

Diving into Citizen Science: Understanding Engagement in the SMILE project

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Background

Global marine systems are under unprecedented pressure, and citizen science has emerged as an effective approach to supporting marine conservation and fisheries management (Kelly et al., 2020). The Reef Environmental Education Foundation (REEF), a nonprofit marine conservation organization, collaborated with social scientists at Colorado State University (CSU) to design and administer a structured survey aimed at understanding the factors that motivate snorkelers and divers to participate in the "Size Matters: Innovative Length Estimates" (SMILE) project.

The SMILE project equips citizen scientists with a low-cost, laser-mounted, waterproof point-and-shoot camera to photograph 12 target reef fish species, including grouper, hogfish, parrotfish, and snapper. Fish length is subsequently estimated from the photographs using AI and depth-of-field technologies, to contribute relevant data directly to reef fish stock assessments and management.

Citizen scientists play an essential role in marine conservation and fisheries management by extending data collection capacity beyond what government and academic programs can achieve alone (Kelly et al., 2020). As citizen science programs evolve, so too does the technology available to support them. However, the introduction of new technologies into citizen science can create barriers, particularly when participants feel uncertain about their ability to use unfamiliar equipment or question whether their contributions will make a meaningful difference (Newman et al., 2012).

The SMILE project was designed with accessibility in mind. Participants do not need prior fish identification experience or underwater camera training to contribute, making it an easy project for marine citizen science. To understand the characteristics, motivations, and concerns of potential and current SMILE participants, REEF partnered with social scientists at CSU to develop and administer a structured survey. The findings here confirm that SMILE has strong potential for broad citizen science adoption, particularly if outreach messaging emphasizes conservation impact and training resources are robust and varied.

Survey Methods

Development and Design

The survey was developed collaboratively by conservation social scientists from CSU and marine scientists from REEF, with input from citizen science experts in the South Atlantic and social scientists from the Florida Fish and Wildlife Conservation Commission (FWC). The survey was piloted prior to full administration.

Survey questions addressed both operational and social-psychological dimensions of SMILE participation. Key variables measured included:

- **Sociodemographic characteristics:** Age, education, and place of residence.
- **Recreation specialization:** REEF membership, survey participation history, dive certification level, number of dives, fish identification knowledge, and underwater camera experience.
- **Comfortability:** Respondents' self-assessed comfort using the SMILE camera with and without training (5-point Likert scale).
- **Motivation:** Respondents ranked up to six reasons for participating from a list of 10 options using a drag-and-drop ranking interface. Scores were assigned based on rank: most motivating = 3 points, second most = 2 points, third most = 1 point.
- **Perceived impact:** Respondents rated the expected impact of their participation on fisheries science, policy, and management (5-point Likert scale). Internal consistency was high (Cronbach's $\alpha = 0.896$).
- **Social norms and self-efficacy:** Assessed using 7-point Likert scale items.
- **Intended behavior:** "If given the opportunity, I am [very unlikely to very likely] to participate in this project" (7-point Likert scale).
- **Training preferences:** Choose-all-that-apply questions on preferred topics and modalities.

Administration and Participation

Surveys were distributed through REEF's communication channels, including email lists, social media, e-newsletter, and QR code postcards at REEF events and partnering dive shops using open recruitment. Because of this broad dissemination approach, a formal response rate cannot be calculated.

The Main Survey received 572 responses; 481 were retained for analysis after removing incomplete responses. The Post Survey received 42 responses; 32 completed surveys were retained. Twelve matched pre-post respondents were confirmed by name. For analysis, respondents were divided into two primary groups:

- **Nonusers** (n=459): Had not participated in SMILE at time of Main Survey completion.
- **Users** (n=55): Comprised of 23 Main Survey respondents who had already participated and 32 Post Survey respondents.

Comparative statistics were performed in IBM SPSS and Posit RStudio and included chi-square tests, Fisher's exact tests, and Wilcoxon rank-sum and signed-rank tests, as appropriate for the data type and distribution.

Respondent Characteristics

Nonuser Demographics

Nonusers were predominantly older (25.2% were 55–64 years old and 24.7% were 65–74 years old (n=417)) and highly educated (39.5% held a Bachelor's degree and 33.0% held a Master's degree (n=415)). Most resided in the United States (90.1%, n=414), with a majority concentrated in the South Atlantic region (45.6%; includes Delaware, Florida, Georgia, North Carolina, and South Carolina).

Most nonusers were REEF members (65.8%, n=459), though 60.8% of survey participants had not previously completed REEF fish surveys (abundance and diversity for the Volunteer Fish Survey Project). Of those with survey experience, the largest group had completed 1–10 surveys (37.2%, n=180), followed by 51–250 surveys (22.2%).

Diver Experience and Specialization

Nonusers demonstrated:

- **Certification level:** Over 50% held a rescue diver certification or higher, including master scuba diver (8.1%), dive master (14.8%), and professional above dive master (18.5%).
- **Dive experience:** Approximately 40% had completed 501 or more dives.
- **Fish identification:** 68.6% reported knowledge of 26–100+ species; 69% expressed interest in learning more than 50 additional species.
- **Underwater camera use:** Most nonusers used underwater cameras "sometimes" to "always." The most common camera types were the same category as the SMILE camera.
- **Previous citizen science experience:** 54% have prior experience contributing to science in marine systems (e.g., coral reef outplanting, benthic surveys) to terrestrial programs (e.g., native plant monitoring, bird identification).

User Demographics

People that had experience working on the SMILE project skewed younger than nonusers (33.3% were 18–24 years old (n=27)). The majority resided in the South Atlantic region (82.1%), were REEF members (83.6%), and had previously completed REEF fish surveys (83.6%). Users demonstrated comparable or higher dive specialization than nonusers: 71% held rescue diver certifications or higher, and 81.9% reported moderate to very high fish identification knowledge.

These demographics were driven by the people that were selected to pilot test the SMILE project in the field based on their abilities and availability.

Key Findings

Finding 1: Comfort with Technology and Likelihood to Participate

A majority of nonusers expressed a positive disposition toward participating in SMILE. Of 426 nonuser respondents, 83.3% (n=355) indicated they were "somewhat likely" to "very likely" to participate in SMILE if given the opportunity.

Comfort increased significantly when training was provided (Wilcoxon signed-rank, $p < 0.001$, $n = 426$), with the distribution shifting markedly toward "comfortable" and "very comfortable" after training was considered.

Nonusers who indicated they were likely to participate differed significantly from those who were unlikely on several dimensions (Wilcoxon rank-sum tests):

Variable	Test Statistic	p-value
Diver certification level	W = 14,913	0.013
Belief about impact on fisheries science	W = 13,477	0.006
Comfort with SMILE camera (current skills)	W = 17,704	<0.001
Comfort with SMILE camera (with training)	W = 18,498	<0.001
Interest in SMILE camera	W = 20,673	<0.001
Underwater camera experience	W = 15,069	0.007

Age was also a significant predictor: nonusers likely to participate had a median age of 56 years (IQR=37–65), compared to 64 years (IQR=51.5–71) for those unlikely to participate (W=7,741, $p < 0.001$). Education level did not differ significantly between groups (W=10,683, $p = 0.433$).

Of those who reported they were unlikely to participate even if the project contributes to fisheries management (n=61, with 49 providing reasons), the most common barriers were external constraints such as access to dive sites, money, and time (n=16); confusion about what

"fisheries management" means or aversion to contributing to commercial fisheries (n=11); and dive experience or skill concerns (n=7).

Finding 2: Motivations to Participate

Respondents ranked up to six reasons for participating in SMILE. Scores reflect the weighted sum of motivations ranked as most (3 pts), second-most (2 pts), or third-most (1 pt) motivating.

Nonusers' top three motivations:

1. Contributing to the management of marine ecosystems
2. Participating in science
3. Challenging myself with a new underwater skill

Users' top motivations (retrospective — why they originally participated):

1. Contributing to the management of marine ecosystems
2. Participating in science
3. Challenging myself with a new underwater skill

Users' top motivations (prospective — why they would participate again):

1. Contributing to the management of marine ecosystems
2. Participating in science
3. I enjoy the challenges of capturing as many fish as possible

The consistency of "contributing to management of marine ecosystems" as the primary motivating factor across all three groups and contexts is a notable finding. It aligns with the theory of recreation specialization (McIntyre and Pigram, 1992), which characterizes highly committed recreationists by strong achievement motivation and willingness to engage in data collection for meaningful conservation outcomes (Rosenblatt et al., 2022).

Motivation patterns were broadly consistent across REEF membership status and prior citizen science experience, though REEF members and those with prior citizen science experience showed slightly stronger connections to conservation-oriented motivations in alluvial plot analysis.

Finding 3: Perceived Impact on Fisheries Management, Policy, and Science

Nonusers were asked to rate the expected impact of their participation on fisheries science, policy, and management (5-point scale from "insignificant" to "immense"). The three impact items demonstrated high internal consistency (Cronbach's $\alpha=0.896$). There was a positive,

though weak, correlation between perceived impact and interest in participating (Spearman's $\rho=0.24$, $p<0.001$, $n=413$).

Importantly, belief about impact on fisheries science, but not fisheries management or policy alone, was significantly associated with likelihood to participate ($W=13,477$, $p=0.006$; see Finding 1 table above). This suggests that communicating the scientific value of SMILE data may be more effective for recruitment than emphasizing regulatory or policy applications.

Among users, **63% agreed or strongly agreed** that their participation provided useful data for fisheries science, with an additional 28.3% "somewhat agreeing."

Finding 4: Training Preferences

Nonusers were asked to select up to three preferred training modalities for both camera use and fish identification. All four training topics, camera use (78.1%), data management and upload (69.3%), fish identification (69.1%), and fish survey methodology (69.1%) were selected at comparable rates, indicating that comprehensive training across all topics is desirable.

For *camera training*, nonusers most preferred:

1. Recorded webinar (selected by majority of respondents)
2. Instructional video of camera set-up and use in the field (~60%)
3. Dockside/boat instruction (~37.6%)

For *fish identification training*, nonusers most preferred:

1. Recorded webinar (55.3%, $n=161$ of 291)
2. Written guide available online for download (55.3%, $n=161$ of 291)

Users reported different preferences based on their lived experience with the project. After participating, they indicated the most effective training modalities were:

1. Dockside/boat instruction just before use of the camera (72%)
2. In-person workshop before use of the camera (46%)
3. Recorded webinar (46%)

Finding 5: Challenges Faced by Users

Users were asked to identify challenges encountered during SMILE participation. The top challenges ($n=48$ respondents) were:

Challenge	n	%
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Target species were skittish	19	39.6%
Target species were scared of the laser	16	33.3%
Encountering few target species	10	20.8%
Low visibility	9	18.8%
Camera battery dying	7	14.6%
No challenges encountered	7	14.6%
Habitat made it challenging to capture photos	6	12.5%

Despite these challenges, users demonstrated strong comfort with the technology overall: over 70% reported feeling "comfortable" to "very comfortable" using the camera to photograph fish, and 78% felt "somewhat comfortable" to "very comfortable" setting up the equipment with instructions. Additionally, 58% indicated they were "likely" to "very likely" to upload their data independently in the future.

Finding 6: Willingness to Pay for Equipment

To inform planning for broader SMILE deployment, users were asked about their willingness to purchase the required equipment independently. Results (among those who responded):

- Underwater camera: 43.6% (n=24) of users reported willingness to pay, with an average of \$283. Including the 22% (n=12) who indicated \$0, the average drops to \$184.
- Laser and mount: Users willing to pay reported an average of \$118. Including those indicating \$0 (n=8), the average drops to \$93.

These figures provide a useful baseline for cost-sharing models and subsidy strategies as REEF considers scaling SMILE participation beyond its current base of highly affiliated members and staff.

Conclusions and Recommendations

Summary of Findings

The SMILE social survey reveals a citizen science base with strong conservation values, high recreational specialization, and broadly positive attitudes toward participating in novel data

collection technology. The primary barriers to participation are not attitudinal, they are logistical (access, time, cost) and technological (comfort with equipment). Both are addressable through targeted programming.

Three recommendations emerge from the data:

Recommendation 1: Center outreach messaging on conservation and science impact. The most consistent motivating factor across all respondent groups was "contributing to the management of marine ecosystems," followed closely by "participating in science." Communications recruiting new SMILE participants should connect diving for the project to fisheries stock assessment and management outcomes. Messaging that emphasizes fisheries science impact may be particularly effective given the significant association between perceived scientific impact and likelihood to participate.

Recommendation 2: Develop a two-stage training model. REEF should maintain and expand its recorded webinar library while ensuring dockside or boat-side instruction is standard at organized SMILE events. A written reference guide for fish identification should also be routinely distributed.

Recommendation 3: Address fish behavior challenges through protocol refinement. The top user challenges, skittish target species and species scared by the laser, that are intrinsic to the technology and field environment should encourage exploration of protocol adaptations such as modified approach techniques, or habitat-specific guidance to improve photo capture rates. Framing these challenges as part of the skill development arc ("challenge of capturing as many fish as possible" ranked third among users' future motivations) may also help retain participants.

Discussion Questions for the SEP Panel

The SEP is asked to provide feedback on the following discussion questions:

- What other projects—particularly marine-based citizen science initiatives using innovative, non-app-based technologies—have reported similar findings? While we have perused peer-reviewed and widely available gray literature, we are especially interested in reports or materials that may be difficult to access.
- Has the panel found effective ways to help citizen scientists feel that their data are meaningful and actively informing management decisions?
- What kinds of future social science research should REEF prioritize in relation to this project?
 - Would it be preferable to conduct another user survey in the future, when we will have more citizen scientists who have engaged with the camera?

- In your opinion, is informal user survey data collected internally by REEF (with no IRB approval) valuable?

References

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