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IWRM in the United States: Integration in the Chesapeake Bay Program

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In the United States, IWRM has been slow to catch on as a label. But for decades, the concept has been implemented in a variety of forms—from small, local projects to large, multi-state efforts—and under a variety of rubrics—from interstate river commissions to ecosystem-based management and "watershed approach." As of 2012, there are hundreds (perhaps thousands) of IWRM-like initiatives under way in the United States; they are united by their focus on the river basin or watershed as a whole, their efforts to engage stakeholders and coordinate the activities of the agencies and jurisdictions operating within a watershed or river basin, and their emphasis on ecological restoration. It is unclear, however, whether and how these enterprises have improved either the process or the outcomes of water management. Therefore, this essay asks: how, and to what extent, has a commitment to the core principles of IWRM yielded genuine integration in water management, and with what consequences for the environment? To answer these questions, we examine the Chesapeake Bay Program (CBP), which is often described as the nation's premier watershed-scale management initiative. Based on journalistic accounts, in-depth interviews, and an extensive review of program documents, we conclude that the CBP has enhanced technical, institutional, and—to a lesser extent—sectoral integration in the Chesapeake Bay watershed. Because the program has relied almost exclusively on voluntary cooperation among state partners and willing compliance by water users, however, implementation of collaboratively developed plans has been uneven and inadequate to meet the program's goals. With neither the authority nor the resources to compel behavior changes, the CBP has been unable to alter the powerful and longstanding incentives facing program participants and stakeholders. As a consequence, despite nearly thirty years of integrated knowledge production and planning, the watershed has seen minimal ecological improvement.

Keywords: IWRM, integration, water management, Chesapeake Bay Program.

Integrated Water Resources Management (IWRM) has been the recommended approach for managing water among international organizations at least since the establishment of the Dublin Principles in 1992, and arguably longer. In the United States, IWRM has been slow to catch on as a label. But for decades, the concept has been implemented

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Table 1
Sample IWRM-like Programs in the United States

Program Name	Date of Origin	States Involved	Size of Watershed (sq. miles)	Coordinating Entity
McKenzie River Basin	1992	Oregon	1,300	Eugene Water & Electric Board; Lane County
Comprehensive Everglade Restoration Plan	2000	Florida	18,000	U.S. Army Corp of Engineers; South Florida Water Management District
California Bay Delta Program	1994	California	39,000	Delta Stewardship Council
Delaware River Basin Commission (DRBC)	1961	Delaware, New Jersey New York Pennsylvania	13,000	Delaware River Basin Commission
Chesapeake Bay Program (CBP)	1983	Maryland Pennsylvania Virginia Washington, D.C.	64,000	U.S. EPA Chesapeake Bay Program
The Great Lakes Regional Collaboration (GLRC)	2004	Illinois Indiana Michigan Minnesota New York Ohio Pennsylvania Wisconsin	200,000	Executive Committee of the GLRC
Interior Columbia Basin Ecosystem Management Project (ICBEMP)	1994	California Idaho Oregon Washington	224,000	U.S. Forest Service; Bureau of Land Management
Gulf of Mexico Program	1998	Alabama, Florida Louisiana Mississippi Texas	1.8 million	U.S. EPA

in a variety of forms—from small, local projects to large, multi-state efforts—and under a variety of rubrics—from interstate river commissions to ecosystem-based management and “watershed approach.” As of 2012, there are hundreds (perhaps thousands) of IWRM-like initiatives under way in the United States; they are united by their focus on the river basin or watershed as a whole, their efforts to engage stakeholders and coordinate the

[1] In the United States, as in other industrialized nations, the impetus for IWRM typically has been concern about deteriorating water quality or intensifying competition for dwindling supplies or a combination of the two; thus, the emphasis on ecological restoration. By contrast, in developing countries, a desire to distribute water more equitably is often the primary motivation.

activities of the agencies and jurisdictions operating within a watershed or river basin, and their emphasis on ecological restoration (see Table 1).[1] It is unclear, however, whether and how these enterprises have improved either the process or the outcomes of water management. Therefore, this essay asks: how, and to what extent, has a commitment to the core principles of IWRM yielded genuine integration in water management, and with what consequences for the environment?

To answer these questions, we examine the Chesapeake Bay Program (CBP), which is often described as the nation's premier watershed-scale management initiative. Based on journalistic accounts, in-depth interviews, and an extensive review of program documents, we conclude that the CBP has enhanced technical, institutional, and—to a lesser extent—sectoral integration in the Chesapeake Bay watershed. Because the program has relied almost exclusively on voluntary cooperation among state partners and willing compliance by water users, however, implementation of collaboratively developed plans has been uneven and inadequate to meet the program's goals. With neither the authority nor the resources to compel behavior changes, the CBP has been unable to alter the powerful and longstanding incentives facing program participants and stakeholders. As a consequence, despite nearly thirty years of integrated knowledge production and planning, the watershed has seen minimal ecological improvement at best. Before presenting evidence to support this argument, we briefly review the evolution of IWRM in the United States and suggest some criteria for gauging improvements in the level of integration brought about by IWRM-like initiatives.

1. The Evolution of IWRM in the United States: A Brief History

The history of water development and management in the United States is one of fragmentation and increasing demand, followed by a growing recognition of the need to conserve and restore aquatic ecosystems to ensure their long-term viability. For the first fifty years following the nation's Declaration of Independence in 1776, states determined the allocation of water within their boundaries, and water development and flood control were typically patchwork local efforts funded by landowners or investment groups. As the nineteenth century wore on and the nation expanded westward, however, demands increased for the federal government to build and manage large-scale infrastructure for flood control, inland waterway navigation, hydroelectric energy provision, and irrigation. The Army Corps of Engineers (Corps), established in 1802, and the Bureau of Reclamation, established a century later, responded with a series of massive projects, including the Hoover and Grand Coulee dams, which together provide nearly one-third of the industrial, household, and irrigation water used in the West (Cech 2003).

Even as federal development accelerated, there were efforts to devise a more holistic approach to water management—that is, one that acknowledged water scarcity and accounted for the multiple demands placed on the nation's water resources. As early as 1878, explorer John Wesley Powell recommended organizing the settlement of the West around watersheds, in hopes that doing so would prompt users to conserve the region's water and rebuff plans to export water to distant sites. Thirty years later, in 1908, President

Theodore Roosevelt's Inland Waterways Commission report reprised Powell's concerns. Focusing on the "interrelated problems of natural resource management," the report emphasized the "need for multipurpose planning, especially how federal planning for navigation should account for other uses … and cooperation between various levels of government" (quoted in Thompson 1999). In the 1930s, as part of the New Deal, the short-lived National Resources Planning Board again elevated the notion of basin-level and multi-use management in resource planning. Despite these intermittent calls for reform, well into the twentieth century water policy was made at the national level by "iron triangles" comprising western water interests, the federal water-development agencies, and congressional committees that were driven primarily by considerations of local economic growth (Gottlieb and Fitzsimmons 1991).

By the 1960s and 1970s, the environmental impacts of growth-driven water management were plainly evident. Dams, erected to divert water for irrigation or urban use or to generate hydroelectric power, had destroyed stream habitat; raised water temperatures and degraded water quality; blocked fish runs; and prevented the movement of sediment, nutrients, and organisms downstream. Also wreaking havoc on rivers were diversions of water for irrigation and urban water supply, as well as river channelization and levee building to facilitate navigation and prevent seasonal flooding (Schneiders 1999). The nation's estuaries were manifesting the cumulative consequences of development and extractive activities on surrounding land (Noss and Cooperrider 1994).

In the 1970s, in response to public alarm about degraded waterways, the federal government passed a series of environmental laws that sought to mitigate some of the most devastating impacts of water diversion and pollution. The Clean Water Act of 1972, which focuses on water quality, makes it illegal to discharge any pollutant into the nation's navigable waters without a permit. Of particular relevance for IWRM, Section 303 of the act requires the Environmental Protection Agency (EPA) and the states to enforce total maximum daily loads (TMDLs) for pollutants entering the waterways of the United States. Under Section 303, states must establish water-quality standards for each waterway, identify the sources of pollutants, set overall limits on those pollutants, allocate that pollution among sources, and implement pollution-reduction plans. For point sources, the state can enforce a TMDL through a permit; for nonpoint sources, the state must show it has an adequately funded program to reduce runoff.[2] The state must write a TMDL for all segments of any waterway that fails to meet its water-quality standards. If a state does not write a TMDL for each impaired segment, the EPA must write one itself.

Three additional federal statutes have powerful implications for water quality and quantity in the United States. The first and most significant is the Endangered Species Act (ESA). Passed in 1973, the ESA seeks to conserve threatened and endangered plants and

[2] The Clean Water Act defines point source pollution as "any discernible, confined and discrete conveyance." By contrast, nonpoint source pollution comes from diffuse sources and is caused by rainfall or snowmelt moving over and through the ground, picking up pollutants in the process and depositing them in rivers, lakes, or wetlands.

animals and the habitats on which they depend; to this end, it requires federal agencies to ensure that actions they authorize, fund, or carry out will not jeopardize the continued existence of any listed species or damage its habitat. The Coastal Zone Management Act, passed in 1972, provides grants and expertise to coastal states to develop and maintain coastal management programs that will "preserve, protect, develop, and where possible . . . restore or enhance the resources of the nation's coastal zone." A primary feature of plans devised under the act is that they must involve federal, state, and local collaboration in their development and implementation. And finally, the Safe Drinking Water Act of 1974 mandates that the EPA establish contaminant limits for drinking water and ensure that all public systems monitor and comply with those standards.

These new federal statutes gave legal standing to environmental claimants, thereby undermining the iron triangles that had long dominated U.S. water politics. Their implementation and enforcement prompted a backlash, however, particularly in the West, where states' allocations of water among users increasingly came into conflict with federal environmental regulations designed to protect water supplies and conserve or restore the integrity of aquatic systems. In response to the political gridlock that ensued, a host of collaborative, watershed-scale initiatives sprang up. Often these endeavors were sparked by enforcement of the Clean Water Act or the ESA, or by a catastrophic event, such as a severe flood or drought. For example, the now-defunct CALFED Bay-Delta Program, a regional watershed management program in northern California, began after a multi-year drought, when operation of federal and state water projects ran afoul of the Endangered Species and Clean Water acts. But sometimes, as in the case of the Comprehensive Everglades Restoration in South Florida, recognition by scientists of a system's interrelatedness combined with rising public concern about its deterioration spurred plans for restoration (Layzer 2008).

In the early 1990s, the EPA began to promote watershed-scale planning and management—part of a broader effort by the Clinton administration to advance ecosystem-based planning and management—and in 1999 the National Research Council endorsed the "watershed approach." But only more recently have federal agencies explicitly adopted IWRM as its preferred mode of water management. In the late 2000s, the Army Corps of Engineers convened a conference on IWRM that yielded a report on "Responding to National Water Resources Challenges: Building Strong, Collaborative Relationships for a Sustainable Water Resources Future." In that publication, the Corps defined IWRM in the following way:

> IWRM aims to develop and manage water, land, and related resources, while considering multiple viewpoints of how water should be managed (i.e. planned, designed and constructed, managed, evaluated, and regulated). It is a goal-directed process for controlling the development and use of river, lake, ocean, wetland, and other water assets in ways that integrate and balance stakeholder interests, objectives, and desired outcomes across levels of governance and water sectors for the sustainable use of the earth's resources.

In early 2011, the Corps signed a Memorandum of Understanding with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) to support integrative and adaptive water resources management; eventually, twelve federal agencies are expected to join the initiative. This agreement signals a formal commitment at the federal level to promoting watershed-scale integration. In a further demonstration of interest, in early 2012 the Corps released a draft report, "Towards Integrated Water Resources Management: A Conceptual Framework for U.S. Army Corps of Engineers Water and Related Land Resources Implementation Studies." Similarly, the American Water Resources Association devoted its 2011 summer conference to IWRM. Reflecting persistent uncertainty about the efficacy of IWRM, it called the session *Integrated Water Resources Management: The Emperor's New Clothes or Indispensable Process?*

2. Defining and Measuring Integration

Proponents of IWRM are especially interested in overcoming the historically fragmented nature of water management, in which users operate independently of—and often in competition with—one another. Proponents also have sought to replace a single-minded focus on economic development with broader consideration of social equity. And most expect that IWRM will have salutary consequences for the health of the watershed (Braga 2001; GWP 2000; Grigg 1999; Medema, McIntosh, and Jeffrey 2008; Rahaman and Varis 2005; Thomas and Durham 2003; United Nations 2009; Xie 2006). Proponents are less clear, however, about the forms integration should take and how, precisely, integration leads to environmental sustainability. Below we define three main types of integration—technical, institutional, and sectoral; suggest how each type might lead to ecological improvements; and describe what we would expect to see if their hypothetical benefits are borne out in practice. Importantly, we recognize that integration may include more or fewer mechanisms to ensure accountability across levels of government, jurisdictions, and stakeholder groups. Therefore, in assessing a program's achievements, we think of integration as being a matter of degree, rather than as present or absent.

- *Technical integration* involves the adoption of a systemic perspective among scientists and other technical experts that is reflected in their analytic approach, and the forging of a productive relationship between experts and policymakers. It is best understood in distinction to the pervasive situation in which experts work in isolation, on different aspects of a problem or elements of the ecosystem and are unable or unwilling to communicate with policymakers. Technical integration ought to lead to environmental improvements by illuminating the cause-and-effect relationships between human actions and ecological responses, thereby enabling policymakers to choose effective interventions. It is likely to manifest itself in the following ways: (1) experts redefine the problem(s) facing the watershed and establish criteria for assessing success in ways that reflect whole-system thinking rather than an exclusive focus on individual system elements; (2) experts develop comprehensive models or frameworks to analyze problems and potential solutions; (3) experts from different disciplines collaborate in teams, informal or institutionalized, to address specific problems; and (4) experts and managers jointly establish goals and benchmarks, choose management actions, assess progress, and adjust practices in response to those assessments.

- *Institutional integration* aims to solve problems of governmental fragmentation. Consistent with a systemic view of the problem, vertical integration involves linkages between higher and lower levels of government, while horizontal integration entails cooperation across equivalent levels (for example, among states or among federal agencies). Institutional integration ought to lead to environmental improvements by enabling jurisdictions to set common goals and efficiently coordinate their pursuit of those goals. It is likely to manifest itself in the following ways: (1) organizations are created to facilitate intergovernmental communications and cooperation; (2) participating jurisdictions and agencies establish shared, watershed-scale goals and collaborate to devise strategies for attaining those goals; and (3) during implementation, the activities of program partners complement one another, and local activities are explicitly linked to higher-order objectives and actions.
- *Sectoral integration* refers to the incorporation of all relevant stakeholders in addressing the problem(s) afflicting the watershed. It addresses the myriad problems that arise when stakeholders operate independently of one another and without consideration of the watershed as a whole. Sectoral integration ought to enhance environmental conditions by highlighting the contributions of various sectors to a watershed's decline and reconciling their competing demands to ensure its restoration. It is likely to manifest itself in the following ways: (1) stakeholder groups representing key water-use sectors agree on the definition of the problem, program goals, and the metrics for evaluating progress; (2) stakeholders acknowledge their roles in both causing and mitigating the watershed's problem(s); and (3) stakeholders curb practices that are harmful to the watershed in proportion to their responsibility for its problem(s).

3. Integration and Its Consequences in the Chesapeake Bay

If IWRM enhances integration, we ought to observe both the process and its consequences in the Chesapeake Bay Program. The CBP is one of the nation's oldest and most venerable examples of IWRM; it has been widely touted as an exemplar of the "watershed approach" (Adler 2000; Cannon 2000; Imperial, Robadue, and Hennessey 1992; Landy, Susman, and Knopman 1999; Sabel, Fung, and Karkkainen 1999). It boasts a dedicated program office established by statute that explicitly seeks to achieve all three kinds of integration identified above. Nearly three decades have passed since its inception in 1983—more than enough time for integration to take hold. During that time, many of the same high-level players have been active participants in the program, creating continuity despite political turnover at the state level. In addition, Presidents and Congresses have repeatedly recognized the bay as a national treasure; as a result, the program has been well funded, with the federal government and the states spending more than $6 billion on restoration-related activities (Fahrenthold 2008b). No other case of large-scale watershed restoration in the United States can boast the same level of formal organization, continuity of personnel, and consistent federal support over such a long period.[3] In short, we consider the CBP a most-likely case—that is, if we do not see evidence of effective integration here, we are unlikely to see it in other large-scale watershed restoration projects; moreover, challenges to integration that arise here are likely to crop up elsewhere. Although the results of this kind of analysis are not generalizable to the many other IWRM-like initiatives operating at different scales in the United States, they can suggest ways that integration is likely to arise at large scales, the limits it may encounter, and its probable environmental consequences.

3.1 Origins and Evolution of the Chesapeake Bay Program

The 64,000-square-mile Chesapeake Bay watershed stretches from southern New York State to Virginia. At roughly 190 miles long, 30 miles across at its widest point, and an average of 21 feet deep (though as little as 6 feet deep in places), the Chesapeake is among the most productive estuaries in the world. At one time, sunlight nourished 600,000 acres of underwater grasses that formed the basis of the bay's food chain while providing spawning grounds for its abundant striped bass and blue crabs. A massive oyster population filtered a volume of water equal to the entire bay in only a few days. For more than three centuries after its settlement by Europeans in 1607, although it experienced intermittent local problems, the bay appeared to withstand the effects of a growing human population. In the 1960s and 1970s, however, the combined impact of accelerating suburban sprawl, changes in farming practices, and the construction of several large dams began to take a discernible toll (Boesch and Greer 2003; Ernst 2003).

The bay's problems became particularly evident in June 1972, when tropical storm Agnes struck, causing record flooding and prompting a precipitous decline in the bay's underwater grasses. The following year, a study by the Army Corps of Engineers identified nutrients—particularly nitrogen and phosphorus—as the primary culprits in the bay's degradation. The Corps' report prompted Democratic senator Charles Mathias of Maryland to request a detailed investigation by the EPA into the sources of nutrients and their precise impacts on the bay. Released in the fall of 1983, the EPA report, "Chesapeake Bay: A Framework for Action," described how excessive amounts of nitrogen and phosphorus pouring into the bay spurred the growth of algae, whose proliferation led to oxygen depletion and the consequent decline of vital underwater grasses.[4] Scientists estimated that the

[3] Among the comparable cases we would include some large-scale initiatives within a single state, such as the Everglades Restoration and the now-defunct CALFED Bay-Delta Program. We would also include multi-state efforts, such as the Columbia River Basin Restoration, the Great Lakes Restoration, the Platte River Restoration, the Gulf Coast Ecosystem Restoration, and others.
[4] Although it emphasized that nutrients were the main culprit in the bay's decline, the report also identified excessive sediment loads, overharvesting of marine life, and toxics as key concerns. For reasons of space, we focus on nutrient pollution, widely regarded as the bay's overriding issue.

amount of water in the bay's channel with little or no dissolved oxygen in the summer had increased tenfold since 1950 (Kenworthy 1983). It also identified the main drivers of the bay's decline: poor agricultural practices, inadequate treatment of sewage, and runoff from urban and suburban development. And it highlighted the consequences of the bay's deteriorating water quality: a precipitous drop in the region's historically, economically, and ecologically important blue crabs, oysters, striped bass, and shad.

The EPA report prompted the states of Maryland, Virginia, and Pennsylvania, the Chesapeake Bay Commission—a legislative body formed in 1980 to advise the general assemblies of those states and the U.S. Congress on environmental matters related to the bay—the District of Columbia (D.C.), and the EPA to sign a three-paragraph Chesapeake Bay Agreement. The agreement recognized the historical decline in the bay's living resources and pledged that its signatories would work cooperatively to reduce the flow of nutrients into the bay. The report also spurred the creation under the Clean Water Act of an institutional structure to address the problems facing the bay: the Chesapeake Bay Program, formally headquartered in Annapolis, Maryland, and administered by the EPA.[5] In 1984, a suite of federal agencies—the EPA, Corps, Fish and Wildlife Service, USGS, and NOAA—signed interagency agreements to collaborate on bay restoration as well.

In 1987, the bay program partners crafted and signed a new, more explicit agreement that committed them to managing the bay as an "integrated ecosystem." Specifically, they agreed to reduce by 40 percent the amount of nitrogen and phosphorus entering the bay by 2000—the minimum necessary to begin restoring ecological health. The compact included 29 specific commitments aimed at helping to attain those goals. Like the 1983 pact, however, the 1987 agreement was entirely voluntary; it contained no penalties or sanctions if the states failed to achieve its objectives. Moreover, it soon became apparent that the 40-percent goal politicians had agreed to was less ambitious than it originally appeared. Upon realizing that a large fraction of the nutrients coming into the bay was airborne or runoff from forests, the signatories decided to reduce only "controllable" nutrients by 40 percent. So in reality, the partners were planning to reduce annual runoff by 24 percent for nitrogen (74 million pounds) and 35 percent for phosphorus (8 million pounds) (Boesch, Brinsfield, and Magnien 2003).

Despite their modesty, even those goals proved elusive. By the mid-1990s, the CBP partners were spending between $40 million and $50 million each year on bay-related activities (Shields 1997). Much of that funding paid for scientific research, particularly efforts to construct a multimillion-dollar, three-dimensional, hydrologic model of the bay's complex circulatory system. Most of the remainder went toward implementing policies and programs expected to reduce nutrient pollution in the agricultural, development, and sewage-treatment sectors. Yet the 2001 annual report by the Chesapeake Bay Commission acknowledged that, despite modeling results showing a 15 percent reduction

[5] Section 117 of the Clean Water Act provides the authorization for the CBP and directs the EPA to maintain a CBP office; it charges the program with coordinating restoration efforts among bay partners and tasks it with reporting to Congress every five years.

in the amount of nitrogen entering the bay between 1985 and 2000, "water quality monitoring data from the Bay's largest tributaries revealed no discernable trends in nutrient loads" (CBC 2001, 35). Subsequently, the bay program conceded that it had fallen short by 2.3 million pounds per year for phosphorus and 24 million pounds per year for nitrogen (CBP 2002).

In hopes of averting a regulatory hammer in the form of a TMDL, the bay partners responded to this information by committing themselves voluntarily to removing the bay and its tributaries from the list of impaired water bodies under the Clean Water Act by 2010.[6] To demonstrate their seriousness, they signed Chesapeake 2000, a twelve-page compact containing five major goals and dozens of specific milestones. They also prescribed a detailed new process for attaining those goals. Increasing the program's comprehensiveness, two years later, three more states signed on as "headwater partners": Delaware, New York, and West Virginia. Still, meeting the program's new goals promised to be difficult. About 16 times more phosphorus and 7 times more nitrogen was entering the bay in 2000 than had done so prior to the arrival of British colonists, and upgraded Corps modeling showed that a 50 percent reduction in nitrogen would be necessary to avert unacceptable ecological consequences (Boesch 2006).

Given these challenges, few observers were surprised that, as the 2000s wore on, the CBP was not on track to meet its water quality commitments. In late 2004, the *Washington Post* ran a series of articles documenting how the program consistently overstated progress by relying on models, despite monitoring data that suggested the picture presented by the models was too rosy (Whoriskey 2004a, 2004b). Both the Government Accountability Office (GAO) and EPA's inspector general subsequently issued reports that criticized the program for a lack of integration in implementation and assessment (U.S. EPA 2008; U.S. GAO 2005). Most important, the bay itself continued to suffer: water quality remained sharply degraded; as a result, blue crabs, oysters, shad, river herring, and menhaden were at record lows and half of the striped bass were infected with mycobacteriosis, a chronic wasting disease (Blankenship 2004). In response to these developments, in 2007 the CBP crafted the Chesapeake Action Plan, which revamped the program's organizational structure, creating six goal implementation teams to enhance integration. But the region's environmentalists had already lost patience with the CBP's non-regulatory approach and had begun demanding that the federal government take more draconian steps, starting with imposing a TMDL on the watershed (Huslin 2003b, June 17; Craig 2003; Ernst 2009).

In May 2009, President Obama obliged the dissidents by signing Executive Order 13508, which signaled a dramatic shift in the approach to Chesapeake Bay restoration. It created a Federal Leadership Committee composed of representatives from seven federal agencies and tasked it with devising an overall strategy for restoring the bay, as well as crafting annual action plans for carrying out that strategy. The following spring,

[6] In the late 1990s, the EPA began working on an overall TMDL for the Chesapeake Bay. It agreed to put that process on hold, however, when the governors of Maryland, Virginia, and Pennsylvania signed Chesapeake 2000.

the administration released its "Strategy for Protecting and Restoring the Chesapeake Bay Watershed," complete with a "sweeping vision" for a revived Chesapeake Bay and a commitment to complete the job by 2025. According to EPA administrator Lisa Jackson, "This strategy outlines the broadest partnerships, the strongest protections and the most accountability we've seen in decades" (U.S. EPA 2010). Most important, the EPA followed up with a draft TMDL that contained a "pollution diet" allocating pollution among the 92 segments that comprise the bay and tidal portions of its tributaries and embayments. Based on these allotments, each state was required to write a detailed Watershed Implementation Plan (WIP) specifying how it would meet its goals and establishing two-year, enforceable milestones. On December 29, 2010, the EPA issued the final TMDL for the Chesapeake Bay, the largest and most complex such rule ever written.

3.2 Technical Integration in the Chesapeake Bay Program

The complex and finely tuned "pollution diet" on which the Chesapeake Bay TMDL rests is the product of three decades of technical integration under the auspices of the bay program. Even before the program began, tropical storm Agnes sparked the development of a more holistic view of the bay. For most of the twentieth century, scientific research had focused on localized problems, such as the visible effects of industrial and municipal pollution, toxic pesticides, and channel dredging and spoil disposal (Boesch, Brinsfield, and Magnian 2003). But according to political scientist Howard Ernst, by wiping out vast swaths of eelgrass and other plants, Agnes caused the scientific community to "see the Bay as a distinct ecosystem that is dominated by the influence of its watershed" (Ernst 2003, 58). The process of reconceptualizing the bay continued with the development of the 1983 EPA report, which provided a systemic view of the estuary and made manifest the relationships among various drivers and different parts of the watershed. In other words, integrated scientific activity both created the impetus for a comprehensive restoration and laid the foundation for action.

From its inception, the bay program sought to generate multidisciplinary, problem-focused research that would deepen the scientific understanding of the complex bay ecosystem. Among the first steps taken by the inchoate program was to assemble a Scientific and Technical Advisory Committee (STAC) comprising experts from universities, research institutes, and federal agencies to provide an integrative scientific basis for the restoration. The program also forged links to a network of well-established researchers throughout the watershed, particularly members of the Chesapeake Research Consortium, an association of six institutions with long-standing research engagement with issues affecting the bay. The body of work generated by these scholars is the program's signature achievement; as one official boasted to Rena Steinzor and Shana Jones (2008), "We have the best understanding of any ecosystem in the world."

In addition to supporting integrative scientific research, the program asked technical experts from the Corps and the EPA to build a set of state-of-the-art watershed-scale computer models that could help policymakers choose nutrient-reduction measures and gauge their effectiveness. Two models have been particularly important. The first is the hydrodynamic Chesapeake Bay Watershed Model, which divides the watershed into multiple river basin segments and estimates past and current nutrient loadings. The second is the Estuarine Model, a three-dimensional model that estimates the effects of the loads generated by the Watershed Model on water quality and living resources in the bay. Widely considered the world's most sophisticated, the Estuarine Model simulates the growth of algae, the vertical and horizontal movements of water and nutrients, the amount of oxygen available in different parts of the bay, and other critical variables.

Complementing the modeling effort is a sustained effort to monitor actual conditions in the bay. By 1985, the bay program had established the Chesapeake Bay Monitoring Program, a cooperative enterprise that involved Maryland, Virginia, Pennsylvania, D.C., several federal agencies, 10 research institutions, and more than 30 scientists. These entities began tracking 19 physical, chemical, and biological characteristics of the bay, collecting data 20 times per year in the bay's mainstem and tributaries (CBP N.d.c). Over time, the monitoring program evolved to incorporate improvements in monitoring design, new measurement methods, and "continuous, automated, and synoptic observations that span regional and temporal scales" (Boesch and Goldman 2009).[7] A 2000 review of the monitoring system conducted for the STAC characterized the bay program's monitoring database as one of the most comprehensive compilations of its kind anywhere (Anon. 2000). In 2004, a dozen entities—including every state in the watershed—signed an MOU to enhance the monitoring system for non-tidal portions of the bay to help assess the efficacy of actions taken at the tributary level.[8]

Beyond conducting integrative, policy-relevant research, modeling, and monitoring, scientists and other technical advisors have influenced bay program policymakers directly. It was the scientific analyses completed in the 1970s and early 1980s that provided the impetus for the bay program and the initial bay agreement. Subsequently, a report by the STAC presented evidence that both phosphorus and nitrogen removal would be required to improve water quality in the bay and its tributaries; it also identified cost-effective technologies for removal of these nutrients from point sources. According to Donald Boesch and his colleagues, the scientific consensus embodied in this report "provided the rationale and credibility for the bold action of the Second Chesapeake Bay Agreement in 1987" (Boesch, Brinsfield, and Magnien 2003). Between 1987 and 2000, the Chesapeake

[7] Monitoring also expanded to include conditions on land. For example, program partners began monitoring land-use changes using remote-sensing technology; in addition, the EPA produces data on 15 types of land cover, while the Fish and Wildlife Service generates information on wetlands loss as part of its National Wetlands Inventory.

[8] The goals of the new network were threefold: to measure and assess the status and trends of nutrient and sediment concentrations and loads in the tributary strategy basins across the watershed, to help assess the factors affecting nutrient and sediment status and trends, and to improve calibration and verification of partners' watershed models. The network was expected to cost $45 million per year for 100 stations; there was no permanent funding source, however, so it was unclear whether the network would materialize or be sustainable (Hammer 2004).

Executive Council issued numerous reports, directives, agreements, and amendments rooted in scientific assessments of what would be needed to restore the water quality and living resources of the bay. For instance, although nutrient allocations among states involved horse trading, they ultimately had to pass muster with the bay program's models (Batiuk 2003). Critiques of the program by the STAC prompted introspection and adjustment. For example, in the early 2000s the STAC convinced the bay states to revise their assumptions about the effectiveness of agricultural best management practices, even though it meant they would need to do more than expected to achieve their goals (Batiuk 2003).

Policymakers in the bay region regularly have asked the region's scientists to weigh in on important decisions. For instance, after a 1997 outbreak of the microbe *Pfiesteria piscicida* killed millions of fish and sickened the watermen who ply the bay, the program asked Donald Boesch, a highly regarded scientist at the University of Maryland, to provide a synthesis of what was known about the disease, the uncertainties, and the most effective responses. The program then distributed that document to general assemblies and advocacy groups in hopes that it would serve as a credible basis for policy (Batiuk 2003). The decision not to introduce the Asian oyster to the bay also exemplifies the program's strong interface between science and policy. In the early 2000s, policymakers considered allowing the introduction of the Asian oyster in hopes that it would thrive in the bay's nutrient-enriched waters. But a precautionary response prevailed in response to the convergence of three lines of science (Hershner 2013). First, scientists argued that the Asian oyster could be a disease vector that would wreak havoc on the system in ways that were not yet fully understood. Second, scientists demonstrated that they were making progress on breeding disease-resistant native oysters. And third, there were developments in aquaculture: it turned out that hatchery-raised triploid oysters, which emerged from research aimed at making non-native oysters safe, could increased productivity in native stocks without posing the risks associated with the Asian oyster.

Although the CBP has attained high levels of technical integration, critics have pointed out several ways in which such integration has fallen short. During the 1990s, scientists charged that there was a chasm between the engineers developing the models and the researchers generating empirical data and basic insights about the bay. As a result, the models tended to lag behind the scientific understanding, and their outputs bore little relationship to the results of monitoring.[9] Yet, "Because they yield[ed] clear numerical results with which to gauge progress, the models ha[d] a seductive appeal to policymakers and managers, an appeal that risk[ed] false confidence and misconception" (Boesch, Brinsfield, and Magnien 2003, 311). When academic scientists peer reviewed the watershed model in 2000 they were harshly critical: "It is the opinion of this team," they wrote, "that the Water Quality Model does not currently provide information suitable for major

[9] Specifically, model predictions were very sensitive to several tenuous assumptions; the models predicted "average" conditions in a variable world; and the models assumed immediate benefits of source reductions when in fact there were significant lag times (Boesch, Brinsfield, and Magnien 2003).

management decisions and that use of the model for such purposes should be suspended" (quoted in Blankenship 2000). Despite these cautions, the program came under fire again during the mid- and late 2000s for its excessive reliance on the optimistic projections of its models rather than the more sobering results of monitoring (Whoriskey 2004a, 2004b; Fahrenthold 2007, 2008a; Williamson 2005).

Monitoring in the CBP has also been the subject of criticism. The 2000 review of the monitoring program found that the subcommittees of the bay program did not coordinate their monitoring programs effectively and that the program struggled to integrate the findings of regional monitoring networks (Anon. 2000). The panel urged the bay program to commit to a larger leadership role in the watershed and work to coordinate monitoring with management and research efforts, as well as to ensure compatible sampling designs and methodologies among government and academic studies. Still, in 2005 the GAO commented, "the program has not yet developed an integrated approach that would allow it to translate [the] individual measures [reported annually in the *State of the Bay*] into an assessment of overall progress toward achieving the five broad restoration goals outlined in *Chesapeake 2000*."

Perhaps the most criticized aspect of technical integration in the bay program has been the science-policy interface. Despite the efforts of committed individuals, problems persist in terms of communication between scientists and managers, and it remains difficult to translate scientific data on the bay into information managers can use to make decisions. In part, this is because managers are rarely consulted when monitoring and other long-term research programs are established. In fact, Denice Wardrop, former STAC chair, notes that when the STAC convened the environmental managers from the bay watershed, one thing they said was: "No one's ever gotten us in the room and asked us what we want out of the monitoring program, what are the questions we have" (Wardrop 2012). More fundamentally, according to former STAC chair Carlton Hershner, the region's scientists have struggled to convey the uncertainties in their understanding of bay processes and the likely effectiveness of conservation measures. As a result, as the National Research Council (2011) pointed out, the bay program has struggled to implement adaptive management, the ultimate form of science-policy integration.

3.3 Institutional Integration in the Chesapeake Bay Program

In many respects, the Chesapeake Bay Program has also achieved notable levels of institutional integration, both vertical and horizontal. In terms of horizontal integration, the Chesapeake Executive Council—comprising the governors of the signatory states, the mayor of D.C., the EPA administrator, and the chairperson of the Chesapeake Bay Commission—signals the high-level commitment among partners to pursuing program goals. The council, which meets annually, produces joint policy statements and

[10] Legal scholar Jon Cannon (2000) points out that the principals meet for some period of time without staff, a custom that allows frank exchange and facilitates bargaining.

implementation directives to guide partners' implementation efforts.[10] The EPA-run program office, whose permanent staff is housed in Annapolis, serves as the day-to-day organizational hub for the eleven main federal agencies that operate in the bay watershed, as well as for the participating states.

A testament to the relationships among bay program partners is their ability to forge interstate agreements on watershed management policy, even reaching consensus on specific numeric reduction targets and the strategies to be used for meeting them. In 1987, for instance, the bay states, through the executive council, committed themselves to a 40 percent reduction in "controllable" nutrients entering the Chesapeake's main stem. In 1992, they developed an interstate strategy for meeting those loading reductions: recognizing the importance of managing the waterways feeding the bay, they pledged to develop specific tributary-scale strategies by 1993. With Chesapeake 2000, the states agreed to over 100 specific commitments across five program areas and adopted an even more detailed tributary-strategy approach. As Jon Cannon (2000) observes, "The progressively more elaborate and specific formulations among the parties provides some indication … of successful institution-building in a cooperative setting" (390).

Although the numerous agreements forged among bay partners suggest an impressive level of horizontal integration, the planning documents prepared by the bay program's committees have not always been consistent with those produced by the states. For example, in 2000 a working group of the bay program's Living Resources Subcommittee developed a strategy for restoring 25,000 acres of wetlands by 2010. Subsequently, each state in the watershed and D.C. developed its own tributary strategy that, taken together, would restore over 200,000 acres of wetlands. As the GAO (2005) remarked: "Having such varying targets causes confusion for partners and stakeholders regarding what actions are actually needed; moreover, such an approach seems to contradict the underlying rationale for the program, which is that coordinated action is needed."

More seriously undermining the effectiveness of the bay program's horizontal integration is the fact that historically there have been no mechanisms by which partner states can hold one another accountable. Cannon (2000) contends that the "norms of mutual dependence and cooperation that have been developed in the course of the program offer some protection against forms of strategic behavior such as free riding" (400). In fact, though, the states have implemented joint agreements with very different levels of stringency depending on their political culture and proximity to the bay (Ernst 2003). Maryland, the state with the most direct experience of the bay's problems, almost invariably has taken the lead, while Virginia and Pennsylvania have lagged behind. Maryland established its leadership at the program's inception: in 1984, Governor Harry Hughes stated that the bay was his top priority and that he anticipated spending $15 million in operating costs and $20 million in capital expenditures that year. By contrast, Virginia expected to spend a total of $6 million in year one, and Pennsylvania projected spending $1 million (Phillips 1983).

This pattern of inconsistent effort across states persisted for the next three decades. With respect to sewage treatment, for example, Maryland and D.C. led the way, but—with no incentive to do so—the other states declined to follow. Beginning in the 1980s, Maryland provided a 50 percent cost share to local governments to upgrade their plants to 8 mg per liter of nitrogen with biological nutrient removal (BNR), the most effective treatment available at the time. As a result, by 1998, 23 of the state's 66 significant wastewater treatment plants had BNR, and construction or design was under way on another 20 (Lipton 1998). Meanwhile, in Virginia, state and local governments squabbled over the state's role and whether to focus on the contribution of sewage or agriculture. It was not until the late 1990s that Virginia instituted a cost-share program. As a consequence, only 2 of 31 sewage treatment plants in Virginia's portion of the Potomac and Shenandoah river basins had BNR in place by the late 1990s (Lipton 1998).

By 2000, just 65 of the watershed's 288 major sewage treatment plants had installed BNR; none were employing the best-available technology; and funding for improvements had dried up (Huslin 2003a). The EPA estimated that as much as $4.4 billion would be needed to install state-of-the-art nutrient-removal technology at the watershed's major plants (Blankenship 2008). Finally, in 2003 the EPA—which had deferred to the states' voluntary arrangements for more than a decade—asserted that the states had the "right and obligation" to set nitrogen limits in treatment plants' discharge permits. The bay partners responded to this regulatory crackdown by agreeing to issue permits that contained enforceable nutrient caps and monitoring requirements to the region's significant sewage treatment plants. (This agreement was noteworthy for its comprehensiveness; some of the dischargers were hundreds of miles upstream.) Five years later, the regulatory approach seemed to have had its intended effect: the EPA's inspector general hailed progress in sewage treatment as one of the program's greatest accomplishments; in each state, the largest wastewater treatment plants were on track to meet 95 percent of their 2010 goals for nitrogen reduction and to exceed their phosphorus goals (Blankenship 2008).

With respect to vertical integration, the CBP coordinates baywide activities and provides technical advice to participating entities; with funding from annual appropriations under the Clean Water Act, the program also distributes grants to partner states, NGOs, and academic institutions. But ultimately, the states are responsible for carrying out the policies and practices that will restore the bay, and until 2010 they relied on the implementation of the river-specific cleanup plans known as tributary strategies. Initiated in the early 1990s to implement the 1987 agreement, and reprised with more vigor following Chesapeake 2000, the tributary-strategy approach involved allocating nutrient pollution loads throughout the bay's 36 major sub-basins. It then required each state to devise specific plans to meet those reductions for each sub-basin in its jurisdiction. To formulate those plans, the states assembled diverse teams of stakeholders and asked them to help determine the optimal combination of approved practices—from planting cover crops to building retention ponds to making sewer upgrades—to meet the watershed's allotted reductions. The tributary teams' output was explicitly linked to the program's larger goals: before it could be finalized, each tributary strategy had to be evaluated through the CBP's Watershed Model to confirm that the proposed actions would achieve the nutrient- and sediment-reduction goals assigned for the area under average rainfall conditions (Blankenship 2005a).

But the program's purely voluntary nature undermined the effectiveness of its vertical integration. For example, in Maryland, participation in many tributary teams dropped off over time as it became apparent that, without enforcement or accountability mechanisms or adequate funding, the teams' prescribed reductions could not be achieved (Donegan 2012). Even when teams could agree to reductions across sectors, they were often reluctant to assign them to specific jurisdictions; again, with no authority to ensure changes in behavior, teams hesitated to clarify who should be doing what (Donegan 2012; Shanks 2012). Also, to pass muster with the Watershed Model, the teams devised strategies that rested on unrealistic scenarios; for example, some plans called for the conversion of thousands of acres of agricultural land to wetland in regions where soil conditions were prohibitive. In any case, because of time constraints, and because the plans devised by stakeholder groups did not come close to achieving the reductions necessary to meet program goals, the states ultimately wrote the tributary strategies themselves (McElfish et al., 2006). In the process, they called for levels of implementation that went beyond those agreed to by stakeholders. In fact, the final strategies relied on nearly 100 percent implementation of voluntary actions—an extremely unlikely result (Blankenship 2004).

3.4 Sectoral Integration in the Chesapeake Bay Program

In addition to facilitating technical and institutional integration, the CBP coordinates the activities of the myriad water-use sectors whose participation is essential to the restoration. As the program's Web site observes: "Pollution loads in the Chesapeake Bay watershed come from hundreds of wastewater treatment plants, thousands of farms, and the millions of people who reside and recreate in the watershed. A comprehensive restoration strategy such as the one pursued by the Chesapeake Bay Program may be the only effective way to address an expansive ecosystem that integrates developed areas, agriculture, and natural resources as thoroughly as in the Chesapeake Bay watershed" (CBP N.d.b). The CBP set out to coordinate pollution reduction across sectors by quantifying the contributions of key sectors to the bay's nutrient load. Scientists estimated that roughly one-quarter of the bay's nutrients came from point sources, primarily the major sewage treatment plants in the watershed. More than one-half of the nitrogen and phosphorus came from nonpoint sources, with agriculture being the main culprit and shoreline development the second-largest contributor. Atmospheric sources were responsible for the remainder (Ernst 2003).

The next step was for the program to allocate responsibility for reducing nutrient flows into the bay. Because it would rely so heavily on voluntary behavior change by residents, agricultural interests, municipalities, and local industry, the CBP recognized that it needed to engage stakeholders in formulating and implementing strategies for making these reductions. To that end, the program incorporated stakeholders formally through its citizens advisory committee and local governments advisory committee. It also established more informal consultation mechanisms, like working groups formed to come up with recommendations for actions in each area—from nonpoint source pollution to atmospheric deposition to wetlands (Winegrad 2012). Beginning in the 1990s, the program engaged stakeholders through the tributary-strategy process. According to the CBP, "Citizen involvement in the development review, refinement, and implementation of the tributary strategies [was] a key ingredient." The program went on to say that while each jurisdiction treated the process of engagement differently, "Emphasis was placed on a consensus building process with major 'stakeholders' to reach final recommendations" (CBP 1994, 6).

One of the major sectors targeted by the bay program is agriculture. By the early 1990s, agricultural operations were applying nearly 700 million pounds of commercial fertilizer annually, while also spreading thousands of tons of manure on farm fields in the region (Boesch and Greer 2003). Nutrients not taken up by crops leave the soil by one of three routes: running off the surface, traveling in shallow subsurface pathways, or dissolving in groundwater. Farmers can adopt a host of best management practices (BMPs) to reduce runoff from their operations—such as employing conservation tillage (minimal plowing), applying nutrients under the soil's surface, planting cover crops, building ponds to silt out the soil before it reaches creeks, constructing terraces and grass-planted drainage ditches to filter silt from water, protecting streams with fencing, and installing manure-holding structures. The bay program estimates that fully implementing BMPs could prevent as much as 100 million pounds of nitrogen from entering the bay each year (Ernst 2003).

Anecdotes abound about farmers throughout the watershed who have implemented BMPs or adopted cutting-edge techniques—such as reducing the nitrogen and phosphorus in animal feed, rotational grazing, or subsurface nutrient application—particularly in response to federal incentive programs (Anon. 2008; Blankenship 1994, 2005b; Faber 2005; Kobell 2012; Pipkin 2012). At the same time, however, the bay's agricultural operations, and particularly their trade associations, have persistently denied responsibility for their share of the bay's pollution and resisted efforts to regulate their operations.[11] Maryland has been a leader in regulating agriculture—yet even its efforts have fallen short thanks to resistance by farmers and their political allies. In 1989, Maryland established a Nutrient Management Program, a voluntary nutrient-reduction program designed to help farmers

[11] Agriculture is largely exempt from federal pollution-control regulations. In the 1990s, a farm classified as a concentrated animal feeding operation, or CAFO (more than 1,000 animal units), was required to get a permit under the Clean Water Act's NPDES system or get a state permit, unless it qualified for an exception. In 2003, the EPA issued new CAFO regulations intended to tighten up state requirements, in response to data showing that only 20 percent of the nation's CAFOs had actually obtained permits as of 1997. In 2008, in response to a 2005 judicial decision, the EPA issued revised rules that expanded the regulatory scope of the Clean Water Act by requiring CAFOs to obtain permits if they had the potential to discharge pollution into the nation's waters. In 2011, however, the Fifth Circuit Court of Appeals ruled that the EPA lacked the authority to require CAFOs to obtain discharge permits on the presumption that they would pollute rather than on evidence that they had polluted.

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reduce the runoff from their fields. But that program received inadequate funding and was a low priority for the state government, so few farmers participated. Spurred by the 1997 *Pfiesteria* outbreak, Maryland's General Assembly adopted a more stringent regulatory approach: the Water Quality Improvement Act (WQIA) required all but the smallest farmers to develop nutrient-management plans by the end of 2001 and then to implement those plans or face substantial penalties. State enforcement of the new regulations was lax, however. By the deadline to submit nutrient-management plans, only 20 percent of Maryland's 1.7 million acres of farmland were governed by such plans; only 2,152 of more than 7,000 farms had even submitted plans, while nearly 3,000 farms had filed for delays and the rest had not submitted any forms at all (Ernst 2003). Given the combination of weak regulations and lax enforcement, it was hardly surprising when the USDA concluded in the spring of 2011 that 80 percent of the bay's 84,000 agricultural operations could do a lot more to protect water quality (Blankenship 2011a).

The poultry industry is especially notorious for its resistance to controls on its operations. According to the CBP, poultry manure was the largest source of excess nitrogen and phosphorus reaching the bay from the lowest Eastern Shore of Maryland and Virginia in the 1980s and 1990s (Goodman 1999a).[12] In the chicken trade, large poultry companies supply contract growers with chicks and feed, then reclaim the birds when they are ready to be slaughtered. The simplest arrangement would be for regulators to hold the large producers accountable for the massive volume of manure generated. But the region's five major poultry companies have staunchly resisted that approach. Chicken production is "an intensely competitive business," explains James A. Perdue, president of the Perdue corporation. "If our costs go up, we simply can't survive" (quoted in Goodman 1999b). So the burden of compliance has fallen on the growers, who operate on much thinner margins.

In response to the WQIA, which linked the permits for national poultry processors to the proper disposal of waste, Maryland poultry producers mobilized to fend off efforts to regulate their activities, forming a political action committee to support candidates sympathetic to the industry. In July 1999, a Delmarva trade group kicked off a public relations campaign to counter the image of chicken companies as polluters. "Much of the work that we have done in 1998, and will do in 1999, involves protecting you from government intrusion," Kenneth M. Bounds, president of the Delmarva Poultry Industry, Inc., told growers, bankers, grain salespeople, and others in the chicken business. "Our industry is under attack, and everyone must rally to its defense. Our critics are armed with fear and misinformation. We must overcome them" (quoted in Goodman 1999a). Industry leaders threatened to abandon the region, pointing out that the Delmarva chicken industry was a $1.6 billion business, employing some 14,000 people (Goodman 1999a). Industry lobbying appears to have paid off. In 2007, Governor Martin O'Malley proposed additional regulations on poultry operations, but applied them to only 200 of the 800 largest

[12] According to the EPA, the poultry farms on the Delmarva peninsula create 3.2 billion pounds of waste per year, containing 13.8 million pounds of phosphorus and 48.2 million pounds of nitrogen (Ernst 2003).

companies. In 2008, in response to pressure from the industry, the governor retreated even further, applying the regulations to only 75 operators (Ernst 2009).

Another major set of stakeholders, the bay's 1,650 municipalities, has likewise been unwilling to implement protective measures for the bay. Between 1975 and 1999, suburban development consumed 1.2 million acres of agricultural land in the watershed; in the 1990s, the rate of land conversion more than doubled over the previous decade (Boesch and Greer 2003). During this period, increasing amounts of lawn fertilizers, pet waste, and other contaminants in stormwater runoff added to the bay's nutrient load. Air pollution from the ever-increasing number of automobiles contributed as well. As with agriculture, Maryland moved most aggressively among the bay states to counter these impacts by regulating land use. In 1984, the state assembly passed the Maryland Critical Areas Law, designating a 1,000-foot collar of land surrounding the bay and its tidal waters as the "critical area." The new law allowed intensive building on only 5 percent of the undeveloped shoreline areas; on the remaining 95 percent of undeveloped land, it allowed construction of one house per twenty acres. It also established a 100-foot protective buffer for bayside development. And it created a 25-member Chesapeake Bay Critical Areas Commission to establish criteria for implementing the law at the county and municipal levels. Importantly, the law gave the commission the power to reject a municipality's critical area plan and even to prepare such a plan in the event a jurisdiction failed to do so.

The targets of the law resisted implementing it, however; without penalties or an overarching regulatory framework, each municipality faced disincentives to impose restrictions on development. Before planning criteria took effect, municipalities "grandfathered" thousands of subdivided parcels of less than 20 acres within designated Resource Conservation Areas. Moreover, developers quickly figured out ways to capitalize on vagueness in the law. For example, the law allowed only an average of one house every 20 acres in the critical area. But developers realized they could cluster houses at the shoreline and leave the rest of the land undeveloped, and still meet the letter—if not the spirit—of the law (Meyer 1988). In Anne Arundel County, lack of knowledge among local officials combined with developers' ability to circumvent restrictions allowed more than 40 percent of the shoreline north of the Severn River Bridge to be developed by the early 2000s, while south of the bridge about 70 percent of the shoreline was developed or altered (Huslin 2003a). A 2006 report by the University of Maryland Law Clinic confirmed that the two-decades-old law was not working well. The researchers found that local procedures and criteria varied widely, resulting in weak and uneven enforcement. They concluded that a lack of resources and a variety of legal interpretations led municipalities to favor development and to impose few penalties for violations (Lutz 2006).

Virginia's efforts to curb sprawl were even more ineffectual, as its cooperative approach was easily undermined by savvy developers and local officials unwilling or unable to carry out restrictions. In 1988, Virginia's General Assembly passed the Chesapeake Bay Preservation Act, which affected the 84 independent cities, counties, and towns that border on tidal waters and their tributaries—a region known as Tidewater Virginia. The law created the nine-member Chesapeake Bay Local Assistance Board to oversee the local assistance department that administers the act. The law also created two conservation designations: Resource Protection Areas (RPAs), which include the land most critical to reducing runoff, such as tidal wetlands and non-tidal wetlands connected to tidal wetlands or tributary streams; and Resource Management Areas (RMAs), which contain areas of secondary importance to protecting water quality. Like Maryland, however, Virginia provided exemptions for approved agricultural and forestry practices—a huge loophole (Peter and Harper 2001a). As important, the law gave local governments exclusive to authority to designate the RPAs and RMAs within their jurisdictions.

An analysis by journalists Jennifer Peter and Scott Harper in the early 2000s revealed that developers were easily skirting the law, and most local governments were openly flouting it. Cities routinely approved applications to build within the 100-foot buffer, often without public comment; some developers were allowed to build within 50 feet of the water's edge (Peter and Harper 2001a, 2001b). City officials, worried about antagonizing developers and reluctant to risk infringing on landowners' property rights, declined to enforce the law. The local assistance department lacked the funding, staff, and political support to crack down on localities. Even after the Virginia legislature tightened the law to eliminate loopholes, some municipalities made clear they would resist the new rules (Harper 2002).

3.5 Consequences of Integration for the Chesapeake Bay

Most observers agree that the Chesapeake Bay Program has saved the bay from complete devastation in the face of explosive population growth and rising affluence in the watershed. Even its critics acknowledge that the program has fostered a comprehensive view of the bay as a single, interdependent system. That image, combined with new institutional mechanisms, has facilitated coordinated planning by program partners and sparked action by participating states. Since the bay program began in 1983, states in the watershed have passed legislation banning phosphorus detergents, providing funding to upgrade sewage treatments plants, and encouraging municipalities to combat sprawl and agribusinesses to adopt BMPs.[13] The program has also enabled state and local governments and citizen organizations to raise awareness of and connect the actions of water users to the bay's health. These efforts have, in turn, yielded concrete benefits. For instance, the bay program's effort to promote the planting of forested riparian buffers mobilized legions of volunteers, who in turn planted more than 2,000 miles of buffers by 2002, well before the deadline set in Chesapeake 2000 (Blankenship 2010b). Farmers throughout the watershed have adopted innovative nutrient-management practices, many of them motivated by a desire to minimize their impact on the bay. And citizens have modified their behavior—from improving their landscaping practices to maintaining or replacing their septic systems.

[13] The states have taken measures unrelated to nutrient reductions as well. For example, in 1985, Maryland enacted a ban on fishing for striped bass; four years later, Virginia followed suit. These bans, combined with an aggressive hatchery breeding program, led to a resurgence in striped bass along the Atlantic seaboard.

Yet despite these actions, the bay remains on life support. In 2010, the program's annual Bay Barometer put the health of the bay at 45 percent—with 100 percent signifying a fully restored ecosystem. Nitrogen and phosphorus pollution declined slightly in 2009, but water quality in the bay remained poor; a scant 12 percent of the bay and its tidal tributaries met Clean Water Act standards for dissolved oxygen between 2007 and 2009 (CBP 2010). The 2011 Bay Barometer was delayed, as program officials struggled to revise the model on which its assessments were based. But an annual survey conducted by the Virginia Institute of Marine Sciences revealed that in 2011 there were only approximately 63,074 acres of underwater grasses in the bay, a 21 percent decline from 2010 that was largely the result of extreme weather conditions in the region (CBP N.d.a). According to the report card put out by the University of Maryland Center for Environmental Science, the Chesapeake's overall condition slipped slightly in 2011, for the first time in four years, to a C-minus, or "moderately poor" (CBP 2012).

For many observers, these disappointing environmental outcomes indicate that a more integrative technical understanding of the bay, along with greater institutional and sectoral integration, have not overcome the impediments to restoring the bay's ecological health. There is a broad consensus that the program's voluntary structure and its reliance on non-regulatory mechanisms, in particular, bear the main responsibility for the program's inability to achieve more than minimally beneficial results (Ernst 2003, 2009; Fahrenthold 2008b; Horton 2003). In particular, stakeholders continue to face strong incentives to evade responsibility for cleanup and to engage in activities that pollute the bay. Historically, the CBP has had neither the authority nor the resources to counteract or countermand those incentives, and the states have varied in their willingness to use regulation in the absence of guarantees that their neighbors will follow suit.

In recognition of the pathologies associated with voluntary IWRM, the TMDL released in early 2011 took a far more regulatory approach than the agreements that preceded it. Under the TMDL, every state must implement enough pollution-control measures to attain water-quality goals for the bay by 2025. To ensure that state officials do not procrastinate, 60 percent of those measures must be in place by 2017. Importantly, the TMDL specified a set of sanctions the EPA can invoke if states do not meet their targets. For example, the EPA can require permits for more animal feedlots and stormwater systems than are currently regulated, object to air and water permits issued by the states or require the states to permit facilities covered by less specific guidelines, require "net improvement" offsets for new or expanding discharges, require additional reductions from wastewater treatment plants and other regulated dischargers to compensate for inadequate reductions from unregulated nonpoint sources, step up enforcement and compliance reviews for dischargers, or even issue more restrictive water quality standard for local rivers and streams (Blankenship 2010a).

Ironically, although it has enhanced transparency and accountability, the TMDL may weaken integration among program partners. When they were engaged in voluntary planning, the states operated as equal partners, regardless of their contributions to the bay's problems. The TMDL made clear, however, that the states have different amounts of responsibility, and not everyone relishes this kind of transparency. The TMDL also strained the relationship between the federal government and the states: state officials are reluctant to adopt new, potentially costly goals set by federal agencies in addition to complying with required nutrient and sediment reductions (Blankenship 2010b). For its part, the EPA must simultaneously ensure accountability and try to facilitate cooperation among bay partners. And local officials throughout the watershed are pushing back against the stringent TMDL requirements arguing that, in a period of tight budgets, they lack the resources to ensure the necessary reductions are made. They have joined with agricultural and homebuilding interests to contest the TMDL in court and in Congress.

Despite the chafing, the states have been moving forward. By the end of May 2012, five states and D.C. had submitted Phase II WIPs detailing their nutrient reduction plans at the county and small watershed scale. (According to the EPA, Maryland, D.C., Delaware, and West Virginia submitted strong Phase II WIPs, while Virginia and Pennsylvania submitted improved but still problematic plans. Virginia's plan, for example, failed to provide any clear local targets. New York still had not submitted a final plan (Blankenship 2012a). Furthermore, early results suggest the TMDL approach is having its intended effect: in the summer of 2012, the Chesapeake Executive Council declared that the states had largely met the first set of two-year milestones established in 2009 (Blankenship 2012b).)

4. Conclusion

For most of its history, the "mainstays" of the Chesapeake Bay Program have been "the sense of community and the place we hold in common as citizens of the Chesapeake watershed, and the willingness to make decisions necessary to protect a national resource" (CBP 1994, 10). To its credit, the program has tapped into this sense of stewardship to achieve substantial levels of technical, institutional, and sectoral integration. Although it has stopped short of adaptive management, the bay program has attained relatively high levels of technical integration; it has supported the development of scientific models that create awareness of the bay as a whole, and has prompted diverse experts to collaborate among themselves and with policymakers to devise and evaluate solutions to the bay's problems. Institutional integration, while substantial, has been more modest. The program has facilitated joint goal setting, but translating those goals into policy has been uneven; even when policymaking has been coordinated, enforcement has often been lax. Sectoral integration has faced the most significant obstacles. Although it has illuminated the responsibility of different sectors for the bay's problems and enabled the adoption of conservation practices among willing farmers, municipalities, and developers, the bay program has failed to bring about major changes across the board in stakeholder behavior.

A careful analysis of the Chesapeake Bay case reveals that, although the CBP has enhanced integration in watershed-scale knowledge construction and planning, its reliance on voluntarism has undermined the implementation of jointly crafted program goals. Moral suasion, although effective at times, has not been sufficient to overcome longstanding power arrangements in the absence of resources or regulatory mechanisms that create new incentives. This assessment is broadly consistent with other empirical analyses of the Chesapeake Bay Program (Adler 2000; Ernst 2003), as well as with investigations of IWRM-like initiatives elsewhere in the United States and overseas (Blomquist and Schlager 2005; Fischhendler and Heikkila 2010; Ioris 2005; Layzer 2008). The narrower result about the ambiguous relationship between stakeholder collaboration and beneficial environmental outcomes is also consistent with prior research (Beierle and Cayford 2002; Frank 2009; Lubell 2004; Leach, Pelkey, and Sabatier 2002).[14] These findings suggest that simply devising new forms of interaction is likely to be insufficient to change behavior in a large-scale, complex system. Accountability mechanisms, powerful incentives, and sanctions must accompany more integrative processes and institutions. At the same time, adding a regulatory component to IWRM is unlikely to be a panacea; unless cleverly designed and adequately funded, regulatory tools may undermine cooperation and information sharing.

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