Fisheries Science with a SMILE
Size Matters: Innovative Length Estimates

NOAA CORAL REEF CONSERVATION PROGRAM

South Atlantic Fishery Management Council — Citizen Science

REEF

Fish & Wildlife Foundation of Florida

Axiom Data Science

SCRIPPS INSTITUTION OF OCEANOGRAPHY

UC San Diego

ENGINEERS FOR EXPLORATION

SECOORA SOUTHEAST COASTAL OCEAN OBSERVING REGIONAL ASSOCIATION

Overview

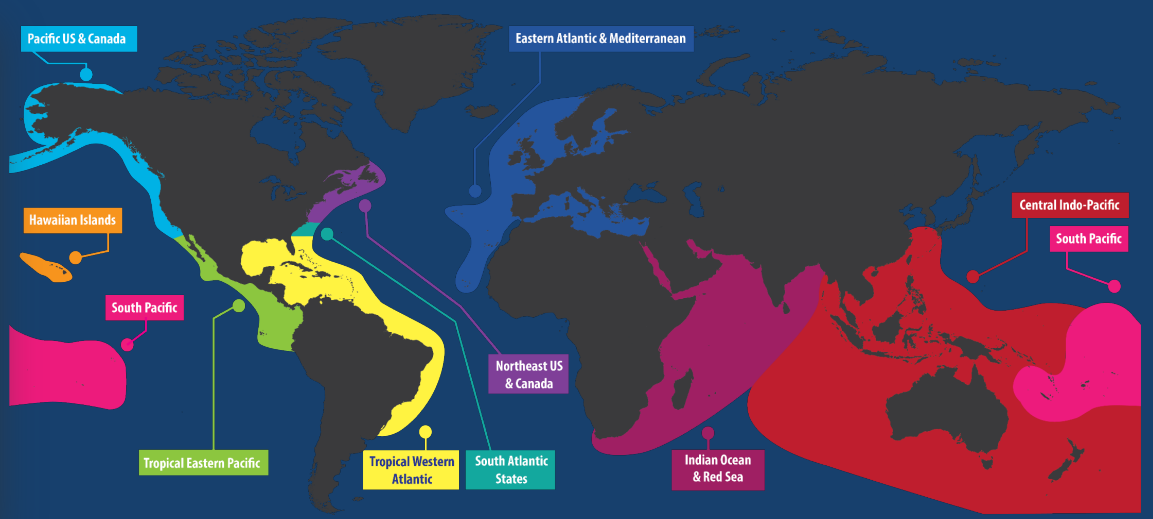
REEF Introduction

SMILE Project

Discussion

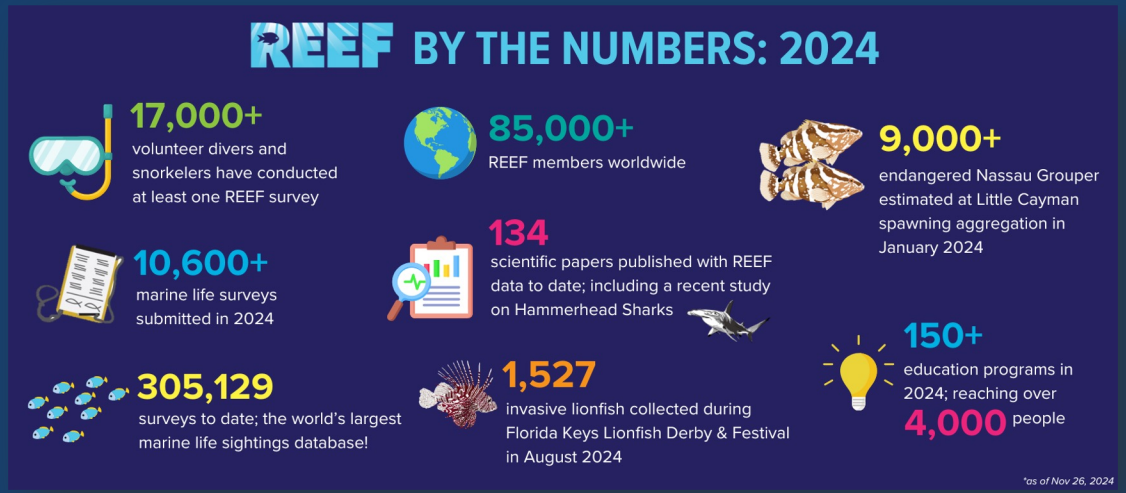
Reef Environmental Education Foundation

- International conservation organization that organizes and manages the largest marine life sightings database
- Recreational divers underutilized source of data collection
  - Valuable to fill data gaps in fisheries



REEF Volunteer Fish Survey Project

- Roving diver surveys assess relative abundance and diversity
- Divers trained in fish ID record all fish through the duration of their dive
- Database reports novice and expert surveys



REEF Data

- Relative abundance and diversity of all fishes reported
- Density – measure of how many individuals reported on a scale of 1-4 (single -> abundant)

$$= \frac{(nS*1)+(NF*2)+(nM*3)+(nA*4)}{\text{Total \# of Surveys}_{species}}$$

- Sighting Frequency – measure of how often species is observed

$$= \frac{\text{\# surveys report}_{species}}{\text{Total \# of Surveys}}$$

- Abundance score – metric of sighting frequency and density
- Reports identify novice through expert surveyors; dive metadata

REEF Data

- Tracks reef fish populations similar to NOAA
  - Variation among taxonomic groups (e.g. cryptic spp.)
  - Highest agreement with large-bodied, solitary spp

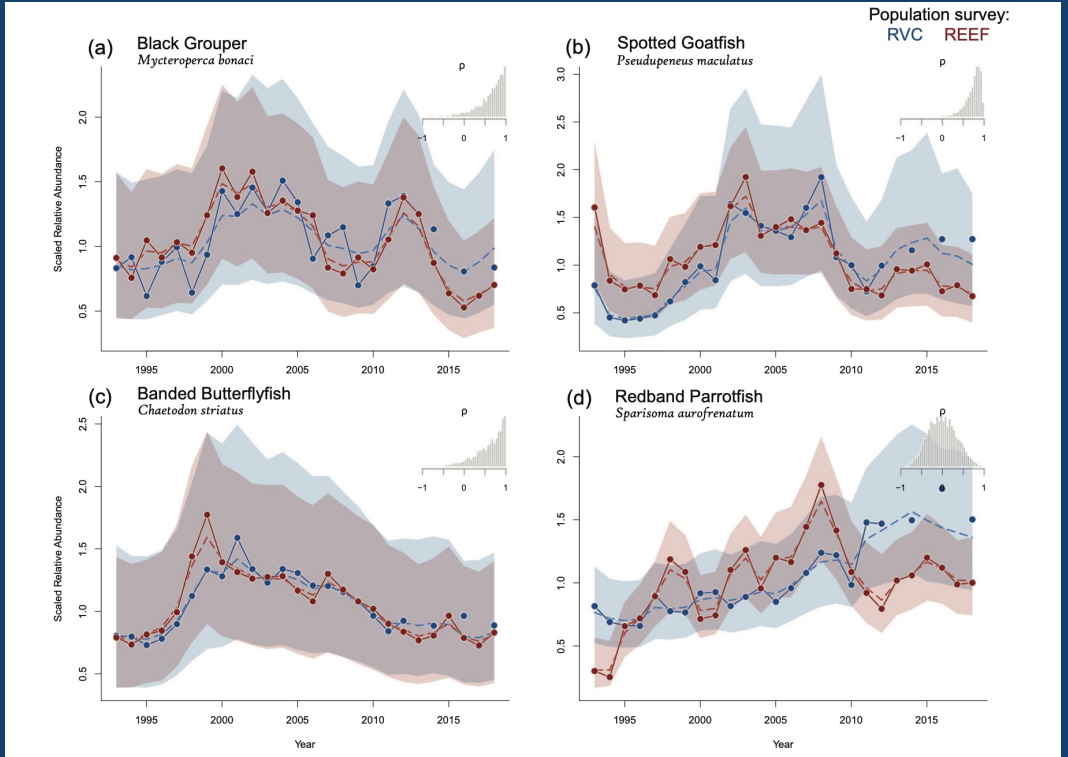


FIGURE 2 Examples of species' relative abundance time-series estimated from structured RVC surveys (in blue) and opportunistic REEF citizen scientist surveys (in red). Solid lines and points represent median estimates of the annual expected abundance (α_t) with both process and measurement deviance, while dashed lines indicate the model-estimated estimated population state (x_t) with only process deviance. Shaded areas represent 90% Bayesian credible intervals for the latent population states. Time-series plots for all species comparisons are available in the Appendix.

Greenberg et al. 2024, *Cons. Lett.*

SAFMC Citizen Science Research Priorities & Project Selection

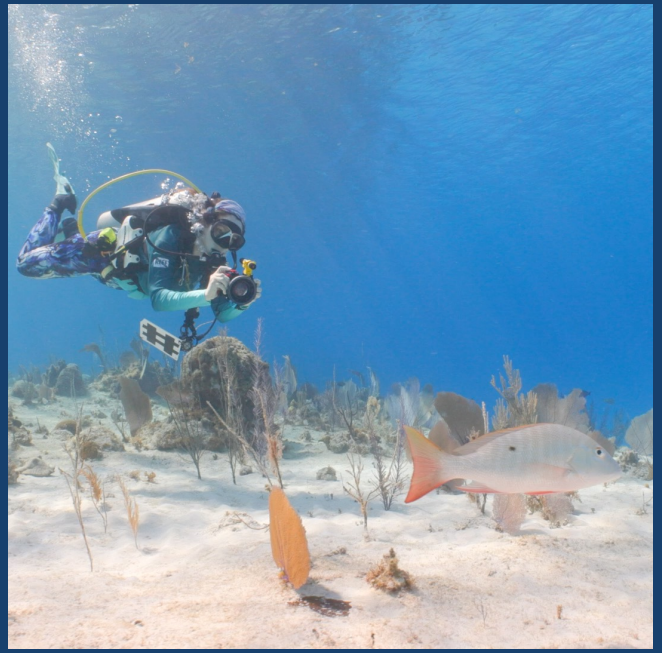
- Meets a CitSci research priority
- Helps address a data gap or deficiency
- Works well with a citizen science approach
- Resources available to support
- Formation of diverse design team
- Clearly identifies how data could be used for assessment or management

Citizen Science

Topic	Data Needed	Potential Outcome
Age Sampling	Otolith & fin clip (future) collection	Characterize the age of catches
Discard Information	Length, depth, quantity, discard reason, devices used, terminal gear, disposition	Characterize the size of discards, Improved discard removal estimates
Genetic Sampling	Fin clips	Stock identification, Species ID, Ageing (still developing)
Fishing Infrastructure	GPS location and details of fishing-related infrastructure	Baseline for fishing-related infrastructure, help better define communities for social analysis
Historical Fishing Photos	Digitized images	Species and length compositions, improved historical information
Fishery Oral Histories & Historic Logbooks	Fishermen interviews, digitized logbooks	Improved understanding of changes in fishery over time
Oceanographic & Environmental Conditions	Various environmental data including bottom temperature and weather	Database of climate and changing conditions, fishery patterns
Shifting, Rare or Data Limited Species Observations	Point observations of data limited or rarely encountered species; length info for data limited species	Baseline for species shift, increased information for data limited species
Observations in Managed Areas	Species, length, depth, videos, photos, effort, edge effects	Species composition, occurrence of spawning, info on compliance
Movement & Migration	Species, location, length, tag details, supporting existing tagging programs	Movement and migratory patterns
Shark & Mammal Depredation	Observations of depredation, location, species, photo, DNA swab	Document depredation observations
Habitat Characterization	Photos, videos - focused on EFH	Ground truth bathymetry data

SMILE – Size Matters: Innovative Length Estimates

- Professional length estimation methods can be size and species restricted; resource limited
- SMILE collects fish length measurements with an *in-situ* tool used by citizen scientists
- **Goal:**
  - Complement existing REEF fish surveys
  - Improve future stock assessments for data-limited species, and inform management & conservation efforts



“Fish Sense Lite” (FSL) Camera

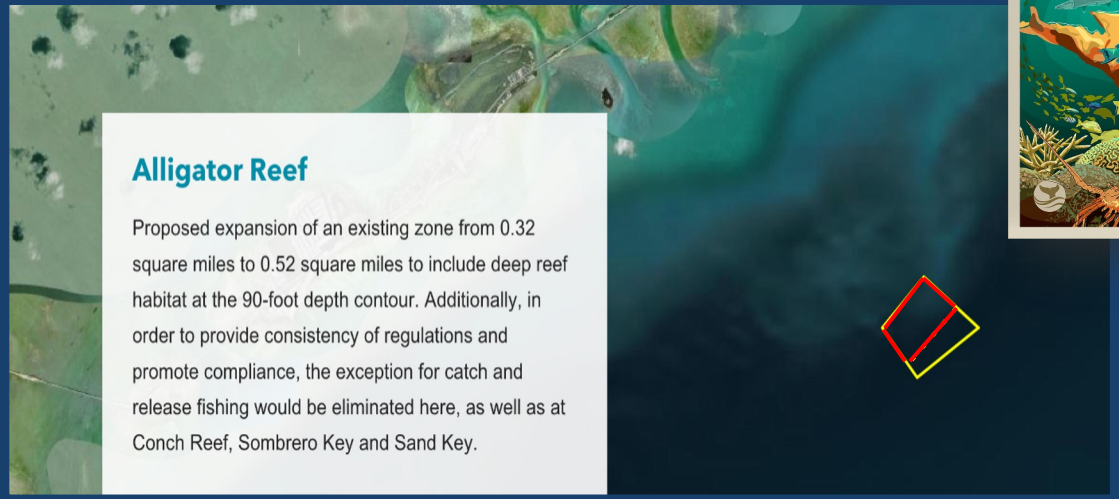
Laser-Mounted Olympus TG6 Cameras

Methods – Data Collection

- Location: Florida Keys
- FSL camera used by citizen scientist divers to collect images with laser on lateral side of 11 target spp.
- Stereovideo camera used by staff to compare with FSL cameras
  - Paired Dives (i.e. same fish, both systems)
  - Roving
  - 30m Belt Transects

Collaboration

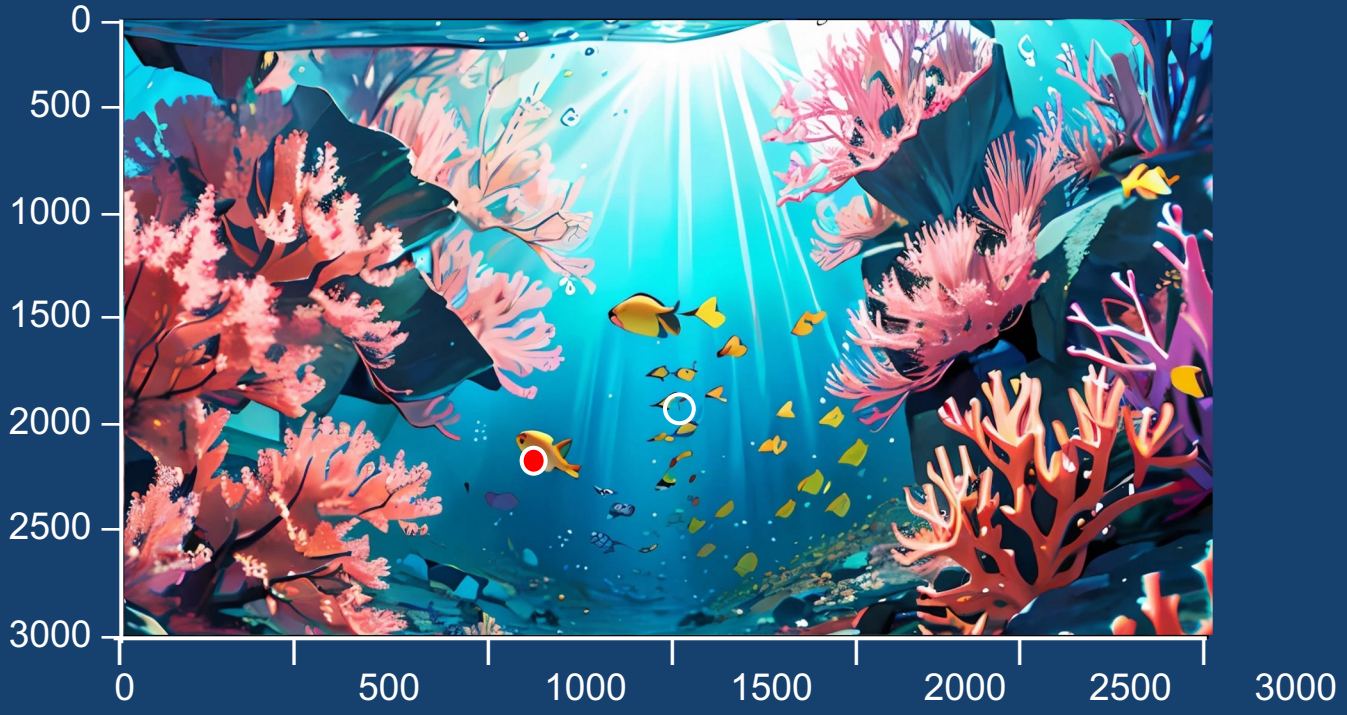
Stakeholder panel advises on methods (e.g., site, species selections) and end data usage



Methods – Target Species

Methods – FSL Data Processing

Single-laser method relies on depth-of-field, AI workflow to I.D. head/tail, and raw image file to compute fish length



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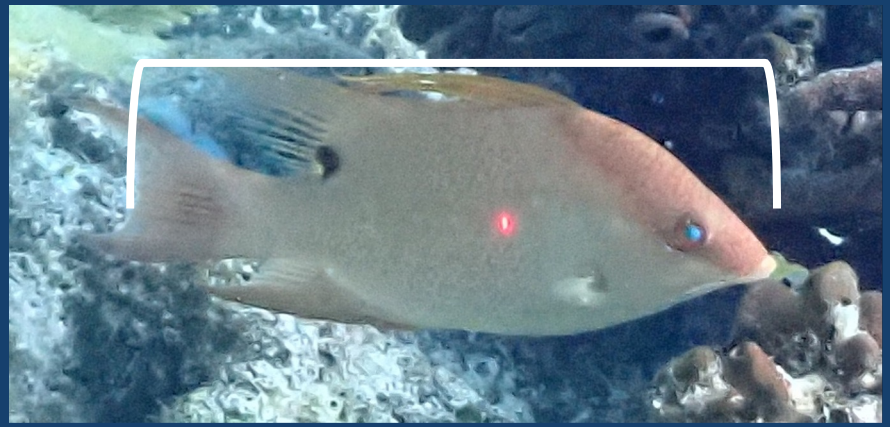
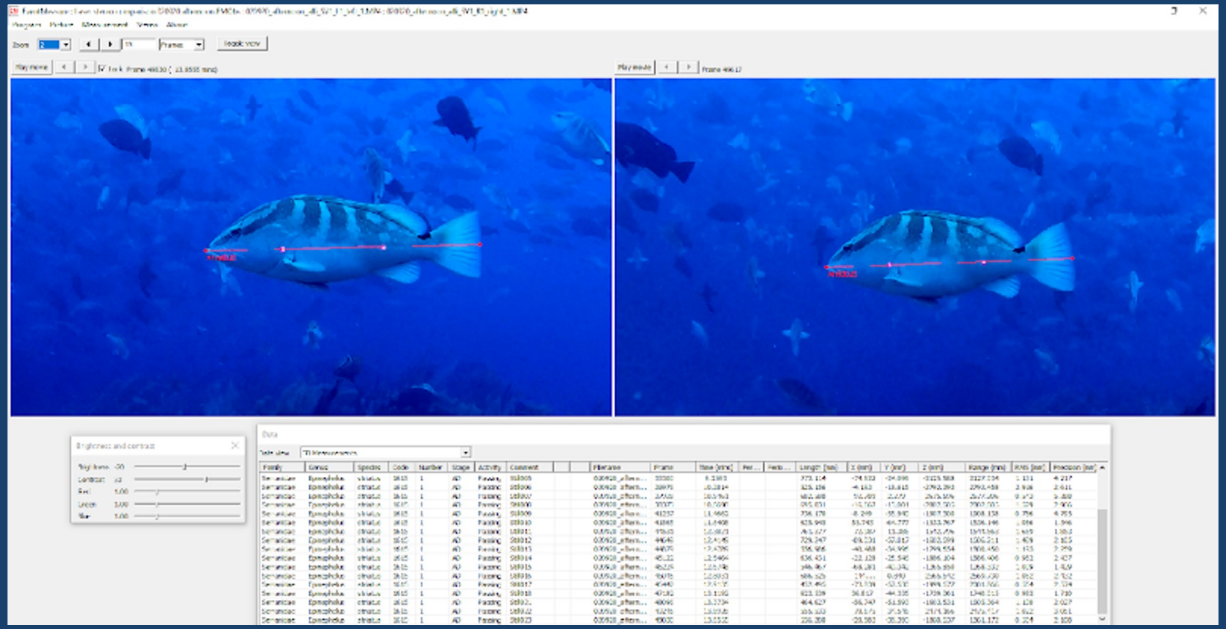


Methods – Stereovideo Data Processing

SeaGIS Event Measure Software

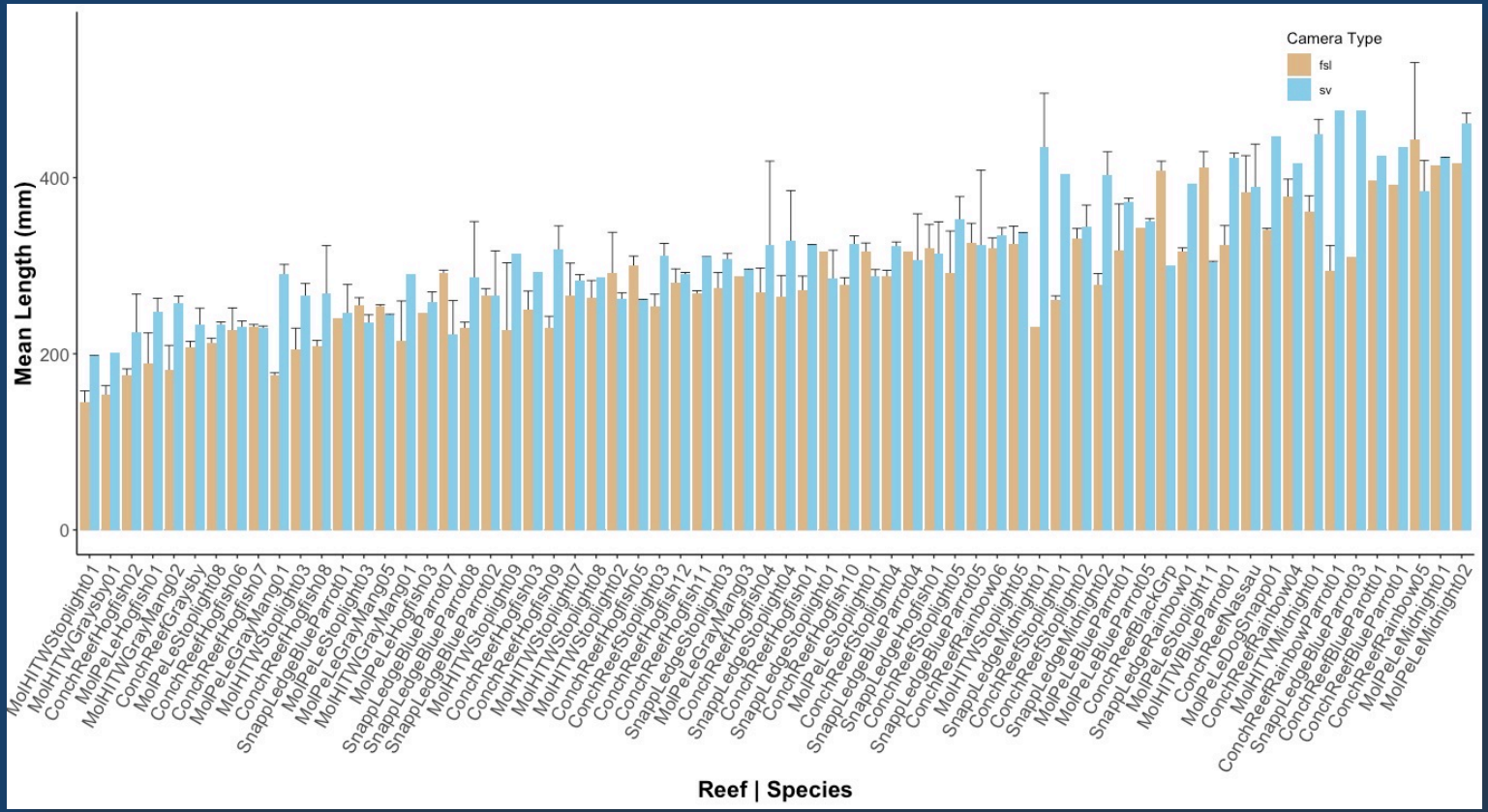


Metadata Availability

- Length (mm, FL)
- Date/Time
- Location (Site Name; Lat/Long)
- GPS tracks
- Bottom Time
- Camera number
- Dive Conditions (temperature, depth, visibility, diver name)

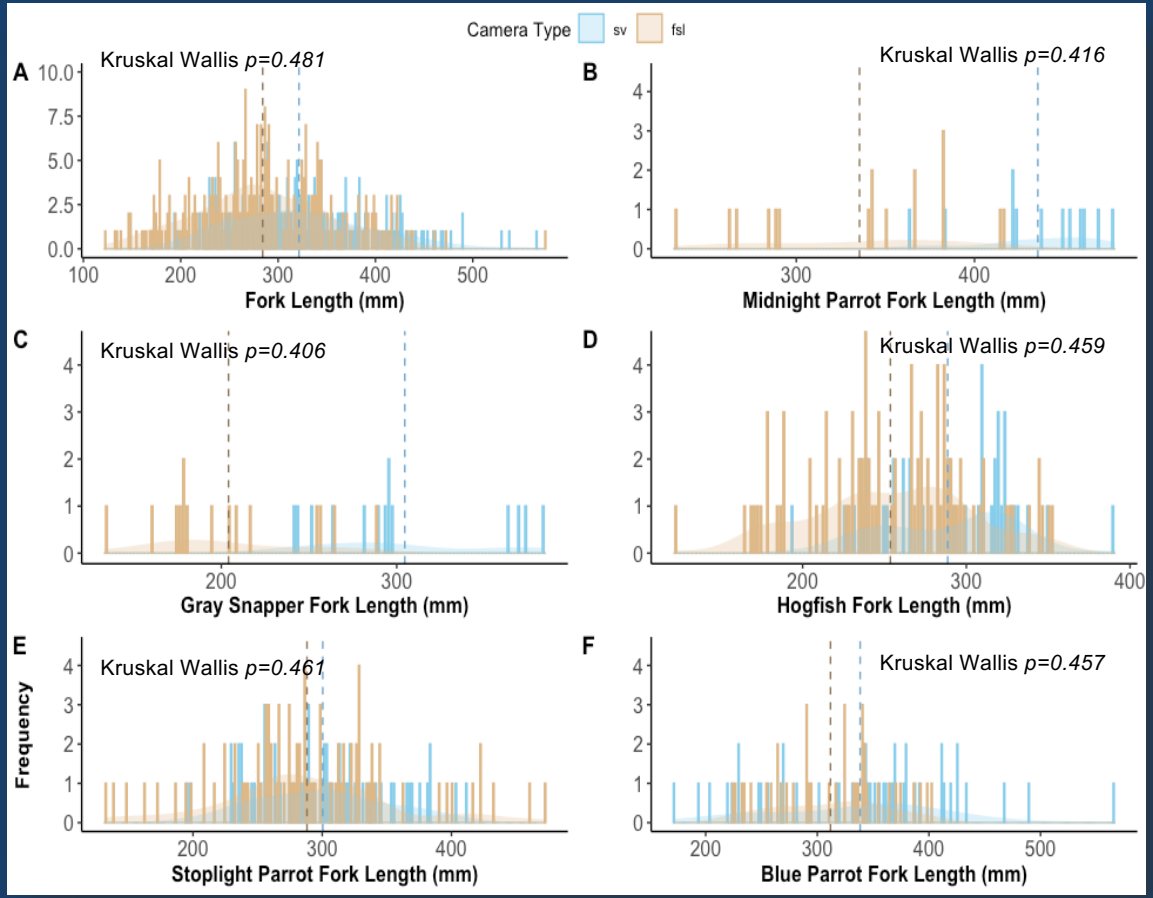
Preliminary Results –

Paired Tests (Individual fish)

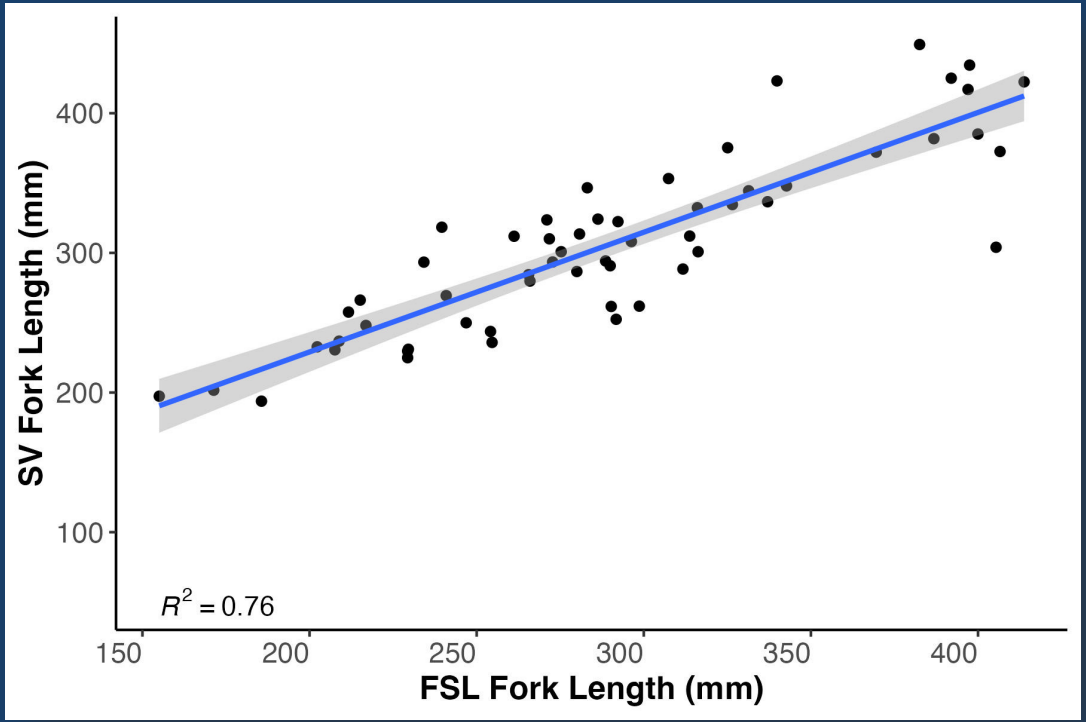


(N=66) Kruskal-Wallis chi-squared = 94, df = 94, p-value = 0.481

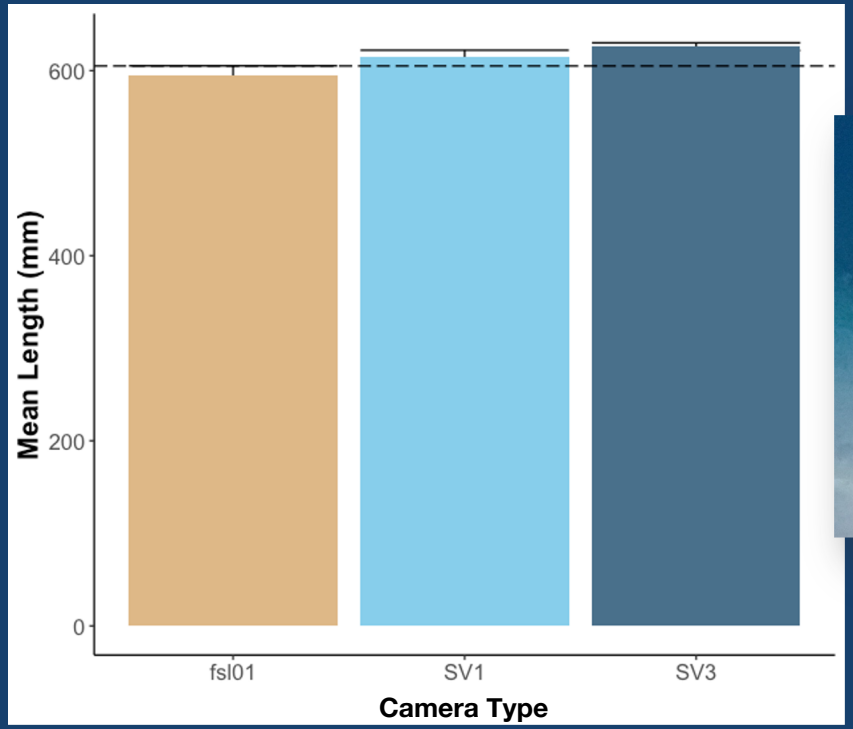
Preliminary Results - Length Distribution x Species



Preliminary Results – Length Regression x Camera System



Preliminary Results –
Known Objects



Kruskal-Wallis chi-squared = 4.4351, df = 3, p-value = 0.2181

Laser Development

- Dual (parallel) or single encased laser
- Rechargeable battery
- More robust mount, eventually adaptable to other camera models

BACKSCATTER
UNDERWATER VIDEO & PHOTO

Citizen Science Participation

- 46 different volunteers; 295 total dives in Keys; 7 REEF Survey Trips
- Local dive operators partnership
- Formal survey to examine motivators & barriers to participation; camera performance & use
    - Assess demographics for target audience

What would be your level of interest in using the camera as part of this project?

If you participate in marine species monitoring, how much of an impact do you believe your contribution would have on fisheries management?

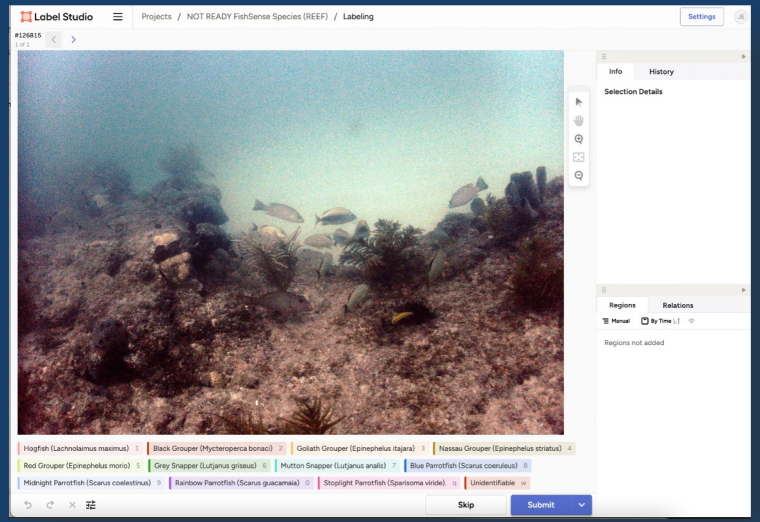
What type of training would you prefer to learn the skills to participate in the project?

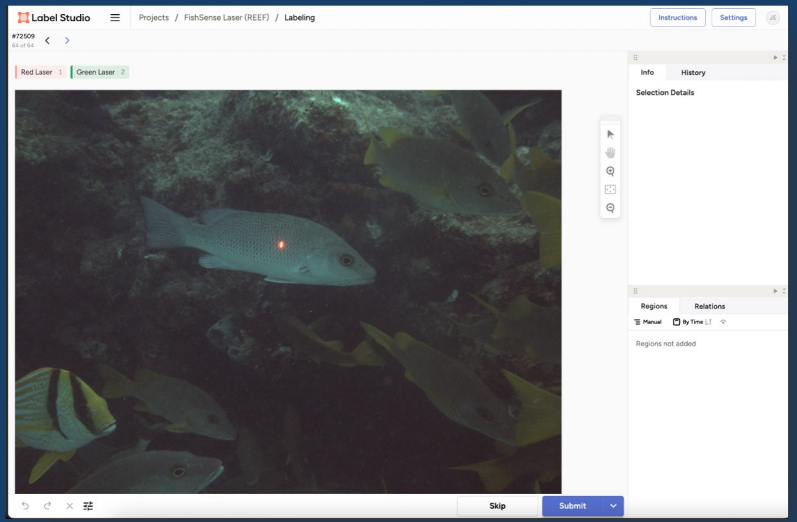
How easy was it to perform both a REEF survey and use the camera for the SMILE project at the same time?

What would most motivate you to participate in the project?

Citizen Scientist Participation

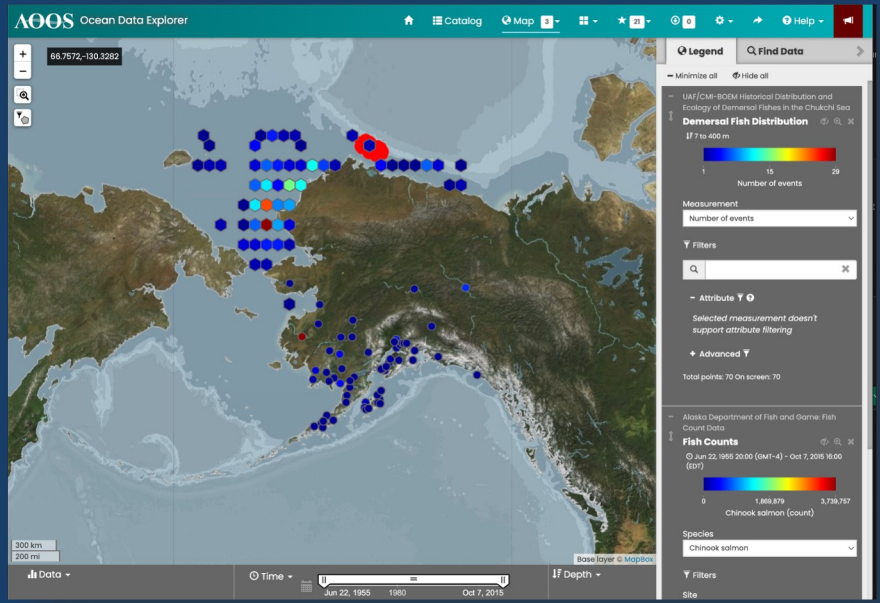
- Volunteers perform AI training tasks through label studio
  - Identify laser location and fish species





Collaboration

- Data application and management platform
- Data visualization



Axiom DATA SCIENCE

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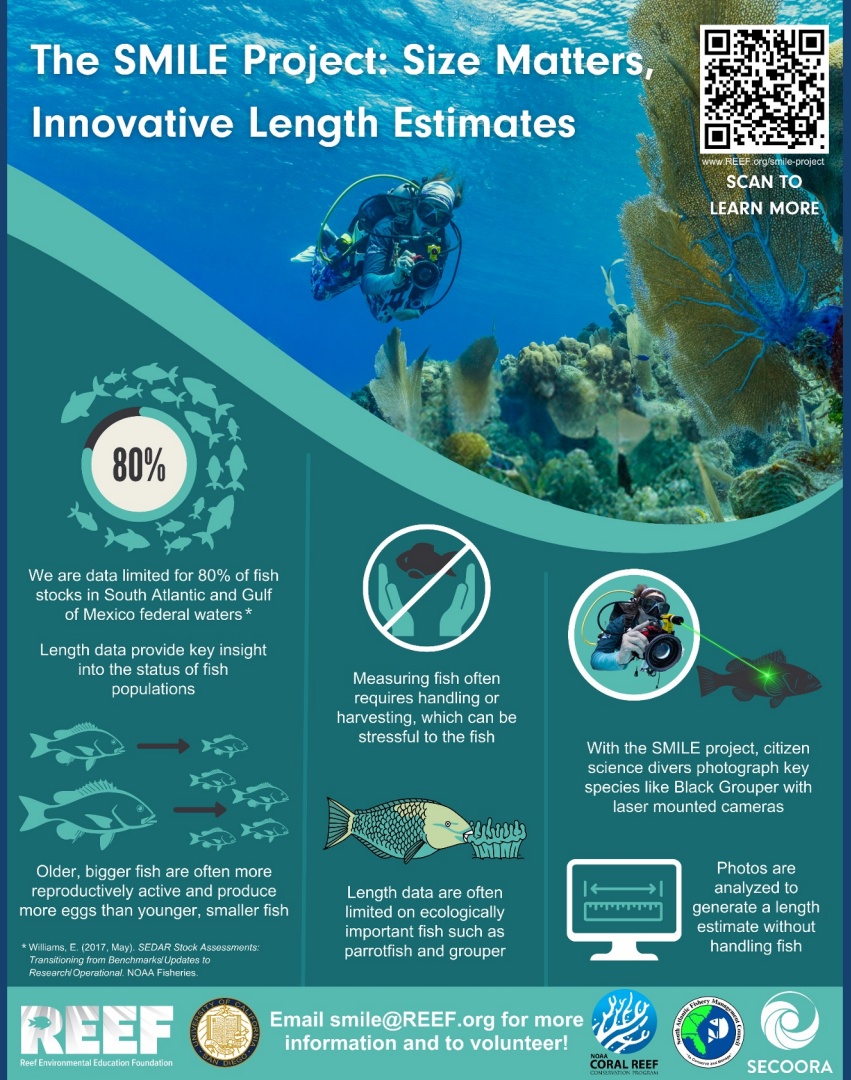
Summary

- Camera systems are comparable to each other to generate lengths
  - Stereovideo tends to measure larger than Fish Sense Lite
- Troubleshooting hardware/software challenges
- Positive citizen scientist response
- Publicly available data, akin to REEF's VFSP

THANK YOU!



Questions for me?

Questions

- Methodology:
  - Informative for size data needed for stock assessments and/or management?
    - Suggestions/concerns, to boost confidence in this data source
  - Repeat sightings of fish?
- Data suggestions:
  - Species selection?
  - What data sources are most useful for assessors and managers?
- Data provision:
  - Data accessibility preferences?

EXTRA SLIDES

Slides as needed for any additional reference/questions

REEF Volunteer Fish Survey Project

Example of Data Interpretation

Caribbean Example

Den	%SF	Explanation
HIGH Den >3.0	HIGH %SF >50	Species is often observed and observed at high densities. Species is seen > 50% of the time and when it is seen the abundance category most often recorded is M or A. Species examples: bicolor damselfish, blue chromis, brown chromis
HIGH Den >3.0	LOW %SF <50	Species is not often seen, but when it is seen, it is observed at high densities. Species is seen < 50% of the time and when it is seen the abundance category most often recorded is M or A. Species examples: silversides/herrings, garden eel
LOW Den <3.0	HIGH %SF >50	Species is often observed, but always at low densities. Species is seen > 50% of the time and when it is seen the abundance category most often recorded is F or S. Species examples: trumpetfish, rock beauty, foureye butterflyfish
LOW Den <3.0	LOW %SF <50	Species is not often observed and when it is observed, it is at very low densities. Species is seen < 50% of the time and when it is seen the abundance category most often recorded is F or S. Species examples: green moray, saucereye porgy, spotted scorpionfish

REEF Database Citation

Please cite REEF's Database as: REEF. year. Reef Environmental Education Foundation Volunteer Fish Survey Project Database. World Wide Web electronic publication. www.REEF.org, date of download (day month year).

Abundance Codes: S-Single; **F**-Few 2-10; **M**-Many 11-100; **A**-Abundant >100

Diver Name: _____ Date: _____ Time Start: _____ Bottom Time: ____

Dive Site Name and REEF Zone Code: _____

Water Temp: _____ Visibility: _____ Max Depth: _____ Avg Depth: _____ Current: _____ Habitat: ___

0119	Black Hamlet *(Hypoplectrus nigricans)*	None
0121	Butter Hamlet *(Hypoplectrus unicolor)*	None
Family	**Hogfish *(Labridae)***	**Number seen**
0130	Hogfish *(Lachnolaimus maximus)*	None
0131	Spanish Hogfish *(Bodianus rufus)*	None
Family	**Jack *(Carangidae)***	**Number seen**
0133	Bar Jack *(Caranx ruber)*	None
0137	Horse-eye Jack *(Caranx latus)*	None
Family	**Parrotfish *(Scaridae)***	**Number seen**
0144	Blue Parrotfish *(Scarus coeruleus)*	None
0147	Greenblotch Parrotfish *(Sparisoma atomarium)*	None
0148	Midnight Parrotfish *(Scarus coelestinus)*	None
0149	Princess Parrotfish *(Scarus taeniopterus)*	None
0150	Queen Parrotfish *(Scarus vetula)*	None
0151	Rainbow Parrotfish *(Scarus guacamaia)*	None
0152	Redband Parrotfish *(Sparisoma aurofrenatum)*	None
0154	Redtail Parrotfish *(Sparisoma chrysopterum)*	None
0155	Stoplight Parrotfish *(Sparisoma viride)*	None
0156	Striped Parrotfish *(Scarus iseri)*	None
0153	Yellowtail (Redfin) Parrotfish *(Sparisoma rubripinne)*	None
Family	**Porcupinefish and Pufferfish**	**Number seen**
0163	Balloonfish *(Diodon holocanthus)*	None
0166	Porcupinefish *(Diodon hystrix)*	None
0167	Sharpnose Puffer *(Canthigaster rostrata)*	None
Family	**Razorfish *(Labridae)***	**Number seen**
0173	Green Razorfish *(Xyrichtys splendens)*	None
0175	Rosy Razorfish *(Xyrichtys martinicensis)*	None
Family	**Seabass *(Serranidae)***	**Number seen**
0180	Creolefish (Atlantic) *(Paranthias furcifer)*	None
0234	Greater Soapfish *(Rypticus saponaceus)*	None
0181	Harlequin Bass *(Serranus tigrinus)*	None
0182	Lantern Bass *(Serranus baldwini)*	None
0185	Tobaccofish *(Serranus tabacarius)*	None
Family	**Snapper *(Lutjanidae)***	**Number seen**
0192	Gray Snapper *(Lutjanus griseus)*	None
0193	Lane Snapper *(Lutjanus synagris)*	None
0194	Mahogany Snapper *(Lutjanus mahogoni)*	None
0195	Mutton Snapper *(Lutjanus analis)*	None
0196	Schoolmaster *(Lutjanus apodus)*	None
0197	Yellowtail Snapper *(Ocyurus chrysurus)*	None
Family	**Squirrelfish *(Holocentridae)***	**Number seen**
0198	Blackbar Soldierfish *(Myripristis jacobus)*	None
0200	Longjaw Squirrelfish *(Neoniphon marianus)*	None
0201	Longspine Squirrelfish *(Holocentrus rufus)*	None
0203	Squirrelfish *(Holocentrus adscensionis)*	None
Family	**Surgeonfish *(Acanthuridae)***	**Number seen**
0204	Blue Tang *(Acanthurus coeruleus)*	None
0205	Doctorfish *(Acanthurus chirurgus)*	None

REEF

Introduction

- Fisheries stock assessments incorporate size data
  - Reflect population age structure and change, reproductive potential, biomass
- Lengths traditionally obtained via harvest or handling
  - Loss of fish or induces stress
  - Limited distribution of sizes and species
- Existing *in situ* methods is limited to scientists