch</td>
<td>12.1</td>
<td>7</td>
<td>Scrapers (41)</td>
<td>0.74</td>
<td>[Autotrophic]</td>
</tr>
<tr>
<td>McCready Gulch</td>
<td>5.4</td>
<td>8</td>
<td>Total Collectors (52)</td>
<td>0.32</td>
<td>Heterotrophic</td>
</tr>
</tbody>
</table>

*Fish per m (mean fish per linear meter of stream); Fish rank (ranking of fish per m); Dominant FFG (%) (dominant group and its mean relative %); P/R (ratio of Scrapers to total collectors + shredders, a surrogate for ratio of gross primary production to community respiration); Heterotrophy vs Autotrophy based on a P/R threshold of > 0.75 – autotrophic.
Table 5
Invertebrate functional feeding group (FFG) and behavioral drift ratios as surrogates for stream ecosystem attributes

<table>
<thead>
<tr>
<th>ECOSYSTEM ATTRIBUTE</th>
<th>DESCRIPTION</th>
<th>FFG RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>P/R</td>
<td><em>Autotrophy/Heterotrophy Index</em></td>
<td>Scrapers&lt;br&gt;Shredders + Total Collectors&lt;br&gt;(Threshold: 0.75)</td>
</tr>
<tr>
<td></td>
<td>Gross Primary Production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Community Respiration</td>
<td></td>
</tr>
<tr>
<td>CPOM/FPOM</td>
<td><em>Shredder-Riparian Index</em></td>
<td>Shredders&lt;br&gt;Total Collectors&lt;br&gt;(Threshold: Fall-Winter 0.50; Spring-Summer)</td>
</tr>
<tr>
<td></td>
<td>Benthic CPOM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benthic FPOM</td>
<td></td>
</tr>
<tr>
<td>TFPOM/BFOM</td>
<td><em>Suspended Load Index</em></td>
<td>Filtering Collectors&lt;br&gt;Gathering Collectors&lt;br&gt;(Threshold: 1.00)</td>
</tr>
<tr>
<td></td>
<td>FPOM in Transport</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benthic FPOM</td>
<td></td>
</tr>
<tr>
<td>STABILITY</td>
<td><em>Substrate Stability Index</em></td>
<td>Scrapers + Filtering Collectors&lt;br&gt;Shredders + Gathering Collectors&lt;br&gt;(Threshold: 0.60)</td>
</tr>
<tr>
<td></td>
<td>(Cobbles + Wood)</td>
<td></td>
</tr>
<tr>
<td>SALMONID FOOD</td>
<td><em>Juvenile Salmonid Food Index</em></td>
<td>Behavioral Drifters*&lt;br&gt;Accidental Drifters&lt;br&gt;(Threshold: 0.50)</td>
</tr>
<tr>
<td></td>
<td>Predictable Invertebrate Supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unpredictable Invertebrate Supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Approximation of Index:</td>
<td>Filtering + Gathering Collectors&lt;br&gt;Scrapers+Shredders+Predators&lt;br&gt;(Threshold: 0.50)</td>
</tr>
</tbody>
</table>
Table 6
Juvenile salmonid gut analyses from Cloney Gulch.
SH = steelhead trout, n = 10;
CT = cutthroat trout, n = 12;
CO = coho salmon, n = 11

<table>
<thead>
<tr>
<th>Fish</th>
<th>Mean Fish wt (gm)</th>
<th>Mean No. Inverts per Stomach</th>
<th>Mean total wt Inverts per Stomach (mg)</th>
<th>Mean wt individual Invert (mg)</th>
<th>mg Inverts per gm Fish</th>
<th>Mean total wt (mg) Aquatic Inverts per Stomach</th>
<th>Mean total wt (mg) Terrestrial Inverts per Stomach</th>
<th>% Fish without Terrestrial Inverts</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH</td>
<td>15.7</td>
<td>18.7</td>
<td>7.7</td>
<td>0.4</td>
<td>0.49</td>
<td>5.1</td>
<td>5.3</td>
<td>50</td>
</tr>
<tr>
<td>CT</td>
<td>24.7</td>
<td>8.3</td>
<td>55.3</td>
<td>6.7</td>
<td>2.24</td>
<td>25.8</td>
<td>44.3</td>
<td>33</td>
</tr>
<tr>
<td>CO</td>
<td>6.0</td>
<td>20.6</td>
<td>14.1</td>
<td>0.7</td>
<td>2.35</td>
<td>10.1</td>
<td>5.5</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>15.5</td>
<td>15.4</td>
<td>27.1</td>
<td>1.8</td>
<td>1.75</td>
<td>14.2</td>
<td>17.0</td>
<td>39</td>
</tr>
</tbody>
</table>

Table 7
Ratio of behavioral drifter to accidental drifter invertebrates in juvenile salmonid stomach samples collected in Cloney Gulch.
(Threshold for adequate food supply of behavioral drifters for drift-feeding fish taken as ≥ 0.50.)

<table>
<thead>
<tr>
<th>Number of Fish Stomachs</th>
<th>Number Ratio</th>
<th>Weight Ratio</th>
<th>With Caddis* Number Ratio</th>
<th>With Caddis* Weight Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>0.73</td>
<td>0.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>2.23</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>% Fish Above Threshold</td>
<td>29</td>
<td>23</td>
<td>26</td>
<td>32</td>
</tr>
</tbody>
</table>

* Lepidostoma with organic case and < 4 mm length included as behavioral drifters
Appendix I
Field Key used in the study of the Freshwater Creek Basin

KEY TO INVERTEBRATE
FUNCTIONAL FEEDING GROUPS

Ken Cummins, Interim Director
Institute for Forest and Watershed Management

Peggy Wilzbach, Assistant Leader
California Cooperative Fishery Research Unit

Rich Merritt, Chair
Department of Entomology, Michigan State University

Ken Cummins
kwc7002@humboldt.edu
June 2003

IRE
592 14th Street
Arcata, CA 95521
KEY TO FUNCTIONAL FEEDING GROUPS

1. ANIMALS IN HARD SHELL (Phylum Mollusca)
   a. LIMPETS (Class Gastropoda)
      ![Limpet Image]
      Indicates size or range of sizes

2. SNAILS (Class Gastropoda)
   ![Snail Image]
   Scapers
   Snails are generalized facultative feeders and can also function as shredders.

3. CLAMS OR MUSSELS (Class Pelecypoda)
   ![Clam Image]
   Filtering Collectors

2. SHRIMP-LIKE ANIMALS (Class Crustacea)
   ![Shrimp Image]
   Decapoda
   Isopoda
   Amphipoda
   Shredders
   Can also function as facultative gathering collectors

3. LARVAE IN PORTABLE CASE OR "HOUSE".

4. LARVAE IN FIXED RETREAT WITH CAPTURE NET
   Go to KEY 2
   Note: Care must be taken when collecting to observe marks

5. WITHOUT CASE OR FIXED RETREAT.
   a. WORM-LIKE LARVAE, WITHOUT JOINTED LEGS.
   b. NYMPHS OR ADULTS WITH JOINTED LEGS.
   Go to KEY 4
   Go to KEY 5
   5. DOES NOT FIT KEY 5 EXACTLY
   Go to KEY 6 or KEY 7
KEY 2

FIRST LEVEL OF RESOLUTION

LARVAE IN PORTABLE CASE
Caddisflies (Order Trichoptera)

CASES, ORGANIC
Leaf, stick, needle, bark

CASES MINERAL
Sand, fine gravel

Families Limnephilidae (in part)
Leuctriidae (in part), Hydropsychidae,
Leptoceridae (in part)

Families Glyptosternidae,
Limnephilidae (in part), Heptageniidae

SHREDDERS
SECOND LEVEL OF RESOLUTION considers a few fairly common caddisflies that would be misclassified above
on the basis of case composition alone.

CASES ORGANIC
Cases square in cross section
and tapered, with no bark or flat leaf
pieces included. Forelegs attached to
substrate. Larvae extend legs and
filter the current.

Foreleg with
Filtering hairs

Family Brachycentridae (in part)

FILTERING COLLECTORS

CASES MINERAL
Cases long, slender and
tapered, made of plant material

Cases long, slender and tapered
(mostly fine sand), or case avoid
and very thin in cross section

Family Leptoceridae (in part)

GATHERING COLLECTORS

Family Leptoceridae (in part)

GATHERING COLLECTORS
KEY 3

FIRST LEVEL OF RESOLUTION
LARVAE WITH FIXED RETREAT AND CAPTURE NET
Note: Care must be taken when collecting to observe nets.

Caddisflies (Order Trichoptera)

FLATTENED SOCK-LIKE OR TRUMPET-SHAPED NET OF FINE MESH

TRUE FLIES (Order Diptera)

TRUE MIDGE (Family Chironomidae)

FAMILIES: Hydropsychidae, Philopotamidae, Polycentropodidae

FILTERING COLLECTORS
SECOND LEVEL OF RESOLUTION separates free living larvae those net spinning caddisflies that may have been inadvertently collected without being associated with their nets.

NET SPINNING CADDISFLIES
Frequently separated from their nets

FREE LIVING CADDISFLIES
Non net spinning

HEAD AS WIDE AS THORAX
Especially Philopotamidae (bright yellow) and Hydropsychidae (bright green or brown)

FILTERING COLLECTORS

HEAD LONG, SMALL, AND NARROWER THAN THORAX
Rhacophilidae (often bright green)

PREDATORS
KEY 4

FIRST LEVEL OF RESOLUTION

WORM-LIKE LARVAE WITHOUT JOINTED LEGS

LARGE

Larger than

Head retractile and poorly developed Caudal lobes with eye-like spiracles

Craneflies (Family Tipulidae (in part))

SHREDDERS

LONG AND SLENDER

Smaller than

Bulbous base usually fastened tightly to substrate

True Midge (Family Chironomidae)

Note: Subtract 10% of count for Predators

Biocldes (Family Simulidae)

GATHERING COLLECTORS

FILTERING COLLECTORS

SECOND LEVEL OF RESOLUTION considers some worm-like Predators that would be misclassified in the above key.

WORM-LIKE LARVAE WITHOUT JOINTED LEGS

LARGE

Posterior segment swollen

Head retractile

Family Tipulidae (Enoploplecta type)

PREDATORS

Family Araneidae

Small

Prolegs along entire length

Head visible

Family Tipulidae (Dictyopoda type)

Prolegs poorly developed or absent; jaws well developed; very active

Family Araneidae
**KEY 5**

**FIRST LEVEL OF RESOLUTION**

- 3 (or 2) TAILS (FILAMENTS) AT BACK, NO EXTENDIBLE LOWER LIP (LABIUM)

**NYMPHS WITH JOINTED LEGS**

- 3 (or 2) TAILS WITH LATERAL ABDOMINAL GILLS, Mayflies (Order Ephemeroptera)

**2 TAILS WITHOUT LATERAL ABDOMINAL GILLS**

- Stonflies (Order Plecoptera)

- 3 FLAT PADDLES OR POINTS AT BACK, EXTENDIBLE LOWER LIP

- 3 FLAT PADDLES AT BACK, POINTS AT BACK

**Body shape**

- Body shape ovoid, Flat in cross section.
- Body shape cylindrical, Round in cross section.
- Bright color pattern, Very active.
- Dull brown or black, sluggish.

**Families**

- Families Heptageniidae, Ephemerellidae (in part), Ephemeroptera
- Families Baetidae, Leuctridae (in part), Ephemeroptera
- Setipalpian Stonflies
- Filipalpian Stonflies

**Predators**

- Predator Damselflies (Suborder Zygoptera)
- Predator Dragonflies (Suborder Anisoptera)

**GATHERING COLLECTORS**

**SHREDDERS**

**SCRAPERS**
KEY 6

SECOND LEVEL OF RESOLUTION considers some fairly common insects that do not fit in the above key or would be misclassified on the basis of body shape alone.

LARVAE, NYMPHS, OR ADULTS WITH JOINTED LEGS WITHOUT CASE OR FIXED RETREAT

WITH LONG TAIL(S) OR CAUDAL HOOKS

CAUDAL HOOKS
1 TAIL (FILAMENT)

3 LONG CERCI

Body shape ovoid. Head and legs totally concealed beneath body. Long hairs on inside of front legs.

Water Pennies (Family Psephenidae)

With ventral suckers or disc-shaped.

Adult beetle

Slender, larvae, triangular in cross section

Riffle Beetles (Family Elmidae)

SCRAPERS

SCCRAPERS

Predators

GATHERING COLLECTORS

Family Corydidae

Family Sialis

Family Ephemeraeidae (in part), Caenidae, Tricorythidae

FILTERING COLLECTORS

Family Isoperlidae

Family Lepidostomatidae

Family Elephantidae

If larva has spines along lateral margins, it is a wood-eating shredder.

Riffle Beetles (Family Elmidae)

GATHERING COLLECTORS

Order Diptera

Lobed body. Ventral suckers.
KEY 7
SECOND LEVEL OF RESOLUTION considers some fairly common insects that do not fit in the above key or would be misclassified on the basis of body shape alone.

NYMPHS AND ADULTS WITH BEAK AND HEMELYTRA

Beak triangular, front legs smaller

Family Corbiidae

SCRAPERS

Sharp beak, front legs large

Family Naucoridae

Family Boratonzididae

PREDATORS
**Appendix II**

Example Field Data Sheet

### Invertebrate Functional Group Assessment – Field Form

**Stream:** Cloney Gulch  
**Reach:** 2  
**Drainage:** Freshwater  
**Date:** 8-2-04  
**Crew:** John Matousek & April Shackelford  
**H2O Temp:** 16°C  
**Time:** 2:42 PM  
**Flagged for stomach sampling:** Yes

**Sample Type (circle one):** Cobble  Wood  Leaf Litter  Fine Sediments  Composite  **SAMPLE #: C1**

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Tally</th>
<th>Total</th>
<th>Identifiable Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td></td>
<td>22</td>
<td><strong>Lymnaeidae (organic case)</strong></td>
</tr>
<tr>
<td>Scrapers</td>
<td>4, 45, 5, 2, 3, 1</td>
<td>22</td>
<td><strong>Gastropoda, Helicidae (adult)</strong></td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>2, 3</td>
<td>5</td>
<td><strong>Trichoptera, Ephemeroptera (larva)</strong></td>
</tr>
<tr>
<td>Predators</td>
<td>1</td>
<td>1</td>
<td><strong>Hydracarina</strong></td>
</tr>
</tbody>
</table>

**Sample Type (circle one):** Cobble  Wood  Leaf Litter  Fine Sediments  Composite  **SAMPLE #: P51**

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Tally</th>
<th>Total</th>
<th>Identifiable Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>3, 2, 1, 3</td>
<td>7</td>
<td><strong>Limnephilidae (sand case)</strong></td>
</tr>
<tr>
<td>Scrapers</td>
<td>3, 2, 1, 3</td>
<td>7</td>
<td><strong>Lymnaeidae (sand case)</strong></td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>3, 1, 2, 3, 3, 1, 4, 1, 2, 1, 1</td>
<td>21</td>
<td><strong>Lepidostomatidae, Ceratopogonidae (larva), Diptera (adult)</strong></td>
</tr>
<tr>
<td>Predators</td>
<td>1, 1, 4, 1, 1, 3, 1, 3, 1, 1</td>
<td>15</td>
<td><strong>Hydracarina, Helicidae (adult)</strong></td>
</tr>
</tbody>
</table>

**Sample Type (circle one):** Cobble  Wood  Leaf Litter  Fine Sediments  Composite  **SAMPLE #: L41**

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Tally</th>
<th>Total</th>
<th>Identifiable Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>24, 95, 5, 2, 1</td>
<td>71</td>
<td><strong>Lymnaeidae (organic case), Heteroptera, Lepidostomatidae (adult)</strong></td>
</tr>
<tr>
<td>Scrapers</td>
<td>3, 3, 1</td>
<td>5</td>
<td><strong>Ephemeroptera (adult), Gastropoda</strong></td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>1, 2, 1</td>
<td>4</td>
<td><strong>Lepidophlebiidae, Diptera, Orthocladiinae</strong></td>
</tr>
<tr>
<td>Predators</td>
<td>1, 1, 1</td>
<td>3</td>
<td><strong>Anisoptera, Hydracarina</strong></td>
</tr>
</tbody>
</table>
Appendix III

FFG Percent Composition invertebrate functional feeding groups in Freshwater Creek Middle Mainstem and tributaries (Graham Gulch, Little Freshwater, South Fork, and Falls Gulch)
Invertebrate (FFG) Percent Composition,
Middle Freshwater Creek, Freshwater Basin (Summer 2004)

All Samples and Habitats

<table>
<thead>
<tr>
<th>Category</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>46.0%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>26.5%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>17.2%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>6.1%</td>
</tr>
<tr>
<td>Predators</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

n=27

Cobble Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>54.6%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>22.2%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>5.9%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>11.9%</td>
</tr>
</tbody>
</table>

n=17

Fine Sediment Samples

No Data Available

n=0

Leaf Litter Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>76%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>6%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>13%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>2%</td>
</tr>
</tbody>
</table>

n=9

Wood Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>57.9%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>21.1%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

n=1

Juvenile Salmonids per Meter: 3.47
Length of Middle Freshwater: 3.91 km
Invertebrate (FFG) Percent Composition
Graham Gulch, Freshwater Basin (Summer 2004)

All Samples and Habitats

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>13.9%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>53.5%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>22.6%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>1.6%</td>
</tr>
<tr>
<td>Predators</td>
<td>8.4%</td>
</tr>
</tbody>
</table>

n=26

Cobble Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>4.8%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>5.0%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>17.9%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>3.0%</td>
</tr>
<tr>
<td>Predators</td>
<td>69.3%</td>
</tr>
</tbody>
</table>

n=12

Fine Sediment Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>6.6%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>6.3%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>28.7%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td></td>
</tr>
<tr>
<td>Predators</td>
<td>58.4%</td>
</tr>
</tbody>
</table>

n=5

Leaf Litter Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>63.1%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>10.0%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>9.7%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>2.6%</td>
</tr>
<tr>
<td>Predators</td>
<td>23.6%</td>
</tr>
</tbody>
</table>

n=7

Wood Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>41.4%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>10.0%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td></td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td></td>
</tr>
<tr>
<td>Predators</td>
<td>48.6%</td>
</tr>
</tbody>
</table>

n=2

Juvenile Salmonids per Meter: 2.61
Length of Graham Gulch: 2.04 km
Invertebrate (FFG) Percent Composition
Little Freshwater Creek, Freshwater Basin (Summer 2004)

All Samples and Habitats

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>3.4%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>9.3%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>15.9%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>70.9%</td>
</tr>
<tr>
<td>Predators</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

n=36

Cobble Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>0.6%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>13.1%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>1.7%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>82.2%</td>
</tr>
<tr>
<td>Predators</td>
<td>2.4%</td>
</tr>
</tbody>
</table>

n=18

Fine Sediment Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>17.2%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>0.9%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>68.1%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>13.8%</td>
</tr>
</tbody>
</table>

n=3

Leaf Litter Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>0.3%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>61.2%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>3.1%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>12.0%</td>
</tr>
<tr>
<td>Predators</td>
<td>23.4%</td>
</tr>
</tbody>
</table>

n=10

Wood Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>45.8%</td>
</tr>
<tr>
<td>Scrapers</td>
<td>22.9%</td>
</tr>
<tr>
<td>Filtering Collectors</td>
<td>17.7%</td>
</tr>
<tr>
<td>Gathering Collectors</td>
<td>11.5%</td>
</tr>
<tr>
<td>Predators</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

n=5

Juvenile Salmonids per Meter: 1.68  Length of Little Freshwater Creek: 3.31 km
Invertebrate (FFG) Percent Composition
South Fork, Freshwater Basin (Summer 2004)

All Samples and Habitats

- Shredders: 5.4%
- Scrapers: 18.9%
- Filtering Collectors: 26.9%
- Gathering Collectors: 3.2%
- Predators: 45.6%

n=42

Cobble Samples

- Shredders: 4.4%
- Scrapers: 69.0%
- Filtering Collectors: 19.4%
- Gathering Collectors: 3.1%
- Predators: 4.1%

n=24

Fine Sediment Samples

- Shredders: 10.3%
- Scrapers: 7.6%
- Filtering Collectors: 70.8%
- Gathering Collectors: 11.4%

n=3

Leaf Litter Samples

- Shredders: 26.6%
- Scrapers: 5.3%
- Filtering Collectors: 49.7%
- Gathering Collectors: 12.9%
- Predators: 5.4%

n=11

Wood Samples

- Shredders: 38.1%
- Scrapers: 7.2%
- Filtering Collectors: 43.2%
- Gathering Collectors: 0.7%
- Predators: 10.8%

n=4

Juvenile Salmonids per Meter: 1.46
Length of South Fork Freshwater: 3.26 km
Invertebrate (FFG) Percent Composition  
Falls Gulch, Freshwater Basin (Summer 2004)

All Samples and Habitats

- Shredders: 28.1%
- Scrapers: 21.5%
- Filtering Collectors: 4.4%
- Gathering Collectors: 39.7%
- Predators: 6.4%

n=41

Cobble Samples

- Shredders: 5.9%
- Scrapers: 20.1%
- Filtering Collectors: 7.6%
- Gathering Collectors: 7.2%

n=23

Fine Sediment Samples

- Shredders: 75.3%
- Scrapers: 9.8%
- Filtering Collectors: 9.3%
- Gathering Collectors: 5.6%

n=5

Leaf Litter Samples

- Shredders: 15.5%
- Scrapers: 50.9%
- Filtering Collectors: 6.3%
- Gathering Collectors: 15.5%

n=10

Wood Samples

- Shredders: 53.5%
- Scrapers: 21.1%
- Filtering Collectors: 9.9%
- Gathering Collectors: 15.5%

n=3

Juvenile Salmonids per Meter: 1.99
Length of Falls Gulch: 0.50 km
Invertebrate Functional Group
Community Organization,
Survey Units,
and
Observed Salmonid Redds
on McCready Gulch during
Aug - Sept, 2004

Invertebrate Functional Groups
- Shredders
- Scrapers
- Filterers
- Gatherers
- Predators

Survey Locations
(with unit number displayed)

Number of Observed Redds
- 0
- 1 - 3
- 4 - 7

Streams in Survey

Streams

Sources:
Data contact: Kenneth W. Cummins and Dana R. McCanne, Institute for River Ecosystems, Humboldt State University, Arcata, CA
Projection system: UTM Zone 10N, NAD 1927
Data layers:
Unit, Redd, and Invertebrate Data: Developed using event methodology
on the routed hydrography
Streams: 1:24k routed hydrography developed by the Calif. Dept. of Forestry and Fire Protection
Map compiled by: Angie Brown, IRE. April 2005
May contain errors of omission or commission
Invertebrate Functional Group
Community Organization,
Survey Units,
and
Observed Salmonid Redds
on the Upper Mainstem
of Freshwater Creek during
Aug - Sept, 2004

Invertebrate Functional Groups
- Shredders
- Scrapers
- Filterers
- Gatherers
- Predators

Survey Locations
(with unit number displayed)
Number of Observed Redds
- 0
- 1 - 3
- 4 - 13
Streams in Survey
Streams

North Coast California
Freshwater Creek System

Sources:
Data contact: Kenneth W. Cummings and Dana R. McCanne, Institute for River Ecosystems, Humboldt State University, Arcata, CA
Projection system: UTM Zone 10N, NAD 1927
Data layers:
Unit, Reddan and Invertebrate Data: Developed using event method on the routed hydrography
Streams: 1:24k routed hydrography developed by the Calif. Dept. of Forestry and Fire Protection
Map compiled by: Angie Brown, IRE. April 2005
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