Summary of Puerto Rico Spiny Lobster SEDAR 91 Additional Sensitivity Runs: Incorporating Standardized Fishery-Dependent Indices of Abundance and 2024 Terminal Year

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Executive Summary

This report describes the requested supplemental analysis following the SSC's initial review of the SEDAR 91 assessment, highlighting a fundamental improvement to the modeling framework through the incorporation of standardized indices of abundance (Martínez Rivera and McCarthy 2026) and recruitment deviations into the assessment model. While the original SEDAR 91 Base model—which lacked these dynamic components—indicated the stock was overfished (SSB / $SSB_{SPR\ 30\%} < 1$) and undergoing overfishing (F / $F_{SPR\ 30\%} > 1$), the updated sensitivity run (labeled 8324_03g) suggests a more optimistic stock status. By transitioning to F parameter estimation and enabling recruitment deviations, the model identifies a decade of strong recruitment signals that reconcile the simultaneous increases in CPUE and catch observed in recent commercial landings (Matos-Caraballo et al. 2024). Under this more biologically representative configuration, the sensitivity run indicates the Puerto Rico spiny lobster stock is not overfished (SSB / SSB_{SPR} 30%~ > 1) and not undergoing overfishing (F / $F_{SPE\ 30\%} < 1$). Incorporating abundance indices fundamentally improves the SEDAR 91 modeling framework by allowing the model to distinguish between overfishing and natural recruitment fluctuations, providing more accurate and responsive management advice.

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1 Background and Objectives

Following the review of the SEDAR 91 benchmark assessment for Caribbean Spiny Lobster, the SSC requested additional sensitivity runs for the Puerto Rico (PR) stock. These runs incorporate an additional year of data (extending the terminal year to 2024) and investigate strong positive trends in pounds landed per trip reported in the Caribbean Coastal Logbook (CCL) data (Matos-Caraballo et al. 2024).

The Southeast Fisheries Science Center (SEFSC) developed standardized fishery-dependent indices from CCL data, accounting for season, coast, and gear-specific effort (Martínez Rivera and McCarthy 2026). These indices are intended to provide a more informative signal of underlying stock abundance than nominal catch-per-unit-effort (CPUE).

1.1 Model Configuration

The sensitivity runs utilized the Stock Synthesis 3 (SS3) framework established in SEDAR 91 (SEDAR 2025). The SEDAR 91 model for Puerto Rico is structured with two fleets (Dive and Trap) and two independent surveys (SEAMAP-C, HJR). Key updates to the model structure include:

- **Abundance indices** were input as biomass with assumed lognormal error. Consistent with the SS3 manual and SEFSC assessments using fishery-dependent CPUE data, CVs from the standardization process were scaled to a mean of 0.20 and input as standard error in natural log space.
- **Catchability (q) parameters** for both fleets were set to "float," allowing q to be calculated analytically as a scaling factor.

1.2 Addressing Model Rigidity and Data Conflict

Initial sensitivity runs failed to fit the newly developed CPUE time series. The data-limited configuration of the base SEDAR 91 model was found to be too rigid to reconcile the conflicting signals between observed catch and the increasing CPUE trend. To allow the model the necessary flexibility to find a solution, the following structural adjustments were made:

1. **F Estimation Method**: The model was transitioned from the "Hybrid F" approach (which assumes catch is known with near-perfect precision) to estimating fishing mortality (F) as parameters.
2. **Catch Uncertainty**: The standard error on catch inputs was increased from 0.01 to 0.15. This allows the model to treat catch as an observation with uncertainty rather than an absolute constant, facilitating a better fit to the indices.

3. **Recruitment Deviations**: While SEDAR 91 assumed constant average recruitment, these sensitivity runs enabled the estimation of recruitment deviations. Without time-varying recruitment, the model was forced into a fundamental conflict between fitting the indices and the catch. This is a fundamental improvement in this modeling framework. Previously the SEDAR 91 model did not have any indices of abundance and also assumed constant recruitment, such that increases or decreases in catch could not be explained by recruitment deviations. By incorporating indices and estimating recruitment deviations this allowed the model to be dynamic rather than simply a static model.

1.3 Summary of Figures and Tables

While various models were explored in the process of developing this sensitivity report, Sections 3 and 4 focus on comparing the SEDAR 91 Base model and the 0524_03g CPUE Sensitivity run for Puerto Rico spiny lobster (Table 1).

Table 1 summarizes the structural differences between sensitivity scenarios. Tables 2 and 3 provide specific parameter estimates and derived values, including SD and CV. Parameters with correlations greater than 0.9 or less than -0.9 are listed in Table 4. The resulting model stock status metrics and MSY estimates are summarized in Tables 5 and 6. Notably, Table 5 illustrates how status determinations are sensitive to model structure: while the SEDAR 91 Base model suggests the stock is overfished and undergoing overfishing, the inclusion of recruitment deviations and CPUE indices in the sensitivity run suggests a more optimistic status, where the stock is neither overfished nor undergoing overfishing.

Landings, standardized indices of abundance, selectivity, and length-frequency fits are visualized in Figures 1 through 4. The resulting model outputs are summarized Figures 5 through 8, including time series for spawning stock biomass (SSB), fishing mortality (F), and recruitment.

2 Results and Management Implications

By enabling recruitment deviations, the model estimates a decade of strong recruitment signals. This explains the observed "recovery" trend where CPUE and catch have increased simultaneously. The 8324_03g run is represents a cautious potential model for SSC deliberation, as it relies on four key assumptions: (1) Transition to F parameter estimation; (2) Increased Catch SE, (3) **Including CPUE indices for each fleet**; and (4) **Estimating recruitment deviations**.

Incorporating indices of abundance represents a fundamental and essential improvement to the modeling framework and its ability to provide advice. Previously the SEDAR 91 model was static and any catches above the long-term MSY proxy level resulted in overfishing,

independent of whether these increased catches could have occurred as a result of good recruitment. Similarly, the model could not respond to periods of low recruitment as catches below the long-term yield would be predicted to simply be underfishing, even if the stock were actually declining due to reduced recruitment. Critically, the previously static SEDAR 91 model had no other option than to interpret the recent increases in catches above the long-term equilibrium MSY as overfishing. Assuming that the upward trends in the indices reflect true increases in abundance fundamentally alters the model's interpretation of the increases in catch as it attributes these to positive recruitments. Similarly, this model now has the ability to detect stock downturns that could arise out of a series of poor recruitments. Hence it is immensely improved framework for providing management advice and illustrates the importance of having CPUE indices

Under these assumptions, the CPUE Sensitivity model suggests that current catch levels do not constitute overfishing for the Puerto Rico spiny lobster stock and that the stock is not overfished. Steepness (h) remains fixed at 0.99, which makes an assumption of high recruitment potential even at reduced spawning stock biomass levels. Finally, there is a known risk of Finally, there is a known risk that models may estimate spurious recruitment deviations in data limited situations. While there is always a concern when interpreting fishery-dependent data, the risk is really only that the recent upward trends may give a more positive stock status. However, this is not terribly problematic for the provision of catch advice as, in this case, the last three years of recruitment revert to the long-term average and the fishery operates primarily on younger animals. This minimizes the risk of spuriously high or low recruitment estimates affecting future catch levels.

3 Tables

Table 1: **Model scenarios for the SEDAR 91 supplemental analysis**. While several scenarios were evaluated for diagnostic purposes, this report focuses on comparing between the SEDAR 91 Base scenario with the CPUE Sensitivity run 8524_03g.

Stage	Scenario	Model Description
Base	8523_00	Reproduced base from SEDAR 91
CPUE Sensitivity	8524_03g	8523_03 + Rec dev + Trap index + Dive index

Table 2: Puerto Rico spiny lobster parameters, standard deviations (SD), and coefficient of variation (CV) by model scenario. CV is calculated as the SD divided by the parameter estimate.

Parameter	Scenario	Estimate	SD	CV	Gradient
Dive initial F	8523_00	0.18	0.04	0.22	-7.5e-06
	8524_03g	0.15	0.04	0.27	-3.3e-06
Dive retention	8523_00	1.61	0.20	0.12	-1.3e-05
	8524_03g	1.58	0.19	0.12	-1.3e-06
Dive selectivity 1st limb	8523_00	0.18	0.01	0.06	-2.0e-06
	8524_03g	0.17	0.01	0.06	-2.4e-05
Dive selectivity 2nd limb	8523_00	0.28	0.03	0.11	6.2e-07
	8524_03g	0.28	0.03	0.11	-5.0e-06
Dive selectivity asymptote	8523_00	0.36	0.00	0.00	5.2e-07
	8524_03g	0.36	0.00	0.00	5.4e-05
HJR selectivity 1st limb	8523_00	0.27	0.15	0.56	2.3e-06
	8524_03g	0.30	0.16	0.53	6.6e-06
HJR selectivity 2nd limb	8523_00	0.08	0.08	1.00	-8.6e-07
	8524_03g	0.08	0.07	0.88	3.6e-06
HJR selectivity asymptote	8523_00	0.29	0.03	0.10	7.3e-06
	8524_03g	0.29	0.02	0.07	1.3e-05

Parameter	Scenario	Estimate	SD	CV	Gradient
Pot/trap initial F	8523_00	0.34	0.08	0.24	3.1e-06
	8524_03g	0.29	0.09	0.31	-4.4e-06
Pot/trap retention	8523_00	2.62	0.44	0.17	-4.0e-07
	8524_03g	2.50	0.42	0.17	6.8e-07
Pot/trap selectivity 1st limb	8523_00	0.18	0.01	0.06	-1.0e-06
	8524_03g	0.18	0.01	0.06	4.7e-05
Pot/trap selectivity 2nd limb	8523_00	0.33	0.04	0.12	1.7e-06
	8524_03g	0.34	0.04	0.12	7.9e-06
Pot/trap selectivity asymptote	8523_00	0.36	0.01	0.03	-6.7e-06
	8524_03g	0.36	0.01	0.03	-9.9e-05
SEAMAPC selectivity 1st limb	8523_00	0.14	0.09	0.64	-1.1e-05
	8524_03g	0.14	0.09	0.64	-2.6e-06
SEAMAPC selectivity 2nd limb	8523_00	0.09	0.15	1.67	-3.8e-07
	8524_03g	0.10	0.16	1.60	-5.7e-07
SEAMAPC selectivity asymptote	8523_00	0.29	0.06	0.21	-1.4e-05
	8524_03g	0.29	0.05	0.17	-4.9e-06
Unfished Recruitment (R0)	8523_00	6.94	0.10	0.01	-1.2e-06
	8524_03g	7.06	0.11	0.02	-7.6e-05

Table 3: Puerto Rico spiny lobster derived quantities for unfished and initial spawning stock biomass in metric tons (mt) along with standard deviations (SD), coefficient of variation (CV) and the ratio between the Unfished and Initial estimates of SSB. CV is calculated as the SD divided by the parameter estimate.

Derived Quantity	Scenario	Estimate	SD	CV
SSB Unfished (mt)	8523_00	3.64e+08	3.49e+07	0.10
	8524_03g	4.09e+08	4.44e+07	0.11
SSB Initial (mt)	8523_00	1.10e+08	3.36e+07	0.31
	8524_03g	1.41e+08	4.94e+07	0.35
Ratio SSB Initial:Unfished	8523_00	0.30	0.07	0.23
	8524_03g	0.34	0.09	0.27

Table 4: Correlations between estimated Puerto Rico spiny lobster parameters. The table shows correlations greater than 0.9 or less than -0.9. Correlations that are greater than 0.95 or less than -0.95 are shown in red.

Scenario	Estimated Parameters		Correlation Coefficient
8523_00	HJR selectivity asymptote	HJR selectivity 1st limb	-0.911
8523_00	SEAMAPC selectivity asymptote	SEAMAPC selectivity 1st limb	-0.902
8524_03g	HJR selectivity asymptote	HJR selectivity 1st limb	-0.911

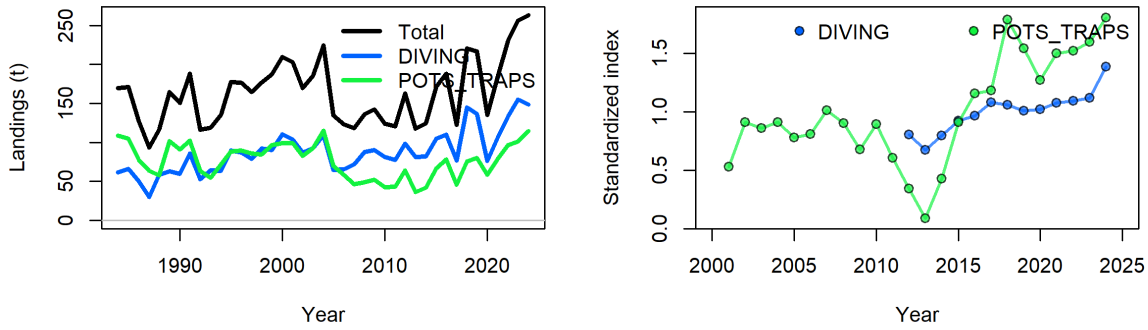
Table 5: Puerto Rico spiny lobster fishing mortality rate and spawning stock biomass ratios relative to the rate and biomass of the stock associated with the MSY proxy (based on SPR 30%). The relative fishing mortality ratio is expressed as a three-year geometric mean of the annual fishing mortality rates divided by the fishing mortality rate associated with $MSY_{SPR\ 30\%}$. The relative stock biomass ratio is expressed as the model's terminal year spawning biomass divided by the spawning stock biomass at $MSY_{SPR\ 30\%}$. The SEDAR 91 Base model indicated that the stock was overfished ($SSB / SSB_{SPR\ 30\%} < 1$), and the stock was undergoing overfishing ($F / F_{SPR\ 30\%} > 1$). In the sensitivity run, which includes recruitment deviations and two indices of abundance, the corresponding values suggest the stock is not undergoing overfishing ($F / F_{SPR\ 30\%} < 1$), and is not overfished ($SSB / SSB_{SPR\ 30\%} > 1$).

Metric	Scenario	Value	Terminal Year
F / F SPR 30%	8523_00	1.26	2023
	8524_03g	0.96	2024
SSB / SSB SPR 30%	8523_00	0.92	2023
	8524_03g	1.32	2024

Table 6: Puerto Rico spiny lobster derived quantities of the MSY proxy (based on SPR 30%) in metric tons and in pounds. CV is calculated as the SD divided by the parameter estimate.

Scenario	MSY Proxy	SD	CV	MSY Proxy in Pounds
8523_00	179.68	15.38	0.09	396,133
8524_03g	202.60	19.56	0.10	446,668

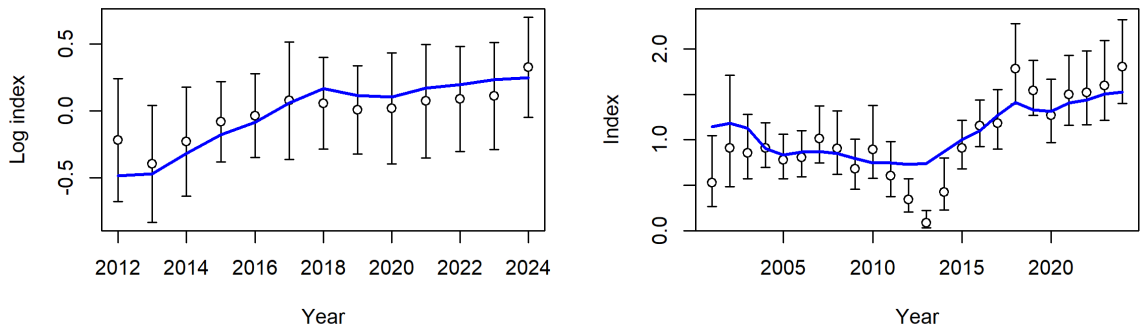
4 Figures



(a) Landings

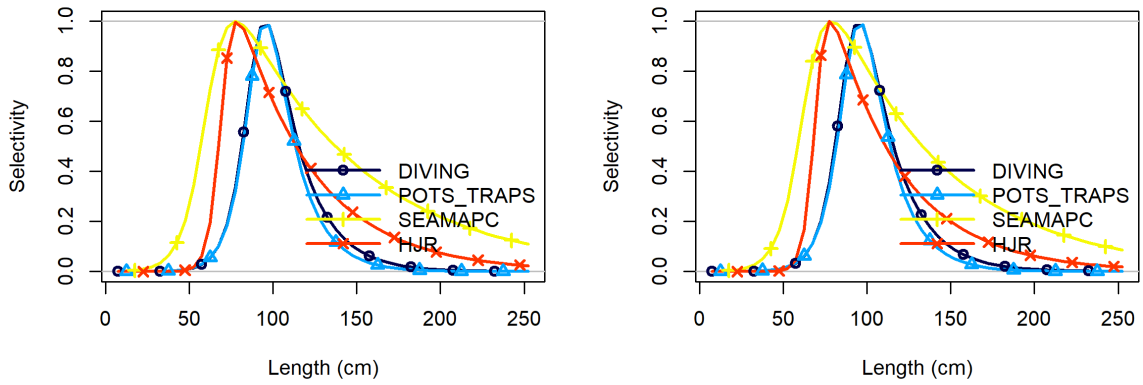
(b) Standardized indices of abundance

Figure 1: Puerto Rico spiny lobster (a) landings (mt) during 1985-2024 by fleet: dive (blue), trap (green), total (black), and (b) standardized indices of abundance overlaid.



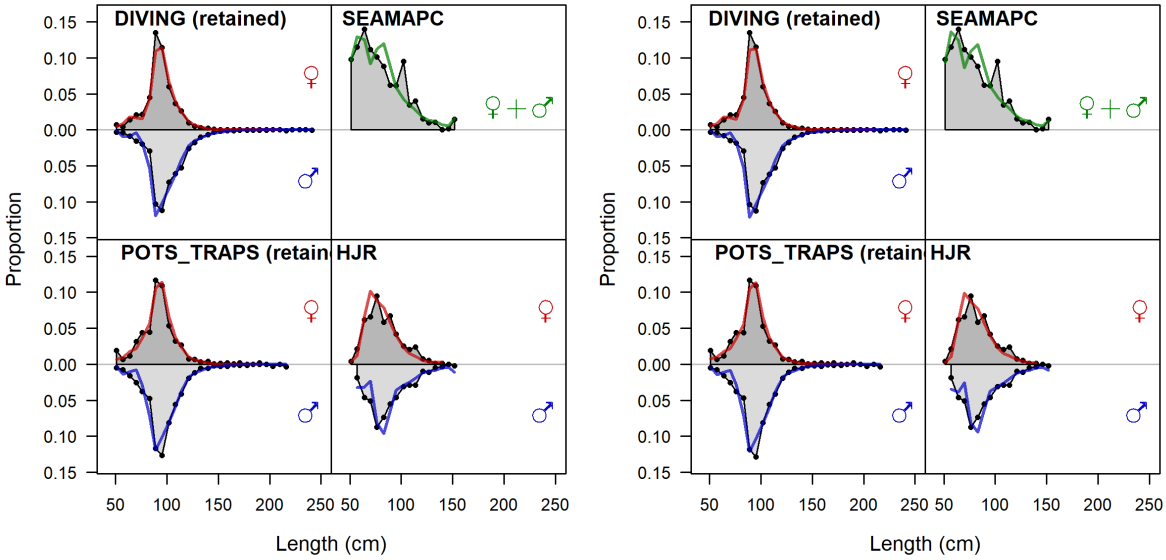
(a) Dive (b) Trap

Figure 2: Puerto Rico spiny lobster observed (open circles) and predicted indices of relative abundance (blue) and 95% uncertainty interval standard errors bars for the 8524_03g CPUE sensitivity model scenario based on the model assumption of lognormal error.



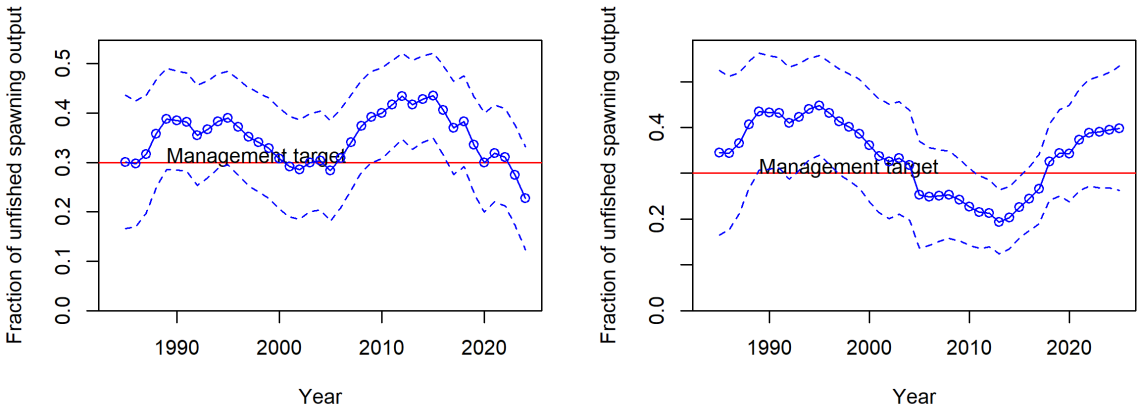
(a) SEDAR 91 Base (b) CPUE Sensitivity

Figure 3: Puerto spiny lobster selectivity by model scenario and by fleet: dive (dark blue), pot/trap (light blue), SEAMAPC (yellow), and HJR Reefscaping (red).



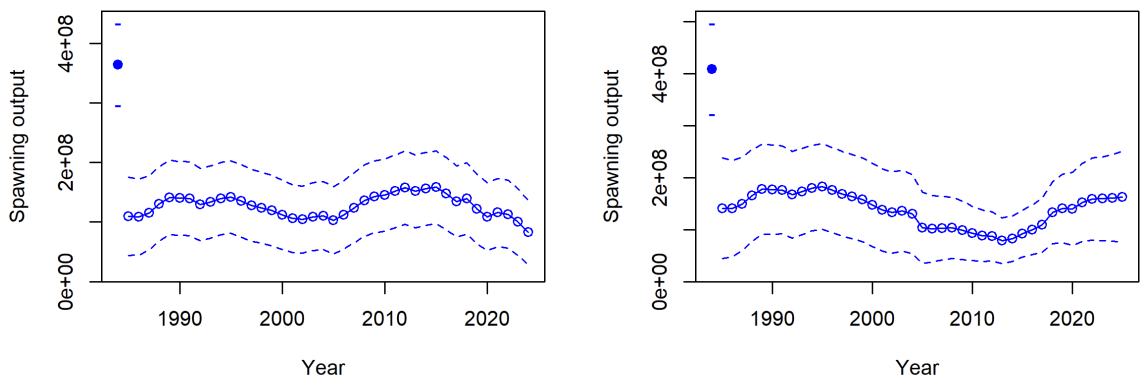
(a) SEDAR 91 Base (b) CPUE Sensitivity

Figure 4: Puerto Rico spiny lobster observed and predicted length distributions in millimeters for the 8524_00 SEDAR 91 base and 8524_03g CPUE sensitivity model scenario. Red and blue solid lines represent predicted length compositions, while gray regions represent observed length compositions.



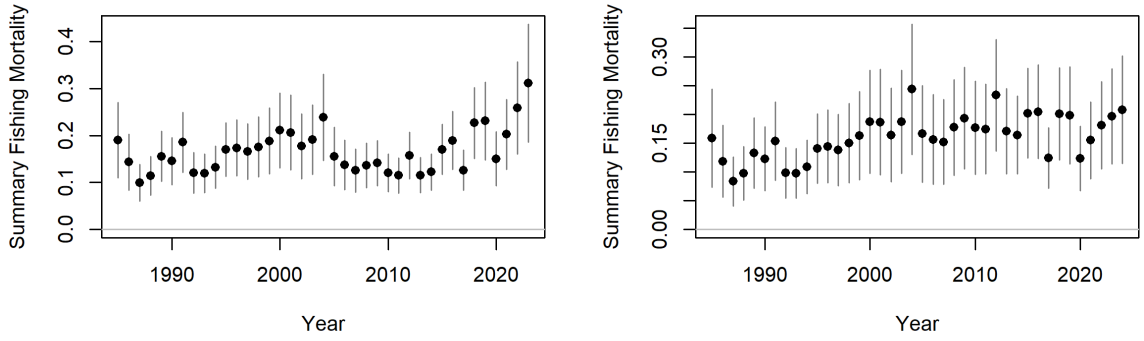
(a) SEDAR 91 Base (b) CPUE Sensitivity

Figure 5: Puerto Rico spiny lobster spawning biomass ratio (total biomass / unfished spawning stock biomass) for the 8524_00 SEDAR 91 base and 8524_03g CPUE Sensitivity model scenarios. The dotted lines represent 95% confidence intervals.



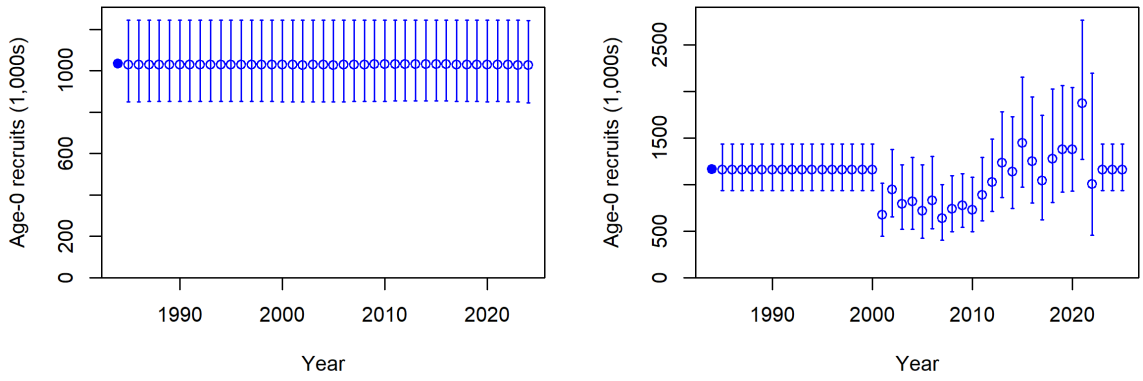
(a) SEDAR 91 Base (b) CPUE Sensitivity

Figure 6: Puerto Rico spiny lobster spawning stock biomass in metric tons for the 8524_00 SEDAR 91 base and 8524_03g CPUE Sensitivity model scenarios. The dotted lines represent 95% confidence intervals.



(a) SEDAR 91 Base (b) CPUE Sensitivity

Figure 7: Puerto Rico spiny lobster fishing mortality (total biomass killed / total biomass) time series for the 8524_00 SEDAR 91 base and 8524_03g CPUE Sensitivity model scenarios. The shaded areas in the derived quantities time series represent 95% confidence intervals.



(a) SEDAR 91 Base (b) CPUE Sensitivity

Figure 8: Puerto Rico spiny lobster recruitment in thousands of fish for the 8524_00 SEDAR 91 base and 8524_03g CPUE Sensitivity model scenarios. The vertical bars in the derived quantities time series represent 95% confidence intervals. For the CPUE Sensitivity model scenario, recruitment is estimated as deviations from the underlying spawner-recruit relationship. The model estimates a "main" recruitment deviation vector from 2001 to 2022 and uses a bias adjustment ramp that begins in 1988.

5 References

Martínez Rivera, Stephanie, and Kevin J. McCarthy. 2026. "Caribbean Spiny Lobster Fishery Dependent Standardized Indices of Abundance for Puerto Rico 2001-2024." *In-Prep* SEDAR 91 Addendum Report for April 2026 CCFMC SSC.

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