Fisheries science to 'SMILE' (Size Matters: Innovative Length Estimates) about: using camera-equipped citizen scientists to estimate fish lengths *in situ*

La ciencia pesquera utilizará "SMILE" (Size Matters: Innovative Length Estimates) para estimar la longitud de los peces in situ mediante el uso de científicos ciudadanos equipados con cámaras.

La science halieutique « SMILE » (Size Matters : Innovative Length Estimates) porte sur : l'utilisation de scientifiques citoyens équipés de caméras pour estimer la longueur des poissons in situ

JENNIFER LOCH[1], ALLISON CANDELMO[1], BRICE SEMMENS[2], SCOTT HEPPELL[3], DYLAN HEPPELL[1,4], JULIA BYRD[5], CHIP COLLIER[5], CHRISTY PATTENGILL-SEMMENS[1], CHRISTOPHER L. CRUTCHFIELD[6], NATHAN HUI[7], RYAN KASTNER[7], JENNIFER DORTON[8], KYLE HU[7], LYALL BELLQUIST[2], AVIK GHOSH[7], AND CURT SCHURGERS[7]

[1] *Reef Environmental Education Foundation, 98300 Overseas Hwy, Key Largo, FL 33037; jen.loch@reef.org*

[2] *Scripps Institution of Oceanography, 9500 Gilman Drive La Jolla CA, 92093-0202 University of California San Diego;*

[3] *Department of Fisheries and Wildlife Oregon State University 104 Nash Hall, Corvallis, OR 97331;*

[4] *College of Earth, Ocean and Atmospheric Sciences, Oregon State University Corvallis, OR 97331;*

[5] *South Atlantic Fishery Management Council 4055 Faber Place, Suite 201 North Charleston, SC 29405;*

[6] *Department of Electrical and Computer Engineering University of California San Diego 9500 Gilman Drive La Jolla, CA 92093;*

[7] *Department of Computer Science and Engineering, UC San Diego 9500 Gilman Drive La Jolla, CA 92093 University of California San Diego*

[8] *Southeast Coastal Ocean Observing Regional Association PO Box 13856 Charleston, SC 29422*

,

EXTENDED ABSTRACT

As global fisheries experience intense pressure, there is a need to further modernize fisheries sampling methods that are non-extractive and non-destructive, yet comprehensive, cost effective, and accurate to optimize management. Biological data, such as length frequency estimates, improve fisheries stock assessments, however, many managed species are considered data-limited. Traditionally, collecting fish length data requires handling or harvesting the fish, which can impact local fish populations and require significant investments, which are often resource limited. Additionally, harvested fishes frequently represent a limited distribution of sizes and species due to harvest restrictions. To help fill this gap, non-traditional data sources, like citizen science programs, can supplement data collection through marine monitoring programs. Recreational divers are a particularly underutilized source of data, yet frequent the marine environment, providing a cost-effective data stream. For example, Reef Environmental Education Foundation's (REEF) Volunteer Fish Survey Project utilizes trained citizen scientist recreational divers to assess fish populations on dives around the world. The collaborative SMILE (Size Matters: Innovative Lengths Estimates) project expands upon REEF's long-term fish population dataset to supply length data sources into stock and ecosystem assessment processes using single laser-mounted cameras ("FishSenseLite"). In collaboration with South Atlantic Fisheries Management Council (SAFMC), University of California San Diego and Scripps Institute of Oceanography, Southeast Coastal Ocean Observing Regional Association (SECOORA), and Axiom Data Science, SMILE equips recreational scuba divers or citizen scientists with a low-cost camera system to capture images of select target species of management priority through roving diver surveys.

The FishSenseLite camera consists of an Olympus TG6 point-and-shoot camera enclosed in manufacturer underwater housing with a laser mounted in the cold shoe, along with a detachable wide-angle lens to reduce image distortion. Fish lengths are extracted from the images via an AI workflow using depth of field technology to calculate the distance the subject fish is from the camera (i.e. laser position) and quantifying pixelation of the fish from the associated raw image file. Here, we perform validation of this novel system through multiple approaches, including known size objects and paired surveys with a roving stereo-video system on tropical coral reefs of the upper Florida Keys. Data collection is focused on 11 economically and ecologically important, federally managed data-limited species: Hogfish (*Lachnolaimus maximus*), Black Grouper (*Mycteroperca bonaci*), Goliath Grouper (*Epinephelus itajara*), Nassau Grouper (*Epinephalus striatus)*, Red Grouper (*Epinephelus morio*), and Mutton Snapper (*Lutjanus analis*). In addition, ecological indicator species are monitored: Blue Parrotfish (*Scarus coeruleus*), Midnight Parrotfish (*Scarus coelestinus*), Rainbow Parrotfish (*Scarus guacamaia*), and Stoplight Parrotfish (*Sparisoma viride*). Since citizen scientists are a vital component to the success of the project, we also assess their user experience with the cameras through online surveys.

Thus far, the project has collected length data on thousands of individuals of 11 target species by 37 different volunteers over 230 dives between August 2023 and October 2024. Preliminary data demonstrate that length of both natural fish (Kruskal-Wallis chi-squared = 94, df = 94, p-value = 0.481, n=66) and known-size objects (Kruskal-Wallis chi-squared = 4.435, df = 3, p-value = 0.218) were comparable between existing stereo-video and the novel FishSense camera methods.

Length frequency distributions are also comparable across species (Kruskal Wallis chi-squared = 94, df = 94 p=0.481) and sites (Kruskal-Wallis chi-squared = 16, df = 16, p-value = 0.479). While stereo-video skews marginally larger in length estimation relative to the FishSense cameras, these differences are not statistically distinguishable. Further exploration of the data will examine potential influence of species, thus body morphology, on length estimations. The project encountered a few challenges, namely related to the robustness of the lasers, which is being addressed through development of a rechargeable and more robust laser, which will also allow for dual and single laser options, along with a stronger mount product made from aluminum in lieu of the plastic material currently in use.

Divers that have participated in the project thus far have reported 100% satisfaction with the camera system, with two-thirds of them in agreeance that the project can easily be implemented into the existing REEF Volunteer Fish Survey Project, while the remaining third of respondents were neutral. A formal survey has been developed and currently undergoing pilot testing with social scientist partners to assess participant motivation and barriers, and gauge interest and likely demographics for participation in an effort to inform management agencies of the utility of similar citizen science projects to provide data for future fisheries assessments. The project is also engaging with citizen scientists to participate in data processing through identification of the laser and fish species in the imagery to train the AI datasets for improved efficiency.

Preliminary testing of the novel FishSenseLite camera system for the SMILE project demonstrates sufficient accuracy and precision in capturing length data of data-limited fish species with a cost-effective technology and public engagement. These data will supplement fisheries assessments for data-limited species that are particularly deficient in length distributions across the region to ultimately advance conservation and management of these iconic species. Lastly, this project encourages public engagement within both fisheries science and management to contribute data to agencies charged with assessing these species.

KEYWORDS: Fisheries Science, SMILE, Innovative Length Estimates, camera-equipped citizen scientists, fish lengths. in situ
.