<u>Workgroup 2:</u> Technical Aspects of Using Biological Data in Water Resource Management

Part I. Developing indices of biotic integrity
Part II. Using biological data in TMDLs
Part III. Current plans for using biological data in Region 6/9
Part IV. Discussion: Overcoming scientific and political hurdles to implementation

Aquatic Bioassessment Laboratory

San Diego Regional Index of Biotic Integrity (IBI)

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Interpreting Biotic Condition from Community Data: the IBI Concept

- **Premise:** A great deal of information about stream condition can be obtained by studying the community of organisms found a site.

- **Primary Challenges:**
  1. How to translate a list of species into numbers that water quality managers can use to make management decisions
  2. Biological communities are fundamentally variable

- **Goal of IBI:** Control for variability to maximize detection of environmental degradation

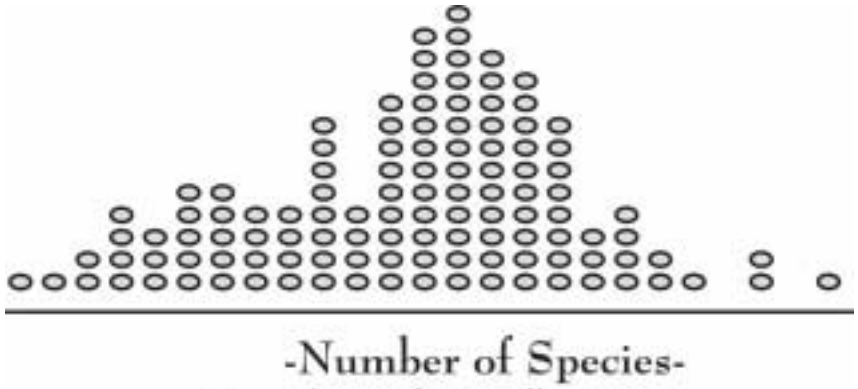
- **Basic Strategy:** Determine the best measures (metrics) of biotic condition and use them to calculate an index score for stream reaches (Index of Biotic Integrity-IBI)

* techniques developed by Karr 1981, Kerans and Karr 1994

** recommended by the EPA (Barbour et al. 1999) as a sound approach for developing regional bioassessment programs and to support biocriteria

Translating Biology into Stream Condition

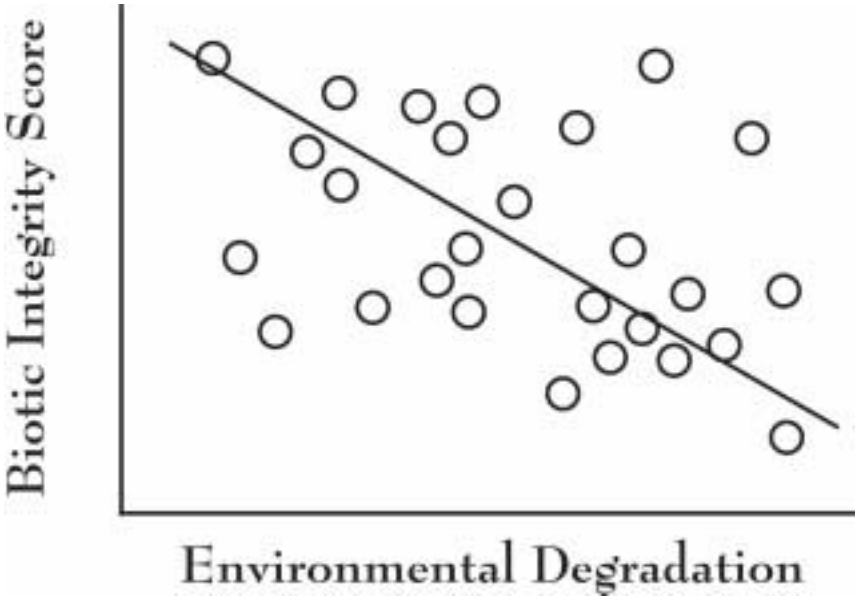
- If we went to a series of stream sites and collected samples of bugs present we'd see that each site had a different set of species present



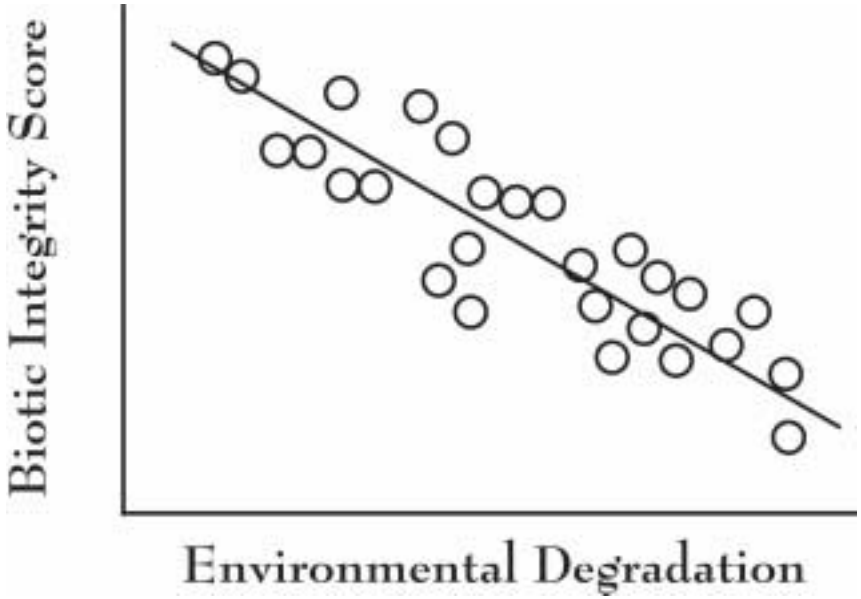
- If the relationship between taxa list and stream health was as simple as **"more species = better stream condition"**, then we'd just count number of species

- We know its more complicated, so the appropriate question is:
"what measures (metrics) give the best signal and least variation"

Biological communities are inherently variable;
IBI Goal is to find the best signal to noise relationships

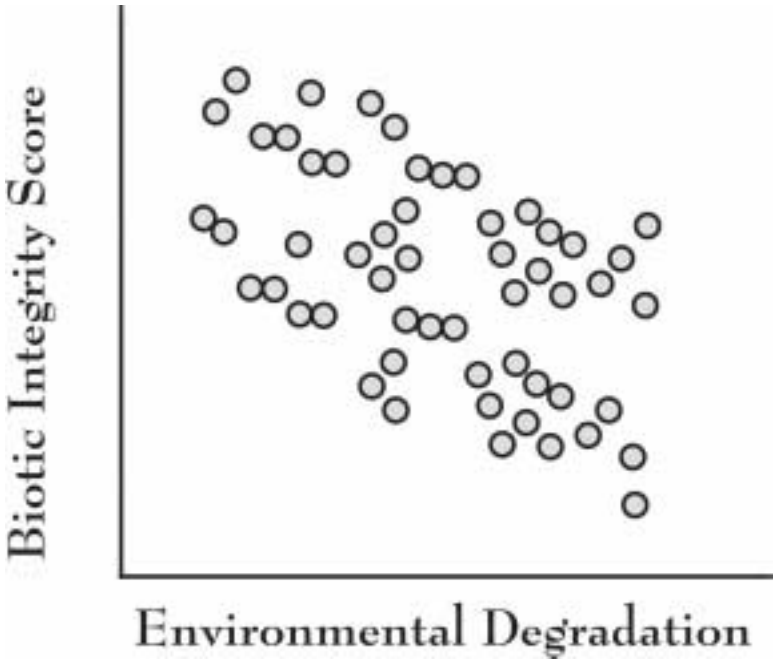


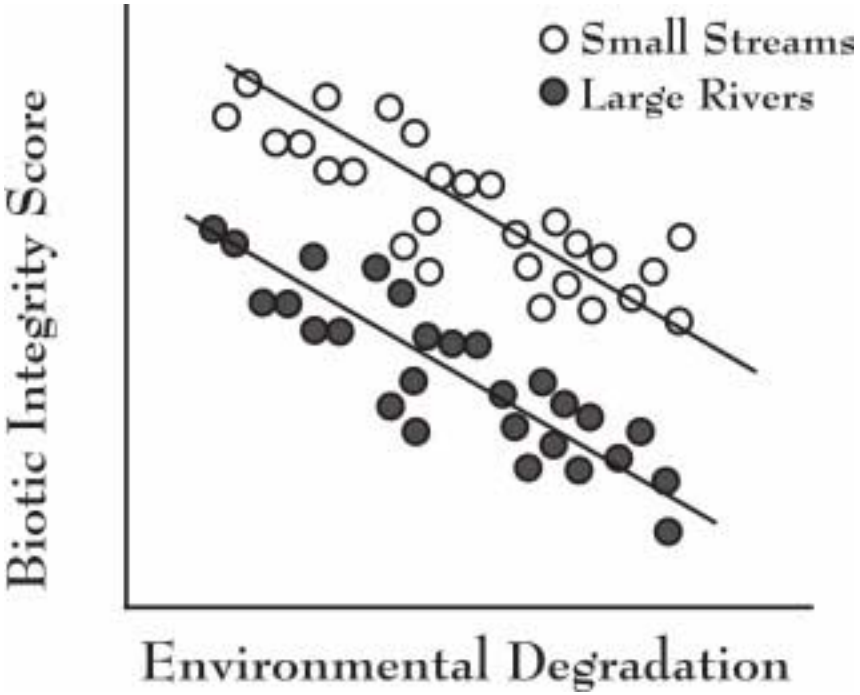
Poor Signal to Noise Relationship



Good Signal to Noise Relationship

Classes can clarify signals





Can we find ways of partitioning this variation so that signals become clearer?

Solution: Develop two IBIs for the region

Steps for Creating an Index of Biotic Integrity (IBI)

EPA Rapid Bioassessment Protocol (Barbour *et al*. 1999) identify 6 major steps involved in the development of an IBI; each step can be modified to meet unique needs of a region or take advantage of new science.

I. **a.** Classify stream types to partition natural variation
b. Select reference sites
II. Identify potential metrics (measures of biotic condition)
III. Screen metrics to select the most robust ones
IV. Score metrics and combine scores into an integrated IBI
V. Assign rating categories to IBI score ranges
VI. Evaluate performance of IBI and refine (ongoing process)

Step Ia: Classify Stream Types

- **Examples of Class Categories:**
  - Stream Size (Strahler Order, etc.)
  - Elevation
  - Season
  - Ecoregion
- **Too many IBIs become unmanageable**
- **Goal:** Use the fewest categories necessary to partition variation

In San Diego IBI, this step was performed last

Step Ib: Selecting Reference Sites

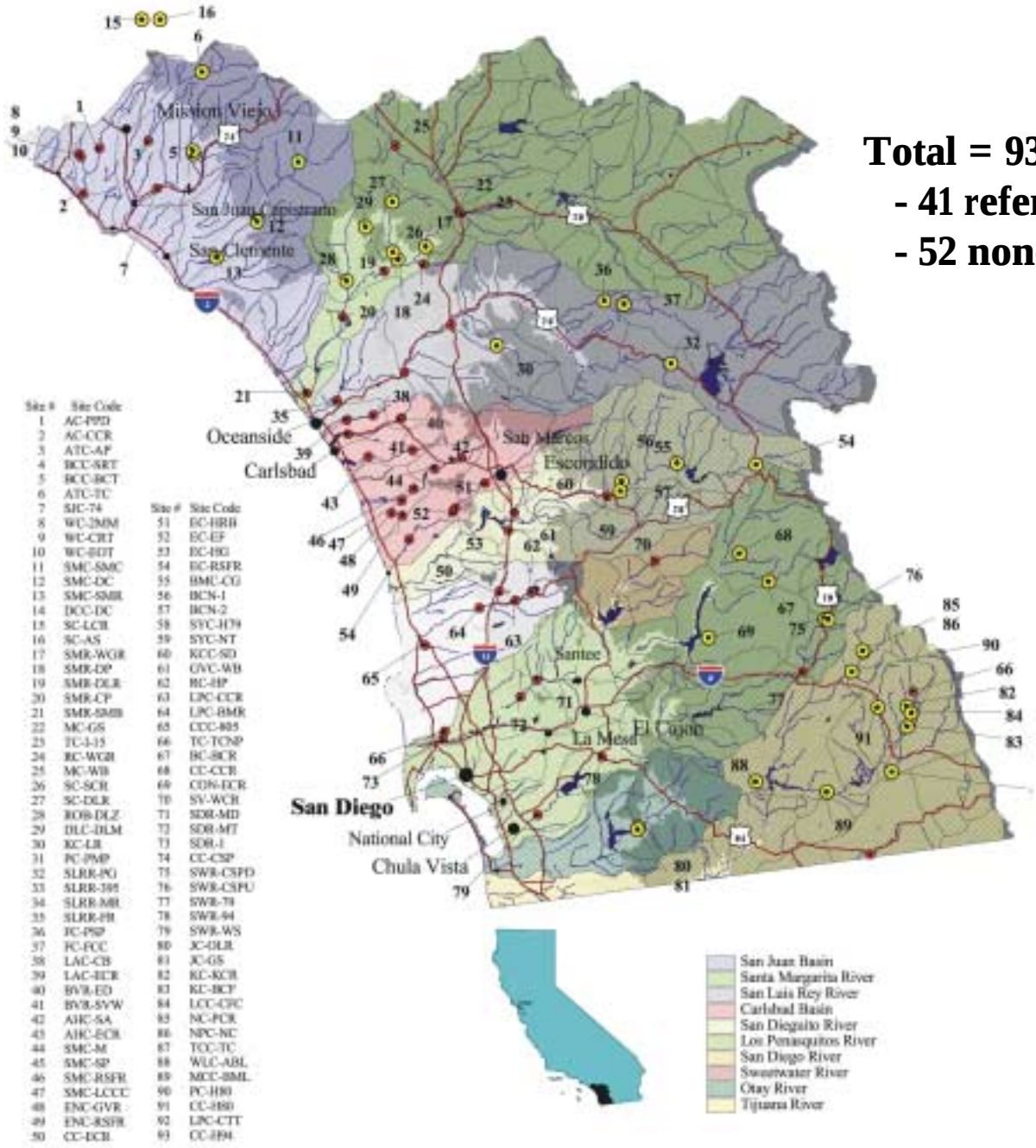
- Reference sites are the least disturbed sites in a region of interest
- Assigning sites to either a reference group or a non-reference group is the first step in calculating an IBI.
- Many approaches to identifying reference sites: we advocate an quantitative objective approach
  - DFG/ SNARL Quantitative Reference Site Selection Methodology Presented Last Year
  - San Diego Sites were selected before we developed that technique. Most sites were selected by David Gibson (San Diego Regional Board ES) on the basis of the following criteria:

Reference Site Selection:
Gibson Score Rating Criteria

1. **Relatively Easy Access**
2. **No Known Problems with Base Flow Stream Chemistry**:
3. **Absence of Grazing**: (or minimal grazing) during the previous 5 years.
4. **Minimal Residential Land Use**: Areas without residential land use or where residential land use was minimal.
5. **Stream Flow Status**:
   - Perennial streams 1st Order
   - Perennial streams 2nd –3rd Order
   - Intermittent streams (1st –2nd Order) with at least 3-4 months of reliable flow (typically March - June).

5. **Additional Criteria:**
   - Upstream of road crossings and recreational areas
   - Upstream of impoundments or on drainages without impoundments.
   - If upstream impoundments were present, site was located at least 5 stream-miles downstream
   - Presence of mature riparian habitat and an otherwise high RBP physical habitat score.
6. **Professional Judgement**

7. **Elevation**: Considerable effort was taken to select a comparable number of sites above and below 1000 feet elevation so that we could evaluate minimally disturbed sites in both regions.



Site #	Site Code
1	AC-PPD
2	AC-CCR
3	ATC-AP
4	BCC-SRT
5	BCC-BCT
6	ATC-TC
7	SJC-74
8	WC-2MM
9	WC-CRT
10	WC-DDT
11	SMC-SMC
12	SMC-DC
13	SMC-SMR
14	DCC-DC
15	SC-LCR
16	SC-AS
17	SMR-WGR
18	SMR-DP
19	SMR-DLR
20	SMR-CP
21	SMR-SMR
22	MC-GS
23	TC-I-15
24	RC-WGR
25	MC-WB
26	SC-SCR
27	SC-DLR
28	ROB-DLZ
29	DLC-DLM
30	RC-LR
31	PC-PMP
32	SLRR-PG
33	SLRR-395
34	SLRR-MR
35	SLRR-PR
36	PC-PSP
37	PC-PCC
38	LAC-CB
39	LAC-ECR
40	BVR-ED
41	BVR-SVW
42	AHC-SA
43	AHC-ECR
44	SMC-M
45	SMC-SP
46	SMC-RSFR
47	SMC-LCCC
48	ENC-GVR
49	ENC-RSFR
50	CC-ECR

Site #	Site Code
51	EC-HRB
52	EC-EF
53	EC-HG
54	EC-RSFR
55	BMC-CG
56	BCN-1
57	BCN-2
58	SYC-H79
59	SYC-NT
60	KCC-SD
61	OVC-WB
62	RC-HP
63	LPC-CCR
64	LPC-BMR
65	CDC-805
66	TC-TCNP
67	RC-RCR
68	CC-CCR
69	CDN-ECR
70	SV-WCR
71	SDR-MD
72	SDR-MT
73	SDR-1
74	CC-CSP
75	SWR-CSPD
76	SWR-CSPU
77	SWR-78
78	SWR-94
79	SWR-WS
80	JC-DLR
81	JC-GS
82	KC-KCR
83	KC-RCP
84	LCC-CFC
85	NC-PCR
86	NPC-NC
87	TCC-TC
88	WLC-ABL
89	MCC-BML
90	PC-HR0
91	CC-HR0
92	LPC-CTT
93	CC-HW

Total = 93 sites selected

- **41 reference**
- **52 non-reference**

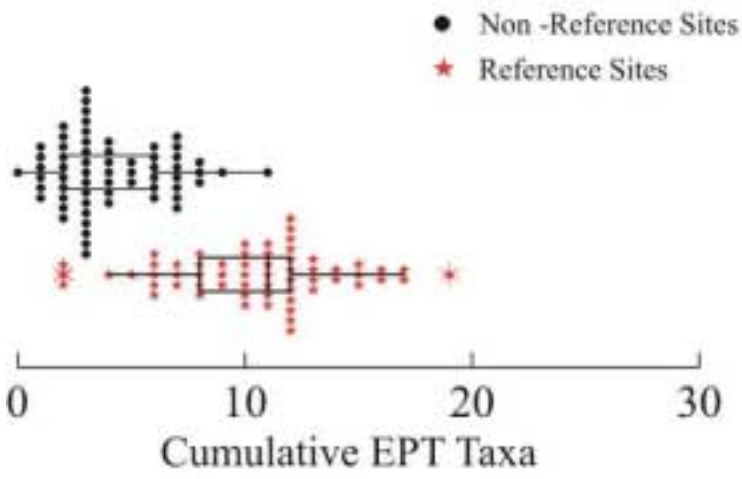
Steps II and III:
Metric Selection and Screening

Process: Identify which aspects of the community (metrics) are most closely related to biotic integrity. Evaluate as many metrics as possible with several screening tools.

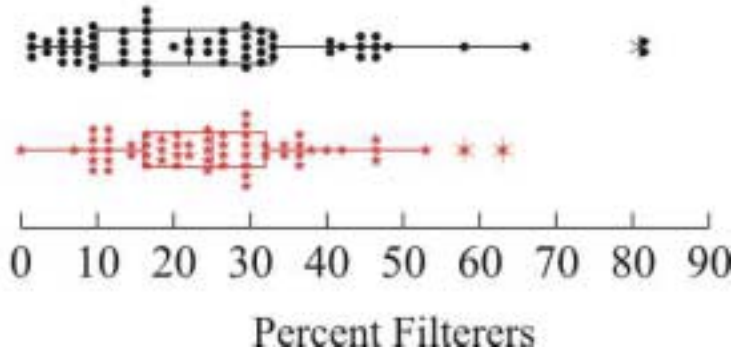
Look for metrics with:

- Strong dose-response relationships with impact gradients
- Good discrimination between reference and non-reference sites
- High signal to noise ratios
- High index of repeatability
- Independence of measurement ("orthogonality" or "redundancy" tests)

Screening Metrics: Discriminatory Power

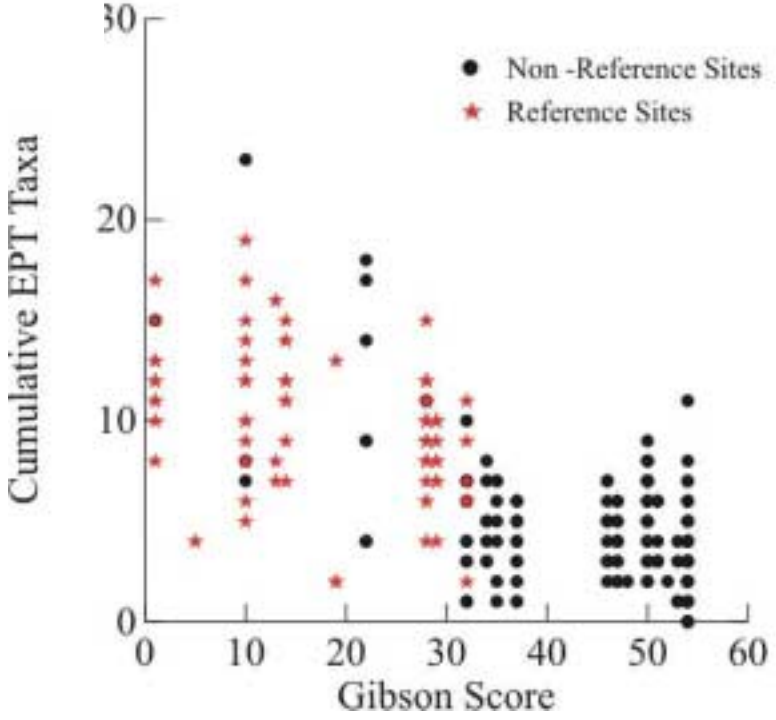


Good discrimination

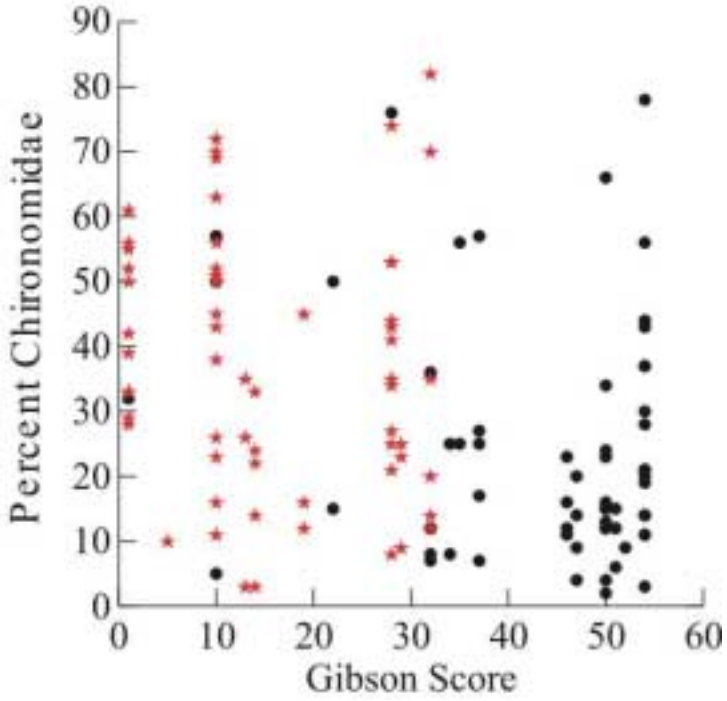


Poor discrimination

Screening Metrics: Dose-response Curves



Strong Dose-response Relationship



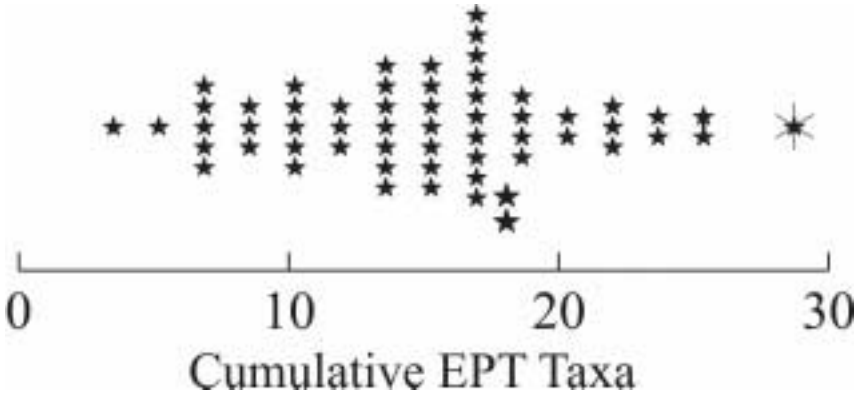
Weak Dose-response Relationship

Selected Core Metrics

1. Cumulative Taxa
2. Cumulative EPT Taxa
3. Percent Sensitive EPT
4. Percent Dominant Taxon
5. Shannon Diversity
6. Intolerant Taxa
7. Percent Grazers

Step IV: Defining Scoring Ranges for Component Metrics

Problem: How do you assign scores to a site base on its metric values?

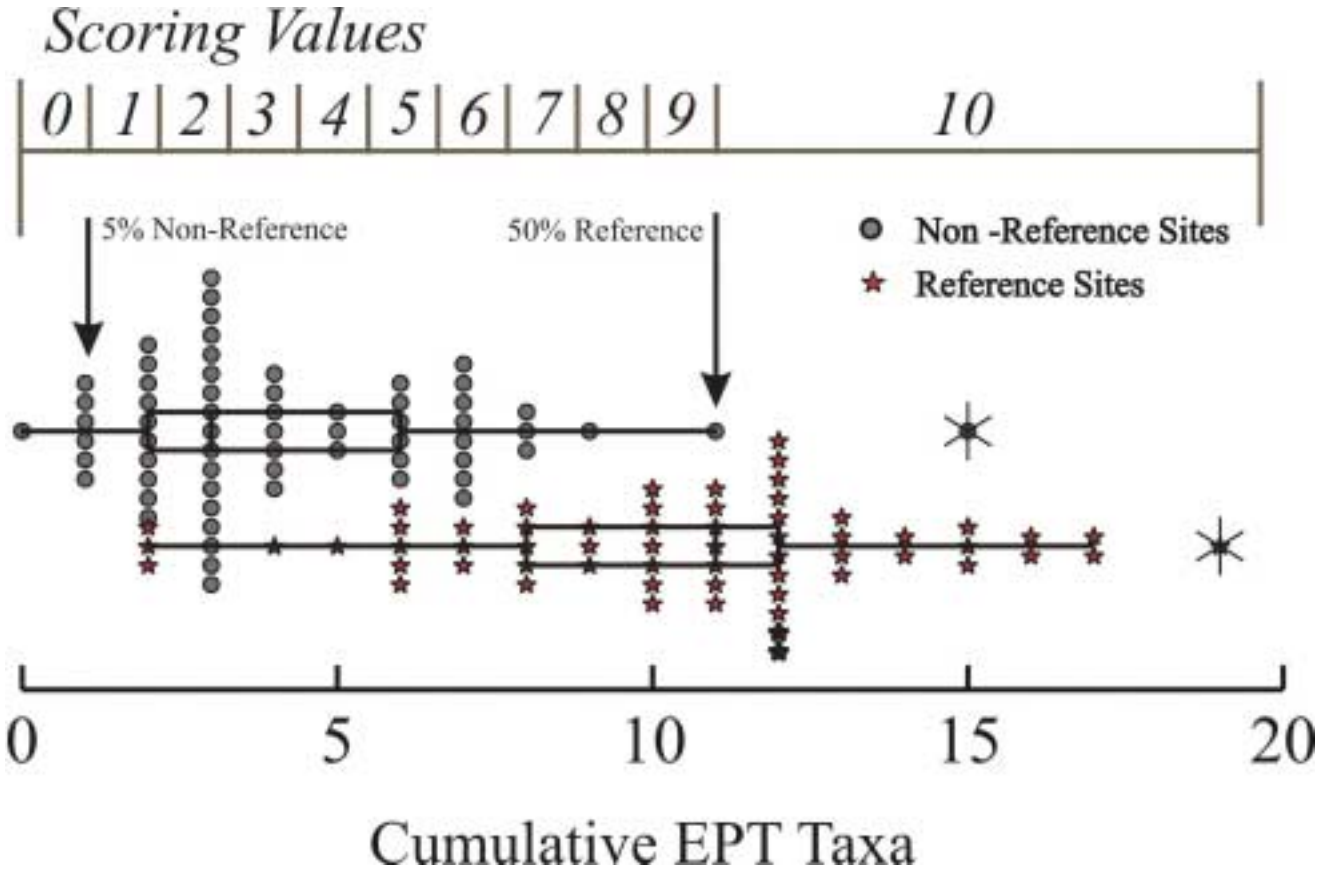


We evaluated several approaches:

- Karr 1981
- Harrington 1999 (Russian River IBI)
- Barbour et al. 1999

We determined that a recent approach used for fish and zooplankton by **Hughes** and **McCormick (1998, 2001)** gave us the best discrimination.

Step IV: McCormick and Hughes Scoring Methodology



Step IV: Cumulative Metric Scores

	Metric Scoring Ranges for San Diego IBI						
Score	**Cumulative Taxa**	**Dominant Taxon**	**Sensitive EPT Index**	**Cumulative EPT Taxa**	**Shannon Diversity**	**Intolerant Taxa**	**Percent Grazers**
0	0-16	>56	0-0.6	0-1	0-1.31	0-.5	0-0.6
1	17-19	54-56	0.7-1.3	2	1.31-1.4	0.6-1.0	0.7-1.3
2	20-21	51-53	1.4-2.0	3	1.41-1.49	1.1-1.6	1.4-2.0
3	22-23	49-50	2.1-2.7	4	1.5-1.58	1.7-2.1	2.1-2.7
4	24-25	47-48	2.8-3.3	5	1.59-1.67	2.2-2.7	2.8-3.4
5	26-27	45-46	3.4-4	6	1.68-1.76	2.8-3.2	3.5-4.1
6	28-29	42-44	4.1-4.6	7	1.77-1.84	3.3-3.8	4.2-4.8
7	30-31	40-41	4.7-5.3	8	1.85-1.93	3.9-4.3	4.9-5.5
8	32-33	37-39	5.4-6	9	1.94-2.02	4.4-4.9	5.6-6.2
9	34-35	34-36	6.1-6.9	10	2.03-2.11	5.0-5.4	6.3-7
10	>35	0-33	>6.9	11	>2.11	>5.4	>7

IBI Scores	**Very Poor**	**Poor**	**Fair**	**Good**	**Very Good**
	0-12	**13-25**	**26-37**	**38-54**	**55-70**

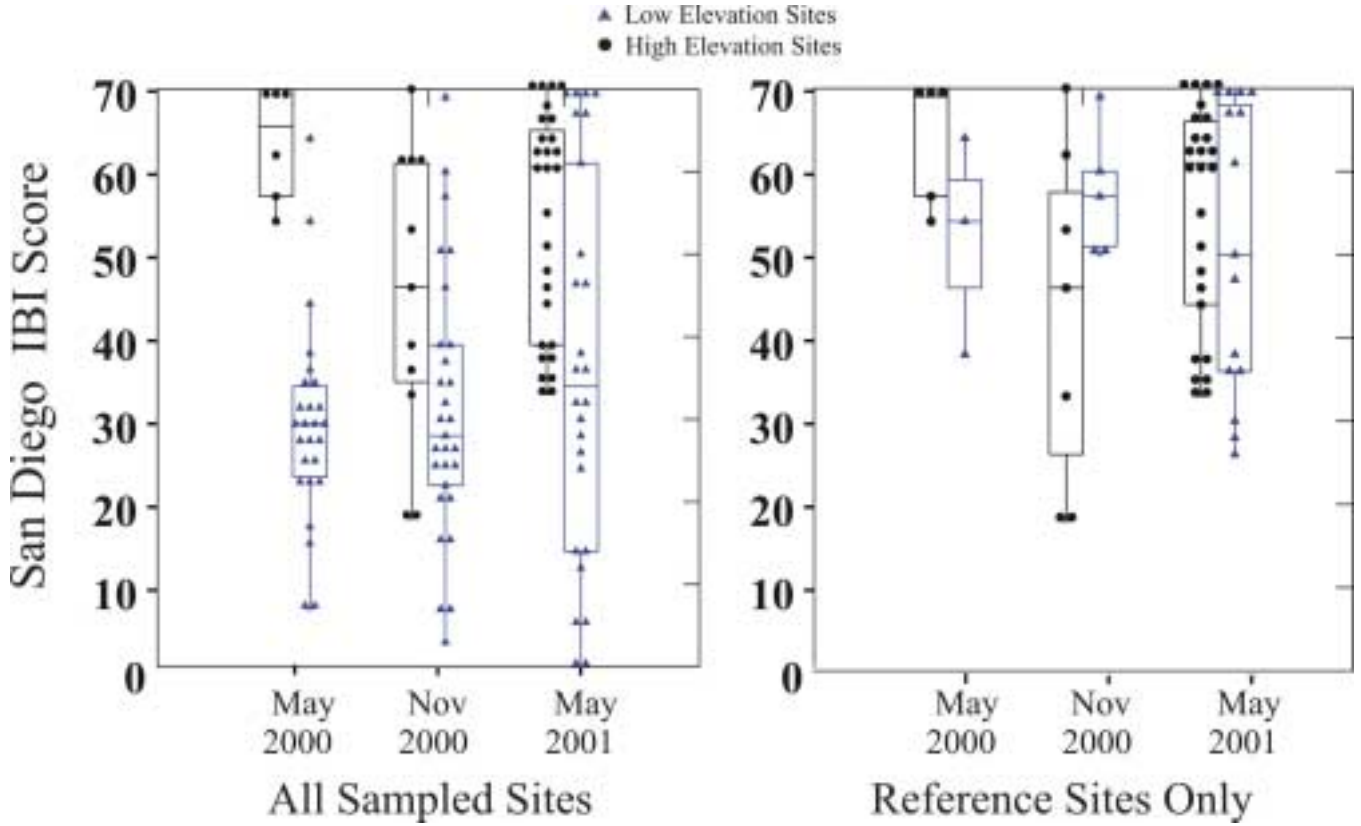
Step V: Assign rating categories to IBI scoring ranges

- Use 25th percentile of reference sites to establish boundary between **Fair** and **Good**
- Divide lower half into three sections and upper half into two

Step Ia: Revisited

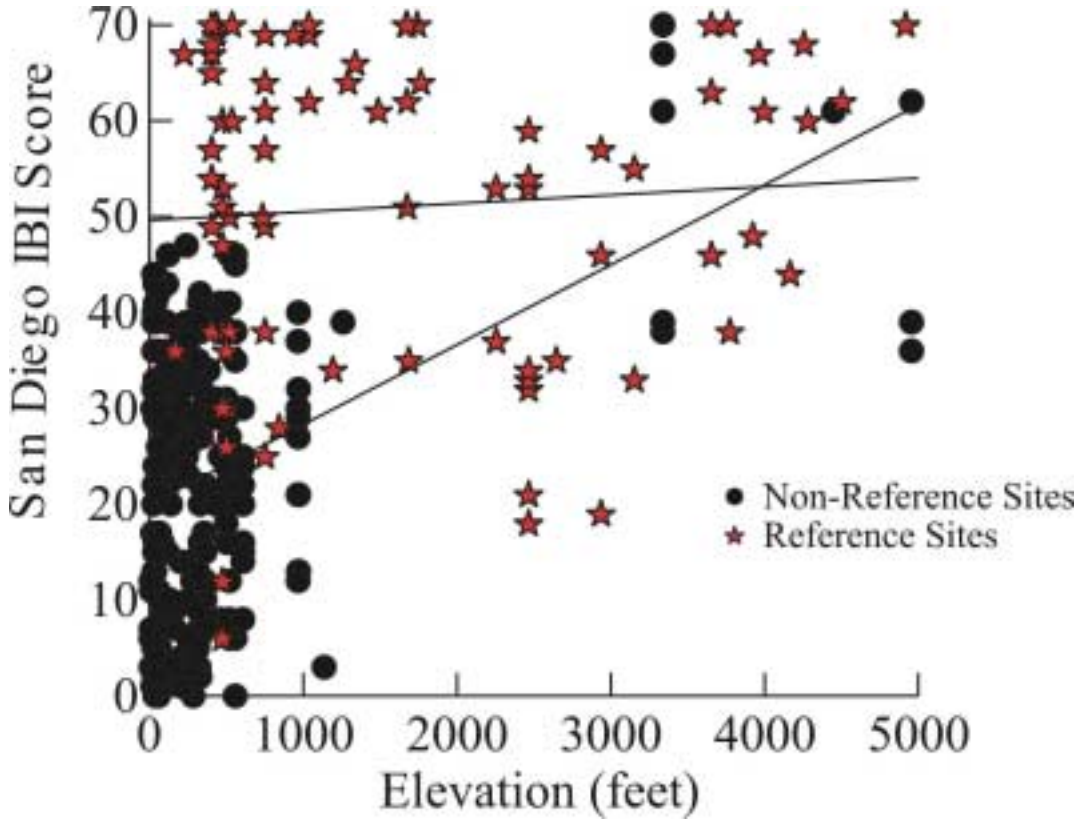
- Do we need to create multiple IBIs for the San Diego Region?
- We evaluated elevation and season to see if individual metrics behaved differently in these classes.

Step Ia (revisited): Evaluating the need to classify based on elevation

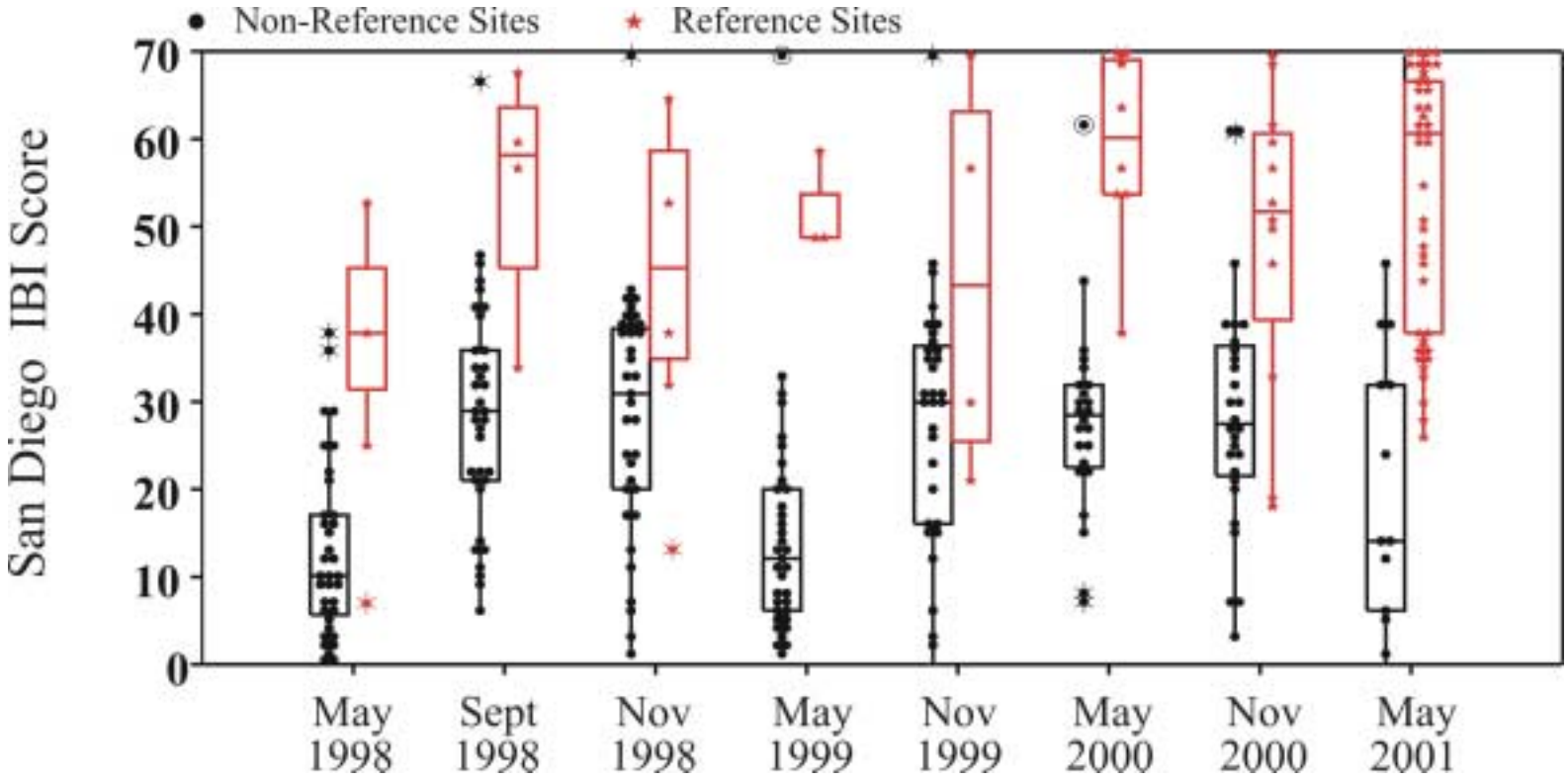


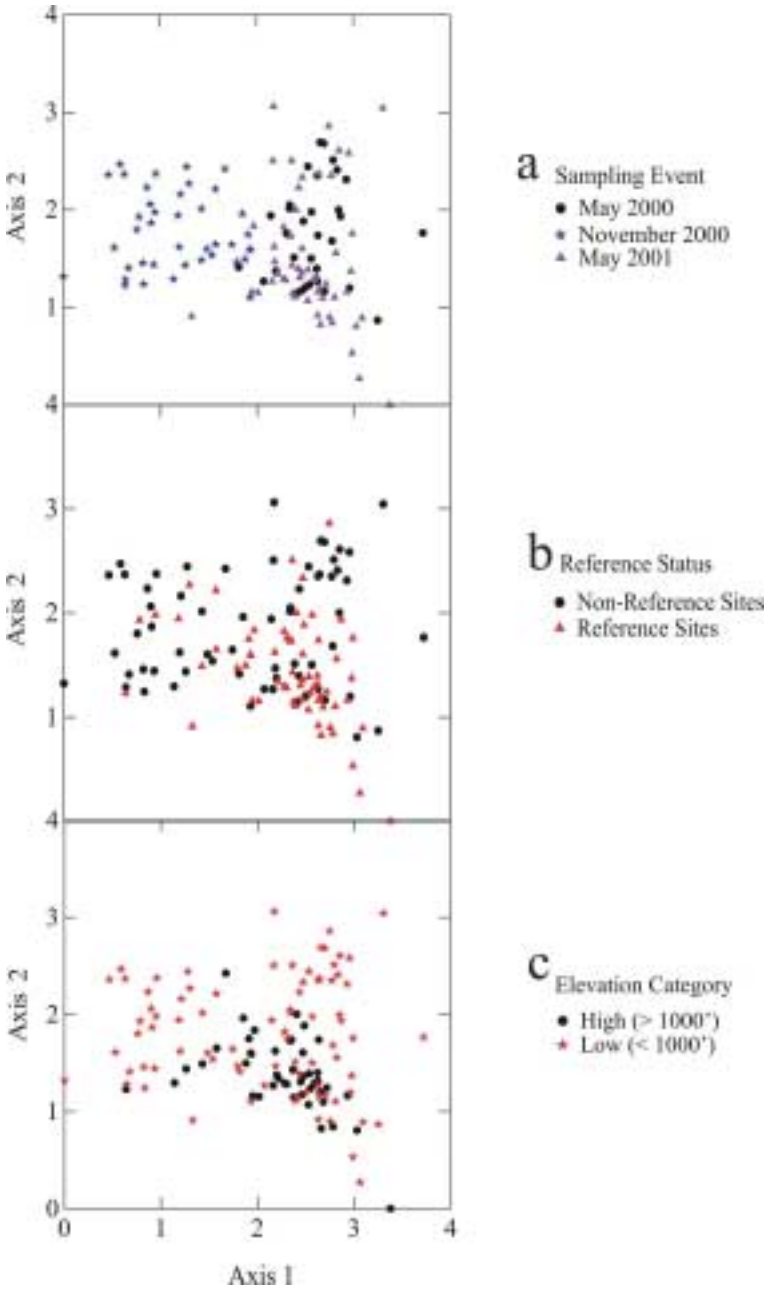
- Although there appeared to be an elevation effect, this seems to have been due to the lack of reference sites in earlier sampling events.

Step Ia (revisited): Classifying based on elevation



Step I (revisited): Evaluating the need to classify based on season

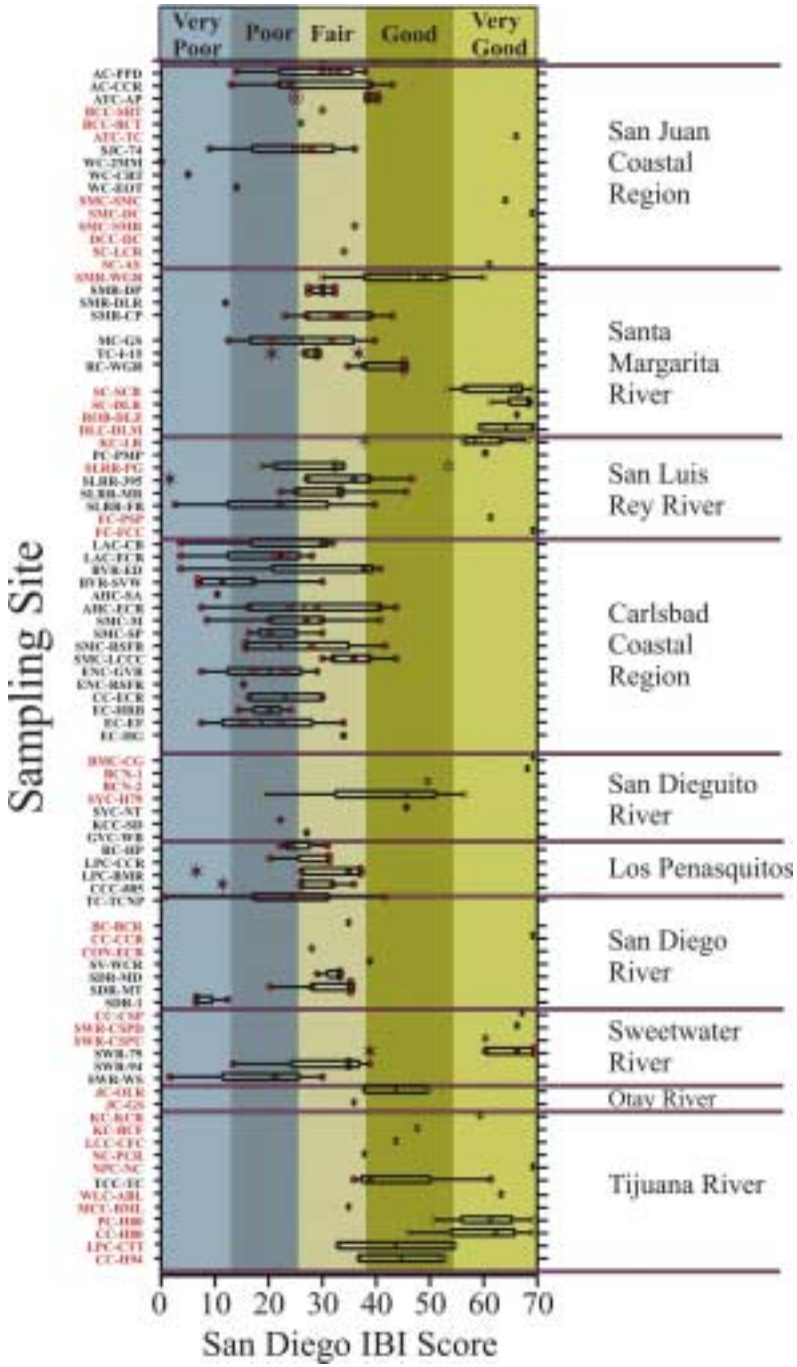




Step Ia: Multivariate techniques for evaluating the need to classify

- Communities were quite different in spring and fall
- Communities in reference sites were comparable to those in non-reference sites
- Communities were somewhat different in high and low elevation sites (maybe 3 groups?)

- **However, IBI scores were unaffected by season or elevation**



Step VI: Evaluating the IBI's performance

IBI precision:

- Some sites are very consistent, while others are highly variable
- What are the sources of the variation?
- Are reference sites less variable than non-reference sites?
- Can we distinguish natural variation from impact-related variation?

➢ The goal of future work is to reduce this variability by selecting metrics that are less susceptible to natural variation. This will help us detect impact-related variation.

Summary

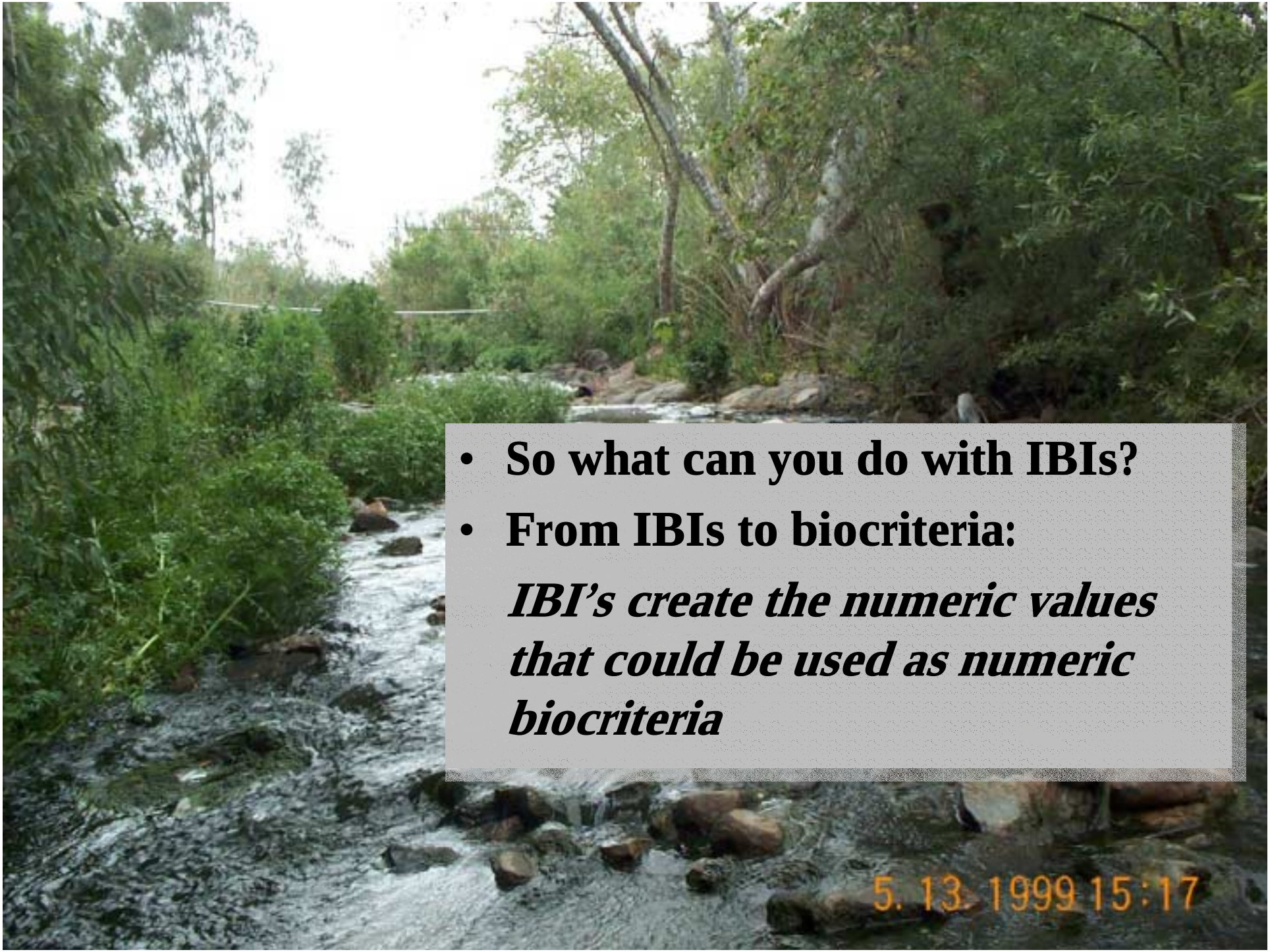
- Indices of Biotic Integrity (IBIs) provide a means for managing the variability of biological data
- Biological information can be translated into a numeric score that relates to stream condition using this IBI technique
- The IBI described here is a tool that can be used immediately
- Initial evidence suggests that there is no need to create separate seasonal IBIs or elevational IBIs

Recommendations

- We recommend evaluating sites over multiple sampling events before assigning a rating category to them
- We recommend that the San Diego RWQCB invest effort toward improving IBI precision
  - Need continued monitoring of sites (intensive quantitative physical and chemical monitoring at all sites, reference and non-reference)
  - Need repeated measures of IBI performance so that IBI scores can be assigned a degree of estimated precision
  - Need to continue to identify reference sites

Future Directions

- We are currently evaluating the potential for expanding the scope of this IBI to the Southern California Coastal Region
- We plan to integrate data from USFS, EMAP and Regional Boards (Regions 3,4,7,8,9) ….currently have data from ~250-300 sites
- Most of the effort needed is in metrics development (which metrics respond to which gradients) and classification of stream types



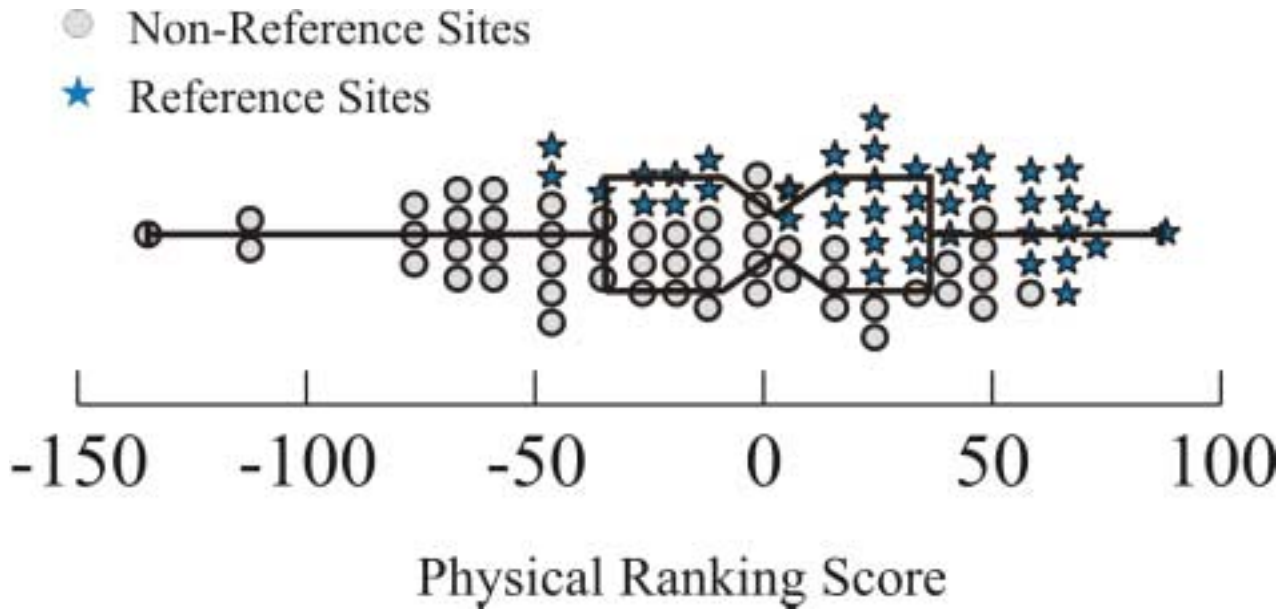
- **So what can you do with IBIs?**
- **From IBIs to biocriteria:**

  IBI's create the numeric values that could be used as numeric biocriteria

Further Rejection of Candidate Reference Sites

We eliminated a few sites from the pool based on their physical habitat scores.

We used 8 physical habitat metrics, representing both reach and riffle-scale measures of physical habitat integrity (**Epifaunal Substrate, Riffle Embeddedness, Sediment Deposition, Bank Vegetation, Canopy Cover, Substrate Consolidation, Percent Fines, Specific Conductance**)



Caveat: Avoiding Circularity

There is a need to make sure that we don't use biological data to assign sites to reference/ non-reference groups.

Challenge: How do we refine the IBI without falling subject to circularity?