Designing the FISHstory Project to Support Fisheries Management

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FEATURE

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An example photo from the FISHstory photo set from a completed fishing trip on the Mako from July 18, 1960. Photo credit: Rusty Hudson and the Hudson, Timmons, and Stone families.

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The U.S. South Atlantic region has many long-standing data needs and limited data collection resources for federally managed marine fish stocks. Much of the harvest is dominated by recreational fisheries, where data are limited, especially during historic time periods. FISHstory, a pilot project developed through the South Atlantic Fishery Management Council's Citizen Science Program, developed a standardized protocol for archiving and analyzing historic photos from the 1940s to 1970s from a for-hire fleet based in Florida. These photos document the beginnings of the South Atlantic for-hire fishery and are potentially an untapped source of data that can help recreate information on catch and length composition prior to when dedicated fishery dependent surveys began. Many careful steps were taken in the design of FISHstory to ensure data collected would be fit for purpose and useful to management. This paper highlights these steps and describes lessons learned through project development.

BACKGROUND

Managers in the U.S. South Atlantic region (North Carolina southward through the Florida Keys) have many longstanding data needs, and there are limited resources for data collection on federally managed marine stocks. Much of the finfish harvest for the species managed in the U.S. South Atlantic region is dominated by recreational fisheries, which differs from many other regions where commercial fisheries comprise more of the harvest (National Marine Fisheries Service 2019). Recreational fisheries are challenging to sample due to the diverse departure points and volume of participants (National Research Council 2006; van der Hammen et al. 2016). Worldwide, limited information is available on recreational fisheries (Venturelli et al. 2017), and this pattern is no different in the U.S. South Atlantic region, especially during historic time periods (SEDAR 2012, 2015). Few recreational fishery-dependent surveys were in existence prior to the 1970s in the U.S. South Atlantic; those that existed were limited in scope and lacked comprehensiveness and continuity. For example, regular monitoring of the recreational headboat fishery began in the 1970s in the U.S. South Atlantic region and monitoring of private and charter fishing began in the early 1980s (SEDAR 2012, 2015), although there is indication that recreational fisheries were already operating in the region (Clark 1962; Moe 1963; U.S. Fish and Wildlife Service and U.S. Census Bureau 1991). Information on overall catch or size composition prior to the initiation of regular monitoring could improve understanding of historical catch and fishery conditions.

The for-hire fishery (i.e., charter and headboats) in the U.S. South Atlantic region is an important part of the recreational sector. For-hire fleets have a longstanding tradition of bringing the day's catch back to the dock and displaying fish on a leaderboard for a commemorative photo. Photos of this nature are not incorporated into current data collection programs and have the potential to provide quantifiable species and length composition data at a point in time when fishery dependent surveys of the for-hire fleet did not exist (McClenachan 2009).

Fishermen in the U.S. South Atlantic region have consistently expressed willingness to aid in data collection to improve management of their fisheries, including supplying photographs that could help fill in data gaps in historic time periods. This type of sentiment led the South Atlantic Fishery Management Council (SAFMC) to develop a Citizen Science Program. The SAFMC is a U.S. regional fishery management council responsible for managing fisheries from 3 to 200 mi offshore in the South Atlantic U.S. (Figure 1). The SAFMC's Citizen Science Program was built over the course of several years with guidance from a wide array of stakeholders and partners (Bonney et al. 2021). The SAFMC recognized the opportunity to recreate historic catch and length compositions from photographs and collaborated with partners to develop FISHstory, one of the first pilot projects underneath the SAFMC's Citizen Science Program.

The FISHstory project developed a standardized protocol for archiving and analyzing historic photos from the 1940s to 1970s from a for-hire fleet based in Florida to document the beginnings of the South Atlantic for-hire fishery and collect data on catch and length composition prior to development of dedicated fishery dependent surveys. FISHstory was designed following program standards and using support resources from the SAFMC Citizen Science Program, which are based on Shirk and Bonney (2015). Following these standards and protocols helped ensure that the data collected through FISHstory would be fit for purpose and useful to management. This paper highlights these steps and describes lessons learned through project development.

PROJECT OVERVIEW AND APPLICATION

The FISHstory project has three primary components: digitizing and archiving historic fishing photos; analyzing historic photos to estimate for-hire catch composition and effort; and developing a method to estimate fish length in historic

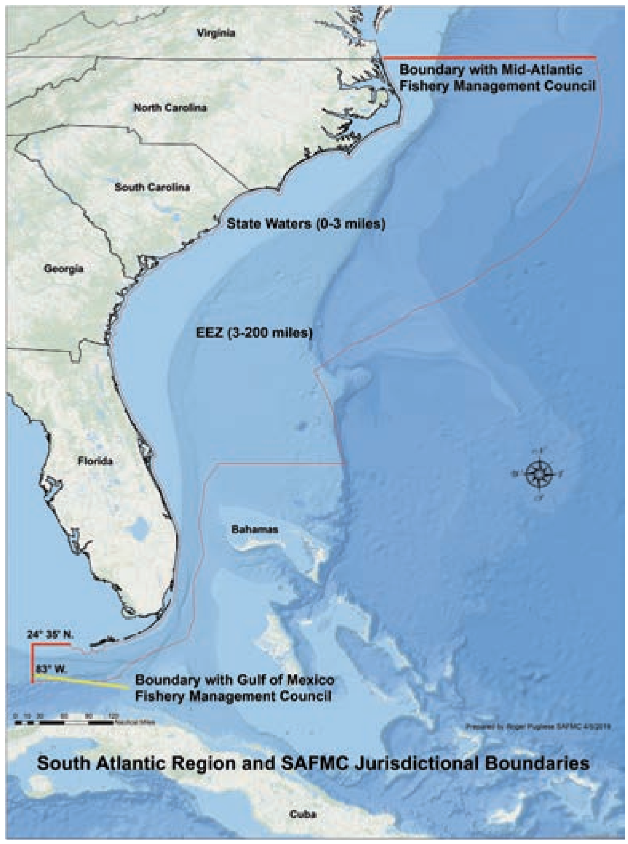

Figure 1. The jurisdictional area of the South Atlantic Fishery Management Council (SAFMC) includes federal waters (3–200 miles offshore) off of North Carolina, South Carolina, Georgia, and the eastern coast of Florida.

Figure 2. **(A)** An example photo from the FISHstory photo set from a completed fishing trip on the *Marianne* on September 2, 1964. **(B)** An example photo from the FISHstory photo set from a completed fishing trip on the *Little Critter* on July 27, 1974. Photo credit: Rusty Hudson and the Hudson, Stone, and Timmons families.

photos. Photos for the FISHstory pilot project were provided and digitized by Captain Rusty Hudson and represent his family's fishing fleet from Daytona Beach, Florida, from the 1940s to 1970s (Figure 2A, 2B). To describe for-hire catch composition and effort, the project is piloting a method to analyze historic photos using crowdsourcing via the Zooniverse platform (https://www.zooniverse.org/; Simpson et al. 2014). The FISHstory project built into Zooniverse trains volunteers to identify and count the fish and people in the photos. Outside of Zooniverse, the project developed a protocol to measure fish length from the historic photos using lumber in the leaderboards as a scale through the open-source software, Image J. Within each photo, three reference measurements on the leaderboard are taken of the scalar (i.e., lumber), followed by individual measurements of the fish species of interest (Figure 3). The protocol developed is being pilot tested on King Mackerel *Scomberomorus cavalla*.

Potential Data Use in Management

To account for the lack of information from recreational fisheries prior to the 1970s, stock assessment scientists often

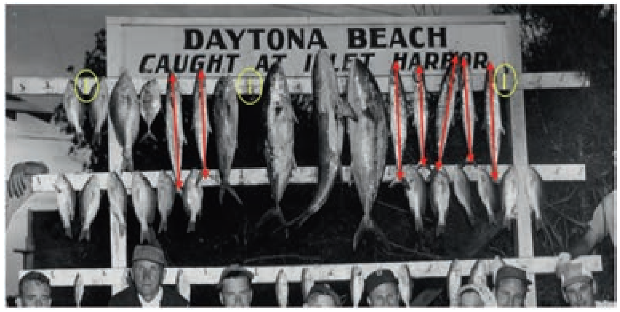

Figure 3. An illustrated example of completed length measurements in a photo from the FISHstory project. Yellow lines represent scalar measurements. Red lines represent King Mackerel measurements. Photo credit: Rusty Hudson and the Hudson, Stone, and Timmons families.

rely on species ratios and catch estimates from other sectors (e.g., commercial fisheries) as proxies to estimate landings; alternately, modern landings trends are regressed back in time to recreate historical landings (SEDAR 2012, 2015). Data collected through the FISHstory pilot project can provide information on two important aspects of fisheries at the start of the Florida for-hire offshore fishery: species composition of landings and length distribution of the landings. The species composition from this historic time period can be compared with landings composition collected through more modern monitoring programs to better understand the relative importance of different species within the fishery and how compositions may have changed over time. Additionally, very limited size composition data are available in the U.S. South Atlantic region from the recreational sector prior to the 1970s. Data collected through the length component of the FISHstory pilot project can provide historical length composition data for King Mackerel, an important recreational species. These data could be used in the South Atlantic King Mackerel stock assessment, which starts in 1900, to help inform or evaluate selectivity during the 1940 to 1970s.

PROJECT DESIGN AND DEVELOPMENT

The SAFMC Citizen Science Program developed best practices to ensure that there is direct application of the data collected through projects for use in management or stock assessments. To ensure that projects fill data gaps and address research needs, the SAFMC identifies citizen science specific research priorities, which are updated every 2 years with input from stakeholders. The priorities help narrow the focus from the many data needs in the U.S. South Atlantic region to tangible ideas that are most important to fishery managers and stakeholders. The FISHstory project addresses one of these research needs—using historic photos to improve recreational catch and size composition information (SAFMC 2021).

Projects supported by the Citizen Science Program are encouraged to form a design team of diverse stakeholders (e.g., fishermen, scientists, managers) who provide guidance throughout the design and development of a project. The FISHstory project used this approach bringing together fisheries scientists, fish identification experts, a fisherman, and an outreach specialist to form a design team. Additionally, the FISHstory team consulted with SAFMC scientific advisors and stock assessment scientists to help ensure that the methods developed would allow the data collected to be useful for management.

For-Hire Catch Component

The for-hire catch component of FISHstory is intended to describe species composition of the landed catch. Fish identification for many species can be challenging, especially in historic photos that lack detail and are often black and white. During the development of the project in Zooniverse, input was incorporated from the FISHstory design team, Zooniverse staff, and Zooniverse beta test volunteers to refine data collection protocols, improve volunteer training resources, and provide mechanisms for data quality review. Listening to this feedback and adapting the project during the design stage proved critical and helped improve the data collected through the project, as noted through the examples below.

One of the first steps for building the FISHstory project in Zooniverse was identifying the level of data collection needed to develop species compositions and the level of identification that would be feasible for the volunteers to complete successfully. The design team suspected that the quality of the photos would prevent volunteers from identifying all fish to species. The photos included over 50 species, many of which look similar; therefore, the design team recommended a tiered data collection system within Zooniverse based on whether the species was managed by the SAFMC and the relative occurrence of a species in a subset of photographs. Data collection first focused on SAFMC managed species that were most common in the photos using a mark species tool in Zooniverse where volunteers would individually mark the species of interest. Species that were less likely to occur based on Captain Hudson's recall, but still of interest, were counted using a survey tool where volunteers would report binned counts. Species that were likely rarely landed were grouped into an "other" category within the survey tool. Additionally, species groups were modified to aggregate some of the more difficult species' identifications. The final FISHstory species/species groups are summarized in Table 1.

During project development, feedback from both Zooniverse staff and beta test volunteers emphasized the need to simplify the data collection process, which essentially had three parts: counting people, counting fish, and fish identification. Some volunteers noted that they enjoyed looking at the historic photos but became frustrated when trying to identify all the species within a photo. This led the design team to break the data collection into two workflows—one for volunteers who wanted to participate in the project but were not yet comfortable trying species identifications (FISH and PEOPLE: Count) and one for volunteers who knew or wanted to learn fish identification techniques (FISH: Classify). In the FISH and PEOPLE: Count workflow, volunteers used a marking tool to count the total number of fish and the total number of people in the photos. In the FISH: Classify workflow, volunteers identified and counted the fish within the photo to species or species group. By breaking up the data collection into two pieces, the design team felt it would improve data quality while also preventing volunteer frustration. The team also anticipated that the easier workflow would build volunteer interest and recruit participants for the more difficult workflow.

A variety of training tools developed in the Zooniverse project's field guide included practice photos from the project where users could test their identification skills, numerous example photos that were extracted from photos in the project, and illustrations that had species identification tips. Additional feedback from the beta test recommended an external field guide that could be referenced while volunteers were classifying photographs. Zooniverse talk boards provided another training opportunity. Staff monitored these boards not only to provide support and answer questions, but also to recognize which species volunteers had difficulty identifying. When multiple volunteers had difficulties with the same species, team members would distribute a talk board post and monthly newsletter with identification tips targeted toward the species in question.

The FISHstory design team also addressed data quality by incorporating two levels of data review into the Zooniverse project. The first was by having multiple volunteers classify each photo, using the power of the crowd to narrow down a central tendency alleviating concerns about misidentification or errant counts by an individual volunteer. Ten replicates per photo were used for the simpler FISH and PEOPLE: Count workflow, while the more challenging FISH: Classify workflow used 20 replicates per photo. The second level of review was done by a validation team of fish identification experts who examine photos with substantial volunteer disagreement based on visual examination of frequency plots for each photo. Validation team members were recruited from SAFMC fishermen advisory panels as well as state and federal fishery agency partners. A separate project was built in Zooniverse that was only accessible by validation team members. This project mimics the public project, allowing validation team members to classify photos identically to the FISHstory volunteers. Each photo triggered for validation team examination was reviewed by at least two team members independently.

Length Component

The primary focus for the length component of FISHstory was to develop a protocol to measure fish size in the historic photos to create a length distribution. Key steps taken throughout the protocol development highlighted the importance of testing and training, including verification of items of known length to gauge precision and accuracy as well as training and comparison of length analysts to ensure all readers were measuring consistently.

To initially test the length protocol developed and gauge precision and accuracy, wooden boards of known length (n = 49) were measured using 2 × 3 lumber as a scalar (which served as a proxy for the 2 × 4 and 2 × 6 lumber in the historic photos). The boards and scalars were set up like the fish display leaderboards in the historic photos and photos were taken. Using the photos, two readers measured the boards and scalars independently, recording the board name and the number of pixels for each measurement using the line measurement tool in Image J. Based on the number of pixels per inch estimated from the scalar, estimates of board length were developed for each board by reader. Length estimates between readers were compared and significant differences were not found between the distributions (Kolmogorov–Smirnov $P = 0.997$) or central tendencies (Wilcoxon rank sum $P = 0.056$), indicating that the estimates were within acceptable limits ($P > 0.05$; Table 2). The known board lengths were converted to the nearest inch measurement, based on the 2-inch size bins used in the most recent South Atlantic King Mackerel stock assessment (SEDAR 2020). Ninety-six percent of the readers' measurements were within 2 inches of the known board measurements, demonstrating that the protocol developed could produce measurements precise and accurate enough for use in assessment.

Table 1. Species or species groupings with their corresponding data collection tool in the FISH: Classify workflow in the FISHstory project in Zooniverse. Grouper species with an asterisk could be identified to species with an optional secondary mark tool. Species in the "other" group were very uncommon in the FISHstory photographs.

Species or species group	Species included	Workflow tool
Amberjack group	Greater Amberjack *Seriola dumerili*, Lesser Amberjack *S. fasciata*, Almaco Jack *S. rivoliana*	Mark species
Grouper, all	Gag* *Mycteroperca microlepis*, Atlantic Goliath Grouper *Epinephelus itajara*, Red Grouper* *E. morio*, Scamp *M. phenax*/Yellowmouth Grouper* *M. interstitialis*, Snowy Grouper *Hyporthodus niveatus*, Speckled Hind *E. drummondhayi*, Warsaw Grouper *H. nigritus*	Mark species
King Mackerel	King Mackerel *Scomberomorus cavalla*	Mark species
Red Snapper	Red Snapper *Lutjanus campechanus*	Mark species
Black Sea Bass	Black Sea Bass *Centropristis striata*	Survey
Cobia	Cobia *Rachycentron canadum*	Survey
Dolphinfish/Mahi Mahi	Dolphinfish *Coryphaena hippurus*	Survey
Flounder	Gulf Flounder *Paralichthys albigutta*, Southern Flounder *P. lethostigma*, Summer Flounder *P. dentatus*	Survey
Gray Triggerfish	Gray Triggerfish *Balistes capriscus*	Survey
Jack, other	Banded Rudderfish *Seriola zonata*, Crevalle Jack *Caranx hippos*	Survey
Little Tunny	Little Tunny *Euthynnus alletteratus*	Survey
Porgy/Grunt	Knobbed Porgy *Calamus nodosus*, Jolthead Porgy *C. bajonado*, Red Porgy *Pagrus pagrus*, Whitebone Porgy *C. leucosteus*, White Grunt *Haemulon plumierii*	Survey
Snapper, other	Gray Snapper *Lutjanus griseus*, Vermilion Snapper *Rhomboplites aurorubens*, Yellowtail Snapper *Ocyurus chrysurus*	Survey
Hammerhead Shark	Great Hammerhead *Sphyrna mokarran*, Scalloped Hammerhead *S. lewini*	Survey
Shark, other	Atlantic Sharpnose Shark *Rhizoprionodon terraenovae*, Blacktip Shark *Carcharhinus limbatus*, Dusky Shark *C. obscurus*, Nurse Shark *Ginglymostoma cirratum*, Sandbar Shark *C. plumbeus*, Silky Shark *C. falciformis*, Spinner Shark *C. brevipinna*, Tiger Shark *Galeocerdo cuvier*, Common Thresher Shark *Alopias vulpinus*	Survey
Other	African Pompano *Alectis ciliaris*, Great Barracuda *Sphyraena barracuda*, Black Drum *Pogonias cromis*, eels (Muraenidae), Ocean Sunfish *Mola Mola*, Octopus (Octopoda), Red Drum *Sciaenops ocellatus*, Remora *Remora remora*, Sailfish *Istiophorus platypterus*, Sheepshead *Archosargus probatocephalus*, Caribbean spiny lobster *Panulirus argus*, stingrays (Dasyatidae), Tarpon *Megalops atlanticus*, toadfishes (Batrachoididae), Atlantic Tripletail *Lobotes surinamensis*, Wahoo *Acanthocybium solandri*	Survey

Table 2. Comparison of length estimates (scalar = 2 × 3 board) for the two primary readers using two different statistical tests: Kolmogorov–Smirnov and Wilcoxon rank sum tests.

Test	Sample size	Statistic	*P*-value
Kolmogorov–Smirnov	$n = 49$	0.833	0.997
Wilcoxon rank sum (paired)	$n = 49$	88	0.056

The length analysis was then operationalized using five length analysts with fish identification expertise to measure King Mackerel in the FISHstory photos. Prior to measuring, all analysts completed a virtual training session to learn the measuring and reporting process. Additionally, a standard comparison set of randomly selected photographs were completed by each analyst prior to reviewing the data set for practice and to determine if different readers had bias. When analyzing a photo, readers selected which fish were King Mackerel and which King Mackerel could be measured (e.g., were not obstructed). The total number of lengths measured was compared among readers to check if there were potential misidentifications, and additional training was provided as needed. Both statistical (Anderson–Darling goodness of fit) and visual tests were used to compare analysts' measurements from the training set. Significant differences were not observed among four of the five readers (Table 3; Figure 4). Based on variation being observed between analysts and not knowing the true length, it was determined that each photograph should be analyzed by at least two analysts and the potential catch distribution would be developed through a resampling approach to capture the variation in analyst estimation for length. Although this increased the workload, the protocol could be adapted to a platform such as Zooniverse in the future to provide a high number of analysts as well as have a high number of reviewers for each photograph.

LESSONS LEARNED

(1) *Investing time in well thought out preparation can give a project the best chance of success*. Following the SAFMC Citizen Science Program's standards and support resources helped our team think through the key aspects

Table 3. P-values for the Anderson–Darling goodness of fit tests used to compare length estimates from the standard comparison set of historic photos by the different analysts. Bold text indicates significant differences between analysts.

	Analyst 1	Analyst 2	Analyst 3	Analyst 4	Analyst 5
Analyst 1	NA	0.547	**0.0240**	0.119	0.9950
Analyst 2	NA	NA	**0.0173**	0.053	0.7945
Analyst 3	NA	NA	NA	0.467	**0.0310**
Analyst 4	NA	NA	NA	NA	0.0956
Analyst 5	NA	NA	NA	NA	NA

of developing a citizen science project from making sure FISHstory focused on a specific research need to developing and testing protocols with data quality and volunteer success in mind to developing a communication plan with volunteer recruitment and engagement strategies.

(2) *Involve a team with diverse expertise in project development*. Having the design team, a multidisciplinary stakeholder group, guiding the project development greatly benefited the FISHstory project. Fishermen and other stakeholders' input helped to ensure that data collection methods are feasible. Scientific input was critical to ensure that the project is designed so that data collected can meet its intended use. Additionally, relationships developed through the FISHstory design team extended into support for other aspects of the project, as design team members with fish identification expertise served on the validation team and members helped identify analysts for the length component of the project.

(3) *Listen and incorporate feedback from experts*. Both Zooniverse staff and beta test volunteers recommended simplification of the data collection in FISHstory. As a result, data collection was divided into two workflows and the species groupings in the FISH: Classify workflow were narrowed down to 16 categories of interest. This helped with data collection by limiting which species volunteers would need to identify, building multitiered data collection so the most common species of interest were classified first, and providing opportunities for volunteers to participate with varying levels of fish identification knowledge. Not only did these changes help improve data quality, but the easier FISH and PEOPLE: Count workflow served as a recruitment tool, getting volunteers interested in the project enough to transition into the more challenging FISH: Classify workflow.

(4) *Training was a key component in multiple facets of the FISHstory project*. Volunteers needed to be trained to identify and count fish and people in the historic photos, validation team members needed to be trained to review photos within Zooniverse, and length analysts needed to be trained to measure fish within the photos. Developing easy-to-use training materials and holding live training sessions, as appropriate, are critical to ensuring that your volunteers and team members have the resources they need to be successful. We also found that it was helpful to provide refresher training when there were stretches of time in between data collection activities for validation team members and length analysts to help ensure consistency.

(5) *Include data end-users in project design*. Collaborating with scientists early on, especially those likely to be involved in the evaluation and application of project outcomes, can increase buy-in from the scientific community, help ensure the project is designed so that data can meet their intended use, and help identify barriers so that the project can overcome future challenges. Consulting with SAFMC scientific advisors and stock assessment scientists during the FISHstory project helped improve the protocols developed and provided insights to consider, as we hope to expand the project moving forward.

(6) *There are costs associated with citizen science projects*. A common misconception is that citizen science projects require limited funding since data collection is done with volunteers. Although volunteers are used to collect data, the projects require individuals with experience in project design, volunteer training and engagement, and data management, quality control, and analysis (Bonney et al. 2009). Even if designed well, citizen science projects often require a team to nurture them and keep volunteers engaged. Through our experience with FISHstory, having a dedicated project coordinator who could not only oversee daily activities, but could also lead coordination efforts between team members working on different aspects of the project has proved critical.

(7) *Leverage learning from other citizen science projects*. Other citizen science organizations across the world have developed data collection platforms and support resources. Using these resources is extremely beneficial for a new project. Working with a partner like Zooniverse, was invaluable to the FISHstory project. Our original reason for using Zooniverse was the free platform it provided to build and host a crowdsourced project. However, the most beneficial part of working with Zooniverse was the guidance provided during project development and beta testing, easy ways to communicate with volunteers via talk boards and online newsletters, and an immediate connection to a community of potential volunteers. We knew that FISHstory would be a challenging project and were concerned that this would limit participation. How-

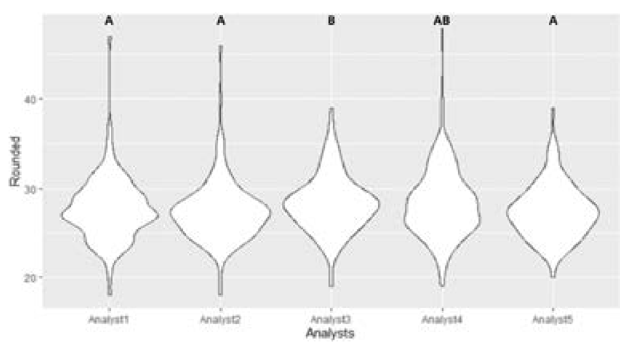

Figure 4. Violin density plots for the length estimates completed by the length analysts for the FISHstory training data set. Letters indicate differences among analysts.

ever, since launching in May 2020, our project has had 2,175 volunteers participate in the project making 35,617 individual classifications (e.g. identifications and counts), which greatly exceeded our expectations.

NEXT STEPS

Data analysis for the FISHstory pilot project is underway now. Findings from these analyses will help us evaluate the protocols and techniques developed during this pilot and improve the project moving forward. In the future, the Citizen Science Program hopes to expand the temporal and geographic scope of the FISHstory project, as well as apply the length protocol to additional species in the existing photo set and pilot the incorporation of the length methodology into the Zooniverse platform. While the initial geographic scope of the FISHstory pilot project is small, the image analysis methods have a high likelihood of scalability and transferability to multiple agency partners or other regions. If successful, the protocols and techniques developed through this pilot project could be applied to photos from other locations throughout the region.

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