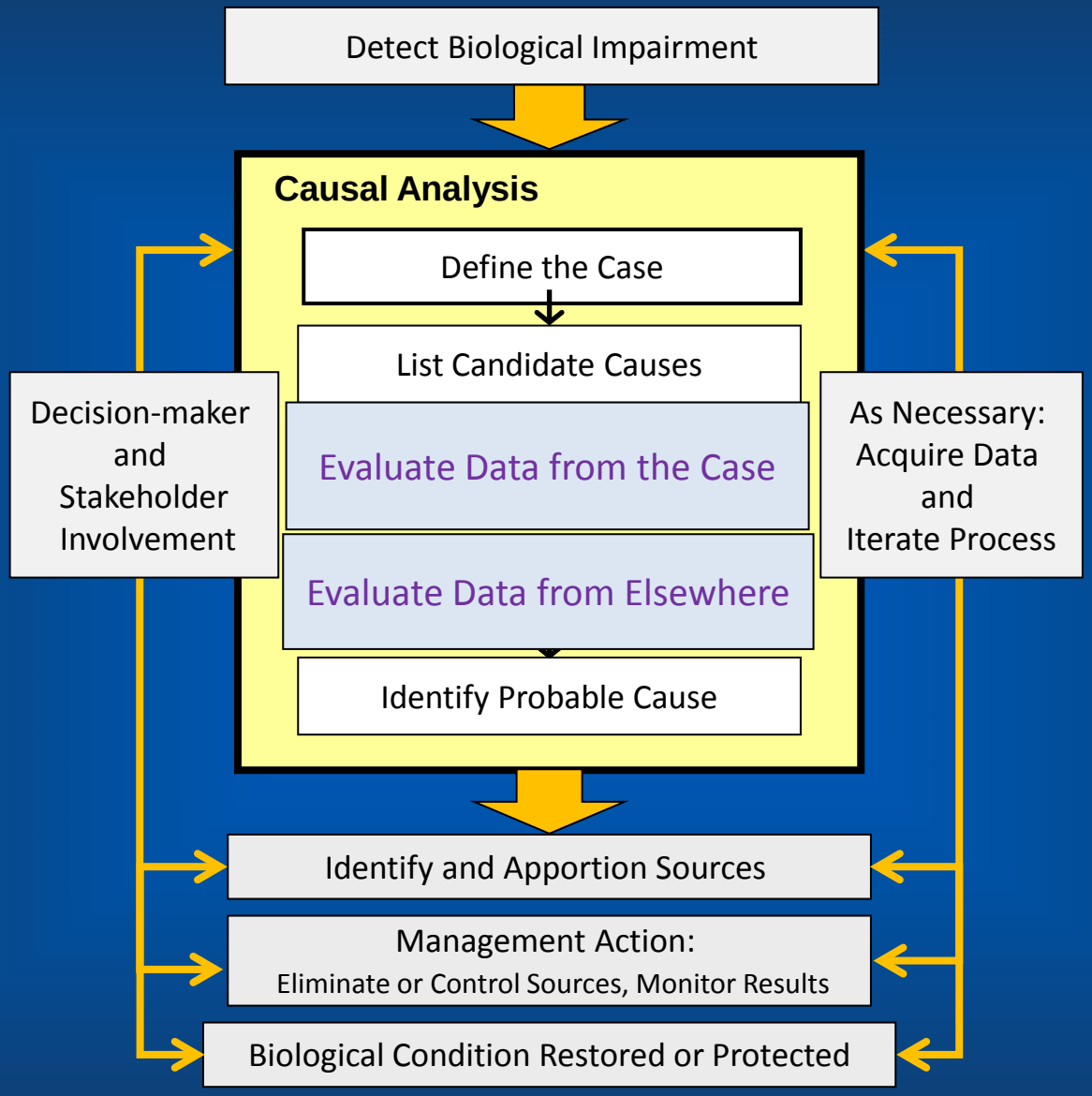
Evaluating Data from Different Lines of Evidence

Steps 3 & 4

San Diego Creek Causal Assessment Workshop 1
December 17, 2014


Detect Biological Impairment
Causal Analysis
Define the Case
List Candidate Causes
Evaluate Data from the Case
Evaluate Data from Elsewhere
Identify Probable Cause
Decision-maker and Stakeholder Involvement
As Necessary: Acquire Data and Iterate Process
Identify and Apportion Sources
Management Action:
Eliminate or Control Sources, Monitor Results
Biological Condition Restored or Protected

Evaluation of the Data

- Each type of analysis is different line of evidence (LOE)
- Each LOE will be applied to each proximate stressor
  - May even have sub-/ analyte-level evaluations
  - Then aggregated for up to each candidate cause
- Variety of different LOE detailed on the CADDIS website and the CA guidance document

San Diego River

Test vs. comparator site

Candidate Causes

Lines of Evidence

		MLS vs. TWAS 2-2				
Candidate Cause		Elevated Conductivity	Habitat Alteration	Heavy Metals	Increased Nutrients	Pesticides
Spatial Co-Occurrence		+	0	+	+	+
Stressor Response	Collector Abundance	0	+	-	0	-
	Non-Insect Taxa	+	0	0	0	+
	Tolerant Taxa	-	0	-	0	0
	Amphipod Abundance	++	+	++	-	0
Reference Condition Comparison		+	+	NE	NE	NE
Stressor Response From Outside the Case	Collector Abundance	0	+	0	-	NE
	Non-Insect Taxa	+	0	0	0	NE
	Tolerant Taxa	+	0	0	0	NE
	Amphipod Abundance	0	0	0	0	NE
Stressor Response From Laboratory		NE	NE	--	NE	--
Continuity		+/+/-/+	+/0/0/0	-/-/-/-	-/0/0/-	-/+/-/-

Scoring the Lines of Evidence

- Scoring of data is done to help with record keeping
  - Provides a shorthand for summarizing results at the end of the assessment
- Scores
  - Supporting evidence (+, ++, or +++)
  - Weakening evidence (-, --, or ---)
  - Ambivalent evidence (0)
  - No evidence (NE)
  - Refute (R)

Within the Case Evidence

- Lines of evidence that make direct use of data collected at the test and comparator sites
  - Spatial/temporal co-occurrence
  - Evidence of exposure
  - Causal pathway
  - Stressor-response from the field
  - Manipulation of exposure
  - Laboratory tests of site media
  - Temporal sequence
  - Verified predictions
  - Symptoms

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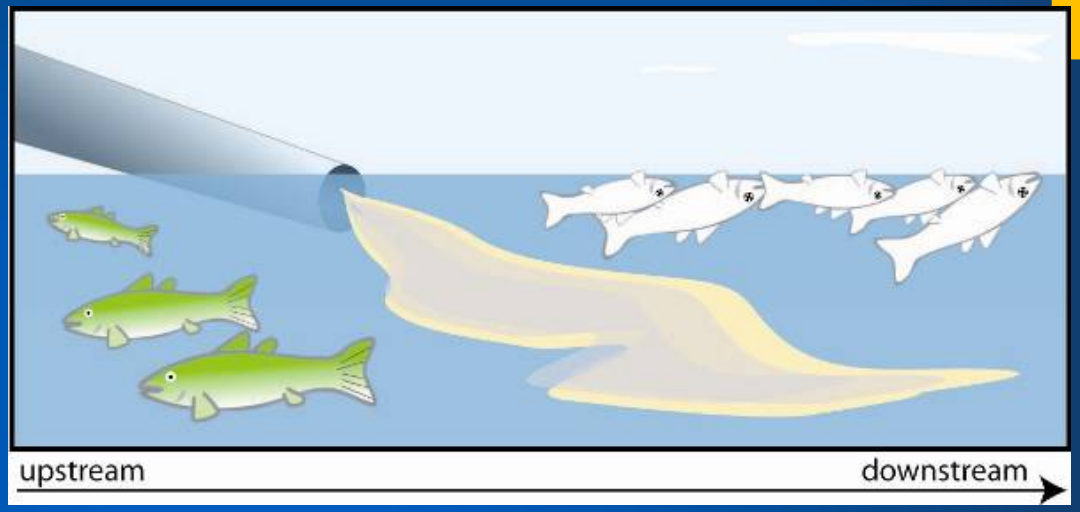
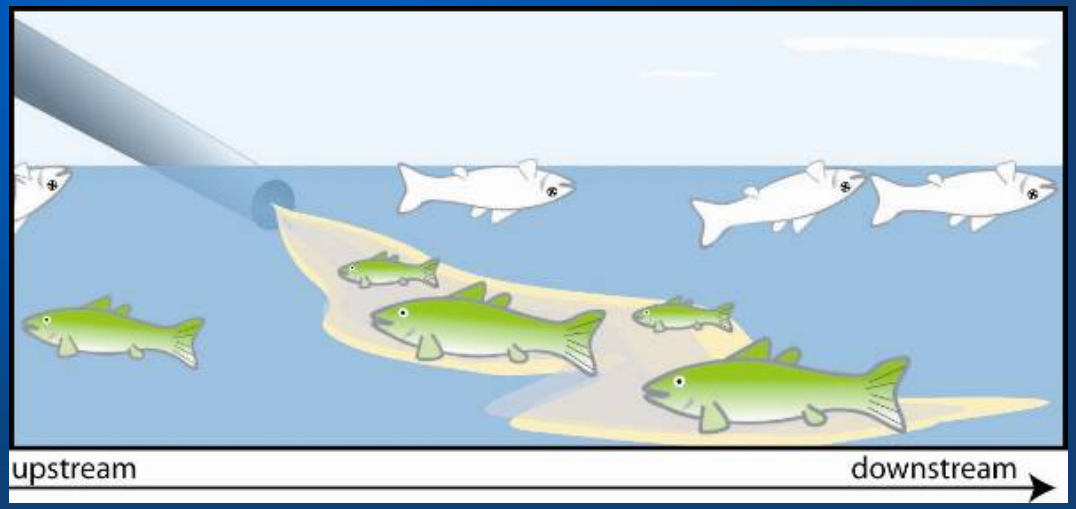
Spatial-Temporal Co-Occurrence

Concept

Is the stressor present at the test site and is the exposure greater than at the comparator site?

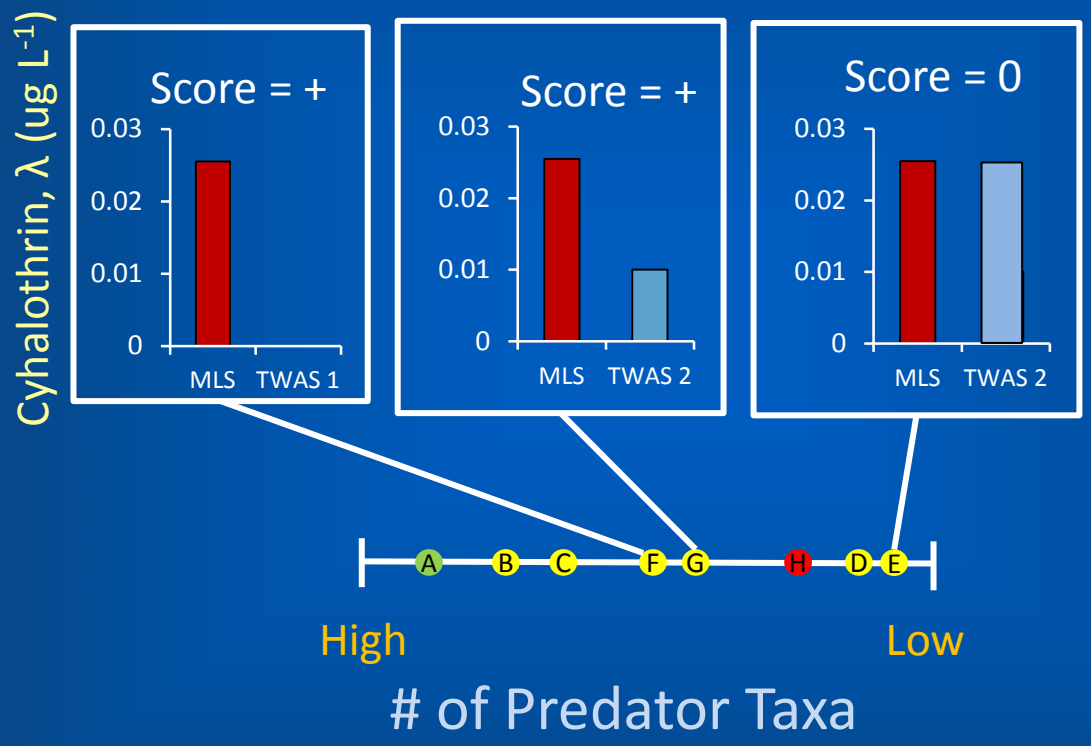




Spatial-Temporal Co-Occurrence

+	The effect occurs where or when the candidate cause occurs, OR the effect does not occur where or when the candidate cause does not occur.
0	It is uncertain whether the candidate cause and the effect co-occur.
- - -	The effect does not occur where or when the candidate cause occurs, OR the effect occurs where or when the candidate cause does not occur.
R	The effect does not occur where or when the candidate cause occurs, OR the effect occurs where or when the candidate cause does not occur, AND the evidence is indisputable.

Spatial-Temporal Co-Occurrence



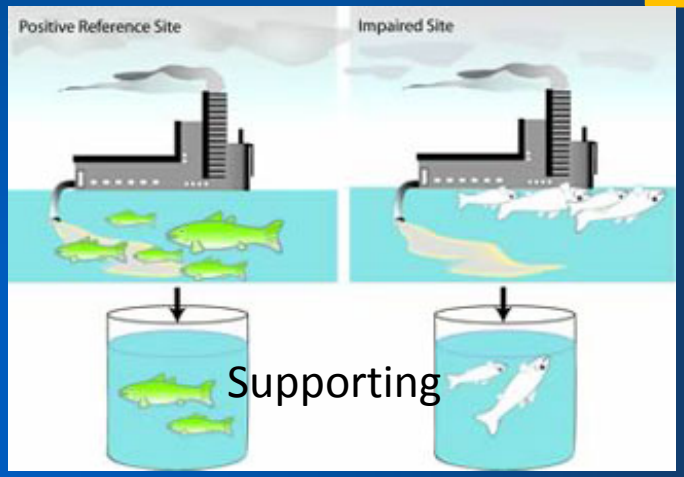
Comparator & test site condition

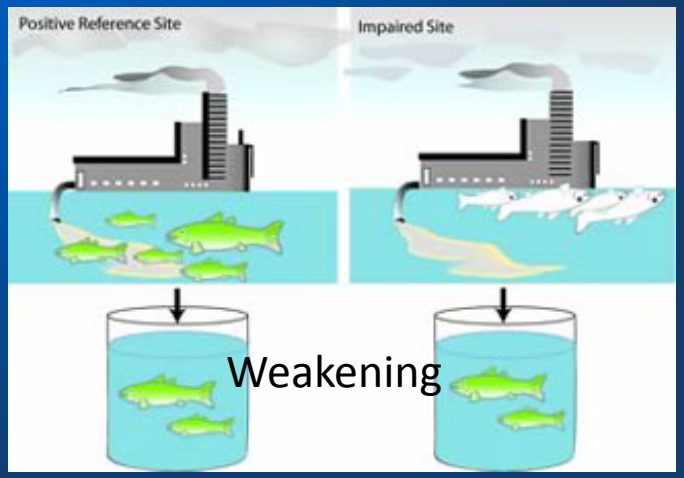
Candidate Cause	Proximate Stressor	Measurement	Components (units)	RD Value	RE Value	Difference	Component Score	Proximate Stressor Score
Heavy Metals								
	Increase in Dissolved Metals							---
		Mean of Previous Quarter (BDL = 1/2 MDL)						
			Antimony (µg L^{-1})	0.62667	0.52667	0.10	0	
			Arsenic (µg L^{-1})	0.81667	1.35667	-0.54	---	
			Barium (µg L-1)	41.7	47.5	-5.80	---	
			Beryllium (µg L^{-1})	0.125	0.125	0.00	---	
			Cadmium (µg L^{-1})	0.09	0.13	-0.04	---	
			Chromium (µg L^{-1})	0.23	0.7	-0.47	---	
			Copper (µg L^{-1})	3.42	3.72	-0.30	---	
			Hexavalent Chromium (mg L^{-1})	0.005	0.0015	0.00	---	
			Iron (mg L^{-1})	0.1	0.53	-0.43	---	
			Lead (µg L^{-1})	0.1	0.31	-0.21	---	
			Mercury (µg L^{-1})	0.02	0.02	0.00	---	
			Nickel (µg L^{-1})	6.86333	5.91667	0.95	0	
			Selenium (µg L^{-1})	1.32667	1.89667	-0.57	---	
			Silver (µg L^{-1})	0.125	0.01	0.12	---	
			Thallium (µg L^{-1})	0.125	0.125	0.00	---	
			Zinc (µg L^{-1})	27.9667	29.5333	-1.57	---	
	Increase in Particulate Bound Metals							NE
				No Data Available				
	Increase in Metals in Periphyton							NE
				No Data Available				
Elevated Conductivity								
	Increase in Conductivity							0
		Mean of Previous Quarter						
			Conductivity µmhos cm^{-1}	1207.33	1232.33	-25.00	---	
		Mean of Diel Measurements (24hr)						
			Conductivity µmhos cm^{-1}	1233.88	1161.52	72.36	+	
	Increase in Total Dissolved Solids							---
		Mean of Previous Quarter						
			TDS (mg L^{-1})	788	815	-27.00	---	
			Chloride (mg L^{-1})	128.5	116.5	12.00	+	
			Hardness (mg L^{-1})	350	380.667	-30.67	---	

Laboratory Tests of Site Media

Concept

Organisms exposed to test media brought back to the lab exhibit a similar response to the field





Laboratory Tests of Site Media

+++	Laboratory tests with site media show clear biological effects that are closely related to the observed impairment.
+	Laboratory tests with site media show ambiguous effects, OR clear effects that are not closely related to the observed impairment.
0	Laboratory tests with site media show uncertain effects.
-	Laboratory tests with site media show no toxic effects that can be related to the observed impairment.

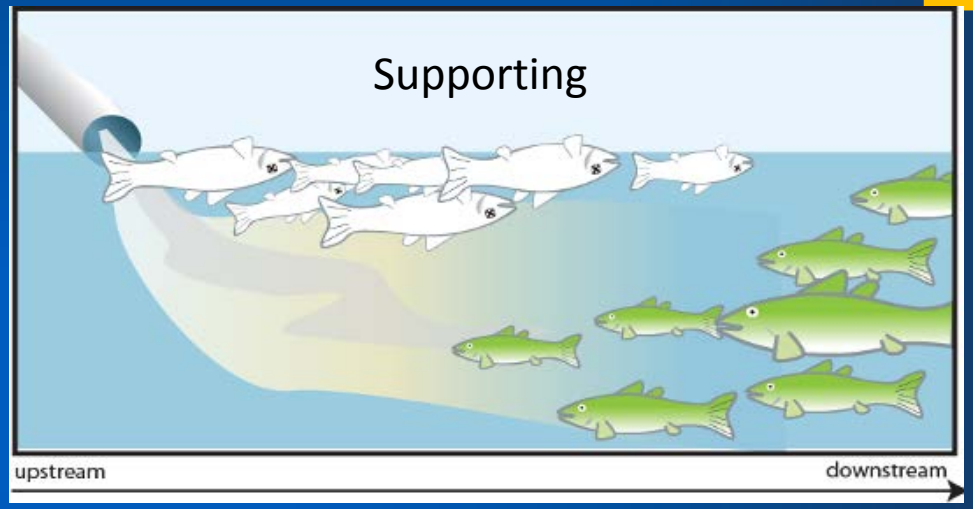
Laboratory Tests of Site Media

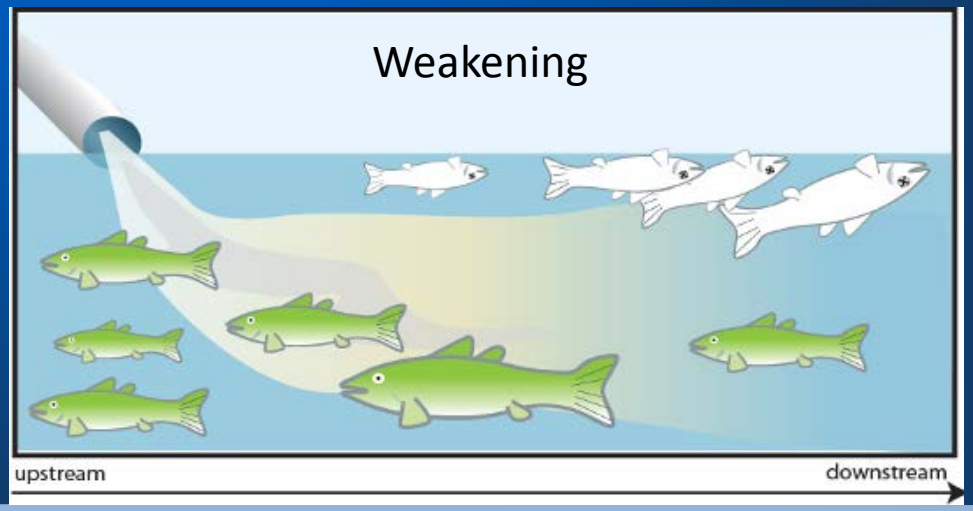
Site	Control Survival	Test Survival	Pyrethroid Score	Burial Score
A	9	10	-	0
B	10	3	+	0
C	8	8	-	0

Stressor Response From the Field

Concept

As exposure to the cause increases, intensity, or frequency of the biological effect increases; as exposure to the cause decreases, intensity, or frequency of the biological effect decreases.

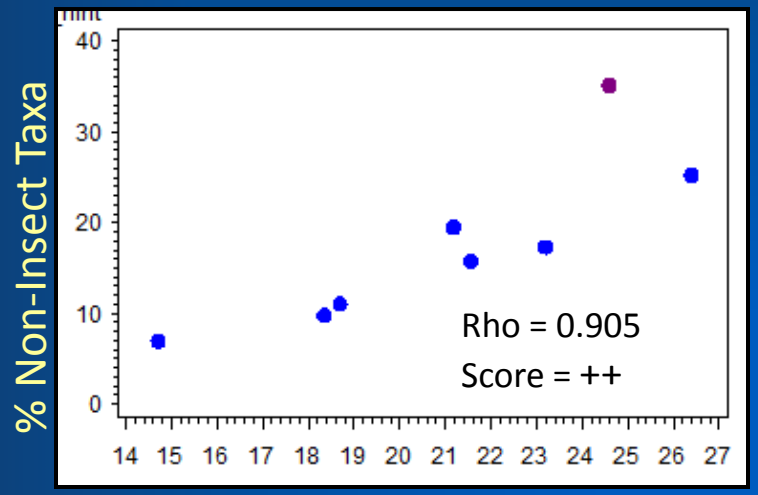


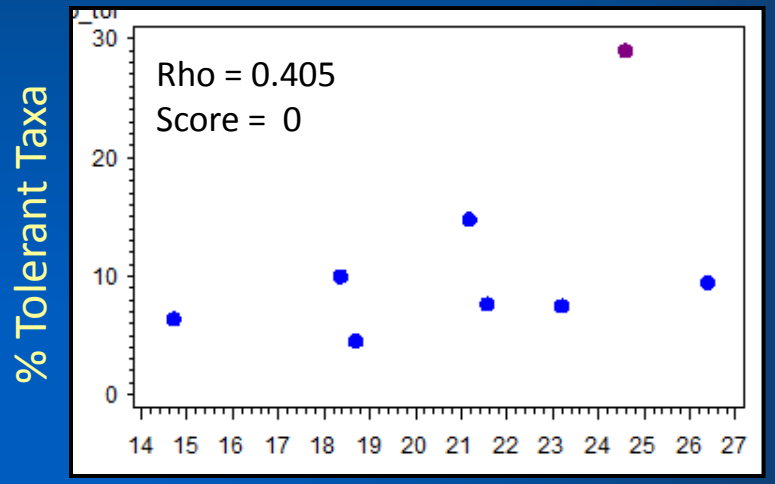


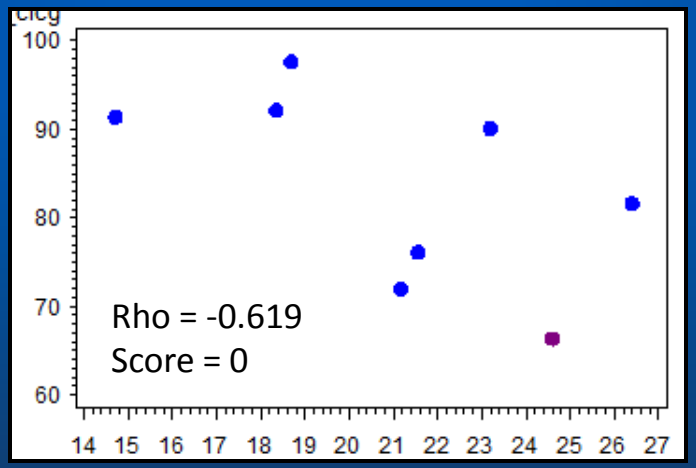
Stressor Response From the Field

++	The stressor-response relationship in the case agrees quantitatively with stressor-response relationships from other field studies.
+	The stressor-response relationship in the case agrees qualitatively with stressor-response relationships from other field studies.
0	Agreement between the stressor-response relationship in the case and stressor-response relationships from other field studies is ambiguous.
-	The stressor-response relationship in the case does not agree with stressor-response relationships from other field studies.
--	There are large quantitative differences or clear qualitative differences between the stressor-response relationship in the case and the stressor-response relationships from other field studies.

Stressor Response From the Field







TDS (mg L^{-1})

Candidate Cause	Proximate Stressor	Measurement	Components (units)	% Collector-Gatherer Abundance				% Non- Insect Taxa			
				Rho	Score	Proximate Stressor Score	comment	Rho	Score	Proximate Stressor Score	comment
Heavy Metals											
	Increase in Dissolved Metals					+	Support for Asenic and Selenium, but counter support for Barium, Cadmium, and Mercury			+	Support for Antimony, counter suport for Arsenic, Barium, Beryllium, and Mercury
		Mean of Previous Quarter (BDL = 1/2 MDL)									
			Antimony (µg L^{-1})	-0.800	-			0.800	+		
			Arsenic (µg L^{-1})	0.800	+			-0.800	-		
			Barium (µg L-1)	bdl	--			bdl	--		
			Beryllium (µg L^{-1})	bdl	--			bdl	--		
			Cadmium (µg L^{-1})	0.738	0			-0.738	0		
			Chromium (µg L^{-1})	0.738	0			-0.738	0		
			Copper (µg L^{-1})	-0.400	0			0.400	0		
			Hexavalent Chromium (mg L^{-1})	-0.258	0			0.258	0		
			Iron (mg L^{-1})	0.258	0			-0.258	0		
			Lead (µg L^{-1})	-0.400	0			0.400	0		
			Mercury (µg L^{-1})	bdl	--			bdl	--		
			Nickel (µg L^{-1})	0.400	0			-0.400	0		
			Selenium (µg L^{-1})	0.800	+			-0.800	-		
			Silver (µg L^{-1})	-0.258	0			0.258	0		
			Thallium (µg L^{-1})								
			Zinc (µg L^{-1})	-0.400	0			0.400	0		
	Increase in Particulate Bound Metals					NE				NE	
				No Data Available				No Data Available			
	Increase in Metals in Periphyton					NE				NE	
				No Data Available				No Data Available			
Elevated Conductivity											
	Increase in Conductivity					+				-	
		Mean of Previous Quarter									
			Conductivity µmhos cm^{-1}	0.800	+			-0.800	-		
		Mean of Diel Measurements (24hr)									
			Conductivity µmhos cm^{-1}	-0.762	-			0.548	0		
	Increase in Total Dissolved Solids					+				-	
		Mean of Previous Quarter									
			TDS (mg L^{-1})	0.800	+			-0.800	-		
			Chloride (mg L^{-1})	-0.800	-			0.800	+		
			Hardness (mg L^{-1})	0.800	+			-0.800	-		

Outside of the Case Evidence

- Evaluations that provide context to data from the test site
  - Reference comparison
  - Stressor-response from non-comparator sites
  - Stressor-response from laboratory
  - Modelled stressor-response patterns
  - Mechanistically plausible cause
  - Manipulation of exposure at other sites
  - Analogous stressors

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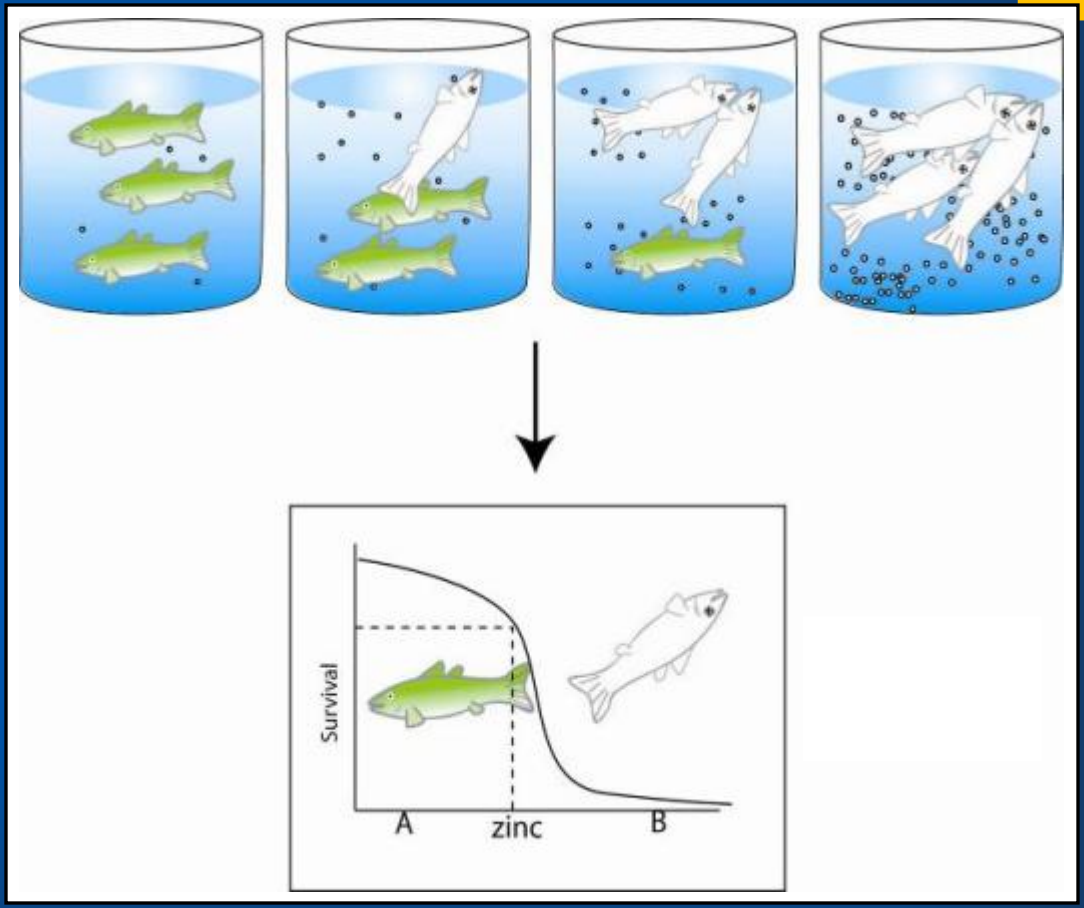
Stressor Response From the Lab

Concept

At the impaired sites, the cause must be at levels sufficient to cause related biological effects in laboratory studies.



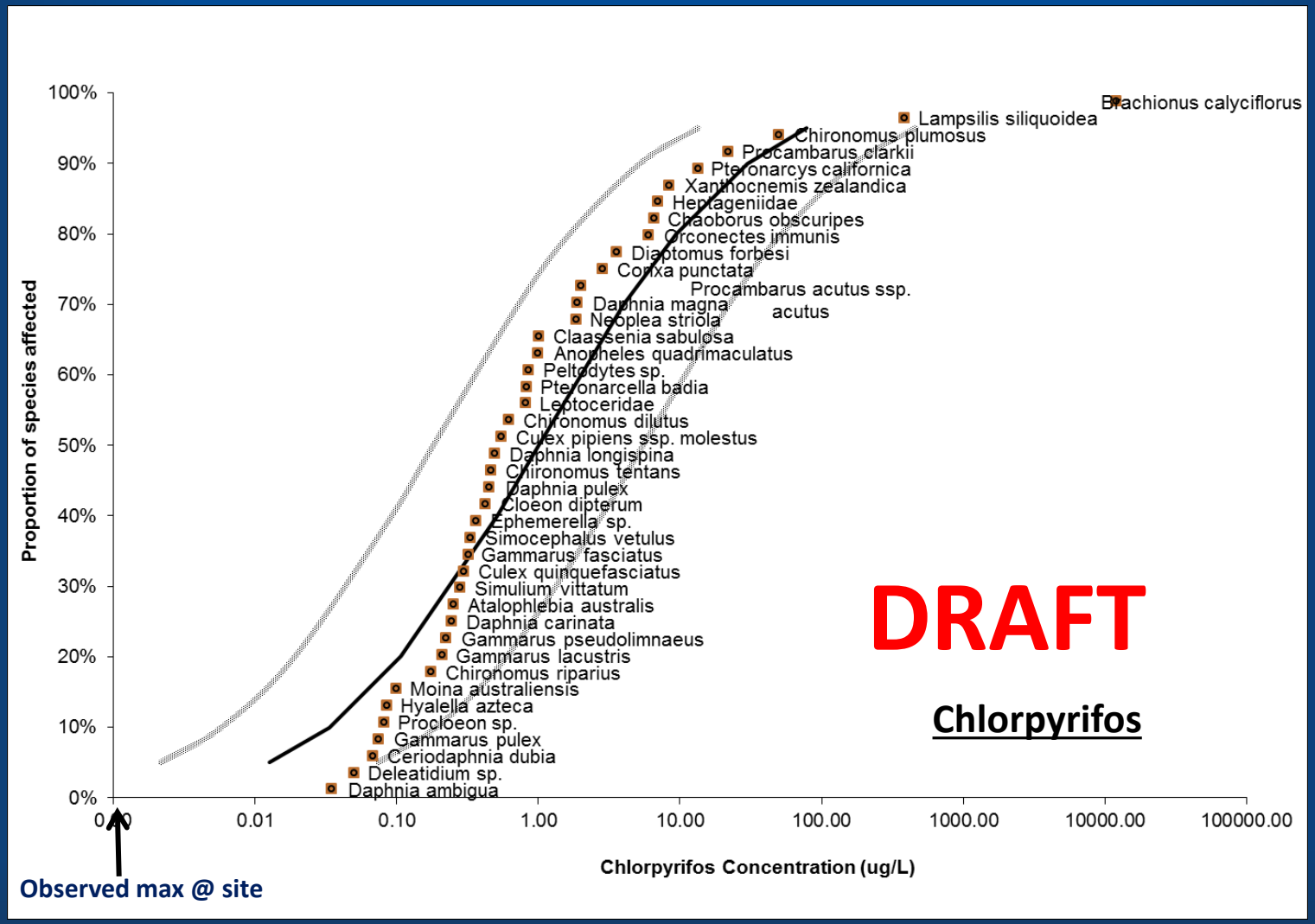
Stressor Response From the Lab

Finding	Interpretation	Score
The observed relationship between exposure and effects in the case agrees quantitatively with stressor-response relationships in controlled laboratory experiments.	This finding *strongly supports* the case for the candidate cause, but is not convincing because the correspondence could be coincidental due to confounding or differences in organisms or conditions between the case and the laboratory.	+ +
The observed relationship between exposure and effects in the case agrees qualitatively with stressor-response relationships in controlled laboratory experiments.	This finding *somewhat supports* the case for the candidate cause, but is not strongly supportive because the correspondence is only qualitative, and the degree of correspondence could be coincidental due to confounding or differences in organisms or conditions between the case and the laboratory.	+
The agreement between the observed relationship between exposure and effects in the case and stressor-response relationships in controlled laboratory experiments is ambiguous.	This finding *neither supports nor weakens* the case for the candidate cause.	0
The observed relationship between exposure and effects in the case does not agree with stressor-response relationships in controlled laboratory experiments.	This finding *somewhat weakens* the case for the candidate cause, but is not strongly weakening because there may be differences in organisms or conditions between the case and the laboratory.	-
The observed relationship between exposure and effects in the case does not even qualitatively agree with stressor-response relationships in controlled laboratory experiments, or the quantitative differences are very large.	This finding *strongly weakens* the case for the candidate cause, but is not convincing because there may be substantial and consistent differences in organisms or conditions between the case and the laboratory.	- -

Stressor Response From the Lab

- Established single-compound thresholds
  - Regulatory thresholds (e.g., California toxics rule)
  - Ecological thresholds (e.g., anoxia, hypoxia)
- Species-sensitivity distribution curves for single compounds
  - Aggregation of LC_{50} values for different taxa

Stressor Response From the Lab

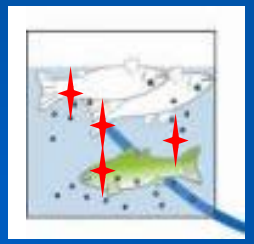


Reference Comparison

Concept

Stressor values that are no different than those observed at environmentally similar reference sites are probably not causing the observed impairment

Supporting



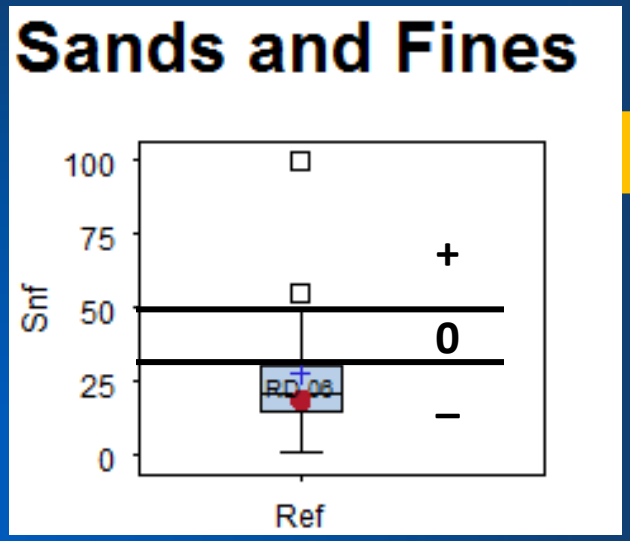
Weakening

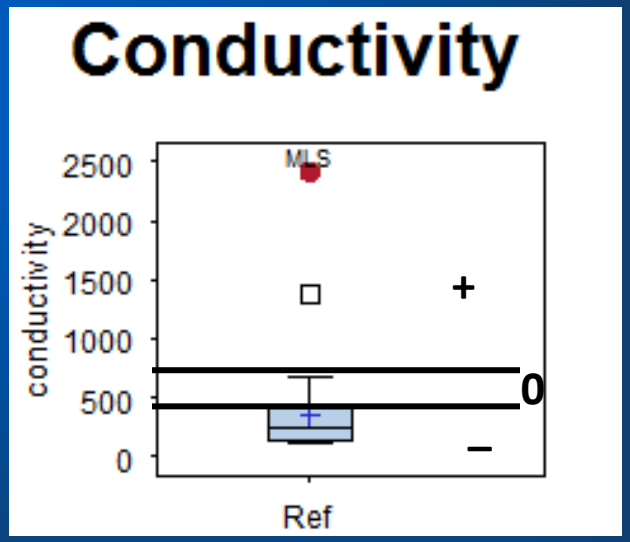
Reference Comparison

Finding	Interpretation	Score
The stressor value observed at the test site is similar (within 25th – 75th percentile) to the central distribution of values from environmentally similar reference sites where there is no biological impairment	Stressor levels are similar to that at reference sites, so therefore that stressor is likely not causing the biological impairment at the test site	-
The stressor value observed at the test site is outside of the central distribution of values (<25th or >75th percentile) from environmentally similar reference sites where there is no biological impairment	Stressor levels are not similar, but not distinctly different than at reference sites, so therefore it is unclear if that stressor is causing the biological impairment at the test site	0
The stressor value observed at the test site is distinctly different from environmentally similar reference sites where there is no biological impairment	Stressor levels are distinctly elevated or depressed than at environmentally similar reference sites, so that stressor *may* be causing the biological impairment at the test site	+

Reference Comparison

- Most relevant for "natural" stressors
  - Habitat, conductivity, nutrients, etc.
- Distinguish background from anthropogenic effects

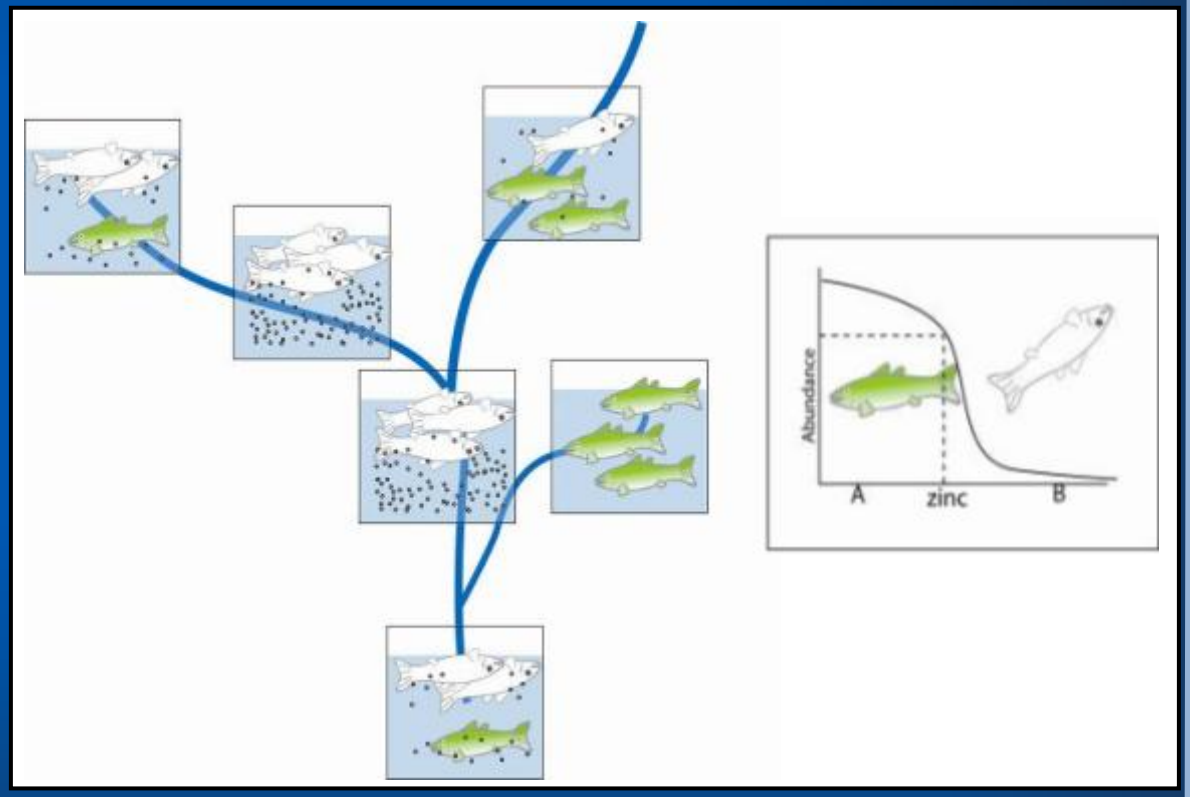




Stressor Response Non-Comparator Sites

Concept

At the impaired sites, the cause must be at levels sufficient to cause similar biological effects in other field studies.



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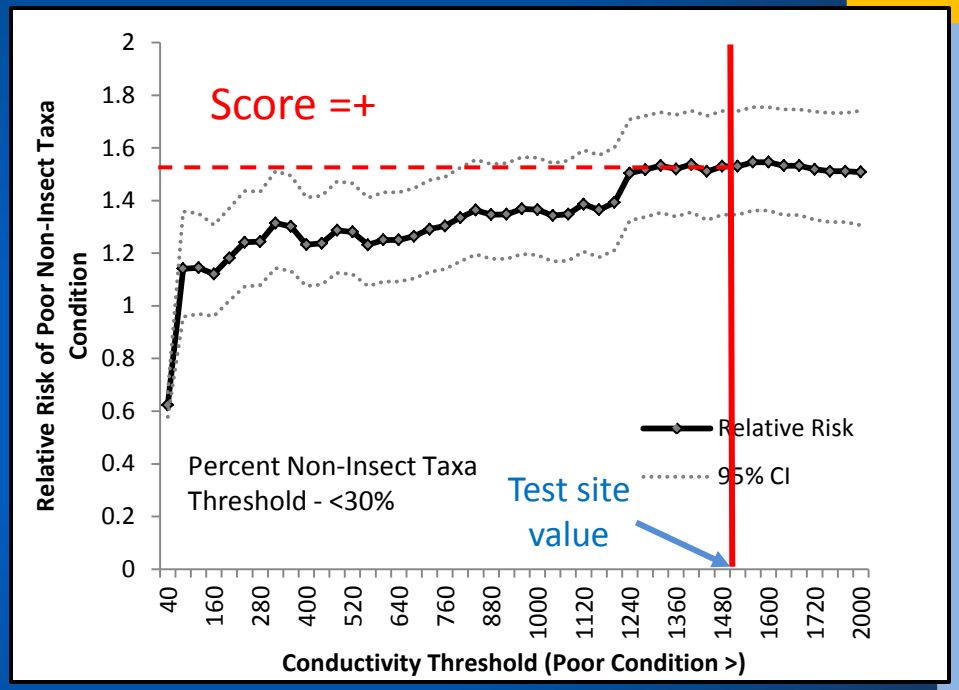
Stressor Response Non-Comparator Sites

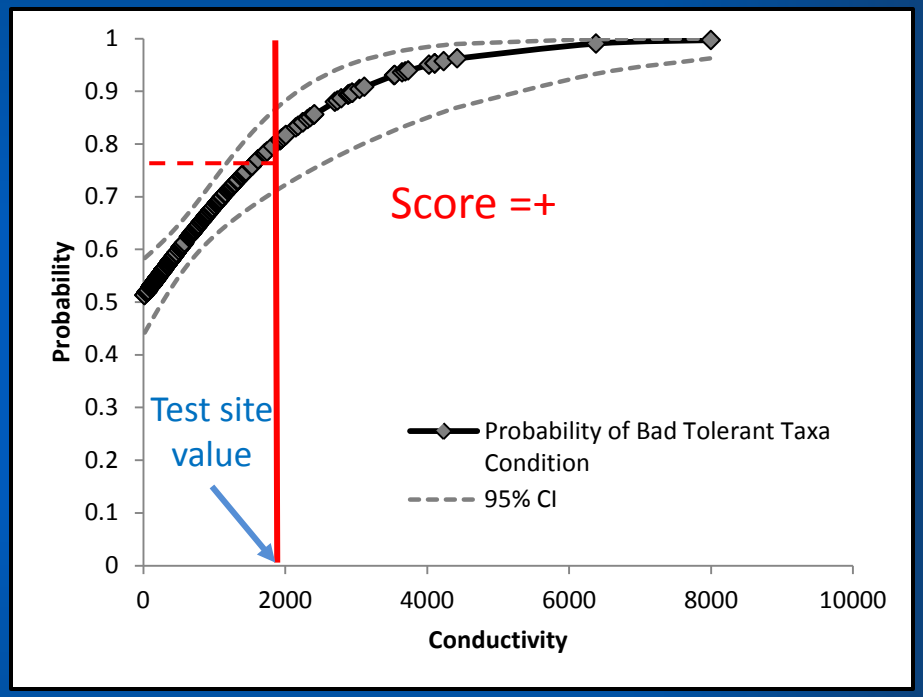
- Relative risk
  - Ratio of the probability of bad biology given bad conditions: probability bad biology given good conditions
  - 0-1 = no risk to biology
  - >1.2 risk to biology



	Good Condition	Bad Condition
Good Biology	152	203
Bad Biology	57	429

Stressor Response Non-Comparator Sites

- Logistic Regression
  - Biological condition and continuous stressors
  - Probability of finding bad biology along a gradient of condition



	Frequency	Stressors
Good Biology	355	$\beta_g x + \varepsilon_g$
Bad Biology	486	$\beta_b x + \varepsilon_b$

The Scoring Matrix

- Matrix of scores to keep track of the results from all analyses
  - Different levels of aggregation
    - Analytes, proximate stressors, or candidate causes
- Plusses and minuses are not additive
- Frequency is important
- Magnitude is also important
  - +++, ---, or R are persuasive

The Scoring Matrix

Garcia River

	Low DO	pH	Temp	Cond-uctivity	PHAB	Sediment (bed)	Flow	Increased Pesticides	Increased Nutrients	Increased Petroleum
Types of Evidence That Use Data From the Case										
Spatial/Temporal Co-Occurrence	+	0	0	+/--- overall: ---	+	---/+ overall: +	---	NE	NE	NE
Causal Pathway	0	-	0	-	+	+	+	0	0	0
Stressor Response From the Field	-	-	-	-	+ (weak!)	-	-	NE	NE	NE
Types of Evidence That Use Data From the Elsewhere										
Stressor Response From Other Field Studies	-	-	-	-	+ (weak!)	+	-	NE	NE	NE
Evaluating Multiple Types of Evidence										
Consistency of Evidence	-	-	-	-	+	+	-	0	0	0