Utah Law Review

Volume 2022 | Number 1 Article 3

1-2022

Information as Power: Democratizing Environmental Data

Annie Brett
University of Florida Levin College of Law, brett@law.ufl.edu

Recommended Citation
Annie Brett, Information as Power: Democratizing Environmental Data, 2022 ULR 127 (2022). doi: 10.26054/0d-1n1y-s8a0

INFORMATION AS POWER: DEMOCRATIZING ENVIRONMENTAL DATA

Annie Brett*

Abstract

Environmental data systems have largely escaped scrutiny in the past decades. But these systems are the foundations for evaluating environmental priorities, making management decisions, and deciding which perspectives to value. Information is the foundation of effective regulation. The decisions regulators make about gathering, assimilating, and sharing information are, in many cases, determinative of the outcomes they reach. This is certainly true in the case of the environment.

This paper looks at how current environmental regulation has created data systems that undermine scientific legitimacy and systematically prevent stakeholder participation in environmental decision-making. These data systems concentrate power within federal and state agencies that are often ill-equipped to use this data effectively. New calls to open environmental data have the potential to shift these norms, but they will not be successful without fundamental restructuring in the regulatory treatment of environmental data. This paper uses fisheries management as a case study to expose how outdated data perceptions and architectures are at the root of many current environmental management failures. Technological innovation is challenging many of these norms, creating opportunities for better management that can only be achieved if agencies fundamentally rethink environmental data management. I argue that federal agencies can support better regulatory outcomes by creating Environmental Data Offices and open data systems.

I. INTRODUCTION

Bert, a groundfish fisherman from Cape Cod, is subject to near-constant government surveillance.[1] Before leaving the dock on a fishing trip, he must submit

---

 Assistant Professor, University of Florida Levin College of Law. With thanks to Jim Leape, Mark Abbot, Melissa Garren, Kate Wing, Victoria Lee, Kevin Chand, Ling Cao, Hide Sakaguchi, Yimnang Golbuu, Tara Martin, Juan Mayorga and Mari S. Myksvoll for input on the ideas in this Article.

[1] *See generally* KEITH PORCARO, BUILDING A FISHERMEN FIRST DATA ECOSYSTEM (2019) (reporting "opportunities and possible models for the New England groundfish community to own, control, manage, and use fisheries data, with a particular focus on governing electronic monitoring data").

a Pre-Trip Notification to his regional fisheries managers.[2] Once on the water, his location is continually monitored by a GPS sensor on his vessel and transmitted in real-time back to NOAA's Office of Law Enforcement. Depending on the trip, he may be accompanied by a government observer who also tracks his location and watches as he catches fish and brings them onboard. Alternatively, he could have an electronic monitoring camera system installed that captures fishing footage for review by regulators. Once he returns to the dock, he must self-report by submitting a Trip Report of his own to regulators, including detailed information on where he was fishing and how much fish he caught. When he sells his fish to a dealer, that dealer is required to confirm with regulators how much of Bert's fish they bought.

This current fisheries surveillance system generates vast quantities of data, many of which are redundant. Bert, for instance, tracks his location using three separate systems on any given trip. This data is automatically transmitted to various parts of NOAA's fisheries management administration and locked into agency data silos where even different offices within the same agency may have difficulty locating and using it. Bert must not only pay for the sensors and observers that generate redundant data but will never himself have access to any data on his own activities.

This is the new information age in environmental law.[3] Over the last two decades, scholars have pointed to the lack of information on environmental conditions as a major impediment to environmental management and highlighted the promise of emerging technologies to fill data gaps.[4] But the reality is far from achieving this promise. Yes, new technologies are generating new data on environmental conditions. But systemic challenges throughout the data lifecycle prevent this data from being used effectively to inform decision-making. Data is often redundant, inaccessible, and unavailable to key stakeholders. Bert's case is being repeated in various forms throughout environmental regulation.

Data policy has become a hot-button topic outside of environmental law, with many raising concerns about the consequences of large technology companies

---

[2] *Pre-Trip Notification System (Northeast)*, NOAA FISHERIES (June 25, 2020), https://www.fisheries.noaa.gov/resource/tool-app/pre-trip-notification-system-northeast [https://perma.cc/3YJA-LGN8] (explaining that all owners and operators of vessels in specified fisheries are "required to notify Northeast Fisheries Observers Program prior to each trip" of their fishing plans).

[3] For an early take on the promise of the information age to improve and expand environmental management, see generally Daniel C. Esty, *Environmental Protection in the Information Age*, 79 N.Y.U. L. REV. 115 (2004). ("[W]e stand on the verge of an environmental revolution perhaps as important as that which launched the modern environmental movement four decades ago.").

[4] Gregg P. Macey, *The Architecture of Ignorance*, 6 UTAH L. REV. 1627, 1632 (2013) (arguing that data "allows us to explore a broader range of transaction costs that shape our response to environmental harms"); Eric Biber, *The Problem of Environmental Monitoring*, 83 UNIV. COLO. L. REV. 1, 4–5 (2011); Esty, *supra* note 3, at 188 (suggesting that addressing information gaps represents a key to environmental progress).

holding data monopolies.[5] The massive quantities of data collected by Google, Facebook, and others exacerbate existing imbalances of power and concentrate power in the hands of those that hold data.[6] While big tech is the focus of public scrutiny, private companies are certainly not the only ones holding large and strategically important data monopolies. The federal government also owns massive amounts of data. Federal agencies engage in similar data collection and storage practices that in many ways mimic the practices of private enterprises. These federal data monopolies are no less dangerous.

In the context of environmental law, federal government data monopolies significantly impede effective environmental management.[7] Most environmental data is a regulator-driven ecosystem, where data is collected for government purposes and incorporated into legislatively created data systems that, at their best, are merely inefficient. For instance, despite the plethora of data on individual fishing activity mandated by regulators, our gaps in understanding of fisheries are massive, undermining management goals and leading to rampant overexploitation of this resource.[8] This is not true only in fisheries: EPA and other agencies are struggling with how to manage vast volumes of data at the same time as they lack information

---

[5] *See, e.g.*, Cecilia Kang, *F.T.C. Approves Facebook Fine of About $5 Billion*, N.Y. TIMES (July 12, 2019), https://www.nytimes.com/2019/07/12/technology/facebook-ftc-fine.html [https://perma.cc/JJ4C-4DV3] (describing the reaction to Facebook's mishandling of data in the Cambridge Analytica scandal); *Online Platforms and Market Power, Part 6: Examining the Dominance of Amazon, Apple, Facebook, and Google*: *Hearing Before the Subcomm. on Antitrust, Com. and Admin. L. of the H. Comm. on the Judiciary*, 116th Cong. (2020) (raising congressional concerns about the power of large technology companies and their data practices).

[6] *See, e.g.*, Kate Klonick, *The New Governors: The People, Rules, and Processes Governing Online Speech*, 131 HARV. L. REV. 1598, 1599 (2018) ("[W]e must abandon traditional doctrinal and regulatory analogies and understand these private content platforms as systems of governance. These platforms are now responsible for shaping and allowing participation in our new digital and democratic culture, yet they have little direct accountability to their users.").

[7] *See infra* Section III.B (discussing the problems with government data monopolies).

[8] Malin L. Pinsky, Olaf P. Jensen, Daniel Ricard & Stephen R. Palumbi, *Unexpected Patterns of Fisheries Collapse in the World's Oceans*, 108 PROC. NAT'L. ACAD. SCI. U.S. 8317 (2011); David A Kroodsma, Juan Mayorga, Timothy Hochberg, Nathan A. Miller, Kristina Boerder, Francesco Ferretti, Alex Wilson, Bjorn Bergman, Timothy D. White, Barbara A. Block, Paul Woods, Brian Sullivan, Christopher Costello & Boris Worm, *Tracking the Global Footprint of Fisheries*, 359 SCI. 904 (2018).

on basic ecosystem conditions across all sectors of the environment.[9] Current environmental data systems are unable to meet their core goal of enabling science-based environmental management.[10]

Moreover, current methods of collecting, storing, and disseminating environmental data systemically exclude the majority of stakeholders.[11] The ways that agencies view environmental data are rooted in outdated concerns about confidentiality initially aimed at protecting stakeholder interests but that now actively prevent their engagement in resource management. As a result, fishermen like Bert do not have access to the vast quantities of data collected about their own fishing activities. Critical data on coastal storms and sea level rise collected by FEMA is essentially unavailable to people looking to purchase homes in coastal areas. Data on drinking water quality is not disseminated to the public, even when water is so contaminated that it becomes a public health crisis.[12]

Opening data to stakeholders leads to the addition of new sources of data, new perspectives, and more meaningful stakeholder engagement.[13] Stakeholder engagement is particularly important in overcoming historic environmental injustice and inequity.[14] Access to environmental data is a critical component of participatory environmental management that includes marginalized communities.[15] All of this leads to better environmental decision-making.

This Article begins in Part II by laying out the importance of environmental data, both as a tool to support agency decision-making and as a vehicle for engaging stakeholders in environmental management. It shows how current regulatory data systems have been structured in ways that make achieving either of these goals impossible. It argues that deficiencies in data structures are becoming more critical in the face of improving environmental technologies. Current large-scale calls for open environmental data have been unsuccessful because they discount the importance of these structural barriers. Part III looks at fisheries data as a case study

---

[9] *See, e.g.*, *NOAA Expands Public Access to Big Data*, NAT'L CTRS FOR ENV'T INFO. (Dec. 10, 2018), https://www.ncei.noaa.gov/news/noaa-expands-big-data-access [https://perma.cc/WWN6-9JU2] (discussing the challenges NOAA faces in storing oceanographic and climate data); Biber, *supra* note 4, at 20–21 (describing the gaps in environmental data availability).

[10] Robin O'Malley, Anne S. Marsh & Christine Negra, *Closing the Environmental Data Gap*, 25 ISSUES SCI. & TECH. 69, 69–74 (2009); Cary Coglianese, Heather Kilmartin & Evan Mendelson, *Transparency and Public Participation in the Federal Rulemaking Process: Recommendations for the New Administration*, 77 GEO. WASH. L. REV. 924, 933, 940 (2009).

[11] *See infra* Part III.

[12] *See* Mitch Smith, Julie Bosman & Monica Davey, *Flint's Water Crisis Started 5 Years Ago. It's Not Over.*, N.Y. TIMES (Apr. 25, 2019), https://www.nytimes.com/2019/04/25/us/flint-water-crisis.html [https://perma.cc/L9XL-AKV2].

[13] *See* Thomas C. Beierle, *The Quality of Stakeholder-Based Decisions*, 22 RISK ANALYSIS 739, 739 (2002).

[14] Jason Corburn, *Bringing Local Knowledge into Environmental Decision Making*, 22 J. PLAN. EDUC. & RSCH. 420, 429–30 (2003).

[15] *See* Thomas C. Beierle & David M. Konisky, *Values, Conflict, and Trust in Participatory Environmental Planning*, 19 J. POL'Y ANALYSIS & MGMT. 587, 598–99 (2000).

to understand how foundational decisions about how data is collected and stored impact regulatory efficiency. It focuses on two technological innovations—public transparency and electronic monitoring—to show how outdated regulatory data structures are undermining the potential of new technological tools to improve management and enable broader stakeholder participation. It draws on fisheries and other case studies to show how government-dominated environmental data systems prevent positive environmental outcomes. Part IV uses lessons from fisheries data to propose reforms to environmental data management: creating Environmental Data Offices in agencies and rethinking confidentiality norms to provide open access to environmental data. These changes are needed to support sustainable development outcomes and to engage disparate and often marginalized environmental stakeholders.

II. UNDERSTANDING ENVIRONMENTAL DATA

We know very little about many ecosystems of the planet. The gaps in our knowledge of global environmental conditions are pervasive.[16] And yet, informed decision-making about the environment is impossible without accurate baseline information.[17]

While there has been considerable discussion in the legal academy of how to fill gaps in scientific data to drive better environmental regulation, these discussions neglect to address the impacts of the broader environmental data systems that these regulations create.[18] Early attention to environmental data systems by Gregg Macey highlights how an increasingly data-rich ecosystem will demand the reworking of

---

[16] *See* Sara M. Maxwell, Elliott L. Hazen, Rebecca L. Lewison, Daniel C. Dunn, Helen Bailey, Steven J. Bograd, Dana K. Briscoe, Sabrina Fosette, Alistair J. Hobday, Meredith Bennett, Scott Benson, Margaret R. Caldwell, Daniel P. Costa, Heidi Dewar, Tomo Eguchi, Lucie Hazen, Suzanne Kohin, Tim Sippel & Larry B. Crowder, *Dynamic Ocean Management: Defining and Conceptualizing Real-Time Management of the Ocean*, 58 MARINE POL'Y 42, 42 (2015); Biber, *supra* note 4, at 4; R.H. Thurstan, L. McClenachan, L.B. Crowder, J.A. Drew, J.N. Kittinger, P.S. Levin, C.M. Roberts & J.M. Pandolfi, *Filling Historical Data Gaps to Foster Solutions in Marine Conservation*, 115 OCEAN & COASTAL MGMT. 31, 31 (2015); Abby J. Kinchy & Simona L. Perry, *Can Volunteers Pick Up the Slack? Efforts to Remedy Knowledge Gaps About the Watershed Impacts of Marcellus Shale Gas Development*, 22 DUKE ENV'T L. & POL'Y F. 303, 303–23 (2012); Gordon D. Blasco, Danielle M. Ferraro, Richard S. Cottrell, Benjamin S. Halpern & Halley E. Froehlich, *Substantial Gaps in the Current Fisheries Data Landscape*, FRONTIERS MARINE SCI., Dec. 17, 2020, at 1, 2.

[17] *See* Biber, *supra* note 4, at 4; Linwood H. Pendleton, Hawthorne Beyer, Estradivari, Susan O. Grose, Ove Hoegh-Guldberg, Denis B. Karcher, Emma Kennedy, Lyndon Llewellyn, Cecile Nys, Aurélie Shapiro, Rahul Jain, Katarzyna Kuc, Terry Leatherland, Kira O'Hainnin, Guillermo Olmedo, Lynette Seow & Mick Tarsel, *Disrupting Data Sharing for a Healthier Ocean*, 76 ICES J. MARINE. SCI. 1415 (2019).

[18] Biber, *supra* note 4, at 14–18 (discussing how more ambient environmental data is needed to support management); Esty, *supra* note 3, at 118 (arguing that new technologies are broadening available environmental information and enabling a new era of regulation).

fundamental data architectures. Others have expanded on this, noting how the shift away from data as a limiting factor in environmental decision-making can increase the political value of data, particularly the value to agencies of keeping data closely held.[19]

This section explores the role of environmental data in supporting management decisions and argues that beyond its core scientific function, environmental data serves a critical role in enabling stakeholder engagement in environmental management. I show here how current regulatory data systems exacerbate existing environmental injustices and inequity by systematically excluding certain types of external participation, in addition to not meeting their goals of providing a scientifically accurate basis for management decisions. I then examine how technology is changing the landscape of environmental data and challenging existing data structures.

A. What Is Environmental Data?

Data on baseline environmental conditions is the foundation for environmental management decisions.[20] Understanding current ecosystem conditions and accurately predicting future impacts is an essential function of environmental scientists and managers. To do this, managers rely on many different types of data, both scientific data but also social and economic data.

Environmental science data ranges from biological assessments of species density to pathogen concentrations in coastal waters to hydrogeographic models of river flows to simple atmospheric measurements of temperatures.[21] These are the scientific measurements of baseline environmental conditions that inform understanding of the current environmental condition. Environmental science data also includes complex model outputs predicting the impacts of future carbon dioxide emissions on global ecosystems.

These types of scientific measurements are generally quantitative data. However, different methods of measurement can lead to data with different units and uncertainty factors that make it very difficult to compare even measurements of the same condition. For instance, atmospheric pressure is commonly measured both in inches of mercury and millibars. To be usable, before these data are entered into a database, they need to be converted to an agreed-upon standard unit.[22]

Environmental data also includes social data. Understanding human pressure on and interaction with local environments is essential to weighing management priorities and developing feasible solutions. This social data is sometimes

---

[19] Ryan P. Kelly, *Will More, Better, Cheaper, and Faster Monitoring Improve Environmental Management?*, 44 ENV'T. L. 1111, 1142 (2014) ("Another issue with a more powerful microscope is the potentially inconvenient data that the microscope might reveal.").

[20] *See* Biber, *supra* note 4, at 14–18 (discussing the importance of monitoring data in environmental management).

[21] *Id.* at 16–22 (listing different environmental monitoring programs).

[22] Determining standardized units across scientific communities is incredibly difficult. *See, e.g.*, Pendleton et al., *supra* note 17, at 1416, 1418–19.

quantitative, for instance, demographic variables or economic calculations, but is also frequently qualitative. Qualitative social environmental data includes community perceptions of environmental conditions, traditional ecological knowledge, and other types of information that are important for decision-making but that are very difficult to include in more traditional environmental databases.

One of the key challenges of environmental data is how to effectively collect, use, and disseminate these diverse types of data.

B. Environmental Data Collection

The majority of the data used by federal managers is collected by the agencies that use it, from EPA to NOAA to DOT: ambient environmental monitoring is an essential public function.[23] Environmental scientists also contribute important data sources and analysis, but this is generally less tied to specific regulatory outcomes.

Environmental data must be collected both frequently and over long intervals to be effective in supporting environmental decision-making.[24] Frequent data collection is needed to effectively monitor environmental conditions that change rapidly. In some ecosystems, rivers, for example, conditions can change on an hourly basis in response to different weather events or human activities.[25] Frequent monitoring is needed to understand these changes and inform river users about unsafe conditions in near real-time.[26] Likewise, human activities also need to be monitored frequently as they can change quickly. Industrial outputs and wastewater, for instance, need to be monitored constantly to ensure compliance with environmental regulations.[27] Frequent monitoring is costly and logistically difficult.[28]

Long-term environmental data is equally important. Scientists often need decades of data to accurately identify ecosystem trends. The poster child of climate change science, the Keeling Curve, required over 20 years of ambient observations before scientists began to point out increasing carbon dioxide levels in the

---

[23] *Id.* at 1415–16.

[24] *See*, *e.g.*, Kinchy & Perry, *supra* note 16, at 338 (discussing the data needs in environmental law).

[25] *See, e.g.*, Rebecca N. Handcock, Christian E. Torgersen, Keith A. Cherkauer, Alan R. Gillespie, Klement Tockner, Russel N. Faux & Jin Tan, *Thermal Infrared Remote Sensing of Water Temperature in Riverine Landscapes*, FLUVIAL REMOTE SENSING FOR SCI. & MGMT. 85, 96–98, 103 (Patrice E. Carbonneau & Hervé Piégay eds., 1st ed. 2012) (describing typical fluctuations in river water temperature and composition over time).

[26] Robert L. Glicksman, David L. Markell & Claire Monteleoni, *Technological Innovation, Data Analytics, and Environmental Enforcement*, 44 ECOL. L. Q. 41–88 (2017).

[27] In these compliance cases, the burden for monitoring generally has been shifted onto the regulated entities. *See How We Monitor Compliance*, EPA, https://www.epa.gov/compliance/how-we-monitor-compliance [https://perma.cc/SM9S-4LDP] (last visited Aug. 14, 2021). Data generated by industrial actors is submitted to federal regulators for review and storage. *See id.*

[28] Biber, *supra* note 4, at 32.

atmosphere.[29] Similarly, long-term datasets have helped illuminate key environmental issues, from the loss of biodiversity to the discovery of the ozone hole.[30]

Long-term environmental datasets are notoriously rare. Ambient environmental monitoring over time is not the type of cutting-edge research that garners substantial funding. Very few entities provide the funding commitments needed to support these projects.[31] Keeling's studies of carbon dioxide, for example, were initially funded by the U.S. government not as a long-term study, but because Keeling had come up with a new, more precise method of measuring carbon dioxide concentrations.[32] Keeling spent the next decades of his life defending the need to continue taking measurements to government funders that viewed his work as "routine."[33] This "routine" work became the critical basis for most climate change research today. Despite the importance of this project, the U.S. government finally discontinued funding for the Keeling observations in 2014.[34] Private technology billionaires Eric and Wendy Schmidt stepped in to continue funding the work going forward.[35] Most long-term environmental datasets lack the notoriety or support of the Keeling Curve, making funding struggles even more acute.

Environmental data must also be collected at as high a spatial resolution as possible. Environmental conditions are highly location-specific and can vary dramatically over small spatial scales.[36] Climate global circulation models, for instance, predict climate impacts for areas of 100 to 300 square kilometers.[37] This

---

[29] Daniel C. Harris, *Charles David Keeling and the Story of Atmospheric CO2 Measurements*, 82 ANAL. CHEM. 7865 (2010).

[30] Graham J Edgar, Rick D. Stuart-Smith, Trevor J. Willis, Stuart Kininmonth, Susan C. Baker, Stuart Banks, Neville S. Barrett, Mikel A. Becerro, Anthony T. F. Bernard, Just Berkhout, Colin D. Buxton, Stuart J. Campbell, Antonia T. Cooper, Marlene Davey, Sophie C. Edgar, Günter Försterra, David E. Galván, Alejo J. Irigoyen, David J. Kushner, Rodrigo Moura, P. Ed Parnell, Nick T. Shears, German Soler, Elisabeth M. A. Strain & Russell J. Thomson, *Global Conservation Outcomes Depend on Marine Protected Areas with Five Key Features*, 506 NATURE 216, 216 (2014) (discussing how global conservation targets for marine protected areas based on area alone does not optimize protection of marine biodiversity); Susan Solomon, *The Discovery of the Antarctic Ozone Hole*, 575 NATURE 46 (2019).

[31] F. Stuart Chapin III, Erika S. Zavaleta, Valerie T. Eviner, Rosamond L. Naylor, Peter M. Vitousek, Heather L. Reynolds, David U. Hooper, Sandra Lavorel, Osvaldo E. Sala, Sarah E. Hobbie, Michelle C. Mack & Sandra Día, *Consequences of Changing Biodiversity*, 405 NATURE 234, 234–242 (2000).

[32] Harris, *supra* note 29, at 7866.

[33] *Id.* at 7870.

[34] Robert Munroe, *Keeling Curve Receives Continuation Funding from Eric and Wendy Schmidt*, UCSD NEWS (Oct. 15, 2020), https://scripps.ucsd.edu/news/keeling-curve-receives-continuation-funding-eric-and-wendy-schmidt# [https://perma.cc/2JK3-CSEX].

[35] *Id.*

[36] Biber, *supra* note 4, at 22.

[37] Tongli Wang, Andreas Hamann, Dave Splittlehouse & Carlos Carrol, *Locally*

leads to a great deal of uncertainty about impacts on more localized areas, making decision-making difficult for environmental managers and members of industry.[38] Scientists recommend using data at the 4-kilometer level, or even smaller in highly heterogeneous ecosystems, to support accurate decision-making.[39]

The challenge of environmental data is a multi-pronged one: environmental decision-making requires high-quality data from a broad range of scientific disciplines, collected as frequently and consistently as possible over a period of decades at the small spatial scales that allow for locally disparate impacts to be understood. This is a tall order.

New efforts are broadening the scope of who collects environmental data beyond traditional groups of scientists and agencies. Citizen science, for instance, is involving members of the public in data collection.[40] Volunteers help to carry out water quality monitoring under the Clean Water Act and are spearheading a new wave of public participation in environmental data collection.[41]

1. Environmental Data Classification and Storage

Cleaning, categorizing, and storing environmental data is an often overlooked portion of its lifecycle. But this type of data management is critical for creating usable, accessible datasets. Creating effective data management systems is particularly important as volumes of data being collected increase exponentially.

The largest problems in this stage for environmental data stem from a lack of resources devoted to this critical stage.[42] Often data is collected and then sent in its

---

Downscaled and Spatially Customizable Climate Data for Historical and Future Periods for North America, PLOS ONE, Jun. 8, 2016, at 1–2.

[38] L. O. Mearns, W. Easterling, C. Hays & D. Marx, *Comparison of Agricultural Impacts of Climate Change Calculated from High and Low Resolution Climate Change Scenarios: Part I. The Uncertainty Due to Spatial Scale*, 51 CLIMATE CHANGE 131, 131–33 (2001) (discussing the growing prominence of spatial scale as an important uncertainty).

[39] Wang et al., *supra* note 37, at 3–4.

[40] *Citizen Science*, NAT'L GEOGRAPHIC https://www.nationalgeographic.org/encyclopedia/citizen-science/ [https://perma.cc/4FQ2-LGPL] (last visited Sept. 7, 2021) ("Citizen science is the practice of public participation and collaboration in scientific research to increase scientific knowledge. Through citizen science, people share and contribute to data monitoring and collection programs.").

[41] Kinchy & Perry, *supra* note 16, at 328–29.

[42] Toste Tanhua, Sylvie Pouliquen, Jessica Hausman, Kevin O'Brien, Pip Bricher, Tacode Bruin, Justin J.H. Buck, Eugene F. Burger, Thierry Carval, Kenneth S. Casey, Steve Diggs, Alessandra Giorgetti, Helen Glaves, Valerie Harscoat, Danie Kinkade, Jose H. Muelbert, Antonio Novellino, Benjamin Pfeil, Peter L. Pulsifer, Anton Van de Putte, Erin Robinson, Dick Schaap, Alexander Smirnov, Neville Smith, Derrick Snowden, Tobias Spears, Shelley Stall, Marten Tacoma, Peter Thijsse, Stein Tronstad, Thomas Vandenberghe, Micah Wengren, Lesley Wyborn & Zhiming Zhao, *Ocean FAIR Data Services*, 6 FRONTIERS MARINE SCI., Aug. 7, 2019, at 1–4 (explaining the main challenges against moving ocean data management toward the FAIR principles of being findable, accessible, interoperable, and reusable).

messy form to be stored on various office servers.[43] It may not be cleaned or cataloged. Individuals beyond the one receiving the data likely do not know it exists, or if they do, how to access and use it.

Global efforts have focused on improving and standardizing metadata, the contextual information such as time and date that is attached to the data itself. These efforts have made important progress in the scientific communities, ensuring that data collected by different individual scientists in different countries is interoperable and can all be added to global environmental datasets.

Just to integrate scientific data into large global databases is an extremely resource-intense endeavor. Cleaning and formatting data so it meets agreed-on standards and quality control criteria is essential for creating usable datasets, but agencies and others have failed to devote sufficient resources to this area.

2. Environmental Data Use and Access

Effective environmental management depends not just on accurate data about environmental conditions but also on external engagement with environmental stakeholders.[44] Stakeholder engagement contributes to regulatory legitimacy.[45] Data is a foundational component of effective stakeholder engagement.[46]

Information transparency is a critical element of effective environmental governance.[47] Providing data on environmental conditions to members of the public can widen participation and increase buy-in for environmental decision-making.[48] This is particularly important over the long term, where providing meaningful opportunities for engagement between stakeholders and managers is essential to

---

[43] Pendleton et al., *supra* note 17, at 1416.

[44] *See, e.g.*, Sheila Jasanoff, *Technologies of Humility: Citizen Participation in Governing Science*, 41 MINERVA 223, 232 (2003) (noting the position by Funtowicz and Ravetz that peer review should be extended to include stakeholders affected by the use of the science).

[45] Coglianese et al., *supra* note 10, at 927 ("[T]ransparency and public participation are . . . tools that can enhance regulators' ability to achieve society's goal of high-quality and legitimate rules.").

[46] *See generally* NAT'L RSCH. COUNCIL, PUBLIC PARTICIPATION IN ENVIRONMENTAL ASSESSMENT AND DECISION MAKING (Thomas Dietz & Paul C. Stern, eds., 2008) (studying the merits and failings of participation that concludes with 'best processes' that can enhance effective participation and thereby improve environmental assessment).

[47] *See, e.g.*, Matilda T. Petersson, *Transparency in Global Fisheries Governance: The Role of Non-Governmental Organizations*, MARINE POL'Y, July 9, 2020, at 1 ("Transparency is recognized as a critical component of good governance that can enhance governance capacity and the effectiveness to solve complex environmental problems.").

[48] *See, e.g.*, R. Kingston, S. Carver, A. Evans & I. Turton, *Web-Based Public Participation Geographical Information Systems: An Aid to Local Environmental Decision-Making*, 24 COMPUT. ENV'T & URB. SYS. 109 (2000), https://www.sciencedirect.com/science/article/pii/S0198971599000496 [https://perma.cc/NB2S-DVKY]; Gene Rowe & Lynn J. Frewer, *Public Participation Methods: A Framework for Evaluation*, 25 SCI. TECH. & HUM. VALUES 3 (2000).

reducing conflict in the face of complex and dynamic issues.[49] Current proposals to shift the focus in environmental law from sustainability to resilience also note the importance of considering social interactions with the law, of which access to data is a critical piece.[50]

Transparency increases the likelihood that regulated entities will comply with a final rule.[51] In the context of environmental regulations, many of which lack meaningful enforcement, this is a critical consideration. Transparency, moreover, is particularly important when agency decisions unequally burden certain groups. Understanding why agencies made the decisions can ensure these "losers" still find legitimacy in the process.[52]

The Obama Administration recognized the problems inherent in governments holding data too tightly and pushed for more openness and transparency in data reporting by federal agencies.[53] In response to the Open Government Action Plan, agencies made hundreds of thousands of data sets available to the public.[54] These are important efforts, and the move towards data transparency is beginning to be embraced in many different areas of environmental management.[55] At its best, transparency can promote stakeholder engagement and support of environmental policies. Transparency alone will not achieve these goals,[56] but evidence suggests

---

[49] Christina H. Drew, Timothy L. Nyerges & Thomas M. Leschine, *Promoting Transparency of Long-Term Environmental Decisions: The Hanford Decision Mapping System Pilot Project*, 24 RISK ANALYSIS 1641, 1642 (2004).

[50] Robert L. Fischman, *Letting Go of Stability: Resilience and Environmental Law*, 94 IND. L.J. 689 (2019).

[51] *See* Coglianese et al., *supra* note 10, at 926–28.

[52] *Id.* at 927.

[53] THE OPEN GOVERNMENT PARTNERSHIP: NATIONAL ACTION PLAN FOR THE UNITED STATES OF AMERICA (2011), https://obamawhitehouse.archives.gov/sites/default/files/us_national_action_plan_final_2.pdf [https://perma.cc/X8MB-JUWU].

[54] *Id.* at 2.

[55] *See* Sheila Jasanoff, *Transparency in Public Science: Purposes, Reasons, Limits*, 69 L. & CONTEMP. PROBS. 21 (2006) (discussing environmental management generally); Ruth A. Davis & Quentin Hanich, *Transparency in Fisheries Conservation and Management Measures*, MARINE POL'Y, June 19, 2020, at 1 (explaining how transparency impacts fisheries); Rosemary Lyster, *REDD+, Transparency, Participation and Resource Rights: The Role of Law*, 14 ENV'T SCI. POL'Y 118, 123–26 (2011) (analyzing ways to facilitate transparency in forest management); Mehdi Azadi, Stephen A. Northey, Saleem H. Ali & Mansour Edraki, *Transparency on Greenhouse Gas Emissions from Mining to Enable Climate Change Mitigation*, 13 NATURE GEOSCIENCES 100, 103 (2020) (suggesting ways to increase transparency in the mining industry).

[56] *See generally* Aarti Gupta, *Transparency Under Scrutiny: Information Disclosure in Global Environmental Governance*, 8 GLOB. ENV'T POL., May 2008, at 1 (discussing barriers to achieving meaningful transparency); Anna Wesselink, Jouni Paavola, Oliver Fritsch & Ortwin Renn, *Rationales for Public Participation in Environmental Policy and Governance: Practitioners' Perspectives*, 43 ENV'T PLAN. 2688 (2011).

that little progress can be made without data transparency.[57] Stakeholders can also participate in the production of environmental data, broadening the information available for environmental decision-making.[58]

Beyond transparency, data ownership can expect to become a more central issue for many stakeholder communities. In the case of fisheries, discussed in Part IV, fishermen are increasingly interested in owning and controlling the data collected by the government about their activities.

Similarly, a global movement towards indigenous data sovereignty recognizes the importance of giving tribal communities control over their own data for improving management outcomes.[59] In the case of indigenous data, data monopolies by the federal government have exacerbated existing inequities.[60] Federal agencies collect the vast majority of data on tribal populations.[61] These agencies decide what data is needed and then collect and analyze this data before sharing it in limited amounts with tribal governments. Tribes are not involved in designing data collection methodologies, undermining the accuracy and usability of federally generated data.[62] This state of "data dependence" limits the data available to tribes to that which the federal government deems necessary. Some have gone so far as to equate territorial sovereignty with data sovereignty.[63]

Other stakeholders, like academic researchers, are also barred from engaging with environmental data. Empirical studies are much less common in environmental

---

[57] *See, e.g.*, Jeff A. Ardron, Henry A. Ruhl & Daniel O.B. Jones, *Incorporating Transparency into the Governance of Deep-seabed Mining in the Area Beyond National Jurisdiction*, 89 MARINE POL'Y 58, 63 (2018) (discussing how a lack of public awareness of deep-sea mining or its dangers undermines effective regulation); Anne N. Glucker, Peter P.J. Driessen, Arend Kolhoff & Hens A.C. Runhaar, *Public Participation in Environmental Impact Assessment: Why, Who and How?*, 43 ENV'T IMPACT ASSESSMENT REV. 104 (2013) (describing the essential role of public participation in environmental impact assessment).

[58] *See, e.g.*, Christine Overdevest & Brian Mayer, *Harnessing the Power of Information Through Community Monitoring: Insights from Social Science*, 86 TEX. L. REV. 1493 (2008); Gwen Ottinger, *Buckets of Resistance: Standards and the Effectiveness of Citizen Science*, 35 SCI. TECH. & HUM. VALUES 244 (2015); Rebecca Lave, *The Future of Environmental Expertise*, 105 ANNALS ASS'N AM. GEOGRAPHERS 244 (2015); ROBERT GELLMAN, WOODROW WILSON INT'L CTR. SCHOLARS, CROWDSOURCING, CITIZEN SCIENCE AND THE LAW: LEGAL ISSUES AFFECTING FEDERAL AGENCIES 3 (2015), https://www.wilsoncenter.org/sites/default/files/media/documents/publication/executive_summary_gellman.pdf [https://perma.cc/995D-WF8D].

[59] *See* Rebecca Tsosie, *Tribal Data Governance and Informational Privacy: Constructing "Indigenous Data Sovereignty*,*"* 80 MONT. L. REV. 229 (2019).

[60] *Id.* at 244–45.

[61] *Id.*

[62] *See* Sabrina Imbler, *Training the Next Generation of Indigenous Data Scientists*, N.Y. TIMES (July 2, 2021), https://www.nytimes.com/2021/06/29/science/indigenous-data-microbiome-science.html [https://perma.cc/H2SD-X9L2].

[63] Tsosie, *supra* note 59, at 233–34.

law than in other legal fields.[64] Some have suggested that this may derive from environmental data being published in inaccessible formats or venues.[65] Making environmental data available to researchers is particularly important as federal agencies increasingly turn to adaptive management strategies.[66] Commercial entities rely on environmental data for many services, from weather prediction to industrial plant management. Private industry demand can play a critical role in creating data markets and enabling new ways of funding public environmental data collection.

3. The Role of Government in Environmental Data

Historically, the government has taken on the role of gathering and disseminating environmental data.[67] This makes sense: the EPA and other agencies need baseline information to effectively make rules, and no one else is collecting the relevant, comprehensive data that are needed.[68] Ambient monitoring, in particular, fulfills an essential public function.[69]

U.S. environmental regulation is embedded with requirements for gathering environmental data.[70] The major environmental laws of the 1970s created mandates for many different types of data collection, both enforcement-oriented monitoring to ensure industrial facilities were meeting regulatory targets and ambient monitoring aimed at establishing environmental baselines.[71]

The regulations of the 1970s did not foresee many of our problems with environmental data collection. Resource and logistical constraints to gathering sufficient data have proven insurmountable for agencies. The Clean Water Act, for example, requires that federal and state agencies monitor all the waters of the U.S.

---

[64] *See* Robert L. Fischman & Lydia Barbash-Riley, *Empirical Environmental Scholarship*, 44 ECOLOGY L.Q. 767 (2018).

[65] *See* Michael Faure, *Effectiveness of Environmental Law: What Does the Evidence Tell Us?*, 36 WM. & MARY ENV'T L. & POL'Y REV. 293, 295 (2012); Charuleka Varadharajan, Shreyas Cholia, Cory Snavely, Valerie Hendrix, Christina Procopiou, Diana Swantek, William J. Riley & D. A. Agarwal, *Launching an Accessible Archive of Environmental Data*, EOS.ORG (Jan. 8, 2019), https://eos.org/science-updates/launching-an-accessible-archive-of-environmental-data [https://perma.cc/P9YB-6963].

[66] Fischman & Barbash-Riley, *supra* note 64, at 803 ("A high priority for environmental law must be to build into implementation the monitoring that can determine whether the models employed in the front-end analyses accurately predicted outcomes.").

[67] Biber, *supra* note 4, at 46.

[68] *See* Lynn E. Blais & Wendy E. Wagner, *Emerging Science, Adaptive Regulation, and the Problem of Rulemaking Ruts*, 86 TEX. L. REV. 1701, 1728–29 (2007); William V. Luneburg, *Where the Three Rivers Converge: Unassessed Waters and the Future of EPA's Total Maximum Daily Load Program—A Case Study*, 24 J.L. & COM. 57, 58–59 (2004).

[69] Biber, *supra* note 4, at 5.

[70] *See, e.g.*, Flood Insurance Program, 44 C.F.R. § 60.3 (requiring developer to provide floodplain study data when requesting permit); Clean Air Act § 412, 42 U.S.C. § 7651k.

[71] *See generally* Biber, *supra* note 4, at 14–15 (discussing the distinction between compliance and ambient environmental monitoring).

annually.[72] In practice, only about 1/3 of these waters are actually monitored.[73] There is no baseline information on even the most basic questions, for instance, what percentage of U.S. national waters are part of marine protected areas.[74]

Environmental data is particularly important as environmental management shifts increasingly towards an adaptive management model.[75] Adaptive management requires managers to collect extensive data that enable rigorous analysis of ecosystem and management outcomes.[76] This data is essential to understand whether management programs are achieving their desired goals and, if they are not, to allow these programs to adapt in the trial-and-error process envisioned by adaptive management proponents.

Our current legislatively created data systems not only fail to fill the data gaps they were designed to remedy; they also systemically exclude external participation in environmental decision-making.

Public involvement holds a special place in environmental regulation, with most major environmental laws allowing citizen suits.[77] Citizen enforcement provides an avenue for the public to meaningfully engage with environmental laws beyond the typical notice and comment process. Scholars have recognized the importance of this function in promoting democratic values.[78] Citizens are a critical

---

[72] 33 U.S.C. § 1254(a)(5). The mileage of rivers and streams in the U.S. totals over 3.5 million miles and the acreage of lakes and ponds total over 41 million acres. Oliver A. Houck, *The Clean Water Act Returns (Again): Part I, TMDLs and the Chesapeake Bay*, 41 ENV'T L. REP. 10208, 10212 (2011).

[73] William V. Luneburg, *Where the Three Rivers Converge: Unassessed Waters and the Future of EPA's TMDL Program: A Case Study*, 24 J. LAW COMMER. 57 (2004); Houck, *supra* note 72, at 10212.

[74] Jennifer Sletten, Mimi D'Iorio, Mary G. Gleason, Alex Driedger, Timothé Vincent, Claire Colgrove, Dawn Wright & Virgil Zetterlind, *Beyond the Boundaries: How Regulation-Centered Marine Protected Area Information Improves Ocean Protection Assessments*, MARINE POL'Y, Feb. 2021, at 1 (discussing the use of new GIS techniques to generate baseline information on what levels of marine protection exist in different areas).

[75] For discussions of the trend towards adaptive management in environmental law, see generally Eric Biber, *Adaptive Management and the Future of Environmental Law*, 46 AKRON L. REV. 933 (2013) [hereinafter Biber, *Adaptive Management*]; J. B. Ruhl & Robert L. Fischman, *Adaptive Management in the Courts*, 95 MINN. L. REV. 424 (2011); Holly Doremus, *Adaptive Management as an Information Problem*, 89 N.C. L. REV. 1455 (2010); Fischman, *supra* note 50.

[76] Ruhl & Fischman, *supra* note 75, at 429 ("[M]anagement policy must put a premium on collecting information, establishing measurements of success, monitoring outcomes, using new information to adjust existing approaches . . . .").

[77] *See, e.g.*, 33 U.S.C. § 1365 (citing the Citizen Suit provision of the Clean Water Act); 42 U.S.C. § 6972 (citing the Citizen Suit provision of the Resource Conservation and Recovery Act); 42 U.S.C. § 7604 (citing the Citizen Suit provision of the Clean Air Act).

[78] Barton H. Thompson Jr., *The Continuing Innovations of Citizen Enforcement*, 2000 U. ILL. L. REV. 185, 188 (2000) ("By permitting citizens to monitor and prosecute environmental violations, we give citizens a socially important means of directly participating in and influencing the formulation and implementation of environmental policy.

part of the environmental monitoring infrastructure in the United States. Volunteer water quality monitors are a cornerstone of the Clean Water Act's monitoring program and support regional waterkeeper efforts.[79] Air quality monitoring by citizens has been used to detect major pollution violations.[80] However, the data collected by these members of the public generally remain inaccessible inside government datasets. When it is made available, it is often in formats that require significant scientific expertise to access and analyze. Government data—including those from government-funded research—on environmental conditions should be shared with the public.

Government data sources and storage are vulnerable to concealment or neglect amid changing administrations and priorities.[81] The result is that, historically, neither managers nor the public have had sufficient data to make informed environmental management decisions.[82] Our choices have been based on scientific evidence that is the best available but lacks the spatial and temporal resolution to make accurate decisions.[83]

The current environmental data systems made some amount of sense when they were created in the 1970s. Industry was concerned that making data public would lead to either commercially sensitive data being disclosed to competitors or bring increased public scrutiny of their activities.[84]

The EPA held similar concerns.[85] If the public found out how short the EPA was falling in meeting its legislatively mandated monitoring goals, there would likely have been much quicker public scrutiny. In the case of the Clean Water Act, it took until the early 1990s, nearly 20 years after the Act was passed, before citizen suits targeted the agency for lack of action on ambient monitoring.[86] The EPA benefitted from a system where data was difficult to find and, for the most part, closely held.

Simply opening enforcement channels to citizens gives them a voice that is crucial to the stature and power of private citizens in a democratic society.").

[79] Ashlee Jollymore, Morgan J. Haines, Terre Satterfield & Mark S. Johnson, *Citizen Science for Water Quality Monitoring: Data Implications of Citizen Perspectives*, 200 J. ENV'T MGMT. 456 (2017).

[80] *See, e.g.*, Overdevest & Mayer, *supra* note 58, at 1494, 1510.

[81] Sarah Lamdan, *Lessons from Datarescue: The Limitations of Grassroots Climate Change Data and the Need for Federal Records Law Reform*, 166 U. PA. L. REV. ONLINE 231, 239–240, 244 (2017).

[82] *See generally* Biber, *supra* note 4, at 23.

[83] *Id.* at 22; Esty, *supra* note 3, at 132–33 (citing the invisible buildup of carbon dioxide and other greenhouse gases as a paradigmatic example).

[84] Wendy E. Wagner, *Commons Ignorance: The Failure of Environmental Law to Produce Needed Information on Health and the Environment*, 53 DUKE L.J. 1619, 1631–1659 (2004) (discussing the reasons industry actors resist sharing information on their activities).

[85] Biber, *supra* note 4, at 48–51 (describing agency hesitancy to engage in or disclose monitoring results when it may raise awareness of new environmental problems).

[86] Oliver A Houck, *TMDLs III: A New Framework for the Clean Water Act's Ambient Standards Program*, 28 ENV'T L. REP. 10415, 10415–43 (1998).

The confidentiality concerns of industry and the desire of the EPA to avoid public scrutiny became the foundation for how environmental data is gathered and accessed to this day. These concerns may have become less pressing over time, but inertia keeps data systems intact.

The result is data systems that are public in name only. Basic data on environmental conditions is unavailable to communities that need it to understand and manage their own resources. This exacerbates existing inequalities, raising issues of environmental justice and inclusion. While many environmental agencies and regulations require stakeholder consultation and incorporation of traditional knowledge where possible, the data systems that these agencies use to make decisions systemically exclude many stakeholders.[87]

The EPA and others make implicit arguments that only certain types of data are useful to members of the public. For instance, data that indicates unsafe bacterial levels in local waters is used to determine when beaches should be closed.[88] More technical data is much less likely to be shared when it is not tied to specific public needs.

However, current technological capabilities are expanding the analytical ability of members of the public. While historically only a few scientists or government agencies may have had the technical expertise needed to interpret and understand environmental data, this is no longer the case.

4. Technology Is Driving a New Era in Environmental Data

Technology is fundamentally changing the potential for data collection, data management, and stakeholder engagement at all points of the data supply chain. We are in the midst of an explosion in new environmental data from the proliferation of new observing systems, the ability to draw on social media and other sources, and, with the hyper-connectivity of 5G and other communications advances, the rapid expansion of an environmental "internet of things."[89] Artificial Intelligence (AI) and other emerging processing techniques create the prospect of assimilating these data streams in new ways, bringing a radically new understanding of global ecosystems.[90] The "always on, always connected" environment could soon be a reality. The same

---

[87] *See, e.g.*, Kelsey Leonard, *Putting Indigenous Place-Names and Languages Back on Maps*, ESRI: ARCNEWS (Aug. 2, 2021), https://www.esri.com/about/newsroom/arcnews/putting-indigenous-place-names-and-languages-back-on-maps/ [https://perma.cc/B79P-7SSK] ("[T]he absence of Indigenous participation in broader ocean planning forums has a deep connection to our erasure in maps. If we are not on maps, we usually don't have a seat at the table. And there is no justice for Indigenous Peoples if we are not participating in the decision-making that affects our territories.").

[88] Luneburg, *supra* note 68, at 78–79.

[89] *See* Macey, *supra* note 4, at 1665–67 (outlining the ways in which new technologies are being used to collect environmental data).

[90] *See, e.g.*, William Boyd, *Environmental Law, Big Data, and the Torrent of Singularities*, 64 UCLA L. REV. DISCOURSE 544, 551–54 (2016) (describing "The Age of Big Data" in environmental management, spanning from the 2010s–2030s).

advances spurring new opportunities for scientific data collection present parallel opportunities to improve oversight of human activity at global and local scales.

Technology has changed what scope of data collection is possible, and big data initiatives abound.[91] The private and philanthropic sectors are driving many of these advancements.[92] Government agencies are also beginning to employ new tools but have been limited by historical conceptions of what is possible that are built into regulatory structures. Air quality regulations, for example, are based on the fallacy that the direct measurement of emissions is impossible.[93] While this was true when the Clean Air Act was passed, it no longer is. Relying on outdated assumptions about what data is possible to collect hampers environmental decision-making at all levels.

Technology is also enabling innovations in environmental management regimes. In recent years, rights-based management and dynamic management have shown notable promise in overcoming complex environmental management problems.[94] In the private sector, the transparency and traceability enabled by technological advancements can drive incentive shifts.[95] Emerging technologies enable these tools, creating the potential for more robust and nimble management.

Over the course of history, advances in technology have generally led to increased exploitation of the environment. Current mineral exploitation in the ocean is only possible because new, sophisticated robotics can descend to previously impossible depths.[96] These new capabilities thus come with two imperatives. The first is management—as the ability to exploit resources expands, effective management of resources will be ever more vital. The second is accountability—information on resource conditions and use must be public so that users of public resources are accountable to governments and markets.

Just as new technologies are enabling better data collection to support innovations in management, they are also enabling a new era of public transparency. Data that was once stored on hard drives in government agencies can now easily be shared through new tools, from blockchain to cloud-based computing.[97] These infrastructure advances are enabling calls for a new era of open environmental data.

Opening environmental data to the public has powerful potential. Agencies standing alone often struggle to design data collection programs that ask and answer the right questions.[98] Opening up data to the public in some cases may lead to better

---

[91] Linda K. Breggin & Judith Amsalem, *Big Data and the Environment: A Survey of Initiatives and Observations Moving Forward*, 44 ENV'T L. REP. 10984, 10987–91 (2014).

[92] *See, e.g.*, Yafit Lev-Aretz, *Data Philanthropy*, 70 HASTINGS L.J. 1491, 1491 (2019) (discussing the rise of private sector data being used for public benefits).

[93] Adam Babich, *The Unfulfilled Promise of Effective Air Quality and Emissions Monitoring*, 7 GEO. ENV'T L. REV. 569, 570 (2018).

[94] Biber, *Adaptive Management*, *supra* note 75; Ruhl & Fischman, *supra* note 75.

[95] *See generally* Gupta, *supra* note 56.

[96] *See* Ardron et al., *supra* note 57, at 59.

[97] *NOAA Expands Public Access to Big Data*, *supra* note 9; Mahdi Farnaghi & Ali Mansourian, *Blockchain, an Enabling Technology for Transparent and Accountable Decentralized Public Participatory GIS*, CITIES, Oct. 2020, at 1, 2.

[98] Biber, *supra* note 4, at 27–31.

and more rigorous analysis than relying on government scientists alone. Government agencies are notoriously unable to effectively integrate new sources of environmental data.[99] Resources are limited, and agency scientists aren't generally able to research questions out of curiosity. Members of the public, including new private enterprises, have more flexibility to pursue these questions. Expanding data access to the public increases the opportunities for environmental data analysis and understanding.

The public asks different questions of data than regulators do. These questions sometimes yield a better understanding of environmental conditions. In the past, environmental non-profits and members of the public have provided some of the most forward-looking, innovative solutions to environmental problems.[100] Providing these actors with the data they need to engage with environmental decision-making can help improve environmental outcomes.

The EPA and other agencies have begun to make public statements about the importance of open data and stakeholder engagement. In 2015, the EPA itself noted this shift, recognizing that new data tools could provide near real-time data not just to managers but to members of the public.[101] These statements remain largely lip service: the reality is that our current data structures make open data and meaningful stakeholder engagement effectively impossible. Implementing open data principles will require a complete reworking of how federal agencies treat environmental data.

However, efforts to introduce data transparency can hide ulterior motives.[102] Under the guise of ensuring public transparency, the Secret Science Reform Act prevented the EPA from basing any rule-making decisions on science that was not transparent or reproducible.[103] Outwardly, the argument for this law was that it ensured the science that the EPA used was sound by making it open to scrutiny from the public. In practice, it severely undermined the EPA's decision-making abilities. The EPA was prevented from using critical classes of data, for instance health data, because of confidentiality requirements that prevent these data from being made public.[104]

More government data transparency increases the power of the public but can also lead to increased power for corporate actors. In fact, more sophisticated private

---

[99] *See* Blais & Wagner, *supra* note 68, at 1701.

[100] Thompson, *supra* note 78.

[101] *See* Boyd, *supra* note 90, at 553 (quoting EPA Assistant Administrator for Office of Enforcement and Compliance Cynthia Giles: "We are moving toward a world in which states, EPA, citizens, and industry will have real-time electronic information regarding environmental conditions, emissions, and compliance.").

[102] Karen EC Levy & David Merritt Johns, *When Open Data Is a Trojan Horse: The Weaponization of Transparency in Science and Governance*, BIG DATA & SOC'Y, Mar. 23, 2016, at 1.

[103] Hannah Perls, *The Downfall of the "Secret Science" Rule, and What It Means for Biden's Environmental Agenda*, HARV.: ENV'T & ENERGY L. PROGRAM (Mar. 5, 2021), https://eelp.law.harvard.edu/2021/03/final-secret-science-rule/ [https://perma.cc/9PNM-YYHS]. *See also* 40 C.F.R. § 30 (2021).

[104] *See* Perls, *supra* note 103.

actors are potentially able to benefit more from open data developments.[105] Data that is transparent is easier to challenge. Corporations with large existing teams of data scientists can reanalyze existing datasets with different assumptions and uncertainty factors, providing new tools to challenge federal regulatory decisions. The Climategate email scandal of 2009 showed the danger of exposing internal scientific debate to the public and provided fodder for those wishing to undermine climate science.[106] Similar issues may occur when opening new datasets to the public.

The Climategate emails reflected a truth of the scientific process: debate over outcomes is a constant and required piece of scientific advancement.[107] Exposing these debates publicly can provide the grounds for adversarial actors to challenge outcomes. This same reality holds true for agency decision-making, which requires considerable debate and balancing of competing priorities. Complete transparency over these processes has real dampening effects on the ability of agency members and scientists to engage in the robust and sometimes critical dialogue necessary to ensure good regulation.

Too much transparency can be detrimental in other ways to agencies and the public. Transparency is costly to agencies.[108] Databases require significant resources to create and maintain. Although increasing transparency can also lead to greater public engagement, it also carries with it time costs for the agency that must handle this engagement. Prioritizing transparency will necessarily come at a cost to other worthwhile efforts.

Too much transparency can also make lay engagement difficult. Opening datasets can rapidly lead to floods of data that overwhelm the public and fail to provide meaningful information. Integrating newly released datasets into existing databases can help with these issues.

Even when the public is provided with meaningful data, this does not always drive changes in regulatory outcomes. Citizen-driven monitoring of air quality, for example, dramatically improved public understanding and participation in environmental enforcement.[109] However, without comprehensive integration of these programs into environmental management, they made little difference in enforcement outcomes.[110]

---

[105] *See* Levy & Johns, *supra* note 102, at 2–3.

[106] Robin McKie, *Climategate 10 Years on: What Lessons Have We Learned?*, GUARDIAN (Nov. 9, 2019, 14:19 EST), https://www.theguardian.com/theobserver/2019/nov/09/climategate-10-years-on-what-lessons-have-we-learned [https://perma.cc/8364-4WHN].

[107] *See generally* Anthony A. Leiserowitz, Edward W. Maibach, Connie Roser-Renouf, Nicholas Smith & Erica Dawson, *Climategate, Public Opinion, and the Loss of Trust*, 57 AM. BEHAV. SCIENTIST 818, 819 (2012).

[108] Coglianese et al., *supra* note 10, at 928.

[109] *See* Overdevest & Mayer, *supra* note 58, at 1494, 1510; Ottinger, *supra* note 58.

[110] *See generally* Dara O'Rourke & Gregg P. Macey, *Community Environmental Policing: Assessing New Strategies of Public Participation in Environmental Regulation*, 22 J. POL'Y ANALYSIS & MGMT. 383 (2003).

Environmental data systems have escaped scrutiny for decades. They can no longer continue to do so in the face of rapid social, environmental, and technological changes. We must now rethink how we gather, store, and publish environmental data.[111] The choices that regulators make in creating these systems will determine who has a seat at the decision-making table.

New technological capabilities have prompted considerable legal thought on how to fill data gaps and improve environmental monitoring.[112] However, little attention has been paid to how our current regulatory structures can facilitate or restrict the incorporation of these advancements.[113] In the face of increasing calls for open environmental data, we must rethink how environmental data is structured. Too often these calls frame the issue primarily as a choice: federal agencies simply need to choose to share their data with the public. In practice, moving from current data systems to more open ones require significant restructuring and reinterpreting of regulation itself. In many cases, opening up data systems may not be possible without reconsidering the fundamental definitions of why governments collect data.

III. FISHERIES DATA SYSTEMS

This Article uses fisheries management as a case study to understand how regulatory artifacts limit data-driven decision-making and prevent stakeholder engagement in environmental management. Emerging technologies highlight and exacerbate flaws in existing regulatory structures. While real-time, high-quality environmental data collection is more achievable and cost-effective than ever before, outdated regulatory data architectures are preventing the uptake and use of new data sources. Ultimately, this undermines the effectiveness of environmental regulation and limits meaningful stakeholder participation.

Fisheries are a cornerstone of the U.S. food supply. Together, U.S. commercial and recreational fisheries account for over $210 billion in sales annually.[114] Fisheries have always been subject to extreme fluctuations in productivity as the result of human and environmental pressures. However, climate change and increasing global populations are threatening the health and sustainability of fish stocks more than ever before.[115] The United Nations Food and Agriculture Organization (FAO)

---

[111] Macey, *supra* note 4, at 1679.

[112] *See, e.g.*, Glicksman et al., *supra* note 26; Boyd, *supra* note 90; Breggin & Amsalem, *supra* note 91, at 10995.

[113] With some notable exceptions, for work on structural needs in data-intensive environmental regulation, see Macey, *supra* note 4, at 1631–32.

[114] *Economic Impact of U.S. Commercial, Recreational Fishing Remains Strong*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. (Dec. 13, 2018), https://www.noaa.gov/media-release/economic-impact-of-us-commercial-recreational-fishing-remains-strong [https://perma.cc/T4LY-X4LK].

[115] Reg A. Watson, William W. L. Cheung, Jonathan A. Anticamara, Rashid U. Sumaila, Dirk Zeller & Daniel Pauly, *Global Marine Yield Halved as Fishing Intensity Redoubles*, 14 FISH & FISHERIES 493 (2013); *see generally* Boris Worm, Ray Hilborn, Julia

estimates that over one-third of global fish stocks are critically overfished, with an additional 60% being fished at capacity.[116] Ensuring that fisheries remain healthy in the long run is important both economically and socially, with many areas turning to fish as a critical source of protein for growing populations.[117]

Legislation regarding fisheries recognizes the importance of maintaining healthy fish stocks. The Magnuson-Stevens Act,[118] the primary fisheries management regulation in the United States, mandates that "[c]onservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery."[119]

Fisheries managers are tasked with putting in place measures that will ensure optimum sustainable yields over time. This requires balancing the competing priorities of maximizing short-term economic gain for fishing communities and ensuring that fish populations remain healthy enough to continue replenishing themselves at a sustainable rate. Balancing these priorities requires managers to make difficult decisions with significant economic consequences for fishing communities, including restricting catches and even closing entire fisheries. Fisheries managers are often forced to make these highly controversial decisions using incomplete data.[120] This results in decisions that do not always achieve the Magnuson-Stevens goal of preventing overfishing.[121]

K. Baum, Trevor A. Branch, Jeremy S. Collie, Christopher Costello, Michael J. Fogarty, Elizabeth A. Fulton, Jeffrey A. Hutchings, Simon Jennings, Olaf P. Jensen, Heike K. Lotze, Pamela M. Mace, Tim R. McClanahan, Cóilín Minto, Stephen R. Palumbi, Ana M. Parma, Daniel Ricard, Andrew A. Rosenberg, Reg Watson & Dirk Zeller, *Rebuilding Global Fisheries*, 325 SCI. 578 (2009); *see generally* Daniel Pauly & Dirk Zeller, *Catch Reconstructions Reveal that Global Marine Fisheries Catches Are Higher than Reported and Declining*, 7 NAT. COMMC'NS 1 (2016), http://www.nature.com/articles/ncomms10244 [https://perma.cc/3P32-4B7Z].

[116] FOOD & AGRIC. ORG. U.N., THE STATE OF WORLD FISHERIES AND AQUACULTURE 96 (2018).

[117] CHRISTOPHER COSTELLO, LING CAO & STEFAN GELCICH, HIGH LEVEL PANEL SUSTAINABLE OCEAN ECON., THE FUTURE OF FOOD FROM THE SEA 28 (2019) (noting that "[s]eafood consumption per capita has more than doubled since 1961," and "[t]otal global consumption of seafood is projected to increase by 20 percent . . . by 2030").

[118] 16 U.S.C. §§ 1801–91d.

[119] *See id.* § 1851(a)(1).

[120] *See* Blasco et al., *supra* note 16, at 1("[W]hile fisheries management is improving in many areas there remain key gaps in data resolution that are critical for fisheries assessments and conservation of aquatic systems into the future."); Monica Medina & Scott Nuzum, *Electronic Reporting and Monitoring in Fisheries: Data Privacy, Security, and Management Challenges and 21st-Century Solutions*, 49 ENV'T L. REP. 10670, 10675 (2019) ("One of the most significant gaps in the current regime is the dearth of up-to-date information related to the quantity and location of catches. The lack of quality data, in turn, compromises the quality of FMPs and means that NOAA is not meeting the mandates outlined in the national standards.").

[121] *See* Medina & Nuzum, *supra* note 120, at 10672–73 (describing the history of overfished stocks in the United States).

Fish stocks have fluctuated wildly in the past century, almost entirely as a result of human fishing activity and fisheries management decisions.[122] Historically, this fluctuation was generally caused by a lack of complete scientific understanding of fishery ecosystems combined with political pressure for managers to set fish takes as high as possible to help fishing communities survive economically.

Today, we have much more scientific data on fisheries and the supporting ecosystems than ever before, but outdated data systems do not provide adequate data to fisheries managers and systematically exclude participation by stakeholders. The result is management decisions that continually fail to achieve optimum sustainable yield. This section looks at how fisheries data is currently collected and managed by NOAA, arguing that current data systems lead to scientifically suboptimal data and increased tension between government managers and external stakeholders. It then looks at emerging fisheries management innovations and argues that significant changes are needed to fisheries data regulation to meet the goals of the Magnuson-Stevens Act.

A. Current Fisheries Data Structures

The Magnuson-Stevens Act (MSA) recognizes that quality scientific information is needed to support effective fisheries management.[123] This

---

[122] Unlike with agriculture, where droughts and other weather events can ruin a whole season's crop, fisheries are much more stable in the absence of human interference. A particularly warm winter may cause fish populations to stay slightly further offshore. Natural variations in the El Niño Southern Oscillation (ENSO) cause species to migrate and fewer fish to be present in certain areas. *See generally* Ray Hilborn, Ricardo Oscar Amoroso, Christopher M. Anderson, Julia K. Baum, Trevor A. Branch, Christopher Costello, Carryn L. de Moor, Abdelmalek Faraj, Daniel Hively, Olaf P. Jensen, Hiroyuki Kurota, L. Richard Little, Pamela Mace, Tim McClanahan, Michael C. Melnychuk, Cóilín Minto, Giacomo Chato Osio, Ana M. Parma, Maite Pons, Susana Segurado, Cody S. Szuwalski, Jono R. Wilson & Yimin Ye, *Effective Fisheries Management Instrumental in Improving Fish Stock Status*, 117 PROC. NAT. ACAD. SCI. 2218 (2020); *see also* ARNAUD BERTRAND, MATTHIEU LENGAIGNE, KEN TAKAHASHI, ANGEL AVADÍ, FLORANCE POULAIN & CHRIS HARROD, FOOD & AGRIC. ORG. U.N., EL NIÑO SOUTHERN OSCILLATION (ENSO) EFFECTS ON FISHERIES AND AQUACULTURE vi (2020), https://doi.org/10.4060/ca8348en [https://perma.cc/75MU-PDZH] (indicating that these natural variations in fish stocks account for a "-18.8% to +34.9%" variation over time. Additionally, "La Niña [i]s associated with more extreme production anomalies than neutral or El Niño events.").

[123] *See* 16 U.S.C. § 1851(a)(2) ("Conservation and management measures shall be based upon the best scientific information available.").

information is obtained from fishermen,[124] government observers,[125] and independent fisheries scientists,[126] in addition to NOAA's own staff.

1. Fisheries Data Collection

Fisheries data is collected onboard fishing vessels in several different ways. The majority of data comes from fisheries observers. Observers are mandated in most fisheries of the United States, with varying requirements for how many trips observers are required to be present on.[127] Observers are contracted government employees who collect information on the fish brought on board, including species, size, and other pertinent information.[128] This observer data is the critical foundation of fisheries stock assessments in the United States and globally.

There are significant downsides to the observer program. Fishing vessels must pay for observers and find space for them to sleep and live on already crowded vessels.[129] Observers are onboard to record compliance with fishing regulations, leading to tense interactions between observers and vessel crew.[130] Moreover,

---

[124] *See id.* § 1853(a)(5) ("[S]pecify[ing] . . . the pertinent data which shall be submitted to the Secretary with respect to commercial, recreational, charter fishing, and fish processing in the fishery, including, but not limited to, information regarding the type and quantity of fishing gear used, catch by species in numbers of fish or weight thereof, areas in which fishing was engaged in, time of fishing, [and] number of hauls").

[125] *See id.* § 1853(b)(8) ("[R]equir[ing] . . . one or more observers be carried on board a vessel of the United States engaged in fishing for species that are subject to the plan, for the purpose of collecting data necessary for the conservation and management of the fishery").

[126] *See id.* § 1881(e)(1) ("The Secretary may use the private sector to provide vessels, equipment, and services necessary to survey the fishery resources of the United States when the arrangement will yield statistically reliable results.").

[127] *See id.* § 1853(b)(8); Read D. Porter, *Fisheries Observers as Enforcement Assets: Lessons from the North Pacific*, 34 MARINE POL'Y 583, 583 (2010).

[128] *See generally National Observer Program*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. FISHERIES, https://www.fisheries.noaa.gov/national/fisheries-observers/national-observer-program [https://perma.cc/DLK6-5WL4] (last visited Aug. 2, 2021) (explaining the National Observer Program, which helps support data collection from fisheries, to support fishery health and sustainability); Christopher Ewell, John Hocevar, Elizabeth Mitchell, Samantha Snowden & Jennifer Jacquet, *An Evaluation of Regional Fisheries Management Organization At-Sea Compliance Monitoring and Observer Programs*, MARINE POL'Y, Feb. 17, 2020, at 1 (discussing the role of observers in global fisheries).

[129] *But see* 16 U.S.C. § 1851(b)(8) ("[A] vessel shall not be required to carry an observer on board if the facilities of the vessel for the quartering of an observer, or for carrying out observer functions, are so inadequate or unsafe that the health or safety of the observer or the safe operation of the vessel would be jeopardized.").

[130] *See* Martin Purves, *The Role of a Fisheries Observer*, HUMAN RIGHTS SEA, July 2020, at 1, 4, https://www.humanrightsatsea.org/wp-content/uploads/2020/08/HRAS_Insight-Briefing-Note_Role-of-Fisheries-Observer_JULY_2020_SP_LOCKED.pdf [https://perma.cc/EHE7-955Z] ("If an observer discovers things they weren't intended to know about, they can face intimidation, threats, violence, and in the worst cases, murder.").

observers are not required to be on vessels all the time. Fishing vessels often operate differently when observers are aboard, often making trips as short as possible. This means that the data collected by observers is not particularly accurate in its representation of actual fishing behavior.[131] While fishermen are mostly concerned about ensuring observers do not see them doing anything illegal, from an environmental management standpoint, it is much more concerning that the scientific data collected by observers may not be accurate due to temporary behavioral changes.[132]

The majority of vessels do not have observer coverage, so data is obtained primarily through self-reporting. Captains are responsible for logging data on when and how long they fish and how much and of what species they catch.[133] This reporting is notoriously inaccurate or in analog forms that are difficult to assimilate into management databases.[134]

Self-reports are combined with remote sensing technologies that track fishing vessel movement. Vessel Monitoring Systems (VMS) are the most important of these. These tamper-proof boxes are mandated on fishing vessels in most fisheries of the U.S.[135] VMS units use GPS to track vessel location and transmit this information back to regulators in real-time at regular intervals.[136] Some units have sensors that can additionally record when fishing gear is deployed, but for the most part, VMS units do not transmit data on where and when vessels are fishing.[137] Nor do they have data on what fish vessels catch. Functionality is limited, and observers are needed to fill in the resulting data gaps.

---

[131] *See* Porter, *supra* note 127, at 583 (discussing the impact of having observers onboard on fishing behavior).

[132] *Compare* Ewell et al., *supra* note 128, at 8–10 (noting behavioral changes), *with* Porter, *supra* note 127 (arguing that despite potential for their "resultant influence of fisher behavior," North Pacific observers serve an important enforcement role that should be emulated elsewhere).

[133] *See* 16 U.S.C. § 1853(a)(5).

[134] *See* Medina & Nuzum, *supra* note 120 (noting the inaccuracy of self-reporting data); ANNIE BRETT, WORLD ECON. F., ENDING ILLEGAL FISHING: DATA POLICY AND THE PORT STATE MEASURES AGREEMENT 9–10 (2019) (examining how historically paper-based fishery data systems might help better categorize data).

[135] *See* 50 C.F.R. § 600 (2019) (implementing the Magnuson-Stevens Fishery Conservation and Management Act and setting overall federal regulation of VMS and type-approvals); *See, e.g.*, *id.* § 622.28 (2019) (setting VMS requirements for the Gulf of Mexico); *id.* § 622.205 (2019) (setting VMS requirements for the South Atlantic Shrimp Fishery); *id.* §§ 648.9–.10 (2019) (setting VMS requirements for the Northeastern United States); *id.* § 660.14 (2019) (setting VMS requirements for the Western United States).

[136] *See id.* § 600.1500.

[137] *Cf.* KATIE WESTFALL, MONICA GOLDBERG, SHEMS JUD, JOHANNA THOMAS, CHRIS CUSACK, MELISSA MAHONEY, HUFF MCGONIGAL, SEPP HAUKEBO, KIM DIEP & MADELEINE DWYER, ENV'T DEF. FUND, ELECTRONIC TECHNOLOGIES & DATA POLICY FOR U.S. FISHERIES: KEY TOPICS, BARRIERS, AND OPPORTUNITIES 5, 10 (2020) (outlining how different vessels can use different electronic monitoring and electronic recording systems).

Beyond VMS, Automated Identification System (AIS) transmitters, originally placed on vessels for safety purposes, also track fishing vessel location and are used for some fisheries monitoring purposes.[138] AIS data has lower temporal resolution than VMS data and, importantly, can be turned off at any time. VMS is much preferred as a data source for decision-making, but confidentiality concerns have limited the dissemination of VMS data.[139] In general, VMS data is only available to regulators in the country a vessel is registered in, while AIS data can be made available publicly.[140]

2. Data Use and Storage

Data from observers and VMS are gathered on fishing vessels under regulatory mandates and transmitted directly to managers.[141] This data is managed and stored by NOAA. The National Archives and Records Administration (NARA) dictates the length of time that various datasets must be stored with observer data subject to the unusually stringent requirement of indefinite storage.[142]

Current MSA systems have created data silos within NOAA itself.[143] Data is collected and used for three major purposes: management, enforcement, and science. Data collected primarily for enforcement, most notably VMS data, is managed, stored, and administered by NOAA's Office of Law Enforcement (OLE).[144] Data collected primarily for scientific purposes, including most observer and vessel self-reports, is transmitted to NOAA's Fisheries Sampling Branch, where it is stored and disseminated.[145] Functionally, this data is not shared between departments.

3. Data Access and Sharing

Fisheries data is more sensitive than some other types of environmental data.[146] Most regulated entities have some concerns that sharing data about their practices

---

[138] *See* 33 C.F.R. § 164.46(a) (2019). AIS units are not mandated under the Magnuson-Stevens Act, but by the U.S. Coast Guard under their mandate to regulate vessel safety. AIS must be carried by all U.S. commercial vessels over 65 feet in length. *See id.* § 164.46(b)(1)(i) (2019).

[139] *See* BRETT, *supra* note 134, at 10.

[140] *See id.*

[141] *See* WESTFALL ET AL., s*upra* note 137, at 10, 14.

[142] NOAA, NOAA RECORDS SCHEDULES CHAPTER 1500 – FISHERY AND LIVING MARINE RESOURCE FUNCTIONAL FILES (2018). For a discussion of the costs imposed by this lengthy storage requirement, see WESTFALL ET AL., *supra* note 137, at 11–14.

[143] For a general overview, see PORCARO, *supra* note 1, at 7 tbl. 1a (detailing the datastreams for New England groundfish controlled end-to-end by government agencies).

[144] *Id.*

[145] *Id.*

[146] *See* Biber, *supra* note 4, at 9–14 (discussing the differences in how ambient and compliance data is treated).

may lead to further scrutiny or identification of illegal behavior.[147] The fishing sector shares these and other concerns, including that data on their vessel movements will be used by other fishermen to identify prime fishing spots. Fishermen are successful because of where and how they choose to fish—practices they have historically been extremely secretive about. Particularly productive spots are highly guarded secrets, as is knowledge on what areas are best to fish in response to various weather conditions. This knowledge was the source of most major economic differentiation between fishermen in the past.[148] The same vessels leaving the same port for the same amount of time could have dramatically different hauls based on where they chose to go.[149] Because of the importance of these trade secrets, fishermen can be highly secretive about their location information and highly resistant to sharing it.[150]

Fisheries regulations were built to protect this commercially sensitive fisheries location data.[151] There wasn't much other choice. When regulators first proposed methods of collecting location data, there was near-universal outcry from fishermen. Fishermen had legitimate concerns that if data on where they were fishing was shared, it would invite competition for prime spots from other fishermen as well as violate their own personal privacy concerns.[152] Given that one of the primary goals of the Magnuson-Stevens Act, when it was first passed, was to protect U.S. fishermen against intrusion by international fleets, Congress was extremely receptive to these concerns.[153]

In response, managers created legislation that attempted to protect locational confidentiality for fishermen.[154] Data agreements stipulated that managers would not share information unless it was anonymized by clumping data from a minimum of three vessels together. Data was also not released until a certain amount of time had passed.

---

[147] *See, e.g.*, John S. Applegate, *Bridging the Data Gap: Balancing the Supply and Demand for Chemical Information*, 86 TEX. L. REV. 1365 (2008); Bradley C. Karkkainen, *Bottlenecks and Baselines: Tackling Information Deficits in Environmental Regulation*, 86 TEX. L. REV. 1409 (2008); Rena I. Steinzor, *Reinventing Environmental Regulation: The Dangerous Journey from Command to Self-Control*, 22 HARV. ENV'T. L. REV 103, 150–83 (1998).

[148] *See, e.g.,* Johan A. Mistiaen and Ivar E. Strand, *Location Choice of Commercial Fishermen with Heterogeneous Risk Preferences,* 82 AM. J. AGRIC. ECON. 1184, 1184 ("Fishermen targeting the same species typically have dramatically different returns depending on their location choice.").

[149] *Id.*

[150] *See, e.g.,* Craig Palmer, *Telling the Truth (Up to a Point): Radio Communication Among Marine Lobstermen,* 49 HUMAN ORG. 157 (1990) (discussing secrecy and communication practices in the Maine lobster fishery).

[151] WESTFALL ET AL., *supra* note 137, at 16–17.

[152] Medina & Nuzum, *supra* note 120, at 10680 ("[F]ishers fear that electronic monitoring will lead to the government releasing to the public (and their competitors) their confidential business information related to their fishing methods and locations").

[153] *See id.* at 10673.

[154] *See* WESTFALL ET AL., *supra* note 137, at 16–17; Medina & Nuzum, *supra* note 120, at 10675–78.

Functionally, fishermen's secrets were protected not only by regulatory requirements but also by the reality that data moves through the federal government extremely slowly. While not explicitly protected in fisheries regulation, the practice of NMFS involves several lengthy steps for data transmission and storage. Data collected by observers, for example, is first sent from the observers in analog form to intermediary contractors before being sent to regional councils and NOAA, where it is eventually processed and analyzed.[155] The upshot is that it may be years before data is available to the public. By this time, data is much less valuable or likely to lead to commercially sensitive information being portrayed.

The data confidentiality systems that were put in place to protect individual fishermen are now proving to be detrimental to fishing communities as a whole. Fishermen do not have access to their own data, eliminating opportunities for any kind of self-management or adaptation. The role of data in enabling stakeholder engagement is particularly important under the Magnuson-Stevens Act, which aims to "encourage user-group self-regulation within legislatively prescribed scientific and policy-based parameters."[156] Magnuson-Stevens is a "law without courts," reliant on agency administration, stakeholder involvement, and notably little judicial review.[157]

This goal of Magnuson-Stevens is not being met. Fishermen often do not trust managers to make well-informed decisions, which partially stems from past examples of managers making ineffective decisions based on inaccurate or incomplete data.[158] In other cases, the management decisions may be sound but managers have not worked effectively with local fishing communities to ensure there is support and buy-in for decisions. This commonly plays out in scenarios where fishermen are catching record hauls of fish, which they believe denotes healthy and abundant stocks. Managers see record hauls as cause for concern, indicating that more fish are being caught than their models have predicted. Managers then place tighter restrictions on fishing quotas, confusing the fishermen who see no reason for these restrictions in the face of such good catches. This disconnect has many causes, but one of them is certainly communication of and access to data.

Fishermen who are able to see the information being used as the basis for management decisions are more likely to support management decisions and less

---

[155] PORCARO, *supra* note 1 (detailing the data stream for observer data, which is first collected by observers before being sent to the vendors they are employed by and then to NOAA).

[156] Marian Macpherson & Mariam McCall, *Judicial Remedies in Fisheries Litigation: Pros, Cons, and Prestidigitation?*, 9 OCEAN & COASTAL L.J. 1, 4 (2003).

[157] Robin Kundis Craig & Catherine Danley, *Federal Fisheries Management: A Quantitative Assessment of Federal Fisheries Litigation Since 1976*, 32 J. LAND USE & ENV'T L. 381, 383 (2017).

[158] The collapse of the Canadian Groundfish fishery is a classic example. *See* Anthony T. Charles, *Living with Uncertainty in Fisheries: Analytical Methods, Management Priorities and the Canadian Groundfishery Experience*, 37 FISHERIES RSCH. 37, 42–48 (1998).

likely to engage in illegal activity.[159] Nearly 90% of fish stocks globally are overexploited due to ineffective management and illegal fishing.[160] Illegal, Unreported, and Unregulated (IUU) fishing is a major contributor to this, undermining efforts to sustainably manage ecosystems, threatening food security, and facilitating human rights abuses.[161] IUU costs the global economy over $23 billion in annual economic losses.[162]

Efforts to better manage fisheries and tackle IUU fishing have been stymied by the difficulties of monitoring and enforcing in distant areas of the ocean. Current solutions rely on human observers placed on fishing vessels to oversee catches and report back to fisheries managers. The information gathered by observers is critical to combatting IUU and ensuring sustainable fisheries. However, placing observers on vessels is costly and exposes them to considerable safety risks, resulting in limited coverage from current observers. The vast majority of fishing vessels have no such oversight and can easily operate illegally with little chance of detection. Improving monitoring technology coupled with better stakeholder engagement may be able to stem this tide.

B. Technological Innovation Is Prompting a New Era in Management

Observers and VMS are still the cornerstones of fisheries data collection, but this is changing rapidly. Improving technological capabilities are opening new doors for how we understand and manage fisheries. These technologies are being incorporated into existing regulatory structures in ways that limit their potential usefulness. In this section, I look to understand both how new technologies can best be used to support fisheries management and what needs to happen to our current regulatory structures to allow this.

Rampant data gaps, particularly regarding what is actually happening on fishing vessels, combined with a lack of public transparency, have defined our fisheries data systems for decades. New technologies are changing both of these paradigms. Tools like Global Fishing Watch are ushering in a new era of transparency by providing the public with near-real-time location tracking for the majority of fishing vessels in the world. In 2015, Google, Oceana, and SkyTruth came together to form Global Fishing Watch (GFW), a tool intended to spur sustainability in the fisheries sector through transparency.[163] A suite of other tools known as electronic monitoring enables new possibilities for the information that we collect on vessels themselves.

---

[159] Davis & Hanich, *supra* note 55, at 10489.

[160] Worm et al., *supra* note 115.

[161] Dana D. Miller & U. Rashid Sumaila, *IUU Fishing and Impact on the Seafood Industry*, *in* SEAFOOD AUTHENTICITY AND TRACEABILITY: A DNA-BASED PERSPECTIVE 83 (Amanda M. Naaum & Robert H. Hanner eds., 2016).

[162] *Growing Momentum to Close the Net on Illegal Fishing*, FOOD & AGRIC. ORG. U. N. (June 5, 2018), http://www.fao.org/news/story/en/item/1137863/icode/ [https://perma.cc/D5P6-EGHW].

[163] *About Us*, GLOB. FISHING WATCH, https://globalfishingwatch.org/about-us/ [https://perma.cc/UYT7-A4V7] (last visited July 28, 2021).

This section looks at these two developments specifically as cornerstones of a new era of fisheries management.

1. The Move Towards Public Transparency: Global Fishing Watch

Global Fishing Watch publishes near real-time locations of fishing vessels around the world for free on their website.[164] This type of tracking marked a fundamental shift in how fisheries transparency was approached. Prior to Global Fishing Watch's publication, very little data on the fishing locations of fishing vessels were publicly available. None of it was available in near-real-time. Prior to its launch, academics and the private sector questioned what impact this transparency would have.[165]

Global Fishing Watch's impact has far exceeded expectations, spurring a new culture of transparency in the fishing industry. GFW quickly became the darling of the global ocean policy community, garnering recognition and high-profile partnerships globally.[166] Their idea was far from revolutionary but implementing it well enabled critical new audiences to meaningfully engage with fisheries management.

The majority of GFW data is drawn from AIS units and is consequently less accurate than data available to in-country managers via VMS.[167] However, a number of countries have agreed to share their VMS data through the platform.[168] This is notable because it affords a much greater degree of transparency and shows a willingness to move beyond the concerns over privacy that have limited location data sharing in the past. The willingness of countries to share their fishing data has been driven by a fundamental shift in the culture of fisheries: increasing technological capabilities has rendered much of the need for secrecy effectively moot. Whether countries want it or not, it is relatively easy for anyone with advanced radar or satellite tools to tell exactly where their fleets are fishing at any given time. Publishing this information more broadly to the public does little to impair their

---

[164] *Id.*

[165] *See generally* Aarti Gupta, *Transparency in Global Environmental Governance: A Coming of Age?,* 10 GLOB. ENV'T POL., August 2010, at 6–8 (discussing the potential negative impacts of transparency initiatives).

[166] *See, e.g.,* Sarah Bladen, *U.S. Government and Nonprofit Organization Host Prize Competition to Leverage the Latest Technology to Detect and Defeat Illegal Fishing*, GLOB. FISHING WATCH (Jul. 22, 2021), https://globalfishingwatch.org/press-release/usgovt-gfw-xview3/ [https://perma.cc/5LFB-WXSL]; Kimbra Cutlip, *Peter Benchley Ocean Awards: Global Fishing Watch Partners Win Big*, GLOB. FISHING WATCH (June 2, 2016), https://globalfishingwatch.org/news-views/peter-benchley-ocean-awards-global-fishing-watch-partners-win-big/ [https://perma.cc/B8YX-2AED].

[167] *See* Bjorn Bergman, *Systematic Data Analysis Reveals False Vessel Tracks,* GLOB. FISHING WATCH (July 29, 2021), https://globalfishingwatch.org/data/analysis-reveals-false-vessel-tracks/ [https://perma.cc/WRC8-6BY3].

[168] *Transparency,* GLOB. FISHING WATCH, https://globalfishingwatch.org/transparency/ [https://perma.cc/WU3K-4GS9] (last visited Oct. 11, 2021).

commercial prospects while promoting a culture of transparency that may ultimately help in the fight against illegal fishing.

Global Fishing Watch is introducing a new era of transparency for fisheries data. This has had positive impacts throughout seafood supply chains. It has enabled not only the public but scientific researchers to conduct revolutionary new studies of fisheries activity.[169] The advances in scientific research spurred by GFW's transparency are particularly notable, ostensibly because scientists are one stakeholder group that federal regulators most easily provide data. In practice, GFW's uptake by the scientific community is evidence of how unworkable federal data systems are.[170] Government constraints, including confidentiality restrictions and onerous review requirements, make the real-time publication of fisheries data impossible.

2. Electronic Monitoring

For managers, understanding what is actually happening onboard fishing vessels has been one of the largest information gaps in fisheries. Without observers onboard, there has simply been no way to know when vessels are fishing, what species or how much fish they are catching. This information is critical for scientific assessments of fish populations and the resulting management decisions.

New tools are opening new possibilities for gathering data onboard fishing vessels. Electronic monitoring (EM) technologies are at the center of present-day discussions for how to incorporate new technology into fisheries management.[171] At its most basic, EM places video cameras on fishing vessels.[172] EM systems record footage that monitors when vessels are fishing. More complex systems are being designed to capture information on what species are being caught and how many fish are brought aboard.[173] Coupling these video cameras with analysis driven by automated machine learning, there is great potential to vastly increase the amount of information regulators have available and fill existing gaps about what is happening onboard fishing vessels.

However, NOAA has been slow to integrate EM into existing fisheries management regimes. Current efforts are largely regionally driven, with some

---

[169] *See, e.g.*, Kroodsma et al., *supra* note 8; Douglas J. McCauley, Caroline Jablonicky, Edward H. Allison, Christopher D. Golden, Francis H. Joyce, Juan Mayoraga & David Kroodsma, *Wealthy Countries Dominate Industrial Fishing*, SCI. ADVANCES, Aug. 1, 2018, at 1, 2–3, https://advances.sciencemag.org/content/4/8/eaau2161.short [https://perma.cc/GY3X-EGFH].

[170] Several groundbreaking studies have been based on GFW data. *See* McCauley et al., *supra* note 169; Kroodsma et al., *supra* note 8.

[171] Melissa Garren, Forrest Lewis, Laura Sanchez, Daniella Spina & Annie Brett, *How Performance Standards Could Support Innovation and Technology-Compatible Fisheries Management Frameworks in the U.S.*, MARINE POL'Y, June 11, 2021, at 1, https://doi.org/10.1016/j.marpol.2021.104631 [https://perma.cc/K9WV-TJFJ].

[172] *Id.*

[173] WESTFALL ET AL., *supra* note 137.

regions, such as the Pacific Northwest, driving early adoption of EM while the majority of others lag behind.[174] In some ways, this reflects the structure of the Magnuson-Stevens Act, which vests regional management councils with significant flexibility in how they manage fisheries.[175] However, the piecemeal approach to EM adoption has hindered technological development because the market for EM hardware remains small, while at the same time raising significant questions about how EM fits in with federal management requirements that have yet to be answered.

NOAA's slow incorporation of EM into existing fisheries regulation highlights the flaws in how environmental data are currently collected and managed by federal agencies. We need an integrated national framework that encourages technological innovations. The legal structures needed to create it already exist. However, NOAA is often limited by a desire to draw on and not deviate significantly from previous regulatory efforts. In the case of EM, this means that NOAA rule-makers are looking to VMS rules as a template for how EM should be regulated.

VMS rules, however, are not a robust template for EM regulation. VMS itself is a case study for how a lack of technical expertise within NOAA led to the creation of rules that have hindered technological advancement in the space. Within NOAA, the division of technical expertise and legal expertise into different offices has prevented the creation of comprehensive and forward-looking regulation. Using pre-existing rules as a template to be modified when new technologies are developed can allow NOAA to promulgate rules more quickly, but it also can promote technical artifacts that are less efficient and ultimately de-incentivize technological innovation in the long run.

Most relevantly from the data perspective, current rules segment technology, and the data generated from it, by technology type and not by the data that are ultimately collected.[176] This means that different types of fisheries data, like those originating from onboard observers and VMS, are sent to different NOAA offices furthering existing data siloes and hampering even intra-agency data access.

Beyond NOAA, one of the largest questions as EM moves forward will be who has access to EM data and how this access is facilitated. Data from other fisheries technologies, notably VMS, is generally controlled end-to-end by the government and not made available to other interests, including fishermen themselves. The reasons for this current model have been at least partially legally driven: federal fisheries law requires vessel and ecosystem data to fulfill management and enforcement duties.[177] The government thus collects and controls the majority of data relevant to U.S. fisheries. Some of this data is eventually shared after regulators use it, but much of it remains closely held by the government due to strict interpretations of confidentiality laws.

---

[174] Garren et al., *supra* note 171, at 4.

[175] *See* Magnusson-Stevens Fishery Conservation and Management Act of 1976, Pub. L. No. 94-265, 90 Stat. 331 (codified as amended at 16 U.S.C. §§ 1801–91d).

[176] Garren et al., *supra* note 171.

[177] *See* WESTFALL ET AL., *supra* note 137, at 7, 12.

Going forward, EM and other fisheries technologies will be more useful and well-adopted if they provide parallel data access to fishermen and others. Early work by Digital Public and the Cape Cod Fisherman's Forum details how parallel data access systems for EM could work.[178] In some systems, fishermen retain ownership of their data, while in others, the government or vendors own data but grant access to fishermen and other interested parties.[179] NOAA should not determine a data access system on the federal level, but it should enable these systems to be designed at a regional or fishery level by ensuring that vendors, fishermen, and scientists are allowed to access EM data.

Data access frameworks must be in line with existing confidentiality regulations. The majority of these restrictions are currently driven by the fact that EM data is classified as observer data. Creating a new data category for EM data is the desirable outcome, but in the meantime, EM data is subject to the same confidentiality regulations as observer data more broadly.[180] NOAA has found in emerging EM rules that third-party vendors are not subject to MSA confidentiality requirements.[181] In the West Coast groundfish EM program, third-party vendors may share EM data with others if authorized by the vessel owner.[182]

Government managers must work with stakeholders to design the legal data governance structures for EM data. These systems will be subject to existing confidentially requirements, but beyond this, creating the legal frameworks that govern EM data ownership and access will require developing new contractual agreements between the relevant parties. To the extent that this moves beyond the existing model of end-to-end government data control, developing these agreements will add another layer of complexity to EM implementation. It is nonetheless essential that federal EM regulation includes provisions that support and drive more comprehensive data access systems.

EM is emerging into a piecemeal, historically driven regulatory landscape that importantly will neither generate the necessary data nor engage the necessary stakeholders to achieve NOAA goals without major revision. Combining these historically driven policies with calls for open data has the potential to undermine efforts to engage stakeholders and address environmental inequities.[183] Unless major changes are made, data will remain siloed within NOAA and not be used to support management to the greatest extent possible. Fishermen will remain disconnected from their data and excluded from meaningful participation in fisheries management. Other external stakeholders will likewise be unable to take advantage of the data-rich ecosystem that should inform environmental management.

---

[178] PORCARO, *supra* note 1.
[179] *Id.*
[180] Garren et al., *supra* note 171.
[181] *See* WESTFALL ET AL., *supra* note 137, at 16.
[182] *Id.* (citing 50 C.F.R. § 660.603(n)(3)).
[183] Levy & Johns, *supra* note 102.

C. The Dangers of Government Dominated Environmental Data Systems

Fisheries data systems highlight issues that are prevalent throughout environmental management. FEMA collects large volumes of data on sea level rise, coastal storms, and other hazards.[184] This data is used to help calculate flood risks and insurance premiums and to determine where government infrastructure investments should be made.[185] However, the only pieces of this information that are generally available to the public are very limited data on 100-year flood risks.[186] Most consumers do not fully understand how to interpret these risks or know that many orders of magnitude more sophisticated flood risk data could be available. Providing this data to consumers interested in purchasing coastal property could reduce government costs in the long run by deterring high-risk purchases. Some NFIP data is available, though even sophisticated researchers note that it is "messy."[187] Providing access to this data allows for new types of analyses and understanding of flood risk potential.

Under the Clean Water Act, only a minimal amount of water quality data is made available to the public. States are required to monitor all the waters within their borders to determine if they meet water quality criteria.[188] Data is reported to the EPA and available to the public on the EPA website, including in map-based form.[189] However, available data is generally at least several years old and provides only a broad categorization of whether a given water is impaired or not.[190] This level of information is not helpful in promoting transparency and public engagement.

These case studies illustrate the issues with government-dominated environmental data systems. Government may be better equipped than any other entity to provide the public good of collecting, storing, and disseminating environmental data, but they should not do this alone. Allowing others to participate in environmental data systems importantly generates better scientific outcomes, reduces inequities, and fosters a more robust environmental management landscape.

---

[184] *See generally National Flood Hazard Layer,* FEMA (last updated Aug. 26, 2021), https://www.fema.gov/flood-maps/national-flood-hazard-layer [https://perma.cc/9S6Z-GDJ7] ("The National Flood Hazard Layer (NFHL) is a geospatial database that contains current effective flood hazard data.").

[185] *Id.*

[186] *See Flood Maps*, FEMA (last updated June 22, 2021), https://www.fema.gov/flood-maps [https://perma.cc/KK5Q-GVR9] (giving the public access to FEMA flood layer maps detailing whether or not homes are in flood zones based on 100-year flood probabilities).

[187] Oliver E.J. Wing, Nicholas Pinter, Paul D. Bates & Carolyn Kousky, *New Insights into US Flood Vulnerability Revealed from Flood Insurance Big Data*, NATURE COMMC'NS, Mar. 19, 2020, at 1, http://dx.doi.org/10.1038/s41467-020-15264-2 [https://perma.cc/ALZ2-YH7E].

[188] Clean Water Act, § 303(d) (codified at U.S.C. § 1313(d)).

[189] *See Water Quality Data,* EPA, https://www.epa.gov/waterdata/water-quality-data [https://perma.cc/EP8Z-EJKW] (last visited Oct. 11, 2021).

[190] *Waters GeoViewer*, EPA, https://www.epa.gov/waterdata/waters-watershed-assessment-tracking-environmental-results-system [https://perma.cc/6CML-FMFY] (last visited Oct. 11, 2021) (providing data based on state's biannual water quality submissions).

Environmental data is limited and, in many management contexts, limiting. The norm of government data collection impedes further and more experimental data sources from being included in environmental decision-making. Some sectors have overcome this problem. For instance, volunteers have been critical contributors to water quality monitoring under the Clean Water Act's TMDL program for decades. Including these additional sources creates more robust environmental databases and has the potential to improve management outcomes.

However, including citizen science and other data types in regulatory decision-making raises important questions about data quality.[191] Creating data systems that can account for and mitigate these potential issues is not simple. And it requires significant deviation from the current model of government collected environmental data.

Government-dominated data systems also systemically exclude stakeholder participation. The difficulty in accessing environmental data creates an ecosystem that benefits highly sophisticated, technically savvy entities that are able to devote the resources to making sense of messy data sources. For the most part, these are large corporate players that have a commercial interest in having good data on environmental conditions. Less technically savvy members of the public are often shut out from engaging with environmental data because of its complexity. This reality exacerbates existing unequal power structures and prevents meaningful public engagement in resource protection.

New partnerships are beginning to allow the public better access to environmental data. In the world of air quality data, the EPA's partnership with the private company PurpleAir has vastly expanded air quality data sources and availability for the public.[192] These efforts are largely public-private partnerships, though, and without corporate interest and backing, many areas of environmental data remain out of reach to members of the public.

IV. TOWARDS BETTER ENVIRONMENTAL DATA SYSTEMS

Environmental regulation is built on outdated assumptions about how environmental data can be gathered and how it should be used. Accelerating technological change has brought these regulatory deficiencies to light. Much of environmental regulation is built on the understanding that certain data cannot be gathered and relies instead on models and other proxy methods to determine environmental conditions on the basis of limited data.[193] These constraints are no

---

[191] Margaret Kosmala, Andrea Wiggins, Alexandra Swanson & Brooke Simmons, *Assessing Data Quality in Citizen Science*, 14 FRONTIERS ECOLOGY ENV'T 551 (2016).

[192] *Study Explores Ways to Improve Accuracy of Air Sensors, in* INNOVATIONS IN AIR QUALITY MONITORING, EPA SCI. MATTERS 2 (June 2020), https://www.epa.gov/sites/default/files/2020-06/documents/air_monitoring_newsletter_6_2020_web_0.pdf [https://perma.cc/NU2E-A7VV] (noting that air sensors from commercial vendors "have been used to fill the gaps in understanding of local air quality").

[193] Macey, *supra* note 4, at 1630.

longer relevant, with new technologies and tools able to fill data gaps.[194] However, our regulatory systems have not changed in time with technological change. The gap between what is technologically possible and what environmental regulation allows is only widening.

This is true not just of the tools used to gather environmental data but also the methods in which it is stored. Current regulatory systems for gathering and storing environmental data were created when data was primarily collected with pen and paper.[195] It didn't matter that data could take months to work its way through an agency when decisions were made based on annually updated data.[196] It also was not of huge concern that data access schemes did not allow timely access for stakeholders or members of the public because there was little demand.[197] In the face of real-time data availability and an expectation that management be dynamic and transparent, these systems, which once operated at the same pace as the data around them, are becoming the constraining factor on real-time data availability.

The private sector has stepped up in the face of government failure to provide information to the public, in near-real time and in ways that are accessible even to non-technical members of the public. Global Fishing Watch is one of many new, private sector solutions that aim to provide the public with baseline information about environmental conditions and the human impacts on them. In many cases, these solutions fill gaps that could not currently be filled by government agencies, which remain constrained by outdated data confidentiality restrictions and unwieldy data management regimes.

Despite the growing role of the private sector in creating environmental data solutions, the government remains the largest and most important provider of environmental data. We must rethink how the government manages and uses this data to ensure it remains effective into the future.[198] We must change our data systems to embody the priorities and capabilities of the 21st century. Drawing on lessons from fisheries, I point here to several fundamental changes that are needed to reshape how environmental data is understood, collected, and used at the federal level.

A. Create Environmental Data Offices

The EPA and NOAA should each create an office devoted solely to data assimilation, storage, and dissemination. These departments should not be charged

---

[194] Babich, *supra* note 93.

[195] Macey, *supra* note 4, at 1627–30.

[196] *See generally* BRETT, *supra* note 134, at 10 (discussing the benefits and drawbacks of electronic data storage systems).

[197] *Id.* at 10.

[198] EPA employees agree, noting outdated technology, reduced use of science in decision-making and lack of attention to environmental justice as critical areas that the Agency must address. Marianne Sullivan, Chris Sellers, Leif Fredrickson, Alissa Cordner, Ellen Kohl & Jennifer Liss Ohayon, *Re-envisioning EPA and Its Work in the Post-Trump Era: Perspectives from EPA Employees*, 42 J. PUB. HEALTH POL'Y 281 (2021).

with making any decisions based on data. Instead, they should focus on creating data ecosystems that enable a new era of "data-rich regulation."[199] A single department focused on data, an Environmental Data Office, is needed to end data silos that exist within agencies, to improve the speed at which agencies process data, and to disseminate this data to other federal regulators as well as members of the public. Many government environmental grant programs now encourage that a certain percentage of funds be devoted solely to data management.[200] It is time federal agencies also embrace this principle and commit resources to developing and maintaining effective data structures.

Many of the current problems with environmental data systems are the result of historical artifacts that shaped agency decisions in the past and are now embedded in how these agencies manage data.[201] In many cases, a thoughtful and complete reworking of these systems is necessary. This has the potential to be a resource-intense endeavor, but it is one that even those within EPA and NOAA have recognized is necessary to overcome existing inefficiencies.[202]

In the next ten years, frontier efforts will see siloed data systems combined in a "digital ecosystem for the environment" that aggregates many sources of data to provide high-quality information to decision-makers in real time.[203] This digital ecosystem is being championed for its potential to overcome existing constraints built into single-issue and geographically limited data tools by providing a comprehensive picture of environmental conditions globally.

These new systems must overcome the existing barriers to effective knowledge transfer between scientists and policymakers and ensure that data ecosystems cover the social architecture of how people interact with and use data. Many examples show that even when managers are provided with high-quality information, data must be available in formats that integrate with existing workflows and align with organizational incentives; otherwise, they are not used.[204] Even the smallest difficulty in accessing information (for instance, a delay of one-quarter of a second in a webpage loading) leads to significant declines in use.[205] Understanding the important role of knowledge translation between scientific data and policy-relevant

---

[199] Macey, *supra* note 4, at 1679.

[200] Tanhua et al., *supra* note 42, at 8; Pendleton et al., *supra* note 17, at 1419.

[201] Macey, *supra* note 4, at 1683.

[202] Sullivan et al., *supra* note 198.

[203] DAVID JENSEN & JILLIAN CAMPBELL, THE CASE FOR A DIGITAL ECOSYSTEM FOR THE ENVIRONMENT (2018).

[204] Steve Rayner, Denise Lach & Helen Ingram, *Weather Forecasts Are for Wimps: Why Water Resource Managers Do Not Use Climate Forecasts*, 69 CLIMATIC CHANGE 197, 220 (2005).

[205] *See* Steve Lohr, *For Impatient Web Users, an Eye Blink Is Just too Long to Wait*, N.Y. TIMES (Feb. 29, 2012), https://www.nytimes.com/2012/03/01/technology/impatient-web-users-flee-slow-loading-sites.html [https://perma.cc/CV9R-4Y73] ("[E]ven 400 milliseconds—literally the blink of an eye—is too long, as Google engineers have discovered.").

information is critical to designing effective systems going forward. Environmental Data Offices are needed to create data expertise and design these systems.

Other academics have called for offices within EPA devoted solely to carrying out environmental monitoring.[206] Environmental Data Offices should build on the goals of providing centralized oversight of monitoring to include all data, from that collected directly by agency scientists to outside data submitted to the agency as part of compliance monitoring.

Environmental Data Offices should be the first stop for any data entering the federal government, regardless of its source or destination. Data can be cleaned by data scientists and aggregated into one central system that allows dissemination to whatever individual office needs specific datasets. More advanced systems could use data tagging to automatically transmit data to the relevant offices. Any government manager could determine if needed data exists and easily access it by querying the data office.

Environmental Data Offices can provide expertise to other parts of the agency and the federal government. For instance, data offices should work with other departments to develop data-oriented standards. Data standards should build on existing global efforts to promote data standardization and interoperability. Creating standard formats and quality margins instead of prescribing particular methods allows flexibility in how data is collected at the same time as it ensures that data can be easily aggregated.

Environmental Data Offices have the potential to vastly increase the efficiency and effectiveness of data use by federal agencies. Staff members whose jobs are heavily devoted to data management are currently scattered throughout agencies, often with insufficient support or resources to effectively manage complex data ecosystems. Many of these individuals may end up dealing with the same datasets as others, doing redundant analysis and aggregation. Creating Environment Data Offices that concentrate these resources together and decrease redundancy could dramatically improve data systems.

B. Rethink Environmental Data Confidentiality

The environmental regulations of the 1970s were written at a time when corporate confidentiality concerns were paramount. Any kind of environmental surveillance and monitoring was a departure from the status quo and garnered a great deal of pushback from regulated entities.[207] Things have changed in the fifty years since then. Compliance monitoring is now a well-accepted, if not well-loved, norm in environmental regulation.[208]

---

[206] *See* Biber, *supra* note 4.

[207] Sharon L. Groeger, *EPA Inspections by Private Consultants and Trade Secret* Confidentiality, 57 IND. L.J. 623, 624–25 (1982) (noting three recent cases involving regulated entities challenging EPA inspections on the basis that such inspections would violate corporate confidentiality).

[208] Wendy E. Wagner, *The Science Charade in Toxic Risk Regulation*, 95 COLUM. L.

The years since the 1970s have brought technological innovations that enable more sophisticated government surveillance of industry.[209] Government use of these technologies, for instance, near-surface aerial surveillance, has withstood many Fourth Amendment challenges.[210] The result of these shifts is that regulated entities expect far less privacy for their operations than they did in the 1970s.[211] This shift in corporate expectations of privacy has not been reflected in any changes in how environmental monitoring takes place or how government agencies view data confidentiality.[212] Environmental laws are still designed to protect interests that no longer legally need to be protected.

Some efforts to open specific environmental datasets have been successful. For instance, military satellite images from the Cold War era have been declassified in the past decade, providing a rich source of information to study changes in climate and land use.[213] While some data may be declassified after requests from scientists, larger problems stem from the fact that most scientists and managers simply have no idea what datasets have been collected by disparate government projects. Without the baseline knowledge of what data exists, it is impossible to ask for access to this data. Furthermore, it creates inefficient duplication of efforts as scientists devote significant resources to gathering data that may have already been collected by others. The first step in unlocking these datasets should be in providing a comprehensive overview of what datasets currently exist, a job for newly formed Environmental Data Offices.

Decreased corporate and societal expectations of privacy are coupled with increasing calls for transparency and open data.[214] Open data advocates argue that in order to realize the full value of data, it needs to be shared. Few, if any, entities lose in an open data ecosystem. Instead, making data open and accessible to broad audiences creates new insights and ways of using this data. Open data hold particular

---

REV. 1613, 1693–94 (2013) ("The reform, which has been implemented by Congress in critical sections of the Clean Water Act and the Clean Air Act, and by the EPA in the Resource Conservation and Recovery Act, has resulted in the promulgation of a far greater number of standards in less time.").

[209] *Cf.* Blais &Wagner, *supra* note 68, at 1701, 1717–18 (discussing the impacts of technology growth since the 1970s on environmental regulations and focusing on pollution control mechanisms).

[210] M. Ryan Calo, *The Drone as a Privacy Catalyst*, 64 STAN. L. REV. 29, 31 (2011) ("Neither the Constitution nor common law appears to prohibit police or the media from routinely operating surveillance drones in urban and other environments.").

[211] *See generally* Timothy T. Takahashi, *Drones and Privacy*, 14 COLUM. SCI. TECH. L. REV. 72 (2012); Medina & Nuzum, *supra* note 120, at 10672–73.

[212] *See* Medina & Nuzum, *supra* note 120.

[213] *See, e.g.*, U.S. GEOLOGICAL SURV., DECLASSIFIED INTELLIGENCE SATELLITE PHOTOGRAPHS (2008), http://pubs.usgs.gov/fs/2008/3054/pdf/fs2008-3054.pdf [https://perma.cc/6HN8-BPZ9].

[214] *See generally* Pendleton et al., *supra* note 17; Jasanoff, *supra* note 55; Latanya Sweeney & Mercè Crosas, *An Open Science Platform for the Next Generation of Data*, SSRN (2015), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2302084 [https://perma.cc/UHR7-UDRQ]; Ardron et al., *supra* note 57.

promise when it comes to environmental sources. Environmental data is generally less susceptible to privacy concerns than many other datasets.[215] And this kind of data is relevant to many seeking to learn more about the environmental conditions around them.

The benefits of open data in the environmental world are clear. Coupled with decreased corporate expectations of privacy, there is little standing in the way of rethinking how environmental data is managed. It is time to change the default for environmental data. Instead of defaulting to confidentiality, with a few exceptions when data can be shared,[216] the default should be that environmental data is shared openly.

Opening environmental data is not simple. Data collected by NOAA and the EPA are used by scientists globally to address and understand major environmental threats.[217] This data is already made available, but we must move beyond putting data on a website and hoping for the best.[218] The majority of environmental datasets are inaccessible to those without scientific or technical training.[219] Making data meaningfully open will require legislative action and the implementation of new rules.[220]

Government provisions requiring open data about the oceans should be viewed as an important public good, but the costs associated with this can be significant. In addition to the direct economic costs, additional indirect costs of open data related to access, equity, and participation also need to be considered in relation to the purpose and potential benefits of open access data.[221] For environmental data, opening data can enable new models to support research and management databases. Existing research databases employ several main revenue models to support their ongoing costs. The majority rely on public funding from governments, universities, or other research institutions, with a minority also generating revenue through use and access fees.[222]

---

[215] *See, e.g.*, Annie Brett, *Secrets of the Deep: Defining Privacy Underwater*, 84 MO. L. REV. 47 (2019).

[216] *See, e.g.*, 16 U.S.C. § 1881(b)(1) ("Any information submitted to the Secretary, a State fishery management agency, or a marine fisheries commission by any person in compliance with the requirements of this chapter shall be confidential and shall not be disclosed except [in limited circumstances]").

[217] Macey, *supra* note 4, at 1658.

[218] Tanhua et al., *supra* note 42, at 5, 14–16.

[219] ANNE BOWSER, ANDREA WIGGINS & ROBERT D. STEVENSON, DATA POLICIES FOR PUBLIC PARTICIPATION IN SCIENTIFIC RESEARCH: A PRIMER 9 (2013).

[220] *See generally* Mercè Crosas, Gary King, James Honaker & Latanya Sweeney, *Automating Open Science for Big Data*, 659 ANNALS AM. ACAD. POL. SOC. SCI. 260 (2015); Macey, *supra* note 4, at 1667–68.

[221] *See generally* Peter A. Johnson, Renee Sieber, Teresa Scassa, Monica Stephens & Pamela Robinson, *The Cost(s) of Geospatial Open Data*, 21 TRANSACTIONS GIS 434 (2017).

[222] ORG. ECON. COOP. DEV., BUSINESS MODELS FOR SUSTAINABLE RESEARCH DATA REPOSITORIES 1, 11 (2017), https://www.oecd-ilibrary.org/docserver/302b12bb-en.pdf, [https://perma.cc/59NE-24MV].

The cost of storing large quantities of data can be prohibitively high. Several creative solutions exist. NOAA, for instance, through its Big Data Project, reached an agreement with Amazon Web Services (AWS) for storage of key ocean data.[223] For AWS, storing NOAA data supported key knowledge services and made it possible to subsequently reduce costs due to lower computing requirements by bringing the stored data significantly closer to the computation. In return, NOAA was able to store large quantities of data for free on the AWS servers and saw large increases in public use of this data.[224]

Opening access to environmental data is particularly crucial for ensuring that stakeholders who are supplying data, like fishermen, retain access to their own data. One of the more interesting developments catalyzed by new technologies is the return to relevance of traditional self-governance tools. Work by Elinor Ostrom and others shows that self-governance under the right conditions can be one of the most effective ways to manage common-pool resources.[225] Access to information facilitated by new technologies has the potential to enable a new era of self-management, in which individual actors and communities can make decentralized resource consumption decisions.

New data systems that are built around "portal and download" with little regard to how data will be used within a framework of user-driven services provide a potential template for future open environmental data projects.[226] A fundamental rethinking of data systems architecture where data is democratized can enable users to build their own knowledge systems. In a sense, rather than a pre-defined data organization structure, data would reside in tagged, unstructured data lakes where the schema are written as the data are accessed. Much as data lakes are transforming machine learning and analytics, a similar development environment needs to be created for environmental observing systems that would enable knowledge services to be driven by the user.

We must move away from outdated understandings of data confidentiality and toward open environmental data ecosystems. Federal agencies can enable this move by leveraging data expertise in Environmental Data Offices to use new tools and infrastructures to realize the vision of the digital ecosystem for the environment. This ecosystem is needed to effectively engage stakeholders and achieve sustainable management goals.

---

223 Jeff Barr, *Announcing the NOAA Big Data Project*, AWS NEWS BLOG (Apr. 21, 2015), https://aws.amazon.com/blogs/aws/announcing-the-noaa-big-data-project/ [https://perma.cc/9782-FW84].

224 *NOAA Expands Public Access to Big Data*, *supra* note 9.

225 ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION (1990).

226 Justin J.H. Buck, Scott J. Bainbridge, Eugene F. Burger, Alexandra C. Kraberg, Matthw Casari, Kenneth S. Casey, Louise Darroch, Joaquin Del Rio, Katya Metfies, Eric Delory, Philipp F. Fischer, Thomas Gardner, Ryan Heffernan, Simon Jirka, Alexandra Kokkinaki, Martina Loebl, Pier Luigi Buttigieg, Jay S. Pearlman & Ingo Schewe, *Ocean Data Product Integration Through Innovation-The Next Level of Data Interoperability*, 6 FRONTIERS MARINE SCI., Feb. 28, 2019, at 1, 16.

V. CONCLUSION

We are in the middle of an explosion in new methods of collecting environmental data, creating enormous potential for advances in our understanding and stewardship of natural resources. An exponential increase in the number and variety of environmental observing systems and other new data sources has created the prospect of a "digital ecosystem" for the environment. Advances in processing techniques and visualization are rapidly expanding our ability to extract information from those data and present these in meaningful ways to both technical and non-technical audiences.

Taking advantage of these innovations will require environmental agencies to move away from archaic models of managing data towards methods that allow for near real-time data assimilation and access. Expertise in the form of Environmental Data Offices is needed to create these shifts.

We must also rethink the culture of confidentiality built into environmental regulation. Much environmental data is now locked in the servers of government agencies, businesses, or researchers. Data holders should establish, and governments should require, a new default—that environmental data are broadly available to other users. Radical transparency of data from fishing and other resource use can allow the public to hold governments accountable for their management of environmental resources and create opportunities for resource users to engage in self-governance.