

Preliminary Report on Benthic Macroinvertebrate Data  
Dry Creek Conservancy Bioassessment Program 2000 to 2006

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## Summary

Bioassessment is a widely accepted method of evaluating water quality and watershed health. Dry Creek Conservancy began a bioassessment program in 1997 with help from state agencies which has continued to the present. Data was gathered in accordance with the California Stream Bioassessment Procedure. The purpose of the program was to assess Dry Creek stream and watershed condition. This paper reports the results of the program by analyzing what is considered high quality data from 2000 through 2006.

Tom King of BioAssessment Services analyzed the data using composite metric scores and calculated an index of biotic integrity (IBI) for each sample site based on the Southern California IBI method. This IBI was considered appropriate for Dry Creek in the absence of a foothill or valley IBI.

Results of the analysis showed that:

- Sites have very similar values resulting in little difference between tributaries. The exception is the upstream site on Secret Ravine.
- There is no discernible trend over time.
- The BMI community is in generally poor health based on the SoCal B-IBI and compared to similar nearby streams.

Some questions raised by the IBI analysis are:

- Why is the upstream site on Secret Ravine an outlier?
- Why are Coon Creek IBI's so much higher than Dry Creek values?
- What is the cause of the generally depressed condition of the Dry Creek BMI community?
- Why are Coleoptera taxa lacking in the Dry Creek data?
- Why is the most downstream site IBI relatively high?

A set of hypotheses is suggested to answer these questions based on watershed indicators such as:

- Amount of impervious cover.
- Instream measures such as embeddedness and sediment.
- Water quality measures such as temperature.
- Riparian corridor measures such as canopy cover.
- Manipulated instream flows - The Dry Creek Watershed receives imported water in many tributaries.
- The possibility of other metrics that might be more appropriate for the Dry Creek ecoregion.

These issues should be followed up to explain the current condition of Dry Creek BMI and its implications for the health of the Dry Creek Watershed. Desired conditions should be agreed on as goals for future management decisions. Dry Creek can be used as an example for guiding land use and management decisions in similar watersheds.

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**Introduction**

Biological monitoring (bioassessment) is becoming a widely used and accepted method for evaluating water quality throughout the United States (SWRCB, 2003). Periphyton, aquatic vertebrate and benthic macroinvertebrates (BMI) are commonly monitored aquatic assemblages in bioassessment monitoring (U.S. EPA, 1999). In order to conduct a cost-effective, scientifically valid rapid biological assessment, monitoring may be reduced to one aquatic assemblage (U.S. EPA, 1999). BMI are the common aquatic assemblages measured in rapid monitoring protocols. They are useful in evaluating the overall health of flowing water systems, and are affected by changes in a stream's chemical and or physical structure (Karr and Kerans, 1991). Their sensitivity to stresses (temperature, dissolved oxygen, chemical and organic pollution) makes them effective indicators of specific anthropogenic disturbances (House et al., 1993). Streams within the California central valley have been greatly altered to accommodate urban and agricultural development. Physical habitat (vegetation and substrate) is often reduced or removed completely, greatly impacting aquatic organisms within the stream. (The paragraph above is from Department of Pesticide Regulation Environmental Monitoring Branch Study Proposal #233)

**Purpose**

This is a report on BMI data gathered fall 2005 and 2006 and a statistical analysis of data gathered by Dry Creek Conservancy (DCC) from 2000 through 2006. Bioassessment for 2005 and 2006 was funded by the Sacramento River Watershed Program's 2004 Proposition 50 CALFED Watershed Protection Grant. Data sets for 2000 through 2006 are provided in Appendix 1. In addition this report serves as a final summation of the current DCC BMI program. DCC has carried on BMI sampling since 1996 to establish baseline conditions; a good data set has been established. At this time no resources are available to continue the current program. We intend to seek funding for studies to answer specific questions in the future.

Goals of the DCC program are to assess the overall condition of the Dry Creek Watershed, to discover differences in condition among tributaries, and to detect trends over time in stream condition. DCC sampled BMI with three different protocols, two of which are the professional standard and one for volunteers. In 2005 and 2006 we used the new professional protocol developed for California. In order to compare this data with data gathered before 2005, data gathered with the earlier protocol had to be recast in the newer format. That has been done for years 2000 through 2004 and is provided in Appendix 1 to this report. The resulting data set from 2000 to 2006 was analyzed using composite metric scores and an IBI that was developed for southern California streams (Appendix 5). No IBI exists for the Dry Creek ecoregion but the Southern California IBI appears to be the best fit available. It provides a relative ranking of streams and suggestion of stream condition based on the SoCal model. It is not within the resources and scope of this report to exhaustively interpret the results of the statistical analysis. Some general observations are made and suggestions of possible questions for future studies.

### **History of DCC and the DCC bioassessment program.**

DCC incorporated in 1996. The mission included community education, watershed assessment and monitoring, restoration, and planning and management. A Coordinated Resource Management and Planning stakeholder group (currently known as the American Basin Council of Watersheds) was also formed in 1996.

The DCC Monitoring Group was started in April 1996 at a community meeting with the National Water Quality Assessment program of the US Geological Survey, State Water Resources Control Board, Central Valley Regional Water Quality Control Board (CVRWQCB), and Sacramento area nonprofits called to discuss use of citizen rapid bioassessment monitoring. In May 1996 the DCC monitoring group participated in a multi group proposal for 319h funds to be administered by Placer County Resource Conservation District to pay for rapid bioassessment training and equipment. The training was held in March 1997 at Sierra College with instructor, Jim Harrington.

During the summer of 1997 DCC volunteers practiced sampling and habitat evaluation every third Saturday. From winter 1997 to summer 2000 an average of 10-15 people met one Saturday of most months for a half day at Sierra College to do taxonomic ID. The group operated unfunded after the first training, except for occasional supplies provided by CVRWQCB, until additional funding was obtained from another 319h grant in September 2000. Additional grants from Prop 204 and Cal-Fed have funded expansion and improvement of the DCC monitoring program such as development of a QAPP, purchase of chemical monitoring equipment, and contracting with a professional entomologist for sample taxonomy. Fall BMI samples have been taken for each year beginning in 1997. Site coverage varied until 2001 due to fluctuation in participation. Since then the same ten reaches have been sampled with adjustments to some sites based on access.

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### **Methods**

DCC collects and processes samples following the California Stream Bioassessment procedure and in accordance with the Dry Creek QAPP. Since 2000 DCC has sent samples to a professional taxonomy laboratory for identification. The laboratory's quality control procedures supercede procedures outlined in the DCC QAPP for citizen volunteers. We have held annual fall field sampling trainings conducted by Wayne Fields before the sampling season. Samples for each fall beginning in 2000 have been delivered to Wayne Fields for taxonomic ID.

In 2005, after a workshop with Jim Harrington, DCC began sampling with the revised California Stream Bioassessment procedure protocol that was eventually formalized as the September 10, 2006 revision. The revision supercedes the California Stream Bioassessment procedure in place at the time of the 2002 DCC QAPP. The revised protocol specifies a 500 organism sub sample for each reach sampled whereas the previous protocol specified three 300 organism sub samples for a total sub sample of 900 organisms per reach. We engaged BioAssessment Services to standardize the data so metrics from the two protocols could be compared. Using 900 organism

counts to calculate metrics and comparing them to metrics generated from the newer 500 count procedure would raise questions of comparability of the metrics. Recast data from 2000 through 2004 are provided in Appendix 1. The recast data along with the 2005 and 2006 data (shown in Appendix 1) will be added to the DCC BMI data base.

Tom King of BioAssessment Services analyzed the data from 2000 to 2006 using composite metric scores (CMS) and calculated an index of biotic integrity (IBI) for each sample site for the seven years. Tom chose the Index of Biotic Integrity for coastal southern California (SoCal B-IBI) described in *Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern coastal California streams. Environmental Management Vol. 35, No. 4, pp. 493-504. Springer Science+Business Media, Inc. (Appendix 2)* as being the most appropriate for our area. The following description of the SoCal ecoregion from Ode et al shows similarities to the Dry Creek Watershed.

The SoCal B-IBI is the most comprehensive assessment to date of freshwater biological integrity in California. As in other Mediterranean climate regions, the combination of aridity, geology, and high-amplitude cycles of seasonal flooding and drying in southern coastal California makes its streams and rivers particularly sensitive to disturbance (Gasith and Resh 1999). This sensitivity, coupled with the burgeoning human population and vast conversion of natural landscapes to agriculture and urban areas, has made it the focus of both state and federal attempts to maintain the ecological integrity of these strained aquatic resources. [Unfortunately the point about being a focus of preservation attempts may not be true of our area.]

The CMS method orients the sites based on the relative quality of BMI assemblages as defined by seven metrics described in Ode et al. The seven metrics used for the CMS and IBI are:

- Coleoptera Richness – the total number of Coleoptera taxa present in the sub samples.
- EPT Richness – the total number of taxa from the Ephemeroptera, Plecoptera and Trichoptera insect orders.
- Predator Richness – total number of taxa categorized as predators.
- Collectors (%) – the percent of individuals present in the sub sample categorized as collectors.
- Intolerant Organisms (%) (0-3) - the percent of individuals present in the sub sample categorized as having a tolerance value of 0 to 3.
- Non-insect Taxa (%) – The percent of the sub sample taxa that are non-insect.
- Tolerant Taxa (%) – The percent of taxa from the sub sample that are considered tolerant of stream degradation.

Because an IBI hasn't been developed for an ecoregion that includes Dry Creek Tom comments that "While several of the metrics used for this analysis are commonly used for characterizing benthic macroinvertebrate assemblages they may not be optimal for characterizing BMI assemblage quality for the Dry Creek watershed region."

The IBI scores were calculated by:

- Finding the means for the metrics identified above over the years sampled for each site.

- Applying the scoring ranges as described in Ode et al. to each mean metric value. A factor of 1.43 is multiplied to the summed metric scores yielding the IBI. The IBI can range from 0 to 100.

As Tom suggests, caution is warranted for using the SoCal IBI because it was developed for streams in southern California.

The difference between the CMS and IBI is that the CMS produces scores that are based on the samples used in the calculation; scores change as new data are added. The IBI is based on scores assigned to empirically determined ranges of metric values from very large regional data sets.

To gain maximum benefit of the CMS nearly all BMI data collected by DCC were included in the analysis including multiple years of data. The best use of the CMS is the simple plotting of scores by site and year of sampling. Plots provide insight into longitudinal trends in stream reaches, annual variation, and magnitude of difference between reference sites and non-reference sites.

### Sampling Sites

An annotated list of all samples taken by DCC is provided in Appendix 3 (file `bmireportSites051507(2).xls`). Not all of these samples were used in this analysis; data from a standard set of sites since 2000 shown in the tab called “analysis samples” was used in the metric calculation. Table 1 describes sample site locations. BMI sampling locations are shown on the map in Appendix 4 along with locations of other monitoring methods.

Table 1

Site ID	Location	Justification
DCC 1	Antelope Creek at King Road Bridge (Traylor Ranch)	Rural background setting. Upstream of Rocklin. Previous DCC physical/chemical and benthic macroinvertebrate (BMI) data available.
DCC 2	Miner's Ravine East of Auburn Folsom Road between Horseshoe Bar Road and Dick Cook Road off Miners Cove Circle.	Upper part of Miner's Ravine above Cottonwood Dam. Potential anadromous habitat.
DCC 2Alt	Miner's Ravine Creek above WWTP outfall (Dick Cook Rd.)	Upper end of stream just above Placer County wastewater treatment plant outlet. Previous DCC physical/chemical and BMI data. CVRWQCB monitored intermediate sites above treatment plant.
DCC 3	Linda Creek at Barton Road	Upstream of Roseville. No previous data. CVRWQCB previously monitored downstream in Roseville.
DCC 3Alt	Linda Creek at Country Court	Upper end of stream, very urbanized and thought to be more representative than the Barton Road site.
DCC 4	Clover Valley Creek prior to golf course	Tributary to Antelope Creek, A large development is planned. Previous DCC physical/chemical and BMI data available.
DCC 5	Secret Ravine Creek at Rocklin Road Bridge	Site of a DCC in-stream logger. Below several small headwater tributaries. Above several large drainages from urbanized Rocklin. Previous DCC physical/chemical and large amount of BMI data available from training samples
DCC 6	Secret Ravine Creek above Miners Ravine Creek	Previous DCC physical/chemical and BMI data available. Downstream end of Roseville Preserve. Large development being built upstream.

DCC 7	Miner's Ravine Creek above Secret Ravine Creek	Lower end of stream. Previous DCC physical/chemical and BMI data available. Downstream end of Roseville Preserve. Large development being built upstream.
DCC 8	Antelope Creek at Atlantic Ave.	Downstream of Rocklin and decommissioned landfill. Near confluence with Dry Creek. Previous DCC physical/chemical and BMI data available.
DCC 9	Dry Creek at Royer Park	Intermediate site. CVRWQCB to monitor downstream sites above and below Roseville wastewater treatment plant and in Rio Linda. Previous years data available. Central Roseville after confluence of Antelope, Secret Ravine, and Miners Ravine. At restoration site. Above rail yard. Previous years data available.
DCC 9Alt	Cirby Creek above Dry Creek Confluence	Includes drainage from the larger Linda Creek WS. Previous DCC physical/chemical and BMI data available. Salmon and WQ data from GANDA and CVRWQCB.
DCC 10	Dry Creek at Rio Linda Road Bridge	Lower end of Dry Creek. Previous DCC physical/chemical and BMI data available. Data available from DWR for Steelhead Creek.

An upstream and downstream site are located on each tributary. Clover Valley, which is tributary to Antelope Creek, has one sampling site. In addition to Dry Creek sites four sites from Coon Creek sampled by DCC in 2005 and a site from Greenwood Creek, a tributary of the South Fork of the American River at about 500 feet elevation, were added to the data for comparison.

## Results

Figure 1 shows the plot of CMS scores for each sample site from 2000 through 2006. Figure 2 plots the Index of Biotic Integrity for each of the sample sites for the period from 2000 through 2006.

The scores for the Dry Creek sites show:

- Composite Metric Scores for most Dry Creek sites are similar.
- DCC5 stands out as being higher for all years.
- Most sites had the highest scores in 2002 and 2006 but not significantly so.
- IBI rankings are mostly as expected based on field observations of stream and stream corridor condition except for the relatively high scores for DCC10.
- Scores for Coon Creek sites are significantly higher than Dry Creek sites.
- Greenwood Creek scores are even higher than Coon Creek.

Based on these scores the questions the DCC bioassessment program asked could be answered as follows.

- Are there differences in health among tributaries?

BMI metrics indicate that sites are very similar with the exception of DCC5 which has higher scores than all other sites. A corollary to this question that is implicit in the site selection is whether upstream sites are in better condition than downstream sites. Table 2 shows that this is generally true though not significantly and with the following exceptions.

- The Clover Valley site is upstream of the downstream site on its tributary, Antelope Creek (see map), and has a lower IBI.
- The upstream site on Linda Creek has a lower IBI than its downstream site on Cirby Creek.

- The IBI for Dry Creek, the most downstream site in the watershed, is exceeded only by the two Secret Ravine sites.

Table 2 Tributary IBI scores (shown in Figure 2)

Tributary	Downstream	Upstream
Antelope Creek	27	30
Clover Valley	23	
Secret Ravine	31	46
Miners Ravine	24	26
Linda Creek, Cirby Creek	26	21
Dry Creek	30	

- Are there trends over time in stream health?

Although CMS values show that there is variation in condition in different years for sites, in general there is no consistent trend over time. As seen in Table 3 sites vary in which year has the highest score and don't appear to have up or down trends over the years.

Table 3 Composite Metric Scores for Dry Creek sites (Shown in Figure 1)

	DCC10	DCC9	DCC8	DCC7	DCC6	DCC4	DCC3	DCC5	DCC2	DCC1
2000		-33.7	-3.5	2.2	-13.3					
2001		-5.6	-3.7	-21.6	-4.9	-39.9	-43.8	30.4	-18.1	-33.1
2002	10.6	-38.2	10.1	-13.1	11.9	-1.3	-2.4	56.3	-11.7	10.0
2003	-5.3	-25.3	-7.0	-24.6	-10.6	-29.1	-41.2	40.8	-31.0	-2.6
2004	34.3	-30.5	-23.0	-21.1	-2.6	-21.8	-31.0	41.3	6.6	13.1
2005	2.2	-5.3	-12.6	-30.6	-16.3	-33.6	-64.1	36.4	-20.0	-15.5
2006	-13.6	-22.1	-0.3	-12.9	25.1	-12.1	-15.5	72.1	-5.3	8.9

- What is the overall health of the Dry Creek Watershed?

Based on the SoCal B-IBI scores the overall health of Dry Creek Watershed appears to be poor. That result must be considered tentative since the SoCal B-IBI wasn't developed for the ecoregion that includes the Dry Creek Watershed. However, the IBI scores for Coon Creek and Greenwood Creek show that similar creeks in the ecoregion have significantly higher IBI scores indicating better condition than Dry Creek.

**Discussion**

These results raise questions about causes of the condition of the BMI community in Dry Creek Watershed and, in general, how BMI data can be explained by measurable watershed conditions. Bioassessment protocols include physical habitat assessments that are taken at the time BMI samples are taken. Physical conditions such as water quality and instream and riparian corridor habitat condition are intended to be used to explain BMI data. These data are currently the subject of a watershed assessment being done by CalEPA Office of Environmental Health Hazard Assessment (OEHHA). This assessment may discover relationships among bioassessment data, water quality parameters taken from instream loggers, grab samples sent for lab analysis, and salmon spawning distribution.

A broader indicator of watershed condition that is widely considered to explain stream and BMI community condition is the amount of upstream impervious cover (For example work by the Center for Watershed Protection and Karr et al). The impact of impervious cover is the focus of work by DWR Municipal Water Quality Investigations and OEHHA for the Dry Creek and the Steelhead Creek Watersheds. In addition, DCC has acquired impervious cover estimates for tributary sub watersheds derived from satellite imagery that can be used to help answer this question.

Some questions raised by the IBI analysis are:

- Why is the DCC5 IBI value significantly higher than other Dry Creek sites?
- Why are Coon Creek IBI's so much higher than Dry Creek values?
- What is the cause of the generally depressed condition of the Dry Creek BMI community?
- Why are Coleoptera taxa lacking in the Dry Creek data?
- Why is the DCC10 IBI value high relative to upstream sites?

Hypotheses to answer these questions can be framed based on:

- Amount of impervious cover and associated impacts influencing sample sites.
- Instream measures such as embeddedness and sediment - Excessive fine sediment can explain the lack of Coleoptera taxa seen in the data. Ode et al, page 503; Wayne Fields, personal communication.
- Water quality measures such as temperature.
- Riparian corridor measures such as canopy cover.
- Manipulated instream flows - The Dry Creek Watershed receives imported water in its major tributaries.
  - Can water deliveries explain the very low Clover Valley IBI since Clover Valley flows in summer are almost entirely due to imported water?
  - Can the higher quality BMI community in Coon Creek be explained by relatively smaller amounts of imported water?
  - Can the higher quality BMI community at SR5 be due to it being above the outlet of the Boardman Canal, a major contributor to dry season Secret Ravine flows? In a 1999 report on BMI fauna in Secret Ravine Wayne Fields noted in-stream flow changes as follows:

The almost daily occurrence of an artificial increase in flow which was observed during habitat mapping and was estimated to sometimes double or even triple the flow in the stream...since the fauna in streams at this elevation is adapted to a regime in which fluctuations in flow are limited to the rainy period, the addition of this much extra water on an irregular basis can only serve to disrupt the usual pattern of life.

In fact, much recent work has been done on the impact on BMI of allochthonous material, which in streams is organic material from outside the stream flow that contributes to stream ecology and the vigor of BMI. (Tom King, personal communication; Lotic System Ecology, Wikipedia) Manipulated flows have been shown to flush this material from streams resulting in a depressed BMI community.

- Are DCC10 IBI scores due to it being located on a higher order stream?

- Might other metrics be more appropriate for the Dry Creek ecoregion? For example Odonata (damselflies and dragonflies) might replace Plecoptera for an EOT rather than EPT metric. (Tom King, personal communication)

▪

### **Conclusions and Recommendations**

These issues should be followed up to explain the current condition of Dry Creek BMI and its implications for the health of the Dry Creek Watershed. Desired conditions should be agreed on as goals for future management decisions. Dry Creek can be used as an example for guiding land use and management decisions in similar watersheds.

Figure 1

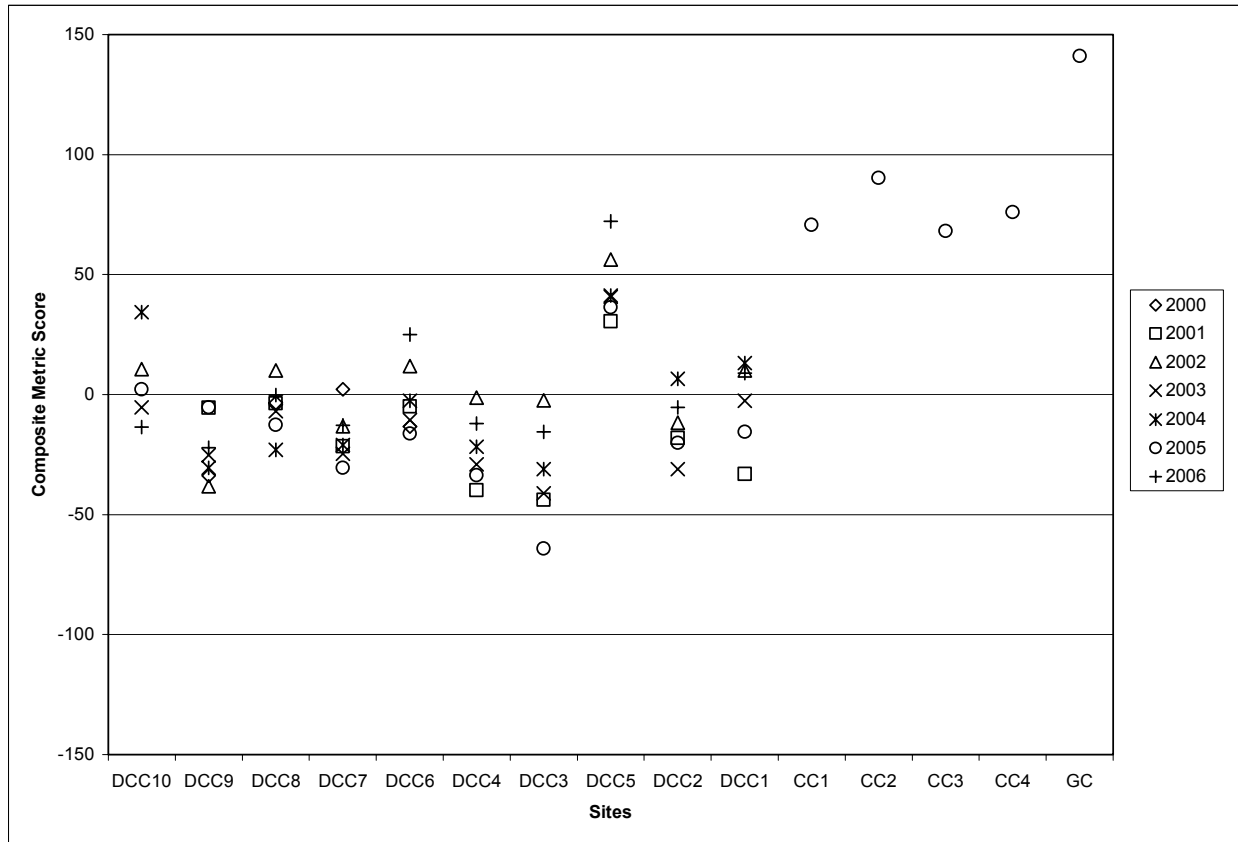
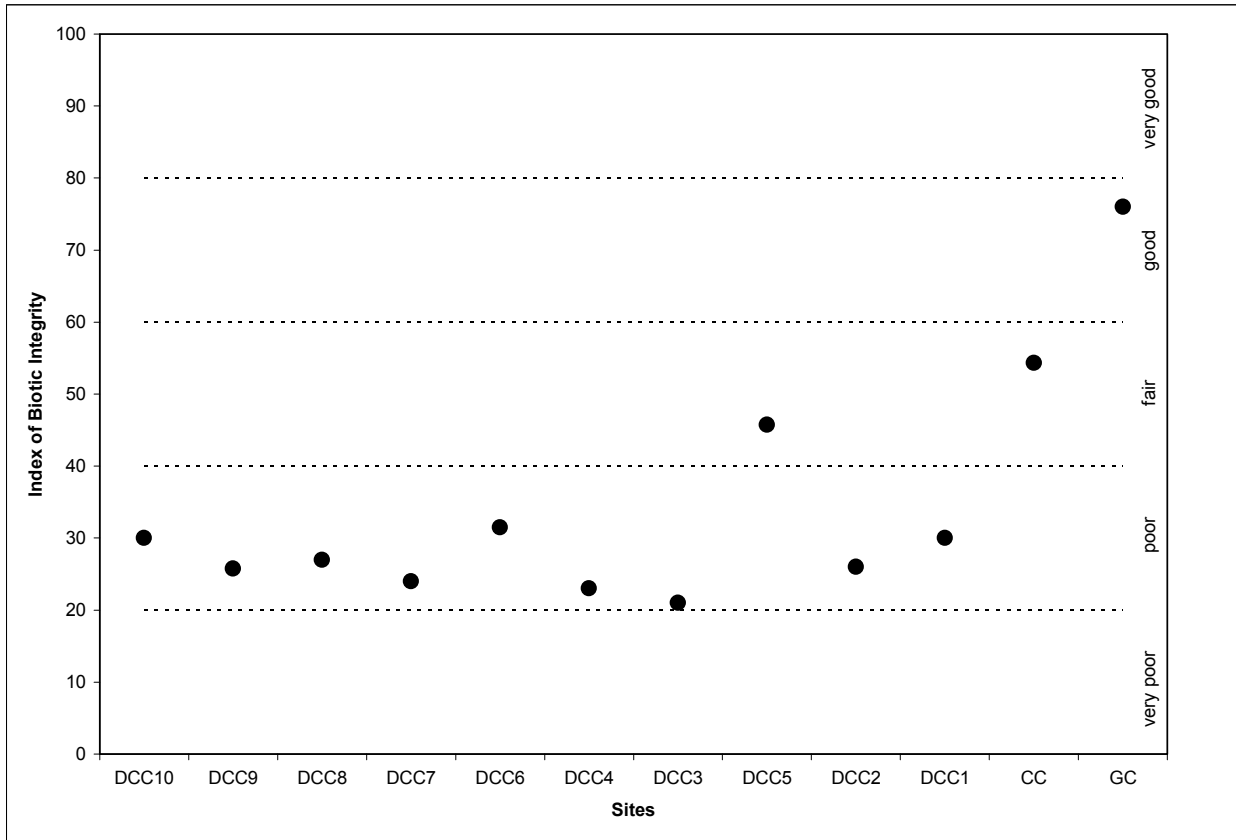


Figure 2



Appendix 1

BMI data – 500 organism protocol, CAMLnet taxa list  
2005 through 2006  
2000 through 2004

## Appendix 2

### A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams

Appendix 3

Dry Creek Conservancy Sample List

Appendix 4

Dry Creek Watershed Sample Locations

Appendix 5

Dry Creek IBI Data