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Putting the Science in Science-Based Policy:

AKA: “Never cut what you can untie; never nail what you can screw.”

A personal reflection on 33 years of bringing collaborators together to create science-based-policy for environmental results.

Mary Reiley
For
Hudson Delaware Chapter – SETAC - 2017
"Never cut what you can untie; never nail what you can screw."

(RW Reiley, 2011)
Policy
(Miriam-Webster 2011)

- **1a**: prudence or wisdom in the management of affairs  
  **b**: management or procedure based primarily on material interest.

- **2a**: a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions  
  **b**: a high-level overall plan embracing the general goals and acceptable procedures especially of a governmental body.
Science and technology policy is concerned with the allocation of resources for scientific research and technical development. It includes government encouragement of science and technology as the roots of strategy for industrial development and in economic growth; but it also includes the use of science in connection with problems of the public sector.

Science and technology are responsible for almost every advance in our modern quality of life. Yet science isn't just about laboratories, telescopes and particle accelerators. Public policy exerts a huge impact on how the scientific community conducts its work.
Science
(Miriam-Webster 2011)

- 3a: knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method

- 3b: such knowledge or such a system of knowledge concerned with the physical world and its phenomena: NATURAL SCIENCE
Science-based policy involves producing high-quality scientific evidence, building bridges between the producers and users of scientific evidence, and incorporating scientific evidence into health policy and practice.

A system or method reconciling practical ends with scientific laws.
**Problem ➔ Science Policy ➔ Science ➔ Science-Based Policy**

**Problem:**
Need a better/good team = Need quality water

**Science Policy:**
Spend your money on the best players = Spend your money to protect & restore the chemical, physical, and biological integrity of the nation’s waters

**No Science:**
Go with your gut – which players have “it”, “the whole package”
= “Fishable-Swimmable”, “Free from visible sheen”

**Science:**
watch the players play, collect the data, run the stats
= run tox tests, collect the data, run the stats for EC25

**Science-Based Policy:**
Pick the players that get on base the most = require water quality to be at or below the EC25
Perfection = Inaction

“We’re going to do it right this time” is ABSURD.
It’s Rarely a Straight Path

"In Our Dreams“ Approach

"Zig-Zag“ Approach
The Reality
Zig-Zag Examples

- Water Quality Based Effluent Limitations
- Metals
- Nutrient Pollution/Eutrophication
- Modeling
- Ecosystem Services
- “Wicked” Problems
- Next Gen Challenges
- Conclusion
Water Quality Science-Policy Change

Technology Based Limits

Water Quality Based Limits
Water Quality-Based Effluent Limitations: Going with Plan B to get to Plan A

Current State: BPT/BAT

Desired State: WQBEL

Tox Data

Enough Data?

Fow Data

7Q10

Models

Mixing Zones

Water Uses

Monitoring

Recovery

Protection

“New” TSD

Original TSD
Science-Policy to Science to Science-Based Policy

“No Toxics in Toxic Amounts”

Lots of Science: toxicology, chemistry, fate & transport, modeling, methods, etc.

Water Quality Approach: Water Quality Standards, WQBEL, TMDLs, New Technology, Incremental Improvement
25 Years of Science-based Metals Policy

Early 1980's
Total Recoverable Metals
Not optimal but stable, reproducible, implementable (USEPA 1985)

1985
Acid Soluble Metals
An acknowledged improvement (USEPA 1985)

1993
Dissolved Metal Concentration
Base metals criteria on bioavailable metal (USEPA, 1993)

1994
Water Effect Ratios
Filled the chemistry gap between lab and ambient water (Davies, 1994)

2007
Biotic Ligand Model
Accounts for the variety of water chemistry parameters that impact metals bioavailability (USEPA, 2007)
We’ve been talking about it forever!

1800’s in the US

1969 NAS Report

“. . the [nutrient]pollution problem is critical because of increased population, industrial growth, intensification of agriculture, river-basin development, recreation use of waters, and domestic and industrial exploitation of shore properties. Accelerated eutrophication causes changes in plant and animal live – changes that often interfere with use of water, detract from natural beauty, and reduce property values”

2014 Toledo, OH
## Nutrient Pollution & the Economy

**EPA Report**

<table>
<thead>
<tr>
<th>Category</th>
<th>Specific</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourism &amp; Recreation</td>
<td>Ohio lakeside restaurant sales, business closure, tourist spending</td>
<td>$37 million over 2 years</td>
</tr>
<tr>
<td>Commercial Fishing</td>
<td>Main coast shellfish bed closure</td>
<td>$2.5 million – softshell clams $460K – mussel</td>
</tr>
<tr>
<td>Property Values</td>
<td>New England</td>
<td>1 meter difference in water clarity = property value changes of $1 K– 60K</td>
</tr>
<tr>
<td>Drinking Water Treatment</td>
<td>Ohio</td>
<td>$13 million over 2 years</td>
</tr>
<tr>
<td>Mitigation</td>
<td>In-lake treatment of sediments</td>
<td>$11K to $28 million (+$1.4 million annual maintenance)</td>
</tr>
<tr>
<td>Restoration</td>
<td>Trading and offset program for Great Miami River Watershed</td>
<td>$2.4 million over 3 years</td>
</tr>
</tbody>
</table>
The “forever” challenge?
- 6,950 surface waters for nutrients
- 6,511 surface waters for organic enrichment/oxygen depletion
- Only pathogens (10,956) and metals/non-mercury (7,465) surpass nutrients as causes of water impairments in the US.

(2010 CWA Sec. 303(d) List)
Nitrogen Cascade

Regulatory authority or incentives

- Energy production
- Terrestrial production
- Human consumption

Air

- Ozone effects
- Particulate matter effects
- Greenhouse gas effects

Land

- Agroecosystem effects
- Grassland effects
- Coastal effects

Water

- Surface water effects
- Ocean effects
- Groundwater effects

EPA

USDA

EPA & USGS

EPA & NOAA

States

EPA

NOAA

Multiple
- Media
- Sources
- Scales
- Agencies

modified from Galloway et al. 2003 and Compton et al. 2011
Progress. But Still a Long Way to Go.

- Primary to Secondary (Tertiary) Treatment
- Phosphate removal from detergents
- Fertilizer application buffer zones
- Changes in fertilizer formulations to remove/reduce phosphorous
- State and municipality restrictions on fertilizer use
- Research and statistical analyses including:
  - reference conditions
  - biological assessments
  - concentrations of nitrogen and phosphorous protective to aquatic systems across the spectrum of types, sizes, and locations of waters
  - the associated indicators of eutrophication: chlorophyll a and clarity,
  - identify which waters need protection or restoration and to provide the targets to do so.
  - Innovative, cost effective technology
The Stretch-Goal in 1972

“Restore and maintain the chemical, physical, and biological integrity of the Nations’ waters”

A current “zag”: Watershed-based water quality, aquatic life, human health protection will be the result of not cutting what you can untie and not nailing what you can screw
All Together, Now!

Watershed-Based Water Quality Protection

- Watershed-based permitting
- Watershed mapping
- Metals, Organics as PBTs
- Biological Assmnt/Condition
- BPT & BAT Limits
- Human Health Risk Assmnt Methods
- IA - WoE
- Whole Effluent Toxicity Testing
- N & P Reduction
- CAFOs, Storm Water, CSOs, BMPs
- Watershed-based permitting
- Biosolids Risk Assmnt.
- Ecological Health Risk Assmnt Methods
- Reference Site Approach
- Water Quality-based Effluent Limits
- Cont. Sediment Risk Assmnt.

Watershed-Based Water Quality Protection
The Zig-Zag of Technology

Cheasapeake Bay model
Ecosystem Services

Global
Regional
Local

Human well-being and poverty reduction
- Material minimum for a good life
- Health
- Good social relations
- Security
- Freedom and choice

Indirect drivers of change
- Demographic
- Economic (e.g., globalisation, trade, market, and policy framework)
- Sociopolitical (e.g., governance, institutional, and legal framework)
- Science and technology
- Cultural and religious (e.g., choices about what and how much to consume)

Ecosystem services
- Provisioning (e.g., food, water)
- Regulating (e.g., climate, water, disease regulation)
- Cultural (e.g., spiritual, aesthetic)
- Supporting (e.g., primary production, soil formation)

Direct drivers of change
- Changes in local land use and land cover
- Species introductions or removals
- Technology adaptation and use
- External inputs (e.g., fertilizer use, pest control, irrigation)
- Harvest and resource consumption
- Climate change
- Natural physical and biological drivers (e.g., volcanoes, evolution uncontrolled by people)

Figure 1. An example of ecosystem connectivity, showing mangroves, seagrasses and coral reefs.
Ecological and physical connectivity between ecosystems is depicted for each ecosystem: terrestrial (brown arrows), mangroves (green arrows), seagrasses (blue arrows), and coral reefs (red arrows). Potential feedbacks across ecosystems from the impacts of different human activities on ecosystem services are also shown (yellow arrows). (Silvestri & Kershaw 2010).
A “Common Currency”

Apitz 2012 in IEAM

TRADITIONAL MARKET/SINGLE STRESSOR-BASED DECISION MAKING

- Resource use for immediate benefit (profit, lifestyle, sustenance)
- Consumptive use of resources
- Don’t account for the full cost of use
- Don’t account for the interconnectedness of habitat and biological processes and functions

ECOSYSTEM SERVICES “CURRENCY”-BASED DECISION MAKING

- Help quantify hidden, unanticipated, or ignored costs of a consumer-focused lifestyle
- Integrate effects from multiple stressors & biophysical interactions at ranges of spatial and temporal scales
- Insights into the true costs and benefits of management choices across industries, regulatory frameworks, habitats, and scales.
- It’s complicated
A Side-Bar: Why is it always about the people?

Why not quality ecosystems for ecosystems sake?

The Star-nosed mole – not exactly charismatic. . .

Lives in wet lowlands of North America

Eats small invertebrates, aquatic insects, worms, and mollusks

Weird & cute dot com
We are left with “Wicked” problems
Stahl and Cimorelle 2012, IEAM

TAME PROBLEMS

- Lend themselves to the strategy of defining, analyzing, and solving in sequential steps
- Mathematical problems, engineering designs, “elegant” experimental design

WICKED PROBLEMS

- Cannot be more clearly defined through simplification; more than the sum of its parts
- Reflect dynamic, interrelated systems in which social processes are an important component even if the problem has technical or scientific elements that might be considered Tame
The New Stretch-Goal is the Same Stretch-Goal: Chemical, Physical and Biological Integrity

- Making a systems approach to Watershed Protection doable?
- Using life-cycle assessment in decision making?
- How about having adequate quantities of quality water for human and ecological uses?
- How will changing demographics, changes in energy policies, changes in agricultural practices be evaluated and brought into the mix of sustainable aquatic ecosystems?
- Can we find a way to make the vast majority, if not all, nitrogen for human uses come from recycled/recovered nitrogen?
- Understanding the potential impact(s) of climate change, how to reduce them, how to adapt to them?
- How about moving up and down space and time scales so that we can have place-based and global-based environmental protection?
- What practices and approaches to improving our habitat will be most palatable to the public; get them to change behavior (full price costing, personal benefit, lifestyle preferences, future generations)?
A really tough “Wicked” problem: Changing people’s habits

- Short attention span
- Immediate need/desire vs long term potential consequences
- Force change through individual action – tipping points
Who do we need? Everybody.

<table>
<thead>
<tr>
<th>Biologist</th>
<th>Chemists</th>
<th>Toxicologists (HH &amp; Eco)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbiologists</td>
<td>Ecologists</td>
<td>Hydrologists</td>
</tr>
<tr>
<td>Geologists</td>
<td>Engineers</td>
<td>Economists</td>
</tr>
<tr>
<td>Social Scientists</td>
<td>Modelers</td>
<td>IT Specialists</td>
</tr>
<tr>
<td>Geneticists</td>
<td>Taxonomists</td>
<td>Mathematicians</td>
</tr>
<tr>
<td>Lawyers</td>
<td>Machinists</td>
<td>Programmers</td>
</tr>
<tr>
<td>Politicians</td>
<td>Fabricators</td>
<td>Educators</td>
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<tr>
<td></td>
<td></td>
<td>. . . Rocket Scientists</td>
</tr>
</tbody>
</table>
What do we need?

- Communication
- Collaboration
- Trust
- Passion
The “Outreach” Stretch-Goal

“Save the crabs... So we can eat them!”

(my favorite bumper-sticker promoting behavior change for Chesapeake Bay restoration and conservation)