D. Crowdsourcing and Citizen Science under Other Authorities

This Appendix provides summaries of select crowdsourcing and citizen science activities voluntarily submitted by agencies that were conducted in FY17 and FY18 under authorities other than that provided by the Crowdsourcing and Citizen Science Act. Agency reporting on crowdsourcing and citizen science activities under other authorities was optional, and therefore the activities presented here are representative rather than comprehensive.

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D.1 Department of Agriculture (USDA)

D.1.1 Invasive Mosquito Project[1]

Lead Sponsoring Agency: Agricultural Research Service (ARS)

Authority: 7 U.S.C. 2272 (Volunteers for Department of Agriculture Programs)

Project Summary and Goals: The Invasive Mosquito Project (IMP) is a public education and national mosquito monitoring program that partners local professionals with high school teachers and community educators to teach about mosquito-borne disease and public health. The project provides teachers with educational materials that meet Next Generation Science Standards and creates community outreach opportunities that benefits mosquito control and public health agencies. The IMP website serves as both an informational resource and a connection platform for teachers and professionals.

Justification for Using Crowdsourcing and Citizen Science: During the summer of 2012, the USDA sampled mosquitoes throughout the entire continental United States using a network of citizen scientists and crowdsourcing. Learning from the effectiveness of this effort, the IMP was formed to make an even larger and more sustainable network at lower cost.

Status: The project started in April 2016 and is ongoing.

Location: The IMP monitors invasive mosquito species across the United States.

Participation: The project targeted middle and high school students, boy scouts, master gardeners, and other community groups. The total number of individuals involved during this period was 2000, and the number of active participants was 50.

Consent: No consent is needed.

Submissions: The IMP collected participant observation data as well as mosquito eggs, mosquito larvae, and adult mosquito samples.

Resources: There is no dedicated budget to support the IMP. However, the use of crowdsourcing and citizen science (CCS) allows USDA-ARS to support the project. By relying on citizens for monitoring and data collection, USDA-ARS saves approximately $15,000 per year in technician travel and equipment related costs. The project costs to raise the mosquitoes is approximately $2,000 per year and 0.1 FTE of a technician. Both FY17 and FY18 resources were used to rear the submitted mosquito egg samples to adults for identification.

Partnerships: Non-Federal partners included Kansas State University.

Advancement of Agency Mission: The USDA uses the submitted mosquito samples for population genetics studies, helping to raise awareness about public health risks through agricultural research.

Results: In addition to helping teach students and communities about the risk of mosquito transmitted pathogens and building a strong network of schools, the IMP allowed the USDA to find the origins and subsequent geographic expansion of two mosquito species in the United States. The USDA is in the

[1] The website for the Invasive Mosquito Project can be viewed at http://www.citizenscience.us/imp/.

process of using the samples to determine which traits are needed for population expansion to new geographic areas, which will help predict future at risk populations.

Data Availability: The data is currently maintained as paper records and is not available at this time.

D.1.2 Collaborative Adaptive Rangeland Management (CARM)[2]

Lead Sponsoring Agency: ARS

Authority: 7 U.S.C. 2272 (Volunteers for Department of Agriculture Programs)

Project Summary and Goals: The CARM study was devised to compare traditional rangeland management used by local ranches with season-long, continuous grazing. A team of stakeholders and scientists were selected to manage yearling cattle for beef production, grassland diversity, and bird conservation. For the experiment, approximately 230 yearling cattle graze 10 130-hectare pastures from mid-May to October; and researchers measure outcomes on grassland birds, vegetation composition and structure, cattle production, and social learning. Decisions to be determined include pasture sequence (what order a pasture is grazed or rested), when to move cattle between pastures, and vegetation management actions (e.g. prescribed burning). Decisions are based on monitoring data and stakeholders' local knowledge. This project is the core common experiment for the USDA-ARS Central Plains Experimental Range Long-Term Agroecosystem Research (LTAR) network. The first stakeholder group meetings were held in 2012, and the experimental baseline sampling began in 2013. Treatments were initiated in 2014 and have been ongoing, with the intent to continue for at least 5 more years.

Justification for Using Crowdsourcing and Citizen Science: The use of citizen science in this study demonstrates how science can be conducted in a real-world manner. Local ranchers across the region are the ultimate end users of the information to be gained from these studies. Engaging a group of local ranchers in the research and data collection helps ensure that the data and analyses are relevant and applicable to managers throughout the region. By allowing the ranchers to engage in the data collection also effectively expands the study area and the number of samples to be analyzed.

Status: The project started in 2012 and is ongoing.

Location: The study is focused in the rangelands of the western Great Plains of North America.

Participation: The project targeted stakeholders of complex rangeland systems, including ranchers, public land managers, conservation organizations, and nongovernmental organizations. The total number of individuals involved during this period was 225, with 164 field day participants, 11 CARM project participants, and approximately 50 guests from associated organizations. The active CARM project participants included 11 CARM stakeholders, 9 non-ARS scientists, and 4 graduate students. The total number of volunteer hours for FY17 and FY18 was 1,400. Volunteer hours only include the hours of persons not employed by an organization where their time was covered.

Consent: All active participants provided consent.

Submissions: Submissions for the CARM study include observations of cattle behavior, grassland birds, and vegetation. CARM stakeholders planned and excuted the Field Day last fiscal year.

Resources: FY17 and FY18 funding, not including full-time equivalent (FTE) time, totaled $425,000 and $450,000, respectively. Additional funding was provided through USDA-NIFA grants: one grant for

[2] The website for Collaborative Adaptive Rangeland Management (CARM) can be viewed at https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/rangeland-resources-systems-research/docs/range/adaptive-grazing-management/research/.

$350,000 over three years, and a second grant for $460,101 over four years. In FY17, $117,000 and $115,000 in funding came from the two grants. USDA-ARS base funds support approximately 8 FTEs from ARS, with about 4 FTEs in Scientist Year and technician time and 4 FTEs in summer students. USDA-ARS base funds also are used through Non-Assistance Cooperative Agreements (NACAs) to support graduate students addressing livestock behavior, economics, ecosystem modeling, and livestock diet selection and quality. USDA-ARS base funds have been used for (1) sample analyses (soils, fecal material, and diet quality); (2) monitoring networks of soil, climate and greenhouse gas fluxes; (3) infrastructure maintenance and upgrades (livestock facilities, fencing, roads, vehicles, and communcation networks); (4) data management and storage; and (5) travel to producer and professional meetings. Soft funds from grants via USDA-NIFA were used to enhance sampling of grassland birds (e.g., number, nest success, and habitat) and social sciences (e.g., participatory research emphasis and collaborative learning).

Partnerships: Federal partners included USDA-NRCS and USDA-FS. Non-Federal partners included The Nature Conservancy, Colorado State Extension, Colorado State Land Board, Crow Valley Livestock Cooperative (4 ranchers), Bird Conservancy of the Rockies, and Environmental Defense Fund.

Advancement of Agency Mission: The mission of the USDA-ARS Center for Agricultural Resources Research (CARR) is to develop and transfer science-based management strategies to improve resiliency, reduce risk, and provide ecosystem goods and services from semiarid rangelands. The CARM project contributes to the CARR mission by examining how grazing management can be implemented in a manner that responds to current and changing rangeland conditions, incorporating active learning, and making decisions based on quantitative, repeatable measurements collected at multiple spatial and temporal scales.

Results: The information obtained by the scientist-stakeholder team is used by land managers using monitoring-informed adaptive management to enhance decision-making, improve resiliency, and reduce risk for rangelands in a changing climate.

Data Availability: Near real-time rangeland data can be accessed at https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/rangeland-resources-systems-research/docs/near-real-time-data/.

D.1.3 FarmLab

Lead Sponsoring Agency: ARS

Authority: 7 U.S.C. 2272 (Volunteers for Department of Agriculture Programs)

Project Summary and Goals: The FarmLab is a new initiative of the U.S. Dairy Forage Research Center, based at the Prairie du Sac research farm. The FarmLab will serve as a farm-scale laboratory for study of the long-term economic, environmental, and social outcomes associated with land use and farming practices. The FarmLab has three priority research areas: (1) soil health; (2) biological diversity; and (3) farm systems research. Efforts will explore the relationships between land cover, land management, soil health (nutrient cycling, carbon sequestration, water infiltration, erosion, soil biota), biodiversity (genetic, species, landscape), and the production of commodities and ecosystem services, examine the social, economic, agronomic, and ecological trade-offs associated with farming practices, and provide decision-making tools and support for producers.

Justification for Using Crowdsourcing and Citizen Science: Several reasons serve as justification for engaging citizens in the data collection, land stewardship, ecological restoration, and outreach programming aspects of the FarmLab project. The long history of public engagement in the reuse of the former Badger Army Ammunition Plant, of which the U.S. Dairy Forage Research Center's Prairie du Sac

research station is a part, provides a foundation for a successful citizen science program. Citizen engagement in matters of agricultural research is especially important for informing the public about the challenges and opportunities agricultural producers face in managing economically and environmentally sustainable agricultural operations. Researchers hear and integrate farmers' concerns and expertise into research design, and farmers hear researchers' expertise and experiences in investigating issues of agricultural sustainability. Engaging agricultural producers in ARS research through farmer-citizen science and outreach events then provides a means of direct communication between researchers and practitioners and builds trust around research design, implementation, and practicality of farm management recommendations.

Status: The project started in 2017 and is ongoing.

Location: The FarmLab is located on former Badger Army Ammunition Plant lands in Wisconsin.

Participation: The project targeted citizens interested in stewardship activities. The total number of individuals involved since 2017 has been 25, and the average number of active participants during 2 consecutive heirloom apple growing seasons has been about five. The FarmLab will begin tracking the total number of volunteer hours in FY19.

Consent: All volunteers have signed a waiver form before contributing volunteer hours.

Submissions: The FarmLab receives four categories of submission data: (1) bluebird monitoring; (2) invasive species management; (3) heirloom apple inventory and stewardship; and (4) farm biomass models.

Resources: There is no dedicated budget for the FarmLab. Funding and in-kind support has been provided by nonprofit partners: two full-time equivalent (FTE) employees supported the effort in FY17 and FY18, with one FTE overseeing the FarmLab project and one FTE conducting the FarmLab research.

Partnerships: A partnership with USDA Natural Resources Conservation Service (NRCS) is in development. Non-Federal partners include Wisconsin Department of Natural Resources, Ho-Chunk Nation, Sauk Prairie Conservation Alliance, Seed Savers, and The Savanna Institute.

Advancement of Agency Mission: FarmLab contributes to the accomplishment of two ARS strategic goals outlined in the ARS Strategic Plan. The first is Goal 4.1, which is to "provide scientific information and biotechnologies to enhance management practices that will ensure an abundant supply of competitively priced animal and aquaculture products: (Animal Production and Aquaculture – NP 101 & 106)". The second is Goal 2.5, which is to "develop and transfer economically viable and environmentally sustainable production and conservation practices, technologies, plant materials and integrated management strategies, based on fundamental knowledge of ecological processes, that conserve and enhance the nation's diverse natural resources found on its range, pasture, hay and turf lands (Rangeland, Pasture, and Forages – NP 215)".

Results: The data will be used to inform farm models, on-farm decision-making, and recommendations about practices that can improve whole-farm, agroecosystem sustainability.

Data Availability: Data will be made available to the public.

D.2 Department of Commerce (DOC)

D.2.1 Cyclone Center[3]

Lead Sponsoring Agency: Citizen Science Alliance

Authority: Weather Service Organic Act, 15 U.S.C. § 313

Project Summary and Goals: Due to the inconsistency of scientific research on tropical cyclones, specifically about the wind speeds of these storms through time, the effects of climate change on the nature and strength of cyclones is not well understood. NOAA has accumulated nearly 300,000 satellite images of tropical cyclones since 1978, and when these images are classified with the "Dvorak technique," critical information about the storms can be extracted. Through the work of volunteers, Cyclone Center will help create a new database of information about cyclones. By answering a few simple questions, volunteers can apply a modified Dvorak technique to interpret satellite images even more effectively than the best computers, ultimately aiding climatologists in the estimation of future storm intensity.

Justification for Using Crowdsourcing and Citizen Science: Citizen Science exists as an efficient and effective means for performing a human analysis of all 300,000 images.

Status: The project started on September 26, 2012 and is ongoing.

Location: The program is managed in North Carolina, but the data analyzed is global in scale.

Participation: The project targeted internet users with an interest in weather or climatology. The total number of individuals involved was 6,700 in FY17 and 7,000 in FY18. The total number of volunteer hours was 1,200 in FY17 and 1,300 in FY18 (assuming 100 image classifications per hour).

Consent: Consent is implicit upon input of data into the web application. The project operates on the condition of anonymity, so no formal consent was sought.

Submissions: Participants view tropical cyclone images and respond to prompts/questions based on the images. They answer approximately 2–5 questions for each image. These responses are used to help determine the strength of the cyclone. The total number of submissions was 120,000 in FY17 and 130,000 in FY18.

Resources: There is no dedicated budget for Cyclone Center. Development was completed five years ago. Initial development of the website was funded and completed by the Citizen Science Alliance with advice from Federal and university partners. Research partners, including university partners and a Federal employee, now work on the project at a very low level of commitment. The project generally receives 0.01 full-time equivalent (FTE) support from a Federal employee and 0.05 FTE support from a non-Federal employee.

Partnerships: Non-Federal partners include the Citizen Science Alliance, the University North Carolina Asheville (UNCA), and the Cooperative Institute for Climate and Satellites - North Carolina (CICS-NC).

Advancement of Agency Mission: Cyclone Center is striving to improve understanding of historical observations of tropical cyclones, which has a direct impact on NOAA's mission to better understand hurricanes, climate, and to some degree, weather.

Results: The most recent efforts have produced a research paper in October 2016, in which results were used to identify the development characteristics of hurricanes/tropical cyclones. Work is ongoing by

[3] The website for the Cyclone Center can be viewed at https://www.cyclonecenter.org/.

university partners to develop more thorough analyses of classifications to determine cyclone intensity estimates.

Data Availability: Data are available to the public upon request.

D.2.2 Meteorological Phenomema Identification Near the Ground[4]

Lead Sponsoring Agency: National Oceanic and Atmospheric Administration (NOAA)

Authority: Weather Service Organic Act, 15 U.S.C. § 313

Project Summary and Goals: Meteorological Phenomena Identification Near the Ground (mPING) is a project to collect weather information from the public through smart phones and mobile devices. The free mPING mobile app was developed through a partnership between the National Severe Storms Laboratory (NSSL), the University of Oklahoma, and the Cooperative Institute for Mesoscale Meteorological Studies. mPING collects observations to aid research into winter precipitation type, frequency, and area, as well as hail occurrence, location, time, and size. Observations are used to develop better forecasts of winter precipitation type and better radar algorithms for discriminating between precipitation types that reach the ground.

Justification for Using Crowdsourcing and Citizen Science: Deploying trained observers in this number and across the continental U.S. is impractical; voluntary observations are the only way to reach necessary coverage.

Status: The project started on December 19, 2012 and is ongoing.

Location: Respondents are global, but research focus is in North America.

Participation: The project targeted anyone with an interest in participating and who owned a mobile device. The app was downloaded approximately 90,000 times, but the application program interface (API) has been included into RadarScope (a private weather provider app) that has an installed user base of over 500,000.

Consent: Consent is implicit upon download of the app or submission of data. The project operated on the condition of anonymity, so no formal consent was sought.

Submissions: Repondents provide precipitation type, flooding severity, wind damage severity, hail size, visibility restrictions, and tornado and waterspout observations. Approximately 1.7 million reports have been received to date.

Resources: All funding is provided via a Director's Discretionary Research Fund. A total of 0.1 FTEs are used each year for app maintenance, database support, and applied research for forecast improvement.

Partnerships: Non-Federal partners include the University of Oklahoma Cooperative Institute for Mesoscale Meteorological Studies.

Advancement of Agency Mission: Better winter precipitation type forecasts from the National Weather Service (NWS) are crucial to maintining infrastructure during winter storms. Knowing precipitation types that are not reported by automated surface observing systems, such as ice pellets, yield important information to NWS forecasters about current conditions. Extended records provide a better climatology of precipitation type and may ultimately help humans better understand and respond to

[4] The website for Meteorological Phenomema Identification Near the Ground can be viewed at https://mping.ou.edu.

climate change. Furthermore, verifying the precipitation type produced by numerical weather prediction models helps refine and improve the performance and utility of those models, the algorithms for remotely sensing precipitation type reaching the surface, and the quantitative precipitation estimation.

Results: All mPING data are received in real time at all NWS weather forecast offices, the Storm Prediction Center, and the Weather Prediction Center. An operational numerical weather prediction model has been directly improved using mPING data and verification. Over 20 formal publications have used mPING data.

Data Availability: Data are available publicly via web display. Upon request, data can be downloaded by users and institutions using a public API key.

D.2.3 Old Weather[5]

Lead Sponsoring Agency: NOAA

Authority: Weather Service Organic Act, 15 U.S.C. § 313

Project Summary and Goals: Nearly everything known about the Global Ocean prior to the satellite era can be linked to a single document type: a ship's logbook. Related primary documents, including muster rolls, field notebooks, photographs, and artwork, often depend on logbooks for context and interpretation. This project focused on historical weather data recovery from the logbooks and muster rolls of U.S. naval vessels (currently 1861-1879 and selected related assets between 1801 and 1940) located at the National Archives. In addition to creating high-resolution digital analogs of unique historical documents of national significance, participants recovered geospatial references, weather and ocean data, and other historical information through Old Weather, our citizen-science program. These data are suitable for computationally intensive retrospective analysis (reanalysis) systems, such as the NOAA/CIRES/DOE 20th Century Reanalysis, and for enhancing the discoverability and application of information from the logbooks. Images and data will be integrated into existing national and international data infrastructure. Large-scale manuscript-to-digital data conversion has great potential to foster new scientific and historical understanding and provide enhanced access to our shared maritime and cultural heritage.

Justification for Using Crowdsourcing and Citizen Science: Manuscripts cannot be read by machine systems at the present time.

Status: The project started in 2010 and is complete.

Location: The data was collected from the Arctic region and the Global Ocean.

Participation: The project targeted interested persons worldwide. The total number of individuals involved was 23,000 over the life of the project. A total of 50 participants are currently working on special tasks off-line.

Consent: Consent is implicit upon download of the app or submission of data. The project operated on the condition of anonymity, so no formal consent was sought.

Submissions: Participants transcribed marine-meteorolgical data and other environmental observations from U.S. Federal ship logs (e.g., Navy, Coast Guard, Coast Survey).

Resources: The various aspects of the project have been funded by a range of competititve grants from public, non-Federal, and foundation sources including the North Pacific Research Board, Alfred P. Sloan

[5] The website for Old Weather can be viewed at www.oldweather.org.

Foundation, National Science Foundation, Department of Energy, Council on Library and Information Resources, Andrew W. Mellon Foundation, and a number of other United Kingdom (UK) and European Union (EU) sources via the UK Met Office. The primary contribution by NOAA has been through occasional support from the Office of Oceanic and Atmospheric Research (OAR) Communications to publicize the project. NOAA/ESRL/PSD has provided support to various researchers to test the resulting weather observations in the NOAA/CIRES/DOE 20th Century Reanalysis Project. An incidental amount of effort was required to put in place a Letter of Agreement between NOAA and the National Archives and Records Administration to facilitate operations at the National Archives (i.e., digital imaging of assets).

Partnerships: Non-Federal partners included the University of Washington's Joint Institue for the Study of the Atmosphere and Ocean (JISAO), the University of Colorado's Cooperative Institute for Research in Environmental Science (CIRES), and the UK Met Office, which funded the Old Weather interface.

Advancement of Agency Mission: Increased understanding of weather in the past is integral for improved modeling and forecasting in the future and the proper diagnosis of extreme events and decadal variability.

Results: Data generated by this project was integrated into the International Comprehensive Ocean Atmosphere Data Set (ICOADS) and the International Surface Pressure Databank (ISPD). The data was then assimilated by high-performance retrospective analysis systems operated by the NOAA Earth System Research Laboratory (e.g., the NOAA/CIRES/DOE 20th Century Reanalysis), by NOAA GlobalTemp and NOAA/NCEI's ERSST, and by the European Center for Medium Range Weather Forecasts (e.g., CERA-20C), among others.

Data Availability: Extracted data are available from ICOADS (Deck 710) and ISPD. Primary source images are integrated into the National Archives digital catalog https://www.archives.gov/research/catalog.

D.2.4 Community Collaborative Rain, Hail and Snow (CoCoRaHS) Network[6]

Lead Sponsoring Agency: NOAA

Authority: Weather Service Organic Act, 15 U.S.C. § 313

Project Summary and Goals: The major goals of CoCoRaHS are to provide high quality precipitation data (at least one gauge every square mile in urban areas and one every 36 square miles in rural areas) and offer educational opportunities focused on climate literacy to project volunteers and the general public. Volunteers register their location on the project website and receiving training online or in-person with a local coordinator. By following a set of simple procedures and using a standardized rain gauge, volunteers measure and report their daily amount of rain (or melted snow) onto the project website, making it readily available in a centralized database. Options to report hail and/or other significant weather are also available, as well as advanced options such as evapotranspiration and drought impact reports.

Justification for Using Crowdsourcing and Citizen Science: The traditional spacing of weather stations in the U.S. has been roughly one every 1,000 to 1,500 square kilometers. With the help of participating volunteers, CoCoRaHS strives to increase spatial resolution to one station per 2–100 square kilometers to allow the true nature of local variability in precipitation to be observed. Automated weather stations, particularily automated rain gauges, have been found to be less accurate than the 4-inch manual guage that is required by CoCoRaHS and approved by the National Weather Service. The atmospheric science

[6] The website for the Community Collaborative Rain, Hail and Snow (CoCoRaHS) network can be viewed at https://www.cocorahs.org/.

community values the CoCoRaHS high-density data source at the same time that the science education community is setting goals for climate literacy.

Status: The project started on June 17, 1998 and is ongoing.

Location: Participants located in the United States (all 50 states, D.C., Puerto Rico, U.S. Virgin Islands), Bahamas, and Canada (all provinces) can participate in CoCoRaHS.

Participation: The project targeted any member of the public with the desire and ability to set up a manual rain gauge and report data by web, smartphone, telephone, or email. The total number of individuals involved was 19,213 in FY17 and 19,765 in FY18. The total number of volunteer hours ranged bewteen 142,904 and 357,261 in FY17 and 140,217 and 350,543 in FY18.

Consent: Consent was received by all participants.

Submissions: The primary data are 24-hour precipitation measurements (rain, hail, and snow), but additional options include real-time hail and intense precipitation reports, evapotranspiration, drought condition monitoring, soil moisture, frost, optics (e.g., rainbows), thunder, and snowflake type.

Resources: There is currently no direct Federal support for CoCoRaHS. Estimates of the funding for the period from June 2017 to May 2018 include four sources: (1) the PRISM Climate Group at Oregon State University ($180,000 subcontract); (2) the National Mesonet Program, via Synoptic Corporation ($60,000); (3) donations from the year-end fundraiser "$5 for CoCoRaHS" ($112,000); and (4) local Colorado data user fees ($26,000). Operational expenses during this period were approximately $415,000, with $354,000 of expenditures and $61,000 of indirect costs. CoCoRaHS is staffed by 2 FTEs, but only a small percentage comes from Federal support.

Partnerships: Federal partners include the National Oceanic and Atmospheric Administration, National Science Foundation, Bureau of Land Management, National Park Service, United States Geological Survey, Department of Agriculture, and United States Army Corps of Engineers. Non-Federal partners include State water agencies, natural resources agencies, universities, local water utilities, regional water utilities, watershed protection groups, Master Gardener, Master Naturalist, K-12 schools, museums, community groups, and other private companies.

Advancement of Agency Mission: CoCoRaHS data is widely used by NOAA entities for a variety of purposes, including rainfall estimation, flood forecasting and warning, and research. The regular, high-resolution collection of precipitation data, and the sharing of that data, advances NOAA's missions to understand and predict changes in climate, weather, oceans, and coasts and to share that knowledge and information with others.

Results: CoCoRaHS precipitation data is used widely by the National Weather Service and other NOAA entities for real-time precipitation monitoring, use in flood warning and prediction, and improvement of operational and experimental quantitative precipitation estimation systems (such as the Multi-Radar Multi-Sensor). The data are also used in national drought monitoring efforts through Federal and State agencies. Several publications have referenced the data from CoCoRaHS.

Data Availability: The data gathered by volunteer observers through the CoCoRaHS network are freely available to governments, academic institutions, and the private sector as well as participants and the general public for the purposes of promoting learning, enhancing scientific knowledge, and protecting life and property. CoCoRaHS data are made available to the public online (www.cocorahs.org). However, NOAA requires all who uses CoCoRaHS data to acknowledge the source when displaying it. Unless otherwise noted, all CoCoRaHS content and data are released under a Creative Commons Attribution 3.0 License. The data are provided "as is, and in no event shall the providers be liable for any damage or loss due to missing data or misinterpretation of its content.

D.2.5 CrowdMag[7]

Lead Sponsoring Agency: NOAA

Authority: Coast and Geodetic Survey Act, 33 U.S.C. § 883a et seq.

Project Summary and Goals: In partnership with the Cooperative Institute for Research in Environmental Sciences (CIRES), NOAA's National Centers for Environmental Information (NCEI) started a crowdsourcing project to collect vector magnetic data from digital magnetometers in smartphones. The aim is to distill meaningful magnetic data from a large number of noisy measurements and use these data to fill gaps in the coverage of global geomagnetic data. Data from a typical phone gives the three components of the local magnetic field with a sensitivity of about 150 to 600 nanotesla (nT), although newer phones are becoming more accurate. Smartphones combine magnetic data and accelerometer data to determine the phone's orientation. CrowdMag uses the phone's internet connection to send magnetic and location data to NCEI. NOAA checks the quality of the magnetic data from all users and makes the data available to the public as aggregate maps. Currently, the CrowdMag project has about 28,000 enthusiastic users who have contributed more than 31 million magnetic data points from around the world.

Justification for Using Crowdsourcing and Citizen Science: Professionally collecting magnetic data at urban and local (<20 km) resolution is prohibitively expensive. Modern smartphones come with digital magnetometer for pedestrian navigation. Citizen-scientists contributing magnetic data from their phones using CrowdMag technology is a cost-effective way to improve NCEI's high-resolution magnetic data coverage.

Status: The project started in January 2015 and is ongoing.

Location: Data is collected on a global scale.

Participation: The project targeted any interested member of the public with a smartphone. The project has had 36,850 application installs (19,150 Android and 17,700 iOS) since inception. A total of 8,342 installs (5,192 Android and 3,150 iOS) occurred in FY17 and 15,171 installs (5,521 Android and 9,650 iOS) occurred in FY18. The average number of active participants at any time was about 7,000.

Consent: Consent to send data to NOAA is received by all participants upon installation of the application.

Submissions: Submission information includes the time stamp, location information (latitude, longitude), location accuracy (in meters), magnetic data (in nano-Tesla), and phone's make (e.g., iPhone 5.2).

Resources: CrowdMag has never received dedicated funding, and the funding has come from small, one-time grants and general funding to the CIRES geomagnetic group. Minimal support from a NOAA software engineer is used to maintain the CrowdMag database hosted at NCEI-CO (0.01 FTE per year). The CrowdMag project uses an NCEI web server and a database system to gather data and host its website, which requires 0.15 FTE of a CIRES Research Scientist and 0.2 FTE of a CIRES professional research associate.

Partnerships: Non-Federal partners include the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado.

Advancement of Agency Mission: NCEI is the national archive for geomagnetic data and information with primary roles in geomagnetic research and modeling. NCEI uses magnetic data collected by

[7] The website for the CrowdMag can be viewed at https://www.ngdc.noaa.gov/geomag/crowdmag.shtml.

observatories, satellites, and ship/airborne surveys to develop magnetic models. However, the available measurements leave gaps in coverage, particularly for crustal and man-made magnetic signal sources. CrowdMag aims to fill the gaps in magnetic data coverage by capitalizing on existing technology and citizen science. Improved magnetic data coverage will lead to better magnetic models to aid navigation. This effort will benefit NOAA, the nation, and the international community.

Results: Since its inception in 2015, the CrowdMag app has been downloaded by more than 36,850 iOS and Android users, making it NOAA's most downloaded mobile app. There are currently about 7,000 active CrowdMag users worldwide. Users have contributed more than 30 million magnetic data points to NOAA's CrowdMag database. CrowdMag data coverage within the contiguous United States is sufficient to identify the broad scale magnetic features of the 48 contiguous states. In the Boulder, Colorado region, the significant concentration of CrowdMag participants has enabled NOAA to make magnetic feature maps with about a 100 m grid cell resolution. Globally, NOAA has sufficient CrowdMag users to define a very coarse but global magnetic model which underscores the potential of the application for mapping the Earth's magnetic field. The current CrowdMag user community is mainly based and sustained by word of mouth communication. However, a few presentations at international scientific meetings, a YouTube video release, and various NOAA and CIRES outreach releases have worked to publicize CrowdMag. The CrowdMag project was cited in the 2015 Colorado Governor's award for high-impact research by the NOAA/CIRES geomagnetism group. The current users consist primarily of people who already identify as STEM professionals or hobbiests. The transformation of the user base from experts to general public users will be of broad interest in the citizen science community.

Data Availability: CrowdMag data are saved at NCEI-CO in an internal database. The data are quality-controlled and provided to the public via ESRI web-maps.

D.2.6 Crowdsourced Bathymetry[8]

Lead Sponsoring Agency: NOAA, National Centers for Environmental Information (NCEI)

Authority: Coast and Geodetic Survey Act of 1947

Project Summary and Goals: The key to successful crowdsourced bathymetry (CSB) efforts are volunteer observers who operate vessels-of-opportunity in places where nautical charts are poor or where the seafloor is changeable and hydrographic assets are not easily available. Most ships and boats are already equipped to measure and digitally record depth in coastal waters, and the measurement capabilities of vessels have been increasing. The CSB vision is to tap into the enthusiasm for mapping the ocean floor by enabling trusted mariners to easily contribute data and augment current bathymetric coverage. The success and usefulness of this data is highly dependent on a bathymetry database, hosted by NOAA's National Centers for Environmental Information (NCEI), with a robust infrastructure and user interface to accommodate the safe archive and distribution of the resulting data. Therefore, the main project objective has been for NCEI to provide archiving, discovery, display, and retrieval capabilities of global CSB data contributed from mariners around the world. Currently, the database contains more than 117 million points of depth data, which have been used by hydrographers and cartographers to improve nautical chart products and knowledge of the seafloor. The goal moving forward is to continue to encourage participation from the maritime community and to explore options for scalable storage as the data volumes continue to grow.

[8] The website for the Crowdsourced Bathymetry can be viewed at https://www.iho.int/srv1/index.php?option=com_content&view=article&id=635&Itemid=988&lang=en and https://maps.ngdc.noaa.gov/viewers/iho_dcdb/.

Justification for Using Crowdsourcing and Citizen Science: In 2014, the International Hydrographic Organization (IHO), at its Fifth Extraordinary International Hydrographic Conference, recognized that traditional survey vessels alone could not be relied upon to solve data deficiency issues and agreed on the need to encourage and support all mariners in an effort to "map the gaps". The International Convention for the Safety of Life at Sea (SOLAS) 1974 carriage requirements oblige all commercial vessels to be equipped with certified echo-sounders and satellite-based navigation systems. As a result, the world's commercial fleet represents a significant, untapped source of potential depth measurements. Most non-commercial ships and boats are already equipped to measure and digitally record their depth in coastal waters, the measurement capabilities of vessels have been increasing. One outcome of the Conference was an initiative to support and enable mariners and professionally manned vessels to collect crowdsourced bathymetry (CSB) to be used as a powerful source of information to supplement the more rigorous and scientific bathymetric coverage done by hydrographic offices, industry, and researchers around the world.

Status: The project started in 2016 and is ongoing.

Location: Data for CSB is collected on a global scale.

Participation: The project targeted mariners and vessel operators of ships and boats in navigable waters. The total number of individuals involved was over 100.

Consent: Consent is received by all participants when the data is submitted.

Submissions: Submission include observations of water depth/bathymetry, location, and time. Approximately 2,300 data submissions have been received.

Resources: In FY17 and FY18, NOAA's Office of Coast Survey (OCS) provided funds to NOAA's National Centers for Environmental Information in order to cover salary support for a data manager, software developers, and GIS staff. Both OCS and NCEI provided FTE in-kind support to manage the project. In both FY17 and FY18, around 24 weeks of development work was required to enhance the infrastructure and interface of the CSB data repository to provide archiving, discovery, display, and retrieval of global crowdsourced bathymetry data contributed by mariners around the world. Support also covered partial salary for a data manager and in-kind FTE for database and international working group support. In FY18, a paid internship was used to program a crowdsource module intended to facilitate mariners submitting their data. Total funding was $200,000 in FY17 and $230,000 in FY18.

Partnerships: Federal partners include the National Geospatial-Intelligence Agency. Non-Federal partners include the University of Colorado's Cooperative Institute in Environmental Science and the International Hydrographic Organization.

Advancement of Agency Mission: This project aligns with NOAA's Office of Coast Survey Strategic Plan priority to Innovate Hydrography, which aims to expand access to data from a broad range of data sources, such as Automatic Identification Systems (AIS), satellite-derived bathymetry, and crowdsourcing, to identify chart discrepancies, update charts, inform product development, and revise hydrographic survey priorities. Enhancing NCEI's database to accommodate the stewardship of crowdsourced bathymetry data, including data collected from AIS, will make it much easier for NOAA to attain this goal. The project directly supports the establishment of a global crowdsourced bathymetry database detailed in this OCS strategic priority. This project also aligns with NOAA/DOC priorities and corporate interests to advance data integration and services and improve decisions by transforming data capabilities to support resilient coastal communities and economies for a data-enabled economy.

Results: The crowdsourced bathymetry database now contains more than 117 million points of depth data, which have been used by hydrographers and cartographers to improve nautical chart products and knowledge of the seafloor. NOAA, working with George Mason University, is using the database depths to assess nautical chart adequacy, determine when areas require updated survey information, and identify chart discrepancies before an incident occurs. The Canadian Hydrographic Service has also used this dataset to update several Inside Passage charts along the coastal routes stretching from Seattle, Washington, to Juneau, Alaska.

Data Availability: In FY18, NOAA announced the end of a testing phase for the development of a new crowdsourced bathymetry database. The public can now access the bathymetric observations and measurements from citizen science volunteers and crowdsourcing programs through the International Hydrographic Organization (IHO) Data Centre for Digital Bathymetry (DCDB) Data Viewer (https://maps.ngdc.noaa.gov/viewers/iho_dcdb/). This operationalized database allows free access to millions of ocean depth data points. The database also serves as a powerful source of information to improve navigation products and the general knowledge about seafloors.

D.2.7 Steller Watch[9]

Lead Sponsoring Agency: NOAA Fisheries

Authority: Endangered Species Act

Project Summary and Goals: The Steller sea lion population in Alaska began to decline in the 1970s with the steepest drops observed in the 1980s. Since 2002, eastern populations began to stabilize or recover, but those in the Aleutian Islands have continued to decline. In response, the Marine Mammal Laboratory (MML) in the Alaska Fisheries Science Center (AFSC) of NOAA Fisheries began a long-term life history study. With a mark-recapture method of hot-branding sea lions and observing these sea lions throughout their lifetime, NOAA can understand the movements of the sea lions, estimate the survival and birth rates of this population, and collect information helpful for determining the cause of the continuing population decline. Unfortunately, the Aleutian Islands are extremely remote, and MML only accesses this area once a year at most. Thus, sighting these marked animals proves to be a challenge.

Justification for Using Crowdsourcing and Citizen Science: CCS was considered as an option to help with the burden of analyzing large sets of imagery. Rather than developing machine learning or automated techniques, operating a platform where participants can help review and classify images was found to be more efficient. In addition to the crowdsourcing website, an in-person volunteer program in the Seattle-based office hosts one to four volunteers to review images.

Status: The project started on March 15, 2017 and is ongoing.

Location: The sets of imagery come from the Aleutian Islands, Alaska, USA.

Participation: The project was open to participants across the world. A total of 8,163 volunteers have participated as of August 31, 2018. Anywhere from 500–2,000 classifications are completed by volunteer(s) per day. In the first year, participants saved over 300 hours of processing time.

Consent: N/A

Submissions: Participants can work on either of two workflows. These workflow activities involve looking at images (in random order) and answering one to three multiple choice questions about each image. Each single image completed by one user is called a "classification." Several independent

[9] The website for the Steller Watch can be viewed at https://www.zooniverse.org/projects/sweenkl/steller-watch.

classifications are necessary to retire an image for that workflow. In the first year, participants classified 340,000 images

Resources: This project was developed with NOAA High Performance Computing and Communications (HPCC) grant funding and receives support for the primary FTE employee. Two Federal employees were also involved in the developing and launching phases and provided continued support during FY17. There have been primarily a total of three staff involved. Future investment into the project may be beneficial or necessary to update or upgrade the process (e.g., online viewing tools, data processing). Other FTEs may be brought in to help with streamlining the image upload or data compiling processes. The website is hosted at no cost by Zooniverse.org and is operated and maintained by one FTE.

Partnerships: N/A.

Advancement of Agency Mission: This public crowdsourcing website is helping achieve NOAA's mission to conserve the endangered Steller sea lion population in Alaska. The eastern Steller sea lion population was removed from the threatened species listing in 2013 since the population showed 30 years of recovery, but the western stock continues to decline in the Aleutian Islands (Alaska). This population interacts or has potential to interact with commercially important fish species such as walleye pollock, Atka mackerel, and Pacific cod throughout its range. Steller sea lions are also a very important species to the ecosystem, and declines in this population indicate a greater problem in the ecosystem that could also impact commercially vital species.

Results: The final results from Steller Watch are a product of many classifications. Each image is classified by 7–13 participants. Images that are deemed to have a sea lion present are ran through a secondary workflow where participants classify if there is a marked sea lion present, and if so, if the mark is readable. These classifications are then compiled to find the average answer for each image, and images with readable marked sea lions present will be further analyzed by biologists or in-house volunteers to record sightings. These sightings will be used in a larger dataset to calculate vital rates, or survival and birth rates, of Steller sea lions in the western and central Aleutian Islands, Alaska.

Data Availability: The imagery and classification information collected from participants is public information, but the raw data are not publically accessible. Classifications are not intuitively informative in the raw format. When these classifications are processed by MML, sightings of marked animals from the select images can be recorded. These sightings of marked animals will be included in analysis of survival rates and birth rates of the population and published in a scientific journal or government technical memorandum. Currently, the remote camera images are not publicly available online because there is no mechanism or platform to share terabytes of high-resolution imagery online. A select set of these images can be viewed on the Steller Watch site in random order.

D.2.8 Hawaii Bottomfish Heritage Project: Tracing Traditions and Preserving Culture[10]

Lead Sponsoring Agency: NOAA Fisheries, Pacific Islands Fisheries Science Center

Authority: MSA NS-8; MSRA Section 318, Regional Priorities and Management Needs

Project Summary and Goals: The project explores how the culture, traditions, and fishing techniques for the Hawaii bottomfish fishery have evolved from Native Hawaiian populations to modern times. Documenting the bottomfish "family tree", traditional knowledge, techniques, adaptations, culture, and traditions (e.g., fish sharing), will improve the understanding of changes in the fishery over time. Specifically, the project will allow for consideration of traditional values in management programs,

[10] The website for the Hawaii Bottomfish Heritage Project: Tracing Traditions and Preserving Culture can be viewed at https://www.fisheries.noaa.gov/feature-story/hawaii-bottomfish-heritage-project.

improve interpretation of historical data, and ensure sustainable management for the future. The project showcases cooperative research by having people within the bottomfishing community conduct semi-structured interviews with elder fishermen to ensure that the information gathered supports improved management and passes on to future generations of the community. Local fishery knowledge is an important heritage resource often lost forever when elders in the fishing community pass away. In addition, insights gathered through this research could directly support Pacific Islands Fisheries Science Center (PIFSC) stock assessment efforts, which currently work with historical commercial catch data that is lacking in context with respect to community norms and behaviors that may have influenced fisher behavior, reporting, and targeting over time.

Justification for Using Crowdsourcing and Citizen Science: This social science research project relies on the contributions of Hawai'i bottomfish fishermen and Council members to ensure that the research questions would be relevant to the bottomfishing community. To further ensure participation by pioneers in the fishery and exploration of topics of greatest interest to fishermen and managers, fishermen were the primary points of contact and were trained to conduct the oral history interviews.

Status: The project started in January 2016 and is ongoing. Participants volunteered time to help develop the research proposal, research questions, and project design.

Location: The project is based in Hawai'i, USA.

Participation: The project targets Council members and fishermen who are leaders in the bottomfish community. The total number of individuals involved during this period was five. The total number of volunteer hours was 1,250.

Consent: Formal consent was not required. Participants assisted in enabling the formulation of research questions, proposal writing, creating and refining project design, and collecting and interpreting data.

Submissions: N/A

Resources: There is no dedicated funding or account for this project. Project partners and citizens helped write successful proposals that were funded by the Cooperative Research Grant ($44,000) and Preserve America Grant ($8,000) for participants to oversee project, assist in developing protocols, conduct interviews, travel to islands throughout Hawai'i, prepare and review video archives, transcribe videos, purchase supplies, and develop outreach products. Other Federal funds were used for staff travel to assist in interviews and reporting ($4,000), a contract to produce spotlight videos ($115,000), and a contract for data analysis ($51,000). Project partners donated a total of $40,000 worth of time in 2017 and 2018. Full-time equivalent (FTE) time (0.15 FTE in FY17 and 0.1 FTE in FY18) was used for project coordination, development of protocols, and assistance in interviews ($3,000 for travel). A $61,000 contract was also initiated to develop spotlight videos of individual fishermen, the Maui Bottomfish Cooperative, and fishing in the Northwest Hawaiian Islands. In addition, a $51,000 contract was initiated for a social scientist to conduct qualitative data analysis of interview transcripts beginning in FY19. FY17 funding totaled $116,000, and FY18 funding totaled $106,000.

Partnerships: Non-Federal partners included Western Pacific Regional Fishery Management Council, Pacific Islands Fisheries Group, Maui Bottomfish Cooperative, and University of Hawai'i, Hilo.

Advancement of Agency Mission: Research findings will support NOAA's mission to conserve and manage coastal and marine resources and foster NOAA's vision of healthy ecosystems, communities, and economies that are resilient in the face of change.

Results: A report summarizing efforts to quantify the history of participation and technical change in the fishery will be provided to stock assessment scientists at the PIFSC. Fishery history and traditions as told from the fisherman's perspective will be produced and packaged utilizing multiple media

formats. A web story and blog series has been initiated at https://www.fisheries.noaa.gov/feature-story/hawaii-bottomfish-heritage-project. Audio products developed will include recorded stories and conversations contributed to the National Marine Fisheries Service "Voices from the Fisheries" online portal, and topic-specific segments could be developed and presented on the "Go Fish with Mike Buck" radio show to cover elements such as fishing legends, traditional practices, technology development, and cultural significance. Fishing technology timelines and narratives can be packaged into PIFSC data reports and popular press media for distribution to the fishing community to include Lawai'a Magazine and Hawaii Fishing News. Video segments could also be prepared for "Hawaii Goes Fishing" broadcasts on the Oceanic Cable network. Research brochures and links to research findings will be disseminated through agency websites, including the informational website designed specifically for the Hawaii bottomfish community (http://hawaiibottomfish.info). Outreach products will be made available at future public events such as the Honolulu Ocean Expo. The Council has agreed to formally integrate project outputs in its education and outreach program.

Data Availability: Videos will be available through the "Voices from the Fisheries" website: https://www.st.nmfs.noaa.gov/humandimensions/voices-from-the-fisheries/index

D.2.9 Cooperative Research Provides New Data for ESA-listed Rockfish in Puget Sound, WA[11]

Lead Sponsoring Agency: NOAA Fisheries, Northwest Fisheries Science Center, Conservation Biology Division

Authority: Magnuson Stevens Act Sec 318 (Sec 318, MSA, 16 USC 1867)

Project Summary and Goals: The primary goal of the research program is to collect new data capable of answering questions related to the recovery of Endangered Species Act (ESA)-listed rockfish in the Puget Sound (PS), WA region. Additionally, the program is broadly interested in forming working relationships with user and stakeholder groups (recreational fishing and SCUBA diving communities) within PS in order to develop recovery actions that will lead to the sustainability of these populations. The knowledge and expertise of these groups have allowed NOAA to collect new data on the life-history characteristics, population abundance, fisheries interactions and genetic structure of ESA-listed rockfish in PS. These groups have successfully helped collect specimens and data across four research projects to date. First, genetic samples of ESA-listed rockfish were collected to determine whether each species met the first criterion of the ESA, which has led to the first de-listing of a marine fish species under the ESA. Second, yelloweye rockfish were targeted, collected, and tagged with acoustic transmitters to monitor movement patterns that could provide new information relevant to the identification of critical habitat. Third, citizen scientist SCUBA surveys have begun to collect new data on the spatial and temporal distribution of young-of-year, juvenile, and adult rockfish in nearshore habitat of PS. Fourth, volunteer anglers are participating in a project targeting lingcod (a species with an active fishery that lives in similar habitats as protected rockfish) using different bait types to examine whether bycatch of rockfish can be limited during this fishery while still maintaining adequate opportunities to fish for lingcod. Each project has been successful due to the local ecological knowledge and angling expertise of these groups.

Justification for Using Crowdsourcing and Citizen Science: Professional charter boat captains are used to provide safe, efficient platforms for fishing and collection of biological samples across three of the projects. NOAA does not have the necessary personnel time or angling expertise within the staff at the

[11] Information relevant to the Cooperative Research Provides New Data for ESA-Listed Rockfish in Puget Sound, WA can be viewed at: https://www.westcoast.fisheries.noaa.gov/protected_species/rockfish/rockfish_in_puget_sound.html.

Northwest Fisheries Science Center (NWFSC) to collect the necessary samples, and paying for extra deck hands as professional anglers would be cost-prohibitive. Thus, NOAA has relied on the engaged recreational fishing community to volunteer their time and angling expertise on each of the fishing days. This provides a collaborative framework to work together with the recreational fishing community, learn from each other, and collect the needed samples to answer policy-relevant questions to rockfish management in the Puget Sound region. This collaboration of scientists, captains, and volunteer anglers brings together all the skills necessary to make these studies a success and provides a better understanding to the public about how these new data will be used to inform management decisions. The days on the water build strong relationships between NOAA scientists and managers and the recreational fishing community in Puget Sound. These relationships have subsequently led to the successful drafting of a Rockfish Recovery Plan for the ESA-listed species and have created an environment where the public has brought forward questions they think are relevant to the recovery of these species. NOAA has evaluated those questions and, when warranted, moved forward with subsequent research studies (e.g., rockfish bycatch project). The recovery of ESA-listed rockfish will be a long process due to their life-histories, and having a respectful and trusting relationship between the scientific, management, and stakeholder communities will help NOAA meet interim recovery goals and ultimately recover these populations such that they can be managed under normal fisheries management conditions.

Status: The project started in April 2014 and is ongoing.

Location: The data for the project was collected in Puget Sound, WA.

Participation: The project targets anglers with bottomfishing experience who either know where to catch threatened and endangered rockfish or have expert angling skills. Approximately 150 volunteer anglers have participated in 104 fishing days since 2014. A total of 50 participants were involved during FY17 and FY18, with three to four volunteer anglers participating each fishing day. The total number of volunteer hours since the start of the project was approximately 3,328 hours. The total number of volunteer hours for FY17 and FY18 was approximately 1136 hours.

Consent: Consent was received by all participants.

Submissions: No official submissions were collected; anglers were only asked to catch fish.

Resources: There are no specific funding sources for this program, and all staffing is funded through base personnel funds of the scientist's division. The NWFSC has received funding from two primary sources to carry out this work to date: NOAA's Cooperative Research Program and NOAA's West Coast Regional Office. The genetics study received $125,000 through the NOAA Cooperative Research Program's annual competition for grants in the FY14 funding cycle. This funding paid for contracts to charter boat captains ($83,000), supplies and processing of genetic samples ($35,000), and travel funds for fieldwork and presentation of results ($7,000). The rockfish bycatch study received $50,000 in FY16 through a grant from NOAA's West Coast Regional Office. This funding paid for contracts to charter boat captains ($48,000) and fishing supplies ($2,000); travel to fieldwork sites was funded out of base funds of the Division. The acoustic telemetry study was funded by two grants from NOAA's West Coast Regional Office ($20,000 in FY15 and $8,000 in FY17). FY15 funding paid for the acoustic transmitters and acoustic releases, and FY17 funding paid for the analyses of the collected data.

Partnerships: Federal partners included NOAA Fisheries West Coast Regional Office. Non-Federal partners included Washington Department of Fish & Wildlife, Puget Sound Anglers, Harbor WildWatch, and REEF.

Advancement of Agency Mission: One mission of the NWFSC is to provide reliable science to help decision-makers and managers build sustainable fisheries and recover endangered and threatened

species. At the time of the ESA listings of three rockfish species, there was uncertainty about the distinctness of these populations in Puget Sound relative to the outer coast. Working with knowledgable captains and expert volunteer anglers allowed NOAA to collect enough samples to answer genetic questions related to the population structure of these fish and led to two new final rulings issued by NOAA concerning them. These data filled gaps that were missing during the initial listing process. A second mission of the NWFSC is to enhance public awareness, education, and stewardship of our marine resources. Including public volunteers during data collection has provided an immeasurably valuable platform for two-way education between scientists and the public. For example, one of the most asked questions by volunteers on these fishing trips is "How old is that fish?". Rockfish are generally long-lived, slow-growing, and slow-to-mature. A 45 cm yelloweye rockfish can be anywhere from 10–80 years old and has a 50/50 chance of being mature. When informed of this fact, anglers begin to understand that these rockfish species will have a difficult time recovering and returning to historical levels of abundance if overfished. These "on the water" moments create lasting impacts and teach the importance of responsible stewardship.

Results: The results of the genetics study have been used for two policy decisions. First, the genetics study showed that canary rockfish collected in the Puget Sound region were not genetically different from canary rockfish collected on the outer coast of Washington state. This provided one piece of new information suggesting that canary rockfish did not meet the first criterion of the Endangered Species Act; in order to be considered a "listable unit", a vertebrate population must be markedly different from other populations of the same species. Using this new information and considering other life history characteristics of canary rockfish (e.g., adults have been shown to move 100's of km), NOAA's West Coast Regional Office (WCRO) issued a final rule in 2017 to de-list canary rockfish in Puget Sound from the endangered species list. Second, the genetics study showed that yelloweye rockfish collected in the Puget Sound region were genetically different from yelloweye rockfish collected on the outer coast. This provided new information directly supporting the listing of yelloweye rockfish under the ESA. However, this new research also showed that yelloweye rockfish in Puget Sound were genetically similar to yelloweye rockfish in other inland waterways of British Columbia that were farther north of the original boundary set for the yelloweye rockfish. Thus, NOAA's WCRO issued a final rule in 2017 to expand the geographical boundaries of the yelloweye rockfish distinct population segment to account for these new findings. Data from the movement and bycatch studies are still being analyzed and have not been used in any management decisions to date. Data collection by volunteer SCUBA divers and analyses to combine formal scientific and citizen science SCUBA surveys into models calculating population abundance have just begun and will be used to estimate the status and trends of the population going forward. These efforts will help identify if or when recovery goals have been met for these populations to downlist or delist.

Data Availability: Some of the data from this program is publicly available. The results from the genetics study were published in the journal Conservation Genetics (https://link.springer.com/article/10.1007/s10592-018-1060-0), and the raw genetic data has been published on the website of the National Center for Biotechnology Information (https://www.ncbi.nlm.nih.gov/bioproject/PRJNA451040). Data collection from the rockfish bycatch study is not complete, but the results will also be published in a peer-reviewed journal. Data from the acoustic telemetry project is still being analyzed but will be published and available upon completion. Individual life history data on each collected fish is publicly available upon request in accordance with Public Access to Research Results (PARR). The only piece of information that will not be available is latitude/longitude information for each fish, as publicly providing this information is against Washington state laws.

D.2.10 NWS Cooperative Observer Program[12]

Lead Sponsoring Agency: NOAA National Weather Service (NWS)

Authority: Organic Act of 1890

Project Summary and Goals: The Cooperative Observer Program (COOP) provides two sets of data: (1) weather observational data, usually consisting of daily maximum and minimum temperatures, snowfall, and 24-hour precipitation totals, required to define the climate of the United States and to help measure long-term climate changes; and (2) weather observational data to support forecast, warning, and other public service programs of the NWS.

Justification for Using Crowdsourcing and Citizen Science: Volunteers have been informally used to record climatic data long before the Weather Bureau was created. The program was codified in the Organic Act of 1890 and is still used today. Many of the volunteers enjoy being part of the program and part of the NOAA mission, and some of the volunteers are multi-generational observers.

Status: This Citizen Science project has formally been in existence for over 125 years, with informal participation at some sites of up to 200 years. The project is ongoing.

Location: Over 8,000 sites across the nation provide daily observation data.

Participation: The project targets volunteer observers who are recruited by NWS Weather Forecast Offices to provide daily observations to support hydrological and climatic missions. Over 8,000 participants are part of this program, and daily participation is required of all volunteer observers. The total number of volunteer hours exceeded 8,000 hours and was based on one hour per day for all volunteers.

Consent: Consent was received from all participants.

Submissions: Submissions included weather observations of daily maximum and minimum temperatures and/or daily precipitation amount, as well as snowfall in some locations.

Resources: Funding for support to the program management and equipment maintenance comes from two portfolios in the NWS budget allocation. A multitude of personnel (both full-time and part-time) from across the agency contribute to this program, including programmatic staff, data system administration staff, logistics staff, repair staff at the NWS headquarters, and focal points at regional headquarters. NOAA provided $2.5 million in FY17 and $2 million in FY18, and the U.S. Army Corps of Engineers and Bureau of Reclamation provided $247,000 in assistance to maintain COOP sites of interest.

Partnerships: Federal partners included United States Geological Survey and Bureau of Reclamation (by interagency agreements).

Advancement of Agency Mission: Observing programs, such as COOP, provide observations that feed into the NWS mission of providing weather watch and warning information for protection of life and property.

Results: Aside from use by NWS, the Federal Emergency Management Agency relies on COOP rainfall and snowfall data as the primary source for disaster declaration and relief efforts. The United States Department of Agriculture risk management models get 80% of their data from COOP for agricultural disaster relief and for baselines with the related insurance and reinsurance industries.

[12] The website for the NWS Cooperative Observer Program can be viewed at https://www.weather.gov/coop/.

Data Availability: Data are free and open to the public and made available via National Center for Environmental Information websites.

D.3 Department of Energy (DOE)

D.3.1 The Open PV Project[13]

Lead Sponsoring Agency: Office of Energy Efficiency and Renewable Energy (EERE)

Authority: Unknown

Project Summary and Goals: The Open PV Project is a collaborative effort between government, industry, and the public that continues to compile a database of available public data for photovoltaic (PV) installation data for the United States. Data for the project are voluntarily contributed from a variety of sources, including solar incentive programs, utilities, installers, and the general public. This database serves as a web-based resource for users to easily explore and understand the current and past trends of the U.S. PV industry. The data collected are actively maintained by the contributors and are always changing to provide an evolving, up-to-date snapshot of the U.S. solar power market.

Justification for Using Crowdsourcing and Citizen Science: Due to the increased rate in PV installations in the United States, the best way to collect updated information on installations is to retrieve installation data from the installers and provide a platform for the public to upload their own PV installation information. However, the fast-paced market necessitates a means for the public to add newly installed systems or systems not captured in other data-collection methods.

Status: The project started in 1998, and is ongoing.

Location: The database comprises information contributed by users across the U.S.

Participation: The project targeted solar-sector stakeholders, including industry, nonprofits, installers, policymakers, and the general public. Twenty-nine individuals provided submissions in FY17, and nine individuals provided submissions in FY18. The National Renewable Energy Laboratory (NREL) staff uploads most data that originates from multiple different sources as part of the Tracking the Sun report. Participation above is for active participants during this time period. Typically, some solar installers are active. The Open PV Project is collecting data from any willing contributor of available information. The core dataset is provided by Lawrence Berkeley National Laboratory (LBNL), which annually produces the Tracking the Sun report, now in its ninth year. LBNL collects data from most state run incentive programs, large utilities, and other organizations. Data are also provided directly by the PV community, including installers, businesses, and consumers. The installations represented in the LBNL dataset comprise about 78% of the more than 1 million installations in the Open PV database, with the rest coming from the community. It is our hope that the database will continue to grow through contributions from the PV community.

Consent: N/A

Submissions: Members of the public are asked to input information about their solar installations on a volunteer basis. In total, there are 1,020,717 installation records that were either uploaded by the public or NREL staff in coordination with installer or research entities.

Budget and Resources: There is no dedicated budget for the continued maintenance of the Open PV Project. Funding for general maintenance tends to come from solar projects within the NREL. The NREL

[13] The website for the The Open PV Project can be viewed at https://openpv.nrel.gov/.

has received maintenance funds for the last several years and anticipates minimal funding for the next few years. Funding for FY17 and FY18 totaled $4,500 each fiscal year and was used for server maintenance, data cleaning, data uploads, user requests and answering user questions. In addition, 0.01 FTE employees were used each year.

Partnerships: Non-Federal partners included community groups, for-profit entities, and State or local governments.

Advancement of Agency Mission: The Open PV Project is working to advance the agency's mission—to ensure America's security and prosperity by addressing energy, environmental, and nuclear challeneges through transformative science and technology solutions—by engaging the public to share information about their PV installations and providing a platform for other members of the public to see general trends in PV installation data addressing American energy challenges. LBNL also makes data from the annual Tracking the Sun report available for download by the public.

Results: Data provided to the Open PV Project is available for download by the public, including data uploaded to the database and from the LBNL Tracking the Sun public data file. The most common request for data is for research and analysis of small-scale PV installation trends. Note that most of the data is not crowdsourcing and citizen science results, but those results are integrated into the larger dataset.

Data Availability: Data is made available to the public through the download portal: https://openpv.nrel.gov/search.

D.4 Department of Health and Human Services (HHS)

D.4.1 Crowdsourcing Optimal Cancer Treatment Strategies that Maximize Efficacy and Minimize Toxicity[14]

Lead Sponsoring Agency: NIH, National Cancer Institute (NCI)

Authority: NIH UH2 Exploratory/Developmental Cooperative Agreement

Project Summary and Goals: The Treatment Simulator game enables volunteers to manipulate dosing and treatment scheduling to find optimum cancer treatments that result in slowing or stopping tumor growth. These data are sent directly back to the Moffitt Cancer Center where it is used to improve algorithms that predict better treatment strategies. Additional outcomes include increased user education about cancer and cancer treatment and a pending collaboration on deep learning with the Lawrence Livermore National Laboratory.

Justification for Using Crowdsourcing and Citizen Science: This form of gamified distributed computing is the most effective way to get the input necessary to better predict treatment schedules. Doing so in a more traditional fashion is time consuming and limiting. The game is open to anyone with a smartphone who wishes to play, and volunteers do not need to have any particular expertise to participate.

Status: The project was awarded on April 1, 2017 and the public game launch took place on March 24, 2017.

Location: The project took place on a virtual mobile app.

[14] The website for the Crowdsourcing Optimal Cancer Treatment Strategies that Maximize Efficacy and Minimize Toxicity can be viewed at http://cancercrusadegame.com/.

Participation: The project engaged anyone with a smartphone. The app was available for both Android and Apple devices and received over 350 downloads.

Consent: Players give their consent to participate by downloading the game.

Submissions: All participation is voluntary.

Resources: Total funding from NCI in FY17 to support this activity was $268,901.

Partnerships: N/A

Advancement of Agency Mission: NIH's mission is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability. A piece of this mission centers on the advancement of scientific knowledge through innovation, something this project highlights through its creative use of crowdsourced creativity.

Results: The results of this project will be used by the researchers to further scientific knowledge and advancement.

Data Availability: N/A

D.4.2 Applying Protein Databases to Crowdsourcing Structural Protein Design[15]

Lead Sponsoring Agency: NIH, National Cancer Institute (NCI)

Authority: NIH UH2 Exploratory/Developmental Cooperative Agreement

Project Summary and Goals: This project aims to significantly adapt the existing proteomics video game Foldit to incorporate big data from protein databases into computational structural protein design. This data will be used to inform the manipulation of structural components of proteins. Foldit, a scientific discovery game featuring an interactive protein manipulation interface, allows the public to contribute directly to scientific research involving the study of proteins. Previous work with Foldit has shown that with an appropriate interface and introduction, even amateur players with no formal background in biochemistry can make contributions to our knowledge of proteomics. Additionally, preliminary protein design work has shown that players can contribute to the successful redesign of existing protein enzymes. The investigators aim to build upon the existing successes of Foldit in crowdsourcing protein design by leveraging the massive amount of data on protein structures that exists in protein databases like the RCSB Protein Data Bank. By integrating this data into the mechanics of the Foldit game, researchers are hoping to both improve the tools available to the players and allow them to construct more realistic protein-like structures.

Justification for Using Crowdsourcing and Citizen Science: The amount of work could not have been accomplished using traditional methods. By opening up the puzzle solving game to anyone who wishes to play, the project expanded the possibilities for creating novel and creative solutions in protein folding not possible through traditional means, such as utilizing a small group of lab assistants, or running computer simulations, but instead by leveraging the creative intuition and visual processing skills of the human brain across a vast group of online volunteers.

Status: The project started on May 1st, 2017, and is ongoing.

Location: The project takes place online, virtually.

[15] The website for Applying Protein Databases to Crowdsourcing Structural Protein Design can be viewed at https://fold.it/portal/.

Participation: The project engaged anyone with a computer and internet access. The total number of individuals involved during this period was over 700,000 players.

Consent: By using the website and downloading the game, players give their consent to participate.

Submissions: Players are asked only to fold digital models of protein structures, whenever and however each player chooses. There is no set minimum, all participation is voluntary.

Resources: NCI FY17 total cost funding for this project was $293,970. The project is overseen by one FTE NCI program officer, with 10 other program officers from across the NIH acting as secondaries.

Partnerships: N/A

Advancement of Agency Mission: NIH's mission is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability. A piece of this mission centers on the advancement of scientific knowledge through innovation, something this project highlights through its creative use of crowdsourced creativity.

Results: The results of this project will be used by the researchers to further scientific knowledge and advancement.

Data Availability: N/A

D.4.3 OMics Compendia Commons[16]

Lead Sponsoring Agency: NIH, National Institute of Allergy and Infectious Diseases (NIAID)

Authority: Public Health Services Act

Project Summary and Goals: OMiCC is a community-based, biologist-friendly web platform for analyzing annotated gene-expression data sets across multiple studies (meta-analysis) and technology platforms. The OMiCC platform can access more than 24,000 human and mouse studies from the Gene Expression Omnibus (GEO), a database repository that houses data from high-throughput functional genomic studies. An important feature of OMiCC is that it allows users to contribute to the community by sharing meta-data essential for data collation, reuse, and (meta-) analysis across studies. Thus, users of OMiCC can reuse sample groupings and pairings created by other users to construct cross-study data sets. NIH envisions that as more users take advantage of OMiCC to perform biological hypothesis generation and discovery, more users will create and share such meta-data as well as data compendia and analyses with the biomedical research community.

Justification for Using Crowdsourcing and Citizen Science: The cowdsourced nature amplifies the power of the OMiCC platform. As more users use the OMiCC resource and annotate data sets, these data can be effectively transformed into biological insights.

Status: The project started 2016 and is ongoing. The NIH OMiCC Jamboree was held in April 2016, and the OMiCC online resource was published in August 2016.

Location: The NIH Jamboree was held in the Washington, D.C. metro area. The online database comprises information contributed by users worldwide.

Participation: Twenty-nine individuals from the Washington, D.C. metro area participated in the NIH Jamboree, and consisted of faculty, fellows, and students. Participants attended a half-day group training session on using the OMiCC platform followed by a day-long jamboree, where volunteers

[16] The website for the OMics Compendia Commons can be viewed at https://omicc.niaid.nih.gov/.

provided a total of 349 hours of time. The targeted participants for the OMiCC website include biologists and interested citizens around the world. There are currently 421 registered users of the OMiCC website.

Consent: None of the participants were required to complete informed consent.

Submissions: Participants annotate samples in published gene expression studies (e.g. cell types) and create comparison groups between case and control samples. Further analyses can be performed using the comparison groups, either by users or the public, and results can be shared via the OMiCC platform.

Budget and Resources: In FY17, an estimated $16,800 of funds and 0.1 FTEs were used to develop new features, import data, test, and promote the OMiCC platform. In FY18, an estimated $48,000 of funds and 0.24 FTEs were used develop new features, import data, test, and promote the OMiCC platform, as well as develop a manuscript describing recent updates and new features. Other resources contributed over FY17 and FY18 included website hosting and maintenance, provided by the Office of Cyber Infrastructure and Computational Biology, NIAID/NIH.

Partnerships: N/A

Advancement of Agency Mission: This activity addresses facets of the NIH mission, including the application of fundamental knowledge of the behavior of living systems to enhance health and reduce illness. NIH envisions that as more users take advantage of OMiCC to drive biological hypothesis generation and discovery, the more they can increase the ability to obtain new and robust biological insights not discernable from the analysis of any one study. These meta-analyses can also inform the design of new experiments. Previous studies have successfully combined publicly available data from published studies to both reposition drugs and identify robust gene-expression signatures of transplant rejection, infection status, tumor subtypes, and cancer progression. Thus, OMiCC has the potential to grow organically into an increasingly rich resource to help add cross-study, meta-analysis approaches to a biologist's toolbox and thus enable more effective transformation of the increasing amounts of public data into biological insights.

Results: Using the OMiCC platform, researchers tested the idea of using crowdsourcing for exploratory data analysis of public data sets by organizing a jamboree which was advertised to the NIH immunology community. The group focused on using OMiCC to search for and identify/annotate data from five autoimmune diseases and corresponding mouse models of these diseases. The volunteers used meta-analysis to combine data from multiple studies within OMiCC to derive (1) robust gene expression signatures for each disease (disease versus healthy control comparisons) and (2) conserved gene expression signatures across all diseases within each species (pan-disease signatures). The volunteers also examined signature conservation between human and mouse. The jamboree experiment suggests that there are potentially interesting and robust signals to be mined. Given a programming-free, didactic, community-based platform such as OMiCC, together with some upfront training on the platform, biologists with any level of bio- informatics experience can benefit from and contribute to utilizing public data for hypothesis exploration that can be translated into powerful insights about disease and biological processes.

Data Availability: The OMiCC platform and data are freely available to the public at https://omicc.niaid.nih.gov/. Initial results of analyses using the OMiCC platform have been published in a peer-reviewed journal, accessible at https://f1000research.com/articles/5-2884/v1. Articles about OMiCC and a perspective on crowd-sourced data reuse can be found at https://www.nature.com/articles/nbt.3603, and https://www.cell.com/immunity/fulltext/S1074-7613(16)30491-5.

D.4.4 NIDCR 2030: Envisioning the Future, Together[17]

Lead Sponsoring Agency: NIH, National Institute of Dental and Craniofacial Research (NIDCR)

Authority: NIDCR strategic planning

Project Summary and Goals: NIDCR 2030 is a strategic visioning initiative designed to advance dental, oral, and craniofacial research over the next 10-15 years. In 2030, NIH imagines a world where dental, oral, and craniofacial health and disease are understood in the context of the whole body, and research transforms how the United States promotes health, treats disease, and overcomes health disparities, so all people have the opportunity to lead healthy lives. To achieve this, better engage the public, and expand stakeholder outreach, NIDCR obtained and continues to seek input from researchers, faculty, students, healthcare providers, professional and nonprofit organizations, industry representatives, government officials, patients, and other community members. Hundreds of research ideas and comments have been received in the following five goal areas: Oral Health + Overall Health; Precision Health; Autotherapies; Oral Biodevices; and Workforce Diversity. In response to ideas submitted to NIDCR 2030, the Institute has started to identify topical themes for development into symposia, workshops, and research initiatives.

Justification for Using Crowdsourcing and Citizen Science: NIDCR recognizes the unique benefits of crowdsourcing and citizen science, including accelerating scientific research and data acquisition, improving science literacy, and connecting citizens to the mission of NIDCR. Crowdsourcing and citizen science helps advance the Institute's mission and stimulate and facilitate broader public participation in the innovation process, while protecting human subjects and other ethical considerations.

Status: The project started on March 22, 2017, and is ongoing.

Location: The project sources ideas from across the United States.

Participation: The project targets academia and researchers, patients and community members, government representatives, dental care providers, other healthcare providers, professional and nonprofit organizations, and industry. The total number of individuals involved is over 800 and continues to increase. The average number of active participants since the launch date is about 425.

Consent: Approximately 800 participants consented to register and participate in online IdeaScale community via NIDCR's Terms and Conditions of Use.

Submissions: NIDCR requested ideas, comments, and votes on what it will take to reach specific NIDCR research and training goals. A total of over 300 ideas, 300 comments, and 1,300 votes have been received to date.

Budget and Resources: Budget and resources used to support the NIDCR 2030 crowdsourcing project came from NIDCR's Office of the Director. In FY17, $30,000 in funding and 1.5 FTEs were dedicated to execute the project. Funding was used to license the IdeaScale crowdsourcing software and create communication materials (website, fact sheets, etc.) to promote the project and engage with stakeholders. FTE time was used to develop, launch, and implement the NIDCR 2030 crowdsourcing initiative, create communication strategies, and directly engage with the community. In FY18, approxiamately $50,000 in funding, and 0.5 FTEs were dedicated to continuing the project. Funding was used to cover the IdeaScale license fee and renew NIDCR's subscription to the platform. FTE time was dedicated to continuing the implementation of the NIDCR 2030 strategic planning initiative. This included analyzing the results from the community engagement and updating the community, as well

[17] The website for NIDCR 2030: Envisioning the Future, Together can be viewed at https://nidcr2030.ideascale.com/.

as identifying new research and training priorities. In FY17 and FY18, a public health analyst was hired as a contractor to support NIDCR 2030 communications and IdeaScale community website setup and moderation.

Partnerships: N/A

Advancement of Agency Mission: The mission of NIDCR is to improve dental, oral, and craniofacial health through the support of research, training, and dissemination of information. NIDCR 2030 is a strategic visioning initiative designed to advance dental, oral, and craniofacial research over the next 10-15 years. In response to ideas submitted to NIDCR 2030, the Institute is identifying topical themes for development into symposia and workshops, research initiatives, and communications of our ongoing research. Proposed research initiatives are posted to IdeaScale for public comment, along with announcements of upcoming symposia and workshops, as a part of stakeholder engagement.

Results: NIDCR's crowdsourcing outreach efforts have been tremendously successful and resulted in the following accomplishments. (1) Engagement with a large diverse group of stakeholders. Notably, many of these stakeholders represent communities that have been challenging to reach, including dental practitioners and patients. (2) Increased visibility of NIDCR research and training investments across the Federal Government and with policy makers, patients, and the general public. (3) Development of several new government and industry interactions with potential for public-public and public-private partnerships. (4) A focused symposium and workshop on autotherapies, an exciting emerging research area that was highlighted in NIDCR 2030. (5) New initiatives to increase oral health workforce diversity in extramural and intramural research communities. (6) Additional research inactives on a variety of topics that came from NIDCR 2030 stakeholder input, including oral biodevices and digital dentistry. and (7) Gathering of critical community ideas to help develop the next NIDCR strategic plan.

Data Availability: All research ideas and comments are publicly available on the NIDCR 2030 website, which is available to the public at https://nidcr2030.ideascale.com/a/index. Future workshops, research initiatives, and other updates are also available at https://nidcr2030.ideascale.com/a/pages/updates.

D.4.5 Community Mapping Project: Engaging Students in Citizen Science for Safe Routes to School

Lead Sponsoring Agency: NIH, National Library of Medicine (NLM)

Authority: NLM operating budget

Project Summary and Goals: The overall goal of this project is to engage high school students in a coordinated effort to promote public health, walking to school, and identifying local walking conditions using community based participatory mapping. Twenty high school students were educated on the importance of safe walking routes and its impact on physical activities and health via community based participatory mapping. After instruction on the use of Mappler, students took a pre-test survey and were separated into groups of five. They were given a map of the area they were responsible for gathering data on sidewalk conditions. During the community mapping process, the student health ambassador (SHA) and students from Meharry Medical College communicated with high school students about community health issues. Students surveyed and uploaded information using photos about the conditions of street safety. Data were uploaded into an interactive online mapping tool where anyone can view and analyze the information collected. After recording their data, the groups came back for debriefing and a post-test survey. During the debriefing, students were asked what they learned from

the community mapping project and if they had a better understanding or appreciation for public health. Students received four hours of community service for their work.

Justification for Using Crowdsourcing and Citizen Science: By using crowdsourcing and citizen science methods, the project leads were able to engage students in a citizen science project that helped to gain insight into a public health issue in their community. Students were able to investigate the issue and produce maps on safe routes to school and libraries that were shared locally and nationally with the public.

Status: The project started on September 20, 2017, and is ongoing.

Location: The project is located in Nashville, TN.

Participation: The project engaged students from Gallatin High School and Stanton Camp High School, faculty in the Health Disparities Research Center of Excellence at Meharry in collaboration with the National Community Mapping Institute, and students enrolled in health professions. The total number of individuals involved during this period was 20 high school students. The total number of volunteer hours was 200.

Consent: All permissions were given by participants of the project.

Submissions: Students were taught how to use GIS and Mappler mobile app to collect data. They tracked and mapped safe routes to school and neighborhood libraries.

Resources: There is no dedicated CCS resources in the NLM Specialized Information Services budgeted. In FY17, 0.01 FTEs and $7,500 in funding were used to support after hour school activities, to obtain supplies for the project, and to support the subcontractor's overhead costs.

Partnerships: Non-Federal partners included Meharry Medical College.

Advancement of Agency Mission: Goal 3 of the NLM strategic plan is to build a data ready workforce for the future. The project introduced students to the principles of data science, the power of visualization data and the use of data for discovering safety hazards in their community.

Results: This project results will be shared with the national Safe Routes to School Program focused on making walking and bicycling to school fun, accessible, and safe.

Data Availability: Data are available at http://www.immappler.com/srtsnashville/.

D.4.6 NNLM Wikipedia Edit-a-thon[18]

Lead Sponsoring Agency: NIH, National Library of Medicine (NLM)

Authority: Unknown

Project Summary and Goals: The National Network Libraries of Medicine (NNLM) held its first online Wikipedia edit-a-thon on April 17, 2018 to improve consumer health information on Wikipedia. By adding or updating citations using NLM resources, the eight health science libraries that function as Regional Medical Libraries (RML) under NNLM, provided one more way to reach more people through enhanced dissemination and engagement. After months of planning and collocating with the Wikipedia's Medical Wikimedia Community, NNLM offered pre-training to inform interested participants of what to learn and how to prepare for the event. A project page provided links to training, citation editing and rare disease resources. On the day of the edit-a-thon, librarians visited an online dashboard and saw in real time the edit-a-thon, chat with peers, and more. The edit-a-thon promoted

[18] The website for the NNLM Wikipedia Edit-a-thon can be viewed at https://nnlm.gov/wiki.

NLM's trusted health information and tools such as Genetics Home Reference, MedlinePlus, PubMed, and NIH's Genetic and Rare Diseases Information Center. Another edit-a-thon took place November 7, 2018.

Justification for Using Crowdsourcing and Citizen Science: When medical librarians from joined forces through NNLM for the all-day Wikipedia edit-a-thon, this increased access to credible, evidence-based information on rare diseases for people around the world.

Status: The project started in January 2018, and held its first event on April 7, 2018. The project is still ongoing and additional events are being scheduled.

Location: The event took place nationwide.

Participation: The project targeted NNLM staff and members. Over 50 individuals were involved during the first event, and the total number of volunteer hours is 12.

Consent: N/A

Submissions: N/A

Budget and Resources: In FY18, two FTEs were used for event planning and organizing.

Partnerships: Non-Federal partners included the Wikipedia Medical Wikimedia Community.

Advancement of Agency Mission: A major strategic goal of NLM is to "reach more people in more ways through enhanced dissemination and engagement pathways." This project is aimed to improve the use of NLM resources, engage NNLM members, utilize librarian research skills, and make Wikipedia a better, evidence-based resource. Updating and adding credible, evidence-based information on rare diseases to Wikipedia is just one way that NNLM is actively engaged in providing equal access to biomedical information and improving individual's access to information to enable them to make informed decisions about their health.NNLM offers funding, training, community outreach, partnerships to increase health awareness and access to NLM resources.

Results: The April Edit-a-thon resulted in 111 articles edited, including 736 total edits, 43,500 words added, and 838,000 article views, increasing access to credible, evidence-based information on rare diseases. Because of our promotion, an education session was held on using Wikipedia to keep up reference skills and learn about NLM databases.

Data Availability: Data is available on the NNLM Wikipedia Edit-a-thon project page. As the project moves to futures events, NLM will continue to track and show how NNLM can help improve access to consumer health information on Wikipedia.

D.5 Department of Interior (DOI)

D.5.1 Battle of the Atlantic Expedition[19]

Lead Sponsoring Agency: Bureau of Ocean Energy Management (BOEM)

Authority: National Historic Preservation Act (NEPA)

Project Summary and Goals: BOEM and NOAA's Monitor National Marine Sanctuary have committed to a multi-year project to document the Battle of the Atlantic by conducting archaeological investigations

[19] The website for the Battle of the Atlantic Expedition can be viewed at https://marinecadastre.gov/espis/#/search/study/100056.

of both Axis and Allied losses during World War II offshore North Carolina. An Interagency Agreement was developed in 2010 to provide support over a five-year period toward documenting these casualties.

As the longest military campaign of World War II, the Battle of the Atlantic was waged from the waters off England to the east coast of the United States and into the Gulf of Mexico. From its beginnings in 1939 through the end of the war with Germany, hundreds of vessels were lost and are now located on the seafloor as archaeological resources. Given the violent nature of these vessel losses, many are also war graves. The area offshore North Carolina was the closest theater of war to the continental United States. This expedition has identified and investigated Axis and Allied losses in the Graveyard of the Atlantic. The objectives of this project are to collect detailed documentation of these vessels and to develop a complete inventory of WWII losses in the region.

Justification for Using Crowdsourcing and Citizen Science: Crowdsourcing and citizen science techniques were selected to achieve project goals because it allowed BOEM to leverage pre-existing citizen efforts better than other available mechanisms. Specifically, recreational SCUBA diving groups had already formed with an express interest in mapping and documenting WWII Battle of the Atlantic shipwrecks. BOEM and NOAA were able to partner with these citizen scientists to gain the benefit of their expertise and enthusiasm.

Status: The project started in July 2008, and is ongoing.

Location: The project takes place in waters offshore North Carolina

Participation: The project targets recreational technical SCUBA divers with an interest and skill set in shipwreck diving. Over 20 individuals have participated in the project since its inception with an average of 15 active participants per year. Over 1,000 volunteer hours have been contributed.

Consent: All participants provided consent.

Submissions: Submissions by citizen scientists included observations, data, video, still photography, historical research, and drawings.

Resources: FTE resources included scientific support, SCUBA diving support, and financial/contract management. Funding was paid via an Interagency Agreement for resources including equipment, supplies, and services necessary for SCUBA diving fieldwork offshore; specialized software; and consumables necessary to draft maps of the shipwreck sites. In FY17, the funding was $100,000 with approximately 0.2 FTEs. The funding and FTEs were the same in FY18. IT resources, pre-existing agency SCUBA diving supplies and specialized training costs, and access to specialized subject matter references (e.g., scientific literature) were used to support the project.

Partnerships: Federal partners included the National Oceanic & Atmospheric Administration (NOAA). Non-Federal partners included the Battle of the Atlantic Research & Expedition Group (BAREG).

Advancement of Agency Mission: An inventory and evaluation of World War II vessel losses offshore North Carolina is needed to inform BOEM's consideration of historic properties under the National Historic Preservation Act (NEPA). This information is timely and relevant as BOEM is currently considering renewable energy activities in this area.

Results: These results are being used to produce an inventory and evaluation of World War II vessel losses offshore North Carolina needed by BOEM to inform its consideration of historic properties under the National Historic Preservation Act. This information is being used by BOEM to manage the development of offshore energy and marine minerals activities in these areas offshore.

Data Availability: Data will be made publically available via BOEM and NOAA's websites, which are accessible at https://marinecadastre.gov/espis/#/search/study/100056 and https://oceanexplorer.noaa.gov/explorations/16battlefield/.

D.5.2 Aquatic Insect Monitoring in Grand Canyon[20]

Lead Sponsoring Agency: Bureau of Reclamation (USBR), Glen Canyon Dam Adaptive Management Program

Authority: Organic Act of 1879, The Grand Canyon Protection Act of 1992 (Public Law 102-575)

Project Summary and Goals: The goal of this project is monitoring the Colorado River ecosystem and its response to flow management from dams, particularly Glen Canyon Dam. Aquatic insects are the cornerstone of food webs in and around rivers. Quantifying the abundance and diversity of aquatic insects over time and space is important to understanding the health of river ecosystems and how rivers are affected by dam management policies. This dataset is based on simple light traps set at the river's edge every evening by river rafters. Currently, the dataset contains over 10,000 samples of adult aquatic insects and several million individual insects. This citizen science effort allows us to ask and answer questions about the Colorado River that are truly unprecedented in scale, such as how hydropower releases from Glen Canyon Dam affect aquatic insect populations and the health of river food webs, how the phenology (seasonal timing) of aquatic insects varies by species and with distance downstream from the Dam, and how aquatic insect populations vary from year-to-year throughout the entire Grand Canyon.

Justification for Using Crowdsourcing and Citizen Science: Citizen Science has been essential and critical to the success of this project. Sampling aquatic insects on a large scale over long periods of time is impossible for typical research groups of only a few people. However, sampling aquatic insects on a large scale, over long periods of time, can be achieved by working cooperatively with people who are on the river every day, like professional river guides and private boaters. Because of this citizen science collaboration, USGS researchers have been able to collect samples of aquatic insects across the entire Colorado River Basin throughout the entire year.

Status: The project started in April 2012, and is ongoing.

Location: This project takes place in the Colorado River Basin in Arizona, Utah, Colorado, Wyoming, and New Mexico.

Participation: The project targets anyone river rafting on the Colorado River. Over 250 people have participated in the project since it was started in 2012, and the average number of active participants per day is around 5 people collecting light trap samples. The number of volunteer hours is around 10,000. Although some participants are truly unpaid volunteers, USGS does offer a modest stipend for each sample provided and most participants chose to accept the stipend.

Consent: All participants provided formal consent. USGS advertised the opportunity through rafting publications and public lectures and then participants contact the agency if they were interested in helping.

Submissions: Light trap samples of emergent aquatic insects are the primary submission of participants. Participants are provided with a simple light trap that they deploy each night during their rafting trip.

[20] The website for the Aquatic Insect Monitoring in Grand Canyon can be viewed at https://www.usgs.gov/centers/sbsc/science/citizen-science-light-trapping-grand-canyon?qt-science_center_objects=0#qt-science_center_objects.

After one hour, the light trap is turned off, the sample is put in an individual bottle, and at the conclusion of the river trip bottles are returned to the USGS Grand Canyon Monitoring and Research Center for laboratory processing. Since 2012, over 10,000 light trap samples have been collected by citizen scientists.

Resources: Funding for this project in FY17 was provided by the Bureau of Reclamation's Glen Canyon Dam Adaptive Management Program ($200,000) and the Department of Energy's Western Area Power Administration ($50,000). In FY18, funding was provided by the Bureau of Reclamation ($200,000) and the U.S. Fish and Wildlife Service ($75,000, via a FWS and USGS Strategic Science Partnership Award). For both years, around $15,000 was given to citizen science participants as a stipend for collecting samples while the remainder of project funding went towards covering salaries of approximately 3 FTEs each year. FTEs coordinated collection of samples, performed laboratory processing of samples, and conducted the analysis, interpretation, and writing up the data.

Partnerships: Federal partners include the U.S. Geological Survey scientists funded by USBR and the Department of Energy - Western Area Power Administration, which provided funding in FY17 for work in the Upper Colorado Basin in Utah, Colorado, and Wyoming. In FY18, the Fish and Wildlife Service provided funding for work in the Upper Colorado Basin through a Strategic Science Partnership award. The National Park Service is also a partner on this project because the work occurs in National Park Service units including Dinosaur National Monument, Canyonlands National Park, Glen National Recreation Area, and Grand Canyon National Park. Non-Federal partners included Grand Canyon River Guides, which helped facilitate this project by connecting USGS scientists with citizen scientist river guides.

Advancement of Agency Mission: The mission of the USGS Grand Canyon Monitoring and Research Center is providing science in support of adaptive management experimentation at Glen Canyon Dam. This project has fundamentally advanced this mission by identifying links between flow management policies and the health of river food webs, including native endangered fish and highly valued sport fish like rainbow trout.

Results: This project led to a change in flow management policies at Glen Canyon Dam starting in 2018. Specifically, during times when hydropower demands were lowest, flow releases were adjusted to try to enhance aquatic insect abundance and diversity. These Bug Flows were tested at Glen Canyon Dam from May to August 2018 and news of the flow experiment was widely reported in mass media including the *New York Times*, *Washington Post*, and *US News & World Report* (https://www.usnews.com/news/best-states/arizona/articles/2018-04-30/low-steady-flows-from-arizona-dam-could-benefit-bugs).

Data Availability: These data report the abundance and diversity of aquatic insects captured in each of the individual light trap samples. Data are available at https://www.sciencebase.gov/catalog/item/570fe1a6e4b0ef3b7ca3580c.

D.5.3 Archaeology Citizen Science at Fort Vancouver[21]

Lead Sponsoring Agency: National Park Service (NPS)

Authority: 54 U.S.C. 100101, 54 U.S.C. 100301, 54 U.S.C. 100701-706, and 54 U.S.C. 103102(4)

Project Summary and Goals: The NPS is mandated to preserve and interpret cultural resources of park units and affiliated sites for current visitors and future generations. The NPS provides technical

[21] The website for Archaeology Citizen Science at Fort Vancouver can be viewed at https://www.nps.gov/fova/learn/historyculture/archaeology-and-collections-a.htm.

assistance and training in the field of cultural resource management, including archaeology. The Public Archaeology Field School and research project at Fort Vancouver National Historic Site provides an intensive program to teach citizen scientists archaeological field techniques, including surveying, testing, and excavating, while recovering scientific data from one of the most significant archaeological sites in the Pacific Northwest. The project's goals include archaeologically testing portions of the Vancouver Barracks to assess the scientific and historical value of the resources and gathering data on areas that may be affected by utilities upgrades and related construction activities tied to building rehabilitation, landscaping, and parking. Citizen scientists collected evidence of the tangible remains of the Vancouver Barracks and earlier Hudson's Bay Company Fort Vancouver in the summer of 2017 and processed the artifacts in the park's archaeological laboratory in 2017 and 2018. The effort aims to improve the interpretation of U.S. military and fur trade history at Fort Vancouver.

Justification for Using Crowdsourcing and Citizen Science: Citizen science is a valuable tool to augment and integrate into existing archaeology work to meet multiple NPS goals. The project synergistically uses cooperative agreements, staff full-time equivalents (FTEs), and citizen scientists. This structure allows citizen scientists to contribute successfully to the project while ensuring good data quality through data collection and analysis training. By engaging with universities that are dedicated to training future scientists through citizen science, the project also fulfills an on-going desire by the public to participate in archaeological fieldwork and laboratory analysis. Overall, the use of citizen science is a cost-effective means to conduct archaeological science and contribute to park interpretation.

Status: The project started in June 2017 and is ongoing.

Location: The program is located at the Fort Vancouver National Historic Site in the Pacific Northwest region of the United States.

Participation: The project targets university students and the general public interested in archaeology, history, and historic preservation. The total number of individuals involved during this period was 53, and the average number of active participants was about 18 per quarter. The total number of volunteer hours was 4005.

Consent: All 53 participants consented to participate.

Submissions: Citizen archaeologists created and submitted 223 digital excavation level and feature forms, 21 iDraw digital excavation profiles, 248 digital cemetery headstone recording forms, 1,666 digital images, and 4,937 archaeological laboratory recording form lines of data. Additional laboratory recording lines of data from other NPS partnership projects were created and submitted.

Resources: The project is funded through park and region base funds, a cooperative agreement, and non-NPS funds and in-kind services provided by the university partners. University partners also provide graduate student and instructor support for field work. Portland State University provides field equipment and some graduate research assistant (GRA) services in support of the project. In FY17, a GS-12 regional archaeologist served as project manager and PI for project, and a GS-7 park archaeological technician provided field crew support and helped with archaeological laboratory training. Together, the two staff contributed 0.25 FTEs to the project. Funding for FY18 totaled $33,078, and 0.15 FTEs supported the project. A cooperative agreement with Portland State University included funding for a 0.3 FTE GRA to run the archaeological laboratory during the 2017–2018 academic year (October through June).

Partnerships: Federal partners include USFS, Gifford Pinchot National Forest. Non-Federal partners include Portland State University, Washington State University Vancouver, Friends of Fort Vancouver National Historic Site, Oregon Museum of Science and Industry, Vancouver Parks and Recreation, Bike Clark County, and Clark College.

Advancement of Agency Mission: The project serves to further the NPS mission to share information on NPS resources and to conduct scientific outreach to children and adults. The project fosters relationships with conservation partners tied to science and education, provides interpretative programs to improve public access to archaeological sites, and builds new dialog with community members through citizen science. Visitors to the site are encouraged to interact with the citizen scientists who had been trained in modern interpretation and communication skills by NPS staff. Formal tours of the site associated with the project were held with youth from the Fur to Fossil Summer Camp (Oregon Museum of Science and Industry), Bike Skills 101 (Vancouver Parks and Recreation and Bike Clark County), and the Clark College STEM Camp (Clark College). Citizen Scientists share their knowledge with children at the Kids Dig program funded by the Friends of Fort Vancouver National Historic Site.

Results: The citizen scientists collected data from a highly significant archaeological site and interpreted the archaeological program to the public. The student graduate research assistant coordinated and managed citizen scientists in the Fort Vancouver Archaeological Laboratory, assisted and mentored by NPS archaeologists. Multiple collections were cleaned and analyzed and were incorporated into technical reports supporting the adaptive reuse of historical structures and infrastructure upgrades to the East Vancouver Barracks. Results were shared at the 2018 Archaeology Roadshow, a public archaeology event hosted by Portland State University. Data continue to be used in site planning at the Vancouver Barracks.

Data Availability: Data collected from the archaeological site are protected under two Federal laws, the Archeological Resources Protection Act and the National Historic Preservation Act, to prevent looting or other disturbance of sensitive archaeological resources. Professional archaeologists and student researchers affiliated with an accredited University with a mentoring professional archaeologist may be given access to the data for research purposes. Those interested in the results may contact the park cultural resources branch.

D.5.4 Biodiversity Discovery and Phenology in Acadia National Park

Lead Sponsoring Agency: NPS

Authority: National Park Service Organic Act

Project Summary and Goals: Biodiversity discovery and phenology in Acadia National Park engages the public in recording observations of plants and animals in Acadia. Volunteers can participate through a variety of methods, including by participating in targeted bioblitzes such as an intertidal blitz or moth blitz, by attending ranger-led or Schoodic Institute-led programs such as Sea Watch or Hawk Watch, or by submitting observations on their own through iNaturalist, eBird, or Nature's Notebook. In each of these methods, volunteers follow standardized procedures for recording observations of plants and animals. Observations are often accompanied by photographs, and all observations are subject to quality control and data management after submission. The goal of the project is to document biodiversity and phenology in Acadia National Park to: (1) improve understanding of park resources; (2) inform decisions regarding the management of park resources; and (3) provide educational and inspirational experiences for park visitors. These project goals derive from the mission of the National Park Service.

Justification for Using Crowdsourcing and Citizen Science: Citizen science is particularly appropriate for documenting biodiversity and phenology for a number of reasons. Park managers require information on a large number of species and from a large number of locations—more than park staff or cooperating professional scientists can observe on their own. Furthermore, engaging volunteers in the documentation of biodiversity and phenology, especially with additional communication through

interpretation, education, or other means, can help participants learn about natural resources and good stewardship. Studies have established that volunteers with little training can readily document biodiversity and phenology, supporting the use of citizen science for this project.

Status: The project started in June 2004 and is ongoing.

Location: The project is located in Acadia National Park, Maine.

Participation: The project targeted park visitors and local residents. The total number of individuals involved during this period was approximately 10,000, and the average number of active participants per year was about 5,000. However, participation is seasonal, and most participation occurs during the fall.

Consent: All participants provided consent through user agreements and other mechanisms associated with data collection tools (e.g., iNaturalist, eBird, Nature's Notebook) and signed Volunteer agreements.

Submissions: The project received observations on species occurrence and information on timing of seasonal life cycle events.

Resources: There is no dedicated budget for biodiversity discovery and phenology in Acadia National Park. Funding, staff time, and supplies came from a variety of Federal and private sources. In FY17 and FY18, NPS contributed a total of $44,000 ($37,000 in FY17 from Acadia accounts, $7,000 in FY18 from non-Acadia accounts) through Task Agreements to Schoodic Institute. These task agreements supported personnel, methods refinement, training workshops for participants, data management, and communication. NPS contributed staff time and supplies through the Resource Management Division and the Interpretation and Education Division of Acadia National Park, mainly staff and supplies associated with the Research Learning Center in Acadia. Agency full-time equivalents (FTEs) were used to help coordinate the project and run some biodiversity discovery interpretive programs, and 0.5 FTEs supported the project in FY17 and FY18. Schoodic Institute led the implementation of the project and provided additional support for the project through its own funding, staff time, and supplies.

Partnerships: Non-Federal partners included Schoodic Institute.

Advancement of Agency Mission: The project directly supports three major components of the NPS mission by: (1) using the data to inform the management and preservation of natural resources; (2) helping volunteers enjoy, learn, and become inspired about the natural resources in Acadia National Park; and (3) cooperating with partners to extend the benefits of conservation throughout the country, especially when volunteers continue to make observations and otherwise contribute to science, stewardship, and education when they go home.

Results: NPS, Schoodic Institute, and partner scientists and educators use the data generated by this project to understand what species occur in Acadia National Park and when they exhibit different phenological behaviors (e.g., migration, flowering, and fruiting). This information helps to manage natural resources by identifying invasive and vulnerable species, informing restoration projects and assessing their success, and timing fieldwork. Additionally, NPS and Schoodic Institute staff communicate the results to participants and to the public, providing valuable educational experiences. Project results are all important to advancing the NPS mission in Acadia National Park.

Data Availability: Data from this project can be found in free public databases managed by iNaturalist, eBird, USA National Phenology Network, and Hawk Count (Hawk Migration Association of North America). In each of those databases, users can search for data from Acadia National Park; in iNaturalist, users can additionally find data under the project Downeast and Acadia. There are smaller amounts of

data managed by individual researchers who are involved in the project. Those data will be shared at the completion of their projects, if not sooner, in accordance with the conditions of the researchers' permits.

D.5.5 Dragonfly Mercury Project: Engaging Citizens with Resource Conservation[22]

Lead Sponsoring Agency: NPS

Authority: NPS Organic Act (54 U.S.C. 100101(1916))

Project Summary and Goals: Mercury, a toxic pollutant that can harm human and wildlife health, often enters parks as air pollution from distant, human-caused sources, such as coal-burning power plants, and can enter the food web and build up in top predators. The Dragonfly Mercury Project (DMP) is a dynamic national scale program to understand mercury pollution risks to protected areas. Developed in collaboration with the U.S. Geological Survey (USGS), the University of Maine (UMaine), and the National Park Service, and implemented at more than 100 national parks across the country, the DMP engages citizen scientists as key participants in data collection of dragonfly larvae, which serve as indicators of mercury in aquatic food webs. Activities include hiking and sampling a national park waterbody, donning waders and using a net to collect dragonfly larvae from the water's bottom, using approved methods to sort and identify samples, preserving specimens, and filling out a field data sheet. This research helps the NPS better manage risk and protect resources and park visitors from the ill effects of mercury. The DMP was initiated with three main objectves: (1) increase understanding of mercury contamination in national parks across the United States using dragonfly larvae as biosentinels; (2) engage and educate citizen scientists in the collection of scientific data to increase their understanding of field ecology, wetland ecosystems, data literacy, conservation, and the impacts of air pollution; and (3) inform NPS policy and management decisions, such as determining when and where to provide warnings on fish consumption, identifying areas where mercury contamination may be harming wildlife, and identifying sites where mercury remediation may be appropriate. Entering its ninth field season in 2019, the DMP seeks to expand its impact by increasing data relevancy, enhancing the experience of the public participants, expanding partnerships, and informing sound resource management decisions.

Justification for Using Crowdsourcing and Citizen Science: The DMP is conducted via an Interagency Agreement with the U.S. Geological Survey. The scope and broad geographic coverage of this sampling is only possible because of public participation. Participation enables the NPS to foster teachable moments on the management of air, water, and biological resources and connect people to parks using parks as outdoor classrooms and living laboratories. This is a highly cost-effective study that leverages citizen participation to implement a national scale assessment of mercury bioaccumulation in biosentinel organisms across multiple national parks. The full cost of a study of this magnitude that relied solely upon USGS or UMaine technical staff to conduct all aspects of data collection would exceed $1.5 million in technician salary, lab analyses, and travel costs. Additionally, this project benefits from substantial in-kind contributions by the principal investigator's team. Citizen scientists gain new perspectives and practice civic skills, while project scientists gain additional data and insights on mercury in the food web.

[22] The website for the Dragonfly Mercury Project: Engaging citizens with resource conservation can be viewed at https://www.nps.gov/articles/dragonfly-mercury-project.htm.

Status: The project started in May 2011 at four pilot parks in the eastern United States: Acadia National Park, Marsh-Billings-Rockefeller National Historic Park, Saint-Gaudens National Historic Site, and Great Smoky Mountains National Park. The DMP is ongoing.

Location: Participation in the project is possible throughout the United States. All seven NPS Regions, 30 of 32 Inventory & Monitoring Networks, and National Parks in 43 U.S. states and the District of Columbia have participated.

Participation: The project targeted high school students, interns and youth groups, and local community groups. More than 4,000 citizen scientists have engaged in the DMP since the project's inception in 2011. Approximately 600 citizen scientists engaged in FY17, and current reports estimate at least 700 participants in FY18. The average number of active participants per month (May–September) was approximately 200. More than 10,000 volunteer hours have been dedicated to the DMP since 2011. FY17 recorded 3,755 volunteer hours, and current reports estimate at least 4,160 volunteer hours in FY18.

Consent: All participants consented.

Submissions: Over the course of FY17 and FY18, participants submitted about 4,270 dragonfly larvae samples for mercury analysis, 300 field data forms, and 30 observations on iNaturalist for an approximate total of 4,600 submissions.

Resources: Funding for the Dragonfly Mercury Project has been varied and adaptively implemented. The Maine Agricultural and Forest Experiment Station and faculty research funds from the UMaine provided initial support for the project in 2011. Funding responsibilities then shifted to the National Park Service, followed by the USGS/NPS Water Quality Partnership from FY14 to FY16. In-kind contributions from the USGS Environmental Health Mission Area Contaminant Biology Program, UMaine, and the NPS provided additional support during these years. Since FY16, the DMP has been distinctly funded through a combination of park discretionary funds (i.e., parks, regions, networks), other NPS funds (WASO), and non-NPS funds (i.e., in-kind contributions from USGS, NPS, UMaine, and citizen scientists). Funding for FY17 totaled $204,319, and funding for FY18 totaled $353,700. Park funds contributed to 54% of the total NPS funding, while other NPS funds covered the remaining 46%. A total of $558,019 of direct in-kind contributions was obtained over two years, and an estimated $827,381 in matching support (148% of budget, 60% of total project costs) was secured over that same time. This project is heavily leveraged by matching support in the form of NPS staff time and field gear; citizen scientist time; USGS reduced analytical costs, principal investigator (PI) salary, data management, quality assurance; UMaine reduced indirect, graduate student and research support, and project communication. Matching in-kind support included $397,000 (29% of project total) from park staff, $158,300 (11% of project total) from citizen science, $26,250 (2% of project total) from sampling supplies provided by parks, $164,215 (12% of project total) from USGS, and $81,616 (6% of project total) from UMaine. The FY17 and FY18 budgets covered project oversight by USGS and UMaine, PI salaries and a project coordinator, staff training, lab analysis, supplies, data management, reporting, and travel to a DMP core team meeting. FY18 funds also supported affiliated research endeavors. FY17 support was provided by 2.6 full-time equivalents (FTEs), including NPS staff support at 56 parks, five regions, and one NPS Air Resources Division DMP project coordinator. FY18 support was provided by 3.0 FTE, including NPS staff support at 64 parks, five regions, and one NPS Air Resources Divsion DMP project coordinator. Citizen scientists contributed an additional 1.8 and 2.0 FTEs, respectively.

Partnerships: Federal partners included U.S. Geological Survey. Non-Federal partners included the University of Maine, Dartmouth College, and University of Wisconsin-LaCrosse.

Advancement of Agency Mission: The NPS preserves the natural and cultural resources and values of the national parks for the enjoyment, education, and inspiration of current and future generations. Mercury (Hg) is a globally distributed, toxic contaminant that threatens resources the NPS is charged with protecting. The DMP aligns with this NPS mission by advancing scientific understanding of the spatial distribution of Hg contamination in the national parks and creating next generation stewards, enlightening a mainly youth-based pool of citizen scientists about the connection among all living things, the influence humans have upon natural systems, and how environmentally-responsible decisions can protect our parks and the planet. Beyond increasing the understanding of Hg risk across the national parks and informing policy and management decisions, the DMP fosters a deepened engagement with citizen scientists and educators, ultimately advancing an appreciation of national parks and the diversity of resources they contain for thousands of youth across America.

Results: Three conclusions can be drawn from study *Results:* (1) dragonfly larvae are widespread and effective bioindicators of ecosystem risk to Hg; (2) the risk from Hg varies widely across the landscape, influenced by a combination of Hg emissions and deposition, landscape processes that control the entry of mercury into aquatic food webs, and food web structure; and (3) concentrations vary as widely within parks as across parks. Data from the DMP are used by researchers, resource managers, and classrooms and interns to further knowledge of mercury distribution, understand the vulnerability of waterbodies to mercury accumulation in foodwebs, protect resources and park visitors from the ill effects of mercury; and advance environmental literacy on local, regional, and national scales. Annual project-based outcomes include dragonfly larvae sample analysis and subsequent data results, data flyers that interpret results for each individual participating park, a technical report, and a DMP webinar. Core findings have been summarized in numerous national and international presentations at scientific meetings, a USGS fact sheet, a project report, and several pending journal articles. Given the project's wide geographic scope, the resultant data provide a nationwide snapshot of mercury in biota, primarily from undeveloped watersheds. Since the larvae are important prey for fish, and thus can be used as a surrogate for mercury levels in fish, the data can be used to eventually inform the NPS about park- and site-specific threats from mercury to human and wildlife health. Results also provide the foundation for a DMP steering committee, transitioning this NPS-centric project to a more influential, multi-agency program that carries the endeavor into the future.

Data Availability: Data flyers and park data files, organized by park and year, are available only to internal DOI partners. These data are still provisional and are currently undergoing the final review and approval process. The full data release will occur with impending publications and made publicly available. The Dragonfly Mercury Project Data Web Map, a dynamic tool for accessing and visualizing data on mercury in dragonfly larvae, is available to the public at: https://www.nps.gov/articles/dragonflymercury-map.htm. A summary data release is provided by the following article: https://doi.org/10.5066/P9TK6NPT. Other data products are available at: https://irma.nps.gov/DataStore/Collection/Profile/4082. Interpretive products and publications are being finalized now and will be used to put these data in the context of environmental health risk and utility for biomonitoring applications.

D.5.6 Glacier National Park Common Loon Citizen Science[23]

Lead Sponsoring Agency: NPS

Authority: National Park Service Organic Act

Project Summary and Goals: The Common Loon (*Gavia immer*) is considered a "Species of Special Concern" by Montana Fish, Wildlife and Parks due to the species' sensitivity to disturbance during nesting season and its low reproductive and recruitment rates. A volunteer-based annual loon survey began in 1988, which indicated that Glacier National Park (GNP) hosts 20% of the state's loon population and that reproductive rates were low (five chicks per year). The citizen science pilot program started in 2005, the first in Glacier and one of the first in any national park, to increase monitoring of this sensitive species. In 2006, Glacier National Park established the Common Loon Citizen Science project to train volunteers and GNP staff to gather baseline data on population and distribution of common loons, to improve accuracy during an annual Loon Day count, and to increase survey coverage of lakes with loons. The program has established significant baseline data on loon population status, nesting areas, chick hatch and migration dates, and areas of concern for human disturbance, and the goal is to continue this long-term record to provide management recommendations about issues that may affect loon nesting success and habitat, an indicator of lake ecosystem health.

Justification for Using Crowdsourcing and Citizen Science: Long-term monitoring of Common Loons provides a vital insight into the health of freshwater lake ecosystems. Glacier has 45 freshwater lakes across its 1.1 million acres with the potential to support breeding Common Loons. Capacity within current staffing budgets and funding for grants or cooperative agreements for this kind of large-scale monitoring over a long-time period is not available. Prior to the establishment of the project, staff and a small number of untrained volunteers were conducting one annual Loon Day count at each lake to provide information about where loons were located in the park. That information was insufficient for making management decisions about long-term loon conservation. In 2006, Glacier National Park established the Common Loon Citizen Science project to obtain information about nest locations, nesting success, and chick survival rates, which are vital to conservation of the species, using trained volunteers who collect data at lakes more frequently. Common Loons are a good fit for citizen science engagement because they are a highly visible and charismatic species that are of interest to park visitors and the local community.

Status: The project started in May 2005 and is ongoing.

Location: The program is based in Glacier National Park, Montana.

Participation: The project targeted park visitors, local community members, service groups, and students. Participants totaled 117 in 2017 and 140 in 2018, and the average number of active participants per month between June and August was approximimately 50. The total number of volunteer hours equaled 2,192 hours in 2017 and 2,797 hours in 2018.

Consent: All participants provide formal consent to participate.

Submissions: Participants submit observational data and images. A total of 178 submissions were received in 2017 and 233 were received in 2018.

Resources: Agency funding for FY17 totaled $2,000, supplemented by a $12,000 private donation from the Glacier National Park Conservancy. Recreational Fee Program Personal Services amounted to $15,000. Agency funding for FY18 totaled $2,500, supplemented by a $12,000 private donation from the

[23] The website for Glacier National Park Common Loon Citizen Science can be viewed at https://www.nps.gov/rlc/crown/citizen-science.htm.

Glacier National Park Conservancy. Recreational Fee Program Personal Services amounted to $18,000. Resources in both years were used for rental vehicles, fuel, backcountry per diem, field equipment, and supplies. A total of 0.7 full-time equivalents (FTEs), split between a GS-4 Project Coordinator and a GS-7 Program manager, supported the project in FY17 and FY18.

Partnerships: Federal partners include the Common Loon Working Group, whose members include the US Forest Service, US Fish and Wildlife Service, and Confederated Salish and Kootenai Tribes. Non-Federal partners include Glacier National Park Conservancy, Montana State Fish, Wildlife and Parks, and Blackfeet Tribal Community College. The Montana Department of Natural Resources, Weyerhaeuser Timber Company, and the Montana Loon Society also participate in the Common Loon Working Group.

Advancement of Agency Mission: The project advances the NPS's mission to conserve wildlife and natural resources, in this case by engaging the public directly in collecting population data. Conservation of Common Loon populations in an unimpaired state ensures that they are available for the enjoyment of future generations. The project also fosters enjoyment of wildlife and natural resources by participants.

Results: The data gathered by this project have been used as an indicator of the health of freshwater lake ecosystems. They have also been used to inform management decisions, such as trail locations and fishing access planning through the compliance process. Knowledge of loon nesting sites and success rates has informed planning for conservation of other species that also use freshwater lake habitats. The data have also informed a broader understanding of loon population status, breeding success, and migration timing across the state of Montana and on the adjacent Blackfeet Reservation.

Data Availability: Metadata for all data collected for the project are published in the National Park service Integrated Resource Management Applications (IRMA) data portal: https://irma.nps.gov/DataStore/Reference/Profile/2194764. The full dataset is provided to interested parties upon request. An annual summary report of all data is also published each year in the Integrated Resource Management Applications (IRMA) data portal.

D.5.7 Did You Feel It? (DYFI)[24]

Lead Sponsoring Agency: U.S. Geological Survey (USGS)

Authority: Organic Act of 1879, The National Earthquake Hazards and Reduction Program (NEHRP), 42 U.S.C § 7701

Project Summary and Goals: The Did You Feel It? (DYFI) project is designed to gather information available about earthquakes from the people who experience them. By tapping an immense number of users online, DYFI can get a detailed characterization of what people were experiencing during the earthquake, the impacts of the earthquake, and the amount of damage it caused, beyond the scope of traditional information gathering techniques. Data input from users is immediately available on the website, and its interactive platform encourages users to gain a deeper understanding of earth sciences while they participate. The DYFI data are used to inform earthquake response and scientific studies about earthquake shaking and damage.

Justification for Using Crowdsourcing and Citizen Science: The DYFI project taps into a natural crowdsourcing and citizen science (CCS) audience to report the shaking experienced at their location immediately after felt earthquakes. It is one of the most suitable and cost effective uses of CCS, since

[24] The website for the Did You Feel It? online report form is accessible at https://earthquake.usgs.gov/data/dyfi/.

participants are eager to share their observations with the Federal Government, and USGS seismologists and scientists benefit from these citizen science data.

Status: The project started in 1999 in California and then expanded in 2003 for the rest of U.S. and the world, and is still ongoing.

Location: The project takes place internationally, particularly in locations where earthquakes occur.

Participation: The project targets populations affected by an earthquake. The total number of individuals involved is over 4.5 million since 1999, and approximately 650,000 in the 2017 to 2018 reporting period. The average number of active participants per month was approximately 33,000 in 2017 and 2018. The total number of volunteer hours was about 5,400 hours based on an average of approximately 30 seconds per response.

Consent: All participants consent to participating by submitting a report on the DYFI website with the option to provide contact information.

Submissions: Participants answered at least one and up to 15 questions about their earthquake experience. There were approximately 650,000 submissions in the 2017 to 2018 reporting period.

Resources: The DYFI project is extremely cost-effective. Total operations including web support, software design and upkeep, as well as user support for data requests and outreach amounts to less than one 1 FTE, since data are automatically processed.

Partnerships: DYFI is a USGS project and does not have any federal or non-federal partnerships associated with this project.

Advancement of Agency Mission: The DYFI project is one of the USGS's premiere citizen science projects. It is one of the first, most well-known, and well subscribed in the U.S. Government. DYFI takes advantage of the unique opportunity to help and learn from citizens, often by the tens of thousands, immediately after they experience shaking during an earthquake. Both the government and the population benefit from this collaborative relationship. DYFI is also a very cost-effective use of government resources, since three orders of magnitude more macroseismic data are collected in the U.S. as a result of this program, with many fewer personnel than were needed in the past.

Results: The scientific uses of DYFI data have been documented in several scientific publications and scores of scientific peer-reviewed papers use the DYFI data (see https://pubs.er.usgs.gov/publication/70032440 and https://earthquake.usgs.gov/static/lfs/data/pager/AtkinsonWaldDYFI.pdf). Hundreds of abstracts and meeting presentations employ DYFI data as well. The studies use DYFI data to analyze shaking intensity and wave propagation, the relationship between shaking and damage, induced earthquakes, social sciences of human risk perception, and the use of crowdsourcing and citizen science itself.

Data Availability: The DYFI data are documented in various scientific publications, such as https://pubs.er.usgs.gov/publication/70032440. All DYFI data are available at https://earthquake.usgs.gov through the USGS Earthquake Program Comprehensive Earthquake Catalog (ComCat).

D.5.8 iCoast - Did the Coast Change?[25]

Lead Sponsoring Agency: USGS, St. Petersburg Coastal and Marine Science Center

Authority: Organic Act of 1879; National Climate Program Act of 1978; Coastal Zone Management Act of 1976

Project Summary and Goals: The value of iCoast is two-fold: (1) iCoast serves as a communication tool to explain to a broad audience what processes change the coast during major storms, and (2) the oblique imagery data sets contain the information necessary for storm impact model verification. Classification of large volumes of photographs covering a wide area is impractical without employing citizen scientists. iCoast successfully engaged the general public to assist in the classification of coastal oblique aerial imagery collected after Hurricane Sandy made landfall in November 2012. Users were able to match and classify nearly all the images along the coast. The work done by users in classifying the imagery collected after Hurricane Sandy has helped USGS scientists understand the impact of the storm. iCoast users correctly identified mainland and narrow barrier islands along the coast with a high degree of confidence. Our analysis also showed that users could reliably identify all four coastal processes, namely beach erosion, dune erosion, overwash, and inundation. Classifications generated from iCoast users are being used to test the predictive models of storm impacts along the coast by identifying differing levels of geomorphic impacts (e.g., collision, overwash, inundation) along undeveloped and developed coasts and damage to infrastructure caused by a storm.

Justification for Using Crowdsourcing and Citizen Science: iCoast is a cost effective way to classify large volumes of photographs covering a wide area, which was previously impractical due to the number of hours that it would have required for a staff scientist to complete the task. iCoast was developed by the USGS using citizen science and user experience expertise already available to the USGS St. Petersburg Coastal and Marine Science Center. The iCoast interface was designed using human-centered design techniques and by conducting usability testing with USGS scientists and existing iCoast users to ensure iCoast was user-friendly.

Status: The project started in June 2014 to classify images from Hurricane Sandy. This is still an ongoing project, collecting input from users, mostly with regard to Hurricane Joaquin.

Location: The project takes place on online but focuses on imagery collected along the U.S. east coast in areas affected by Hurricane Sandy (Cape Lookout, North Carolina to Montauk Point, New York) and Hurricane Joaquin (South Carolina/North Carolina border to Montauk Point, New York). Since this is an online project, volunteers can be from anywhere around the world that have access to the internet.

Participation: The project targets citizen scientists interested in contributing to the understanding of coastal processes and people interested in learning the impacts of Hurricane Sandy, Hurricane Joaquin, and other extreme storms. Of the 1,630 total users, 1,020 have completed at least one classification in iCoast (i.e., 62% of the people who signed on to iCoast have contributed to the collected data). When iCoast was first released, participation was higher than current numbers. All of the Hurricane Sandy images were classified by October 2015 (1 year and 4 months). Hurricane Joaquin is also 100% classified. The total number of volunteer hours was over 2,867 hours since June 2014, where it takes approximately two and a half minutes per classification.

Consent: All participants had to login and register with iCoast, therefore all participants consented to participate in iCoast.

[25] The website for the iCoast - Did the Coast Change? is accessible at https://coastal.er.usgs.gov/icoast/

Submissions: iCoast users are asked to check for spatial correspondence between image pairs from before and after Hurricane Sandy or Hurricane Joaquin (image matching) and then users are presented with a set of specific tasks to classify the pre-event scene, detect changes, and interpret the process or processes responsible for the changes to the coast. Approximately 69,000 classifications of image pairs have been submitted, although it should be noted that an image pair can have more than one classification by multiple users.

Resources: iCoast is monitored for input from users and to be certain that it is continuing to function. A database programmer is utilized if there is a problem with the functionality of the website. A researcher is available to address any images flagged by users as unusable. iCoast is very low maintenance and functions without daily input from researchers. Other than maintenance work, no funding was provided for iCoast. There is less than 0.4 FTE annually because the project does not require a lot of attention.

Partnerships: No federal or non-federal partnerships associated with this project.

Advancement of Agency Mission: The information iCoast provides allows researchers to focus on derived information contained in the oblique aerial imagery that is collected after a storm. Analysis of user input shows that iCoast users can provide valid information, which can then be used by researchers to increase understanding of coastal storm response. The USGS Coastal and Marine Geology Program is actively engaged in research to further understand storm events and to develop models to predict coastal change hazards. iCoast was developed to further inform coastal change hazards research as well as raise awareness to the public about how extreme storms affect US coastlines. More information about the purpose of iCoast, can be found at https://coastal.er.usgs.gov/icoast/about.php.

Results: The Storm-Induced Coastal Change Hazards component of the of the National Assessment of Coastal Change Hazards project focuses on understanding the magnitude and variability of extreme storm impacts on sandy beaches. The overall objective is to improve real-time and scenario-based predictions of coastal change to support management of coastal infrastructure, resources, and safety (https://coastal.er.usgs.gov/hurricanes/overview.php). Classifications generated from iCoast users are being used to test and validate the predictive models of storm impacts along the coast by identifying differing levels of geomorphic impacts (e.g., collision, overwash, and inundation). Validation of these models is an important part of the research and response to extreme storms.

Data Availability: A Data Release containing the Hurricane Sandy iCoast classifications is available at https://coastal.er.usgs.gov/data-release/doi-P93A9MPE/. iCoast data for Hurricane Joaquin will be made available in the future..

D.5.9 Nature's Notebook[26]

Lead Sponsoring Agency: USGS

Authority: Organic Act of 1879

Project Summary and Goals: The USA National Phenology Network (USA-NPN) is a national-scale monitoring and research initiative focused on collecting, organizing, and delivering phenological data, information, and forecasts. It supports natural resource management and decision-making to advance the scientific field of phenology and promote the understanding of phenology to a wide range of audiences, including researchers, resource managers, educators, communication specialists, non-profit organizations, human health organizations, science networks, and the public.

[26] The websites for the Nature's Notebook are accessible at http://www.naturesnotebook.org, and http://www.usanpn.org.

Justification for Using Crowdsourcing and Citizen Science: USGS has opted to develop and maintain a citizen science program for collecting phenology observations because citizen scientists can collect data at a national scale at a relatively low cost. Engaging volunteers in collecting observations of plant and animal phenology dramatically increases the volume and taxonomic and geographic breadth of data. Furthermore, volunteers are directly involved in conservation science and management, leading to increases in scientific and environmental literacy.

Status: The project started in March 2009, and is ongoing.

Location: The project takes place across the United States.

Participation: The project targets professional scientists, natural resource managers, and amateur naturalists. The total number of individuals involved over the reporting period of FY17 to FY18 was 10,278, and the number of active participants was 3,349. The total amount of volunteer time was 184,140 hours, where it takes approximately two minutes per record.

Consent: All participants are required to agree to the USA-NPN's Terms of Use https://www.usanpn.org/terms. From FY17 to FY18, 10,278 individuals provided formal consent to participate.

Submissions: Participants submit observations of plants and animals. Over the reporting period of FY17 to FY18, participants submitted 5,524,201 records.

Resources: National Coordinating Office staff includes one USGS staff member (1 FTE) and 10 staff members who work for the University of Arizona (8.125 FTE total). The USGS staffer serves as Director, and University of Arizona staff members are managers, programmers, data product developers, outreach and partnership coordinators, researchers, and students. USGS funds not allocated toward salary amounted to $208,509 for each fiscal year. Funding from all sources not allocated toward salary was $437,488 for each fiscal year. FY17 and FY18 combined was $1,424,356 from USGS; $625,476 from FWS; $9,889 from NSF; and $120,780 from NASA.

Partnerships: Federal partners included DOI-USFWS, DOI-NPS, NASA, NOAA, USDA-USFS, and USDA-ARS. USA-NPN maintains partnerships with several hundred Non-Federal institutions (e.g., Arbor Day Foundation, Casey Trees, Chicago Park District, City of Roanoke, Great Basin Bird Observatory, Infinity Science Center, Jacksonville Zoo and Gardens, John D. MacArthur Beach State Park, Knoxville Zoo Classroom Pollinator Project, Monarch Watch, and others).

Advancement of Agency Mission: The USGS Ecosystems Mission Area provides scientific information and decision support to meet Department of Interior's shared responsibility for land and species management, to fulfill treaty obligations with Tribes and foreign governments, to develop energy and mineral resources on Interior lands and the Outer Continental Shelf, and to supply water for irrigation and other human needs. USGS science protects and conserves the Nation's fish and wildlife heritage by bridging the gap between science and management for at-risk species and species of management concern. Within the Ecosystems Mission Area, the Status and Trends Program – which funds the USA-NPN – provides (1) science, technology, and information that resource managers use to understand the current conditions and status of plants, animals, and habitats under management responsibility of Interior bureaus and other Federal, State, and Tribal partners, and (2) collects, analyzes, and delivers data and information about past and potential future changes to species and habitats.

Results: Nature's Notebook data for the USA-NPN are used by university or government scientists for research on topics ranging from understanding, detecting, and controlling plant invasions; predicting effects of frost on tree fruit crops; documenting drought impacts on corn and soybean production; and validating satellite-based assessments of foliage coloration in the autumn. About 60 peer-reviewed

articles have been published in high-quality ecological journals. All information products with USGS authors are compliant with "Fundamental Science Practice" review, approval, and release standards established by the Office of Science Quality and Integrity. Data are also used by Federal, Municipal, and Tribal natural resource managers for field-based decision-making. For example, managers have used the data to plan restoration of degraded habitats in flood-plains, to map invasive plant species to support detection and control activities, to prioritize habitat for migratory animals such as birds and monarch butterflies, to understand patterns of tree pollen production as a hazard to human health, and to plan street-sweeping activities designed to improve water quality in local municipalities.

Data Availability: The USA-NPN National Coordinating Office freely and readily delivers observational data on plant and animal phenology collected through Nature's Notebook in several formats, including minimally processed status and intensity datasets as well as derived phenometrics for individual plants, sites, and regions. These data can be downloaded from https://www.usanpn.org/data/observational and are also accessible via the Phenology Observation Portal (http://dx.doi.org/10.5066/F78S4N1V) and via an Application Programming Interface. The data are documented and described in the 2018 USA National Phenology Network Observational Data Documentation (https://doi.org/10.3133/ofr20181060).

D.5.10 The National Map Corps (TNMCorps)[27]

Lead Sponsoring Agency: USGS

Authority: Organic Act of 1879

Project Summary and Goals: The National Map Corps (TNMCorps) is a crowdsourcing program that is part of the U.S. Geological Survey (USGS) National Geospatial Program's The National Map, which collaboratively improves and delivers topographic information for the Nation. The National Map is free to the public and the government, and its uses range from disaster planning and emergency response to scientific analysis and recreation. The use of The National Map Corps, which encourages citizen participation in volunteer map data collection activities, will result in more complete, current, and accurate national datasets for The National Map.

Justification for Using Crowdsourcing and Citizen Science: The USGS National Geospatial Program (NGP) is currently pursuing a two-pronged approach for acquiring and maintaining structures data (e.g., data on schools, hospitals, post offices, fire stations, cemeteries, and other important public buildings). Where available the Program is seeking authoritative national sources. To fill the gaps and improve the completeness, currency, and accuracy of the structures data, NGP's strategy is to deploy The National Map Corps (TNMCorps) in using new technologies and Internet services to enable members of the public to produce volunteered geographic information (VGI) that will update and enhance the datasets.

The volunteer effort of TNMCorps to collect and improve structures data provides many benefits to the Program, its users, and the Nation. Volunteer participation improves government efficiency, public access to data, and data quality. Participation in The National Map Corps is easy and completely voluntary and raises geographic awareness and improves users' skills in using web-based tools. Developing more complete and current structures data in The National Map may improve emergency preparedness and response. Furthermore, The National Map Corps benefits the agency and the participants by providing opportunities for citizen participation in USGS science as well as creating opportunities for collaboration with other Federal agencies and partners.

[27] The website for the The National Map Corps (TNMCorps) is accessible at https://edits.nationalmap.gov/tnmcorps.

Status: The project started in March of 2012, and is ongoing.

Location: The project encompasses the entire United States, as well as Puerto Rico and the U.S. Virgin Islands. The project takes place online, so all volunteers with internet access can contribute.

Participation: The project targets the general public. The total number of individuals involved during this period was 1,266 participants, and the average number of active participants per month was 100 users. The total number of volunteer hours was 30,828 volunteer hours for FY17 and FY18.

Consent: All users provide consent through account creation.

Submissions: Participants update and verify locations, names, and addresses for geospatial structures data for The National Map.

Resources: N/A

Partnerships: No federal or non-federal partnerships associated with this project.

Advancement of Agency Mission: The mission of the USGS National Geospatial Program (NGP) is to organize, maintain, publish, and disseminate the geospatial baseline of the Nation's topography, natural landscape, and built environment through The National Map, which consists of basic geospatial information provided as a variety of mapping products and services. The use of The National Map Corps and Volunteered Geographic Information (VGI) will result in more complete national datasets in The National Map with improved positional and attribute accuracy.

Results: The use of The National Map Corps encourages citizen participation in volunteer map data collection activities and has resulted in more complete, current, and accurate (position and attributes) national datasets in The National Map.

Data Availability: The data collected by volunteers becomes part of the National Structures Dataset, which is one of the publicly available layers within The National Map and can be found at https://www.usgs.gov/core-science-systems/national-geospatial-program/national-map.

D.6 Environmental Protection Agency (EPA)

D.6.1 Building Capacity to Measure Air Pollution Mitigation Strategies at Schools

Lead Sponsoring Agency: EPA

Authority: Clean Water Act (Section 103)

Project Summary and Goals: Studies have shown that populations spending time near busy roads face elevated risks for many adverse health outcomes including asthma, developmental effects, and premature mortality. Research indicates that noise and vegetative barriers (separately or in combination) can reduce downwind air pollutant concentrations near busy roads. In 2016, EPA funded an intramural study on the effectiveness of roadside vegetation barriers to reduce exposure to vehicle emissions at sites in Oakland and Detroit. One of those locations, Brookfield Elementary School in Oakland, CA, is directly adjacent to a busy goods movement corridor (I-880). EPA assisted in the design of a vegetation barrier that was planted next to an existing noise barrier for air pollution mitigation. EPA also took initial air samples to establish baseline air quality conditions on the school site. Subsequent funding awarded in FY18 supplemented and expanded this work by: (1) acquiring low-cost sensors and designing innovative sensor housing units so that school/community members can monitor the effectiveness of the vegetation barrier as it grows over time; (2) training sensor operators and teachers on how to collect and evaluate sampled data; and (3) developing educational materials for Brookfield Elementary. While the focus of this project is to evaluate the progress and effectiveness of the

vegetative barrier, the methods and resources can also be used to promote and evaluate the implementation of other mitigation strategies to improve air quality at schools based on the recently released EPA report "Best Practices for Reducing Near-Road Air Pollution at Schools."

Justification for Using Crowdsourcing and Citizen Science: The initial phase of this project provided expert technical guidance to the School and the project partners on how best to design a vegetative barrier to mitigate near-road air pollution exposures. Guidelines were developed and applied for how to plant an effective barrier. Many juvenile trees and shrubs have been planted; however, it will take a few years before it will be possible to measure an air quality signal related to the barrier using sensors. In the meantime, resources have been devoted to the design and production of two user-friendly sensor packages; a Solar-Powered Air Quality Sampling System and a Portable Air Quality Sampler System. In May 2018, hands-on training of the equipment was piloted with school staff, though no data were collected. The long-term nature of this project is well-suited to citizen science since the vegetation barrier will need to mature and EPA staff cannot be on hand to regularly collect research data from year to year. Instead, the EPA is investing in building the capacity for the school and its staff to be able to measure air quality on their campus in the future.

Status: The project is ongoing.

Location: The project is located in Oakland, CA.

Participation: The project targeted students and staff of Brookfield Elementary School with possible broader community involvement in the future.

Consent: N/A

Submissions: N/A

Resources: Funding amounting to $40,000 in FY17 and $38,000 in FY18 was used for contractor support, air sensor acquisition, and development of training materials. A total of 0.3 FTEs were used in both fiscal years.

Partnerships: Non-Federal partners included the Bay Area Air Quality Management District, CALFIRE, Urban Releaf, Brookfield Elementary School, and Higher Ground Neighborhood Development Corp.

Advancement of Agency Mission: This project advances the agency's mission to protect human health and the environment by researching a potentially effective mitigation strategy to reduce children's exposure to near-road air pollution. The project is utilizing two innovative approaches: 1) advanced monitoring technologies: the project has funded the acquisition of advanced portable monitoring equipment that will eventually be provided to the school/community along with two innovative sensor housing units (for both fixed site and mobile data collection); and, 2) crowdsourcing and citizen science: the project will support the provision of educational materials and training to the school/community so that they will be able to collect, process, and interpret pollutant concentration data they collect downwind of the vegetation barrier as it matures over time.

Results: Data collection by school staff and students has not yet begun. Initial data collection could begin during the 2018-19 school year.

Data Availability: N/A

D.6.2 Crowdsourcing to Monitor Private Wells and Assess Contaminant Sources

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: The goal of this project is to demonstrate how to use crowdsourcing to provide improved data to assess water quality in private water wells to protect private domestic well users. Private domestic wells (PDWs) are a source of drinking water for 15 percent of the U.S. population. Because private wells are an important drinking water source, it is incumbent upon homeowners to (1) understand potential sources of well contamination; (2) conduct testing of the appropriate parameters that may affect their well; and (3) take action on the results. This project addresses these steps, focusing on key parameters important to the water quality of private wells, including nitrate and *E. coli*. Nitrate is the most common anthropogenic contaminant found in private water wells that exceed human health standards. Assessing nitrate concentrations in private drinking water wells is especially critical in homes with young children (e.g., preparing infant formula using nitrate contaminated water is a known risk factor for methemoglobinemia or blue baby syndrome). *E. coli*, another parameter of key concern in private water wells, can emanate from human and animal fecal wastes. Wells can be contaminated from the surface where the wells are not adequately sealed or through the subsurface via contaminated ground water. In a national study of U.S. aquifers, nearly 30% of over 1100 private wells sampled tested positive for fecal-indicator bacteria.

Justification for Using Crowdsourcing and Citizen Science: Monitoring of private drinking water wells is ideally suited to crowdsourcing and citizen science. This project is being developed as a pilot to develop the training materials needed to conduct sampling, and how to understand the impacts of contamination in domestic wells and potential solutions. It is anticipated after this pilot work is completed that high school STEM classes nationally could independently carry out these efforts to protect this water supply.

Status: The project started in 2018 and is ongoing.

Location: Initially, the project took place in Arkansas high schools and is expanding to other schools.

Participation: The project targets high school STEM classes. The average number of individuals per class is approximately 15. Each class was engaged 1 to 2 times per month. The total number of volunteer hours was approximately 150 hours.

Consent: All individuals provided consent to participate in this activity.

Submissions: Water quality data.

Resources: A total of $50,000 has been allocated for the project, with $10,000 spent in FY18. These funds are being used to purchase equipment and supplies, identifying locations, coordinating with teachers and classes, develop training materials, and design the quality assurance project plan. The project requires less than one FTE per fiscal year.

Partnerships: Non-Federal partners included high school STEM classes.

Advancement of Agency Mission: This project will provide a better understanding of the extent of the fate and transport of key groundwater pollutants, temporally and spatially. It can provide important information to protect a key component of the U.S. domestic water supply.

Results: Data gathered will advance understanding of the quality of water in private domestic wells, to help ensure the safety of these water supplies.

Data Availability: These data will be made available to the public as confirmed by the owners of the wells.

D.6.3 Cyanoscope: EPA collaborative partnership on monitoring harmful algal blooms[28]

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: This program started at the request of the New England State environmental agencies and their efforts to determine how best to monitor and manage harmful algal and cyanobacteria blooms. This initial project evolved into a three-tiered program to educate people on the problem, how to monitor and provide surveillance to better understand the dynamics of harmful algal blooms (HABs), and the collection of key data to assist in determining trends, hotspots, and other important data surrounding HABs.

Justification for Using Crowdsourcing and Citizen Science: Crowdsourcing and citizen science is the most cost-effective way to collect data on HABs. HABs can be very transitory in nature, and having a large collaborative of individuals from all geographic areas provides much better coverage and monitoring/surveillance opportunities. This program provides a large educational component to those who recreate and live near these waterbodies, and offers a real opportunity for data collection that would otherwise be unobtainable.

Status: The project started in March 2013 and is ongoing.

Location: The project takes place globally.

Participation: The project targeted all interested parties. Over 300 organizations participated. Ninety percent of the collaborative effort is accomplished through joint volunteering of time and expertise.

Consent: No consent was needed.

Submissions: Image based documentation of harmful algal blooms, microscopic images of individual organisms, and fluorometric data.

Resources: This project was initially funded in 2014 and overall development has been through the volunteer efforts of the program collaborators. Total FY18 support amounted to $1000 and less than one FTE. Primary expenses were tools and monitoring equipment for surveillance and assessment capabilities.

Partnerships: Federal partners included the U.S. Geological Survey. Non-Federal partners included over 300 collaborative partners ranging from State environmental agencies, academia, lake and watershed organizations, public water suppliers, concerned citizens, public K-9 schools, tribal nations, and private industry.

Advancement of Agency Mission: Protecting the Nation's water resources for ecological and human health reasons is a primary mission of the EPA. Algal toxins in water can cause fish kills, beach closures, and result in unsafe drinking water supplies that endanger human and animal health. Using citizen science advances the mission in two major ways: (1) bringing the importance of recognizing and understanding the causes of harmful algal blooms to the attention of citizens, and (2) add to EPA

[28] The website for Cyanoscope: EPA collaborative partnership on monitoring harmful algal blooms can be viewed at Cyanos.org.

research on improved ways to identify and predict harmful algal blooms by providing more data on bloom occurrence, duration, location, and toxicity.

Results: Much of the result of this program has been educational in nature, with training close to 100 individual public water supply staff, municipal employees, and hundreds of concerned citizens. Hard data collected in the program are used to identify trends, hot spots, areas of improvement from management practices, etc.

Data Availability: Data will be made available to the public using an existing cyanobacteria collaborative webpage where data visualization and data input is currently under development (cyanos.org). These data will be incorporated with other data and collected using the consistent quality assurance protocols and methods to ensure data compatibility. No numeric data from this project are available yet, but image data have been posted on two of our collaborative's webpages https://www.inaturalist.org/projects/cyanoscope and https://www.citsci.org/CWIS438/Browse/Project/Project_Info.php?ProjectID=822&WebSiteID=7 .

D.6.4 EPA/US Coast Guard Auxiliary Partnership for HAB Monitoring

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: The goal of this project is to engage the Coast Guard Auxiliary in the Cyanoscope project. This will increase the volume of data on harmful algal blooms (HABs).

Justification for Using Crowdsourcing and Citizen Science: The United States Coast Guard Auxiliary (USCGA) is a volunteer organization that supports the U.S. Coast Guard whose mission includes such tasks as monitoring aids to navigation, surface vessel towing, providing assistance to boaters, and providing public education in boating and safety to the recreational boating community. The project presented an opportunity to form an EPA/USCGA partnership under the public education-marine safety program. The USCGA has numerous surface (boats) and air (helicopter and fixed wing air craft) assets that could be used to support EPA efforts to monitor and sample for conditions that lead to HABs and to provide sampling of water bodies to mitigate their effects. The number of Coast Guard Auxiliary members and the number of vessels that the USCGA increases the number of samples potentially collected and the area that can be studied, thereby increasing the number of individuals aware of HABs and their negative environmental consequences. Sampling efforts can be expanded to include tow net sampling for nutrients or selected organisms as needed given the availability of USCGA surface vessels.

Status: The project started in March 2017 and is ongoing.

Location: The project is based in the United States.

Participation: The project targeted members of the United States Coast Guard Auxiliary. The total number of individuals involved during this period was initially thirty.

Consent: No consent needed.

Submissions: Anticipated submissions are physical observations and data from CyanoScope HAB identification.

Resources: Funding ($17,000) was only used in FY17; less than one FTE was used in FY17 and FY18. Resources were used to hold interagency workgroup meetings and manage communications with USCG and USCGA contacts about training on the Cyanoscope program. A FY18 memorandum of understanding fostering EPA and USCGA cooperation will be used to conduct training on the Coast Guard Auxiliary in how to contribute observations to Cyanoscope.

Partnerships: Federal partners included the United States Coast Guard Auxiliary.

Advancement of Agency Mission: Harmful algal blooms and associated hypoxia events have devastating consequences for ecosystems, communities, and the health of humans, pets, livestock, and wildlife. Recent large scale HAB events in lakes and reservoirs across the country, as well as in large river systems (e.g., Ohio River), emphasize the need for further research to improve water quality and protect public health. HABs occur when physical, chemical, and biological conditions are optimal for bloom development. Previous research identified factors that influence the likelihood of bloom development, including physical drivers such as rainfall, extreme events, stratification, currents, wind, and mixing as well as temperature and light penetration. Protecting the Nation's water resources for ecological and human health reasons is a primary mission of the EPA. Algal toxins in water can cause fish kills, beach closures, and can cause unsafe drinking water supplies. Citizen science advances the EPA's mission in two major ways: (1) bringing to the attention of citizens the importance of recognizing and the causes behind harmful algal blooms, and (2) adding to the research on the identification and prediction of harmful algal blooms by providing more data on bloom occurrence, duration, and location.

Results: The data collected in this effort will augment data already being collected in Cyanoscope and other ongoing Nutrient/HAB research efforts at EPA.

Data Availability: Data will be made available to the public using an existing Cyanobacteria Monitoring Collaborative webpage where data visualization and data input is currently under development (cyanos.org). This data will be incorporated with other data and collected using the same protocols and methods to ensure data compatibility. No data from this project is available yet.

D.6.5 HiveScience: A Citizen Science Project for Beekeepers[29]

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: HiveScience is a citizen science project designed for beekeepers that promotes EPA public engagement around collecting data on hive health, an important research issue at the local, national and international levels. For this project, beekeepers collect data on the health status of honey bee hives, submit a sample of honey for laboratory analysis for biomarkers of honey bee immune response, and provide data on the overwintering fate of sampled hives using an EPA-branded mobile application. Ultimately, these data will be used to determine if there is a correlation between biomarkers of honey bee colony health and actual colony overwintering performance.

Justification for Using Crowdsourcing and Citizen Science: The beekeeping community is acutely aware of the issues affecting honey bee colony health and is motivated to find solutions. Recognizing the limited capacity of State and Federal agencies to monitor and sample a sufficiently large sample of honey bee colonies, partnering with beekeepers is really the only viable solution. The network of engaged citizen scientists established through this project will increase the likelihood of identifying cost-effective tools capable of predicting honey bee hive health, reducing colony losses, and saving beekeepers both time and money.

Status: The project started in February 2017 and is ongoing.

Location: The project takes place on a National scale.

[29] The website for HiveScience: A Citizen Science Project for Beekeepers can be viewed at https://www.epa.gov/citizen-science/hivescience.

Participation: The project targeted beekeepers. The total number of individuals involved during this period was 100. The total number of volunteer hours was around 200 hours.

Consent: All participants consented to participation by actively downloading the project-specific smartphone mobile application and opting to request a honey sample kit.

Submissions: Volunteer beekeepers completed a hive health survey for one honey bee hive using an EPA-provided smartphone mobile application. The smartphone application also recorded the general location of the honey bee hive. In addition, beekeepers submitted a honey sample from the monitored hive.

Resources: Funding ($35,000 in FY17 and $30,500 in FY18) and agency personnel (less than one FTE in both years) were used to (1) create project-specific smartphone mobile applications (iOS and Android), (2) equip volunteer beekeepers for honey sample collection, (3) develop laboratory methodologies for measuring the production of hydrogen peroxide in honey samples submitted by volunteer beekeepers, and (4) provide student services contract support. The smartphone mobile applications were completed through collaboration with EPA's Office of Environmental Information.

Partnerships: Federal partners included the National Institute of Environmental Health Sciences and the U.S. Department of Agriculture's Agriculture Research Service. Non-Federal partners included the Eastern Missouri Beekeeper's Association.

Advancement of Agency Mission: HiveScience was developed in direct response to commitments made by the EPA in the National Strategy on Pollinator Health and its associated Pollinator Research Action Plan as well as the broader research needs identified in the Colony Collapse Disorder (CCD) and Honey Bee Health Action Plan.

Results: This project was launched less than two years ago and is still in the data collection phase. Some data (i.e., Varroa mite counts, mite mitigation, and general location) related to honey bee colony health assessments are readily accessible on a public webpage (i.e., Geoplatform). Beekeepers can use these data to learn about effective hive management strategies. As the project matures, data will be used to identify biomarkers that are predictive of honey bee colony health. Novel, cost-effective tools will be developed and made available to beekeepers. These tools will be useful for reducing colony losses thereby saving beekeepers time and money. It is anticipated that this project will phase-out in FY19.

Data Availability: Some data (i.e., Varroa mite counts, mite mitigation, and general location) related to honey bee colony health assessments are readily accessible on a public webpage (i.e., Geoplatform).

D.6.6 Kansas City Transportation and Local Scale Air Quality Study (KC TRAQS)

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: KC TRAQS crowdsourcing and citizen science (CCS) was one component of a larger project that includes fixed sites with research grade monitors, research grade mobile monitoring, and modeling. The CCS part of the project had two goals: (1) to evaluate the ability of citizen scientists to collect valid air quality data with little training in collection methods using a custom sensor package, and (2) to evaluate the ability of the AirMappers, a low cost and portable air monitoring package, to collect valid data that can be used for Federal, State, and local air monitoring needs. The project also provided an opportunity for providing educational outreach. The project was being conducted by loaning AirMappers to participants in two ways. (1) Scheduled deployments to participating groups and library checkouts were conducted by giving a presentation to area middle and high school students and the loan of five AirMappers for one week to a class. The class conducted their

own experiments using the AirMappers, but were asked to keep notes and take measurements outdoors in the study area. Other groups in the study area scheduled a similar loan of the equipment, though only one group has participated. 2) AirMappers were also loaned to two libraries in the study area for check out to community members. Those who checked out the AirMappers were provided a manual and contact information for the study leads.

Justification for Using Crowdsourcing and Citizen Science: The only way to gather data on the effectiveness of CCS campaigns is to include citizen science in the study. The awarding of grants or other means to collect data are less effective for this type of study because the agency loses some control of the collection of data and decisions on how the study is conducted.

Status: The project started in October 2017 and concluded in October 2018.

Location: The project is located in Kansas City, KS.

Participation: The project targeted middle and high school classes, community volunteers, and organized group volunteers. There were two organized group volunteers, approximately seven community volunteers, and approximately 20 to 25 classrooms led by nine teachers that participated. Up to two class rooms per week were active during the school year. During the summer, there were two group volunteers and up to two community volunteers per week.

Consent: The libraries and community volunteers provided consent with sign out agreements. The classrooms provided consent through emails with the teachers who participated.

Submissions: Participants collected data using a custom air monitoring package, called the AirMapper. They turned in approximately 50 *Submissions:* 20 to 25 middle and high school classes, 22 library check out submissions (days of use), and one long term scheduled deployment.

Resources: FY17 funds ($50,000 and less than one FTE) were used to build the AirMappers and interact with participants.

Partnerships: N/A

Advancement of Agency Mission: The CCS part of the KC TRAQS project supports the EPA's mission to protect human health and the environment by investigating how air pollutants move in a valley with many transportation-related sources of pollution, determining the contributions of various sources of air pollutants, and by comparing different technologies' capabilities to collect this data. The CCS part of the project investigates the ability of low-cost monitors and citizen scientists to provide quality data, which could increase the ability of all interested parties and reduce costs of collecting environmental data. It also increases public awareness of environmental effects of transportation-related sources of air pollutants on human health by encouraging public participation in data collection.

Results: Science questions pertaining to the citizen science component of the larger KC-TRAQS project were: Can the effectiveness of a self-driven community measurement project be quantified? What is the suitability of a sensor instrument package (e.g., AirMapper) to support real-time mapping of particulate matter by citizens? What is the added value of citizen science in the research process and can this value added be quantified? The goal is to use data collected by the citizen science instrument package (i.e., AirMapper) in analyses that will also use data collected by more traditional methods (i.e., FEF/FRM instrumentation, lower-cost sensors, etc.). These results may be used to inform future citizen science projects (i.e., lessons learned) and also increase community environmental awareness.

Data Availability: All data from the KC TRAQS project will be made available to the public. A website will be created once the project is finished and all data have been collected, organized, and quality assured.

D.6.7 Marine/Water Contact Sanitary Survey Workshops in California[30]

Lead Sponsoring Agency: EPA

Authority: Beaches Environment Assessment and Coastal Health (BEACH) Act

Project Summary and Goals: EPA conducted three day-long workshops in California to educate and train local watershed managers, citizen scientists, environmental justice organizations, and tribal members on EPA's new Sanitary Survey App. The Marine Sanitary Survey App is based on the marine beach sanitary survey form and was developed to provide a technically sound and consistent approach to identify pollution sources and share information (e.g., water quality data, pollutant source data, and land use data) to improve water quality for swimming and other primary contact recreation activites. This was a collaborative outreach effort with the California State Water Resources Control Board's (SWRCB) Clean Water Teams within California Regional Water Quality Control Boards 4, 5, and 8 and onsite co-sponsorship with local and tribal organizations, including the Inland Empire WaterKeeper, Heal the Bay, and the Big Valley Rancheria of Pomo Indians. At each workshop, EPA and the California SWRCB demonstrated the utility of the app and hands-on training for participants.

Justification for Using Crowdsourcing and Citizen Science: Local citizens react positively to training that will help improve water quality. The direct hands-on contact that CCS provides for interested local watershed managers, citizen scientists, environmental justice organizations, and tribal members empowers them to learn how to better manage water bodies. After the training, citizen scientists are able to collect data to identify sources of pollution that cause beach closures or impairment of recreational uses of their waters. With this information they are empowered to identify solutions to improve the quality of local waterbodies.

Status: Workshops were held on September 21 (California RWQCB 5) in Riverside County – Inland Empire WaterKeeper; September 23 (RWQCB 4) in Los Angeles County – Heal the Bay; September 26 (RWQCB 8) in Clear Lake Watershed – Big Valley Rancheria of Pomo Ind. All scheduled events are complete.

Location: The project is located in California.

Participation: The project targeted local beach managers, citizen scientists, and tribal members. The total number of individuals involved during this period was 75, and the average number of active participants was 25+ per workshop. The total number of volunteer hours was 700.

Consent: A total of 75 individuals provided consent to participate in this project.

Submissions: N/A

Resources: There is no direct standing budget allocation in the Office of Science & Technology for this CCS project. However, EPA was able to work with partners to leverage resources to obtain space to hold the workshops and logistics for shipping materials. FY17 funds ($7,500) were used for workshop preparation and administrative support, travel, scheduling and selection of suitable training sites and related coordination, preparation of training materials, shipping materials, setting-up training rooms, and on-site coordination and support (0.25 FTE).

Partnerships: Federal partners included EPA Region 9. Non-Federal partners included the California State Water Resources Control Board and California Regional Water Quality Control Boards 4, 5, and 8 as well as onsite co-sponsorship with local and tribal organizations, including Inland Empire WaterKeeper, Heal the Bay, and the Big Valley Rancheria of Pomo Indians.

[30] The website for the Marine/Water Contact Sanitary Survey Workshops in California can be viewed at https://www.youtube.com/watch?v=w57F_nSV0a4&list=PLMSa5d-iIl6OsjuwK3Fh0tH6D4BOmFneV.

Advancement of Agency Mission: Under the Clean Water Act of 1987 (CWA), EPA reviews and approves water quality standards (WQS), which are established by states and authorized tribes. WQS reflect the management goals for water bodies, must be scientifically sound, and must protect the designated uses of the water body. Additionally, under the BEACH Act amendments to the CWA, EPA supports states, tribes, and local governments in protecting pubic health at beaches. EPA's Office of Science and Technology is responsible for overseeing the national WQS program and the national Beach Program. As a part of this responsibility, the Standards and Health Protection Division (SHPD) provides technology transfer, training, and outreach to water quality professionals and beach managers associated with Federal, State, tribal, and local agencies as well as those within the private sector. As a part of its outreach program, SHPD has been offering comprehensive training sessions since 1991.

Results: The science shared via the Sanitary Survey workshops has enabled participants to better understand their strategies for monitoring fecal indicator bacteria and placing data into context. Having the workshops at various venues throughout California generated interest in adopting water contact surveys by organizations that did not participate in the workshops. To further leverage the workshop's impact, and due to this interest, California produced a video series featuring presentations from the workshop, which can be accessed at www.youtube.com/watch?v=w57F_nSV0a4&list=PLMSa5d-iIl6OsjuwK3Fh0tH6D4BOmFneV. The EPA's collaboration with the State Water Resources Control Board and the Clean Water Team also led to the video An Introduction to Sanitary Surveys, which can be accessed at https://www.youtube.com/watch?v=e2aFg0dauVQ&index=3&list=PLvTjRb8VCkp5xsM7UgA6769YzPlYeiA0r. This video was recorded from a live webinar presentation hosted by two work groups from the California Water Quality Monitoring Council, Safe to Swim, and California Water Quality Monitoring Collaboration Network, as part of the Swimmable California Webinar Series 2017-2018. The training is bearing fruit. In 2018, several of the inland water quality monitoring programs in California are adopting/have adopted water contact sanitary surveys as part of their routine science programs to address fecal contamination in their recreational waters.

Data Availability: Making environmental data open and accessible is important to USEPA. Likewise, this was important to workshop participants. The current table-based app allows the user to collect and export sanitary survey data. However, EPA does not collect this information.

D.6.8 Measuring Coastal Acidification in New England Estuaries

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: Four states in New England have established commissions or legislation to increase investment in research, monitoring, and mitigation strategies to address acidification of coastal areas. High resolution measurements of pH and total alkalinity (the ability of seawater to buffer against acidification) can help coastal water managers assess the health of local estuaries and better understand the threats to these ecosystems and shellfish species. This project will lend new, high quality, more affordable sensors to local volunteer water quality organizations and build capacity at the New England Regional Laboratory (NERL) to measure total alkalinity in seawater samples. These water quality citizen science volunteers will then be able to accurately measure pH and send water samples to the laboratory for total alkalinity analysis, providing valuable insight for coastal management decisions.

Justification for Using Crowdsourcing and Citizen Science: Volunteer water quality monitoring is a cost-effective way to collect data.

Status: The project started contacting potential partners in September 2018.

Location: The project is located in Maine, New Hampshire, and Massachusetts estuaries.

Participation: The project targeted watershed, estuary, and bay protection groups and national estuary programs.

Consent: N/A

Submissions: Water samples to be analyzed for total alkalinity; instrument readings of pH.

Resources: In FY18, $50,000 and less than 0.1 FTE were used to provide equipment, supplies, and contract support.

Partnerships: Federal partners included NOAA's Ocean Acidification Program and Sea Grant. Non-Federal partners included the Northeast Coastal Acidification Network (NECAN), and the states of Maine, New Hampshire, and Massachusetts.

Advancement of Agency Mission: One of EPA's missions of is to protect water quality. The Clean Water Act requires criteria and standards to protect aquatic life and other designated uses. Measurements of coastal acidification will assist the agency in better understanding the variability of calcium carbonate concentrations that specifically impact shellfish resources.

Results: This approach provides new monitoring technology to citizen scientists, which will provide a more regional perspective on the variability of coastal acidification in New England. This project leverages the network of established partners including the Northeast Coastal Acidification Network (NECAN), National Estuary Programs, State coastal managers, and the Integrated Sentinel Monitoring Network, which targets ocean and coastal acidification as an opportunity for development of a network of monitors. This project will educate the public and other stakeholders about the threats posed by coastal acidification and will supplement other data that evaluates threats to aquatic life, as required by the Clean Water Act.

Data Availability: Data will be made public, but the data management plan has not been established yet. EPA plans to utilize existing resources such as NECAN, Northeastern Regional Association of Coastal Ocean Observing Systems, and the Ocean Acidification Information Exchange.

D.6.9 Micro CSI-Urban Edition: A Microbial Citizen Science Initiative in Urban Watersheds

Lead Sponsoring Agency: EPA

Authority: Clean Water Act

Project Summary and Goals: Across the Nation, a number of citizen science efforts have been conducted to monitor water quality. Efforts have included monitoring of bacteriological parameters (*E. coli*, enterococci, and fecal coliforms) and/or physicochemical parameters (e.g., temperature, turbidity, pH, conductivity). Although these efforts are extremely useful to identify a problem area, they can be limited in scope due to insufficient resource availability, human manpower, or even sampling logistics. Likewise, monitoring efforts conducted by county, city, and State governments to identify water quality issues are often limited due to funding and/or lack of available personnel. The aim of our proposal is to build Urban MicroCSI, a program bringing together the efforts of citizen scientists from a variety of urban locations. Information gathered by citizen scientists on microbial water quality will be collected in a central location and used to adapt a statistical modeling tool (Virtual Beach) already used in recreational beaches to urban streams. Virtual Beach will facilitate identification of stream locations prone to impairment due to fecal bacteria and the environmental conditions that produce impairments. The effort will include source identification to better inform mitigation practices.

Justification for Using Crowdsourcing and Citizen Science: One of the main drivers of using this type of program is to facilitate water quality monitoring efforts by citizen scientists and encourage community participation in activities promoting environmental awareness. Sampling surface waters for water quality analysis can be an expensive activity for State and local governments. Monitoring by citizen scientists presents a cost-effective alternative, but it is imperative that the data abides to a QA/QC level acceptable under regulatory criteria. Using CCS allowed testing of the quality and usability of the data, sampling efficiency, and sampling coverage. The program provides an example of how other communities can develop similar monitoring programs using citizen scientists.

Status: The project started in December 2016 and is complete.

Location: The project is located in Proctor Creek and Oconee River Watersheds in Atlanta and Athens, GA, respectively.

Participation: The project targeted volunteers from the city of Atlanta for the Proctor Creek watershed, and University of Georgia (UGA) students in Athens for the Oconee River watershed. More than 30 individuals were involved during this period, and the average number of active participants per week was three.

Consent: Volunteers collecting samples in Proctor Creek Atlanta agreed to participate under a program called Neighborhood Water Watch, a community driven collaborative program between the Chattahoochee River Keeper and local neighborhood groups. In addition, the Chattahoochee River Keeper trains volunteers on sample collection and analysis under an EPA approved QAPP. Students from the University of Georgia agreed to perform sample collection and analysis as part of a class integrating experiential learning in the curriculum.

Submissions: The participants provided data, and shipped or delivered water samples to the EPA.

Resources: A Federal employee (1.0 FTE) designed and coordinated the overall project, managed the contract, and reviewed data for accuracy. Part of the funds ($56,000 in FY17 and $18,000 in FY18) were used to buy materials for sampling kits, materials used to quantify fecal indictors, and reagents to perform DNA extraction and analysis. Money was also used to buy a multiprobe meter to measure environmental parameters and pay volunteer coordinators in Atlanta and Athens. Other resources included efforts by a sustainability class at UGA focusing on experiential learning, which provided volunteers and data during the last sampling semester. Federal staff performed data management and reviewed data for presentation.

Partnerships: Non-Federal partners in Athens included the River Basin Center and Watershed UGA, both at the University of Georgia. In Atlanta, the Non-Federal partner was the Chatahoochee River Keeper.

Advancement of Agency Mission: One of EPA's needs identified in the review of the Beaches Environmental Assessment and Coastal Health Act is the need to provide alternative methodologies for rapid water quality assessments. The need is not only valid for coastal waters, but it is also highly needed for inland waters. The aim of this project was to develop a robust set of information suitable to test and implement the use of Virtual Beach for the rapid assessment of bacterial impairments in urban watersheds. Virtual Beach is a statistical tool developed for freshwater and marine beaches to rapidly identify fecal bacterial levels exceeding ambient water quality criteria using easy to measure environmental parameters. This project will provide information needed by the EPA to test the applicability of the model for urban watersheds. In addition, microbial source tracking information will be integrated to determine the prevalent sources of contamination impacting urban hotspots.

Results: The results from this project will be used to increase environmental education and awareness of citizen scientists on the impact of fecal contaminants in urban streams; develop easily transferable

protocols for the collection by citizen scientists of meaningful data usable for the development and testing of models; empower and encourage local NGOs to develop a consistent and sustainable sampling and analysis plan that provides a reliable source of information for the local government and fosters a healthy partnership in which citizen scientists are an essential part of the process; and finally, it will make Virtual Beach-Stream and River Module widely available to local governments, so that they can use it to better allocate resources when determining and implementing mitigation strategies.

Data Availability: The data collected will be available to the public in a variety of ways. The data from Proctor Creek in Atlanta has been posted in the Chattahoochee River Keeper website, under the neighborhood water watch (https://nww.chattahoochee.org/DataPage). The data collected in Athens, GA will be integrated with the monitoring performed by UGA students under the watershed UGA effort and which will reside in a variety of google documents available to students for a variety of analysis. In addition, some of the data can be found in the Upper Oconee Watershed Network site (http://uown.org/UOWN-Wordpress/monitoring-results). Finally, the data will be available to the scientific community in the form of manuscripts that are currently under preparation by both EPA and UGA.

D.6.10 Using Citizen Science to Analyze Underwater Videos in the Great Lakes[31]

Lead Sponsoring Agency: EPA

Authority: Clean Water Act § 104, 33 U.S.C. § 1254

Project Summary and Goals: The goal of this project is to evaluate a web-based citizen science approach to analyzing underwater videos in the Great Lakes to determine substrate type and presence of invasive species, such as round gobies or dreissenid mussels. Citizen scientists will be trained and tested for accuracy using a subset of underwater videos. The relative precision, accuracy, and cost-effectiveness of the citizen science approach will be compared to expert video interpretations. In addition to increasing our understanding of habitat characteristics and invasive species in the Great Lakes, this project aims to address the following questions: Can a citizen science approach to underwater video analysis meet the information needs of managers? How does the data produced by citizen scientists compare to the data produced by experts in terms of precision, accuracy, and relevancy to management needs? What effects, if any, does video quality and attribute selection have when comparing analysis of experts and citizen scientists?

Justification for Using Crowdsourcing and Citizen Science: A citizen science approach to underwater video analysis provides a cost-effective means for individual videos to be analyzed by multiple viewers. Multiple analysts increase precision and reduce bias but trained professional analysts are expensive. The cost to hire a single expert to review each video is $36,000. The CCS project also offers the opportunity to analyze and share results with the public in a more timely manner than would be possible having experts analyze the videos.

Status: A stakeholder input group was convene in Fall 2017. The project was designed in early 2018 and beta-tested in May – July 2018. Updates to the application are being made and tested, with a public launch planned for 2019. The project is ongoing.

Location: The project is located in the Great Lakes Region of the United States.

[31] The website for Using Citizen Science to Analyze Underwater Videos in the Great Lakes can be viewed at https://www.zooniverse.org/projects/USEPA/deep-lake-explorer.

Participation: The project targeted public and tribal, local, State, and Federal partners with 161 participants visiting the website in the beta-testing phase.

Consent: N/A

Submissions: In the beta-testing phase, 468 images were clipped from 52 videos representing 52 sites. Each image needed to be viewed 15 different times by different people. One hundreed and fifty video clips were pulled from 28 videos representing 28 sites, and each video need to be viewed 10 times each. When reviewing a video clip, three questions were answered and when viewing a image, two questions were answered. As a result, there were approximately 18,540 data submissions.

Resources: In FY17, EPA staff coordinated with stakeholders and designed and managed the project on the crowdsourcing website Zooniverse. A contractor provided technical support to run statistical analysis, modify videos to be used, and assist with programming. Total funding was $12,000 and required less than one FTE. In FY18, Federal staff upgraded the web-based project on the Zooniverse platform to include higher quality videos. External funding was used for video processing and contract support for the redesign and execution of the project. The FY18 budget was $25,000 and required less than one FTE.

Partnerships: Non-Federal partners included the Wisconsin Department of Natural Resources and Michigan Department of Natural Resources with a stakeholder team from 14 other non-Federal agencies. In addition, staff from different offices within EPA helped design the website

Advancement of Agency Mission: To effectively protect and restore water quality, EPA, states, and tribes need high quality data and information. Underwater videos are a tool being developed to help with assessing the overall condition of the Great Lakes as part of the National Coastal Condition Assessment, one of the surveys under the National Aquatic Resource Survey Program. The National Aquatic Resource Surveys (NARS) are collaborative programs between EPA, states, and tribes designed to assess the quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands using a statistical survey design. This work to improve our ability to process, analyze, and assess videos of underwater features and characteristics in a timely and cost-effective approach will increase the viability of using this technology as part of NARS and State/tribal water quality assessments.

Results: Although results from the beta-test are still being evaluated, preliminary results demonstrated that citizen scientists were able to identify substrate type, round gobies, and vegetation. The team also found that the use of crowdsourcing shows promise in being an acceptable and cost-effective means of interpreting/screening videos for experts to analyze in more depth. Additionally, the team learned that the agreement between citizen scientists and expert analysis would likely improve if the quality of the video was improved. Using the finding, the FY18 effort will focus on re-evaluating the tool with higher quality videos. Finally, the team will also be working on establishing a smooth and effective workflow so that when videos collected in 2020 as part of the National Coastal Condition Assessment are submitted, they will be processed and results can be shared in a timely manner that will be useful to resource managers in the Great Lakes.

Data Availability: Results from the beta-test are being reviewed. The preliminary results were shared with stakeholders in August 2018. Results of the beta-test from sites where there was agreement between experts and citizen scientist will be included on the Deep Lake Explorer website and in the 2015 NCCA reports. A report will be posted for the general public and participants at https://www.zooniverse.org/projects/USEPA/deep-lake-explorer.

D.6.11 Using Citizen Science to Improve Drinking Water Epidemiology Studies in Puerto Rico[32]

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: The goal of this project is to showcase the simplicity of an innovative saliva test and improve the way epidemiology studies are designed using citizen science. Families with 3rd to 5th graders will report incidences of gastrointestinal disease to science teachers to facilitate follow-up stool and saliva tests in impacted school districts. The innovative saliva tests use salivary antibodies as a non-invasive indicator of waterborne infections. The project will prepare instructions for parents on how to report incidences of gastrointestinal illness that will be sent home with students at the start of the school year. The school districts in participating rural communities will collect health data when illnesses occur to maximize the effectiveness and improve the results of the epidemiology study. The incidence of illness will then be linked to specific community water systems using Safe Drinking Water Act sample results and violations. This project is important because it inspires citizens (i.e., non-experts) to actively participate in targeted studies to improve their health and understanding of water treatment. A secondary benefit will be the educational aspect for students. School science teachers will encourage students to participate, promote the scientific method behind this epidemiology study and provide information on waterborne illness, human health, and personal hygiene.

Justification for Using Crowdsourcing and Citizen Science: Citizens in Puerto Rico have a great interest in and can be positive contributors to environmental protection and the health of their communities. This citizen science project builds on a long history of working with citizens, community groups, students, and volunteers in rural communities in Puerto Rico. It allows community citizen scientists to become engaged in the process of linking their illnesses to pathogens in their drinking water systems. With the project-generated communication materials, citizens will understand the reason for the study, the trigger points/timing for collection of stool and saliva samples, and the results of the tests. School science teachers are assisting with the recruitment and retention of volunteers and will be able to provide answers to questions at a local level. Funding for this study is providing guidelines on quality assurance and quality control for dissemination to school science teachers and participants in the study.

Status: The project started in August 2017 and is ongoing.

Location: The project is located in Patillas, Adjuntas, and Yabucoa, Puerto Rico.

Participation: The project targeted 3rd to 5th grade school children. The total number of individuals involved during this period was 198 participants. Recruitment and training of school officials and science teachers required an estimated 100 hours, education and participation of 3rd -5th grade students required 600 hours, and survey completion by parents required 100 hours (a total of 800 volunteer hours).

Consent: Human Subject Research (HSR)-000997 approval, Information Collection Request (ICR) 2080-0083 approval, Puerto Rico Dept. of Education and private school approval.

Submissions: A total of 198 participants (33 3rd to 5th Graders from 6 private/public schools) will provide stool/saliva at the beginning of the Citizen Science Epidemiology Study and when gastrointestinal illness (GI) occurs for collection and analysis by Pegasus Technical Services, InterAmerican University in Puerto Rico, and EPA Office of Research and Development (ORD) in Cincinnati, Ohio. Surveys will also

[32] The website for Using Citizen Science to Improve Drinking Water Epidemiology Studies in Puerto Rico can be viewed at https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=340734.

be filled out by parents and 3rd to 5th graders to document the impact of diet and drinking water sources on GI

Resources: One FTE and $3,000 were used in FY17 for supplies and equipment. One FTE and $53,000 were spent in FY18 on extramural support for preparation of Internal Review Board and Information Collection Request applications, the InterAmerican University Work Plan, Quality Assurance Project Plan and Health and Safety Plan to conduct the study in schools in rural Puerto Rico.

Partnerships: Non-Federal partners included Pegasus Technical Services, InterAmerican University, Department of Education, and Private Schools in Puerto Rico.

Advancement of Agency Mission: A majority of Safe Drinking Water Act violations occur in small rural communities that are economically challenged and cannot afford to provide basic filtration and disinfection treatment processes or pay operators to maintain their water systems. As a result, residents are vulnerable to acute illnesses caused by microbial and chemical contaminants. Often, episodes of diarrhea in isolated rural communities follow patterns that become a way of life. One way to identify risk factors for disease is to conduct epidemiology studies that document illness rates, and at the same time, involve and educate members of the community in the process.

Results: This citizen science project investigates the incidence and type of gastrointestinal illness using fecal and saliva tests in communities in Puerto Rico that do not have a municipal drinking water treatment plant. ORD will use saliva tests to look at the incidence of several bacterial and viral pathogens. Additionally, DNA extracted from stool samples will be used to determine the abundance of different bacterial groups, including fecal indicator bacteria, fecal source indicators, bacterial pathogens, and virulence factors. Overall, the information from this project is critical to identify the etiological agents and to evaluate the effectiveness of water treatment.

Data Availability: The data obtained during the study will be publicly available upon publication in a peer-reviewed journal article without personally identifiable information or sensitive personal information. Data will also be available in EPA Science Hub publication datasets.

D.6.12 Low Cost Sensors for Real-time Continuous Water Quality Monitoring in Georgia[33]

Lead Sponsoring Agency: EPA

Authority: Clean Water Act

Project Summary and Goals: The purpose of this study is to evaluate select low-cost water quality sensors in comparison to industry standard equipment as part of a regional innovations initiative supported by the U.S. EPA's Office of Research and Development (ORD). Non-point source monitoring programs, such as Georgia Environmental Protection Division's (GAEPD's) Georgia-Adopt-A-Stream (GA-AAS), that utilize citizen science data collected through volunteer monitoring efforts at the community level are vital to understanding base-line water quality conditions and the state of our nation's waters. In recent years a rapid expansion of open source resources and support have made the design and deployment of low-cost water quality sensors accessible to watershed monitoring organizations, researchers, students, and citizen scientists alike. The U.S. EPA currently maintains an Air Sensor Toolbox for citizen scientists but there is no analogous resource for low-cost water quality sensors. There is currently very limited information on the capabilities and quality of data collected by these emerging low-cost alternatives.

[33] The website for Low Cost Sensors for Real-time Continuous Water Quality Monitoring in Georgia can be viewed at https://github.com/CWQM/sensor-code.

Justification for Using Crowdsourcing and Citizen Science: Non-point source monitoring programs such as GA-AAS currently monitor a wide range of sites in different environments and conditions. This project took advantage of the pre-established network of active volunteers to assist in testing the ease of use and reliability of low cost water quality sensors. Citizen science eliminates the need to find installation locations and reduces travel and FTE on the part of EPA.

Status: The project started on January 23, 2018 in August 2017 and the sensor evaluation study with associated final report was completed in August 2018. . The use and testing of the sensors by volunteer monitoring organizations is ongoing.

Location: EPA Region 4 (Southeast U.S.)

Participation: The project targeted active members of Adopt-A-Stream. In total, 15 monitoring organizations participated in the sensor design workshop and subsequent field testing of the sensors. The total number of volunteer hours was estimated to be around 2,000 from all 15 groups.

Consent: Consent was obtained from 15 volunteering water quality monitoring groups.

Submissions: Observations on equipment, ease of use, durability, and technical issues.

Resources: In FY17, 0.25 FTE was dedicated to project proposal development and conceptual design of a sensor prototype and $27,000 was spent on equipment and supplies required to build and test the prototype sensor and build 20 replicate units during a public workshop and field study planned for FY18. In FY18, less than a $1,000 and 0.75 FTE was dedicated to designing and testing a sensor; pre-assembly of units prior to a public workshop; developing and presenting the workshop; installing, maintaining and troubleshooting equipment; providing support to adopt-a-stream; analyzing data; and writing the final report.

Partnerships: Non-Federal partners included GAEPD's GA-AAS and the University of Georgia.

Advancement of Agency Mission: Quantifying the cumulative water quality impacts on watersheds remains both a regional and national science priority and remains a top research priority for many of the states as summarized in a 2016 survey conducted by the Environmental Research Institute of the States. Collecting in-situ measurements of water quality via traditional instantaneous measurements is often inefficient and ineffective at observing natural patterns, trends, and assessing overall ecological health in extremely dynamic systems. Furthermore, collecting data during storm events can also be difficult and dangerous using traditional means. Advancements in monitoring technologies have made real-time continuous monitoring of water quality possible. This study will provide insight into emerging technologies and how they might be used by citizen scientist to assist in protecting human health and the environment.

Results: Data collected by the citizen science groups involved in this project is for their use. Feedback from the groups will be used in further development of equipment suggestions by EPA.

Data Availability: Data collected by the citizen science organizations involved in this project is shared at their discretion.

D.6.13 Smoke Sense[34]

Lead Sponsoring Agency: EPA

Authority: N/A

Project Summary and Goals: Smoke Sense is a citizen science, crowdsourcing initiative that leverages individual citizen's observations of wildland fire smoke and its health effects to broaden the knowledge base about smoke exposures and how they impact communities. Smoke Sense is facilitated through a mobile application that allows users to explore their current and forecasted daily air quality, maps of fire locations, and satellite images of smoke plumes. It also provides a means for users to learn about health consequences of exposure, record their own health effects, and explore smoke exposure and health in their local community. When combined with educational trivia games, these novel mobile health components promote preventive health behaviors. In total, Smoke Sense delivers an unprecedented degree of resources for wildfire smoke and air quality tracking and health effects management directly to citizen science users. EPA and other researchers will use the observations to determine the extent to which exposure to wildfire smoke affects health and productivity, and to help develop health risk communication strategies that improve public health on smoke days.

Justification for Using Crowdsourcing and Citizen Science: Citizen science and participatory research is the best way to reach individuals when and where hazardous conditions are likely to present as well as when and where individuals need the health risk information the most. The citizen science approach also facilitates democratization of knowledge and issue engagement in a way that other research approaches cannot. The cost of similar-size studies conducted in a traditional way would possibly reach into multiple millions of dollars.

Status: The project started on August 1, 2017 (Android) and October 1, 2017 (iOS) and has been extended beyond its initial completion date.

Location: The project is located in the United States.

Participation: The project targeted participants who are expected to be geographically located across the United States, particularly where wildfires and smoke events are likely to occur. The Smoke Sense mobile app was downloaded more than 5,000 times during the pilot data collection season. Because of the success of the app, EPA obtained permission to keep the app running on EPA servers but had to temporarily disable some functionality. By August, 2018, Smoke Sense had over 13,000 users.

Consent: Participants are not able to use the app without confirming willingness to participate.

Submissions: Participants report their smoke observations and symptoms.

Resources: Under the EPA's Strategic Plan FY2014-2018, the Office of Research and Development initiated research efforts to evaluate the abilities of environmental models to provide timely information on when and where hazardous conditions are likely to present a risk to public health, and on the effectiveness of public health communication strategies that rely on these models to reduce the public health burden. In FY17, a budget of $125,000 and one FTE were used to fund development of the app through an existing contract vehicle. Federal staff developed the project concept, study design, communication materials, and created a website. Smoke Sense also utilized resources at the National Computational Center to host the mobile application and data. In FY18, the budget was $104,000 and required 1.5 FTE.

Partnerships: As Federal partners, NOAA, USFS, and EPA provided data.

[34] The website for Smoke Sense can be viewed at http://www.epa.gov/air-research/smoke-sense.

Advancement of Agency Mission: Protecting public health during smoke exposure is part of EPA's mission. Smoke from fires is a significant source of air pollution in the U.S. and globally. Among the pollutants found in smoke, fine particulate matter and ozone are strongly linked to cardiovascular and respiratory health effects. According to the 2011 National Emissions Inventory, 40% of fine particulate matter and 31% of volatile organic compounds that serve as pre-cursors to ozone formation are due to fires. Moreover, recent trends in factors contributing to the increased frequency and severity of these events, including growth of wildland urban interface, buildup of fuel, and weather patterns, are expected to continue. Additionally, as pollution from anthropogenic sources continues to decline, the relative contribution of smoke is expected to increase. Therefore, improving communication of health risks associated with this important source of two critical pollutants aligns with EPA's missions and goals to protect public health.

Results: Smoke Sense data and results will aim to bring about public health improvements by way of effectively supporting partner agencies who are more closely connected with their communities. The findings will provide insights about the experiences and challenges of our partners as well as their guidance as to how EPA can better support them.

Data Availability: Weekly aggregated summary statistics are shown in the Smoke Sense app under weekly statistics and posted online at https://www.epa.gov/air-research/smoke-sense. Individual level data will be published on EPA sites and used in K-12 curriculum about smoke as well as with community-level initiatives.

D.6.14 Air Sensor Toolbox[35]

Lead Sponsoring Agency: EPA

Authority: Clean Air Act

Project Summary and Goals: The primary goal of this project is to disseminate EPA information on emerging technologies like air quality sensors. The website provides the general public and other interested stakeholders access to technical information and useful tools developed by the EPA.

Justification for Using Crowdsourcing and Citizen Science: The Air Sensor Toolbox represents a key information source for citizen scientists. No performance certification requirements exist for low cost air quality sensors. Peer reviewed findings provided by the EPA on this topic often provide the only technical information available to citizen scientists, regulatory officials, and the general public. As such, information available through the site provides citizen scientists with critical information needed to make informed decisions about use of low cost air quality technology.

Status: The project started in June 2014 and is ongoing.

Location: N/A

Participation: The Air Sensor Toolbox is one of the most widely viewed websites in EPA's Office of Research and Development. Based upon contact inquiries, users include citizen scientists, community action groups, industry, sensor manufacturers, State and other regulatory officials. Thousands of visits and downloads often occur each month.

Consent: No consent is needed for those who access the information provided to all interested stakeholders.

[35] The website for the Air Sensor Toolbox can be viewed at https://www.epa.gov/air-sensor-toolbox.

Submissions: EPA based research findings and project information is provided on the Toolbox. Community air monitoring training materials, sensor use guidelines and host of other well-received tools are provided as the Office of Research and Development (ORD) completes research projects.

Resources: On an annual basis, less than 0.2 FTE in total are used to maintain the Air Sensor Toolbox website. The estimated annual funding (around $15,000) is used for contract support to update and maintain the website.

Partnerships: N/A

Advancement of Agency Mission: The Air Sensor Toolbox supports the Agency's mission by communicating EPA research findings to all interest parties. As such, the Toolbox represents a highly visible portal by which citizen scientists make contact with Agency staff members concerning specific project objectives and results. ORD's Tech Tracker database indicates that hundreds of contact inquiries were received since the database was established in October 2017. Each of these contacts represents acknowledgment of stakeholder awareness of EPA activities, many of which provide here-to-fore unavailable information, tools, or findings in an easy-to-access format.

Results: Citizen scientists and others often access the Air Sensor Toolbox to gain technical information unavailable from any other source (government or private). The tools provide citizens with critical information they need to make informed decisions about how to develop citizen science projects, air quality technologies, and related topics of interest. It is the primary venue by which the Air and Energy Research Program shares timely and topical findings with all interested parties.

Data Availability: The Air Sensor Toolbox website is located at https://www.epa.gov/air-sensor-toolbox.

D.6.15 Community-led Air Sensor Evaluation in North Carolina[36]

Lead Sponsoring Agency: EPA

Authority: Clean Air Act

Project Summary and Goals: EPA provided training to citizen scientists on how to successfully collocate low cost air quality sensors with regulatory monitors and then establish the ability of the sensor to provide purposeful air quality measurements. Low-cost sensors make it possible for citizens to collect air quality data in their own communities, but they still require instruction for optimal results. While low-cost sensors can measure many of the same air pollutants that costlier regulatory monitors measure, they are not required to meet the same rigorous standards of accuracy and reliability. Understanding how to collocate low-cost sensors with regulatory monitors and compare their results ensures that data from the low-cost monitors are collected in a purposeful manner.

Justification for Using Crowdsourcing and Citizen Science: It was paramount in the development of the sensor collocation tools to heavily draw on the perspective and account for the skill level of non-professional individuals. Air quality professionals typically possess skills and training to assess air quality instrumentation. Even so, many professionals have little or no experience operating low cost sensors. Therefore, even basic issues relative to using this type of technology cannot be assumed when EPA staff are working with its stakeholders. Teaming citizen scientists with no low-cost sensor experience and their highly variable skill levels with purposeful use of low cost sensors allowed EPA to gain insight on common questions others might encounter. The research ensured the concepts and

[36] The website for the Community-led Air Sensor Evaluation in North Carolina can be viewed at https://www.epa.gov/air-research/instruction-guide-and-macro-analysis-tool-community-led-air-monitoring.

topics described in tools produced by the EPA would be appropriate. Information gained from the research provided the means for EPA to develop a suite of tools widely transferrable to any low-cost air quality sensor stakeholder (citizen scientist, community group, industry, academia, regulatory officials). The partners in these efforts now have extensive knowledge on the strengths and weaknesses of low cost air quality sensors and how to best integrate this technology into their respective future efforts.

Status: The project ran from April 2017 through June 2017 and is complete.

Location: The project is located in Mecklenburg County, NC and Cherokee, NC.

Participation: The project targeted the Eastern Band of Cherokee Indians (EBCI), a federally recognized Native American tribe living in and around the Cherokee, NC area. Clean Air Carolina (CAC) is a community action group in Charlotte, NC involved in a wide range of environmental air quality initiatives. The total number of individuals involved during this period was 14; an estimated two individuals/week participated from the EBCI and a total of four individuals participated from CAC during the May-June 2017 time period. The EBCI and CAC are estimated to have contributed a total of 200 hours to this research.

Consent: Individual memorandums of understanding were signed by representatives of both the CAC and the EBCI. In like manner, representatives consented to quality assurance requirements of the research.

Submissions: The CAC and EBCI operated low cost air quality sensors for a one-month period using EPA-supplied operating procedures. They provided tabulated data documenting sensor measurements and technical feedback on tools useful in comparing sensor data with local regulatory measurements.

Resources: The funding for this project was $58,000 in FY17 and $22,000 in FY18. A total of 0.8 FTEs were allocated in both fiscal years. Extramural support contract resources were used to assist in the development of a sensor collocation guide document and an accompanying tool used to assist low cost sensor users in establishing the performance characteristics of collocated instrumentation.

Partnerships: Non-Federal partners included the EBCI, CAC, and the Mecklenburg County Department of Air Quality.

Advancement of Agency Mission: The EPA views emerging technologies as being of benefit to future air quality monitoring. Even so, use of low cost air quality sensors represents one of the most technically challenging efforts undertaken by citizen scientists. Many factors can influence air quality measurements (e.g., instrumentation design, environmental conditions). There currently exists no certification requirements for low cost sensors, resulting in a significant uncertainty by all parties as to the veracity of the measurements being obtained. States, regions, and program offices are sometimes confronted with low cost air quality data of unknown accuracy. The tools developed in this project provide the means for citizen scientists to establish the value of their measurements in advance of such discussions. The tools developed here are transferrable to any interested party including sensor manufacturers, who are expected to significantly advance the evolution of low cost sensors to the benefit of EPA and its full range of stakeholders.

Results: EPA has developed a guide and analysis tool for citizen scientists to evaluate the performance of low-cost sensors and interpret the data they collect to help citizen scientists interested in learning about local air quality. The first tool is an instruction guide on conducting a successful collocation evaluation of low-cost air sensors. Collocation refers to the process of operating a regulatory grade reference monitor (FRM/FEM) and non-reference monitor (low-cost sensor) side-by-side in real-world conditions for a defined evaluation period. Collocating low-cost sensors with regulatory monitors can

help citizen scientists evaluate their sensors' performances and the accuracy of their data. The instruction guide contains links to web-based supporting materials and introduces users to the second product––a macro analysis tool. EPA created the user-friendly, Excel-based macro analysis tool to help citizen scientists compare data from low-cost sensors to data from regulatory monitors, and interpret their results. The tool allows users to input data from low-cost and regulatory monitors for comparison, even if measurements were not recorded at precisely the same time, or were collected at different time intervals (e.g., 1-minute vs. 5- minute intervals). This tool addresses one of the major hurdles in citizen-led community air monitoring projects, which is working with and understanding the data. Both of the aforementioned tools are publicly available. The instruction guide and macro analysis tool are available at https://www.epa.gov/air-research/instruction-guide-and-macro-analysis-tool-community-led-air-monitoring.

Data Availability: No measurement data are currently available. The primary outputs of the project were the development of the collocation guide and the analysis tool. The day-to-day experience gained by the citizen scientists in operating low-cost sensors and their feedback on the resulting tools EPA developed to support such efforts were the primary data obtained during the research effort. The Office of Research and Development is currently reviewing the measurement data obtained during the study for any value as part of the Air Sensor Toolbox sensor performance reports provided to the public on individual sensor performance attributes. More information can be found at https://www.epa.gov/air-sensor-toolbox/evaluation-emerging-air-pollution-sensor-performance.

D.6.16 Regional Sensor Loan Program[37]

Lead Sponsoring Agency: EPA

Authority: Clean Air Act

Project Summary and Goals: This project gives EPA Regions the ability to investigate local and regional air quality using lower cost sensors through a sensor pod loan trial. EPA Regions and the communities they serve want to understand the pollutant concentrations in the air they breathe and want to be aware of potential pollution exposures in microenvironments where they live and work. Fixed regulatory monitoring networks might not be able to capture these local-scale conditions. Sensor pods are less expensive portable monitoring equipment that can provide finer spatial and temporal resolution than is possible with traditional monitoring. This trial loan program provides Regions with highly desired access to cutting edge sensor technology. Integration of the Regional need with the Office of Research and Development (ORD) success in sensor development relieves Regional partners of the technical burdens and maintenance aspects of having to develop a similar capability, while allowing ORD further opportunity to define the viability of low cost sensors to meet a wide range of stakeholder research needs.

Justification for Using Crowdsourcing and Citizen Science: ORD and each of the Regional partners have established citizen science efforts that this project builds upon. Previous programs have clearly shown the benefit of collaborative EPA-stakeholder research involving emerging low-cost sensor technologies. The lower cost of some sensor systems and relative ease of operation makes it possible for non-experts to use these technologies to gather air quality information. Some Regions are partnering with citizen scientists to build better relationships, address community concerns, and to teach them how to

[37] The website for the Regional Sensor Loan Program can be viewed at https://www.epa.gov/sites/production/files/2018-03/documents/final_em-3_master_slide_set.pdf

appropriately use sensor technologies. Each of the Regions has specific goals of their planned interactions with citizen scientists. Those goals will be fully established in FY19.

Status: The project started in Spring 2018 and is ongoing.

Location: Region 1 – Mountain Valleys in Vermont; Region 2 – New York/New Jersey; Region 3 – Philadelphia, PA; Region 5 – Saginaw, MI; Region 8 – Denver, CO

Participation: The project targeted collection of community-level data by university students (Regions 2 and 5), community groups (Region 8), and State (Region 1) and Regional (Region 3) staff.

Consent: Human subjects and other considerations are currently in review by each of the Regional partners. Each Regional project represents an independent research engagement with citizen scientists.

Submissions: Participants may be involved in one or more aspects of planning sensor collocation and deployment locations, agreeing to host a deployed sensor on their property, deploying and operating sensors using EPA-supplied operating procedures, weekly data retrievals, and/or data analysis and interpretation.

Resources: FY17 funding ($230,000 and 0.8 FTE) was used to investigate/develop/obtain multi-pollutant low cost sensor pods needed by each Region. Federal staff evaluated research sensor options, explored the cost of the sensor pod creation, and developed partnerships. FY18 funding resources ($230,000 and 3.1 FTE) were used extramurally to obtain ORD-supported multi-pollutant sensor pods. The sensor pod specifications were selected collectively by the Regional partners with ORD providing technical expertise in that effort. ORD support included technical investigation of possible commercial sensor units for meeting project goals, developing needed quality assurance documentation (operating procedures) as well as establishing technical procedures for data collection and recovery. Resources were used to establish the operational status of each sensor pod including comparisons with reference monitors. Resources were used to support the development of an easy-to-use tool to process raw sensor signal into ambient concentrations, track and ship sensor pods to Regional partners, and to support Regional partners with troubleshooting during their loan period.

Partnerships: Federal partners included EPA Regions 1, 2, 3, 5, and 8. Non-Federal partners included the Vermont Department of Environmental Conservation in Region 1; a Regional university (not yet selected) in Region 2; the City of Philadelphia in Region 3; Saginaw Valley State University in Region 5; and the City of Denver and two community groups in Region 8.

Advancement of Agency Mission: EPA's mission is advanced through the efforts of ORD, the Regions, and the many stakeholders engaged in the project (States, municipalities, citizen science groups) to collaborate on the potential use of emerging technologies to meet community-based air monitoring research interests. Emerging technologies can collect air quality data at finer spatial and temporal resolution and at a lower cost than traditional monitoring equipment. However, the accuracy of these measurements can vary considerably not only based on the sensors used but also on integration (e.g., sensor pod design) and environmental conditions (e.g., metrology, pollutant concentration, particle types). States, Regions, and program offices find these technologies potentially valuable but often lack the staff and resources to try technologies that are not well characterized. Additionally, these groups are often confronted with data from their stakeholders with little or no understanding of their accuracy. This project supports the Regions by helping them to access technology that ORD finds promising, supporting them with some technical support and documents (e.g., operating procedures), and introducing them to processes that help ensure data quality (e.g., collocation). The projects selected will help demonstrate potential uses for sensors and develop closer relationships between EPA and project partners.

Results: Each of the Regional partners are engaged in fully establishing all of their individual research efforts. Region 1's goal is to measure wintertime particulate matter concentrations in valley locations. Region 2's goal is to engage students in a community with environmental justice (EJ) concerns to measure air pollutants and better understand their local air pollution. Region 3's goal is to engage EJ communities and to investigate particulate matter concentrations in two such communities. Region 5's goal is to engage college students in air quality monitoring to address local air quality concerns. Region 8's goal is to engage community groups in air quality monitoring using sensors to further their environmental awareness activities.

Data Availability: No data are currently available due to the current status of the study. Citizen science data collections are scheduled to begin in FY19. ORD will be releasing quality assurance data collected while sensors are collocated with reference instruments both at the EPA facility in Research Triangle Park, NC and similar data while deployed within the Regions. These data and summarized findings will be made publicly available at the end of the project when researchers intend to publish a report on the performance of the multi- pollutant sensor pod (estimated to be in FY20). Regions and their project partners are currently establishing data handling and public data release policies for each of their individual research efforts.

D.6.17 Ironbound Neighborhood Air Monitoring [38]

Lead Sponsoring Agency: EPA

Authority: Clean Air Act

Project Summary and Goals: This collaboration provided for community-based participatory environmental monitoring of the particulate matter 2.5 micron size fraction (PM2.5) and gaseous nitrogen dioxide (NO_2), as pollutants chosen jointly by the EPA's Office of Research and Development (ORD), Region 2, and the Ironbound Community using an environmental sensor pod designed by ORD for the particular needs of the community. ORD provided technical commentary on the general research study plans developed by the Ironbound Community/Region 2 and provided data analysis expertise concerning data summarization options ultimately shared with the community. The primary objective of this effort was to develop the approach (Toolbox) needed to support such activities and ensure their success.

Justification for Using Crowdsourcing and Citizen Science: EPA aims to address environmental concerns of vulnerable populations in its research programs. Community-based citizen science efforts have the potential of providing Americans with new information sources useful for understanding local air quality. The Air Sensor Toolbox's technical resources developed for the Ironbound Community represent an example for use by other communities across the country in developing their own air monitoring programs in areas where pollution is a concern. As such, the pilot effort provided EPA an opportunity to work directly with a highly motived citizen science organization, develop a collaboratively agreed upon research plan, and introduce advanced technology to the citizen scientists to meet their needs. The pilot project provided useful lessons in how to improve coordination between EPA and communities, the types of tools and technologies needed to assist communities, and how the lessons learned from this pilot study might be applied to future efforts.

Status: The project started in June 2014 and was completed in June 2016.

Location: The project is located in Newark, New Jersey.

[38] The website for Ironbound Neighborhood Air Monitoring can be viewed at https://www.epa.gov/sciencematters/citizen-science-newark-new-jersey.

Participation: The project targeted the Ironbound Community Corporation. The total number of individuals involved was estimated to be around 20, and the average number of active participants per week was estimated to be 3-4 individuals. The total number of volunteer hours was in the range of 300 to 500.

Consent: No personal monitoring took place. Ironbound Community Corporation secured individual citizen scientists with their principal member providing consent for the effort and being a signatory on all major project documents.

Submissions: Participants were asked to recover air quality data weekly from a total of four sensor pods. Participants tabulated raw data and provided those electronic data files to EPA for validation and processing

Resources: No funds were specifically allocated for this project and less than 0.1 FTEs were used in FY17 and FY18. All primary work was completed in FY14-FY16. EPA activity centered around handling study inquiries and submitting a journal article that summarized the findings.

Partnerships: Non-Federal partners included the Ironbound Community Corporation and the New Jersey Department of the Environment.

Advancement of Agency Mission: EPA's mission is to protect human health and the environment. To move toward achieving this goal, EPA is facilitating identification of potential environmental concerns, particularly in vulnerable communities. This includes actively supporting citizen science projects and providing communities with the information and assistance they need to conduct their own air pollution monitoring efforts. The Air Sensor Toolbox for Citizen Scientists was developed as a resource to meet stakeholder needs. The Toolbox features resources developed by EPA researchers that can be used by citizens to effectively collect, analyze, interpret, and communicate air quality data. The resources include information about sampling methods, how to calibrate and validate monitors, options for measuring air quality, data interpretation guidelines, and low-cost sensor performance information. By testing emerging air sensor technologies, the EPA is evaluating new methods to support its core mission of protecting human health and the environment.

Results: A primary purpose of this effort was the development of needed citizen science tools. These included quality assurance documentation and similar documentation that would be transferable to other communities interested in conducting citizen science air quality research. These tools were publicly released as part of ORD's Citizen Science Toolbox, which can be accessed at https://www.epa.gov/air-sensor-toolbox. In addition, the Ironbound Community received valuable training in how to conduct complex air quality monitoring and its validation. Study results were jointly presented by EPA and the citizen science team to the full community. The community received in-depth air quality information collected by their own citizens highlighting the observed environmental concentrations and how their measurements related to the national air quality standards and other similar communities. This effort provided EPA with invaluable lessons learned on how to plan and execute complex air quality citizen science research efforts.

Data Availability: Data have been publicly available since the publication of the primary peer review journal article summarizing key findings. The data can be accessed at https://edg.epa.gov/metadata/catalog/search/resource/details.page?uuid=%7BDFEDA959-0DBB-434C-B736-0249DD083473%7D and the paper can be accessed at https://doi.org/10.23719/1407516.

D.6.18 The Efficacy of Citizen Science Air Monitoring for Building Public Awareness of Exposures in a US Caribbean Urban Neighborhood Impacted by Heavy Industrial Contamination[39]

Lead Sponsoring Agency: EPA

Authority: Clean Air Act

Project Summary and Goals: A research partnership with a Puerto Rico-based regional consortium, Desarrollo Integral del Sur, Inc. (DISUR), was developed to determine the challenges and benefits of low-cost air quality (AQ) sensors for citizen science. EPA developed a unique low-cost multi-pollutant sensor pod that was provided to the community group and the training/tools needed for its operation. The citizens self-organized a community effort to conduct approximately five months of intensive AQ monitoring in residential areas of Guayanilla and Peñuelas, Puerto Rico, which had little historical data on spatial variability. The citizens successfully completed the intensive data collections, summary of quality assurance checks, and database development. The study provided environmental justice communities in Peñuelas and Guayanilla, as well as surrounding communities, an awareness of local air quality conditions and opportunities for citizen scientists to gain extensive experience in use of emerging sensor technologies. The collaboration provided EPA an opportunity to evaluate low-cost sensor performance under harsh environmental conditions (high relative humidity in a coastal environment).

Justification for Using Crowdsourcing and Citizen Science: Citizens in the study area had an established interest in environmental air quality issues in southern Puerto Rico. In particular, they had concerns about air pollutants from a variety of potential sources including abandoned industrial sites that they did not feel were being fully characterized. Establishing a citizen science project allowed the local communities to be directly involved in not only selected monitoring sites of interest but also providing them with extensive training and experience on the use of emerging air quality technologies (low cost sensors). This project provided the EPA the ability to gain seminal knowledge on the ability of low cost air quality sensors to operate in the harsh Caribbean climate (high temperatures, high relative humidity, and abundant rainfall) for extended periods of time (about six months). The reliability of low cost sensors (environmental impacts as well as lifetime of performance) has not been established and there currently exists no manufacturer's certification of performance. Therefore, the information gained by the project involving non-professional operation and collection of environmental data was highly valuable in establishing "lessons learned" under such conditions. The citizen science project provided direct feedback to local citizens using a credible source (e.g., other community members), therefore providing enhanced understanding about the local air quality conditions from data collection that was not government based.

Status: The project started in October 2016 and is complete.

Location: The project took place in Peñuelas and Guayanilla, Puerto Rico.

Participation: The project targeted community members in Peñuelas and Guayanilla, Puerto Rico. The total number of individuals involved over the full course of the study (October 2016 through February 2018) was 23 participants. Citizen scientists and community group members contributed an estimated 500 total hours.

[39] The website for the Efficacy of Citizen Science Air Monitoring for Building Public Awareness of Exposures in a US Caribbean Urban Neighborhood Impacted by Heavy Industrial Contamination can be viewed at https://www.epa.gov/air-research/citizen-science-air-monitoring-puerto-rico-fact-sheet.

Consent: Consent was received from 20 community members and 3 DISUR staff members. DISUR, as the primary community leader, was a signatory on all key project documents (e.g., QA documentation, community recruitment/training activities).

Submissions: Participants deployed a number of EPA-developed low cost air quality sensor pods and weather monitors at sites community members selected. Data were harvested on a weekly basis. Tabulated data were then provided to EPA.

Resources: FY17 funding ($100,000 and 1 FTE) was used for an extramural support contract that provided the means to develop the low cost sensor pods, establish and conduct a training program for the Puerto Rico-based citizen scientists, and ultimately establish the community-based leadership support with DISUR needed to facilitate citizen science activities, and air quality data collection. Extramural funding was also used for technical support needed to conduct quality assurance review of raw tabulated data provided by the citizen scientists. FY18 funding ($100,000 and 1 FTE) was used for an extramural support contract provided for DISUR to conduct data quality assurance validation efforts and refinement of the tabulated database they had established.

Partnerships: Non-Federal partners included DISUR Community group and the Puerto Rico Environmental Quality Board.

Advancement of Agency Mission: EPA is involved in the discovery, evaluation, and application of low-cost air quality sensors to meet a wide variety of stakeholder needs. One key feature of this effort is the determination of low-cost sensor performance under real-world conditions. The EPA is recognized as one of the premier research organizations in the world investigating the value and potential of emerging air quality sensor technology for evaluating air quality. EPA is also actively supporting citizen scientists by transferring knowledge gained from its own research and directly engaging with them in the pursuit of community-based interests.

Results: Air quality information obtained during the study was directly shared with local citizens by a joint Office of Research and Development/EPA Region 2/DISUR team in February 2018 to mark the completion of the study. At this meeting, air quality information collected during the study was related to historical regulatory monitoring. In particular, validated data from the citizen science study indicated environmental concentrations of the select air pollutants monitored were well below ambient air quality values during the study period. While the study was not long-term and used non-regulatory monitors, citizens received unprecedented information on their local air quality. The maritime climate encountered during the study provided EPA a great deal of performance data on low cost sensors. Data findings revealed that extensive data validation and processing was needed to overcome interference with high relative humidity for many of the low-cost sensors. Data validation techniques developed during that portion of the study are directly transferrable to future EPA field efforts involving this same type of technology. Sensor performance characteristics are not typically known because of the lack of a required manufacturer's certification requirement. Data findings from this study will be published in the peer reviewed literature summarizing the viability of low cost technology to meet air quality monitoring needs under harsh operating conditions.

Data Availability: The data obtained during the study will be publically available upon publication of a submitted peer reviewed journal article. Data will be obtainable at the EPA environmental dataset gateway, accessible at https://edg.epa.gov. The dataset can be retrieved by searching for The Peñuelas Project-SCID:A-K99b or by the name of the senior EPA author, Ron Williams.

D.7 National Aeronautics and Space Administration (NASA)

D.7.1 GLOBE Program[40]

Lead Sponsoring Agency: NASA

Authority: National Aeronautics and Space Act (as amended)

Project Summary and Goals: The Global Learning and Observations to Benefit the Environment (GLOBE) Program is an international hands-on environmental science and education program. GLOBE's Strategic Priorities are to improve student understanding of environmental and Earth system science across the curriculum; contribute to scientific understanding of Earth as a system; build and sustain a global community of students, teachers, scientists and citizens; and engage the next generation of scientists and global citizens in activities to benefit the environment. GLOBE encourages and supports students, teachers and scientists to collaborate on inquiry-based investigations of their local environment, sharing results in person and virtually through local, regional and international science symposia.

Justification for Using Crowdsourcing and Citizen Science: Citizen science and crowdsourcing provide a practical and efficient means to collect local observations of the Earth system globally and over long time periods. GLOBE also engages students and teachers as a way for them to learn more about their own environment (local, regional, and global).

Status: The project started in April 1995 and is ongoing.

Location: Participation is possible in 121 countries and all U.S. states and territories.

Participation: The project targets teachers with K-12 students, as well as the general public. The total number of teachers involved during this reporting period as of August 26, 2018 was 3,163, and with an average of 237 active participants per day, 385 active participants per week, and 596 active participants per month.

Consent: All data submissions and teacher participations are voluntary.

Submissions: GLOBE participants can report measurements in over 70 protocol areas across four Earth spheres: atmosphere, biosphere, hydrosphere, and pedosphere. Approximately 16,489,000 data points were recorded over the FY17 and FY18 timeframe as of August 26, 2018.

Resources: GLOBE has a dedicated budget within NASA's Science Mission Directorate/Earth Science Division. Funding for the citizen science component of GLOBE cannot be pulled out from the overall budget of GLOBE, which includes a wide array of additional science and education activities.

Partnerships: Federal partners included the National Oceanic and Atmospheric Administration, the National Science Foundation, and the Department of State. Non-Federal partners included implementation by the University Corporation for Atmospheric Research.

Advancement of Agency Mission: GLOBE students and teachers contribute to a knowledge base about the Earth system, in support of the NASA strategic goal to "expand human knowledge through new scientific discoveries." GLOBE also serves to meet NASA's strategic objective to "inspire and engage the Public in aeronautics, space, and science."

Results: GLOBE data have been used extensively. Students use the data to conduct research projects for Student Research Symposia (https://www.globe.gov/web/united-states-of-america/home/student-

[40] The website for the Globe Program can be viewed at https://www.globe.gov.

research-symposia) and for the International Virtual Science Symposium (https://www.globe.gov/news-events/globe-events/virtual-conferences/2018-international-virtual-science-symposium). GLOBE data have also been used in hundreds of science and education publications. An example list can be seen at https://www.globe.gov/do-globe/research-resources/publications.

Data Availability: GLOBE provides visualizations, maps, and graphs presenting reported data. Raw data can also be downloaded to compare and contrast local and global environments. The GLOBE visualization website also provides tutorials on how to access data.[41]

D.7.2 Students' Cloud Observations on-Line (S'COOL)[42]

Lead Sponsoring Agency: NASA

Authority: National Aeronautics and Space Act (as amended)

Project Summary and Goals: The S'COOL Project involves participants ages 5-20+ in real science, making and reporting ground truth observations of clouds to assist in the validation of NASA's Clouds and the Earth's Radiant Energy System (CERES) satellite instrument. Clouds are an important part of the atmosphere, and scientists are studying how they affect weather and climate. S'COOL observations provide one more piece of the puzzle.

Justification for Using Crowdsourcing and Citizen Science: CERES observes the entire Earth every day. Citizen science is the only way to get ground truth reports from many geographic areas over the mission lifetime. In 2018, nearly all of the program was ported over to the GLOBE Program, though S'COOL will continue into 2019 to support participants from countries that are not part of the GLOBE Program.

Status: The project started in January 1997 and is ongoing.

Location: Observations for S'COOL are made on a global scale.

Participation: The total number of individuals involved during this period was 159. The project initially targeted K-12 students but eventually included a public citizen science component open to all. Numbers are low in this reporting period because many participants already migrated to the GLOBE Program (teachers and students).

Consent: No specific consent is requested. Consent is assumed when data are reported.

Submissions: A total of 4,034 submission have been received during this reporting period.

Resources: Support was provided through the NASA Science Mission Directorate's Science Activation funding. A total of $267,000 funded 2 WYEs in FY17 who maintained the website and database, responded to participant questions, and worked on porting the project into the GLOBE Program framework. A total of $173,000 funded 1.5 WYEs in FY18 who supported finalizing porting of the project into the GLOBE framework, connecting databases and making sure functions continue to work, and helping participants through the transition

Partnerships: N/A.

Advancement of Agency Mission: S'COOL provides ground truth for the NASA CERES satellite instrument, multiple copies of which are in orbit observing the Earth.

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[41] The website can be accessed at https://www.globe.gov/globe-data/visualize-and-retrieve-data.

[42] The website for the Students' Cloud Observations on-Line (S'COOL) can be viewed at https://scool.larc.nasa.gov.

Results: S'COOL observations are compared to satellite data whenever reports are made within 15 minutes of an overpass. Statistical analyses are performed to understand what types of clouds are missed by the satellite and how often those clouds are missed. The project's utility has been cited in a couple of scientific publications.

Data Availability: The S'COOL project maintains an open database at https://scool.larc.nasa.gov/database.html, which shows cloud observations with corresponding satellite cloud retrievals when available.

D.7.3 Aurorasaurus[43]

Lead Sponsoring Agency: NASA

Authority: N/A

Project Summary and Goals: In 2013, NSF funded a research team to build the first citizen science project around observing the aurora. The Aurorasaurus.org project was funded for its innovative interdisciplinary goals around geospace, informal science education, and human-centered computing. This project had two fundamental objectives which have been successfully achieved: (1) collect real-time, ground-based aurora data from citizen scientists (soft sensors) and (2) incorporate this new type of data into scientific investigations pertaining to aurora. In 2016, NASA provided funding as part of the Space Science Education Consortium and its nation-wide education goals.

Justification for Using Crowdsourcing and Citizen Science: Crowdsourcing and citizen science are the only way to provide these newly available data, enabled by smart phones, digital cameras, and social media sources like Twitter. There are no other real-time verified sources of data indicating accurately where the dynamic aurora are visible (e.g. no imaging satellites, and no cameras that extract the actual locations). This is a unique service for the public who are interested in this information and the scientists who use these data to supplement and ground-truth traditional sources of data about the aurora. There are dedicated communities world-wide who can contribute and benefit by increasing their scientific literacy. In addition, the larger and more rare the auroral event, the less traditional data sources (e.g., ground-based scientific cameras) exist to document the rarer phenomena (e.g., the newly recognized STEVE aurora-like phenomena), and the more citizen scientists can contribute.

Status: The project started in 2012, and is ongoing.

Location: The whole globe, primarily in polar regions.

Participation: The project targeted (1) citizen scientists who see the aurora and want to submit an observation about it; and (2) anyone who is interested to help verify crowdsourced data about the aurora, accomplished through the verify tweets feature. NASA estimates 5,000 to 10,000 participants in FY17 and FY18. The total number of volunteer hours was approximately 14,000 hours for type 1 observations and approximately 4,000 hours for Type 2 observations.

Consent: Per the project's IRB reviews, formal consent is not required to participate. All citizen scientists must agree to the privacy and terms of use statement when submitting data (http://aurorasaurus.org/privacy).

Submissions: Citizen scientist participants fill out a simple form about whether they have or have not seen aurora (including the time/date/location at a minimum). They have the option to include a photo. There have been 7,000 submissions so far. Crowdsourcing participants simply submit a vote (yes or no)

[43] The website for Aurorasaurus can be viewed at www.aurorasaurus.org.

on a tweet that is a potential real-time sighting of the aurora. There have been 500,000 votes or user actions on tweets.

Budget and Resources: NASA provided support for this project (~0.5 FTE) as part of the NASA Space Science Education Consortium Cooperative Agreement. This competitive opportunity was open to both NASA and external entities. The Aurorasaurus team includes NASA FTE as well as external partners. NSF provided support (including postdoc funding, ~1.2 FTE plus additional funds for operations) under the INSPIRE grant. More information at: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1344296&HistoricalAwards=false.

Partnerships: Federal partners included NSF. Non-Federal partners included the New Mexico Consortium.

Advancement of Agency Mission: Aurorasaurus advances the science of heliophysics and serves as a model for other projects within NASA. In addition, it advances the agency's education, outreach, science engagement, partnership, and scientific literacy goals. Citizen scientists are tangibly contributing to NASA scientific discoveries around one of the most beautiful, accessible, and inspiring phenomena in the near-Earth space weather environment. Their contributions have energized the public and personnel throughout NASA in a multitude of ways.

Results: In terms of broader impacts, this work has been featured in a variety of media including Science Friday, Space.com, the New York Times, the Weather Network, and Discovery News. Scientifically, this work has led to publications across multiple fields featuring innovative methods to harness citizen science to verify and improve space weather models. This project has demonstrated that people can robustly detect and document previously unknown auroral features and can impact multiple fields within heliophysics and the larger citizen science community.

Data Availability: The Aurorasaurus team has a paper submitted for publication and have posted the data on Zenodo. Data can be accessed at https://zenodo.org/record/1255196#.W79tlxNKjs0.

D.7.4 Disk Detective[44,45]

Lead Sponsoring Agency: NASA

Authority: National Aeronautics and Space Act (as amended)

Project Summary and Goals: NASA's Wide Field Infrared Explorer (WISE) mission is a discovery tool sensitive enough to detect several thousand debris disks out to 300 parsecs and Young Stellar Objects to 1 kiloparsecs. These circumstellar disks are signposts of planets and serve as roadmaps to guide exoplanet searches and increase understanding of planet formation. However, the confusion noise inherent in the WISE mission data has limited the usefulness of this resource as a tool for disk and planet hunters. The Disk Detective project uses the power of citizen science to remedy this confusion noise problem in the WISE data. Disk Detective engages volunteers to compare images from WISE, NASA's Two-Micron All Sky Survey (2MASS), and optical surveys to search for new circumstellar disk candidates via the website DiskDetective.org. This project is the largest survey for debris disks with WISE and has already uncovered approximately 4,000 disk candidates worthy of follow-up, including 24 late type dwarfs too red for Hipparcos. By the project's completion in 2019, NASA estimates the project will have

[44] The website for the Disk Detective can be viewed at Diskdetective.org.

[45] The Disk Detective project was conducted under the Crowdsourcing and Citizen Science Act as well as 51 USC § 20112(a).

found around 3,200 disk candidates closer than 100 parsecs. These discoveries will guide searches for new groups of young stars and yield new targets for the upcoming James Webb Space Telescope.

Justification for Using Crowdsourcing and Citizen Science: Professional astronomers have been scouring the WISE data archive for years prior to this work, and through trial and error, the community realized that each disk candidate needed to be checked by eye, even when advanced machine learning techniques were applied to the data. Thus, large numbers of individuals are needed to accelerate this task.

Status: The project started in January 2014 and is ongoing.

Location: Participation in the project is available globally through internet access.

Participation: The project targeted the general public. The total number of individuals involved during this period was approximately 40,000, and the average number of active participants per week was between 20 and 40. The total number of volunteer hours was 48,000 hours for the classification work on the Zooniverse site alone, plus approximately the same amount of effort contributed by the advanced user group on various side projects.

Consent: All participants consented to participate. Approximately 13,800 participants have registered with Zooniverse. However, registration is not required for participation.

Submissions: Approximately 2.9 million classifications of movie images have been performed.

Resources: The project has been supported by the NASA Science Mission Directorate. The Space Telescope Science Institute Director's Discretionary Fund funded the development of the data archive. Extramural funding for FY17 and FY18 totaled $80,000 each, and 0.5 internal FTEs supported the project each year. The principal investigator is a NASA civil servant. Most of the funding is used to support the work of one graduate student on the project. Approximately $10,000 was spent each year on publication costs, travel to meetings, and travel to observatories for follow-up observations. The Space Telescope Science Institute spent $30,000 for their developers to build the archive. NASA provided funding in prior fiscal years to Zooniverse (zooniverse.org) to develop and use the Zooniverse platform for this project.

Partnerships: Non-Federal partners include Zooniverse, Carnegie Institute Department of Terrestrial Magnetism, University of Oklahoma, Harvard-Smithsonian Center for Astrophysics, University of Hawaii, Observatorio Astronomico de Cordoba, and the Space Telescope Science Institute.

Advancement of Agency Mission: The project addresses NASA's mission to understand the solar system and the universe by finding nearby circumstellar disks where planets like Earth form.

Results: This project is used to advance scientific understanding and has been cited by several scientific journal publications.

Data Availability: The data will be shared with the public through the Space Telescope Science Institute's Mikulski Science Archive. A beta version of our archive is online at https://mast.stsci.edu.

D.7.5 Globe Observer[46,47]

Lead Sponsoring Agency: NASA

Authority: National Aeronautics and Space Act (as amended)

Project Summary and Goals: The Global Learning and Observations to Benefit the Environment (GLOBE) Observer (GO) is an international network of citizen scientists and scientists working together to learn more about the shared environment and changing climate. GO is built on the GLOBE Program (www.globe.gov) and is intended to make citizen science activities available to GLOBE students more widely accessible to anyone who wants to participate through a smart phone app. The goals in implementing GO were two-fold. First, the program was designed to collect more environmental data in support of scientific research and GLOBE student research. Second, the program is educational and should increase participants' sense of belonging to a scientific community and their scientific literacy.

Justification for Using Crowdsourcing and Citizen Science: GO collects distributed environmental data on an ongoing basis, making citizen science an effective means for accomplishing its goals. It would be cost-prohibitive to collect the same volume and distribution of data through a contract or grant or other funded mechanism. A challenge, by its nature, has an end date, so that format would not work for ongoing data collection. Finally, the education and communication aspect of citizen science allows GO to function as both an educational and scientific program.

Status: The project started in September 2016 and is ongoing.

Location: Data are accepted from participants in the U.S. and in countries participating in the GLOBE Program. GLOBE is implemented through bilateral agreements between the U.S. Government and governments of partner nations.

Participation: The project targeted adults with access to a smart phone or tablet who are located in the U.S. and in countries participating in the GLOBE Program. The total number of individuals involved during this period was 26,460, and the average number of active participants per month was 1,525. The total number of volunteer hours was estimated to total 22,500 hours over two years. The estimate was based on the 270,000 observations in the database and the assumption of a five minute completion rate per observation.

Consent: All participants consent to NASA's knowledge of their location, the participants ownership of all photos submitted, that the photos include no identifiable people, and that NASA and GLOBE may post the pictures.

Submissions: Submissions include observations, location, and photographs.

Resources: FY17 and FY18 funds for GO were provided through a cooperative agreement to NASA Goddard Space Flight Center from the NASA Science Mission Directorate. Funds were dispersed from NASA Goddard to contractor staff for labor and IT support. FY17 funding totaled $825,891, including 2.55 work year equivalents (WYE), and 0.3 FTEs supported the project. FY18 funding totaled $1,126,983, including 2.55 WYE, and 0.3 FTEs supported the project. FTE labor included oversight. WYE labor included protocol development, website development and maintenance, program implementation, evaluation and audience needs assessments, development of material to support informal educators, and direct communication/support of citizen scientists. Non-labor dollars were spent on an IT support

[46] The website for the Globe Observer can be viewed at https://observer.globe.gov/.

[47] The Globe Observer project was conducted under the Crowdsourcing and Citizen Science Act as well as 51 USC § 20111, et seq.

contract (app and website development), printed material and videos to recruit participants, shipping, computers and software, and WYE travel. GO is built on the GLOBE Program, referenced in this report as a separate citizen science project, and all data are stored in the GLOBE database. Database support and management, as well as the management of the overall GLOBE Program, are not included in the FTE or funding estimates. NASA Office of Communication also helped promote the project through web features and social media.

Partnerships: Federal partners included U.S. Department of State.

Advancement of Agency Mission: NASA's vision is to discover and expand knowledge for the benefit of humanity. GO collects citizen science observations of clouds and mosquito habitats. Both types of observations support NASA satellite-based science. The GO team includes educators and scientists connected to relevant fields and missions in NASA's Science Mission Directorate. Furthermore, GO expands scientific knowledge by providing access to authentic scientific data collection to everyone.

Results: Cloud data are being analyzed by scientists at NASA Langley Research Center to compare against satellite-collected cloud data. Initial results show citizen reports identify some clouds that satellites tend to miss. These initial analyses show that as the project matures and collects more data, it can become a useful source of verification data. Mosquito Habitat Mapper data has only been collected for one year. When enough data has been collected, NASA will look to integrate the data into satellite-based models that predict outbreaks of vector-borne disease.

Data Availability: All data collected through GO are screened and then made public in the GLOBE database. Photos and classification information can be previewed at https://vis.globe.gov/GLOBE/. Complete data records may be accessed at https://datasearch.globe.gov/.

D.7.6 Image Detective[48,49]

Lead Sponsoring Agency: NASA

Authority: National Aeronautics and Space Act (as amended)

Project Summary and Goals: Image Detective was developed in direct response to decreases in funding from the International Space Station Program for astronaut photography cataloging (geolocation by image geographic centerpoint and addition of descriptive geographic metadata) at Johnson Space Center. Since members of the public continued to submit data from their own image cataloging and provided positive feedback regarding the usefulness of cataloged imagery, development of a crowdsourcing interface to allow for official public cataloging was the logical next step. The geographical knowledge and other STEM educational benefits to the public are self-evident—participants must examine features in an astronaut photograph and locate those same features in other georeferenced data (e.g. Google Earth) in order to derive a geographic centerpoint. By doing this, participants are gaining better knowledge of Earth's physiographic diversity as well as the current geopolitical landscape.

Justification for Using Crowdsourcing and Citizen Science: While astronaut photography of Earth holds many potential benefits for long-term change studies, the limitations of the dataset (3-band visible wavelength data; high variability in terms of look angle and sun illumination; variable ground sample distance; no native georeferencing data) have acted to limit its application and recognition among the

[48] The website for the Image Detective can be viewed at https://eol.jsc.nasa.gov/BeyondThePhotography/ImageDetective/.

[49] The Image Detective project was conducted under the Crowdsourcing and Citizen Science Act as well as 51 USC § 20112(a).

remote sensing community. As a result, requests for proposals amenable to astronaut photography as a primary science dataset have been few and far between. Grant funding did not represent a viable approach for development or long-term support of the NASA-managed Image Detective. Rather, the International Space Station Program provides stable funding for ongoing mission support of new astronaut photography of Earth, as well as curation of the online database of historical imagery at Johnson Space Center. As many of the components of Image Detective were already in place as part of existing cataloging, database, and website tools, and NASA's team held software and web design skillsets, crowdsourcing and citizen science could be incorporated into ongoing funded activities. As mentioned previously, allied education/outreach efforts and public feedback on NASA's online database indicated a strong public interest in astronaut photography and willingness to participate in cataloging of astronaut images of Earth. A crowsourcing and citizen science interface was both feasible with existing resources and the appropriate mechanism for public engagement.

Status: The project started in 2013 and is ongoing.

Location: The photographs cover all regions of Earth's surface between approximately 52 degrees North and South latitudes, however the dataset is spatially and temporally discontinuous for some regions.

Participation: The project targets the general public. The total number of individuals involved between October 1, 2016 and August 19, 2018 was 670, and the average number of active participants per week was 14. Assuming a cataloging time of 20 minutes per image by a citizen scientist, the total number of volunteer hours was estimated to be 1,036 hours.

Consent: No formal consent was required.

Submissions: Participants are asked to provide three types of information: (1) the geographic coordinates for the centerpoint of a given astronaut photograph of Earth; (2) an estimation of the cloud cover percentage in the image; and (3) the geographic metadata for features visible in the image (e.g., New York City, Mt. St. Helens, Mississippi River, etc.). A total of 3,108 images were added to the public database through Image Detective between October 1, 2016 and August 19, 2018.

Resources: There is no dedicated budget or account to support the NASA Image Detective. Funding for maintenance of the software, interface, and quality assurance/quality control (QA/QC) activities are considered part of our International Space Station mission operations and online database curation activities. In both FY17 and FY18, 0.1 FTE and 0.02 WYE (equivalent to $9,000) supported the project. Resources were used to maintain Image Detective software and image database functions and to perform QA/QC of submitted data prior to incorporation into our public database.

Partnerships: N/A

Advancement of Agency Mission: The Image Detective project furthers the NASA mission by making more of the astronaut photography dataset accessible (i.e., searchable) by scientists, educators, and the general public, improving knowledge of the Earth and forging direct and personal connections with NASA science and human spaceflight. Astronaut photography of the Earth has been collected by every crewed NASA mission since the Mercury Program and thus represents the longest continuously-collected orbital image record of changes to the Earth surface supporting a wide range of geologic, oceanographic, and climatic research. As the images are acquired by human beings using visible-wavelength (true color) cameras rather than robotic sensors, the public has an intuitive connection to the images that strengthens interest and aids in image interpretation, making the dataset powerful for educational applications.

Results: The primary use of the Image Detective results is for reducing the backlog of uncatalogued astronaut photography of Earth. In addition, the crowdsourcing and citizen science cataloged data are

used to add images to specific collections available through NASA's online astronaut photography database website (e.g., volcanos, cities) and for allied education and outreach programs. As the data cataloged through Image Detective are added to the publicly available online database, the data become more useful for downstream scientific and educational applications by other users of the database.

Data Availability: Once data submitted through the NASA Image Detective have been passed through a QA/QC review, the location, cloud cover, and feature metadata are added to the specific image records in the publicly accessible online database, the Gateway to Astronaut Photography of Earth (https://eol.jsc.nasa.gov/). An image with metadata obtained from an Image Detective participant is identified as "Public Inputs (from public image detectives, not NASA)" in the image details section of the image data record.

D.8 Smithsonian Institution (SI)

D.8.1 City Nature Challenge DC 2018[50]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: The City Nature Challenge 2018 is an international effort for people to find and document plants and wildlife in cities across the globe. It is a competition to see which city can make the most observations of nature, find the most species, and engage the most people. The Smithsonian's goal was to increase participation, raise awareness, and become more competitive as a city. Washington, DC placed fourth overall in number of participants, fifth in observations, and eigth in species.

Justification for Using Crowdsourcing and Citizen Science: Nearly 23,000 observations were made in just four days, which mapped species diversity and locations in the DC metropolitan area. The project was designed as a public engagement event, which incidentally contributes data of scientific quality. Other alternatives for documenting biodiversity would not have had the same public impact.

Status: The project ran between April 27 and April 30, 2018, and is complete.

Location: The project took place in the Washington, DC metropolitan region.

Participation: The project targeted District of Columbia metropolitan area residents. The total number of individuals involved during this period was 904, and the average number of active participants was 904 over the four day event.

Consent: Participation was conducted through the iNaturalist app and the agreement to share data was voluntary.

Submissions: Submissions were in the form of images and sound files, both are considered 'observations.' A total of 22,931 observations were submitted on 1,808 identified species.

Resources: The event only required organization and promotional materials, including printing flyers and signs, with a cost of around $100.

[50] The website for the City Nature Challenge DC 2018 can be viewed at https://www.inaturalist.org/projects/city-nature-challenge-2018-washington-dc-metro-area.

Partnerships: Non-Federal partners included the American Association for the Advancement of Science, National Geographic, Biophilic DC, U.S. Green Building Council, and Arlington Regional Master Naturalists.

Advancement of Agency Mission: The Smithsonian Institution's mission is to increase and diffuse knowledge; the National Museum of Natural History (NMNH) focuses that knowledge on the natural world and our place in it. Public engagement is used to increase public understanding of science and the natural world. For the challenge, NMNH used its unique assets, biodiversity collections, and taxonomic expertise to educate the public, and it used its social media channels to recruite people to participate in the project. Moreover, citizen scientists observations that rose to a state of validation became part of the scientific database at the Global Biodiversity Information Facility.

Results: Results that have been validated and are considered research grade were incorporated into the Global Biodiversity Information Facility database. This event contributed 10,828 research-grade observations with images, time, and locality information. The database is used by researchers around the world to study patterns of biodiversity.

Data Availability: All data are available to the public through the iNaturalist City Nature Challenge DC 2018 website. All research-grade data are available on iNaturalist and the Global Biodiversity Information Facility website for download.

D.8.2 Chesapeake Bay Parasite Project[51]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: White-fingered mud Crabs (*Rhithropanopeus harrissi*) are small scavengers native to the Chesapeake Bay that live in oyster reefs and woody debris in the water where they play a key role in the food web structure of this ecosystem. They may also be an indicator species, which means that the health of their population is a direct reflection of the health of their habitat. Mud crabs typically live less than two years, which means they do not have a long time to reproduce. The parasitic barnacle *Loxothylacus panopaei* (Loxo, for short) is an invasive species that castrates these mud crabs when it infects them. Though this project, Smithsonian scientists seek to understand how Loxo affects the mud crab population. Specifically, are mud crab populations steady or are they declining because Loxo hinders their reproduction?

Justification for Using Crowdsourcing and Citizen Science: Engaging citizen scientists enables collection of large amounts of data in a very short period of time. The number of sites sampled has tripled since this project became a citizen science project, which ensures that the environmental conditions impacting crabs at different sites are similar. Volunteers also help process samples in the lab.

Status: The project started in June 2013 and is ongoing.

Location: This project is conducted in the Chesapeake Bay.

Participation: The total number of individuals involved during FY18 was 130. The total number of volunteer hours was 801.

Consent: Participation by the 130 individuals involved during FY18 was voluntary.

[51] The website for the Chesapeake Bay Parasite Project can be viewed at https://serc.si.edu/citizen-science/projects/chesapeake-bay-parasite-project.

Submissions: Submissions are received in the form of data and observations.

Resources: N/A

Partnerships: N/A

Advancement of Agency Mission: This is an initiative of the Smithsonian Environmental Research Center SERC), which leads the nation in discovering the links between land and water ecosystems in the coastal zone. SERC researchers investigate questions related to fisheries, climate change, invasive species, mercury pollution, water quality, ozone depletion, and more.

Results: Results have been presented at professional conferences.

Data Availability: All data are available upon request.

D.8.3 Environmental Archaeology at the Smithsonian Environmental Research Center[52]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: The projects at the Sellman Plantation all fall within the field of environmental archaeology: the study of the relationship between the land and the people who lived on it over time. They seek to understand how people's interactions with the land shaped their cultures and how their cultures shaped the land. Environmental archaeology provides insights into how human-induced environmental changes have affected our surroundings in the past, providing a basis for better decisions about land use today.

Justification for Using Crowdsourcing and Citizen Science: This project is an entirely volunteer effort. There is not an archaeologist on staff at the Smithsonian Environmental Research Center (SERC), but there is a large piece of property that is rich in archaeological sites. By engaging research associates and volunteers, the Smithsonian is able to conduct research that would otherwise never be done.

Status: The project started in April 2014 and is ongoing.

Location: This project is located in Edgewater, Maryland.

Participation: The total number of individuals involved in FY18 was 185. The total number of volunteer hours was 4286.

Consent: Participation by the 185 individuals involved during FY18 was voluntary.

Submissions: Submissions are received in the form of data and observations.

Resources: N/A

Partnerships: N/A

Advancement of Agency Mission: The Smithsonian Environmental Research Center leads the nation in discovering the links between land and water ecosystems in the coastal zone. Environmental archaeology provides insights into how human-induced environmental changes have affected our surroundings in the past, providing a basis for better decisions about land use today.

Results: Results have been presented at professional conferences and in peer reviewed publications.

[52] The website for Environmental Archaeology at the Smithsonian Environmental Research Center can be viewed at https://serc.si.edu/citizen-science/projects/environmental-archaeology-serc.

Data Availability: All data are available upon request.

D.8.4 eMammal[53]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: eMammal is a wildlife image repository that relies on citizen scientists to join projects which place cameras in natural areas and detect wildlife. Data and images are used to determine the distribution of mammals across the project areas.

Justification for Using Crowdsourcing and Citizen Science: The projects relies on data being collected across broad landscapes – beyond the capacity of individual staff to collect.

Status: The project started in 2012 and is ongoing.

Location: The project collects information worldwide.

Participation: The project targeted adults and youth living near natural areas. The total number of individuals involved during FY17 and FY18 was 1750, and the average number of active participants was 1200. The total number of volunteer hours was approximately 18,000.

Consent: Participation by the 1750 individuals involved during FY17 and FY18 was voluntary.

Submissions: Images and associated metadata are collected. To date, nine million images have been submitted.

Resources: The Office of the Chief Information Officer has provided servers and storage. The eMammal team also uses Smithsonian computers and vehicles. The project required 1.5 FTEs in both FY17 and FY18. Grants from the National Science Foundation and the North Carolina Museum of Natural History. In FY18, $10,000 was received from the Smithsonian Conservation Biology Institute in addition to support from existing resources (used in both FY17 and FY18).

Partnerships: Federal partners include the National Park Service. Non-Federal partners include the North Carolina Musuem of Natural History and Conservation International.

Advancement of Agency Mission: eMammal advances the Smithsonian's commitment to exploration and discovery of biological diversity and to sustaining the Earth's wildlife.

Results: Since FY17, publications in peer-reviewed scientific journals include (1) "Do occupancy or detection rates from camera traps reflect deer density?" in the Journal of Mammalogy; (2) "A community effort to document wildlife: eMammal project expands the impact of citizen scientists" in the The Wildlife Professional; (3) Does hunting or hiking affect wildlife communities in protected areas?" in the Journal of Applied Ecology; and (4) "Deer on the lookout: how hunting, hiking and coyotes affect white-tailed deer vigilance" in the Journal of Zoology.

Data Availability: All data, except for some sensitive information like locations of endangered species, are available at eMammal website.

[53] The website for eMammal can be viewed at https://emammal.si.edu/look-pictures.

D.8.5 Fossil Atmospheres[54]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: This project aims to refine proxy estimates of atmospheric carbon dioxide that are based on an understanding of how the properties of stomatal pores in the leaves of *Ginkgo* trees respond to elevated carbon dioxide concentration. This proxy relationship, established using controlled experiments on cultivated *Ginkgo* leaves, will be applied to the ancient record of atmospheric carbon dioxide using fossil *Ginkgo* leaves that are common in sediments deposited during periods when Earth's atmospheric carbon dioxide concentration and climate varied substantially from the present. The project will also educate students and citizen scientists about the scientific method and insights from this research by involving them in collecting specimens, making measurements and analyzing data.

Justification for Using Crowdsourcing and Citizen Science: Crowdsourcing and Citizen Science fits into the Smithsonian's mission to increase the public's understanding of science. An individual cannot classify sufficient leaf cells in a day, week, or month, but thousands of people can classify enough cells for analysis in a reasonable amount of time. The cost benefit makes it virtually the only way this project can be accomplished.

Status: The project started in October, 2017 and is ongoing.

Location: The project is located in Washington, D.C., Edgewater, MD, and the Rocky Mountain Region, USA.

Participation: The project has engaged Citizen Scientists both onsite and online. At the National Museum of Natural History (NMNH), 90 visitors participated in special Fossil Atmospheres programs, contributing a total of 270 hours, and 3 behind-the-scenes volunteers worked for 770 hours. At the Smithsonian Environmental Research Center, 17 volunteers contributed 750 hours. On the Zooniverse website 4855 individuals dedicated approximately 6200 hours.

Consent: Participation from all participants was voluntary.

Submissions: The research studies ginkgo trees grown in controlled environments with manipulated CO_2 concentrations. Magnified images of leaf cells uploaded to Zooniverse, a public platform for citizen science, are downloaded by citizen scientists to classify.

Resources: The project, P2C2: Collaborative Research: New Estimates of Atmospheric pCO2 for the Paleocene-Eocene, is supported by the National Science Foundation (Federal award ID number 1805228) through the Program in Geobioloby & Low Temperature Geochemistry. The award is $671,160 and supports salary, supplies, travel, and broader impact, including the citizen science component. Zooniverse is a free platform with no costs associated other than setting up the project and supplying the images. A Smithsonian funded postdoc with 25% commitment to outreach used the Zooniverse site to set up the project for public participation using 25 hours of their time. Two, three-hour citizen science events were run by two staff members. No Smithsonian funding was directly used to support these events, although miscellaneous office supplies such as a display monitor, paper, and pens were used. The NMNH office of Education & Outreach supported the onsite programs by promoting them through their media channels and facilitating logistics. NMNH volunteers managed the crowd.

[54] The website for Fossil Atmospheres can be viewed at https://www.zooniverse.org/projects/laurasoul/fossil-atmospheres.

Partnerships: N/A

Advancement of Agency Mission: The Smithsonian's mission is to increase and diffuse knowledge, whereas NMNH focuses on the natural world and our place in it. This research project fits squarely within the mission as it will advance our knowledge of the relationships between CO_2 concentrations, atmospheric temperature, ice volume, sea levels, and climate. Understanding the past to project the future is a strength of NMNH research and collections.

Results: The data collected by citizen scientists will be used to refine proxy estimates of atmospheric carbon dioxide that are based on an understanding of how the properties of stomatal pores in the leaves of ginkgo trees respond to elevated carbon dioxide concentration. Leaves from trees grown in enclosures with different concentrations of CO_2 will have stomatal pore counts associated with different CO_2 concentrations. Citizen Scientist classifications will be used to compare modern Ginkgo leaves with known CO_2 concentrations with fossil Ginkgo leaves from the Paleocene and Early Eocene (a period of warm climate).

Data Availability: Results will be shared online at Zooniverse where the public made the classifications and through peer-reviewed scientific journals.

D.8.6 Global Change Research Wetland Plant Census[55]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: Salt marshes are unique ecosystems that serve as nurseries and habitat for wildlife and protect coastal communities from flooding and storms. Scientists are looking at the effect of multiple different types of global change on the growth of the salt marsh. Climate change effects can be simulated by placing plants into different depths of water (sea level rise), pumping predicted amounts of gases into chambers (increase in carbon dioxide), or heating the marsh (global warming).

Justification for Using Crowdsourcing and Citizen Science: By engaging citizen scientists, the Smithsonian is able to collect large amounts of data, related to all of the projects happening at the marsh, in a very short period of time. This ensures that all of the plants are the same age and at the same stage of seasonal development when samples are taken, allowing us to compare across projects and through time. As the number of projects grows, it would not be possible to collect the data in the same small window of time without volunteers.

Status: The project started in July 2014 and is ongoing.

Location: This project is located in the Chesapeake Bay.

Participation: The total number of individuals involved during FY18 was 57. The total number of volunteer hours was 955.

Consent: Participation by the 57 individuals involved during FY18 was voluntary.

Submissions: Submissions are received in the form of data and observations.

Resources: Support for project staff (post doctoral fellows, technicians, principal investigators), maintenance of field site, purchase of supplies were all covered as normal operating expenses for the Global Change Research Wetland Plant Census.

[55] The website for the Global Change Research Wetland Plant Census can be viewed at https://serc.si.edu/citizen-science-research/projects/salt-marsh-census.

Partnerships: Federal partners include the National Science Foundation, Department of Energy, U.S. Geological Survey, and the National Aeronautics and Space Adminsitration, each of which are either currently or previously have provided funding for the project. Non-Federal partners include Maryland Sea Grant and Bryn Mawr College.

Advancement of Agency Mission: The Smithsonian Environmental Research Center provides science-based knowledge to meet the environmental challenges of the 21st century. The Center leads research on coastal ecosystems, such as the Global Change Research Wetland Plant Census, to inform real-world decisions for wise policies, best business practices, and a sustainable planet.

Results: Results are used in numerous peer-reviewed pubications, professional presentations, and graduate student dissertations.

Data Availability: All data are made available on the project website.

D.8.7 Invader ID[56]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: This project focuses on how introducing new organisms to an area can change the numbers and types of other organisms in the marine fouling community. By doing surveys of bays through time, it is possible see how the types and abundances of the organisms change, and how different species interact with one another. It also allows detection of new invasive species before they become problematic. Researchers use the data collected through the fouling community surveys to look at how fouling communities change through time and between one location and another. They combine this information with other data, such as weather data, to try to understand the patterns that they observe. By understanding these patterns, scientists can better predict which species are likely to invade nearby areas and what kinds of impacts they could have.

Justification for Using Crowdsourcing and Citizen Science: Fouling community patterns are most effective when data from lots of places over several years are available. Currently, scientists do all of the identifications, but this is a time consuming process and limits the number of bays that can be surveyed. Involving citizen scientists should increase the rate of data acquisition and the total amount of data available.

Status: The project started in March 2018 and is ongoing.

Location: Online only at this time.

Participation: The total number of individuals involved during FY18 was 1372.

Consent: Participation by the 1372 individuals involved during FY18 was voluntary.

Submissions: 48,542 classifications

Resources: N/A

Partnerships: N/A.

Advancement of Agency Mission: The Smithsonian Environmental Research Center provides science-based knowledge to meet the environmental challenges of the 21st century. The Center leads research

[56] The website for the Invader ID can be viewed at https://www.zooniverse.org/projects/serc/invader-id.

on coastal ecosystems, such as this pilot project, to inform real-world decisions for wise policies, best business practices, and a sustainable planet.

Results: This is a pilot project. No results have been published yet.

Data Availability: This is a pilot project but preliminary data can be shared upon request.

D.8.8 Leafsnap[57]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: Leafsnap is an electronic field guide that helps users learn about tree species and contribute to biodiversity research. Developed by researchers at Columbia University, the University of Maryland, and the Smithsonian, the free mobile app uses visual recognition software to identify tree species from high-resolution photographs of leaves. Leafsnap users automatically share images, species identifications, and geo-coded stamps of species locations with a community of scientists who use the data to map and monitor the ebb and flow of flora.

Justification for Using Crowdsourcing and Citizen Science: N/A

Status: The project started in 2011 and is ongoing.

Location: Northeastern United States and Canada, with plans to expand to full Continental U.S.

Participation: N/A

Consent: N/A

Submissions: N/A

Resources: N/A

Partnerships: Non-Federal partners include Columbia University and University of Maryland.

Advancement of Agency Mission: Leafsnap advances the Smithsonian's commitment to exploration and discovery of biological diversity and to sustaining the Earth's plant life.

Results: N/A

Data Availability: N/A

D.8.9 Neighbor Nestwatch[58]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: Neighborhood Nestwatch provides an outdoor educational experience for backyard wildlife enthusiasts and underserved youth. Participants contribute to important scientific research by re-sighting banded birds and monitoring nests. The Neighborhood Nestwatch approach features face-to-face interaction on an annual basis between Smithsonian scientists, participants, and neighborhood birds. Taking place in metro-area backyards in a growing number of metropolitan regions, Nestwatch seeks to determine how well backyard birds are coping amid rapid land use change

[57] The website for Leafsnap can be viewed at http://leafsnap.com/.

[58] The website for the Neighbor Nestwatch can be viewed at https://nationalzoo.si.edu/migratory-birds/neighborhood-nestwatch.

and simultaneously educate the public about threats and habitat enhancements that affect bird survival.

Justification for Using Crowdsourcing and Citizen Science: Members of the public give direct access to properties and offer first-hand observations of banded birds and nests.

Status: The project started in 2000 and is ongoing.

Location: The project is currently located in the Eastern seaboard and Colorado, and is Expanding to other U.S. metro regions.

Participation: The project targeted homeowners in metro regions. The total number of individuals involved during FY17 and FY18 was 500.

Consent: Participation by the 500 individuals involved during FY17 and FY18 was voluntary.

Submissions: Data observations on bird nests and color-banded birds in their backyards

Resources: Less that one FTE was used for the program, Resources for program management, seasonal field technicians, transportation, and equipment were provided by a Smithsonian "Youth Acess" grant. Additional resources were provided by a Cullman Foundation grant.

Partnerships: Federal partners include the Department of Agriculture. Non-Federal partners include the National Aviary (Pittsburgh), the Fernbank Museum of Natural History (Atlanta), and the Bird Conservancy of the Rockies (Denver).

Advancement of Agency Mission: The citizen science project has brought greater attention to Neighborhood Nestwatch thereby promoting an understanding of the conservation of backyard birds as well as educating the public about local bird survival.

Results: Overall, more than twenty articles have been published directly from Nestwatch data since project inception. Scientific publications in recent fiscal years include "Characterizing avian survival along a rural-to-urban land use gradient" in the journal Ecology, and "Native plants improve breeding and foraging habitat for an insectivorous bird" in the journal Biological Conservation.

Data Availability: Through the program website, Nestwatch participants can view birds banded and nests found at other locations within the Nestwatch participant base. Technical data are not made available until such data are analyzed, published, and disseminated online.

D.8.10 Smithsonian Transcription Center[59]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: The Smithsonian Transcription Center was created to increase and improve the access and use of Smithsonian digital collections, enhance the the quality of public engagement and participation, create new pathways of learning and knowledge, and maintain and build trust with communities of interest. In short, it was designed as an easy-to-use, free, online platform where the public – from anywhere in the world – could interact with digitized collections from around the Smithsonian and help enhance those materials through crowdsourced transcription and review. This

[59] The website for the Smithsonian Transcription Center can be viewed at https://transcription.si.edu/.

process allows public participants to engage with Smithsonian materials and increase the accessibility and discoverability of these collections by creating readable, text-searchable transcriptions.

Justification for Using Crowdsourcing and Citizen Science: The Smithsonian Transcription Center was designed as a crowdsourcing project because there was a defined need across the institution to increase and improve the accessibility of collections that could not be achieved by staff due to limited time and financial resources. Previous transcription projects were done by staff members, contractors, or interns, on a project-by-project basis, when time and resources permitted. Through crowdsourcing with digital volunteers, the stories and information locked within digitized collections is made accessible on a level far beyond the abilities of Smithsonian staff. On average, digital volunteers transcribe and review over seventy-five pages of material per day. The choice to enlist the public in this project for crowdsourcing transcriptions additionally fits into the Smithsonian Institution's mission of engaging the public in the increase and diffusion of knowledge.

Status: The project started in June 2013 and is ongoing.

Location: Materials that are posted for transcription pertain to areas across the United States and around the world.

Participation: The project targeted any member of the public interested in helping transcribe Smithsonian library, archival, and museum collections. By the end of FY18, the Transcription Center had 11,889 participants (registered digital volunteers). Of these, 4,551 were newly registered during FY17 and FY18. Of the new volunteers, 2,927 were active transcribers.

Consent: Participation by the 4,551 volunteers involved during FY17 and FY18 was voluntary.

Submissions: Volunteer participants are asked to transcribe and review digitized Smithsonian archival, library, and museum collections. During FY17 and FY18, volunteers completed 194,827 pages.

Resources: The Smithsonian Transcription Center crowdsourcing platform is supported by the Smithsonian's Office of the Chief Information Officer (OCIO). OCIO staff oversee operations and continued development of the platform, working in close coordination with colleagues in the Smithsonian museums and research centers that contribute collections for transcription. A full-time project coordinator sponsored by OCIO supports unit staff in utilizing the system and fosters the Center's vibrant community of Digital Volunteers. Two to three FTEs were used to execute this project in FY17 and FY18.

Partnerships: N/A

Advancement of Agency Mission: The Smithsonian Transcription Center advances the Institution's historic mission to "increase and diffuse knowledge" by providing a digital platform where the public can take part in making treasures now held in Smithsonian museums, libraries, and archives accessible to the world. The program, which presents materials for transcription spanning the fields of science, history, art, and culture, supports the goals of the current Strategic Plan of engaging and inspiring millions more people – locally and around the globe – through audience-focused pan-Institutional initiatives.

Results: The transcribed pages completed by digital volunteers in the Smithsonian Transcription Center are used in a variety of research projects and exhibits both within and outside the Smtihsonian. Because all of the transcriptions are made publically available on multiple platforms, Smithsonian staff and researchers, along with the public, can find and use the information transcribed for their own research purposes. For example, completed transcription projects have been used by Smithsonian curators to more easily locate information within collection materials to include in museum exhibits; data gathered from transcriptions has been used to map and reveal new information on the growth of different

vegetables around the country, the populations of insect species over time, and the flora and fauna present in various countries throughout different centuries; and transcriptions of correspondence, diaries, field notes, and government and organizational records have been used by both academic researchers and the public to locate genealogical information. Some of the major projects launched and completed in the Transcription Center during FY17 and FY18 include: (1) Records of the Bureau of Refugees, Freedmen, and Abandoned Lands (collaborative project between the National Museum of African American History and Culture and the National Archives, https://s.si.edu/2LlYpkg); (2) Field Book Project (including field notes from around the Smithsonian, https://s.si.edu/2npArut); (3) The Jacques Seligmann & Co. Records from the Archives of American Art (https://s.si.edu/2QqdmV1); (4) Projects related to Frederick Douglass for the Bicentennial of his birth (https://s.si.edu/2Nd4ssF); and (5) Phyllis Diller Gag File from the National Museum of American History (https://s.si.edu/2P6IEQf).

Data Availability: All completed (i.e., transcribed and reviewed) pages are made available to the public online. Transcribed content is always available on the Smithsonian Transcription Center website (transcription.si.edu) on both the project pages themselves and through downloadable pdfs (as individual pages or fully completed projects). The original digitized images of the material being transcribed remain next to the completed transcription for reference. Transcription Center completed pages and projects are also linked internally with the Smithsonian's online, public-facing databases: Collections Search Center (http://collections.si.edu/search/) and the Smithsonian's Online Virtual Archive (https://sova.si.edu/). Within minutes of a page being transcribed, the transcribed content automatically appears alongside the digitized collection page in these online databases and is text searchable.

D.8.11 Smithsonian Transcription Center - Biodiversity Collection Records and Specimen Labels[60]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: Since 2013, one of the primary goals of the Smithsonian Transcription Center has been to increase and improve the access and use of Smithsonian scientific related collections, enhance the quality of public engagement with these materials, and create new pathways of learning and knowledge related to scientific and biodiversity data. By enlisting the public's help in transcribing and reviewing scientific specimen records and collections, the Transcription Center promotes and sustains the discoverability of scientific data.

Justification for Using Crowdsourcing and Citizen Science: The Smithsonian Transcription Center was designed as a crowdsourcing project because there was a defined need across the institution to increase and improve the accessibility of our collections that could not be achieved by staff due to limited time and financial resources. Previous transcription projects were done by staff members, contractors, or interns, on a project-by-project basis, when time and resources permitted. Through crowdsourcing with digital volunteers, the stories and information locked within our digitized collections is made accessible on a level far beyond the abilities of Smithsonian staff. On average, digital volunteers transcribe and review over seventy-five pages of material per day. The choice to enlist the public in this project for crowdsourcing transcriptions additionally fits into the Smithsonian

[60] The website for the Smithsonian Transcription Center - Biodiversity Collection Records and Specimen Labels can be viewed at https://transcription.si.edu/; Paleobiology catalog cards: https://s.si.edu/2NhAuTn; Pollen Cards: https://s.si.edu/2P4U4nM; Botanical Specimen Sheets: https://s.si.edu/2P1nao8; Entomology Bumblee Specimen Sheets: https://s.si.edu/2xRHOQL.

Institution's mission of engaging the public in the increase and diffusion of knowledge. Scientific field books and other archival materials were seen as particularly relevant and important for inclusion into the Transcription Center, as transcriptions of this content would help further unlock hidden data for researchers around the world.

Status: The project started in June 2013 and is complete.

Location: Collection records pertained to locations throughout the U.S., Panama, and other countries.

Participation: The project targeted any member of the public with internet access interested in helping to transcribe and review Smithsonian archival collections related to the history of science and biodiversity. From launch of the Smithsonian Transcription Center in 2013 through the end of FY18, a total of 11,889 individuals have registered on the platform. In FY17-18 alone, the community grew by 4,551 registered users, 2,927 of whom actively transcribed.

Consent: All individuals who registered on the platform provided consent.

Submissions: Participants were asked to transcribe and review digitized specimen labels and collection information for a number of different scientific specimens from the National Museum of Natural History's Department of Botany, Entomology, and Paleobiology, and from the Smithsonian Tropical Research Institute. This transcribed data was used to create catalog records for these materials, increasing accessibility to this scientific research material.

Resources: N/A

Partnerships: N/A

Advancement of Agency Mission: The Smithsonian Transcription Center's projects from the Institution's various biodiversity collections and specimen records advance the mission and strategic objectives of the Smithsonian Institution. By providing a pan-institutional digital platform where the public can not only access digitized science-related collections, but also participate in improving them, the Transcription Center plays a prominent role in the increase and diffusion of knowledge. With over 11,800 active digital volunteers from over fifty different countries, the Transcription Center also advances the goals of the Smithsonian's strategic plan to engage and inspire more people by 2022 through new digital initiatives, interdisciplinary projects, and improve and increase access to our scientific collections.

Results: The transcribed pages completed by digital volunteers in the Smithsonian Transcription Center are used in a variety of research projects and exhibits both within and outside the Smithsonian. Because all of the data (transcriptions) are made publically available on multiple platforms, Smithsonian staff and researchers, along with the public, can find and use the information transcribed for their own research purposes. For example, completed transcription projects from biodiversity specimen collections have been used to enhance and improve data in a variety of scientific research projects. Not only did this work create catalog records for this material that did not exist before, but transcriptions of this data also increased the accessibility and readability of the information related to these various scientific specimens on a level that could not be achieved by department staff. Smithsonian researchers and the public have been able to use this information to more easily study the geographic and chronological population changes of bumblebees, botanical specimens, pollen, and the prehistoric marine invertebrates, and discover, from anywhere in the world, new scientific information about these collections and species.

Data Availability: All completed (i.e., transcribed and reviewed) pages are made available to the public online. Transcribed content is always available on the Smithsonian Transcription Center website (transcription.si.edu) on both the project pages themselves and through downloadable pdfs (as

individual pages or fully completed projects). The original digitized images of the material being transcribed remain next to the completed transcription for reference.

D.8.12 Smithsonian Transcription Center - Project PHaEDRA: Preserving Harvard's Early Data and Research in Astronomy[61]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: Since 2013, one of the primary goals of the Smithsonian Transcription Center has been to increase and improve the access and use of Smithsonian scientific collections, enhance the quality of public engagement with these materials, and create new pathways of learning and knowledge related to scientific and biodiversity data. By enlisting the public's help in transcribing and reviewing research data from the Harvard-Smithsonian Center for Astrophysics, the Transcription Center promotes and sustains the discoverability of scientific research and data for researchers around the world, and makes available primary sources on the evolution of observation methods and astronomy.

Justification for Using Crowdsourcing and Citizen Science: The Smithsonian Transcription Center was designed as a crowdsourcing project because there was a defined need across the institution to increase and improve the accessibility of our collections that could not be achieved by staff due to limited time and financial resources. Previous transcription projects were done by staff members, contractors, or interns, on a project-by-project basis, when time and resources permitted. Through crowdsourcing with online volunteers, the stories and information locked within our digitized collections is made accessible far beyond the abilities of Smithsonian staff. On average, digital volunteers transcribe and review over seventy-five pages of material per day. The choice to enlist the public in this project for crowdsourcing transcriptions additionally fits into the Smithsonian Institution's mission of engaging the public in the increase and diffusion of knowledge. Scientific field books and other archival materials were seen as particularly relevant and important for inclusion into the Transcripiton Center, as transcriptions of this content would help further unlock hidden data for researchers around the world.

Status: The project started in June 2013 and is ongoing.

Location: N/A

Participation: The project targets any member of the public with internet access and access to a computer interested in helping to transcribe and review Smithsonian archival collections related to the history of science and astronomy. From launch of the Smithsonian Transcription Center in 2013 through the end of FY18, a total of 11,889 individuals have registered on the platform. In FY17-18 alone, the community grew by 4551 registered users, 2927 of whom actively transcribed material.

Consent: Participation was voluntary.

Submissions: Participants, or "digital volunteers", were asked to transcribe and review digitized log books and notes created by "human computers" at the Harvard College Observatory in the 19th and 20th centuries. Now held in the Wolbach Library of the Harvard-Smithsonian Center for Astrophysics, these logbooks – and their transcriptions – provide an invaluable resource on the history of astronomy.

[61] The website for the Smithsonian Transcription Center -- Project PHaEDRA: Preserving Harvard's Early Data and Research in Astronomy can be viewed at https://s.si.edu/2xRukol.

Resources: The Smithsonian Transcription Center crowdsourcing platform is supported by the Smithsonian's Office of the Chief Information Officer (OCIO). OCIO staff oversee operations and continued development of the platform, working in close coordination with colleagues in the Smithsonian museums and research centers that contribute collections for transcription. A full-time project coordinator sponsored by OCIO supports unit staff (equivalent to 2-3 FTEs) in utilizing the system and fosters the Center's vibrant community of Digital Volunteers.

Partnerships: Non-Federal partners include Harvard University.

Advancement of Agency Mission: The Smithsonian Transcription Center's projects on astronomy and astrophysics research data from the Harvard-Smithsonian Center for Astrophysics advance the mission and strategic objectives of the Smithsonian Institution. The Transcription Center plays a prominent role in the increase and diffusion of knowledge. With over 11,800 active digital volunteers from over fifty different countries, the Transcription Center also advances the goals of the Smithsonian's strategic plan to engage and inspire more people by 2022 through new digitial initiatives, interdisciplinary projects, and improve and increase access to scientific collections.

Results: All of the transcribed projects from the Harvard-Smithsonian Center for Astrophysics will be available digitally in both Harvard University's databases as well as remaining permanently available in the Transcription Center. The availability of these transcription projects in these online systems allows researchers around the world to more easily discover and study the history of astronomy as a science, the development and evolution of observation methods, changes over time in the night sky, and the role of women in this research during the nineteenth and twentieth centuries. Harvard-Smithsonian Center for Astrophysics' Wolbach Library Staff are already using transcribed data to contextualize and inform related materials in their collections and create outreach and engagement tools, including educational resources related to the history of astronomy.

Data Availability: All of the transcribed projects from the Harvard-Smithsonian Center for Astrophysics are permanently available in the Transcription Center and can be downloaded and searched by anyone interested. The transcriptions will also become full-text searchable in the NASA Astrophysics Data System through Harvard University (https://ui.adsabs.harvard.edu/), and will be linked to the original source material: 500,000 glass plate photographs representing the first picture of the visible universe. These plates are currently being digitized through the DASCH Project at Harvard University (https://platestacks.cfa.harvard.edu/dasch-project). The availability of these transcription projects in the Transcription Center and through Harvard University's online systems allows researchers around the world to more easily discover and study the history of astronomy as a science, the development and evolution of observation methods, changes over time in the night sky, and the role of women in this research during the nineteenth and twentieth centuries. The Project PHaEDRA projects are downloadable and viewable in the Transcription Center at https://s.si.edu/2xRukol.

D.8.13 Smithsonian Transcription Center - Transcription of Science-related Archival Documents[62]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: Since it was created in 2013, the Smithsonian Transcription Center has expanded access to Smithsonian science-related collections, enhanced the quality of public

[62] The website for the Smithsonian Transcription Center, Transcription of Science-related Archival Documents can be viewed at https://s.si.edu/2OYqhx6.

engagement with these materials, and created new pathways of learning and knowledge related to scientific and biodiversity data. By enlisting the public's help in transcribing and reviewing scientific field notes, annual reports, correspondence, and more, the Transcription Center promotes the discoverability and use of scientific data by professional researchers and laypeople.

Justification for Using Crowdsourcing and Citizen Science: The Smithsonian Transcription Center was designed as a crowdsourcing project because there was a defined need across the institution to increase and improve the accessibility of collections that could not be achieved by staff due to limited time and financial resources. Previous transcription projects were done by staff members, contractors, or interns, on a project-by-project basis, when time and resources permitted. Through crowdsourcing with digital volunteers, the stories and information locked within the Smithsonian's digitized collections is made accessible on a level far beyond the abilities of Smithsonian staff. On average, digital volunteers transcribe and review over seventy-five pages of material per day. The choice to enlist the public in this project for crowdsourcing transcriptions additionally fits into the Smithsonian Institution's mission of engaging the public in the increase and diffusion of knowledge. Scientific field books and other archival materials were seen as particularly relevant and important for inclusion into the Transcripiton Center, as transcriptions of this content would help further unlock hidden data for researchers around the world.

Status: The project started in June 2013 and is ongoing.

Location: Archival documents pertaining to locations throughout the United States and beyond.

Participation: The project targets any member of the public interested in helping transcribe Smithsonian archival collections related to science and biodiversity. From launch of the Smithsonian Transcription Center in 2013 through the end of FY18, a total of 11,889 individuals have registered on the platform. In FY17-18 alone, the community grew by 4551 registered users, 2927 of whom actively transcribed material.

Consent: Participation by all individuals is voluntary.

Submissions: Participants, or "digital volunteers", are asked to transcribe and review digitized Smithsonian archival materials related to science and biodiversity, including field notes from scientific expeditions, annual reports of Smithsonian scientific departments, and correspondence from Smithsonian scientific curators. Their efforts make the data within the archival materials more accessible (more readable and keyword searchable) for the scientists and the general public.

Resources: The Smithsonian Transcription Center crowdsourcing platform is supported by the Smithsonian's Office of the Chief Information Officer (OCIO). OCIO staff oversee operations and continued development of the platform, working in close coordination with colleagues in the Smithsonian museums and research centers that contribute collections for transcription. A full-time project coordinator sponsored by OCIO supports unit staff (equivalent to 2-3 FTEs) in utilizing the system and fosters the Center's vibrant community of Digital Volunteers.

Partnerships: N/A

Advancement of Agency Mission: The Smithsonian Transcription Center advances the Institution's historic mission to "increase and diffuse knowledge" by providing a pan-institutional digital platform where the public can take part in making treasures now held in Smithsonian museums, libraries, and archives accessible to the world. The program, which presents materials for transcription spanning the fields of science, history, art, and culture, supports the goals of the current Strategic Plan of engaging and inspiring millions more people—locally and around the globe—through audience-focused pan-Institutional initiatives.

Results: N/A

Data Availability: All completed (i.e., transcribed and reviewed) pages are made available to the public online. Transcribed content is always available on the Smithsonian Transcription Center website (transcription.si.edu) on both the project pages themselves and through downloadable pdfs (as individual pages or fully completed projects). The original digitized images of the material being transcribed remain next to the completed transcription for reference. Transcription Center completed pages and projects are also linked internally with the Smithsonian's online, public-facing databases: Collections Search Center (http://collections.si.edu/search/) and the Smithsonian's Online Virtual Archive (https://sova.si.edu/). Within minutes of a page being transcribed, the transcribed content automatically appears alongside the digitized collection page in these online databases and is text searchable.

D.8.14 Virginia Working Landscapes: Grasslands Biodiversity Survey[63]

Lead Sponsoring Agency: Smithsonian Institution

Authority: N/A

Project Summary and Goals: Virginia Working Landscapes (VWL) is a program of the Smithsonian Conservation Biology Institute (SCBI) that promotes the conservation of native biodiversity and sustainable land-use through research, education, and community engagement. Its goals are to: (1) Create a community network to promote dissemination of information from neighbor to neighbor; (2) Network landowners with State and Federal agencies that can provide them with specific technical and financial assistance; (3) Establish and highlight demonstration sites on working farms that showcase best practices for different land uses, agricultural production, and biodiversity management; and (4) Advance the science of land management and develop best practices relevant both to working farmers and conservationists.

Justification for Using Crowdsourcing and Citizen Science: Citizen science allows VWL to gather data over a large geographic area (incorporating 16 counties) from private landholdings. VWL's focus is on engagement with the community of concerned citizens over a multi-county region of central and northern Virginia, over the broad topic of biological conservation. Citizen science is a means to recruit, train, and continuously provide outreach and education materials to the community. In turn, citizen scientists become ambassadors for the program and the Smithsonian Institution. The program convenes a large audience of citizen scientists, landowners, researchers, other non-profit organizations, and natural resource industry service providers through Smithsonian's field work, frequent training, and enrichment opportunities. The citizen scientists make a direct contribution to research, increase their scientific understanding, and are allowed to immerse themselves in the field of conservation. This all results in highly impactful, personally transformative experiences for the citizen scientist volunteers. The project encourages not only good conservation, but also good community-based, person-to-person networking around a good cause.

Status: The project started in January 2010 and is ongoing.

Location: The project is located in Northern and Central Virginia, Northern Blue Ridge and Northern Piedmont ecoregions.

[63] The website for the Virginia Working Landscapes: Grasslands Biodiversity Survey can be viewed at http://www.vaworkinglandscapes.org/conservation-science/priority-areas/220-grassland-biodiversity-surveys.

Participation: The project targets landowners, research professionals, naturalist volunteers, government and non-government natural resource organizations, conservation land trusts, and for-profit land management businesses. The project involved 83 citizen scientists in 2017 and 64 in 2018. The total number of volunteer hours was 1.19 FTEs.

Consent: Participation by the 131 individuals involved in FY17 and FY18 was voluntary.

Submissions: Participants submitted ecological monitoring data, photographs, and plant and animal specimens collected from the field.

Resources: The program required 0.54 FTEs in FY18.

Partnerships: Non-Federal partners include Blandy Experimental Farm and State Arboretum; Piedmont Environmental Council; Blue Ridge PRISM; Smithsonian-Mason School of Conservation; National Bobwhite Conservation Initiative; Virginia Master Naturalists; Virginia Department of Game and Inland Fisheries.

Advancement of Agency Mission: The Smithsonian's mission is to increase and diffuse knowledge. Virginia Working Landscapes is a program of the Smithsonian Conservation Biology Institute that promotes the conservation of native biodiversity and sustainable land-use through research, education, and community engagement.

Results: Through the development of consistent survey protocols and rigorous volunteer training, the data from VWL surveys has begun to yield results that can be applied to local land management. For example, it is now known that native warm-season grass meadows, such as those established through bobwhite quail conservation programs, support higher densities of declining shrubland birds and overwintering birds. Similarly, citizen scientists study how human activities influence movement patterns of the region's carnivores, explore how urban development impacts bumblebee populations, and identify relationships between native plants, land management, and wildlife. These studies can help delineate areas of conservation priority while engaging landowners and educating them regarding best practices for biodiversity. The results of the analyses derived from data collected through our citizen science project are disseminated to regional planning entities, policy makers, the scientific community, VWL's partner organizations, and landowners. Results appear in peer-reviewed journals and publications as well as through SI media channels and other popular print and online publications. On average, outreach effort includes over twenty formal presentations a year and include hosting or attending at least ten other public outreach events in our region. An additional 5000+ people are reached through social media and website visits each year. Analyses are useful to natural resource agency regulators and partners for identifying population trends among a host of plant and wildlife species, some of which are currently federally endangered or considered at-risk, and many of which are considered in decline. This knowledge will contribute to a growing body of knowledge around grasslands ecology, particularly in the area of grassland breeding birds, native pollinators, the impacts of invasive or introduced plant species on the biodiversity, overall health, and stability of grass-dominated ecosystems in the eastern United States. In addition, each landowner on whose property a survey is conducted is provided an annual report summarizing all the data collected in a given year. Results provide an important input for landowners and land managers, and form a foundation for making good land management decisions.

Data Availability: Data collected by VWL citizen scientists has in the past been made publically available through the website, but due to the sensitive, proprietary nature of private property, and the need to protect the identities of landowners and other private citizens, the practice of publically releasing this information has been ended. VWL intends to explore ways to make the data available in the future through the publication of results.