Maine Policy Review

Volume 32 | Issue 1

2023

Before and After the Clean Water Act: How Science, Law, and Public Aspirations Drove Seven Decades of Progress in Maine Water Quality

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Abstract

In the 1950s, Maine established a water quality classification system creating the conceptual scaffolding of a tiered system of management. Passage of the federal Clean Water Act in 1972 drove dramatic advances in science, technology, and policy leading to systematic improvement for the next five decades. Today's tiered classification system, revised in 1985, provides a range of management goals from natural to various allowable uses. The state assigns uses and standards for each classification, incorporating physical, chemical, and biological indicators. This system has brought steady improvement in water quality, ecological condition, and overall value for human use. Visible evidence of improvement and adoption of these management alternatives have inspired a re-imagining of how Maine's waters can benefit clean water-based businesses, recreation, and amenity development. We use the evolution of Maine's water classification system to follow progress in water quality improvement.

INTRODUCTION

The history of water quality degradation and recovery, both in Maine and across the nation, is long and tortuous, involving a multitude of competing interests, shifting policies, missed opportunities, and readjustments, but eventually leading to inspiring outcomes. This article recounts seven decades of water quality management in Maine, illustrating how early incremental decisions about water quality management, followed by the comprehensive shift in management propelled by the 1972 Clean Water Act (CWA), have inspired Maine to continuously set higher water quality goals at both a waterbody and statewide scale. We describe the historical context and the policy strategies that evolved into a scientifically based process to classify and manage Maine's waters to balance optimal water quality with use, and we extend earlier accounts of Maine's environmental history.[1] A companion publication (Schaffner et al. 2018) and interactive Esri ArcGIS Story Map entitled *Maine: 50 Years of Water Quality Restoration and Protection*[2] contain relevant case studies, maps, and classification changes from the earliest years to the present day.

SUMMARY OF WATER POLLUTION ISSUES IN MAINE

By the mid-1900s, severe water quality problems across the country prompted development of new water quality management technologies, along with greater understanding of these waters as integrated systems. As early as the 1930s, scientists developed the capability to measure direct impacts of pollution on fish and phytoplankton. Aquatic scientists could document the ecology (e.g., fish, insects, plants, algae) of typical, healthy waterbodies to establish a baseline that could show pollution-induced impacts in disturbed waterbodies. This increasingly sophisticated understanding of aquatic life launched the discipline of biological assessment of water quality (Hynes 1960; Patrick 1949). At the same time, sanitary engineers were designing treatment systems to mitigate impacts of sewage on water quality (Perry and Vanderklein 2009). Despite the ability to measure impacts and develop technological solutions, there was little political will to enable governments to address water pollution.

Industrialization along Maine's waterways had led to extensive, highly visible water pollution problems. By the 1930s, discharges from paper mills, textile mills, and tanneries resulted in egregious water quality conditions. The earliest known survey of Maine waters was conducted by the pulp and paper industry for the Maine Department of Health because of the governor's growing concern about the condition of Maine's

rivers. This industry-led study stated that levels of dissolved oxygen in Maine's rivers "effectively guard against the development of offensive odors and at practically all places was capable of supporting fish life" (Maine DOH 1930: 12). The study used a criterion of 3 parts per million dissolved oxygen on a weekly average as their measure of satisfactory condition, a level that keeps only the most tolerant fish species alive and does not account for daily low values. Despite its misleading attempt to reassure, the report documented that water quality in Maine was in serious decline and of increasing public concern. Human sewage, wood debris, pulping chemicals, and textile, tannery, and food-processing wastes compounded by the impact of hydropower dams and annual log drives resulted in persistent drifts of foam and floating sludge, sedimentation, oxygen loss, bacterial contamination, the decimation of fish populations, and production of hydrogen sulfide odors (Crane 2009; Judd 1990; McFarlane 2012).

Origins of Maine's Water Quality Classification System

Maine, along with other northeastern states, began addressing its intra- and interstate water pollution problems and policies around the same time the federal government began grappling with poor national water quality conditions. Established in 1933 as an outgrowth of New Deal policies, the National Resources Planning Board inventoried America's land and water resources, public works, and transportation and industrial infrastructure. The board promoted the development of state and regional planning agencies that would focus on interstate issues such as water pollution and established the Central New England Drainage Basin Committee to represent the six New England states (Clawson 1981). In 1941, the Subcommittee on Classification of Streams in New England recommended a five-tier classification system based on the highest use of the waterbody. Their report also suggested that dual classifications be assigned, one designating current condition and another designating a desired future condition (Scott and Weston 1942). New England Regional Planning Commission five classifications included

- Class A—Suitable for public water supply, cultivation of market shellfish. Character uniformly excellent.
- Class B—Suitable for bathing and recreation, irrigation and agricultural uses, good fish habitat, good aesthetic value. Acceptable for public water supply with filtration and disinfection.
- Class C—Suitable for recreational boating, irrigation of crops not used for consumption without cooking, industrial water supply, habitat for wildlife and common food and game fishes indigenous to the region.
- Class D—Suitable for transportation of sewage and industrial wastes without nuisance, and for power, navigation and other industrial uses.
- Class E—Does not meet the requirements set forth for Class D water, may serve the same uses as Class D, but may constitute a public nuisance depending on the amount of pollution.[3]

In addition to proposing the classification system, the committee recommended that each state begin the process of classifying its waters and that classification and monitoring programs be coordinated among the New England states.[4] This classification system was not adopted, although a similar system would be established a decade later.

Maine's earliest monitoring reports focused on the Androscoggin River and the establishment of the Maine Sanitary Water Board in 1941. This board investigated water quality and began classifying rivers, streams, and coastal waters and recommending means for improvement (Maine SWB 1946). At the time, Maine did not participate actively with the other New England states, and the committee specifically referenced, "Had such planned program been carried out in the past in connection with the Androscoggin River in the state of Maine, the objectionable conditions in that stream recently reported might have been avoided." (Scott and Weston 1942).

World War II interrupted development of water quality standards until 1946 when the New England Interstate Water Pollution Control Commission (NEIWPCC 1948) was formed to coordinate interstate planning. Maine was the last state to join the commission, not joining until 1955 when Edmund Muskie became governor. Certainly, Edmund Muskie's attention to water quality issues as governor would later inform his decisive role in enacting federal water quality legislation as a US senator.

In 1948, the New England Interstate Water Pollution Control Commission approved tentative water quality standards based on the 1942 A-B-C-D-E scheme (NEIWPCC 1948). The standards were subjective and descriptive rather than quantitative. Other than setting minimum dissolved oxygen criteria for Classes A, B, and C, the standards required only that oil and grease, odor, floating solids, color, and turbidity be "not objectionable." Class E was retained,

Edmund Muskie and the Clean Water Act

> *Our planet is beset with a cancer which threatens our very existence and which will not respond to the kind of treatment that has been prescribed in the past. The cancer of water pollution was engendered by our abuse of our lakes, streams, rivers, and oceans; it has thrived on our half-hearted attempts to control it; and like any other disease, it can kill us.*—Senator Edmund Muskie, 1972

Edmund Muskie was elected governor of Maine in 1954. Early on, he primarily focused on revitalizing Maine's traditional industries. Yet, in his inaugural address, he outlined his belief that water pollution had important implications for Maine, and he sought to balance improved water quality with minimal damage to traditional industries. Muskie saw improvements in water quality as part of economic development, as Maine's improved environmental conditions would attract new businesses. To balance the interests of industry and conservationists, he accelerated classification studies and appointed a representative from the conservation community to Maine's Water Improvement Commission. By 1955, Muskie had proposed legislation that would mandate classification of all waters within two years; however, by 1957, he was concerned about the feasibility of compliance with classifications of streams by individual communities (Judd 1990). Frustrated by the undue influence of industry on water quality legislation, Muskie set his sights on a seat in the US Senate.

Muskie served as a US senator from 1959 to 1980, serving on the Public Works Committee and as chair of the subcommittee on Air and Water Pollution. At a statewide conference called "What Price Clean Water?," Raeburn MacDonald, director of the Water Improvement Commission, and Linwood Royal, of the Maine Fish and Game Association, articulated the need for improved water quality to support water-based recreation. Senator Muskie pledged his support for federal water quality legislation (Clint "Bill" Townsend, personal communication). In 1965, Muskie held the first hearing on water quality programs.

Early in his tenure as senator, Muskie supported an approach that would rely on compliance rather than enforcement and the establishment of water quality standards for interstate waters. Senator Muskie introduced federal legislation in 1963, but it was not passed by Congress; he reintroduced it in 1965. The requirement for federal water quality standards was removed and replaced with language requiring states to indicate intent to adopt such standards (Andreen 2003). In his role as senator, Muskie advocated for national pollution control standards that would achieve two goals. First, national standards would reduce the influence of industries on water quality regulation at a state level. Second, Maine industries would not be unduly affected if Maine passed water quality legislation before other states. Muskie's position was shaped by his role as a former governor dealing with concerns raised by Maine industries about the impact of water regulations (McFarlane 2012).

On February 2, 1971, Muskie introduced legislation that proposed increased funding for construction of wastewater treatment plants and extended the definition of regulated waters to include all navigable waters. The law also set a timeline for compliance by states for adopting water quality standards and a plan for meeting these standards (Andreen 2003). On October 28, 1971, Muskie introduced the Clean Water Act, and one of his pivotal roles was to encourage his colleagues to override President Nixon's veto of the Act in 1972.

ACKNOWLEDGMENTS

This piece was developed for an ArcGIS Story Map titled *Maine: 50 Years of Water Quality Restoration and Protection*: https://arcg.is/1fXWby.

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comprising all waters falling below these arbitrary standards. By 1950, the Maine State Water Board was proposing the New England Commission's classification system, but recommending tighter numerical standards for dissolved oxygen, pH, and bacteria measurements (Maine SWB 1950). The proposed standards still remained somewhat subjective. Odor, color, scum, debris, sludge, and turbidity were only required to be "not objectionable." (See Appendix Table 1 for a comparison of the two standards.[5]) The current use of each waterbody was still the primary determinant of its classification, and the concept of setting classification goals for waterbodies was dropped.

Maine's Early Water Classification Program

By 1950, the board completed a survey that included monitoring of oxygen levels and amounts of oxygen-demanding wastes, as well as pH, coliform bacteria, and perceptions of malodorous conditions along Maine's industrialized rivers.[6] This report identified locations of major discharges of untreated sewage from population centers and industrial discharges from pulp, textile, tannery, and food-processing facilities that continued unabated (Maine SWB 1950).

In 1951, the Maine Sanitary Water Board was replaced by the Water Improvement Commission (PL 1951-383). In 1953, the legislature enacted Chapter 403 of the Public Laws officially adopting a four-tiered classification system of A, B, C, and D. Shortly thereafter, the legislature amended the classification law by splitting Class B waters to create a sublevel (B-2) that was less stringent than the original B (Appendix Table 2; Figure 1, upper bar). It is noteworthy that the legislature decided not to "dignify" the New England Commission's Class E waters as a management class, following the recommendation of Scott and Weston (1942). The legislature relaxed the criteria for dissolved oxygen and bacteria for Classes B-2, C, and D and removed language addressing odor, turbidity, sludge, and floating materials, leaving only that Class C be not objectionable. The legislature's response to public concern over degraded water quality still protected industrial uses in Classes B-2, C, and D waters. Between 1953 and 1959, work began in earnest to classify all waters using this system (Figure 1, upper bar).

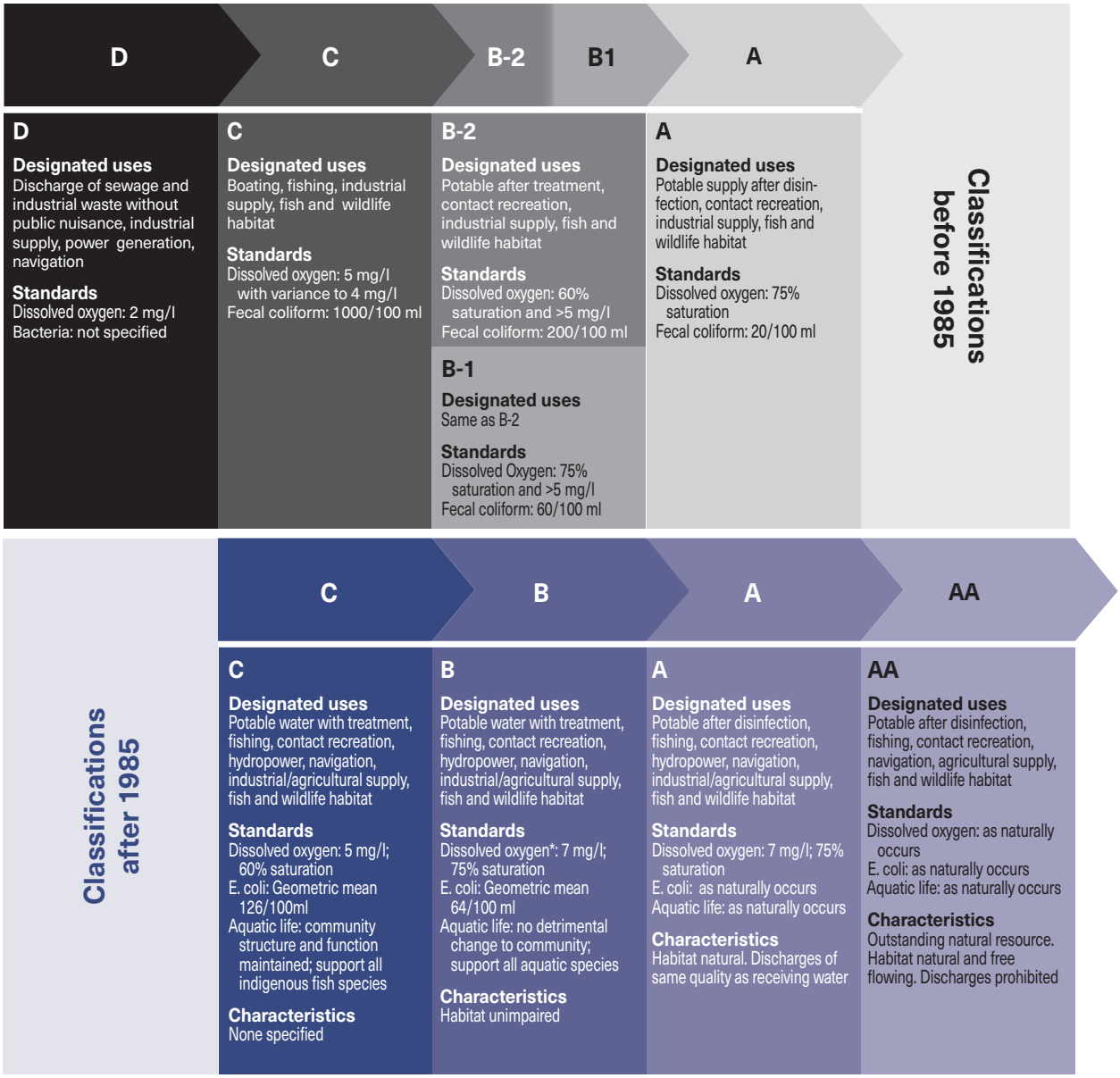
The process of classifying large rivers became particularly contentious. A dramatic gradient of water quality was evident across Maine, from undisturbed, high-quality rivers and streams within the northern forest, to highly polluted segments downstream of industrial and municipal wastewater discharges. The public perception of these disparities, and the cost implications for imposing new standards, influenced public debate about classification assignments. Although many smaller rivers and streams had been classified, controversies delayed classifications on the major industrial rivers. In the early 1950s, the Androscoggin and Kennebec Rivers were at the center of ongoing conflicts between industry and environmentalists amidst a growing re-imagining of the economy of the state in relation to its natural resources (Adler 2014; Judd and Beach 2003).[7]

While Maine and the New England states focused on developing their classification systems, the federal government was also acting to address water quality problems nationally. In 1948, the US Congress passed the Water Pollution Control Act (PL80-85), which provided the first federal funds for construction of public water pollution control facilities (Adler et al. 1993). The Federal Water Pollution Control Act of 1956 (PL84-660) and subsequent legislation in 1961 (PL 87-88), 1965 (PL 89-234), and 1966 (PL 89-753) provided increased funding for wastewater treatment plants. Despite increased funding, federal regulation was limited to interstate pollution, and there was no federal program for regulating industrial or municipal discharges. The Water Quality Act of 1965 required that states adopt water quality standards and plans for implementation and enforcement mechanisms for all interstate waters and established the Federal Water Pollution Control Administration, later to be merged into the US Environmental Protection Agency (EPA) in 1970 (Gaba 1983). However, enforcement was lax and required the difficult proof that a particular discharger's activities caused violation of water quality standards in the receiving water (Adler et al. 1993).

CLASSIFICATION OF MAINE'S WATERS 1965–1985 AND CONNECTIONS TO THE CLEAN WATER ACT

With the establishment of a statewide water classification system, Maine had a foundation for modern water quality management. The effort to monitor all the state's waters and to develop standards and classes had consumed much of the resources of Maine's small Environmental Improvement Commission (formerly Water Improvement Commission) (EIC 1972). Only a few enforcement actions occurred between 1965 and 1972. Similarly, wastewater treatment for both municipal and industrial sources was scarce, unsystematic, and often insufficiently advanced to bring

FIGURE 1: **River and Stream Classification and Standards before and after 1985**



waters into compliance with the standards of their assigned classification.

While the Federal Water Pollution Control Administration only required assessment of interstate waters, Maine was well ahead of the requirement with its statewide classification system. The initial purpose of Maine's classification system was to report on current water quality status, not to envision goals or regulation to achieve improvement.[8] Despite strong political opinion in favor of improving water quality, Maine's classification system languished relatively unchanged and ill-used into the early 1970s. Progress to improve waters enough to meet the requirements of their assigned class was slow, with little federal or state funding for waste treatment facilities and limited enforcement of existing standards.

The Clean Water Act (CWA) of 1972 would change all that in profound ways by setting visionary goals "to restore and maintain chemical, physical and biological integrity of the nation's waters," for the elimination of discharges of pollutants, and to set interim "fishable-swimmable" goals for all waters (33 USC §1251). All states were required to establish uses and standards for their waters (33 USC §1313) usually through some form of classification system. Coinciding with passage of the CWA, Maine created a cabinet level agency, the Maine Department of Environmental Protection (DEP) with oversight by a citizen's Board of Environmental Protection (BEP), to carry out the functions of both state law and the CWA.

The CWA required implementation of universal technology-based treatment standards for different wastewater groups, by industry type, as well as for municipal sewage.[9] These technology standards were coupled with an aggressive timetable for compliance. Most importantly, the US Congress backed up the requirements with a large infusion of public funding through grants and loans. The EPA built corresponding programs to provide technical support to state environmental agencies in developing water quality standards and monitoring programs to track progress. This technology-based approach drove water quality improvement better and faster than all previous attempts. The resulting improvements in water quality compelled Maine to re-envision its classification system and standards.

By the late 1970s, in response to CWA requirements, wastewater treatment had been installed for most discharges. Large industries constructed their own treatment works while small businesses that previously had discharged waste directly to a waterbody used larger collective municipal facilities. The result was a noticeable improvement across most waters. To track changes in water quality and to identify which waters were attaining their classification, Maine was also building an ambient monitoring system. In addition to traditional measures of oxygen and bacteria, this system also monitored nutrients, toxic substances, and other constituents, the effects of which had often been masked by the previously deplorable conditions of many waters. Monitoring also took on a wholly new aspect: biological monitoring. Characterizations of water quality could be confidently made using the organisms found in the waters and provided a more comprehensive and ecologically meaningful evaluation of the water's condition (Rabeni et al. 1985).

The CWA did drive one early change to Maine's classification system. Section 314 of the Act addressed the need to restore the nation's algae-clogged lakes and provided funds for restoration. Although a treasured resource, Maine's lakes had never been classified separately from other freshwaters. During the 1970s, lakes were assigned to Class B-1 with few exceptions (e.g., Sebago Lake, an important public water supply was designated A). The standards in Class B-1 (oxygen, pH, bacteria), designed for rivers, were largely irrelevant to algal blooms and low dissolved oxygen problems caused by eutrophication (i.e., nutrient enrichment). The DEP proposed, and the legislature passed, an amendment creating a new two-tiered classification for lakes, GP-A and GP-B (GP for Great Ponds). Class GP-A established standards for water transparency, phosphorus, and chlorophyll to manage eutrophication and prohibited most discharges to the lakes or their tributaries. Lakes classified GP-B were so designated because they did not attain GP-A standards, thus were eligible for restoration funds.

One other key amendment was made by the legislature in 1979 that ultimately had an important effect on future classification structure. Class A was originally the highest classification, requiring "there shall be no discharge of sewage or other wastes," but it had been assigned to very few waters. A proposed ore mine in northern Maine where waters were Class A propelled the legislature to pass an amendment allowing discharges to Class A waters provided the "effluent will be equal to or better than the existing water quality of the receiving waters" (38 MRS §367, later replaced by §465.2). The change in language papered over the reality that no matter how well regulated, treated, and monitored, mine waste created substantial risk to Class A waters given that toxic and often irreversible effects could occur at concentrations too low to remove or detect.

By the early 1980s, dramatic improvements in water quality were becoming evident due to a constellation of environmental and economic factors. Discharges were being consolidated, making treatment more efficient and easier to track. A decline in textile, food processing, metal finishing, and tanning industries reduced water demand and pollution sources, and the collapse of the broiler chicken industry decreased both nonpoint source problems of manure management and waste discharge problems of meat processing. While some pointed to new environmental requirements as causing the demise of these industries, industrial closures and declines were due more to economic and market conditions, product

competition, and the need for modern efficiencies in manufacturing. Greatly improved water quality was the lasting consequence of consolidation, modernization, or closure of these industries. Despite the public benefits of clean water and growing awareness of gaps in the regulations through this period, Maine's water classification program remained largely unchanged.

The DEP's monitoring indicated that the new technology-based approach had successfully brought many waters to surpass their classification standards, leading to a critical decision point: should Maine's waters be upgraded to maintain the higher quality they were attaining, or should the improved water quality be forfeited by allowing them to remain in their class with opportunities for new or increased discharges of pollutants? It became apparent that causes of serious remaining water quality problems could not be addressed by the limited standards in the existing classification law. For example, in 1968, the waste treatment plant in Corinna, Maine, treated both domestic sewage and waste from the local textile mill. The plant was upgraded and relicensed in the 1970s to meet the new CWA technology-based treatment standards. Yet, biological monitoring downstream of the discharge found the river virtually devoid of aquatic life (Davies et al. 1999). Subsequent studies found a variety of substances from the textile mill were passing through the facility untreated, causing the toxic effect. There was an evident mismatch between the stated water quality goals and the actual waterbody condition, both in terms of the state law and the CWA's treatment requirements. The toxic conditions were entirely missed until the biological condition was assessed, making clear the need to revise Maine' water quality classification standards.

REVISING THE STANDARDS AND CLASSIFICATIONS—1985

In response to dramatically improved water quality and many new requirements in federal law, the DEP determined that a comprehensive revision of the classification law was needed to ensure compliance with the CWA and to incorporate advances in science and water quality management. A new classification law was passed by the Maine Legislature in 1985 (38 MRS §464–470). It raised the standards of the lowest classes (Classes C, SC) to ensure survival and propagation of biota and set human health and safety requirements for recreation in and on the water, also known as the federal fishable-swimmable standard, or the Interim Goal of the CWA. The revised law also deleted classifications with standards below the fishable-swimmable goal (removing Classes D, SD and GP-B). Waters in those deleted classifications were reassigned to classes with more stringent standards to drive improvement up to federally accepted standards.

While compliance with the CWA provided initial motivation to rewrite Maine's classification law, it also created the opportunity to set higher standards, beyond the CWA minimums, to establish more refined classes that better reflected the range of chemical, physical, and biological integrity envisioned in both federal and state law (Figure 1, lower bar). Perhaps the most innovative provision of the 1985 classification law was the introduction of narrative aquatic life standards and accompanying definitions. For each classification, these new standards described the required aquatic life condition relative to that observed in healthy, natural waters.

The changes to the new classification law had important effects on environmental policies and have driven improvements in water quality for decades. Political awareness at the time, fueled by observed water quality improvements and growing public interest in protecting natural resource values, pushed the legislative agenda toward a more progressive and protective water quality management program. The new classification law was precedent-setting, not only for the state of Maine, but nationally as well, in laying the groundwork for federal monitoring of surface waters (Barbour et al. 2000). (See sidebar and Appendix Table 3)

ASSIGNMENT OF WATERS TO NEW CLASSES—1987 TO PRESENT

Following passage of the 1985 law, the procedures for reclassification of waters included a petitioning process for stakeholders and public hearings before the Maine BEP, with subsequent submission of a package of recommended legislative changes. The process was designed to promote significant public engagement. All state waters were subject to at least provisional reclassification. Though the new criteria established higher water quality requirements for all classes, the designation of most waters initially remained unchanged (e.g., Class A remained A, Classes B-1 and B-2 became B, Class C remained C) until the Maine DEP could collect additional information to better align classification assignments with waterbody conditions and public goals.[10]

SIGNIFICANT GOALS AND IMPROVEMENTS IN THE NEW CLASSIFICATION LAW

1. A goal-based classification system "to assign…the water quality classification which shall designate the minimum level of quality which the Legislature intends for the body of water" (38 MRS §464.1). It is this intention to specify a classification goal for each waterbody, rather than describe its present use and condition, that advanced water quality improvement. The law codifies each classification's designated uses and standards, requires regular legislative review of classifications with opportunity for public input, provides for regular reporting to the legislature on classification attainment, and provides a means to progressively secure water quality improvements.
2. New standards to protect waterbody uses that reflected current science and applied in all classes, effectively upgrading all waters (Appendix Table 3; Figure 1, lower bar). The needs of indigenous cold-water fish were addressed via higher oxygen standards for all classes. Maine became the first state to adopt new bacteria standards to protect recreational uses, using *Escherichia coli* (for freshwaters) and *Enterococci* (for marine waters) criteria. The EPA would subsequently publish bacteria guidelines using these new test methods.
3. The incorporation of standards for biological condition into all classes and authorization from the legislature to adopt quantitative methods to assess attainment (i.e., numeric biological criteria), providing a new integrated measure of the effectiveness of water management activities (Courtemanch et al. 1989). Because there was no precedent for the use of biological criteria in water quality law, definitions of ecological terminology were deemed essential by both regulated parties and the state. Statutory definitions of ecological terms provided important operational guidance to express biological integrity goals and the subsequent development of numeric biological criteria to assess attainment of those goals (38 MRS §466). Further, the legislature included specific rulemaking and implementation guidance for the use of numeric biological criteria (38 MRS §464.5 and 464.6). This set in motion provisions where environmental science and law could have a better iterative, coevolving relationship as proposed by Adler (2019).
4. The prohibition of wastewater discharge, and any alteration of natural and free-flowing characteristics for certain designated waters. This was a product of political dissatisfaction over the earlier 1979 elimination of *no-discharge* provisions for Class A waters and the desire to have some waters in Maine protected in their natural state. A new Class AA was established and revisions to Class SA were enacted, preserving these waters "because of their ecological, social, scenic, economic, or recreational importance" (38 MRS §465.1 and 465-B.1). Most Class AA and SA were further identified as "outstanding natural resources" and afforded full protection under the antidegradation policy of the CWA as Outstanding National Resource Waters (40 CFR §131.12(a)(3) and 38 MRS §464.4.F(2)).
5. An antidegradation policy based on a new provision of law that states, "when the actual quality of any classified water exceeds the minimum standards of the next highest classification, that higher water quality must be maintained and protected. The Board shall recommend to the Legislature that that water be reclassified in the next higher classification" (38 MRS §464.4.F(4)). Thus, the legislature must at least consider classification upgrades to any water where water quality monitoring and related uses and characteristics indicate it achieves a higher classification.
6. The incorporation of the standard of a stable or decreasing trophic state for Class GPA that sets the goal for lakes based on water quality trend rather than specific criteria (38 MRS §465-A.1.B). This standard is unique to Maine and provides a strong basis for lake protection. It is important for lake management where water quality can change at a sometimes imperceptible pace until an impact threshold is reached.

The broad aim of reclassification was to conduct a deliberative, orderly, and recurring process for the reassignment of waters into publicly supported and scientifically justified management categories. The DEP had been preparing for this reclassification effort since the early 1980s, first by conducting statewide monthly surveys of waters (>700 sites) using traditional measures: dissolved oxygen levels, bacteria, pH, and conductivity. The DEP used several strategies to propose reassignment, considering factors such as the presence of economically and socially important public and private uses and as receiving waters for permitted wastewater discharges and hydroelectric dams. Additionally, indicators of the current condition of waters, including available water quality data and spatial land use data (e.g., extent of watershed urbanization or agricultural development), helped inform recommendations for appropriate, attainable goal classifications (Maine DEP 2022).[11]

The classification requirements in the new law demanded expansion of the monitoring program to assess compliance with the new standards and criteria. Since 1983, the DEP had conducted biological monitoring using standardized methods, setting the stage for greatly expanded use of biological information. As the biological monitoring program matured, subsequent DEP proposals for reclassification of waters increasingly relied on biological information to identify reclassification recommendations (Davies et al. 2016).

With completion of the statewide reclassification in 1989 and 1990, Maine has continued to search for reclassification opportunities, usually upgrades due to improvements in water quality, use changes (e.g., discontinuance of wastewater discharges), or from new data indicating attainment of a higher classification. One nationally significant upgrade occurred along the Kennebec River in anticipation of the removal of the Edwards Dam in 1999, the first operating hydroelectric dam removed in the United States for ecological reasons (Crane 2009).

As specified in 38 MRS §464.3, the DEP must report to the legislature every two years on the quality of the state's waters, identifying those not attaining their classification, as well as those attaining the standards of a higher classification, thereby requiring consideration for upgrade. While the law requires a three-year cycle of review by the Maine BEP, classification legislation has not always kept pace with that requirement. Significant classification legislation has been passed in 1993, 1999, 2003, 2009, 2017, and 2022, with some minor classification changes occurring during intervening years.

Lake Classification

It was determined that Great Ponds (defined as any natural inland body of water greater than 10 acres and artificially formed water bodies greater than 30 acres) and all natural lakes less than 10 acres should have a common goal to restore and protect their trophic state to assure protection of designated uses, notably their highly valued recreational uses. All lakes (formerly Class GP-A or GP-B) were merged into the single Class GPA with the goal to maintain a stable or declining trophic state, thus maintaining lakes in as close to a natural condition as possible. New discharges to lakes continued to be prohibited, existing ones removed, and by 2022 only four licensed discharges remained (three fish hatcheries and one discharge of treated municipal waste). Additional language, "a change of land use in the watershed of a Class GPA water body may not, by itself or in combination with other activities, cause water quality degradation" provided a groundbreaking link between land use change and trophic state (38 MRS §465-A).

Marine Classifications

Most marine waters along the Maine coast for which monitoring information was available were classified as SB in the initial reclassification process, affording water quality management and allowance for human activities comparable to the riverine Class B (38 MRS §465-B). In subsequent classification initiatives, the DEP identified certain marine waters and tidal estuaries for more protective management as Class SA for their exceptional ecological, economic, scenic, or social value. A difficulty the DEP faced was to determine where effects of discharges in marine waters sufficiently dissipate to support Class SA quality. Therefore, the DEP conservatively established boundaries where there was confidence that effects of adjacent discharges and activities would not impact an adjacent higher class.

FINDINGS

So why did Maine's classification system drive so much improvement in water quality (Davies et al. 1999; Schaffner et al. 2018)? Judd and Beach (2003) elaborated on the power of place, memory, and the nature of people's lives to catalyze a wave of public sentiment to improve and protect water quality. Visible evidence of improvement

and the emergence of new water quality science, treatment technologies, and management alternatives inspired a re-imagining of what the state's waters could be (Johnson et al. 2017; McFarlane 2012). The 1985 classification law provided more refined choices for water quality management and provided the conditions to enable diverse stakeholders to participate in deciding among these choices. The following aspects of the 1985 law have been the most effective in promoting water quality improvement:

1. an environmental planning process that envisions a gradient of classification choices from natural to a full range of human uses allowed within the CWA,
2. the incorporation of biological criteria that define different levels of the biological integrity goal and provide tangible evidence of improvement in ecological condition,
3. an antidegradation policy that sustains water quality improvements, and
4. a deliberative process that engages all parties in recurring water quality classification decisions.

The CWA's goal to fully restore integrity had always created tension between the regulated community, environmental proponents, and regulators as to how the term integrity should be interpreted (Ballentine and Guarraia 1977). The regulated community feared that it meant returning to some natural condition with little opportunity for human use. Environmental advocates voiced concern that it might simply be interpreted as the CWA's Interim Goal, the still undefined fishable-swimmable standard. Rather than having such a dichotomous pass/fail approach, Maine determined that levels of well-functioning ecological conditions could be accurately defined to allow for more refined management choices (Courtemanch et al. 1989; Davies et al. 2016). Maine's classification system specifies designated uses, special restrictions, and characteristics that provide a progression from natural condition to a range of allowable human uses, with technical definitions necessary for implementation included in the law. By providing multiple classification goals, the state has also been able to construct criteria corresponding with different management goals (e.g., dissolved oxygen, bacteria, and biological criteria) included in the classification law.

A second aspect of the new classification law was the incorporation of biological standards with narrative definitions and later a numerical criteria rule (DEP Chapter 579). The DEP recognized biological information was a better measure of waterbody condition and management outcomes than the limited and often inadequate measures of water chemistry (Cairns 1974; Patrick 1949). Biological information integrates the effects of all water quality factors over a period of the life of the organisms. Maine was an early and consistent national leader in developing sound science and policy foundations for use of biological information in water quality classification, standards and management.[12] Public meetings and technical consultations during rule development helped reassure affected parties about how the new biological standards would be applied. Interestingly, the use of biological information was eventually encouraged by many parties in Maine, including regulated dischargers, because it provides an objective demonstration of environmental outcome and condition. The DEP invests the greatest proportion of its monitoring resources on biological monitoring and relies on biological criteria findings in making classification attainment decisions (Maine DEP 2022).

Incorporation of a robust antidegradation policy has become a key feature of the classification law. The antidegradation policy in Maine's classification law reflects much of the same language found in the CWA. However, Maine's law includes the important distinction that whenever a water is found to attain the standards of a higher class, those higher standards must be maintained. Further, the waterbody must be considered for upgrade to that higher class, provided its uses and characteristics are consistent with the higher class. Additionally, waters on state and federal lands, as well as most Class AA and SA waters, receive the highest protection as Outstanding National Resource Waters. By incorporating this antidegradation policy into state law, planning and protection of water quality becomes primarily a state process with federal oversight.

A new reclassification process was built into the 1985 law that requires regular review and revisions of classifications. Maine is unique among states in that its classification standards are in statute, and classification assignment of each waterbody is also in statute. The DEP must regularly make recommendations for statutory reclassification by its own initiative or by recommendations from the public to the Maine BEP. The BEP determines which it finds appropriate, then recommends legislation for enactment (38 MRS §464.2). While this can be a protracted procedure, all parties have opportunity for input at multiple steps of the process before a final statutory decision is

reached. The result is that reclassification assignments are pluralist decisions and largely irreversible, even as political or management inclinations shift.

OUTCOMES AND FUTURE POLICY DIRECTIONS

The history of water quality improvement in Maine complements the history of water quality legislation at the national level. Federal law, together with state law and policy, has resulted in considerable and constant improvement of the water quality of Maine's rivers, lakes, and coastal waters (Schaffner et al. 2018). Maine played a key role in the development of the CWA, especially through the direction of its primary sponsor Maine Senator Edmund Muskie, and benefitted directly from the effects of this federal legislation (Judd 1990; Judd and Beach 2003). Maine's waters are intertwined with the history of water quality improvements, inspiring federal policy, notably the incorporation of biological standards to assess the biological integrity goal of the CWA (Barbour et al. 2000).

Maine also serves as a case study of the impact of state-level water quality policy. The industrialization of Maine's waters through the mid-1900s caused severe degradation and reflected a public perception of water quality as the consequence of its manufacturing-based economy (Judd 1990; McFarlane 2012). A shift away from that perception as well as changes in economic reliance on high-water-usage industries contributed to changes in policy approaches for managing water quality (Davies et al. 1999; Maine WIC 1966). Improvements in the ability to measure water quality both in degraded and unspoiled systems, coupled with technological advancements in water treatment, were instrumental in redefining water quality goals. Aspirational goals, first considered in early classification proposals, finally became enacted as goal-based policy in Maine's 1985 law and were critical in contributing to new policy approaches for improvements in water quality.

Prior to the achievements of the CWA, the Water Improvement Commission had recommended the Androscoggin be set at Class C rather than Class D, which better reflected its actual condition, stating that "(t)he Vacationland State should not be content with mediocre quality waters but should strive for maximum usage in every drop of its most priceless resource-water," reflecting an early aspirational goal (Maine WIC 1966: 5). Although communities have made some investments in river parks in advance of restoration measures, stakeholders have articulated that classification levels have stymied community investments (Johnson et al. 2017). Where waters have seen classification upgrades, communities have leveraged these upgrades into investments in amenities and further restoration measures (Johnson et al. 2018). Restoration of river systems reflects both social and natural revitalization. In looking towards the future, water quality policy should respond to communities' aspirational goals as well as water quality condition to enable restoration at both the social and ecological level.

The re-imagining of Maine's water resource values has contributed to improved management on multiple fronts including waste treatment upgrades, land disposal of wastewater, shoreland zoning, best management practices for land development, dam removals, and fishery restoration. Additionally, Maine communities have come to realize the potential of their waterfronts as sites for recreational and commercial opportunities, cultural events, attractive places for shore-based development, and as destinations for ecotourism, sightseeing boats, and cruise ships (Crane 2009; Johnson et al. 2017, 2018; Opperman et al. 2011). Now, communities want to identify with their water resources. Improving water quality has positive impacts on property values and influences a community's willingness to invest in waterside amenities such as trails and parks (Nicholls and Crompton 2018). High water quality is now integrally linked to growth sectors of Maine's economy and to its social appeal. Maine's economy has seen a resurgence of industries reliant on the availability of clean water such as craft breweries and aquaculture, positioning the state to attract new economic development as a result of high quality-of-place (Crawley 2019; Gabe and McConnon 2017). Maine's water quality represents a success story in how resource management must merge federal and state policy with opportunities for engaging stakeholders in envisioning a future of restoring and maintaining high-quality resource systems.

NOTES

1 See Courtemanch 1995; Courtemanch et al. 1989; Crane 2009; Davies et al. 2016; Johnson et al. 2018; Judd 1990; Rabeni et al. 1985.

2 https://arcg.is/1fXWby

3 The classification system had few numerical criteria for water quality standards, only requiring that Class A and B waters be "clear" with dissolved oxygen levels "near saturation" and having coliform bacteria abundance less than 50/100 milliliters and

1000/100 milliliters, respectively. Class C came the closest to establishing biological water quality criteria, requiring dissolved oxygen levels "adequate for fish life," but without any chemical or physical requirements. Class D waters need only be "free from slick, odors, or visible floating solids" with dissolved oxygen "present at all times" (Scott and Weston 1942).

4 Recognizing the trend of increasing federal control over water conservation and pollution issues, the committee expressed its concern that establishment of national policies "may not recognize the peculiar, and not always selfish, local interests involved" (Scott and Weston 1942).

5 The appendix is available at https://digitalcommons.library.umaine.edu/mpr/vol32/iss1/4/.

6 The 1950 report described dissolved oxygen levels, which were often below 3 parts per million and sometimes devoid of measurable oxygen, along major industrial rivers.

7 In the early 1960s, the Kennebec was the first large, industrialized river in Maine to be classified: Class C beginning at the upstream-most hydropower dam to a large paper mill in Winslow, and Class D downstream to tidewater. In 1966, the Water Improvement Commission established a designation of Class C for the Androscoggin River based more upon the river's imagined potential rather than its very poor water quality. This classification reflected an emerging vision of the role that rivers could play in defining a community's character and how classification might be used to identify water quality goals (Maine WIC 1966).

8 A stark example of the early misuse of classification was the 1966 assignment of Prestile Stream, a high-quality trout stream in Aroostook County, to Class D to accommodate a proposed potato- and sugar-beet-processing plant (L'Hommedieu 2002). The classification led to the severe degradation of the stream and an international incident when Canadians dammed the stream at their border in protest of the foul water emanating from the US side.

9 Technology-based treatment did not consider water classification or standards in establishing treatment standards. Each wastewater type was required to meet designated best practicable treatment (BPT) technology regardless of the quality of the receiving water, its water classification, or the applicable water quality standards. Only where BPT proved insufficient to attain the standards of classification was more advanced best available treatment economically feasible (BAT) required.

10 A further aspect of Maine's classification system acknowledged that it is more risk based than criteria based. Water quality differences between the various classes are not large. Rather, the differences in classification standards must also take into account the different levels of restrictions placed on human activities associated with each class and the descriptive characteristics designated for each. In effect, these restrictions and characteristics establish the state's tolerance for the level of risk that water quality might be degraded, thus threatening attainment of designated uses.

11 To summarize the overarching strategic rationale for the 1989–1990 reclassifications, high-quality waters in largely forested watersheds were proposed for Class A, keeping the previous allowance of restricted discharges and small flow alterations of the former Class A standards. Class AA was proposed for high value, ecologically intact waters, absent of dams or discharges. All waters previously Class B-1 and B-2, or that had licensed discharges or significant nonpoint sources, were assigned to either Class B or C, as determined by known condition or the desired goal. Waters in more populated regions of the state, where future economic development was deemed likely, or where little monitoring data were available, were generally assigned to Class B status to allow for the future possibility of wastewater discharges, land-based development, or hydropower. With passage of the 1985 law, minimum CWA standards required the elimination of Class D. Remaining Class D segments (West Branch of Penobscot and Millinocket Stream) were upgraded to Class C.

12 For more information, see Barbour et al. 2000; Courtemanch et al. 1989; Davies and Jackson 2006; US EPA 2005, 2016.

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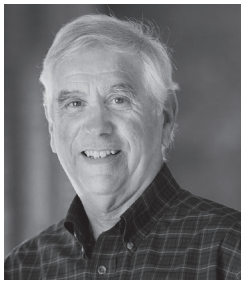

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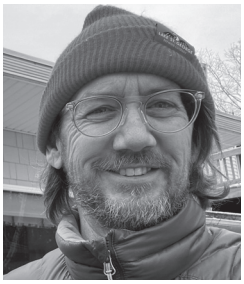

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