Balancing Error When Assessing Attainment of Aquatic Life Use

by Roy Smogor, Illinois EPA

Surface Water Monitoring and Standards Meeting
Chicago, Illinois
March 18-20, 2008

Two Possible Errors When Assessing Aquatic Life Use

Conclude "Full" when water is actually impaired

1. False Security
   - ☹ underestimates environmental harm
   - ☹ no early warning= costly to restore
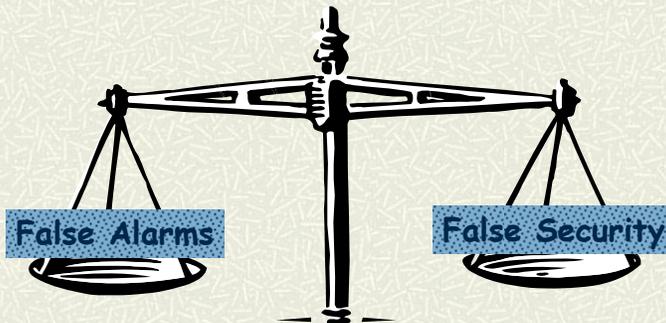   - ☹ possible irreparable damage

2. False Alarm
   - ☹ overestimates environmental harm
   - ☹ wastes effort to "restore"
   - ☹ wastes effort to "control"

Conclude "Non" when water is actually not impaired

Imperfect/Incomplete-Knowledge Balancing Act

False Alarms

False Security

Designing/managing to reduce one type of error results in more vulnerability to the other type.

Balancing Requires Understanding Diagnostic Limits of Biological & Chemical Indicators

Concluding "FULL SUPPORT" ALU	Concluding "NON-SUPPORT" ALU
BIOLOGY	

Concluding "FULL SUPPORT" ALU

BIOLOGY

Pro:
  + indicates biological condition directly
    → can alone show "Full" ALU
  + stays more constant through time

Con:
  − may miss some impacts: imperfect
  − may lack legal authority if not in WQ standards

CHEMISTRY

Pro: (convenient...?)

Con:
  − does not indicate biol. condition directly
    → cannot alone show "Full" ALU
  − lack of exceedance ≠ "Full" ALU
  − lacks constancy through time

Concluding "NON-SUPPORT" ALU

BIOLOGY

Pro:
  + can alone show "Non" attainment
  + stays more constant through time

Con:
  − may miss some impacts: imperfect
  − may lack legal authority if not in WQ standards

CHEMISTRY

Pro:
  + may reveal harm not indicated by biology → early warning
  + exceedances have legal authority

Con:
  − does not indicate biol. condition directly
    → every exceedance ≠ harm to ALU
  − WQ standards are simplistic
    → not consistently accurate

Balancing Requires Understanding Diagnostic Limits of Biological & Chemical Indicators

Concluding "FULL SUPPORT" ALU	Concluding "NON-SUPPORT" ALU

B I O L O G Y

Pro:
+ indicates biological condition directly
→ can alone show "Full" ALU
+ stays more constant through time

Con:
- may miss some impacts; imperfect
- may lack legal authority if not in WQ standards

C H E M I S T R Y

Pro:
+ may reveal harm not indicated by biology → early warning
+ exceedances have legal authority

Con:
- does not indicate biol.condition directly
→ every exceedance ≠ harm to ALU

- WQ standards are simplistic
→ not consistently accurate

Balancing Requires Understanding Diagnostic Limits of Biological & Chemical Indicators

Conclusions:

B I O L O G Y

👍 Direct & reliable, for both "Full" & "Non" ALU...

👎 ...but not perfect at either & may lack legal authority.

C H E M I S T R Y

👍 Has legal authority for indicating "Non" ALU & might reveal "Non" ALU in some instances...

👎 ...but not direct, thus cannot show "Full" ALU & overall less reliable, even for "Non" ALU.

Problems with Using Water Chemistry Independent of Biological Indicators to Indicate "Non-support" ALU

1. Biological indicators are not perfect...
   ≠ ...water chemistry completes picture.

-Imperfect biology does not improve chemistry's unreliability.

2. Chemical exceedance is a legal violation ...
   ≠ ...obliged to conclude "Non-support".

-Continued reliance on simplistic chemical WQ standards provides little incentive to make them more realistic.

3. Using water chemistry independently is precautionary.
   ≠ ...less chance of irreparable harm.

-Precaution has costs; real-world need to balance errors and burdens of proof...

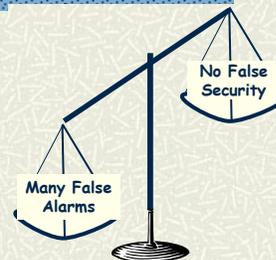**Balancing Error Helps Balance Burden of Proof**

Discharger: "Prove I'm causing harm; otherwise, let me discharge"

Prefers no false alarms

No False Security

Many False Alarms

Prefers no false security

Environ-mentalist: "Prove you are causing no harm; otherwise, do not discharge"

Balancing Act of Errors

False Alarms False Security
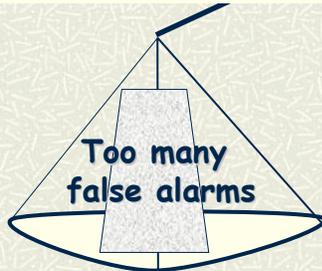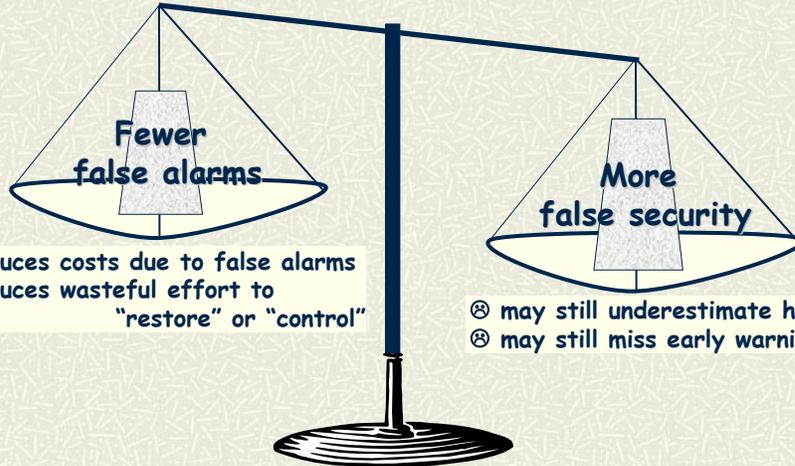

Using water chemistry—<u>regardless</u> of biology—to conclude ALU="Non support"

☹ overestimates environmental harm
☹ wastes effort to
          "restore" or "control"

Little
False Security

☺ enhances protection
☺ precautionary=early warning

Too many
false alarms

Using biology—<u>regardless</u> of water chemistry—to conclude ALU="Full"

Fewer false alarms

More false security

☺ reduces costs due to false alarms
☺ reduces wasteful effort to
　　　"restore" or "control"

☹ may still underestimate harm
☹ may still miss early warning

How Does Illinois EPA Assess Aquatic Life Use ?

Per-Site Data for Assessing Aquatic Life Use
(one sample per site, except for "Water Chemistry")

Data Type	Scenario 1 (fixed-station)	Scenario 2 (rotating basin)	Scenario 3 (point-source)	Scenario 4 (large stream)
Macroinvertebrate IBI	☑	☑	☐	☐
Fish IBI	☑	☑	☐	☐
Macroinvert. tolerance index	☑	☑	☑	☐
Water Chemistry	☑ (≈27 obs. per analyte, during 3 yrs.)	☑ (≈3 obs. per analyte, during 1 summer)	☑ (≈1 obs. per analyte, on 1 day)	☑ (≈27 obs. per analyte, during 3 yrs.)
Physical Habitat	☑	☑	☑	☐
Field observations	☑	☑	☑	☑

Data Type:	Bug IBI	Fish IBI	Bug/tolerance	Chemistry	Habitat	Field obs.
Scenario 1 or 2:	☑	☑	☑	☑ (~27 obs./analyte, 3 yrs; or ~3 obs./analyte, 1 summer)	☑	☑

	Fish IBI		
	Not impaired	Moderate impaired	Severe impaired
Not impaired			NON
Moderate impaired			
Severe impaired			NON

Bug IBI

Final Review
using site-specific knowledge &
all available biological, chemical,
& physical-habitat
information

Using biology, <u>supplemented by</u> water chemistry & habitat, to assess ALU (Full or Non)

Balanced
False Alarms

Balanced
False Security
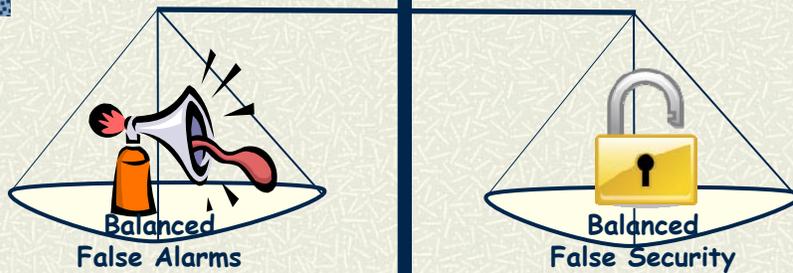
☺ Limits wasteful effort to "restore" or "control"...
...while remains vigilant of irreparable harm.

Some Related Stuff

Applegate, J.S. 2000. The precautionary preference: An American perspective on the precautionary principle. Human and Ecological Risk Assessment 6(3):413-443.

Field, S.A. et al. 2004. Minimizing the cost of environmental management decisions by optimizing statistical thresholds. Ecology Letters 7:669-675.

Krimsky, S. 2005. The weight of scientific evidence in policy and law. American Journal of Public Health 95(S1):S129-S136.

Parkhurst, D.F. 2001. Statistical significance tests: equivalence and reverse tests should reduce misinterpretation. BioScience 51:1051–1057.

Suter, G.W. II. 1996. Abuse of hypothesis testing statistics in ecological risk assessment. Human and Ecological Risk Assessment 2:331-347.

van den Belt, H. and B. Gremmen. 2002. Between precautionary principle and "sound science": distributing the burdens of proof. Journal of Agricultural and Environmental Ethics 15 (1):103-122.

The End!

"Respect my author-i-TEH !!"

E. Cartman

Data Type:	Bug IBI	Fish IBI	Bug tolerance	Chemistry (upstream vs. downstr. sites)	Habitat	Field obs.
Scenario 3: (point source)	☐	☐	☑	☑ (~1 obs./analyte per site 1 day)	☑	☑

Fish and Bug IBIs Unavailable

Bug Tolerance	Not organic polluted	
	Moderate organic polluted	NON
	Severe organic polluted	NON

Data Type:	Bug IBI	Fish IBI	Bug tolerance	Chemistry	Habitat	Field obs.
Scenario 4: (large stream)	☐	☐	☐	☑ (~ 27 obs./analyte, 3 yrs)	☑	☑

		Fish & Bug Data Unavailable	
C h e m i s t r y	No exceed-ances		
	Potential for moderate impairment	*NON*	
	Potential for severe impairment	*NON*	