NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
SCIENCE ADVISORY BOARD

FINAL REPORT

Citizen Science at NJDEP

March 4, 2020

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New Jersey Department of Environmental Protection Science Advisory Board

Citizen Science at NJDEP

Final Report

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A Report to the Science Advisory Board (SAB)

New Jersey Department of Environmental Protection

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Enhancing Citizen Science at NJDEP

Executive Summary

In the summer of 2018, the NJDEP-Science Advisory Board was tasked with assessing how NJDEP can work collaboratively with partner organizations and New Jersey communities to effectively engage with citizen scientists to further the agency's missions. The Commissioner's charge questions to the NJDEP SAB were:

1. How can DEP be proactive in working with citizen (nonprofessional/community) scientists throughout the state?
2. How can DEP help interested communities to frame and answer environmental science questions?
3. How can DEP engage with professional scientists to facilitate high quality citizen science?
4. How can DEP make better use of citizen science data?
5. Review what DEP is currently doing regarding citizen science. Recommend what DEP should be doing to work with citizen scientists to develop mutually beneficial and productive projects and activities. What are other state and federal agencies doing? What are best practices?

Definitions of "citizen science" vary, but there is general consensus that citizen science involves nonprofessional individuals participating in one or more aspects of the scientific research process which may include study design, data collection and analysis, and interpretation and dissemination of results. Although citizen engagement in science has a long history, over the last two decades there has been renewed and growing interest in citizen science, catalyzed by technologies such as mobile communications, the internet, geographic information systems (GIS), and low-cost sensors. Continued growth of technological innovations that enable and facilitate the active participation of more people in science is expected. Citizen science is also aligned with social and political trends towards greater transparency and public participation in decision-making. As described in the review that follows, further engagement of the New Jersey Department of Environmental Protection (NJDEP) with citizen scientists has the potential to extend the reach and capabilities of the agency and further its missions. Citizen science can provide opportunities for the NJDEP to achieve its goals more effectively and efficiently, while at the same time presenting some challenges, ranging from questions about data integrity to management of expectations when the public is involved in civic concerns.

Potential benefits of citizen science for the agency include:

- Leveraging of agency resources by partnering with nongovernmental organizations and volunteers
- Increased scale and cost-effectiveness of data collection
- New ways to identify and address the environmental science and health needs of state residents
- Enhanced community engagement, environmental health literacy, and public support for the agency

Potential challenges of citizen science for the agency may include:

- Resources spent on addressing poor-quality data

- Communication challenges leading to distrust
- Disappointment and damage to relationships due to mismanaged expectations
- Sustainability of citizen science projects and public interest over the long term

Citizen science is a cross-cutting approach that demands an agency-wide strategy. At this time, the NJDEP has several ongoing programs that engage citizen scientists, but the efforts are fragmented and overall agency-wide coordination of citizen science is a revitalized initiative. Currently, there is a need for an agency-wide strategy on using citizen science to further the NJDEP's mission. In order to assess the opportunities and challenges presented by the growing citizen science movement, the agency needs to define its goals for citizen science and to develop a strategy to achieve those goals. The strategy should include guidance and support for citizen science activities, methods to control data quality and data management, and provision of resources, including appropriate incentives for new and expanded citizen science programs and projects.

Citizen science can take many forms, along several dimensions including goals, methods, level of citizen engagement, and the degree to which citizen scientists have autonomy and project decision-making authority. While citizen science may add additional layers of complexity to projects, the potential benefits of citizen science for the agency are great. Evaluation of the net benefits and ways to improve citizen science projects will be an important component of management of citizen science across the agency.

What DEP has done or is currently doing:

- Several established and ongoing programs and projects that utilize volunteer participation
- Identified a DEP coordinator for citizen science
- Started to review agency-specific projects

Summary of recommended NJDEP actions:

Develop agency-wide and departmental citizen science goals and strategies

- Promote awareness and make it easier for NJ residents to learn about opportunities to collaborate with the NJDEP on citizen science projects:
    - Catalog all DEP-specific projects that have a citizen science component
    - Develop and maintain a NJDEP citizen science website displaying the project catalog, resources, contacts, and news items.
    - Designate a Citizen Science Ombudsperson within the agency who will promote citizen science partnerships both within the agency and to groups outside of the agency
    - Contact environmental groups, nature centers, outdoor education groups, and other potential partner organizations to discuss developing citizen science projects together
- Promote engagement with professional scientists to facilitate high-quality citizen science:
    - Develop a resource list of professional scientists who are willing to work with citizen scientists

    - Maintain on a public website requests for proposals (RFPs) related to research questions/data needs that NJDEP has determined might be addressed by citizen scientists, working with professional researchers
    - Reach out to and include professional scientists in the earliest phases of planning NJDEP research needs and data collection
    - Determine the funding needs of the professional scientist during initial project discussions
- Develop policies and guidelines regarding data quality assurance and quality control for citizen science projects:
    - Determine appropriate data quality objectives for different types of projects, depending on the goals of each project
    - Consider alternative uses of data that do not meet data quality objectives, such as use as indicator or sentinel data that may lead to further evaluation.
    - Designate a counterpart to the Citizen Science Ombudsperson to proactively engage with citizen science projects regarding QA/QC issues.
    - Develop methods for validating data and results from projects.
- Provide professional development to NJDEP personnel on the use of citizen science to achieve agency goals and objectives
- Devote resources to evaluating the effectiveness of citizen science projects in achieving agency goals and objectives
- Encourage collaboration between the NJDEP and other NJ State agencies, NGOs, and professional scientists by funding pilot projects to develop and evaluate citizen science methods applicable to management of state environmental resources and health priorities.

What is Citizen Science?

EPA's National Advisory Council (2016) defines citizen science as "*an approach to environmental information that actively and genuinely encourages and solicits public input in the scientific process and incorporates data and information generated outside of traditional institutional boundaries*." Citizen science is an umbrella term for a variety of activities involving non-professionals in scientific activities, some initiated by government, but most launched by informal community groups and non-profit organizations. Well-known New Jersey examples include the Audubon Society's Christmas Bird Count and the Ironbound Community Corporation's neighborhood air and water quality data collection efforts.

The National Academy of Science (2018, pg. 2) applies the term to "projects that share the core feature of non-scientists engaging in doing science" and exhibit eight common characteristics: "actively engage participants, specifically engage participants with data, use systematic approaches to produce reliable knowledge, meet widely recognized standards of scientific integrity and use practices common in science, engage participants who are (primarily) not project-relevant scientists, seek to use the knowledge gained to contribute to science and/or community priorities, generally confer some benefit to the participant for participating, and involve the communication of results." This definition is broader than that used by EPA but also richer because it signals what "good" citizen science likely entails.

Citizen science activities have also been called "civic or community science, community-based monitoring, popular epidemiology, participatory sensing, public participation in scientific research, public science, community environmental policing, street science, do-it-yourself or DIY science, participatory science, crowd science, open science, crowdsourcing," according to EPA (2016). These labels indicate that citizen science initiatives incorporate a great variety of motives, methods, and partnership models.

Numerous approaches to citizen science have been developed that are well summarized by the National Academy of Science report (2018, ch.2). They cite Wiggins and Crowston (2011), who identify five mutually-exclusive categories of citizen science: investigative, virtual, conservation, action, and educational projects. Virtual projects involving computing, thinking, and/or participatory sensing using smartphones have increased in importance in recent years (Haklay 2013, Masters et al. 2016). Current thinking no longer views virtual projects as a distinct category, but instead identifies technology as a core enabling infrastructure element for citizen science (Chari et al. 2017).

In the current political moment there is some sensitivity to the use of the word "citizen," because it can be used as an exclusionary category, but "citizen science" is a longstanding and broadly recognized and accepted term meant to evoke an inclusionary global "citizen of the world."

How agencies use citizen science

NJDEP has many responsibilities that can potentially benefit from citizen science. EPA, NOAA, and other federal agencies and state environmental departments around the country have successfully harnessed the energy of citizen scientists for activities ranging from community engagement to enforcement. Figure 1 summarizes these possibilities. For additional information, see the EPA 2016 report Environmental Protection Belongs to the Public—A Vision for Citizen Science at EPA, which describes the listed initiatives in some detail.

Community engagement and educational activities will typically focus on getting people interested in environmental phenomena and introducing them to experiences they will remember, hence there may be less focus on scientific rigor. Tracking condition indicators and performing research implies using information generated by citizen scientists to generate credible new knowledge about environmental conditions in specific places, thus placing greater weight on data quality. Management and regulatory decision-making are consequential matters that may be litigated and therefore require extremely high scientific standards and the use of officially approved data collection and handling protocols. Regulatory standard setting and enforcement additionally bring a political dimension and an associated need for highly credible science that is well communicated.

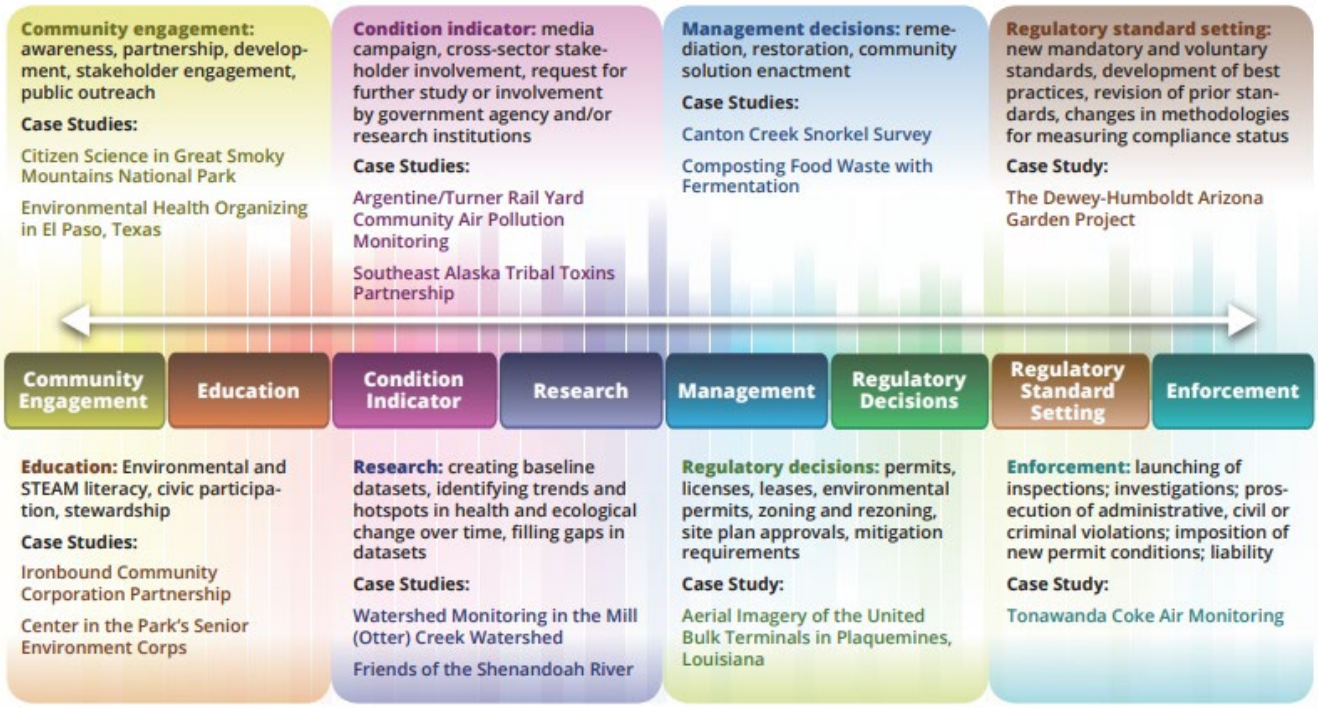

Figure 1: How agencies use citizen science data. (Source: EPA 2016)

The National Academy of Science (2018, pg. 21) recommends that professional scientists view citizen science as another tool in the research arsenal that has its own unique strengths and weaknesses. Unique strengths include:

- Its field-based projects can ground-truth remotely sensed data.
- Its broader-scale, regular monitoring projects can detect rare events.
- Unique ideas, findings, and solutions can emerge from crowd-sourced projects.

Considering a citizen science approach

Shirk and Bonney (2015) provide useful guidance with a series of questions to help agency personnel assess the suitability of a citizen science approach for a particular application. Good candidate applications for citizen science projects have clear aims, a need for community engagement, adequate resources, large-scale sampling requirements, simple protocols, and

strongly-motivated participants. However, people who are experienced with citizen science projects identify successful exceptions to these guidelines. Projects involving long-term volunteers, in particular, can succeed even when scientific protocols are complex. As discussed below, the increased challenge is part of the motivation for long-term experienced volunteers who might otherwise lose interest.

Potential partners

There are many potential citizen science partners for NJDEP, summarized in Figure 2. Educational institutions and non-profit organizations are the primary sources of volunteers, but both public and private sector organizations can play important roles.

Type of Potential Partner	Examples of Organizations	
Government	• Federal • Tribal • State	• Regional • Local
Educational institutions	• K–16 (public, private, home school) • Colleges and universities • Museums • Libraries	• Science centers • Cooperative extensions • Makerspaces
Nongovernmental organizations	• Environmental organizations (conservation groups, environmental health organizations) • Environmental justice organizations	• Volunteer organizations • Hobbyists (outdoor and sportsmen's groups, boaters and outfitters associations) • Land trusts and watershed associations
Industry	• Water users • Water, air and land managers • Water planners • Sampling and analysis equipment developers and providers	• Software, application and systems developers • Agricultural associations • Professional organizations

Figure 2: Potential citizen science partners (Source: EPA 2016)

Each partner has potential strengths and weaknesses. Generically, governmental partners will have strict accountability and scope concerns, educational institutions will be constrained by the schedule of the school year, non-profits may also have advocacy objectives, and private sector actors will have first loyalty to company interests.

Designing & managing citizen science activities

Agency personnel planning to form partnerships and undertake citizen science projects need to consider several factors. Agency-sponsored (or –affiliated) citizen science projects always have two masters: the citizens upon whose participation the project depends, and the agency's management which will demand accountability and a level of data integrity that is appropriate to the project's goals.

Balancing these two objectives involves several activities: (1) identify goals for the science, policymaking or action, and the participants; (2) establish capacity to carry out the work which involves agency staff, volunteers, and partners at all stages of the project; (3) design the activity by developing or refining the scientific protocol, training volunteers to carry out the work, and building a suitable infrastructure for data collection, storage and analysis; (4) manage the activity by encouraging volunteer participation, managing and verifying data flows, and handling both

volunteer and agency expectations about what is to be accomplished; and (5) applying the knowledge gained in the form of research results and agency actions, while assessing the effectiveness of the project and ensuring transparency about means and ends (Shirk & Bonney 2015).

Three items deserve emphasis here. First, every step described above should involve collaboration with leaders of the citizen volunteers to motivate them and ensure that they value the goals and activities of the project. Second, training of volunteers is essential for ensuring the scientific integrity of the project, and this may involve a commitment of resources. Third, large or complex projects are likely to require commensurate infrastructure and resources in the form of app development, web portals, data storage and access arrangements, field equipment, laboratory support, and management.

Social factors are highly important to success, and the National Academy of Science report (2018, pp. 127-140) recommends the following: know the audience, adopt an asset-based perspective, intentionally design for diversity, engage stakeholders in design, capitalize on unique learning opportunities associated with citizen science, support multiple kinds of participant engagement, encourage social interaction, build learning supports into the project, evaluate and refine the project.

Levels of engagement

Public participation in scientific research can take many forms, often arrayed as points on a spectrum or ladder of participation traceable back to Arnstein (1969). The "5 C's" (Table 1) are widely used here: (1) *contractual* participation in which citizens delegate their responsibilities to professional scientists; (2) *contributory* participation in which citizens help by collecting or analyzing data; (3) *collaborative* participation in which citizens help design the project; (4) *co-created* projects where citizens help establish the purpose of the project, its design, and also help carry it out; and (5) *collegial* participation in which there is no difference in the roles of citizen scientists and professional scientists (Andrews 2017). Beyond collegial participation, a "6th C", *citizen-initiated*, may signify projects in which citizen scientists initiate and conduct their own investigations, with varying degrees of engagement with professional scientists or governmental agencies.

The procedural and ethical nuances that accompany each type of participation are an increasing focus of major funders and research enterprises. At the National Science Foundation, the emphasis is on engaging public interest, education, and bringing "diverse perspectives and skill sets to research" (Arriens 2015). The National Academy of Sciences (2018, pg. 7) notes that "because citizen science broadens the scope of who can contribute to science, it can be a pathway for introducing new processes, observations, data, and epistemologies to science." Universities have recognized the value of community-engaged scholarship, but have been slow to reward it (Brazzell 2019); this year the University of Minnesota (2019) is the first in the nation to formalize it within the tenure and promotion process.

The National Institutes of Health carefully distinguish between "community-engaged research" initiated by professional scientists, and "citizen science" initiated by community members (O'Fallon 2015). The former entrains an ethical duty for professional scientists to operate transparently and deliver reciprocal benefits to participating community members. In the latter, the relationship is more instrumental--how can professional scientists support and assist community-led projects

that prioritize action to address community needs? Projects may be initiated by concerned citizens who have become aware of a perceived environmental condition or exposure. Projects initiated by citizen scientists with little if any input from professional scientists or agency personnel may present challenges to NJDEP and other state and federal agencies. In addition to issues regarding meaningful study design and data integrity, the potential for biased data collection can be especially challenging for agency personnel. By being receptive to citizen concerns and working constructively and proactively with citizens to design and implement projects, NJDEP can mitigate these challenges. Offering training and capacity building to community groups may be an important element of the NJDEP's overall strategy for effective use of citizen science. Developing and nurturing relationships, with community groups who are interested in using citizen science approaches to inform environmental and public health decision-making would be an important role of the designated Citizen Science Ombudsperson (see Recommendations).

Perhaps as a result of these challenges, a narrower spectrum of public participation is typically involved in projects initiated by agencies such as NJDEP. Shirk & Bonney (2015) identify contributory, collaborative, and co-created modes as the most common, as shown in Figure 5. Most U.S. agency citizen science projects are contributory, meaning that the focus is on collecting and sometimes analyzing samples and observations.

Role of agency professionals

Professional scientists at NJDEP have two primary responsibilities when engaging with citizen scientists. First, working collaboratively, NJDEP and partner organizations, when applicable, should take appropriate responsibility for quality control, training citizens, standardizing procedures, and assigning do-able tasks. Second, NJDEP and partner organizations should motivate citizen scientists by making the work interesting and meaningful, providing incentives for continued participation, and providing feedback on how the information is being used. The National Academy of Science (2018, pg. 9) pointedly recommends that "designers, researchers, participants, and other stakeholders in citizen science carefully consider and address issues of equity and power throughout all phases of project design and implementation." Table 1 summarizes professionals' roles for different types of projects.

Table 1: Role of professionals (Source: Based on Andrews 2017)

Purpose	**Quality Assurance**	**Motivation**
	e.g., assign do-able tasks, standardize procedures, train citizens	e.g., make it interesting, provide incentives, give feedback
Contributory	Design project, develop training guidance, specify data collection protocol, analyze data	Recruit public participants, provide incentives to continue participating

Collaborative	Lead research design, train participants, specify minimum acceptable data collection protocol	Lead collaborative effort, recognize citizens' accomplishments,
Co-Created/Collegial	Help design project, help train participants, specify quality assurance protocol	Provide substantive feedback, pursue shared recognition (e.g. co-authorship or official acknowledgment)
Citizen-Initiated	Offer resources and training, provide model research and quality assurance protocols (e.g. EPA Air Sensor Toolbox), loan equipment	Provide guidance on how citizen data can inform decisions, including anticipated limitations and appropriate expectations

The practical focus and level of agency and partner effort required during the lifetime of a citizen science project follows a predictable pattern. Following initial efforts to clearly define the purpose and scope of the project and building the required team, additional effort is needed to grow and maintain the project, including management and retention of volunteers, data analysis, communication of results and evaluation of the program.

The factors to consider when designing and implementing citizen science projects may present a new responsibility for many agency personnel. That is one reason why a number of projects really operate as partnerships with non-profits, educational institutions, and others. In these cases, agency personnel will want to use the considerations discussed in this report to assess the viability and likely value of prospective partnerships.

Multiple paths for turning information into action

There are many ways that citizen science can be effective in achieving improved health and environmental quality. Some local problems identified by citizens can be solved without NJDEP involvement. Others require involvement of a non-profit partner over many years to build an evidence base for environmental management, regulation, or enforcement. Sometimes the path from science to action goes through the U.S. Congress and back to the states. Figure 3 illustrates some of these paths and key questions to ask: Who has the information? Who can act? What are the desired actions? What are the desired results?

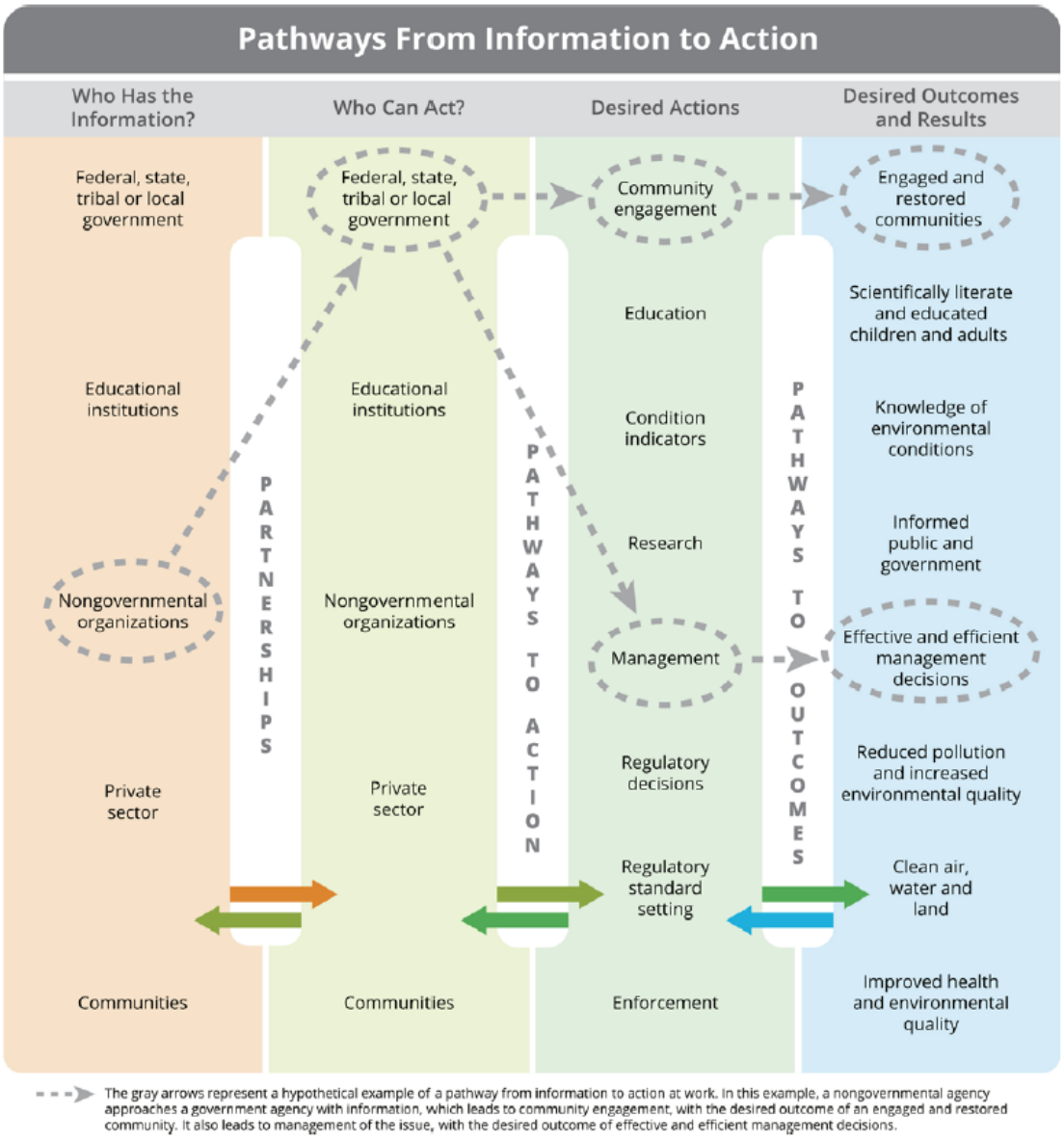

Figure 3: Pathway for turning information into action (Source: EPA 2016)

Current citizen science at NJDEP

DEP is already involved in Citizen Science. A number of NJDEP citizen science projects provide examples of how public involvement might be increased. Examples of current NJDEP citizen science collaborators include Clean Ocean Action in the Navesink River Bacteria Track-down Project, the Barnegat Bay Partnership in the Long Swamp Creek Project, the Water Trails Education in the Sedge Island Marine Conservation Zone, AmeriCorps in the Watershed Ambassadors Program, Coastal Keepers, and the Watershed Institute in the NJ Volunteer Monitoring Network. Two examples are described below, and a partial list of other projects is included in the Appendix. This is

not a complete list of all citizen science projects that the DEP is involved with, but it is meant to highlight certain programs that are well developed and currently active.

Since there are many volunteer water monitoring programs around the state, the community-based New Jersey Volunteer Monitoring Network was formed to track these programs and the level of monitoring they are engaged in (biological, chemical, and visual monitoring). A "Water Quality Restoration Grant" was given to the Watershed Institute in 2018 from the NJDEP Division of Water Monitoring and Standards (DWMS), Bureau of Environmental Analysis, Restoration, and Standards (BEARS). The goal of this project is to create an inventory of volunteer water monitoring efforts, as well as improve and standardize the methods that different organizations are using. Creating a network of existing groups to leverage resources and improve data quality and sharing is a key effort of this project. The funding for this grant comes from the Corporate Business Tax, and the individual monitoring groups provide their own funding outside the grant. The Watershed Institute is the main partner for this effort because they are responsible for coordinating with the individual water monitoring groups. If a water monitoring group has an approved Quality Assurance Project Plan (QAPP) the data is submitted electronically via the Water Quality Data Exchange (WQDE), which the DWMS oversees. The DWMS also provides training and assistance to groups with WQDE submissions. This data is publicly available through the WQDE online portal. Depending on the program or parameter, the data are used for different purposes. If a program has a QAPP the data may be used for filling temporal or spatial gaps in water quality reports. If a program does not have an approved QAPP the data could be used for screening, engagement, or outreach purposes.

Two air quality monitoring projects, in a partnership with USEPA, were designed to increase public outreach and expand scientific understanding of citizens in the Newark and Camden areas. Aethalometers where were used for student air monitoring lessons in Newark and Elizabeth in low, medium, and high traffic areas to monitor air quality in partnerships with Rutgers and local community groups.

There are several factors discussed in this report that help to characterize the distinct types of citizen science activities that NJDEP is already engaged in or is planning to in the future. We summarize these factors using the following categorization scheme. A database of citizen science activities at NJDEP should include the following data fields:

- Name of activity
- Contact information (NJDEP contact, Partner(s) contacts)
- Status (active, inactive)
- Environmental topic (air, water, land, biota)
- Geographic scope
- Goals/ purposes
- Infrastructure (app development, web interface, data storage & access, field equipment, lab capacity, management)
- Level of citizen engagement (contributory, collaborative, co-created, citizen-initiated)
- Quality assurance strategy (study design, quality assurance protocol, review process for protocols and results)
- Motivational strategy (recruitment, retention, feedback, incentives, informal education, gamification, community engagement, altruism)

- How to use the data
- Pointer to additional information (publication, website)

The proposed recommendations will require support and resources from the agency and in-house training for staff may be required. There is also the need for an internal leader to promote NJDEP's enhancement and expansion of citizen science activities.

How can the NJDEP be proactive in working with citizen scientists throughout the state?

There are many other ongoing citizen science projects that currently have no association with NJDEP. This may be because the groups see no benefit to involvement with NJDEP or wish to operate independently of NJDEP. On the other hand, if approached collaboratively they might be receptive to partnering with NJDEP on ongoing and future citizen science projects. Examples of potential projects could include biological surveys, such as bird counts, amphibian surveys, wetland plant surveys, horseshoe crab breeding surveys, and juvenile eel counts, living shoreline pilot projects, as well as air and water quality monitoring projects.

We suggest the NJDEP consider the following proactive options:

1. Agency staff contact environmental groups, nature centers, and outdoor education groups to propose developing citizen science projects together. New projects and protocols could be developed that are agreeable to and supported by both the cooperating organization and NJDEP. The public/private partnership developed would be an ideal way to manage such programs once they are set up. The non-profit organizations have dedicated supporters and members, and so would be better prepared than NJDEP to recruit and manage citizen science volunteers, and to publicize the activities and results to a larger audience.

2. It is important to communicate broadly to the public that NJDEP is committed to involving citizen scientists. The agency should maintain a website about its citizen science programs that is kept up-to-date. The existing NJDEP New Jersey Watershed Watch Network website could be updated and expanded to serve as a central listing of NJDEP programs that have a Citizen Scientist component. Having a website where programs that welcome citizen scientist activities and volunteers would support this message.

3. NJDEP should designate a Citizen Science Ombudsperson to encourage these partnerships. This NJDEP staff member would be a strong communicator with a breadth of knowledge of agency programs and a strong interest in promoting citizen science.

How can NJDEP help interested communities to frame and answer environmental science questions?

In framing questions, it is important to understand the types of projects a community and stakeholders envision, and what approaches they are taking to address the question(s). Different partner groups and different types of projects will have different needs.

Actions NJDEP can take to aid in development of citizen science questions include:

1. Talk with partners to address their concerns, learn what participants want to get from the project, what skills, time, and resources are available. Expectations for outcomes need to be managed within these parameters. Be aware of sociocultural issues: gender and age, ethnicity and race, language and literacy, educational level and scientific knowledge. Focus on listening and being open minded to understand the culture of the community.

2. Feasible outcomes need to be clearly set at the beginning of the project, be realistic and achievable. It is important that participants understand if and how their activities will result in benefits to their community or to the environment in general. NJDEP can provide community members with an understanding of any regulatory or scientific constraints during project development.

3. Identify clear objectives and determine the steps necessary to achieve them. Enough detail must be included (issue(s) to be studied, what data will be collected, what participants will be doing), and outcomes that could occur based on the data collected. Before a project starts, it is important to articulate how results and outcomes will be shared.

4. Acknowledge competencies the community groups bring to the table and develop projects that match these strengths or help the community build their team to achieve further goals. Community group leaders should demonstrate success in public communication, community engagement, visual communication (digital and print), data management, and evaluation of results and outcomes.

5. Project partners need to be financially sound, and may need additional funding to implement the project. Project costs must account for needed equipment and materials, and staff time required for project planning, organizing and coordinating. It is also critical to consider the steps required and costs associated with data management, analysis, and dissemination of results at an early stage of project development.

6. The human connection is critical in creating a successful citizen science project. Make sure the participants know how their contributions will make a difference for the environment in the state. Show respect for their contributions. Keep the doors of communication open and maintain two-way interactions for the duration of the project and beyond.

7. Provide venues for publicizing volunteer activities and dissemination of project results. Communities may have their own social media outlets and publication options. However, including citizen science activities under a broad umbrella of projects offers more recognition and the opportunity to share results with a larger audience.

Information from the online toolkit provides guidance for setting up projects with community participation. https://www.citizenscience.gov/toolkit/howto/step3/#

Since communities are unique, no single template applies to all. Be sensitive to the particular needs, skills and motivation of the community you are working with and use appropriate techniques to interact with your partners. Consider organizational limitations of your

participants and how they fit in with agency protocols. Here are tools to aid in understanding your potential partners and choosing the best ways to make sure everyone gets what they need from the project.

How can NJDEP engage with professional scientists to facilitate high quality citizen science?

To establish effective use of citizen scientist volunteers and the data they collect, NJDEP needs to demonstrate their belief in the value of citizen science, and establish a track record as a good partner with academic, government, NGO, and for profit professional scientists. There are a number of relatively simple steps that NJDEP could take to facilitate such a partnership:

1. Develop an internal list of professional scientists who are willing to work with citizen scientists. This should include basic information - the scientist's affiliation(s), area(s) of expertise, availability, current research interests, and contact information (phone and email). A first step might be NJDEP outreach to the scientific communities at the various State University schools, other government agencies, and NGOs who employ trained scientists.

2. Maintain on a public website RFPs related to research questions/data needs NJDEP believes citizen scientists, working with professional researchers, might address. Communicating these needs in a digital public forum, which is easily accessible, would allow professional scientists to easily consider how citizen science projects might be incorporated into their own research program.

3. Reach out to and include scientists in the earliest phases of planning NJDEP research needs and data collection. The experience of professional scientists in developing research design, knowledge of accepted analytic/data collection techniques, and content of peer-reviewed literature can be invaluable in preparing research/data collection protocols, development of a quality assurance plan (if required by a project funder or NJDEP) and ensuring that the data collected advances the current state of knowledge.

4. Determine the funding needs of the professional scientist during initial project discussions. It is important to recognize that different researchers have different funding requirements, depending on their affiliation, funding sources, and other responsibilities. These needs can run the gamut from paid or unpaid internships, to support for hourly staff, to full funding, to *pro bono* consultation. Depending on the project needs and funding availability, there may be various roles that a professional scientist, their students, staff, or organization could contribute to a project.

5. NJDEP can partner with professional scientists to identify federal funding sources and RFPs that provide significant research funds AND encourage the engagement of citizen scientists in their funded projects.

How Can NJDEP Use Citizen Science Data

There are many steps in evaluating, collecting, and analyzing data, and the question of where citizen scientists (and their data) fit into this complicated system will be defined by how the data is to be used and what the data quality objectives (DQOs) are for that data. Like all data being evaluated by NJDEP, clear **DQOs must be established *before* the data are collected**. The recommendation of this board is to discuss and evaluate the DQOs of a project with the citizen scientists before the project begins. If there is agreement on the DQOs of the citizen science data, and if the DQOs are met, the data can be used as intended.

1. All data collection activities must have well defined DQOs. The DQOs of any study define the data utility (who will use the data) and applicability (what the data can/will be used for). DQOs will differ for each project, but agreement on these objectives must be reached before data collection begins.

2. Some DQOs require only minimal training to implement and are very easy to meet by most citizen scientists. Even subjective evaluations, (e.g. a "healthy ecosystem") can be defined by measurable parameters, such as species counts, water present/absent, or air quality. These parameters can all be evaluated and Quality Controlled (e.g. multiple individuals doing a bird count) as long as the DQOs are established before samples or data are collected. If the DQOs are met, the data can be used by NJDEP for its intended purpose.

3. Some DQOs would be difficult or impossible for citizen scientists to meet. For example, some EPA analytic methods require extensive training, certified laboratories, and regular performance qualifications or external reviews. The office of quality assurance (OQA) has lists of approved testing methods and the requirements for submission of data collected using these methods. Generally, the greater the impact of the data (e.g. enforcement), the stricter or more rigorous the DQOs. Community groups could engage external consultants who are qualified in all aspects of collecting/analyzing high quality data.

4. Data collected to demonstrate compliance/out of compliance (e.g. dissolved oxygen (DO) in water) require a demonstrated capability to measure such values reliably. While the measurement itself is not overly complicated, the calibration of the field measurement instruments requires training. There is also a need for experience with the method including a demonstration of being able to meet DQOs for parameters such as repeatability and reproducibility. Citizen scientists might be able to meet the data quality objectives for sample collection and then could submit the samples to a certified laboratory for analysis.

5. Meeting regulatory level DQOs may place an undue burden on citizen scientists, so a further recommendations would include using citizen science data as sentinel data. For example, a freshwater lake might have DO levels below the compliance limit as measured by a citizen science group not trained to collect such data. Rather than ignore such data, the NJDEP could perform their own sampling and analysis, rather than take the data directly as being out of compliance or ignoring it altogether.

6. The Citizen Science Ombudsperson at NJDEP should have a counterpart liaison in OQA who could explain DQOs to citizen scientists and be available to answer inquiries related to DQO measurements required in citizen science projects.

7. Train NJDEP quality assurance personnel on how to manage both the QA and motivational aspects of citizen science activities.

Conclusion

In conclusion, the continued growth of participation of citizen scientists in activities related to the environment is expected, enabled by technological innovations and public interest in participatory engagement in science and public policy. For a regulatory agency such as the NJDEP, citizen science presents important opportunities and potential management challenges. In preparing this report, the citizen science subcommittee of the NJDEP Science Advisory Board sought to provide recommendations for maximizing the benefits of citizen science for the agency, while anticipating and addressing potential challenges. When aligned with NJDEP strategic goals, citizen science activities can help to advance the NJDEP's core mission to maintain, protect, and enhance public health, safety, and welfare and New Jersey's natural resources.

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NJDEP SCIENCE ADVISORY BOARD CITIZEN SCIENCE CHARGE QUESTION APPENDIX

Representative list of current citizen science at NJDEP

The following is a list of current or future NJDEP citizen science projects.

- **Name of activity:** Navesink River Ambient Bacteria Source Track Down Project
- **Contact information:**
    - Debbie Kratzer- Deborah.Kratzer@dep.nj.gov, 609-633-1441
    - Clean Ocean Action- https://www.cleanoceanaction.org/
- **Status:** Active
- **Environmental topic:** Water
- **Geographic scope:** Navesink River Watershed
- **Goals/ purposes:** To collect ambient bacterial data in the watershed and identify the non-point source pollution that is influencing this shellfish growing area
- **Infrastructure:** NJDEP provides technical assistance, equipment, lab analysis, training, quality assurance, and field support, as well as attending Rally for the Navesink meetings. Clean Ocean Action coordinates volunteers, weekly bacterial sampling, and transportation of samples to the lab.
- **Level of citizen engagement:** Contributory
- **Quality assurance strategy:** NJDEP Bureau of Environmental Analysis, Restoration, and Standards audits the citizen scientists annually, as well as providing two staff members to assist in field collection.
- **Motivational strategy:** Feedback, Community Engagement, Altruism
- **How to use the data:** The citizen scientists prepare data sheets and chains of custody for the samples. The data is entered into the Bureau of Marine Water Monitoring system. Preliminary data is shared with the Navesink River Municipal Committee at Rally for the Navesink meetings. Once a final report is completed, it will be made available to the public.

- **Name of activity:** New Jersey Watershed Ambassadors Program
- **Contact information:**
    - Amanda Lotto- Amanda.Lotto@dep.nj.gov, 609-777-1406
- **Status:** Active
- **Environmental topic:** Water, Land
- **Geographic scope:** Statewide
- **Goals/ purposes:** To work with all sectors of society to improve the quality of New Jersey's waterways, nurturing community-based environmental activities and empowering residents to make responsible and informed decisions regarding their watershed. The Watershed Ambassadors set up volunteer monitoring workshops where they train citizen scientists how to complete biological assessments of streams.
- **Infrastructure:** This is an AmeriCorps program, that started being hosted by NJDEP Division of Water Monitoring & Standards in 2000. Host Agency Sites that host Watershed Ambassadors in each of NJ's 20 Watershed Management Areas are an array of NGO's , Non-Profits, Local Governments, Public Utilities, and Educational Centers.
- **Level of citizen engagement:** Contributory

- **Quality assurance strategy:** AmeriCorps data is QAPP'd and used to support our Integrated Report due to the EPA.
- **Motivational strategy:** Feedback, Community Engagement, Altruism
- **How to use the data:** ArcGIS coverage of streams monitored by AmeriCorps members is available to the public, as well as story maps that tell where stewardship projects have taken place. Through an online database, this assessment data is provided to the NJDEP and is also available to the public.

- **Name of activity:** Long Swamp Creek Citizen Science Monitoring Project
- **Contact information:**
    - Lynette Lurig- Lynette.Lurig@dep.nj.gov, 609-633-1314
    - Barnegat Bay Partnership- https://www.barnegatbaypartnership.org/
- **Status:** Active
- **Environmental topic:** Water, biota
- **Geographic scope:** Long Swamp Creek (tributary of Toms River)
- **Goals/ purposes:** To increase stewardship and awareness of the impacts of nutrient loading and other non-point source pollution that is impacting Barnegat Bay and its local tributaries.
- **Infrastructure:** NJDEP provides funding. Barnegat Bay Partnership (BBP) purchases the equipment. NJDEP recruits volunteers from BBP's contact lists. An AmeriCorps Watershed Ambassador goes out in the field with the volunteers. While in the field, they perform watershed assessments to establish a baseline for water quality and watershed conditions through biological and visual assessments.
- **Level of citizen engagement:** Contributory
- **Quality assurance strategy:** The AmeriCorps Watershed Ambassador ensures that proper procedures are being followed.
- **Motivational strategy:** Feedback, Community engagement, Altruism
- **How to use the data:** The data is collected via paper and given to the Watershed Ambassador. Data is then entered into NJ-GeoWeb (publicly available online map service). Copies of the assessments are also given to the Barnegat Bay Partnership.
- **Pointer to additional information:** NJ-GeoWeb- https://www.nj.gov/dep/gis/geowebsplash.htm

- **Name of activity:** Cyanobacterial Harmful Algal Bloom Freshwater Recreational Response Strategy
- **Contact information:**
    - Vic Poretti- Victor.Poretti@dep.nj.gov, 609-633-1092
- **Status:** Active
- **Environmental topic:** Water
- **Geographic scope:** Statewide
- **Goals/ purposes:** To identify and respond to cyanobacterial harmful algal blooms quickly and effectively.
- **Infrastructure:** NJDEP Bureau of Freshwater and Biological Monitoring (BFBM) provides a website detailing how to properly identify a harmful algal bloom (HAB). Citizen Scientists

report suspected HABs using the online app or calling the WarnDEP hotline. NJDEP BFBM or Bureau of Safe Drinking Water (BSDW), depending on the site, will go out and investigate. If detected, sampling, surveillance, and advisories are posted. There is no formal volunteer pool.

- **Level of citizen engagement:** Contributory
- **Quality assurance strategy:** NJDEP BFBM goes out to the site to verify the report.
- **Motivational strategy:** Feedback, Community engagement
- **How to use the data:** Data is shared back with the public in the form of reports and advisories, which are posted at the site and on the NJDEP HAB response website.
- **Pointer to additional information:** NJDEP HAB response website- https://www.state.nj.us/dep/wms/HABS.html

- **Name of activity:** Water Trails Educators in Sedge Island's Marine Conservation Zone
- **Contact information:**
  - Lynette Lurig- Lynette.Lurig@dep.nj.gov, 609-633-1314
  - Friends of Island Beach State Park- https://www.friendsofibsp.org/
  - Ocean County Sheriff's Department- http://www.co.ocean.nj.us/OCsheriff/
  - Save Barnegat Bay- https://www.savebarnegatbay.org/
- **Status:** Active
- **Environmental topic:** Land use
- **Geographic scope:** Sedge Island's Marine Conservation Zone
- **Goals/ purposes:** To provide information on the use and pressure in the zone and help NJDEP Compliance and Enforcement better patrol the area
- **Infrastructure:** Recruitment of citizen scientists is through Master Naturalists and other groups throughout the watershed. Training is provided by NJDEP's Fish & Wildlife in the winter and Bureau of Marine Water Monitoring in the spring. Paper surveys of who uses the zone and for what reasons, monitoring of when and where personal watercrafts (prohibited) are entering into the zone, where people are buying their clamming licenses and how many they are taking are submitted May through September. An IT specialist from Princeton (volunteer) inputs and analyzes the data.
- **Level of citizen engagement:** Contributory
- **Quality assurance strategy:** Training in the winter and spring.
- **Motivational strategy:** Feedback, Community engagement, Altruism
- **How to use the data:** The data is not shared with the public, but it could be in the future. Compliance and Enforcement uses this data to better patrol the area for personal watercrafts.
- **Pointer to additional information:** Sedge Island website- https://www.nj.gov/dep/fgw/sedge.htm

- **Name of activity:** Coastal Keepers (Living Shorelines Monitoring Project)
- **Contact information:**
  - Garrett "Matt" Warren- Garrett.Warren@dep.nj.gov, 609-633-8438
  - National Fish and Wildlife Foundation (NFWF)- https://www.nfwf.org
  - Partnership for the Delaware Estuary (PDE)- http://www.delawareestuary.org/

    - Barnegat Bay Partnership (BBP)- https://www.barnegatbaypartnership.org/
    - The Nature Conservancy (TNC)- https://www.nature.org/en-us/
    - Jacques Cousteau National Estuarine Research Reserve (JCNERR)- https://jcnerr.org/
    - Sustainable Jersey- http://www.sustainablejersey.com/
    - Rutgers University- https://www.rutgers.edu/
    - NJ Sea Grant Consortium- http://njseagrant.org/
    - New Jersey Audubon Society- https://njaudubon.org/
    - New Jersey Green Teams- http://www.sustainablejersey.com/support-us/volunteer/green-team/
    - New Jersey Environmental Stewards- https://envirostewards.rutgers.edu/
    - New Jersey Master Gardeners- https://njaes.rutgers.edu/master-gardeners/
- **Status:** Active
- **Environmental topic:** Land
- **Geographic scope:** Brigantine, Upper Township, and Atlantic City
- **Goals/ purposes:** To engage the public in citizen science monitoring, which will aid in the collection of information regarding current shoreline and marsh restoration / protection projects, and shorelines or marshes which may be vulnerable to erosion or loss from sea level rise and coastal storms.
- **Infrastructure:** Recruitment of citizen scientists is from local green teams, master gardeners, or environmental stewards. Training is completed by the program coordinator from NJDEP.
- **Level of citizen engagement:** Contributory
- **Quality assurance strategy:** The Coastal Keepers program coordinator goes out to the site a week before the citizen scientist go out and establishes a baseline assessment of the area. A Quality Assurance Project Plan (QAPP) has been produced to ensure the integrity of the data collected.
- **Motivational strategy:** Feedback, Community engagement, Altruism
- **How to use the data:** Data is not currently shared with the public but will be available in the future in the form of public facing online maps. The data will be used to inform stakeholders of current and changing conditions, and to provide input for the State's Coastal Management Program.
- **Pointer to additional information:**
    - Project details can be found on the NJDEP Climate and Flood Resistance Program website-https://www.nj.gov/dep/oclup/case-studies-projects/nj-ecol-solution-projects.html
    - NJDEP Office of Coastal and Land Use Planning webpage- https://www.nj.gov/dep/oclup/

- **Name of activity:** Coastal Keepers (Pilot Flood Monitoring Program)
- **Disclaimer:** **Citizen Scientists are only to pursue flood monitoring in safe conditions.**
- **Contact information:**
    - Garrett "Matt" Warren- Garrett.Warren@dep.nj.gov, 609-633-8438
- **Status:** Future
- **Environmental topic:** Water

- **Geographic scope:** Ocean City, NJ
- **Goals/ purposes:** To facilitate and expedite the monitoring of flood in a time sensitive situation.
- **Infrastructure:** Citizen scientists will take pictures of water levels at pole locations around the town that have been marked with reflective bands at pre-determined heights to illustrate the severity of the flooding.
- **Level of citizen engagement:** Contributory, Community engagement
- **Quality assurance strategy:** TBD
- **Motivational strategy:** Feedback, Altruism
- **How to use the data:** This will help mobilize efforts to areas with the most severe flooding/ most vulnerable areas.

NGO	Program	Purpose/scope	Data Type	Website
American Littoral Society	Beach clean up		Data Recording	https://www.littoralsociety.org/volunteer.html
American Littoral Society	Fish Tagging		Tagging and Data Reporting	https://www.littoralsociety.org/fish-tagging.html
American Littoral Society	Wreck Pond		Monitoring	https://www.littoralsociety.org/blog/category/wreck-pond
NJ Audubon and NJDEP	Various landbird and shorebird surveys	habitat management	bird counts; georeferenced	no current surveys
NJ Audubon and NYC Audubon	Harbor Heron surveys	habitat management; restoration monitoring	Waterbird counts and behavioral surveys	
NJ Audubon	Monarch Surveys		Data Collection	http://www.monarchmonitoringproject.com/
NJ Audubon	reptile survey		Data Collection	https://njaudubon.org/slithering-citizen-science/
USGS, nut local partners in NJ	Breeding Bird Survey	National, but a lot of participants in NJ	bird counts	https://www.pwrc.usgs.gov/bbs/
National Audubon	Christmas Bird count	National, but a lot of participants in NJ	Data Collection	https://www.audubon.org/conservation/science/christmas-bird-count
National Audubon	Great Back Yard Bird count	National, but a lot of participants in NJ	bird counts	https://www.audubon.org/conservation/about-great-backyard-bird-count
Cornell lab Of Onrithology	eBird	National/international, but a lot of participants in NJ	bird counts; georeferenced	https://ebird.org/home
Cornell lab Of Onrithology	Project Feederwatch	National, but a lot of participants in NJ	bird counts at feeders	https://feederwatch.org/
NJ Audubon, Plainsboro Preserve	Project Feederwatch		bird counts at feeders	
Clean Ocean Action	Beach Sweeps		Debris, Microplastic Data Collection	http://www.cleanoceanaction.org/index.php?id=153
CoCO RaHS (Community Collaborative Rain, Hail & Snow Network	Weather Monitoring		Data Collection	https://www.cocorahs.org/state.aspx?state=nj
Conserve Wildlife Foundation NJ	NJ Ospreys and Eagles		Active Nest Census; Online Mapping	http://www.conservewildlifenj.org/blog/tag/citizen-science/
Frogwatch USA	frogs	National, but a lot of participants in NJ		https://www.aza.org/frogwatch
Great Swamp Watershed Association	Frog Watch		Data Collection	https://www.greatswamp.org/event/frog-calling-training/
NJ Audubon, NJDEP, and Conserve Wildlife Foundation	Calling amphibian Monitoring project		Acoustic Monitoring	http://www.conservewildlifenj.org/blog/tag/calling-amphibian-monitoring-project/
NJ Audubon, NJDEP, and Conserve Wildlife Foundation	Amphibian crossing survey		Monitoring	https://www.nj.gov/dep/fgw/ensp/pdf/amphibvols08.pdf
North American Butterfly Association	butterfly count	National, with local participant groups in NJ	data collection	https://www.naba.org/butter_counts.html
Ironbound Community Corporation	Newark Air Quality		Monitoring	https://www.epa.gov/sciencematters/citizen-science-newark-new-jersey
Lower Raritan Watershed Partnership	Visual Habitat Assessments Benthic Macroinvertebrates Pathogen Sampling Soil Sampling		Water Quality Monitoring	http://lowerraritanwatershed.org/field-science/

NGO	Program	Purpose/scope	Data Type	Website
New Jersey Watershed Watch	NJDEP; Cornell Lab of Ornithology		Umbrella for all monitoring programs in NJ	http://www.birds.cornell.edu/citscitoolkit/projects/njdep/watershedwatch/
NY/NJ Baykeeper	Oyster Reintroduction		Oyster survival, growth, settlement	http://nynjbaykeeper.org/restore/#more-80
NY/NJ Baykeeper	Water Quality		Pathogen sampling	http://nynjbaykeeper.org/restore/#more-80
NY-NJ Trail Conference	Invasive Strike Force		Invasive Data Collection	https://www.nynjtc.org/content/invasives
New Jersey Trails Association	Trail volunteer program		Trail information quality control	https://njtrails.org/volunteer-2/
Invasive species strike team	Invasive species monitoring		Monitoring	https://www.fohvos.info/invasive-species-strike-team/
Raritan Headwaters Association	Water Quality		Microplastic sampling, Stream Monitoring	https://www.raritanheadwaters.org/monitoring-water/surface-water/
The Watershed Institute	Water Quality		Stream Watch Data Collection	https://thewatershed.org/volunteer/
Return the Favor NJ	Horseshoe Crab Protection		Data Collection, horseshoe crab rescue	http://returnthefavornj.org/
Wetlands Institute	Horseshoe Crab Protection		Data Collection	https://wetlandsinstitute.org/a-model-citizen-science-and-volunteer-project-turns-5/

Bioblitzes

Organization	Website
Audubon International	https://www.audubonintemational.org/BioBlitz2018
Chrysler Herbarium & Mycological Collection of Rutgers	https://herbarium.rutgers.edu/personal_bioblitz_Spring_2018.html
Ernie Oros Wildlife Preserve	http://www.sustainablejersey.com/fileadmin/media/Events_and_Trainings/Add_Event/2017/6-3-17_BioBlitz/6-3-
Fund for a Better Waterfront (Hoboken)	https://betterwaterfront.org/?page_id=8543
Gateway (National Parks Service)	https://www.nps.gov/gate/jamaica-bay-bioblitz.htm
Glouster County	http://www.co.gloucester.nj.us/depts/p/parks/family/special_events.asp
Littoral Society	https://www.littoralsociety.org/bioblitz.html
Mantiz (Mid-Atlantic Native & Threatened Insect Zoo)	https://www.inaturalist.org/projects/whitesbog-bioblitz
Mount Rose Preser ve	https://www.njconservation.org/MountRosePreserveBioblitz.htm
NJ Audubon - Northwood Center	https://njaudubon.org/northwood-center-bioblitz/
Rutgers Citizen-Scientists	http://btn.com/2018/03/12/rutgers-citizen-scientists-set-out-on-a-bioblitz-btn-livebig/
Union County	http://ucnj.org/bio-blitz/
Upper Delaware	http://upperdelawarebioblitz.com/

A Sampling of Citizen Science Programs at NOAA (and NYSDEC)

1. Greater Farallones National Marine Sanctuary protects nearly 3,300 square miles of north-central California coastal and offshore waters. Coastal monitoring work would ordinarily require a staff far greater than what budgets permit, but "Beach Watch" has involved the public in that effort. Under the management of Greater Farallones Association, volunteers are trained to work with scientists to keep a watchful eye on this ecosystem. Beach Watch monitors the presence of bird, marine mammal, oil and human uses along the California coast. Data are collected by 150 community volunteers highly trained in seabird and marine mammal identification and emergency response. The long-term dataset provides a glimpse into long term changes in wildlife and human use along the coast. Resource managers and scientists leverage Beach Watch data to answer wildlife health and coastal management questions. Unusual mortality events can be used as indicators of wildlife and ecosystem health and changes in climate, wildlife distribution can be used to inform and designate new wildlife protection areas and oil deposition can provide crucial evidence on damages to wildlife and coastline from oil spills. Data gathered by volunteers has helped secure over $52 million to assess damage to and enhance loss of natural resources and recreational uses. **Management of Beach Watch, which has been in existence for 25 years, is by a Public/Private Partnership between NOAA and the Greater Farallones Association. Karen Lindquist of the Farallones Assoc. is the manager and works closely with NOAA staff. The project covers over four counties and has170 volunteers and many surveys. There are two full-time staff plus some part-timers. They utilize a listserv to communicate and keep track of who is doing what. They are selective as to who is accepted into the program, and have an annual orientation and training to teach new people and refresh old-timers about required protocols. Experienced volunteers help train new ones. The Association has an online volunteer portal to enter data and photos. The staff discuss the data with the citizen scientists, then analyze the data and write reports.**

2. The population of Steller sea lions is declining in the western Aleutian Islands. Scientists collect data by counting sea lions using drones, traditional aerial surveys, or binoculars from a boat or land. At six remote sites, cameras have been snapping photos of sea lions throughout the year. When scientists visit, they collect the images—over 300,000 annually—and take them back to their lab in Seattle. More than 8,000 volunteers have helped process images. Scientists have marked many individual sea lions with unique numerical codes for identification. Using the "Zooniverse" crowdsourcing platform, volunteers use the " Steller Watch website and app" to sort through the photos and identify images that contain sea lions with markings.

3. Marine debris research and education are helped by the Marine Debris Monitoring Toolbox, which NOAA partners and volunteers are using to conduct monthly surveys of shorelines and waterways. Results are logged in a NOAA database. There is a toolkit for educators and a "Marine Debris Tracker" that allows trash to be tracked, characterized and logged from anywhere. **Management: California coordinator Sherry Lipiatt. Developed shoreline survey protocols to standardize procedures – standard length of beach and same level of effort.**

Different volunteer groups with two staff members interacting with partners in the community. People take data sheets into the field and later enter their data into online database. Data analyzed by NOAA staff and reported on information sheets and blog. Participants self-organize days and times to do clean-ups. Recommendation – they need to develop better engagement with volunteers to develop a sense of community. Some important links:

https://marinedebris.noaa.gov/research/monitoring-toolbox
https://marinedebris.noaa.gov/mdmap-protocol-documents-and-field-datasheets
https://mdmap.orr.noaa.gov/login

4. Measuring precipitation Whenever rain, snow or hail falls in an area, CoCoRaHS volunteers measure the amount, giving those who require the data an increasingly clear and online picture of precipitation totals and locations. Using low-cost tools, more than 20,000 volunteers across 50 states provide on-the-ground data in real-time for NOAA forecasters, farmers, emergency and water resource managers, and numerous others to analyze and apply.

5. Through the "Old Weather" project, thousands of citizen scientists with highly diverse backgrounds and interests are recovering millions of weather and environmental records from historical ship logs and other documents and converting them to digital formats. The information is then integrated into large-scale datasets supporting analyses of centuries of Arctic and global change. These analyses help predict far-reaching future change and its human and environmental implications.

6. Ocean Video Lab's portal opens an amazing underwater world to citizen scientists, enabling them to explore remote areas of the ocean. Viewing hours of video collected on ocean expeditions, volunteers thematically bookmark content, saving time for scientists. Rather than viewing a full dive, for example, a coral biologist can jump right to a bookmarked coral site. A geologist can advance quickly to footage of faults. Scientists' detailed annotations build on the general notes of volunteers, greatly enhancing the efficiency of ocean exploration.

7. SKYWARN® severe weather spotters give their communities the gift of time – crucial minutes and seconds of lead time that save lives. More than 350,000 National Weather Service-trained volunteers help protect their communities with timely reports of hazardous weather, especially severe local storms. Along with Doppler radar and improved satellite and other data, spotters enable NOAA to issue more timely and accurate warnings for tornadoes, severe thunderstorms and flash floods.

8. Watching marine mammals provides greatly added value in Southern California where 150 trained volunteers identify marine mammals and educate the public during local excursions. Using a "Whale Alert" app that feeds into a marine mammal database, citizen scientists detail sightings in near-real time. Volunteers record sightings of nearly 30 species, including endangered blue whales and humpback whales. An analysis of whale sightings and travel patterns into Santa Barbara

Channel led to modification of ship routes, reducing the threat of ship strikes to large whales.

9. South Maui Marine Turtle Stranding Network Volunteers are specially trained, on-call volunteers that respond to reports of stranded, injured or dead sea turtles along South Maui Beaches. Injured or dead turtles are shipped to the National Marine Fisheries Service in Honolulu for care or necropsy. **Management: Irene Kelly: Currently outsourcing activities to non-profits who use volunteers to respond/retrieve turtles. They put out a call yearly to solicit information from the public regarding turtles they may see with numbers on their shells. Biologists number sea turtles at their nesting habitats and then after animals migrate back to their foraging habitats, the public can report sightings. Information is used to identify important adult foraging habitats. It is a very loose program. They circulate a press release asking for sightings and remind public of the reporting hotline number and email. When they receive calls or emails they catalog the information. They collaborate with Hawaii Hawksbills, a partner that maintains a hawksbill turtle sighting database which currently has 166 individuals identified. This species is rare, prompting the desire to know when and where people are seeing them, and identify important habitats. Reporting tends to be word of mouth, and informational fliers distributed to dive/snorkel shops etc. The program has been active for15+ years so enough people know to send photos when they come across a hawksbill. Again, not much management other than an annual circulation of information and request for sightings, typically associated with a unique hawksbill turtle sighting event.**

10. The Monterey Bay Sanctuary Citizen Watershed Monitoring Network is a consortium of citizen monitoring groups that monitor the health of the eleven watersheds flowing into Monterey Bay National Marine Sanctuary off California. Water quality monitoring programs include, Snapshot Day, First Flush and Urban Watch. **Management – Lisa Emanuelson (lisa.emanuelson@noaa.gov) Several different ongoing projects. One person (herself) in charge of recruiting, training, arranging for background checks on volunteers,, paperwork for the agency, keeping data, analyzing data, writing reports for the Sanctuary and/or the funders, creating multi-year reports to see trends.**

11. LiMPETS is a citizen science program that monitors coastal ecosystems of CA. It provides education for students, educators and volunteer groups. Teachers, students and community groups along the coast collect biological data from rocky intertidal and sandy beach systems to help to protect local marine ecosystems and provide publicly accessible, scientifically sound, long term data to inform marine resource management and the scientific community..

New York State DEC

Citizen Science at NYS DEC – Hudson River Estuary's Glass eel project Put in fyke nets at mouths of Hudson River tributaries for 8 weeks in spring (late Mar – early May) to monitor glass eels coming upriver. Glass eels unmistakable for anything else and have a defined migration season. Volunteers check traps every day, count and weigh the eels and then move them to another spot. Have 13 sites. Each site has notebook with data sheet for each day to fill in (also online system).

Staff pick up sheets periodically and enter data into computer**.** Feed data into state survey for glass eels and national assessment.

Management: Chris Bowser. Strong partnerships with schools (HS and local colleges, including HS in Poughkeepsie with disadvantaged students and local creek) or local nonprofits to recruit volunteers. Pay organizations to manage volunteers. Someone almost full-time at Estuary Program during those three months.

USEPA CITIZEN SCIENCE RESOURCES

The USEPA website contains a number of digital and downloadable references related to Citizen Scientist activities in a number of disciplines. These disciplines cover a wide range, from Air Monitoring to Water Monitoring to Environmental Justice communities. This website also contains links to various U.S. projects, videos, and funding opportunities that feature data collection by Citizen Scientist volunteers. Documents that have been uploaded into the NJDEP Citizen Scientist document sharing folder include:

1. USEPA. 2012. ***Starting Out in Volunteer Monitoring:*** Contains a general description of what volunteer monitors can do in collaboration with State and Federal monitoring programs. An information sheet for individuals who want to begin participating in Citizen Science. 4 pg.
2. USEPA. ***Volunteer Estuary Monitoring: A Methods Manual.*** 2nd Ed. (1st Ed. 1993). USEPA has supported volunteer monitoring activities since 1987 through volunteer symposia, a volunteer newsletter, guidance manuals, and technical support to volunteer programs. This manual was written for both estuarine volunteer program managers and the volunteers themselves. The resource: 1) describes estuaries and the problems they face; 2) establishing a volunteer monitoring program; 3) working with volunteers to make certain water quality data is collected safely and effectively; 4) ensuring data is consistently high quality; and 5) managing the data and making it available to data users. Includes chapters on several water quality parameters (chemical, physical, and biological), the significance of each parameter, and specific monitoring methods. 396 pg.
3. USEPA. 1991. ***Volunteer Lake Monitoring: A Methods Manual.*** This document was developed to provide specific information related to volunteer lake water quality monitoring methods. It is for use by organizers of volunteer lake monitoring programs and the volunteers who will be sampling. The manual summarizes steps necessary to manage a volunteer monitoring program, goal setting, uses and users of collected data, and sound quality assurance procedures. The document concentrates on 3 common lake problems: algal growth, increase in rooted aquatic plants, and low dissolved oxygen levels, all common symptoms of cultural eutrophication. Sedimentation, turbidity, acidification, and bacteriological issues are briefly discussed. 130 pg.
4. USEPA. 1997. ***Volunteer Stream Monitoring: A Methods Manual.*** Streams and rivers monitored by more volunteer programs than any other waterbody type. This document describes in-stream physical, chemical, and biological assessments, as well as landuse or watershed assessments, and is provided

as a tool for program managers who want to launch new stream monitoring programs or enhance existing programs. 227 pg.

5. USEPA. 2001. ***Volunteer Wetland Monitoring: An Introduction and Resource Guide.*** Focused on the importance of wetlands, this manual describes why volunteer monitoring is important and the roles that volunteers play in data collection. Monitoring methods are discussed, the design of wetland studies, and the need for a QAPP to ensure data credibility. A number of resources guides monitoring different wetland habitats are included with digital links. 51 pg.
6. USEPA. 1990. ***Volunteer Water Monitoring: A Guide for State Managers.*** This guide describes the benefits of volunteer monitoring to obtain credible data and educate the public to encourage a sense of stewardship. It provides sections related to planning and implementing a volunteer monitoring program, preparing a QAPP, and obtaining funding for a volunteer program. 84 pg.
7. USEPA. 1996. ***The Volunteer Monitor's Guide to Quality Assurance Project Plans.*** 67 pg. Facing the difficult issue of credibility from data users who are skeptical about volunteer data through use of a Quality Assurance Project Plan (QAPP). This document outline procedures to ensure that collected data meets project requirements. 67 pg.
8. USEPA. 2013. ***Quality Assurance Template for Citizen Scientists.*** This document provides an easy to follow template to create a QAPP for a project involving data collection by citizen scientists. 24 pg.
9. USEPA. 2017. Citizen Science in Action – EPA Region 2. A powerpoint presentation describing Case Studies in Region 2 focused on air and water monitoring that included Citizen Science. Highlights USEPA Region 2 support for Citizen Science initiatives. 22 pg.
10. USEPA. 2017. ***USEPA Region 2 Equipment Loan Program for Citizen Science Water Monitoring.*** Describes equipment available for loan (5 sets for use in NY-NJ in 2017) and details procedures for watershed groups to apply for use of this equipment. Website: www.epa.gov/citizenscience. 6 pg.
11. Dosemagen, S., Parker, A.J. ***Citizen Science Across a Spectrum: Broadening the Impact of Citizen Science and Community Science.*** A review of Citizen and community science, non-traditional partnerships and diverse participation. The article comes out of a report by the National Advisory Council on Environmental Policy and Technology, a federal advisory council for US EPA.

WEB LINKS:

1. EPA volunteer monitoring website: http://water.epa.gov/type/rsl/monitoring/index.cfm
2. Extension Volunteer Monitoring Network homepage: www.usawaterquality.org/volunteer/