California Biodiversity Citizen Science Meetings

May 16-18, 2012
California Academy of Sciences
San Francisco, California

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See appendix for the list of participants and their institutional affiliations.

Goal:

To learn from biodiversity researchers from a variety of institutions, citizen science experts and participants, conservation organizations, and data managers about best practices in citizen science in order to inform the Academy's new citizen science initiative on documenting California biodiversity.

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Executive Summary:
California Biodiversity Citizen Science Meetings
California Academy of Sciences

On May 16-18, 2012, the California Academy of the Sciences gathered together representatives from conservation organizations, research institutions, biologists, and volunteers all engaged in citizen science. The meetings were an opportunity for the Academy to learn from others as they move forward with their Citizen Science Initiative, and for all participants to discuss and share their experiences, successes and challenges in designing and implementing citizen science programs that inform biodiversity research. Each day of the meeting focused on a different theme or perspective, 1) Citizen science participants, 2) Biodiversity research, and 3) Technology, tools and data management, and included presentations, small working groups and panel discussions.

We should consider the spectrum of what it means to participate that varies in terms of degree, scale, and quality.

In the first day of the meetings, the focus was on the roles and experiences of citizen science participants. After a brief introduction to the meetings and the goals of the Academy by Executive Director Greg Farrington and Chief Public Engagement Officer Elizabeth Babcock, Jennifer Shirk and Rhiannon Crain from the Cornell Lab of Ornithology spoke to the group about the importance and types of participation possible in citizen science. Jennifer described a spectrum of what it means to participate that varies in terms of degree, scale, and quality. Rhiannon then discussed how the different kinds of participation could result in different roles for volunteers in citizen science projects.

We then heard from the coordinators of two very different citizen science programs, who shared their experiences of working with citizen scientists in a regionally-focused hands-on program, and in a large nationally-focused online environment. Amy Dean and John Pearse shared the history of the LiMPETS program, that works primarily with students and teachers collecting data on beach and rocky tidal areas of Northern California's coast. Sandra Henderson then discussed the work of Project BudBurst, an Internet-based program in which volunteers collect data about the phenology of their local plants and animals, generating data on a large-scale to help answer questions about impacts of climate change.

The panel of citizen scientists brought to light the passion, curiosity, and important experiences that volunteers bring to their work.

A highlight of Day 1 was a panel discussion with volunteers from different citizen science program in the Bay Area of Northern California, who shared their experiences and perspectives on participating in citizen science. Panelists responded to moderator Elizabeth Babcock's questions about how they got involved in the citizen science program, their interests in conservation and science, and the importance of relevant data and local place. Other meeting participants joined in the conversation, which brought to light the passion, curiosity, and important experiences the volunteers bring to their work as citizen scientists.

Following panel discussion, meeting participants formed small working groups to tackle specific questions related to recruiting, training, managing and retaining volunteers in citizen science programs. Answering the main questions of "what worked" and "what doesn't work" based on our experiences, the groups shared lessons about making sure that experiences for volunteers are rewarding and not too tedious, and that volunteers see how their contributions are truly valuable to science and conservation.

During Day 2, the focus shifted from participants to the scientists and organizers of citizen science projects. Terry Gosliner, Dean of Science and Research at the Academy, opened the day by presenting the Academy's vision and goals for citizen science, focusing on his hopes to engage multiple stakeholders to overcome challenges to biodiversity research, conservation and policy through involving the public in citizen science. Terry briefly described the Academy's two local pilot projects that are working to meet these goals, at Mt. Tamalpais in Marin County and the Gulf of the Farallones/ Fitzgerald Marine Reserve in San Mateo County.

A panel discussion, this time composed of biodiversity researchers and scientists, expressed a range of experiences, explored tensions and discussed strategies for incorporating citizen science into their work. Responding to questions from moderator Terry Gosliner, the panelists discussed the importance of asking and answering rigorous research questions and ways to strategically involve volunteers and help advance conservation science. In particular, because several panelists were from museums housing collections as the Academy does, they discussed how conservation biology shaped the way they package and manage specimens and data, and ways to boost the capacity of volunteers working on projects.

Following the biodiversity research panel, representatives from conversation organizations and citizen science programs presented briefly about their own programs and their successes and constraints working with volunteers to advance conservation science. Rusty Russell, from the Smithsonian National Museum of Natural History, shared his experiences working on biodiversity research with citizen scientists in the San Jacinto Mountains of Southern California, emphasizing the importance of having enthusiasm for both the science of the work and the relationships with volunteer citizen scientists. Lisa Micheli, from Pepperwood Preserve in Sonoma County, described several citizen science projects they are developing that they hope will have impact on biodiversity research and engage the public. Noreen Weeden shared the ways Golden Gate Audubon engages a wide range of people in their many volunteer monitoring projects, some of which began with grassroots initiative from their members. Maria Brown, from Gulf of Farallones National Marine Sanctuary, talked about potential for public-private partnerships to enhance both conservation and citizen science outcomes. Janet Klein and Andrea Williams described their work at the Marin Municipal Water District and their lessons about challenges and successes working with citizen scientists as part of their watershed management. Lastly, Allen Fish presented his many lessons, especially about truly getting to know his volunteers, from three decades of citizen science work with the Golden Gate Raptor Observatory.

The vision is to engage multiple stakeholders to overcome challenges to biodiversity research, conservation and policy through involving the public in citizen science.

After hearing about the variety of lessons from conservation-focused citizen science programs, meeting participants formed small working groups to discuss what works and what doesn't work when focusing on research and conservation outcomes. Each group discussed and then shared their perspectives and experiences from their own conservation programs, revealing important considerations for projects design, such as tailoring research questions and protocol design for the skill sets and interests of volunteers, and making sure that scientists, volunteer coordinators, conservation managers and are all involved in the development of the project from the beginning.

Day 3 of the meetings focused on technology, tools and data management, and was moderated by Jean Farrington, Director for Lifelong Learning at the Academy. At the start of the day, Alison Young, Citizen Science Educator at the Academy, gave a thorough overview of the key issues and examples of the use of technology in citizen science projects, including website design, training tools, keeping participants engaged, data entry and cleaning, data visualization for participants, social media and emerging apps. Following this introduction, representatives from citizen science projects that particularly utilize technology in novel ways described their own approach for using technology. Dan Gluesenkamp of Calflora described the focus of the Calflora website and database as a way to aggregate and share data with scientists, museums and land managers.

At the other end of the user spectrum, Scott Loarie of iNaturalist discussed how the online communities help provide scalable data by merging social networking tools with conservation research, leveraging virtual communities to submit data to databases like Calflora and Encyclopedia of Life. Arfon Smith of the Adler Planetarium explained the work of Galaxy Zoo and other projects in Zooniverse that specifically crowd-source volunteers' ability to classify and curate data such as images from space observatories and whale songs, allowing hundreds of thousands of users to contribute to research not as data collectors, but as data analyzers. Daniel Edelson of the National Geographic Society described the FieldScope project, and their particular niche of citizen science software that gives users the opportunity to manipulate and visualize spatial data in a way that very accessible and user-friendly.

Key issues around using technology for citizen science include website design, training tools, keeping participants engaged, data entry and cleaning, data visualization for participants, social media and emerging apps.

The day ended with small working groups on the use of technology in citizen science. Discussions focused on a series of questions related to the ways that citizen science programs can and do navigate issues of volunteer engagement, data visualization, data collection, and quality assurance specifically concerning the use of technology.

Day 1

Focus on Citizen Science Participants

May 16, 2012

Objectives:

1. Share the Academy's vision for citizen science.
2. Discuss different methods of engaging volunteers in citizen science projects.
3. Hear the perspective of volunteers in citizen science projects to help direct best practices and project development.
4. Identify key strategies for developing biodiversity-related citizen science initiatives that contribute to participant learning and to scientific/conservation knowledge for society.

Moderated by Elizabeth Babcock, Chief Public Engagement Officer and Roberts Dean of Education, California Academy of Sciences

Introduction & Welcome:

The Academy's new citizen science initiative

Gregory Farrington and Elizabeth Babcock

Greg Farrington introduced the work of the Academy as "work that seriously matters" that needs to be done "seriously well." We live in a state that is a major center of biodiversity, makes a tremendous amount of money, and is famous the world over for scientific innovation - yet ranks 47th among states in terms of science education.

The age we are moving into is about two very serious questions, regarding conservation and sustainability - the nature of life and the challenge of sustainability – or, how do we live on earth now, and how do we stay here. Would you prefer these questions be made by people who are informed, or by grown up versions of those who are 47% in science education? That is why the citizen science initiative is so important. In the process of doing good science we are educating people about the process of science.

> "Citizen science is important, for those far away and those near. Thank you for coming and helping us design the best citizen science initiative anywhere ever."

Elizabeth Babcock described the California Academy of Sciences as a *research* institution, but also an *education* organization. So they asked the question, how do we meld real science research and education? Citizen science is an amazing way to do this! The result is a joint effort between Research and Education at the Academy. She acknowledged that there are many definitions of citizen science, but that the Academy has carefully developed its own definition of what constitutes citizen science for this institution. The goal is to tie citizen science efforts, as public engagement, to an active research agenda around questions of sustainability.

California Academy of Sciences *Criteria for Citizen Science*:

- Engaging members of the public in some part of the inquiry
- Data collection and /or sharing
- Tied to an active research agenda
- Implications for conservation and sustainability.

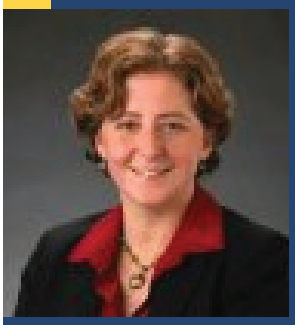
The Academy has developed two pilot projects in partnership with local organizations to explore the possibilities for the Academy's citizen science initiative. The Academy's pilot projects both entail examining current biodiversity to compare it to the historical record and to establish baseline information for future studies (to be described later):

- Marin County Municipal Water District (MMWD) – focused on the flora on Mt. Tamalpais
- Fitzgerald Marine Reserve and Pillar Point (partnering with the Gulf of the Farallones Marine Sanctuary) – focused on intertidal biodiversity.

These meetings are an opportunity for the Academy to learn from others doing

"We are creating a generation that must make wise decisions about the future."

Gregory Farrington
Executive Director
California Academy of Sciences



Elizabeth Babcock
Chief Public Engagement Officer
Roberts Dean of Education
California Academy of Science

"How do we get the public engaged in scientific research that has direct relevance to the world?"

citizen science, Elizabeth explained; to learn about what is working, and what is not working. How do we recruit, manage and inspire the public? How do we use new technologies? How do we scale-up? These meetings are also an opportunity for you all to share the discussions and learning from these meetings with your own institutions.

Presentation & Discussion:
Methods of working with volunteers in citizen science projects
Jennifer Shirk and Rhiannon Crain

Jennifer Shirk
Project Leader
Citizen Science Toolkit Project
Cornell Lab of Ornithology

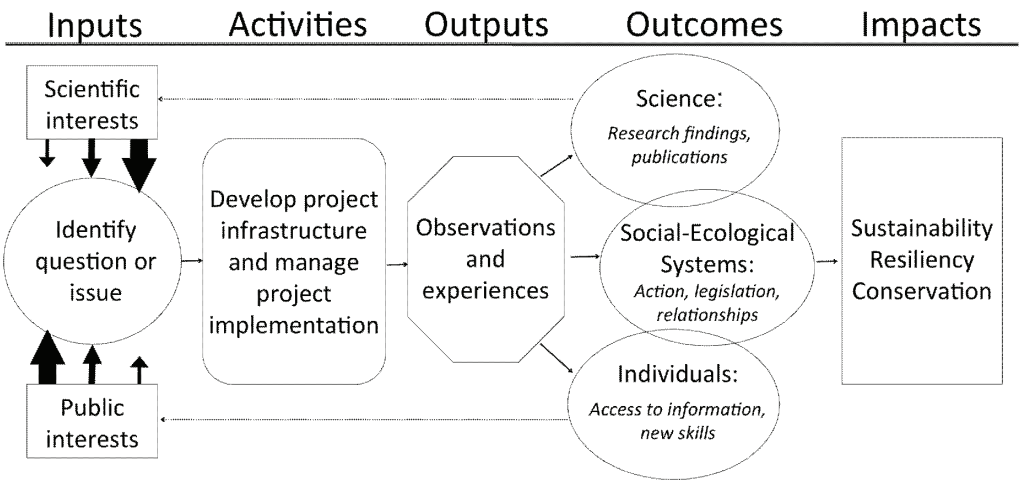
Jennifer Shirk opened with the question, "what is participation and why would we want to think about public volunteers engaging in this process?" She emphasized that Informal Science Education (ISE) institutions like the California Academy of Sciences are ideal places for taking Public Participation in Scientific Research (PPSR) into its newest forms and newest opportunities. She introduced three models for PPSR, which is a broader term that encompasses citizen science but includes other forms of volunteer participation, and highlighted some tensions in designing these projects that vary in scale, degree, and quality of participation. Jennifer pointed out the challenge of balancing the interests of scientists and the interests of volunteers.

Cornell Lab of Ornithology's definition of Citizen Science: "Members of the public engaging in authentic scientific investigations: asking questions, collecting data, and/or interpreting results." Jennifer emphasized that we need to look at what "participation" looks like in citizen science projects; she pointed out the power of observations and experiences. Participation can be about observation:

- For example, eBird's yellow warbler study compiled observations from across the continent to create vast maps of species migration.

Participation is also about experiences:

- For example, the residents of Sherman Creek Pennsylvania already knew their streams intimately, but they contacted local researchers and began collecting data on water quality and through the process of science got to know it scientifically. They truly experienced the scientific process



Presentation slide:
PPSR Logic Model

"The Cal Academy is at a wonderful point in taking time to think about and plan, intentionally, not just for what MIGHT be achieved, but WHOSE outcomes are being considered... This can be a balancing act of thinking about how interests for science and for public volunteers relate to those outcomes we're able to achieve."

Jennifer unpacked the concept of participation and explained that it can vary in terms of *degree*, *scale*, and *quality*.

Degree of Participation - Jennifer defined three models that encompass most PPSR projects, based on a National Science Foundation Inquiry Report for the Center for the Advancement of Informal Science Education (CAISE) she helped author. These models vary in the *degree* to which participants are involved in the stages of the scientific process:

- Contributory projects: volunteers primarily make observations and collect data
- Collaborative projects: volunteers are involved more deeply in the above as well as data analysis and some project design
- Co-created projects: volunteers take the lead and follow it to its conclusion from asking the research question to disseminating findings.

Scale of Participation - Jennifer outlined the tensions that often arise when discussing the effects of scale in PPSR projects:

- National scale projects can reach a large number of participants but have less depth in level of engagement and learning
- Local projects with long-term or high intensity participation can have high impact in terms of engagement and learning
- One type is not necessarily better than the other.

Quality of Participation - She raised key questions that designers of citizen science projects should ask themselves:

- Whose interests are being served?
- To what end participation is happening?

Jennifer explained that the outcomes of participation can be thought of in terms of the effects on individuals, science, and social-ecological systems. However, data on outcomes are limited in the field; hence, tracking what we do (here at this meeting and in our PPSR projects) is an important area of growth.

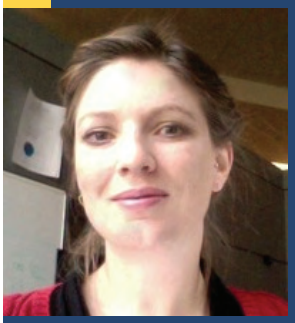
"No one project is locked into any one of these models for participation... we can look at the strengths of the different models. We can think about what we can do to bolster the kinds of outcomes we might achieve by looking at the other models."

Rhiannon Crain built on Jennifer's discussion of the spectrum of participation and focused on the many roles volunteers can play and ways they can participate in citizen science. She noted the commonly-cited tension that exists about whether citizen science is primarily about science or education, and suggested that projects don't have to choose between one or the other. The more important question is what roles can volunteers play, and how can we help them play more roles in any given project?

She described the typical way of viewing participation as a ladder, with the "Creator" role at the top and the "Spectator" role at the bottom - and suggested we can change the way we value participation in citizen science by toppling that ladder on its side. This helps us to think about the many roles volunteers can play as different but all valuable.

Project design suggestions for valuing different kinds of participation:

- Allow for fluidity between roles for participants
- Give participants more access to data, to other participants and to project leaders
- If possible, have options for participants in terms of timing (one-time, seasonal, year-round) and commitment level (one-time, casual, protocol-driven)
- Consider that projects are often limited by institutional resources (e.g. staffing). For example, Cornell Lab of Ornithology calculated the staff time required to run Project FeederWatch to be over 1 full-time employee each year.

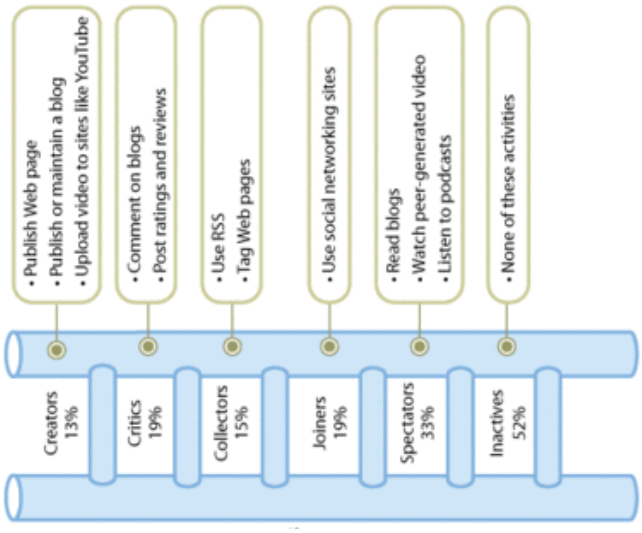


Rhiannon Crain
Project Leader
The YardMap Network
Cornell Lab of Ornithology

"We need to think about turning the ladder on its side."

Different roles or ways of involving participants in citizen science and examples:

- Observe and Monitor: weather data, windshield monitoring by driving around the city recording observations, birding
- Classify and Curate: look at pictures and mark interesting things in that picture and also digitizing data as a way to look historically at change (example: Zooniverse)
- Map Making: collect data, create digital maps, compare

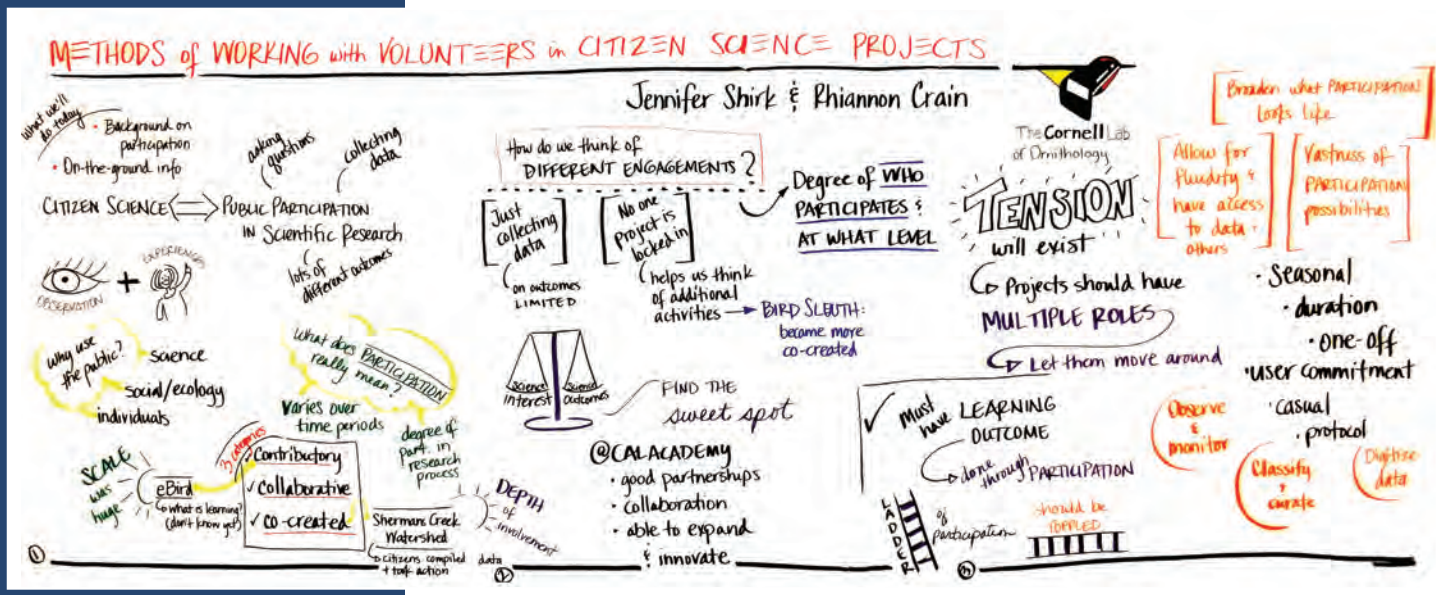


Presentation Slide:
Ladder of Participation - adapted

source: Forrester's NACTAS Q4 2006 Devices & Access Online Survey

"There is a vastness of participation possibilities. The only limits besides imagination are intended outcomes and institutional resources."

with geospatial data
- Picture Video Audio: using different electronic media to collect data
- Conservation and Management: volunteer labor for restoration activities
- Evangelizing: volunteers share results and goals of study with others, "ambassador" projects with teachers training others at their school, and citizen science bloggers get people excited
- Specimen Collection: collecting dead birds in Florida
- Resource Allocation: people can volunteer their computer time, donate money and equipment
- Analysis: undergraduate classrooms are using citizen science data (example from Avian Knowledge Networks) to do real world analysis
- Discourse: encouraging conversations about different scientific processes and commitment levels (one-time, casual, protocol-driven).



Presentation & Discussion:
LiMPETS - Long-term Monitoring Program and Experimental Training for Students
Amy Dean and John Pearse

Amy Dean
Education Manager
Farallones Marine Sanctuary Association

Amy Dean and John Pearse shared the history of the LiMPETS program, including key elements and current directions. LiMPETS (Long-Term Monitoring Program and Experiential Training for Students) was first developed 10 years ago by John and others at U.C. Santa Cruz with funding from Sea Grant. The program currently includes rocky intertidal and beach monitoring projects and primarily involves training teachers and students to conduct on-site monitoring (at all 3 sanctuaries on the California coast) and data entry. With their standards-based curriculum, skilled staff, and hands-on and outdoor experiences, they have engaged a large community of teachers and have worked with over 1,600 participants.

The objectives of LiMPETS:
- Create a new generation of students that care about the ocean and want to protect it
- Foster students to help develop their science investigation skills and potentially pursue a career in the sciences
- Establish and maintain long-term data sets

Key Elements of the Program:

- Participants are mostly high school but also some middle and college students
- Leader or teacher attends a workshop where they learn the monitoring protocol
- Students are required to go through an in-class training
- Teachers decide how and where their class will monitor along the coast
- Participating classes enter their data into an online database.
- Curriculum is designed to help students think about how to analyze the data
- The key reason teachers participate is to improve ocean science literacy in their students.

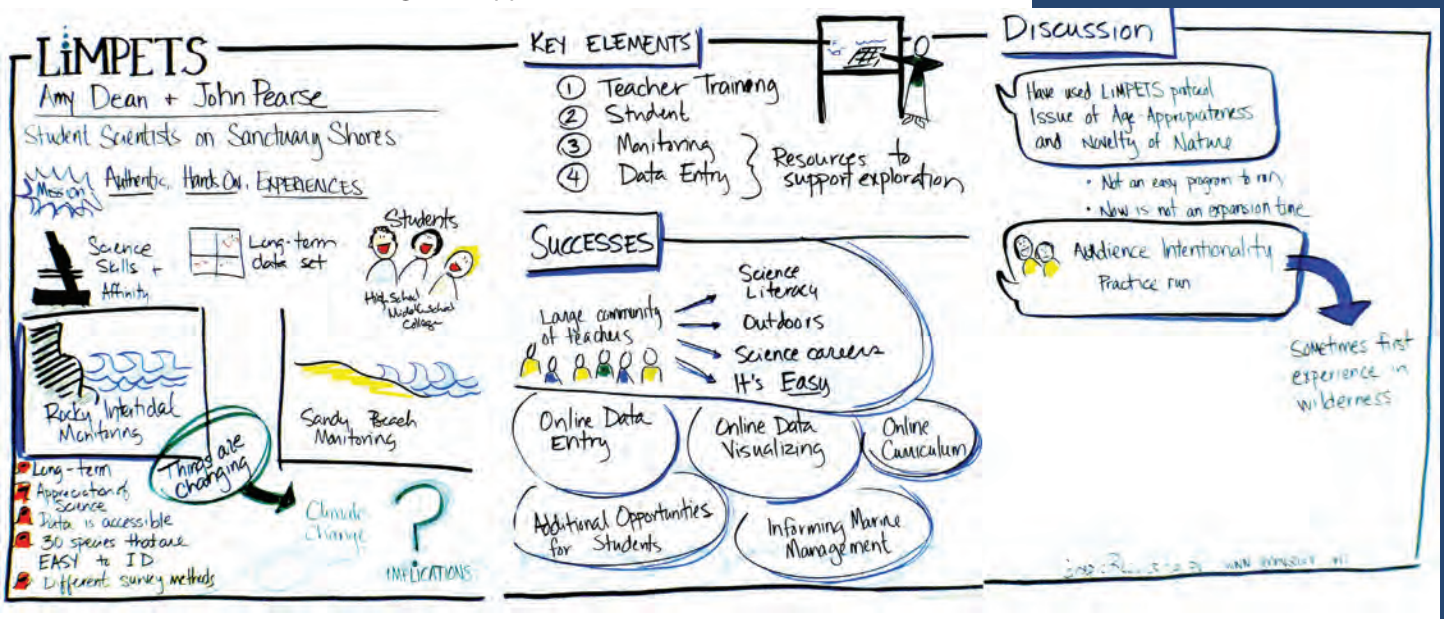
Program Successes and Lessons:

- *Data informs marine management:* The Sandy Beach Monitoring program was established specifically to provide baseline data to the Sanctuary in the case of an oil spill or other similar event for the purpose of assessing damage to the Sanctuary's resources. During the *Cosco Busan* spill in 2007, LiMPETS data was specifically requested for this purpose
- *Teachers learn about Marine Protected Areas*: The program conducts evaluations of teachers who complete a LiMPETS training – so they know that teachers learn about Marine Protected Areas as a result of the program
- *Quality versus quantity:* With 1,600 participants, these project leaders are NOT interested in growing the number of participants. John and Amy explained they are in a new phase, focusing on improving the quality and robustness of the monitoring they are already doing by revising the protocols with the help of a newly established science advisory team of ecologists from across the state. This was discussed as a wise and strategic decision that many project do not make, sometimes sacrificing quality for increased numbers of participants.

Future Directions:

- Goals are to increase their monitoring effectiveness through re-evaluating protocols with new science advisory team
- LiMPETS has been awarded 3-years of funding from the state of California to help establish a baseline for sandy beaches and rocky intertidal areas within the North-Central Coast Marine Protected Areas
- Continue to work in partnerships and find creative ways to fund the program
- Working on a strategic plan and improving their scientific credibility
- Developing new online graphing tools that enable students to not only see their own data, but also to view the larger picture and see how their data fits into the long-term
- They explained that they have reached the point where LiMPETS cannot continue its success without sufficient funding and support.

John Pearse
Professor Emeritus
University of California, Santa Cruz



"Project BudBurst is not just for springtime, but 'Project Leaf Die-Off' didn't have the same ring to it."

Sandra Henderson
Director
Project BudBurst
National Ecological Observatory Network

Presentation & Discussion:
Project BudBurst
Sandra Henderson

Sandra began by saying that climate change is one of the key reasons we are seeing such an increase in citizen science participation across the country. Project BudBurst asks people to make phenological observations of primarily plants (but also to some extent birds, mammals, and insects) to understand the effects of climate change. First and foremost Project BudBurst is an education and outreach project, and the secondary goal is to collect useful information. In its fifth year and now a part of the National Ecological Observatory Network (NEON), they currently have over 12,000 people that have registered locations around the country and over 16,000 observations.

As an illustration of the way we can see the impacts of climate change through phenology, Sandra showed two photographs (from 1868 & 2005) both taken in the same place at the same time in May, but with dramatically different appearances (the earlier resembling winter conditions and the later clearly spring).

- To become involved, participants register on the website, then pick a plant, record the latitude and longitude, and observe and record how their plant changes through the seasons. The program is entirely Internet-based, including instructions for collecting and entering data, and all data are accessible and downloadable for registered users. To help participants engage in more than just data collection, Sandra is working with National Geographic Field Scope as a test case to develop online tools to encourage people to work with and analyze data. They also have developed BudBurst Buddies, a program with activities and cartoon characters to engage young children.

NEON Citizen Science Academy:

- Sandra and her team have developed a new on-line course for formal and informal educators in citizen science. The course provides professional development resources for educators to support citizen science projects and activities in ecology and environmental science. They've received very positive feedback so far - registration in first course closed after only a week, with over 200 registrants. Courses use project BudBurst data, but they are currently working with other organizations to expand collaborations and offerings.

Future Directions:

- Develop a full scale plan for NEON Citizen Science Online courses and programs
- Work on collaborations with other organizations
- Develop templates to facilitate expanded offerings.

"Although we are first and foremost an education project, there has been scientific application. Papers have been published where researchers took the data to help validate their models."

Panel Discussion:

Citizen scientists

Loretta O'Brien, John Odell, Chris Brown, Allan Schreiber and Kathy Soave
Moderated by Elizabeth Babcock

A crucial perspective for a discussion about the practices and impacts of citizen science is that of the participating volunteers themselves, yet their voices are not often heard. The Academy broke this trend and set a new precedent for including citizen scientists in these discussions by inviting a panel of volunteers from regional projects to share their perspectives. After introducing themselves and the projects they participate in, panelists responded to questions about their experiences with citizen science overall. Their stories and insights were inspiring and invaluable in grounding the conversations for the rest of the meetings.

Loretta O'Brien has a background in permaculture and health science, is a backyard farmer and local food enthusiast, and volunteers with many projects including converting an unused soccer field into a native plant garden. She is a manager of Pacifica Gardens.

- "Our job is to plant the biggest bed of sunflowers each year"
- She sees the garden as a teaching tool and a work in progress
- Having spear-headed the planting of a sunflower circle in her neighborhood, she said teachers bringing their students to the garden now use the circle as a teaching tool.

John Odell was raised in New York and went to college in Manhattan. He is a retired faculty member of the City College of San Francisco where he taught in the Broadcasting department, and before that he was in local and network television news.

- He has volunteered with Golden Gate Raptor Observatory (GGRO) since 2006
- He specifically participates in the Telemetry, Hawk Watch and Bay Area Raptor nesting survey projects of the GGRO.

Chris Brown has a Master's degree from San Francisco State University and has worked with the Academy and the Smithsonian Environmental Research Center in documenting marine invasive species in San Francisco Bay. He currently works as an environmental scientist for California State Lands Commission. For this meeting he focused on his participation in iNaturalist.

- He described that he recently came across iNaturalist and immediately became a groupie
- He described iNaturalist as "a great experience and a great app" and a place he can list all his photos and observations
- He sees iNaturalist as a "community-based app."

Allan Schreider graduated from University of Michigan and spent his career as a high school teacher (history & theater), said he always loved hiking and camping, but his background in science was "virtually non-existent."

- He is currently in his 12th year as a Beach Watch volunteer
- He said he "enjoys the experience of doing something with people who know something that you don't know."

Kathy Soave has been a science teacher for 29 years in San Francisco and Marin, has taught marine biology and chemistry. She explained she has a love of the ocean and has developed a love of the Gulf of the Farallones Marine Sanctuary through participating in LiMPETS.

- As part of LiMPETS she takes 30 students every year to collect intertidal data as part of a community service program
- This program is a "way for me to get them connected with the oceans and our beaches right in our backyard"
- Students graph the data, make comparisons, turn results into posters and present at conferences
- The project had real impact on students, with many going into science-related careers.

Loretta O'Brien
Participant
The Great Sunflower Project

John Odell
Participant
Golden Gate Raptor Observatory

Chris Brown
Participant
iNaturalist

Allan Schreider
Participant
Beach Watch

Kathy Soave
Participant
LiMPETS & SF Bay: 2K

Entry point and reasons for getting involved

"Before [Beach Watch] I did not even know there were more than one species of gulls! And then I became hooked. I became a convert."
Allan Schreiber
Beach Watch

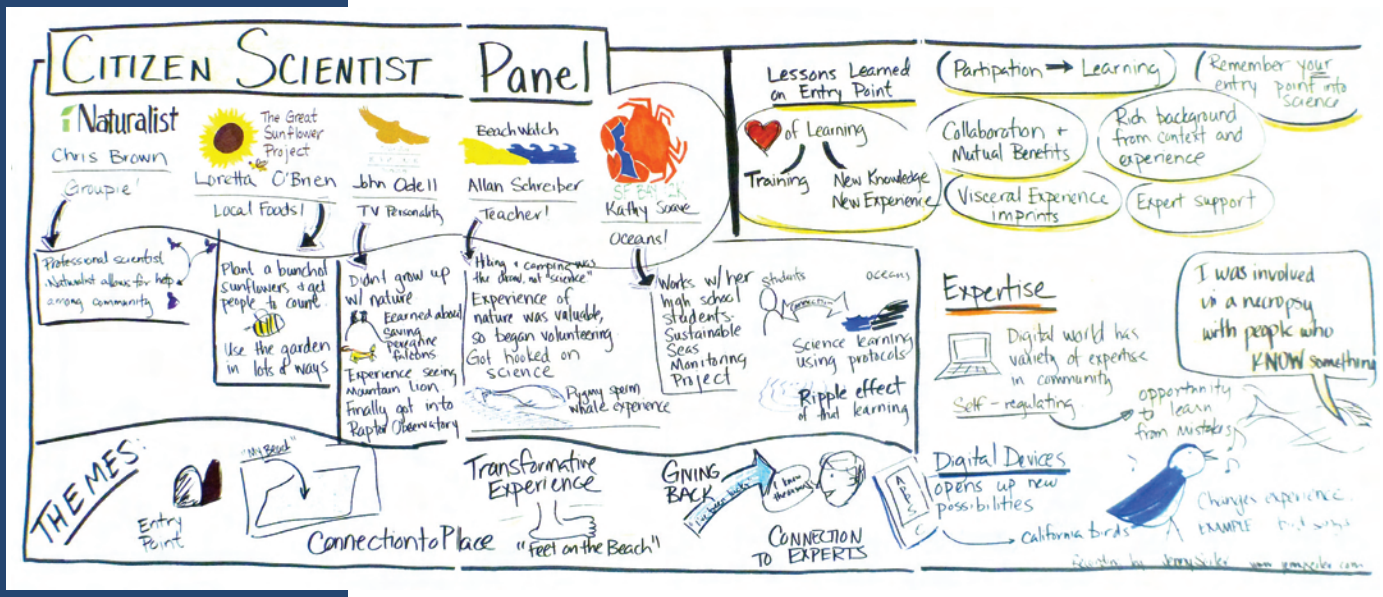
"When I moved to California, I found that I was getting a whole lot of comfort by walking on the beach and camping, and after a few years I realized that had helped me so much, I really needed to pay something back to the environment. I picked up the paper and saw that the Gulf of the Farallones Sanctuary was looking for volunteers.... I found that Beach Watch required over 70 hours of training, and I remembered my terrible experience with science in college so I went to the seal program. And then I became hooked. I became a convert. I was so passionate, so I immediately signed up for Beach Watch and have been doing it for 12 years." – Allan, *Beach Watch*

"We needed to figure out a way to draw pollinators to the garden. It was a convergence when we saw the article about the Great Sunflower Project, so I signed us up. Our job is to plant the biggest bed of sunflowers we can and then look at the bees that come. It has been great for us. Being a part of the Sunflower Project was helpful to us and if we could be a location that was able to track the data we were certainly willing to help. We just hope to keep getting better as citizen scientists as we go along." – Loretta, *The Great Sunflower Project*

"Before, I didn't like science, didn't want to get involved in science.... I took a course at the San Francisco Zoo on raptors, and after the class they said 'we are starting this thing called the Golden Gate Raptor Observatory'. [I applied] and I got back a letter that said we have so many volunteers you don't make the cut. When I retired in 2006, I got back to the GGRO and this time they accepted me! And I've been doing it ever since. I do Hawkwatch - every other Friday I count the hawks on Hawk Hill. I also look for raptor nests, and I'm finishing my first year as a waterbird docent on Alacatraz." – John, *Golden Gate Raptor Observatory*

"I got involved in partnership with Gulf of Farallones when I applied to be a teacher at sea. I thought I was going to get to go in a submarine and do some science and connect to students in that way. It didn't work out but I got involved with the Marine Sanctuaries at the Gulf of Farallones. There's nothing like taking students out there and coming back and hearing what they got out of it – they are so excited to go out." – Kathy, *LiMPETS*

"We all have an entry point to science. For me, it was a teacher who was so excited and got out of breath... and I said 'I want to do that.'" – Chris, iNaturalist



Interest in science & connection to place

"I don't have a literature-based learning style. So it's important to give people a visceral experience (during trainings), so you can learn things for keep. So when you get to hold the bird and watch the bird do the wonderful things it does, you can take that with you." – John, *Golden Gate Raptor Observatory*

"Kids identify that place as 'their reef'. They chose the LiMPETS site, and people thought it would get trashed, but it's been there for 6 years. When you have a place that you connect to, and I get to go out and look at our transects, then it makes it very personal. And that really rich background of the experts (during the training), that is really neat and it buoys you up. I have kids that had been to the ocean but never looked closely; that level of meticulous observation really grabs you." – Kathy, *LiMPETS*

"The garden has been a connecting place for the community members working in it. With the kids, we literally sneak in because we don't want to interrupt the activities of the birds and the bees... they see it as a little bit of a sacred space. It's amazing to watch them, they are quiet and listening." – Loretta, *The Great Sunflower Project*

"I didn't consider myself a scientist at all, took as few science courses as possible. Now I've been doing this for 12 years. One day my partner (for Beach Watch data collection) and I came across a beached whale, and then some Cal Academy scientists came along and they said, 'hey, are you with Beach Watch? Can you help us take apart this whale?' So we got to help with the necropsy of a whale! And yes I talk about 'my beach' – on my cliff I walk on there are peregrine falcons that nest and they are 'our birds.' So when we see people, we stop them and tell them about those birds – any information we have we try to pass on to people – this is a wilderness area and this is a marine sanctuary – we want them to know that." – Allan, *Beach Watch*

"Students feel really passionate, and rightfully so, about the fact that people use their data. They are very quick studies. They are very fast and can be very accurate. They are so excited to be involved and doing real science. There is a ripple effect of getting them out there (to collect data), it has meat to it, they have to be trained and have to be really careful – they take it really seriously. They go on and take that into their careers." – Kathy, *LiMPETS*

"More than 15 years of data is useful, and I know it's used by other science organizations.... we learned how to collect oil samples (from spills) for legal actions. One argument from *Exxon Valdez* (after the oil spill) was that nobody can say how many birds might have died before the spill, so 'how can you say it's because of the oil spill'…so I think it's (collecting this data) very important and practical." – Allan, *Beach Watch*

"We just hope to keep getting better as citizen scientists as we go along." *Loretta O'Brien, The Great Sunflower Project*

"I have kids that had been to the ocean but never looked closely; that level of meticulous observation really grabs you."
Kathy Soave, LiMPETS

Importance of knowing that the data is used for 'real' science

Group Discussion & Report-Out:
Project design - Working with citizen scientists

Small Group Discussions focused on a series of questions related to project design and working with volunteers. These groups, consisting of 6-8 people representing a variety of biodiversity-focused citizen science projects, discussed the key questions and then reported out to the whole. We ended with a larger discussion about successes and challenges of recruiting, training, retaining, providing for and engaging volunteers in data gathering and observation as well as other opportunities.

The question posed to all groups for each of the topics below was: "In your own projects, what worked, and what mistakes did you learn from?"

Recruiting volunteers

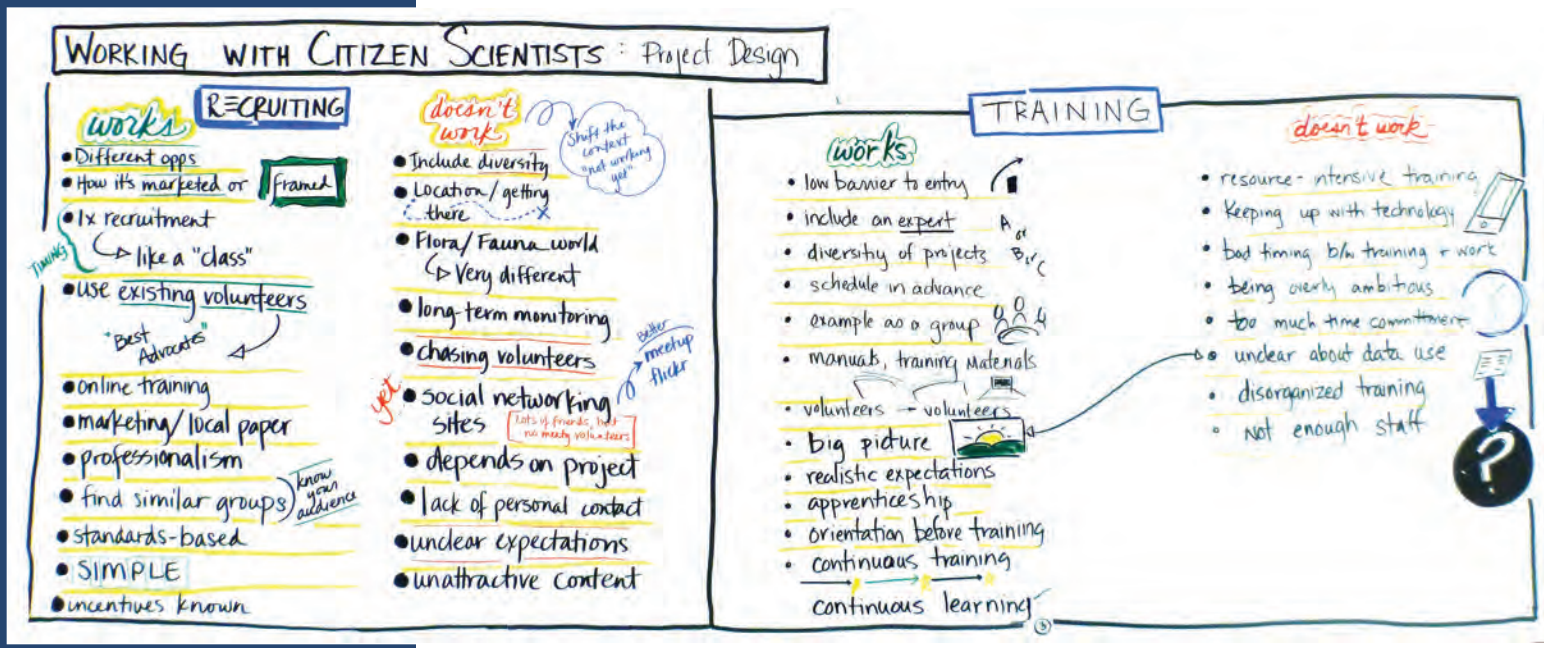
Groups reported three key successful ways to recruit volunteers: 1) using their existing volunteer base to recruit others, 2) ensuring that the project experience is relevant to the particular experience of volunteers, and 3) tapping into existing social networks of friends, Facebook, etc. to recruit. In particular, targeting local communities where local issues are of more concern (example: for marine conservation projects look for recruits through the local dive shop) is a good way to find volunteers. Groups also reported that being clear about goals for volunteers and making sure that recruitment strategies align with the needs of the program are very important.

In our large group discussion we also noted that a key challenge to citizen science as a field is that we have not succeeded in recruiting racially and culturally diverse citizen scientists. Partnering with organizations that serve these audiences, that typically do not participate in citizen science, may be a way to recruit across the spectrum of the community and enrich our projects.

Groups also noted that participants need to know what they are signing up for, so it is important to make sure expectations are clear both on the part of participants and organizers.

What works

- Provide different types of opportunities for volunteers
- Think about how "services" are marketed to the volunteers
- Use existing volunteers to recruit other volunteers



- Contact local higher learning institutions
- Reach out to similar groups through organizations' partnerships
- Do one-time recruitment once a year and make it a large-scale public production
- Use online formats and social networking (works for some programs and in some contexts)
- Use standards-based content (for working with teachers and students)
- Provide the opportunity to work with live animals!
- Know your audience (well).

What does not work (or is challenging)

- Recruiting for diversity across multiple socioeconomic levels is huge challenge
- Politically navigating when volunteers may/may not be able to contribute to the project effectively
- Chasing volunteers (one at a time)
- Finding long-term monitors for plant programs - flora and fauna are often different kinds of people
- Online recruiting and social network (depends on context – but can lack personal connection necessary for some types of programs)
- Having unclear expectations.

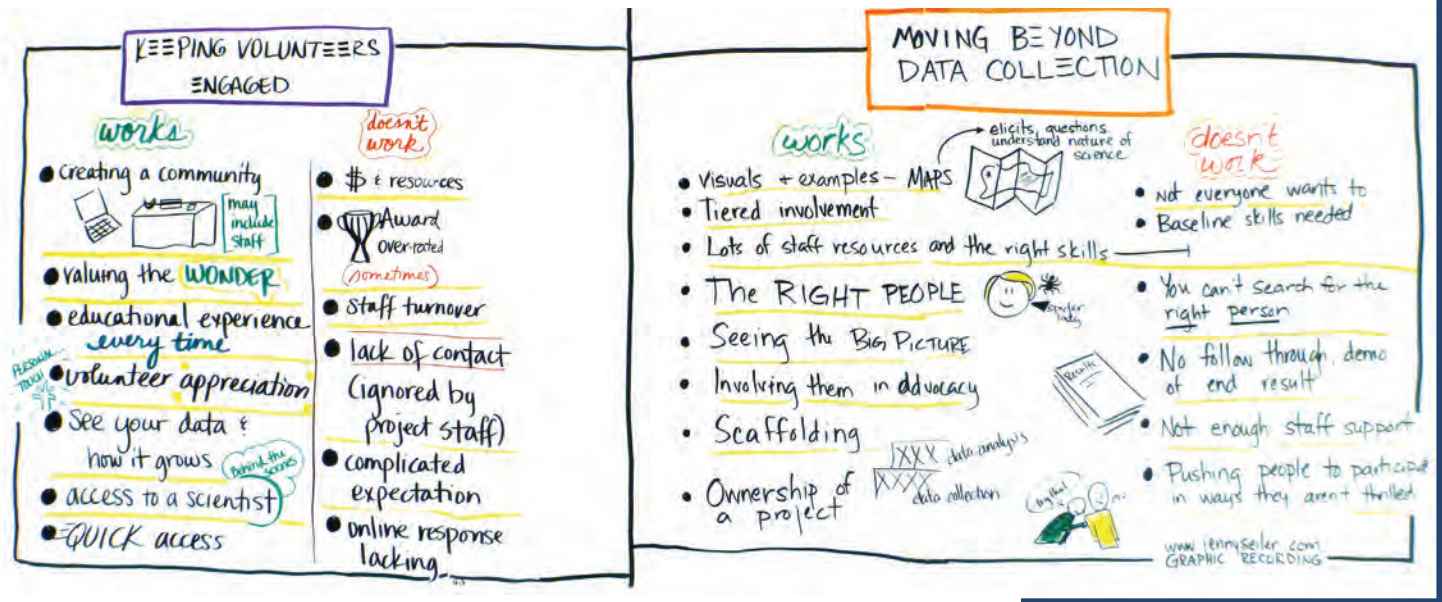
Training volunteers

Groups reported that providing entry points for different volunteers so they feel comfortable, having an expert involved in the training, having peer to peer training among citizen scientists, and providing ongoing training opportunities were all effective strategies to train volunteers. Groups also described that variation among their volunteers' backgrounds and interests requires creativity in order to provide training for people at different ability levels and with different interests.

Challenges shared by the groups related to funding and finding the staff time to provide trainings, the temptation to be overly ambitions that becomes problematic when trying to actually complete the work, and the need for clear expectations. One other point discussed among the groups was the need to make sure that citizen scientists understand the big picture for the project they are working on; for example, if they understand that what they are going to collect will be kept for 100 years they will understand why they need to take such care in making sure it's collected well.

What works

- Schedule trainings well in advance of data collection needs
- Provide a variety of professionals and/or experts at the training events
- Require volunteers to attend trainings
- Use current volunteers to train new volunteers (benefits both!)
- Provide materials in a document that people can access remotely in place of a physical manual



- Let volunteers digest what they learned instead of training and then immediately sending them off to collect data
- Use a tiered approach or different ways for volunteers to engage with the same project
- Provide more than one initial training but also continue to train and encourage volunteers to learn throughout the project.

What does not work (or is challenging)

- Training sessions that don't have any follow-up
- Not enough staff expertise to get novices out into the field collecting data
- Not enough funding to provide adequate staff time for trainings
- Overly ambitious goals for trainings
- Unclear expectations.

Keeping volunteers motivated & engaged

Groups described how there is a personal touch that needs to be a part of good citizen science programs to keep volunteers engaged, including opportunities to recognize individual volunteers for their hard work. Treating volunteers with respect goes a long way in terms of motivating and engaging volunteers. For intensively involved volunteers, for example, one key volunteer was given her own office space and supplies and access similar to an employee.

The social and community nature of citizen science was also reported as a key part of engaging volunteers in a citizen science program. For larger programs and projects, it is impossible for staff to know every volunteer; however, larger projects can create communities regionally (virtual and real) as a way for volunteers to interact in a more personal way.

Groups reported that creating these communities of citizen scientists seems essential to program success, but that it remains a challenge. A key mistake many have learned from is requiring more complicated data collection procedures that seemed to decrease volunteer motivation; this has caused otherwise smoothly running programs and volunteer work to grind to a halt.

What works

- Value peoples' sense of wonder, and remember that every volunteer event is giving people a new educational experience
- Show appreciation for volunteers and their contributions (e.g. celebrations, morale boosters, gifts, shout-outs, newsletters)
- Provide ways for volunteers to able to see their own data, and what they put in over time, to allow them to have ownership over that data
- Give feedback on data entries or observations as much as possible
- Provide access and enrichment (working with scientists, tours behind the scenes, access to special places, etc.)
- Provide quick access to results from volunteer data collection

What does not work (or is challenging)

- Some groups suggested that paper certificates don't work, instead of acknowledging in a personal way; others felt they were effective
- High staff turnover so connections with volunteers are often severed
- *Social isolation for volunteers* – not having access to other people involved in the project
- Complicated procedures that are difficult or time-consuming may turn off some volunteers.

Moving beyond data observation

Groups expressed that it is certainly a good goal to have citizen scientists participate in ways beyond just collecting data, but there are challenges involved. One is that there are particular skills sets necessary for research design and analysis, so finding the right volunteer and the right staff to make this work is difficult. The groups raised questions any project should ask when considering moving citizen scientists beyond data collection, such as 'why would you want people to do this?', and 'what are the goals and end product?' In general, moving beyond data collection was reported as a big question and issue for projects.

When moving beyond data collection is a goal, the groups decided it is essential to show volunteers how their work fits in the broader scheme of the project and research question. Requiring volunteers to present their piece of the process to others may also inspire citizen scientists to ask questions of the data and gain more of an interest in analysis.

What works

- Visualization techniques such as mapping to encourage volunteers to take the next step

toward data analysis
- *Tiered involvement* - for volunteers that have been doing data collection for a while, provide an opportunity for them to move into thinking about what the data means
- *Involve volunteers in advocacy* - if they have ownership and are communicating about the project to others they are more likely to take the next step
- Scaffold the process to make sure volunteers have the skills and tools they need to move beyond data collection.

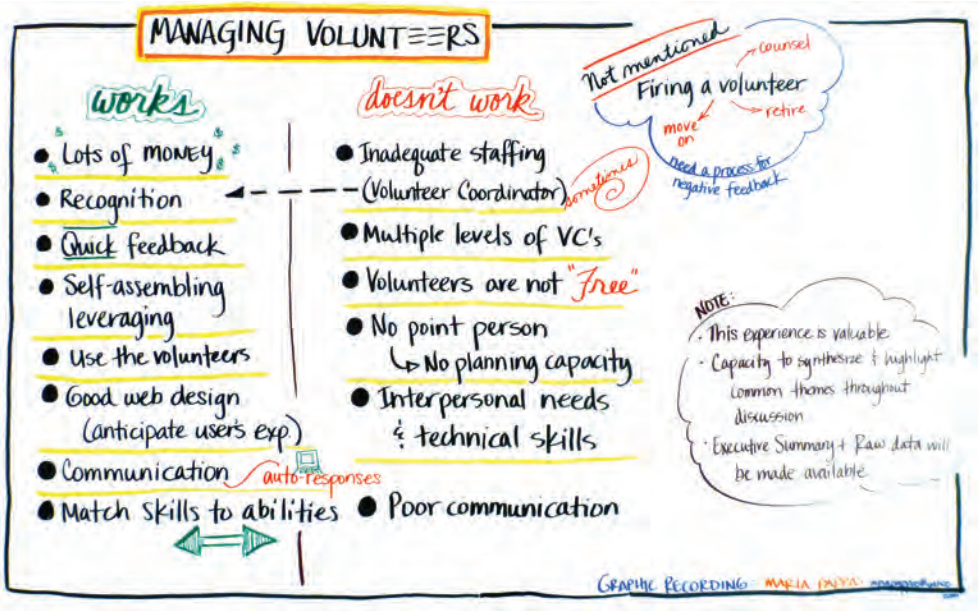
What does not work (or is challenging)
- A baseline skill set is required for people to move beyond data collection - difficult to provide training in those skills
- Takes a lot of staff time and resources
- Volunteers who already have the skills to design, analyze, etc., are few; you can't go out and find them, they have to find you (e.g. one volunteer that basically runs an entire spider survey project)

Staffing and support for volunteers

The key point raised by the groups about staffing is it takes a lot more staff time than most realize to do everything needed for a successful citizen science project, from training, recruiting and coordinating. So you often can't expect one person to do everything. Groups also described ways to minimize the workload of staff members and for project management in general: move information and communications into a website and post information rather than rely on staff to always communicate one-on-one with volunteers, build communities (virtual and real), and have experienced citizen scientists help manage new members to the project. Communicating in a timely way was also considered a key way to minimize confusion that can take staff time overall and in the long term.

What works
- Raise or have money – a well-funded program can hire enough staff to deliver a good program
- Have a volunteer coordinator on staff
- Create self-assembling group architecture like Wikipedia
- Leverage assets
- Employ a train- the- trainer model (if rigor can be maintained in data collection)
- Have lead volunteers mentor other volunteers
- Use web design to reduce the amount of staff hours required for a lot of the simple questions
- Be sensitive to interpersonal needs or volunteer and staff comfort zones.

What does not work (or is challenging)
- Trying to run a whole program or several programs with only one-person managing
- Not having a designated "point person" for volunteers
- Low-level planning capacity
- One person wearing five different hats!



Clockwise from top left: Citizen Science Meetings participants outside the California Academy of Sciences; Elizabeth Babcock, Day 1 moderator; citizen scientists on Mt. Tamalpais; plant pressing at the Mt. Tamalpais BioBlitz; a citizen science team out on the reef at the Academy's Pillar Point Surveys; citizen scientists from the Day 1 panel discussion; a BioBlitz team at work on Mt. Tamalpais; group discussion at the Citizen Science Meetings.

Day 2

Focus on Research Objectives and Conservation Outcomes

May 17, 2012

Objectives

1. Learn about best practices and successful projects that marry research goals with informing conservation policy and practice.
2. Hear the perspective of biodiversity researchers who have worked with citizen scientists and who have not worked with citizen scientists --- success stories, conservation outcomes.
3. Hear from local conservation organizations about data needs and the potential of citizen scientists to help meet those needs.
4. Identify key strategies for developing biodiversity-related citizen science initiatives that contribute to concrete research and conservation outcomes.

Moderated by Terry Gosliner, Dean of Science and Research Collections, Harry W. and Diana V. Hind Chair in the Department of Invertebrate Zoology, California Academy of Sciences

Introduction:
Research & conservation goals with the Academy's new citizen science initiative
Terry Gosliner

Terry Gosliner
Dean of Science and Research Collections
Harry W. and Diana V. Hind Chair in the Department of Invertebrate Zoology
California Academy of Sciences

Terry Gosliner's opening talk transitioned the convening from a focus on participants to a focus on the scientists and organizers of citizen science projects. He described the Academy's vision and goals for citizen science. Terry first revisited insights from Day 1, highlighting the potential for motivation and transformation that participation in citizen science work can hold. To the participants' stories heard on Day 1, he added his own beginnings as a citizen in science: "When I think about my beginning as a biologist, there wasn't anything different than what motivates them (the other citizen scientists)... For those that become scientists, we remember being enamored with the natural world, having mentors to guide us through that process and building a spark into glowing coals."

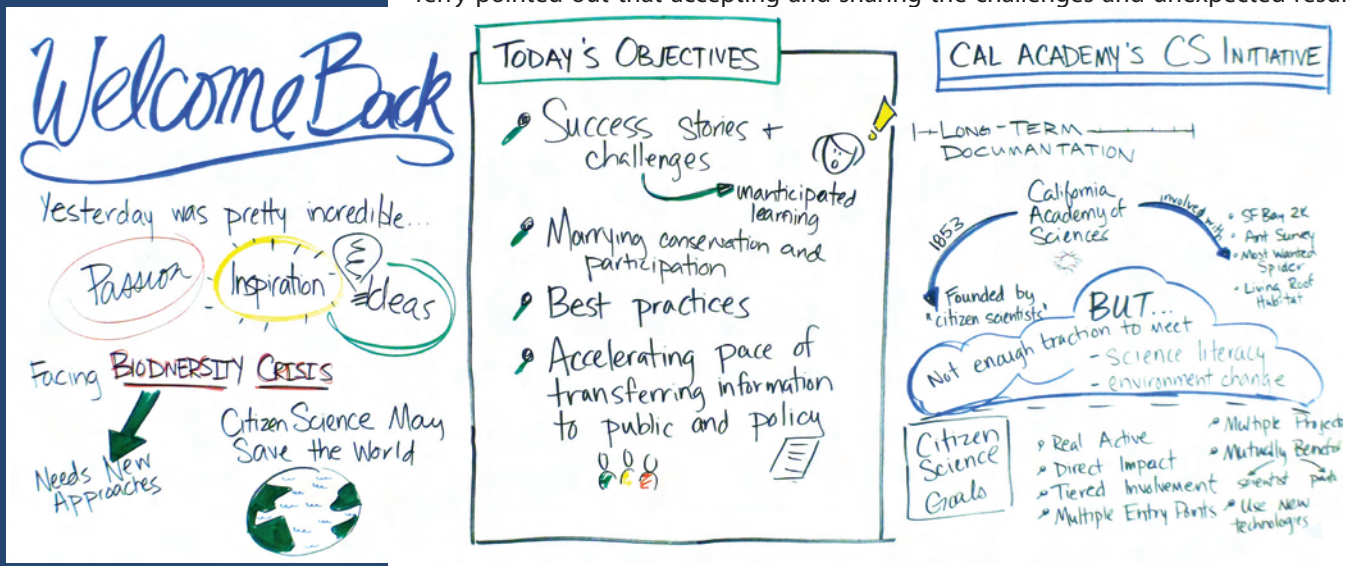
As an example of how citizen scientists can contribute to our understanding of changing biodiversity over time, Terry recounted his experience as a high school student, exploring the tidepools around Bolinas alongside current Academy colleague, scientist Gary Williams and others. On a class trip, they discovered a new species of nudibranch, named it after their high school teach and mentor, and began connecting with professional scientists. With the careful records from their exploration, "we were able to publish a couple papers that documented some of the first climate change-related biodiversity changes and it's because we knew what was there before. So I am believer that getting people out there making observations is how we are able to document changes." Given the biodiversity crisis facing us, 'getting people out there' is also how scientists and educators can begin engaging people in a way that can transform the crisis – and that "may save the world."

> "We are facing a biodiversity crisis – possibly the sixth great extinction – caused by us. We have the opportunity to change that.... Citizen science is wonderful at motivating people, wonderful at scientific results, and may save the world. We shouldn't lose sight of that."

The Academy's goals for citizen science: Terry outlined a few of the goals he hopes the day will begin working toward in addressing the many challenges to conserving and researching biodiversity:

- Bringing together multiple stakeholders – from biodiversity researchers to regulatory agencies – to make use of limited resources
- Sharing best practices to build a "collective understanding" of challenges and direction
- Marrying research goals with conservation policy and practice
- Using technological tools – like social media – to accelerate transfer of information into the hands of citizens and policy makers

Terry pointed out that accepting and sharing the challenges and unexpected results that



researchers encounter are common to professional science, as well as citizen science. "When dealing with citizens and students, the fact that not everything is known, and the number of things that aren't known, is profound… We know about a tenth of species that inhabit the planet. Yet we're making decisions based on what we know." Alongside scientists, citizens can become a part of discovery, transfer, and transformation.

Stating the need for "a new biodiversity baseline," Terry laid out a vision and case for citizen science at the California Academy of Sciences, beginning with historical precedent:

- The Academy itself was founded by citizens who saw the impact of hydraulic mining in the Sierras and wanted to build a base for scientific discovery – in 1853, before the universities had been established in California, "there were only citizen scientists"
- The Academy has been involved in citizen science projects – such as Bay 2K, the Bay Area Ant Survey, invasive spider research, and even monitoring of the Academy's new living roof ecosystem.

Pulling from Day 1 conversations, he highlighted particular goals of California biodiversity-focused citizen science work:

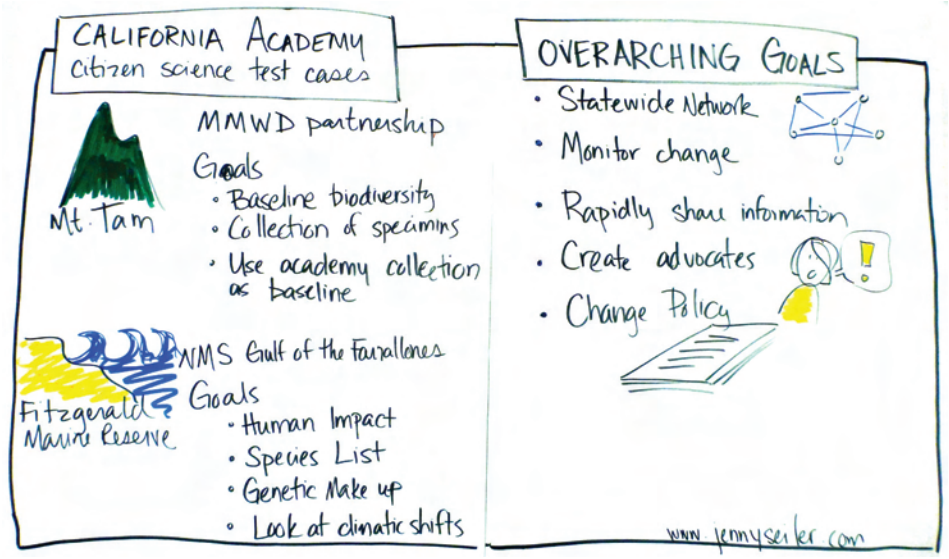
- Engage scientists in active research on biodiversity
- Engage projects that have direct impact on biodiversity, science literacy and conservation
- Engage participants through multiple entry points and tiered involvement – "turning the ladder over on its side" – so that involvement can happen at multiple points in life and multiple stages in the scientific enterprise: "It doesn't matter how they're involved, but that they are involved"
- Help participants see how research takes place and what the individual data points actually mean as part of a larger scientific puzzle
- Engage scientists and participants in mutually beneficial work – the need to see past a dichotomy of scientist versus participation perspective – and create win-win projects
- Use new technologies
- Advance new ways of measuring outcomes and moving successes to scale.

The Academy's Pilot Citizen Science Projects: Terry explained that together with UC Berkeley and a few other institutions, the Academy has one of the most comprehensive collections of biodiversity anywhere. Using historical collections as a baseline, the Academy is investigating the ways citizen science can document change. Building from two pilot projects, they want to create a statewide network of projects to document and monitor California's biodiversity.

- *Mt. Tamalpais plant biodiversity surveys with the Marin Municipal Water District (MMWD):* fill taxonomic gaps in the historical collection and establish a new benchmark against which to measure climate change. On Mt. Tamalpais over 900 plant and 400 animal species have been documented; and 15% of the flora in California can be found on the watershed
- *Intertidal monitoring with Gulf of the Farallones and the Fitzgerald Marine Reserve:* collect specimen data to establish populations and find out if one population is replacing another. By comparing protected areas to non-protected areas, monitoring can document the impact of human use, ecological interactions, and climate change.

"There are challenges, just like in science. You don't always discover what you thought, but you learn something profound."

"We need to activate participants as advocates. We need to create conservation and regulatory policies that reverse loss. That's how we'll change the planet. So that's our vision.... That's the answer to why we're involved."



Panel Discussion:
Biodiversity research
Michelle Koo, Carol Spencer, John Hafernik, and Layla Aerne Hains
Moderated by Terry Gosliner

For many citizen science projects, considerations about design and impacts on participants are left to educators or volunteer coordinators, but the goals, interests and even personalities of the research scientists can greatly impact the outcomes of a project. The biodiversity research scientists convened for this panel represent a range of experiences, from those who have been deeply involved in citizen science projects for many years, to those who are just beginning to dabble in this field. The experiences and insights they offered during the panel discussion ensured that the meeting stayed focused on the importance of asking and answering rigorous research questions that involved volunteers strategically in roles that help advance conservation science.

Michelle Koo
Grinnell Resurvey Project
Museum of Vertebrate Zoology
UC Berkeley

Michelle Koo is an alumnus of the Academy and has worked with HerpNet and some citizen science projects, but her research focuses on herpetology and modeling of species distributions.

The Grinnell Resurvey project:

- Builds from systematic field notes taken by Joseph Grinnell over 100 years ago, an ecologist and founding director of the MVZ who was alarmed by the rapid changes in biodiversity
- Field notes describe species and ecological conditions and allow researchers to go back to the same locations and ground-truth current ecological conditions for comparison as well as provide data for statistical models that forecast and look back at species distribution changes over time
- Michelle pointed out that an area that has not been focused on, but that has potential area for robust citizen science, is photography for comparison to Grinnell's original photographs of survey sites.

Carol Spencer
Grinnell Resurvey Project
Museum of Vertebrate Zoology
UC Berkeley

Carol Spencer is also an alumnus of the Academy, now a staff curator at the MVZ researching biogeography and history of evolution. She is also involved in bioinformatics projects like HerpNet, VertNet, Amphiweb, FishNet and Ornis that are all focused on making species data available to researchers and the public that has previously only been available to and through museum curators.

- The goal of these projects is to bring worldwide data online and train students and professionals on how to use these data
- Citizen science has input a great deal of data, especially bird data, including some of the oldest observations. The projects also involve citizen scientists through the Encyclopedia of Life.

John Hafernik
Professor of Biology
San Francisco State University

John Hafernik's research is focused on urban biodiversity. He discovered a parasite that attacks honey bees and affects their behavior, creating what he has called "ZomBees." His research focus stems from the fact that much of society is "more urban than rural," and children will experience biodiversity in an urban environment.

- John is just beginning a citizen science project – ZomBee Watch (zombeewatch.org) – to learn more about the "zombie fly" parasite range and prevalence
- He is working now in the Presidio to find out what arthropods use the area as habitat and then will use this to guide restoration work, and has worked with students and citizens to gather baseline anthropod data on the Academy's living roof. John is President of the Academy's Board of Trustees.

Layla Aerne Hains
San Diego County Plant Atlas
San Diego Natural History Museum"

Layla works with Jon Rebman, a biologist who began collecting plants, and discovered a population of retired folks looking for something to do. In San Diego, a hotbed of biodiversity, he modeled the Plant Atlas Project off of the successful Bird Atlas Project.

- Collecting does not require a background in botany, but is time intensive, so most volunteers, called parabotanists, are retired professors or teachers
- Parabotanists 'adopt' a 3-mile grid square and go out three times a year to bring back plants, each of which Rebman identifies – over 56,000 have come in this year
- Layla explained that San Diego has desert, coastal, and mountain ecosystems and is the southern extent for many species, so there is a lot for volunteers to explore
- She said the San Diego Plant Atlas project is at a stage of transition toward more staff collection, with volunteer activity focused around events that allow participants to go out with and learn from Rebman in the field, which is a huge value.

"One thing we're always facing is that we tend to write for an audience of academics and that might not be the most important audience to whom to direct that information. But we are in the midst of reassessment and revolution in how we look at data – the way we collect, store, and publish." – Terry, *California Academy of Sciences*

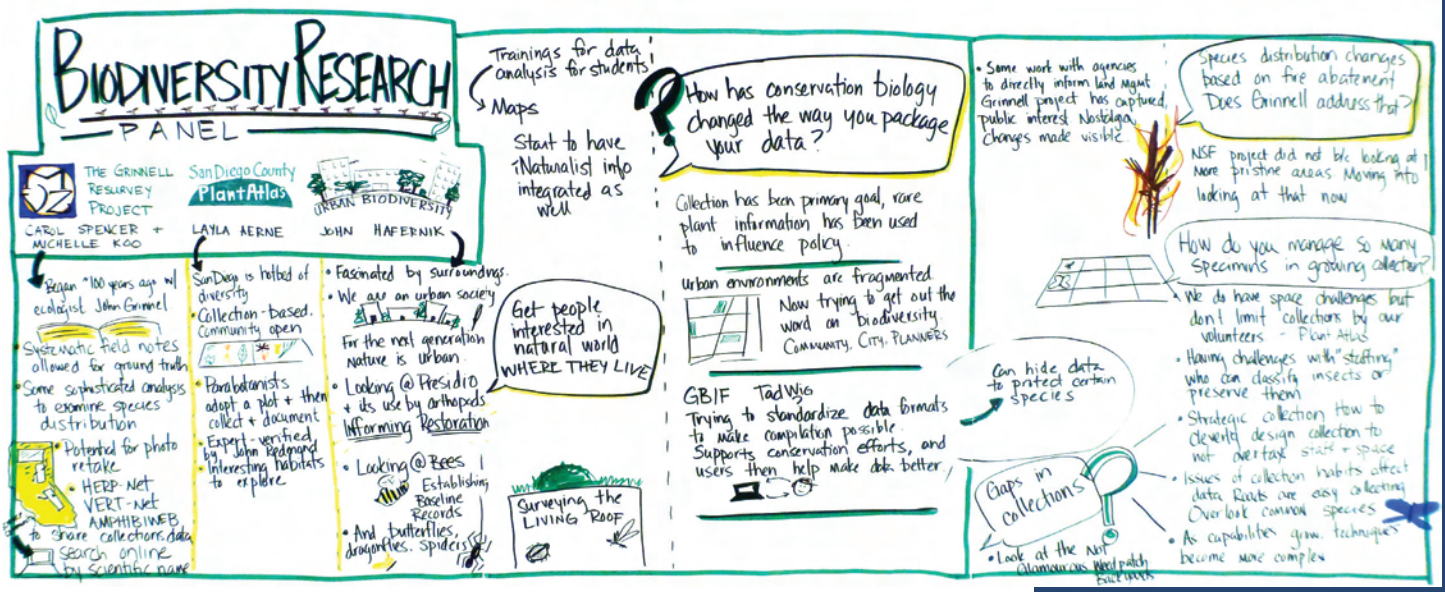
"A beginning goal for us was *documentation*… [What we found] has been able to be put to use in policy. Jon Rebman sits on the county board for species conservation, so the work informs what species need to be monitored, mitigated and conserved." – Layla, *San Diego Plant Atlas*

"Conservation is an increasingly important part of what I do." Working in urban environments, John sees fragmentation as a big issue – "the boogey man for extinction." John's project are looking at characteristics and trying to tease out factors, as well as trying to get the word out to a broader audience. He works with community groups and planners to connect resources together that can have a positive effect on natural areas and organisms that live there. – John, *San Francisco State University and the Academy*

Because data have been available, but are difficult to access – or in different formats – Carol and project partners have worked with people, mostly biologists and programmers, to get them to follow standards developed by them and to have commonalities. "We try to convert data and map it back into one form so it can be downloaded as one giant table... It's a difficult issue and every specimen isn't going to be perfect. So we make it available and people who use it are going to make it better." They are trying to help people convert and use the data, allowing people to annotate and search under synonyms, for species and place. – Carol, *Grinnell Resurvey Project*

"A lot of fundamental museum activities are directly tied to conservation decision-making…. For the Grinnell Resurvey, I haven't been a part of another project that has captured the public's attention as much. It captures nostalgia as well as important changes that people can experience themselves. We can show a photo of Yosemite Valley from 1908. People can drive down and see the same block of trees, but now surrounded by an understory that is overwhelming. It's speaking very directly to folks." – Michelle, *Grinnell Resurvey Project*

How has conservation biology shaped the way you package and manage your data?



How do you curate and manage all the specimens and data citizen scientists bring in?

"We're definitely running out of space! We have about 200,000 specimens and our volunteers at the museum are screaming at us to tell people to stop." Because they want each specimen from each grid square in the county, the project has not established a policy to stop receiving specimens. – Layla, *San Diego Plant Atlas*

"Many of our spiders and specimens will go to the Academy. One challenge is having enough labor in sorting through and identifying, which requires some expertise…. I've relied on students who have a variety of training in entomology…. [but] you have to take care of them, so it's a big deal.... The amount of handling, and preserving of specimens so they can be used later, is a challenge, as is getting out a final report!" – John, *San Francisco State University and the Academy*

"On one hand we're saying, 'I wish we had that data,' and on the other, you have constraints – we are finding there's no space and handling for the overflow. They don't build roads until you have traffic jams, but I like what you're doing in terms of strategic collections: the idea of cleverly documenting biodiversity without putting pressure on resources." – Rusty Russell, *Smithsonian Museum of Natural History*

Are there gaps in your collections? How can citizen scientists fill those gaps?

"At Berkeley, we've found that many common species found in Bay Area we weren't actually collecting…. So there's gaps." – Carol, *Grinnell Resurvey Project*

"This is an ongoing discussion for us at the museum: How much time to devote to doing survey work and collecting versus doing identification? We have some old timers around since the 50's [and compared to then] we're spending more processing time…. There's much more sophisticated techniques that require more time and training." For example, MVZ takes DNA, liver tissue, time of death for an analysis of which genes are turned on. – Michelle, *Grinnell Resurvey Project*

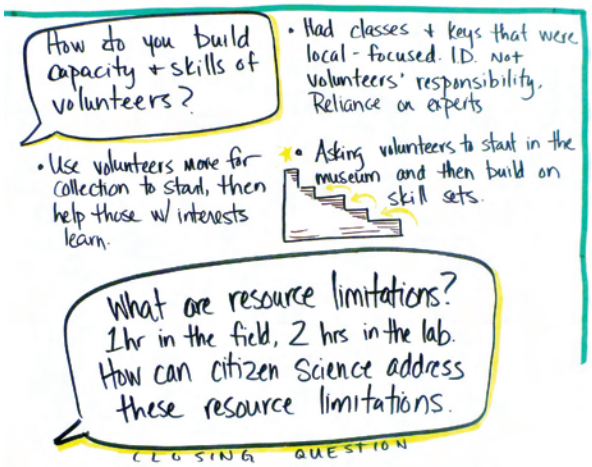
"If you look at a micro-level… we tend to think less about vacant lots, backyards, and about creatures associated with introduced weeds – those sorts of places. All those places are part of the fabric of biodiversity. There are opportunities for citizen science projects that focus on those types of habitats." – John, *SF State Univ. and the Academy*

Have you tried to boost the capacity of volunteers that work on your projects?

A majority of volunteers come to the Plant Atlas with no scientific background, so for awhile, the San Diego Natural History Museum was holding classes focused on families common in San Diego County. However, the programs were recently cut. "Folks that have been with us have become better at initial identification, but Jon [Rebman] is the ultimate. He looks at everything…. It still comes down to the expert." – Layla, *San Diego Plant Atlas Project)*

"We utilize students of all varieties and ages, including adults. They've been most useful in sampling work; you can train pretty easily in collecting with taxonomic expertise, but it's really valuable when we find students that get hooked and want to learn and find out more…. A number [of students] have gone on to PhDs, postdocs, etc. and their fascination with systematics and that kind of science got started by experiencing a lot of interesting creatures." – John, *San Francisco State University and the Academy*

Terry closed the session by calling attention to what the resource limitations are, suggesting that citizen science may tremendously help bridge these limitations. "What are some insurmountable issues in terms of collection and processing of data? A lot of citizen scientist participants relish the opportunity to do field collections. My rule of thumb for what it takes to process: for every hour in the field you need two hours to process and prepare specimens. These are resource factors you have to put into the equation." – Terry, *California Academy of Sciences*



Presentation & Discussion:
Biodiversity research and citizen science - Plant life of California's mountains (or, 'Dude, where'd I leave my volunteer?')
Rusty Russell

The focus of Rusty Russell's talk was on finding creative solutions to accessing resources for biodiversity research and working with volunteers, including youth. He presented a range of project models and prompted citizen science project designers to think about new ways of engaging the public in science and conservation. He emphasized the importance of a connection "between data, the natural world, and people's lives." The take-aways Rusty provided included 1) giving volunteers the power to participate without being told what to do every step of the way, 2) following up with them to keep them engaged, and 3) demonstrating enthusiasm for both the science work as well as the personal relationships of citizen science.

Touching upon the nomenclature of citizen science (citizen science, PPSR, volunteering, etc.), Rusty characterized citizen science volunteers as essential to his institution's work - the "unpaid staff... getting people to do what you wish you could do if you had more time, for free."

Making collections relevant: Rusty explained that the Smithsonian has "as its underpinning," the importance of specimen collection as a way of making sure you have a baseline of data in order to understand change, and much of his work has focused on making this accessible outside the institution. He provided several examples:

- The Smithsonian was able to pull together thousands of historical records to assist the State Department in habitat restoration planning in post-civil war Liberia.
- Four years of specimen collection and research done by over 100 Earthwatch volunteers led to discovery of a third more uses of Fijian plants than were in records and showed how plants' names, in Tongan, changed over time.
- For the cyanolichen index, the Museum had planned to bring experts together to certify pages that would provide species data for Encyclopedia of Life (EOL). However, finding few experts to provide the extensive time required, Rusty brought together students who could comb the research literature, organize information, and create a "project of expertise, just assembled by people who weren't experts." The project posted over 600 pages that are mappable and include data about type, habitat, and a wide range of publication citations.
- The Field Book Project engages volunteers, staff and multiple partners, including the Academy, in digitizing field research journals from the past and developing an international registry to which people can contribute data. It will include links to actual objects so that specimen identification is unambiguous. Through a blog, the project also brings to life volunteers' experiences, through accounts of historical field research sites, as well as volunteers' emotions of walking in the woods and analyzing the notes and lives of past field explorers.

Mapping a Century of Change in the San Jacinto Mountains, California: "Connected at the hip," Rusty and James Bryant, from Metropolitan Museum in Riverside, developed the Mapping project in order to help the Bureau of Land Management understand the species distribution and history of a recently established National Monument in San Jacinto. The area is another of California's hot spots of biodiversity, spanning the desert floor to natural lakes at 8,000+ feet. Using data from the Consortium of California Herbaria, Rusty was able to gather 220,000+ records, without leaving the office. Rusty and James used the historical data as a general baseline, then divided the data set into half-centuries to track losses and gains. This showed huge change in species that Rusty suspected wasn't the case.

With funding from Earthwatch Institute, the Mapping project set out to create a new baseline for the area – to "find the things that looked like they disappeared." Earthwatch

Rusty Russell
Collections Manager
Smithsonian National Museum of Natural History

"The good is that you can get data quickly. The bad is that it's a mess."

"You can go out *now* and collect, but you can't go back."

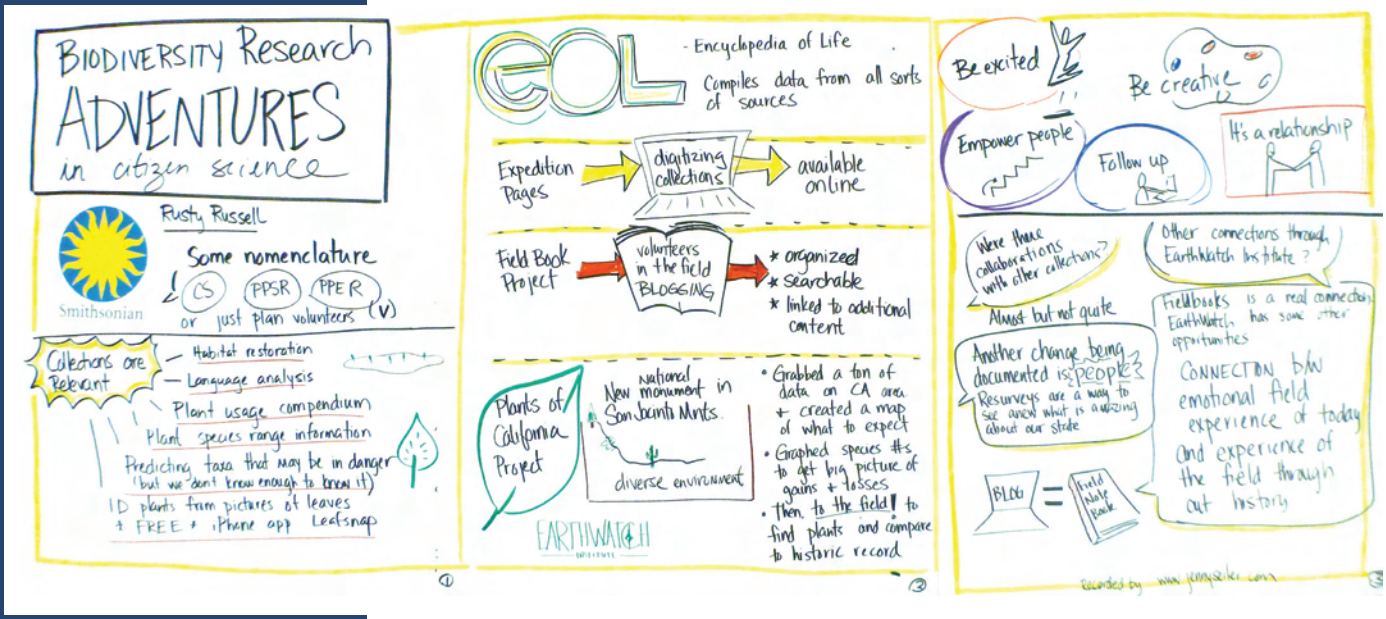
funding supported two different models of citizen science work:

1. *Retail Model:* Volunteers pay Earthwatch to be able to come out with you and work. In turn Earthwatch funds the scientist. He pointed out that because Earthwatch convinces people to pay to participate in science, these people expect something. By working with scientists to solve environmental problems, they and the donors are giving people the opportunity – empowering people – to get involved and make a difference.
2. *Youth Fellowship Model*: Earthwatch sponsors high school kids to join scientists in the field for two weeks. This project was, in Rusty's words, "for my money, the most transformative I've done." Earthwatch recruited students from all over the country to stay at James Reserve and "work their butts off," hiking, driving all over the reserve, and collecting. Additionally, Rusty had the students write about their experiences on a project blog, which turned into a transformative space for many of the youth. The project had a high impact on youth involved, from Tony, the first in his family to go to college, to Caitlin, who returned to help lead the trips and then continued to work on conservation work with AmeriCorps and is now back at the Smithsonian to analyze the data collected. Projects like this and the Field Book Project that connect blog writing and field collection with historical work have a lot of potential for youth-focused citizen science.

"They pay Earthwatch, Earthwatch pays me: my head hurts - it's a very good deal."

"I don't have a background in science education. I just have a gut feeling. If *you* are as excited as you want them to be, it will happen."

Rusty closed by saying that a key to success in projects like these is being creative and being "as excited as you want [participants] to be." Though not easy with a project that has 100,000 participants, Rusty reminded the convening to think about the personal relationships in a project. James Bryant pointed out that citizen science provides the opportunity to depict not only change in ecology, but change in human activity. Citizen science has arrived just in time to help people rediscover the original resources of California and help "match unmatchable resources" needed to further research and conservation work.



Conservation Organization Presentations:

Data needs, management questions, constraints and use of volunteers

Pepperwood Preserve, Golden Gate Audubon, Gulf of the Farallones National Marine Sanctuary, Marin Municipal Water District, and Golden Gate Raptor Observatory

Pepperwood Preserve

Lisa Micheli

With strong partnerships in California and beyond, Lisa Micheli described four projects Pepperwood is currently engaged in with great potential for impactful biodiversity research and work with citizen scientists.

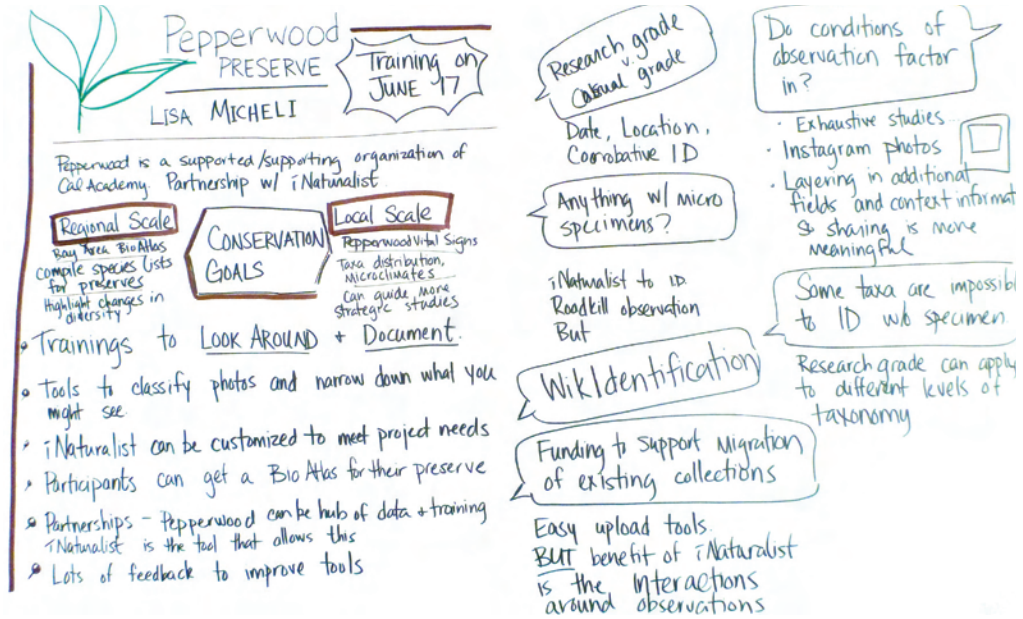
Pepperwood is part of the *Terrestrial Biodiversity and Climate Change Collaborative* (TBC3), which is an innovative way of getting experts together to think collaboratively about responses to climate change. The Preserve also partners with *iNaturalist*, which is a mobile device application and web interface that allows users to map species within the preserve itself, as well as across the region. As its fiscal sponsor, Pepperwood is working with iNaturalist to develop and offer training to the public and Preserve naturalists to effectively use the app for scientific as well as social networking purposes. Goals of the Pepperwood - iNaturalist project include: tracking biodiversity over time and utilizing this information for decision making at Pepperwood; getting people to use the tool through volunteer training and outreach to other preserves; partnering with other organizations and schools.

Some iNaturalist highlights that Lisa discussed, with questions and clarifications from other convening participants, notably iNaturalist co-founder and developer Scott Loarie, include:

- Ability to appeal to community of users if you need help with identification
- Includes a validation process to distinguish casual observations from "research grade" observations. This process – coined "wikidentification" by a convening participant – is based on number of community confirmations, as well as observation metadata, like location, additional photos, etc. And because it's a Pepperwood project, their managers can trump the community process and up- or downgrade observations.
- Observations can get "research grade" status at any level of the taxanomic tree if, for example, photos aren't clear enough for positive identification at the species level.
- Integration with Calflora and similar initiatives so that participants can be a part of multiple projects, at the local and global scale, and iNaturalist project areas can accommodate diverse participant interests.
- Some people who come to iNaturalist don't even have e-mail accounts, so some people do need training
- No "non-detection field" yet – for "things you didn't see." This may be a next step.
- Built from a social network model. Although it is easy to upload large data sets, the tool is designed for interaction around the observations.

Lisa Micheli
Executive Director
Pepperwood Preserve

"We want it to be exciting... we want people to have a conversation."



Pepperwood also sponsors one site of the *California Naturalist training program* with Santa Rosa Junior College, which is a University of California Cooperative Extension program for training volunteers to be stewards at Pepperwood as well as citizen science leaders.

The *Bay Area Biodiversity Atlas* initiative in collaboration with Pepperwood is using iNaturalist to build a mobile atlas that can establish and map a baseline for species distribution across many preserves. The database is compiled using volunteer and staff observations and will help reveal changes and will create "synthetic" species lists for areas where atlas has not yet been completed. This will also allow Pepperwood to better track and understand volunteer activity.

Golden Gate Audubon

Noreen Weeden

Noreen Weeden
Conservation Project Manager
Golden Gate Audubon

Noreen Weeden described the many volunteer monitoring projects of Golden Gate Audubon (GGA) with conservation outcomes. Said a convening participant, GGA's volunteer projects across San Francisco, Alameda, and Contra Costa counties provide "a great example of tiers of involvement, [with] lots of entry points – some people once a year, some hardcore people." By creating multiple opportunities and turning volunteer efforts into concrete conservation outcomes (and activities), Noreen said GGA currently engages over 1000 volunteers and they could still use more.

"We encourage volunteers; they're looking for opportunities, so we give them a variety. We think even just one experience can do a lot."

Noreen explained the GGA's approach to citizen science and examples in her talk highlighted the multiple roles that the organization takes on, paralleled by the diverse roles and points of engagement available to volunteers.

- In work around the Caspian Tern, GGA advocates for habitat, shares and compares data with other agencies, and compiles datasets. Volunteers in Tern Watch collect information during breeding season and in the off-season they continue meeting once a month to advocate on behalf of the terns, share knowledge, and prepare the habitat for the next season, e.g. by removing invasive plants.
- Experienced volunteers in the MLK Jr Shoreline bird breeding project did a full census to develop protocols that shorter term or less experienced volunteers appreciate and use.
- Volunteer committee (of diverse volunteers) for each county makes recommendations to staff for monitoring and restoration initiatives and sites. Members of the committee then support the recommendations through advocacy and on-the-ground work. These committees make possible a grassroots and "practical approach to picking sites for research and restoration," pointed out Elizabeth Babcock.
- Other examples of roles include docent work at Cesar Chavez park; monitoring, documenting and outreach at Lake Merritt; monthly restoration projects; training as oil response spill network first response volunteers; plant surveys at Pier 94.

Noreen also highlighted that GGA staff compile data and make reports each year to document and move this work forward through dissemination. Other highlights include:

- Data from monitoring is used for recommendations to GGA, in litigation efforts, and to inform agency decisions.
- GGA shares data and reports back to volunteers so they can become advocates (for example, at Pier 94, Tern Watch, and Lake Merritt nesting birds).
- Grants that sponsor consultants have also been critical to compilation and publication of data when, for example, there was ten years of data projects in the MLK Shoreline to compile, or when a volunteer-initiated project documented birds around the bay but the data needed to be analyzed and the report written.

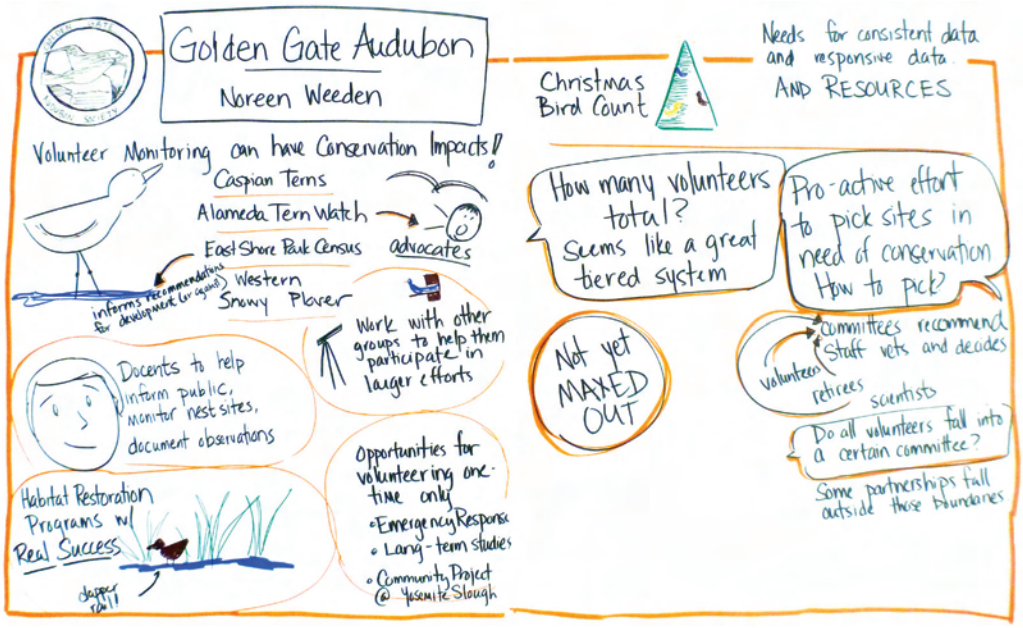
"We also need resources... time to train, monitor, compile, document meaningful data."

Partnerships have been successful, but often difficult to document. Noreen introduced the idea of "DIY" projects – those that are driven or initiated by volunteers or an outside organization, for which GGA is a resource:

- GGA partners with other citizen science programs, in projects like NestWatch, Great Backyard Bird Count and Audubon Christmas Bird Count
- When organizations, like a senior center, contact GGA and say "we want to do that, but

we don't know many birds," GGA sends volunteers as activity leaders. They'll "go with a spotting scope and talk about birds that are right there in their garden"… a win for both the community members and volunteers.

Noreen's talk also emphasized that restoration and conservation efforts "go to show that restoration does work." At Pier 94, restoration efforts since the *Cosco Busan* oil spill have had a significant impact on endangered plants as well as bird species. Restoration also helps "get people to know that it is possible to connect with nature even in urban environments."



Gulf of the Farallones National Marine Sanctuary

Maria Brown

Maria Brown's presentation highlighted the potential of public-private partnerships for strong citizen science and conservation outcomes. These partnerships, alongside strong protocols and consistency through programs like Beach Watch, have been essential not only to science and public education efforts, but also to conservation efforts through policy and litigation.

Using citizen science to influence management policy: Emphasizing the agency's congressional mandate to "investigate and enhance ecosystem processes," Maria first mentioned the Sanctuary's flagship program, Beach Watch, a public-private partnership with the Farallones Marine Sanctuary Association. Highlights included:

- Established in 1993, the program has between 80 and 120 volunteers monitoring 40 to 57 beaches each year. Due to very high volunteer retention rate, the program does not do new volunteer training each year.
- Volunteers report on presence of live and dead "beach-cast" organisms. These data establish a baseline that can be used to monitor listed species and to gauge changes. Photo-documentation of the beach has further helped demonstrate changes, even over just the 15 years of records.
- Monitoring also allows for early detection of problems, like harbor seal or sea bird die-offs, that scientists can follow-up on to pinpoint causes. By being able to clearly demonstrate links between pollutant sources, like oil spills or landfills, and wildlife death, the data have helped win some of the largest legal settlements that in turn are used to restore damaged resources. In response to a question from Terry Gosliner, Maria emphasized the importance of their monitoring protocol and QA/QC to upholding citizen science data in court.
- She pointed out that volunteers feel a great sense of ownership about the beaches they monitor, acting as stewards and educators of the public while they are out on the beach.

"Those results are put together each year, and we compile the data and share with volunteers. And that encourages them to go back the next year and become strong advocates."

Maria Brown
Superintendent
Gulf of Farallones National Marine Sanctuary (GFNMS)

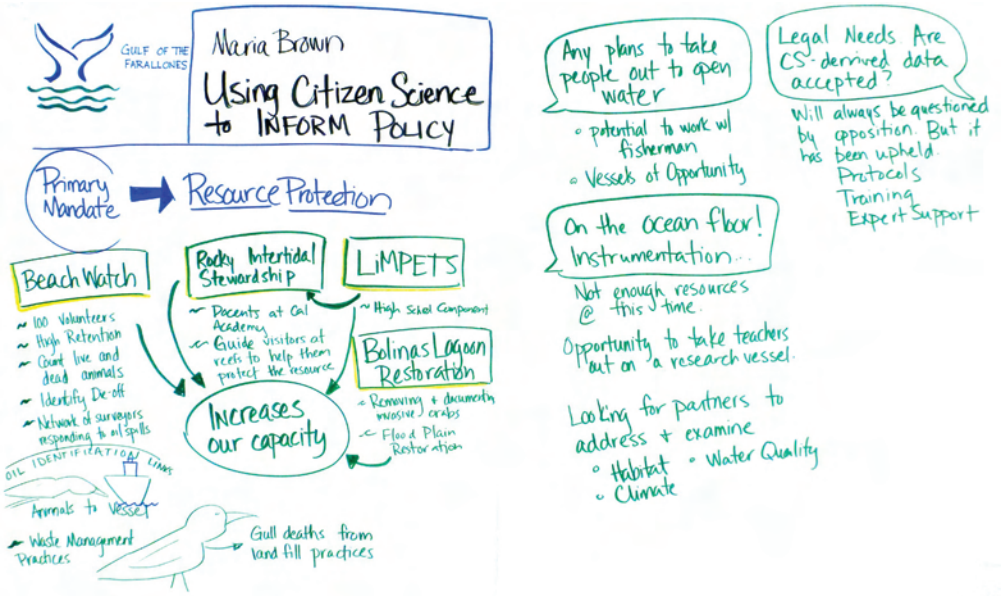
"[Beach Watch volunteers] educate the public about the beach - about *their* beach. Their ownership. They have intimate knowledge."

Other GFNMS programs Maria discussed include:

- The Rocky Intertidal Stewardship project, a partnership with the California Academy of Sciences. Volunteers are trained by Academy and Sanctuary scientists to engage in docent activities at the science centers, fieldwork with scientists, and public education on high-use days that helps protect reef animals
- LiMPETS, a high school component of the rocky intertidal project (see *Day 1*)
- Bolinas Lagoon and Kent Island restoration projects, both of which involve invasive species removal of plants and animals. Partners include Audubon and a local farm, where green crabs are composted.

Responding to questions from convening participants, Maria also described ideas for potentially working with the fishing community and vessels for the opportunity to conduct more open sea research. These projects, however, are hindered by resource constraints. GFNMS could use also use additional help expanding citizen science activities around near shore water quality and wildlife disturbance.

"Citizen science data will always be questioned by whoever is opposing our action .... We were able to present data over 15 years that showed our beaches were clean. This was upheld. This is because we have protocols and training in place, and QA/QC that helps add credibility."



Janet Klein
Natural Resources Program Manager
Marin Municipal Water District

"A lot plays out in local politics. There is a lot of biodiversity policy that happens at the local level."

Marin Municipal Water District

Janet Klein & Andrea Williams

The primary mission of the Marin Municipal Water District (MMWD) is not conservation or education, but provision of "reliable, high quality drinking water at a reasonable price." As such, Janet Klein and Andrea Williams reinforced, with experience and humor, the importance of thinking strategically about the strengths and weaknesses of citizen scientists as part of a land management equation. Balancing this equation is especially critical when facing a need to both inform and act in order to protect the "spectacular and amazing" resources of their watershed from problems like non-native weeds and sudden oak death (SOD). Andrea and Janet also stressed their strategies for successful citizen science projects: "checking [data] that seem out of place, knowing what to throw out, and knowing what motivates volunteers."

Currently 5% of the MMWD watershed is impacted by invasive species. One of the worst is French broom, which doesn't directly impact water quality, but which heightens fire danger, drawing significant financial resources away from other initiatives. When Janet arrived at MMWD, she had to bring resources immediately to bear on the problem, so started to employ the "slave labor" of volunteers and students. To address invasive species, MMWD's strategies include:

- Conducting density counts to measure the effectiveness of industrial and chemical weed removal against that of volunteers removing by hand. This allowed MMWD to develop models to forecast spread of invasives based on various management strategies. These models have been important when weighing use of herbicides in an area used for drinking water - and educating stakeholders like board members, fire staff, land managers, and the general public who pay bills and drink water.
- Using multiple student groups for removal of weeds and surveying. This "volume of data lets you throw out the noise." Janet said it is important to give some volunteers, especially kids who are new to the outdoors, time to just be outside and "be awed" without jeopardizing viability of a project.
- Using volunteers for data collection and weed removal in sensitive areas, where they are most effective, but not, for example, in larger scale weed removal. Janet reminded the convening, "people like to talk about the power of volunteers. But there is also limit to volunteers" that must be considered.

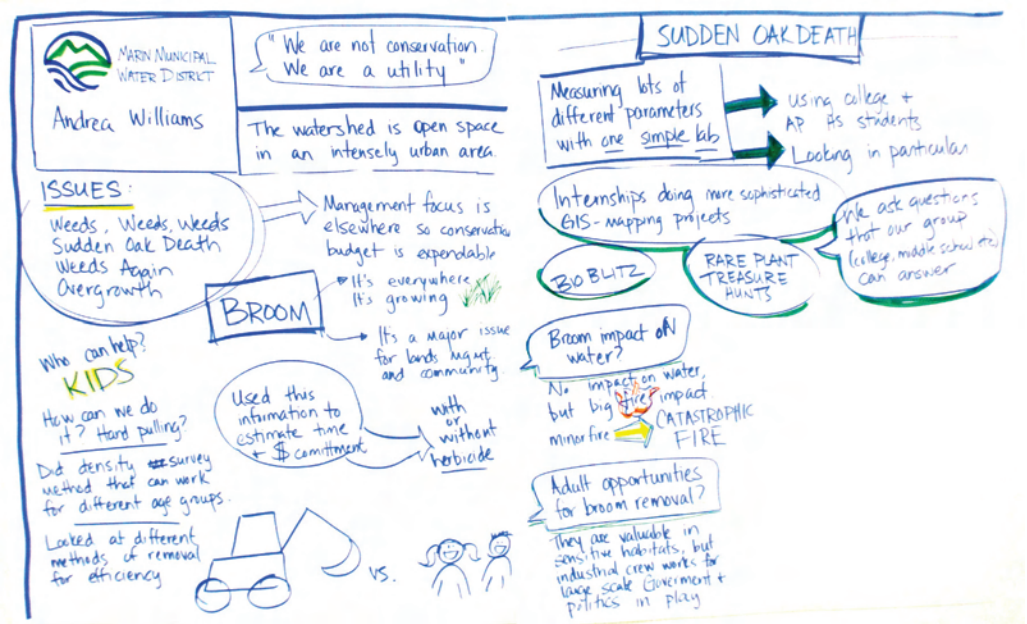
To address other issues in the watershed, MMWD's other citizen science initiatives include:

- Recruiting college and advanced high school students for ongoing surveying of oak stands and developing protocols that rely only on very general identification, observation and photography to document multiple characteristics of the forest
- Developing projects for students and interns in high interest areas like GIS, as well as family oriented activities like the turtle observer program
- Using centennial events for the public as a way to establish a new baseline for future research and contrasting with historical records
- Partnering with the Academy and California Native Plant Society for activities like the Mt. Tamalpais BioBlitz and Rare Plant Treasure Hunt.

Andrea and Janet described their strategies for success in citizen science projects:

- We ask the right questions that are appropriate for the group we are working with
- Use many ways to get at the answers
- Have written protocols, trainings, and quality checks – knowing which data to throw out, checking things that seem out of place, go out with people at the beginning of the project
- Know what motivates or limits your volunteers – we have some people who are really happy to get out in the field with an ecologist, who are motivated by the magic of science - others are glad to connect with the land and so we just get them out there

> "If kids are awed, we let them be awed and don't make them count [plants]. But others we make count."



Andrea Williams
Vegetation Ecologist
Marin Municipal Water District

"We're not NPS (National Park Service), so we don't get glamorous volunteers."

Golden Gate Raptor Observatory

Allen Fish

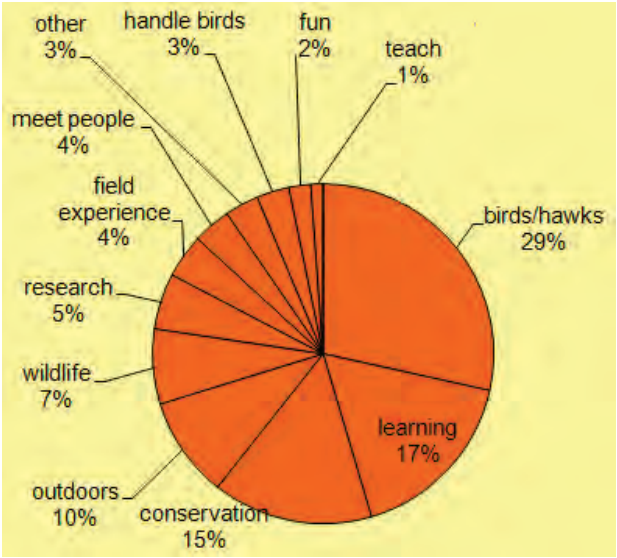
Allen Fish
Director
Golden Gate Raptor Observatory

Allen Fish presented lessons from three decades of citizen science work. Golden Gate Raptor Observatory's (GGRO) program, a cooperative program of the Golden Gate National Parks Conservancy and National Recreation Area, engages more than 2,000 volunteers in 44,000+ hours of science participation each year. Allen highlighted the history of raptor monitoring alongside the contributions, both "frustrating and lovely," that volunteers can make. GGRO's strategy is to train volunteers well and retain them at a high level (75-80%), utilizing a "middle management" group of volunteer leaders. They still make sure to let each volunteer feel that someone's "going to miss you if you're not here."

Allen framed his talk, and role in citizen science, with the question: "how can you save the environment if you don't know what it is?" Sponsored in part through public-private sponsorship with the Parks Conservancy, GGRO's programs at Hawk Hill, one of the west coast's hawk 'hot spots', work to "interest people and inspire preservation," creating an "open air school for budding migration watchers." Highlights of his citizen science program include:

- Counting and banding: Though it is "not hard to get people to work with charismatic species" like hawks, in GGRO's focal program, hawk counting volunteers are recruited and trained once a year, banding volunteers only once every two years. GGRO has developed a core of "fast, furious," and committed raptor trackers, from soccer moms, to kindergarten teachers, to polio-survivors
- Volunteers commit one day, every other week. Allen has to "counsel out" the few that don't seem to fit well and drop "without an exit interview" those that miss more than two sessions a season
- Counting and banding programs are dependent on Volunteer Day Leaders. These leaders allow activities to continue even when Allen "may not be in the office." The system works well, but Allen still works to learn each volunteer's name, pets, kids, and interests
- GGRO couldn't find monitoring methodology, and therefore began without a strict protocol, but over 3 years and a "100 different ways" of counting hawks, they developed a quadrant system in which volunteers work in small teams
- GGRO also conducts nest watch and radio-tracking programs, in which committed volunteers "wake up before dawn… and eat at bad restaurants."
- GGRO has conducted volunteer surveys that reveal a diverse set of motivations and values on the part of participants. Allen works to keep track of volunteer interests and allow them "time and space to get out of the bus and go crazy for a while."

"As stories came out naturally (from volunteers), I heard stories about drug abuse, child abuse...and people especially in urban areas, for deep, deep reasons were interested in spending time in natural areas."



Presentation slide:
Why People Volunteer for GGRO
1983 - 2003 (n = 806)

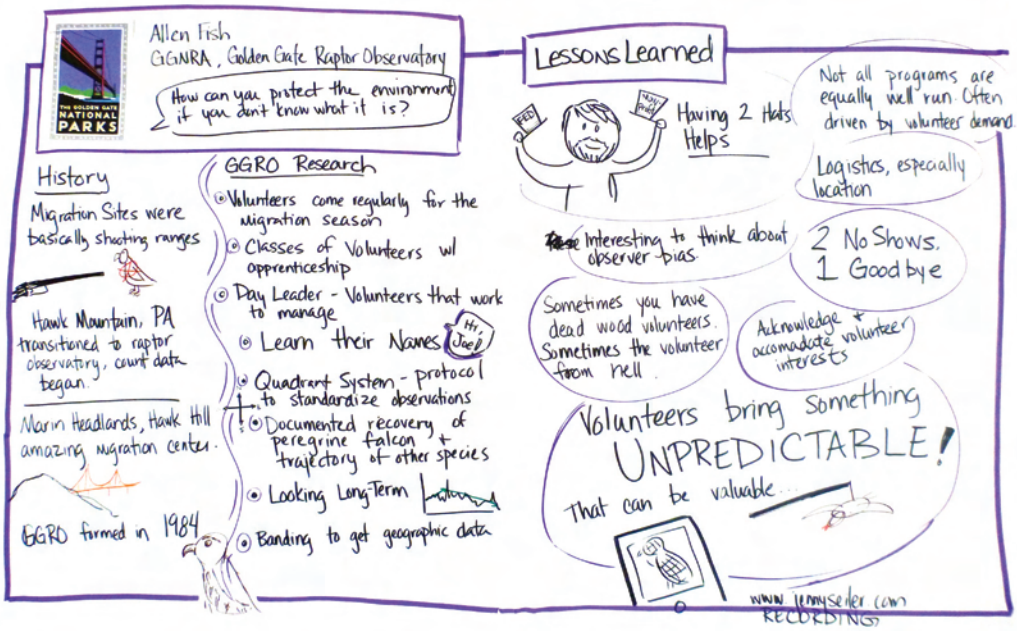
In addition to their successes, Allen discussed some of GGRO's challenges:

- When coordinators "break-down" and agree with volunteers to take on additional initiatives, staff can be pushed beyond capacity
- Volunteers need a car to access hawk watching sites (restricting who can participate somewhat)
- There are human biases in data collection – GGRO is initiating a study on rates of misidentification to inform analysis of citizen science data
- Allen has found that one volunteer in 20 "doesn't do anything, but loves being around."

One in 500 is a "volunteer from hell" and can take a huge amount of staff time to manage
- He also mentioned access to science journals as an important issue for conservation organizations that may want the information in journals but can't access it.

Allen ended by reemphasizing the power of volunteers – even one person:
- One urban myth claims that an "annual crazy lady call" led to discovery of Hawk Hill
- Volunteers have developed several key research methods for GGRO's programs, volunteers have developed the quadrant system of monitoring, nonliving lures for raptor banding, and a 3D raptor identification mobile app
- Simple tracking activities are critical to species monitoring. Early hawk watchers showed the impact of DDT, and GGRO's monitors are helping demonstrate the effects of climate change and developing climate change models
- Work in environmental psychology also showed Allen that citizen science can help volunteers share and heal, even discovering that the highs of watching birds rivaled those of lithium.

"Any study of bird data is studying climate change impact."



Group Discussion & Report-Out:
Project design - Research and conservation outcomes

In the convening's second breakout session, participants shared experiences and perspectives on how citizen science can help organizations meet both research and conservation goals, as well as how to balance demands of scientific and policy objectives with those of volunteer engagement and education. In relation to four aspects of project design, participants answered the questions, "How did you decide what was working? Whose needs were you trying to meet (participants vs. research)? Concluding the session's 'share out,' moderator Terry Gosliner summarized themes that emerged: simplicity, communication between stakeholders, and designing situations in which citizen scientists can be successful, credible and confident.

The question posed to all groups for each of the topics below was: *"In your own projects, what worked, and what mistakes did you learn from?"*

Designing a project

"[Grinnell] didn't have this in mind when marching around the Sierra. He was just making observations. We don't always know what the impact is going to have for future generations.... The data collection process should allow people to take notes, even if not part of protocols. Allow room for creativity."

Once you had your questions decided, what was the process of designing your project to answer them? Flexibility and adaptability were two recurring principles of project design that participants highlighted: launch quickly, fail quickly, and refine with feedback. They recommended looking for partnerships, identifying relevant resources, and taking into account needs of both volunteers and scientists. Some participants described a tension between wanting volunteers to shape things, but not direct activities.

They also pointed out the tension between boredom (activities volunteers don't want to do) and irrelevance (data that aren't useful to scientists). Lastly, it was noted the "doesn't work" side of the chart, might better read "doesn't scale"; designers need to take into account their goals when evaluating what strategies are appropriate.

What works

- For experimental design: pilot project activities with staff, interns, etc. Design your data sheet and see if it will answer your question – then map your workflow, build in feedback, and plan for data storage
- Use appropriate metrics: start with your end in mind and make sure to meet the needs of the scientists or agencies you're giving the data to
- Co-created projects: involve citizen scientists (and other stakeholders) in design from the beginning
- Make sure there are payoffs for volunteers; these might include social events, graduation from training, swag, and feedback on activities
- Be feasible: take resources into consideration
- Have a "notes" field for volunteers to add more information
- Appeal to citizen scientists – charismatic fauna and interesting management questions help!
- Get feedback from data collectors AND data users
- Remember volunteers can be involved with many aspects of a project. Capitalize on partnerships and "plagiarize with pride" – don't reinvent the wheel
- Have good staff (coordinator, etc.) underpinning volunteer activities
- Develop a training manual and do targeted recruitment.

What does not works (or is challenging)

- Projects that are too much like "work" for volunteers (including tasks that are too close to the professional obligations of the volunteers)
- Difficult language that requires you to create definitions or be a translator for volunteers
- Other organizations that want you to collect information for them (know your standards and your limits)
- Too much specificity or really complex protocols
- Sending people out without training
- Going too slow: planning for too long and waiting too long between activities
- Designing in a vacuum.

Balancing goals and experiences

How did you balance research/conservation with education/participant experience? Participants shared measured optimism in discussing the balance between competing objectives, with some questioning the "sometimes false continuum" that puts research at one end of the spectrum and education at the other. They highlighted the importance of sharing the big picture – of both research and conservation processes and goals – with citizen scientists in order to make the work meaningful and engaging.

Group discussions also pointed out the potential of "learning by doing," which can transform awareness and understanding into strong relationships and stewardship. However, they also noted the difficulty of "finding the sweet spot, where all these are happening," and stressed the need to have "people at both ends" or, ideally, people with both kinds of expertise: someone with science, who understands the education, or someone trained in science education, who knows enough to speak with scientists. Overall, "it comes back to knowing the goal of your project" and being clear about it.

What works

- Provide meaningful activities that interest citizen scientists; give them some independence
- Make it clear to volunteers why they're collecting data and how it's being used – the bigger picture (See Lawrence Hall of Science's "How science works" website)
- Match the work to the skills of the participant. Know who your audience is – whether an agency or volunteer-initiated project – and be intentional about civic and conservation

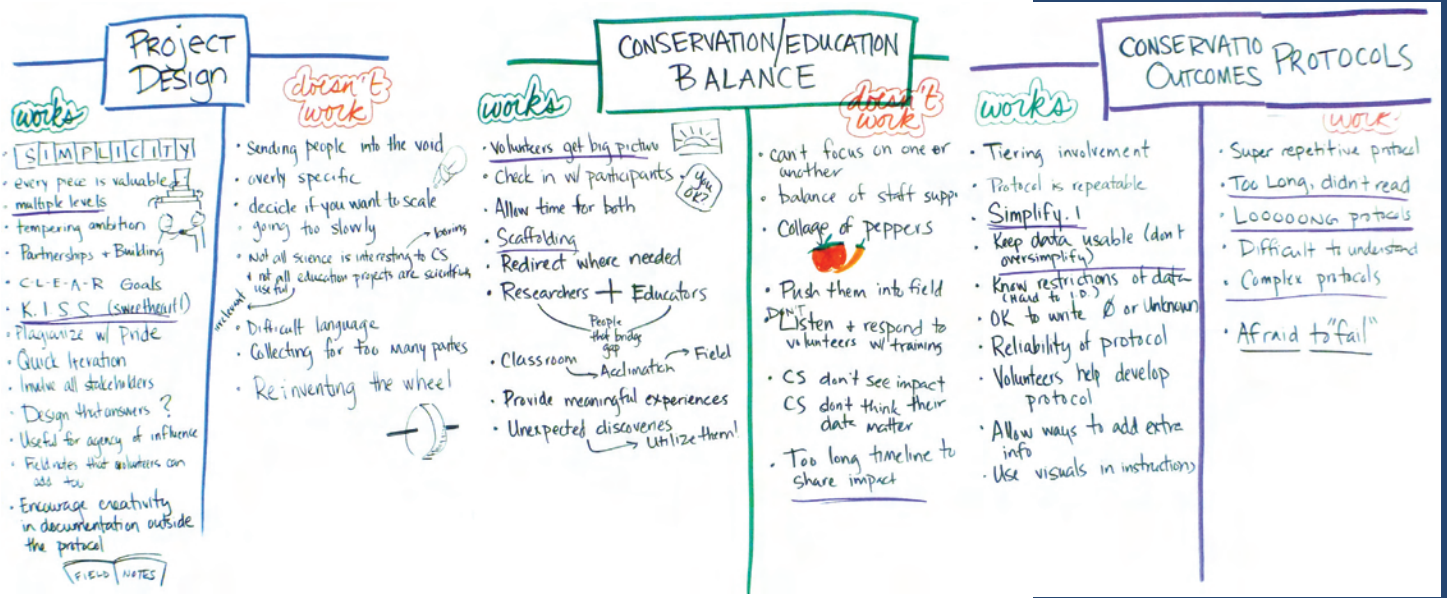
engagement aspects – are they an entry point or an outcome?
- Take advantage of unexpected innovations and discoveries of volunteers - that's science.
- Allow citizen scientists time to enjoy nature and its psychological benefits; a "tiered phase-in" is one approach
- Find volunteers who already have a connection to place
- Do continual self-evaluation and checking-in with volunteers
- Allow time for each of these goals
- Distinguish "good science" from OK science; don't crack down too much, but don't lose control
- Use tiered involvement and redirect volunteers who don't quite fit.

What does not work (or is challenging)
- Volunteers not able to see the impact of their work
- Volunteers not thinking their work is important and being used
- Focusing on one side or the other: you need to have staff on education/volunteer side, as well as research side
- The "collage of peppers": citizen scientists who just don't get it (and not having a way to deal with data and/or dynamic they produce)
- Presuming others want you to educate them
- Assuming, or disregarding, volunteer expertise
- Having too long a timeline to share impact with volunteers.

Developing protocols

How did you go about deciding what protocols were going to work for data collection by volunteers? If you didn't use citizen scientists, how would you change your protocols to accommodate them? Discussion emphasized that protocols still should be as simple as they can be while still producing usable data. Designers should look at data needs and protocols, think about future use, and think about how much of that volunteers can realistically do.

What works
- Simplify, simplify, simplify: protocols need to be repeatable and user-friendly
- Add interesting activities to boring aspects of data collection
- Continually refine the protocols
- Match protocols to volunteer training
- Make sure you're meeting your scientific goals: think about where the data are going and how they will be used, and have quality-control built into the data sheet
- Make it clear that is OK to have "no observation" or "unknown" on your data sheet; also, leave room for volunteer comments and unexpected observations
- Work with scientists to develop protocols and do pilot testing; use citizen scientists like a "focus group"
- Experienced volunteers can be mentors
- Explain what a protocol is
- Use visual aids in instructions.



Addressing conservation outcomes

"I'm a science educator: I see the education as a conservation outcome and as increasing conservation potential."

What does not work (or is challenging)

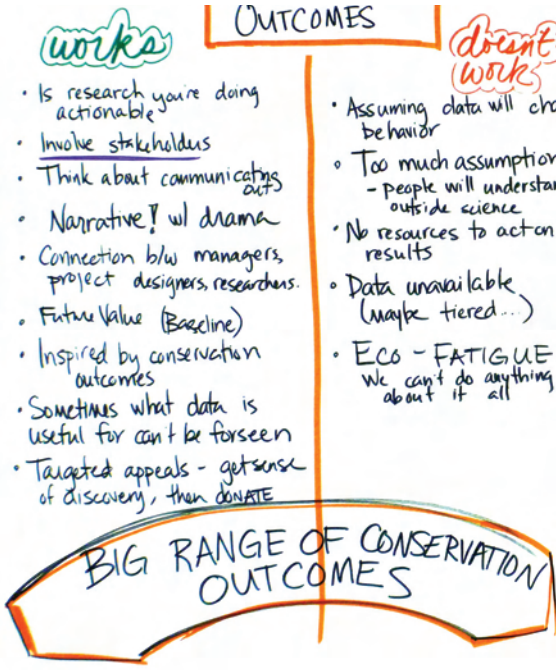
- Super repetitive protocols or overly simplistic protocols – these can annoy volunteers and produce unusable data
- Exhausting the citizen scientists
- Species that are difficult to ID; find alternatives to capturing those species
- Making previous data unavailable or unusable when you refine your protocol
- Too many steps, or difficult steps; people will skip them
- Not all mentors are created equal: be aware of staff, volunteer, and scientists' strengths
- Complex data entry; being afraid to fail
- Extra notes and volunteer comments can be a challenge.

Did your project have any conservation outcomes? Did you go into your project with these outcomes in mind? Hearing from these conservation organizations, how would you address these needs if you were re-designing your project?" In addressing the final topic, participants admitted that there is a big range of conservation outcomes – including education itself as an outcome. Many also maintained that, "for some data, we don't realize the importance until 100 years later" and encouraged citizen science project designers to ask themselves, "what data do you wish someone had collected 100 years ago?"

However, they also described "citizen science bloopers" in which projects had unintended consequences or met few stated objectives. Like with earlier topics, participants stated a need to think ahead when designing around conservation outcomes and finding solutions that are scalable or appropriate in size.

What works

- Tight, "co-created" connection between conservation managers, researchers, and project designers
- Actionable results
- Research that clearly describes the problem and suggests a solution
- Use volunteers as storytellers and advocates – "sharers of knowledge"
- Pay attention to the value and future, often unexpected, benefits of baseline data
- Projects inspired/initiated by conservation outcomes
- Inspire behavior change among volunteers
- Shape conservation outcomes to your locale
- Allow volunteers the excitement of discovery
- Use citizen science to empower volunteers to realize that everyone can help and everyone can be a scientist
- Target appeals for financial support
- Orient citizen science toward business
- Meet people where they're at and reinforce success stories



- Clear, accessible data
- Understand the need for narrative – look for ways that data can inspire
- Bring stakeholders in to foster their ownership of a project

What does not work (or is challenging)

- No resources to implement solutions
- Making data unavailable – you learn a lot by how others use your data. Tiered availability of data can be considered
- "Eco-fatigue" – too many stories of crisis
- Indefensible data
- Assuming that something will work
- Assuming that conservation attitudes equal conservation behaviors
- Too much jargon
- Failure to understand stakeholder perspectives

Keynote & Discussion:
Vital Signs Maine
Sarah Morrisseau & Christine Voyer

Sarah Morriseau and Christine Voyer described Vital Signs, based in Maine, which is a 10+ year old program that integrates many of the strategies and conservation stakeholders discussed at this meeting – agency scientists, community members, educators and students. The program starts from a big question that is compelling to many of these stakeholders, "Where are invasive species and where aren't they?" Sarah and Christine used stories, maps and quantitative data to illustrate the "multiple pathways" into this question that Vital Signs supports. Field-based and analytical "missions" can be initiated by students, teachers, scientists, or community members. The missions cover a range of activities and time commitments relevant to "mapping and monitoring and detection efforts."

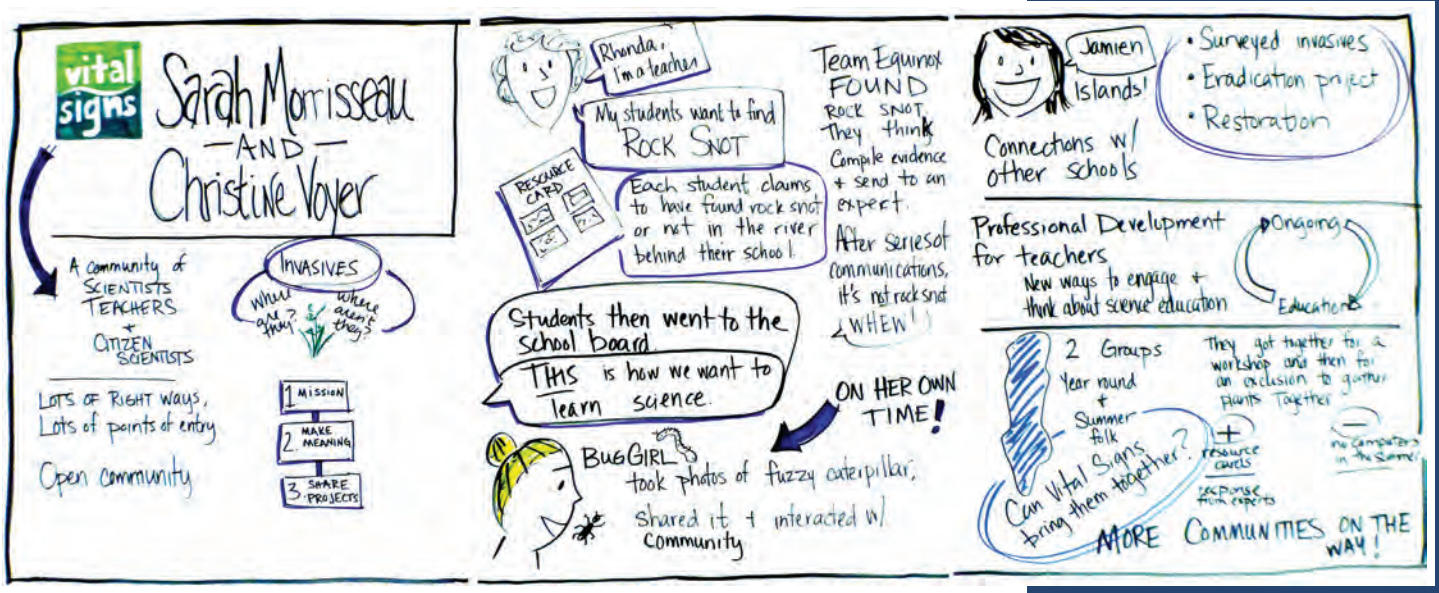
By connecting to stakeholders early in the design process, Sarah and Christine showed how "tools and scaffolding" can be built to give scientists access to data they need, educators access to meaningful, hands-on science with which to engage students, and community members direct access to policy makers and an active group of experts and enthusiasts.

With activities spanning Connecticut, Maine, Massachusetts, New Hampshire and New York, Vital Signs works with over 50 species experts, 200 educators, thousands of students and has been working with community groups. Seventy master gardeners and watershed group members have been trained in Vital Signs summer institutes. Sarah and Christine used examples of teachers, classes of students, and enthusiastic individual young people to illustrate common ways students and classes interact with Vital Science – and with science:

- The variety of missions allows students to be "set loose" and find topics that interest them – like searching for "rock snot" (an invasive freshwater species) in local streams or mapping species on their island
- Using resource cards for identification created by Vital Signs with their partners, students conduct field observation, then have to "make a claim" based on the evidence they found.
- After posting observations and claims, students have the opportunity to interact with State Department of Environmental Protection (DEP) scientists, make and post a video about the experience, and in some cases, advocate at the local school board for "real research" in science education. These activities provide multiple ways for students to be

Sarah Morrisseau
Christine Voyer
Vital Signs Maine

"Students went on to create video that shared an experience and took it to the school board – took it to the top. They told the school board that they did real research and this is how they prefer to learn science."



involved in science

- Sarah described the example of "Bug Girl" (a student's pseudonym), which demonstrated that Vital Signs can support students who "are starting to use (Vital Signs) on their own." With the chance to view and produce video and receive feedback from experts and other community members, the program allowed Bug Girl to both experiment in the environmental sciences and participate in an online science community.

In addition to the value that Vital Signs brings to young citizen scientists, Sarah and Christine discussed how the program works to benefit adult participants. Historically this has been primarily teachers, but Vital Signs is currently working to expand and enhance their interactions with community-based groups as well.

For teachers, Vital Signs provides:

- 'research-based" and "standards-aligned" curricula
- long-term learning communities to discuss science teaching practices
- the chance to learn from (and become) an educator-leader, working with students on the ground and helping new teachers integrate citizen science work.

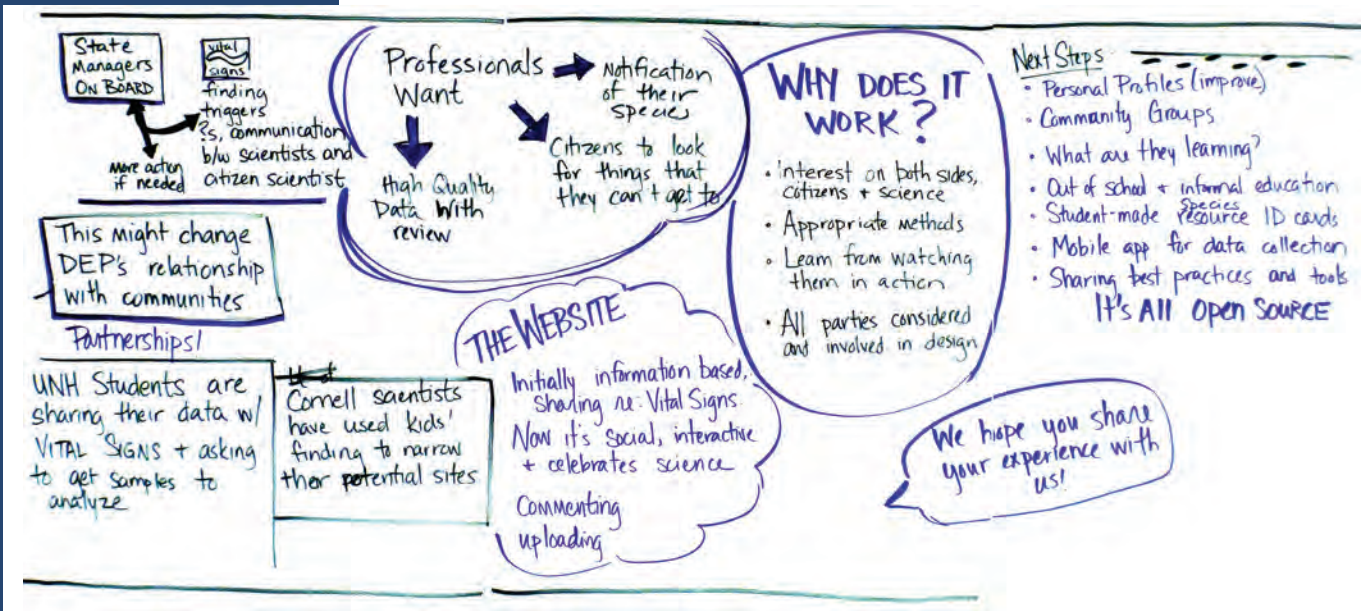
For community groups, they offered an example: Several community members living on a lake in northwestern Maine were concerned about invasive species. They approached Vital Signs to bring together groups who "don't always get along." Vital Signs held a training institute and helped them successfully launch the project; 12 trainees motivated 35 citizen scientists to join the project.

While incredibly successful as a foray into community-based work, Vital Signs learned useful lessons from this project about how their protocols, training and expectations needed to be adapted to working with community groups. For example, participants loved having the data stored in a common place so they and the DEP could both access it, but they did not love entering data on their computers in the summer instead of being outdoors! Sarah and Christine adapted by having students enter the data, filling a gap and connecting to students.

"One thing that is most engaging and motivating is knowing their data are being looked at and used.... Our species experts see observations and leave questions and comments [online]. They thank participants, and encourage participants to look more closely, or look somewhere else."

Scientists' and managers' involvement in Vital Signs began before the project launched. Vital Signs team members met with agency personnel and sat in on researcher meetings to make sure the project asked researchable questions. The resulting relationships and tools have been essential to guiding projects and building a dynamic community.

- DEP and Maine Forest Service managers use Vital Signs for data that they can follow-up on, and use to guide research, management decisions, use of resources
- DEP-initiated missions allow scientists to raise awareness of little-known invasives
- Beyond the 'science,' Vital Signs helps DEP change its relationship with communities. Instead of being seen negatively as a regulatory agency only, they now hope DEP is viewed as an invited partner in a community-led effort
- Researchers can also take advantage of the unique strengths of citizen scientists through Vital Signs– for example, one researcher has noted that kids are "really good at finding



little crabs."

Sarah and Christine shared some key lessons they have learned (and hope to conduct formal evaluation in the future to continue learning):

- A good question is essential - one "scientists need help with and citizens are invested in"
- Ask questions of scientists early in the process to guide data collection goals and protocol development
- Field test protocols and resources with students and learn from their feedback
- Project design must be flexible and able to grow; for example, websites need re-design for social networking
- Graphs and analysis of user data allows Vital Signs to adapt program and be prepared for demands of the data and the citizen scientists – for example, being ready for lots of activity in the fall.

Vital Signs has several goals for future directions of the program, including involving more community-based groups and out-of-school educators, improving their evaluations of participants' motivations and learning, and finding ways to help students share their stories and questions more broadly. Christine and Sarah made it clear they want to share their technology tools as well, which are open source on a Creative Commons license. During the discussion, several other points were raised about Vital Signs' successful programs:

Q: How do you monitor what kids are posting on the website?

A: Vital Signs accounts are set up by teachers for students, setting up a system of accountability and allowing teachers to configure permissions and moderate comments where they feel it's necessary.

Q: How do you get scientists to participate so much and well?

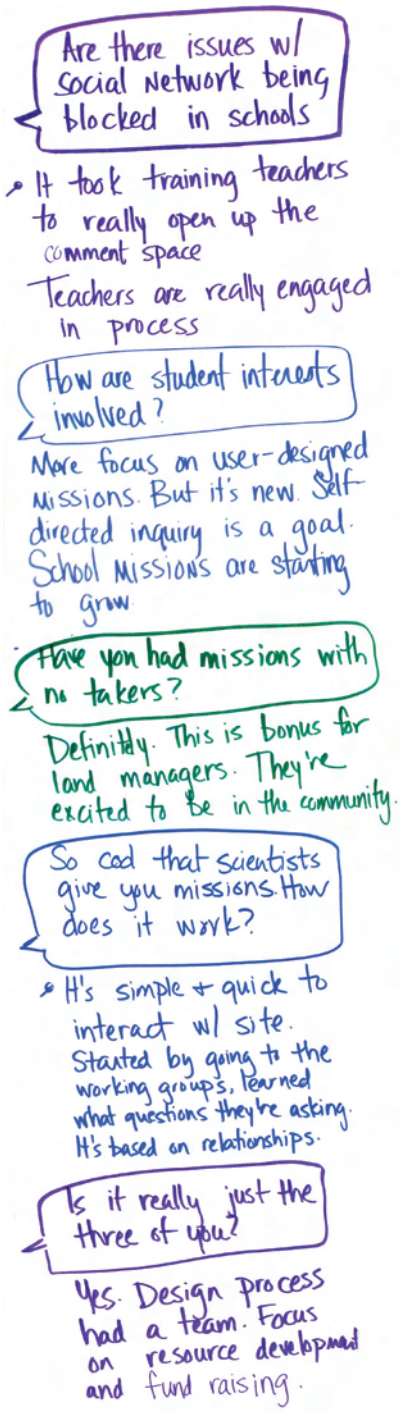
A: Quick and simple interface on the website, and "actually going to [scientists'] meetings"

Q: How do you keep the conservation going and get users to enter comments online?

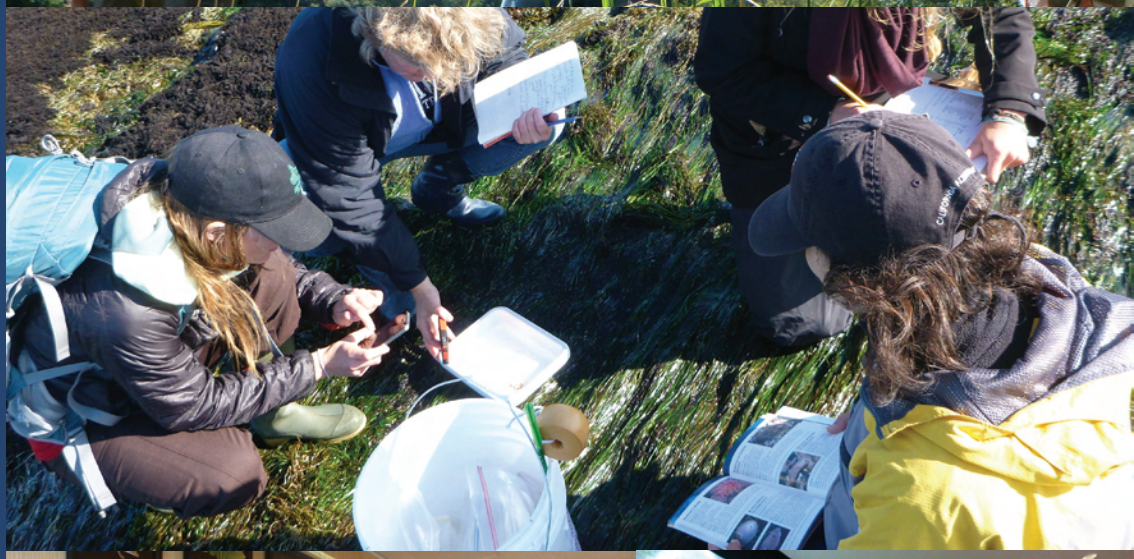
A: Sarah, Christine, and third team member Sarah Kirn do lots of commenting themselves, have held trainings for teachers, and check in with experts and community members to seed conversations.

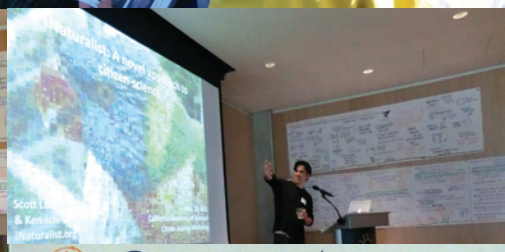
Q: How many people do you have working on all this?

A: Vital Signs programs – from coding to teacher training to resource and relationship development – are run by a team of only these three "rock stars," as one convening participant titled them.



"Sometimes the science and the tools need to come next and humans need to come first."





Clockwise from top: Citizen scientists collecting data at the Mt. Tamalpais BioBlitz; a Pillar Point Survey team working on species identification; a Day 3 Technological Tools Presentation by Scott Loarie; stickies from Day 1 group discussions; Day 2 group discussion in action; Day 2 Conservation Organization panelists.

Day 3

Focus on Technology and Data Management

May 17, 2012

Objectives

1. Review tech-related options for engaging the public in citizen science projects.
2. Hear the perspective of citizen science coordinators and website designers/data managers who have worked with citizen science projects - what has worked, what has been a challenge, etc.
3. Identify key strategies for developing website/database/apps/etc. that would directly serve a biodiversity-related citizen science project.

Moderated by Jean Farrington, Director of Lifelong Learning, California Academy of Sciences

Reviewing the Field:
Tech tools to engage citizen scientists
Alison Young

Alison Young
Citizen Science Educator
California Academy of Sciences

Alison Young described some of the key issues in use of technology in citizen science projects, and presented examples of projects that are making use of technology in their citizen science programs as tools for training, to create on-line communities, and provide tools for data visualization. Then we discussed some of these issues and added several examples from participants' own experiences.

Alison outlined the many ways she has found that technology can be used by and for citizen science projects, and then gave examples of many of the projects she likes best for these aspects:

- Website design
- Training material
- Rewarding participation/Keeping participants engaged
- Forums/discussions
- Data visualization – often the first step for people to think about the science (beyond data collection) by looking through trends and graphs
- Data entry and data cleaning - so many citizen science projects have stacks of paper data that never get entered! Developing ways to have users enter their own data online is key.
- Explore new research questions – to help participants move beyond data entry
- Social media – to reach out to participants
- Administration –putting in parameters
- Apps – what tools can and should you have on the smart phone?

Using Technology for Training:

- *Evolution MegaLab* - Trained citizen scientists all over Europe with an on-line training in multiple languages. After signing up, participants are given the protocol and tested using photographs of snails to test their identification skills. This serves not only as a training option, but the coordinators also have the option to link participants' test results with the data they subsequently enter, providing a measure of confidence of the user's ability to identify. They have published a paper on their work.
- *Neptune Canada Center for Global Studies* - Users characterize sea creatures through video clips and advance through levels that are increasingly more detailed (like a video game). As a user goes through the lists they can collect cards with information about the marine invertebrates (like baseball cards!).

"This is good motivation because I *like* these things.... they were telling me about these creatures. And I liked that each time I got to tell them *more* [sophisticated] information."

Online Communities:

- *Galaxy Zoo* participants work entirely on line but they feel a part of a community. They have an online forum and "the café at the end of the universe" where they talk about anything they want. They have a social community and people feel they know each other.
- *iNaturalist* allows for on-line feedback on data posted by users. Alison reported an experience posting about a snail and getting feedback from a scientist about potential name change. A researcher who published a paper on the genus ended up giving verification through the on-line process. This is a real way to interact with scientists!

Data Visualization:

- *LiMPETS* provides a teacher curriculum that guides teachers and students through the data visualization process. Providing explicit instructions on how to ask questions of the data, the data graphing tools are also open to other users, and allow one to select the intertidal zone, year, location, species and a method for display.
- *National Geographic FieldScope* is new project funded by the National Science Foundation to develop data analysis and visualization tools to help existing citizen science projects encourage their participants to engage in data analysis. Alison showed us an example of water quality monitoring for Chesapeake Bay, for which users can select their own layers,

x and y axes (e.g. looking a correlation of air temperature and water temperature). For this project users can look at all student data entered for a certain point. (See more on FieldScope below).

- *Open Data Kit* is an open-source project that allows users to build their own survey forms, customize their own fields, and get them on a smartphone.

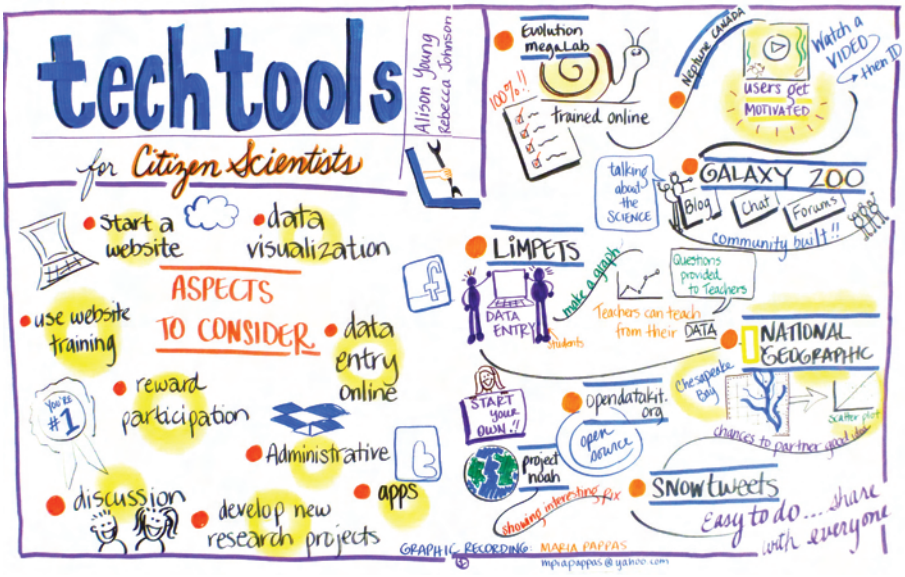
Social Media:

- *Project Noah* is a popular website (with 250,000 "likes" on Facebook) that allows users to start their own "mission" to ask and answer questions about the natural world and wildlife.
- *Vital Signs Maine* (see Keynote Presentation Day 2) also allows users, primarily teachers and students, to choose or start a mission and then comment and share online their observations and evidence for their claims.
- *iNaturalist* (see below and Pepperwood Preserve Day 1) is an online program with a very user friendly app that allows users to join or start projects, take photos and identify organisms, and verify or critique identifications in a community of users online.
- *Snowtweets* allows users to "tweet" the data from their snow gauge and it automatically uploads into a database for use by scientists.

"These people are working entirely online, not going out into the field together, but feel they're a part of the community."

The group then discussed the myriad examples and issues Alison raised. For example, many in the group were interested in the phenomenon of the "uber contributors", who in fact contribute a large portion of the data in these online communities of citizen scientists (and in many online communities). This is an important consideration for citizen science programs trying to reach out to a large number of people - who you get the data from might be important. Several participants added projects they particularly find useful to add to Alison's list:

- *Herbarium at Home* is a program in which participants look at scanned specimens and collect data on the image by entering the data that is on the herbarium specimen label. Multiple participants enter one sample to avoid data error.
- *Citsci.org* was touted as one of the leaders in developing tools for citizen science projects by Gretchen LeBuhn (Founder of the Great Sunflower Project). They have 50-60 small projects and work with each project individually to develop and provide tools for data entry and data visualization. Users send in a request for a project of interest - anyone can participate.



Technological Tools Presentations:
Online tools and applications for citizen science
Calflora & iNaturalist

Calflora
Dan Gluesenkamp

Dan Gluesenkamp
Executive Director
Calflora

Dan Gluesenkamp focused his presentation on transitioning from technology that helps people collect data, to projects like Calflora that helps aggregate and share that data with scientists.

Dan described his presentation as a cautionary tale, because we need to think carefully about "what to do with data?" once they're collected. He described Calflora's role as creating the "there" for the data collected through the many citizen science online and app projects, and as the aggregator of the information collected. He described the ways that programs like his can link with citizen science programs like iNaturalist to create a bridge between the citizens and professional land managers and scientists.

Calflora is a place for people to share and pool information primarily with professional scientists, plant propagators and land managers. The tools can also be used by citizen scientists but the focus of Calflora is more on making data collected by citizen scientists available and useful to professionals. Dan outlined the key considerations when envisioning where the data goes once it's collected through online communities:

- The data need to be usable, labeled carefully - we can't accidentally be pulling in fiction.
- We need creative ways for professionals to upload data sets and make complex data available to managers.
- Calflora developed an app for professional-grade mapping to collect better information
- Think about data accessibility in layers; land managers do not want some information to be shared (e.g. endangered species locations), so information can be hidden selectively.

Dan pointed out that there are tensions in trying to bridge between the interests and needs of citizen scientists and those of professionals. Right now, he explained, we have a "Tower of Babel" of data collection websites and apps, with people using different formats and standards. Calflora is trying to take these many systems that collect information and retrofit the information in a way that is useful to land managers, but could also be used by citizen scientists. He described their approach, which includes using a central system so data can be pulled from many programs. For example, they are working on a system that will allow data created and verified on iNaturalist to be shared into Calflora's database.

"This is a Tower of Babel: [people collecting data] are all using different formats and standards. Data sits there and nothing happens with it. We need to share and connect the dots on the map.... These are things we have to do today if we're going to save tomorrow."

Calflora has tools that allow land managers to download data and use it in their agency's GIS system, and tools for uploading geo-tagged photos as a way for professionals to map plants and use these in their project reports. Dan concluded with his hope to keep partnering with programs collecting citizen science-generated data and to figure out how to metabolize data so it can be useful to the scientific community.

iNaturalist

Scott Loarie

Scott Loarie introduced iNaturalist as "citizen science through and through" that takes advantage of the rapidly evolving technology becoming available. Scott posed the idea that scalable data gathered through citizen science projects like iNaturalist can help revolutionize conservation and combat threats to biodiversity posed by accelerating land-use and climate change. He explained how iNaturalist works for users: "Make an observation, upload the photo, link to a project or place, verify the ID with the online community."

Throughout his presentation, Scott emphasized the end goal of conservation, rather than just using technology and cool apps for their own sakes. "We are asking people to be citizens AND scientists," to contribute to conservation in real ways. He also emphasized that merging social networking tools with conservation and research, through projects like iNaturalist can build and leverage virtual communities to advance science and conservation.

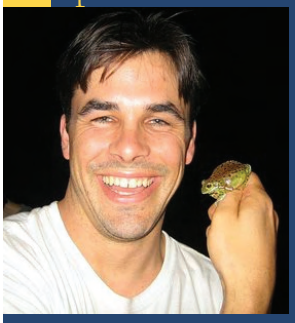
Social Networks of Citizen Scientists Can Provide Verifiable and Scalable Data: Scott pointed out that "data has power that spans time and space." For example data on butterfly distribution can be correlated with temperature data. Citizen science can engage a wide base of users, harnesses the energy of the "crowd," and can provide scalable data in a whole new way. The work of Cornell Lab of Ornithology has shown the power of citizen science data for conservation. Now, this kind of data collection is moving into other taxa of concern and using technology in new ways, for example, integrating with Google Earth.

Social networking and photo-sharing: Photo-sharing and social networks are a growing part of citizen science efforts and technology tools, such as iNaturalist. For example, PhD graduate student David Bloom used Facebook to identify fish species in the amazon because he couldn't bring the specimen back to the U.S.

As the co-director, Scott explained that iNaturalist.org is a non-commercial service that taps into a community of thousands of naturalist sharing over 60,000 photos of plants and animals. Since the beginning of the year, "iNat" has averaged over 4,500 visitors, 1,200 observations, and 100 new users each week. Using the photo as a shared voucher and social networks to connect scientists and amateurs, iNat is able to verify data and send it to the museum community as a GBIF data provider and to the IUCN red-list.

Scott highlighted several other "projects" created by users in iNaturalist that have been particularly successful and useful, including:

"As a biodiversity scientist you realize the power of data that spans time and space."



Scott Loarie
Co-director
iNaturalist
Post-doctoral Researcher, Department of Global Ecology, Carnegie Institution for Sciences
Stanford University

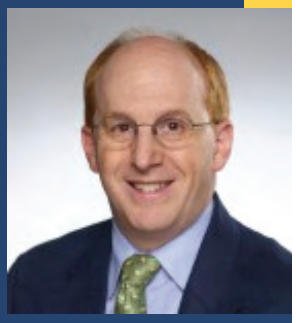
"I've drank the Kool-Aid and I think [scalable data] will come from citizen science... [iNaturalist] is now getting about an observation every 4 minutes."

- A special iNat app Redwood Watch he created for Save the Redwoods League
- Global Amphibian BioBlitz that allowed an army sergeant in Iraq save a frog species, and has documented new species of frogs and toads in a reserve in Colombia
- Conservation photographers, which lets users use their photo skills to get engaged with science and nature

Future directions for iNaturalist – Scott explained they would like to keep working to be more compatible with complex data collection projects without losing scalability, would like to provide an educational service and crowd-sourced field guide, and would like to partner with new projects (for example, the Gulf of the Farallones National Marine Sanctuary).

National Geographic FieldScope

Daniel Edelson



Daniel Edelson
Vice President for Education
National Geographic Society

Danny Edelson began by pointing out how complementary many of these technologies and websites can be for citizen science and that even similar programs are often not redundant in terms of their overall function. FieldScope is a "community geography" project trying to fill a niche in citizen science with software that gives user the opportunity to manipulate data, in a way that does not require a lot of technical skills, time or money to do so. Two years into their 4-year National Science Foundation- funded project, they hope these tools will encourage citizen science programs to make data visualization and analysis part of their core practice. Danny explained that the first goal of the program is focused on participants' experiences and outcomes, and secondarily about generating scientific findings. The hope is that FieldScope will be applicable and useful to small communities and also on a global scale.

FieldScope aims to use software to encourage and assist citizen scientists to make data visualization and analysis a part of their routine. Some of the highlights of the program, both current and in development, include:

- Goal is to create powerful analysis tools that are understandable to more than just scientists (e.g. school age students and public users)
- Program is designed for clients that are citizen science program providers
- FieldScope can be used with variety of users, from those who want a simple, "turn-key" program and don't want to host their own server or create software, to those that are interested in more program development on their own servers.
- A variety of tools, including watershed mapping tools, query tools, and other visualization tools such as the swipe tools allow users a variety of options to examine their data.

One innovation is that FieldScope allows for integrating data from these research and agency data sources with student collected data. Dan presented an example of how the FieldScope program can work using real time NOAA buoy data from off the coast of Maryland.

The program also allows users to model the watershed they live in. For example, a student in Maryland could enter an address and map the path a drop of water would take from his home, down the drain and into Chesapeake Bay. Users can ask questions of the data using query tools, for example asking for statistics on the permeability of surfaces. Using another of the available tools, the Swipe Tool, users can swipe between different sides of the map showing different time periods to view the changes over time.

Presentation & Discussion:

Zooniverse

Arfon Smith

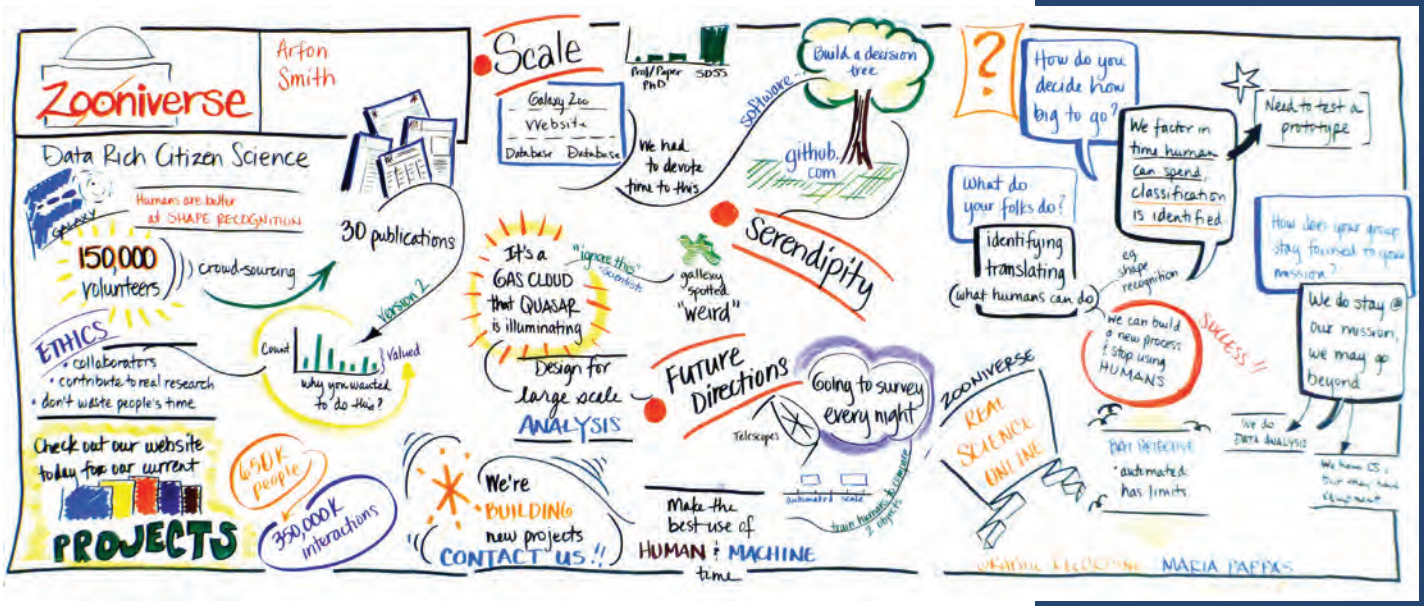
Arfon Smith provided background to the Zooniverse program which consists of many citizen science projects including Galaxy Zoo, how it works, and its application as a platform for data rich citizen science. Building from the work of the Galaxy Zoo program which was launched over 5 years ago and has had 150,000 contributors and published 30 peer reviewed journal articles from the data, Zooniverse has captured a community of people interested in asking questions and contributing to research.

Arfon Smith
Director of Citizen Science
Adler Planetarium
Zooniverse

The Zooniverse approach is based on classifying and curating the massive amounts of data generated by scientists that cannot be coded well by computers and for which there are not enough scientists or technicians in the world to handle. Projects are diverse, from solar, whale calls, ancient Greek text, climate change record analysis, bio transcription and bat audio recordings. The rules of the program are simple: participants are considered contributors, and with that in mind all projects have to have a real research purpose and no tasks will be a waste of time regarding that research question. Today, the program is about 650,000 people strong and has produced 350,000,000 classifications or interactions with data.

Arfon discussed some of the integral components and key issues that Zooniverse raises for citizen science programs and the uses of technology:

- *Working at Scale:* in early days of Galaxy Zoo, they dealt with hundreds to thousands of



images in a month. After launching Zooniverse, they received 70,000 per day. Programs need to be ready for scaling-up!
- *Data Rich:* program involves thousands of people and a wide variety of projects
- *Serendipity is at Play*: users find new and interesting things, and there must be space in programs for allowing for interaction between users and professional scientists, and unexpected findings
- *Designed for involvement*: contributors can do large-scale analysis but also make time for inquisitive thinking
- *Platform for Conversation*: uses an object-centric discussion tool. After an interaction, participants go to a page about this object that includes the "talk" or conversation about the object. This talk has led to the discovery of new planets.

"You shouldn't waste people's time. If you could use a computer to do it better, use a computer. You should [use citizen science], not because it is fun, but because it's the only way to do it."

In particular, Arfon gave some amazing examples of how the Internet-based "talk" that is attached to each observation citizen scientists have made has led to real discoveries in science. For example, noticing an anomalous green blob in the photo she was classifying, a teacher was persistent in pointing it out to the astronomers she corresponded with through Galaxy Zoo, who later determined she had discovered a new entity in the universe: the death of a quasar.

Arfon also expressed that follow-up interaction once a user has classified a photo or audio-recording is a crucial piece of the overall program and that building a place for citizen scientists to do real work is only one step. Making citizen scientist a component of the system truly brings them into the fold and can lead to real progress in research and the kind of participation that we expect from citizen science in general.

Group Discussion & Report-Out:
Project design - The use of technology in citizen science

Small Group Discussions focused on a series of questions related to the ways that citizen science programs can and do navigate the issues of volunteer engagement, data visualization, data collection, and quality control/quality assurance specifically concerning the use of technology. These groups, consisting of 6-8 people representing a variety of citizen science projects and programs, discussed the key questions and then reported out to the whole. The participants ended with a larger discussion about successes and challenges that serve as lessons for programs hoping to take advantage of the myriad apps, websites and other technologies for citizen science.

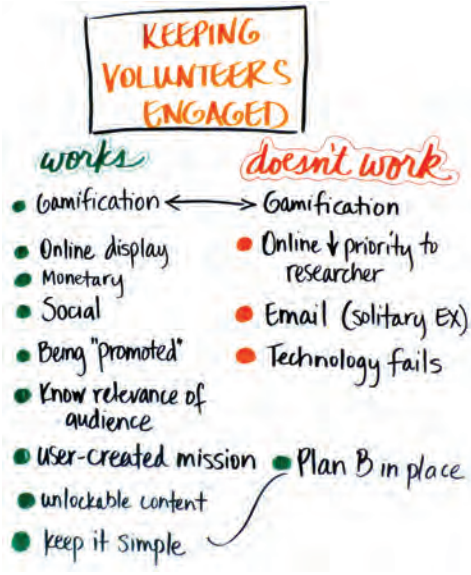
The question posed to all groups for each of the topics below was: *In your own projects, what worked, and what mistakes did you learn from?*

Keeping volunteers engaged

A key point that arose several times in discussions throughout the day is that one key use of technology in citizen science is that of keeping volunteers engaged through interactions with scientists, social interactions with each other, being able to see their data aggregated and part of the larger whole of the data within a project, and getting feedback on the quality of their data. Technology can also appeal to the "digital natives" who may not engage with science or the natural world otherwise.

What works
- "Gamification": making data collection, curation and classification, and analysis more like playing a game
- Visually appealing online displays
- Money - In some context providing a monetary incentive (coffee farmers in Chiapas) and other times, charging people to participate sometimes will create longer-term users because they've invested
- Technology and virtual communities that make science social

- Levels of training and experience that allow users can track their own improvement and move to higher levels
- Knowing the relevance of the research question to your audience
- User-created "missions" and research questions
- Unlockable content
- Keeping it simple
- Always having a "Plan B" in place



What does not work (or is challenging)

- "Gamification": if data collection, online interface, or apps are too much like games, science learning and data quality might suffer
- Realizing that researchers don't often have the time and energy to interact with users online to provide that desired "interaction with a scientist" users crave
- When you don't have a Plan B and the technology fails, which it often does!

Usefulness of apps

Most of the discussion shared by groups focused on the double-edged sword of mobile technology and mobile applications, or *apps*; the features that make them useful and appealing for citizen scientists also may make them difficult to rely on and design for in a rapidly changing field. Many people raised the issue of access to mobile technology for underserved audiences (in terms of expense) and for older or non-digital native audiences (who don't have smartphones), while at the same time mobile technology may bring in new audiences (young people) who wouldn't otherwise engage with citizen science. Key for apps is to make them useful in the field (the ability to work offline) and having a clear purpose or question that the app is designed for.

What works

- Apps that allow users to work offline, including in the field
- Apps that are easy to use
- Democratizing data
- Having a clear purpose
- Mobile "hot spots" for events like bioblitzes
- Sharing resources
- Appealing to the "tech generation" digital natives
- Appealing to a broad audience
- Working with many mobile devices (phones, iPads, smartphones)
- Using SMS and text messaging
- Using apps eliminates need for more data entry by users or staff
- Transforming an indoor activity to an outdoor activity

What does not work (or is challenging)

- Requiring users to have a lot of expensive equipment - not everyone has a smartphone or tablet
- High price of mobile technologies
- Dealing with the variety in technology can be a design nightmare - having an app for every platform is difficult
- Realizing who really has access and ability to participate in your project, and who doesn't
- Relying on networks that may stall or fail
- Don't require too many keystrokes on mobile phones!
- Mobile devices don't work well in bad weather!

Data entry & visualization

We discussed the amazingly positive role that technology and web-based interfaces can play in helping citizen science move from data collection to other forms of participation in science like data visualization. New online programs allow users to ask and answer questions of the data in a way that has not been possible until recently. Key recommendations for these programs were to make sure the user experience is simple, elegant and fast, with training and infrastructure provided that helps users move from raw data to analysis intuitively. Mapping was cited as one of the important ways that users can grasp and visualize large data sets and ask questions of spatial data. However, the demand for speed, elegance and intuitiveness means that designers must test their sites and tools with real users to ensure all the bugs are removed!

What works

- "Elegant" user experiences
- "Fast and snappy" process of visualization and exploration
- Spaces where users can explore and play with the data
- Training and structures for users to analyze data
- Tangible outputs
- Keeping it simple (KISS)
- Mapping is key: maps are one of the most intuitive and interactive ways for people to visualize data
- Building time into your design process to test tools with users
- "Canned" or pre-packaged tools that help people take the data straight to graphs and visualization.

What does not work (or is challenging)

- Slow upload or download process - people want speed
- Tools or processes that are not intuitive
- Allowing too much time to elapse between Beta testing and going live
- Web projects that take too much time and have to be updated every year
- Don't change for the sake of change in terms of re-design of websites.

Data quality control & quality assurance

The last topic of the day, QA/QC, encompassed many of the concerns that research often have about relying on citizen scientist-collected data. However, participants in the discussion pointed out the numerous ways that quality of data can be controlled and assured in citizen science projects, but that these procedures must be designed and integrated into the program from the beginning, not added later as an after-thought. Training and certification of citizen scientists,

statistical tools that allow for data reliability checks and filters for anomalous observations, and having protocols reviewed and tested by scientific and citizen science experts for quality and usability are all methods to assure high data quality from citizen science projects.

What works

- Keeping the limits of your audience in mind when designing QA/QC
- Protocols based on where people are in terms of skills and abilities
- Statistical tools that check data reliability
- Built-in filters for data quality
- Using experts for data verification judiciously and strategically
- Training of volunteers to ensure data quality
- Making sure users know how their data are being used, improves collection quality
- Teams of citizen scientists that include experienced and novice volunteers to get better data
- Asking the right questions
- Consistent and standardized protocols
- Review of protocols and findings before data goes live
- More contributors increases confidence in data
- Testing your designs thoroughly.

What does not work (or is challenging)

- Lead scientists or experts may not be the best for QA/QC
- Citizen scientist fatigue if protocols are too complicated
- Do NOT have your data only in one place
- All the data entered on the web may not all be vetted - people can learn the process of science by knowing how to challenge and verify data.

Summation

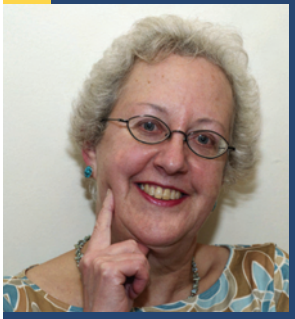
Jean Farrington

At the end of the Citizen Science Meetings, Jean Farrington thanked everyone for their high level of participation and great energy.

She summed up some of the themes meeting participants had covered in the past three days:

- *What is citizen science?* Is there a real research question or is it observational?
- Is it data collection or analysis?
- The desire to value all kinds of participation, not one kind over another; an emphasis on multiple tiers.
- *Quality control*: how good is it? Are citizen science data as good as those from the professionals? Seventh graders, adults, researchers?
- *Importance of feedback to volunteers:* 'my data and input' - the ability to track project online.
- *Don't reinvent the wheel:* are there data and tools already out there?
- *Is there a research question?*
- Do we make our volunteers aware of the bigger picture - where and how their contribution matters?
- What resources are required for volunteers, support and infrastructure?
- *Keep the work simple.*
- Use and take advantage of the power of the crowd.

Lastly, we focused on technological tools, incentives, and what you do when you get the data. Thank you all again; this has been great learning experience for all of us at the Academy.



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Director for Lifelong Learning
California Academy of Sciences

California Biodiversity Citizen Science Meetings
May 16-18, 2012
At the California Academy of Sciences

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Heidi Ballard
Assistant Professor, UC Davis School of Education

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Marine Invasive Species Program, California Lands Commission
Citizen scientist with iNaturalist

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