BUG CATCHING FOR THE STATE: GATHERING BASELINE ECOLOGICAL INFORMATION UNDER WAVE

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I. INTRODUCTION

Achieving water quality standards throughout the United States has long been a dream of regulators. In the 1948 adoption of the Federal Water Pollution Control Act and its subsequent amendments in 1956 and 1961, Congress required federal and state governments to meet clean water standards through water quality governance.[1] However, Congress' prescient action was based on sparse information about what would be required to accomplish the monumental task of obtaining

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1 Federal Water Pollution Control Act of 1948, Pub. L. No. 845, 62 Stat. 1155; Pub. L. No. 84–660, 70 Stat. 498 (1956); Pub. L. No. 87–88, 75 Stat. 204 (1961).

clean waterways. During the subsequent adoption of the Clean Water Act ("CWA"), Congress altered its approach to clean water management to focus on the control of point sources, which are specific pollution sources that can be permitted and controlled.[2] Establishing a point source regulatory process provided a key element of regulatory control because it allowed regulators to identify and control end of the pipe effluents, and it provided an immense amount of information about the existing health of aquatic ecosystems throughout the nation. Yet, point source discharge improvements to the CWA did not provide a comprehensive understanding of the quality of our nation's water. Moreover, insufficient public resources to allocate to water quality investigations increased the informational deficiency.

At present, our environmental regulatory system continues to suffer from a lack of information about our nation's water resources.[3] Thousands of miles of waterways have yet to be inventoried and assessed, and there is no reasonable prospect of finding sufficient public funding to complete the task.[4] We are left with inadequate information from which to govern ecosystem functionality, with few tested and available means of data acquisition. This circumstance should be understood as geometrically problematic: informational deficiencies have a tendency to compound themselves across successive blind decisions.

One idea that might prove effective in curbing the informational deficit might be to combine volunteer citizen monitoring with the efficiency of indicator species analysis. The former calls for the assistance of volunteers to gather information about the condition of the environment in specific locations. The latter requires agencies to reduce the complexity of water quality assessment by identifying environmental conditions—specific species and other aspects of ecological structure—that are indicative of water quality conditions.[5]

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[2] Clean Water Act, 33 U.S.C §1362(14) (1977).

[3] *See* Eric Biber, *The Problem of Environmental Monitoring*, 53 U. COLO. L. REV. 1, 14–18 (2011).

[4] *See* U.S. GENERAL ACCOUNTING OFFICE, WATER QUALITY: KEY EPA AND STATE DECISIONS LIMITED BY INCONSISTENT AND INCOMPLETE DATA (2000), *available at* http://www.gao.gov/new.items/rc00054.pdf.

[5] It is not here suggested that the concepts and goals involved in this project are new and novel. Indeed, many state and federal agencies have completed the task of determining how to use local and regional ecological data to assess ecological conditions. *See, e.g.*, N.Y. DEP'T OF ENVTL. CONSERVATION, STANDARD OPERATING PROCEDURE: BIOLOGICAL MONITORING OF SURFACE WATERS IN NEW YORK STATE (2012), *available at* http://www.dec.ny.gov/docs/water_pdf/sbusop12.pdf; MICHAEL T. BARBOUR ET AL., U.S. ENVTL. PROTECTION AGENCY, RAPID BIOASSESSMENT PROTOCOLS FOR USE IN STREAMS AND

Increasingly, state regulatory agencies are implementing citizen monitoring programs and, consequentially, have implemented quality assurance techniques to provide reliable ecological information.

This article will highlight state programs and their corresponding quality assurance techniques as a primer for the introduction of New York's Wadeable Assessment of Volunteer Evaluators ("WAVE") pilot program. Under the WAVE pilot program, the New York Department of Environmental Conservation ("NYDEC") combines the productivity of ecological indicator techniques with the cost-effective labor of citizen volunteers to assess and monitor the health of New York's water bodies. Specifically, WAVE requires that trained citizen participants gather information on the "most wanted" macroinvertebrates in waterways as indicators of stream health.[6]

This article introduces NYDEC's WAVE efforts and outlines the legal framework in which WAVE will produce data on stream health in New York. In addition, this article will highlight the results of the WAVE program and the future of the ecological data that has been collected by volunteer monitors in New York. Although the program is in its infancy—it has been piloted only in the Hudson Valley watershed—and is expected to produce its first data set at the time of publication of this article, the need for the program and its comprehensive structure suggest that it will succeed. Accordingly, this essay identifies the basic regulatory principles at stake and provides insights into the challenges that NYDEC will face as it expands the program throughout the state.

II. SURROGATES, PROXIES, AND ECOLOGICAL INDICATORS

This section introduces the regulatory use of environmental surrogates—also known as proxies, environmental indicators, or ecological indicators. Surrogates allow regulatory agencies to accurately estimate particular environmental conditions by observing interdependent events or those that bear some close correlative relationship.[7] In many cases, the use of ecological surrogates is

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WADEABLE RIVERS: PERIPHYTON, BENTHIC MACROINVERTEBRATES, AND FISH §§ 3.7.2, 3.8.2, 3.9.2 (2d ed. 1999), *available at* http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm.

6 N.Y. DEP'T OF ENVTL. CONSERVATION, QUALITY ASSURANCE PROJECT PLAN: WAVE (WADEABLE ASSESSMENTS BY VOLUNTEER EVALUATORS) (2013), *available at* http://www.dec.ny.gov/docs/water_pdf/waveqapp.pdf.

7 *See generally* James M. McElfish, Jr. & Lyle M. Varnell, *Designing Environmental Indicator Systems for Public Decisions*, 31 COLUM. J. ENVTL. L. 45 (2006); Pac. Shores Subdivision Cal. Water Dist. v. U.S. Army Corps of Eng'rs, 538 F. Supp. 2d 242, 257 (2008)

preferable to a direct study of the environmental condition, such as in the assessment of an endangered or threatened species.[8] An analysis of proxy conditions is simpler and avoids any harassment of a species in decline that may have hard-to-identify characteristics. In such cases, it is safer and more rational to use surrogates when enough information exists on the endangered or threatened species habitat needs.[9]

The use of surrogates to monitor or regulate environmental quality is not new.[10] For instance, the U.S. Forest Service has long recognized that "in many cases it will be impractical to consider each species individually in the planning process."[11] In such cases,

> the Responsible Official may identify a manageable subset of species on which to focus species conservation measures and evaluation in the plan, plan amendment, or plan revision. For this purpose, species groups and/or surrogate species may be used as an evaluation and analysis tool to improve planning efficiency and for development of plan components. When

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(quoting Ariz. Cattle Growers' Ass'n v. Salazar, 273 F.3d 1229, 1249 (9th Cir. 2001)) (discussing that the NFMS may use an ecological surrogate "for defining the amount or extent of incidental take . . . so long as these conditions are linked to the take of the protected species").

8 *See* Gifford Pinchot Task Force v. U.S. Fish & Wildlife Serv., 378 F.3d 1059, 1066–67 (9th Cir. 2004) (holding that the use of changes to habitat as a proxy for the jeopardy to the spotted owl is a sound method and noting that the "test for whether the habitat proxy is permissible . . . is whether it 'reasonably ensures' that the proxy results mirror reality").

9 *See* Northwest Envtl. Def. Ctr. v. U.S. Army Corps of Eng'rs, 817 F. Supp. 2d 1290, 1303, 1304, 1306 (D. Or. 2011) ("Although Congress expressed a preference for quantifying take numerically, NFMS may use a surrogate if no number may be practically obtained."). Using this standard, the court upheld the NFMS's use of a surrogate that related the disturbance of a gravel bar by mining to the take of juvenile coho (fish). The court agreed with NFMS that this surrogate was the "best available indicator for the extent of take," especially noting that the deferential standard of review under the APA precludes the court from concluding, in this case, that the surrogate was arbitrary and capricious. *Id.*

10 *See, e.g.*, ROYAL C. GARDNER, *Mitigation*, *in* WETLANDS LAW AND POLICY: UNDERSTANDING SECTION 404 253, 263 (Kim Diana Connolly et al. eds., 2005) (noting that "[w]here site-specific data are lacking, the Corps may use acreage 'as a reasonable surrogate for no net loss of functions and values"'); *see also* T.M. Caro & Gillian O'Doherty, *On the Use of Surrogate Species in Conservation Biology,* 13 CONSERVATION BIOLOGY 805, 806 (1998), *available at* http://gis.fs.fed.us/emc/nfma/includes/2007_rule/1999_08_Caro%20and%20Doherty%201999.pdf ("Surrogate species are employed to indicate the extent of various types of anthropogenic influence or to track population changes of other species; these types of species are by far the best worked examples.").

11 U.S. FOREST SERVICE HANDBOOK, § 1909.12, ch. 43.24, *available at* http://www.fs.fed.us/im/directives/fsh/1909.12/1909.12_40.doc; *see also Consol. Salmonid Cases*, 791 F. Supp. 2d 802, 881 (E.D. Cal. 2011) ("[W]hen direct evidence or similar evaluations are not available for the species under analysis, NMFS has utilized data and results from the use of surrogates that exhibit strong similarities in physiological needs, in life history stages, and in general behaviors.").

> groups of species have been identified, one or more species within each group may be selected to serve as surrogates for the ecological condition for other species in the group, or surrogate species may be selected based on other concepts such as umbrella species, keystone species, ecological indicators, and so forth. If species groups and/or surrogate species are used, clearly describe the process for identifying groups or surrogates including critical assumptions and the uncertainty of conclusions. Explain why assumptions are reasonable and why the degree of uncertainty is acceptable. Identification and use of surrogate species is strictly an analysis and evaluation tool that may be used to improve planning efficiency.[12]

The directive further explains that "one or more species within each macro-habitat group may be selected as surrogates if they can be demonstrated to represent the ecological conditions for all species in the group," and that, "[i]f the needs of surrogate species are met, then most needs of other species within the habitat group should also be met."[13]

Although there is regulatory familiarity with the use of indicators or surrogates, such programs have faced challenges.[14] The standard of review employed by the courts in deciding whether to overrule agency action requires an "arbitrary, capricious" abuse of discretion, or an action otherwise not in accordance with the law.[15] In deciding whether

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[12] U.S. FOREST SERVICE HANDBOOK, *supra* note 11, at § 1909.12, ch. 43.24 (emphasis added).

[13] *Id.* The concept of selecting a few species to represent a large group of species deemed to have similar habitat requirements is called the MIS, or Management Indicator Species, concept. *See* Sierra Club v. Martin, 71 F. Supp. 2d 1268, 1282 (N.D. Ga. 1996) ("A particular species is chosen as an MIS species because population changes in these species are thought to represent the effects of management activities on the larger group of represented species.").

[14] Virginia H. Dale & Suzanne C. Beyeler, *Challenges in the Development and Use of Ecological Indicators*, 1 ECOLOGICAL INDICATORS 3, 5 (2001) (discussing problems associated with use of ecological indicators in facilitating narrow, oversimplified management programs); Vincent Carignan & Marc-André Villard, *Selecting Indicator Species to Monitor Ecological Integrity: A Review*, 78 ENVTL. MONITORING & ASSESSMENT 45, 50–52 (2002) (reviewing problems associated with the use of indicator species to monitor ecological integrity). *See generally* U.S. GAO, ENVIRONMENTAL INDICATORS: BETTER COORDINATION IS NEEDED TO DEVELOP ENVIRONMENTAL INDICATOR SETS THAT INFORM DECISIONS, 5–7 (2004), *available at* http://www.gao.gov/products/GAO-05-52 (discussing challenges to the use of environmental indicators, which include "ensuring that a sound, balanced process is used to develop indicators," "obtaining sufficient data on environmental conditions and trends and their conditions," and "coordinating and integrating the various related federal and other indicator sets in order to advance knowledge about the environment").

[15] Administrative Procedure Act, 5 U.S.C. § 706(2)(A); *see also* Ariz. Cattle Growers' Ass'n v. U.S. Fish & Wildlife, 273 F.3d 1229, 1236 (9th Cir. 2001); Pyramid Lake Paiute Tribe of Indians v. U.S. Dep't of the Navy, 898 F.2d 1410, 1414 (9th Cir. 1990) (stating that under section 706 of the Administrative Procedure Act, the reviewing court must determine that agency

an agency decision was arbitrary and capricious, a court will assess "whether the decision was based on a consideration of the relevant factors and whether there has been a clear error of judgment."[16] This standard is highly deferential to the agency decision-making process.[17]

An instructive—though vague—standard was developed by the federal district court in Oregon in *Oregon Natural Desert Association (ONDA) v. Tidwell*.[18] ONDA involved a challenge to a Biological Opinion ("BO" or "BioOp") prepared by the National Marine Fisheries Service ("NMFS") in the preparation of an incidental take statement ("ITS") for steelhead trout. The plaintiffs alleged that grazing management practices had resulted in harm to steelhead, which were listed as threatened under the Endangered Species Act ("ESA"). Permittees alleged violations of the ESA by establishing arbitrary grazing limitations.

NMFS prepared a BO to assess the relationship between grazing and threats to the continued existence of listed steelhead populations. In the BO, NMFS recognized the difficulties of documenting an actual "take" of a listed endangered species and instead relied on ecological circumstances as a benchmark. Specifically, NMFS decided to design species monitoring that focused on gauging stream bank stability, which

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decisions are not "arbitrary, capricious or an abuse of discretion, or otherwise not in accordance with the law," and that absent such arbitrariness, capriciousness, or abuse of discretion, "[t]he court is not empowered to substitute its own judgment for that of the agency").

16 Motor Vehicles Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43 (1983); *see also* Pac. Shores Subdivision Cal. Water Dist. v. U.S. Army Corps of Eng'rs, 538 F. Supp. 2d 242, 248 (D.D.C. 2008) (quoting Motor Vehicles Mfrs. Ass'n, 463 U.S. at 43) ("An agency rule is arbitrary and capricious if 'the agency has relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise.'").

17 In *Idaho Sporting Congress, Inc. v. Rittenhouse*, 305 F.3d 957 (9th Cir. 2002), the Forest Service employed a "proxy on proxy" approach to meeting the requirement of maintenance of the species in the area, explaining that "[b]y monitoring the health of the pileated woodpecker population, the health of a wide range of other species which use similar habitat would be monitored as well." *Id.* at 962. The Court struck down the Forest Service's indicator species program because the Forest Service's own monitoring report found that the approach using the old growth habitat of the woodpecker for monitoring was invalid and inadequately implemented (considering that the Forest Plan identified land as containing old growth which did not actually contain old growth). *Id.* at 972–75; *cf. Forest Service Evaluation of Grazing Impacts on Sage Grouse Invalidated by Ninth Circuit*, ENDANGERED SPECIES L. & POL'Y (March 18, 2010), *available at* http://www.endangeredspecieslawandpolicy.com/2010/03/articles/court-decisions/forest-service-evaluation-of-grazing-impacts-on-sage-grouse-invalidated-by-ninth-circuit/ (discussing the Ninth Circuit's refusal to uphold the Forest Service's use of a proxy on proxy approach when "the habitat proxy does not reasonably ensure viable populations of the species at issue").

18 716 F. Supp. 2d 982 (D. Or. 2012).

is pivotal to stream health and steelhead trout. Yet, stream bank stability, which is loosely defined as the ability of stream banks to maintain structure and function against water flow and pressure, is not easily measured. As such, NMFS opted to measure stream bank alteration instead as a proxy for "take" of steelhead trout.[19]

The district court employed a functional view of ecological indicators to understand the use of stream banks as proxies. The court reasoned that under the ESA,

> an ITS "sets forth a 'trigger' that, when reached results in an unacceptable level of incidental take, invalidating the safe harbor provision, and requiring the parties to reinitiate consultation." When possible, the trigger is a specified number of the protected species that may be incidentally taken. However, as here, where it is difficult or impossible to measure the number of a species harmed by an action, "the use of ecological conditions as a surrogate for defining the amount or extent of incidental take is reasonable so long as these conditions are linked to the take of the protected species." When establishing a habitat proxy for take in an ITS, the NMFS need not "demonstrate[] a specific number of takings" but "must

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19 The BO defines bank alteration as follows:

> Bank alteration occurs when cattle walk on the streambank and their hoof prints expose at least 12 millimeters (mm) (about 1/2 inch) of bare soil, their hooves break vegetation, and leave hoof print at least 12 mm deep, or they compact soil by walking over the same area repeatedly even if their hooves displace or sink into the soil less than 12 mm. Linear amount of broken streambank resulting from hoof shearing is also considered.

716 F. Supp. 2d at 998. This is not the first time that NMFS has found the measuring of streambank alteration to be reliable in determining the take of a protected species. *See* NATIONAL MARINE FISHERIES (NMFS) POSITION REGARDING BANK ALTERATION AS THE BEST AVAILABLE INDICATOR FOR THE EXTENT OF INCIDENTAL TAKE FOR THE PROPOSED GRAZING STRATEGY ON ALLOTMENTS IN THE MALHEUR NATIONAL FOREST (MNF) (2009), *available at* http://www.blm.gov/or/esa/files/nmfs_position_statement.pdf. The NMFS approved the use of bank alteration as an appropriate monitoring indicator in the Malheur National Forest (MNF) Biological Assessment for 2007-2011 livestock grazing, which listed the possible adverse effects that the livestock grazing could have on listed Middle Columbia River steelhead. In the biological assessment, it was stated that "bank alteration is the relative measure of damage to a stream bank that is directly attributable to livestock of all the end-point indicators; it is 'probably the most important.'" *See also* Ctr. for Biological Diversity v. Salazar, 695 F.3d 893, 911–12 (9th Cir. 2012) (noting "an ITS may 'utilize[ ] a surrogate instead of a numerical cap on take,' so long as it 'explain[s] why it was impracticable to express a numerical measure of take'"); Wild Fish Conservancy v. Salazar, 628 F.3d 513, 531 (9th Cir. 2010) (citing Ariz. Cattle Growers', 273 F.3d at 1250–51) (noting the ITS also "must articulate a rational connection between the surrogate and the taking of the species").

> establish a link between the activity and the taking of species before setting forth specific conditions."[20]

Here, the NMFS established a link by showing specific percentage bank reductions as triggers for additional species and habitat review.[21]

Challengers to the ITS argued that the ITS should not be issued because of questionable connections amongst bank alteration, bank stability, sedimentation, and other steelhead habitat impacts. The challengers also argued that the use of bank alteration standards was arbitrary because of the high margin of error in making bank alteration measurements. The court disagreed with the alleged lack of causal connection, stating that "[t]he fact that the NMFS is not unable to determine exactly how many steelhead will be harmed at a specified level of bank alteration provides no basis to set aside their expert determination."[22]

In addition, the court marginalized the effect of error in using bank alteration as a proxy. The court held that

> [t]he administrative record suggests that the margin for error is a significant problem and can range from four to eleven percent. However, the degree of error can be reduced through training and the margin of error is lower at alteration levels below twenty percent. That the bank alteration standard is subject to inaccurate measurement is problematic. However, because it strikes a balance in favor of the species, as it must, and fulfills what has been "termed the 'institutionalized caution mandate' of the ESA," the court does not find it to be arbitrary and capricious.[23]

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20 716 F. Supp. 2d at 999 (internal citations omitted).

21 *Id.* at 999. However, in *Oregon Natural Resources Council v. Allen*, 476 F.3d 1031, 1038 (9th Cir. 2006), the Ninth Circuit struck down a BO that gave no explanation as to why the Fish and Wildlife Service could not quantify the level of take of the northern spotted owl. In that case, the BO discussed how the surveys of the northern spotted owl had been discounted or reduced, and FWS provided no reason as to why it was not possible to update the surveys so as to obtain an estimate of the number of takings. *Id.* at 1037–38.

22 Or. Natural Desert Ass'n v. Tidwell, 716 F. Supp. 2d at 999.

23 *Id.* at 999–1000. *See generally* Memorandum from the Regional Technical Team to the Interagency Coordinators Subgroup (Dec. 10, 2009) (on file with the author) (discussing how some channel types and streambank alterations are "more susceptible to SA [Streambank Alteration] than others," and that "[t]herefore, it is not possible to definitively determine whether any particular level of SA by itself, particularly in a single year, is likely to lead to adverse effects to listed fish or their habitat").

The court justified its deferential approach by stating that the type of prediction that NMFS made was "within its area of special expertise, at the frontiers of science."[24]

In the case of *Miccosukee Tribe of Indians of Florida v. United States,* the court was not willing to defer completely to the judgment of the agency. Plaintiffs argued that an ITS by the Fish and Wildlife Service ("FWS") was invalid because of its reliance on a habitat marker instead of a numerical trigger for three endangered species in the Everglades: the sparrow, snail kite, and wood stork.[25] In analyzing FWS's decision to use a habitat marker over a numerical trigger, the court employed the following standard:

> If an agency's incidental take statement uses an ecological surrogate as a trigger instead of a number, the agency must establish that 1.) "no such numerical value could be practically obtained," and 2.) that the "use of ecological conditions as a surrogate for defining incidental take . . . [is] linked to the take of the protected species."[26]

The court analyzed whether the use of a numerical trigger would be impractical regarding the three endangered species. The court articulated three practicality factors: "1.) the availability and quality of actual or estimated population figures; 2.) the ability to measure incidental take; and 3.) the ability to determine the extent to which incidental take is attributable to the action prompting the biological opinion and the incidental take statement."[27]

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24 716 F. Supp. 2d at 999 (citing Lands Council v. McNair, 537 F.3d 981, 993 (9th Cir. 2008)). Other courts have deferred to judgments of agencies and commissions on the grounds that the predictions being made are "within its area of special expertise, at the frontiers of science." *See Consol. Salmonid Cases*, 791 F. Supp. 2d 802, 821 (E.D. Cal. 2011) ("What constitutes 'best' available science implicates core agency expertise to which Congress requires the courts to defer; a court should be especially wary of overturning such a determination on review."). *See generally* Balt. Gas & Elec. Co v. NRDC, 462 U.S. 87, 103 (1983) ("[A] reviewing court must remember that the Commission is making predictions, within its area of special expertise, at the frontiers of science. When examining this kind of scientific determination, as opposed to simple findings of fact, a reviewing court must generally be deferential.").

25 Miccosukee Tribe of Indians of Fla v. United States, 697 F. Supp. 2d 1324, 1329 (S.D. Fla. 2010).

26 *Id.* at 1331 (quoting Ariz. Cattle Growers Ass'n v. U.S. Fish and Wildlife, 273 F.3d 1229, 1250 (9th Cir. 2001)).

27 *Id.*; *see also* Swan View Coal. v. Barbouletos, No. CV 06-73-M-DWM, 2008 U.S. Dist. LEXIS 56677, at *58 (D. Mont. 2008) ("Where a numerical value cannot practically be obtained, [FWS] may express take using ecological conditions as a surrogate, provided that there is a scientifically supported link between ecological surrogate and the take of the protected species *and* the Service has given an adequate explanation as to why numerical expression of take is impractical."); Ariz. Cattle Growers' Ass'n v. U.S. Fish and Wildlife, 273 F.3d 1229, 1250 (9th

The court deferred to FWS staff that the use of numerical triggers for the snail kite and wood stork would be impractical. The wide geographical distribution of the populations complicated the study's methodologies and made it difficult to account for region-specific ecological circumstances.[28] However, the court was not willing to defer to the agency's judgment when it came to the use of a habitat marker for the sparrow. The court held that FWS did not provide sufficient reasons as to why a numerical trigger could not be used over a habitat marker, thus finding the amended ITS regarding the sparrow arbitrary and capricious.

In reaching this conclusion, the court looked at alternatives that FWS should have considered in deciding whether it was practical to use a numerical trigger. Unconsidered alternatives included "establishing a numerical trigger measured by changes in sparrow population estimates, establishing a trigger that combines changes in population estimates with ecological surrogates, or establishing an ecological surrogate that is adequately supported by a showing of the impracticality of using a numerical trigger."[29] The court pointed out that, in the amended ITS, FWS stated that the available population estimates provided a reliable trend in population estimates over time.[30] While this did not establish that it was practical to use a numerical trigger, neither did it establish that it was impractical.

Deferral to an agency's decision was again denied in *San Luis & Delta-Mendota Water Authority v. Salazar*.[31] The delta smelt was classified as an endangered species under the ESA.[32] FWS produced a BO in 2008 that found that proposed water supply projects would jeopardize the viability of the delta smelt.[33] The water project suppliers challenged the 2008 BO.[34]

Cir. 2001) ("Moreover, while Congress indicated its preference for a numerical value, it anticipated situations in which impact could not be contemplated in terms of a precise number.").

28 *Miccosukee Tribe of Indians of Fla.*, 697 F. Supp. 2d at 1346; *see also* Ariz. Cattle Growers' Ass'n v. U.S. Fish and Wildlife, 273 F.3d 1229, 1250 (9th Cir. 2001) ("In the absence of a specific numerical value, however, the Fish and Wildlife Service must establish that no such numerical value could be practically obtained.").

29 *Id*. at 1341.

30 *Id*. at 1336.

31 760 F. Supp. 2d 855 (E.D. Cal. 2010).

32 50 C.F.R. §17.11 (2013).

33 *San Luis,* 760 F. Supp. 2d at 864.

34 *Id*.

The 2008 BO had five main components designed to limit the amount of water exported from the Delta through the water projects,[35] based on monitoring and analyzing the flows of the Old and Middle Rivers ("OMR"). In analyzing FWS's BO, the court employed the following standard:

> Under the ESA, an agency's actions must be based on "the best scientific and commercial data available." In formulating its Biological Opinion, any reasonable and prudent alternatives, and any reasonable and prudent measures, the [agency] will use the best scientific and commercial data available . . . A failure by the agency to utilize the best available science is arbitrary and capricious.[36]

The court noted the best available science standard looks to the best available science at the time of the decision, reasoning that "[an] agency cannot wait for or promise future studies."[37] A court will defer to an agency's judgment in deciding what constitutes the best available science. However, the court cautioned that the standard did not require judicial blinders. For instance, the court would be compelled to forego deference to an agency's expertise in the event that an agency relied on "ambiguous studies as evidence" or unexplained scientific reasoning, or the agency showed a disregard for "available scientific evidence better than the evidence on which it relies."[38]

The 2008 BO called for flows of the OMR to be set within specific ranges. The court found that the 2008 BO failed to use the best available science when analyzing the upper and lower OMR flow limits. Specifically, the court rejected the methodology employed in the BO to

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35 *Id.* at 864–65; *see also Consol. Salmonid Cases*, 713 F. Supp. 2d 1116, 1159 (E.D. Cal. 2010) (citing Greenpeace Action v. Franklin*,* 14 F.3d 1324, 1337 (9th Cir. 1992)) ("Mere uncertainty, or the fact that the evidence may be "weak," is not fatal to an agency decision.").

36 *San Luis,* 760 F. Supp. 2d at 871 (quoting Pac. Coast Fed'n of Fishermen's Assns. v. Gutierrez, 606 F. Supp. 2d 1122, 1144 (E.D. Cal. 2008)).

37 *Id.*; *see also* Ctr. for Biological Diversity v. Rumsfeld, 198 F. Supp. 2d 1139, 1156 (D. Ariz. 2002) ("This standard recognizes that the best available scientific evidence will most likely always be available in the future.").

38 *San* Luis, 760 F. Supp. 2d at 872 (citing Kern Cnty. Farm Bureau v. Allen, 450 F.3d 1072, 1080 (9th Cir. 2006)). Courts have reiterated that the "best available standard is not unlimited." *See Consol. Salmonid Cases*, 791 F. Supp. 2d at 822; *see also* Tucson Herpetological Soc'y v. Salazar, 566 F.3d 870, 879 (9th Cir. 2009) (holding that "ambiguous studies" may not be used as evidence in order to support agency findings under the ESA); Rock Creek Alliance v. U.S. Fish & Wildlife Serv., 390 F. Supp. 2d 993, 1088 (D. Mont. 2005) (rejecting a BO's reliance on a disputed scientific report).

estimate salvaged fish numbers because the methods were contrary to those found in standards of fisheries management.[39]

Although courts have generally deferred to the expertise of agencies, judicial review of ecological indicator regulations has shown that courts disagree with the agencies' use of ecological proxies. In this developing law, judges may play an increasingly important role in the determination of whether agencies choose reliable indicators in appropriate circumstances.

III. CITIZEN MONITORING OF THE ENVIRONMENT

Although environmental science research can be technical and complex, observations of the natural world can be made by anyone. Some disciplines have grasped this truth more effectively than others: amateur bird watching, for instance, produces volumes of information on avian trends, population, migrations, and habitat persistence that might otherwise be difficult to access.[40] In some circumstances, volunteer monitoring projects[41] may be able to fill various informational gaps that presently pose significant obstructions to effective environmental and conservation regulations.

In 1972, the New York State Department of Environmental Conservation ("NYDEC") implemented a biological monitoring program for the state.[42] The Federal Water Pollution Control Act mandated a biological assessment of the state's water resources, which

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39 *San Luis*, 760 F. Supp. 2d at 889 ("There is widespread agreement among the scientific experts that the use of normalized salvage data rather than gross salvage data is the standard accepted scientific methodology among professionals in the fields of fisheries biology/management.").

40 *See* THE CORNELL LAB OF ORNITHOLOGY, CITIZEN SCIENCE (2012), *available at* http://www.birds.cornell.edu/page.aspx?pid=1664 ("Each day, bird watchers report tens of thousands of bird observations to citizen-science projects at the Cornell Lab of Ornithology, contributing to the world's most dynamic and powerful source of information on birds.").

41 Volunteer monitors may be associated with a governmental program at the state, local, or federal level, or they may answer to independently run organizations. *See* U.S. ENVTL. PROT. AGENCY, THE VOLUNTEER MONITOR'S GUIDE TO QUALITY ASSURANCE PROJECT PLANS ch. 1 (1996), *available at* http://www.epa.gov/owow/monitoring /volunteer/qapp/vol_qapp.pdf.

42 *See* N.Y. DEP'T OF ENVTL. CONSERVATION, DIVISION OF WATER, STANDARD OPERATING PROCEDURE: BIOLOGICAL MONITORING OF SURFACE WATERS IN NEW YORK STATE 4 (2012) [hereinafter STANDARD OPERATING PROCEDURE], *available at* http://www.dec.ny.gov/docs/water_pdf/sbusop2012.pdf. *See generally Federal Water Pollution Control Act (Clean Water Act)*, U.S. FISH & WILDLIFE SERV., http://www.fws.gov/laws/lawsdigest/FWATRPO.HTML (last visited Nov. 24, 2013) ("The Federal Water Pollution Control Act Amendments of 1972 . . . stipulated broad national objectives to restore and maintain the chemical, physical and biological integrity of the of the Nation's waters.").

New York sought to accomplish through the collection and analysis of macroinvertebrate species as indicators of ecological conditions.[43] Although the 1972 program's aspirations may have been more modest than that of contemporary programs, its use of macroinvertebrates was thought to be cost-effective by the NYDEC for several reasons:

> 1) They are sensitive to environmental impacts, 2) they are less mobile than fish, and thus cannot avoid discharges, 3) they can indicate effects of spills, intermittent discharges, and lapses in treatment, 4) they are indicators of overall, integrated water quality, including synergistic effects and substances lower than detectable limits, 5) they are abundant in most streams and are relatively easy and inexpensive to sample, 6) they are able to detect non-chemical impacts to the habitat, such as siltation or thermal changes, 7) they are readily perceived by the public as tangible indicators of water quality, 8) they can often provide an on-site estimate of water quality, 9) they bioaccumulate many contaminants, so that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain, and 10) they provide a suitable endpoint to water quality objectives.[44]

At the time, NYDEC biological professionals conducted the entire biological monitoring program—a luxury that has disappeared today, as smaller state governments possess fewer resources for such programs.[45] Today, despite the existence of rapid and cost effective techniques for collecting macroinvertebrate indicators, most government regulators

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43 *See id*.

44 *See id*. at 4. For a discussion of the lack of resources for monitoring and managing water resources, see generally STANFORD L. LOEB & ANNE SPACIE, BIOLOGICAL MONITORING OF AQUATIC SYSTEMS, PART 15 156 (1994), *available at* http://books.google.com/books?hl=en&lr=&id=J1bbo7JS__8C&oi=fnd&pg=PA1&dq=Karr,+James+R+1994.+Biological+monitoring:+challenges+for+the+future.&ots=z73x9TQAni&sig=qfI9XeAllpPdOAYgp9c5jGzgxWA#v=onepage&q=professional&f=false ("Thus the question is what can we impart to non-professional lotic investigators, or those with incomplete levels of professional training, to enable them to accomplish these tasks of monitoring and management? It should be remembered that the notion of management of natural systems is really quite arrogant, and ability to monitor does not imply an ability to manage.").

45 *See* STANDARD OPERATING PROCEDURE, *supra* note 42, at 10; *see, e.g.*, *Illinois Volunteer Lake Monitoring Program*, ILLINOIS ENVTL. PROT. AGENCY, http://www.epa.state.il.us/water/vlmp/index.html (last visited Nov. 24, 2013) (discussing how the use of volunteer monitors in the Volunteer Lake Monitoring Program (established by the Illinois EPA) serves not only as an educational program for citizens but as a cost-effective method of gathering important information regarding Illinois inland lakes); *see also* SHANNON HUBLER, WADEABLE STREAMS CONDITIONS IN OREGON 6 (2007), *available at* http://www.deq.state.or.us/lab/techrpts/docs/DEQ07-LAB-0081-TR.pdf ("We are unable to access approximately 36% of the perennial wadeable streams in Oregon—primarily due to access denials from private landowners and a smaller portion were not sampled due to unsafe conditions or inaccessibility.").

cannot conduct the hundreds of tests required to assess thousands of miles of streams.[46]

One of the largest national monitoring programs in the United States is the Wadeable Streams Assessment ("WSA"), which is coordinated by EPA. This program has endeavored to produce defensible information on the condition of the nation's smaller water bodies.[47] Under this program, private consultants collect benthic macroinvertebrates that aid in the biological assessment of wadeable streams.[48] The program studied wadeable streams in the continental United States; assessment field crews were able to sample 1,392 streams.[49] The EPA model uses professional monitors to conduct stream assessments, which is a luxury many states cannot currently afford.

Trained volunteer monitoring programs have helped states to improve their water quality inventory in a cost-effective and reliable manner.[50] In 1985, New York set in place the Citizens Statewide Lake Assessment Program, which collected high quality data, identified problems and alterations, and educated the public on water quality needs for the state's lakes.[51] Citizen volunteer monitors performed the essential tasks, which reduced the state government's financial burden. The program trained volunteers to use approved sampling methods and to deliver their results to certified labs for testing. Professionals interpreted the data, and their conclusions were entered into a statewide database used in the management of New York's water resources.[52]

In response to an increase in citizen-led monitoring programs, a 1993 conference was held to address concerns regarding the implementation

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46 Sarah R. Engel & J. Reese Voshell, Jr., *Volunteer Biological Monitoring: Can It Accurately Assess the Ecological Condition of Streams*, 48 AM. ENTOMOLOGY 164, 165 (2002), *available at* http://www.vasos.org/images/stories/docs/Engel&VoshellAmerEnto2002.pdf.

47 U.S. ENVTL. PROT. AGENCY, WADEABLE STREAMS ASSESSMENT: A COLLABORATIVE SURVEY OF THE NATIONS ES4 (2006) [hereinafter WSA COLLABORATIVE SURVEY], *available at* http://water.epa.gov/type/rsl/monitoring/streamsurvey/upload/2007_5_16_streamsurvey_WSA_Assessment_May2007.pdf.

48 *Id.* at 20.

49 U.S. ENVTL. PROT. AGENCY, http://water.epa.gov/type/rsl/monitoring/streamsurvey/ (last visited Feb. 7, 2014); *see also* NATIONAL PARKS SERVICE, UPPER COLUMBIA BASIN NETWORK INTEGRATED WATER QUALITY MONITORING PROTOCOL: STANDARD OPERATING PROCEDURES VERSION 1.8 262 (2013), *available at* http://science.nature.nps.gov/im/units/ucbn/publications.cfm?tab=3&ProtocolWaterQuality=open#ProtocolWaterQuality ("The sampling of aquatic macroinvertebrates is reasonably efficient compared to other biotic indicators . . . and consequently, is relatively cost-effective.").

50 Engel & Voshell, *supra* note 46, at 165.

51 N.Y. STATE DEP'T OF ENVTL. CONSERVATION, THE BEGINNING OF CITIZENS STATEWIDE LAKE ASSESSMENT PROGRAM (2013), *available at* http://www.dec.ny.gov/chemical/81790.html.

52 *Id.*

phases of citizen volunteer monitoring programs that use macroinvertebrate indicators.[53] Several states have implemented programs; however, reliability concerns still exist. This section highlights the quality standards used in volunteer programs—state and federal—to deliver reliable data that can be used for regulatory purposes.[54] This brief discussion of ongoing programs, including EPA's WSA program, provides a range of approaches used by volunteers to assess water quality through indicator species. Close consideration reveals distinct strengths and weaknesses as to how different programs manage data collection by non-professionals.

A. U.S. Environmental Protection Agency and Wadeable Streams Assessment

Although it has not used volunteers, EPA has been at the frontier of assessing the biological conditions of wadeable streams. In 2000, EPA launched a robust, statistically-driven biological assessment of wadeable streams throughout the United States.[55] The WSA was designed to facilitate the assessment of water quality and biological conditions of wadeable streams. The CWA sparked the need for information

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53 Engel & Voshell, *supra* note 46, at 165.

54 Other volunteer water quality assessment programs include the Michigan Clean Water Corps (MiCorps), which is a state program that trains volunteers to collect ecological information from streams and lakes using benthic macroinvertebrates to assess the biological conditions of local water bodies. Additionally, in Michigan, the volunteers are trained to conduct visual assessments of stream conditions and watershed characteristics and report their findings. *See About MiCorps*, MICHIGAN CLEAN WATER CORPS, http://www.micorps.net/about.html (last visited Nov. 24, 2013). Similarly, in Iowa, the Iowa Water Monitoring (IOWATER) program uses volunteer monitors for a three-tiered assessment, including biological, physical, and chemical monitoring. IOWA VOLUNTEER WATER QUALITY MONITORING, http://www.ipm.iastate.edu/ipm/icm/2002/12-23-2002/iowater.html (last visited Nov. 24, 2013). IOWATER has resulted in the training of 1,300 volunteers across the state, making this water quality monitoring program a successful one. The IOWATER program standardizes a biological, physical, and chemical analysis, including counts of present benthic invertebrates; a watershed analysis, habitat assessment, turbidity, water temperature and stream flow; and observations of dissolved oxygen, pH, nitrate and phosphate levels in the water. *Id.* On an international level, the Global Water Watch program helps communities around the world establish volunteer groups which then monitor the physical, chemical, and biological condition of watersheds. GLOBAL WATER WATCH, http://www.globalwaterwatch.org/GWW/GWWeng/GWWhomeEng.aspx (last visited Nov. 24, 2013). Global Water Watch implements four different monitoring methods for watersheds: water chemistry monitoring, bacteriological monitoring, stream bio-monitoring, and total suspended solids and stream discharge monitoring. *Methods*, GLOBAL WATER WATCH, http://www.globalwaterwatch.org/GWW/GWWeng/ GWWmethodsEng.aspx (last visited Nov. 24, 2013).

55 *Wadeable Streams Assessment*, U.S. ENVTL. PROT. AGENCY, http://water.epa.gov/type/rsl/monitoring /streamsurvey/index.cfm (last visited Nov. 24, 2013).

regarding the water quality and condition of our nation's streams.[56] Through the WSA, EPA has successfully gathered information in a consistent and valid manner, which can be compared regionally and shared amongst the states.[57]

In order to manage the "first nationally consistent, statistically valid study of the nation's wadeable streams," the WSA process was designed to provide states with the funding and expertise to enhance their water quality monitoring and biological assessment of streams.[58] The WSA process drives the manner and quality of information gathering and is guided by three questions: how sampling sites should be chosen, how the streams should be assessed, and how to set reasonable expectations for comparison.

The WSA employs a modern survey design that accommodates a large range of components—namely streams. To ensure the target streams are wadeable and perennial, the WSA team relies on the National Hydrography Datasheet and the River Reach File to locate subject streams and determine each segmented region's length of streams. The 1,392 tested stream sites were picked at random by a probability-based sample design in which "every element in the [targeted] population has a known probability of being selected for sampling." Fifty sites were drawn randomly for each region, referred to as ecoregions.[59]

Next, EPA devised a sampling method that would allow for consistent and statistically valid results.[60] The WSA program uses benthic macroinvertebrates as indicators of a stream's biological condition because they accurately reflect the quality of a habitat, and they respond predictably to human disturbances.[61] Macroinvertebrates

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56 WSA COLLABORATIVE SURVEY, *supra* note 47, at ES4.

57 The purpose of the WSA program was fourfold: (1) to report on the ecological condition of all wadeable and perennial streams within the United States, (2) to use aquatic life as a way to measure the biological condition of the various wadeable streams, (3) to identify and rank chemical and physical stressors, and (4) to enhance the ability of the state to implement design and measuring tools similar to the WSA. *Id.* at ES5.

58 *Id.* at 3.

59 Choice of ecoregions also included identification of a large number of replacement sites. Replacement sites were used when selected sites were determined to be improper for testing due to lack of sufficient water, safety concerns, or access problems with private landowners. *Id.* at 17.

60 EPA stated that trained crews would sample selected streams in a uniform manner. The field crews took water and biological samples, including the collection macroinvertebrates. A standardized method of collecting samples was employed to allow for consistent results throughout the national survey. *Id.* at 20.

61 *Id.* at 27; *see also Benthic Macroinvertebrates*, ENVIROSCIENCE, http://enviroscienceinc.com/benthic-macroinvertebrates/ (last visited Nov. 24, 2013) ("Benthic macroinvertebrates . . . represent a choice group of organisms for use in biological monitoring

attach to the rocks and debris, burrow under the stream bottoms, and reside along the stream's edge. Macroinvertebrates serve as food sources for fish. They are widespread and are consistently present under particular ecological circumstances; specifically, the integrity of a stream is reflected in its capability to support certain macroinvertebrate species.[62] As such, macroinvertebrates can serve as indicators throughout the geographic area being tested.

In the WSA process, macroinvertebrate samples are collected by research teams and sent to laboratories for identification. EPA receives information on the classification or grouping of macroinvertebrates from each site (known as the "taxa "of the macroinvertebrates).[63] The various metrics indicating a stream's biological condition include taxonomic richness, taxonomic composition, taxonomic diversity, feeding groups, habitats, and pollution tolerance.[64]

The WSA program also assesses aquatic stressors that may impact the stream's health. During this assessment, the WSA process is intended to determine the presence of a stressor but not the source. However, these stressors are often the result of human activity. The WSA process focuses on three types of stressors. First, the assessment looks for chemical stressors, including total phosphorus, total nitrogen, salinity, and acidification. Second, the assessment identifies physical habitat stressors, such as streambed sediments, in-stream fish habitat,

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programs . . . . Unlike fish, these populations tend to be relatively immobile, and as a result are continuously exposed to the constituents of the surface water they inhabit."); *Benthic Macroinvertebrates*, THE LOWER FOX RIVER WATERSHED MONITORING PROGRAM, http://www.uwgb.edu/watershed/data/monitoring/macroinvertebrates.htm (last visited Nov. 24, 2013) ("Generally speaking, mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), and riffle beetle larvae (Coleoptera) require a relatively pristine environment. Macroinvertebrates highly tolerant of pollution include midge larvae (Diptera), snails (Gastropoda), leeches (Hirundinea), and aquatic worms (Oligochaeta). Organisms such as scuds (Amphipoda), clams (Bivalvia), crayfish (Decapoda), cranefly larvae (Diptera), and aquatic sowbugs (Isopoda), are somewhat tolerant, and are found in a wide variety of water conditions.").

62 WSA COLLABORATIVE SURVEY, *supra* note 47, at 21.

63 Taxonomic richness tries to identify any distinct taxa (group of macroinvertebrates) that may indicate a certain biological stressor (e.g. pollution). Taxonomic composition identifies different taxa groups to determine ecologically vital organisms. These taxa groups are then compared to the entire sample to assess its impact. *Id.* at 29. For example, an unhealthy stream would have a high number of macroinvertebrates that are within a pollution-tolerant taxa, as compared to other groups of macroinvertebrates. Taxonomic diversity examines all taxa groups and then calculates the organisms within that group. A diverse collection is an indicator of a healthy stream. The feeding groups of macroinvertebrates will reveal the changing nature and consistency of the stream, which can be a basis to indicate its biological condition. Lastly, pollution tolerance is used as a metric because some macroinvertebrates have the capability of tolerating a high level of pollution and therefore indicate poor water quality. *Id.*

64 *Id.*

riparian vegetative cover, and riparian disturbance. Third, the assessment identifies biological stressors, such as might be evidenced by the presence of non-native species.[65]

To establish baseline or benchmark ecological conditions for purposes of comparison and reference, the WSA program identifies "least disturbed" streams. Least disturbed sites "represent the best available chemical, physical, and biological habitat conditions given the current state of the landscape."[66] These least disturbed sites were identified in accordance with explicit screening tools to define what is least disturbed by human activity. Within each region, least disturbed reference sites were tested and the results were used to establish benchmarks for various thresholds—good, fair, and poor biological condition.[67]

The WSA was groundbreaking because it contemplated a more comprehensive collection of ecological information than conventional water quality sampling and made the collected information more accessible than programs that depended on agency resources. Nevertheless, EPA's program was essentially a compilation of ideas from pre-existing state biological assessment programs.

B. Virginia's Training Program

Virginia's Save Our Streams ("VASOS"), a volunteer stream monitoring program, was founded in 1989 to further a national watershed education and outreach program.[68] The VASOS program uses citizen volunteers to collect ecological data from approximately 400 stream sites.[69] The program trains volunteers in biological monitoring of streams and rivers, which uses the presence, absence, or abundance of aquatic indicator species—macroinvertebrates—to rate the biological conditions of Virginia's streams and rivers.[70] Complementing the program is the quality assurance requirements that guide volunteers' sampling techniques to ensure reliable and consistent data. The quality

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[65] *Id.* at 46–48.

[66] *Id.* at 23.

[67] *Id.* at 24.

[68] *Save Our Streams*, THE IZAAK WALTON LEAGUE OF AMERICA, http://www.iwla.org/index.php?ht=d/sp/i/1977/pid/1977 (last visited Nov. 24, 2013) (noting that the national watershed education and outreach program is the Izaak Walton League of America Save Our Streams (SOS) program).

[69] VIRGINIA SAVE OUR STREAMS, http://www.vasos.org (last visited Oct. 18, 2012).

[70] *VA SOS Policy on Data Use*, VIRGINIA SAVE OUR STREAMS, http://www.vasos.org/component/content/article/5-whats-new/14-va-sos-policy-on-data-use-.html (last visited Nov. 24, 2013).

assurance project plan focuses on training of volunteers, procedures, study design, data management and analysis, and specific quality control measures.

Before volunteers can collect macroinvertebrates, they must attend at least one training session by a VASOS staff or regional trainer.[71] After the training sessions, the volunteer must become certified during a practice period in which they perfect their sampling and identification skills.[72] In addition, the VASOS program requires volunteers to pass a test, achieving at least eightyfour percent accuracy.[73] The test includes hands-on sample testing techniques and identification of macroinvertebrates that are examined by a trained professional.[74] All certified volunteer monitors must be audited every two years to maintain certification, which involves certain quality control assurances that must be strictly followed.[75]

In Virginia, all levels of quality assurance oversight have guidelines that must be met. For example, the Quality Assurance Officer ("QAO") shall periodically review and check volunteer equipment, relay observations to the VASOS, and assist volunteers in sample preservation.[76] To become a QAO, a volunteer must be certified for at least six months and attend two monitoring events, at which the volunteer must demonstrate precise sampling techniques.[77]

Regional training staff are monitored and subjected to rigorous quality assurance procedures. The trainers must observe at least two training sessions conducted by VASOS staff, achieve 100 percent accuracy on the macroinvertebrate portion of the certification test, have their first training session evaluated by VASOS staff, undergo annual performance reviews, and conduct at least one training session and certify at least one volunteer per year.[78]

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71 *VA SOS Quality Assurance Program: Volunteer Monitors*, VIRGINIA SAVE OUR STREAMS, http://www.vasos.org/quality-assurance.html (last visited Nov. 24, 2013) [hereinafter *VA SOS Quality Assurance Program*].

72 *Id.*

73 Engel & Voshell, *supra* note 46, at 166.

74 *Id.* To ensure that volunteers remain certified, they shall not be absent from sampling for eighteen months, or six sampling events; otherwise, they will lose certification. *VA SOS Quality Assurance Program*, *supra* note 71.

75 *VA SOS Quality Assurance Program*, *supra* note 71. The quality assurance audit includes a field visit by the quality assurance auditor, who reviews the volunteers' sampling methods, equipment, and ability to preserve the sample. The specimens collected during the audit will be sent to the VA SOS coordinator to re-identify, checking the volunteers' accuracy. *Id.*

76 *Id.*

77 *Id.*

78 *Id.*

The VASOS program employs a unique sampling methodology relative to other volunteer monitoring collection methods. Under the VASOS program, organisms are released back into the stream[79] after the volunteers collect the samples[80] and the presence of each organism is recorded. This practice is dissimilar from other programs because the VASOS program does not require preservation of the organisms to be verified by professionals in a lab. The state is therefore relying on the ability of the volunteers to correctly assess and identify the individual macroinvertebrates as well as entire macroinvertebrate categories within each stream.[81]

The VASOS program's heavy reliance on volunteer monitors and use of the data for regulatory purposes increases the need for quality control and assurance. An incorrect assessment by volunteer monitors can lead to an agency misclassifying stream conditions.[82] However, the program has largely relied on the assumption that proper volunteer training and a comprehensive quality assurance plan can ensure the accuracy of the assessments to the level necessary for reliable use in regulatory decisions.[83]

One way to address the risk of inaccurate volunteer reporting is to subject the results of volunteer-gathered data to independent verification. Many programs, including VASOS, ensure data quality by requiring reviews by professionals who retest and reevaluate sites

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79 *Id.*

80 The VA SOS program uses three individual kick net samples, whereby the kick net is placed in a riffle habitat by one volunteer while a second volunteer disturbs the rocky subsurface to free the organisms into the net. Once the collection is complete, the organisms are picked from the net and sorted by taxa to be identified based on previous training and picture aids. Engel & Voshell, *supra* note 46, at 166.

81 Three categories of macroinvertebrates have been identified based on the organisms' sensitivity to polluted water: sensitive, somewhat sensitive, and tolerant. *Id.* To determine the stream's ecological condition, the VA SOS program has developed a calculus that involves multiplying the number of taxa present in each category by a tolerance value and then adding the results to provide a water quality measurement for the stream.

82 Engel & Voshell, *supra* note 46, at 175 ("If volunteers conclude that a stream is impaired, when in truth is it not, regulatory actions can be triggered that will waste the time and meager budget of professional biologists, as well as cause significant negative socioeconomic consequences. If volunteers conclude that a stream has acceptable ecological conditions, when in truth it is impaired from human activities, the problem will likely worsen and cause significant damage to the environment that could have been avoided by accurate early detection. Thus, the consequences of inaccurate volunteer biological monitoring may be worse than not making any official use of volunteer data. However, our study has shown that this does not have to be the case.").

83 *Id.* at 165.

assessed by volunteers.[84] On three different occasions, the VASOS program compared the results from volunteers and professionals in an effort to perfect the accuracy of their data. The first report was finalized in 2002 and involved the concurrent sampling of twenty-three stream sites.[85] Professional samples were also taken at historical sites where volunteers had collected and recorded data in the past. The results displayed moderate deviations between the professional and volunteer results, which were noted as potentially impacting the reliability of the data for official use by an agency.[86]

The question became whether the discrepancies resulted from the collection methods or the calculated analysis employed by the VASOS program.[87] The most likely source of discrepancy was in overlooking or misunderstanding the relevance of certain abundant and particularly tolerant (or facultative) taxa groups, which if found in high numbers represent moderate water quality disturbances.[88] VASOS calculations for ranking water quality were potentially culpable for the varied results because the calculations were based purely on the presence or absence of taxa and did not focus on the abundance of macroinvertebrates; thus, the calculations weighed all taxa evenly.[89] For example, the calculation treated one pollution-sensitive organism equally to hundreds of pollution tolerant organisms, resulting in inaccurate data.[90] While volunteers were asked to estimate the abundance of macroinvertebrates, the estimate was not reflected in the final water quality calculation.[91]

Researchers proposed modifications to the VASOS protocol to correct for potentially inaccurate data. Two such modifications included enhancing the identification process to lower taxonomic levels (family) and adding the abundance of macroinvertebrates into the water quality calculation.[92] Yet, any change made must consider the ability of volunteer monitors to accomplish the new protocol in the field. As such,

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84 For instance, in Connecticut, collection methods were modified after a professional review, which resulted in more accurate volunteer data. Conversely, a study in the State of Washington proved that volunteer data was very accurate when compared to professional resampling. Mixed results were found in North Carolina, where volunteers were only able to identify streams with enhanced water quality, and in Ohio and Illinois, where volunteers overrated the water quality of many streams. *Id.*

85 *Id.* at 165.

86 *Id.* at 175.

87 *Id.* at 168.

88 Engel & Voshell, *supra* note 46, at 169.

89 *Id.*

90 *Id.*

91 *Id.*

92 *Id.* at 170.

a more intensive family level identification of all macroinvertebrates was deemed to be infeasible for volunteer monitors.[93] Researchers determined that the only feasible solution would be to incorporate a numerical score based on calculations that account for the abundance of various organisms within each sample.[94] A multi-metric index was created to integrate all of the ecological data in a comprehensive manner, which led to more accurate information.[95]

In 2006, the Department of Entomology at Virginia Tech reexamined the modifications made in 2002 to assess any changes in the accuracy of volunteer data.[96] This report found that there were still considerable differences between the volunteer data and the professional data.[97] The report hypothesized that the discrepancy was due to the type of metrics—"cutoffs numbers" for type and quantity of macroinvertebrates—that designated a stream as either acceptable or unacceptable.[98] The problem was resolved by raising the cutoff number for acceptable streams, as a higher cutoff number was more accurate when compared to professional assessments.[99]

A third validation study was completed in 2007 to determine whether using volunteers to collect macroinvertebrates for water quality assessments was appropriate for use by Virginia's Department of Environmental Quality ("DEQ") in its CWA mandated reports (CWA § 303(d) and 305(b)).[100] The results showed that volunteer monitors had the ability to appropriately identify the macroinvertebrates, yielding a mean percentage of correctly identified organisms of 95% (with a range of 89% to 98%).[101] However, data only accurately reflected the ecological condition of 69% of the sites tested.[102] The report concluded that this low percentage, while useful for prioritizing professional

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93 *Id.*

94 Engel & Voshell, *supra* note 46, at 170.

95 *Id.* at 172.

96 *See* J. REESE VOSHELL, JR. & STEPHEN W. HINER, VALIDATION OF THE MODIFIED VIRGINIA SAVE-OUR-STREAMS PROTOCOL (2006), *available at* http://www.vasos.org/images/stories/docs/Rept-VaSOS-Validate-2005-061.pdf.

97 *See id.* at 4–5.

98 *See id.* at 8.

99 *See id.* at 13. Furthermore, if Virginia seeks to have a "gray zone," marking the presence of uncertain water quality, the report recommended that criterion be set at a score of eight. *Id.*

100 ANDREW L. GAREY & LEONARD A. SMOCK, COMPARISON OF VIRGINIA SAVE OUR STREAMS AND VIRGINIA STREAM CONDITION INDEX SCORES IN STREAMS OF THE EASTERN PIEDMONT OF VIRGINIA 3 (2007), *available at* http://www.vasos.org/images/stories/docs/SOS%20report%20%28revised%207%20Feb%29.pdf.

101 *Id.* at 7.

102 *Id.* at 12.

testing areas and citizen engagement, is not accurate enough for the reporting required by the CWA §§ 303(d) and 305(b) listings.[103]

C. Connecticut's Rapid Bioassessment Model

In 1990, Connecticut initiated a stream monitoring program that similarly utilizes citizen monitors to collect water quality data based on indicator species, more specifically macroinvertebrates.[104] The program seeks to increase the amount of data that is collected and analyzed by the Department of Energy & Environmental Protection ("CTDEEP"). As such, the Rapid Bioassessment by Volunteers ("RBV") program produces standardized methods for collecting usable volunteer data.[105]

For the collection of macroinvertebrates, the CTDEEP has identified three methods that may be appropriate for any stream assessment program. Each method has a greater degree of technicality that must be considered for the style of program being implemented. Furthermore, the CTDEEP states that the intended use of the data should guide the method of data collection.

The most technical level of sampling is the Species Level ID method, which requires very experienced personnel and produces definitive water quality assessments. The CTDEEP notes that Species Level ID is not recommended because it is not practical and takes months of species identification. The second most difficult methodology is the Family Level ID, which requires personnel with some experience and produces somewhat definitive water quality assessment. This method takes between a few days to a week for a complete assessment because it requires rigorous identification with the family level key and microscope. Lastly, the Field Based ID is suggested by the CTDEEP for any volunteer monitoring program because it requires little experience to conduct an assessment and is a screening tool for very high or low water quality. The Field Based ID involves a two-hour training session,

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103 *Id.*

104 The indicators used in the RBV program are riffle-dwelling benthic macroinvertebrates present in freshwater streams and rivers. Similar to other programs, The DEP has recognized that macroinvertebrates are very sensitive to environmental stressors and therefore well suited to determine environmental perturbation that result from the introduction of pollutants. *See* CONN. DEP'T OF ENERGY & ENVTL. PROT., RAPID BIOASSESSMENT IN WADEABLE STREAMS & RIVERS BY VOLUNTEER MONITOR: PROGRAM DESCRIPTION, VERSION 3 (2012) [hereinafter RAPID BIOASSESSMENT BY VOLUNTEERS], *available at* http://www.ct.gov/deep/lib/deep/water/volunteer_ monitoring/rbvpt1.pdf.

105 Important to the data collecting method is the use of straightforward equipment, standardized, inexpensive, and rapid testing. RAPID BIOASSESSMENT BY VOLUNTEERS, *supra* note 104, at 3.

an onsite sampling and identification process by trained volunteers, and a verification process conducted by trained entomologists.[106] The Field Based ID methodology is applied by the CTDEEP in the RBV program.

In order to identify macroinvertebrates that correlate with stream health, the CTDEEP separated macroinvertebrates into three identifiable categories: most wanted (representing good water quality), moderately wanted (representing minimum good water quality), and least wanted (representing poor water quality). The RBV program does not involve the technical multi-metric approach to the identification and assessment process. This sampling method is developed to yield screening results of good and poor water quality at a rapid rate with a standardized reliable procedure.[107]

To test the accuracy of the Field Based ID, the CTDEEP compared its results to assessments conducted on certain reference sites that were designated minimally impaired (reflecting the best attainable water quality conditions) by the Species Level ID methodology. A minimum of four, a mean of seven, and a maximum of nine most wanted macroinvertebrates were found at these sites, which indicated good ecological condition. The comparison concluded that a sample of seven or more most wanted macroinvertebrates from a site represents the best attainable water quality conditions.[108] In addition, the comparison showed that a sample of four most wanted macroinvertebrates indicates that the water body is capable of fully supporting aquatic life. From the analysis, it was concluded that water bodies with four or more most wanted species are at most slightly impaired and are in fact very close to best attainable.[109]

The CTDEEP also recognizes that the absence of most wanted macroinvertebrates is not a *per se* indicator of poor water quality. Where no most wanted macroinvertebrates are found, the CTDEEP notes that further analysis and testing may be required to definitively identify organisms present, characteristics of land use, and any potential sampling and methodology errors. Therefore, the most definitive data produced are from the presence of most wanted indictors, representing good water quality.[110]

When using volunteer monitors, the CTDEEP has recommended using a three-tiered approach. The first tier includes periodic visual

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106 *Id.* at 7.
107 *Id.* at 9.
108 *Id.* at 11.
109 *Id.* at 12.
110 *Id.*

observations to identify the physical condition of water bodies. The second tier includes the RBV program conducted by volunteer monitors that will utilize the Field Based ID methodology. Lastly, a more specific monitoring project can be completed including a detailed quality assurance and quality control plan. This tier of monitoring is not initially recommended because of its time-prohibitive technicalities.

The RBV program's Quality Assurance Project Plan ("QAPP") was approved by EPA and was found to be in accordance with EPA's Requirements for Quality Assurance Project plans.[111] The QAPP discusses all quality control aspects of the program that allow the CTDEEP to rely on the volunteer data. Included in this discussion is a required training session for all volunteer monitors. A one-day training session is conducted with the CTDEEP volunteer monitoring coordinator, who provides a presentation and guides fieldwork to train volunteer monitors on collecting samples.[112]

The QAPP also accurately describes the sampling process to ensure the results are standardized and reliable. Volunteer monitors gather riffle habitat macroinvertebrates, identify the sample and sort by organism type, and place a specimen (one of each type) into a vial, where the sample is preserved for the volunteer coordinator. At this time, the volunteers use the field identifications to identify the macroinvertebrates and then record the findings on the field data sheet.[113] The CTDEEP volunteer coordinators verify all of the specimens collected and correct misidentifications. While these steps are taken to ensure that precision and accuracy are protected in the methodology, the CTDEEP states that this method of collecting "does not support measurable precisions nor accuracy/bias calculations."[114]

To ensure that the data collected are a good representation, sampling segments are limited to riffle habitats within wadeable stream sections. The volunteer monitors are required to perform a traveling kick at six locations along the riffle habitat. A traveling kick requires the volunteer to shuffle and kick and otherwise physically displace stones on the stream bed to free macroinvertebrates from their shelter and hiding places, which then travel in the current into the volunteer's net. The

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111 Memorandum from Arthur E. Clark, Chemist, EPA, Quality Assurance Office, to Larry MacMillian, EPA, Conn. State Team (Apr. 30, 2003), *available at* http://www.ct.gov/deep/lib/deep/water/volunteer_monitoring/qapp.pdf.

112 *Id.* at 7.

113 CONN. DEP'T OF ENERGY & ENVTL. PROT., RAPID BIOASSESSMENT IN WADEABLE STREAMS & RIVERS BY VOLUNTEER MONITORS, INSTRUCTIONS 5 (2009), *available at* http://www.ct.gov/deep/lib/deep/water/volunteer_ monitoring/rbvpt2.pdf.

114 Memorandum from Arthur E. Clark, *supra* note 111, at 9.

volunteer monitor coordinator is tasked with rotating through the groups of volunteers to make sure participants are complying with program requirements.[115] Volunteer supervisors, including CTDEEP coordinators or a volunteer participant with over two years of sampling experience, help preserve the quality of samples taken by less experienced volunteers.

Any deficiencies identified during sampling are to be documented on the field data sheet and forwarded to the DEP coordinator. The monitoring staff and field crew supervisors discuss all deviations to reach a consensus as to corrective actions. The corrective actions are based on the intended use of the data. For example, if the deviation or condition jeopardizes the use of the data, then sampling is suspended until the issue can be resolved. Most common jeopardizing conditions include stream flow, habitat, or accessibility issues.[116]

D. Challenges to Volunteer Data Collection

Volunteer monitoring programs face significant challenges and require agencies to develop a quality assurance plan for the collection and interpretation of the ecological data, as even energetic, dedicated volunteer monitors may be seen as poor substitutes for the extensive education and training of professionals. For example, in a successful volunteer monitoring program that detects trace pollutants as they occur in waterways or the air, volunteers must collect evidence of a highly specialized and sophisticated nature. As such, the program will need to provide expertise to support the information-gathering process.[117] It has been noted that volunteer monitoring of trace pollutants may require a higher precision of analysis than can be produced by volunteers.[118] To alleviate this concern, Eric Biber notes that volunteer monitoring should follow certain guidelines: " a.) the monitoring techniques are relatively inexpensive and simple; b.) the effectiveness of the volunteer monitoring program is relatively simple for auditors or outsiders to assess (to reduce the perception of bias); and c.) the continuity of the monitoring program over time is less important."[119]

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115 *Id.* at 9.

116 *Id.* at 12–13.

117 *See* Eric Biber, *The Problem of Environmental Monitoring*, 53 U. COLO. L. REV. 1, 24 (2011).

118 *Id.* at 59.

119 *Id.* at 59. On this basis, the Audubon Christmas Bird Count (CBC) occurs every year from December 14th through January 5th. *Christmas Bird Count*, NATIONAL AUDUBON SOCIETY, http://birds.audubon.org/christmas-bird-count (last visited Dec. 23, 2013). The CBC helps to inform conservationists of strategies that are needed to protect birds and their habitats,

EPA has responded to this concern with increased planning from the top-down. The Office of Research and Development administers EPA's quality-assurance programs.[120] The Office of Research and Development has the following responsibilities:

> Evaluation and standardization of total measurement systems—sampling, analysis, data collection and presentation; preparation of quality assurance criteria, guidelines and manuals; preparation and distribution of reference samples and materials; interlaboratory testing of systems' and operator performance; on-site inspection of laboratories and performance audits; data audits and development of statistical methodology; and quality assurance assistance and participation in training programs.[121]

Participation in these quality assurance measurements is required by "all Regional Offices, Program Offices, EPA Laboratories, and those

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particularly because bird populations can serve as accurate indicators of the effects of habitat fragmentation, water contamination, or improper pesticide use. *How the Christmas Bird Count Helps Birds,* NATIONAL AUDUBON SOCIETY, http://birds.audubon.org/how-christmas-bird-count-helps-birds (last visited Dec. 23, 2013). Volunteers throughout the United States and Canada report on the incidence of all bird species seen or heard, as well as weather details and other facts relevant to the presence or perception of bird species. *Audubon's Christmas Bird Count—Tallying the Birds of the Americas for over a Century,* VIMEO, http://vimeo.com/47611445# (last visited Dec. 23, 2013). All the data collected by these volunteers are reported to compilers, who then consolidate and enter the data into an online CBC database. Biber suggests that this is a "plausible" method for bird monitoring: "[T]he CBC uses extremely simple methodologies, occurs only once a year, and involves an activity (bird-watching) that many people do for fun on their own." Biber, *supra* note 117, at 59.

Not all believe that bird counting provides credible information. For instance, the National Audubon Society has stated that "because count effort is not uniform or standardized, the proportion of the true population that is counted each year and in each location is highly variable." NATIONAL AUDUBON SOCIETY, IMPROVING THE CHRISTMAS BIRD COUNT: REPORT OF A REVIEW PANEL 35 (2004), *available at* http://web4.audubon.org/bird/cbc/pdf/104_034-43REPORTfeature.pdf. Furthermore, according to Audubon, "density of count location is correlated with human population density." *Id.* Therefore, data analysts tend to take steps to avoid over-representation of geographic areas where the population is dense.

In theory, the methodology could be improved upon. Audubon, for instance, suggested standardization and accounting for redundancies. *Id.* at 123. On the other hand, bird counting might be understood to benefit from sampling size and might be flexible enough to allow biases to be held as constants. Of course, most bird counting programs "only rely on a selected list of common species . . . [that are] are generally the easiest to detect and the most abundant." Vincent Devictor, Robert J. Whittaker, & Coralie Beltrame, *Beyond Scarcity: Citizen Science Programmes as Useful Tools for Conservation Biogeography*, 6 DIVERSITY AND DISTRIBUTIONS 354, 356 (2010), *available at* http://vincent.devictor.free.fr/Articles/Devictor_CitizenScience_2010.pdf.

[120] Memorandum from James H. Finger, Dir., EPA Surveillance & Analysis Div., to Div. Dirs. & Office Chiefs, EPA Surveillance & Analysis Div. 1 (July 6, 1979), *available at* http://www.epa.gov/region07/air/nsr/nsrmemos/quality.pdf.

[121] *Id.*

monitoring and measurement efforts supported or mandated through contracts, regulation or other formalized agreement."[122] EPA has published a guide for volunteers to promote quality assurance of project plans.[123] This publication outlines ways in which volunteer monitoring programs can aim to ensure the quality of their results, "not only to convince skeptical data users about the quality of the project's findings, but also to record methods, goals and project implementation steps *for current and future volunteers* and for those who may wish to use the project's data over time."[124]

All volunteer monitoring programs are subject to challenges regarding the competency of the results because the public may believe individual monitoring groups have agendas that may influence the validity of the data collected.[125] Additionally, because the methods of information gathering by volunteer monitors are administered by private individuals who are not bound by public duties of obligation to public offices, they may be vulnerable to claims of agency capture and agency favoritism. Yet, vulnerabilities in this context may not be fatal. This section examines New York's Water Assessments by Volunteer Evaluators ("WAVE") program, administered by the state's Department of Environmental Conversation ("NYDEC"), and highlights the various quality assurance controls designed to implement the science of environmental surrogates while taking advantage of the economics of volunteer environmental monitoring and producing statistically valid and reliable data.

IV. NYDEC'S WAVE PILOT PROJECT

While the previous section identified challenges for both indicator-based regulations and baseline information gathering by non-experts, this section provides an examination of the NYDEC's WAVE project to illustrate how the project's use of macroinvertebrates as indicators of aquatic health may be able to avoid challenges and secure the information needed to govern water quality in New York.

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122 *Id.*

123 ENVTL. PROT. AGENCY, THE VOLUNTEER MONITOR'S GUIDE TO QUALITY ASSURANCE PROJECT PLANS (Sept. 1996), *available at* http://water.epa.gov/type/rsl/monitoring/upload/2002_08_02_monitoring_volunteer_qapp_vol_qapp-2.pdf.

124 *Id.*

125 Biber, *supra* note 117, at 23.

A. New York's WAVE

The NYDEC is currently experimenting with its WAVE program. WAVE employs the assistance of volunteer citizen monitors to assess the health of streams in the Hudson River watershed. The goal of the WAVE project is to produce baseline impairment information on previously unassessed stream segments as a part of New York's biological monitoring program.[126] Similar to EPA's WSA program, WAVE has identified certain metrics to guide their analysis of biological conditions in order to provide a reliable study.[127]

WAVE benefitted from the experiences of several states and the New York State Stream Biomonitoring Program. Data collection under WAVE relies on trained citizen volunteers (citizen monitors) that collect the biological samples of macroinvertebrates and evaluate other aquatic stressors to indicate stream health and water quality. Of course, with the use of citizen monitors, certain variables must be controlled; without the same expertise and certification as the NYDEC/industry professionals, citizen monitors are not expected to evaluate streams to the same standard of the biological monitoring program operated by NYDEC employees. To alleviate concerns about volunteer monitors, the NYDEC prepared a Quality Assurance Project Plan that establishes safeguards that are relevant to producing consistent and statistically valid data.[128]

Before the volunteer monitors can begin conducting their first assessments, they must select stream segments they wish to evaluate and submit their preferences for NYDEC approval. On its face, the site selection process allows NYDEC to prioritize particular streams, manage the data collection process. The review process also encourages volunteers to choose nearby NYDEC historic sampling locations and dissuades volunteer efforts at sites like headwater streams or slow sandy

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126 This program is the result of a federal mandate under the Federal Water Pollution Control Act of 1972.

127 In addition to the biological monitoring program, the results of the WAVE project will be used for various DEC activities and requirements. Unimpaired sites identified by citizen monitors will be included for Waterbody Inventory and Clean Water Act 305(b) reporting. In addition, the data will guide trend monitoring reports and rotating integrated basin studies, as well as provide basic background information on water quality for DEC personnel working on non-point source discharges.

128 N.Y. DEP'T OF ENVTL. CONSERVATION, QUALITY ASSURANCE PROJECT PLAN: WAVE (WATER ASSESSMENTS BY VOLUNTEER EVALUATORS) 7 (May 20, 2013) [hereinafter WAVE Quality Assurance Project Plan], *available at* http://www.dec.ny.gov/docs/water_pdf/waveqapp.pdf.

streams, where physical characteristics of the stream make accurate assessments difficult.[129]

Second, each citizen monitor must attend a training session to gain an overview of the project, hands-on instruction on appropriate and acceptable data collection methods, and to learn how to identify the various macroinvertebrate indicators. Completion of training certifies monitors to take and report stream samples during the sampling season, which runs from July through September.[130] One specimen from each species identified is then preserved in a collection container and submitted to the NYDEC to ensure proper macroinvertebrate identification.

Finally, the volunteer monitors conduct a "user perception" survey of the tested stream. The survey asks monitors to evaluate the visual and recreational qualities of the site. Many of the questions contemplate more subjective responses, which are then correlated with the recorded occurrence of more objective measures, such as water clarity, levels of phytoplankton, periphyton, and macrophyte cover, as well as the presence of odor, trash, and discharge pipes.[131] Importantly, the survey asks the monitors whether they would be willing to use the water at various levels of contact and exposure, such as swimming (the highest degree of user contact, called "1st degree contact") or fishing ("2nd degree contact").

The macroinvertebrate data reporting sheet is organized by species that are "Most Wanted" and those that are "Least Wanted." Where they are present, species on the "Most Wanted" list serve as indicators of a high quality, unimpaired stream segment, which is defined by the NYDEC as a stream that has the capacity to "fully support aquatic life and include waterbodies with no known impacts, threatened waterbodies and water with minor impacts."[132] As a general rule, the NYDEC will designate a stream unimpaired if four or more "Most Wanted" macroinvertebrates have been collected and properly identified. On the other hand, if four or more "Least Wanted" specimens are identified, the stream will be deemed possibly impaired and will

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129 *Id.* at 13.

130 WAVE Quality Assurance Project Plan, *supra* note 128, at 8. Monitors will complete two tasks during the sampling process. First, they will use kick nets to collect the indicator specimens (macroinvertebrates), sift through the collection, and identify each macroinvertebrate type. Next, monitors will record the results on a data sheet and place a sample of each species found in a collection container to deposit with the DEC.

131 WAVE ASSESSMENT OF RECREATIONAL USE PERCEPTION, http://www.dec.ny.gov/docs/water_pdf/wave userper.pdf (last visited Feb. 4, 2014).

132 WAVE Quality Assurance Project Plan, *supra* note 128, at 7.

require additional evaluation by the NYDEC. If four or more organisms from each category are found in the stream, the segment will be designated unimpaired.[133]

B. WAVE's Challenges

Not surprisingly, the use of citizen volunteer monitors in a scientific process raises legitimate concerns about the consistency, credibility, and validity of volunteer evaluative efforts. The Quality Assurance Project Plan considers a variety of these common concerns and provides a detailed description of how the accuracy of the testing will be preserved.

The NYDEC feels strongly that the "Most Wanted" indicator metric will accurately identify *unimpaired* streams. This metric was derived from an analysis of approximately 6,000 professionally assessed sites within the NYDEC's Stream Biomonitoring database. A total of 1,857 sites in the database had four or more of the "Most Wanted" macroinvertebrates. Of those, 99.4 percent were correctly identified as unimpaired according to the most wanted metrics.[134] Therefore, the NYDEC determined that when using the most wanted indicators the possibility of a false positive is incredibly low.

In contrast, the NYDEC metric for *impaired* streams has a high risk of false positives. For this calculation, NYDEC found 570 sites in the professionally assessed database that offered four or more of the "Least Wanted" specimens. However, only 61 percent of these sites were actually deemed impaired, suggesting a problematic risk of false positives for identifying impaired streams under the WAVE methodology. To mitigate the accuracy concern caused by a high risk of false positives, the NYDEC re-inspects any streams identified by citizen monitors as having four or more "Least Wanted" specimens.[135]

Although citizen monitors are trained in collection methods, it cannot be assumed that they will precisely follow the standardized data collection methods; perhaps it is not enough that the WAVE project suggests a low risk of false positives for identifying unimpaired streams. This concern is alleviated in several ways. First, an External Data Coordinator compares the results recorded on the data sheet and the contents of the voucher collection to ensure proper macroinvertebrate identification. If a specimen is present in the voucher collection container but not recorded on the data sheet, the species will be added to

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133 *Id.* at 8.
134 *Id.* at 9.
135 *Id.* at 10.

the data sheet. Conversely, if a macroinvertebrate is recorded on the datasheet but is not present in the voucher collection, the NYDEC will remove the species from the datasheet.[136] This process is intended to minimize the risk of macroinvertebrate misidentification.

Second, all assessed sites deemed possibly impaired through the WAVE methodology must be confirmed through a professional assessment. NYDEC is likely to perform this confirmation, but limited resources may impede its assessment.

Third, the External Data Coordinator randomly selects and performs an independent assessment of stream segments used as test sites for quality assurance and effectiveness. The citizen monitor notifies the coordinator when they will sample the selected stream, allowing the coordinator to professionally test that stream within two weeks after the monitor.

Fourth, the WAVE pilot project has a zero tolerance policy on falsified data. The primary data produced from the WAVE pilot project includes the specimen contents and associated recorded data. NYDEC reviews each sample, and if a citizen monitor is found to have intentionally submitted false data, the citizen will be excluded from the WAVE pilot project indefinitely. False information and data could include falsified user perception surveys or data sheets and included specimens and collection locations of stream segments identified on the collection container label.[137] This control illustrates that the External Data Coordinator will always act as the last safeguard, ensuring proper and reliable data. When submitting samples, all sample contents must be properly labeled; site locations must be approved by the External Data Coordinator in accordance with the Quality Assurance Plan; data sheets must be accompanied by a voucher collection; and user perception surveys must be complete. If these standards are not met, the Coordinator will not accept the data or collections. Furthermore, the coordinator may reject suspect data for any reason, even one not listed.[138]

C. WAVE's Final Report 2012

In response to the 2012 sampling season, the NYDEC examined the data collected under the WAVE program and analyzed the program's effectiveness. The fate of the program and the potential to use the data

136 *Id.*
137 *Id.* at 16.
138 WAVE Quality Assurance Project Plan, *supra* note 128, at 13.

for regulatory purposes was dependent on the efficiency and accuracy of the results. All properly labeled samples were analyzed by the NYDEC WAVE coordinator, who "identified macroinvertebrates in each sample[] to the level of family and used these data to calculate [the] assessment."[139]

Interestingly, minor changes were made to the metrics that were originally designed. Previously, four or more "Most Wanted" organisms indicated an unimpaired stream. However, pursuant to the final assessment, if a sample contained six or more "Most Wanted" organisms it was an indication that the stream has "No Known Impact."[140] There was no change to the metric used to identify "possibly impaired" streams, which remained four or more "Least Wanted" organisms.[141] The assessment confirmed that the metrics for "possibly impaired" streams was not as accurate as the metrics for streams with "No Known Impact." In fact, the final report found that 52 percent of the samples with four or more "Least Wanted" organisms were actually healthy.[142] As stated in the Quality Assurance Project Plan, although the "Least Wanted" metrics may not be as accurate, they are useful as "red flags" to identify streams in need of additional professional testing.[143] The final report reaffirmed that if none of the above metrics were found, no conclusion was made about the stream's water quality.[144]

In the final report, several organisms were added to the "Most Wanted" and "Least Wanted" macroinvertebrate lists.[145] The final assessment stated that WAVE volunteers were able to collect a more diverse sample of organisms than expected during the training sessions.[146] It was noted that employing the more diverse list of macroinvertebrates greatly improved the efficiency of the WAVE program.[147]

In addition, the Quality Assurance Project Plan determined that all streams with four or more "Most Wanted" organisms were to be deemed "unimpaired." Aside from changing this metric to six Most Wanted organisms, the Final Report replaced "unimpaired" with "No

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139 N.Y. DEP'T OF ENVTL. CONSERVATION, WAVE FINAL REPORT FOR THE 2012 SAMPLING SEASON 3 (2013) [hereinafter WAVE FINAL REPORT].
140 *Id.*
141 *Id.*
142 *Id.*
143 *Id.*
144 *Id.*
145 WAVE FINAL REPORT, *supra* note 139, at 4–5.
146 *Id.* at 5.
147 *Id.*

Known Impact."[148] The report states that the former "was a broad category that covered streams with some amount of pollution to those with none at all."[149] Attention to different levels of water quality resulted in more specificity, including "waters with 'Minor Impacts' and 'No Known Impacts' in NYS DEC's Waterbody Inventory and EPA's 305b report and 'non impacted' and 'slightly impacted' in NYSDEC trend reports."[150] The new list of macroinvertebrates allowed the NYDEC to be more specific when labeling the stream quality for NYSDEC Waterbody Inventories and CWA 305b reporting.[151]

The Final Report also outlined the results of all samples collected. For the 2012 sampling season, there were 99 trained citizen monitors, 144 samples collected, 109 sites assessed, 47 sites defined as "No Known Impact," and 7 sites defined as "Possibly Impaired."[152] The Final Report was confident in the quality of the data collected for healthy streams: "we never identif[ied] a stream as high quality when it is actually impaired."[153] The coordinator tested twenty eight WAVE sites two weeks after citizen monitors had collected samples and found that, on average, the coordinator's samples were 57 percent more likely to identify the stream's quality than the citizen monitor.[154] This number dropped to 27 percent when applying the original metrics.[155] The difference was the result of volunteers not being trained to identify the newly added organisms and was deemed to be an acceptable level of inefficiency by the WAVE program coordinator.[156]

Finally, the report outlined how the data will be used in the regulatory and administrative process. First, the data will be used for state and federal reporting, specifically for the NYS Waterbody Inventory and the CWA 305b reporting requirements.[157] Second, the data will be used for trend monitoring reports and rotating integrated basin studies.[158] Third, the data will provide background information on water quality conditions to be used by regulatory personnel working on non-point source discharges.[159] Lastly, local governments and nonprofit

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148 *Id.*
149 *Id.*
150 *Id.*
151 WAVE FINAL REPORT, *supra* note 139, at 5.
152 *Id.*
153 *Id.* at 6.
154 *Id.*
155 *Id.*
156 *Id.*
157 WAVE FINAL REPORT, *supra* note 139, at 7.
158 *Id.*
159 *Id.*

organizations will use the data as they seek to implement local stream restoration projects.[160]

V. CONCLUSION

As states continue to research viable options for assessing and maintaining water quality, innovative research programs have struggled to ensure the acquired data meets a requisite level of reliability to be used for state regulatory purposes. For example, although the Virginia program does not require preservation of ecological samples collected by volunteers for professional identification, the VASOS program compensates by committing more resources to the training process in an attempt to ensure that volunteers identify macroinvertebrates correctly, thereby eliminating the need for consistent professional review. The VASOS program has survived three separate peer reviewed processes by professional researchers, and the program has been adjusted to account for the findings of these reviews.

The Connecticut program proposes a level of identification that is appropriate for a volunteer monitoring program to be rapid, effective, and reliable. Connecticut's DEP champions the Field Based ID method because non-professional volunteers can accurately identify macroinvertebrates quickly at the testing site with the appropriate materials for recording. The Connecticut DEP requires volunteers to preserve the samples for professional identification, which, when coupled with the less technical on-site identification process, assures that accurate data is recorded. While other important quality assurances are discussed in the sections above, these highlighted aspects and others are integrated into New York's WAVE pilot program and are likely to play significant roles in the effectiveness of WAVE.

This last point should be emphasized: New York's WAVE pilot program results from a careful and functional analysis of biological monitoring efforts across the nation and over a significant period of time. The WAVE pilot program is, in an important sense, a synthesis of the best practices illustrated in other private and public water monitoring projects. Although those responsible for administering the WAVE program will undoubtedly look to improve the program in the upcoming years, it is reasonable to think the foundations of the program are defensible.

The final WAVE report summarizes the assessment at each sampling location and discusses the quality of the data. The summary provides an

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160 *Id.*

overview of the data collected as a result of the WAVE pilot project and the efforts of the citizen monitors. The report surveys the degree to which the results are able to fill the informational gaps that exist regarding New York's water quality. Finally, and most importantly, the report highlights that the WAVE program will continue and expand into the 2013 sampling season.[161] The final report is critical for an assessment of whether the WAVE pilot project has avoided the risks that accompany volunteer monitoring programs and the scientific drawbacks of using ecological indicators. In the meantime, the success of WAVE should illustrate the opportunities that citizen monitoring programs offer to water quality protection around the nation. Where WAVE's multiple feedback loops help to produce reliable information, the process of collecting ecological data will be less costly to regulator agencies.

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161 *Id.* at 8.