Puerto Rico Deepwater Reef Fish Survey: Fishery-Independent Monitoring Data

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Puerto Rico Deepwater Reef Fish Survey: Fishery-Independent Monitoring Data

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SEDAR 103: US Caribbean Application of Alternative Assessment Methods

Summary

To address critical data gaps for deepwater demersal species (> 50 m) in the U.S. Caribbean, a standardized fishery-independent hook-and-line survey was established in Puerto Rico. The survey targets mesophotic and deepwater reef fishes, with an emphasis on commercially and recreationally important deepwater snappers (silk snapper *Lutjanus vivanus*, queen snapper *Etelis oculatus*, blackfin snapper *Lutjanus buccanella*, wenchman snapper *Pristipomoides aquilonaris*, cardinal snapper *Pristipomoides macrophthalmus*, and vermilion snapper *Rhomboplites aurorubens*). Survey sampling follows a stratified random survey design across 500 m × 500 m grid units, stratified by depth and rugosity. Over multiple survey years (2017 – 2026), the program has expanded island-wide (2023 +), contributing data for 90 taxa overall, with 70 distinct taxa caught within the primary target depth of 50 to 450 m (Appendix 1). The recent expansion of the survey frame to include shallow-water overlap strata (20 - 50 m) provides intercalibration data with other ongoing fishery-independent survey efforts. The data from the survey is generating estimates of relative abundance (CPUE), occurrence (P) and length-frequency compositions for several key taxa, as well as critical life history samples (otoliths, gonads, and tissue) for target species. This document outlines the survey history, sampling protocols, geographic scope, and data outputs prepared for evaluation during SEDAR 103.

I. Introduction

The marine ecosystems of Puerto Rico support vital commercial and recreational fisheries targeting a wide array of complexes from shallow-water to deep-dwelling demersal fishes. Historically, quantitative stock assessments for deepwater species have been severely constrained by the lack of reliable fishery-independent abundance indices and biological data. While established nearshore monitoring programs can effectively characterize shallow-water habitats (< 20 m), key commercial and recreational species such as (but not limited to) silk snapper (*Lutjanus vivanus*), and queen snapper (*Etelis oculatus*), inhabit mesophotic to deepwater environments, at depths ranging from 50 m to 450 m.

To extend fishery-independent survey capabilities into mesophotic and deepwater (50 – 450 m, recently expanded to 20 - 450 m) environments, a collaborative effort was initiated between NOAA Southeast Fisheries Science Center, the University of Miami Rosenstiel School of Marine, Atmospheric, and Earth Science, the Puerto Rico Department of Natural and Environmental Resources (DNER), local consulting entity HJR Reefscaping, and commercial fishers.

The program evolved over four major developmental phases:

1. **2015 – 2017 (Development & Experimental Trials):**

   Supported by Saltonstall-Kennedy funding, project scientists collaborated with commercial fishers to define a standardized sampling methodology. Experimental fishing trials evaluated gear configurations, drift patterns, drop times, and spatial clustering to establish the fundamental sample unit (500 m x 500 m grid cell).

   Initial spatial survey frames and rugosity maps were developed using available multibeam sonar bathymetry (50 – 500 m) across three focus regions (Northwest, Northeast, Southeast).

2. **2017 – 2018 (Initial Pilot Survey):**

   Conducted across grid cells in the Northwest, Northeast, and Southeast regions. The sampling validated a 7-depth/2-rugosity composite stratification scheme (using Arc-Chord Ratio, ACR) that reduced variance and the required sampling effort by 36 - 46% relative to simple random sampling (Table 1).

3. **2018 – 2022 (Optics & Depth Expansion):**

   Funded in part by Southeast Deep Coral Initiative, research expanded into deeper waters (100 – 650 m) across low, medium, and high rugosity strata to look at habitat associations of deepwater reef fishes, specifically with deepwater corals and sponges. The integration and R&D began for non-extractive optical systems, including GoPro, stereo-video setups, and wavelength modified deepwater lighting.

4. **2023 – 2026 (Island-Wide Implementation):**

2023 – 2024: Implemented island-wide sampling in Puerto Rico across 50 - 450 m depths using 7-depth/2-rugosity strata (Table 1).

2024 – 2026: In addition to 7-depth strata (50 - 450 m), survey depth capabilities were expanded to include shallow-water overlap (20 - 50 m) and expanded to 3-rugosity strata following re-assessment of survey design and sampling effort (Table 2).

Current Initiatives: In addition to continued sampling using the 7-depth/3-rugosity strata with the standard hook and line methodology, a separate study is taking place that is focused on gear intercalibration: comparing hook-and-line fishing, stereo-video, and diver visual surveys (50 m x 50 m nested grids within 500 m x 500 m survey grid) to estimate relative fishing power and gear efficiency, island-wide from 20 - 450 m.

The survey design employs Neyman allocation of sampling effort among strata, accounting for stratum area and stratum variance of catch per unit effort (CPUE). By optimizing depth and rugosity strata, a substantial reduction in sampling effort and increased precision was achieved compared to a simple random design. Power analysis of the island-wide dataset showed that it is feasible to achieve 15 - 30% CVs of CPUE for species of interest using this design.

II. Sampling Method

Sampling is conducted via commercial fishing vessels and experienced local captains who are accompanied by trained biological observers. Surveys target ≥ 200 grids annually via stratified random sampling as explained below:

<u>Standard Fishing Gear & Configuration</u>

The standard fishing sample utilizes vertical line gear (electric reels) standardized across all vessels:

Reel & Lines: Two electric reels fished per sample unit (grid), this is referred to as a “station”.

Terminal Rig: Main line with 12 hooks per line.

Hooks: Circle hooks, size #9.

Gangions/Leaders: 6-inch mono leader, spaced 18 inches apart along the main line.

Weight & Attraction: 5 – 10 lb weight attached to the bottom of the main line

Bait: California Squid (*Loligo*) and Mackerel/Tuna alternated on consecutive hooks.

Field Sampling Protocol

Within a designated 500 m x 500 m selected grid, the vessel navigates to the center point. The Captains execute multiple gear "drops" (line deployment and retrieval), ensuring that the fishing remains within the 500 m x 500 m designated grid cell. Fishing continues until a cumulative 30 minutes of bottom fishing time is logged per line (measured independently using dedicated stopwatches). Onboard biological observers log start/end times, depths, and GPS coordinates for every individual drop (deployment and retrieval).

A. Sampling Years

The following are the survey years included in the main analysis for SEDAR 103.

2017–2018: Initial regional pilot survey (NW, NE, SE regions).

2023–2024: Island-wide survey Year 1.

2024–2025: Island-wide survey Year 2.

2025–2026: Island-wide survey Year 3.

B. Geographic Range

The survey covers the insular shelf break and upper slope waters surrounding Puerto Rico (Fig. 1). The survey depth range is from 50 - 450 m, which was recently expanded (2025 - 2026) to 20 - 450 m to facilitate gear intercalibration and generation of data for shallow and mesophotic species. The initial pilot survey focused on three primary regions (constrained due to multibeam bathymetry data availability): Northwest, Northeast and Southeast. The contemporary operational scope (2023 +) covers all insular shelf waters surrounding Puerto Rico island-wide.

C. Sample Size

The survey target sample size is 200 stratified random grid stations within 50 - 450 m, per year, island-wide. Specific sample numbers can be found in Table 3. Starting in 2025, additional grid stations (n = 50) were collected from 20 - 50 m.

D. Variables or Data Types Collected

1. Stratum Weighted Catch and Abundance Metrics: Catch-per-unit-effort (CPUE), defined as number of fish caught per 500 m × 500 m grid per 30 minutes of line bottom time; includes Standard Error (SE) and Coefficient of Variation (CV, %).

2. Stratum Weighted Frequency of Occurrence (P): Proportion of sampled grid stations containing target species.

3. Stratified Population Mean Length ($\bar{L}$): Stratified estimates of mean fork length (FL, mm) and associated precision ($SE_{\bar{L}}$, $CV_{\bar{L}}$)
4. Morphometric Measures: Fork Length (FL, mm), Total Length (TL, mm), and Girth (mm) recorded for caught individuals.

5. Biological Tissues & Life History Samples: Retained catch of target species sampled for paired sagittal otoliths, gonads, paired whole eyes, and fin clips (genomics studies).

6. Environmental and Spatial Metadata: High-resolution gear deployment/retrieval coordinates (latitude/longitude).

7. Deployment start/end depths.

8. Surface environmental conditions: wind speed (knots), wave height (ft), and current speed (Low/Medium/High).

III. Results

The survey yielded comprehensive data on species composition, occurrence, relative abundance (CPUE), and size structure across mesophotic and deepwater reef fish complexes. Across all sampling years, a total of 90 taxa spanning 34 families were recorded from depths of 16 m to 640 m (Appendix 1, Table 3). Annual sampling effort, depth distributions, and length metrics (minimum, maximum, and average FL) are summarized in Tables 3 and 4.

Within the target survey depth range (50 - 450 m), 70 distinct taxa were caught (Table 5). Taxonomic identification challenges in the early development phases of the pilot survey required pooling of certain genera (*Pristipomoides* spp. and *Squalus* spp.) prior to 2023 (island-wide sampling). Restricting the focus to species meeting a ≥ 3% average proportion of positive occurrence across years identified target snapper (Lutjanidae), grouper (Epinephelidae), and shark (Squalidae) taxa (Table 5; Smith et al., 2011; Bryan et al., 2016).

Stratified random sampling across depth and rugosity provided stratum-weighted estimates of relative occurrence (P) and CPUE (number of fish per station/grid unit per 30 minutes bottom time) for the primary assessment species (Table 6). Silk snapper (Lutjanus vivanus) maintained the highest composite average occurrence ($\bar{P}$ = 14.7%, peaking at 20.1% in 2023 - 2024; Table 5), and exhibited the highest relative abundance among snappers, ranging from a CPUE of 0.344 to 0.457, with a high relative precision across all contemporary years (CV ≤ 24.3%) (Table 6). Queen snapper (Etelis oculatus) exhibited a composite average occurrence of $\bar{P}$ = 10.5% , with an initial CPUE of 0.207 (CV = 22.2%) in 2023 - 2024 that leveled off at 0.104 - 0.107 (CV = 24.4 - 25.3%) in subsequent years (Table 5 - 6). Following species-level identification standardization in 2023 for the genus *Pristipomoides*, cardinal snapper (*Pristipomoides*

macrophthalmus) maintained a contemporary annual occurrence of P = 6.7 - 14.6% with a CPUE ranging from 0.155 to 0.222 (CV = 16.6 - 27.6%), while wenchman snapper (*Pristipomoides aquilonaris*) maintained consistent annual occurrence (P = 9.8 - 10.0%, CPUE = 0.233 - 0.270, CV = 21.2 - 28.7%) (Table 5 - 6).

Species with distributions along the upper mesophotic shelf break exhibited lower CPUE and higher variance. Blackfin snapper (*Lutjanus buccanella*) contemporary annual occurrence ranged from P = 3.0 - 4.0% with CPUE ranging from 0.041 to 0.156 (CV = 32.8 - 61%), while vermilion snapper (*Rhomboplites aurorubens*) exhibited an annual occurrence of P = 2.3 - 2.9% and CPUE ranging from 0.039 to 0.082 (CV = 29.4 - 46.2%) (Table 5 - 6). Similarly, red hind (*Epinephelus guttatus*), also exhibited low occurrence during initial deepwater operations (P = 0.3% in 2017 - 2018), increasing to P = 3.9 - 4.9% during the 2023 - 2025 island-wide expansion, and peaking at P = 5.5% with a CPUE of 0.142 (CV = 48.7%) in 2025 - 2026 (Table 5 - 6).

Length frequency compositions generated across the island-wide survey years (2023 - 2026) demonstrated distinct species-specific size structures and length composition across target deepwater complexes (Table 4, Fig. 2 - 10). Silk snapper exhibited a unimodal size structure centered between 240 mm and 300 mm fork length (FL), with larger individuals recorded up to 680 mm FL. Queen snapper displayed a broader length distribution ranging from 160 mm to 720 mm FL, with primary modal frequencies occurring between 260 mm and 340 mm FL. Blackfin snapper exhibited a size composition ranging from 208 mm to 502 mm FL, with primary modal frequencies occurring between 260 mm and 320 mm FL. Vermilion snapper exhibited a narrower size distribution ranging from 198 mm to 344 mm FL, with modal frequencies occurring between 220 mm and 260 mm FL. Wenchman snapper results showed a constrained modal distribution peaking at 200 mm FL (range: 110 - 500 mm FL), whereas cardinal snapper exhibited a slightly broader size composition with modal peaks occurring between 220 mm and 280 mm FL (range: 160 - 440 mm FL). Although deepwater dogfishes (*Squalus clarkae* and *Squalus cubensis*) were caught across wide size ranges (208 – 690 mm FL and 261 - 862 mm FL, respectively), elasmobranchs were excluded from the stratified population mean length ($\bar{L}$) analyses.

For the six primary target deepwater snapper species with comprehensive spatial and depth coverage (silk, queen, blackfin, cardinal, wenchman and vermilion snapper), stratified population mean length ($\bar{L}$) estimates demonstrated high precision, with $CV_{\bar{L}}$ consistently below 5% for five of the six species (Table 7). Queen snapper yielded the largest average size among snappers at $\bar{L}$ = 381.64 mm (SE = 17.58 mm, CV = 4.61%), followed by silk snapper at $\bar{L}$ = 325.59 mm (SE = 10.19 mm, CV = 3.13%) and blackfin snapper at $\bar{L}$ = 324.22 mm (SE = 6.38 mm, CV = 1.97%). Cardinal snapper averaged $\bar{L}$ = 293.44 mm (SE = 9.09 mm, CV = 3.10%) while wenchman snapper averaged $\bar{L}$ = 220.29 mm (SE = 34.37 mm, CV = 15.60%). Lastly, vermilion snapper averaged $\bar{L}$ = 256.98 mm (SE = 3.95 mm, CV = 1.54%). Due to limited temporal coverage in shallow-water strata (20 - 50 m), stratified population mean length was omitted for red hind at this time.

IV. Discussion

Survey Design Performance & Addressing Regional Data Limitations

The establishment of a standardized, fishery-independent hook and line survey across Puerto Rico fills a critical data gap for deepwater species (50 - 450 m) in the U.S. Caribbean. Historically, stock assessments for many tropical marine fish species in the U.S. Caribbean are currently ranked as “data-poor” due to the lack of reliable catch-effort time series. This includes the deepwater reef fishes queen snapper (*Etelis oculatus*) and silk snapper (*Lutjanus vivanus*), which are among the top landed finfish in the region and have been identified as indicator species for managing other poorly known stocks within a stock complex. By implementing a probability-based stratified random design optimized via Neyman allocation across bathymetric depth (50 - 450 m; 20 - 50 m) and benthic rugosity (Arc-Chord Ratio) strata (Du Preez, 2015; Ault et al. 2018b), we were able to generate indices of relative abundance (CPUE), standard errors, and coefficients of variation for the primary commercial snapper species, including silk snapper, queen snapper, cardinal snapper (*Pristipomoides macrophthalmus*), and wenchman snapper (*Pristipomoides aquilonaris*). These CVs were within the 12 - 28% range across contemporary survey years (2023 - 2026).

The developmental evolution of the survey reflects key methodological refinements that enhanced data quality. During initial pilot operations (2017 - 2018), field identification ambiguity necessitated pooling within certain genera, specifically *Pristipomoides* spp. (*P. aquilonaris* vs. *P. macrophthalmus*) and *Squalus* spp. (*Squalus clarkae* vs. *Squalus cubensis*). Specialized biological scientist training implemented prior to island-wide implementation in 2023 successfully resolved these species-level field identification challenges. Consequently, contemporary survey years provide robust, species-specific indices of abundance and occurrence across all target taxa.

The recent expansion of the survey frame in 2025 - 2026 to incorporate the shallow-water overlap strata (20 - 50 m) provide crucial depth intercalibration with shallow-water visual surveys, and generate baseline data for shallow to mesophotic species. While this expansion successfully captured shelf-edge occurrences for species occupying shallow to mesophotic depths (20 - 120 m), sampling within these shallower strata remains limited relative to the survey's primary deepwater focus. For example, red hind (*Epinephelus guttatus*) exhibited increased positive occurrence following the shallow-water depth expansion. However, because the core survey design remains optimized for mesophotic and deepwater habitats (> 50 m), with specific emphasis on silk and queen snapper, sampling intensity within shallow-water strata remains limited in temporal duration. As a result, calculating the stratified population mean length ($\bar{L}$) for red hind was omitted at this time; while the expanded frame now encompasses its shallow-water habitat, a single year of sampling remains insufficient to generate a representative demographic baseline.

Species-Specific Relative Abundance (CPUE) and Occurrence Trends

Silk snapper was the most widespread and abundant target species caught throughout the survey, maintaining the highest composite average occurrence, the highest relative CPUE among all caught species, and achieving robust annual precision across survey years (Tables 5 - 6). Queen snapper represented the predominant species in deep shelf break strata (> 200 m). Following the initial 2023 - 2024 season, queen snapper CPUE leveled off at lower rates (0.104 - 0.107), while precision remained consistent (CV = 24.4 - 25.3%) in subsequent years. The genus *Pristipomoides* represented a substantial portion of total snapper catches. Cardinal snapper maintained consistent relative abundance and occurrence across contemporary survey years. Wenchman snapper catch rates and station occurrences similarly remained consistent across years (Table 5 - 6).

Blackfin snapper were encountered less frequently, with a relative abundance peak in 2025 - 2026. However, CPUE variance was higher, which is likely reflective of lower sample density along the upper mesophotic edge of the survey frame. Vermilion snapper similarly exhibited lower overall composite average occurrence and CPUE across all survey years. Red hind exhibited low occurrence during initial deepwater operations, but positive occurrence increased during the initial island-wide expansion and peaked following the introduction of shallow-water overlap strata (20 - 50 m) in 2025 - 2026.

These higher coefficients of variation for shallow to mesophotic species are expected. The survey stratification and sampling effort allocation are optimized specifically to minimize variance for deepwater species targets (specifically silk snapper and queen snapper); species occupying the upper bathymetric boundary of the survey frame (20 - 120 m) experience lower sampling density, which yields higher spatial variance in relative abundance. To reduce index uncertainty and achieve target CVs (15 - 25%) for these shallow to mesophotic species, additional stratified sampling effort would likely need to be allocated specifically within the 20 - 120 m depth strata.

Deepwater elasmobranchs, primarily Genie's dogfish (*Squalus clarkae*) and Cuban dogfish (*Squalus cubensis*), represented non-teleost catches in deep strata (> 250 m). While relative abundance indices for these species exhibited high variance, reflecting the lower sampling frequency and patchy spatial distributions characteristic of deep slope habitats, the primary value of these encounters lies in baseline documentation. These catches highlight the survey’s unique capacity to track occurrence and generate essential biological data for vulnerable, data-limited elasmobranch complexes in the U.S. Caribbean.

Utility of Length Compositions and Population Mean Length ($\bar{L}$) in Stock Assessment

Standardized length frequency distributions generated across survey years provided high-resolution characterizations of population size structure for teleosts and elasmobranchs. While deepwater dogfishes were caught across broad size ranges (208 - 862 mm FL), they were

excluded from population mean length ($\bar{L}$) estimation, as standard length-based mortality models assume continuous teleost growth and recruitment dynamics that do not conform to elasmobranch life histories.

The precise stratified population mean length ($\bar{L}$) estimates generated for the target deepwater snapper complex demonstrated high statistical precision (CV < 5% for target species; Table 7). Together with time series of relative abundance (CPUE), occurrence (P), and size composition, these standardized data outputs provide SEDAR 103 with a foundational empirical dataset to support the evaluation of alternative assessment methods. Sustained execution of this survey will be critical to tracking population trends over time and supporting future evaluations of U.S. Caribbean mesophotic and deepwater reef fisheries.

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I. Tables and Figures

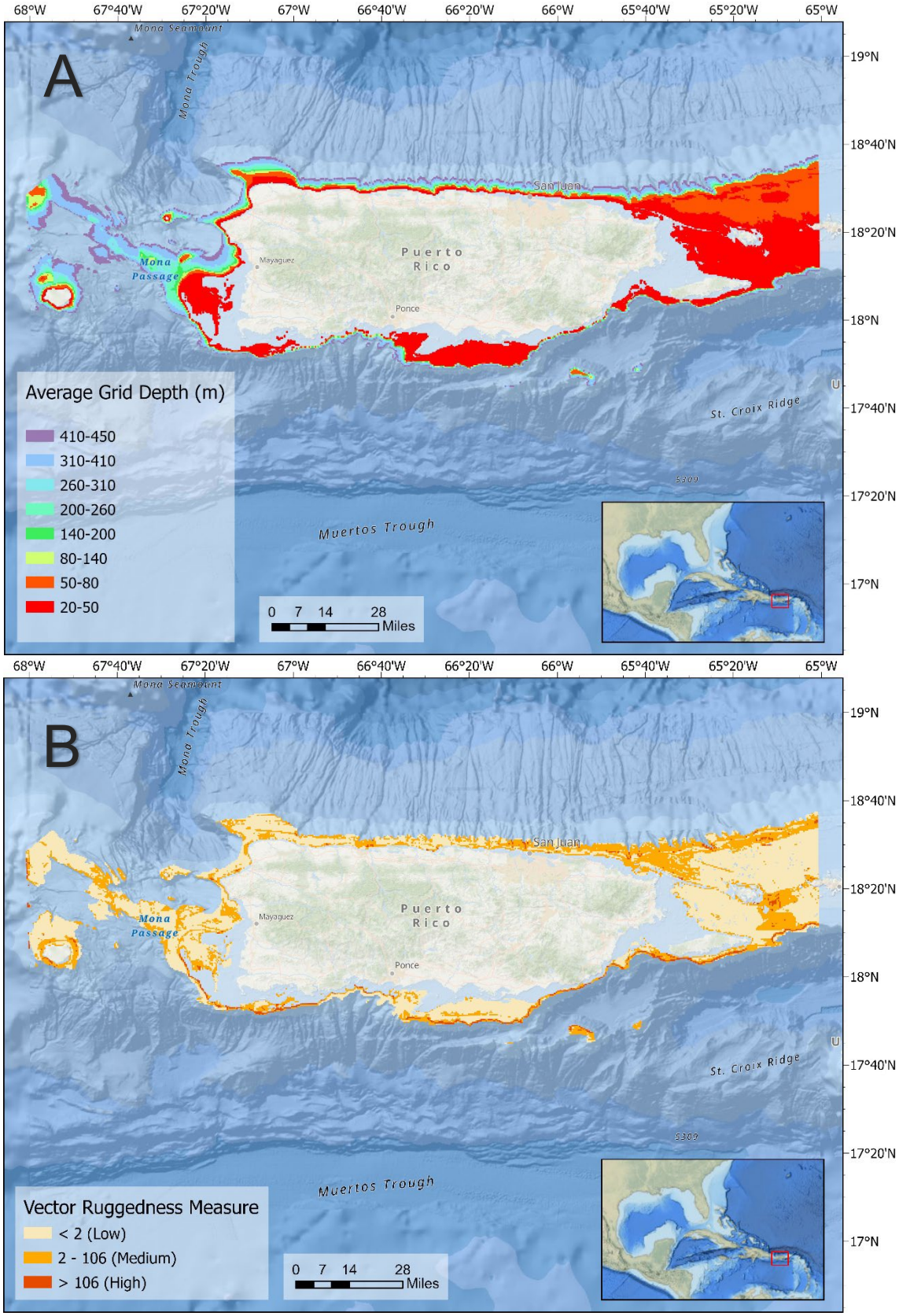

Figure 1. Maps depicting the island-wide survey footprint for the Puerto Rico Deepwater Reef Fish Survey by A) Depth, and B) Rugosity, measured as Vector Ruggedness Measure.

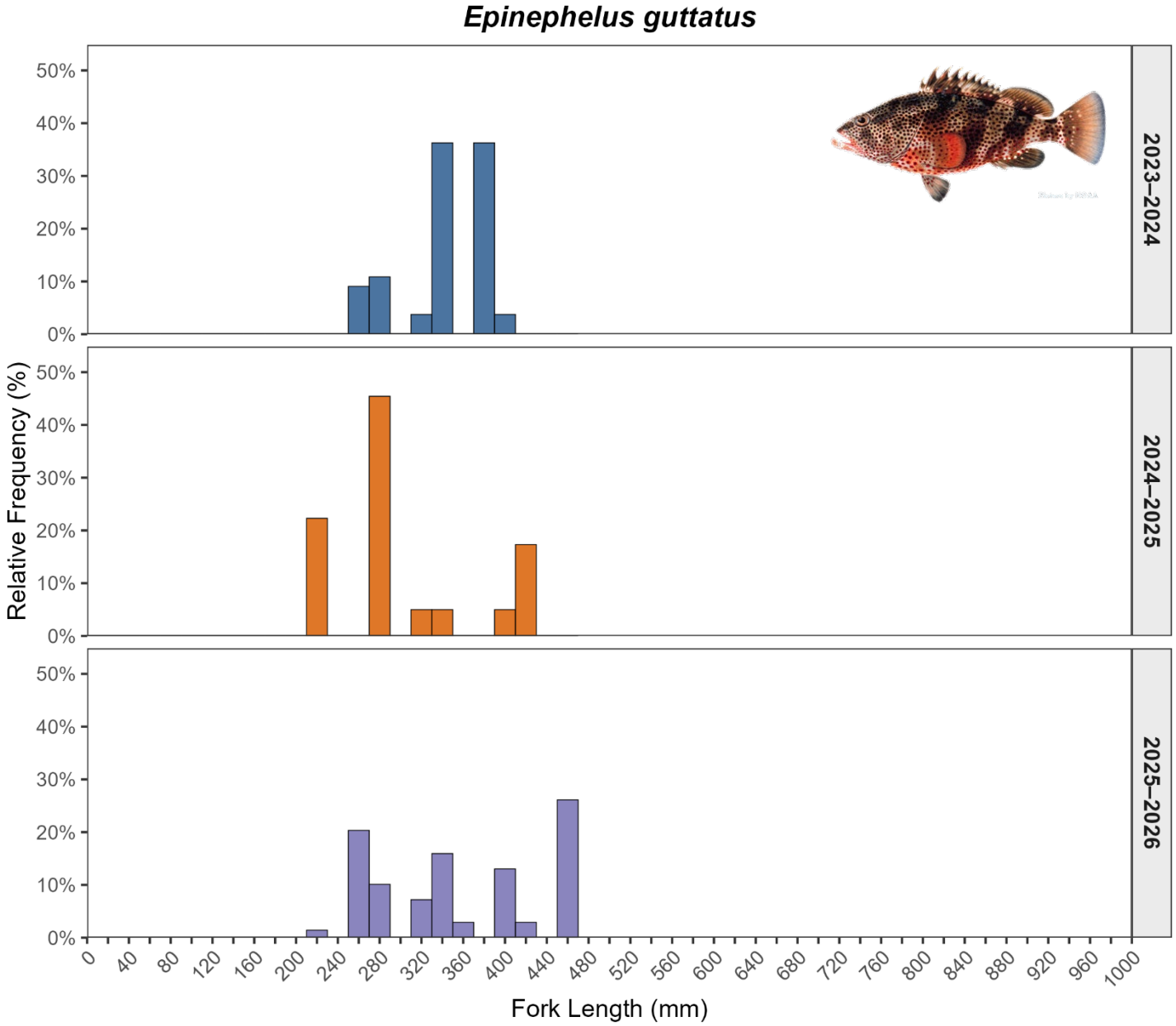

Figure 2. Relative length-frequency distribution in 20 mm bins of red hind (*Epinephelus guttatus)* collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

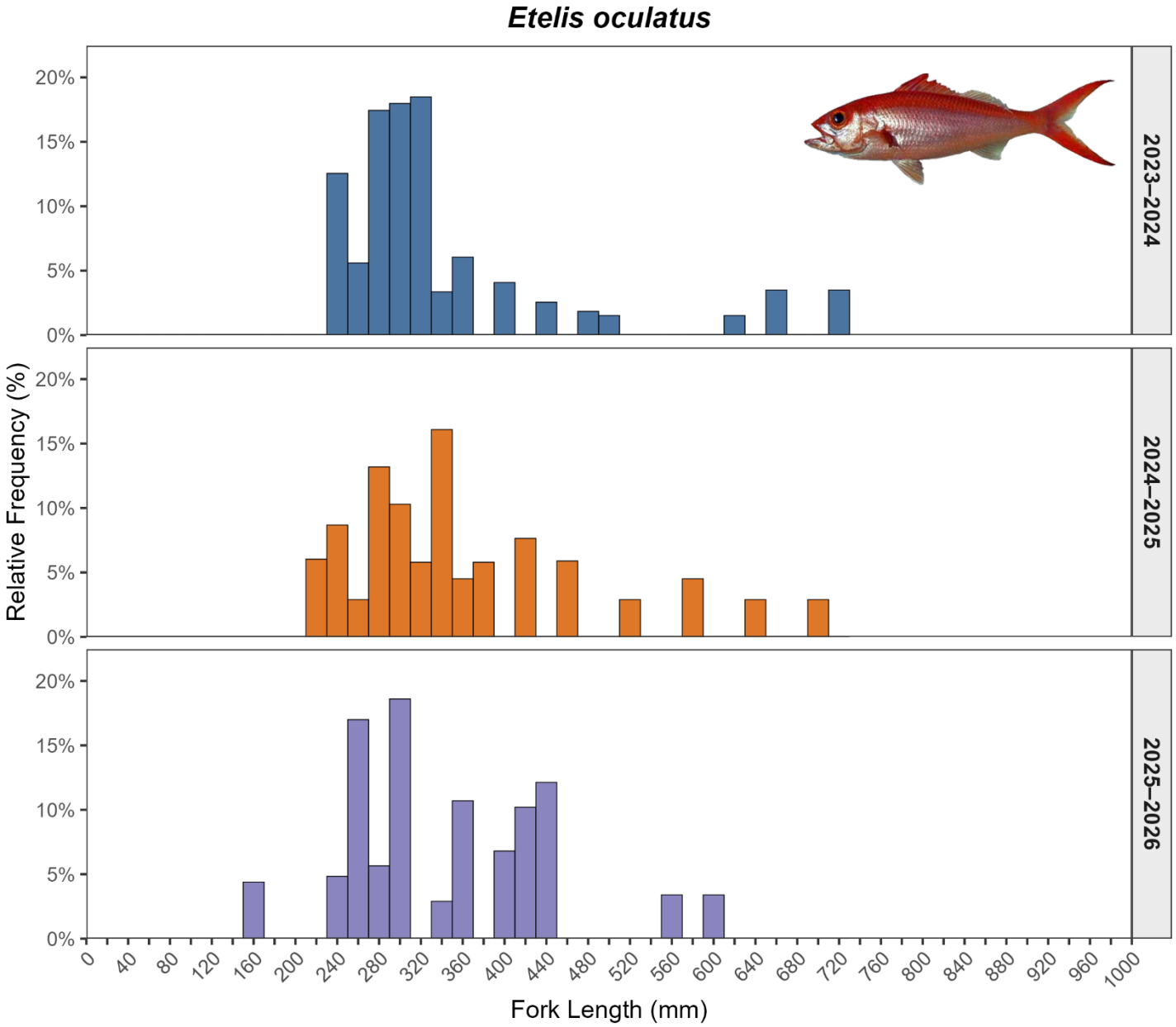

Figure 3. Relative length-frequency distribution in 20 mm bins of queen snapper (*Etelis oculatus)* collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

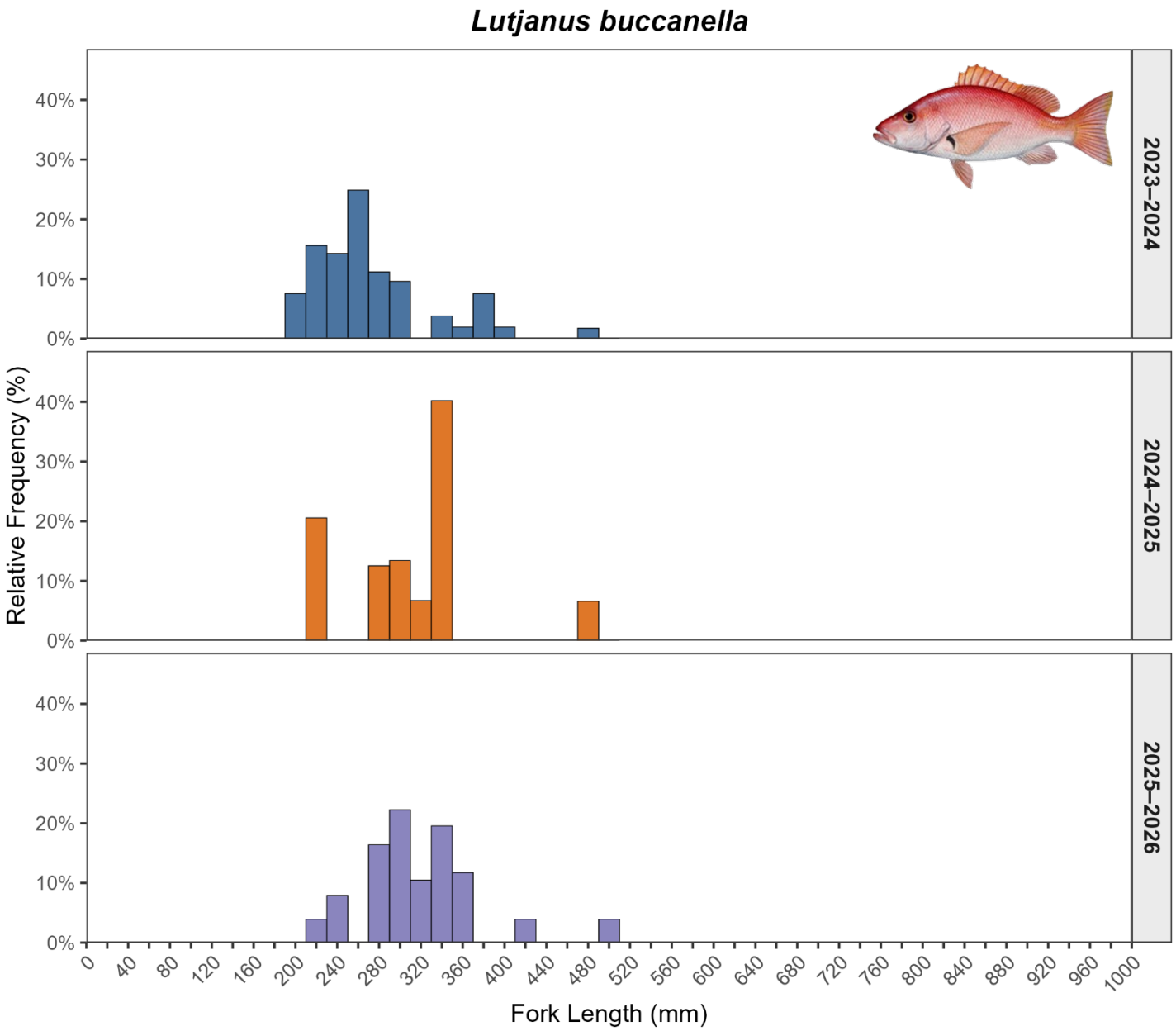

Figure 4. Relative length-frequency distribution in 20 mm bins of blackfin snapper (*Lutjanus buccanella*) collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

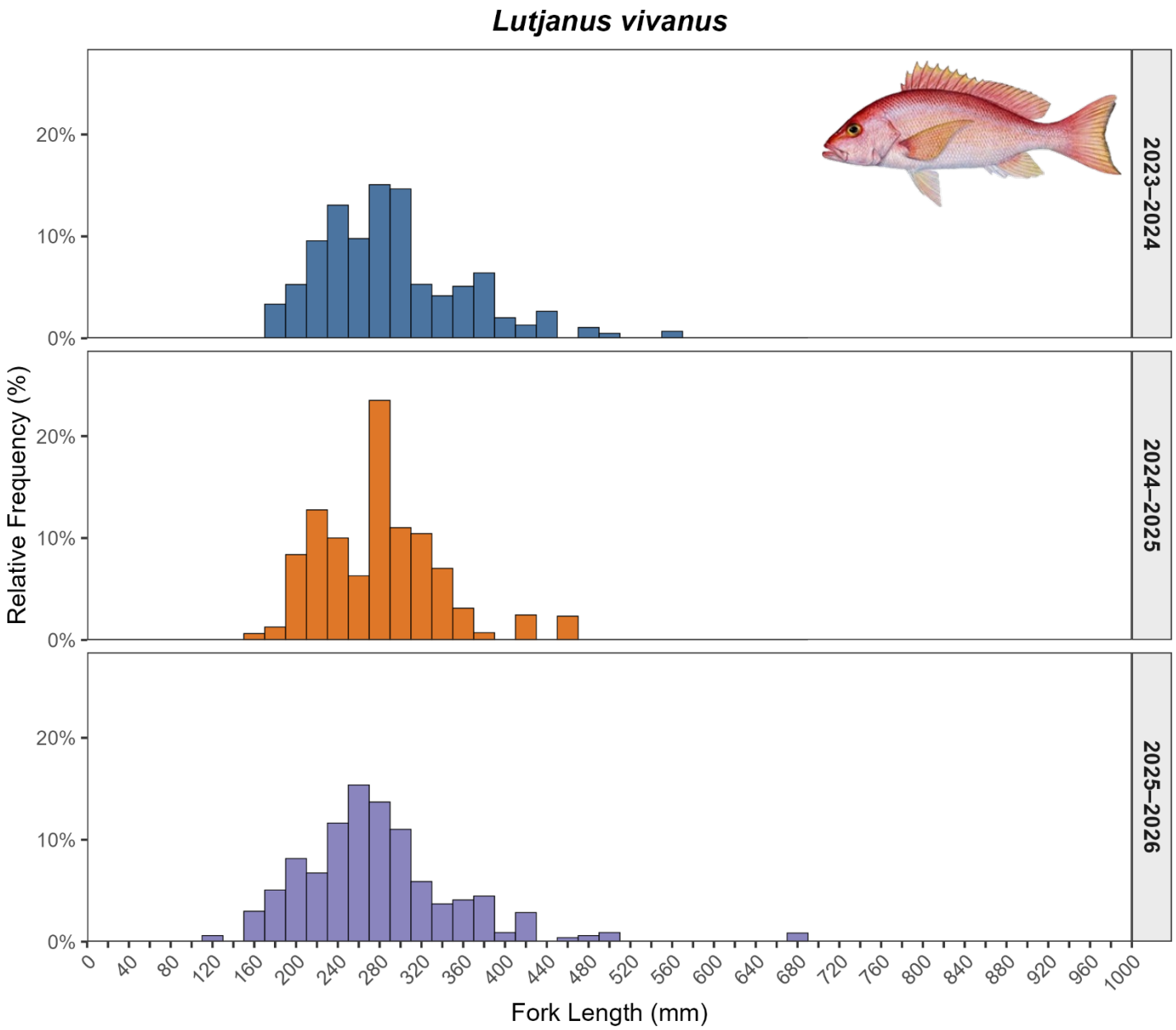

Figure 5. Relative length-frequency distribution in 20 mm bins of silk snapper (*Lutjanus vivanus*) collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

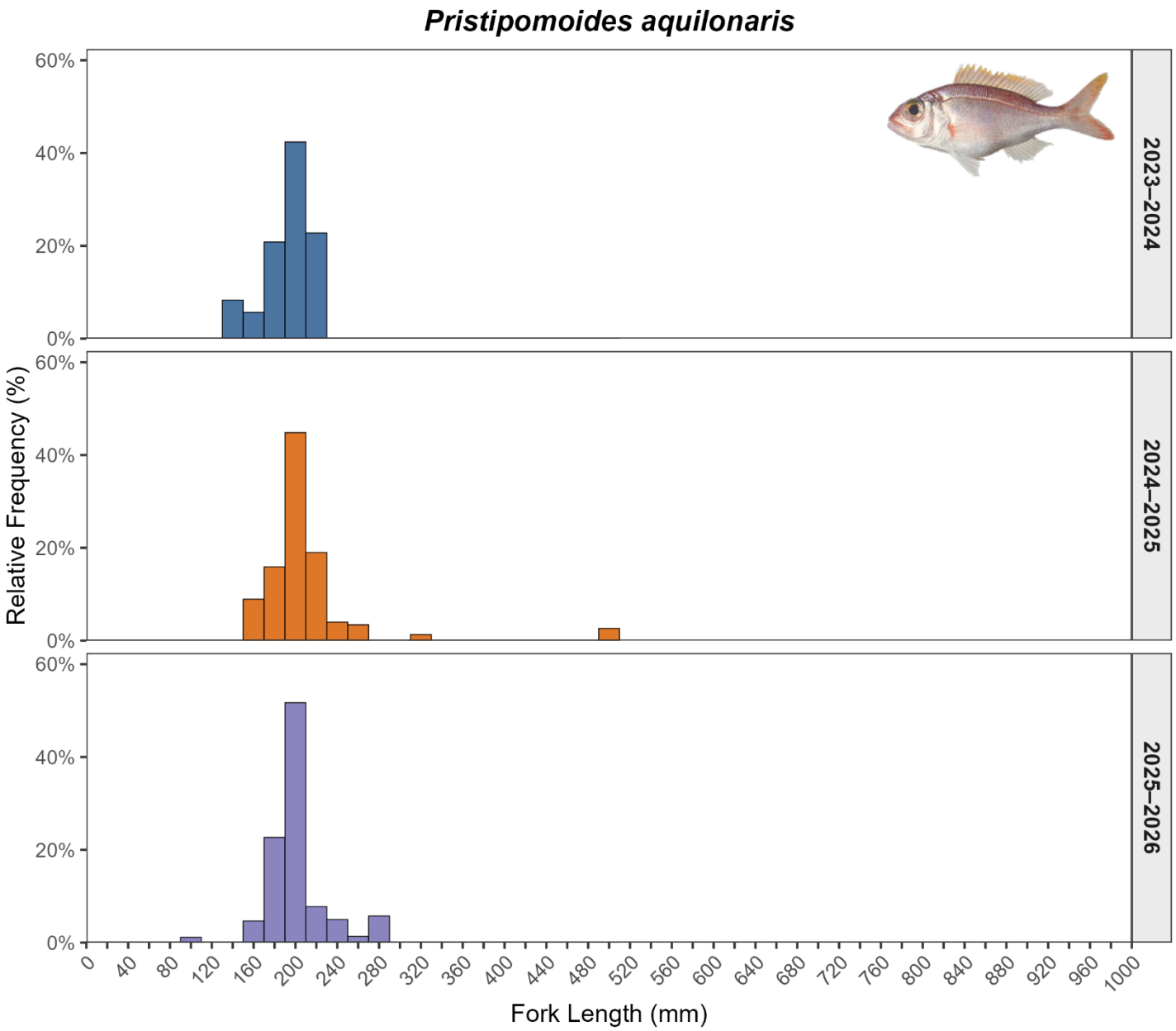

Figure 6. Relative length-frequency distribution in 20 mm bins of wenchman snapper (*Pristipomoides aquilonaris*) collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

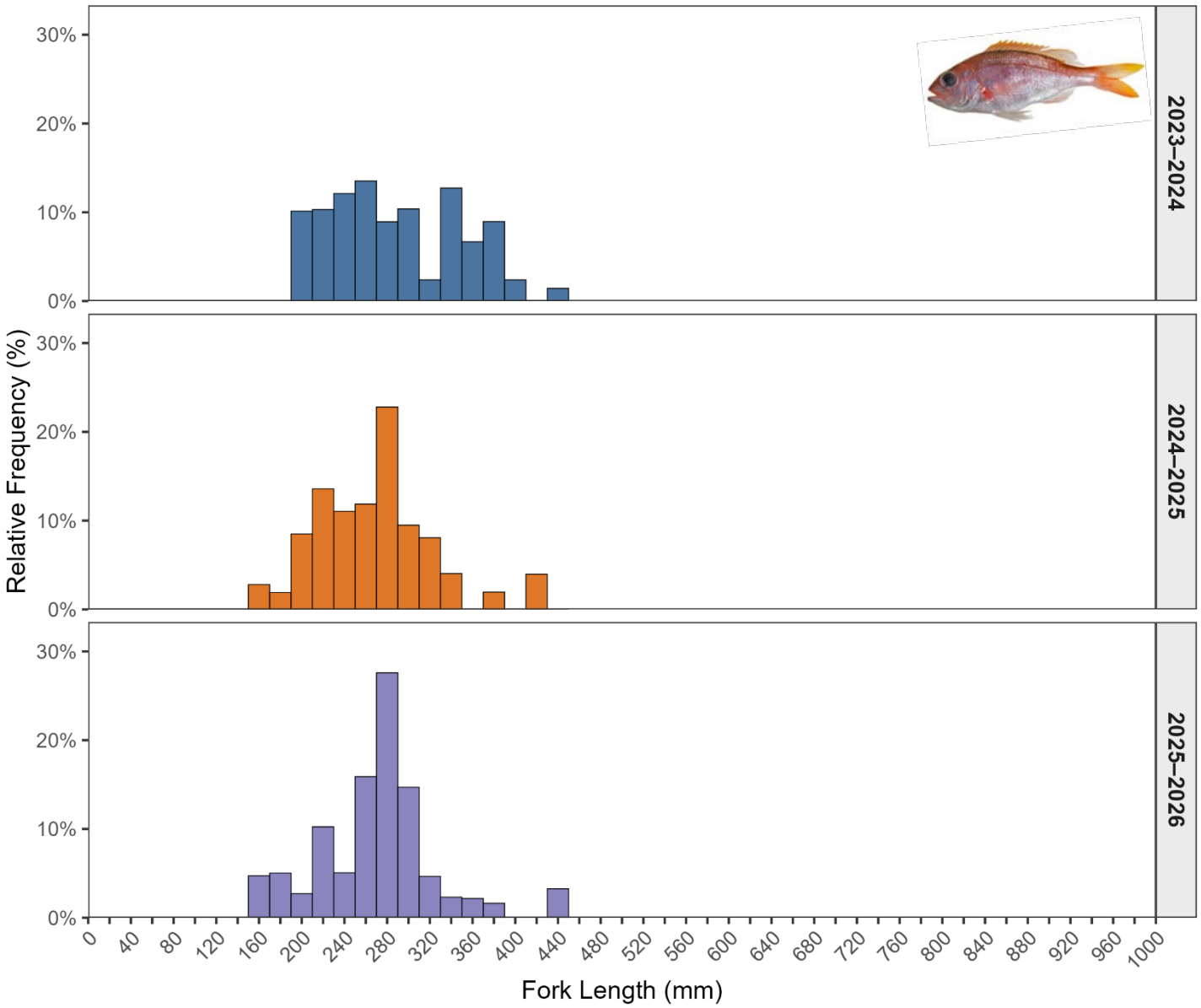

Figure 7. Relative length-frequency distribution in 20 mm bins of cardinal snapper (*Pristipomoides macrophthalmus*) collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

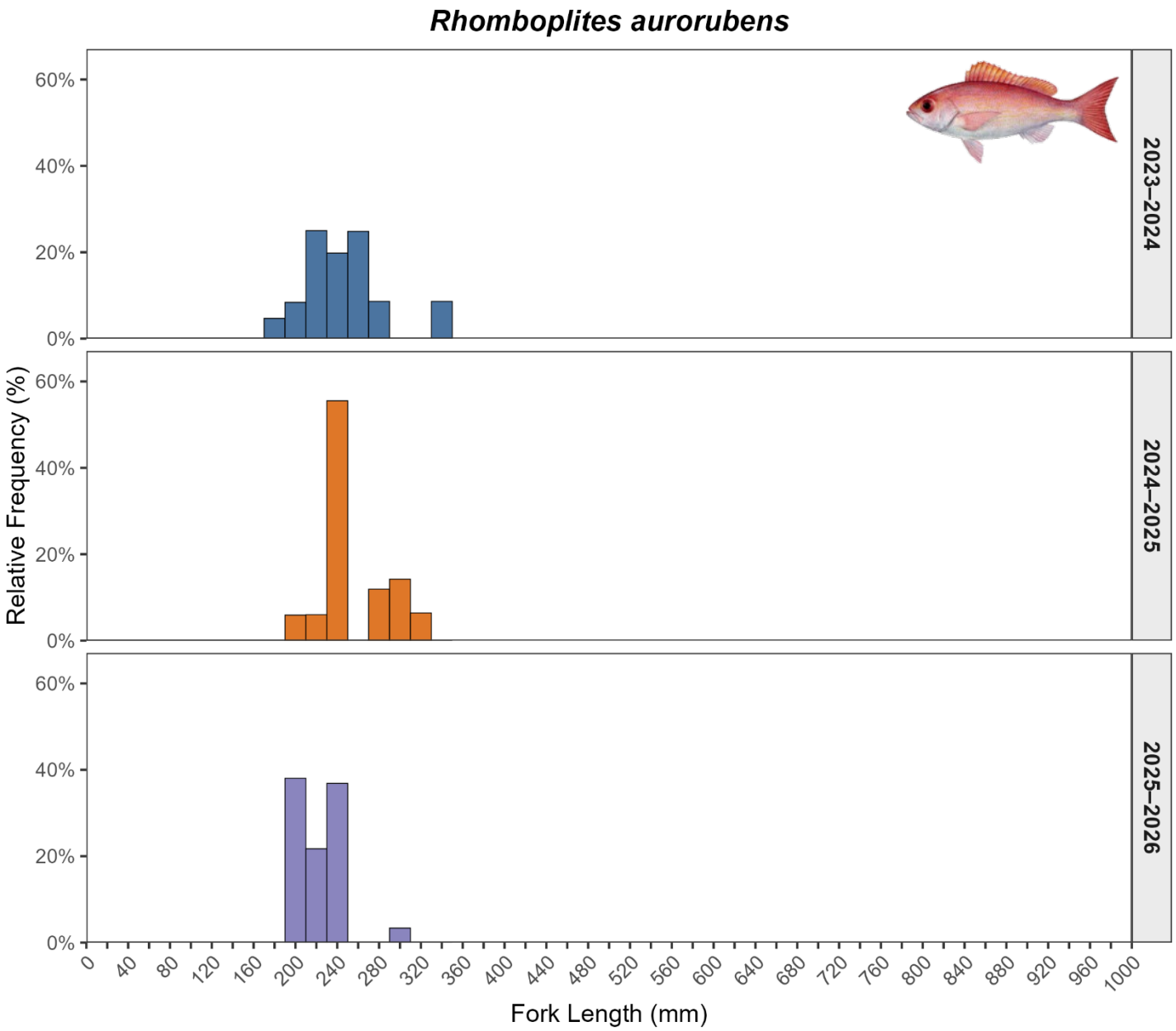

Figure 8. Relative length-frequency distribution in 20 mm bins of vermilion snapper (*Rhomboplites aurorubens*) collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

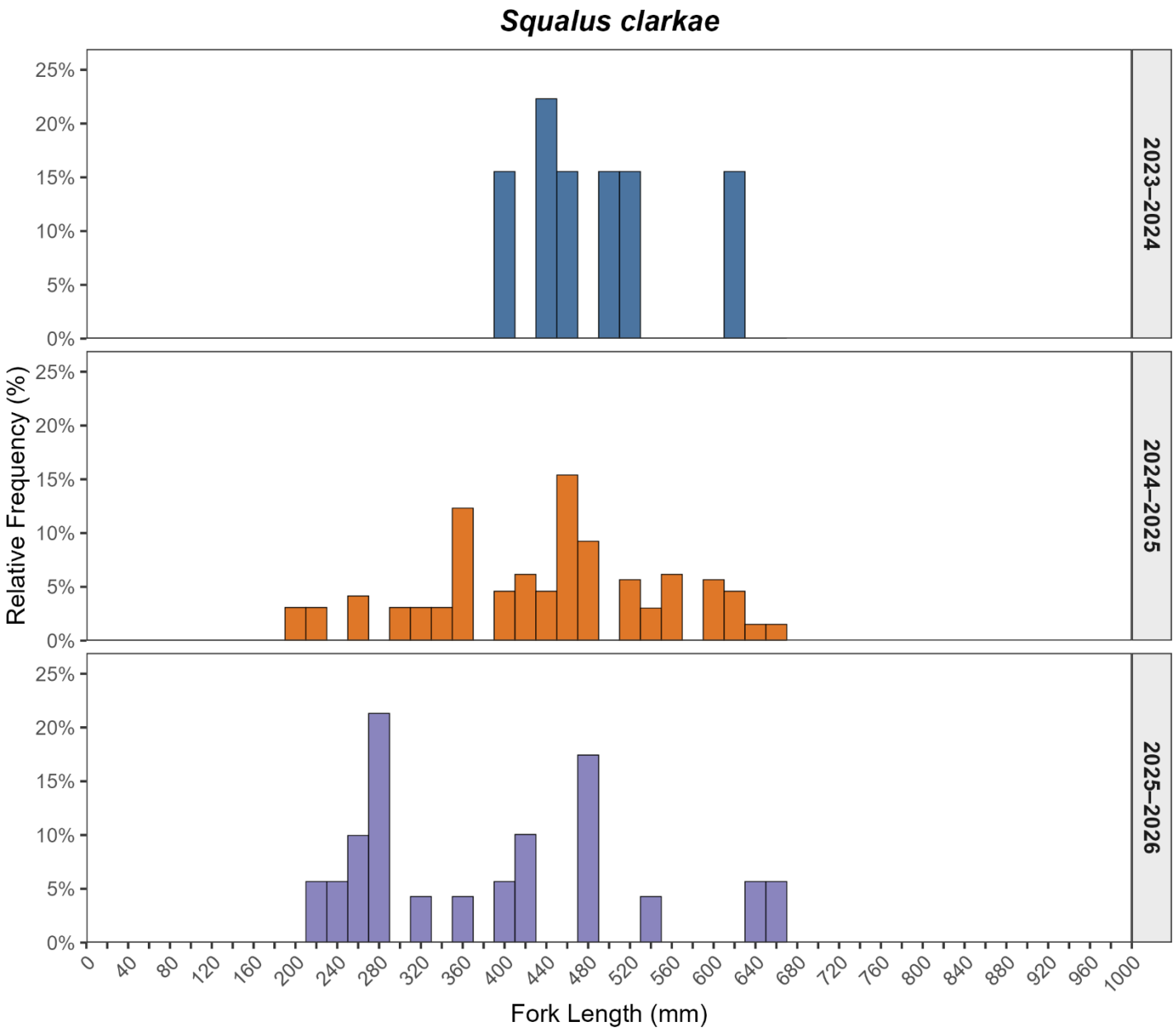

Figure 9. Relative length-frequency distribution in 20 mm bins of Genie's dogfish (*Squalus clarkae*) collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

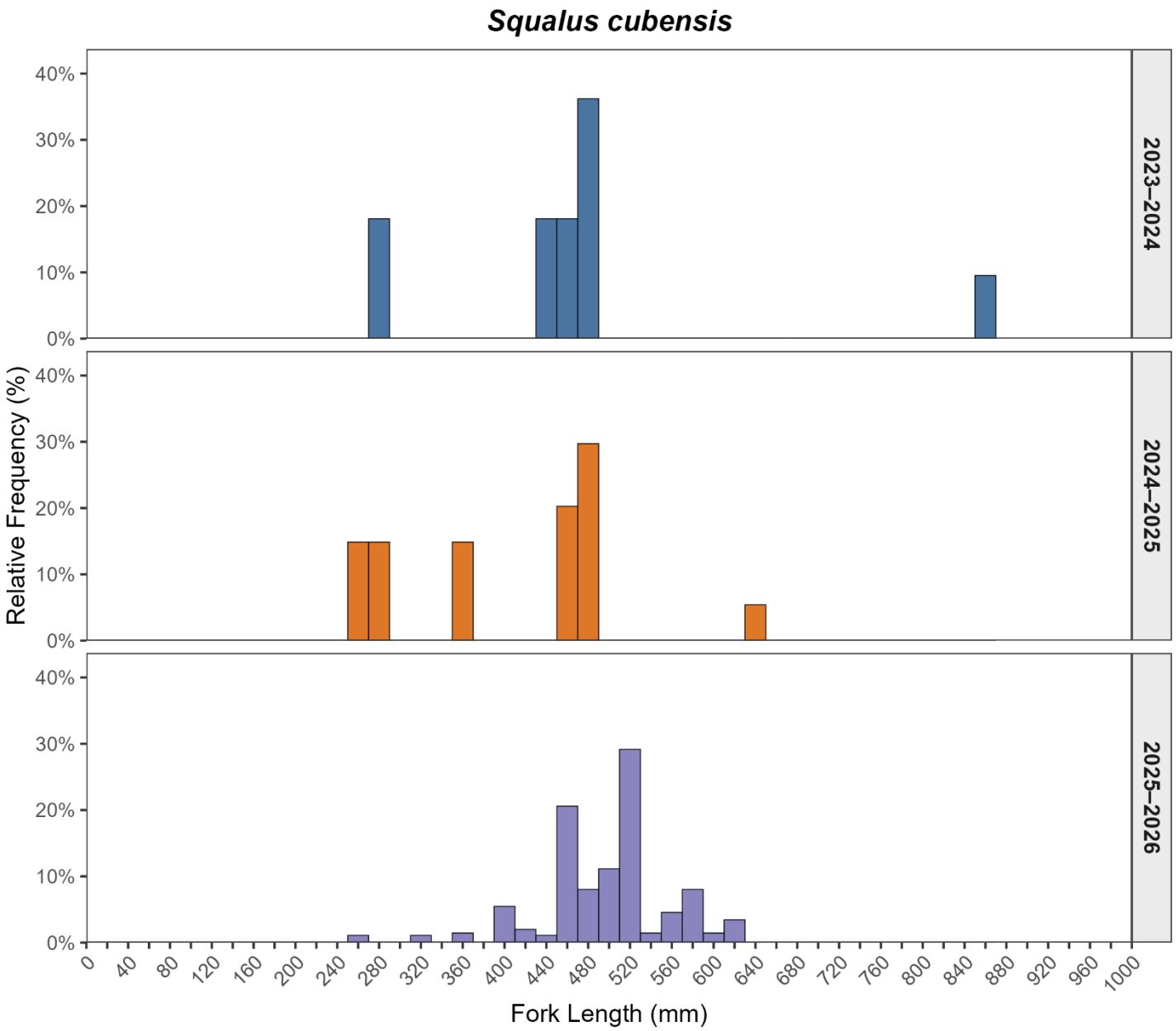

Figure 10. Relative length-frequency distribution in 20 mm bins of cuban dogfish (*Squalus cubensis*) collected during 2023 – 2024 (blue), 2024 – 2025 (orange), and 2025 – 2026 (purple).

Table 1. Initial stratification framework for the Puerto Rico Deepwater Reef Fish Survey (50 - 450 m) utilized during pilot sampling (2017 – 2018) and initial island-wide implementation (2023 – 2024). The stratification incorporates seven bathymetric depth strata (D1 - D7) and two Arc-Chord Ratio (ACR) vector rugosity strata (R1: low rugosity < 70; R2: high rugosity ≥ 70). For each stratum, the total available 500 m x 500 m grid cells (ntot), stratum weighting factor (wh), and baseline annual stations (nh).

Strat	Depstrat	Depth (m)	Vrmstrat	Avg vrm	ntot	wh	nh
S01	D1	50-80	R1	< 70	3392	0.25583	5
S02	D1	50-80	R2	≥ 70	254	0.01916	5
S03	D2	80-140	R1	< 70	620	0.04676	20
S04	D2	80-140	R2	≥ 70	217	0.01637	8
S05	D3	140-200	R1	< 70	524	0.03952	20
S06	D3	140-200	R2	≥ 70	204	0.01539	9
S07	D4	200-260	R1	< 70	1133	0.08545	23
S08	D4	200-260	R2	≥ 70	263	0.01984	8
S09	D5	260-310	R1	< 70	1098	0.08281	21
S10	D5	260-310	R2	≥ 70	268	0.02021	8
S11	D6	310-410	R1	< 70	2888	0.21781	41
S12	D6	310-410	R2	≥ 70	656	0.04948	13
S13	D7	410-450	R1	< 70	1449	0.10928	14
S14	D7	410-450	R2	≥ 70	293	0.0221	5
Total							**200**

Table 2. Stratification framework for the Puerto Rico Deepwater Reef Fish Survey showing the Top: primary 7 depth (D1 – D7; 50 – 450 m) and 3 rugosity stratum design (R1: < 2 R2: 2 - 106 R3: ≥ 106; Arc-Chord Ratio [ACR] vector rugosity strata) implemented island-wide starting in 2024 - 2025; and Bottom: supplemental shallow-water overlap stratum design (20 – 50 m) integrated during 2025 - 2026 for gear intercalibration. Detailed for each stratum are the depth bounds, Arc-Chord Ratio (ACR) vector rugosity categories, total available 500 m x 500 m grid units (ntot), stratum weighting factors (wh), and baseline annual stations (nh).

50 – 450 m							
Strat	**Depstrat**	**Depth (m)**	**Vrmstrat**	**Avg vrm**	**ntot**	**wh**	**nh**
S01	D1	50-80	R1	< 2	1572	0.11495	4
S02	D1	50-80	R2	2 - 106	1194	0.08731	4
S03	D1	50-80	R3	≥ 106	692	0.0506	7
S04	D2	80-140	R1	< 2	166	0.01214	4
S05	D2	80-140	R2	2 - 106	451	0.03298	9
S06	D2	80-140	R3	≥ 106	334	0.02442	8
S07	D3	140-200	R1	< 2	76	0.00556	4
S08	D3	140-200	R2	2 - 106	414	0.03027	9
S09	D3	140-200	R3	≥ 106	253	0.0185	5
S10	D4	200-260	R1	< 2	307	0.02245	5
S11	D4	200-260	R2	2 - 106	803	0.05872	15
S12	D4	200-260	R3	≥ 106	339	0.02479	4
S13	D5	260-310	R1	< 2	347	0.02537	4
S14	D5	260-310	R2	2 - 106	763	0.0558	20
S15	D5	260-310	R3	≥ 106	353	0.02581	6
S16	D6	310-410	R1	< 2	933	0.06823	8
S17	D6	310-410	R2	2 - 106	1936	0.14157	46
S18	D6	310-410	R3	≥ 106	898	0.06567	10
S19	D7	410-450	R1	< 2	452	0.03305	5
S20	D7	410-450	R2	2 - 106	922	0.06742	18
S21	D7	410-450	R3	≥ 106	470	0.03437	5
Total							**200**

20 - 50 m							
Strat	**Depstrat**	**Depth (m)**	**Vrmstrat**	**Avg vrm**	**ntot**	**wh**	**nh**
SH01	DS1	20-50	R1	< 2	2468	0.2699	10
SH02	DS1	20-50	R2	2 - 106	3472	0.3797	20
SH03	DS1	20-50	R3	≥ 106	3204	0.35039	20
Total							**50**

Table 3. Depth distribution summary by species across survey periods (1718: 2017 – 2018; 1822: 2018 – 2022; 2324, 2425, 2526: 2023 – 2026). Shown for each recorded taxon are the taxonomic family, scientific name, number of positive sampling sites, and species-specific minimum, average, and maximum depths (m) observed per survey period. Values in parentheses under the survey year columns for number of positive sites represent the total number of stations sampled island-wide during that survey period; values in parentheses in the depth header columns represent the overall minimum depth sampled that year and the overall maximum depth sampled, respectively.

		Number Positive Sites					Minimum Depth (m)					Average Depth (m)					Maximum Depth (m)				
Family	**Scientific Name**	**1718 (282)**	**1822 (668)**	**2324 (233)**	**242 (199)**	**2526 (237)**	**1718 (59)**	**1822 (33)**	**2324 (51)**	**2425 (42)**	**2526 (16)**	**1718**	**1822**	**2324**	**2425**	**2526**	**1718 (494)**	**1822 (640)**	**2324 (517)**	**2425 (495)**	**2526 (490)**
Acropomatidae	*Acropomatidae sp*	0	1	0	0	0	-	293	-	-	-	-	293	-	-	-	-	293	-	-	-
Alopiidae	*Alopias superciliosus*	0	0	0	0	1	-	-	-	-	233	-	-	-	-	233	-	-	-	-	233
Aulopidae	*Aulopus filamentosus*	0	2	1	0	0	-	340	343	-	-	-	343	343	-	-	-	343	343	-	-
Balistidae	*Balistes vetula*	0	0	0	1	2	-	-	-	110	28	-	-	-	110	38	-	-	-	110	38
Bramidae	*Eumegistus brevorti*	0	0	1	0	0	-	-	411	-	-	-	-	411	-	-	-	-	411	-	-
Carangidae	*Caranx crysos*	3	0	1	1	3	77	-	88	60	33	82	-	88	60	42	82	-	88	60	42
	Caranx latus	0	0	0	0	1	-	-	-	-	48	-	-	-	-	48	-	-	-	-	48
	Caranx lugubris	1	1	0	1	0	268	70	-	110	-	268	70	-	110	-	268	70	-	110	-
	Caranx ruber	0	0	0	1	1	-	-	-	54	48	-	-	-	54	48	-	-	-	54	48
	Decapterus sp	1	0	0	0	0	355	-	-	-	-	355	-	-	-	-	355	-	-	-	-
	Seriola dumerili	5	1	4	6	1	156	166	88	48	157	211	166	167	147	157	211	166	167	147	157
	Seriola fasciata	0	0	1	0	0	-	-	179	-	-	-	-	179	-	-	-	-	179	-	-
	Seriola rivoliana	2	1	2	1	2	78	183	79	77	48	117	183	121	77	127	117	183	121	77	127
	Seriola sp	0	1	0	0	0	-	254	-	-	-	-	254	-	-	-	-	254	-	-	-
Carcharhinidae	*Carcharhinus falciformis*	0	0	1	0	0	-	-	241	-	-	-	-	241	-	-	-	-	241	-	-
	Carcharhinus plumbeus	0	0	2	0	0	-	-	178	-	-	-	-	219	-	-	-	-	219	-	-
	Carcharhinus sp	1	3	1	0	1	222	132	389	-	421	222	285	389	-	421	222	285	389	-	421
Centrophoridae	*Centrophorus granulosus*	0	1	0	0	1	-	604	-	-	401	-	604	-	-	401	-	604	-	-	401
Chondrichthyes	*Chondrichthyes*	1	0	0	0	0	391	-	-	-	-	391	-	-	-	-	391	-	-	-	-
Echeneidae	*Echeneis naucrates*	1	0	0	0	0	319	-	-	-	-	319	-	-	-	-	319	-	-	-	-
	Remora remora	0	0	0	1	0	-	-	-	87	-	-	-	-	87	-	-	-	-	87	-
Epinephelidae	*Cephalopholis cruentata*	0	0	0	1	2	-	-	-	94	22	-	-	-	94	30	-	-	-	94	30
	Cephalopholis fulva	2	0	4	5	14	100	-	55	48	16	102	-	75	63	40	102	-	75	63	40
	Epinephelus guttatus	1	2	6	7	16	138	110	76	48	16	138	126	94	75	56	138	126	94	75	56
	Epinephelus morio	0	0	0	1	0	-	-	-	80	-	-	-	-	80	-	-	-	-	80	-
	Gonioplectrus hispanus	0	0	1	0	0	-	-	240	-	-	-	-	240	-	-	-	-	240	-	-
	Hyporthodus mystacinus	2	1	1	0	0	202	188	192	-	-	213	188	192	-	-	213	188	192	-	-
	Hyporthodus niveatus	0	1	0	2	1	-	269	-	263	307	-	269	-	316	307	-	269	-	316	307
Etmopteridae	*Etmopterus schultzi*	0	0	1	0	0	-	-	517	-	-	-	-	517	-	-	-	-	517	-	-
	Etmopterus sp	3	0	0	0	0	384	-	-	-	-	439	-	-	-	-	439	-	-	-	-
Ginglymostomatidae	*Ginglymostoma cirratum*	0	0	3	1	2	-	-	79	71	25	-	-	85	71	29	-	-	85	71	29
Haemulidae	*Haemulon melanurum*	0	0	0	0	1	-	-	-	-	40	-	-	-	-	40	-	-	-	-	40
	Haemulon striatum	0	0	0	1	0	-	-	-	151	-	-	-	-	151	-	-	-	-	151	-
	Pomadasys sp	1	0	0	0	0	231	-	-	-	-	231	-	-	-	-	231	-	-	-	-
	Rhonciscus pauco	0	1	0	0	1	-	254	-	-	228	-	254	-	-	228	-	254	-	-	228
Hexanchidae	*Heptranchias perlo*	0	0	3	3	3	-	-	280	369	66	-	-	368	390	281	-	-	368	390	281
	Hexanchus griseus	0	0	0	0	1	-	-	-	-	328	-	-	-	-	328	-	-	-	-	328
	Hexanchus vitulus	1	1	0	0	0	358	377	-	-	-	358	377	-	-	-	358	377	-	-	-
Holocentridae	*Holocentrus adscensionis*	0	0	1	0	0	-	-	87	-	-	-	-	87	-	-	-	-	87	-	-
	Ostichthys trachypoma	0	1	0	0	0	-	408	-	-	-	-	408	-	-	-	-	408	-	-	-
Latilidae	*Caulolatilus bermudensis*	0	1	0	0	1	-	205	-	-	275	-	205	-	-	275	-	205	-	-	275
	Caulolatilus chrysops	0	0	1	0	0	-	-	196	-	-	-	-	196	-	-	-	-	196	-	-
	Caulolatilus cyanops	0	0	3	2	0	-	-	182	178	-	-	-	217	191	-	-	-	217	191	-
	Caulolatilus dooleyi	0	1	0	0	0	-	194	-	-	-	-	194	-	-	-	-	194	-	-	-
	Caulolatilus sp	6	0	0	0	0	60	-	-	-	-	192	-	-	-	-	192	-	-	-	-
	Caulolatilus williamsi	0	3	0	0	1	-	121	-	-	106	-	276	-	-	106	-	276	-	-	106
Lutjanidae	*Apsilus dentatus*	0	1	0	0	2	-	139	-	-	106	-	139	-	-	164	-	139	-	-	164
	Etelis oculatus	54	106	27	19	17	148	101	244	42	203	306	315	327	329	326	306	315	327	329	326
	Lutjanus analis	0	0	0	0	1	-	-	-	-	47	-	-	-	-	47	-	-	-	-	47
	Lutjanus apodus	0	0	0	0	1	-	-	-	-	24	-	-	-	-	24	-	-	-	-	24
	Lutjanus buccanella	9	11	12	7	8	96	77	70	71	38	125	137	126	123	100	125	137	126	123	100
	Lutjanus vivanus	78	108	76	34	37	84	90	55	77	90	202	208	182	202	195	202	208	182	202	195
	Ocyurus chrysurus	0	0	0	0	5	-	-	-	-	16	-	-	-	-	30	-	-	-	-	30
	Pristipomoides aquilonaris	16	37	29	23	24	174	165	129	187	180	285	276	289	309	294	285	276	289	309	294
	Pristipomoides macrophthalmus	34	146	37	19	29	200	33	124	61	113	309	310	316	287	307	309	310	316	287	307
	Pristipomoides sp	48	0	0	0	0	157	-	-	-	-	271	-	-	-	-	271	-	-	-	-
	Rhomboplites aurorubens	23	24	12	8	13	60	120	85	103	48	187	194	191	190	176	187	194	191	190	176

Table 3 cont. Depth distribution summary by species across survey periods (1718: 2017 – 2018; 1822: 2018 – 2022; 2324, 2425, 2526: 2023 – 2026). Shown for each recorded taxon are the taxonomic family, scientific name, number of positive sampling sites, and species-specific minimum, average, and maximum depths (m) observed per survey period. Values in parentheses under the survey year columns for number of positive sites represent the total number of stations sampled island-wide during that survey period; values in parentheses in the depth header columns represent the overall minimum depth sampled that year and the overall maximum depth sampled, respectively.

		Number Positive Sites					Minimum Depth (m)					Average Depth (m)					Maximum Depth (m)				
Family	**Scientific Name**	**1718 (282)**	**1822 (668)**	**2324 (233)**	**242 (199)**	**2526 (237)**	**1718 (59)**	**1822 (33)**	**2324 (51)**	**2425 (42)**	**2526 (16)**	**1718**	**1822**	**2324**	**2425**	**2526**	**1718 (494)**	**1822 (640)**	**2324 (517)**	**2425 (495)**	**2526 (490)**
Malacanthidae	*Malacanthus plumieri*	0	0	3	3	1	-	-	78	48	43	-	-	91	71	43	-	-	91	71	43
Malakichthyidae	*Verilus atlanticus*	0	1	0	0	0	-	271	-	-	-	-	271	-	-	-	-	271	-	-	-
	Verilus sordidus	0	2	0	0	0	-	293	-	-	-	-	311	-	-	-	-	311	-	-	-
Muraenidae	*Anarchias similis*	0	2	0	0	0	-	214	-	-	-	-	284	-	-	-	-	284	-	-	-
	Gymnothorax maderensis	0	1	0	0	0	-	329	-	-	-	-	329	-	-	-	-	329	-	-	-
	Gymnothorax moringa	0	0	0	0	1	-	-	-	-	25	-	-	-	-	25	-	-	-	-	25
	Gymnothorax ocellatus	0	0	1	0	0	-	-	293	-	-	-	-	293	-	-	-	-	293	-	-
	Gymnothorax polygonius	0	0	0	3	0	-	-	-	235	-	-	-	-	254	-	-	-	-	254	-
	Muraena retifera	0	0	1	0	0	-	-	203	-	-	-	-	203	-	-	-	-	203	-	-
Ophichthidae	*Ophichthus spinicauda*	0	8	0	2	2	-	254	-	300	298	-	346	-	353	366	-	346	-	353	366
Polymixiidae	*Polymixia lowei*	0	3	1	0	0	-	287	505	-	-	-	341	505	-	-	-	341	505	-	-
	Polymixia nobilis	0	2	2	1	2	-	404	407	409	338	-	412	437	409	414	-	412	437	409	414
	Polymixia sp	11	2	0	2	0	229	379	-	327	-	360	385	-	377	-	360	385	-	377	-
Priacanthidae	*Cookeolus japonicus*	1	2	1	2	0	221	260	279	258	-	221	310	279	279	-	221	310	279	279	-
Scombropidae	*Scombrops oculatus*	2	1	0	0	0	319	349	-	-	-	338	349	-	-	-	338	349	-	-	-
Scorpaenidae	*Pontinus sp*	2	0	0	0	0	407	-	-	-	-	430	-	-	-	-	430	-	-	-	-
	Pterois volitans	0	1	0	0	0	-	109	-	-	-	-	109	-	-	-	-	109	-	-	-
Scyliorhinidae	*Galeus antillensis*	0	0	1	0	1	-	-	417	-	66	-	-	417	-	66	-	-	417	-	66
	Scyliorhinus torrei	0	2	3	2	0	-	347	429	300	-	-	471	486	326	-	-	471	486	326	-
Serranidae	*Centropristis fuscula*	0	0	0	0	1	-	-	-	-	38	-	-	-	-	38	-	-	-	-	38
	Serranus notospilus	1	1	2	3	0	178	188	174	166	-	178	188	189	188	-	178	188	189	188	-
	Serranus phoebe	0	1	1	1	0	-	131	178	71	-	-	131	178	71	-	-	131	178	71	-
Sphyraenidae	*Sphyraena barracuda*	0	0	0	1	0	-	-	-	103	-	-	-	-	103	-	-	-	-	103	-
Squalidae	*Squalus clarkae*	0	19	7	13	6	-	346	308	345	300	-	420	401	401	384	-	420	401	401	384
	Squalus cubensis	0	1	8	3	14	-	377	405	393	66	-	377	463	406	384	-	377	463	406	384
	Squalus sp	32	27	6	0	0	339	329	344	-	-	423	415	417	-	-	423	415	417	-	-
Synagropidae	*Caraibops trispinosus*	0	1	0	0	0	-	311	-	-	-	-	311	-	-	-	-	311	-	-	-
Synodontidae	*Saurida caribbaea*	0	0	1	0	0	-	-	333	-	-	-	-	333	-	-	-	-	333	-	-
	Saurida normani	0	2	1	0	0	-	327	282	-	-	-	340	282	-	-	-	340	282	-	-
	Synodus sp	0	1	0	0	0	-	183	-	-	-	-	183	-	-	-	-	183	-	-	-
Tetraodontidae	*Sphoeroides pachygaster*	0	0	0	2	0	-	-	-	219	-	-	-	-	227	-	-	-	-	227	-
Triakidae	*Mustelus canis*	0	2	5	15	3	-	240	277	312	247	-	325	375	377	330	-	325	375	377	330
	Mustelus sp	12	4	0	0	0	183	330	-	-	-	309	402	-	-	-	309	402	-	-	-

Table 4. Summary of positive station occurrences, total catch counts, and minimum and maximum fork lengths (FL, mm) by species across survey years (2017 – 2026). Values in parentheses under the survey year headers indicate the total number of stations sampled in that year.

		Number of Positive Sites					Number of Fish					Min FL (mm)					Max FL (mm)				
Family	Scientific Name	1718 (282)	1822 (668)	2324 (233)	2425 (199)	2526 (237)	1718	1822	2324	2425	2526	1718	1822	2324	2425	2526	1718	1822	2324	2425	2526
Acropomatidae	*Acropomatidae sp*	0	1	0	0	0	-	1	-	-	-	-	215	-	-	-	-	215	-	-	-
Aulopidae	*Aulopus filamentosus*	0	2	1	0	0	-	2	1	-	-	-	259	242	-	-	-	269	242	-	-
Balistidae	*Balistes vetula*	0	0	0	1	2	-	-	-	1	3	-	-	-	370	350	-	-	-	370	356
Bramidae	*Eumegistus brevorti*	0	0	1	0	0	-	-	1	-	-	-	-	385	-	-	-	-	385	-	-
Carangidae	*Caranx crysos*	3	0	1	1	3	10	-	4	1	11	200	-	255	298	260	380	-	360	298	330
	Caranx latus	0	0	0	0	1	-	-	-	-	1	-	-	-	-	540	-	-	-	-	540
	Caranx lugubris	1	1	0	1	0	1	1	-	2	-	460	460	-	371	-	460	460	-	372	-
	Caranx ruber	0	0	0	1	1	-	-	-	1	4	-	-	-	340	420	-	-	-	340	440
	Decapterus sp	1	0	0	0	0	1	-	-	-	-	370	-	-	-	-	370	-	-	-	-
	Seriola dumerili	3	1	3	6	1	4	1	5	6	2	270	290	554	360	430	1140	290	825	963	630
	Seriola fasciata	0	0	1	0	0	-	-	1	-	-	-	-	327	-	-	-	-	327	-	-
	Seriola rivoliana	2	1	2	1	2	2	1	2	1	4	310	484	380	290	265	330	484	400	290	420
	Seriola sp	0	1	0	0	0	-	1	-	-	-	-	420	-	-	-	-	420	-	-	-
Carcharhinidae	*Carcharhinus falciformis*	0	0	1	0	0	-	-	1	-	-	-	-	725	-	-	-	-	725	-	-
	Carcharhinus plumbeus	0	0	2	0	0	-	-	2	-	-	-	-	777	-	-	-	-	805	-	-
	Carcharhinus sp	1	3	1	0	1	1	3	1	-	1	920	730	902	-	307	920	822	902	-	307
Centrophoridae	*Centrophorus granulosus*	0	1	0	0	1	-	1	-	-	1	-	90	-	-	472	-	90	-	-	472
Chondrichthyes	*Chondrichthyes*	1	0	0	0	0	1	-	-	-	-	470	-	-	-	-	470	-	-	-	-
Echeneidae	*Echeneis naucrates*	1	0	0	0	0	1	-	-	-	-	790	-	-	-	-	790	-	-	-	-
	Remora remora	0	0	0	1	0	-	-	-	1	-	-	-	-	508	-	-	-	-	508	-
Epinephelidae	*Cephalopholis cruentata*	0	0	0	1	2	-	-	-	1	2	-	-	-	220	170	-	-	-	220	267
	Cephalopholis fulva	2	0	4	5	14	2	-	5	15	23	240	-	245	212	185	260	-	342	308	289
	Epinephelus guttatus	1	2	6	7	16	1	2	10	15	29	270	205	265	225	230	270	383	411	460	470
	Epinephelus morio	0	0	0	1	0	-	-	-	1	-	-	-	-	680	-	-	-	-	680	-
	Gonioplectrus hispanus	0	0	1	0	0	-	-	1	-	-	-	-	264	-	-	-	-	264	-	-
	Hyporthodus mystacinus	2	1	1	0	0	3	1	1	-	-	460	465	372	-	-	750	465	372	-	-
	Hyporthodus niveatus	0	1	0	2	1	-	1	-	2	1	-	280	-	392	460	-	280	-	771	460
Etmopteridae	*Etmopterus schultzi*	0	0	1	0	0	-	-	2	-	-	-	-	220	-	-	-	-	280	-	-
	Etmopterus sp	3	0	0	0	0	4	-	-	-	-	180	-	-	-	-	240	-	-	-	-
Ginglymostomatidae	*Ginglymostoma cirratum*	0	0	3	1	2	-	-	3	1	2	-	-	1500	1219	1219	-	-	2438	1219	2000
Haemulidae	*Haemulon melanurum*	0	0	0	0	1	-	-	-	-	1	-	-	-	-	240	-	-	-	-	240
	Haemulon striatum	0	0	0	1	0	-	-	-	1	-	-	-	-	180	-	-	-	-	180	-
	Pomadasys sp	1	0	0	0	0	1	-	-	-	-	280	-	-	-	-	280	-	-	-	-
	Rhonciscus pauco	0	1	0	0	1	-	1	-	-	1	-	285	-	-	227	-	285	-	-	227
Hexanchidae	*Heptranchias perlo*	0	0	3	3	3	-	-	4	3	3	-	-	381	690	452	-	-	668	824	644
	Hexanchus griseus	0	0	0	0	1	-	-	-	-	1	-	-	-	-	462	-	-	-	-	462
	Hexanchus vitulus	1	1	0	0	0	1	1	-	-	-	560	530	-	-	-	560	530	-	-	-
Holocentridae	*Holocentrus adscensionis*	0	0	1	0	0	-	-	1	-	-	-	-	227	-	-	-	-	227	-	-
	Ostichthys trachypoma	0	1	0	0	0	-	1	-	-	-	-	180	-	-	-	-	180	-	-	-
Latilidae	*Caulolatilus bermudensis*	0	1	0	0	1	-	1	-	-	1	-	390	-	-	270	-	390	-	-	270
	Caulolatilus chrysops	0	0	1	0	0	-	-	1	-	-	-	-	340	-	-	-	-	340	-	-
	Caulolatilus cyanops	0	0	3	2	0	-	-	3	2	-	-	-	281	290	-	-	-	334	291	-
	Caulolatilus dooleyi	0	1	0	0	0	-	1	-	-	-	-	325	-	-	-	-	325	-	-	-
	Caulolatilus sp	6	0	0	0	0	7	-	-	-	-	240	-	-	-	-	330	-	-	-	-
	Caulolatilus williamsi	0	3	0	0	1	-	3	-	-	1	-	250	-	-	340	-	350	-	-	340
Lutjanidae	*Apsilus dentatus*	0	1	0	0	2	-	1	-	-	2	-	501	-	-	310	-	501	-	-	520
	Etelis oculatus	54	106	27	19	17	107	165	44	31	29	230	200	240	232	170	650	829	721	700	603
	Lutjanus analis	0	0	0	0	1	-	-	-	-	1	-	-	-	-	366	-	-	-	-	366
	Lutjanus apodus	0	0	0	0	1	-	-	-	-	1	-	-	-	-	350	-	-	-	-	350
	Lutjanus buccanella	9	11	12	7	8	20	13	28	9	35	200	220	208	237	220	350	440	484	480	502
	Lutjanus vivanus	77	104	75	34	37	176	188	177	98	115	170	192	185	162	120	480	470	562	478	690
	Ocyurus chrysurus	0	0	0	0	5	-	-	-	-	7	-	-	-	-	165	-	-	-	-	301
	Pristipomoides aquilonaris	16	37	29	23	24	45	75	76	64	64	160	135	140	170	110	260	370	235	512	298
	Pristipomoides macrophthalmus	34	146	37	19	29	108	307	55	45	54	170	140	201	171	161	440	480	445	435	445
	Pristipomoides sp	48	0	0	0	0	115	-	-	-	-	140	-	-	-	-	450	-	-	-	-
	Rhomboplites aurorubens	23	24	12	8	13	57	52	17	16	36	150	180	198	213	200	290	340	344	334	318

Table 4 cont. Summary of positive station occurrences, total catch counts, and minimum and maximum fork lengths (FL, mm) by species across survey years (2017 – 2026). Values in parentheses under the survey year headers indicate the total number of stations sampled in that year.

		Number of Positive Sites					Number of Fish					Min FL (mm)					Max FL (mm)				
Family	**Scientific Name**	**1718 (282)**	**1822 (668)**	**2324 (233)**	**2425 (199)**	**2526 (237)**	**1718**	**1822**	**2324**	**2425**	**2526**	**1718**	**1822**	**2324**	**2425**	**2526**	**1718**	**1822**	**2324**	**2425**	**2526**
Malacanthidae	*Malacanthus plumieri*	0	0	3	3	1	-	-	4	3	1	-	-	349	161	270	-	-	463	410	270
Malakichthyidae	*Verilus atlanticus*	0	1	0	0	0	-	2	-	-	-	-	250	-	-	-	-	260	-	-	-
	Verilus sordidus	0	2	0	0	0	-	5	-	-	-	-	272	-	-	-	-	340	-	-	-
Muraenidae	*Anarchias similis*	0	2	0	0	0	-	2	-	-	-	-	565	-	-	-	-	850	-	-	-
	Gymnothorax maderensis	0	1	0	0	0	-	3	-	-	-	-	530	-	-	-	-	705	-	-	-
	Gymnothorax moringa	0	0	0	0	1	-	-	-	-	1	-	-	-	-	508	-	-	-	-	508
	Gymnothorax ocellatus	0	0	1	0	0	-	-	1	-	-	-	-	640	-	-	-	-	640	-	-
	Gymnothorax polygonius	0	0	0	3	0	-	-	-	4	-	-	-	-	514	-	-	-	-	814	-
	Muraena retifera	0	0	1	0	0	-	-	1	-	-	-	-	590	-	-	-	-	590	-	-
Ophichthidae	*Ophichthus spinicauda*	0	7	0	2	1	-	11	-	2	1	-	380	-	692	1000	-	3000	-	830	1000
Polymixiidae	*Polymixia lowei*	0	3	1	0	0	-	5	1	-	-	-	150	285	-	-	-	340	285	-	-
	Polymixia nobilis	0	1	2	1	2	-	2	2	1	2	-	180	180	130	160	-	200	252	130	180
	Polymixia sp	11	2	0	2	0	14	2	-	2	-	140	140	-	145	-	320	201	-	235	-
Priacanthidae	*Cookeolus japonicus*	1	2	1	2	0	1	3	2	2	-	350	413	450	368	-	350	461	490	521	-
Scombropidae	*Scombrops oculatus*	2	1	0	0	0	2	1	-	-	-	310	290	-	-	-	700	290	-	-	-
Scorpaenidae	*Pontinus sp*	1	0	0	0	0	1	-	-	-	-	280	-	-	-	-	280	-	-	-	-
Scyliorhinidae	*Galeus antillensis*	0	0	1	0	1	-	-	1	-	1	-	-	291	-	302	-	-	291	-	302
	Scyliorhinus torrei	0	1	3	2	0	-	1	3	3	-	-	420	380	392	-	-	420	480	423	-
Serranidae	*Centropristis fuscula*	0	0	0	0	1	-	-	-	-	1	-	-	-	-	235	-	-	-	-	235
	Serranus notospilus	1	1	2	3	0	1	1	2	3	-	200	207	175	191	-	200	207	200	202	-
	Serranus phoebe	0	1	1	1	0	-	1	1	1	-	-	183	191	324	-	-	183	191	324	-
Sphyraenidae	*Sphyraena barracuda*	0	0	0	1	0	-	-	-	1	-	-	-	-	900	-	-	-	-	900	-
Squalidae	*Squalus clarkae*	0	17	6	13	6	-	41	7	36	18	-	240	402	208	221	-	690	620	678	673
	Squalus cubensis	0	1	8	3	14	-	1	14	8	36	-	610	292	264	261	-	610	862	650	631
	Squalus sp	23	24	5	0	0	72	46	14	-	-	230	214	245	-	-	680	660	660	-	-
Synagropidae	*Caraibops trispinosus*	0	1	0	0	0	-	1	-	-	-	-	310	-	-	-	-	310	-	-	-
Synodontidae	*Saurida caribbaea*	0	0	1	0	0	-	-	1	-	-	-	-	360	-	-	-	-	360	-	-
	Saurida normani	0	2	1	0	0	-	2	1	-	-	-	360	248	-	-	-	390	248	-	-
	Synodus sp	0	1	0	0	0	-	2	-	-	-	-	332	-	-	-	-	407	-	-	-
Tetraodontidae	*Sphoeroides pachygaster*	0	0	0	1	0	-	-	-	1	-	-	-	-	186	-	-	-	-	186	-
Triakidae	*Mustelus canis*	0	2	5	14	3	-	2	6	18	4	-	730	580	400	441	-	730	882	850	900
	Mustelus sp	11	3	0	0	0	13	5	-	-	-	450	430	-	-	-	830	680	-	-	-

Table 5. Stratum-weighted annual frequency of occurrence (P), composite mean occurrence ($\bar{P}$), and standard error ($SE_{\bar{P}}$) across sampling periods (2017–2018 regional pilot survey and 2023–2026 island-wide surveys) for target deepwater reef fish species in Puerto Rico.

	Annual Occurrence (P)					
Species	**1718**	**2324**	**2425**	**2526**	$\bar{P}$	$SE_{\bar{P}}$
Lutjanus vivanus	0.141804899	0.201290537	0.131080045	0.115595142	0.147442656	0.018695311
Etelis oculatus	0.170162338	0.120982661	0.064549778	0.063976276	0.104917764	0.018682945
Pristipomoides macrophthalmus	0.075198724	0.146274184	0.067296443	0.116075683	0.101211258	0.018119483
Pristipomoides aquilonaris	0.040273785	0.100306385	0.099265099	0.097859905	0.084426293	0.017637318
Rhomboplites aurorubens	0.092135298	0.029375165	0.02314526	0.029131442	0.043446792	0.019951153
Squalus cubensis	0	0.025527988	0.014287604	0.129023371	0.042209741	0.024668548
Epinephelus guttatus	0.003245676	0.049488523	0.038989234	0.0554035	0.036781733	0.022049931
Squalus clarkae	0	0.044630828	0.062128933	0.0317639	0.034630915	0.012623513
Squalus sp	0.104291653	0.031797567	0	0	0.034022305	0.011345053
Lutjanus buccanella	0.02089238	0.040059351	0.030038631	0.031684948	0.030668828	0.010548449
Seriola dumerili	0.009489055	0.012445575	0.075754908	0.002055657	0.024936299	0.029479755
Mustelus canis	0	0.016052435	0.063597376	0.01138195	0.02275794	0.009464918
Pristipomoides sp	0.086420685	0	0	0	0.021605171	0.007536557
Cephalopholis fulva	0.007152701	0.047303677	0.025699777	0.006145643	0.021575449	0.019007008
Heptranchias perlo	0	0.015672876	0.014287604	0.053896967	0.020964362	0.023091697
Caranx crysos	0.050393756	0.001823279	0.014552102	0.016422042	0.020797795	0.020901006
Ginglymostoma cirratum	0	0.010317286	0.057477148	0	0.016948609	0.028936813
Polymixia sp	0.048189678	0	0.009141475	0	0.014332788	0.008321856
Galeus antillensis	0	0.007239488	0	0.043656307	0.012723949	0.022105212
Malacanthus plumieri	0	0.037478367	0.01086167	0.002023157	0.012590798	0.016778214
Seriola rivoliana	0.016562201	0.008222048	0.014552102	0.002936015	0.010568092	0.011089231
Caulolatilus sp	0.026555357	0	0	0	0.006638839	0.008438839
Ophichthus spinicauda	0	0	0.014307707	0.009978585	0.006071573	0.006819019
Mustelus sp	0.022051761	0	0	0	0.00551294	0.003732805
Serranus notospilus	0.00155306	0.005073984	0.009659489	0	0.004071633	0.003427515
Polymixia nobilis	0	0.00528287	0.00469052	0.00469052	0.003665977	0.004208276
Scyliorhinus torrei	0	0.007239488	0.005948767	0	0.003297064	0.0041576
Caulolatilus cyanops	0	0.008431428	0.004651635	0	0.003270766	0.003004365
Carcharhinus sp	0.003510055	0.003809524	0	0.004815879	0.003033864	0.003504933
Serranus phoebe	0	0.00171654	0.008433882	0	0.002537605	0.004281782
Cookeolus japonicus	0.000798294	0.003150518	0.006143696	0	0.002523127	0.00268021
Gymnothorax polygonius	0	0	0.009405934	0	0.002351484	0.002686237
Apsilus dentatus	0	0	0	0.009204753	0.002301188	0.003398992
Etmopterus sp	0.009190708	0	0	0	0.002297677	0.003726438
Hyporthodus niveatus	0	0	0.005948767	0.003099736	0.002262126	0.002580865
Caranx ruber	0	0	0.008433882	0	0.00210847	0.00419862
Scombrops oculatus	0.007700225	0	0	0	0.001925056	0.003012276
Eumegistus brevorti	0	0.007239488	0	0	0.001809872	0.003601416
Sphoeroides pachygaster	0	0	0.006524477	0	0.001631119	0.002212653
Caulolatilus williamsi	0	0	0	0.006106033	0.001526508	0.00303468
Chondrichthyes	0.005749005	0	0	0	0.001437251	0.002856163
Decapterus sp	0.005749005	0	0	0	0.001437251	0.002856163
Hexanchus vitulus	0.005749005	0	0	0	0.001437251	0.002856163
Saurida caribbaea	0	0.00528287	0	0	0.001320717	0.00262309
Caulolatilus bermudensis	0	0	0	0.005162706	0.001290676	0.002563006
Centrophorus granulosus	0	0	0	0.00469052	0.00117263	0.002326907
Hexanchus griseus	0	0	0	0.00469052	0.00117263	0.002326907
Cephalopholis cruentata	0	0	0.002427788	0.002023157	0.001112736	0.001554175
Epinephelus morio	0	0	0.002427788	0.002023157	0.001112736	0.001554175
Sphyraena barracuda	0	0	0.002427788	0.002023157	0.001112736	0.001554175

Table 5 cont. Stratum-weighted annual frequency of occurrence (P), composite mean occurrence ($\bar{P}$), and standard error ($SE_{\bar{P}}$) across sampling periods (2017–2018 regional pilot survey and 2023–2026 island-wide surveys) for target deepwater reef fish species in Puerto Rico.

	Annual Occurrence (P)					
Species	**1718**	**2324**	**2425**	**2526**	$\bar{P}$	$SE_{\bar{P}}$
Carcharhinus plumbeus	0	0.003957334	0	0	0.000989334	0.001385486
Aulopus filamentosus	0	0.003809524	0	0	0.000952381	0.001886392
Caranx lugubris	0.001081763	0	0.002713792	0	0.000948889	0.001436778
Haemulon striatum	0	0	0.003700183	0	0.000925046	0.001831719
Carcharhinus falciformis	0	0.003357444	0	0	0.000839361	0.00166034
Gonioplectrus hispanus	0	0.003357444	0	0	0.000839361	0.00166034
Muraena retifera	0	0.003357444	0	0	0.000839361	0.00166034
Hyporthodus mystacinus	0.001596587	0.00171654	0	0	0.000828282	0.000993189
Alopias superciliosus	0	0	0	0.002936015	0.000734004	0.001449611
Rhonciscus pauco	0	0	0	0.002936015	0.000734004	0.001449611
Balistes vetula	0	0	0.002713792	0	0.000678448	0.00133849
Remora remora	0	0	0.002713792	0	0.000678448	0.00133849
Gymnothorax ocellatus	0	0.002240794	0	0	0.000560199	0.001101964
Saurida normani	0	0.002240794	0	0	0.000560199	0.001101964
Echeneis naucrates	0.00195122	0	0	0	0.000487805	0.000957154
Pontinus sp	0.00195122	0	0	0	0.000487805	0.000957154
Holocentrus adscensionis	0	0.001823279	0	0	0.00045582	0.000893171
Caulolatilus chrysops	0	0.001551319	0	0	0.00038783	0.000757157
Seriola fasciata	0	0.001551319	0	0	0.00038783	0.000757157
Pomadasys sp	0.000798294	0	0	0	0.000199573	0.000380426

Table 6. Proportion of positive stations (Occurrence, *P*) and stratum weighted Catch-Per-Unit-Effort (CPUE) with Standard Error (SE) and Coefficient of Variation (CV, %) for nine primary deepwater species.

	Occurrence, 2324		Occurrence, 2425		Occurrence, 2526		CPUE, 2324			CPUE, 2425			CPUE, 2526		
Species	**Mean (SE)**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**CV (%)**	**Mean**	**SE**	**CV (%)**	**Mean**	**SE**	**CV (%)**
Epinephelus guttatus	0.049	0.033	0.039	0.018	0.055	0.022	0.094	0.066	70.6	0.049	0.022	44.3	0.142	0.069	48.7
Etelis oculatus	0.121	0.021	0.065	0.014	0.064	0.014	0.207	0.046	22.2	0.104	0.025	24.4	0.107	0.027	25.3
Lutjanus buccanella	0.040	0.012	0.030	0.013	0.032	0.009	0.089	0.029	32.8	0.041	0.020	48.3	0.156	0.095	61.0
Lutjanus vivanus	0.201	0.019	0.131	0.023	0.116	0.016	0.457	0.059	12.9	0.383	0.093	24.3	0.344	0.073	21.3
Pristipomoides aquilonaris	0.100	0.017	0.099	0.022	0.098	0.017	0.265	0.056	21.2	0.233	0.067	28.7	0.270	0.060	22.2
Pristipomoides macropthalmus	0.146	0.022	0.067	0.016	0.116	0.018	0.221	0.037	16.6	0.155	0.043	27.6	0.222	0.046	20.9
Rhombolplites aurorubens	0.029	0.008	0.023	0.008	0.029	0.008	0.039	0.011	29.4	0.046	0.021	46.2	0.082	0.032	39.6
Squalus clarkae	0.045	0.014	0.062	0.016	0.032	0.013	0.052	0.018	35.1	0.199	0.074	37.2	0.085	0.044	51.9
Squalus cubensis	0.026	0.012	0.014	0.009	0.129	0.047	0.040	0.023	57.2	0.056	0.050	89.1	0.332	0.144	43.3

Table 7. Stratified population mean length ($\bar{L}$, mm), standard error ($SE_{\bar{L}}$) and coefficient of variation ($CV_{\bar{L}}$) for six primary target deepwater snapper species derived from the survey (2023 - 2026). Note: Red hind (*Epinephelus guttatus*) was omitted due to limited sampling years in shallow-water strata (20 - 50 m), and elasmobranchs (*Squalus clarkae, Squalus cubensis*) were excluded.

Species	$\bar{L}$	SE	CV
Etelis oculatus	381.636746	17.5838128	4.60747372
Lutjanus buccanella	324.224407	6.3808457	1.96803373
Lutjanus vivanus	325.589534	10.1869273	3.12876374
Pristipomoides aquilonaris	220.288072	34.3712517	15.6028655
Pristipomoides macrophthalmus	293.439849	9.08584612	3.0963232
Rhomboplites aurorubens	256.982496	3.95427567	1.53873346

Family	Common Family	Scientific Name	Common Name	Species Code
Acropomatidae	Lanternbellies	Acropomatidae sp	Lanternbelly sp	ACRO
Alopiidae	Thresher Sharks	Alopias superciliosus	bigeye thresher	ALSU
Aulopidae	-	Aulopus filamentosus	royal flagfin	AUFI
Balistidae	Triggerfishes	Balistes vetula	queen triggerfish	BAVE
Bramidae	Pomfrets	Eumegistus brevorti	-	EUIL
Carangidae	Jacks	Caranx crysos	blue runner	CACR
		Caranx latus	horse-eye jack	CALA
		Caranx lugubris	black jack	CALU
		Caranx ruber	bar jack	CARU
		Decapterus sp	scad sp	DESP
		Seriola dumerili	greater amberjack	SEDU
		Seriola fasciata	lesser amberjack	SEFA
		Seriola rivoliana	almaco jack	SERI
		Seriola sp	amberjack sp	SESP
Carcharhinidae	Requiem Sharks	Carcharhinus falciformis	silky shark	CAFA
		Carcharhinus plumbeus	sandbar shark	CAPL
		Carcharhinus sp	requiem shark sp	CASP
Centrophoridae	Gulper Sharks	Centrophorus granulosus	gulper shark	CEGR
Chondrichthyes	Sharks	Chondrichthyes	shark sp	CHON
Echeneidae	Remoras	Echeneis naucrates	sharksucker	ECNA
		Remora remora	remora	RERE
Epinephelidae	Groupers	Cephalopholis cruentata	graysby	CECR
		Cephalopholis fulva	coney	CEFU
		Epinephelus guttatus	red hind	EPGU
		Epinephelus morio	red grouper	EPMO
		Gonioplectrus hispanus	Spanish flag	GOHI
		Hyporthodus mystacinus	misty grouper	HYMY
		Hyporthodus niveatus	snowy grouper	HYNV
Etmopteridae	Lantern Sharks	Etmopterus schultzi	fringefin lanternshark	ETSC
		Etmopterus sp	lantern shark sp	ETSP
Ginglymostomatidae	Nurse Sharks	Ginglymostoma cirratum	nurse shark	GICI
Haemulidae	Grunts	Haemulon melanurum	cottonwick	HAME
		Haemulon striatum	striped grunt	HAST
		Pomadasys sp	grunt sp	POMS
		Rhonciscus pauco	opalescent grunt	RHPA
Hexanchidae	Cow Sharks	Heptranchias perlo	sharpnose sevengill shark	HEPE
		Hexanchus griseus	bluntnose sixgill shark	HEGR
		Hexanchus vitulus	bigeye sixgill shark	HEVI
Holocentridae	Squirrelfishes	Holocentrus adscensionis	squirrelfish	HOAD
		Ostichthys trachypoma	bigeye soldierfish	OSTR
Latilidae	Deepwater Tilefishes	Caulolatilus bermudensis	Bermuda tilefish	CABE
		Caulolatilus chrysops	Atlantic goldeneye tilefish	CACH
		Caulolatilus cyanops	blackline tilefish	CACY
		Caulolatilus dooleyi	bankslope tilefish	CADO
		Caulolatilus sp	Deepwater tilefish sp	CAUS
		Caulolatilus williamsi	yellowbar tilefish	CAWI
Lutjanidae	Snappers	Apsilus dentatus	black snapper	APDE
		Etelis oculatus	queen snapper	ETOC
		Lutjanus analis	mutton snapper	LUAN
		Lutjanus apodus	schoolmaster	LUAP
		Lutjanus buccanella	blackfin snapper	LUBU
		Lutjanus vivanus	silk snapper	LUVI
		Ocyurus chrysurus	yellowtail snapper	OCCH
		Pristipomoides aquilonaris	wenchman	PRAQ
		Pristipomoides macrophthalmus	cardinal snapper	PRMA
		Pristipomoides sp	Prisitipomoides genus	PRSP
		Rhomboplites aurorubens	vermilion snapper	RHAU

Appendix 1. The scientific family, common family name, genus and species (scientific name), common name, and survey species code for each taxon caught a minimum of one time in the Puerto Rico Deepwater Reef Fish Survey.

Family	Common Family	Scientific Name	Common Name	Species Code
Malacanthidae	Tilefishes	Malacanthus plumieri	sand tilefish	MAPL
Malakichthyidae	Temperate Ocean Basses	Verilus atlanticus	not assigned	VEAT
		Verilus sordidus	ocean bass	VESO
Muraenidae	Morays	Anarchias similis	pygmy moray	ANSI
		Gymnothorax maderensis	sharktooth moray	GYMA
		Gymnothorax moringa	spotted moray	GYMO
		Gymnothorax ocellatus	ocellated moray	GYOC
		Gymnothorax polygonius	polygon moray	GYPO
		Muraena retifera	reticulate moray	MURE
Ophichthidae	Snake Eels	Ophichthus spinicauda	Antillean snake eel	OPSP
Polymixiidae	Beardfishes	Polymixia lowei	beardfish	POLO
		Polymixia nobilis	stout beardfish	PONO
		Polymixia sp	beardfish sp	POSP
Priacanthidae	Bigeyes	Cookeolus japonicus	bulleye	COJA
Scombropidae	Gnomefishes	Scombrops oculatus	Atlantic scombrops	SCOC
Scorpaenidae	Scorpionfishes	Pontinus sp	scorpionfish sp	PNSP
		Pterois sp	lionfish	PTVO
Scyliorhinidae	Cat sharks	Galeus antillensis	Antillean marbled cat shark	GAAN
		Scyliorhinus torrei	dwarf catshark	SCTO
Serranidae	Sea Basses	Centropristis fuscula	twospot sea bass	SEFU
		Serranus notospilus	saddle bass	SENO
		Serranus phoebe	tattler	SEPH
Sphyraenidae	Barracudas	Sphyraena barracuda	great barracuda	SPBA
Squalidae	Dogfish Sharks	Squalus clarkae	Genie's dogfish	SQCL
		Squalus cubensis	Cuban dogfish	SQCU
		Squalus sp	dogfish sp	SQSP
Synagropidae	Splitfin Ocean Basses	Caraibops trispinosus	Threespine bass	CATR
Synodontidae	Lizardfishes	Saurida caribbaea	smallscale lizardfish	SACA
		Saurida normani	shortjaw lizardfish	SANO
		Synodus sp	lizardfish sp	SYSP
Tetraodontidae	Puffers	Sphoeroides pachygaster	blunthead puffer	SPPA
Triakidae	Hound Sharks	Mustelus canis	smooth dogfish	MUCA
		Mustelus sp	smoothhound sp	MUSP

Appendix 1 cont. The scientific family, common family name, genus and species (scientific name), common name, and survey species code for each taxon caught a minimum of one time in the Puerto Rico Deepwater Reef Fish Survey.