Approaches for Disseminating Water Quality Information: Development and Use of Applied Water Quality Indices and Report Cards

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Abstract - A questionnaire was developed by the New Jersey Department of Environmental Protection with input from the National Water Quality Monitoring Council to gather available information on composite water quality indices and report cards used by governmental environmental agencies and other water quality practioners to disseminate results to various audiences. We received 17 completed questionnaires from state and federal agencies and academia from across North America. The goal of our survey was to better our understanding of the uses, strengths and limitations, development process, and the applicability of each method to convey water monitoring information in an integrated manner. Several participants in the survey utilized Water Quality Indices(WQI) in freshwater rivers and streams, estuarine, coastal embayments, and Laurentian Great Lakes. The most popular parameters used in a WQI are dissolved oxygen, pH, chlorophyll *a*, total nitrogen and total phosphorus. Contrary to WQI, Water Quality Report Cards were also utilized by participants as an approach to assess the condition of freshwater streams, rivers and lakes. The Water Quality Report Card (WQRC) concept was originally developed by Warren Kimball, formerly of the Massachusetts DEP, and is becoming a popular model used by a number of water resource agencies. The WQRC uses 10 indicators pertaining to aquatic life, recreation, and fish edibility that are color coded to provide an assessment of a waterbody based on standardized 305(b) reporting procedures. Regardless of the approach, both Water Quality Indices and Water Quality Report Cards appear to be useful tools to provide an overall evaluation of a water resource and present the data in a manner that is quickly and easily understood by multiple audiences.

Water Quality Indices

Generally, a single value (score) used to summarize water quality and resource condition for a particular time and location. Indices are typically composed of several parameters (4-12) of importance to water quality and are then aggregated and calculated into an overall score. Indices reported include measures of water column chemistry, sediment, biology and habitat.

Example of a composite water column WQI for Oregon rivers

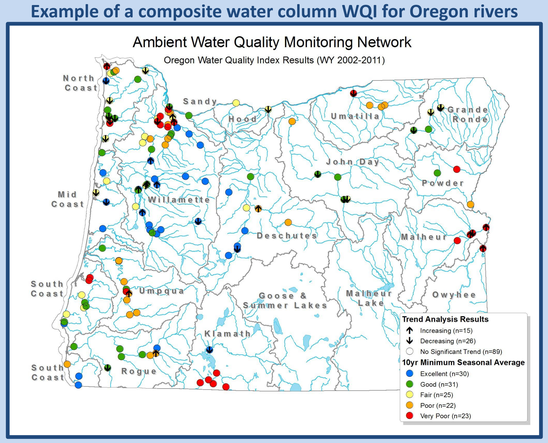

Figure 1. Example of spatial display of Oregon's WQI and trends results. Source: Merrick, L. and S. Hubler, 2013. Oregon Water Quality Index Summary Report, Water Years 2002-2011 and 2003-2012.

Applications and objectives of WQI

Frequently used to communicate water quality conditions to the public, stakeholders, local officials, water resource managers and also to track progress of management practices and strategic goals. Most WQI's are not used for an regulatory purposes in part because many parameters often have no water quality standards.

Table 1. Participants of questionnaire that use a "Water Quality Index." Note: Biological mutimetric indices that do not integrate additional water quality parameters were not included here.

Organization	Water Resource	Media	Contact
Iowa Department of Natural Resources	Rivers and streams	Water column	Mary Skopec
Kentucky Department of Environmental Protection	Rivers and streams	Water column, sediment	Katie McKone
McMaster University	Great Lakes coastal marshes	Water column	Patricia -Chow Fraser
Oregon Department of Environmental Quality	Rivers (4th and 5th order)	Water column	Lesley Merrick
South Carolina Estuarine and Coastal Assessment Program (SCECAP)	Coastal tidal rivers and bays	Water column, sediment, biology	David Chesnut
University of Maryland Center for Environmental Sciences-Integration and Application Network	Estuaries,coastal bays	Water column, biology	Heath Kelsey
USEPA (National Coastal Condition Assessment)	Estuaries	Water column, sediment, biology, habitat, fish tissue	Sarah Lehmann
Vermont Department of Environmental Conservation	Lakes	Water column, biology, habitat	Neil Kamman
USGS National Water-Quality Assessment (NAWQA) Program (Pesticides only)	Rivers and streams	Water column	Karen Beaulieu

Parameters generally used in WQI

Chemical/Physical (water column)

- The most common parameters shared among water quality indices are dissolved oxygen, pH, chlorophyll *a*, total nitrogen and total phosphorus
- Additional parameters such as temperature, fecal coliform, total solids, biochemical oxygen demand, ammonia + nitrate nitrogen, specific conductivity and pesticides are often used

Biological

- A few WQI's incorporate a biological component into the overall composite WQI
- A benthic macroinvertebrate index is most commonly used when biological assessments are incorporated into a WQI

Sediment

- Parameters used in WQI's include contaminants, toxicity, total organic carbon, TSS, turbidity, embeddedness

Development Process and Calculation of WQI

- Many are developed by agency scientists with input from a panel of experts, and peer reviewed internally or published in a peer reviewed journal.
- Methods for aggregating subindices/parameters into an overall cumulative index calculation include weighted means, unweighted harmonic square means, and averaging ranked subindices into an overall score
- When standards exist, they are generally applied
- When no standards exist, published findings, best professional judgment, or thresholds derived from percentiles of historical data are commonly used to set breakpoints among rating categories (e.g. good, fair , poor)

Example of a composite index integrating three indices into an overall Habitat Index for the South Carolina Estuarine and Coastal Assessment Program

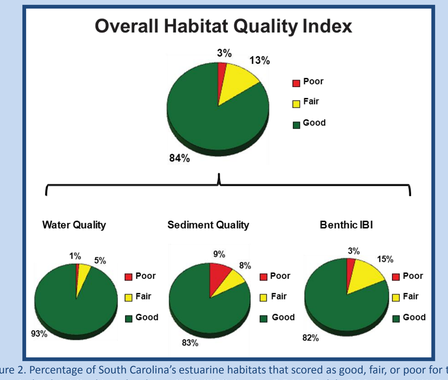

Figure 2. Percentage of South Carolina's estuarine habitats that scored as good, fair, or poor for the integrated Habitat Quality Index during 2009-2010. Source: R.F. Van Dolah, D.M. Sanger, G.H.M. Riekerk, S.E. Crowe, M.V. Levisen, D.C. Bergquist, D.E. Chestnut, W. McDermott, M.H. Fulton, E. Wirth. 2013. The Condition of South Carolina's Estuarine and Coastal Habitats During 2009-2010: Technical Report. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 107. 64 p.

Limitations

- May not align with state's 305(b)/303(d) Integrated Report assessments
- Generally not used for regulatory purposes
- May do not include toxics, habitat, fish tissue or biological indices
- Single parameters of importance may lose significance in composite index

Strengths

- Summarizes large amounts of data for a variety of audiences
- May include information for parameters for which there are no regulatory standards
- Enables spatial display of ratings
- Enables trends analysis of WQI score
- Generally understood by public, however calculation of index may be confusing

Water Quality Report Cards

The WQRC's described here, use ten indicators pertaining to aquatic life, recreation, and fish edibility uses that are color coded to provide an assessment of a waterbody based on the standardized 305(b) reporting procedures. The ten indicators are biology, chemistry, nutrients, toxics, sediments, flow, habitat, bacteria, aesthesis, and fish tissue.

Applications and Objectives of WQRC

These are used to communicate water quality conditions to public, stakeholders, local officials and water resource managers. The WQRC condenses the 305(b) assessment into a one page summary of a water resource. It can be used to assess the effectiveness of management practices, guide decision makers, identify monitoring needs and coordinate monitoring programs.

Development

The WQRC concept was originally developed by Warren Kimball of the Massachusetts DEP

- Uses ten indicators pertaining to aquatic life, recreation, and fish edibility that are color coded to provide an assessment of a waterbody based on the standardized 305(b) reporting procedures
- Each individual state's water quality standards and criteria are used to determine condition rating

Table 2. Participants of questionnaire that use a "Water Quality Report Card."

Organization	Water Resource	Media	Contact
California State Water Resources Control Board	Rivers and streams	Water column, sediment, biology, habitat	Lilian Busse
Massachusetts Department of Environmental Protection	Rivers and streams	Water column, sediment, biology, habitat	Warren Kimball

Millers River — WATER QUALITY REPORT CARD — *2000 Assessment*

COLOR KEY: GOOD, CONCERN, FAIR, POOR, N/A

	AQUATIC LIFE							RECREATION		FISH EDIBILITY
SEGMENT	BIOLOGY	CHEMISTRY	NUTRIENTS	TOXICS	SEDIMENTS	FLOW	HABITAT	BACTERIA	AESTHETICS	FISH TISSUE
MILLERS RIVER										
to Whitney pond	F					Q				Hg
to Winchendon WWTF		pH		U		Q		B	C	Hg,PCB
to Otter River		pH	P	U		Q				Hg, PCB
to South Royalston			P		PCB					Hg,PCB
to Orange Center	A,F	pH	P		PCB	Q				Hg, PCB
to Erving WWTF	A,F	pH	P		PCB	Q				Hg, PCB
to Connecticut River		pH	P	U	PCB	Q			C	Hg, PCB
OTTER RIVER										
to Gardner WWTF	I,F	DO,pH,T	P						C	Hg, PCB
to Seaman Paper Co.	I,F	DO,pH T	P	U	Me	Q	S		C,D	Hg, PCB
to Millers River	I,F	pH	P		PCB	Q			O,C,D	Hg, PCB
TULLY RIVER										
East Branch	F	pH					S		G	Hg, PCB
Boyce Brook		pH								Hg, PCB
West Branch										Hg, PCB
Lawrence Brook		pH								Hg,PCB
Main Stem	F									Hg, PCB

Figure 3. Example of Massachusetts Department of Environmental Protection's Water Quality Report Card for a watershed illustrating use of colors to assess water quality for each indicator and causes of impairment. Source: Kimball, W. (2012, Sept. 12). Water Quality Report Cards- Assessments made accessible, the Massachusetts experience [Webinar]. http://acwi.gov/monitoring/webinars/index.html. Webinar to the National Water Quality Monitoring Council.

Limitations

- No overall rating category (e.g. good, fair, poor) of waterbody or segment
- Lack of spatial display of rating
- Limited trends analyses

Strengths

- Summarizes large amounts of water quality data
- Complements 305(b)/303(d) Integrated Report
- Identifies monitoring gaps (gray areas in Figure 3)
- Includes toxics, habitat, fish tissue and biological assessments
- Identifies reasons for impairment (e.g. Hg, PCB)
- Generally understood by public

Conclusions and Next Steps

- Both WQI and WQRC approaches seek to provide a integrated evaluation of the condition of the water resources they are assessing
- Many participants felt that the public, stakeholders and policy makers are more likely to get involved to help improve water quality if clear summaries of water resource conditions are made available through WQI's
- Participants expressed that these approaches can be great tools to educate the public about water quality and promote volunteers and watershed groups to protect and restore water quality
- A report will be prepared summarizing all questionnaires received and will be made available on the National Water Quality Monitoring Council 's website

**Thank you to all of the participants that completed the questionnaire. A copy of the WQI questionnaire and a complete list of participants is located in the folder attached to this poster.
***Only questionnaires that were representative of these two approaches (WQI and WQRC) were displayed here. Biological indices alone were not included in this poster.