Alignment of Ocean Tipping Points Science with the Water Quality-Based Approach to Pollution Control under the Clean Water Act

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Purpose Statement

This document briefly summarizes key statutory and regulatory requirements for managing water quality and identifies points in the regulatory process where tipping points science may be most useful to managers and improving existing practice. The "Summary for Managers" describes these high level insertion points for tipping points science. A more comprehensive analysis of the Clean Water Act's water quality-based approach to pollution control (i.e., water quality criteria and total maximum daily loads) follows.

This document is designed for use primarily by water quality managers and agency scientists interested in using tipping points science in their work. However, we have attempted to make this document accessible to a broader audience by including background information on the statutory and regulatory requirements of the Clean Water Act.

This document regularly refers to tipping points scientific strategies, which are not explained in detail in this document. For information on these strategies, please refer to the Ocean Tipping Points Guide.

Summary for Managers

The Ocean Tipping Points strategies are designed to facilitate the establishment of regulatory limits that are directly linked to ecological thresholds, and complementary management actions. Thus, they can help identify ecological thresholds of concern under the Clean Water Act, explore social preferences and acceptable levels of risk, and designate regulatory limits and management approaches to meet those limits. Ocean Tipping Points strategies can also expand the integration of social and cultural concerns and impacts into management decisions. While the essential considerations outlined in this project are not new to water quality management, the systematic process and guidance for identifying and managing ecological thresholds of concern provided by the Ocean Tipping Points Guide can improve the use of ecological thresholds in water quality management decisions.

The Ocean Tipping Points project team has identified that tipping points science is well-suited to assist water quality managers to:

- Incorporate ecosystem thresholds in water quality criteria – The tipping points strategy for characterizing tipping points and their drivers can assist managers in crafting water quality criteria that are directly linked to ecological thresholds.
- Identify appropriate indicators and indicator targets – The tipping points strategy for identifying early warning indicators can assist managers in identifying and monitoring parameters that will indicate the approach of an ecological threshold.
- Incorporate social and cultural concerns and risk tolerance into water quality decisions – The tipping points strategy for characterizing social preferences and risk tolerance can assist managers in making decisions that are broadly aligned with public opinion and priorities.
- Create conceptual models of ecosystems that include drivers and responses – The tipping points strategy for characterizing drivers and responses in an ecosystem can assist managers in creating conceptual models of their ecosystem to evaluate different monitoring and management strategies.

- Facilitate translation of load allocations to concrete management actions for non-point sources – The tipping points strategy for setting targets and limits based on social and ecological thresholds, risk tolerance, and social preferences can assist managers in setting appropriate waste-load and load allocations. The tipping points strategy for developing future management scenarios and evaluating different approaches can assist managers in allocating pollutant budgets to various actors and developing management strategies likely to achieve those budgets.

While the science and application of tipping points are still evolving, a growing number of examples reveal successful application of tipping points science in action. For real-world examples, see our case study write-ups:

- Seagrasses in Florida Bay
- Ocean acidification and Oyster in the U.S. Pacific Northwest
- Submerged Aquatic Vegetation in Chesapeake Bay

For more detail, continue to the full analysis on page 4.

Introduction

The primary controls on pollutants in the Clean Water Act (CWA) are technology based effluent limitations that require the use of the best technology available for controlling pollutants from point sources (i.e., pipe, drainage ditch, any other discrete conveyance of pollutants).[1] However, the CWA also includes a regulatory "safety net," that emphasizes the overall quality of water within a water body and requires the use of water quality based controls when technology based controls are insufficient to ensure publicly valued uses of waterbodies. This safety net includes the designation of water quality standards and, in some cases, total maximum daily loads. The following text and table explore the applicability of Ocean Tipping Points strategies (*See Table 1*) to the development and implementation of water quality standards and total maximum daily loads.

Table 1: Ocean Tipping Point Strategies
Characterize tipping points in your system a. Define tipping points of concern b. Link ecosystem change to key drivers
Define management objectives in relation to ecosystem state a. Characterize social preferences for ecosystem states b. Analyze risk of crossing a tipping point and characterize people's risk tolerance to changes that could result
Set targets and design monitoring a. Identify early warning indicators that signal approach of a tipping point b. Use social preferences, risk tolerance and social and ecological thresholds to inform target-setting
Evaluate management scenarios and select a course of action a. Develop potential future management scenarios and choose appropriate decision support tools to evaluate them

Water Quality-Based Approach to Pollution Control

The CWA requires the designation of water quality standards (WQSs) for every waterbody. WQSs comprise a designation of uses of that water body (e.g., swimming, fishing, boating) and the water quality criteria that are necessary to meet those uses. Due to technological limitations of controlling point source pollution and the prevalence of non-point source pollution in certain areas, technology based effluent limitations on point sources have failed to ensure that WQSs are met in many waterbodies. Section 303(d) of the CWA requires the designation of these waters as impaired and the development of Total Maximum Daily Loads (TMDLs) for criteria pollutants in the impaired waterbody. TMDLs and their associated implementation plans have emerged as the only effective means to meet water quality standards in many waters of the United States. Implementation of TMDLs occurs within the larger context of the CWA's management program, frequently leading to comprehensive plans to reduce pollutants from non-point sources and/or revised permits for point sources with stricter effluent limitations to reduce the total pollutant load entering the relevant water body to acceptable levels. Because it is easier and less costly in

[1] 33 U.S.C. § 1313.

the long term to prevent impairments rather than retrofit controls to clean up pollution problems, the CWA also encourages States to identify TMDLs for waters that are meeting water quality standards.[2]

Establish water quality standards

The CWA requires that States designate water quality standards for every waterbody, in consultation with the public.[3] First, the states must establish designated uses for each waterbody.[4] The designation process must consider the use and value of each waterbody "for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes including navigation."[5] Second, states must adopt criteria that specify maximum ambient levels of pollutants that ensure the waters can be used for their designated purposes.[6] These water quality criteria are generally numerical values or narrative standards based on EPA guidance[7] and must be based on sound scientific rationale.

- The designated uses of water quality standards should be based on the **social preferences** for the human use of the water body.
- When establishing water quality criteria, **tipping points of concern** should be identified and **their drivers characterized** to determine the point at which a pollutant compromises a designated use.
- The water quality criteria should coincide with **targets and limits based on known ecological thresholds and the social preference** represented by the designated use.

For a real-world example of managers using a tipping points perspective to establish water quality standards based on ecological tipping points of concern and social preferences, see our case study write-up of Seagrasses in Florida Bay

Monitor water quality

The CWA calls for States to establish appropriate monitoring methods and procedures necessary to compile and analyze water quality data.[8] The data collected is used to support a range of CWA decision needs. Based on established monitoring methods and procedures, the State collects data on a variety of water quality parameters. Monitoring strategies should include objectives and indicators.[9] Based on the data collected, states must identify water quality trends over time and assess whether waters meet designated standards.[10]

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[2] 33 U.S.C. § 1313(d)(3).
[3] 33 U.S.C. § 1313(c).
[4] 40 C.F.R. §§ 131.6(a) & 131.10.
[5] 40 C.F.R. § 131.10. *See also* Environmental Protection Agency, Water Quality Standards Handbook ch 2, pg 1–6 (1994) *available at* http://www2.epa.gov/wqs-tech/water-quality-standards-handbook-chapters.
[6] 40 C.F.R. §§ 131.6(c) & 131.11.
[7] EPA has released several guidance documents that recommend water quality criteria for hundreds of pollutants. These documents include the "Green Book" (FWPCA, 1968), the "Red Book" (USEPA, 1976), the "Blue Book" (NAS/NAE, 1973), and the "Gold Book" (USEPA, 1986a), which is updated from time to time.
[8] 33 U.S.C. § 1256(e). 40 C.F.R. § 130.4.
[9] EPA Guidance at 3–4.
[10] EPA Guidance at 4.

- **Early warning indicators** can strengthen monitoring by providing a parameter that is known to show predictable changes in advance of an event.
- Based on monitoring results, **analyze the risk of crossing the water quality criteria threshold**.

For a real world example of managers using a tipping points perspective to monitor water quality and establish early warning indicators of detrimental water quality conditions, see our case study write-up of ocean acidification and Oyster in the U.S. Pacific Northwest

Identify and rank impaired waterbodies

The CWA requires states to create a list of "impaired waters" that are too polluted or otherwise degraded to meet the water quality standards.[11] Priority ranking should be given based on the severity of the pollution and the importance of designated uses. States are required to identify any waterbodies that do not meet applicable water quality standards.[12] All impaired waterbodies must be included in a list that provides a comprehensive inventory of waterbodies impaired by all sources, including point sources, nonpoint sources, or a combination of both. For those waterbodies identified as impaired, the state must establish priority rankings.[13] Priority rankings ensure the most efficient use of limited resources by focusing state efforts on the most threatened waterbodies.[14]

- Based on monitoring results, **analyze the risk of crossing the water quality criteria threshold** for each waterbody.

Develop Total Maximum Daily Load (TMDL)

The CWA requires that states establish TMDLs for the waterbodies listed during step 3.[15] TMDLs provide the analytical framework to develop watershed-based solutions for impaired waters. The state must calculate pollutant budgets—the maximum amount of a pollutant that a waterbody can receive while still meeting its applicable water quality standards—for the impaired waterbodies.[16] Once the pollutant budget is calculated, the state must allocate pollutant shares among point and nonpoint sources. The state must identify all sources of a pollutant in a waterbody and allocate a portion of the total pollutant budget to each source. This may be challenging when multiple sources are present—potentially including nonpoint sources such as runoff, groundwater discharge and atmospheric deposition. Waste load allocations are allocated to point sources and load allocations are allocated to nonpoint sources.[17] TMDL allocations must also consider natural background levels and sources of pollutants, seasonal variation, and must include a margin of safety to account for uncertainty.[18]

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[11] 33 U.S.C. § 1313(d).
[12] 40 C.F.R. § 130.10(d)(1).
[13] 40 C.F.R. § 130.7(b)(4).
[14] EPA Guidance at 6.
[15] 33 U.S.C. § 1313(d)(1)(C).
[16] EPA Guidance at 6.
[17] 40 C.F.R. § 130.2(g–h).
[18] 40 C.F.R. § 130.7(c)(1–2); EPA Guidance at 6.

- Pollutant budgets should coincide with **targets and limits based on social preferences, risk tolerance and social and ecological thresholds.**
- **Identify all drivers of tipping points** (i.e., sources of the pollutant) in order to allocate the TMDL effectively.
- **Evaluate alternative management scenarios** for allocating loads to meet the TMDL.

For a real world example of managers using a tipping points perspective to establish TMDLs based on ecological tipping points of concern and social preferences, see our case study write-up of Submerged Aquatic Vegetation in Chesapeake Bay

Establish and implement control measures

The CWA requires that states integrate TMDLs into other management activities, including the National Pollutant Discharge Elimination System (NPDES) and strategies for managing nonpoint source pollution. For point sources, effluent limitations included in facility permits must be revised to include water quality based effluent limits that are consistent with the wasteload allocation applicable to the facility.[19] For nonpoint sources, states must implement or revise nonpoint source controls—such as management measures or best management practices—to ensure compliance with load allocations.[20]

- **Develop future management scenarios** (i.e., identify a variety of control and management practices that may be utilized by point or nonpoint sources to comply with allocations).
- **Evaluate management alternatives using appropriate tools and take action.**

Ongoing monitoring of compliance and water quality

The CWA requires monitoring of water quality by both private and public entities.[21] Monitoring is a crucial element of water quality-based approaches to pollution control. Monitoring provides the data used to assess compliance with water quality-based controls and for evaluating whether TMDLs and control actions based on such TMDLs attain water quality standards.[22] Monitoring is required for point sources[23] and ambient water quality,[24] and is strongly encouraged for nonpoint source contributions.[25]

- This step is not unique to a tipping points perspective, but is crucial for closing the adaptive management loop.

[19] 40 C.F.R. § 122.44(d).
[20] 40 C.F.R. § 130.6(c)(4); EPA Guidance at 8–9.
[21] Many facilities must undertake monitoring pursuant to their NPDES permits. *See* 33 U.S.C. § 1318. States must undertake monitoring as part of nonpoint source pollution control programs. *See* 33 U.S.C. § 1329.
[22] EPA Guidance at 10.
[23] 40 C.F.R. § 122.48.
[24] 40 C.F.R. § 130.4.
[25] EPA Guidance at 11 ("EPA guidance on nonpoint source management plans and funding watershed plans with CWA Section 319 funds have placed a heavy emphasis on managing nonpoint source pollution on a watershed basis. As a result, monitoring the effectiveness of nonpoint source pollution control activities is usually a part of the watershed approach used by [managers].")

Revise as necessary
The CWA requires revisions to water quality standards, the list of impaired waters, TMDLs, and management measures if necessary based on monitoring and new information.

- This step is not unique to a tipping points perspective, but is crucial for closing the adaptive management loop.