SEDAR

Southeast Data, Assessment, and Review

SEDAR 84

Stock Assessment Report

US Caribbean Yellowtail Snapper – Puerto Rico

August 2025

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 84

US Caribbean Yellowtail Snapper – Puerto Rico

SECTION I: Introduction

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Overview

SEDAR 84 addressed the stock assessment for US Caribbean Yellowtail Snapper – Puerto Rico. The process consisted of an in-person Data Workshop, with several webinars before and after the workshop, series of assessment webinars, and an in-person Review Workshop. The assessment was conducted by the SEFSC.

The Stock Assessment Report is organized into 6 sections. Section I – Introduction contains a brief description of the SEDAR Process, Assessment and Management Histories for the species of interest, and the management specifications requested by the Cooperator. The Data Workshop Report can be found in Section II. It documents the discussions and data recommendations from the Data Workshop Panel. Section III is the Assessment Process report. This section details the assessment model, as well as documents any changes to the data recommendations that may have occurred after the data workshop. Consolidated Research Recommendations from all stages of the process can be found in Section IV for easy reference. Section V documents the discussions and findings of the Review Workshop (RW). Finally, Section VI – Addenda and Post-Review Workshop Documentation consists of any analyses conducted during or after the RW to address reviewer concerns or requests. It may also contain documentation of the final RW-recommended base model, should it differ from the model put forward in the Assessment Report for review.

The final Stock Assessment Report (SAR) for US Caribbean Yellowtail Snapper – Puerto Rico was disseminated to the public in August 2025. The Council’s Scientific and Statistical Committee (SSC) will review the SAR. The SSCs are tasked with recommending whether the assessments represent Best Available Science, whether the results presented in the SARs are useful for providing management advice and developing fishing level recommendations for the Council. An SSC may request additional analyses be conducted or may use the information provided in the SAR as the basis for their Fishing Level Recommendations (e.g., Overfishing Limit and Acceptable Biological Catch). The Caribbean Council’s SSC will review the assessment at its December 2025 meeting, followed by the Council receiving that information at its December 2025 meeting. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

1 SEDAR PROCESS DESCRIPTION

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR seeks improvements in the scientific quality of stock assessments and the relevance of information available to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is managed by the Caribbean, Gulf, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South

Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; a representative from the Highly Migratory Species Division of NOAA Fisheries, and Interstate Commission representatives: Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is normally organized around two workshops and a series of webinars. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. The second stage is the Assessment Process, which is conducted via a workshop and/or a series of webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. The final step is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. The completed assessment, including the reports of all 3 stages and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

SEDAR workshops are public meetings organized by SEDAR staff and the lead Cooperator. Workshop participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

2 MANAGEMENT OVERVIEW

Puerto Rico Yellowtail Snapper are managed under the Puerto Rico Fishery Management Plan (Crabtree, 2019). In 2023, the Caribbean Fisheries Management Council transitioned from species-based to island-based fisheries management (Figure 4.1). The management measures in the new island-based fishery management plans became effective on October 13, 2022.

Currently, the allowable biological catch for Yellowtail Snapper was established using Tier 4a of the 4-tiered control rule. The combined commercial and recreational total allowable biological catch and the annual catch limit are 357,678 and 339,794 pounds whole weight, respectively.. Annual catch limits for Council-managed finfish in federal waters are also set by sector. However, since recreational landings are not available, commercial annual catch limits are applicable for all harvest. The total allowable biological catch and the annual catch limit for the commercial sector are 332,427 and 315,806 pounds whole weight, respectively.

A SEDAR 84 Data Workshop working paper summarizes relevant federal management actions relevant to Yellowtail Snapper in St. Thomas and St. John (Malone, 2024). On September 21 1986, a federal size limit was instituted with the implementation of the Reef Fish Fishery FMP. The regulation prohibited the take of Yellowtail Snapper that measured less than 8 inches total length for the first fishing year, and was increased one inch per year until the limit reached 12 inches on September 22, 1989. Initially, the federal size limit only applied to the U.S. Exclusive Economic Zone (EEZ), which is defined as the federal waters ranging from 9 to 200 nautical miles (17 – 370 kilometers) from the nearest coastline point of the Commonwealth of Puerto Rico (Figure 4.2). Additionally, a condition that Yellowtail Snapper possessed in the EEZ must have their heads, fins, and tails intact became effective November 29, 1990. Finally, a federal recreational bag limit became effective on January 30, 2012. The limit is 5 per person per day, and 15 per vessel per day, if 3 or more people are aboard.

Starting in 1936, commercial fishing in Puerto Rico was regulated by Law Num. 83, which included regulations like banning dynamite fishing and the use of nets at river mouths (Matos Caraballo, 2008). In 1998, Puerto Rico established Regulation 278, known as the Fisheries Law. It was later amended in 2004, 2005, 2009, and 2010.

In 2004, a size limit of 10.5 inches fork length for yellowtail snapper was implemented under Regulation 6768 (DRNA, 2004). Additionally, in 2004, beach seines were prohibited within Puerto Rico inner waters and river mouths. The seines were also prohibited in jurisdictional waters beginning in 2007. In 2010, Puerto Rico DRNA issued Regulation 7949, which superseded Regulation 6768, and permitted beach seins except within Puerto Rico inner water and within 300 meters of rivers mouths (DRNA, 2010).

References

Crabtree, Roy E. (2019). Comprehensive Fishery Management Plan for the Puerto Rico Exclusive Economic Zone Including Environmental Assessment, Regulatory Impact Review, and Fishery Impact Statement. https://repository.library.noaa.gov/view/noaa/45274

Departamento de Recursos Naturales y Ambientales de Puerto Rico. (2004). Reglamento de Pesca de Puerto Rico. http://app.estado.gobierno.pr/ReglamentosOnLine/Reglamentos/6768.pdf

Departamento de Recursos Naturales y Ambientales de Puerto Rico. (2010). Reglamento de Pesca de Puerto Rico. http://app.estado.gobierno.pr/ReglamentosOnLine/Reglamentos/7949.pdf

Malone, G. (2024). Summary of Management Actions for Yellowtail Snapper (Ocyurus chrysurus) from Puerto Rico and St. Thomas/St. John (1985 - 2021) as Documented within the Management History Database. SEDAR84-WP-06. SEDAR, North Charleston, SC. 31. https://sedarweb.org/documents/sedar-84-dw-06-summary-of-management-actions-for-yellowtail-snapper-ocyurus-chrysurus-from-puerto-rico-and-st-thomas-st-john-1985-2021-as-documented-within-the-management-history-database/

Matos-Caraballo, Daniel. (2008). Lessons learned from the Puerto Rico's Commercial fishery, 1988-2008 Proc. Gulf Caribbean Fish. Inst. 61st . Annual Session.

3 ASSESSMENT HISTORY AND REVIEW

Before the current SEDAR 84 assessment, three assessments had been attempted for Yellowtail Snapper in the U.S. Caribbean (Appledorn et. al., 1992; SEDAR, 2005; SEDAR, 2016). The first, by Appeldoorn et al. (1992), was part of a broader assessment of shallow water reef fish using length frequency analyses. In 2005, SEDAR 08 investigated CPUE trends and examination of changes in length frequency. Due to the lack of data with which to parameterize models, the earlier evaluations resulted in unsatisfactory determinations of stock status. In 2018, the SEDAR 46 evaluations were performed using the Data-Limited Methods Toolkit (Carruthers, 2018). The approach applied data-limited stock assessment models and management procedures, for six species and island units, including Yellowtail Snapper in Puerto Rico. Ultimately, the SEDAR 84 results were not used for management advice.

References

Appeldoorn, Richard & Beets, J. & Bohnsack, James & Bolden, S. & Matos, D. & Meyers, S. & Rosario, Aida & Sadovy, Yvonne & Tobias, W.. (1992). Shallow water reef fish stock assessment for the U.S. Caribbean. NOAA Tech. Mem.. 1-70. https://repository.library.noaa.gov/view/noaa/6063

Carruthers, T. R., & Hordyk, A. R. (2018). The Data-Limited Methods Toolkit (DLMtool): An R package for informing management of data-limited populations. Methods in Ecology and Evolution, 9(12), 2388–2395. https://doi.org/10.1111/2041-210x.13081

SEDAR. (2005). Stock Assessment Report of SEDAR 8 Caribbean Yellowtail Snapper. https://sedarweb.org/documents/sedar-08-stock-assessment-report-caribbean-yellowtail-snapper/

SEDAR. (2016). SEDAR 46 Caribbean data-limited species stock assessment report. https://sedarweb.org/documents/sedar-46-final-stock-assessment-report-caribbean-data- limited-species/

4 REGIONAL MAPS

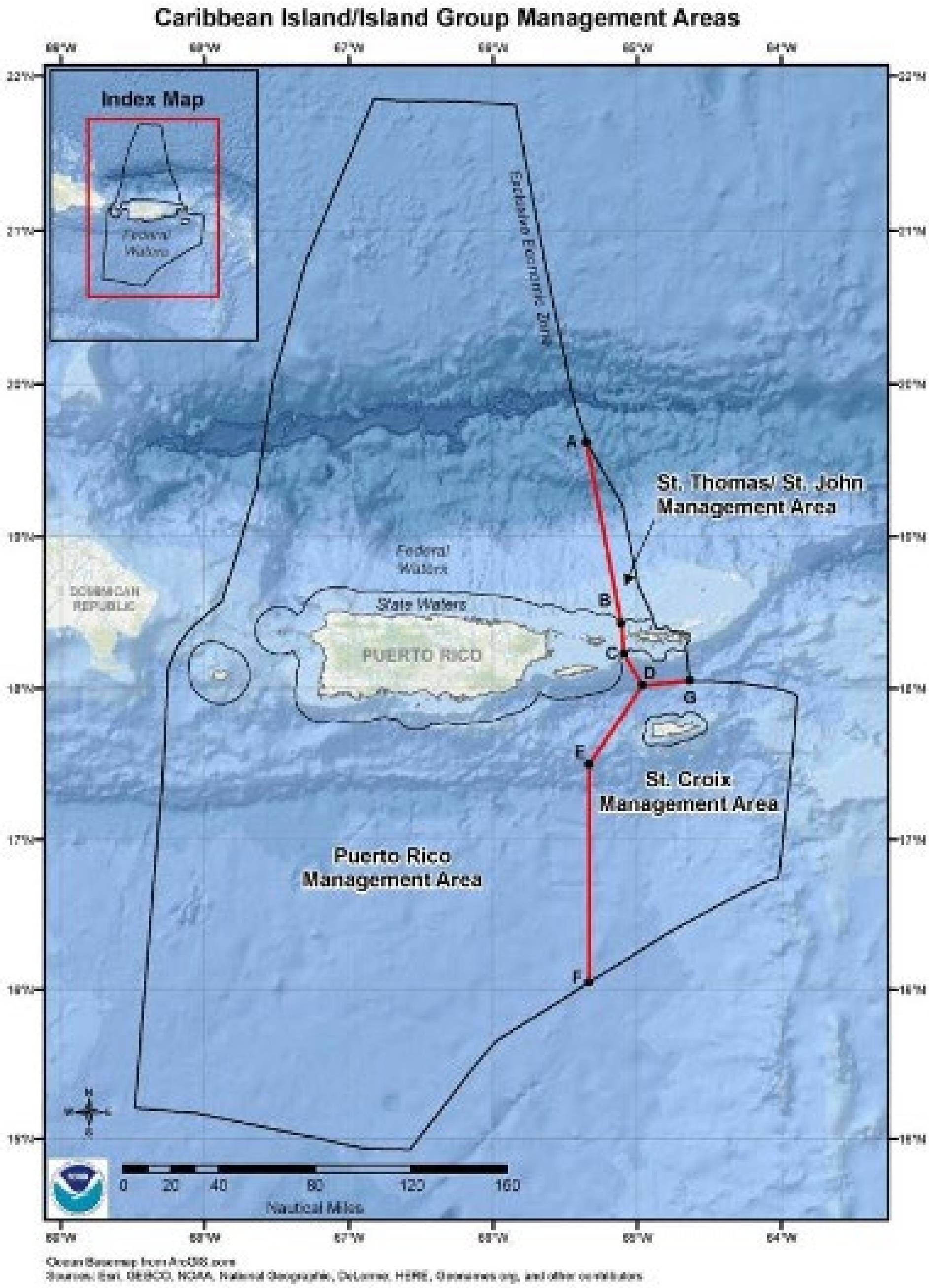

Figure 4.1 Jurisdictional boundaries of the Caribbean Fishery Management Council.

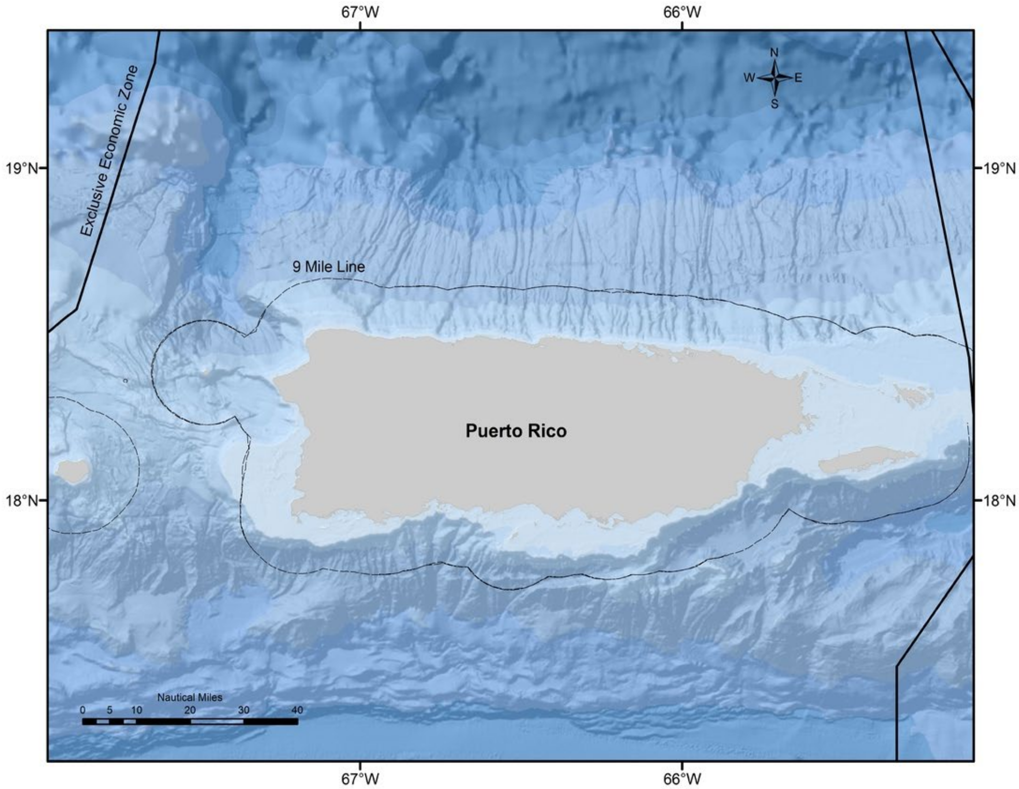

Figure 4.2: The U.S. Exclusive Economic Zone is defined as the federal waters ranging from 9 to 200 nautical miles (17 – 370 kilometers) from the nearest coastline point of the Commonwealth of Puerto Rico.

5 SEDAR ABBREVIATIONS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder (software program)
ALS	Accumulated Landings System: SEFSC fisheries data collection program
AMRD	Alabama Marine Resources Division
APAIS	Access Point Angler Intercept Survey
ASMFC	Atlantic States Marine Fisheries Commission
B	Biomass (stock) level
BAM	Beaufort Assessment Model
B_{msy}	B capable of producing MSY on a continuing basis
BSIA	Best Scientific Information Available
CHTS	Coastal Household Telephone Survey

CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	Catch Per Unit Effort
EEZ	Exclusive Economic Zone
F	Fishing mortality (instantaneous)
FES	Fishing Effort Survey
FIN	Fisheries Information Network
F_{MSY}	F to produce MSY under equilibrium conditions
F_{OY}	F rate to produce OY under equilibrium
$F_{XX\%\ SPR}$	F rate resulting in retaining XX% of the maximum spawning production under equilibrium conditions
F_{max}	F maximizing the average weight yield per fish recruited to the fishery
F_o	F close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	Florida Fish and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	General Linear Model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
HMS	Highly Migratory Species
LDWF	Louisiana Department of Wildlife and Fisheries
M	natural mortality (instantaneous)
MARFIN	Marine Fisheries Initiative
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
MFMT	Maximum Fishing Mortality Threshold: value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey: combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSA	Magnuson Stevens Act
MSST	Minimum Stock Size Threshold: value of B below which the stock is deemed to be overfished
MSY	Maximum Sustainable Yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OST	Office of Science and Technology, NOAA

OY	Optimum Yield
SAFMC	South Atlantic Fishery Management Council
SC DNR	South Carolina Department of Natural Resources
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment and Review
SEFIS	Southeast Fishery-Independent Survey
SEFSC	Southeast Fisheries Science Center, NMFS
SERFS	Southeast Reef Fish Survey
SERO	Southeast Regional Office, NMFS
SRFS	State Reef Fish Survey (Florida)
SRHS	Southeast Region Headboat Survey
SPR	Spawning Potential Ratio: B relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SS	Stock Synthesis
SSC	Scientific and Statistical Committee
TIP	Trip Interview Program: biological data collection program of the SEFSC and Southeast States
TPWD	Texas Parks and Wildlife Department
Z	total mortality (M+F)

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SEDAR 84

US Caribbean Yellowtail Snapper
Puerto Rico

SECTION II: Data Workshop Report

April 2024

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1 INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 84 Data Workshop was held January 23-25, 2024, in San Juan, Puerto Rico. In addition to the in-person workshop, a series for webinars were held before (July and December 2023) the meeting.

1.2 TERMS OF REFERNCE

Data Workshop Terms of Reference:

1. Develop a stock assessment model for Puerto Rico and St. Thomas/St. John Yellowtail Snapper and St. Croix Stoplight Parrotfish stocks using an appropriate approach.
2. Review available data inputs and provide tables and figures including, but not limited to:
   a. Commercial and recreational catches and/or discards.
   b. Length/age composition data
   c. Life history and ecological information
   d. Indices of abundance
3. Construct a stock assessment model that is appropriate for the available data.
4. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on research goals, data to be collected, and how the research will inform stock assessment.

5. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section II of the SEDAR assessment report).

1.3 LIST OF PARTICIPANTS

Data Workshop Participants

Adyan Rios (Lead Analyst) .... NMFS/SEFSC
Noemi Peña Alvardo .... DNER, PR
Sarah Beggerly .... NMFS/SEFSC
Jeremiah Blondeau .... NMFS/SEFSC
J.J. Cruz-Motta .... CFMC SSC, UPRM
Kyle Dettloff .... NMFS/SEFSC
Carlos Farchette .... Stakeholder - STX
Jorge R. Garciá .... CFMC SSC
Katherine Godwin .... UM-CIMAS
Sennai Habtes .... USVI DPNR
Marcos Hanke .... Stakeholder – PR
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Daniel Matos-Caraballo .... PR DNER
Vivian Matter .... NMFS/SEFSC
Kevin McCarthy .... NMFS/SEFSC
Maggie Motiani .... USVI DPNR
M. Refik Orhun .... NMFS/SEFSC
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Wilson Santiago Soler .... PR Fisheries Liaison
Michelle Scharer .... CFMC SSC
Derek Soto ....

Staff

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Albert Fort .... Tech Support/Recording
Liajay Rivera Garciá .... CFMC Staff
Graciela Garcia-Moliner .... CFMC Staff
Meisha Key .... SEDAR Staff
Kiara Matias .... CFMC Staff

Workshop Observers

Jerald S. Ault .... Univ of Miami

Angel Normandia .... Stakeholder - PR
Angel E. Normandia .... Stakeholder - PR

Data Process Webinar Observers
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Edwin Javier Arroyo ....
Rachal Banton ....
David Behringer ....
Manuel Coffill-Rivera ....
Sophia Costa ....
Carly Daiek ....
Todd Gedamke .... MER Consultants
Nicole Greaux .... OEAP Liaison STT/STJ
Keisha Correa Vélez Hedalgo ....
Mariangeline León ....
Maria López ....
Cristina Olán .... CFMC Staff
Emmanuel Maldonado ....
Efrai Maraguez ....
Martha Prada ....
Yamitza Rodriguez .... DRNA
Aurea E. Rodriguez Santiago ....
Virginia Shervette .... Univ SC
Wilfredo ....

1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERNCE DOCUMENTS

Document #	Title	Authors	Date Submitted
Documents Prepared for the Data Workshop			
SEDAR84-DW-01	Radiocarbon Age Validation for Caribbean Parrotfishes	Jesus Rivera Hernández and Virginia Shervette	9 January 2024 Updated: 5 March 2024
SEDAR84-DW-02	SEDAR 84 Commercial fishery landings of Yellowtail Snapper (*Ocyurus chrysurus*) in St. Thomas and St. John, US Caribbean, 2012-2022	Stephanie Martínez Rivera, Kimberley Johnson, and M. Refik Orhun	18 January 2024 Updated: 21 February 2024
SEDAR84-DW-03	SEDAR 84 Commercial fishery landings of Stoplight Parrotfish (*Sparisoma viride*) in St. Croix, US Caribbean, 2012-2022	Stephanie Martínez Rivera, Kim Johnson, and M. Refik Orhun	18 January 2024 Updated: 21 February 2024

SEDAR84-DW-04	Analysis of SEAMAP-C hook and line survey data for yellowtail snapper in Puerto Rico (1992-2020)	Walter Ingram, Refik Orhun, and Carlos M. Zayas Santiago	19 January 2024
SEDAR84-DW-05	Summary of Management Actions for Stoplight Parrotfish (*Sparisoma viride*) from St. Croix (1985 - 2021) as Documented within the Management History Database	G. Malone	22 January 2024 Updated: 21 February 2024
SEDAR84-DW-06	Summary of Management Actions for Yellowtail Snapper (*Ocyurus chrysurus*) from Puerto Rico and St. Thomas/St. John (1985 - 2021) as Documented within the Management History Database	G. Malone	22 January 2024 Updated: 21 February 2024
SEDAR84-DW-07	Addressing Critical Life History Gaps for U.S. Caribbean Yellowtail Snapper: Bomb radiocarbon of age estimation method and a summary of the regional demographic patterns for size, age, and growth	Virginia Shervette, Jesus Rivera Hernandez, Sarah Zajovits	22 January 2024 Updated: 15 February 2024
SEDAR84-DW-08	U.S. Caribbean Yellowtail Snapper Population Demographics, Growth, and Reproductive Biology: Addressing Critical Life History Gaps	Virginia Shervette, Jesus Rivera Hernandez, Noemi Pena Alvarado	18 February 2024
SEDAR84-DW-09	SEDAR 84 Trip Interview Program (TIP) Size Composition Analysis of Yellowtail Snapper (*Ocyurus chrysurus*) in Puerto Rico, U.S. Caribbean, 1983-2022	Katherine Godwin, Adyan Rios, Kyle Dettloff	21 February 2024
SEDAR84-DW-10	SEDAR 84 Trip Interview Program (TIP) Size Composition Analysis of Yellowtail Snapper (*Ocyurus chrysurus*) in St. Thomas/St. John, U.S. Caribbean, 1983-2022	Katherine Godwin, Adyan Rios, Kyle Dettloff	21 February 2024
SEDAR84-DW-11	SEDAR 84 Trip Interview Program (TIP) Size Composition Analysis of Stoplight Parrotfish (*Sparisoma viride*) in St. Croix, U.S. Caribbean, 1983-2022	Katherine Godwin, Adyan Rios, Kyle Dettloff	21 February 2024
SEDAR84-DW-12	SEDAR 84 Commercial fishery landings of Yellowtail Snapper	Stephanie Martínez Rivera, Kimberley	21 February 2024

	(Ocyurus chrysurus) in Puerto Rico, US Caribbean, 2012-2022	Johnson, and M. Refik Orhun	
SEDAR84-DW-13	Length-Frequency Snapshot of Yellowtail Snapper from Image Analysis in Puerto Rico	Derek Soto, Alejandro Carrera Montalvo, Todd Gedamke	22 February 2024
SEDAR84-DW-14	Fishery-Independent Reef Fish Visual Survey Population Density and Length Composition for Stoplight Parrotfish in the St. Croix	Laura Jay W. Grove, Jeremiah Blondeau, and Jerald S. Ault	16 February 2024
SEDAR84-DW-15	Fishery-Independent Reef Fish Visual Survey Population Density and Length Composition for Yellowtail Snapper in the Puerto Rico	Laura Jay W. Grove, Jeremiah Blondeau, and Jerald S. Ault	16 February 2024
SEDAR84-DW-16	Fishery-Independent Reef Fish Visual Survey Population Density and Length Composition for Yellowtail Snapper in St. Thomas/John	Laura Jay W. Grove, Jeremiah Blondeau, and Jerald S. Ault	16 February 2024
Reference Documents			
SEDAR84-RD01	Selectividad Pesquera del Buche (Seno) en Chinchorros de Playa con mallas de 2.5, 2.0 y 1.0 pulgadas, a lo largo de la costa Oeste y Noreste de la Isla de Puerto Rico	Edgardo Ojeda Serrano, Omayra Hernandez Vak, and Samuel Garcia Vazquez	
SEDAR84-RD02	Monitoring of Mesophotic Habitats and Associated Benthic and Fish/Shellfish Communities from Abrir la Sierra, Bajo de Sico, Tourmaline, Isla Desecheo, El Seco and Boya 4, 2018-20 Survey	Jorge R, Garcia-Sais, Stacey Williams, Evan Tuohy, Jorge Sabater-Clavell and Milton Carlo	
SEDAR84-RD03	Population Size, Growth, Mortality and Movement Patterns of Yellowtail Snapper (*Ocyurus chrysurus*) in the U.S. Virgin Islands Determined Through a Multi institutional Collaboration	St. Thomas Fishermen's Association	

SEDAR84-RD04	S8-DW-09: An Update on the Reported Landings, Expansion Factors and Expanded Landings for the Commercial Fisheries of the United States Virgin Islands (with Emphasis on Spiny Lobster and the Snapper Complex)	Mónica Valle-Esquivel and Guillermo Díaz
SEDAR84-RD05	SEDAR68-DW-13: Marine Recreational Information Program Metadata for the Atlantic, Gulf of Mexico, and Caribbean regions	Vivian M. Matter and Matthew A. Nuttall
SEDAR84-RD06	Nearshore habitats as nursery grounds for recreationally important fishes, St. Croix, U S. Virgin Islands	Ivan Mateo
SEDAR84-RD07	Seasonal Patterns of Juvenile Fish Abundance in Seagrass Meadows in Teague Bay Bank Barrier Reef Lagoon, St. Croix, U.S. Virgin Islands	Ivan Mateo and William J. Tobias
SEDAR84-RD08	The Distribution of Herbivorous Coral Reef Fishes within Fore-reef Habitats: the Role of Depth, Light and Rugosity	Michael Nemeth and Richard Appeldoorn
SEDAR84-RD09	The Use of Vertical Distribution Data in the Identification of Potential Spawning Sites and Dispersal Pathways for Parrotfish (Genera *Sparisoma* and *Scarus*) within Territorial Waters of the U.S. Virgin Islands	Kristen A. Ewen
SEDAR84-RD10	Evaluating the impact of invasive seagrass *Halophila stipulacea* on settlement, survival, and condition factor of juvenile yellowtail snapper, *Ocyurus chrysurus*, in St. Thomas, USVI	Sophia Victoria Costa

2 Life History

2.1 Overview

Table 2.1 provides a summary of parameters, definitions, nomenclature, and units for the life history parameters included within this report (SEDAR 46 SAR v2). Yellowtail Snapper life history data were provided in Shervette et al. (2024a).

2.2 Stock Definition and Description

The Yellowtail Snapper stock was defined by the CFMC Island-based Fishery Management Plan. The Puerto Rico stock is defined as the population within the Puerto Rico territorial waters and the adjacent EEZ.

2.3 Meristic & Conversion factors

The length-length and length-weight relationship equations with parameters for Yellowtail Snappers collected 2013-2023 for the combined sexes (Shervette et al. 2024) are shown are in Table 2.2.

2.4 Natural Mortality

The DW panel recommended that the assessment team explore various methods of estimating natural mortality (M) based on life history parameters. This may include methods that apply one point estimate to the entire age range of the fish, such as Hewitt and Hoenig (2005) or Then et al. (2015). Additional, and perhaps preferred methods, include using the methods of Charnov et al. (2013) which features age-varying natural mortality as a function of size of the fish. The age specific M may be calculated using the von Bertalanffy population growth parameters, $L\infty$ and K, and the predicted fork length at the mid-point of each age. The mid-point of each year class can be used to represent the mean size of the fish in a calendar year.

2.5 Reproduction

Yellowtail Snapper reproductive data were provided in Shervette et al. (2024). The overall male to female sex ratio was estimated to be 1:1.04. A total of 892 mature female and 856 mature male Yellowtail Snapper had reproductive phase information. The months with the greatest proportion of spawning capable females were March and April. Males with testes in the spawning capable phase occurred in all months of the year. Yellowtail snapper from the U.S. Caribbean exhibit year-round spawning.

A total of 454 female Yellowtail Snapper samples were evaluated for maturity and indicators of active spawning to estimate spawning fraction, spawning interval, and spawning frequency. Female Yellowtail Snapper spawning fraction overall was 0.13; overall spawning interval, defined as the number of days between spawning events in a female, was 7 days, indicating that a female spawns approximately 49 times over the estimated ~365-day spawning season.

When examining trends in spawning fraction, interval and frequency by length, spawning frequency increased with increasing length class. Females in the smallest fork length (FL) class had an estimated spawning frequency of six times over the spawning season, while females in the largest FL class had an estimated spawning frequency of 69 times over the spawning season. Similar increases in spawning frequency occurred when examined by age classes. Females in the oldest age class (13+ y) spawned approximately 85 times a year.

A total of 949 U.S. Caribbean Yellowtail Snapper samples with length, age, and sexual maturity information were used to obtain estimates of length and age at 50, 90, and 95% maturity (Shervette et al. 2024). Results are shown in Tables 2.3a (length at maturity) and 2.3b (age at maturity).

2.6 Age and Growth

Table 2.4 provides the results of fitting the von Bertanlanffy (VB) growth parameters for various length variables (Shervette et al. 2024). Figure 2.1 shows the fishery-dependent (FD) and fishery independent (FI) length-at-age data and the predicted overall VB growth curve. A summary list of available life history inputs is provided in Table 2.5; from Shervette et al. (2024).

2.7 SEDAR Panel Discussions of Life History Data for Assessment Analyses

Table 2.6 shows the life history parameters used in SEDAR 46 and those provided in Shervette et al. (2024).

Issue 1: Are sufficient life history data available?

Options:

- Use recent and regionally relevant life history data made available in SEDAR working papers.
- Use previously established life history parameters obtained from literature reviews.

Decision:

- Tentatively accept the life history parameters presented. The life history team will work with the assessment team to finalize the working paper.
- Aggregate the maturity data from USCA and SEAMAP-C.

Rationale:

- Both datasets (USCA and SEAMAP-C) show a reproduction peak from March to June, suggesting that the data can be combined.
- Tentatively accept the life history parameters provided. Providing the submission of the working paper, the team will review the results.

2.8 Life History Tables

Table 2.1 Summary of parameters, definitions, nomenclature and units for model parameters included within this report (SEDAR 46 Table 2.2.1).

Parameter	Definition	Management Strategy evaluation Stock Input	Real world data input	Units
$L\infty$	Asymptotic length	Linf	vbLinf	mm FL
K	Brody growth coefficient	K	vbK	year $^{-1}$
$t0$	Theoretical age at length 0	t0	vbt0	years
α	Weight-length scalar	a	wla	dimensionless
β	Weight-length power	b	wlb	dimensionless
$W\infty$	Asymptotic weight	--	--	g
Lm	Length at maturity	L50	L50	mm FL
tm	Age at maturity	--	--	years
$t\lambda$	Maximum age	Max. age	Max. Age	years
$L\lambda$	Mean length of Max age	--	--	mm FL
M	Natural mortality	M	Mort	year $^{-1}$
$S\lambda$	Survivorship to Max age	--	--	dimensionless

Table 2.2 Regression equations for U.S. Caribbean Yellowtail Snapper length-length and length-weight relationship. n = number of fish

Variables				
X	y	n	Equation	R^2
SL	FL	1538	y= 1.1156x+7.9985	0.9974
SL	TL	1520	y = 1.4435x - 69857	0.9917
SL	Wt	1532	$y = 0.00008x^{2.7772}$	0.9842
FL	SL	1538	y = 0.8694x- 6.4783	0.9974
FL	TL	1530	y= 1.2937x-17.299	0.9944
FL	Wt	1542	y = 0.00004x2.8642	0.9882
TL	SL	1520	y = 0.687x- 6.92	0.9917
TL	FL	1530	y = 0.7686x + 14.945	0.9944
TL	Wt	1524	$y = 0.00005x^{2.7185}$	0.9839

Table 2.3a, b Caribbean Yellowtail Snapper a) lengths (mm FL) and b) ages (years) as sexual maturity. Values in parentheses are 95% prediction intervals.

a)

Variable	Sexes Combined	Female	Male
Number of samples	1,876	922	954
L50	194 (189 - 199)	207 (202 - 211)	182 (174 - 190)
L90	238 (233 - 242)	244 (238 - 249)	229 (221 - 235)
L95	253 (246 - 258)	256 (248 - 264)	245 (235 - 253)

b)

Variable	Sexes Combined	Female	Male
Number of samples	949	482	464
A50	1.5 (1.4 - 1.6)	1.5 (1.3 - 1.9)	1.6 (1.4 - 1.7)
A90	2.2 (2.0 - 2.3)	2.1 (1.9 - 2.3)	2.3 (2.0 - 2.6)
A95	2.4 (2.2 - 2.6)	2.3 (2.0 - 2.6)	2.5 (2.2 - 2.9)

Table 2.4 U.S. Caribbean Yellowtail Snapper von Bertanlanffy (VB) growth function (VBGF) results. Parameter estimates are provided using fork length (FL) and total length (TL). Also provided are computed parameter estimates using theoretical age at length 0 (t_0) = -0.96 for comparison with the Caribbean study by Manooch and Drennon (1987) and using (t_0) = -1.93 for comparison with growth parameter estimates for Southeastern U.S. Yellowtail Snapper as reported in SEDAR 64.

Model	L∞ (mm)	K	t0	R2
FLmm	508 (479-547)	0.12 (0.10-0.14)	-2.73 (-3.29- -2.26)	0.70
TLmm	653 {635-648)	0.11 (0.10-0.13)	-2.67 (-3.18- -2.18)	0.70
FL mm to-fixed Carib	424 (415-434)	0.23 (0.22-0.24)	-0.96	0.68
FL mm to-fixed Fla	467 (454-481)	0.16 (0.15-0.18)	-1.93	0.70

Table 2.5 Summary of Yellowtail Snapper studies focused on estimating growth parameters. * indicates that a fixed t_0 value of -0.96 was used so that other growth parameters results from the Shervette et al, 2024 study could be compared to results from Manooch and Drennon (1987) ** indicates that a fixed t_0 value of -1,93 was used so that other growth parameter results from the Shervette et al, 2024 study could be compared to results from Florida (SEDAR 64/Stevens et al. 2019).

Study Area Study Citation	Time period (n) sample source	Size range (mean) mm	Age range (mean) y	L_∞/K/t_0 Opaque zone formation	Comments
U.S. Caribbean Current study	2013-2023 (1554) FI + FD	FL: 28-572 (291)	0-26 (5)	FL: 508/0.12/-2.73 424/0.23/-0.96* 467/0.16/-1.93** Mar-Jun	Age validation via radiocarbon
U.S. Caribbean Manooch and Drennon 1987	1983-1984 (468) FD	FL: 140-590	1-17	FL: 503/0.14/-0.96 Mar-May	Used back-calculated size-at-age
Cuba Claro 1983	1972-1974 (3593) FD	FL: 160-460	0-6	FL: 681/0.16/-0.85 Mar-Jun	No validation of age estimates; otoliths read whole
FL east coast Allman et al. 2005	1980-2002 (6679) FI + FD	FL: 115-605 (312)	1-17 (4)	FL: 410/0.27/-2.03 Feb-May	
Southeast FL Garcia et al. 2003	1994-1999 (1528) FD	FL: 220-561	1-13	FL: 484/0.17/-1.87 Mar-May	
Southeast FL Johnson 1983	1979-1980 (807) FD	FL: 134-567	1-14	FL: 451/0.28/-0.36	
Florida SEDAR 2020	1980-2017 (42,985) FD (<1% FI)	FL: 100-600*	0-28	FL: 426/0.20/-1.93 Mar-Jun	Growth model accounted for truncated size-at-age

Table 2.6 Life history parameter values for Yellowtail Snapper provided by Shervette et al, 2024 and those used in SEDAR46 (S46 report Table 2.2.2). Values provided include the mean and CVs. Units are defined in Table 2.1 Asterisks denote values where the CV was not reported in the literature and instead imputed by SEDAR 46 Life History Working Group.

Parameter	Yellowtail Snapper (Shervette et al, 2024)	Yellowtail Snapper (Sedar 46)
vbLinf	508	502.5 (0.05)
vbK	0.12	0.139 (0.16)
vbt0	-2.73	−0.96 (0.45)
wla	4.0E-05	3.45E-05 (0.05*)
wlb	2.8642	2.859 (0.05*)
W∞		1,870
L50	194	248 (0.15*)
tm		3.939 (0.25*)
Lλ		471.1
Max. Age	26	19
Mort (M)		0.189 (0.083*)
Sλ		0.0276

2.9 Life History Figures

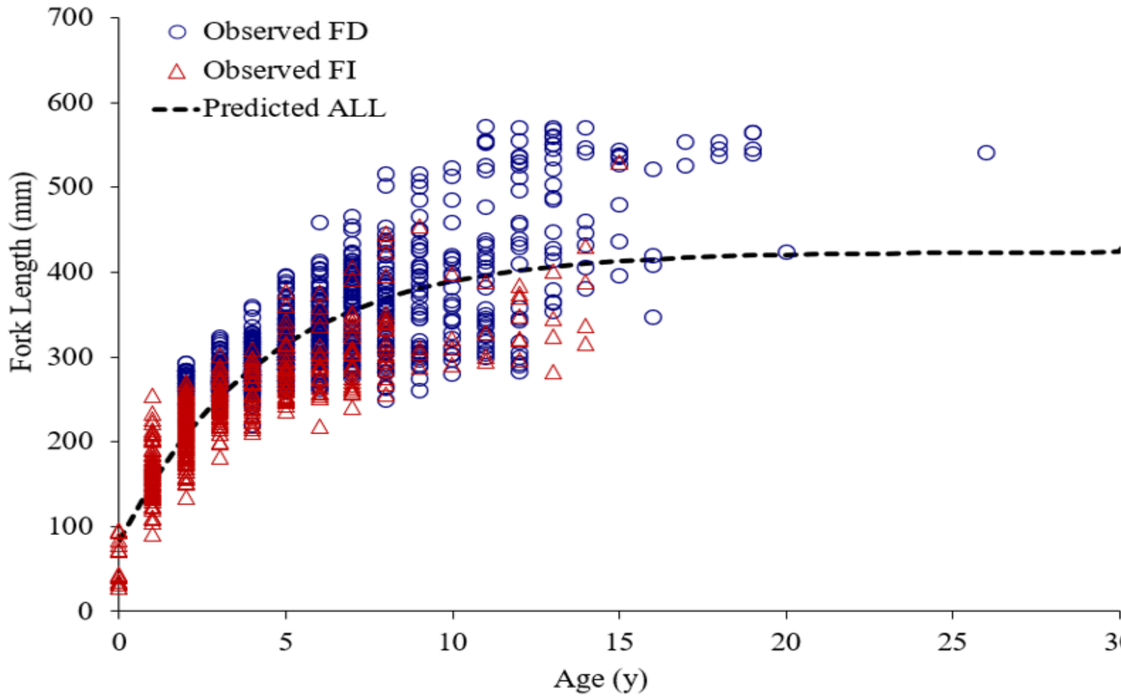

Figure 2.1 U.S. Caribbean Yellowtail Snapper length-at-age for FD and FI samples and von Bertalanffy growth based on $t_0 = -0.93$.

3 Commercial Fishery Statistics

3.1 Commercial Landings

3.1.1 Overview

Commercial fishery landings in Puerto Rico were obtained from self-reported fisher logbook data (Caribbean Commercial Logbook, CCL) the fishers mail or deliver monthly to the Puerto Rico Department of Natural and Environmental Resources. A proportion of fishers are reporting to an e-reporting system that began in January 2020.

Commercial landings were reported by species, fishing gear, and the fishing center where the catch was landed. Puerto Rico commercial landings have been incompletely reported throughout the available time series (Caribbean Fisheries Data Evaluation Final Report, 2009) and correction factors have been used to estimate total landings. Commercial fishery landings data for Yellowtail Snapper in Puerto Rico were available for the years 1983-2022. The commercial landings were produced in pounds by year and fishing gear (Table 3.1.1 and Figure 3.1.1).

3.1.2 Correction factors and Calculation of Commercial Landings

Compilation of commercial fishery landings of 1983-2002 (see Appendix 1 of working paper on Puerto Rico commercial landings, Martinez et al 2024) used a single, island-wide, correction factor. For the years 2003 to 2022, correction factors were coast-specific (north, south, east, west). Reported landings were assigned to a coast based upon the fishing center reported for a trip. Over the years, there have been a few examples where the correction factor was adjusted. Refer to the working paper for these years along with the reasoning and solution behind the deviation. Total landings were estimated as the reported landings (island-wide or coast specific, as appropriate) divided by the correction factor (correction factors are less than one and reported landings are a fraction of the actual landings).

3.1.3 Outlier removal

Outlier removal was conducted by using a mean and standard deviation method. In Puerto Rico, fishers combined landings from multiple trips in single logbook reports in several years. In those cases when multiple trips combined in a single report, we used reported landings (not expanded landings) divided by the number of trips to estimate landings per trip for the outlier analysis. If the landings of Yellowtail Snapper reported on a trip were greater than three standard deviations from the mean (i.e., 99.73% quantile), the report was assumed to be in error and those data were removed from the dataset. Two methods were used to identify outliers: Method 1, the values to define outliers were calculated by gear group across all years (Table 3.1.2), and Method 2, the values to define outliers were calculated by year and gear group (Table 3.1.2).

3.2 Commercial Discards

Commercial discards are not reported in Puerto Rico fisher logbook data.

3.3 Commercial Effort

Commercial trips with reported Yellowtail Snapper landings per year and gear group were compiled from 1983 to 2022 (Table 3.3). No correction factors for estimating total trips were available for Puerto Rico; correction factors were designed to more accurately estimate total landings.

3.4 Biological Sampling

3.4.1 Overview

The NOAA Fisheries, Southeast Fisheries Science Center Trip Interview Program (TIP) collects length and weight data from fish landed by commercial fishing vessels, along with information about fishing area and gear. Data collection began in 1983 with frequent updates in best practices; the latest being in 2017. Data are collected by trained shore-based samplers (Beggerly, Stevens, and Baertlein 2022).

Additional length composition data from the commercial fishery in Puerto Rico were collected by MER Consultants during the period 2017-2019 with additional sampling in 2023 using image analysis (Soto et al. 2024).

3.4.2 Length Composition Sampling Intensity

The TIP data pertaining to Yellowtail Snapper in Puerto Rico consists of 103,730 length observations across 5,159 unique port sampling interviews (Figure 3.4.1). Of the Yellowtail Snapper measured, 103,520 were fork length observations (99.8%). Plots and summary statistics of the currently available length frequency data of Yellowtail Snapper sampled from the predominant gears in Puerto Rico are included in the working paper (Godwin et al. 2024).

The MER Consultants data set included more than 20,000 images taken, of which 2,484 were Yellowtail Snapper measurements provided for SEDAR 84. Samples were collected from locations throughout Puerto Rico.

3.4.3 Length Distributions

A large variety of fishing gears were used by Puerto Rico commercial fishers to catch Yellowtail Snapper. An analysis was conducted to establish gear groups among the many commercial fishing gears with groups based upon Yellowtail Snapper size composition differences among the gears. The resulting groups are recorded in Table 3.4.1. Summary statistics produced by a generalized linear mixed model (GLMM) analysis of the available length frequency data from 1983 to 2022 are also found in Table 3.4.1. Gear groups were identified based on GLMM analysis using a gamma-distributed dependent variable and a covariate to account for changes in mean size over time. Random effects for interview ID and categorical year were included to account for non-independence of observations.

The aggregated density plot for all gears combined of Yellowtail Snapper fork lengths collected across three or more unique interviews per gear group across the time series 1983-2022 are summarized in Figure 3.4.2. Aggregated density plots of Yellowtail Snapper landed by gears with 2% or more of the samples are summarized in Figure 3.4.3.

MER Consultant samples were collected from locations throughout Puerto Rico (Fig. 3.4.4). A histogram of Yellowtail Snapper fork lengths for all years is shown in Table 3.4.5. Histograms of Yellowtail Snapper fork lengths for 2017-2018 and 2023, plotted separately, are provided in Figure 3.4.6. Density plots of Yellowtail Snapper fork lengths are shown in Figure 3.4.7 for 2017-2019 and 2023 (plotted separately).

3.4.4 Adequacy of Size Composition Data for Characterizing Catch

Due to reasonable levels of available data throughout the time series, TIP data can be considered to inform selectivity and annual population trends in the SEDAR 84 assessment. A high number of length and weight pairs flagged as possible outliers and further investigation into the filtering process will need to be executed to understand the reason those data were identified as outliers (Godwin et al 2024).

As necessary, the analysts will communicate the high uncertainty across the measurement units associated with the TIP data for Yellowtail Snapper. Additionally, further investigation into how the length-weight relationship varies by month and year (reflecting seasonality and variability in reproduction) is suggested.

The MER Consultants Yellowtail Snapper data in Puerto Rico reflects the size composition of fish landed in the commercial fishery and may be combined with TIP data.

3.5 SEDAR Panel Discussion of Commercial Statistics Data for Assessment Analyses

3.5.1 Adequacy of Commercial Landings Data

Issue 1: Are analysis-ready commercial landings data available for SEDAR 84?

Options:
- Use all available expanded landing data (starting in 1983) and using newly calculated 2020-2022 expansion/correction factors.
- Use all available expanded landing data (starting in 1983) and using coast-specific expansion factors averaged across the years 2014-2019 as proxy expansion factors to calculate 2020-2022 commercial landings.
- Truncate the time series if electronic logbook data are not available

Decision:
- Move forward using all available landings data and using coast-specific expansion factors averaged across the years 2014-2019 as proxy expansion factors to calculate 2020-2022 commercial landings.
- Acquire reports from the 1950s to the 1970s. Those reports may include additional species-specific information.

Rationale:
- These data represent the best and most complete information available.

Issue 2: How uncertain are the commercial landings?

Options:

- Consider uncertainty around the landings. (e.g. +/- 5%)
- Consider directional bias. (e.g. + 5%)

Decision:

- Consider uncertainty around the landings.

Rationale:

- This decision was based on the opinion of panel members.

Issue 3: Should data outliers in the commercial landings be flagged for additional investigation?

Options:

- Identify and flag outliers.
- Do not identify and flag outliers.

Decision:

- Conduct outlier analysis flagging by year and gear.

Rationale:

- Through the flagging process, we can identify outliers to investigate further, allowing us to understand the situations occurring within the fishery and their potential impact.

3.5.2 Adequacy of Discard and Discard Mortality Data

Issue 1: Do we have estimates of commercial discards and estimates of discard mortality?

Options:

- Identify a data source quantifying commercial discards.
- Do not consider discards.

Decision:

- Do not consider discards.

Rationale:

- Discard mortality was deemed negligible. Anecdotally, discard quantities are small, and most discarded fish survive.

Issue 2: Do we have estimates of recreational discards and estimates of discard mortality?

Options:

- Investigate the data further for consideration at the SEDAR 84 Assessment Workshop.
- Do not consider recreational discard data.

Decision:

- The assessment team and contributors will present the results of this investigation at the assessment workshop.

Rationale:

- It is crucial to explore the little available information.

3.5.3 Adequacy of Length Composition Data

Issue 1: Can the TIP size data be used for SEDAR 84 to inform selectivity?

Options:
- Use filtered TIP lengths available by year from 1983 to 2022.
- Do not use the data to inform SEDAR 84.

Decision:
- Consider TIP data to inform selectivity and annual population trends in the SEDAR 84 assessment.
- Apply filtering based on the condition factor.
- Supply complete TIP time series for use in SEDAR 84 investigations.

Rationale:
- Use the TIP data since there were reasonable levels of available data.
- Investigate the filtering process further. The high number of flagged pairs of length and weights need to be better understood. Alternatively, communicate high uncertainty across the measurement units associated with the TIP data for Yellowtail Snapper.

Issue 2: Are the pilot Yellowtail Snapper length-frequency image analysis data available for consideration in SEDAR 84?

Options:
- Do not consider the image analysis data in SEDAR 84.
- Combine image analysis data with TIP data for length frequency and size composition analysis.

Decision:
- Obtain the image analysis data so that it can be combined with TIP data for length frequency and size composition analysis.

Rationale:
- The image analysis data of Yellowtail Snapper in Puerto Rico data reflects the size composition of fish landed in the commercial fishery. Including this data with the TIP data would be entirely appropriate.

Issue 3: Are the seine net study data available for consideration in SEDAR 84?

Options:
- *Use the data in the size composition analysis.*
- *Do not use the data in the size composition analysis.*

Decision:
- Using the seine net data to investigate length-weight relationships to identify trends over time.

Rationale:
- The seine net data may also help inform the TIP outlier identification.

Issue 4: Should length composition analysis be performed on available recreational data?

Options:

- Consider this information.
- Do not consider this information.
- Investigate the dataset further.

Decision:

- Investigate the dataset further.

Rationale:

- It is crucial to explore the little available information.

3.6 Commercial Statistics Tables

Table 3.1.1 Commercial landings of Yellowtail Snapper in Puerto Rico from 1983-2022 reported in pounds by year and gear group.

Year	Lines	Seines	Traps	Other	Total landings
1983	149,406	25,970	86,535	12,731	274,642
1984	131,087	26,058	58,738	11,551	227,434
1985	144,349	12,145	70,487	23,561	250,542
1986	62,075	5,455	26,006	31,456	124,992
1987	73,055	1,856	24,742	23,371	123,024
1988	90,913	2,553	21,402	22,997	137,865
1989	123,814	13,088	23,140	18,500	178,542
1990	158,339	15,525	23,957	12,152	209,973
1991	224,461	11,469	38,528	16,816	291,274
1992	188,932	10,375	27,955	21,243	248,505
1993	236,203	18,335	30,267	20,143	304,948
1994	216,496	19,672	34,091	20,705	290,964
1995	351,076	8,930	30,454	18,991	409,451
1996	298,343	5,103	38,889	40,440	382,775
1997	277,622	5,512	34,534	32,134	349,802
1998	273,493	3,554	25,614	19,860	322,521
1999	300,224	5,277	29,267	21,774	356,542
2000	539,669	15,409	38,101	39,279	632,458
2001	380,300	17,982	33,130	33,715	465,127
2002	268,390	11,666	33,567	24,396	338,019
2003	222,036	19,559	25,663	14,943	282,201
2004	274,280	13,494	32,804	23,940	344,518
2005	232,924	3,771	15,780	9,601	262,076
2006	248,891	196	16,006	9,500	274,593
2007	189,707	132	8,711	7,887	206,437
2008	354,259	183	7,138	12,030	373,610
2009	196,272	1,935	17,915	6,470	222,592
2010	194,288	2,491	13,963	4,057	214,799
2011	127,667	1,383	10,434	10,105	149,589
2012	173,240	2,006	18,550	14,356	208,152
2013	111,739	2,079	12,363	5,086	131,267
2014	169,273	2,689	14,905	5,941	192,808
2015	156,712	2,216	14,652	4,011	177,591
2016	168,254	1,863	12,885	5,119	188,121
2017	109,539	2,029	8,768	5,002	125,338
2018	127,408	895	12,479	8,417	149,199
2019	142,782	336	11,913	9,262	164,293
2020	97,231	462	9,145	17,347	124,185
2021	113,007	132	12,699	23,143	148,981
2022	136,046	1,162	13,132	24,596	174,936

Table 3.1.2 Comparison of commercial landings of Yellowtail Snapper in Puerto Rico from 1983-2022 in relation to the outlier removal methods.

Year	Landings (no outlier removal)	Landings (outlier removal method 1)	Landings (outlier removal method 2)	Diff (method 1)	Diff (method 2)
1983	274,642	272,354	268,303	-1%	-2%
1984	227,434	225,728	223,160	-1%	-2%
1985	250,542	249,476	241,602	0%	-4%
1986	124,992	115,866	119,388	-7%	-4%
1987	123,024	110,585	116,893	-10%	-5%
1988	137,865	131,922	133,256	-4%	-3%
1989	178,542	170,217	171,512	-5%	-4%
1990	209,973	205,342	202,956	-2%	-3%
1991	291,274	285,211	282,720	-2%	-3%
1992	248,505	233,250	235,594	-6%	-5%
1993	304,948	283,662	290,127	-7%	-5%
1994	290,964	275,370	280,661	-5%	-4%
1995	409,451	389,674	391,947	-5%	-4%
1996	382,775	372,211	371,393	-3%	-3%
1997	349,802	328,188	335,542	-6%	-4%
1998	322,521	299,913	308,796	-7%	-4%
1999	356,542	336,897	343,957	-6%	-4%
2000	632,458	596,566	607,693	-6%	-4%
2001	465,127	433,541	446,612	-7%	-4%
2002	338,019	325,605	325,872	-4%	-4%
2003	282,201	275,807	272,098	-2%	-4%
2004	344,518	330,700	324,337	-4%	-6%
2005	262,076	253,478	251,652	-3%	-4%
2006	274,593	271,765	269,411	-1%	-2%
2007	206,437	203,520	201,544	-1%	-2%
2008	373,610	373,060	365,904	0%	-2%
2009	222,592	221,852	219,382	0%	-1%
2010	214,799	213,999	209,141	0%	-3%
2011	149,589	149,258	145,412	0%	-3%
2012	208,152	207,631	202,538	0%	-3%
2013	131,267	131,267	128,245	0%	-2%
2014	192,808	192,808	188,385	0%	-2%
2015	177,591	177,591	173,347	0%	-2%
2016	188,121	186,624	183,166	-1%	-3%
2017	125,338	124,004	121,405	-1%	-3%
2018	149,199	147,998	144,098	-1%	-3%
2019	164,293	161,539	159,455	-2%	-3%
2020	124,185	124,185	121,694	0%	-2%
2021	148,981	147,010	144,751	-1%	-3%
2022	174,936	174,936	170,123	0%	-3%

Table 3.3 Commercial trips with reported Yellowtail Snapper landings in Puerto Rico 1983-2022.

Year	Lines	Other	Seines	Traps	Total Trips
1983	3,785	378	390	4,359	8,912
1984	4,154	455	288	4,328	9,225
1985	5,277	1,077	286	4,540	11,180
1986	2,085	973	128	1,762	4,948
1987	1,753	368	31	1,246	3,398
1988	1,672	364	44	756	2,836
1989	2,836	244	118	998	4,196
1990	3,420	456	75	1,443	5,394
1991	5,219	557	232	2,495	8,503
1992	4,510	555	105	1,516	6,686
1993	5,661	733	149	1,960	8,503
1994	6,099	869	147	1,830	8,945
1995	12,496	1,551	343	3,757	18,147
1996	11,480	2,771	219	5,116	19,586
1997	11,719	2,550	342	4,115	18,726
1998	9,109	1,438	79	2,805	13,431
1999	11,686	2,351	171	3,839	18,047
2000	11,102	2,915	169	3,342	17,528
2001	10,750	2,572	219	3,221	16,762
2002	10,560	2,399	236	3,502	16,697
2003	4,130	712	93	1,367	6,302
2004	3,167	553	84	1,125	4,929
2005	2,918	368	27	781	4,094
2006	2,497	310	8	709	3,524
2007	2,117	374	13	419	2,923
2008	1,869	354	15	425	2,663
2009	1,761	352	36	514	2,663
2010	1,744	269	40	444	2,497
2011	2,042	349	23	408	2,822
2012	2,179	417	14	581	3,191
2013	2,596	241	12	724	3,573
2014	3,025	277	28	924	4,254
2015	2,885	250	52	936	4,123
2016	2,626	291	47	803	3,767
2017	1,729	219	29	519	2,496
2018	1,736	331	20	528	2,615
2019	2,422	323	21	721	3,487
2020	1,606	336	10	521	2,473
2021	2,120	431	6	661	3,218
2022	2,527	533	14	656	3,730

Table 3.4.1 Generalized linear mixed model (GLMM) analysis summary results for Puerto Rico TIP Yellowtail Snapper fork lengths (cm) from 1983 to 2022. The column "group" indicates the group(s) where mean lengths are not statistically different from other gears with matching group number(s). The "n" column indicates the number of unique lengths recorded for each gear. The "Percentage" column indicates the percent of the total recorded lengths for each gear. Shaded rows indicate gears with less than two percent of the total recorded lengths.

Gear	Mean	Estimated Marginal Mean	LCL	UCL	Group	Fish (n)	Interview (n)	Percentage	Gear Group
LINES HAND	30.03	3.38	3.37	3.40	5	79,750	2,644	76.50	Hand Line
HAUL SEINES	25.13	3.18	3.14	3.21	1	7,214	212	6.92	Haul Seine
POTS AND TRAPS; FISH	25.05	3.22	3.21	3.24	1,2	6,995	1,282	6.71	Haul Seine or Trap
BOTTOM LINE	29.70	3.38	3.35	3.42	5	4,776	204	4.58	Hand Line
ENTANGLING NETS (GILL) UNSPC	26.28	3.28	3.24	3.31	2,3,4	1,338	123	1.28	Trap, Net, or Diving
TRAMMEL NETS	27.55	3.31	3.28	3.33	3,4	1,005	224	0.96	Net or Diving
LINES LONG SET WITH HOOKS	27.59	3.35	3.30	3.40	3,4,5	634	61	0.61	Net, Diving, or Hand Line
BY HAND; DIVING GEAR	30.18	3.36	3.32	3.39	4,5	557	117	0.53	Diving or Hand Line
LINES POWER TROLL OTHER	30.29	3.39	3.32	3.45	3,4,5	419	36	0.40	Net, Diving, or Hand Line
FISH POT	25.09	3.25	3.21	3.29	1,2,3	369	99	0.35	Haul Seine, Trap, or Net
ROD AND REEL	27.61	3.35	3.28	3.42	2,3,4,5	366	32	0.35	Trap, Net, Diving, or Hand Line

POTS AND TRAPS; SPINY LOBSTER	28.56	3.31	3.20	3.42	1,2,3,4,5	235	14	0.23	Haul Seine, Trap, Net, Diving, or Hand Line
BEACH SEINE	27.96	3.24	3.09	3.39	1,2,3,4,5	177	7	0.17	Haul Seine, Trap, Net, Diving, or Hand Line
LONGLINE	31.30	3.34	3.23	3.46	1,2,3,4,5	78	10	0.07	Haul Seine, Trap, Net, Diving, or Hand Line
SCUBA DIVING	29.52	3.32	3.25	3.39	1,2,3,4,5	48	29	0.05	Haul Seine, Trap, Net, Diving, or Hand Line
TRAMMEL NET	27.50	3.35	3.24	3.46	1,2,3,4,5	45	11	0.04	Haul Seine, Trap, Net, Diving, or Hand Line
LOBSTER POT	23.34	3.19	3.07	3.31	1,2,3,4,5	28	10	0.03	Haul Seine, Trap, Net, Diving, or Hand Line
GILL NET	27.57	3.31	3.15	3.47	1,2,3,4,5	22	5	0.02	Haul Seine, Trap, Net, Diving, or Hand Line
NOT CODED 000	24.20	3.21	3.05	3.38	1,2,3,4,5	23	4	0.02	Haul Seine, Trap, Net, Diving, or Hand Line
SKIN DIVING	31.04	3.40	3.20	3.59	1,2,3,4,5	18	4	0.02	Haul Seine, Trap, Net, Diving, or Hand Line
TROLL LINE	24.86	3.29	3.10	3.48	1,2,3,4,5	16	3	0.02	Haul Seine, Trap, Net, Diving, or Hand Line

3.7 Commercial Statistics Figures

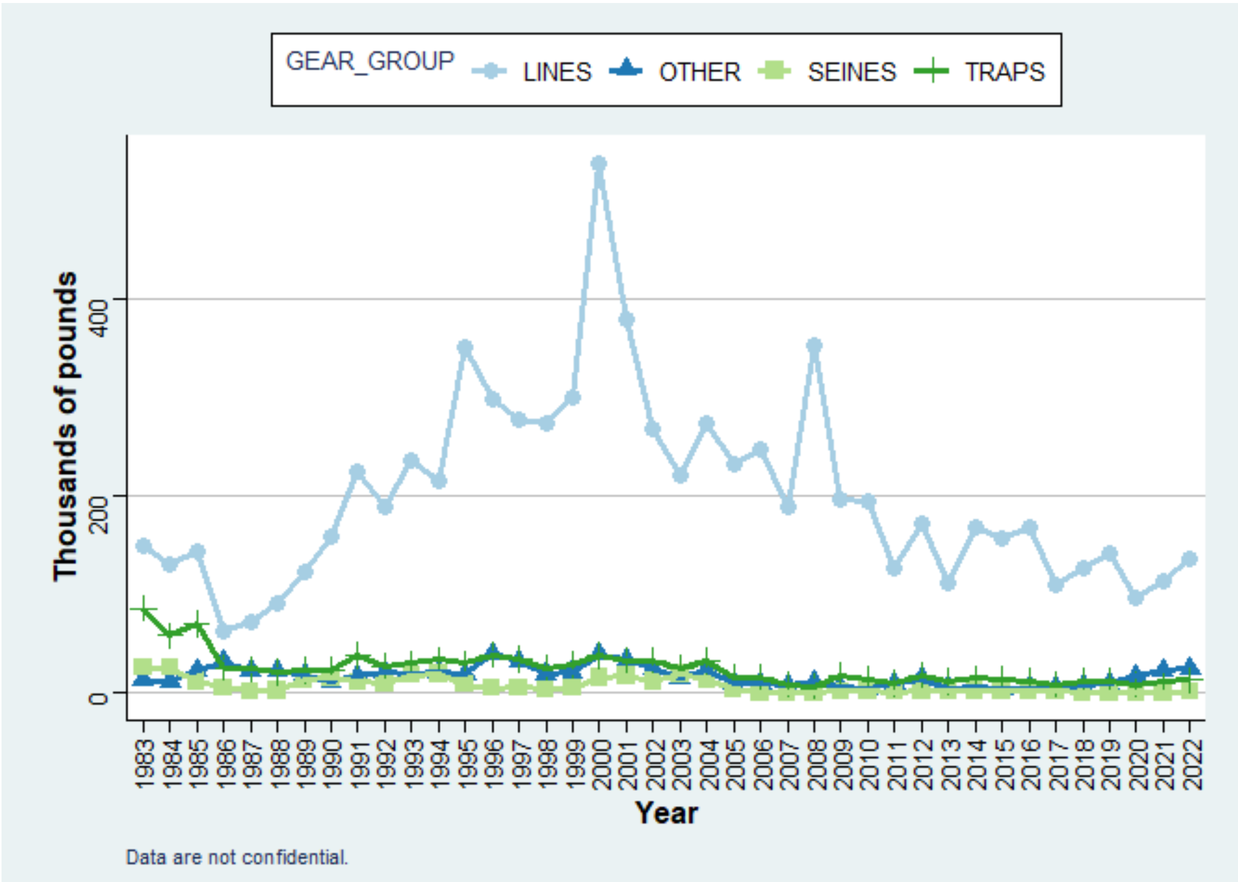

Figure 3.1.1 Commercial landings in pounds of Yellowtail Snapper by year and gear group in Puerto Rico.

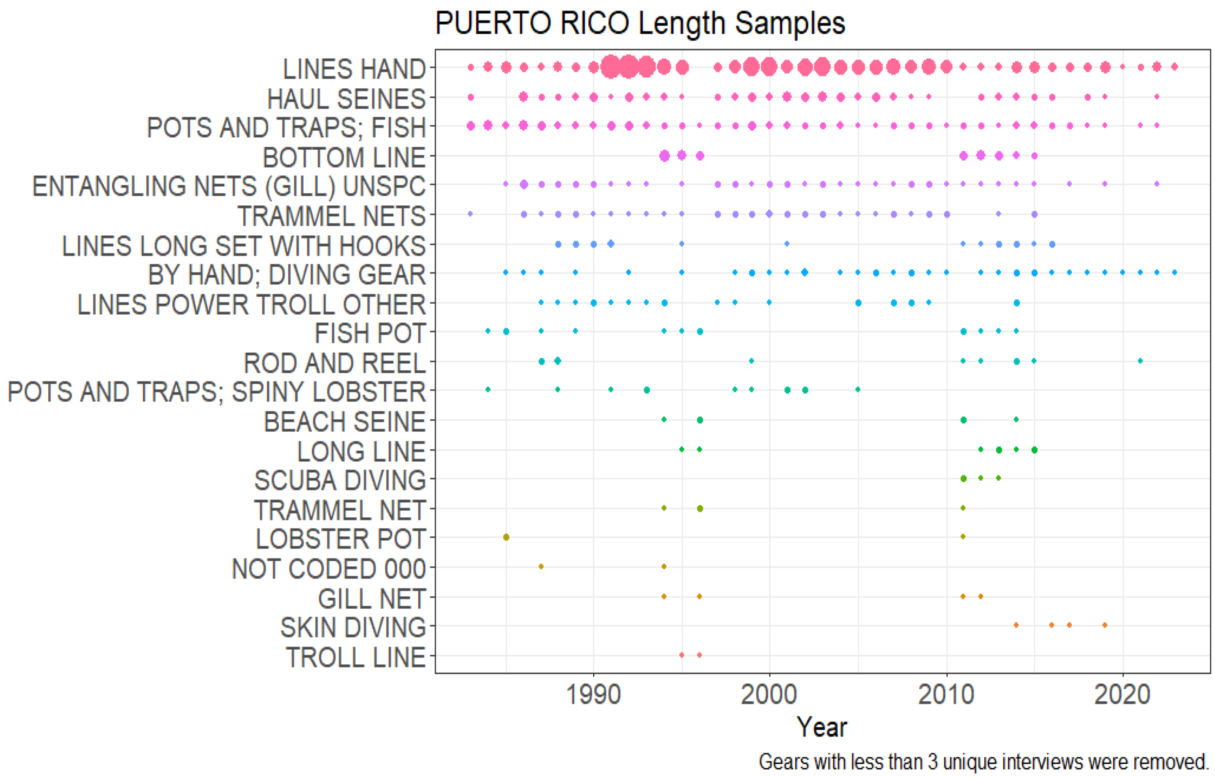

Figure 3.4.1 Plot showing relative number of Yellowtail Snapper lengths in Puerto Rico across time collected. Each point is color specific to the gear it represents. Gears are arranged from largest to smallest sample size of individual recorded lengths.

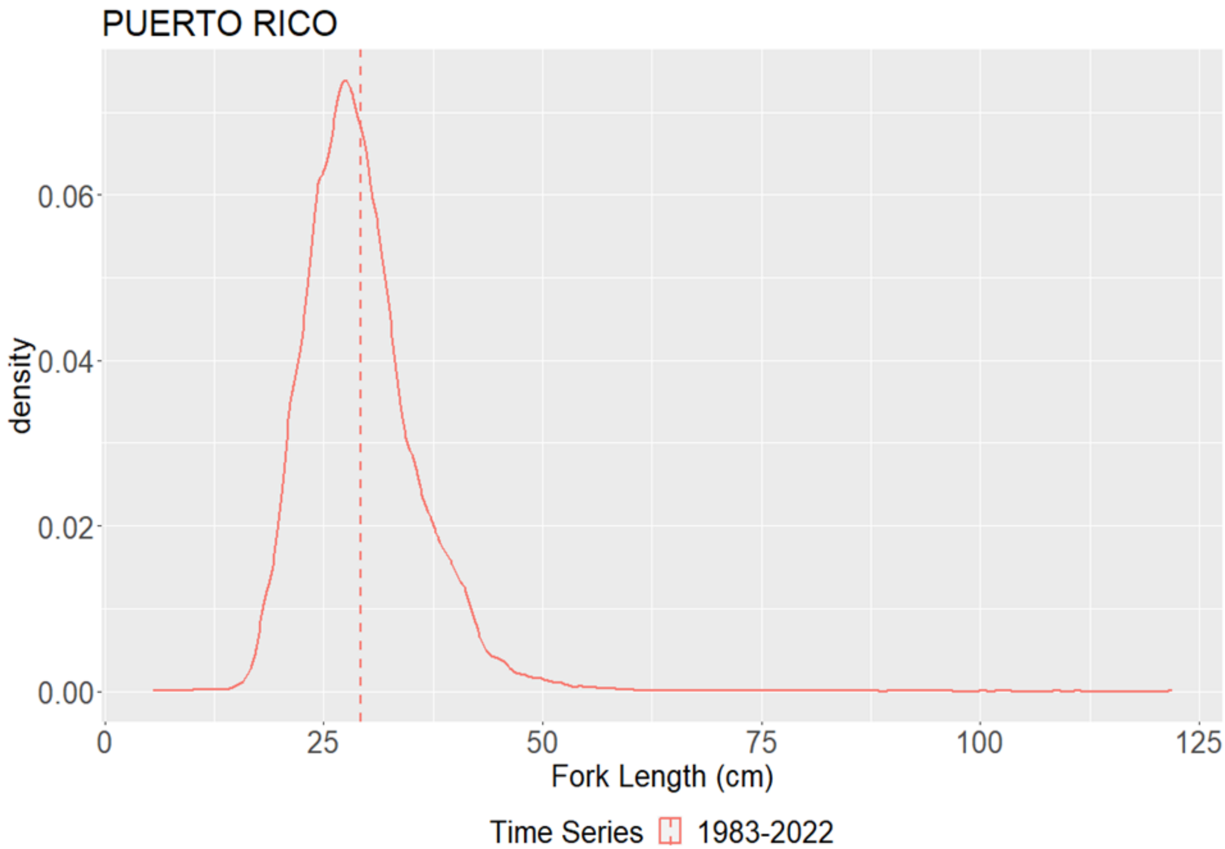

Figure 3.4.2 Aggregated density plot of lengths (cm) of Yellowtail Snapper in Puerto Rico, all gears combined. Dotted line represents mean length (29.22cm).

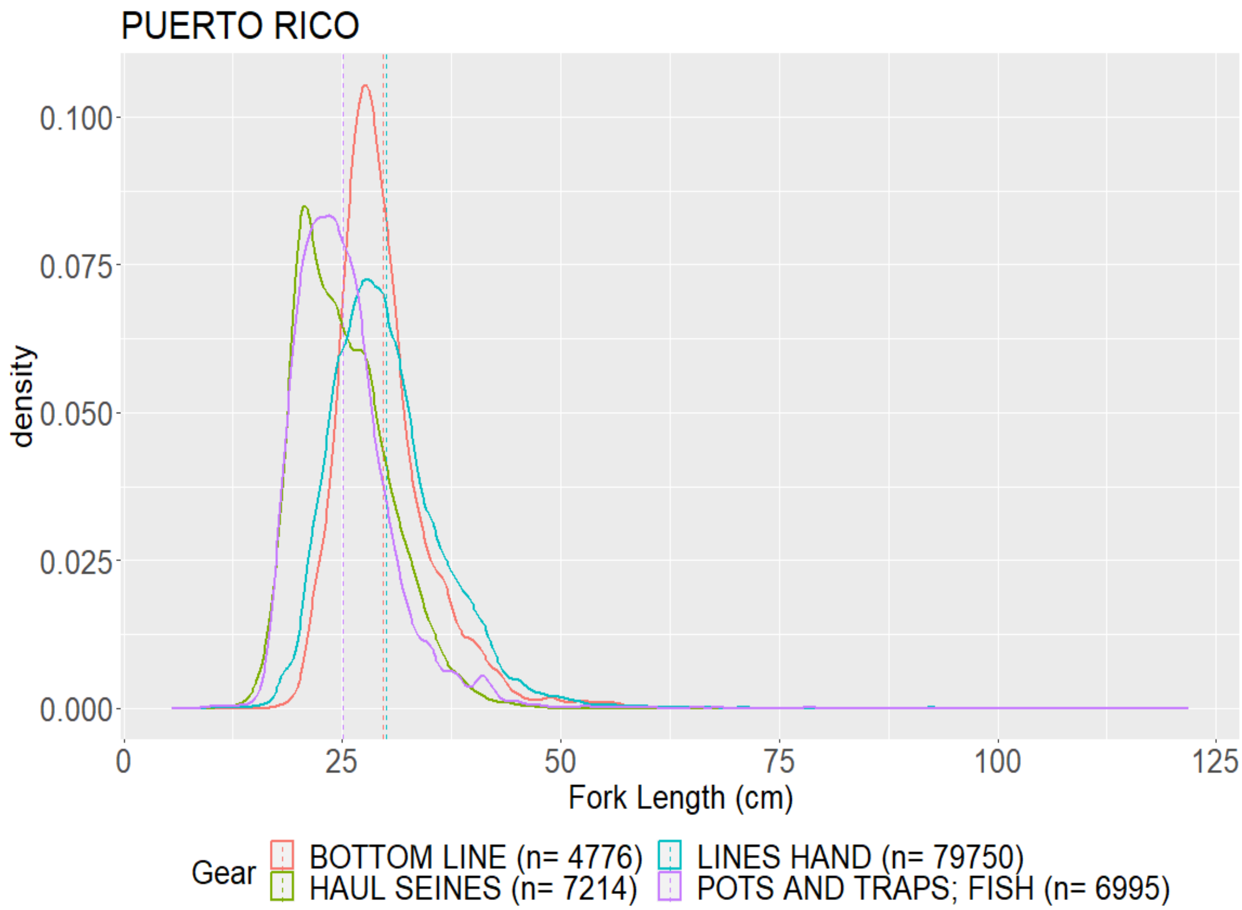

Figure 3.4.3 Aggregated density plot of lengths (cm) by gears with greater than 2% of total samples of Yellowtail Snapper in Puerto Rico from 1983 to 2022. Dotted line represents mean length. Mean lengths by gear can be found in Table 3.4.1.

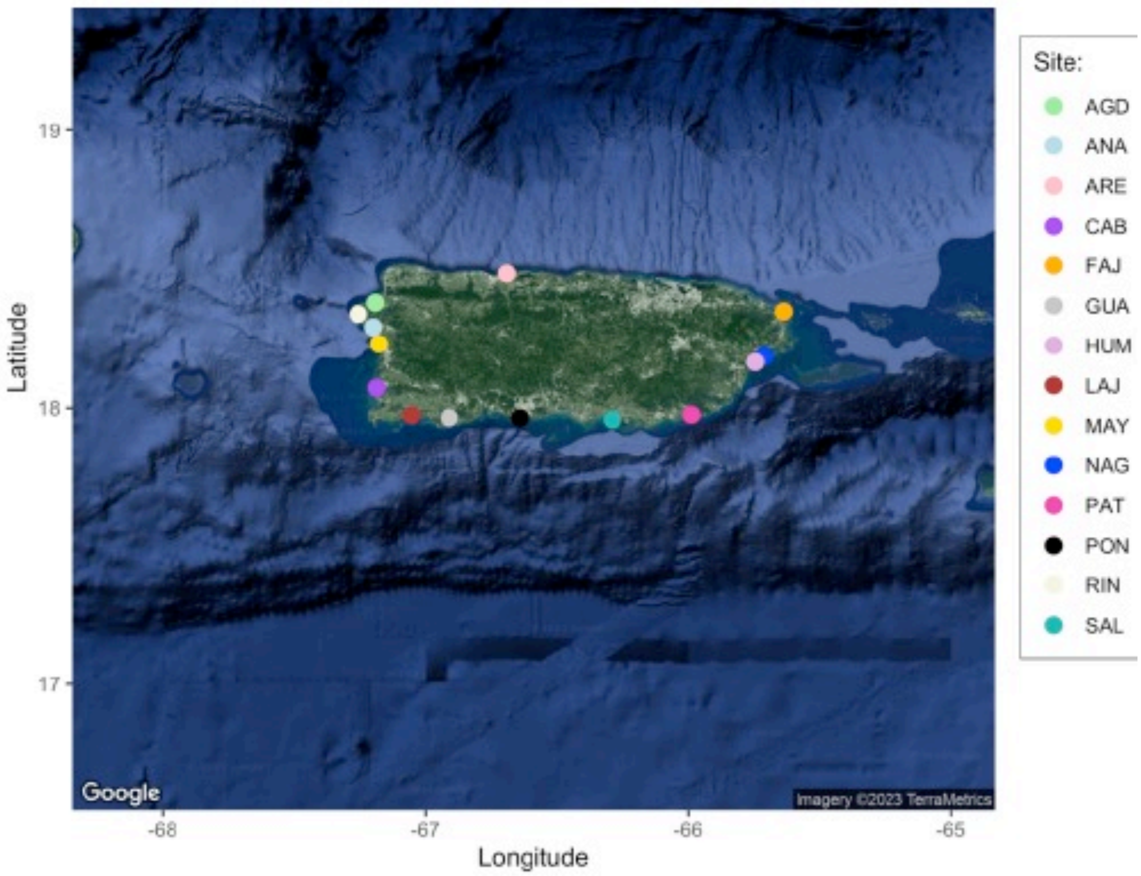

Figure 3.4.4 Map of the MER Consultant 2023 port sampling study.

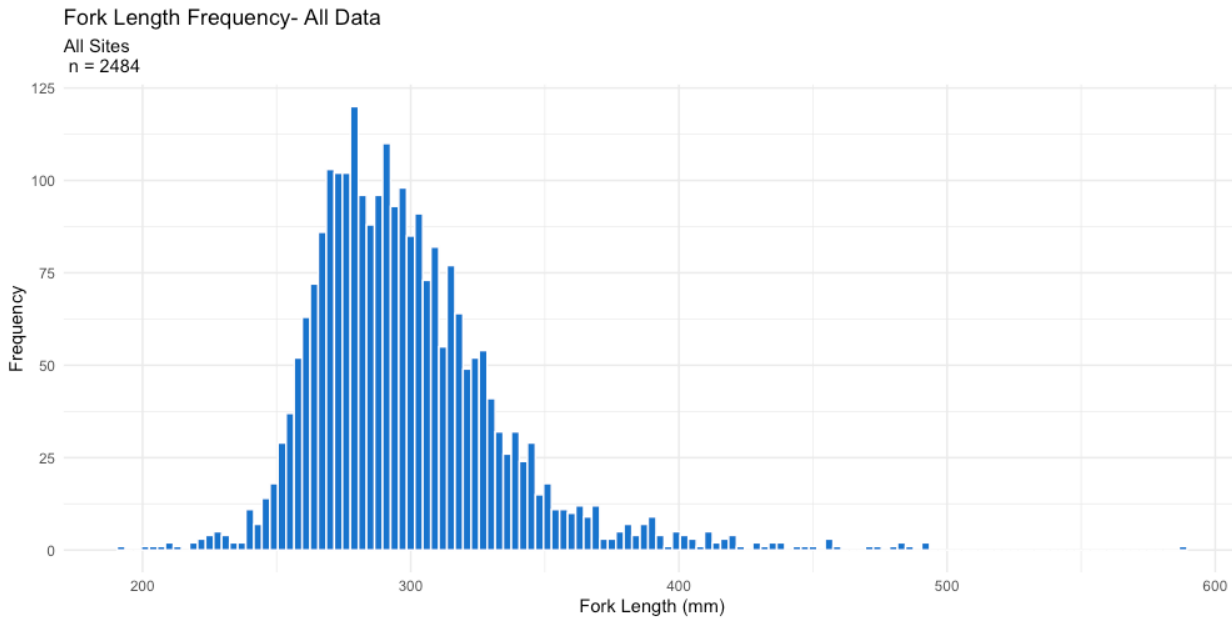

Figure 3.4.5 Digitally measured fork length frequency histogram of Yellowtail Snapper for 2023 and 2017-2019 datasets.

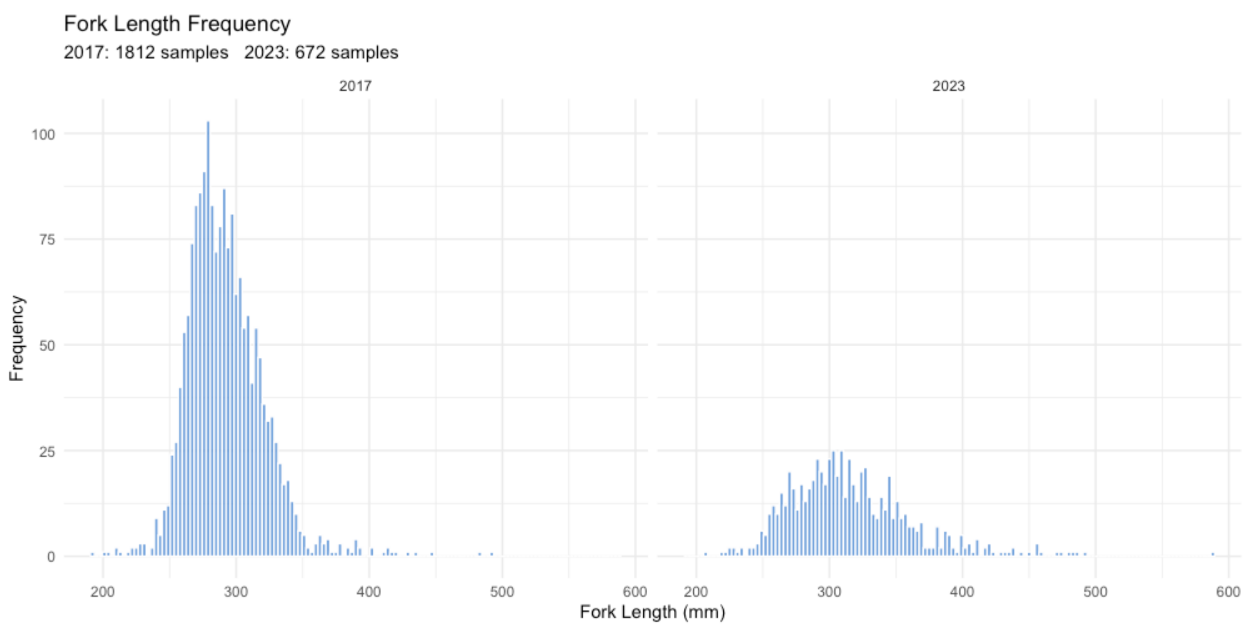

Figure 3.4.6 Digitally measured fork length frequency histogram of Yellowtail Snapper for 2023 and 2017-2019 datasets. Note: plot labeled 2017 includes data from 2017-2019.

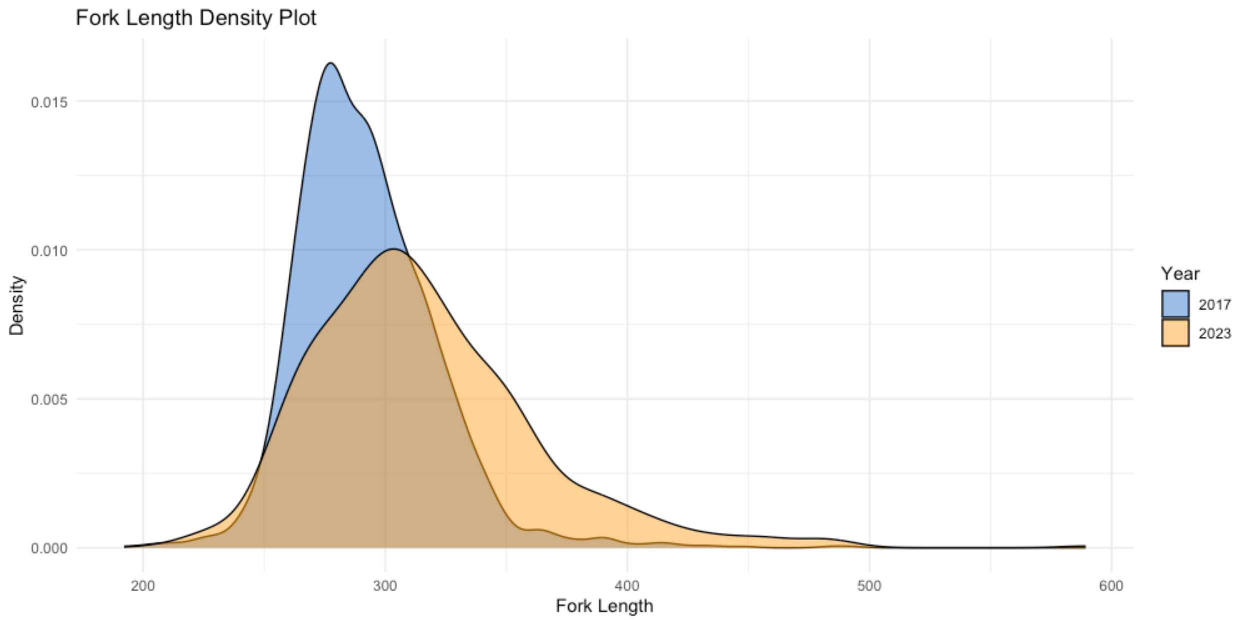

Figure 3.4.7 Density plot of Yellowtail Snapper fork lengths by subsets. Note: plot labeled 2017 includes data from 2017-2019.

4 Recreational Fishery Statistics

4.1 Overview

Overview of Yellowtail snapper (*Ocyurus chrysurus*) available for SEDAR 84 collected in the Department of Natural and Environmental Resources' Marine Recreational Fisheries Statistics Program.

4.2 Summary

The Puerto Rico Marine Recreational Fisheries Statistics Program has been collecting information on fishing tournaments since 2000. The goal is to estimate tournament landings and/or releases by kilogram and catch per unit effort of marine recreational anglers. These data are utilized to examine biostatistical and socioeconomic statistics, as well as on-site effort, landings, and/or release data, all of which are useful for Puerto Rico fishery management. Tournament surveys cover pelagic, reef, and shore fishing competitions.

4.3 Methodology

Then, project staff attended each tournament and collected the landings and/or releases data as well as total effort information from records (logbooks) and collected biometrical data. These include information on sex (whenever possible), length, weight, and species identifications as a minimum.

From the period of 2000-2022 a total of 824 fishing tournaments have been visited by project staff, of those 63 had yellow tail snapper reported as catch (Table 4.1, Figure 4.1). It should be noted that Yellowtail Snapper is not the target species in any fishing competitions.

Among the tournament fishing modes that were sampled, Yellowtail Snapper was mentioned in the reports from shore and kayak fishing competitions. It's important to note that these shore-based competitions are mostly catch-and-release affairs with an emphasis on youth participation (Figure 4.2).

Available MRIP data are still being analyzed and the SEDAR DW Panel recommended that those MRIP data for Puerto Rico be fully reviewed at the Assessment Workshop.

4.4 SEDAR Panel Discussions on Use of Recreational Landings Data for Assessment Analyses

Issue 4: Are analysis-ready recreational landings data available for SEDAR 84?

Options:

- Investigate the MRIP and Puerto Rico Marine Recreational Statistics Program data further for consideration at the SEDAR 84 Assessment Workshop.
- Do not use the recreational landings data.

Decision:

- The assessment team and contributors will present the results of this investigation at the assessment workshop.

Rationale:

- It is crucial to explore the little available information

4.5 Recreational Landings Tables

Table 4.1 List of marine fishing tournaments that reported Yellowtail Snapper *(Ocyurus. chrysurus*) as catch.

Year	Number of tournament	Total number of fish reported	Number of Yellow tail snapper fish mearsured	Number of yellow tail weight
2000	1	10	10	10
2005	1	4	0	4
2009	2	23	23	19
2010	2	6	6	5
2011	3	20	20	18
2012	5	17	17	15
2013	5	48	16	42
2014	9	33	16	24
2015	8	67	56	13
2016	5	33	24	9
2017	9	42	41	5
2018	1	7	5	6
2019	7	48	41	34
2021	2	2	0	2
2022	3	6	7	2
Total	**63**	**366**	**282**	**208**

4.6 Recreational Landings Figures

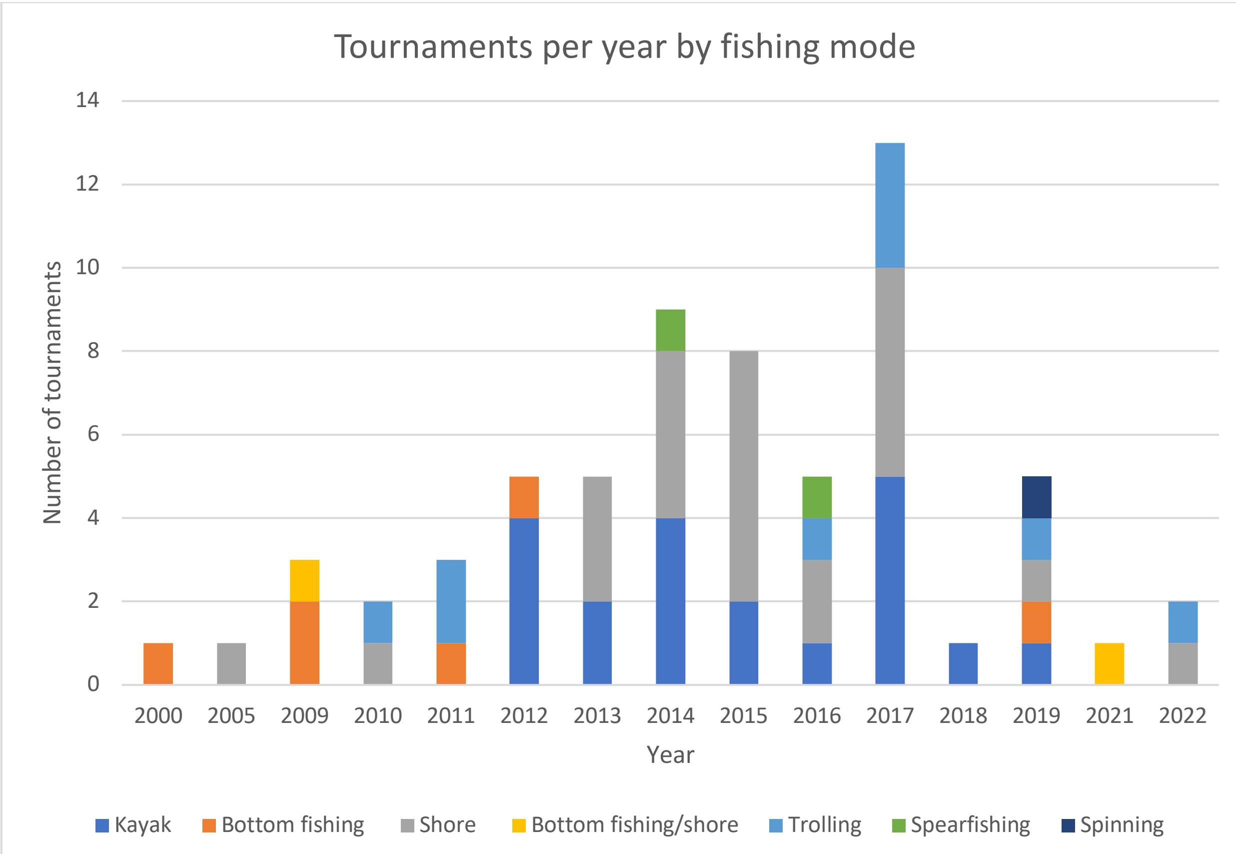

Figure 4.1 Fishing tournament type by year where Yellowtail Snapper (*Ocyurus. chrysurus)* was reported as catch.

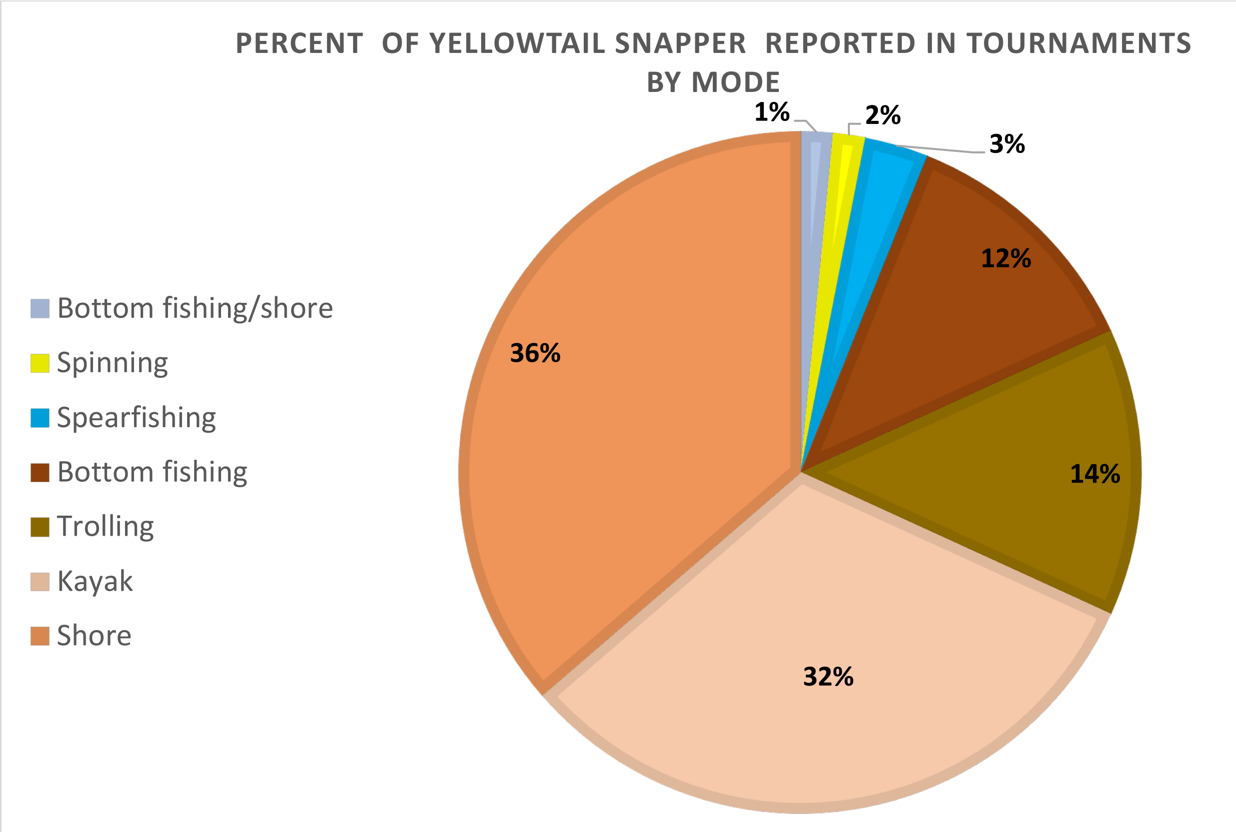

Figure 4.2 Percent of Yellowtail Snapper Reported in tournaments by fishing mode.

5 Measures of Population Abundance

5.1 Overview

The SEDAR 84 DW Panel reviewed several measures of abundance from both fishery independent and fishery dependent data sources during the workshop. The following sections briefly summarize those data or provide references that summarize the methods and data

5.2 Review of Working Papers

SEDAR84-DW-15 (Ingram et al 2024): Analysis of SEAMAP-C hook and line survey data for Yellowtail Snapper summarized the analysis of the fishery independent SEAMAP-C hook & line survey data for Yellowtail Snapper in Puerto Rico from 1992 through 2020.

SEDAR84-DW-16 (Blondeau et al 2024): NCRMP FI Survey of Yellowtail Snapper (*Ocyurus chrysurus*) in USVI U.S. Caribbean summarized NCRMP survey data for Yellowtail Snapper in Puerto Rico from2014 to 2022.

5.3 Fishery Independent Surveys

5.3.1 Analysis of SEAMAP-C Hook and Line survey

The Southeast Area Monitoring and Assessment Program Caribbean Survey (SEAMAP-C) is aimed at determining abundance and seasonal fluctuations of commercially exploited species in selected areas.

Recently, all the available SEAMAP-C finfish data from the U.S. Virgin Islands and Puerto Rico since its inception in 1989 through 2022 have been archived into a "Gold Copy." These fishery-independent data were collected through survey methods that include trap fishing and hook and line data. These SEAMAP-C data were analyzed to determine if there are trends that exist in abundance for Yellowtail Snapper (YTS) in eastern and western Puerto Rico and both areas combined.

The analyses focused on hook and line survey data, since it contained the largest number of samples of the longest series of time. The SEAMAP-C data for Puerto Rico consisted of five Sampling Programs extending from 1992-2020. During each of these Sampling Programs, hook and line methodologies differed to align with the different priorities of each program.

The reef fish survey officially began in 1992 as a SEAMAP survey in Puerto Rico. Until 2004, sampling was conducted using two gears: hook-and-line and fish traps. The use of fish traps ceased in 2006, and hook-and-line is now the primary gear used for this survey. In 2016, the reef fish survey was revamped and expanded to include video and bottom longline to complement the hook-and-line gear.

The Sampling Programs used differing numbers of lines, numbers of hooks per line, numbers of gear immersions, total sampling time, and hook types. Also, during early Sampling Programs the vessel was set to drifting, while later the vessels were anchored during sampling. During the earlier Sampling Programs, stations were randomly selected from of 2 x 2 nautical miles quadrats off the west and east insular shelves. During later Sampling Programs, sample site selection included a two-factor random stratified sampling design based on depth and benthic habitat type within the 50-fathom contour of eastern and western Puerto Rico. During all Sampling Programs, all YTS were counted, weighed and measured.

In order to calculate the CPUE of YTS collected by hook and line surveys from Puerto Rico, the number of YTS were divided by the product of the number of lines per vessel, the number of hooks per line, and the time spent sampling. Due to the differences in methodologies and research focus between Sampling Programs, resulting effort estimations were very different. In addition, these differing methodologies are confounded in time. The CPUE data were standardized before employing the delta-lognormal model, by first calculating the CPUE as above, and then standardize that CPUE to a mean of one within each Sampling Program. The variables employed in the delta-lognormal model included year, quarter, position method (i.e., anchored or drifting), hook type (J or C) and survey area (east or west Puerto Rico) for the combined model. Models were constructed using a backward selection procedure, based on Type 3 tests of significance, and residual analyses were used to determine model performance. Finally, length frequencies for all specimens combined, by gear year (i.e., hook and line, longline, and trap), by year, and by gear and are provided.

Figure 5.3.1 is a chart of all hook and line survey stations used in this analysis. Figure 5.3.2 and Table 5.3.1 summarize the time series of hook and line indices for eastern and western Puerto Rico combined. Due to the changes in methodologies and research focus between Sampling Programs being confounded in time, the standardization technique of scaling the CPUE to a mean of one within each Sampling Program could mask changes in abundance trends. It was decided that it would be best to use an index based on the NCRMP data rather than the SEAMAP-C data, since the data provided with NCRMP are more stable and consistent in terms of methodology.

5.3.2 National Coral Reef Monitoring Program (NCRMP)

Methods, Gears, and Coverage (Map Survey Area)
This section outlines the data and methodologies used to estimate density and abundance-at-length compositions for the SEDAR84 Yellowtail Snapper Assessment for Puerto Rico.

For more background details about the reef visual survey program (historic and NCRMP), methodology, data, and sampling coverage including maps of all survey sites completed by year (2001–2019) in each U.S. Caribbean sampling domain (Puerto Rico, St. Thomas/St. John, and St. Croix) see SEDAR80-WP-02 (Grove et al. 2021). Sampling in 2021 had similar island-wide coverage for each of the island assessments as previous NCRMP surveys. Total sample sites in Puerto Rico 2021 was 234 (Figure 5.3.3)

Two levels of calibration were needed to incorporate historical transect data. First, we analyzed the regionally restricted transect data from 2001 to 2013 in La Parguera in Puerto Rico. We determined that similar density distributions existed within strata between the regional data and whole island-wide data, and that each strata was represented in the sampling for proper area weighting. Secondly, a robust method calibration was conducted to convert belt transect (BT) densities (2001–2015) to RVC stationary point count (RVC-SPC) densities (2016–2021). In short, paired BT and RVC-SPC sampling was conducted a number of times within each survey strata. Density and occurrence were modeled in a two-stage GLM regression using a "delta" framework for estimation of the gear correction (method calibration) factors. The method calibration factor was then applied to the BT dataset prior to any domain level estimations (Ault et al. 2020). For more details, see Grove et al. 2022 Appendix I.

Domain-wide density and variance estimates were calculated using standard stratified random design-based principles (Smith et al. 2011). Metric estimates and associated variance were computed in each strata and multiplied by the stratum weighting factor. Area weighted stratum density and variance was then summed across all strata for the final domain wide estimate. All density data are presented as reef visual census stationary point count (RVC-SPC) estimates (number per 178 m2, ± SE). For more details, see Grove et al. 2022 Appendix II. Three different time series estimates of density are presented in this working paper and made available as complete datasets; 1) population-level estimates include all sizes of Yellowtail Snapper surveyed, 2) pre-exploited density estimates filters sizes to only include those that are less than minimum size limit (12 inches TL), set by management, in federal waters and 3) exploited density estimates filters sizes to include all sizes greater than or equal to 12 inches TL (or, 25cm FL).

Sampling Intensity – Time Series

Sampling Intensity and the time series of the NCRMP reef survey in Puerto Rico is illustrated in Table 5.3.2. Sampling began in 2001 and was conducted every year from 2001 to 2012 and then from 2014, 2016, 2019 and 2021. Samples were divided to 0-12m and the 12-30m strata. Sampling was only conducted on hard-bottom strata which were distinguished into five categories (shown in alphabetical order)

- Aggregate
- Bedrock
- Patch
- Pavement
- Coral/Rock

Additional information of sampling intensity consisted of total number observations of Yellowtail Snapper and the number of lengths measured, each by year.

Size Data

Length size frequency distribution of Yellowtail Snapper on Puerto Rico are shown for 2016, 2019, and 2019 in Figure 5.3.4.

Catch Rates in Numbers per Area Sampled

The time series of estimated mean Yellowtail Snapper population density in numbers per sampled area, i.e. per 178 m^2 +/- SE, is shown Figure 5.3.5. In addition, a time series of estimated population density of the pre-exploited phase. i.e., fish <25cm fork length, was constructed and compared to that of the exploited phase fish, i.e., > 25cm, in Figure 5.3.6.

5.4 Fishery-Dependent Measures

5.4.1 Overview

U.S. Caribbean commercial logbook (CCL) landings and effort were used to construct nominal indices of abundance. CCL data are self-reported. The time series for a Puerto Rico fishery dependent index of abundance include the years 1991 through 2019. Due to inconsistencies between databases that require exploration, the years 2020-2022 are not included in the analysis. Data years prior to 1991 were excluded due to changes in minimum size regulations.

Based on the generalized linear mixed model analysis of TIP size composition data (Table 3.4.1), data from the gears bottom_line, long_line_ rod_reel, and hand_line were combined into a single gear, Lines, and a nominal index was constructed.

5.4.2 Methods of Estimation

Effort variables explored for constructing a nominal index of abundance included,

- Numbers of trips
- Gear hours
- Gear quantity

The variable gear hours had sufficient data to calculate CPUE as: pounds of Yellowtail Snapper landed/gear hours fished. Gear quantity data were insufficiently reported over time to calculate CPUE. Trips as an effort measure was considered to lack sufficient detail to provide a meaningful effort measure. A plot of CPUE (as calculated using gear hours) over effort is shown in Figure 5.4.1. CPUE should not be affected by increasing effort (although catch likely will);

i.e., the slope should be zero. The very small negative slope of CPUE based upon gear hours plotted over effort suggests that gear hours is an appropriate effort measure.

5.4.3 Sampling Intensity

All commercial fishers are required to report landings and effort to CCL. CCL reporting is therefore considered to be a census of commercial landings and fishing effort, however underreporting and misreporting are known issues in Puerto Rico.

5.4.4 Size/Age data

CCL includes only landed fish, therefore TIP data provides size composition data for this index

5.4.5 Catch Rates – Number and Biomass

Catch rates throughout the time series in pounds per gear hour fished are shown Figure 5.4.2. Nominal catch rates are shown; i.e., this CPUE series has not been standardized to account for fishing practice and other effects that may mask true trends in abundance.

5.4.6 Uncertainty and Measures of Precision

Coefficients of variance (CV) around the nominal CPUE index were large, particularly prior to 2012 (Figure 5.4.1).

5.5 SEDAR Panel Discussions of Indices Data for Assessment Analyses

Issue 1: Should the fishery-independent density estimates from SEAMAP-C be used in SEDAR 84?

Options:
- Use the SEAMAP-C data.
- Do not use the SEAMAP-C data.

Decision:
- Do not use the SEAMAP-C data.

Rationale:
- The data provided with NCRMP are more stable and consistent regarding methodology. It is best to use the NCRMP data rather than the SEAMAP-C data.

Issue 2: Should the fishery-independent density estimates from NCRMP be used in SEDAR 84?

Options:
- Use the density estimates and length composition data from 2014 forward, which includes years calibrated to account for the transition from belt transect to cylinder survey method.
- Use all years of data, 2001-2022, with the caveat that data from 2001-2011 was not an island-wide survey.
- Do not use NCRMP data for constructing an index of abundance.

Decision:
- Start the index at the domain-wide (island-wide) survey beginning in 2014.

Rationale:
- The NCRMP survey is the most consistent island-wide survey available.

Issue 3: Should the commercial fishery-dependent data be used to conduct an index?

Options:
- Consider this information.
- Do not consider this information.
- Investigate the dataset further.

Decision:
- Do not consider this information for an abundance index.

Rationale:
- Concerns with the commercial fishery-dependent data set include questionable data values and incomplete effort units. The data are inconsistent across years. Additionally, the panel has recommended the fishery-independent data for an index.
- Time spent fishing does not necessarily translate to nominal CPUE, equating to where you could look at patterns over time. Experienced commercial fishers know how to target the species effectively, which may differ from inexperienced fishers. Therefore, we must include other aspects within the index to make it more representative.

Issue 5: Can the recreational data be used to develop an abundance index?

Options:
- Explore constructing an abundance index.
- Do not explore an abundance index using recreational data.

Decision:
- Do not explore an abundance index using recreational data.

Rationale:
- Data are insufficient (sample sizes too low) for index construction.

5.6 Measures of Population Abundance Tables

Table 5.3.1 SEAMAP-C sample size modeled index (with 95% CL), nominal index, nominal frequency, and CV by year for eastern and western Puerto Rico combined.

Year	N	Nominal Frequency	Nominal Index	Index	LCL	UCL	CV
1991	35	0	0	0	0	0	
1992	111	0.02703	0.02402	0.01285	0.00336	0.04922	0.75477
1993	141	0.04965	0.04413	0.02555	0.00971	0.06717	0.51305
1994	120	0.04167	0.04444	0.02099	0.00691	0.06373	0.60114
1995	35	0.08571	0.07619	0.058	0.01521	0.22115	0.75157
1996	0						
1997	56	0.01786	0.01587	0.00474	0.00068	0.03291	1.2477

1998	13	0	0	0	0	0	
1999	9	0.11111	0.09877	0.06296	0.00936	0.42329	1.21611
2000	33	0.18182	0.26936	0.10686	0.03743	0.30508	0.56276
2001	29	0.06897	0.0613	0.04614	0.00974	0.21867	0.91185
2002	0						
2003	0						
2004	15	0	0	0	0	0	
2005	59	0.0678	0.0678	0.04369	0.01315	0.14515	0.65873
2006	16	0.0625	0.125	0.07791	0.01137	0.53391	1.23481
2007	0						
2008	0						
2009	88	0.25	0.01244	0.01005	0.00575	0.01755	0.28428
2010	100	0.39	0.49366	0.15251	0.09907	0.23477	0.21822
2011	37	0.51351	0.67387	0.55166	0.3065	0.99293	0.30032
2012	66	0.33333	0.4612	0.76174	0.45029	1.2886	0.26746
2013	165	0.31515	0.31593	0.23	0.15453	0.34232	0.20082
2014	58	0.39655	0.35584	0.16145	0.09269	0.28124	0.28292
2015	15	0.73333	0.90204	1.30665	0.71291	2.39491	0.31002
2016	52	0.38462	0.21627	0.0758	0.03795	0.15139	0.35648
2017	230	0.36087	0.39005	0.58618	0.39701	0.86549	0.1967
2018	88	0.13636	0.15593	0.02062	0.0085	0.05	0.4656
2019	254	0.08268	0.07458	0.05096	0.02684	0.09673	0.32889
2020	35	0.22857	0.2381	0.49542	0.21606	1.13598	0.43344

Table 5.3.2 Number of reef fish visual survey sites by hard-bottom strata and depth categories per year from the reef fish visual surveys in the Puerto Rico coral reef ecosystem (2001–2021). Empty cells indicate zero samples. Length totals represent the number of individual length observations recorded.

	0 - 12 meters					12 - 30 meters						
Year	**Aggregate**	**Bedrock**	**Patch**	**Pavement**	**Coral/Rock**	**Aggregate**	**Bedrock**	**Patch**	**Pavement**	**Coral/Rock**	**Site Total**	**Length Total**
2001	15		6	5		2		5	3		**36**	**42**
2002	21		11	9	1	5		8	15	1	**71**	**93**
2003	18		16	3	2	8		15	20		**82**	**90**
2004	16		12	7	5	17		13	11	2	**83**	**66**
2005	17		7	5	1	20		14	24	7	**95**	**72**
2006	10		5	10		42		9	21	3	**100**	**155**
2007	21		18	28	1	46		14	36	9	**173**	**288**
2008	7		4	8		30		7	25	5	**86**	**92**
2009	18		12	8		42		5	24	7	**116**	**244**
2010	13		1	14		12		10	16	8	**74**	**116**
2011	6		3	9	1	3		5	19	5	**51**	**138**
2012	1		1	8		11		2	12		**35**	**165**
2014	31	14	19	36	6	42	4	20	37	14	**223**	**522**
2016	24	7	14	38	8	48	2	27	57	15	**240**	**670**
2019	38	10	16	28	9	42	1	16	27	16	**203**	**872**
2021	29	8	14	46	4	48	2	28	43	12	**234**	**1,238**

5.7 Measures of Population Abundance Figures

Figure 5.3.1 SEAMAP-C Hook and line survey sampling positions around Puerto Rico.

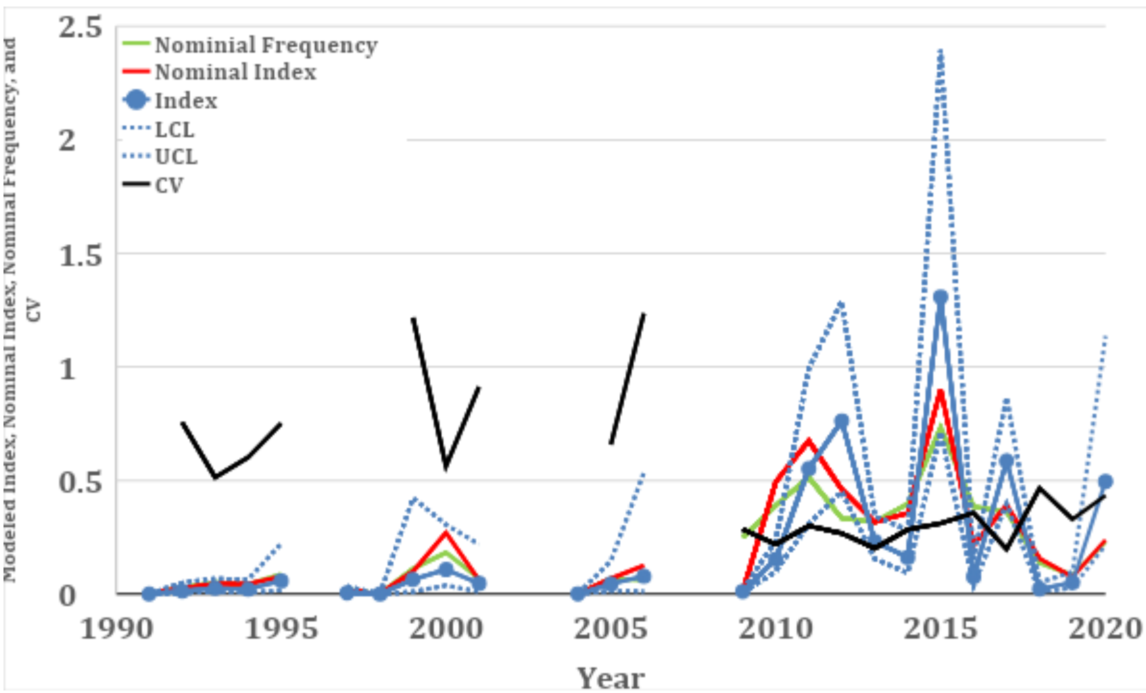

Figure 5.3.2 The modeled index (with 95% CL), nominal index, nominal frequency, and CV plotted by year for eastern and western Puerto Rico combined based on SEAMAP-C data.

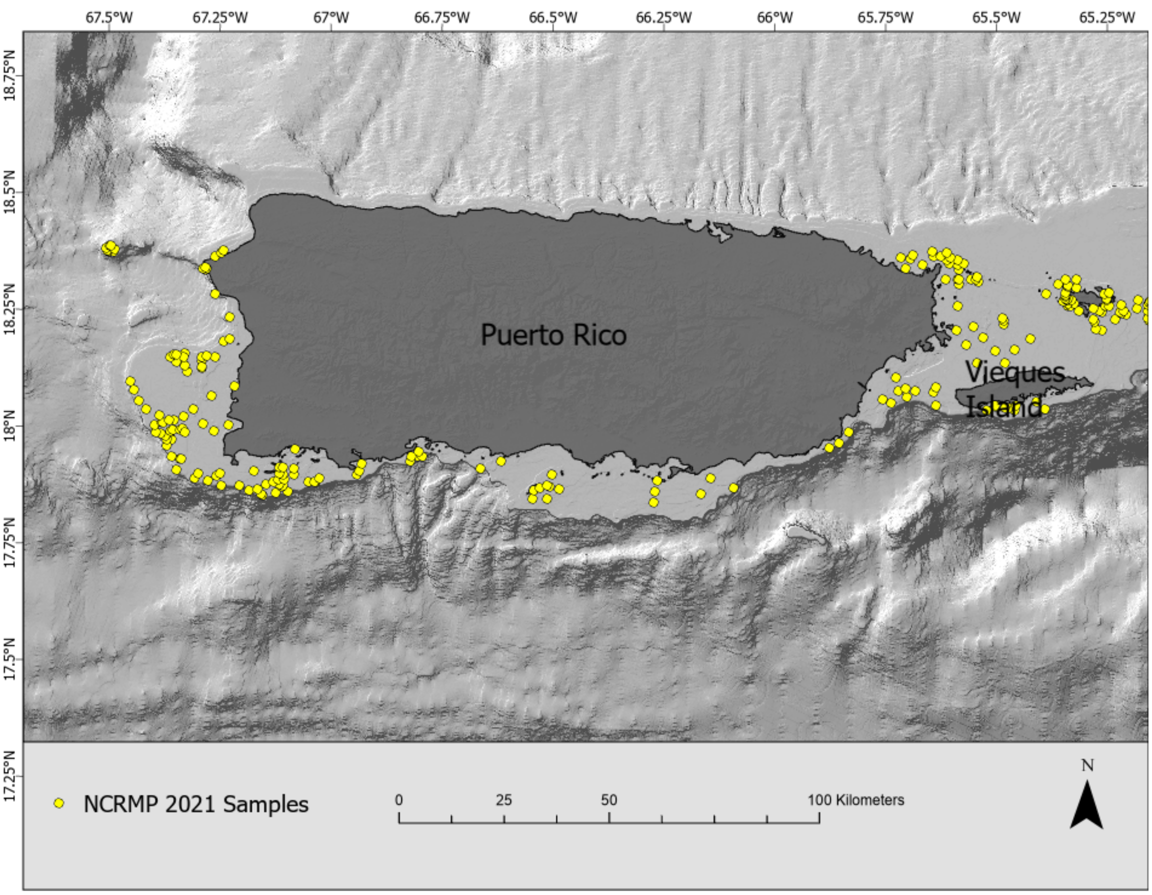

Figure 5.3.3 Puerto Rico NCRMP sampling sites 2021 (n = 234).

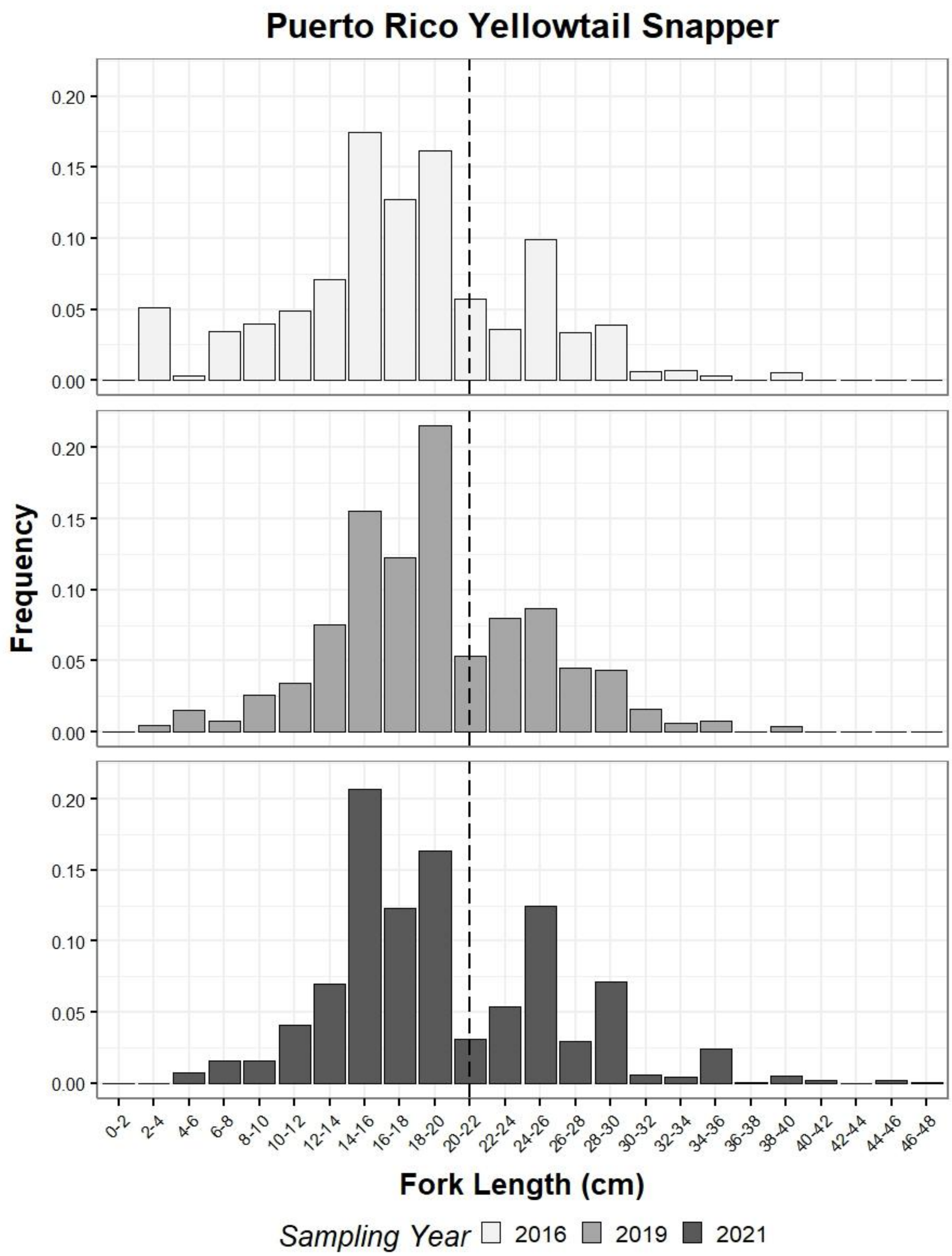

Figure 5.3.4 Yellowtail Snapper population size-frequency distribution at 2-cm bins from the 2016 - 2021 NCRMP RVC-SPC Puerto Rico surveys. Vertical dashed line is length at capture (25.0 cm fork length; i.e., minimum size regulation).

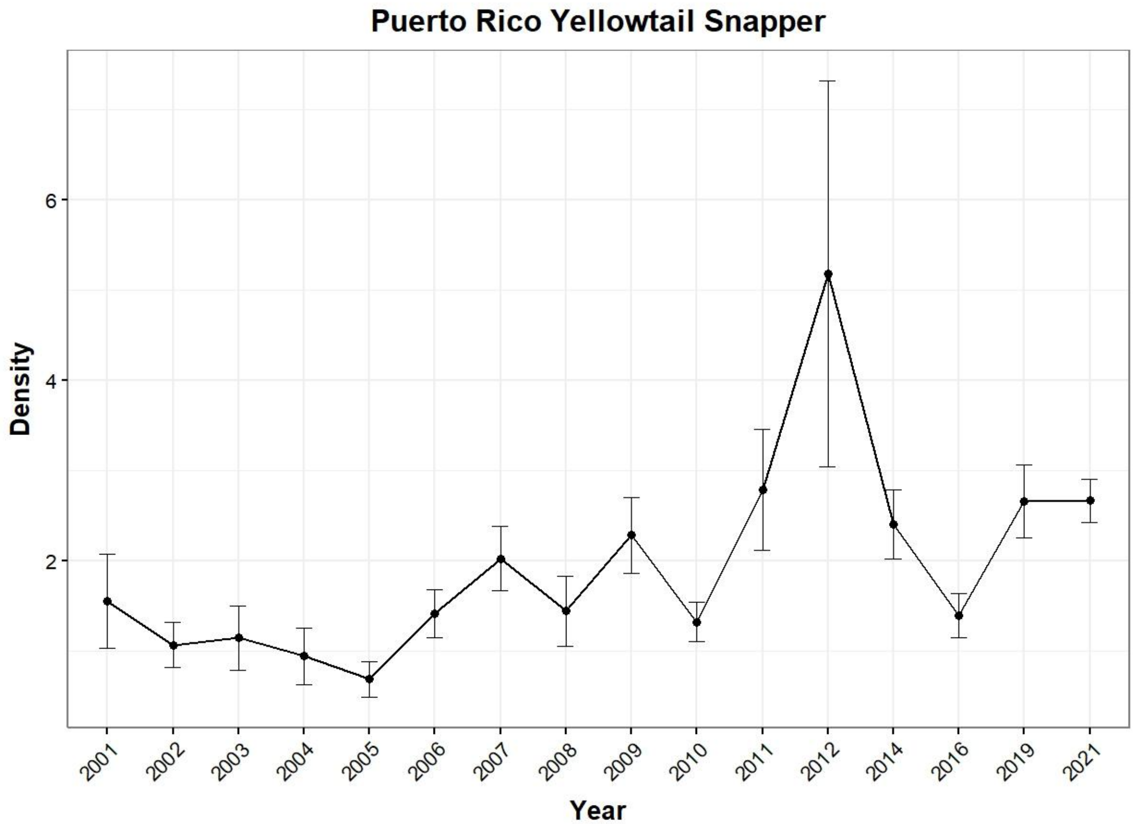

Figure 5.3.5 Time series (2001–2021) of Yellowtail Snapper (*Ocyurus chrysurus*) mean population density (number per 178 m2, ± SE) from the reef fish visual surveys in the Puerto Rico coral reef ecosystem

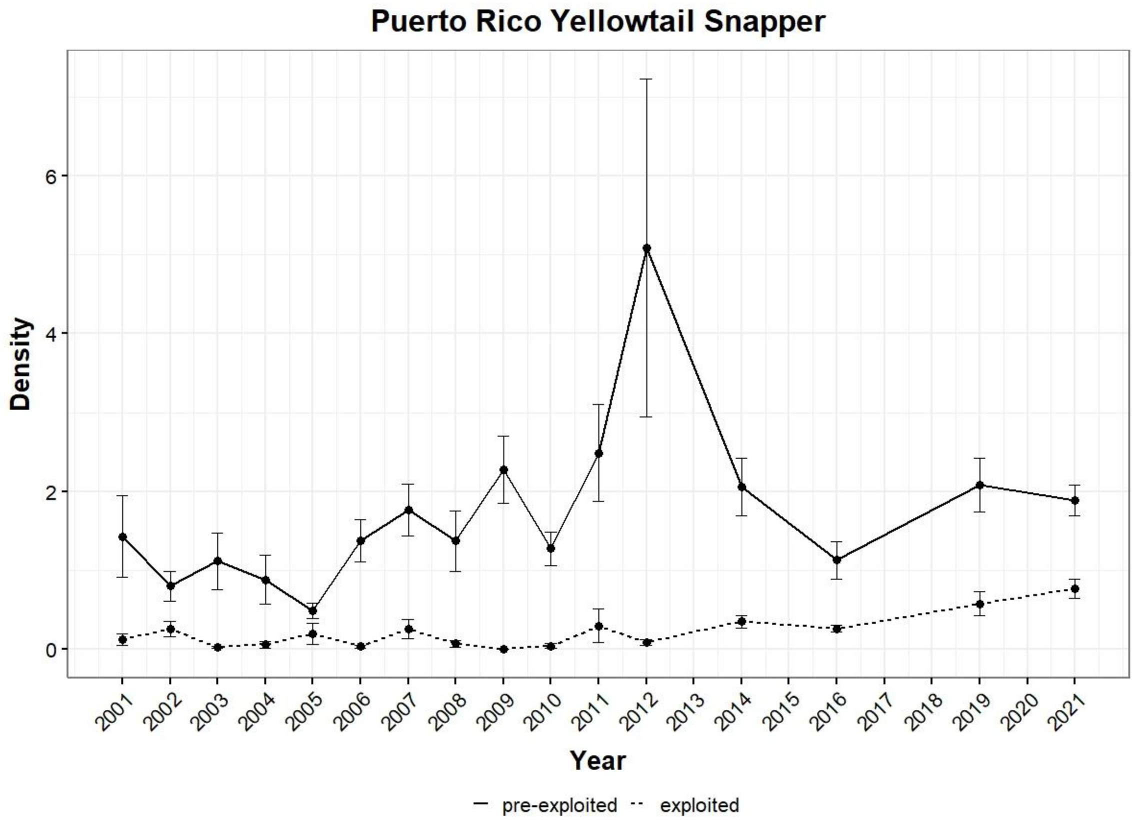

Figure 5.3.6 Time series (2001–2021) of pre-exploited (solid line, < 25 cm) and exploited (dotted line, ≥ 25 cm) Yellowtail Snapper mean population density (number per 178 m2, ± SE) from the reef fish visual surveys in the Puerto Rico coral reef ecosystem.

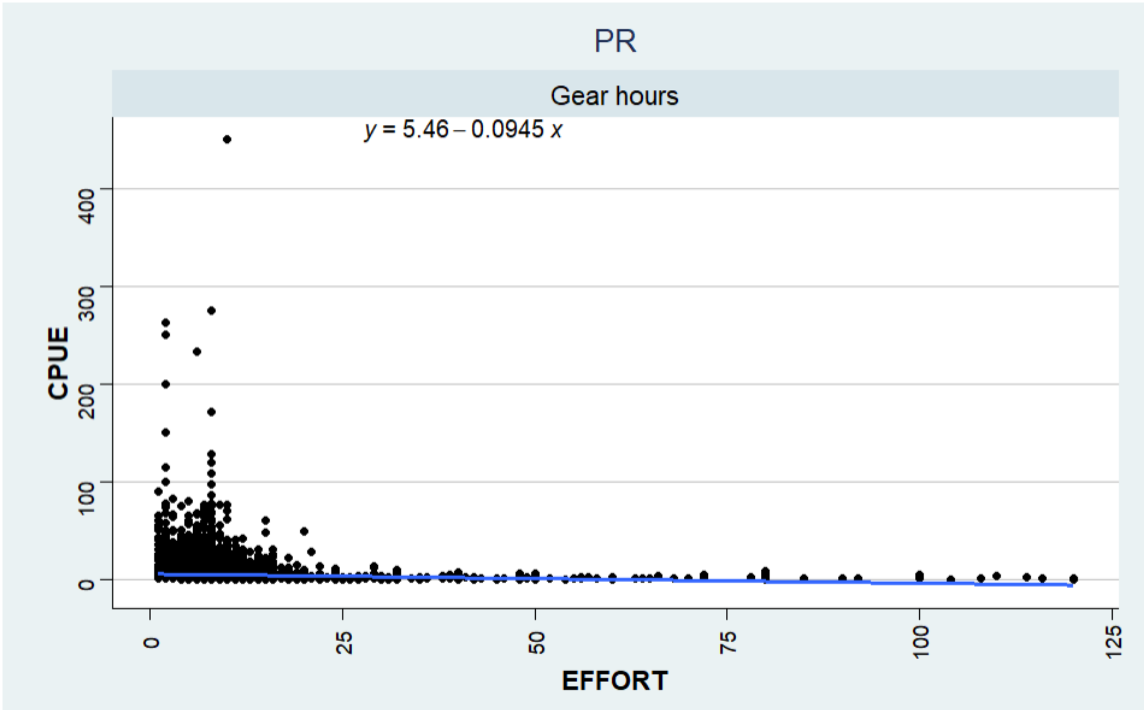

Figure 5.4.1 Catch per unit effort (CPUE) as a function of gear hours for the commercial Yellowtail Snapper fishery in Puerto Rico 1991-2019.

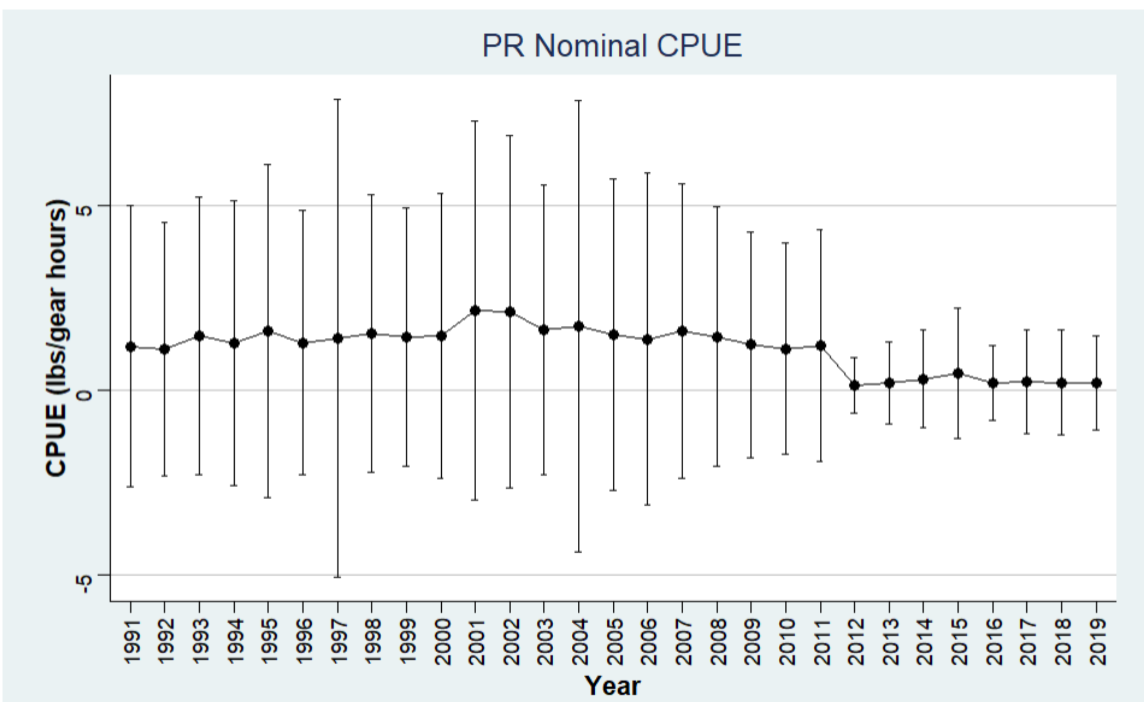

Figure 5.4.2 Nominal CPUE index in pounds per gear hours landed for the commercial Yellowtail Snapper fishery in Puerto Rico from 1991 to 2019,

6 Research Recommendations

6.1 Life History Research Recommendations

Issue 1: Are sufficient life history data available?

- Life history sampling should be done with statisticians to ensure more efficient collection programs (e.g., optimizing sample sizes within size bins).
- Ensure statistically robust sample sizes of small and large size classes of fish.

6.2 Commercial Statistics Research Recommendations

6.2.1 Commercial Landings Research Recommendations

Issue 1: Are analysis-ready commercial landings data available for SEDAR 84?

- Investigate trends in effort, major socioeconomic and environmental events, and associated effects on the demographics, gears used, and species landed.
- Increased port sampling is needed to enable analyses required for quantifying removals.

Issue 2: How uncertain are the commercial landings?

- Increase efforts towards landings validation, e.g., port sampling to estimate landings for comparison with CCL landings.

Issue 3: Should data outliers in the commercial landings be flagged for additional

- Operationalize an outlier flagging process for future SEDAR assessments.

Issue 4: Are analysis-ready recreational landings data available for SEDAR 84?

- Conduct recreational fishery port sampling surveys to determine removals from recreational fishing.
- Identify and obtain additional recreational data sources. Obtain data from economic surveys.

6.2.2 Length Composition Research Recommendations

Issue 1: Can the TIP size data be used for SEDAR 84 to inform selectivity?

- Look at the representativeness of where sampling occurs and where samples are coming from.
- Make hard copies of TIP PR data forms before 2010 available to help investigate flagged TIP data.
- Increase collection efforts to increase sample size in TIP.
- Work with port samplers and fishers to implement the trip interview program better and ensure critical fishing times are captured adequately (e.g., at night).
- Develop a data management system to link TIP to CCL. A linked system would require changing the overarching structure of collecting fishery-dependent data.
- Develop a fishery information network system for the US Caribbean.

- Operationalize an outlier flagging process for future SEDAR assessments.
- Investigate if relative weight at a given length has changed across years or clusters of years.
- Examine the number of trips when considering the representativeness of TIP samples; do not limit the investigation to the number of fish or the weight of the catch, samples, and trips.
- Going forward, we need a recommendation on how to do a new sampling strategy that is more holistic.
- Investigate how the length-weight relationship varies by month and year (seasonality and reproduction). And the fact that they are fed lots of bait during fishing (anchored) which could increase the weight of a fish over what is expected.

6.2.3 Discards and Discard Mortality Research Recommendations

Issue 1: Do we have estimates of commercial discards and estimates of discard mortality?

- Investigate release mortality further.

6.3 Recreational Statistics Research Recommendations

Issue 1: Are analysis-ready recreational landings data available for SEDAR 84?

- Conduct recreational fishery port sampling surveys to determine removals from recreational fishing.
- Identify and obtain additional recreational data sources. Obtain data from economic surveys.

6.4 Measures of Population Abundance Research Recommendations

Issue 1: Should the fishery-independent density estimates from SEAMAP-C be used in SEDAR 84?

- Professional fishers should be trained to support the methodologies of fishery-independent study designs. Trained fishers would improve the knowledge transfer between both sides of the process (fishers and scientists).
- Allocate funding towards new generalized survey methods optimized to target and capture this species more effectively than current surveys.
- Consider a cooperative scientific survey for Yellowtail Snapper designed in collaboration with fishers.

Issue 2: Should the fishery-independent density estimates from NCRMP be used in SEDAR 84?

- Work with fishers to improve methodologies to access areas that are not currently accessible with the SCUBA surveys.

Issue 3: Should the commercial fishery-dependent data be used to conduct an index?

- Further investigate logbook data and their utility for constructing an index
- Change in targeting multi-species

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 84

US Caribbean Yellowtail Snapper – Puerto Rico

SECTION III: Assessment Process Report

June 2025

SEDAR
4055 Faber Place Drive, Suite 201
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Assessment Process Report Summary

The SEDAR 84 Puerto Rico Yellowtail Snapper (*Ocyurus chrysurus*) stock assessment process consisted of four webinars between April 2024 and October 2024. The data available for the assessment included:

- An annual species-specific catch time series from commercial logbooks
- Fishery-dependent length compositions from commercial port sampling
- Fishery-independent length compositions from a reef fish survey
- Fishery-independent indices of abundance from a reef fish survey
- Life history information from otolith analysis and gonad histology

The assessment used Stock Synthesis, a statistical catch-at-age model (Methot et al., 2020). Stock Synthesis V3.30.22 models were initially configured with an annual catch time series, while length composition data from each source were aggregated across all available years. Model development proceeded stepwise from the simplest configuration to those of moderate complexity. Those sequential steps included the inclusion of dome-shaped selectivity, indices of abundance, and annual length compositions. Models were run with and without the estimation of recruitment deviations. Finally, sensitivities of assessment outcomes were investigated using alternative inputs for longevity-informed natural mortality, coefficient of variation on growth, and uncertainty on initial equilibrium catch.

Model diagnostics assessed convergence, fit, and consistency using gradients, residuals, likelihood profiles, hindcast cross-validation, and jitter analyses. Those diagnostics revealed that, although data contrast was limited and recruitment estimates were highly uncertain, the available length and catch data—particularly from fishery-independent sources—provided information that the models can use to determine potential catch advice, particularly in a grid or model ensemble approach that accounts for key model assumptions and data-limited caveats.

Sensitivity analyses evaluated the effects of assumptions about natural mortality, growth variability, and initial equilibrium catch conditions. These scenarios showed that key uncertainties can influence estimated productivity and biological reference points, with, two of the six model configurations presented indicating that the stock could be overfished and that overfishing could be occurring. However, diagnostics and sensitivity analyses revealed important caveats, primarily due to the strong influence of fixed parameter assumptions including uncertainty initial conditions and the final value of the dome-shaped NCRMP index.

1 Introduction

1.1 Workshop Time and Place

The SEDAR 84 Assessment Process was held via webinars from April to November 2024.

1.2 Terms of Reference

1. Develop and apply assessment tools that are compatible with available data and consistent with standard practices. Document input data, model assumptions and configuration, and equations for each approach considered.
2. To the extent possible given data limitations, provide management benchmarks and status determination criteria, including:
   a. Maximum Fishing Mortality Threshold (MFMT) = F_{MSY} or proxy
   b. MSY proxy = yield at MFMT
   c. Minimum Stock Size Threshold (MSST) = SSB_{MSY} or proxy
   d. If alternative status determination criteria are recommended, provide a description of their use and a justification.
3. To the extent possible, develop projections to support estimates of maximum sustainable yield (MSY, the overfishing limit (OFL) and acceptable biological catch (ABC) as described below. If projections are not possible, and alternative management procedures are recommended, provide a description of their use and a justification.
   a. Unless otherwise recommended, use the geometric mean of the three previous years' fishing mortality to determine $F_{Current}$
   b. Project F_{MSY} or proxy
   c. If the stock is overfished:
      i. Project $_{F0}$
      ii. Project $F_{Rebuild}$
4. Provide recommendations for future research and data collection.
5. Provide an Assessment Workshop Report to address these Terms of reference and fully document the input data and results.

1.3 List of Participants

Assessment Panel	
Adyan Rios (Lead Analyst)	NMFS/SEFSC
Richard Appeldoorn	SSC
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Observers	
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Jay Grove	NMFS/SEFSC
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Graciela Garcia-Moliner	CFMC Staff

1.4 List of Assessment Process Working Papers and Reference Documents

1.4.1 Documents Prepared for the Assessment Process

Document #	Title	Authors	Date Submitted
SEDAR84-AP-01	Report on the status of U.S. Caribbean stoplight parrotfish Sparisoma viride age, growth, and reproductive biology for the SEDAR84 Stock Assessment	Jesús M. Rivera Hernández and Virginia Shervette	6 July 2024

1.4.2 Reference Documents

Document #	Title	Authors
SEDAR84-RD11	The Commercial Yellowtail Snapper Fishery off Puerto Rico, 1983-2003	Nancie J. Cummings
SEDAR84-RD12	S8-DW-08: The commercial reef fish fishery in Puerto Rico with emphasis on yellowtail snapper, Ocyurus chrysurus: landings and catch per unit of effort from 1983 through 2003	Nancie J. Cummings and Daniel Matos-Caraballo
SEDAR84-RD13	The Net Buyback and Ban in St. Croix, U.S. Virgin Islands	Juan J. Agar, Flavia Tonioli, Chloe Fleming

2 Data-Informed Modeling Decisions

The data available for use in the current assessment are documented in the SEDAR 84 U.S. Caribbean Yellowtail Puerto Rico Data Workshop Report (SEDAR, 2024). Provided here is a summary of those data with a focus on the associated model configurations explored using Stock Synthesis. Throughout this report, **bold text** is used to highlight and summarize the model settings and configurations relevant to the various phases of model development.

Additional details for each data input are available in their respective references:

1. **Landings** from self-reported commercial fisher logbooks (Martínez Rivera et al., 2024)
2. **Length compositions** from shore-based port sampling (Godwin et al., 2024)
3. **Length compositions** from a fishery-independent survey of reef fish (Grove et al., 2024)
4. **Indices of abundance** from a fishery-independent survey of reef fish (Grove et al., 2024)
5. **Life history information** from otolith analysis and gonad histology (Shervette, Rivera Hernández, & Peña Alvarado, 2024; Shervette, Rivera Hernández, & Zajovits, 2024)

Based on the available data, the assessment was configured with one area, one season, one commercial fleet, and one fishery-independent survey.

2.1 Commercial Fleet Data

2.1.1 Catch

The catch data for the commercial fleet came from the Caribbean Commercial Logbook program (Martínez Rivera et al., 2024). Commercial fishery landings data for Yellowtail Snapper in Puerto Rico were available for the years 1983-2022.

The handline gear group made up 80% of the reported landings catch of Yellowtail Snapper in Puerto Rico. All gears (handline, trap, rod and reel, and other) were included into a single commercial fleet (Table 7.1). Potential outliers discussed during the assessment webinars were investigated and retained as valid trips.

In the SEDAR 84 Stock Synthesis models, **the catch was input as biomass (in metric tons) and was treated as if it occurred over an entire fishing season; i.e., each fishing year.**

The years of the available species-specific self-reported commercial fisher logbook landings and effort data determined the start and end years of the Stock Synthesis models. **The start and end years of the model were 1983 and 2022, respectively.**

It is important to note that the stock was not unexploited at the start year of the available catch time series. Appeldoorn et al. (1992) reported declines in landings across all reef fish combined, with landings in Puerto Rico peaking in 1979, reaching a low in 1988, and slightly increasing in 1989 and 1990. Initial F was estimated for the commercial fleet and a corresponding initial equilibrium catch. The reference point for the initial equilibrium catch was defined as the geometric mean of the first three years of available catches (168.3 metric tons).

The input standard error for the landings was set to 0.3. When implemented with few data inputs, Stock Synthesis strongly prioritizes fitting the annual landings time series, often replicating the observed values almost exactly, particularly when small standard errors (e.g., 0.01) are used. The initial configurations with low input uncertainty resulted in the model tightly fitting both the observed landings and the input initial equilibrium catch. To allow the model greater flexibility in estimating the initial equilibrium catch, and avoid anchoring it too closely to the input value, a higher standard error of 0.3 was specified for the initial equilibrium catch. This increased uncertainty enables the model to balance trade-offs among other data sources and internal dynamics when estimating initial conditions. A description of the sequential model configurations and development process is provided later in this report.

A higher standard error of 2 was explored as part of the sensitivity analysis to evaluate the influence of extreme uncertainty in the initial equilibrium catch input. This value was intentionally selected to represent a scenario with minimal confidence, allowing the model to substantially down-weight this input and reveal how strongly model outputs depend on the assumed precision of the initial equilibrium catch.

Commercial discards are not reported in Puerto Rico fisher logbook data. Based on expert judgment and available information, discards of Yellowtail Snapper in the Puerto Rico commercial fishery are considered negligible, with minimal associated mortality (SEDAR (2024)). Given this limited data and the expectation of low discard rates, **discards were not explicitly included in the model inputs or parameterized through a retention function. The assessment assumed full retention of catch.**

Alternative model configurations associated with the commercial fleet data are described later in this report. They included:

- The initial equilibrium catch was explored via likelihood profiling.
- A higher standard error of 2 was explored via sensitivity analysis.

2.1.2 Length Composition

Gear-specific annual length frequencies for the commercial fleet came from the commercial shore-based port-sampling Trip Interview Program (TIP) (Godwin et al., 2024). The Trip Interview Program manages data from Puerto Rico collected by Department of Natural & Environmental Resources personnel. Port sampling personnel collect length and weight data from fish landed by commercial fishing vessels, along with information about general area of capture and gear used. Data collection began in 1983 with frequent updates in best practices; the latest being in 2017. The Yellowtail Snapper length data from Puerto Rico included 103,730 length observations across 5,159 unique port sampling interviews.

Although the catch data can be separated into handline and non-handline related gears, 77% of the length measurements for Puerto Rico Yellowtail Snapper from 1983-2022 were associated with handlines. Those data were used to characterize the commercial fleet's length-based selectivity pattern. Since multiple fish length measurements can be obtained from a single sampled trip, each length does not represent an independent observation. **The relative model weighting of the commercial fleet length composition data was based on the number of trips sampled**.

From 1983 - 2022, the data included 83,341 shore-based length measurements obtained across 2,829 trips. Nineteen trips were flagged and removed as potential outliers with unusually large lengths. **The Trip Interview Program length compositions of the commercial fleet were assumed to be representative of the total catch.**

Although a federal minimum size limit was implemented in 1986, it did not apply in Puerto Rico territorial waters extending from land to 9 nautical miles offshore. In 2004, Puerto Rico established a compatible minimum size of Yellowtail Snapper.

A double normal function was used to model the relative vulnerability of capture by length for the commercial fleet. However, only two parameters were estimated, effectively describing a logistic selectivity for the commercial fleet. The double normal function allows for domed or logistic selectivity. It combines two normal distributions; the first describes the ascending limb, while the second describes the descending limb. Achieving the logistic shape with the double normal Stock Synthesis pattern facilitated model configurations for SEDAR 84. The two parameters used to achieve a logistic selectivity shape were the length associated with peak selectivity and the width of the ascending limb. Domed selectivity was explored for the fishery independent survey data described in the following section.

2.2 Survey Data

2.2.1 Index of Abundance

The National Coral Reef Monitoring Program (NCRMP) supports reef fish sampling on hard-bottom habitats from 0 to 30 meters depth (Grove et al., 2021). In Puerto Rico, NCRMP sampling began in 2001 and was conducted every year from 2001 to 2012 and then 2014, 2016, 2019, and 2021. The data used in SEDAR 84 were from nonconsecutive years during 2014 - 2022 when the survey was conducted island-wide. Data collected prior to 2017 were calibrated to account for a transition from belt transect to a cylinder survey method.

Annual mean density and associated standard errors for NCRMP for SEDAR 84 were provided by Grove et al. (2024). In Stock Synthesis, the time series of mean density across all observed lengths **were input as an index in numbers with a lognormal error distribution**. The associated length composition data, described in the following subsection, suggested that **the index reflected the abundance of juveniles but did not observe the larger adults concurrently observed in the commercial catch data**.

2.2.2 Length Composition

The NCRMP survey in Puerto Rico provided counts by individual lengths estimated to the nearest centimeter. **The length data inputs for both the commercial fleet and the surveys used 3-centimeter bins**, despite 1-centimeter data being available. This level of aggregation is common practice in stock assessments, as it helps reduce noise and overfitting associated with fine-scale variability that may not be informative for model estimation. Using 1-centimeter bins can introduce spurious detail due to measurement error or small-sample fluctuations. The 3-centimeter bins were used to strike a balance between preserving key patterns in the size composition while considering model stability.

Since multiple fish can be observed during a single dive, individual lengths are not independent observations. **The relative model weighting of the NCRMP survey length composition data across years was based on the number of paired dives.**

The length composition data provided reasonable support that younger fish were available to the NCRMP survey. Over half of the lengths from the NCRMP survey were smaller than 20 centimeters fork length, and 99% were below 33 centimeters fork length. **Dome-shaped selectivity was explored for the NCRMP survey.**

Models were initially configured in Stock Synthesis with length composition data aggregated across the available years for each source of length data. Investigation of additional model configurations proceeded stepwise from the simplest configuration to those of moderate complexity. The steps included the inclusion of annual fishery-independent length compositions. The sequential model configurations are described later in this report.

2.3 Life History Data

The life history data used in the assessment included longevity-informed natural mortality, growth, length-weight, and maturity analyzed from 1,554 samples of Yellowtail Snapper collected across the U.S. Caribbean from 2013 to 2023 (Shervette, Rivera Hernández, & Peña Alvarado, 2024; Shervette, Rivera Hernández, & Zajovits, 2024). The largest fish was 57.2 centimeters fork length and the oldest was 26 years old.

Based on the available information, **the Yellowtail Snapper population was modeled from age 0 through age 26, and from 0 to 56-centimeters fork length, in 1-centimeter bins, with the largest values for each as plus groups.**

Note that SS3 allows the length bins of the data inputs to be larger than the bins used in the population model. **The bin size of all the length data inputs were 3 centimeters, the model's simulated population bin size was 1-centimeter bins.** When the population is modeled at a higher resolution concerning bin size, the likelihood function, which aims to match the observed data inputs and the simulated population estimates, operates at the resolution of the data inputs.

2.3.1 Growth

The SS3 growth formulation requires five parameters:

- Length at the youngest age
- Length at the maximum age
- Von Bertalanffy growth parameter (K)
- Coefficient of variation at the youngest age
- Coefficient of variation at the maximum age

Parameter estimates for Von Bertalanffy growth parameter (K) and the length at maximum age (L_∞) were based on 1,554 samples of Yellowtail Snapper collected across the U.S. Caribbean from 2013 to 2023 (Shervette, Rivera Hernández, & Peña Alvarado, 2024). When t_0 was fixed to -0.96, K was 0.23, and L_∞ was 42.4 centimeters fork length. When t_0 was estimated, it was -2.73, K was 0.12, and L_∞ was 50.8 centimeters fork length.

The SEDAR 84 assessment models were configured using the parameter estimates associated with the fixed t_0. Furthermore, **the estimated length at age zero from otolith analysis by Shervette, Rivera Hernández, & Peña Alvarado (2024) was modified in Stock Synthesis so that the length of the youngest age, age 0, was set to zero.** Without this modification, the model would be unable to fit the substantial amounts of small (<10cm) Yellowtail Snapper observed in the survey length composition data.

Coefficients of variation for both younger and older ages were initially set to 0.15. Ideally, growth coefficients of variation should be derived from observed length-at-age data, however, the assumed values are consistent with species of moderate growth variability (Ono et al., 2015; Schemmel et al., 2022).

Alternative model configurations associated with the growth data are described later in this report. They included:

- A higher growth coefficient of variation of 0.25 for younger ages was explored via sensitivity analysis.

2.3.2 Morphometric Conversion

The relationship between weight in grams and length in millimeters provided by Shervette, Rivera Hernández, & Peña Alvarado (2024) was converted to weight in grams and length in centimeters and used as a fixed model input. **The length-weight relationship was $W = 2.93 \times 10^{-5} * L^{2.8642}$, with weight (W) in kilograms and length (L) in centimeters.**

2.3.3 Maturity and Fecundity

Maturity was modeled as a logistic function. Parameter estimates for maturity were based on 1,876 samples of Yellowtail Snapper collected across the U.S. Caribbean from 2013 to 2023 (Shervette, Rivera Hernández, & Peña Alvarado, 2024). **The fecundity of Yellowtail Snapper was estimated with a proxy (body weight * maturity at age).**

2.3.4 Stock Recruitment

A Beverton-Holt stock-recruit function was used to parametrize the relationship between spawning output and resulting recruitment of age-0 fish. The stock-recruit function requires three parameters:

- Steepness (h) characterizes the initial slope of the ascending limb (i.e., the fraction of recruits produced at 20% of the unfished spawning biomass).
- The virgin recruitment (R0; estimated in log space) represents the asymptote or unfished recruitment levels.
- The variance term (sigma R) is the standard deviation of the log of recruitment and describes the amount of year-to-year variation in recruitment.

Only the virgin recruitment (R0) was estimated. **Sigma R and steepness were fixed at 0.7 and 0.99, respectively.** The 0.7 sigma R reflects slightly high variation in recruitment. A value of 0.6 is a moderate level of recruitment variability, with lower values indicating lower variability and more predictable year-to-year recruitment. The primary assumption for steepness was that this stock is not a closed population, so recruitment may not be strongly tied to the local spawning stock biomass. **In initial model configurations, annual deviations from the stock-recruit function were not estimated.** Steepness and R0 were explored via likelihood profiling.

Continuous recruitment was parameterized in SS3 using four settlement events. Equal proportions of recruits were assigned to each settlement event, and they were spaced such that recruitment would happen in months 1, 4, 7, and 10. This allowed growth to be staggered, reflecting a closer approximation of the observed stock dynamic of year-round spawning activity.

2.3.5 Maximum Age and Natural Mortality

Empirical estimates of natural mortality (M) can be derived using life history information such as longevity, growth, and maturity. For this assessment, the Natural Mortality Tool was used to estimate M (Cope & Hamel, 2022). Various methods were explored, incorporating factors such as maximum age, the Von Bertalanffy growth parameter (K), theoretical age at length zero (t_0), asymptotic length (L_∞), and age at 50% maturity.

Inputs for the Natural Mortality Tool were sourced from Shervette, Rivera Hernández, & Peña Alvarado (2024), which reported a maximum age of 26 years for Yellowtail Snapper in the U.S. Caribbean. However, the mean age of 1,554 sampled fish was 5 years.

Table 7.2 summarizes the empirical methods used to estimate M based on available life history data. The primary approach for determining natural mortality in this assessment was longevity-based (Hamel & Cope, 2022).

A natural mortality value of 0.208 was used in the initial model runs. This value corresponds with the maximum age of 26 years reported by Shervette, Rivera Hernández, & Zajovits (2024). Model configurations incorporating an alternative M value associated with a slightly higher maximum age were explored through sensitivity analyses, which are discussed later in this report.

2.4 Summary of Data-Informed Modeling Configurations

- Based on the available data, the assessment was configured with one area, one season, one commercial fleet, and one fishery-independent survey.

2.4.1 Commercial Fleet

- The catch was input as biomass (in metric tons) and was treated as if it occurred over an entire fishing season; i.e., each fishing year.
- The start and end years of the model were 1983 and 2022, respectively.
- Based on expert input and limited data, discards were not modeled. The assessment assumed full retention of catch.
- The input standard error for the landings was set to 0.3.
  - A higher standard error of 2 was explored via sensitivity analysis.
- The initial equilibrium catch was configured in initial runs as 168.3 metric tons.
  - The initial equilibrium catch was explored via likelihood profiling.
- The relative model weighting of the commercial fleet length composition data was based on the number of trips sampled.
- The length compositions of the commercial fleet were assumed to be representative of the total catch.
- A double normal function was used to model the relative vulnerability of capture by length for the commercial fleet.

2.4.2 Survey

- The NCRMP index reflected the abundance of juveniles.
- The survey was configured as an index in numbers with a lognormal error distribution.
- The relative model weighting of the surveys length composition data across years were based on the number of paired dives.
- The length data inputs used 3-centimeter bins.
- The model's simulated population bin size was 1-centimeter bins.
- The model development process explored dome-shaped selectivity for the fishery independent survey.

2.4.3 Life History

- The Yellowtail Snapper population was modeled from age 0 through age 26, and from 0 to 56-centimeters fork length, in 1-centimeter bins, with the largest values for each as plus groups.
- Parameter estimates for Von Bertalanffy growth parameter (K) and the length at maximum age (L_{∞}) were based on samples of Yellowtail Snapper collected across the U.S. Caribbean from 2013 to 2023.
- The estimated length at age zero from otolith analysis by Shervette, Rivera Hernández, & Peña Alvarado (2024) was modified in Stock Synthesis so that the length of the youngest age, age 0, was set to zero.
- Coefficients of variation for both younger and older ages were initially set to 0.15.
  - A higher growth coefficient of variation of 0.25 for younger ages was explored via sensitivity analysis.
- The length-weight relationship was W = 2.93 x 10^-5 L^ 2.8642, with weight in kilograms and length in centimeters.
- A natural mortality value of 0.208 was used in the initial model runs.
  - Alternative M values were explored through sensitivity analyses.
- Maturity was modeled as a logistic function.
- The fecundity of Yellowtail Snapper was estimated with a proxy (body weight * maturity at age).
- A Beverton-Holt stock-recruit function was used to parametrize the relationship between spawning output and resulting recruitment of age-0 fish.
- Sigma R and steepness were fixed at 0.7 and 0.99, respectively.
- In initial model configurations, annual deviations from the stock-recruit function were not estimated.
- Continuous recruitment was parameterized in SS3 using four settlement events.

3 Model Development

3.1 Framework

Stock Synthesis V3.30.22 was the modeling approach applied in the current SEDAR 84 assessment because of compatibility with the available data and consistency with standard practices.

Stock Synthesis is a statistical catch-at-age model that uses a population model, an observation model, and an estimation model and applies a likelihood function in the estimation process (Methot et al., 2020). Stock Synthesis, commonly referred to as SS3, has been applied extensively worldwide for stock assessment evaluations (Methot & Wetzel, 2013). It has also been used for previous data-limited and data-moderate SEDAR assessments, including the SEDAR 57 assessments and subsequent updates for Caribbean Spiny Lobster (*Panulirus argus*), and the SEDAR 80 assessments for Queen Triggerfish (*Balistes vetula*) (SEDAR, 2019, 2022).

The Stock Synthesis modeling framework is a compatible tool for SEDAR stock assessments in the U.S. Caribbean because it can accommodate a wide range of model complexities, from data-limited to highly detailed assessments (Cope, 2024). Stock Synthesis allows for the characterization of stock, fishing fleet, and survey dynamics through various parameters, which can be either fixed based on external data or estimated when sufficient assessment data are available. Additionally, it can incorporate complex biological dynamics, such as continuous recruitment, which is appropriate for accurately assessing Puerto Rico Yellowtail Snapper.

Finally, R packages such as r4ss and ss3diags facilitate critical evaluations of model reliability and model comparisons (Carvalho et al., 2021; Taylor et al., 2021). For example, R4SS provides visualization and diagnostic tools to summarize and interpret fit, convergence, and key output metrics. SS3diags focuses on retrospective analyses, hind-casting, and residual pattern evaluations. The integration of these tools allows rigorous uncertainty analysis, streamlined sensitivity analyses, and enhanced transparency in decision-making.

Stock Synthesis models were initially configured using an annual commercial catch time series and length composition data that were aggregated across the available years for each source of length data. Model development proceeded stepwise from the simplest configuration to those of moderate complexity.

3.2 Overview

The SEDAR 84 model development process started with simple data-limited configurations, followed by exploring data-moderate configurations, individually and combined. The simplest configurations aggregated length composition data across years by implementing the super-period approach in Stock Synthesis. When using super-periods, the estimation model generates annual values, but the likelihood function will compare the expected composite to the data composite across the super-period. When using this approach on the length composition data, Stock Synthesis models will still aim to identify parameter values for selectivity that achieve a fit between the predicted and observed data.

The initial setup steps and description of the modeling scenarios documented in this report are listed in Table 7.3. For the SEDAR 84 Yellowtail Snapper assessment, the data-moderate considerations explored included: (a) indices of abundance, (b) annual fishery-independent length compositions, (c) annual fishery-dependent length compositions, (d) dome-shaped selectivity, (e) recruitment deviations, and (f) fishery-dependent selectivity time blocks. Additional model configurations were not pursued.

The Stock Assessment Continuum Tool was used to develop the initial model setup by importing CSV input files and utilizing its Shiny application interface (Cope, 2024). Starting from the Continuum Tool (ct) model, a series of sequential modifications were applied to represent three key biological and data-related complexities: adjusted length at age zero (m1), continuous recruitment (m2), and increased catch uncertainty (m3).

This report focuses on the results and sensitivities associated with the m3 models, evaluated under the various data configurations summarized in sec-data-summary. While a full discussion of sensitivity runs is provided later in the report, they are also summarized in Table 7.3 to help familiarize the reader with the terminology used throughout. For instance, model **v08_m3_s1** refers to the eighth scenario (**v08**, which includes an index, annual fishery-independent length compositions, and dome-shaped selectivity), the third level modification (**m3**, reflecting continuous recruitment and higher catch uncertainty), and the first sensitivity scenario (**s1**, higher uncertainty on growth). The numbering of model runs in Table 7.3 reflects a structured approach used to track configurations consistently across all three assessments. Not every model was used for every island because the data available varies, but the numbering stays the same so that the same model structure means the same thing across all islands and helps show how the models became more complex over time.

Due to the lack of an estimable spawner-recruit relationship across the explored models, a commonly used 40% spawning potential ratio (SPR) was used as a proxy for Maximum Sustainable Yield (MSY) and as the basis for management reference points (Shertzer et al., 2024). The SPR proxy reflects the ratio of expected lifetime reproductive potential under fished conditions compared to virgin conditions.

4 Model Diagnostics

Model diagnostics aimed to follow the conceptual process described by Carvalho et al. (2021). Their approach includes evaluating goodness of fit, information sources and structure, prediction skill, convergence, and model plausibility. Although Carvalho et al. (2021) advise detours and additional model explorations when initial diagnostic tests fail, advanced diagnostics, such as likelihood profiles, retrospective, and jitter analyses, were conducted even when initial tests failed to comprehensively communicate the various model configurations explored.

4.1 Convergence

Three approaches were used to check for model convergence. They were investigating for the presence of (1) bounded parameters, (2) high final gradients, and (3) a positive definite hessian. As described by Carvalho et al. (2021), checking for bounded parameters can indicate discrepancies with data or model structure. Additionally, small final gradients and a positive definite hessian can indicate that the objective function achieved good convergence.

The models presented in this report all had a positive definite Hessian, indicating that each reached a local minimum and a locally optimal fit. None of the models had parameters that were bounded, suggesting the optimization was not constrained by parameter limits. Finally, the parameter gradients in all models were small and well below 0.001, which is commonly used in the R4SS R package to identify large gradients (Table 7.4).

4.2 Correlation Analysis

High correlation among parameters can suggest model overparameterization and lead to poor model stability. By performing a correlation analysis, modeling assumptions that lead to inadequate configurations can be identified. Because of the highly parameterized nature of stock assessment models, some parameters are expected to be correlated (e.g., stock recruit parameters). However, many strongly correlated parameters suggest reconsidering modeling assumptions and parameterization.

High correlations (correlation coefficients greater than 0.95 or less than -0.95) were observed between selectivity parameters for the v08_m2 and v31_m3 (Table 7.5).

In the initial default configurations of both the m1 and m2 model scenarios, the standard error on the initial equilibrium catch was fixed at a low value of 0.01. This tightly constrained the model to the input catch of 168.3 metric tons effectively limiting flexibility in estimating the corresponding initial fishing mortality. To address this issue, the standard error was increased to 0.3, allowing the estimated initial catch to diverge from the fixed input value (Table 7.6). The effects of increasing the standard error beyond 0.3 are discussed further in the sensitivity analyses section.

All model scenarios showed moderate or high correlations between some of the parameters used to define selectivity, except v19_m3. Correlations between these selectivity parameters is expected. While estimated values varied slightly among models, they produced similar length-based selectivity curves for the commercial fleet (Figure 8.1). Time blocks applied in model v31_m3 resulted with lower peaks in the first block (1983-2003), higher peak in the second block (2004-2010) for the commercial selectivity pattern (Figure 8.2). The selectivity for the NCRMP survey differed across the models, particularly with regard to the end selectivity. These differences, in addition to the correlations among NCRMP selectivity parameters, highlight that the estimated parameters informing the NCRMP selectivity relationship are not strongly informed by the available data.

4.3 Evaluating Variance

To check for parameters with high variance, parameter estimates are reported with their resulting standard deviations. Table 7.4 presents the model-estimated values and standard deviations for the main active parameters. While it's important to consider the scale of each parameter, the results suggest that various parameters are being estimated with unusually high precision (less than 0.1). However, four parameters have large coefficients (greater than 0.3) including the initial fishing mortality, the NCRMP ascending selectivity, the NCRMP end selectivity and the NCRMP top selectivity.

Figure 8.3 illustrates how the estimates and uncertainty for the unfished recruitment (R0) and virgin spawning stock biomass change throughout the sequential steps of model development. In general, increasing the complexity of the model results in wider distributions, particularly for the model with the annual fishery dependent data (v31_m3) and recruitment deviations estimated (v19_m3 and v31_m3). The uncertainty across the response surface for key parameters is further examined later in the report using likelihood profiles.

Stock Synthesis also provides estimates and standard deviations for derived quantities such as unfished spawning stock biomass, initial year spawning biomass, and the initial depletion. Initial depletion is defined as the initial biomass divided by the unfished biomass. Table 7.7 shows this information and it is also plotted in Figures 8.4a and 8.4b.

Compared to the other m3 model scenarios, Model v31_m3 had the highest initial depletion reflected in the highest spawning biomass ratio (SSB Initial/SSB Unfished) reported in Table 7.7. This ratio is also plotted as a time series of total biomass relative to virgin spawning biomass in Figure 8.4a. The sensitivity runs described later build on the exploration of uncertainty in these model scenarios.

4.4 Jitter Analysis

Jitter analysis is a relatively simple method that can be used to assess model stability and to determine whether the search algorithm has found a global, as opposed to local, solution. The premise is that all starting values are randomly altered (or 'jittered') by an input constant value, and the model is rerun from the new starting values. If the resulting population trajectories across many runs converge to the same solution, this provides support that a global minimum has been obtained. This process is not fault-proof; no guarantee can ever be made that the 'true' solution has been found or that the model does not contain misspecification. However, if the jitter analysis results are consistent, it provides additional support that the model is performing well and has come to a stable solution. For this assessment, a jitter value of 0.2 was applied to the starting values, and 30 runs were completed. The jitter value defines a uniform distribution in cumulative normal space to generate new initial parameter values (Methot et al., 2020).

Consistent with earlier results indicating that the models reached local minima (positive definite Hessian), no jitter runs produced a lower likelihood than the best fit already identified for each model. However, with models frequently converging at higher likelihoods, the jitter analysis suggests some instability in the model scenarios (Figure 8.5).

Comparing the Spawning stock biomass over time and the selectivity patterns across the jitter runs reveals that the jittered runs resulted on different NCRMP selectivity patterns (Figure 8.6 and Figure 8.7).

4.5 Residual Analysis

The primary approach to investigate model performance was a residual analysis of model fit to each data set (e.g., catch, length compositions, indices). Any temporal trend in model residuals or disproportionately high residual values can indicate model misspecification and poor performance. Ideally, residuals are randomly distributed, conform to the assumed error structure for that data source, and are not of extreme magnitude. Any extremely positive or negative residual patterns indicate poor model performance and potential unaccounted-for process or observation error.

4.5.1 Catch

All models closely matched the observed 1983 - 2022 catch data, which was expected given the data-limited configurations. In these configurations, Stock Synthesis relies heavily on the input catch data, with minimal additional information to support estimation of values that differ from the observations. The effect of increasing the standard error on the catch to 0.3 during the model development m3 scenario was to give the model more flexibility in estimating initial equilibrium catch and corresponding initial fishing mortality. This adjustment allowed the model to explore alternative fits while remaining informed by the assumption of a larger level of historically sustained catch. Increasing the standard error from 0.01 in the m2 model scenarios to 0.3 in the m3 model scenarios resulted in higher estimates of the initial equilibrium catch across all models, except v19 (Table 7.6). This topic will be revisited in the sensitivity analyses, where model runs with even higher catch standard error of 2 are compared. Allowing the estimated initial equilibrium catch to differ from the assumed initial equilibrium catch of 168.3 metric tons is further investigated via likelihood profiles (See Section 4.7.2).

4.5.2 Indices

For the models without recruitment deviation being estimated (a_m3, v01_m3, and v08_m3), the predicted NCRMP index is flat or shows a slight increase (Figure 8.8). In the model scenarios with estimated recruitment deviations (v19_m3 and v31_m3), there is only a slightly improved fit to the index capturing a slight increase over time. Notably, high uncertainty in the index was observed in 2021 of the NCRMP index (Figure 8.8).

4.5.3 Length Compositions

Figure 8.9 shows the cumulative fit across all years between the observed and predicted length composition by fleet for each model. Figure 8.10 shows the annual Pearson residuals by fleet for each model. Figure 8.11 provides the year-specific NRMP survey length compositions for the model scenarios that included annual fishery-independent length data (v01_m3, v08_m3, v19_m3, and v31_m3). Figure 8.12 provides year-specific length compositions for the model scenario that included annual fishery-dependent length data (v31_m3).

To define the initial time blocks for model v31_m3, years corresponding to changes in Puerto Rico's territorial fishery regulations were used. While alternative breakpoints could be considered, 2004 and 2011 were initially selected. These years provide a reasonable fit to the commercial (TIP) length composition data (Figure 8.12). The resulting residuals show some trends but generally capture a shift in selectivity: from smaller fish being selected early in the time series, to larger fish, and eventually settling on a pattern similar to the selectivity estimated without a time block. Although a more detailed and comprehensive approach could be developed, it is important to consider the potential drivers behind the observed changes in selectivity patterns reflected in the data.

Among the models with the annual fishery-independent length data (v01_m3, v08_m3, v19_m3, and v31_m3), the models with recruitment deviation being estimated (v19_m3 and v31_m3), has improved fits to the annual NCRMP length composition data (Figure 8.9). In the scenarios without recruitment deviations, the predicted NCRMP composition is identical across years and similar to cumulative fit when the length data were aggregated in model a_m3. Figure 8.13 shows the observed and predicted mean length by year. In the model scenarios with estimated recruitment deviations (v19_m3 and v31_m3), there is an improved fit to the mean length capturing an increase over time.

Among the model with the annual fishery-dependent length data (v31_m3), the model with recruitment deviation being estimated (v31_m3), has improved fits to the overall commercial length composition data (Figure 8.9). Finally, Figure 8.14 shows the observed and predicted mean length by year. In the model scenarios without and with estimated recruitment deviations (v31_m3, respectively), there is decreased error and an improved fit to the mean length capturing an increase over time.

4.6 Retrospective Analysis

A retrospective analysis is a helpful approach for investigating the consistency of terminal year model estimates (e.g., SSB, Recruits, Fs) and is often considered a sensitivity exploration of impacts on key parameters from changes in data (Carvalho et al., 2021). The analysis sequentially removes a year of data and reruns the model. Suppose the resulting estimates of derived quantities such as SSB or recruitment differ significantly. In such a case, serial over- or underestimation of important quantities can indicate that the model has an unidentified process error and could require reassessing model assumptions. It is expected that removing data will lead to slight differences between the new terminal year estimates and the estimates for that year in the model with the complete time series of data. Estimates in years before the terminal year may have increasingly reliable information on cohort strength. Therefore, slight differences are usually expected between model runs as more years of length composition data are sequentially removed. Ideally, the difference in estimates will be slight and randomly distributed above and below the estimates from the model with complete data set time series.

The results of a five-year retrospective analysis are plotted in Figure 8.15 and Figure 8.16. All retrospectives show wide 95% confidence intervals. The retrospective pattern was most divergent in the scenarios with recruitment deviations and annual fishery-independent length data, model v31_m3. The model v19_m3 retrospective is also unusual as the models ending in 2019 and 2020 reflect an entirely different pattern over the time series, with drastically different estimates for initial fishing mortality.

4.7 Likelihood Profiles

Profile likelihoods are used to assess the stability of parameter estimates by examining changes in the negative log-likelihood for each data source and evaluating the influence of each source on the estimate. The analysis is performed by holding a given parameter at a constant value and rerunning the model. The model is run repeatedly over a range of reasonable parameter values. Ideally, the graph of change in likelihood values against parameter values will yield a well-defined minimum. When the profile plot shows conflicting signals or is flat across its range, the given parameter may be poorly estimated.

Typically, profiling is carried out for key parameters, particularly those defining the stock-recruit relationship (steepness, virgin recruitment, and sigma R). Profiles were explored across virgin recruitment (R0), initial equilibrium catch, and steepness.

4.7.1 Unfished Recruitment (R0)

Figure 8.17 shows the profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for Puerto Rico Yellowtail Snapper across models. All models show relatively poorly defined minimums, with a range of equally plausible values reflected by only small changes in likelihood. However, with the current plots in the report, this is difficult to notice due to the large y-axis scale due to runs that converged at much higher likelihoods. A number of the profiles include peaks or spikes in the likelihood profile. These reflect some instability in the model scenarios also identified from the jitter analysis. Figure 8.18 shows the corresponding change in the Maximum Sustainable Yield Proxy based on SPR 40% across the range of unfished recruitment values explored. Across the range of R0 values explored (0.7 to 1.3 times the estimated R0 for each respective model), the estimates of the MSY proxy (based on SPR 40%) range between 100 and 300 metric tons and reflect a positive relationship with R0 (higher R0 values are associated with higher estimates of the MSY proxy).

4.7.2 Initial Equilibrium Catch

Figure 8.19 shows the profile likelihood for the initial equilibrium catch for Puerto Rico Yellowtail Snapper across model scenarios. A number of the profiles include peaks or spikes in the likelihood profile. These reflect some instability in the model scenarios also identified from the jitter analysis. The models, with the exception of v19_m3, suggest improved fit around 200 metric tons of fixed initial equilibrium catch. Model v19_m3 suggests that given further flexibility the initial equilibrium may be estimated lower. This was further examined through sensitivity runs further relaxing the information that informs the initial model conditions. Figure 8.20 shows the corresponding change in the MSY SPR 40% across the range of initial equilibrium catch values explored.

4.7.3 Steepness

Figure 8.21 shows the profile likelihood for the steepness parameter of the Beverton – Holt stock-recruit function for Puerto Rico Yellowtail Snapper across models. A number of the profiles include peaks or spikes in the likelihood profile. These reflect some instability in the model scenarios also identified from the jitter analysis. The lowest likelihoods are not associated with the highest values of steepness. Instead they are associated with intermediate steepness values between 0.7 and 0.9. Figure 8.22 shows the corresponding change in the MSY SPR 40% across the range of steepness values explored.

4.8 Sensitivity Runs

Sensitivity analyses were conducted to evaluate the impact of key model assumptions on derived quantities. Details of the process and naming conventions are provided in Table 7.3. The analyses explored alternative assumptions for the CV on growth, fixed input for maximum age-informed mortality, and the standard error applied to catch data.

For each model scenario and sensitivity run:

- Table 7.6 provides the initial equilibrium catch
- Tables 7.8 and 7.9 provide the MSY proxy (based on SPR 40%)
- Table 7.10 summarizes the 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 40%)

4.8.1 Growth CV

The first sensitivity scenario (s1) assumed the coefficient of variation (CV) for young fish was increased from 0.15 to 0.25. The m3_s1 sensitivities resulted in a slight increase to estimated initial equilibrium catch relative to the corresponding m3 sensitivity model configurations Table 7.6. The MSY proxy (based on 40% SPR did not change relative to corresponding m3 configurations (Figures 7.8, 7.9). Lastly, all of the models except v19_s1, had higher spawning stock biomass ratios in 2022 and slightly lower relative 2022 fishing mortality rates copared to their corresponding s3 configurations (Table 7.10). Growth is a critical process in all stock assessment models, and in this assessment, the CV for young fish was a particularly relevant sensitivity to examine due to the large number of small individuals (less than 8 cm) observed in the NCRMP fishery-independent survey length compositions. While additional sensitivities related to growth were considered, they will be revisited in the discussion section as part of the research recommendations. The current models use the best available growth parameters from Shervette, Rivera Hernández, & Peña Alvarado (2024).

4.8.2 Natural Mortality

The second sensitivity scenario (s2) explored a slightly lower natural mortality of 0.193, corresponding to a higher maximum age of 28 years (SEDAR, 2020). This higher maximum age, observed along the northern range of the species (off North Carolina and South Carolina), is only slightly older than the maximum age of 26 years observed by Shervette, Rivera Hernández, & Zajovits (2024). Although the true maximum age is often larger than the maximum age observed, particularly for species that have sustained historical fishing pressure, the Hamel (2015) method estimates natural mortality based on the maximum observed age. In this assessment, age is the only factor used to inform the estimate of natural mortality, making it important to consider the implications of assuming a lower M, which reflects a less productive stock. The m3_s2 sensitivity models were similar to the corresponding m3 configurations (Tables 7.6, 7.8, 7.9, and 7.10).

4.8.3 Standard Error on Catch

The third sensitivity scenario (s3) examined the effect of further relaxing the information that informs the initial model conditions. In the m3 model scenarios, a standard error of 0.3 was applied to the landings data (see Section 2.1.1). Compared to the m2 model scenarios, this resulted in higher estimates of initial equilibrium catch, except for model v19_m3. The likelihood profiles (see Section 4.7.2) for v19_m3 showed improved fit at even lower fixed estimates of equilibrium catch. This led to the exploration of increased input uncertainty using a standard error of 2.0 associated with the input equilibrium catch.

Effectively, this provides greater flexibility in estimating initial conditions. The s3 sensitivities produced similar estimates as the corresponding m3 models except for model v19a_m3_s3 which had slightly lower initial catch, slightly higher yield (Tables 7.6, 7.8, 7.9, and 7.10).

These results highlight the significance of uncertainty in initial conditions and underscores the value of longer historical data series. Without them, there is considerable uncertainty in defining the initial conditions, and the m3_s3 results imply that if early landings were larger than assumed in the m3 models, the stock may be more productive.

4.8.4 Standard Error on Catch and Natural Mortality

The fourth sensitivity scenario (s4) explored the combined implications of two sensitivities: increased uncertainty around initial equilibrium catch and lower natural mortality associated with higher maximum age. By evaluating both assumptions simultaneously, this scenario investigates the compounding uncertainty associated with the baseline m3 model configurations.

The combined effect of these changes were similar to the third sensitivity scenario exploring only the standard error on catch, except for model v19_m2_s4 (Tables 7.6, 7.8, 7.9, and 7.10). Model v19_m2_s4 resulted in the highest fishing mortality ratio (2.02) and lowest biomass ratio (0.36) across all models documented in this report.

5 Discussion

This assessment presents a series of model configurations developed to address key uncertainties in both the data and model structure, using an integrated framework to evaluate the stock status of Yellowtail Snapper in Puerto Rico. Across the wide range of scenarios explored, two of the model configurations (v19a and v31a) indicate that the stock could be overfished and that overfishing could be occurring (Table 7.10). However, diagnostics and sensitivity analyses revealed important caveats, primarily due to the strong influence of fixed parameter assumptions including uncertainty initial conditions and the final value of the dome-shaped NCRMP index.

A major source of uncertainty stems from unknown initial catch levels, which are strongly tied to the resulting levels of sustainable yield. Because these dynamics remain confounded we strongly recommend either extending the catch history if a reliable catch time series extending back to the unexploited state is available or exploring methods that decouple the estimation of initial fishing mortality and starting year depletion level.

Among all sensitivity analyses, assumptions about historical catch levels had the greatest influence on model outcomes. Although not yet explored as a sensitivity in the current assessment, the models indicate that the interpretation of stock status is sensitive to the shape and extent of the NCRMP dome-shaped selectivity. These results highlight the importance of structured sensitivity testing to better understand how uncertainty affects model results. Future research should explore the use of model grids or ensemble approaches to formally incorporate uncertainty and improve the reliability of management advice.

Growth is a key biological input that influences estimates of stock productivity and selectivity. Alternative growth curves should be considered, potentially by incorporating broader regional data sets and accounting for the length and age distribution of samples. The variability of size at age for Yellowtail Snapper noted in Shervette, Rivera Hernández, & Zajovits (2024) is an important consideration, thus revisiting the growth inputs via additional sensitivities could strengthen the biological realism and performance of future assessments.

Recruitment deviations, when estimated, were particularly uncertain. However, the availability of fishery-independent length data from the NCRMP survey provides a valuable information source. The observed abundance of small fish may allow better inference of recruitment in future assessments. Finer resolution data (e.g., using 1 cm bins for specific years) could improve model performance and reduce uncertainty.

Integrated models such as Stock Synthesis are powerful not only for synthesizing multiple data sources but also for making key assumptions explicit and testable. Without this flexibility, assessments risk producing outputs that must be taken at face value, with little opportunity to evaluate the effects of underlying assumptions.

While not every species will have sufficient data for an integrated assessment, wherever possible, structured scenario testing should be pursued to explore alternative hypotheses and better understand the drivers of population dynamics. Such efforts strengthen the scientific foundation for management advice and help balance the need for both rigorous and practical assessment frameworks.

This assessment assumes an open population with recruitment not tightly linked to local spawning stock. This assumption could benefit from future exploration of regional connectivity, as it has implications for both model structure and management scale. If connectivity across islands is strong, larger-scale stock definitions or spatially explicit metapopulation modeling approaches may be warranted.

Finally, the stepwise modeling approach used in this assessment offers a framework that could be applied to other Caribbean species. Expanding the approach through targeted data collection and method development could improve the timeliness and robustness of stock assessments across the region. This will require continued support for long-term monitoring programs, higher-resolution data collection, and investment in model development and bridging exercises to deliver science-based, real-time management advice.

6 Assessment Process Research Recommendations

To mitigate some of the data uncertainties it is recommended to:

- The differences in the NCRMP selectivity across models could benefit from additional exploration with informative priors within the Stock Synthesis framework.
- Expand fishery-independent survey time series and resolution (e.g., retain and use 1-cm length bin data where available).
- Further evaluate natural mortality and growth assumptions. Collect and analyze additional life history data to evaluate the accuracy around growth and natural mortality rates.
- Conduct focused research on historical catches and fishing history to inform and constrain early model conditions.
- Consider using simpler production models or age-structured models with fixed selectivity to isolate and evaluate different data inputs.
- Develop and evaluate model ensembles or uncertainty grids to guide catch advice under different plausible scenarios.
- Investigate stock connectivity to better understand local versus regional recruitment dynamics and their implications for informing steepness.
- Research methods, including simulations, to “right-size” model complexity to match data availability, avoiding overparameterization in data-limited contexts.
- Support Management Strategy Evaluations that are robust to key uncertainties to guide harvest advice.
- Ensure the continuation of fishery-independent survey programs (e.g., National Coral Reef Monitoring Program) with consistent spatial and temporal coverage.
- Maintain and expand commercial catch monitoring programs. Expand port sampling and other fishery-dependent data collection to fill gaps in length composition and effort data.

- The use of initial catch in this assessment was intended to inform an initial starting depletion for the population. However, model evaluations show it also strongly informs maximum sustainable yield estimates. This is an undesirable outcome and additional research into how to decouple these impacts would significantly improve model result reliability.
- Investigate data on the lengths of discarded fish to inform length-based retention. Explore parameterizing retention to improve selectivity of the commercial fleet and interpret the apparent high selectivity of larger individuals that are poorly estimated by the current models.

7 Tables

Table 7.1: Commercial landings of Yellowtail Snapper reported in Puerto Rico from 1983 - 2022 in metric tons and pounds by year, along with the percentage of the total commercial landings that came from each gear group.

Year	Metric Tons	Pounds	Handline	Other	Rod & Reel	Traps
1983	124.6	274,642	54%	5%	9%	32%
1984	103.2	227,434	58%	5%	11%	26%
1985	113.6	250,542	58%	9%	5%	28%
1986	56.7	124,992	50%	25%	4%	21%
1987	55.8	123,024	59%	19%	2%	20%
1988	62.5	137,865	66%	17%	2%	16%
1989	81	178,542	69%	10%	7%	13%
1990	95.2	209,973	75%	6%	7%	11%
1991	132.1	291,274	77%	6%	4%	13%
1992	112.7	248,505	76%	9%	4%	11%
1993	138.3	304,948	77%	7%	6%	10%
1994	132	290,964	74%	7%	7%	12%
1995	185.7	409,451	86%	5%	2%	7%
1996	173.6	382,775	78%	11%	1%	10%
1997	158.7	349,802	79%	9%	2%	10%
1998	146.3	322,521	85%	6%	1%	8%
1999	161.7	356,542	84%	6%	1%	8%
2000	286.9	632,458	85%	6%	2%	6%
2001	211	465,127	82%	7%	4%	7%
2002	153.3	338,019	79%	7%	3%	10%
2003	128	282,201	79%	5%	7%	9%
2004	156.3	344,518	80%	7%	4%	10%
2005	118.9	262,076	89%	4%	1%	6%
2006	124.6	274,593	91%	3%	0%	6%
2007	93.6	206,437	92%	4%	0%	4%
2008	169.5	373,610	95%	3%	0%	2%
2009	101	222,592	88%	3%	1%	8%
2010	97.4	214,799	90%	2%	1%	7%
2011	67.9	149,589	85%	7%	1%	7%

Year	Metric Tons	Pounds	Handline	Other	Rod & Reel	Traps
2012	94.4	208,152	83%	7%	1%	9%
2013	59.5	131,267	85%	4%	2%	9%
2014	87.5	192,808	88%	3%	1%	8%
2015	80.6	177,591	88%	2%	1%	8%
2016	85.3	188,121	89%	3%	1%	7%
2017	56.9	125,338	87%	4%	2%	7%
2018	67.7	149,199	85%	6%	1%	8%
2019	74.5	164,293	87%	6%	0%	7%
2020	56.3	124,185	78%	14%	0%	7%
2021	67.6	148,981	76%	16%	0%	9%
2022	79.3	174,936	78%	14%	1%	8%
Total	4,551.7	10,034,686	80%	7%	3%	10%

Table 7.2: Empirical estimates of natural mortality (M) derived using life history information and the Natural Mortality Tool (Cope & Hamel, 2022). All models included in this report utilize the natural mortality estimate of 0.208 corresponding with the maximum age observed by Shervette, Rivera Hernández, & Peña Alvarado (2024), except two of the sensitivity scenarios (s2 and s4) which utilize the 0.193 natural morality corresponding with the estimated maximum age from SEDAR (2020). Higher estimate of mortality result from the meta-analysis available in the FishLife R package (Thorson et al., 2017).

Input Source	Input Type	Input	M	Method
SEDAR (2020)	Maximum age	28	**0.193**	Hamel_Amax
Shervette, Rivera Hernández, & Peña Alvarado (2024)	Maximum age	26	**0.208**	Hamel_Amax
Meta-analysis	Scientific name	*Ocyurus chrysurus*	0.348	FishLife

Table 7.3: Summary of process and naming conventions used across different model development stages of the SEDAR 84 Puerto Rico Yellowtail Snapper stock assessment. The numbering of model runs reflects a structured approach used to track configurations consistently across all three SEDAR 84 assessments.

Stage	Code	Sequential modeling steps
Initial	ct	model initialized with continuum tool (ct)
Initial	m1	ct + adjusted length at age zero
Initial	m2	m1 + continuous recruitment
Initial	m3	m2 + catch uncertainty
Scenario	null	catch and super-year length data
Scenario	a	index
Scenario	v01	index + annual fishery-independent length data
Scenario	v08	index + annual fishery-independent length data + dome-shaped fishery-independent selectivity
Scenario	v19	index + annual fishery-independent length data + dome-shaped fishery-independent selectivity + recruitment deviations
Scenario	v31	index + annual fishery-independent length data + annual fishery-dependent length data + dome-shaped fishery-independent selectivity + time block + recruitment deviations
Sensitivity	s1	higher CV on growth young
Sensitivity	s2	higher age and lower m
Sensitivity	s3	higher catch uncertainty
Sensitivity	s4	s2 + s3

Table 7.4: Puerto Rico Yellowtail Snapper parameters, standard deviations (SD), and coefficient of variation (CV) by model scenario (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). CV is calculated as the SD divided by the parameter estimate.

Parameter	Scenario	Estimate	SD	CV	Gradient
Commercial Ascending Selectivity	a_m3	3.39	0.09	0.03	4.5e-08
	v01_m3	3.40	0.09	0.03	-1.1e-05
	v08_m3	3.45	0.09	0.03	3.6e-08
	v19_m3	3.61	0.09	0.02	-1.7e-04
	v31_m3	2.86	0.23	0.08	6.3e-06
Commercial Ascending Selectivity 1983 - 2003	v31_m3	3.08	0.15	0.05	-3.5e-05
Commercial Ascending Selectivity 2004 - 2010	v31_m3	3.81	0.20	0.05	4.8e-05
Commercial Selectivity Peak	a_m3	28.73	0.35	0.01	6.4e-08
	v01_m3	28.75	0.35	0.01	7.1e-06
	v08_m3	29.25	0.38	0.01	-2.7e-08
	v19_m3	30.53	0.57	0.02	1.1e-04
	v31_m3	29.70	0.70	0.02	-1.9e-05
Commercial Selectivity Peak 1983 - 2003	v31_m3	26.82	0.55	0.02	2.8e-05
Commercial Selectivity Peak 2004 - 2010	v31_m3	32.37	1.03	0.03	-8.1e-06
Initial F	a_m3	0.34	0.08	0.24	-6.7e-08
	v01_m3	0.36	0.08	0.22	-5.7e-07
	v08_m3	0.59	0.16	0.27	3.7e-09
	v19_m3	0.18	0.06	0.33	-2.3e-05
	v31_m3	0.82	0.18	0.22	-4.8e-07

Parameter	Scenario	Estimate	SD	CV	Gradient
NCRMP Ascending Selectivity	a_m3	6.61	4.55	0.69	-1.5e-10
	v01_m3	5.85	2.07	0.35	-3.5e-08
NCRMP Selectivity End	v08_m3	-0.18	0.20	-1.11	-4.5e-10
	v19_m3	0.13	0.28	2.15	1.7e-05
	v31_m3	-0.39	0.22	-0.56	-8.3e-05
NCRMP Selectivity Peak	a_m3	16.56	1.03	0.06	-1.1e-08
	v01_m3	16.95	1.17	0.07	6.6e-08
	v08_m3	7.34	0.56	0.08	-8.8e-10
	v19_m3	19.74	0.89	0.05	-5.5e-06
	v31_m3	18.97	0.90	0.05	-3.6e-05
NCRMP Selectivity Top	v08_m3	-0.47	0.04	-0.09	-4.0e-08
	v19_m3	-5.15	9.50	-1.84	-7.0e-07
	v31_m3	-3.16	0.62	-0.20	-4.0e-05
Unfished Recruitment (R0)	a_m3	7.16	0.01	0.00	9.7e-06
	v01_m3	7.16	0.01	0.00	-1.3e-07
	v08_m3	7.16	0.01	0.00	-3.7e-07
	v19_m3	6.96	0.05	0.01	1.4e-03
	v31_m3	7.03	0.06	0.01	-6.3e-05

Table 7.5: Puerto Rico Yellowtail Snapper correlations between estimated parameters across the m3 model scenarios. 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
a_m2	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.917
a_m3	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.906
v01_m2	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.919
v01_m3	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.909
v08_m2	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.917
v08_m2	NCRMP Selectivity Top	NCRMP Selectivity Peak	-0.982
v08_m3	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.926
v19_m2	Initial F	Unfished Recruitment (R0)	-0.945
v31_m2	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.922
v31_m2	Commercial Ascending Selectivity 1983	Commercial Selectivity Peak 1983	0.945
v31_m2	Commercial Ascending Selectivity 2004	Commercial Selectivity Peak 2004	0.909
v31_m3	Commercial Ascending Selectivity	Commercial Selectivity Peak	0.924
v31_m3	NCRMP Selectivity Top	NCRMP Selectivity Peak	-0.994
v31_m3	Commercial Ascending Selectivity 1983	Commercial Selectivity Peak 1983	0.935
v31_m3	Commercial Ascending Selectivity 2004	Commercial Selectivity Peak 2004	0.909

Table 7.6: Puerto Rico Yellowtail Snapper estimated initial equilibrium catch in metric tons by model scenario including across sensitivity runs. The input value was 168.3 metric tons with a standard error of 0.3.

Parameter	Scenario	a	v01	v08	v19	v31
Commercial Equilibrium Catch	m2	168.9	168.9	169.2	168.2	168.0
	m3	210.1	211.4	225.0	144.1	188.7
	m3_s1	225.5	225.8	232.3	156.5	193.8
	m3_s2	215.4	217.1	225.3	156.6	183.7
	m3_s3	210.9	212.2	225.2	135.5	197.4
	m3_s4	215.8	217.4	225.4	157.8	184.0

Table 7.7: Puerto Rico Yellowtail Snapper derived quantities for unfished and initial spawning stock biomass in metric tons (mt) along with standard deviations (SD) and coefficient of variation (CV) by model scenario (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). CV is calculated as the SD divided by the parameter estimate.

Derived Quantity	Scenario	Estimate	SD	CV
SSB Unfished (mt)	a_m3	666.20	3.48	0.01
	v01_m3	666.52	3.48	0.01
	v08_m3	667.66	3.61	0.01
	v19_m3	547.68	29.37	0.05
	v31_m3	588.98	34.37	0.06
SSB Initial (mt)	a_m3	194.16	32.24	0.17
	v01_m3	189.51	31.52	0.17
	v08_m3	131.70	25.96	0.20
	v19_m3	261.56	41.57	0.16
	v31_m3	75.15	11.30	0.15
Ratio SSB Initial:Unfished	a_m3	0.09	0.00	0.04
	v01_m3	0.09	0.00	0.04
	v08_m3	0.10	0.01	0.06
	v19_m3	0.10	0.03	0.26
	v31_m3	0.15	0.02	0.11

Table 7.8: Puerto Rico Yellowtail Snapper derived quantities of the MSY proxy (based on SPR 40%) in metric tons by model scenario (a_m3, v01_m3, v08_m3, v19_m3, v31_m3) and corresponding each model scenario's four sensitivity runs. CV is calculated as the SD divided by the parameter estimate. Estimates of the MSY proxy are also presented in pounds in Table 7.9.

Scenario	MSY Proxy	SD	CV
a_m3	187.77	1.09	0.01
a_m3_s1	187.61	1.04	0.01
a_m3_s2	187.35	1.19	0.01
a_m3_s3	187.86	1.09	0.01
a_m3_s4	187.43	1.18	0.01
v01_m3	187.93	1.09	0.01
v01_m3_s1	187.70	1.04	0.01
v01_m3_s2	187.68	1.19	0.01
v01_m3_s3	188.02	1.08	0.01
v01_m3_s4	187.75	1.18	0.01
v08_m3	190.35	1.24	0.01
v08_m3_s1	190.06	1.16	0.01
v08_m3_s2	190.40	1.35	0.01
v08_m3_s3	190.41	1.23	0.01
v08_m3_s4	190.54	1.35	0.01
v19_m3	159.97	7.82	0.05
v19_m3_s1	156.01	7.05	0.05
v19_m3_s2	158.86	8.15	0.05
v19_m3_s3	157.95	8.62	0.05
v19_m3_s4	159.63	8.43	0.05
v31_m3	177.98	10.34	0.06
v31_m3_s1	179.31	11.00	0.06
v31_m3_s2	174.86	9.98	0.06

Scenario	MSY Proxy	SD	CV
v31_m3_s3	185.85	11.34	0.06
v31_m3_s4	175.25	10.10	0.06

Table 7.9: Puerto Rico Yellowtail Snapper derived quantities of the MSY proxy (based on SPR 40%) in pounds by model scenario (a_m3, v01_m3, v08_m3, v19_m3, v31_m3) and corresponding each model scenario's four sensitivity runs.

Scenario	a	v01	v08	v19	v31
m3	413,958	414,315	419,650	352,671	392,374
m3_s1	413,600	413,797	419,022	343,937	395,306
m3_s2	413,047	413,770	419,753	350,233	385,505
m3_s3	414,169	414,522	419,789	348,229	409,733
m3_s4	413,212	413,922	420,071	351,928	386,364

Table 7.10: Puerto Rico Yellowtail Snapper 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 40%). The relative fishing mortality ratio is expressed as a three-year geometric mean of the annual fishing mortality rates for 2020-2022 divided by the fishing mortality rate associated with MSY SPR 40%. Relative fishing mortality rates that are above one are shown in red font. The relative stock biomass ratio is expressed as the 2022 spawning biomass divided by the spawning stock biomass at MSY SPR 40%. Relative stock biomass ratios that are below 0.75 are shown in red font.

Metric	**Scenario**	**a**	**v01**	**v08**	**v19**	**v31**
F Current / F SPR 40%	m3	0.63	0.63	0.60	1.58	1.05
	m3_s1	0.59	0.59	0.57	1.77	0.91
	m3_s2	0.70	0.69	0.65	1.79	1.16
	m3_s3	0.63	0.63	0.59	1.64	0.82
	m3_s4	0.69	0.69	0.64	2.02	1.15
SSB 2022 / SSB SPR 40%	m3	1.06	1.06	1.11	0.46	0.66
	m3_s1	1.13	1.13	1.16	0.43	0.79
	m3_s2	0.97	0.97	1.02	0.41	0.60
	m3_s3	1.06	1.07	1.11	0.45	0.82
	m3_s4	0.97	0.97	1.03	0.36	0.60

8 Figures

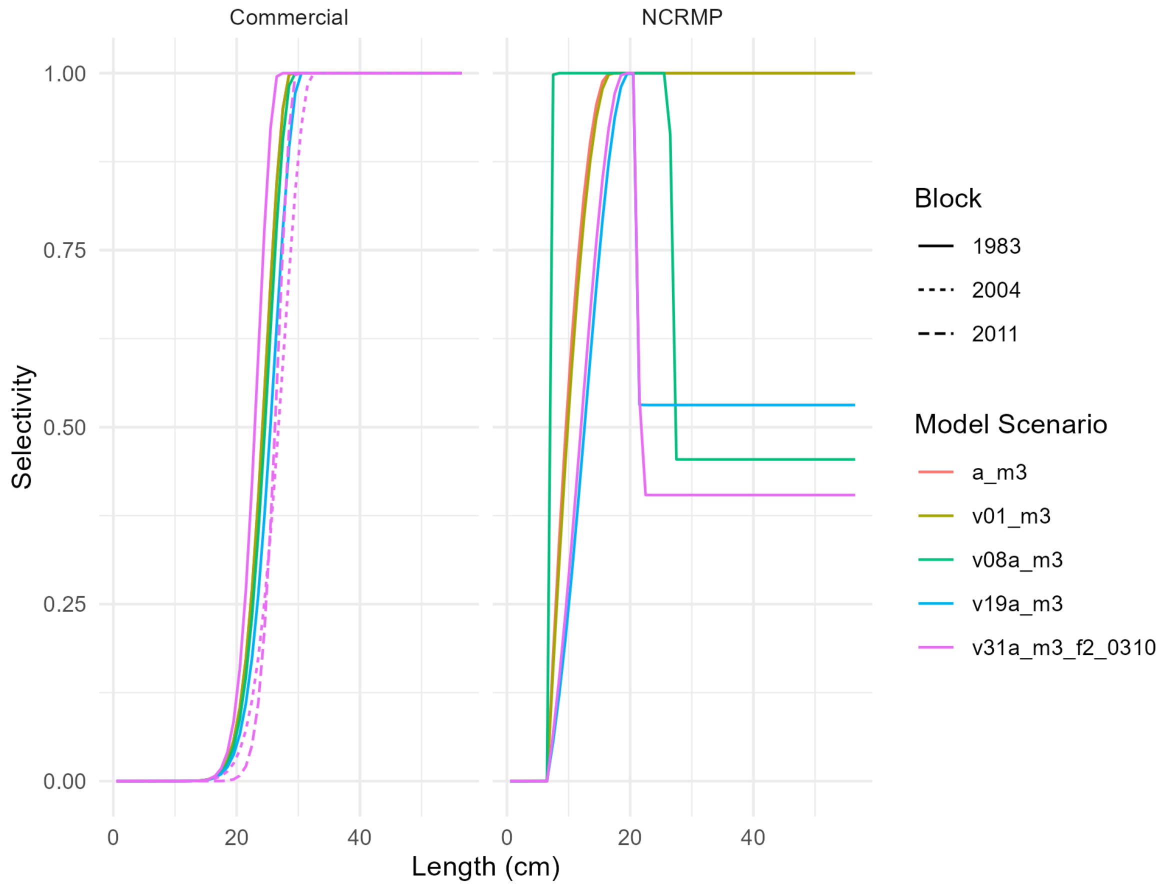
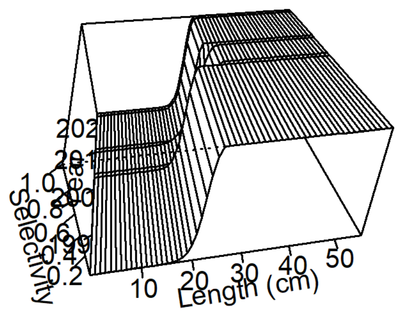
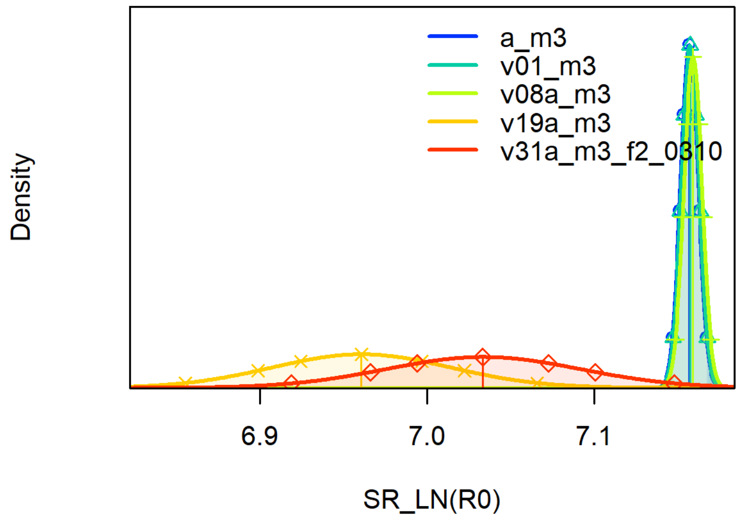


Figure 8.1: Puerto Rico Yellowtail Snapper commercial fleet and NCRMP survey selectivity across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Selectivity patterns reflect the probability that a fish of a given length will be caught by a particular fishing fleet or observed in a given survey. To define the initial time blocks for model v31_m3, years corresponding to changes in Puerto Rico's territorial fishery regulations were used. While alternative breakpoints could be considered, 2004 and 2011 were initially selected.

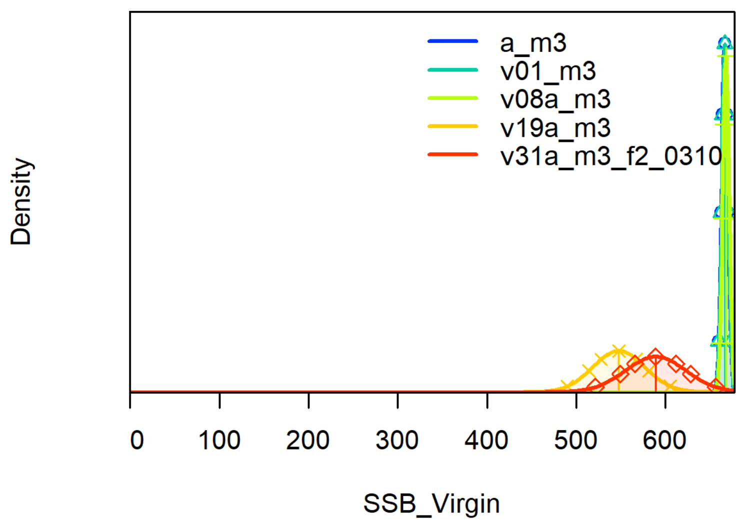


(a) Model v31_m3

Figure 8.2: Puerto Rico Yellowtail Snapper commercial fleet logistic selectivity across model scenarios with time blocks (v31_m3). To define the initial time blocks for model v31_m3, years corresponding to changes in Puerto Rico's territorial fishery regulations were used. While alternative breakpoints could be considered, 2004 and 2011 were initially selected.

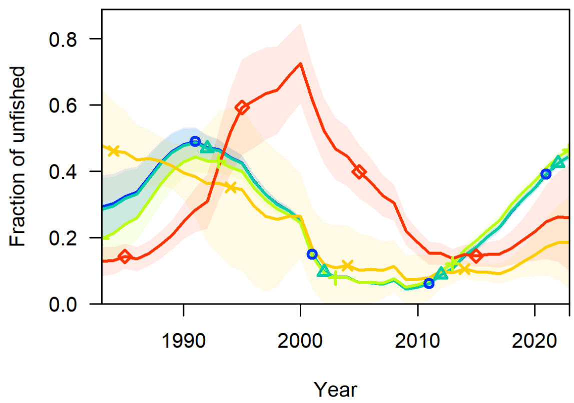


(a) Unfished recruitment

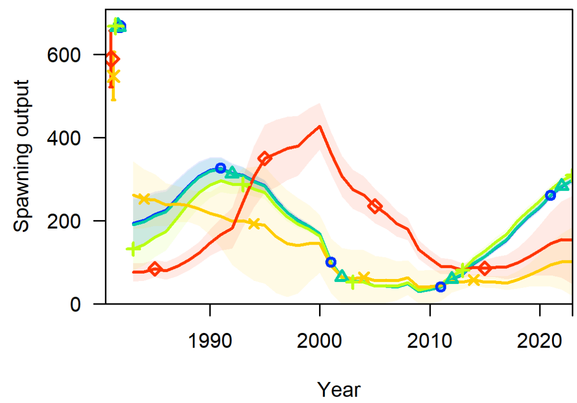


(b) Virgin Spawning Stock Biomass

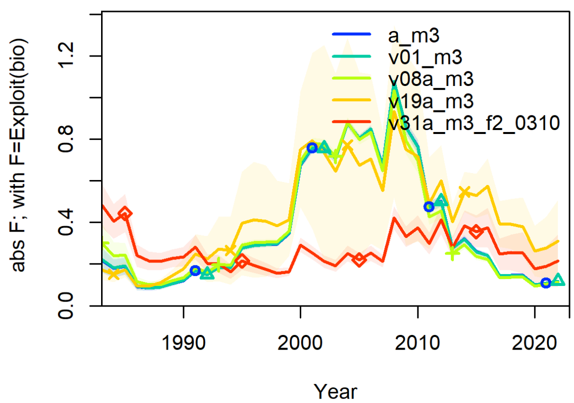
Figure 8.3: Puerto Rico Yellowtail Snapper parameter distribution for (a) the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function and (b) virgin spawning stock biomass in metric tons across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3).



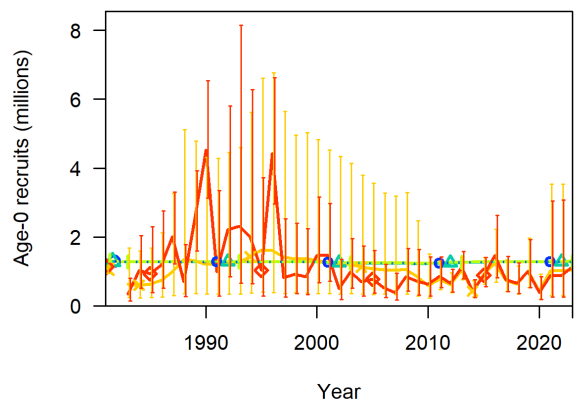
(a) Spawning Biomass Ratio



(b) Spawning Biomass

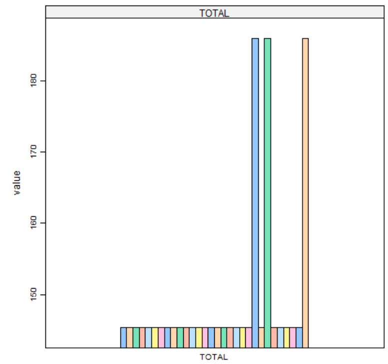


(c) Fishing Mortality

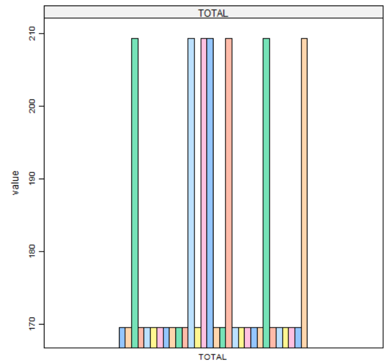


(d) Recruitment

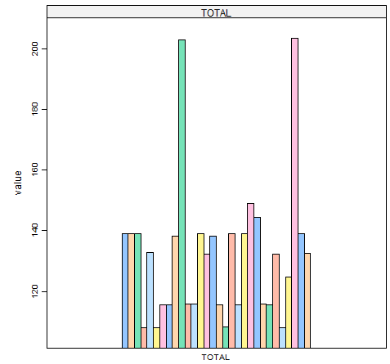
Figure 8.4: Puerto Rico Yellowtail Snapper derived quantity time series across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Derived quantities plotted over time for (a) the relative spawning stock biomass (total biomass / virgin spawning stock biomass), (b) spawning stock biomass in thousands of metric tons, (c) fishing mortality (total biomass killed / total biomass), (d) and recruitment in millions of fish. The shaded areas and vertical bars in the derived quantities time series represent 95% confidence intervals. The values plotted prior to the model start year of 2012 reflect the unfished conditions and associated 95% confidence intervals.



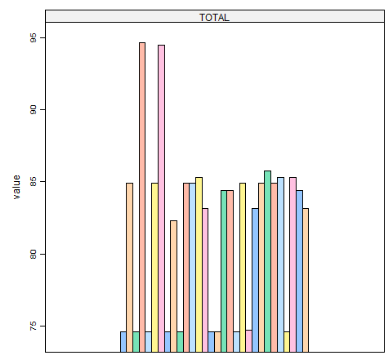
(a) Model a_m3



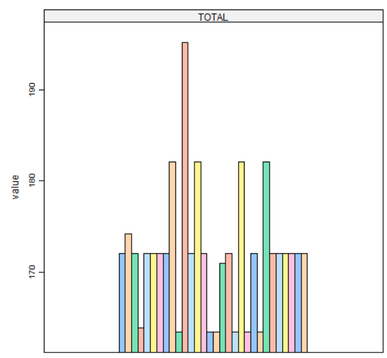
(b) Model v01_m3



(c) Model v08_m3

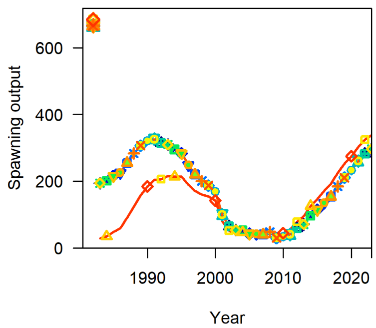


(d) Model v19_m3

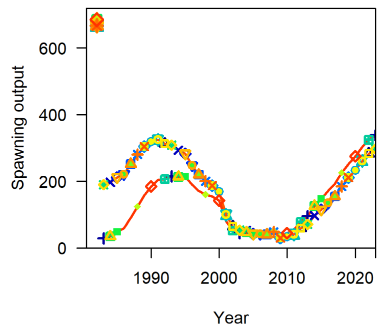


(e) Model v31_m3

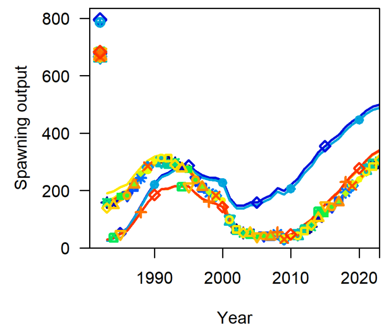
Figure 8.5: Puerto Rico Yellowtail Snapper jitter analysis total likelihood across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Each panel gives the results of 30 runs of the corresponding model scenario where the starting parameter values for each run were randomly changed by 20% from each model's predicted values using a uniform distribution in cumulative normal space.



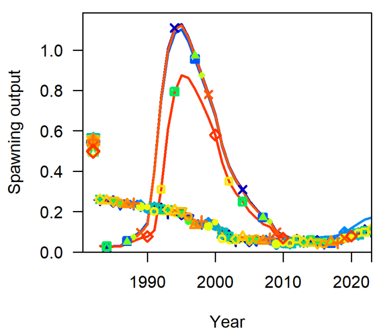
(a) Model a_m3



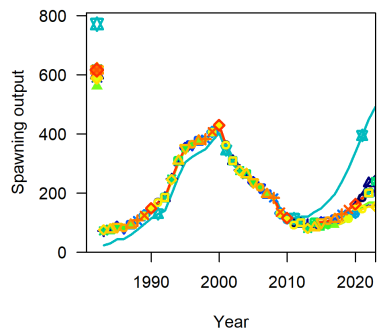
(b) Model v01_m3



(c) Model v08_m3

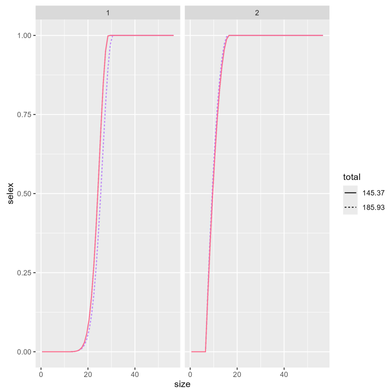


(d) Model v19_m3

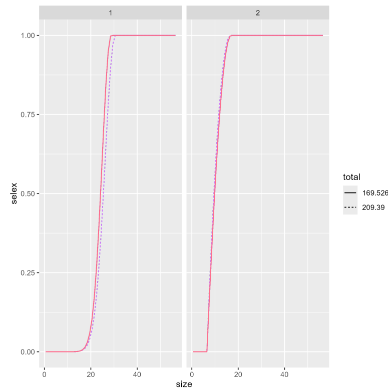


(e) Model v31_m3

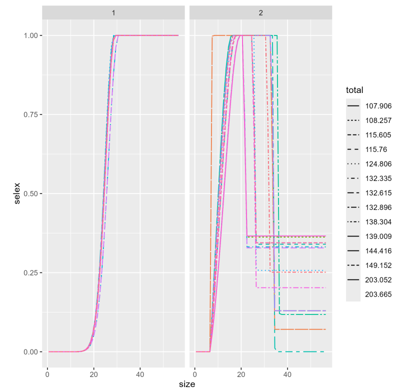
Figure 8.6: Puerto Rico Yellowtail Snapper jitter analysis relative spawning stock biomass in metric tons (a_m3, v01_m3, v08_m3, v31_m3) and in thousands of metric tons (v19_m3) across jitters. Each panel gives the results of 30 runs of the corresponding model scenario where the starting parameter values for each run were randomly changed by 20% from each model's predicted values using a uniform distribution in cumulative normal space.



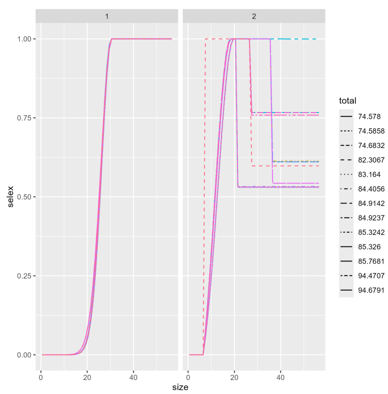
(a) Model a_m3



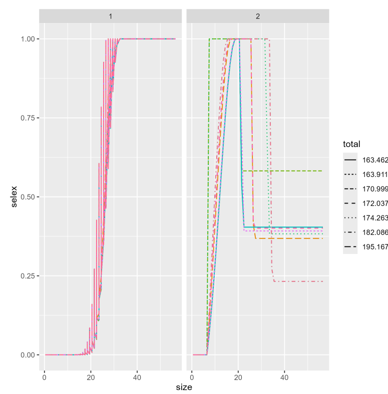
(b) Model v01_m3



(c) Model v08_m3

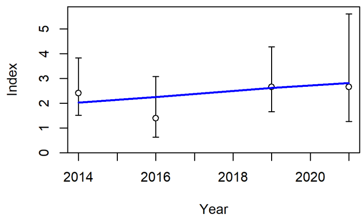


(d) Model v19_m3

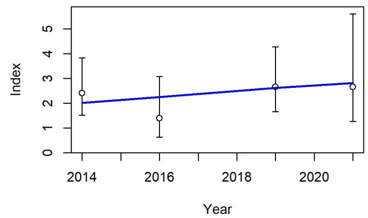


(e) Model v31_m3

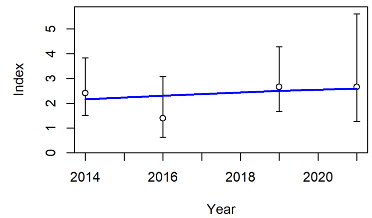
Figure 8.7: Puerto Rico Yellowtail Snapper jitter analysis length-based selectivity by fleet across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Each panel gives the results of 30 runs of the corresponding model scenario where the starting parameter values for each run were randomly changed by 20% from each model's predicted values using a uniform distribution in cumulative normal space.



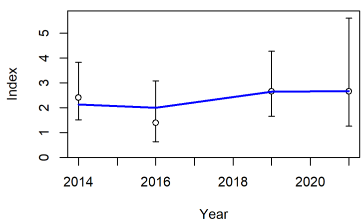
(a) Model a_m3



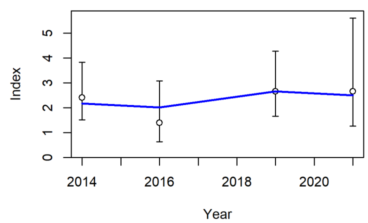
(b) Model v01_m3



(c) Model v08_m3

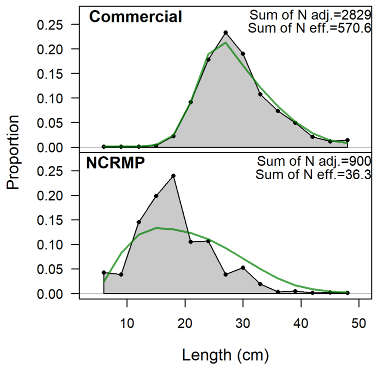


(d) Model v19_m3

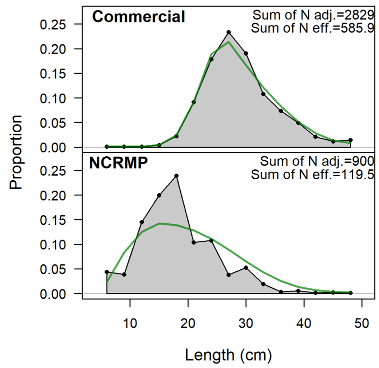


(e) Model v31_m3

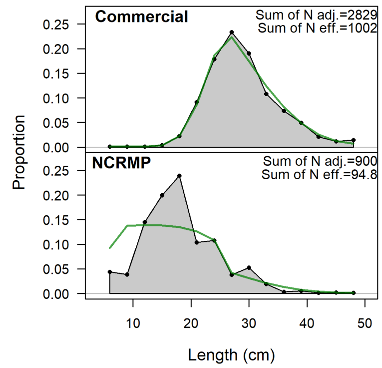
Figure 8.8: Puerto Rico Yellowtail Snapper National Coral Reef Monitoring Program (NCRMP) observed (open circles) and predicted (blue line) indices of relative abundance and associated standard errors across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Error bars indicate a 95% uncertainty interval around observed index values based on the model assumption of lognormal error. Model scenarios a_m3, v01_m3, and v08_m3 do not estimate recruitment deviations, while model scenarios v19_m3 and v31_m3 do.



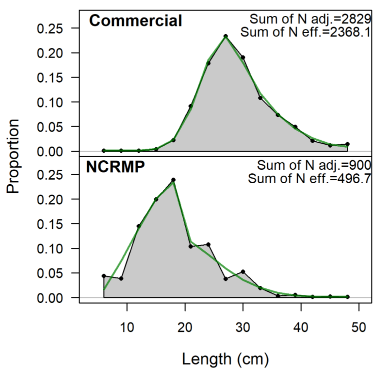
(a) Model a_m3



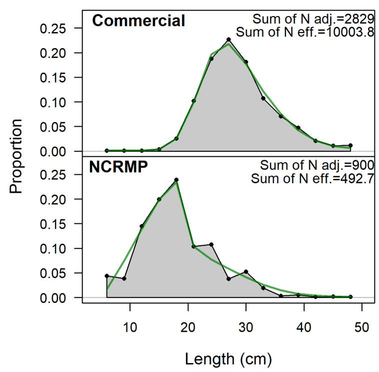
(b) Model v01_m3



(c) Model v08_m3

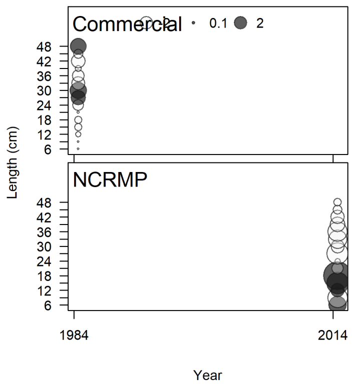


(d) Model v19_m3

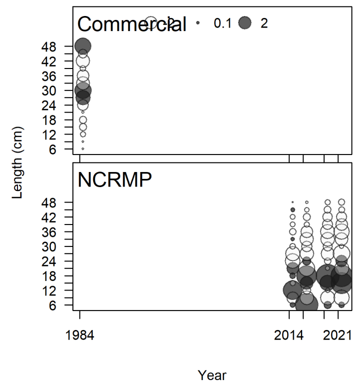


(e) Model v31_m3

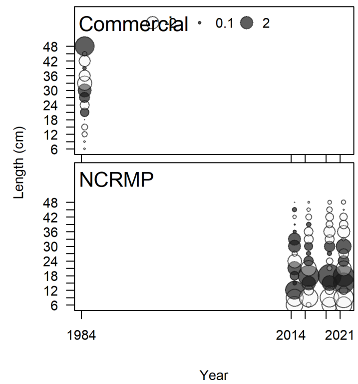
Figure 8.9: Puerto Rico Yellowtail Snapper observed and predicted length distributions in centimeters aggregated across years for the Commercial (TIP) and National Coral Reef Monitoring Survey (NCRMP) length composition across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Green lines represent predicted length compositions, while gray regions represent observed length compositions. The effective sample sizes used to weight the length composition data are provided by N adj (the input sample size) and N eff (the calculated effective sample size) and are shown in the upper right corners. Model scenarios a_m3, v01_m3, and 08_m3 do not estimate recruitment deviations, while model scenarios v19_m3 and v31_m3 do. Super years are utilized for the commercial fleet in scenarios a_m3, v01_m3, v08_m3, and v19_m3 and for the national coral reef monitoring survey in scenario a_m3.



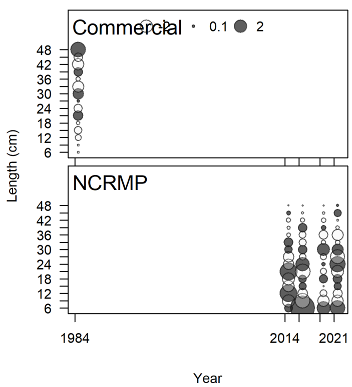
(a) Model a_m3



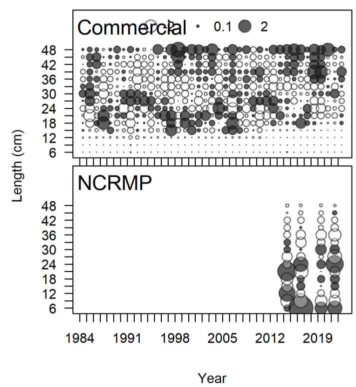
(b) Model v01_m3



(c) Model v08_m3

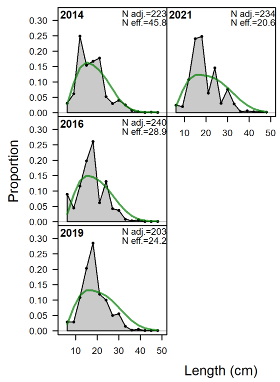


(d) Model v19_m3

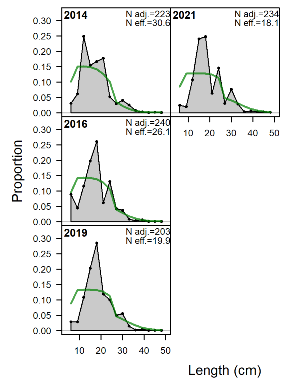


(e) Model v31_m3

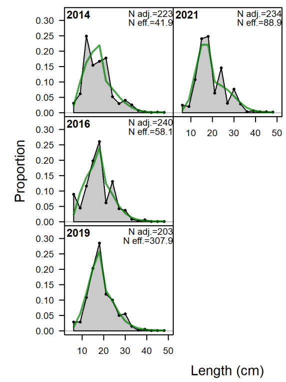
Figure 8.10: Puerto Rico Yellowtail Snapper length composition Pearson residuals, by fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). Model scenarios a_m3, v01_m3, and v08_m3 do not estimate recruitment deviations, while model scenarios v19_m3 and v31_m3 do. Super years are utilized for the commercial fleet in scenarios a_m3, v01_m3, v08_m3, and v19_m3 and for the national coral reef monitoring survey in scenario a_m3.



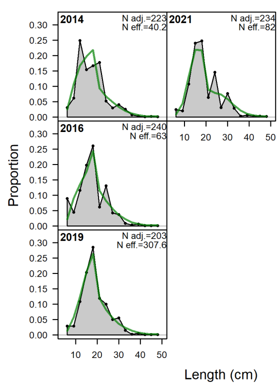
(a) Model v01_m3 NCRMP by year



(b) Model v08_m3 NCRMP by year



(c) Model v19_m3 NCRMP by year



(d) Model v31_m3 NCRMP by year

Figure 8.11: Puerto Rico Yellowtail Snapper observed and predicted length distributions in centimeters by year for the National Coral Reef Monitoring Survey (NCRMP) length compositions for across model scenarios. Green lines represent predicted length compositions, while gray regions represent observed length compositions. The effective sample sizes used to weight the length composition data are provided by N adj (the input sample size) and N eff (the calculated effective sample size) and are shown in the upper right corners.

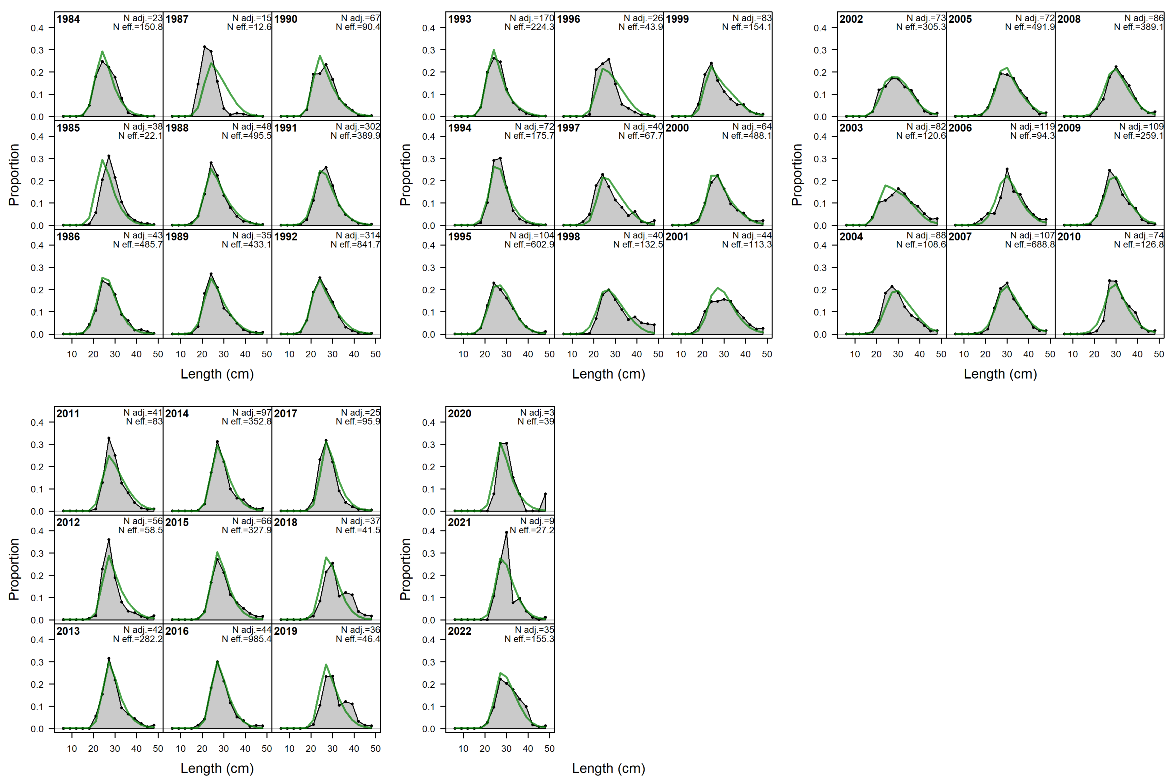
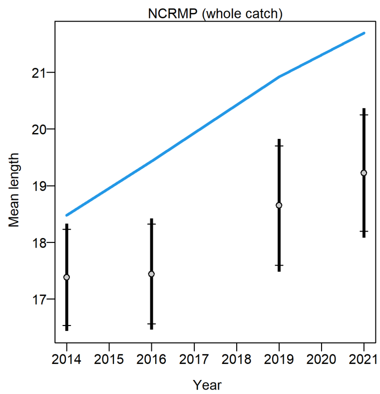
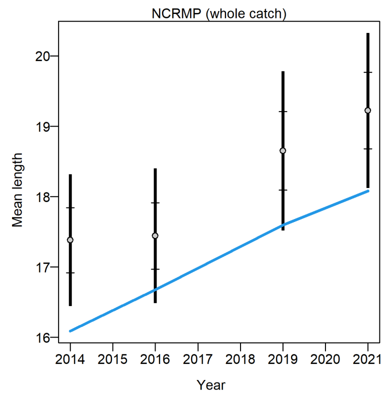


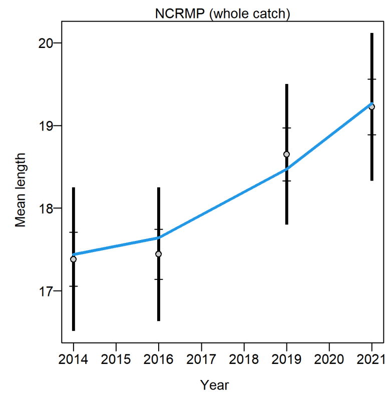
Figure 8.12: Puerto Rico Yellowtail Snapper observed and predicted length distributions in centimeters by year for the commercial fleet length compositions for the v31_m3 model scenarios. Green lines represent predicted length compositions, while gray regions represent observed length compositions. The effective sample sizes used to weight the length composition data are provided by N adj (the input sample size) and N eff (the calculated effective sample size) and are shown in the upper right corners.



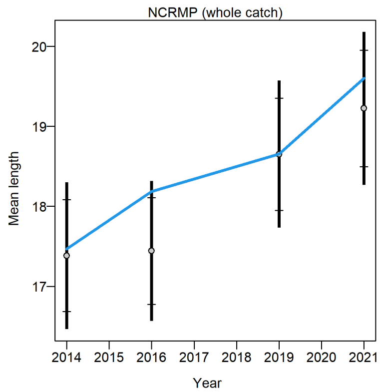
(a) Model v01_m3



(b) Model v08_m3

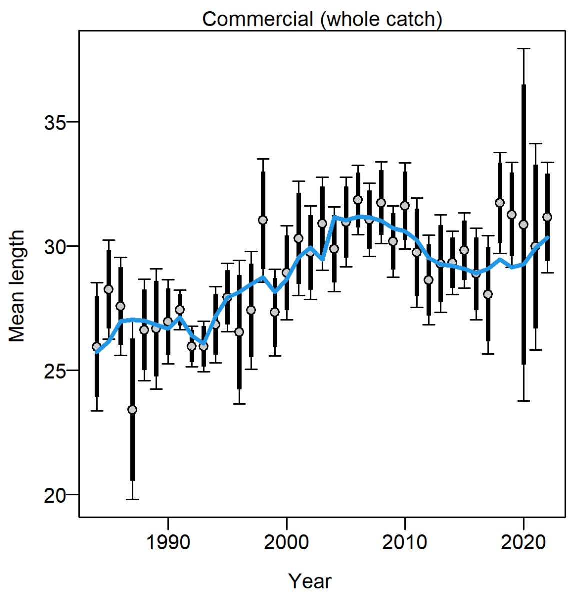


(c) Model v19_m3



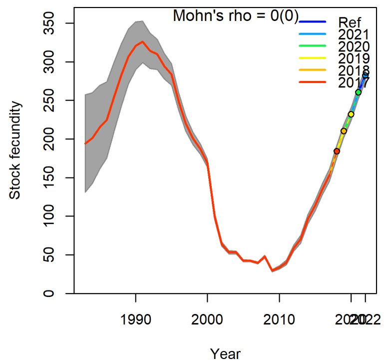
(d) Model v31_m3

Figure 8.13: Puerto Rico Yellowtail Snapper observed (open circles) and predicted (blue line) mean length in centimeters by year across model scenarios that include annual fishery-independent National Coral Reef Monitoring Survey (NCRMP) data without recruitment deviations (v01_m3 and v08_m3) and with recruitment deviations (v19_m3 and v31_m3).

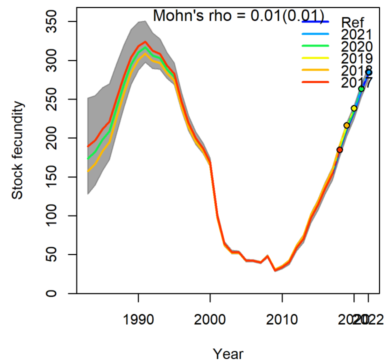


(a) Model v31_m3

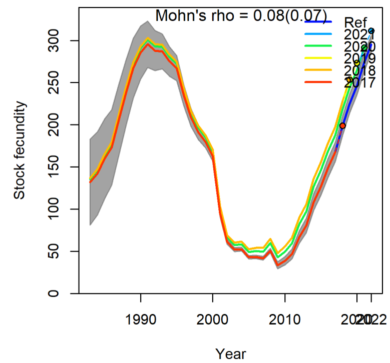
Figure 8.14: Puerto Rico Yellowtail Snapper observed (open circles) and predicted (blue line) mean length in centimeters by year across model scenarios that include annual fishery-dependent commercial data and recruitment deviations (v31_m3).



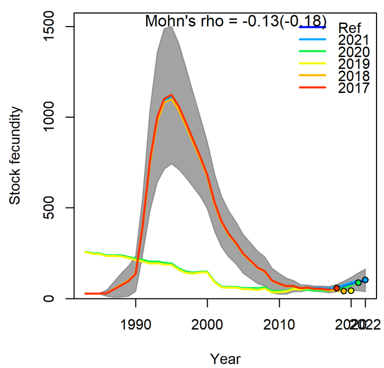
(a) Model a_m3



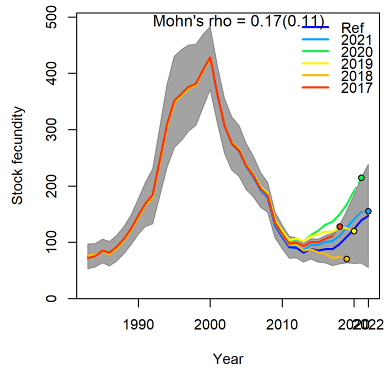
(b) Model v1_m3



(c) Model v08_m3

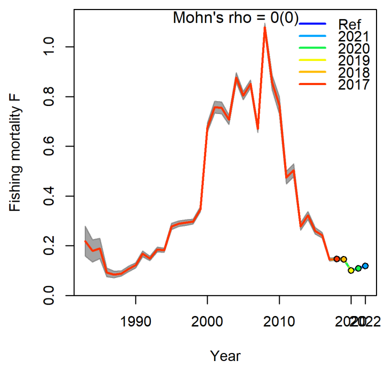


(d) Model v19_m3

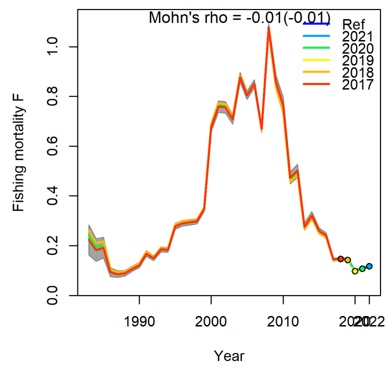


(e) Model v31_m3

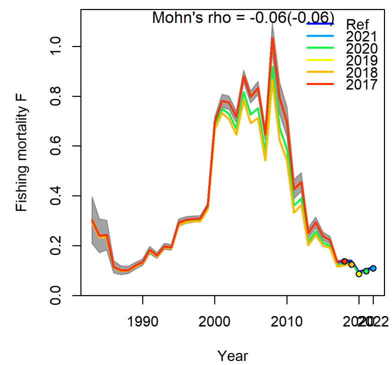
Figure 8.15: Puerto Rico Yellowtail Snapper retrospective analysis of fecundity conducted by refitting models after removing five years of observation, one year at a time sequentially. Mohn's rho statistics and the corresponding "hindcast rho" measure the severity of retrospective patterns. The reference models (Ref) include the full time series ending in 2022. One-year-ahead projections are denoted by color-coded dashed lines with terminal points. Grey shaded areas are the 95% confidence intervals.



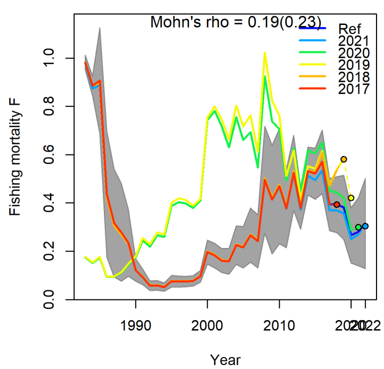
(a) Model a_m3



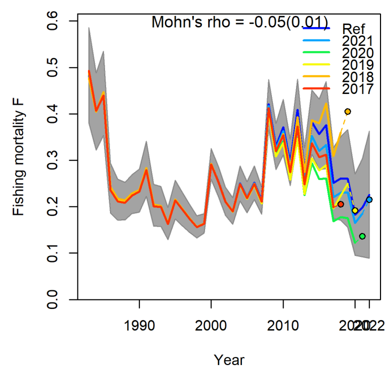
(b) Model v1_m3



(c) Model v08_m3

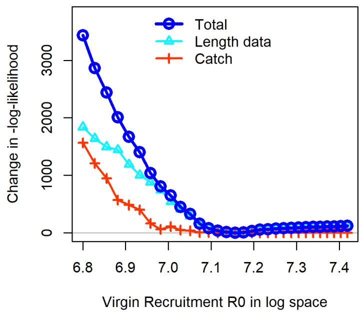


(d) Model v19_m3

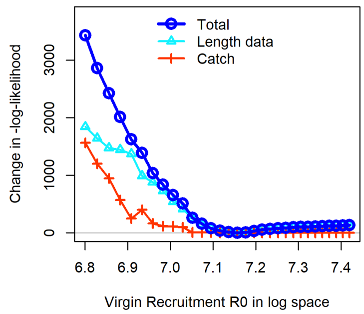


(e) Model v31_m3

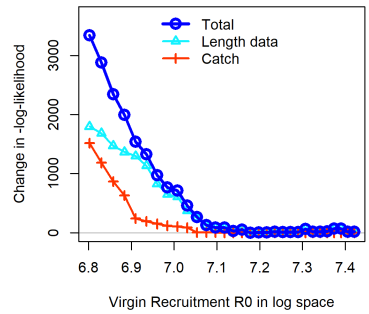
Figure 8.16: Puerto Rico Yellowtail Snapper retrospective analysis of fishing mortality conducted by refitting models after removing five years of observation, one year at a time sequentially. Mohn's rho statistics and the corresponding "hindcast rho" measure the severity of retrospective patterns. The reference models (Ref) include the full time series ending in 2022. One-year-ahead projections are denoted by color-coded dashed lines with terminal points. Grey shaded areas are the 95% confidence intervals.



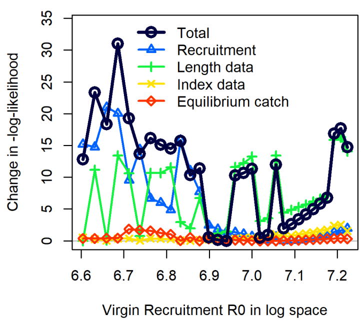
(a) Model a_m3



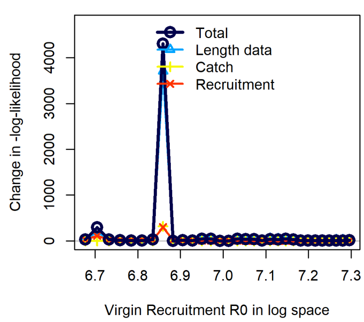
(b) Model v01_m3



(c) Model v08_m3

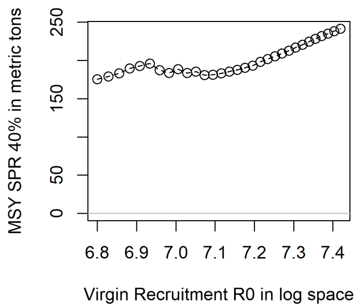


(d) Model v19_m3

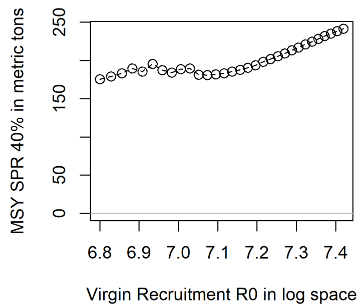


(e) Model v31_m3

Figure 8.17: The profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for Puerto Rico Yellowtail Snapper across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed unfished recruitment values tested in the profile diagnostic run.

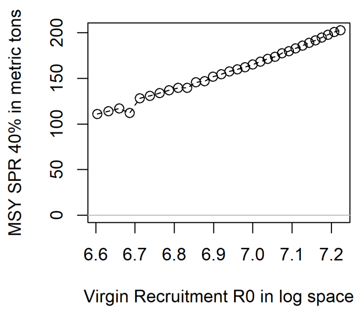


(a) Model a_m3

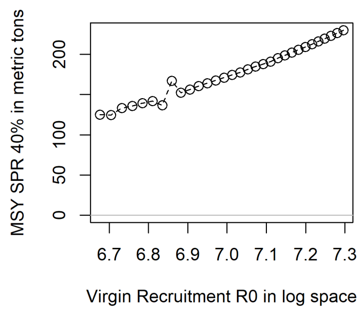


(b) Model v01_m3

(c) Model v08_m3

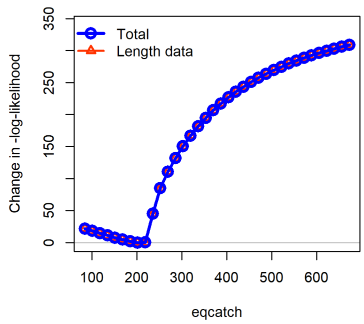


(d) Model v19_m3

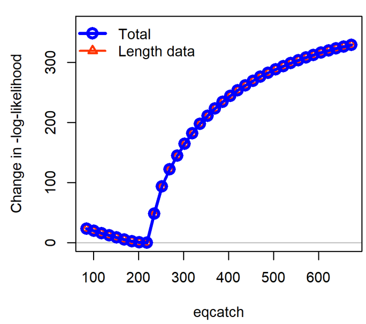


(e) Model v31_m3

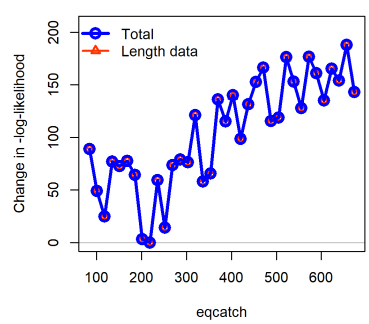
Figure 8.18: Estimates of the MSY proxy (based on SPR 40%) across the range of unfished recruitment values explored in the Puerto Rico Yellowtail Snapper likelihood profile. These estimates, expressed in metric tons, are shown for model scenarios a_m3, v01_m3, v08_m3, v19_m3, v31_m3.



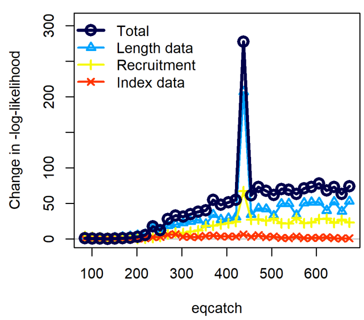
(a) Model a_m3



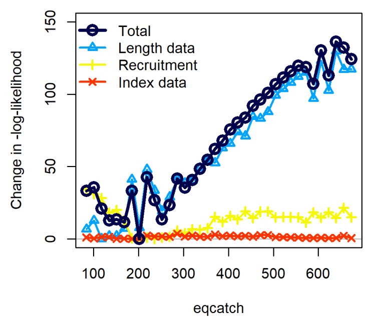
(b) Model v01_m3



(c) Model v08_m3

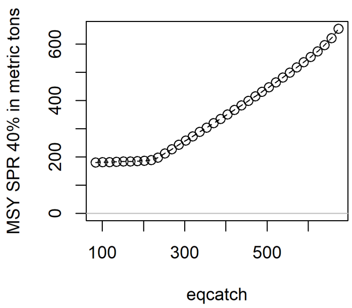


(d) Model v19_m3

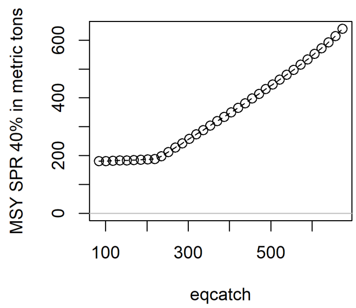


(e) Model v31_m3

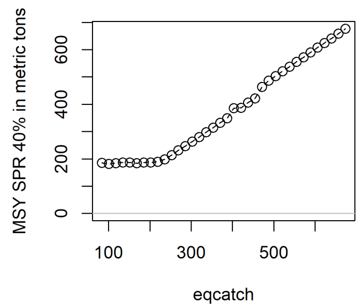
Figure 8.19: The profile likelihood for the fixed initial equilibrium catch for Puerto Rico Yellowtail Snapper across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed equilibrium catch values tested in the profile diagnostic run.



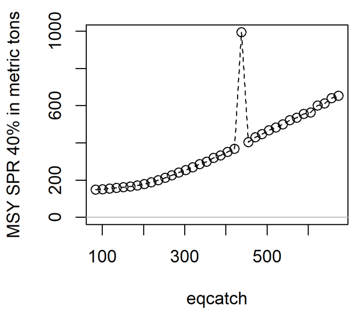
(a) Model a_m3



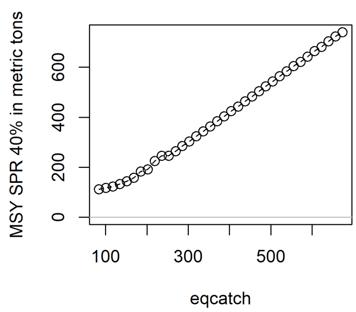
(b) Model v01_m3



(c) Model v08_m3

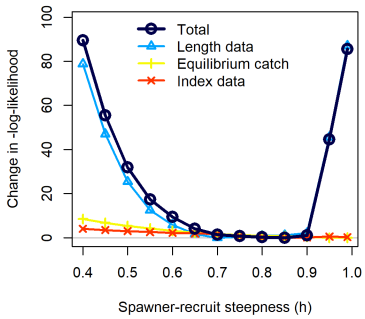


(d) Model v19_m3

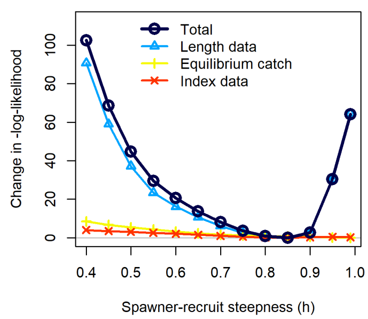


(e) Model v31_m3

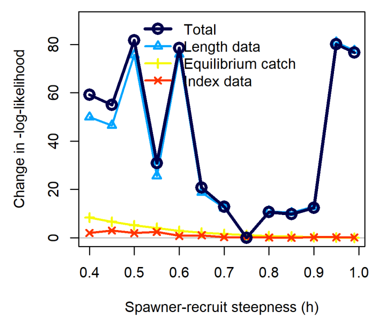
Figure 8.20: Estimates of the MSY proxy (based on SPR 40%) across the range of initial equilibrium catch values explored in the Puerto Rico Yellowtail Snapper likelihood profile. These estimates, expressed in metric tons, are shown for model scenarios a_m3, v01_m3, v08_m3, v19_m3, v31_m3.



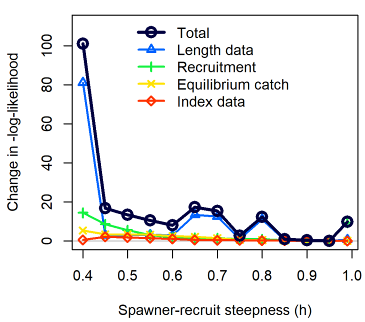
(a) Model a_m3



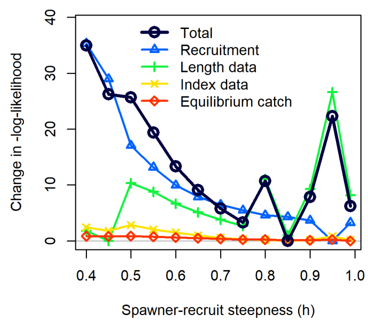
(b) Model v01_m3



(c) Model v08_m3

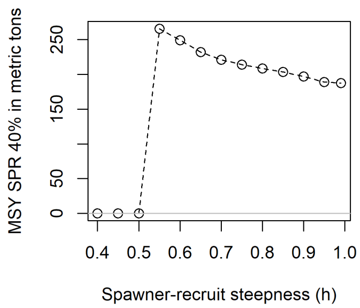


(d) Model v19_m3



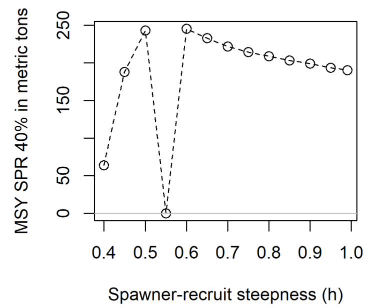
(e) Model v31_m3

Figure 8.21: The profile likelihood for the steepness parameter of the Beverton – Holt stock-recruit function for Puerto Rico Yellowtail Snapper across model scenarios (a_m3, v01_m3, v08_m3, v19_m3, v31_m3). Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed steepness values tested in the profile diagnostic run.

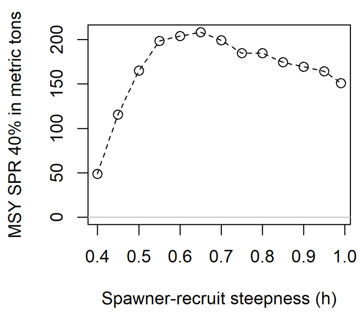


(a) Model a_m3

(b) Model v01_m3



(c) Model v08_m3



(d) Model v19_m3

(e) Model v31_m3

Figure 8.22: Estimates of the MSY proxy (based on SPR 40%) across the range of steepness values explored in the Puerto Rico Yellowtail Snapper likelihood profile. These estimates, expressed in metric tons, are shown for model scenarios a_m3, v01_m3, v08_m3, v19_m3, v31_m3.

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 84

US Caribbean Yellowtail Snapper – Puerto Rico

SECTION IV: Research Recommendations

SEDAR
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Table of Contents

1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 LIFE HISTORY RESEARCH RECOMMENDATIONS

Issue 1: Are sufficient life history data available?

- Life history sampling should be done with statisticians to ensure more efficient collection programs (e.g., optimizing sample sizes within size bins).
- Ensure statistically robust sample sizes of small and large size classes of fish.

1.2 COMMERCIAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

1.2.1 Commercial Landings Research Recommendations

Issue 1: Are analysis-ready commercial landings data available for SEDAR 84?

- Investigate trends in effort, significant socioeconomic and environmental events, and associated effects on the demographics, gears used, and species landed.
- Increased port sampling is needed in St. Thomas and St. John to enable analyses required for quantifying removals.
- Conduct recreational fishery port sampling surveys to determine removals due to recreational fishing.
- Investigate the applicability of hindcasting for all parrotfish combined or other applicable future assessments.

Issue 2: What should the gear fleets be for the commercial landings data?

- Investigate cases where there may be a miscommunication between databases, which can impact the gear types (i.e., hook and line unknown)
- Operationalize a gear grouping process for future SEDAR assessments.

Issue 3: How uncertain are the commercial landings from 2012 - 2022?

- No research recommendation.

Issue 4: Should data outliers in the commercial landings be flagged for additional investigation?

- Operationalize an outlier flagging process for future SEDAR assessments.

1.2.2 Length Composition Research Recommendations

Issue 1: Are analysis-ready size data available for SEDAR 84?

- Increase collection efforts to increase sample size in TIP.
- Work with port samplers and fishers to implement the trip interview program better and ensure critical fishing times are captured adequately (e.g., at night).
- Develop a data management system to link TIP to CCL. A linked system would require changing the overarching structure of collecting fishery-dependent data. A fishery information network system for the US Caribbean could comprehensively resolve this issue.
- Operationalize an outlier flagging process for future SEDAR assessments.
- Investigate if relative weight at a given length has changed across years or clusters of years.
- Examine the number of trips when considering the representativeness of TIP samples; do not limit the investigation to the number of fish or the weight of the catch, samples, and trips.
- Going forward, we need a recommendation on how to do a new sampling strategy that is more holistic.

1.3 RECREATIONAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

Issue 1: Can tournament data inform recreational removals?

- This data type would be valuable for pelagic species, like wahoo and mahi, with consistent effort and catch. Therefore, this dataset should continue to be explored and standardized for future assessments. There is consistent participation in and support for these tournaments by participants.

1.4 MEASURES OF POPULTAION ABUNDANCE RESEARCH RECOMMENDATIONS

Issue 1: Should the fishery-independent density estimates from NCRMP be used in SEDAR 84?

- Continue DCRMP work in the future.
- Look into National Parks transect data and compare it to the NCRMP data
- Provide RVC to DCRMP comparison for the 2021 year. If they are similar in that year, then what we see in 2022 is more a pulse of large fish than a difference in where the fish are.

Issue 2: Should fishery-dependent information (commercial logbooks) be considered to conduct abundance indices?

- Look into environmental patterns or fisher behavior as an assignment of CPUE or effort that we can use to look into changes in the population.
- Request for USVI fisher to provide their logbooks to further investigate the fisher behavior as an index assignment for CPUE.

2. ASSESSMENT PROCESS RESEARCH RECOMMENDATIONS

To mitigate some of the data uncertainties it is recommended to:

- The differences in the NCRMP selectivity across models could benefit from additional exploration with informative priors within the Stock Synthesis framework.
- Expand fishery-independent survey time series and resolution (e.g., retain and use 1-cm length bin data where available).
- Further evaluate natural mortality and growth assumptions. Collect and analyze additional life history data to evaluate the accuracy around growth and natural mortality rates.
- Conduct focused research on historical catches and fishing history to inform and constrain early model conditions.
- Consider using simpler production models or age-structured models with fixed selectivity to isolate and evaluate different data inputs.
- Develop and evaluate model ensembles or uncertainty grids to guide catch advice under different plausible scenarios.
- Investigate stock connectivity to better understand local versus regional recruitment dynamics and their implications for informing steepness.
- Research methods, including simulations, to "right-size" model complexity to match data availability, avoiding overparameterization in data-limited contexts.
- Support Management Strategy Evaluations that are robust to key uncertainties to guide harvest advice.
- Ensure the continuation of fishery-independent survey programs (e.g., National Coral Reef Monitoring Program) with consistent spatial and temporal coverage.
- Maintain and expand commercial catch monitoring programs. Expand port sampling and other fishery-dependent data collection to fill gaps in length composition and effort data.
- The use of initial catch in this assessment was intended to inform an initial starting depletion for the population. However, model evaluations show it also strongly informs maximum sustainable yield estimates. This is an undesirable outcome and additional research into how to decouple these impacts would significantly improve model result reliability.
- Investigate data on the sizes of discarded fish to inform size-based retention. Explore parameterizing retention to improve selectivity of the commercial fleet and interpret the apparent high selectivity of larger individuals that are poorly estimated by the current models.

3. REVIEW PANEL RESEARCH RECOMMENDATIONS

The RP supports the research recommendations outlined in the DW and AW reports for the U.S. Caribbean Yellowtail Snapper assessment processes. Based on those recommendations, the following were identified as high priority and are listed in order of importance:

St. Thomas/St. John and Puerto Rico Yellowtail Snapper

- Short term
    - Investigate the applicability of hindcasting for all parrotfish combined or other applicable future assessments (for St. Thomas/St. John commercial catch data)
    - Further evaluate natural mortality and growth assumptions
        - Explore the use of natural mortality at age
    - Explore parameterizing retention to improve selectivity of the commercial fleet and interpret the apparent high selectivity of larger individuals that are poorly estimated by the current models.
    - Request for USVI fisher to provide their logbooks to further investigate the fisher behavior as an index assignment for CPUE.
    - Investigate stock connectivity to better understand local versus regional recruitment dynamics and their implications for informing steepness
- Long term
    - There are several biases in the current NCRMP survey design. Notably, the survey is conducted over a limited time frame (for two weeks every two years), which would miss seasonal or environmental changes. Additionally, the survey may not be adequately capturing the full size distribution of the population (e.g., upwelling/high turbulence areas that have high density of larger fish, underrepresentation of young of the year etc.). Currently, there is limited DCRMP data, which would target larger, older fish that are in deeper waters and help complement the NCRMP survey. The RP support the following recommendations for the NCRMP and DCRMP surveys:
        - Ensure the continuation of fishery-independent survey programs (e.g., National Coral Reef Monitoring Program) with consistent spatial and temporal coverage
        - Expand fishery-independent survey time series and resolution
        - Continue DCRMP work in the future.
        - Look into National Parks transect data and compare it to the NCRMP data
    - Maintain and expand commercial catch monitoring programs. Expand port sampling and other fishery-dependent data collection to fill gaps in length composition and effort data

    - Increased port sampling is needed in St. Thomas and St. John to enable analyses required or quantifying removals.
    - Increase collection efforts to increase sample size in TIP.
  - Conduct recreational fishery port sampling surveys to determine removals due to recreational fishing.

The RP also recommends the following:

- St. Thomas/St. John and Puerto Rico Yellowtail Snapper
  - Further investigate the population structure of those two stocks.
    - Conduct population structure studies through genetics, tagging, fish larvae, otolith microchemistry, or modelling.
  - Improve otolith samples
  - Reconsider not removing old NCRMP survey data (before 2013/2014; La Parguera)

SEDAR
Southeast Data, Assessment, and Review

SEDAR 84

Caribbean Yellowtail Snapper and Stoplight Parrotfish

SECTION V: Review Workshop Report

August 2025

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1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 84 Review Workshop was held in Fort Lauderdale, Florida July 15-18, 2025.

1.2 TERMS OF REFERENCE

1. Evaluate the data used in the assessment, addressing the following:
- Are data decisions made by the DW and AW sound and robust?
- Are data uncertainties acknowledged, reported, and within normal or expected levels?
- Are data applied properly within the assessment model?
- Are input data series reliable and sufficient to support the assessment approach and findings?

2. Evaluate the methods used to assess the stock, taking into account the available data.
- Are methods scientifically sound and robust?
- Are assessment models configured properly and used consistent with standard practices?
- Are the methods appropriate given the available data?

3. Evaluate the assessment findings with respect to the following:
- Can the results be used to inform management in the U.S. Caribbean (i.e., develop annual catch recommendations)?
- Is it likely the stock is overfished? What information helps you reach this conclusion?
- Is it likely the stock is undergoing overfishing? What information helps you reach this conclusion?

4. Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

5. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.

Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.

6. Provide guidance on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.

7. Provide recommendations on possible ways to improve the SEDAR process.

8. Prepare a Peer Review Summary summarizing the Panel's overall conclusions and recommendations.

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1.4 LIST OF REVIEW WORKSHOP WORKING PAPERS AND DOCUMENTS

Document #	Title	Authors	Date Submitted
Documents Prepared for the Review Workshop			
SEDAR84-RW-01	SEDAR 84 Public Comment	Public Comment	25 July 2025
Reference Documents			
SEDAR84-RD14	Best practices for defining spatial boundaries and spatial structure in stock assessment	Steven X. Cadrin[a], Daniel R. Goethel[b], Aaron Berger[c], Ernesto Jardim[d]	
SEDAR84-RD15	Good practices, trade-offs, and precautions for model diagnostics in integrated stock assessments	Maia S. Kapur [a,*], Nicholas Ducharme-Barthe [b], Megumi Oshima [b], Felipe Carvalho [b]	

2. REVIEW PANEL REPORT

Executive Summary

SEDAR is organized into three main workshops. First is the Data Workshop (DW), during which fisheries, monitoring, and life history data of a fish stock are reviewed and compiled. The second is the Assessment Workshop (AW) during which assessment models are developed and population parameters are estimated using the information provided from the DW. The third step is the Review Workshop (RW), during which independent experts review the input data, assessment methods, and assessment products. The final stock assessment (which is yet completed), includes the reports of all three aforementioned stages along with all supporting documentation. The completed assessment report is then forwarded to the Council SSC (in this case the CFMC/SSC) for certification as 'appropriate for management' and development of specific management recommendations.

Now we are in the third stage of the SEDAR 84 process, entitled The U.S. Caribbean Yellowtail Snapper and Stoplight Parrotfish Stock Assessment RW. This review workshop was held between July 15-18, 2025 in Fort Lauderdale, Florida, USA. The review team (or Panel) consists of the Review Panel (RP), the Analytic Team, and of appointed observers.

The RP consisted of five panel members: two CFMC/SSC members and three scientists appointed by the Center for Independent Experts (CIE). The Analytic Team consisted of two members, both from the SEFSC (NMFS). There were four Appointed Observers: three from the CFMC District Advisory Panel of St. Croix (USVI) and one from the CFMC District Advisory Panel of St. Thomas/St. John (USVI). Fourteen additional observers (*via* Webinar) also participated, which included three from NOAA, two from the regional office (SERO) and two Science Centers (SEFSC and SWFSC). Two staff members (one from SEDAR and one from the CFMC) and one Workshop Observer (from the SEFSC) participated in person.

SEDAR 84 addressed the stock assessments of two data-limited U.S. Caribbean species: Yellowtail Snapper (*Ocyurus chrysurus*) and Stoplight Parrotfish (*Sparisoma viride*). The Caribbean Yellowtail Snapper stock has been addressed in two earlier SEDAR stock assessment processes (i.e., in SEDAR 8 and, in SEDAR 46). In the latter, Stoplight Parrotfish stock was also included. At present, both species are classified as reef fish and managed as data-limited stocks under their respective Island Based Fisheries Management Programs.

Although both species are reef fish units, they are very different not only in their systematics, but also in their life histories (e.g., the Yellowtail Snapper is dioecious, having separate sexes), while the Stoplight Parrotfish is protandrous, a sequential hermaphrodite with three sexes). In addition, their feeding habits, their behavior, and their ecological functions differ: the Yellowtail Snapper is carnivorous and preys on the water column (e.g. on small fish and squids) as well as on benthic reef invertebrates (e.g. on decapod crustaceans).

The Stoplight Parrotfish is a macroalgal grazer (herbivorous) and equipped with pharyngeal mills for grinding seaweeds along with sediment, sand, coral, and rock. *S.viride* employs an excavating grazing mode, and feeds almost exclusively on algae associated with dead coral substrates. Preferred food types are large and sparse turfs growing on carbonate substrates inhabited by endolithic algae (Bruggerman et al.).

As reported in SEDAR 46, the Yellowtail Snapper (*Ocyurus chrysurus*) in Puerto Rico had the highest number of recorded length measurements among finfish and the second largest average annual commercial landings. Yellowtail Snapper landings were reported from more handline fishing trips than any other species in Puerto Rico. Throughout the time series, handline has been either the first or second most reported fishing gear in the self-reported commercial logbook data from Puerto Rico.

As indicated in the SEDAR 46 process Stoplight Parrotfish in St. Croix (USVI) was the finfish with both the second most total measured lengths and the second highest average annual commercial landings. Additional considerations supported the selection of Stoplight Parrotfish as a representative species and the diving fleet as the most appropriate fishery for tracking their abundance. Stoplight Parrotfish landings have been reported from more diving trips in St. Croix than any other finfish since species-specific reporting started in 2011. In addition, diving has been the most frequently reported fishing gear in the self-reported commercial logbook data in St. Croix since 2003. Populations of both of these species are widely distributed throughout the Wider Caribbean Region (i.e. the West Indian Biogeographic Region).

All three stocks were assessed using Stock Synthesis (SS3), an age-structured modeling platform suitable for a range of data availability. While the assessments incorporated appropriate data sources, concerns were raised regarding short time series, limited length composition data, and exclusion of historical survey years. During the RW, the RP requested several model revisions and additional runs for all three assessments. Although SS3 was implemented correctly, the quality and availability of the data were not robust enough to fully support such a complex model. Diagnostics and the additional model runs revealed sensitivities to assumptions about catch uncertainty (fits to the catch vs index data) and estimation of growth. These findings raised concerns about model structural issues or data quality issues (e.g., data conflicts), particularly for the St. Croix Stoplight Parrotfish and St. Thomas/St. John Yellowtail Snapper, where data were especially limited. Even though the Puerto Rico Yellowtail Snapper had a longer time series, the model showed similar issues, such as instability and conflicting signals across model runs and among datasets.

The RP concluded that none of the assessments were reliable enough to inform management decisions as key metrics like Spawning Potential Ratio and depletion were highly sensitive to modeling assumptions, and results varied among runs. The RP recommended further data collection, consideration of alternative modeling approaches, and reintegration of historical information. A combined Yellowtail Snapper model for St. Thomas/St. John and Puerto Rico was explored by the Analyst Team as recommended by the RP. While the model did not converge in the first attempt, the second model run converged. Despite some instability and absence of a fully diagnostic suite for the second model run, this combined model provides a promising first step towards a Yellowtail Snapper stock assessment model.

ADDRESSING THE REVIEW WORKSHOP TERMS OF REFERENCE

TOR1. Evaluate the data used in the assessment, addressing the following:

A. Are data decisions made by the DW and AW sound and robust?

Overall, some decisions made by the Data Workshop (DW) and Assessment Workshop (AW) were supported by the Review Panel (RP), and some were not.

Stock assessment models have been developed for the St. Croix Stoplight Parrotfish, St. Thomas/St. John Yellowtail Snapper and Puerto Rico Yellowtail Snapper using an appropriate approach (Stock Synthesis; SS3).

Data used for the assessments included landings data for appropriate species and gear types, length composition data from the Trip Interview Program (TIP), indices of abundance and length composition data from fisheries independent surveys, National Coral Reef Monitoring Program (NCRMP) and Deep NCRMP (DCRMP), and life history parameters including age and growth from otolith analysis, and reproduction characteristics from gonad studies.

The Analyst Team developed and applied assessments tools, however SS3 may not be compatible with the available data due to data limitations. Input data and configurations were documented, however model assumptions were not documented in the AW report. For example, the F method was not specified in the report, which needed to be changed during the Review Workshop (RW). The type of reference point/management benchmarks used were mentioned (Spawning Potential Ratio - SPR), however the Analyst Team did not define the exact values of the maximum fishing mortality threshold (MFMT) and minimum stock size threshold (MSST). The Analyst Team did not conduct any projections but also did not provide alternative management procedures (default alternative is going back to the previous approach: ratios from landings).

Below are the details for each assessment:

St. Croix Stoplight Parrotfish

For the commercial length distributions, a variety of fishing gears are used to fish for Stoplight Parrotfish. A generalized linear mixed model (GLMM) was applied to find the most representative gear group for the commercial length composition data. This seems valid. An outlier removal was conducted on the commercial landings data, which also seems valid.

It was recommended to only use commercial landings data starting in 2012 because it was not possible to hindcast the data. While the rationale is reasonable, this is concerning for the stock assessment model as the Stoplight Parrotfish has a max age of 30, and this would only give 12 years of data, which does not cover the life span of the species. Also, no CPUE index for the commercial fishery was used as diver hours were considered not the most appropriate effort measure due to divers fished for many species (i.e., multispecies trips) and the nominal catch per unit of effort (CPUE) coefficient of variation (CV) was too high.

Discard mortality is assumed to be negligible for valid reasons (nature of spearfishing). There are no recreational catch records of Stoplight Parrotfish, so recreational landings data could not be included in the model. The recreational catch of Stoplight Parrotfish is considered negligible on St. Croix as they are not easily caught by hook and line and are not targeted as a consumption or trophy fish by recreational spearfishers.

Due to the low sample size of the commercial length composition data, the decision made by DW was to combine the TIP length data across all years (i.e., super-year period) to inform selectivity in the stock assessment model. While the rationale makes sense, it is concerning that there may not be enough information on the size structure of the population, cohort strength, and/or recruitment and mortality trends.

There are still some limitations and uncertainties about life history (e.g., age-specific natural mortality, fecundity). The maximum age was set to 30. While it seems like this could be a possibility, this should not define what the plus group will be in the assessment. It should be based on available data, which seems like it would be more appropriate to set the plus group to 10-15+.

The calibration method for the index of abundance seems valid; the calibration was used to integrate old (belt transect) and new sampling schemes (stationary point counts), account for domain changes (regionally restricted to island-wide), and estimate for gear correction factors. After calibration, a design-based estimator was applied to obtain an index of abundance. However, only three years of fisheries independent survey length composition data was applied. This seems limited for the stock assessment model, especially considering that the other source of information is from commercial length composition (which was compiled into a super-year period).

St. Thomas/St. John and Puerto Rico Yellowtail Snapper

For the Yellowtail Snapper model in St Thomas/St. John and Puerto Rico, the stock unit should have been explored further. The decision to separate the stocks was made based on administrative needs, which is common when a management system is put in place for the first time. However, the definition of the stock unit for assessment purposes needs to reflect the biology of the species and its dynamics. The management and the assessment units do not need to be the same and can be adjusted to the reality of the management process, which will be better supported if the stock assessment correctly reflects the dynamics of the stock and the reality of the fisheries exploiting the stock. Other island specific comments follow:

St. Thomas/St. John: An outlier removal was conducted on the commercial landings data, which seems valid. For the commercial length distributions, a variety of fishing gears are used to fish for Yellowtail Snapper. A GLMM was applied to find the most representative gear group for the commercial length composition data. This also seems valid.

It was recommended to only use commercial landings data starting in 2012 because it was not possible to hindcast the data. While the rationale is reasonable, this seems concerning for the stock assessment model as the Yellowtail Snapper has a max age of 26, and this would only give 12 years of data which does not cover the life span of the species. No CPUE index was used for the commercial fishery as hook hours were not considered an appropriate measure of effort.

Due to a low sample size of the commercial length composition data, the decision was to combine the TIP length data across all years to inform selectivity in the stock assessment model. While the rationale makes sense, it is concerning that there may not be enough information on the size structure of the population, cohort strength, and/or recruitment and mortality trends.

There are still some limitations and uncertainties about life history (e.g., age-specific natural mortality, fecundity), The maximum age was set to 26. While it seems like this could be a possibility, this should not define what the plus group will be in the assessment. It should be based on available data, which seems like it would be more appropriate to set the plus group 10-15+ given the available data.

NCRMP data is restricted to a limited depth (30 m) so only represents shallow water fish, and the majority of the fisheries are in deeper waters (30-65 m). The DCRMP data set was used (surveys up to 45 m) to accommodate for that, however both surveys were limited in the amount of data (time series and length composition data), especially DCRMP. There were some older fisheries independent data sets that were not used which could have been applied in the stock assessment. Decisions about throwing away data should be made with considerations to the performance of the stock assessment data. Because of this decision, there were not enough length composition data and historical trends could not be seen in the index data (flat trend in the recent years when this was not the case in the overall time series).

Puerto Rico: The survey in Puerto Rico has been conducted since 2001, but only the time series from 2014 onward was used in the assessment. Although the sampling coverage before 2014 was different and only became island-wide from that year, the Panel team requested the Analyst Team to include the earlier time series as a separate index to provide information on the stock trend in the earlier years.

There are still some limitations and uncertainties about life history (e.g., age-specific natural mortality, fecundity), The maximum age was set to 26. While it seems like this could be a possibility, this should not define what the plus group will be in the assessment. It should be based on available data, which seems like it would be more appropriate to set the plus group 10-15+ given the available data.

The NCRMP only covers a limited depth (30 m) and only represents shallow water fish, and the majority of the fisheries are in deeper waters (30-65 m). Older index and length data before 2014 was thrown out which could have been applied in the stock assessment. Decisions about throwing away data should be made with considerations to the performance of the stock assessment data. Because of this decision, there were not enough length composition data and historical trends could not be seen in the index data (flat trend in the recent years when this was not the case in the overall time series).

The SouthEast Area Monitoring and Assessment Program Caribbean (SEAMAP-C) data was not used as the data was not consistent in terms of methodology, so the decision to exclude this dataset was reasonable. Recreational catch data was also not used due to inconsistencies and mistrust of reporting. No CPUE index was used for the commercial fishery. There was a valid reason not to use it (i.e., gear hours were considered not the most appropriate effort measure).

B. Are data uncertainties acknowledged, reported, and within normal or expected levels?

Some uncertainties were acknowledged in the DW and AW reports, including short time series in landings reports, difficulty in quantifying fisher CPUE, distrust in commercial landings report data, limited samples of fisheries dependent (TIP) length composition data, and incomplete datasets (e.g., not capturing juvenile trends). However, other uncertainties were not acknowledged. For example; there are limitations with the NCRMP data due to seasonality and methodology to accurately capture indices of abundance for large Yellowtail Snapper or juvenile parrotfish.

In Puerto Rico, the NCRMP survey showed a huge increase in Yellowtail Snapper population density (in numbers/m2) in 2012 with high uncertainty, and the reason for this was not explained in the DW report. During the Review Workshop, it was found that this was because of a high density of fish at one the sample events in 2012. It is unclear if this was the result of the single large aggregation or an actual increase in the population (effort did shift away from fishing for Yellowtail Snapper and net bans were implemented). This increase in density was not included in the assessment model as the data started in 2014 in the assessment.

C. Are data applied properly within the assessment model?

Based on the model requirements, the best available data used was appropriately applied.

D. Are input data series reliable and sufficient to support the assessment approach and findings?

St. Croix Stoplight Parrotfish

There is a short time series for parrotfish catch reports due to a change in gear type in 2008 and difficulties in quantifying fisher CPUE due to multispecies diving trips during certain parts of the year (i.e. conch season). Additionally, there is very limited TIP length composition data (66 samples in 6 years) and an overall distrust in catch report data. These issues raised concerns about the input data series being sufficient to support such a complex assessment model like SS3.

St. Thomas/St. John Yellowtail Snapper

The data for the St. Thomas/St. John Yellowtail Snapper is also limited in the amount of data available. Without using historic landings data, the time series is limited to only 12 years, for a fish that lives 20-30 years. Using historical data requires estimating Yellowtail Snapper catch based on recent percentages in the catch of snapper and potfish since these groups were not historically separated, which would include additional uncertainty. These issues raised concerns about the input data series being sufficient to support such a complex assessment model like SS3.

Puerto Rico Yellowtail Snapper

The time series for the Puerto Rico commercial catch is longer and there is more commercial length composition data. However, there is still not enough information on a scale of the population because a lot of the historical survey data was thrown out. The survey data that was retained (2014-2022) had a relatively flat abundance trend, which does not reflect what was seen in the historical index of abundance. There have been changes in regulations that involve size limits and gear bans, indicating that selectivity may be changing over time. This brings another challenge to the stock assessment model, especially with limited data. Moreover, there is no recreational data available in Puerto Rico and recreational fishing for Yellowtail Snapper is significant around the island.

TOR2. Evaluate the methods used to assess the stock, taking into account the available data.

A. Are methods scientifically sound and robust?

Stock Synthesis (SS3) was applied for all three stock assessments (St. Croix Stoplight Parrotfish, St. Thomas/St. John Yellowtail Snapper, and Puerto Rico Yellowtail Snapper). SS3 has been used extensively for many stock assessments across the country and is part of NOAA's Fisheries Integrated Toolbox. This modeling tool and framework has been validated in many peer reviewed assessments and follows best practices in stock assessment. It is capable of handling a broad spectrum of model complexities, ranging from data-limited to data-rich assessments. SS3 allows for analysts to begin with a simple model structure and incrementally incorporate additional complexity as needed. For example in data-limited applications, there is a wrapper function and package (SS-DL-tool; https://github.com/shcaba/SS-DL-tool) that helps start data-limited assessments within the SS3 modeling framework by building the input files for provided data and life history information. Additionally, the model supports key biological settings, such as hermaphroditism, which is particularly relevant for the St. Croix Stoplight Parrotfish. The Analyst Team conducted an appropriate amount of diagnostic tests to test convergence, validate the model, and test key uncertainties through the r4ss R package; https://github.com/r4ss/r4ss.

B. Are assessment models configured properly and used consistent with standard practices?

Before the RW, there were some concerns about the configuration of the models in SS3. The configurations and assumptions of the models were not all documented in the AW report (e.g., fixed vs estimated parameters, which options were selected within SS3, etc). During the RW, these configurations and assumptions were clarified, and the RP made additional recommendations to explore sensitivities of these choices made by the Analyst Team. For all three assessments, there were a few changes in the configuration and inputs of SS3 during the RW:

- Modification 1: During the RW, the option to model fishing mortality in SS3 (referred to as the "F method") was modified. The model was initially set to F method 3 (Hybrid F), which treats fishing mortality as tuning coefficients that closely match the input catch data, rather than estimating them as free model parameters. However, early model runs showed a sensitivity: the model fit the catch data tightly but poorly fit the index of abundance. In response, the RP asked the Analyst Team to explore how different data weights on the catch and index data affected model results — using SE = 0.3 to increase the influence (tighter fit) and SE = 2 to decrease it (looser fit). To enable flexibility in fitting the catch data, the Analyst Team switched to F method 2, which uses the Baranov equation and estimates fishing mortality for each year.

- Modification 2: The standard error units for the NCRMP surveys in SS3 were incorrectly specified in the AW report, but this was fixed during the RW.
- Modification 3: The St. Thomas/St. John and Puerto Rico Yellowtail Snapper models were supposed to have a single sex configuration, but two sexes were turned on for all model runs. The Analyst Team fixed this during the RW.

New base models were created for each of the stock assessments (see Appendix 1 for list of base cases and model runs for). The additional sensitivity tests that the RP requested are also listed in Appendix 1. For all three assessments, the two most critical sensitivity tests were i) the trade-off between fitting the between the commercial catch time series versus fishery independent surveys (NCRMP, DCRMP) and ii) the estimation of growth. When the catch standard error was increased from SE = 0.3 to SE = 2, the growth parameters had to be estimated to achieve convergence.

Another concern regarding the configurations of the three assessment models was the decision to fix steepness at h = 0.99. While the Analyst Team justifies this by stating that the stocks are not a closed population and recruitment may not be strongly tied to the local spawning stock biomass, fixing steepness to 0.99 carries consequential assumptions. Fixing steepness has significant implications for derived uncertainty estimates, and it essentially assumes that recruitment is not influenced by the spawning stock biomass (i.e., random recruitment). This is a strong and questionable assumption as it could overestimate stock productivity. By removing the relationship between spawning biomass and recruitment, this approach reduces the model's sensitivity to stock depletion. During the RW, it was found that steepness could not be estimated in the models. The Analyst Team explored fixing the steepness in the combined St. Thomas/St. John and Puerto Rico Yellowtail Snapper assessment based on the value obtained from the FishLife R package (Thorson et al. 2023) (model run PR_STTJ_RW_2).

Below are the details for each assessment:

St. Croix Stoplight Parrotfish

The use of age 30+ as the plus group was questioned by the RP given the limited amount of data out to the larger length bins in the length compositions and there were not many older aged fish in the growth data (DW report figure 2.3). While this specific sensitivity was not explored for St. Croix Stoplight Parrotfish, reducing the plus group to 12+ was explored for the St. Thomas/St. John Yellowtail Snapper (STTJ_RW_3). The Analyst Team showed that there were no differences between the two plus group configurations, and therefore the configuration of plus group = 30+ was retained for Stoplight Parrotfish. After the RW, it remained unclear if other model configurations were correctly specified based on the diagnostics (see more details in TOR 4). For example, the standard errors (SE) around the estimate of fishing mortality were high, indicating that the model was not able to estimate fishing mortality well. This could either be an indication of model misspecification or data quality issue (i.e., there is not enough contrast in the length composition data to effectively estimate fishing mortality). There was also poor convergence of F_{MSY}. It should be noted that the Analyst Team is using SPR as the reference point for Stoplight Parrotfish, however the poor convergence of F_{MSY} is another indication of model misspecification or data quality issues as this points to high uncertainty in the fishing mortality estimates.

St. Thomas/St. John Yellowtail Snapper

The use of dome-shaped selectivity for the two fishery-independent surveys (NCRMP and DCRMP) was questioned by the RP as this assumption has strong implications for the representation of large fish in the population and the fishery. Additionally, the choice of age 26+ as the plus group was questioned given the limited amount of data (i.e., length composition) out to the larger length bins and the smaller number of older fish in the growth data in the DW report. It appeared that the large plus group may have influenced the estimation of selectivity, so the Review Panel asked the Analyst Team to reduce the plus group (Analyst Team chose plus group = 12+) for a model run (STTJ_RW_3). The Analyst Team found no differences between the two plus group configurations, and the shape of selectivity for NCRMP and DCRMP remained unchanged. As a result, the plus group configuration of 26+ and dome-shaped selectivity were retained for Yellowtail Snapper (including the Puerto Rico Yellowtail Snapper). After the RW, it remained unclear if other model configurations were correctly specified based on the diagnostics, or issues were related to data quality (see more details in TOR 4). Similar issues to those observed with the St. Croix Stoplight Parrotfish model were evident for this model as well, including high variance around fishing mortality and recruitment estimates and poor convergence of F_{MSY}.

Puerto Rico Yellowtail Snapper

The RP raised concerns about the use of dome-shaped selectivity for the NCRMP survey and the choice of age 26+ as the plus group. These choices were retained based on the tests and additional model runs from the St. Thomas/St. John model. After the RW, it remained unclear if other model configurations were correctly specified based on the diagnostics (see more details in TOR 4). Although this assessment included longer time series than the St. Thomas/St. John assessment, the high variance around fishing mortality and recruitment estimates suggests that the data may not be able to differentiate between these two processes, indicating a potential data quality issue. Similar issues to those observed with the St. Croix Stoplight Parrotfish and St. Thomas/St. John Yellowtail Snapper models were evident for this model as well, including high variance around fishing mortality and recruitment estimates and poor convergence of F_{MSY}.

C. Are the methods appropriate given the available data?

St. Croix Stoplight Parrotfish

The RP was concerned about the short time series (commercial catch, length composition, index of abundance). While SS3 is a flexible and powerful stock assessment model, its performance depends on having sufficient data to inform the model. In this case, data appears insufficient to support the model's complexity even with data-limited/moderate settings. There are too many uncertainties about key parameters (e.g., initial equilibrium catch, natural mortality, steepness, etc.) and population processes (e.g., growth, recruitment). Additionally, only five years of survey index were available, along with one super year period that includes just 66 TIP trips over the entire time series for commercial length composition (with no age composition). Even though SS3 allows length composition only configurations, SS3 is ultimately an age-structured model that converts lengths to ages, which this assessment does not have enough information or data for. Sensitivity analyses (base model **m3_v7**, STX_RW_1 and STX_RW_2) conducted during the Review Workshop also showed how sensitive the model outputs were to the trade-off of fits between the commercial catch and NCRMP survey and estimation of growth parameters. The two model runs also showed opposite signals in overfishing and overfished statuses, also indicating the sensitivity of the model. The data was not sufficient enough for the Analyst Team to produce a final assessment model.

St. Thomas/St. John Yellowtail Snapper

Similar to the St. Croix Stoplight Parrotfish stock assessment, the RP was concerned about the short time series and the data appears insufficient to support the complexity of SS3. There are too many uncertainties about key parameters (e.g., initial equilibrium catch, natural mortality, steepness, etc.) and population processes (e.g., growth, recruitment). Only 3-5 years of fishery-independent survey and length composition data (NCRMP and DCRMP) were available, along with one super-year period for commercial length composition (due to low sample sizes). Even though SS3 allows length composition only configurations, SS3 is ultimately an age-structured model that converts lengths to ages, which this assessment does not have enough information or data for. Sensitivity analyses (base model **m3_v19**, STTJ_RW_1, STTJ_RW_2, and STTJ_RW_3) conducted during the Review Workshop also showed how sensitive the model outputs were to the trade-off of fits between the commercial catch and NCRMP + DCRMP surveys and estimation of growth parameters. Therefore, the data were not sufficient enough for them to produce a final assessment model.

Puerto Rico Yellowtail Snapper

While longer time series data were available for the Puerto Rico Yellowtail Snapper stock assessment, model diagnostics (e.g., high standard deviations on key parameters, parameters hitting bounds, poor convergence in F_{MSY}) indicate that either the model was not configured correctly or SS3 may still be too complex given the data quality. Although SS3 allows length composition only configurations, it is still ultimately an age-structured model that converts lengths to ages. Sensitivity analyses (base model **m3_v31**, PR_RW_1, PR_RW_2, PR_RW_2, PR_RW_3, PR_RW_4) conducted during the RW showed how sensitivity model outputs were to the trade-off of fits between the commercial catch and NCRMP + NCRMP La Parguera surveys (the latter covering an older, smaller NCRMP survey domain time series from 2002-2012) and estimation of growth parameters. The RP suggested that the Analyst Team investigate combining the St. Thomas/St. John and Puerto Rico Yellowtail Snapper assessments instead of further revising the Puerto Rico assessment. Given that it is unclear if the model is sensitive because of model misspecification or data quality issues, and considering the sufficient length of data, it remains uncertain if SS3 is the appropriate model for this assessment.

TOR3. Evaluate the assessment findings with respect to the following:

A. Can the results be used to inform management in the U.S. Caribbean (i.e., develop annual catch recommendations)?

St. Croix Stoplight Parrotfish

The panel concludes that the model results cannot be used to inform management of the St. Croix Stoplight Parrotfish stock. The additional model runs requested by the reviewers highlighted that the model outcomes, in terms of assessment of stock status, was highly dependent on the decisions made about the model assumptions about catch uncertainty and estimation of the von Bertalanffy growth model parameters.

Depending on the weight assigned to the two main data streams, catch and index, and allowing the model to estimate the growth parameters, the model produced conflicting results, indicating either an underfished or overfished stock (Figure 1), along with vastly different trends in key metrics such as numbers at age and fishing mortality.

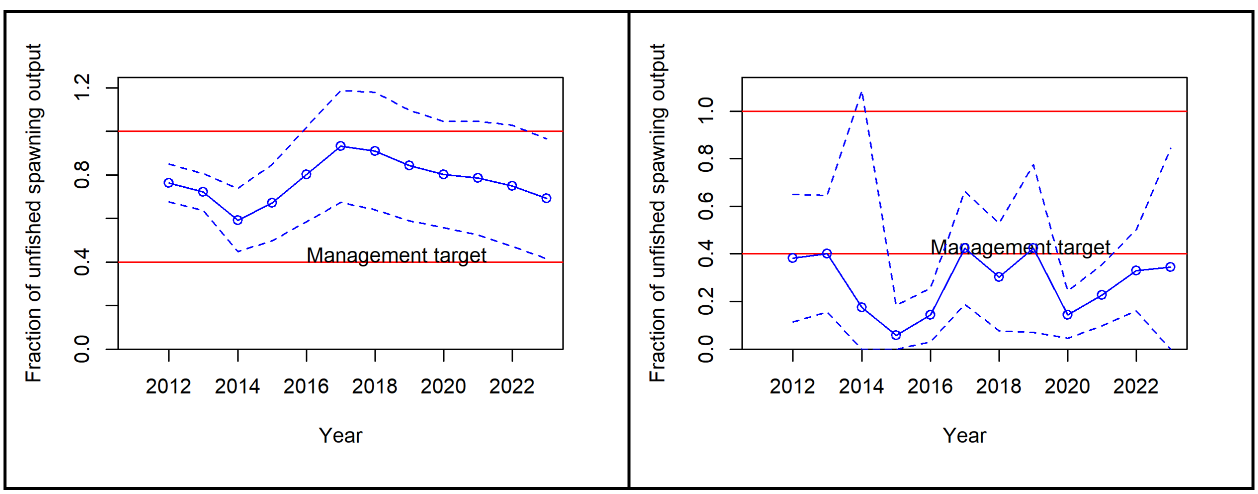

Figure 1 - Depletion level (i.e., fraction of unfished spawning output) estimated by the base run (STX_RW_1; left) and sensitivity run (STX_RW_2; right).

There were also concerning diagnostic patterns (e.g., likelihood profiles, variances in fishing mortality) that further underscore the model's instability. Given the limited datasets, there was a conflict among the index, length compositions, and commercial catch data, which contributed to the challenges in the assessment model and cannot be easily resolved.

Moreover, the current management framework is based on setting fishing opportunities for a species complex, which includes two indicator species, Stoplight and Redtail Parrotfish, neither of which is currently assessed using analytical models. Incorporating an analytical assessment for Stoplight Parrotfish alone would require adjustments to the management framework to accommodate the use of such results for only one species, which is not a straightforward task.

The panel is unaware of whether and how the management system might be modified to allow for this, adding further uncertainty to the feasibility of using the current results for management purposes. As mentioned in ToR 2, SS3 seems too complex for this stock and fishery. The panel suggests that data poor methods may be more appropriate and in line with the data available, the size of the fishery, and the stock.

St. Thomas/St. John Yellowtail Snapper

The assessment was undermined by a short and fragmented time series across key data streams: length composition, survey indices, and commercial catches, which limited the ability of the model to characterize population dynamics robustly. Furthermore, the stock unit definition remains uncertain, adding another layer of ambiguity that could lead to spurious or misleading model outcomes.

Diagnostic outputs such as likelihood profiles, jitter analyses, and estimated variances in fishing mortality and recruitment revealed instability and sensitivity within the model. The model was highly dependent on the relative fits between catch data and the index of abundance, as well as assumptions around growth estimation. The two primary fishery-independent survey datasets (NCRMP and DCRMP), had conflicting signals and cannot be reconciled within the current modeling framework without arbitrarily favoring one dataset over the other.

While the three current model runs converged to a similar SPR and fishing intensity (1-SPR), suggesting the stock is not overfished nor undergoing overfishing, the second model run, which integrates higher catch standard errors and growth estimation (run code STTJ_RW_2), showed high uncertainty in SPR values and oscillated between overfished and underfished statuses before 2022 (Figure 2). Additionally, temporal trends in overfished status were inconsistent between model runs.

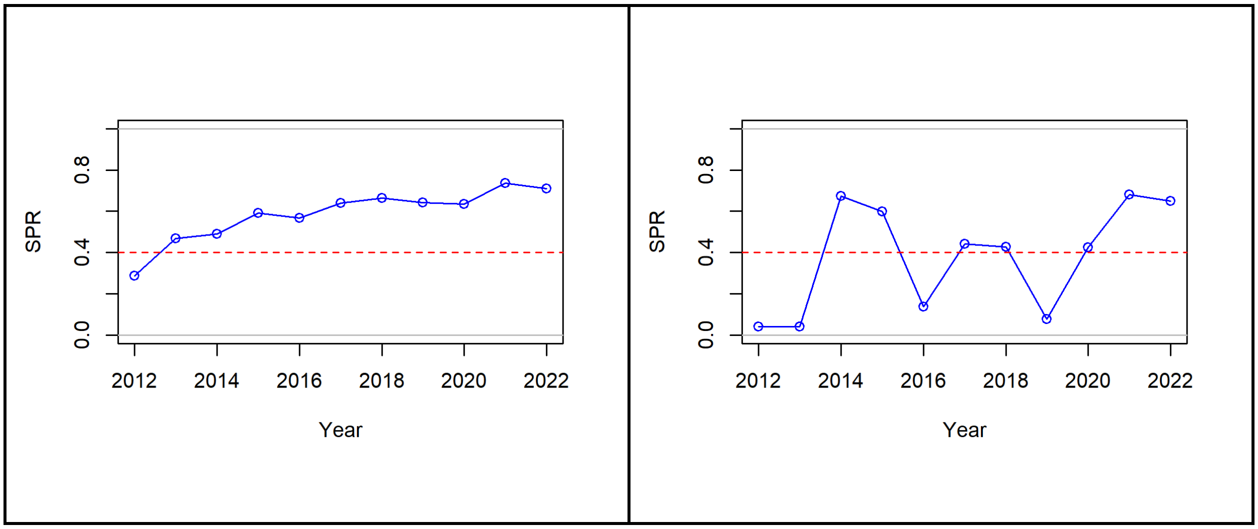

Figure 2 - Spawning Potential Ratio (SPR) estimated by the base run (STTJ_RW_1; left) and sensitivity run (STTJ_RW_2; right) .

Given these limitations, the assessment results are not sufficiently robust to support the development of reliable annual catch limits or other management measures for the U.S. Caribbean region.

Puerto Rico Yellowtail Snapper

The current assessment for Puerto Rico Yellowtail Snapper does not support the development of annual catch recommendations for management in the U.S. Caribbean. Despite having a longer time series compared to the St. Thomas/St. John assessment, the model exhibited instability and high sensitivity, as demonstrated by diagnostic tools such as likelihood profiles, jitter analyses, and large variances in estimated fishing mortality and recruitment. These indicators raised concerns about the model's internal coherence and its ability to provide reliable stock status estimates.

While the issue of stock unit definition is less severe than in the St. Thomas/St. John assessment, due in part to better spatial coverage by the modeled platform, the stock unit definition still contributed to assessment uncertainty. The model also faced unresolved conflicts between different data sources, particularly between commercial catch data, length composition, and the fishery-independent survey.

Although all four model runs converged to a similar SPR and fishing intensity, roughly around the management target, this convergence masked significant historical variability, including periods of overfishing and overfished status. Of particular concern is the second model run (PR_RW_2), which incorporated higher uncertainty in catch estimates and growth parameters; it demonstrated high uncertainty in SPR and depletion estimation (Figure 3).

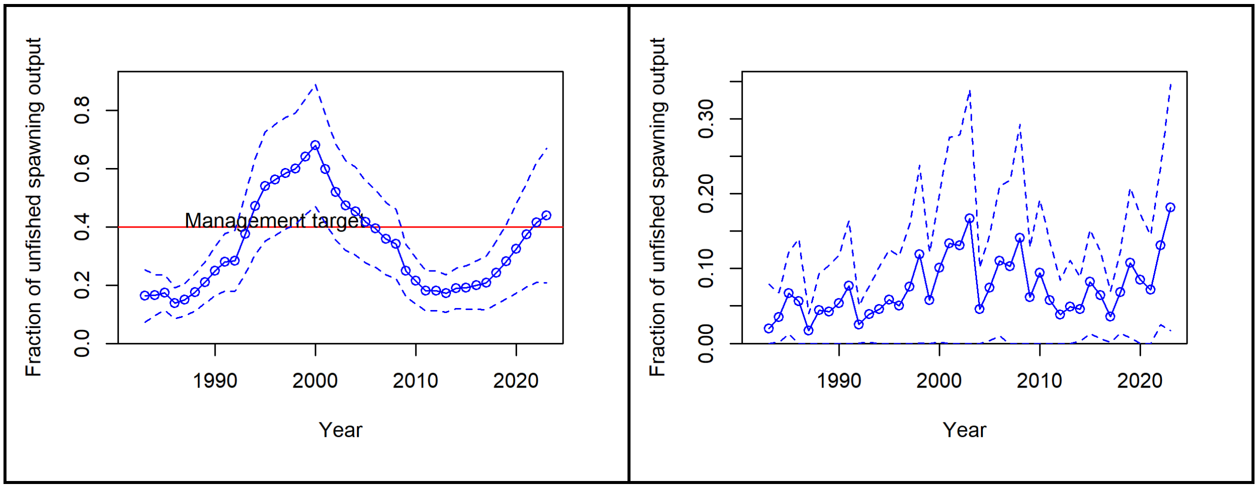

Figure 3 - Depletion level (i.e., fraction of unfished spawning output) estimated by the base run (PR_RW_1; left) and sensitivity run (PR_RW_2; right)

Overall, the combination of model sensitivity to assumptions, data conflicts, and uncertain historical trends limits the assessment's utility for informing robust, science-based management measures.

B. Is it likely the stock is overfished? What information helps you reach this conclusion?

St. Croix Stoplight Parrotfish

Unknown, the results are too sensitive to model assumptions to allow for a conclusion about this topic. See TOR 2 and TOR 4.

St. Thomas/St. John Yellowtail Snapper

Unknown, the results are too sensitive to model assumptions to allow for a conclusion about this topic. See TOR 2 and TOR 4.

Puerto Rico Yellowtail Snapper

Unknown, the results are too sensitive to model assumptions to allow for a conclusion about this topic. See TOR 2 and TOR 4.

C. Is it likely the stock is undergoing overfishing? What information helps you reach this conclusion?

St. Croix Stoplight Parrotfish

Unknown, the results are too sensitive to model assumptions to allow for a conclusion about this topic. See TOR 2 and TOR 4.

St. Thomas/St. John Yellowtail Snapper

Unknown, the results are too sensitive to model assumptions to allow for a conclusion about this topic. See TOR 2 and TOR 4.

Puerto Rico Yellowtail Snapper

Unknown, the results are too sensitive to model assumptions to allow for a conclusion about this topic. See TOR 2 and TOR 4.

TOR4. Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

SS3 includes a set of standard approaches to investigate uncertainties. These tools were applied and presented in the assessment report, and a standard set of diagnostics was used to evaluate model stability for the three stocks. These diagnostics included checks for convergence, correlation analysis, variance evaluation, jitter analysis, residuals analysis, retrospective analysis, and likelihood profiles. Additionally, sensitivity runs were conducted. The base models from the AW were modified during the RW due to configuration errors that were identified (see TOR 2). In addition, a new model combining the two Yellowtail Snapper stocks, following the RP recommendations, was developed and presented on the third day of the meeting. Note that the full set of diagnostics were not updated for the new base models agreed upon during the RW, and nor for the combined model.

US Caribbean Stoplight Parrotfish

During the meeting, the model **m3_v7** was presented as the base model, and the methods used to evaluate uncertainty were appropriately applied and explained. However, the model was found to be highly sensitive and not found appropriate to use as a basis for advice, making it difficult to isolate and clearly identify the most influential sources of uncertainty. Several key uncertainties were identified during the RW, particularly concerning initial equilibrium catch, natural mortality (M), and steepness. The model showed strong sensitivity to these parameters. A full set of diagnostics was presented.

Although the model converged successfully and the jitter analysis appeared satisfactory, other diagnostics revealed structural and data-related concerns. A strong correlation was observed between commercial selectivity parameters, whether it is unclear if this is biologically plausible or driven by the model's tendency to produce knife-edge selectivity. The retrospective pattern showed poor performance, and the likelihood profiles indicated a conflict between the equilibrium catch and the length composition data. The model struggled to reliably estimate equilibrium catch, suggesting that the data may provide limited information on this parameter.

While the fits to the length composition data were reasonably good, the model was unable to simultaneously fit both the commercial catch data and the survey index of abundance well.

During the RW, efforts were made to clarify assumptions related to population dynamics and model configuration, which had been unclear in earlier documentation. The RP recommended several sensitivity analyses, particularly focusing on assumptions around catch uncertainty (i.e., standard errors), growth parameters, and selectivity formulations. These were appropriate steps for testing the model; however, time constraints limited exploration of additional uncertainties, such as estimating fixed parameters (e.g., catchability) or testing alternative model structures.

The new base model agreed upon during the RW, including the modifications described in the section above (see TOR 2; a single-sex structure, F method 2, and corrected survey SE) still showed high sensitivity to assumptions about catch uncertainty and the estimation of von Bertalanffy growth parameters. The model was sensitive to assumptions about growth and the estimation of length at age likely due to the absence of age composition data. Notably, estimates of stock status differed across sensitivity runs (indicating overfished vs. underfished conditions), which further complicates interpretation.

In summary, while appropriate diagnostics and sensitivity runs were conducted, the combination of model instability and interacting uncertainties made it difficult to confidently attribute outcomes to specific sources. This makes it difficult to reach clear conclusions due to the various sources of uncertainty. Further investigation of model assumptions, alternative parameterizations, and potential data conflicts is necessary.

St. Thomas/St. John Yellowtail Snapper

Prior to the RW some concerns were raised about the model configuration, and on the first day of the meeting the RP requested modification to the base model. In the RW, model **m3_v19** was presented as the base model, and the diagnostics (without the modifications) to evaluate uncertainty were appropriately applied in the assessment report. These modifications (a single-sex structure, F method 2, and corrected survey SE) are specified in TOR 2. The new base model was presented the second day of the meeting, and sensitivity runs are documented in Appendix 1. This model was found to be highly sensitive, making it difficult to isolate and clearly identify the most influential sources of uncertainty. Several key uncertainties were identified during the RW particularly concerning initial equilibrium catch, natural mortality (M), and steepness. The model showed strong sensitivity to these parameters. The time series was too short and there was conflict between both surveys.

The full set of diagnostics for model m3_v19 are documented in the assessment report. While the model converged, the jitter test showed instability, since it did not consistently converge to the same maximum likelihood estimate (MLE), indicating misspecification or conflicting data. The likelihood profile for equilibrium catch showed signs of instability, and indicated a conflict between the equilibrium catch and the length composition and index datasets. There were poor retrospective patterns as well.

The new base model was also found to be highly sensitive. It was unable to simultaneously fit the catch and the survey data. Model runs STTJ_RW_1 (SE = 0.3) and STTJ_RW_2 (catch SE = 2 and estimated growth) showed a strong correlation among the commercial selectivity parameters. Additionally, there was poor convergence in Fmsy, suggesting that the data may not provide enough contrast to estimate fishing mortality. There was a conflict between the two fishery-independent surveys and also between commercial catch and length compositions indicating uncertainty in the population trends. In STTJ_RW_3, a sensitivity run explored a 12+ plus group thinking that it will improve the selectivity estimation, but no differences were found. At the end of the meeting, it remained uncertain whether other configurations were appropriate.

In summary, the combination of model instability and interacting uncertainties made it difficult to confidently attribute outcomes to specific sources. As a result, drawing clear conclusions remains challenging. To address this, improvements in data quality, increased data collection, extension of the time series and combining this stock with Puerto Rico are recommended.

Puerto Rico Yellowtail Snapper

Similar to the St. Thomas/St. John assessment, concerns on the model configurations for the Puerto Rico stock were detected previous to the RW and the same changes to the base model were requested (a single-sex structure, F method 2, and corrected survey SE). The new base model was presented as the base model. However, the model was found to be highly sensitive and not found appropriate to use as a basis for advice, making it difficult to isolate and clearly identify the most influential sources of uncertainty. Also several key uncertainties were identified during the RW in key parameters concerning initial equilibrium catch, natural mortality (M), and steepness and population processes (growth, recruitment).

The full set of diagnostic is found in the assessment report for the initial base model **m3_v31**, indicating incorrect configuration of the model or problems with the quality of data.While the model converged, the jitter analysis showed instability, the likelihood profiles showed instability in the total and equilibrium catch, and the retrospective revealed different patterns at the terminal year estimates.

Four different sensitivity analyses detailed in Appendix 1 were conducted and presented during the RW. Although the time series was extended, the older survey data were excluded, and only the 2014-2022 series was retained. A key suggestion was to reintroduce the historical time series (as a separate survey since the coverage was different); however, the corresponding sensitivity run (PR_RW_3) failed to converge. Overall, the sensitivity runs showed high sensitivity in models outputs. Additionally, strong correlation among growth parameters was found, indicating that growth could not be reliably estimated. There was also evidence of conflict between catch, length composition and survey indices indicating uncertainty in the population trends.

In summary, the combination of model instability and interacting uncertainties made it difficult to confidently attribute outcomes to specific sources. As a result, drawing clear conclusions remains challenging. To address this, improvements in data quality, increased data collection, extension of the time series and combining this stock with St. John/St.Thomas are recommended.

Combined St.Thomas/St John/Puerto Rico Yellowtail Snapper

The RP recommended building a combined model using data from both St. Thomas/St. John and Puerto Rico due to uncertainties in the model structure, the recognition that the stocks from St. Thomas/St. John and Puerto Rico are part of a larger population, the short time series available for the stock in St. Thomas/St. John, and looking into the survey índices that peaked in 2012 in Puerto Rico and in 2013 in St. Thomas/St. John. Efforts were initiated, presented and discussed during the RW. While the first combined model run (PR_STTJ_RW_1) did not converge, a second attempt (PR_STTJ_RW_2, fixed selectivity and steepness) successfully converged.

Despite showing some instability, and without evaluating the full set of diagnostics, this run provided a good first step to developing a stock assessment model for the Yellowtail Snapper stock in St.Thomas/St John and Puerto Rico to inform management of this fishery in the U.S. Caribbean. Results of this can be found in the Addendum of the AW report.

TOR5. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.

The RP supports the research recommendations outlined in the DW and AW reports for the U.S. Caribbean Stoplight Parrotfish and Yellowtail Snapper assessment processes. Based on those recommendations, the following were identified as high priority and are listed in order of importance:

St. Croix Stoplight Parrotfish

- Short term
    - Investigate the applicability of hindcasting for all parrotfish combined or other applicable future assessments.
        - For example, the proportion of Stoplight Parrotfish could be investigated from 2012, and a mean of that proportion could be applied to split the catches prior to the species-specific split
        - Conduct focused research on historical catches and fishing history to inform and constrain early model conditions

    - Further evaluate natural mortality and growth assumptions
        - Explore the use of natural mortality at age
    - Investigate the relationship between the catch and effort of the diving data to document the disconnect between time diving and species-specific targeted effort for species considered bycatch or opportunistically targeted.
    - Investigate stock connectivity to better understand local versus regional recruitment dynamics and their implications for informing steepness
- Long term
    - Ensure statistically robust sample sizes of small and large size classes of fish
    - Maintain and expand commercial catch monitoring programs. Expand port sampling and other fishery-dependent data collection to fill gaps in length composition and effort data.
        - Increase collection efforts to increase sample size in TIP
    - There are several biases in the current NCRMP survey design. Notably, the survey is conducted over a limited time frame (for two weeks every two years), which would miss seasonal or environmental changes. Additionally, the survey may not be adequately capturing the full size distribution of the population (e.g., upwelling/high turbulence areas that have high density of larger fish, underrepresentation of young of the year etc.). The RP support the following recommendations for the NCRMP survey:
        - Ensure the continuation of fishery-independent survey programs (e.g., National Coral Reef Monitoring Program) with consistent spatial and temporal coverage
        - Expand fishery-independent survey time series and resolution
        - Investigate the potential impact of changes in habitat on the surveys.
        - There is an association between the habitat and fish, but we should consider whether the habitat changes the spatial distribution of fish.
        - Investigate highly turbid areas that are currently not surveyed.
        - Expand fishery-independent surveys to seagrass/mangrove habitats since these areas are essential for recruitment.
    - Conduct recreational fishery port sampling surveys to determine removals due to recreational fishing

St. Thomas/St. John and Puerto Rico Yellowtail Snapper

- Short term
    - Investigate the applicability of hindcasting for all parrotfish combined or other applicable future assessments (for St. Thomas/St. John commercial catch data)
    - Further evaluate natural mortality and growth assumptions

        - Explore the use of natural mortality at age
    - Explore parameterizing retention to improve selectivity of the commercial fleet and interpret the apparent high selectivity of larger individuals that are poorly estimated by the current models.
    - Request for USVI fisher to provide their logbooks to further investigate the fisher behavior as an index assignment for CPUE.
    - Investigate stock connectivity to better understand local versus regional recruitment dynamics and their implications for informing steepness
- Long term
    - There are several biases in the current NCRMP survey design. Notably, the survey is conducted over a limited time frame (for two weeks every two years), which would miss seasonal or environmental changes. Additionally, the survey may not be adequately capturing the full size distribution of the population (e.g., upwelling/high turbulence areas that have high density of larger fish, underrepresentation of young of the year etc.). Currently, there is limited DCRMP data, which would target larger, older fish that are in deeper waters and help complement the NCRMP survey. The RP support the following recommendations for the NCRMP and DCRMP surveys:
        - Ensure the continuation of fishery-independent survey programs (e.g., National Coral Reef Monitoring Program) with consistent spatial and temporal coverage
        - Expand fishery-independent survey time series and resolution
        - Continue DCRMP work in the future.
        - Look into National Parks transect data and compare it to the NCRMP data
    - Maintain and expand commercial catch monitoring programs. Expand port sampling and other fishery-dependent data collection to fill gaps in length composition and effort data
        - Increased port sampling is needed in St. Thomas and St. John to enable analyses required or quantifying removals.
        - Increase collection efforts to increase sample size in TIP.
    - Conduct recreational fishery port sampling surveys to determine removals due to recreational fishing.

The RP also recommends the following:

- St. Croix Stoplight Parrotfish
    - Conduct population structure studies through genetics, tagging, fish larvae, otolith microchemistry, or modelling.

    - Improve otolith samples
- St. Thomas/St. John and Puerto Rico Yellowtail Snapper
    - Further investigate the population structure of those two stocks.
        - Conduct population structure studies through genetics, tagging, fish larvae, otolith microchemistry, or modelling.
    - Improve otolith samples
    - Reconsider not removing old NCRMP survey data (before 2013/2014; La Parguera)

TOR6. Provide guidance on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.

Key improvements in data or modeling approaches are:

US Caribbean Stoplight Parrotfish

- If there are enough otolith samples, try to convert length compositions into ages. The conditional age-at-length approach in SS3 allows the incorporation of length and age data whenever available.
- Consider the entire stock complex rather than single species for stock assessment
- Increase the time series for all key data streams: commercial catch, commercial length compositions, NCRMP index of abundance, and NCRMP length compositions
- Consider using model-free approaches (e.g., harvest control rules based on life history and/or fisheries data) or data-limited methods

US Caribbean Yellowtail Snapper

- If there are enough otolith samples, try to convert length compositions into ages. The conditional age-at-length approach in SS3 allows the incorporation of length and age data
- Consider using model-free approaches (e.g., harvest control rules based on life history and/or fisheries data) or data-limited methods
- Explore model-based approaches for analyzing index data, such as spatial-temporal models
    - Potential to combine the NCRMP indices from both islands.
- Combine the St. Thomas/St. John and Puerto Rico assessments: This combined SS3 model seems like a good path forward for future assessments. Right now, this combined model cannot be used for management advice because of the instability and sensitivity of the model. With further tweaking of model configurations, it may be possible to obtain a converged, stable model.

TOR7. Provide recommendations on possible ways to improve the SEDAR process.

The SEDAR process was well organized and the meeting was efficient. All background material was provided to the RP on time (two weeks before the workshop). The RP suggests a review of the current terms of references to avoid questions that are not possible to answer. For example for TOR 3a, it asks if the results can be used to inform management (i.e., develop annual catch recommendations). However, the RP cannot provide a response to this as the RW focused primarily on the stock assessment and any comments related to the management procedure fall outside the scope of the assessment. The RP also suggests including additional stock assessment experts in all the workshops, including the DW. Those experts would have helped validate the amount of data that would need to be retained for the stock assessment. For example for the St. Thomas/St. John and Puerto Rico Yellow Snapper assessment, a lot of historical survey data was thrown away due to issues with the different survey domains (regionally restricted to island-wide) and different sampling schemes (belt transect vs stationary point counts) even though a calibration analysis was conducted to integrate these changes and compiled a single index of abundance (Grove et al. 2022).

TOR8. Prepare a Peer Review Summary summarizing the Panel's overall conclusions and recommendations.

This report completes the task in TOR8.

References

Bruggemann, J. H., van Oppen, MJH., & Breeman, A. M. (1994). Foraging by the stoplight parrotfish *Sparisoma viride*. I. Food selection in different, socially determined habitats . *Marine Ecology Progress Series*, *106*(1-2), 41-55. https://doi.org/10.3354/meps106041.

Grove, L.J.W., Blondeau, J., & Ault, J.S. (2022). Fishery-Independent Reef Fish Visual Survey Population Density and Length Composition for Queen Triggerfish in the U.S. Caribbean. SEDAR80-WP-08. SEDAR, North Charleston, SC. 32 pp.

Thorson, J. T., Maureaud, A. A., Frelat, R., Mérigot, B., Bigman, J. S., Friedman, S. T., ... & Wainwright, P. (2023). Identifying direct and indirect associations among traits by merging phylogenetic comparative methods and structural equation models. *Methods in Ecology and Evolution*, *14*(5), 1259-1275.

Appendix 1

Table A1. List of stock assessment model runs developed during the SEDAR 84 Review Workshop (RW).

Model Name	Description
STX_RW_1	single sex + F method 2 + catch standard error = 0.3 + corrected survey standard error
STX_RW_2	STW_RW_1 + catch standard error = 2 + estimated growth
STTJ_RW_1	single sex + F method 2 + catch standard = 0.3 + corrected survey standard error
STTJ_RW_2	STTJ_RW_1 + catch standard error = 2 + estimated growth
STTJ_RW_3	STTJ_RW_1 + plus group = 12+
PR_RW_1	Single sex + F method 2 + catch standard error = 0.3 + corrected survey standard error
PR_RW_2	PR_RW_1 + catch standard error = 2 + estimated growth
PR_RW_3	PR_RW_1 + La Paraguera survey + selectivity spline
PR_RW_4	PR_RW_3 + estimated growth
PR_STTJ_RW_1	PR_RW_3 + STTJ fleet and STTJ survey
PR_STTJ_RW_2	PR_STTJ_RW_1 + estimated length at maximum age + fixed selectivity + steepness = 0.8

For the Stoplight Parrotfish in St. Croix (STX), the initial model used a single-sex configuration and applied F method 2 (Baranov continuous F) with corrected standard error units for the National Coral Reef Monitoring Program (NCRMP) survey (STW_RW_1) and catch standard error of 0.3. The second model run for Stoplight Parrotfish (STW_RW_2) applied an increased standard error on catch (SE = 2) and estimated growth parameters (growth coefficient and mean length at maximum age).

For the Yellowtail Snapper in St. Thomas and St. John (STTJ), the initial model used a single-sex configuration and applied F method 2 (Baranov continuous F) with corrected standard error units for the National Coral Reef Monitoring Program (NCRMP) survey (STTJ_RW_1) and catch standard error of 0.3. The second model run for St. Croix Yellowtail Snapper (STTJ_RW_2) applied an increased standard error on catch (SE = 2) and estimated growth parameters (growth coefficient and mean length at maximum age). The third model run for St.

Thomas and St. John Yellowtail Snapper (STTJ_RW_3) explored the use of a plus group at age 12.

For the Yellowtail Snapper in Puerto Rico (PR), the initial model used a single-sex configuration and applied F method 2 (Baranov continuous F) with corrected standard error units for the National Coral Reef Monitoring Program (NCRMP) survey (PR_RW_1) and catch standard error of 0.3. The second model run for Puerto Rico Yellowtail Snapper (PR_RW_2) applied an increased standard error on catch (SE = 2) and estimated growth parameters (growth coefficient and mean length at maximum age). The third model run for Puerto Rico Yellowtail Snapper (PR_RW_3) included a survey corresponding to the spatially restricted years of the NCRMP (La Parguera) and a combination of splines and time blocks to model commercial selectivity. The fourth model (PR_RW_4) built on the third model run with estimated growth parameters (growth coefficient and length at maximum age).

The St. Thomas and St. John and Puerto Rico Yellowtail Snapper models were developed with combined data (PR_STTJ). This included two commercial fleets and five surveys (two historical surveys, two NCRMP, and one DCRMP; PR_STTJ_RW_1). The second model run (PR_STTJ_RW_2) built on the first model run with fixed selectivity and steepness (value = 0.8 obtained from the FishLife R package) and estimated length at maximum age.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 84

US Caribbean Yellowtail Snapper – Puerto Rico

SECTION VI: Post-Review Workshop Addenda

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Addendum

SEDAR 84 Puerto Rico Yellowtail Snapper

Table of contents

1 Introduction

This addendum provides supplementary analyses developed in direct response to requests made by the SEDAR 84 Review Workshop Panel. The model runs and plots presented here build on the configurations documented in the SEDAR 84 Assessment Process Report for US Caribbean Yellowtail Snapper in Puerto Rico.

The additional model runs conducted during the Review Workshop are intended to document exploratory work that may inform next steps toward refining the assessment framework for consideration by the Caribbean Fishery Management Council's Science and Statistical Committee (SSC).

Only the model runs reviewed by the panel during the Review Workshop are included in this addendum. While additional exploratory analyses could be pursued (e.g., steepness values informed by FishBase rather than assuming steepness near 1), these were not examined during the workshop. Future work to be considered by the SSC will integrate further panel recommendations and additional sensitivity analyses once the Review Workshop Report is finalized.

2 Key Considerations

- All model runs included here were developed under the direction of the Review Workshop Panel to explore data use and model behavior.
- The models remain preliminary and sensitive to consequential assumptions (e.g., initial equilibrium catch, recruitment steepness, selectivity). Further work is required to address these uncertainties and develop models more robust for informing management advice.
- At the panel's recommendation, an exploratory run was developed combining data from Puerto Rico and St. Thomas/St. John. This model run deviates from the Data Workshop guidance to analyze island platforms separately and to exclude spatially restricted survey data from La Parguera, Puerto Rico and St. John prior to when the surveys were conducted island-wide. The panel suggested this model configuration in an attempt to retain additional information to better fit length compositions and stabilize model initialization. Those results are only included in the Puerto Rico addendum.
- These models do not represent final scientific advice. They are intermediate steps in an iterative review process leading to future model development, SSC review, and eventual management consideration.

3 Model Runs

Included is a compilation of the stock assessment model runs developed during the SEDAR 84 Review Workshop held from July 15 to July 18, 2025 in Fort Lauderdale, Florida.

Building on the models documented in the assessment process report for Yellowtail Snapper in Puerto Rico, the review workshop recommended several refinements and exploratory model runs. The initial review workshop model adopted a single-sex configuration, applied the Stock Synthesis fishing mortality method option 2 (F Method = 2), and corrected the standard error units for the NCRMP survey index of abundance. This represented a deliberate improvement over the setup reported in the assessment process report, which had implemented F Method = 3, referred to as the hybrid method. The hybrid method sequentially applies Pope's and Baranov catch equations to tune fishing mortality as a factor based on retained catch for each fleet. As noted in the SS3 manual, this approach generally performs best when catches are known with high precision (standard error < 0.05) and when the overall fishing mortality is not substantially higher than natural mortality.

In contrast, F Method = 2 treats fishing mortality as a parameter, which is often more appropriate in cases where fishing mortality is relatively high or where fleets have both retained and discarded catch. Changing from method 3 to method 2 was therefore an important refinement, as was correcting the index standard error units and simplifying the model to a single-sex structure, given that no sex-specific data inputs were available for this assessment.

These recommendations were motivated by the observed behavior in the initial models where catch data were fit almost exactly, largely due to the combination of the hybrid method and low uncertainty on the catch inputs. Switching to F Method = 2 provided the model with greater flexibility to balance the fit between fishery-dependent catch data and fishery-independent survey indices. This was particularly important because the NCRMP survey is a statistically designed survey providing independent information on abundance trends.

A second exploratory model run further increased the standard error on the catch and allowed estimation of two growth parameters (the growth coefficient, K, and the mean length at maximum age). This recommended model run aimed to test whether relaxing constraints on catch and growth assumptions would allow the model to better align with the survey data.

However, these two exploratory models produced notably different results, highlighting a significant trade off. This underscores an important area for further investigation. Additional work is required to evaluate model weightings, data input uncertainties, and configuration choices to ensure an appropriate balance in how information from different sources informs the assessment outcomes.

A third model, recommended for the Puerto Rico Yellowtail Snapper assessment, incorporated a spatially restricted NCRMP survey covering only the years when data from La Parguera were available. This configuration also introduced a flexible selectivity pattern, modeled using splines with time blocks, to better capture observed shifts in the size composition of the commercial fleet over time. Splines are polynomial functions that allow selectivity curves to change flexibly across sizes or time periods, avoiding rigid assumptions about fleet behavior.

The intention of this approach was to explicitly represent changes in fishing selectivity, interpreting the size composition of landings as a direct consequence of fishers' selection patterns, rather than as a signal of underlying population structure or availability trends. In other words, this model sought to decouple population dynamics from the commercial fishery data, while still ensuring that the Trip Interview Program (TIP) data informed the size-specific removals.

A fourth exploratory model was recommended which retained the spatially restricted La Parguera survey and spline selectivity setup but also estimated growth parameters—the growth coefficient (K) and the mean length at maximum age—to further explore whether relaxing fixed growth assumptions would improve convergence and overall model fit.

Finally, two panel recommended models were developed with combined data from Puerto Rico and St. Thomas and St. John, USVI. These included two fleets and five surveys. This included two spatially restricted NCRMP surveys from 2001 to 2011, conducted in La Parguera, PR and in St. John, which were incorporated separately from the island-wide surveys (PR NCRMP, STTJ NCRMP, and STTJ DCRMP) that were recommended by the data workshop and included in the respective assessment process report model runs. To test for model convergence, the second model built on this combined island structure with fixed selectivity and steepness and estimated length at maximum age.

Table 1 summarizes the models described above and figures are provided in Section 6.

For each model, key Spawning Potential Ratio (SPR) plots are provided with horizontal red lines indicating the MSY proxy of 40% SPR. The SPR plot shows the estimated spawning potential ratio over time. Similarly, the unfished ratio plot presents the time series of the fraction of unfished spawning output. Lastly, the fishing intensity plot displays the inverse of the SPR ($1 - \text{SPR}$).

4 Conclusions and Next Steps

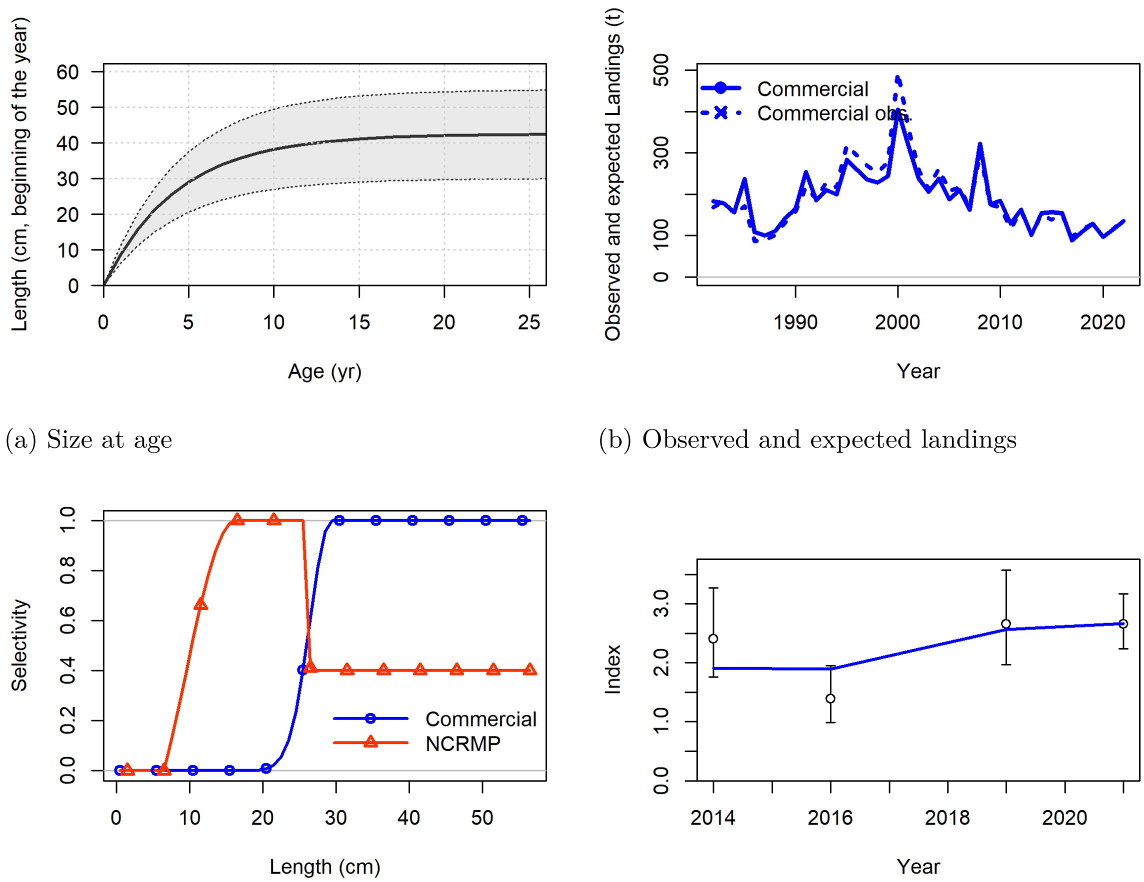
These analyses are exploratory and were conducted under panel direction during the SEDAR 84 Review Workshop. Further work is required to evaluate consequential assumptions, add sensitivity runs (e.g., steepness from FishBase), and ensure models are robust to uncertainty. Final recommendations and additional work steps will be determined following completion of the Review Workshop Report, outside of the SEDAR 84 process.

5 Tables

Table 1: Summary of Review Workshop SEDAR 84 models for Yellowtail Snapper in Puerto Rico.

Model	Description
PR_RW_1	Single Sex, F method 2, Catch SE = 0.3, and Corrected Survey SE
PR_RW_2	PR_RW_1 + Catch SE = 2 and Estimated Growth
PR_RW_3	PR_RW_1 + La Parguera Survey and Selectivity Spline; **does not converge**
PR_RW_4	PR_RW_3 + Estimated Growth
PR_STTJ_RW_1	PR_RW_3 + STTJ Fleet and STJ Survey; **does not converge**
PR_STTJ_RW_2	PR_STTJ_RW_1 + Estimated Length at Maximum Age and Fixed Selectivity and 0.8 Steepness

6 Figures



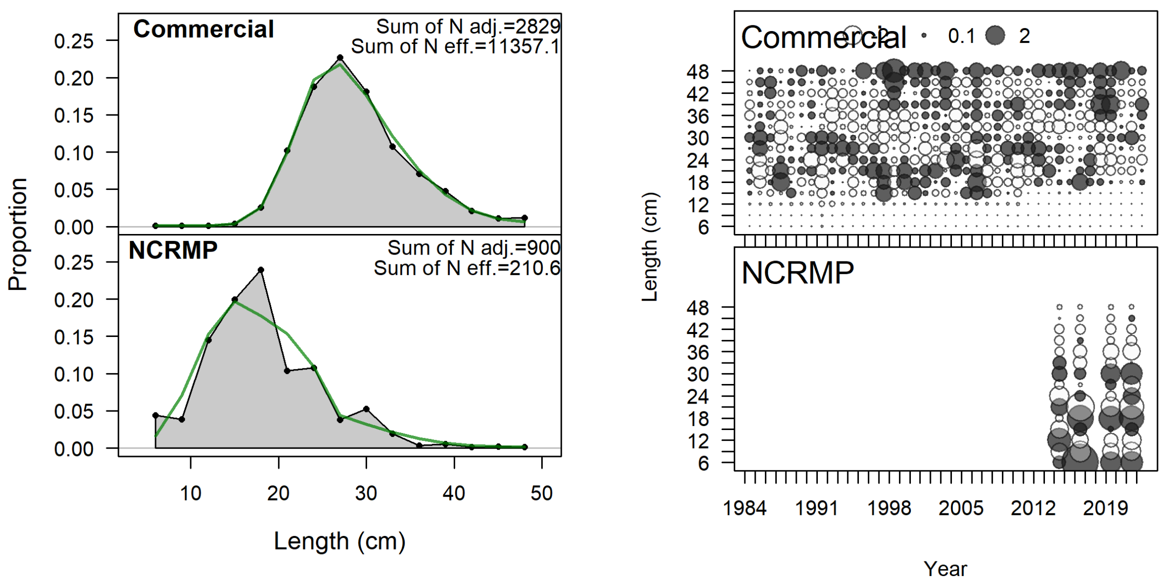
(a) Size at age

(b) Observed and expected landings

(c) Selectivity

(d) Index NCRMP

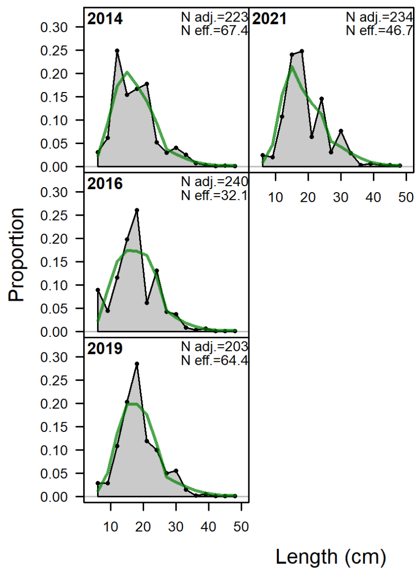
Figure 1: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; (c) selectivity at length by fleet; and (d) fit to index data for the NCRMP survey.



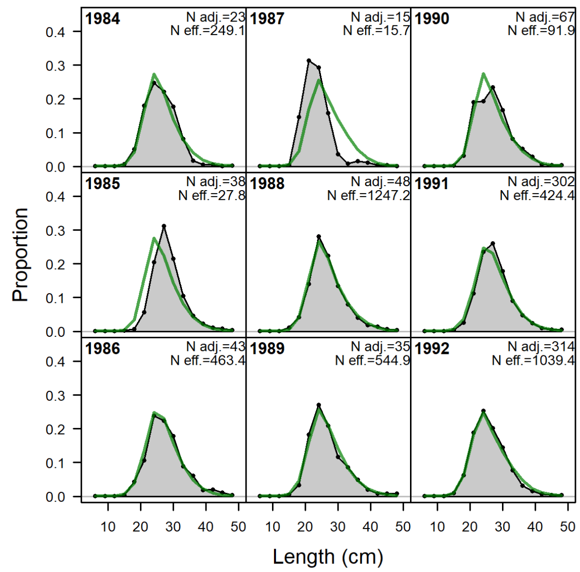
(a) Length fit aggregated across time

(b) Length fit

Figure 2: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method; and (b) Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

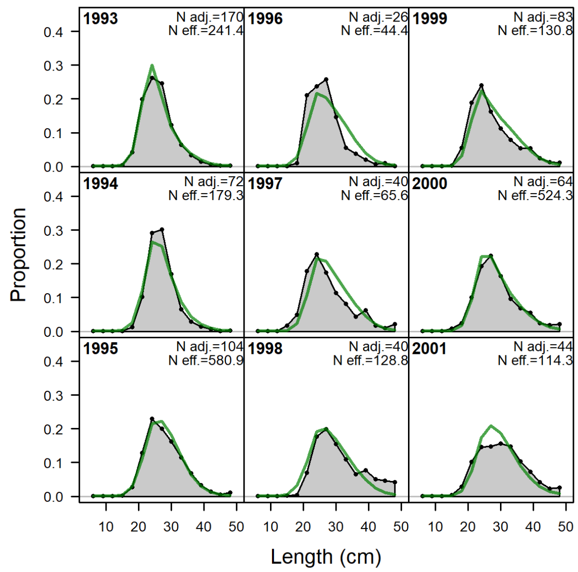


(a) Length comps NCRMP

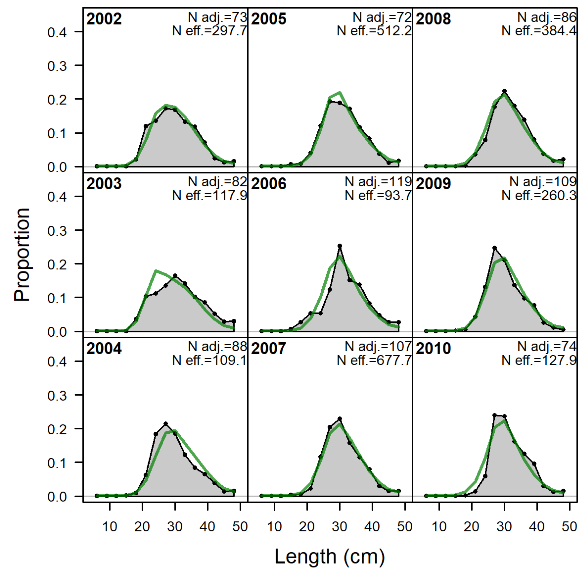


(b) Length comps Commercial pg. 1 of 5

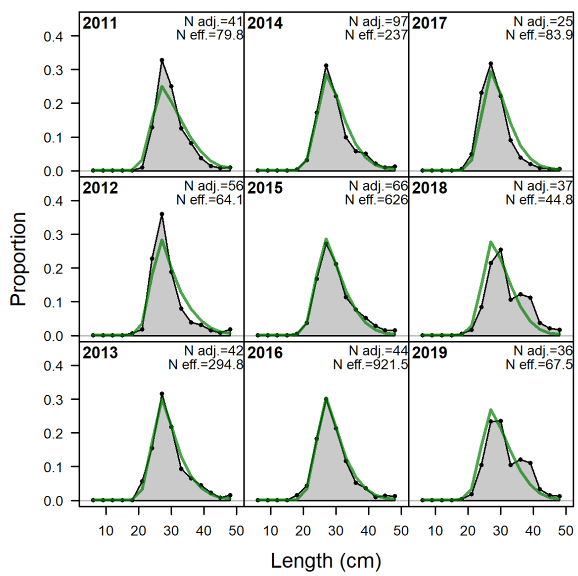
Figure 3: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1. (a) Observed and predicted length distributions in centimeters, by year for the NCRMP survey; and (b) observed and predicted length distributions in centimeters, by year for the commercial fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



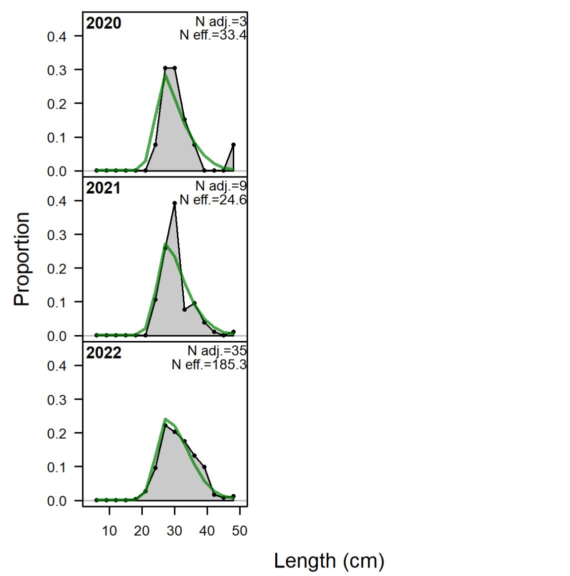
(a) Length comps Commercial pg. 2 of 5



(b) Length comps Commercial pg. 3 of 5

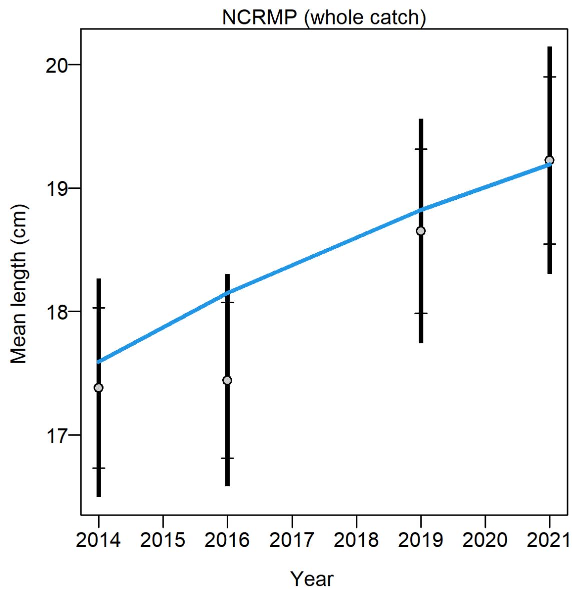


(c) Length comps Commercial pg. 4 of 5

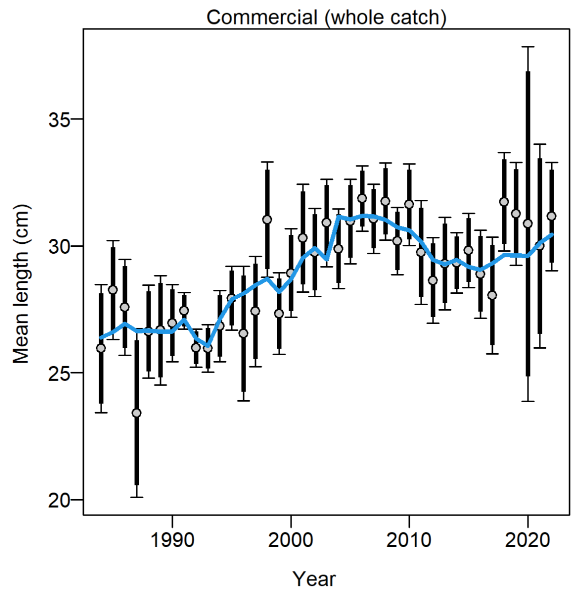


(d) Length comps Commercial pg. 5 of 5

Figure 4: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1. Observed and predicted length distributions in centimeters, by year for the commercial fleet (continued). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

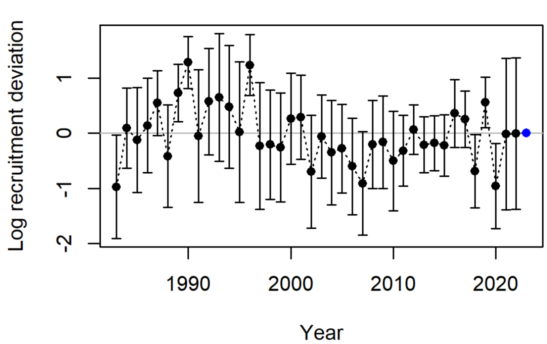


(a) Mean length NCRMP

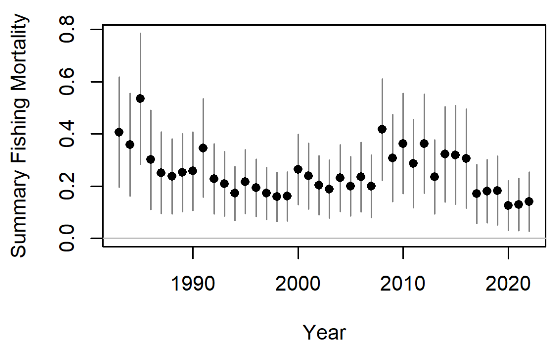


(b) Mean length Commercial

Figure 5: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1. Mean length for with 95% confidence intervals for (a) the NCRMP survey and for (b) the commercial fleet.

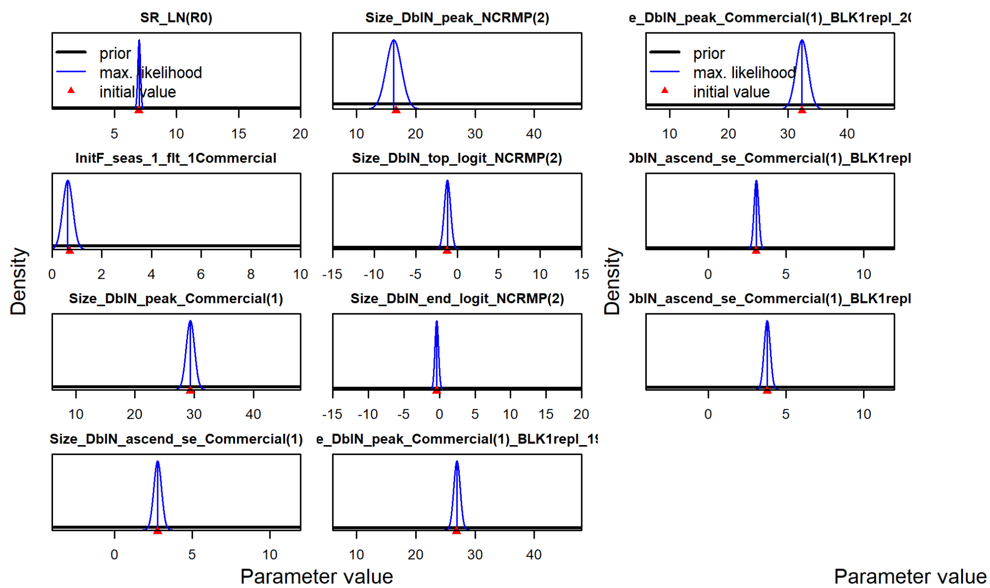


(a) Recruitment deviations



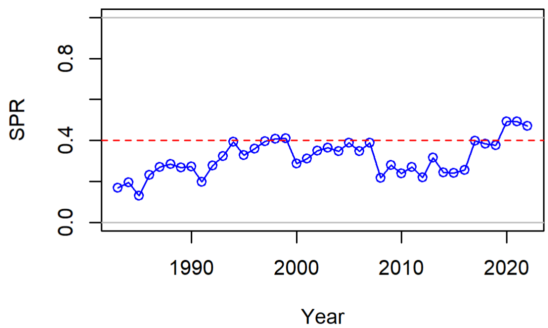
(b) Fishing Mortality

Figure 6: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1. (a) Recruitment deviations with 95% intervals; and (b) fishing mortality (total biomass killed / total biomass).

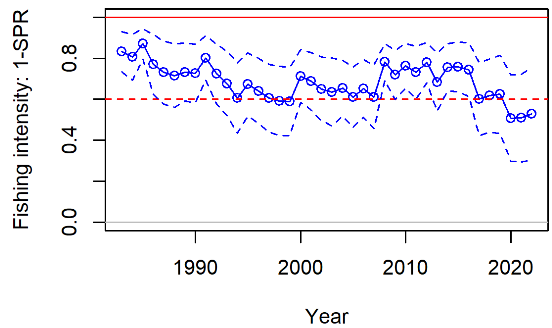


(a) Parameters pg. 1 of 2 (b) Parameters pg. 2 of 2

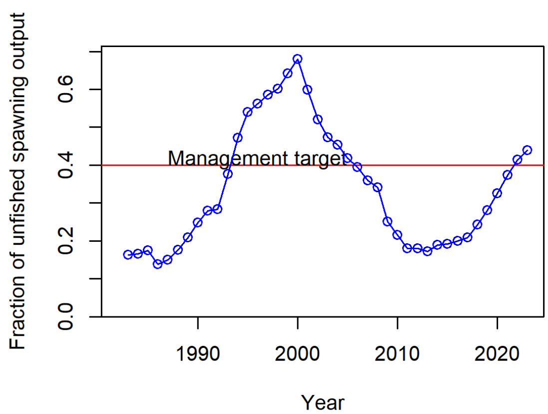
Figure 7: Parameter distribution plots for the Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1.



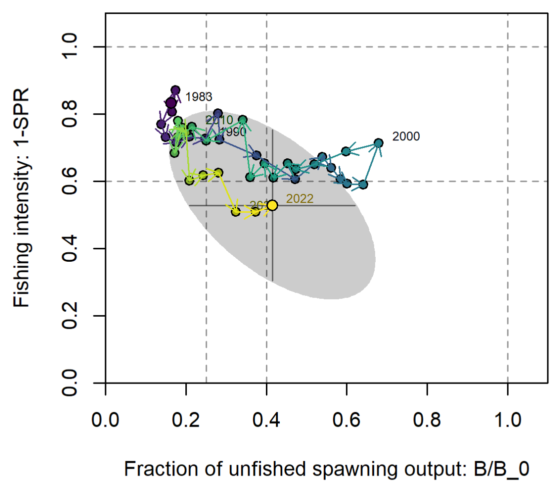
(a) SPR



(b) SPR Ratio

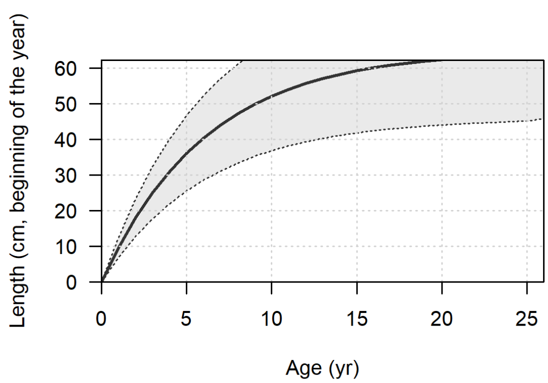


(c) Unfished ratio

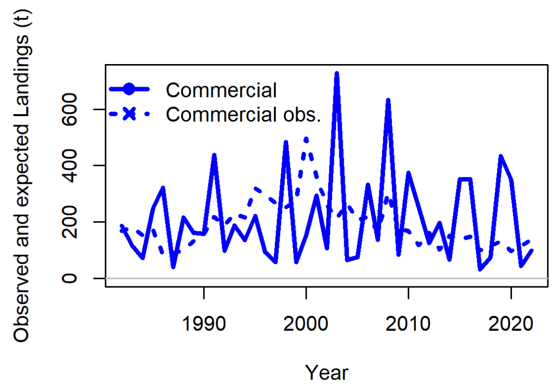


(d) SPR Phase

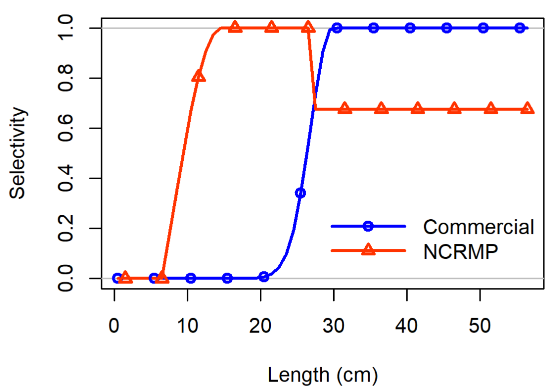
Figure 8: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_1. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4; (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass) with ~95% asymptotic intervals. Horizontal reference line at SPR target: 0.4; and (d) phase plot of biomass ratio vs. SPR ratio where warmer colors (red) represent early years and colder colors (blue) represent recent years. Lines through the final point show 95% intervals based on the asymptotic uncertainty for each dimension. The shaded ellipse is a 95% region which accounts for the estimated correlation between the two quantities: -0.567.



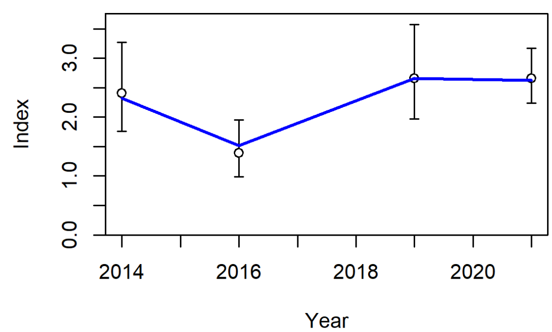
(a) Size at age



(b) Observed and expected landings

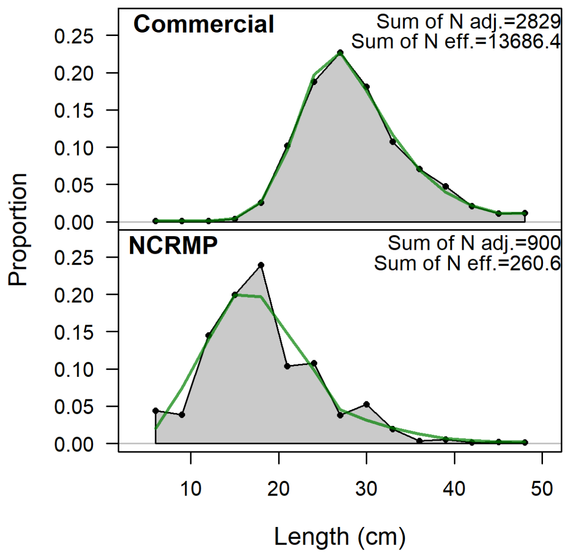


(c) Selectivity

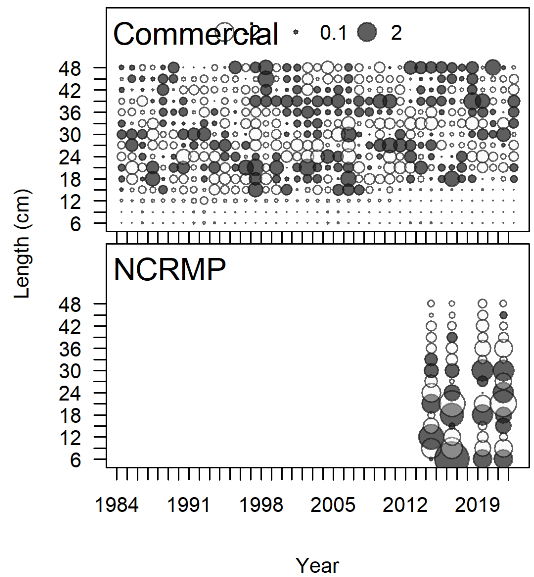


(d) Index NCRMP

Figure 9: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; (c) selectivity at length by fleet; and (d) fit to index data for the NCRMP survey.

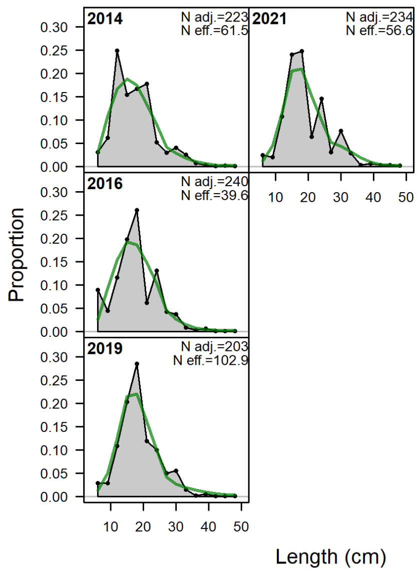


(a) Length fit aggregated across time

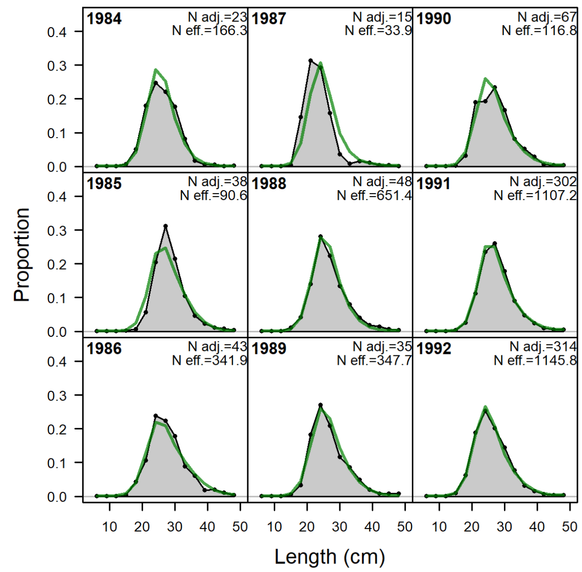


(b) Length fit

Figure 10: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method; and (b) Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

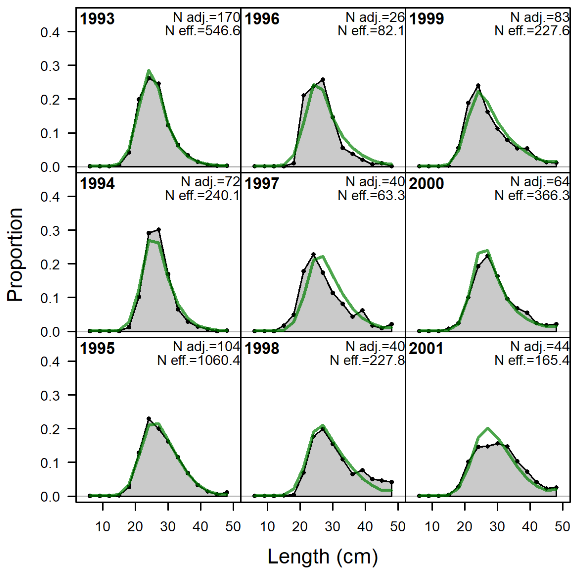


(a) Length comps NCRMP

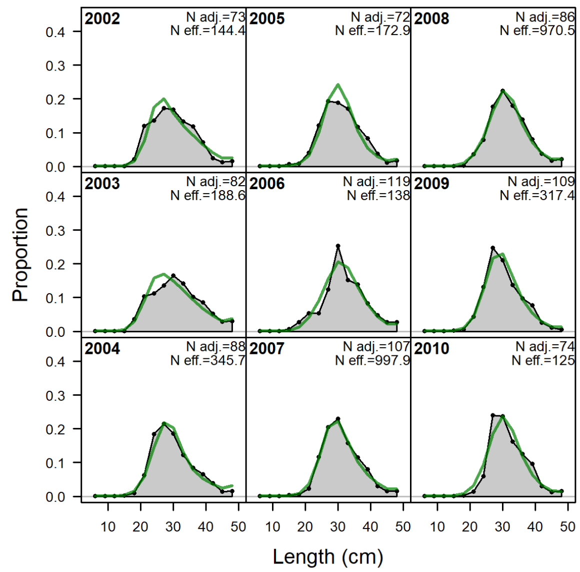


(b) Length comps Commercial pg. 1 of 5

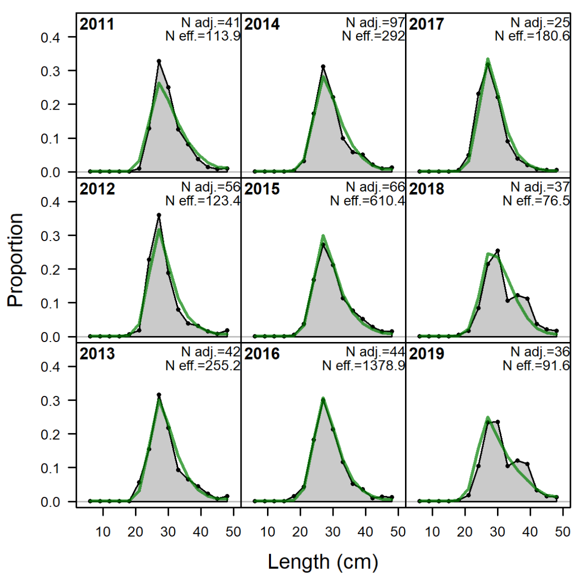
Figure 11: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2. (a) Observed and predicted length distributions in centimeters, by year for the NCRMP survey; and (b) observed and predicted length distributions in centimeters, by year for the commercial fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



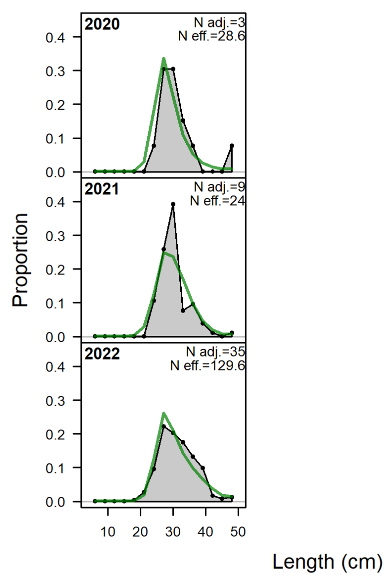
(a) Length comps Commercial pg. 2 of 5



(b) Length comps Commercial pg. 3 of 5

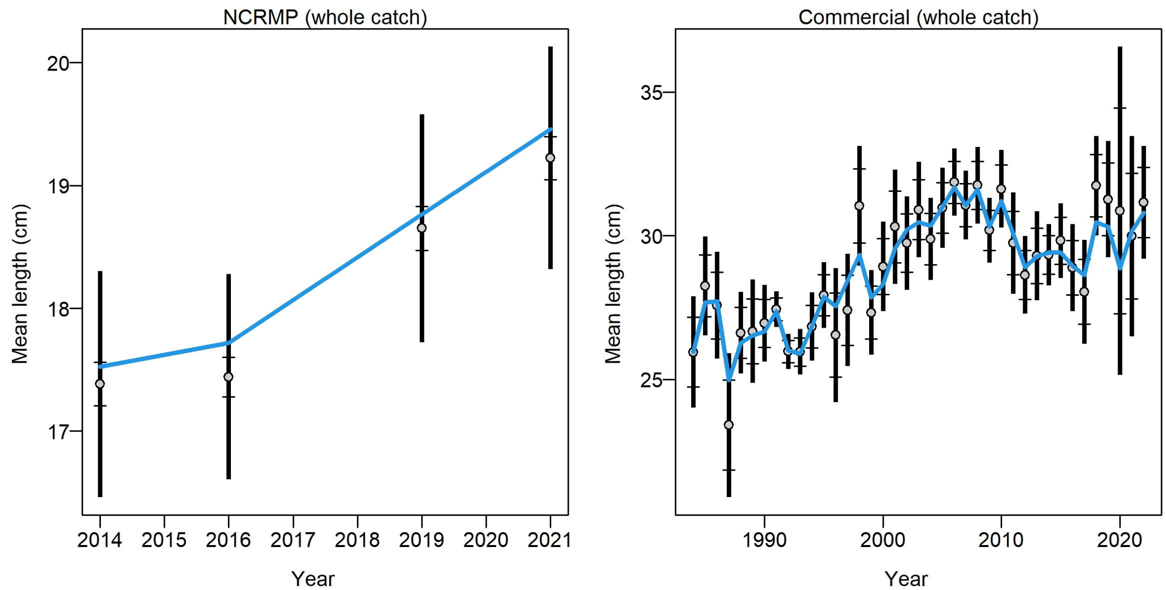


(c) Length comps Commercial pg. 4 of 5



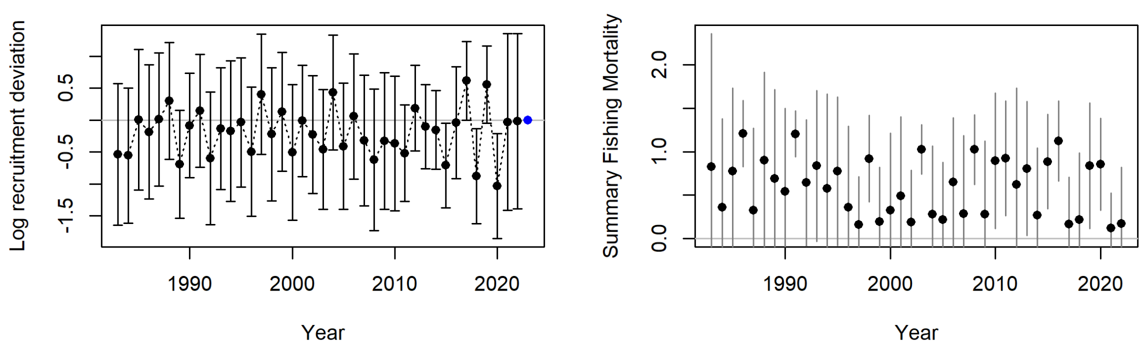
(d) Length comps Commercial pg. 5 of 5

Figure 12: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2. Observed and predicted length distributions in centimeters, by year for the commercial fleet (continued). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



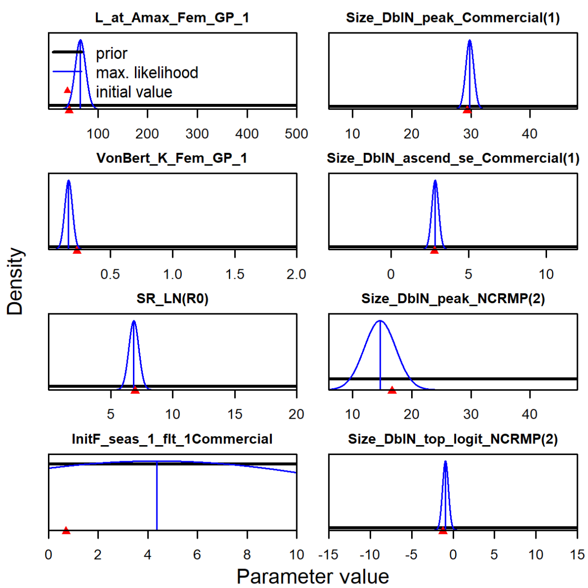
(a) Mean length NCRMP (b) Mean length Commercial

Figure 13: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2. Mean length for with 95% confidence intervals for (a) the NCRMP survey and for (b) the commercial fleet.

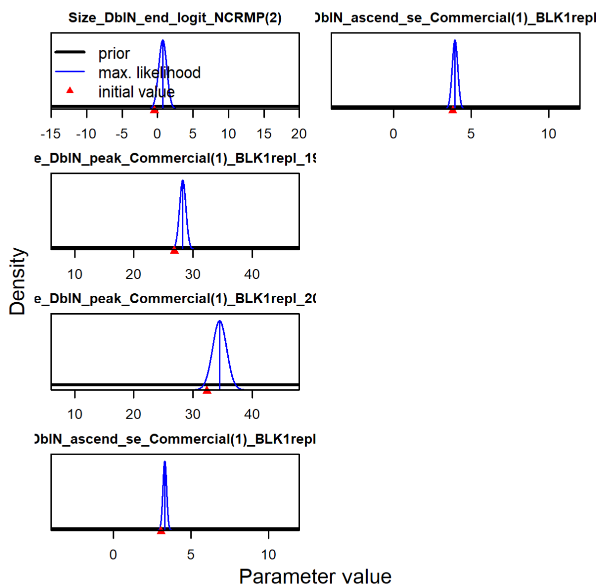


(a) Recruitment deviations (b) Fishing Mortality

Figure 14: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2. (a) Recruitment deviations with 95% intervals; and (b) fishing mortality (total biomass killed / total biomass).

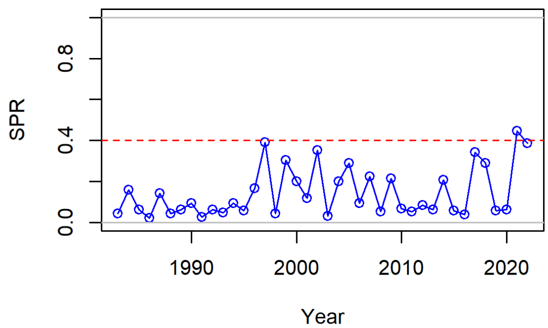


(a) Parameters pg. 1 of 2

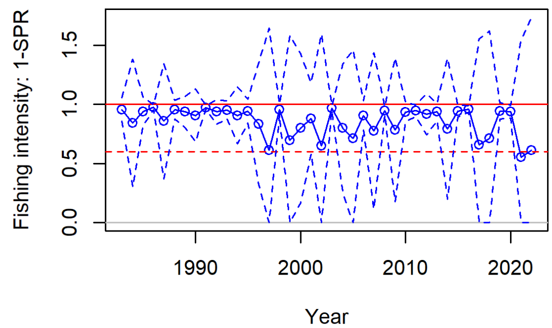


(b) Parameters pg. 2 of 2

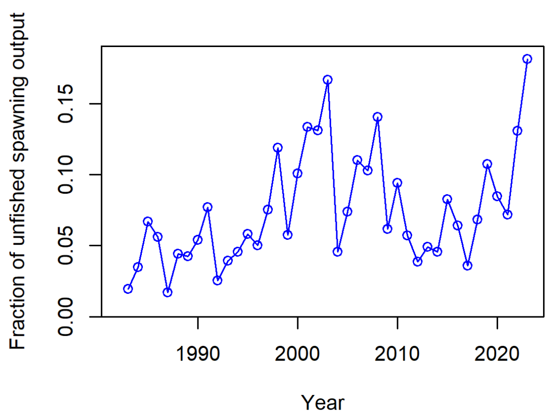
Figure 15: Parameter distribution plots for the Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2.



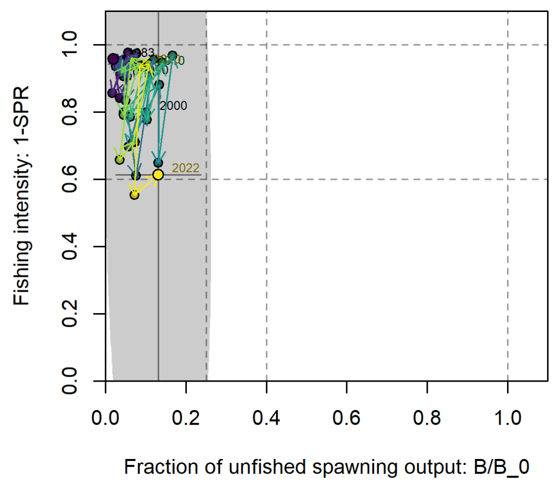
(a) SPR



(b) SPR Ratio

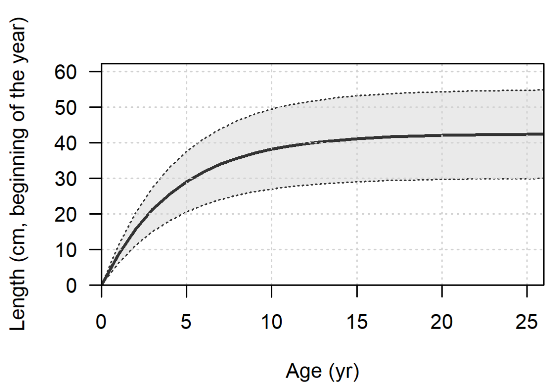


(c) Unfished ratio

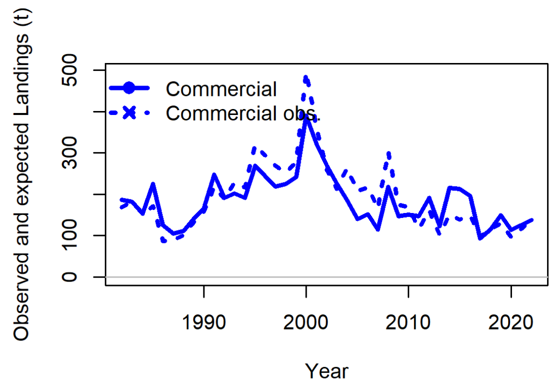


(d) SPR Phase

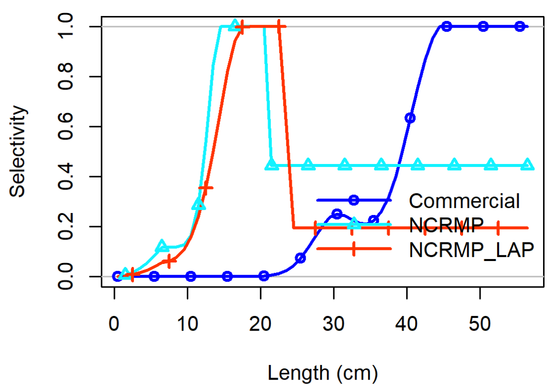
Figure 16: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_2. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4; (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass) with ~95% asymptotic intervals; and (d) phase plot of biomass ratio vs. SPR ratio where warmer colors (red) represent early years and colder colors (blue) represent recent years. Lines through the final point show 95% intervals based on the asymptotic uncertainty for each dimension. The shaded ellipse is a 95% region which accounts for the estimated correlation between the two quantities: -0.102.



(a) Size at age

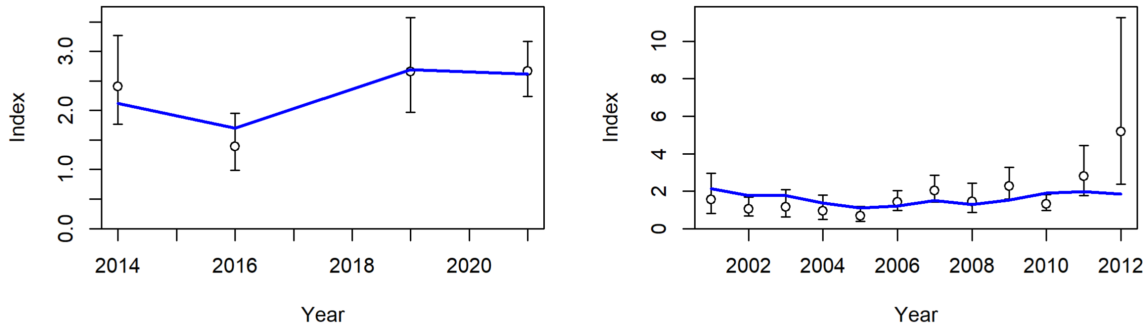


(b) Observed and expected landings



(c) Selectivity

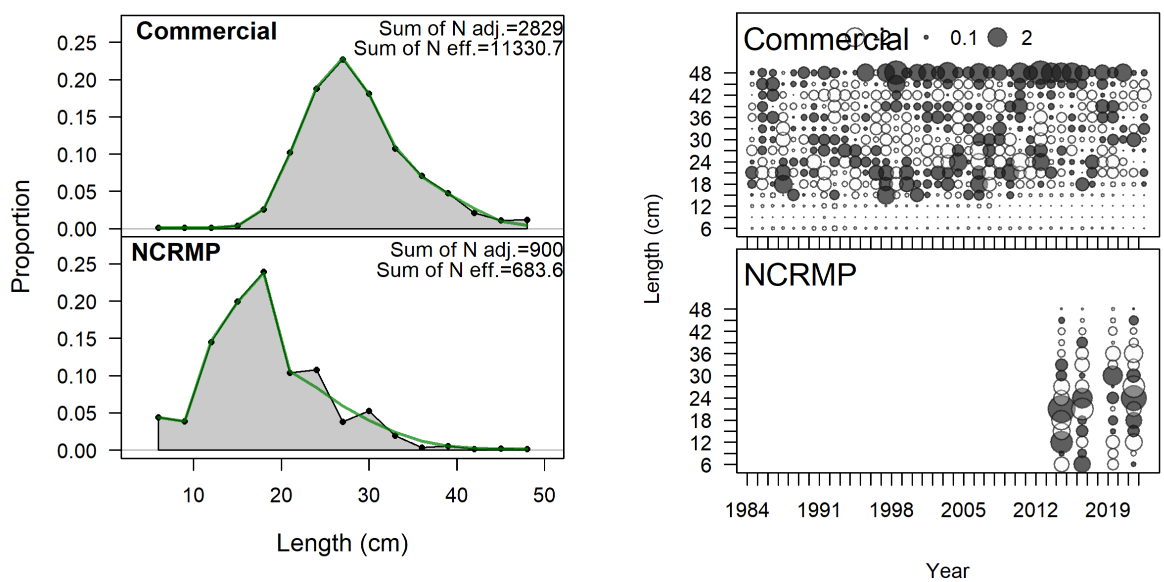
Figure 17: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; and (c) selectivity at length by fleet.



(a) Index NCRMP

(b) Index La Parguera NCRMP

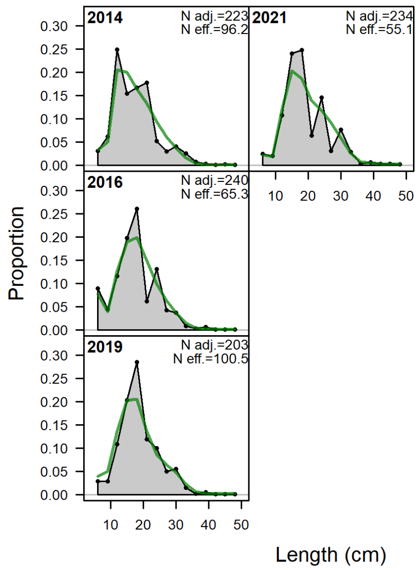
Figure 18: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. Fit to index data for the (a) NCRMP survey and (b) La Parguera NCRMP survey.



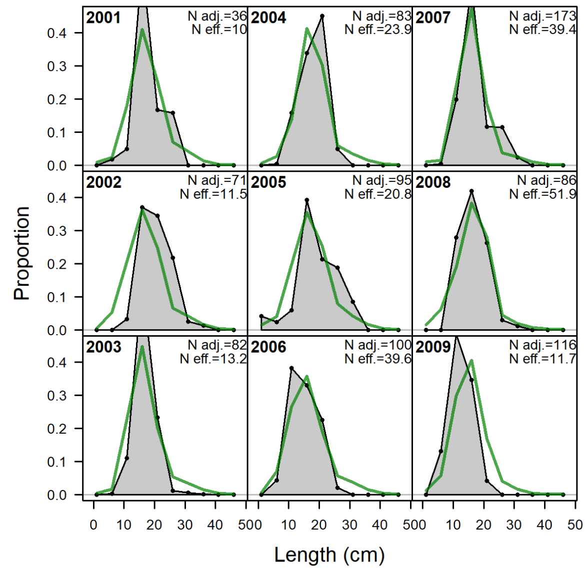
(a) Length fit aggregated across time

(b) Length fit

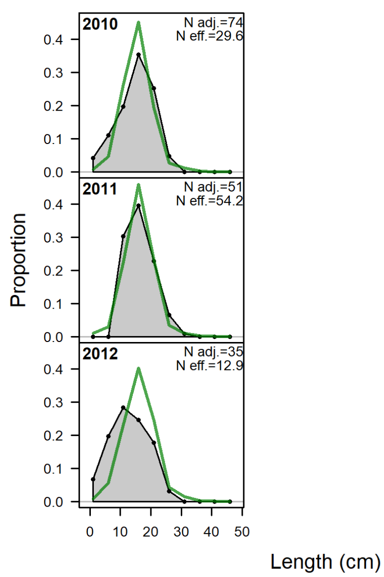
Figure 19: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method; and (b) Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).



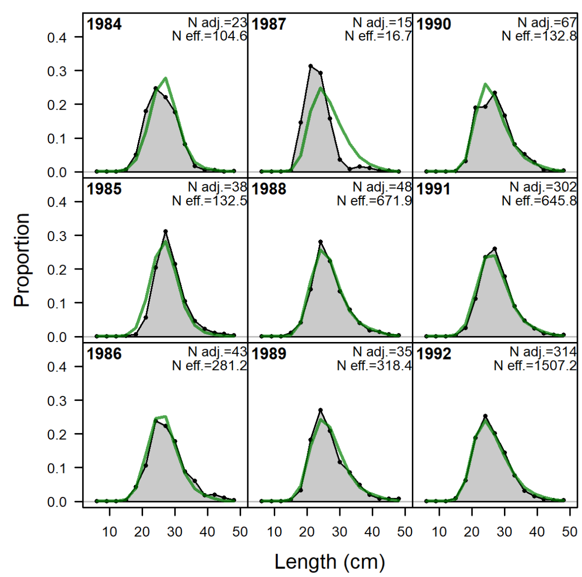
(a) Length comps NCRMP



(b) Length comps La Parguera NCRMP pg. 1 of 2

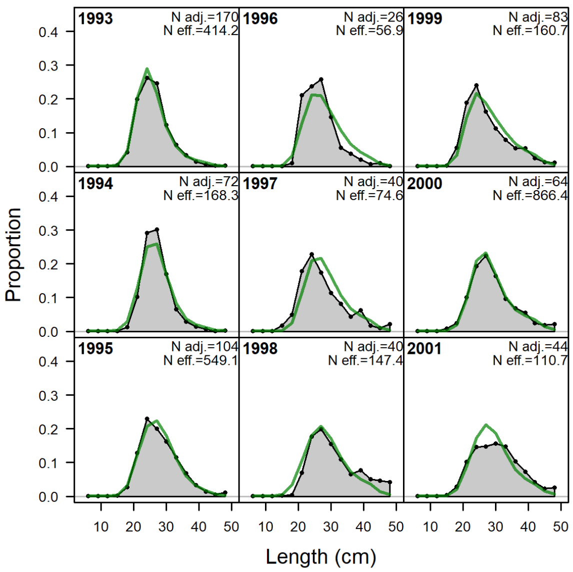


(c) Length comps La Parguera NCRMP pg. 2 of 2

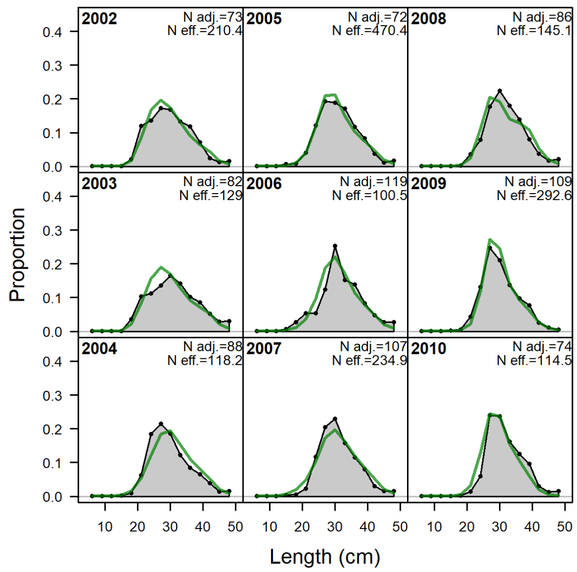


(d) Length comps Commercial pg. 1 of 5

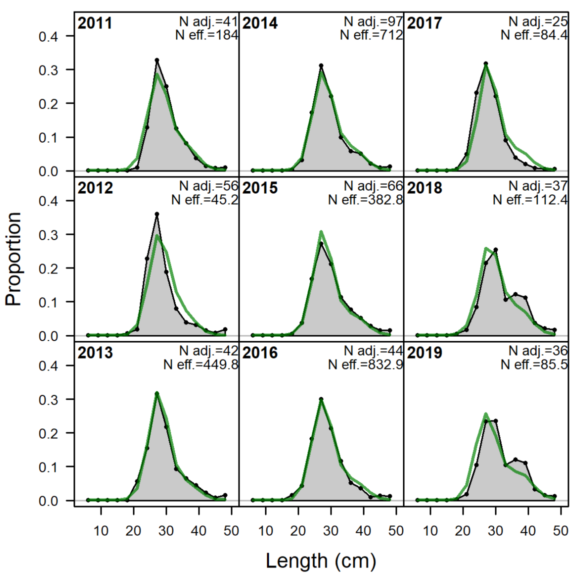
Figure 20: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. Observed and predicted length distributions in centimeters, by year for (a) the NCRMP survey; (b) the La Parguera NCRMP survey, and (c) the commercial fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



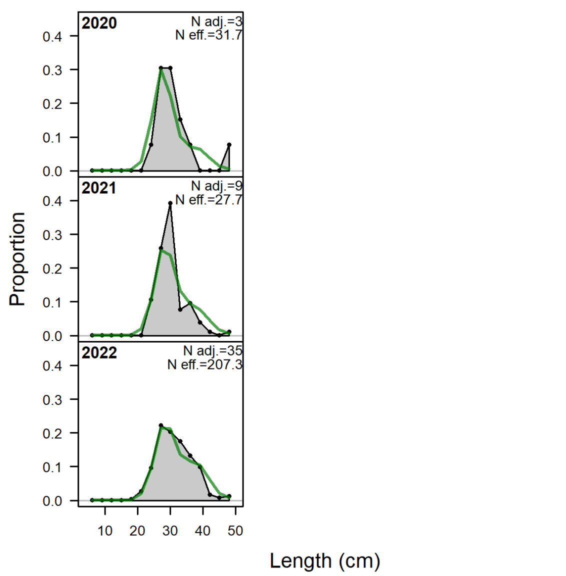
(a) Length comps Commercial pg. 2 of 5



(b) Length comps Commercial pg. 3 of 5

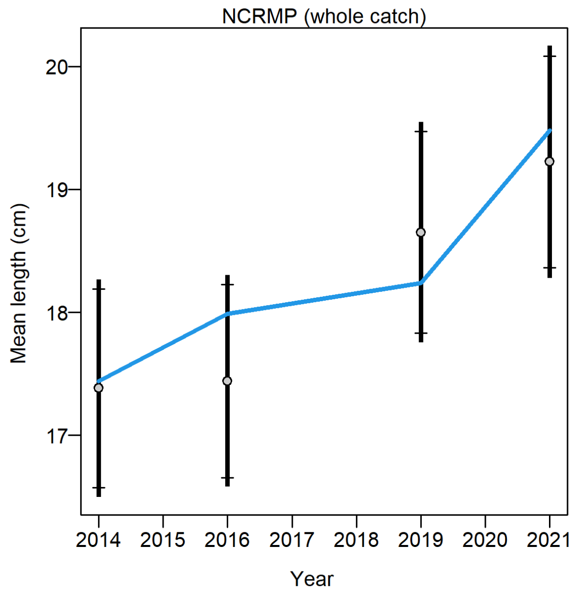


(c) Length comps Commercial pg. 4 of 5

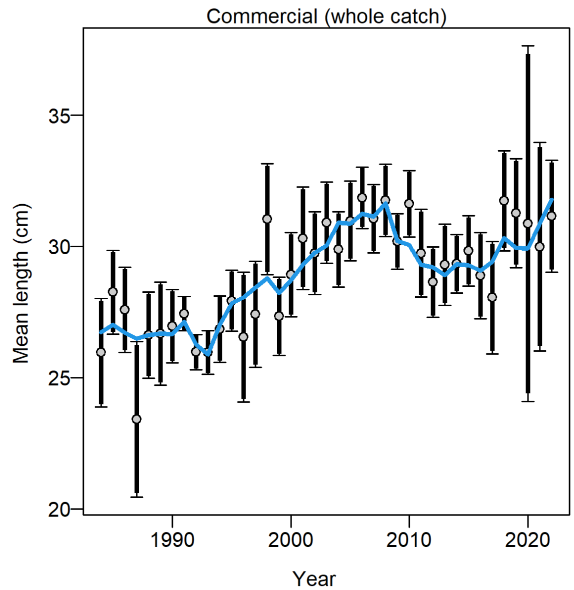


(d) Length comps Commercial pg. 5 of 5

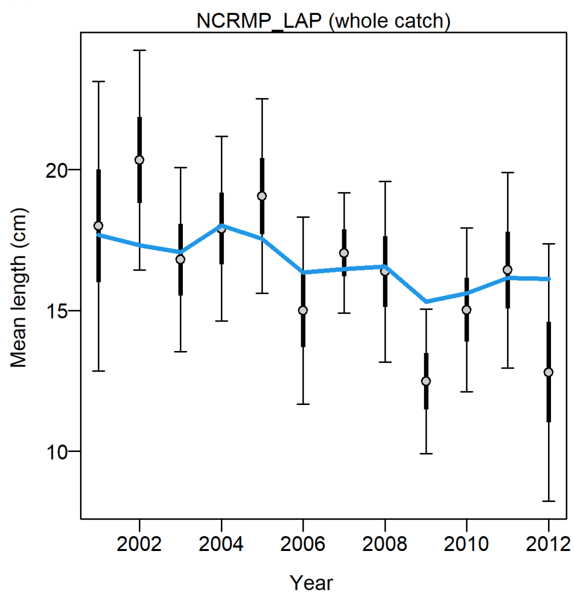
Figure 21: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. Observed and predicted length distributions in centimeters, by year for the commercial fleet (continued). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



(a) Mean length NCRMP

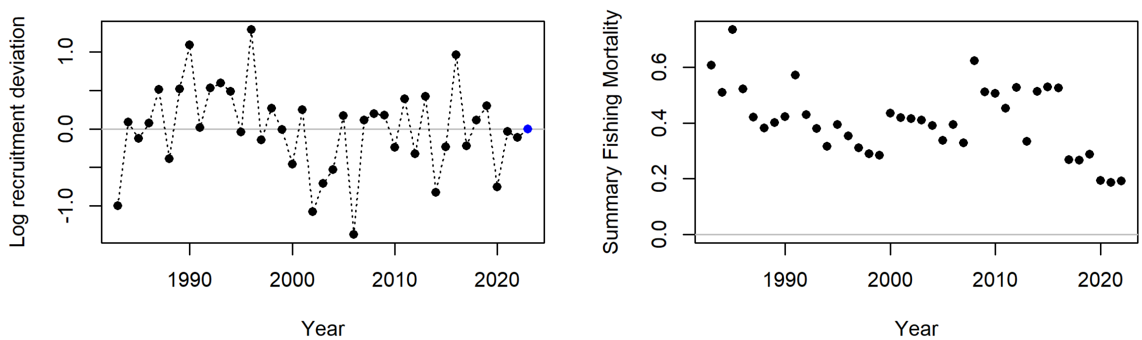


(b) Mean length Commercial



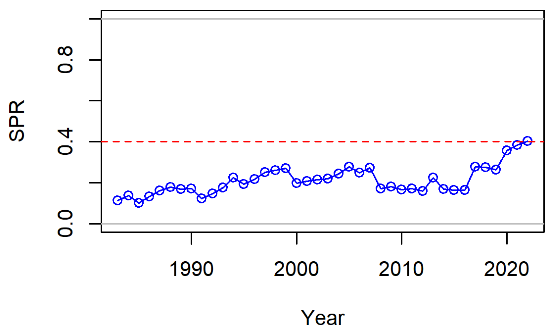
(c) Mean length NCRMP La Parguera

Figure 22: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. Mean length for with 95% confidence intervals for (a) the NCRMP survey, (b) the commercial fleet, and (c) the La Parguera NCRMP Survey.

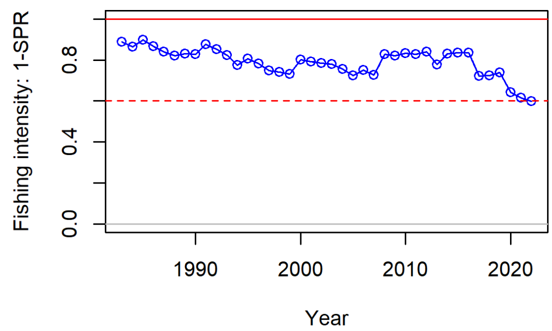


(a) Recruitment deviations (b) Fishing Mortality

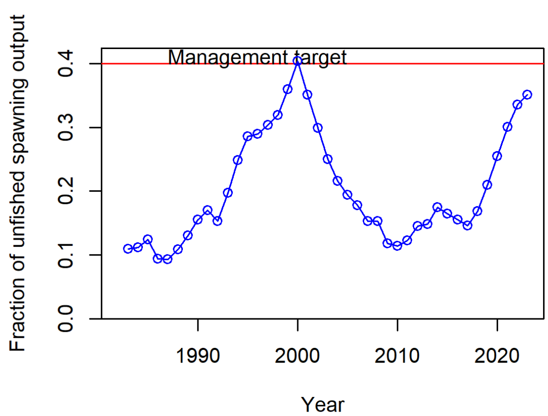
Figure 23: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. (a) Recruitment deviations; and (b) fishing mortality (total biomass killed / total biomass).



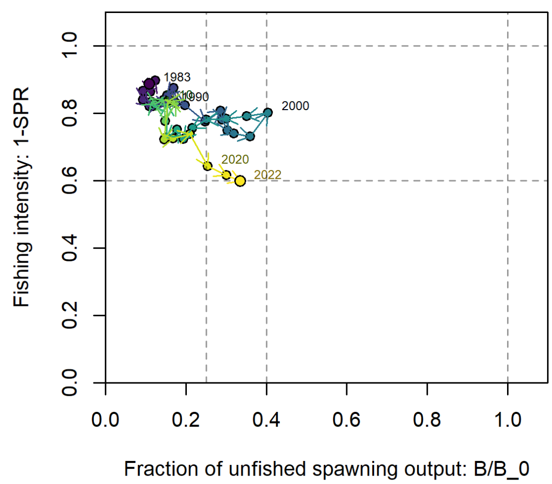
(a) SPR



(b) SPR Ratio

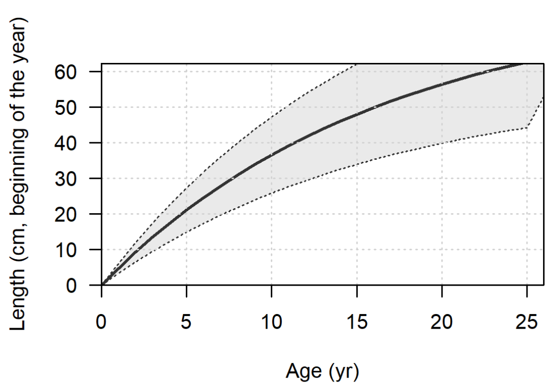


(c) Unfished ratio

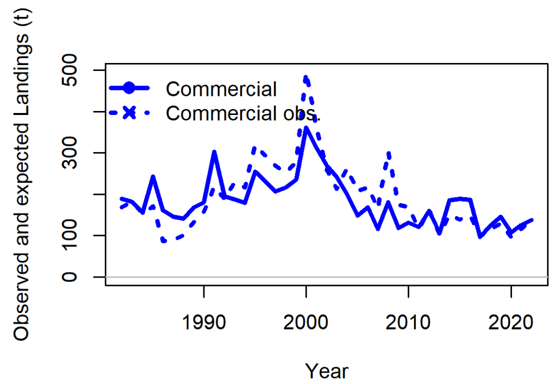


(d) SPR Phase

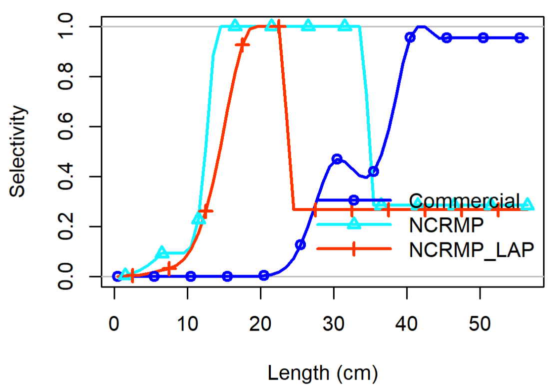
Figure 24: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_3. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4; (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass). Horizontal reference line at SPR target: 0.4; and (d) phase plot of biomass ratio vs. SPR ratio where warmer colors (red) represent early years and colder colors (blue) represent recent years.



(a) Size at age

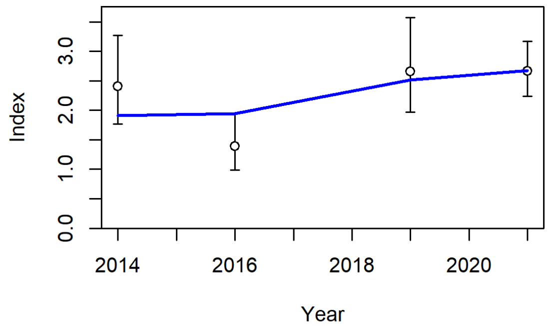


(b) Observed and expected landings

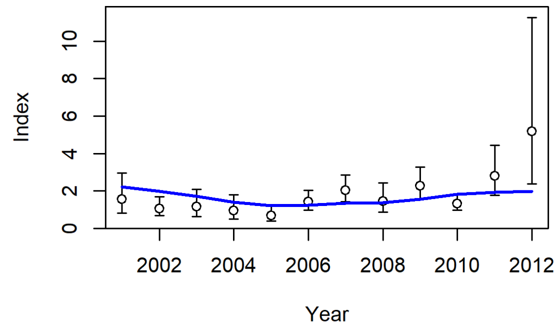


(c) Selectivity

Figure 25: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; and (c) selectivity at length by fleet.

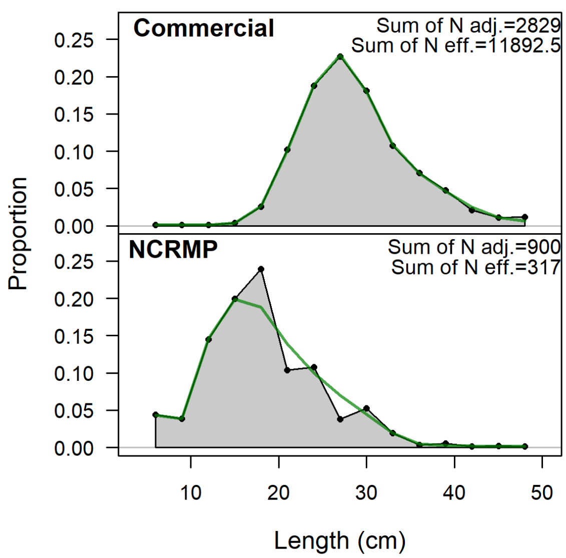


(a) Index NCRMP

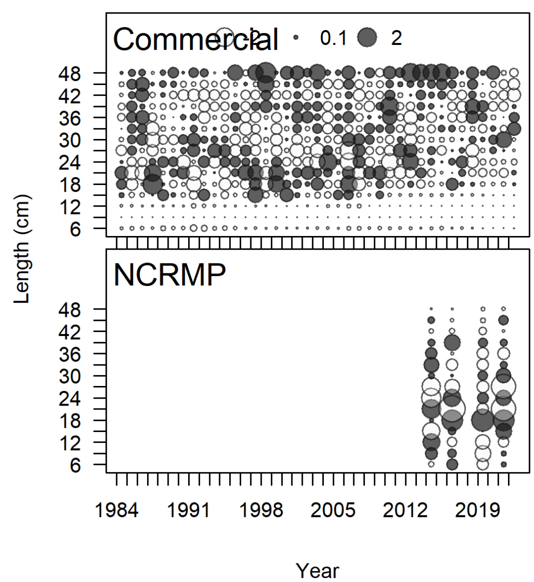


(b) Index La Parguera NCRMP

Figure 26: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. Fit to index data for the (a) NCRMP survey and (b) La Parguera NCRMP survey.

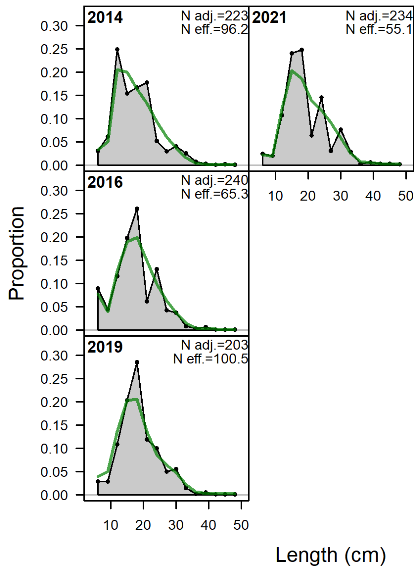


(a) Length fit aggregated across time

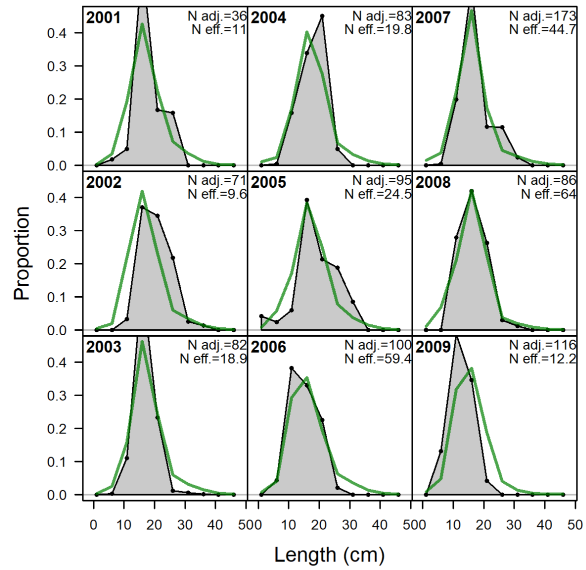


(b) Length fit

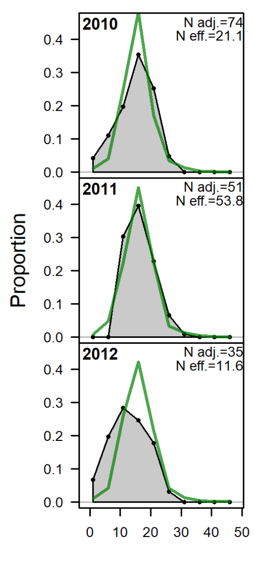
Figure 27: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method; and (b) Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).



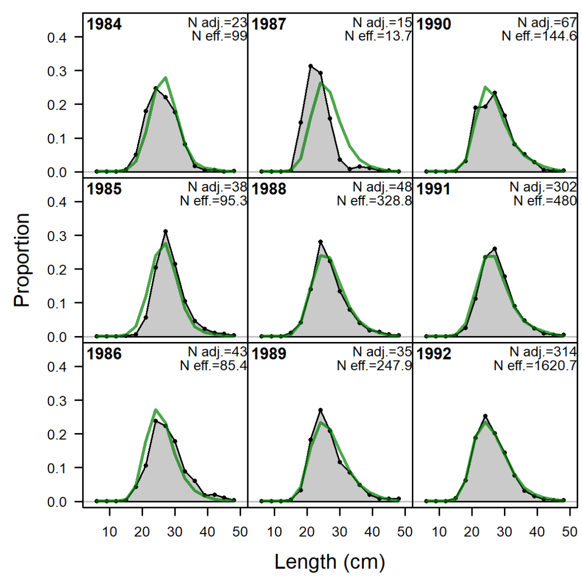
(a) Length comps NCRMP



(b) Length comps La Parguera NCRMP pg. 1 of 2

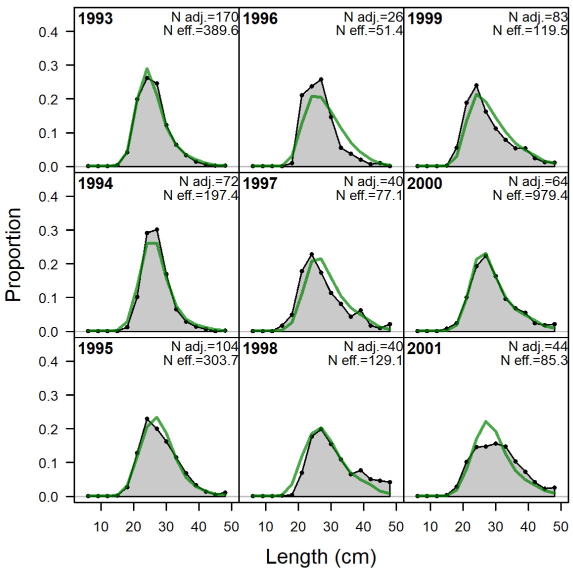


(c) Length comps La Parguera NCRMP pg. 2 of 2

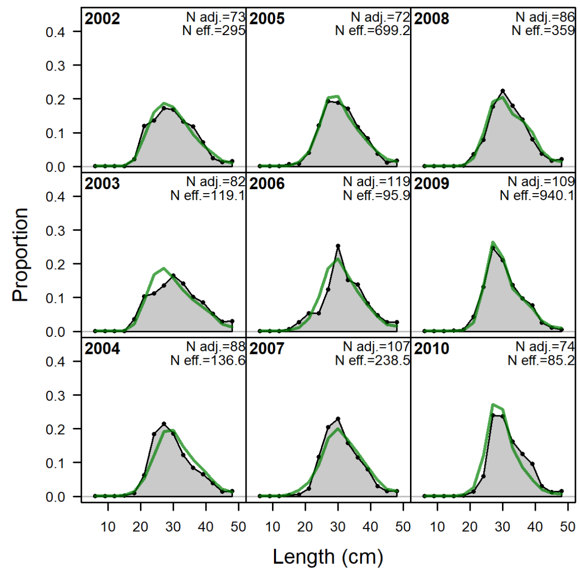


(d) Length comps Commercial pg. 1 of 5

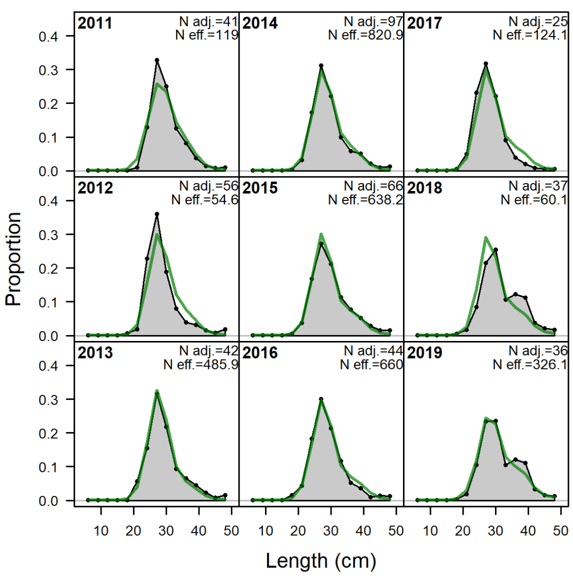
Figure 28: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. Observed and predicted length distributions in centimeters, by year for (a) the NCRMP survey; (b) the La Parguera NCRMP survey, and (c) the commercial fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



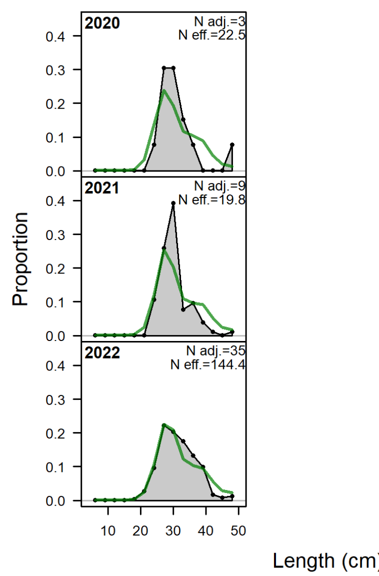
(a) Length comps Commercial pg. 2 of 5



(b) Length comps Commercial pg. 3 of 5

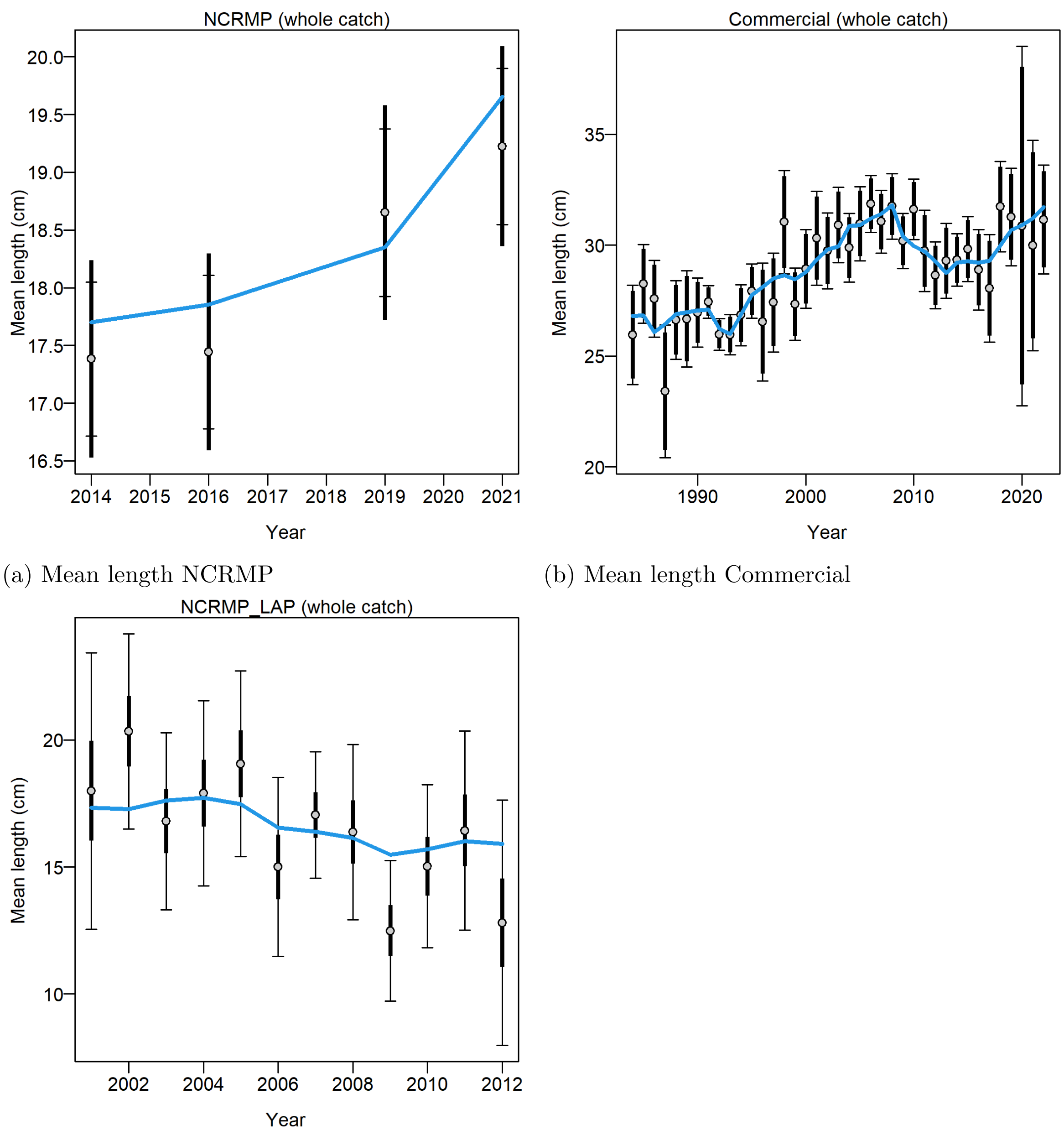


(c) Length comps Commercial pg. 4 of 5



(d) Length comps Commercial pg. 5 of 5

Figure 29: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. Observed and predicted length distributions in centimeters, by year for the commercial fleet (continued). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

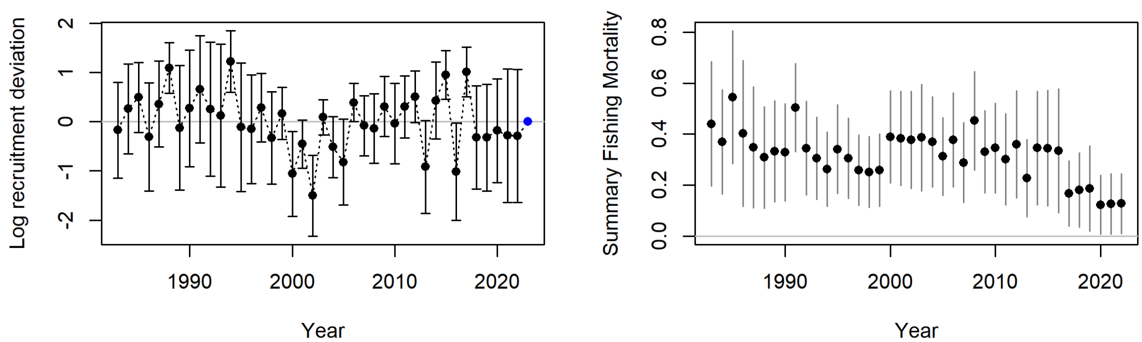


(a) Mean length NCRMP

(b) Mean length Commercial

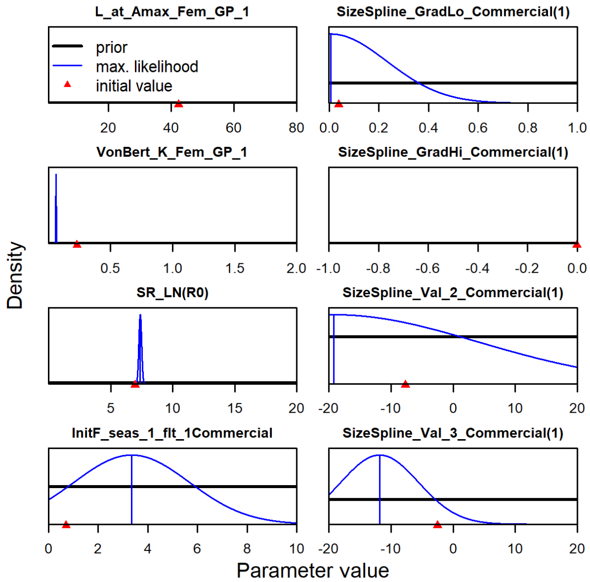
(c) Mean length NCRMP La Parguera

Figure 30: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. Mean length for with 95% confidence intervals for (a) the NCRMP survey, (b) the commercial fleet, and (c) the La Parguera NCRMP Survey.

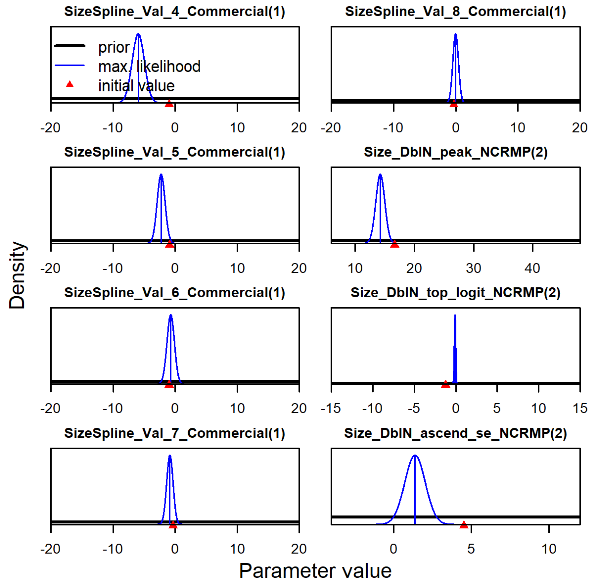


(a) Recruitment deviations (b) Fishing Mortality

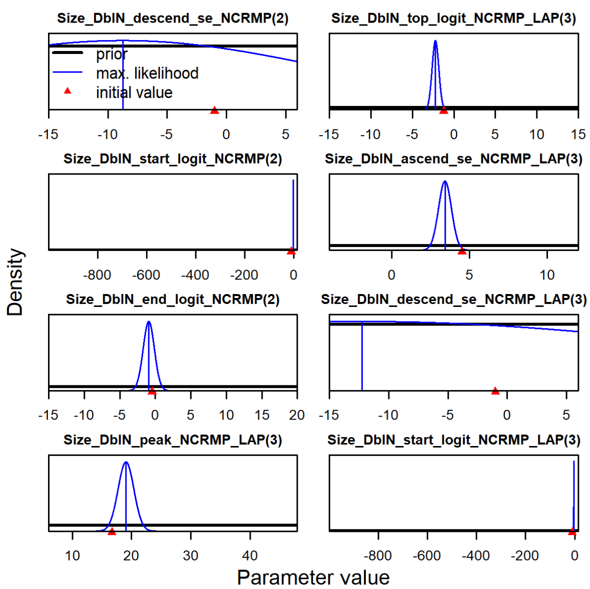
Figure 31: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. (a) Recruitment deviations with 95% intervals; and (b) fishing mortality (total biomass killed / total biomass).



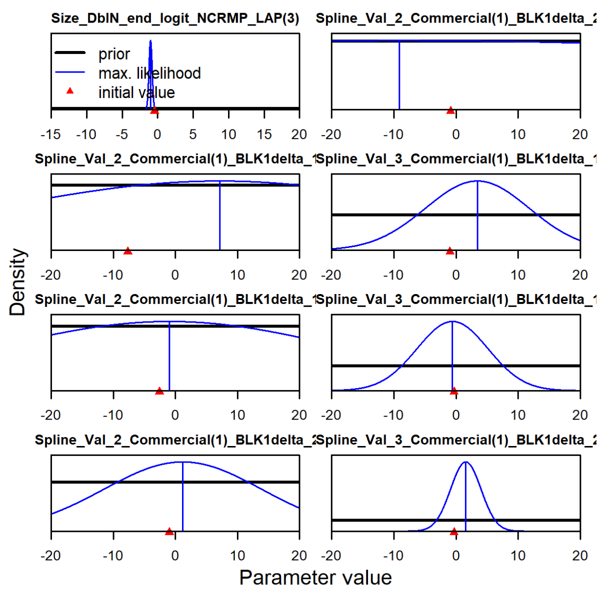
(a) Parameters pg. 1 of 7



(b) Parameters pg. 2 of 7

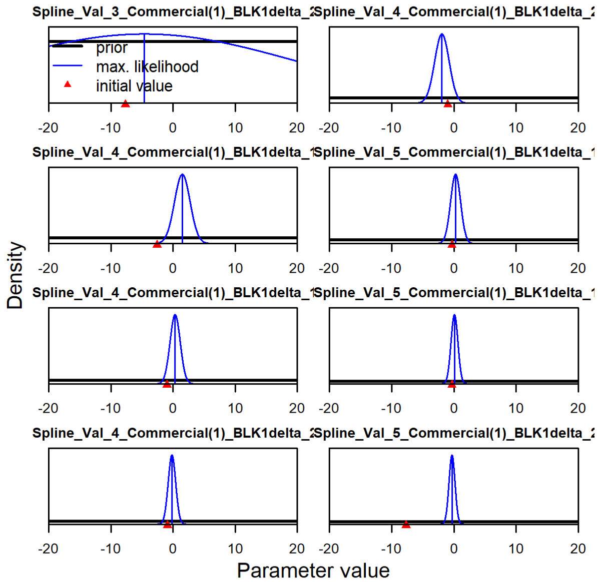


(c) Parameters pg. 3 of 7

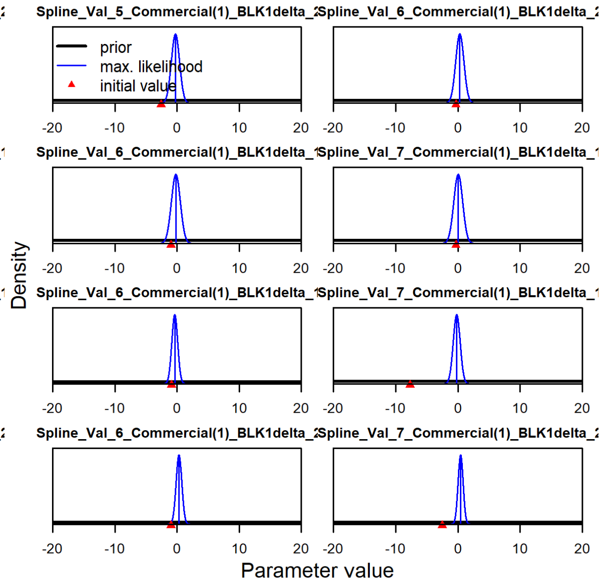


(d) Parameters pg. 4 of 7

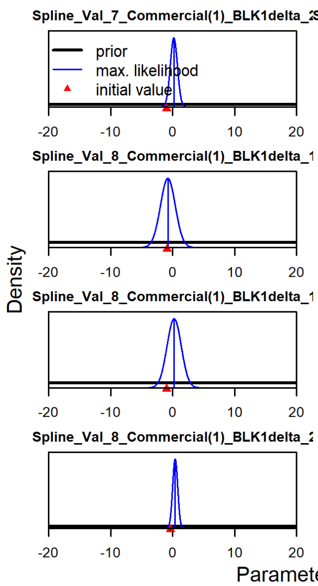
Figure 32: Parameter distribution plots for the Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4.



(a) Parameters pg. 5 of 7

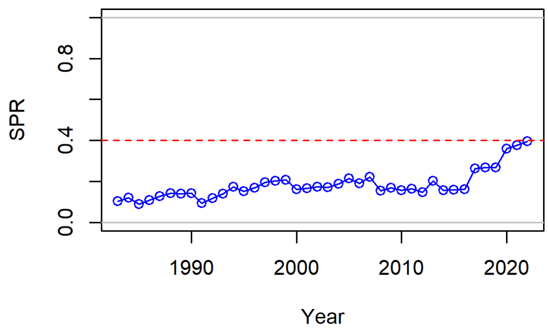


(b) Parameters pg. 6 of 7

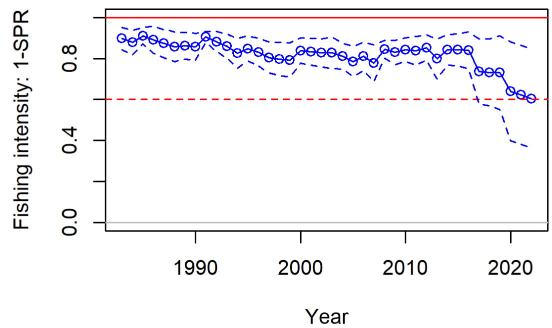


(c) Parameters pg. 7 of 7

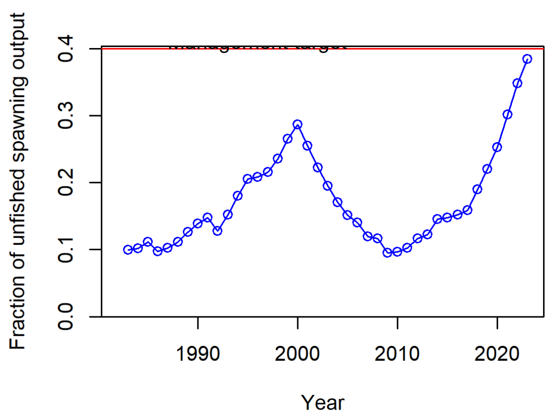
Figure 33: Parameter distribution plots for the Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4 (continued).



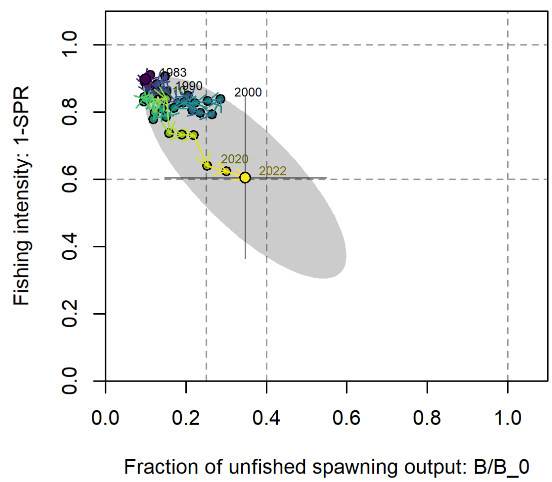
(a) SPR



(b) SPR Ratio

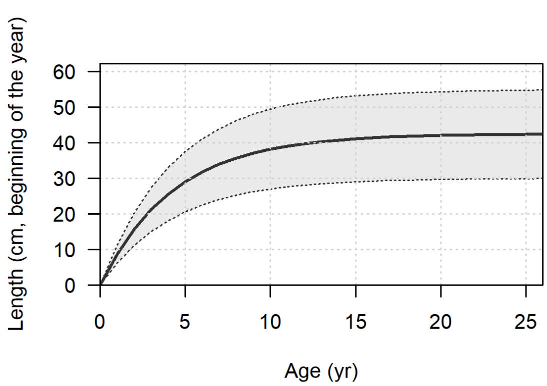


(c) Unfished ratio

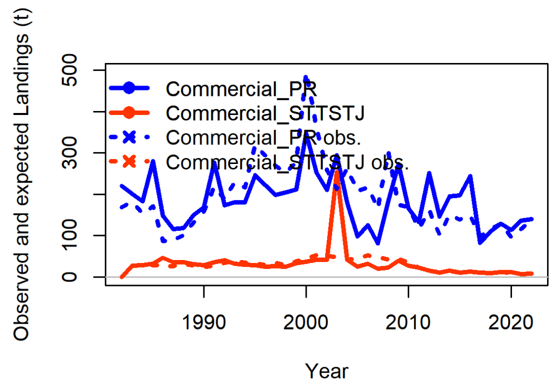


(d) SPR Phase

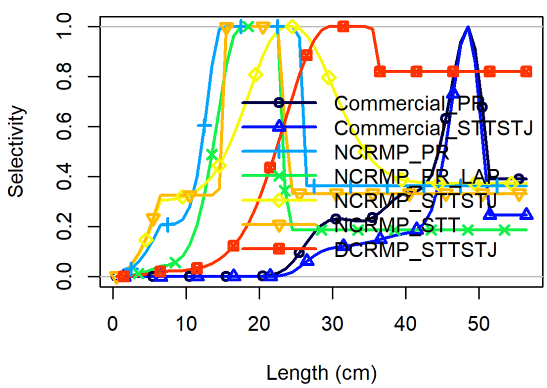
Figure 34: Puerto Rico Yellowtail Snapper Review Workshop Model PR_RW_4. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4; (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass) with ~95% asymptotic intervals. Horizontal reference line at SPR target: 0.4; and (d) phase plot of biomass ratio vs. SPR ratio where warmer colors (red) represent early years and colder colors (blue) represent recent years. Lines through the final point show 95% intervals based on the asymptotic uncertainty for each dimension. The shaded ellipse is a 95% region which accounts for the estimated correlation between the two quantities: -0.77.



(a) Size at age

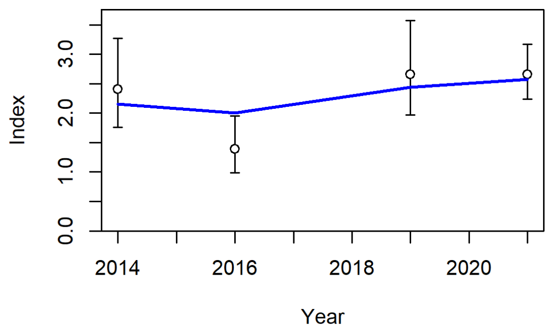


(b) Observed and expected landings

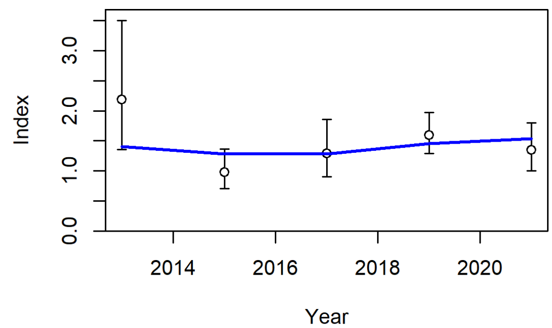


(c) Selectivity

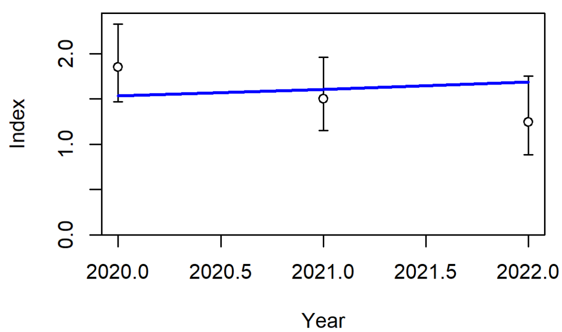
Figure 35: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; and (c) selectivity at length by fleet.



(a) Index PR NCRMP

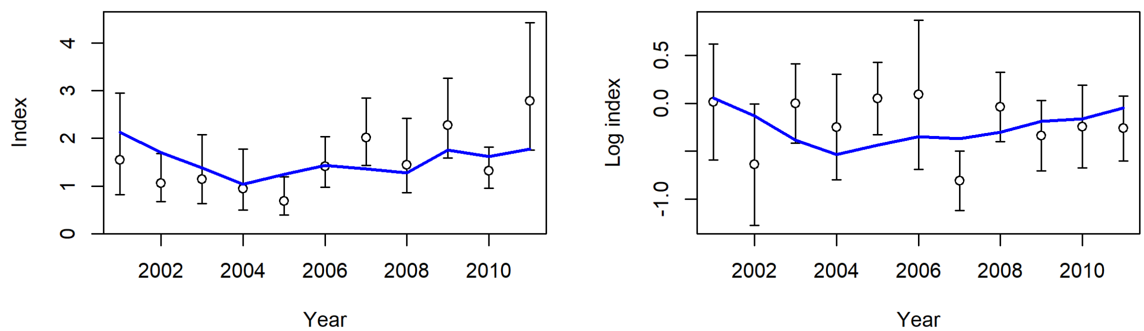


(b) Index STTJ NCRMP



(c) Index STTJ DCRMP

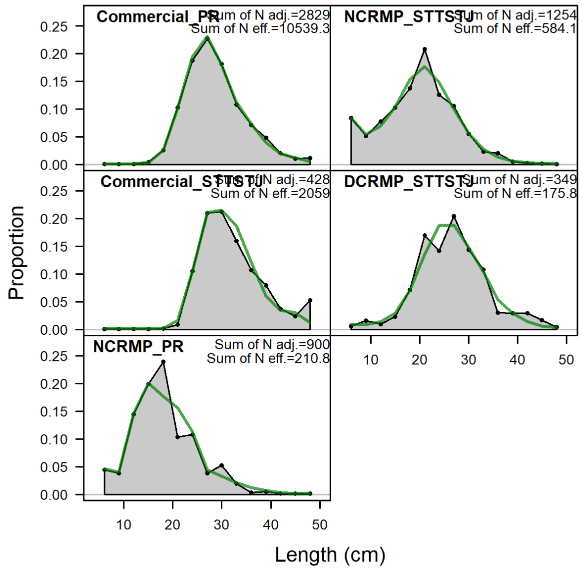
Figure 36: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Fit to index data for the (a) Puerto Rico NCRMP survey, (b) St. Thomas and St. John NCRMP survey, and (c) St. Thomas and St. John DCRMP survey.



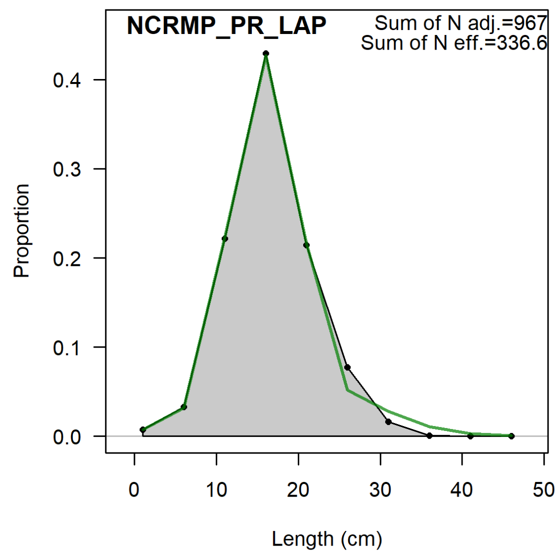
(a) Index PR La Parguera

(b) Index STJ

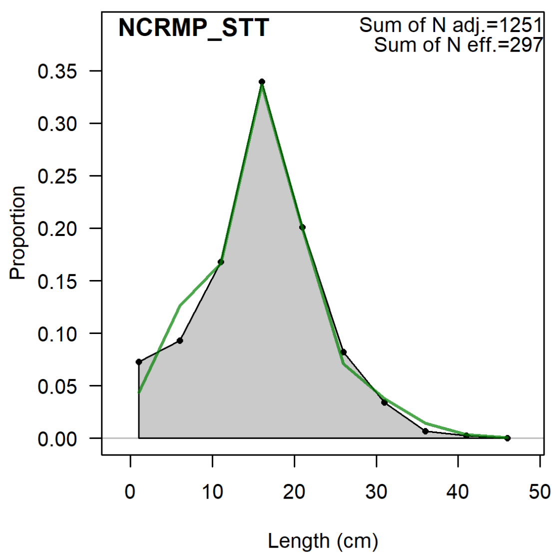
Figure 37: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Fit to index data for the (a) Puerto Rico La Parguera survey, and (b) St. John survey.



(a) Length fit aggregated across time 1 of 3

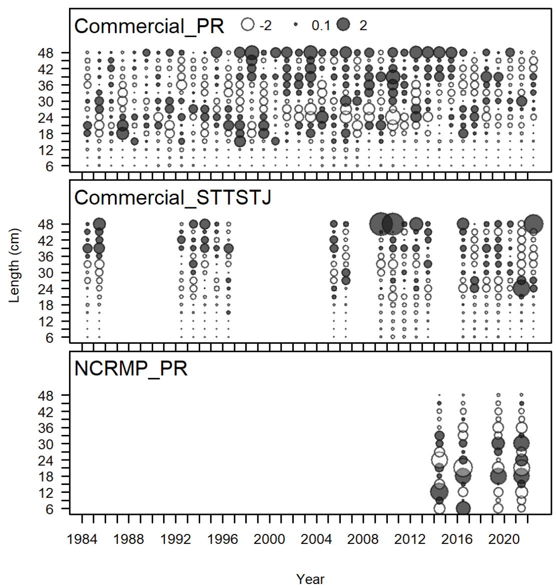


(b) Length fit aggregated across time 2 of 3

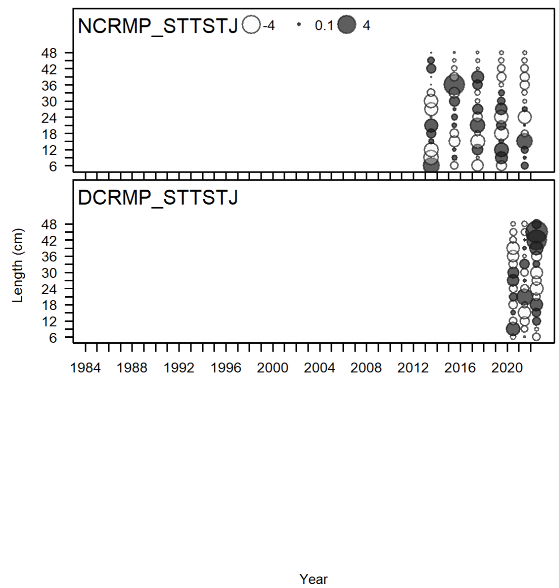


(c) Length fit aggregated across time 3 of 3

Figure 38: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

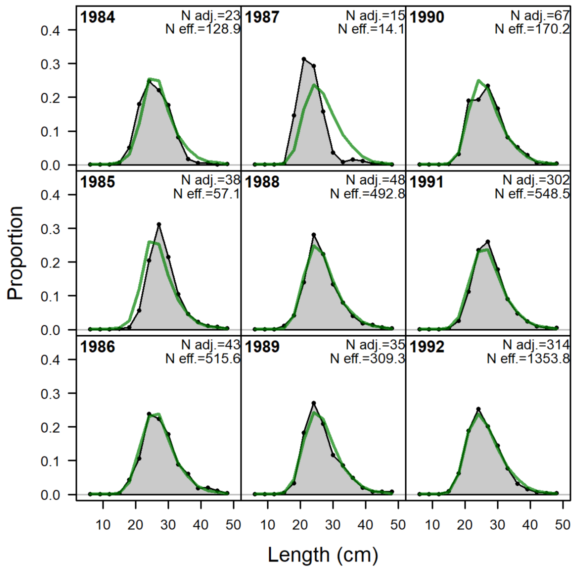


(a) Length fit pg. 1

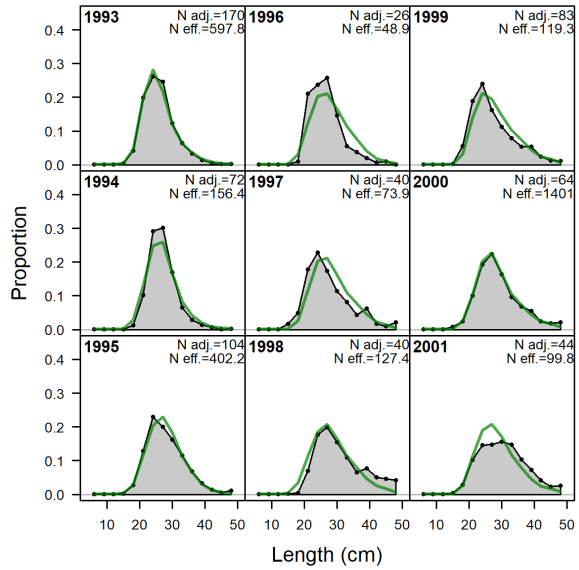


(b) Length fit pg. 2

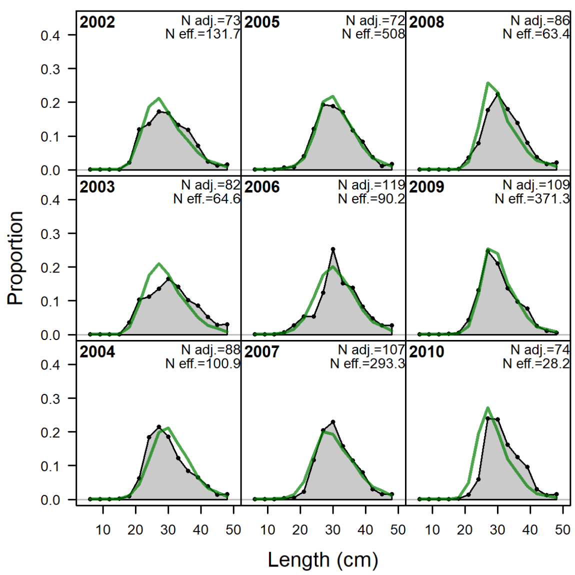
Figure 39: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).



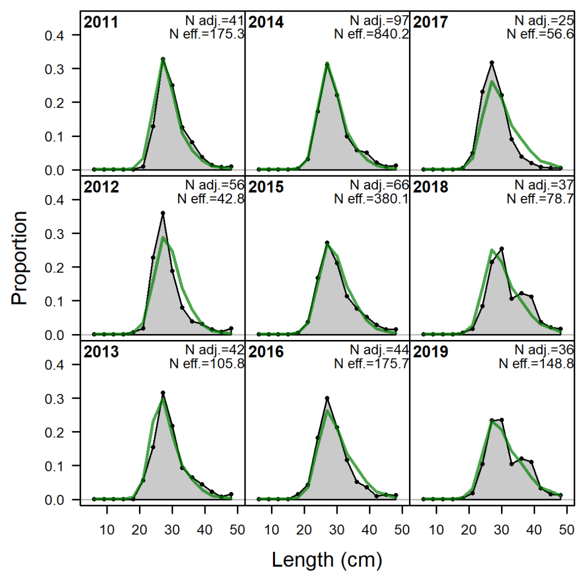
(a) Length comps PR Commercial pg. 1 of 5



(b) Length comps PR Commercial pg. 2 of 5

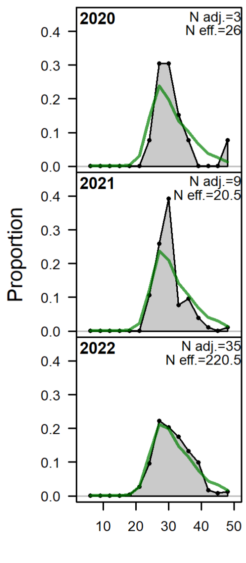


(c) Length comps PR Commercial pg. 3 of 5

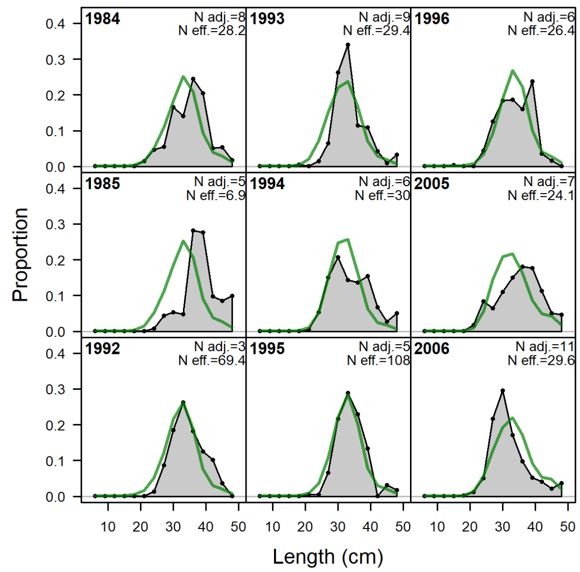


(d) Length comps PR Commercial pg. 4 of 5

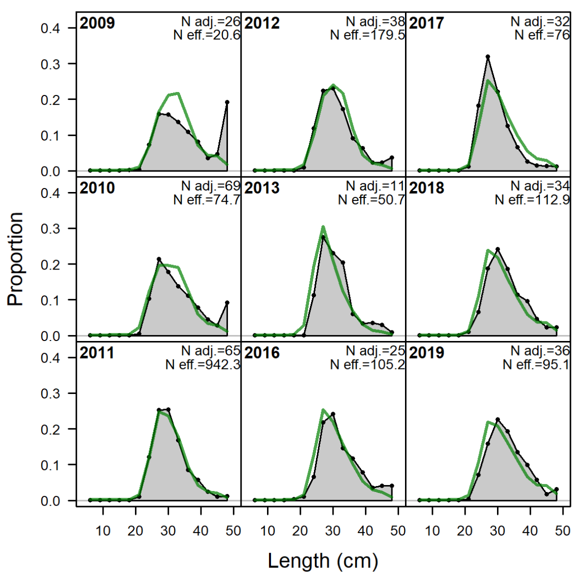
Figure 40: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Observed and predicted length distributions in centimeters, by year for the Puerto Rico commercial fleet.



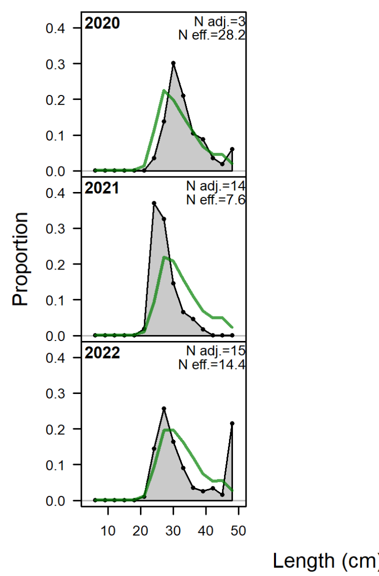
(a) Length comps PR Commercial pg. 5 of 5



(b) Length comps STTJ Commercial pg. 1 of 3

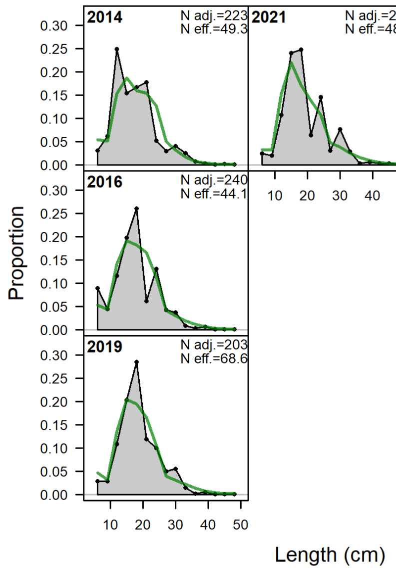


(c) Length comps STTJ Commercial pg. 2 of 3

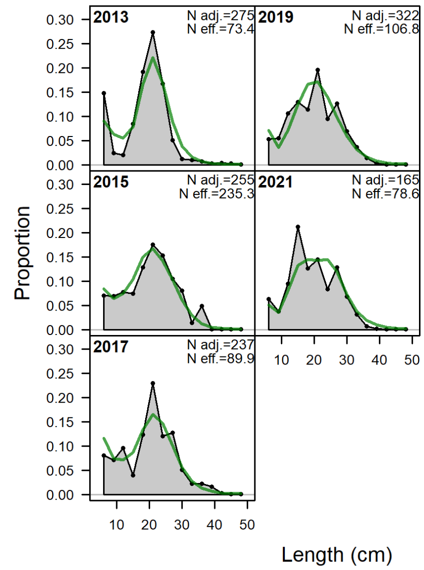


(d) Length comps STTJ Commercial pg. 3 of 3

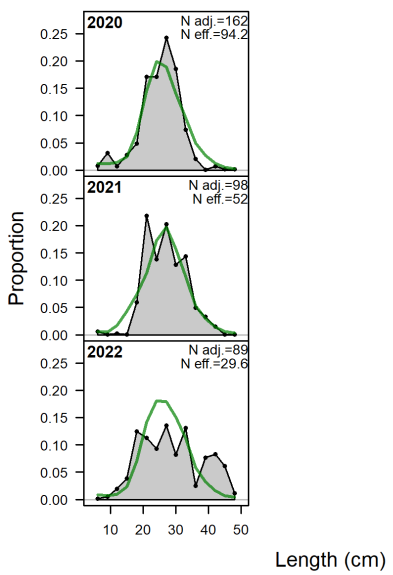
Figure 41: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Observed and predicted length distributions in centimeters, by year for (a) the Puerto Rico commercial fleet (continued); and (b-d) the St. Thomas and St. John Commercial Fleet. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



(a) Length comps PR NCRMP

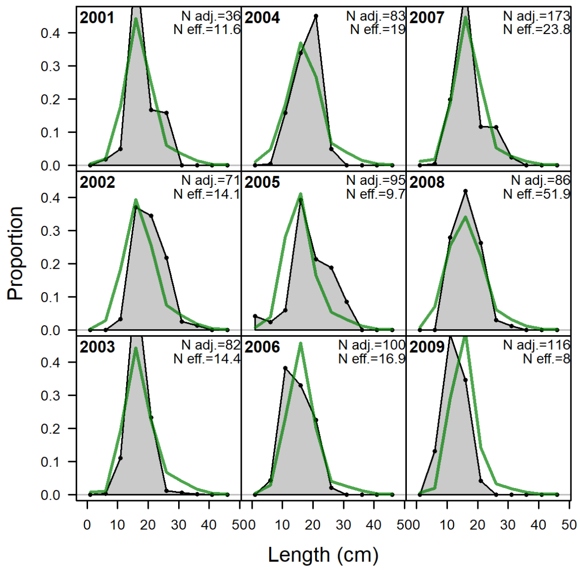


(b) Length comps STTJ NCRMP

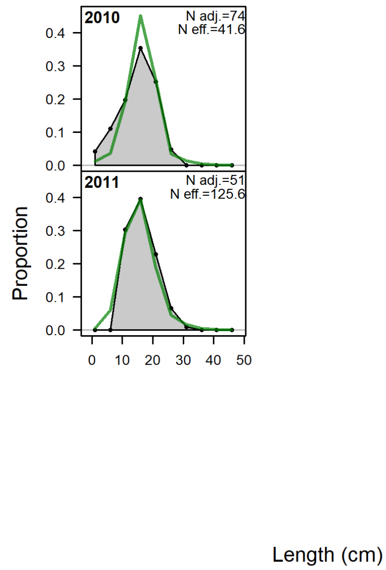


(c) Length comps STTJ DCRMP

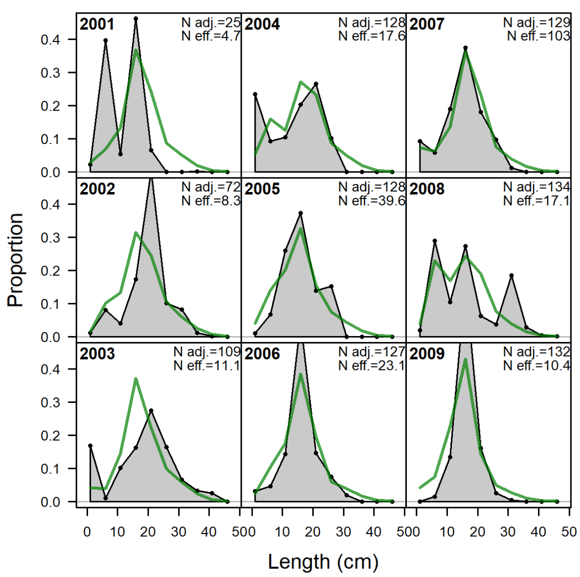
Figure 42: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Observed and predicted length distributions in centimeters, by year for (a) the Puerto Rico NCRMP survey; (b) the St. Thomas and St. John NCRMP survey; and (c) the St. Thomas and St. John DCRMP survey. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



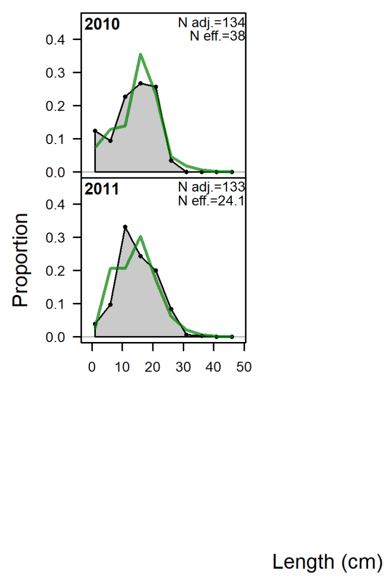
(a) Length comps PR La Parguera pg. 1



(b) Length comps PR La Parguera pg. 2

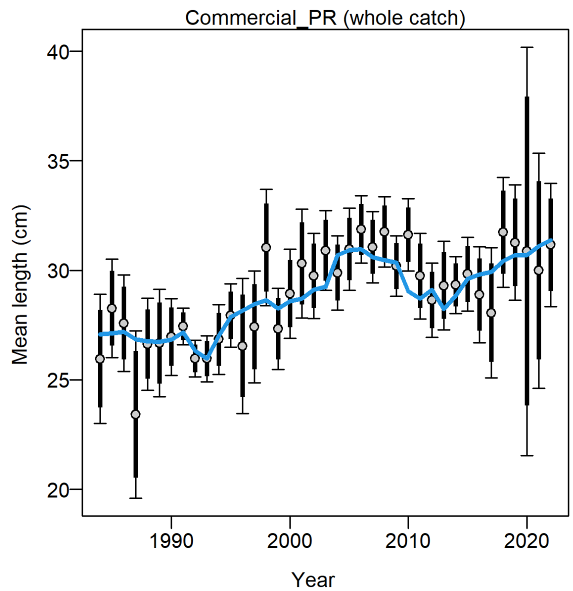


(c) Length comps STJ pg. 1

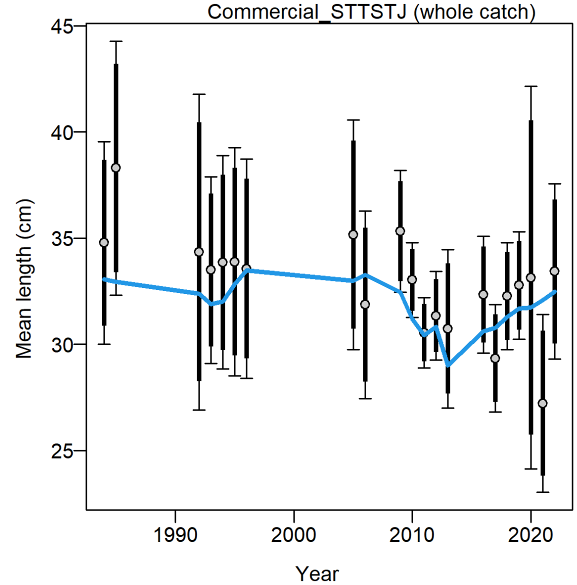


(d) Length comps STJ pg. 2

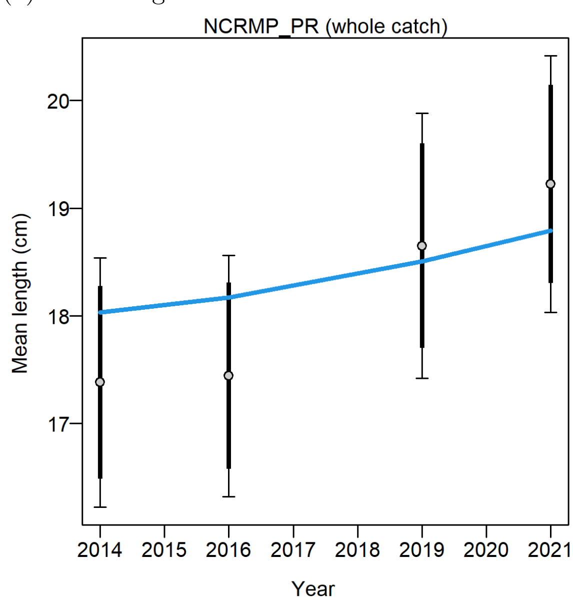
Figure 43: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Observed and predicted length distributions in centimeters, by year for (a-b) the Puerto Rico La Parguera survey; and (c-d) St. John survey. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



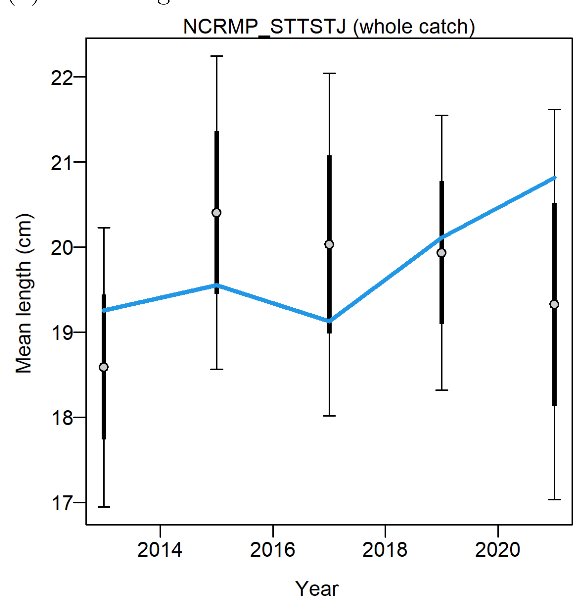
(a) Mean length PR Commercial



(b) Mean length STTJ Commercial

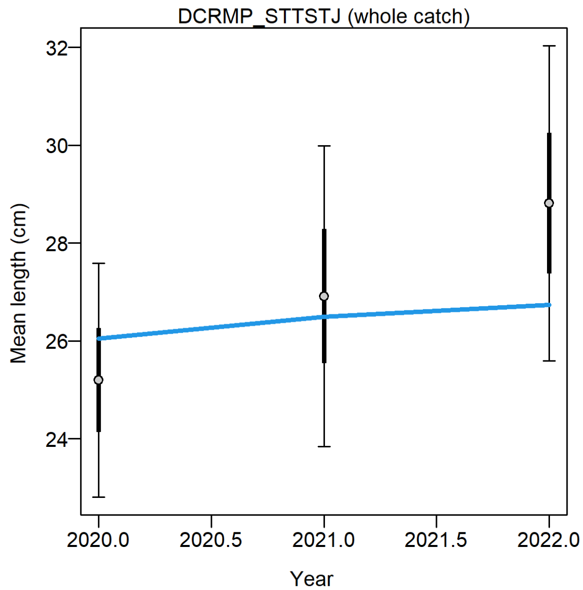


(c) Mean length PR NCRMP

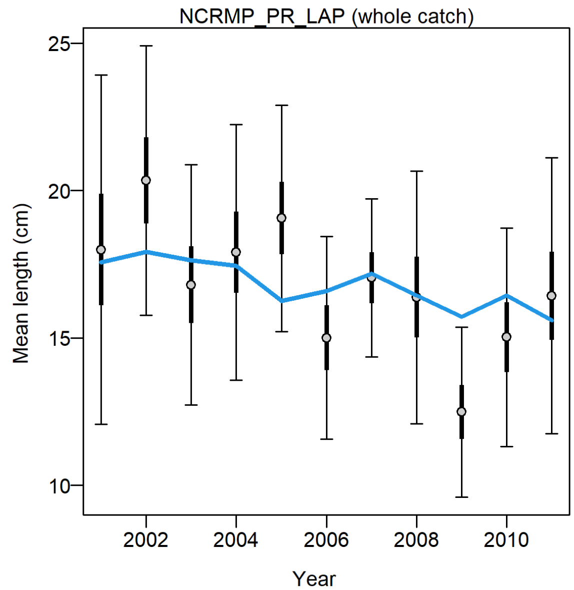


(d) Mean length STTJ NCRMP

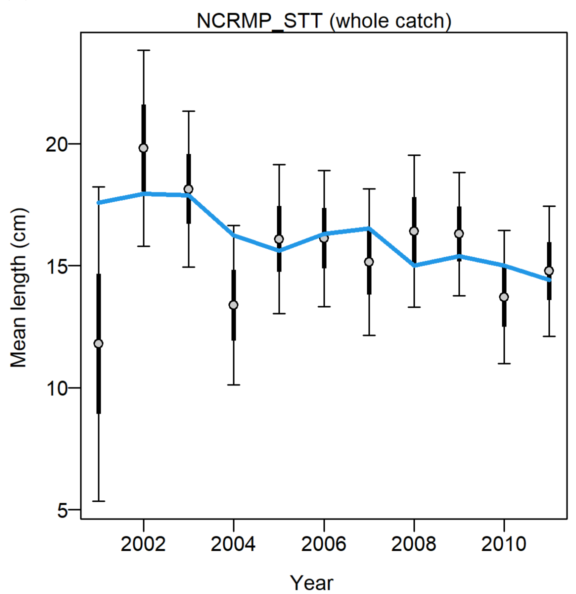
Figure 44: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Mean length for with 95% confidence intervals for (a) the Puerto Rico commercial fleet, (b) the St. Thomas and St. John commercial fleet, (c) the Puerto Rico NCRMP survey, and (d) the St. Thomas and St. John NCRMP survey.



(a) Mean length STTJ DCRMP

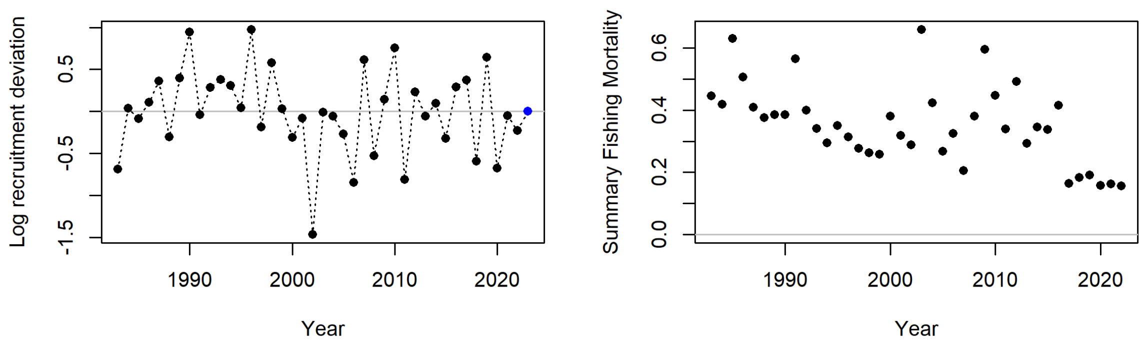


(b) Mean length PR La Parguera



(c) Mean length STJ

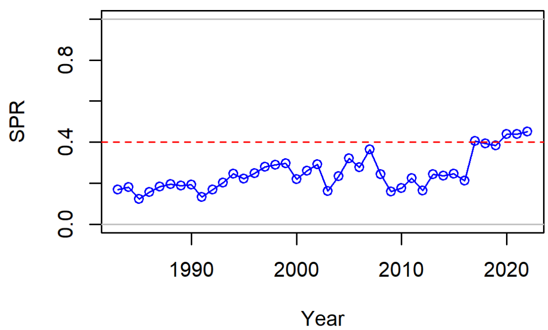
Figure 45: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. Mean length for with 95% confidence intervals for (a) the Saint Thomas and St. John DCRMP survey, (b) the Puerto Rico La Parguera survey, and (c) the St. John survey.



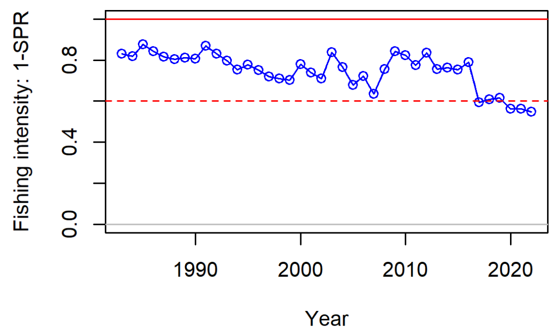
(a) Recruitment deviations

(b) Fishing Mortality

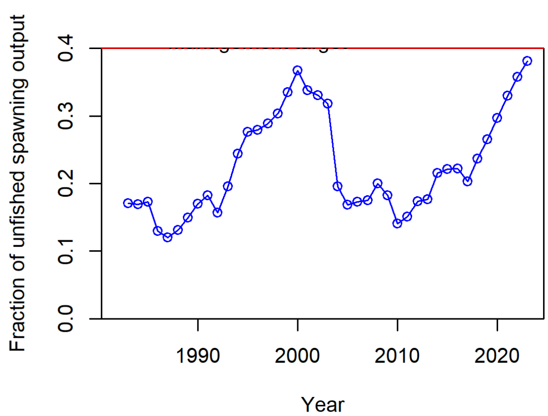
Figure 46: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. (a) Recruitment deviations; and (b) fishing mortality (total biomass killed / total biomass).



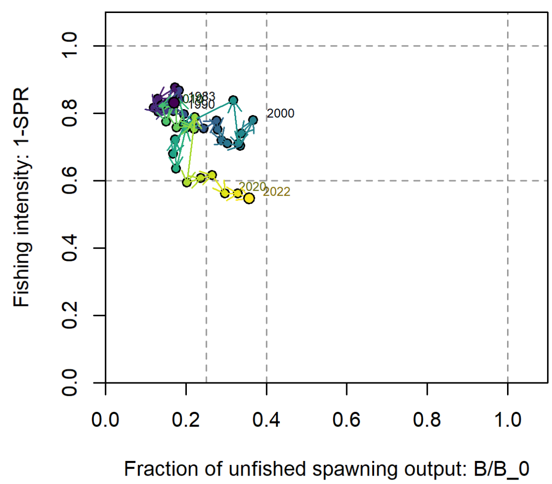
(a) SPR



(b) SPR Ratio

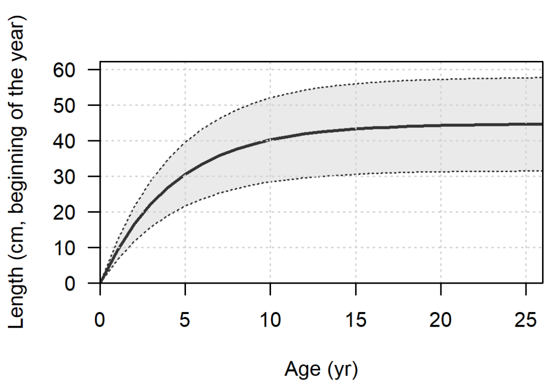


(c) Unfished ratio

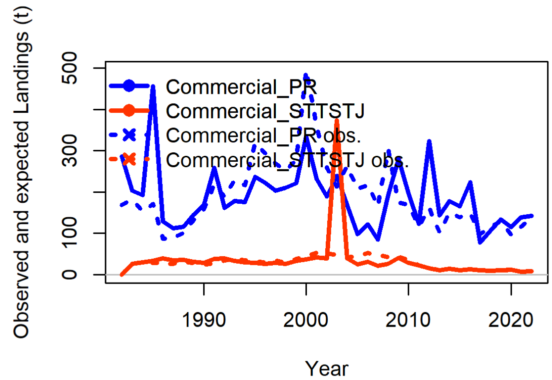


(d) SPR Phase

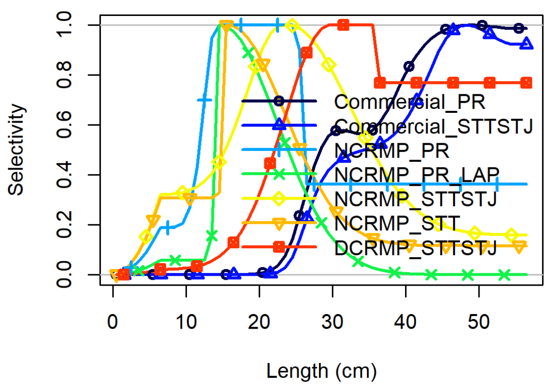
Figure 47: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_1. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4; (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass). Horizontal reference line at SPR target: 0.4; and (d) phase plot of biomass ratio vs. SPR ratio where warmer colors (red) represent early years and colder colors (blue) represent recent years.



(a) Size at age

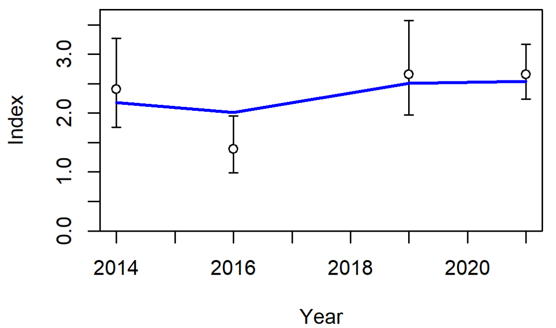


(b) Observed and expected landings

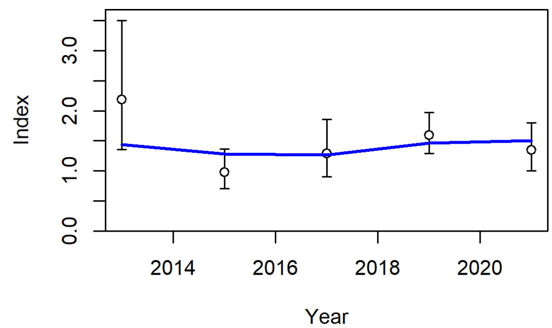


(c) Selectivity

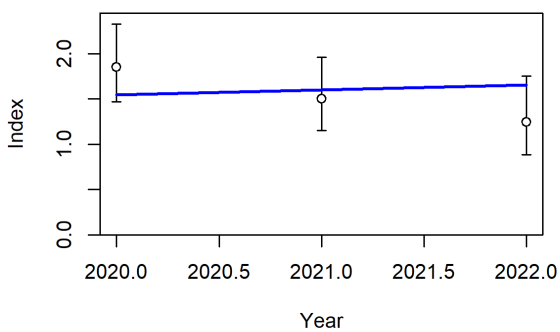
Figure 48: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; and (c) selectivity at length by fleet.



(a) Index PR NCRMP

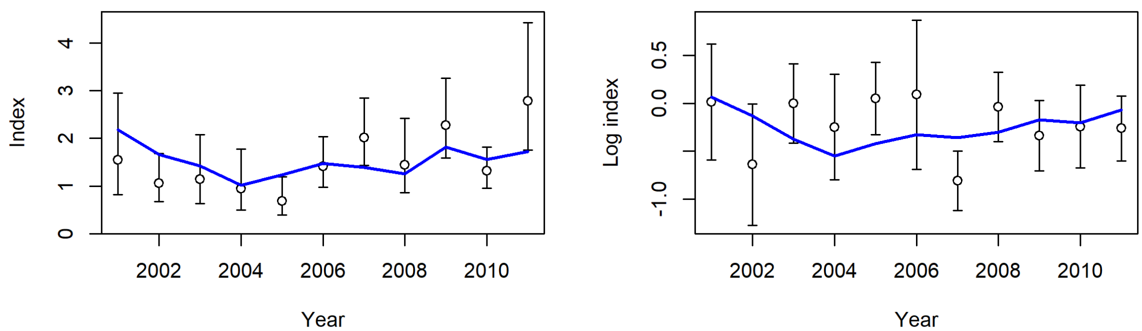


(b) Index STTJ NCRMP



(c) Index STTJ DCRMP

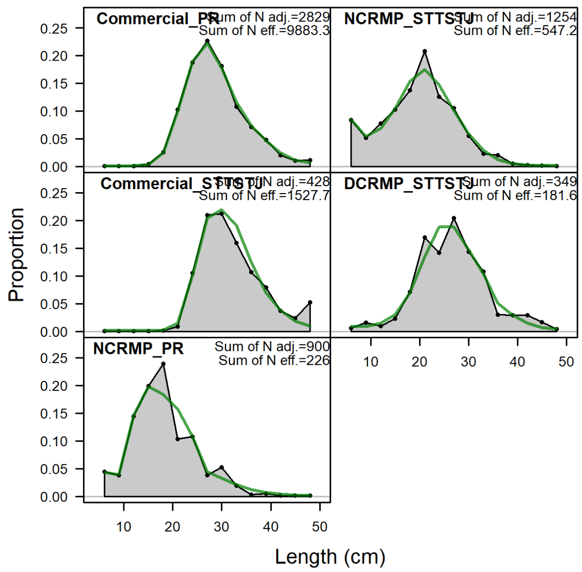
Figure 49: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Fit to index data for the (a) Puerto Rico NCRMP survey, (b) St. Thomas and St. John NCRMP survey, and (c) St. Thomas and St. John DCRMP survey.



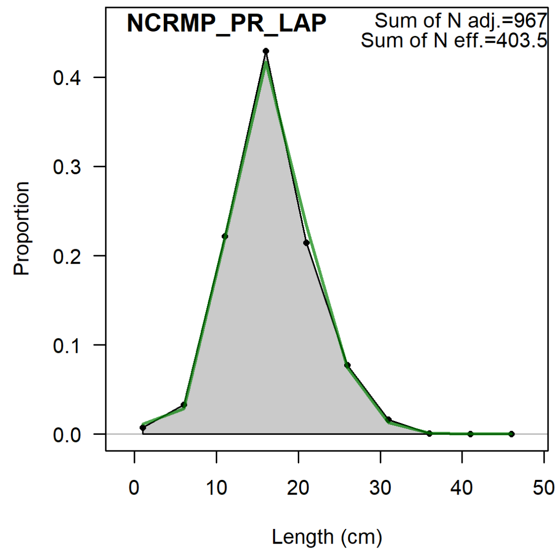
(a) Index PR La Parguera

(b) Index STJ

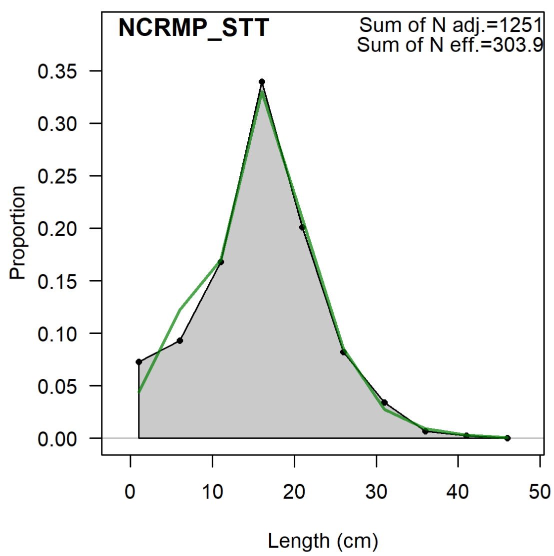
Figure 50: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Fit to index data for the (a) Puerto Rico La Parguera survey, and (b) St. John survey.



(a) Length fit aggregated across time 1 of 3

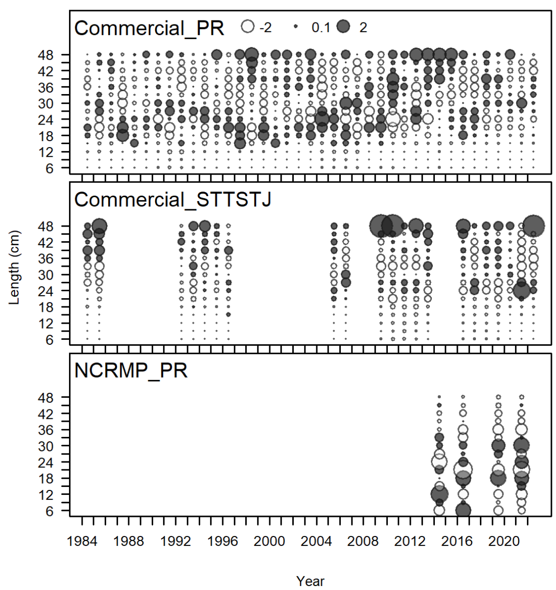


(b) Length fit aggregated across time 2 of 3

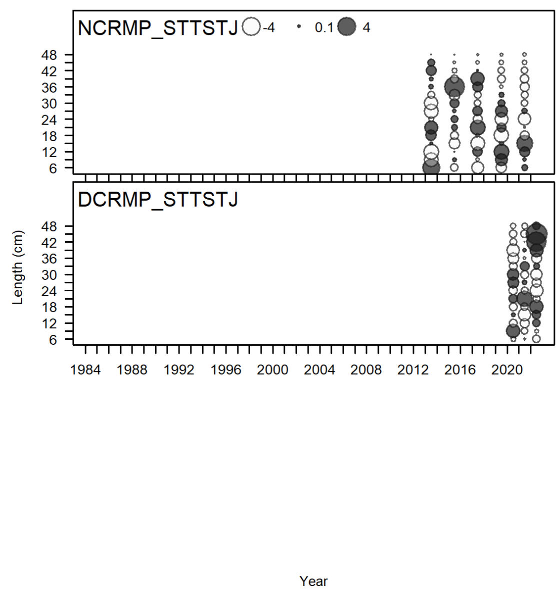


(c) Length fit aggregated across time 3 of 3

Figure 51: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

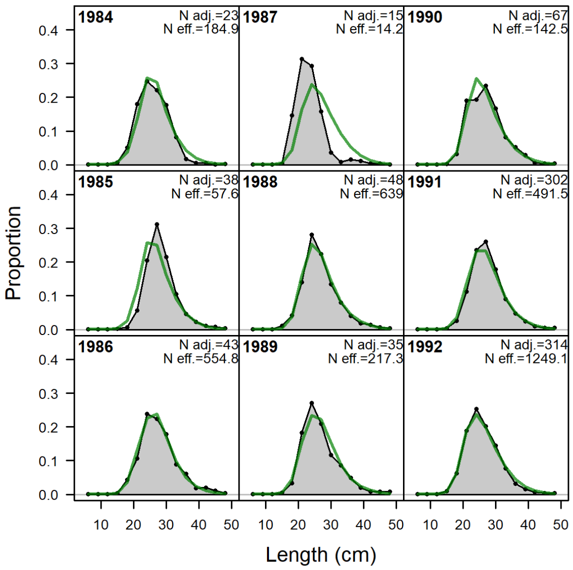


(a) Length fit pg. 1

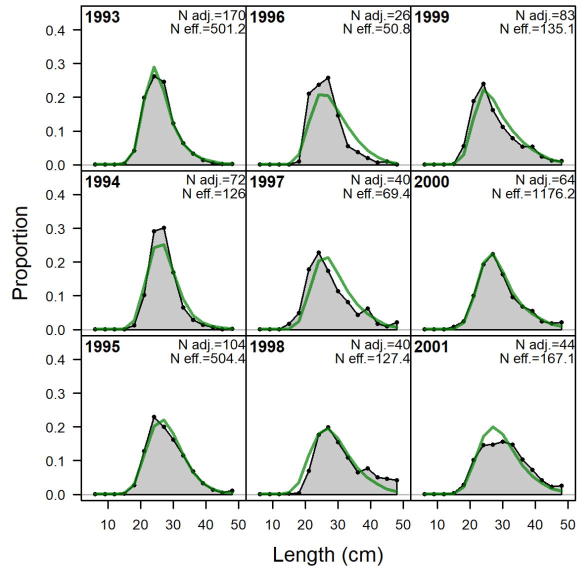


(b) Length fit pg. 2

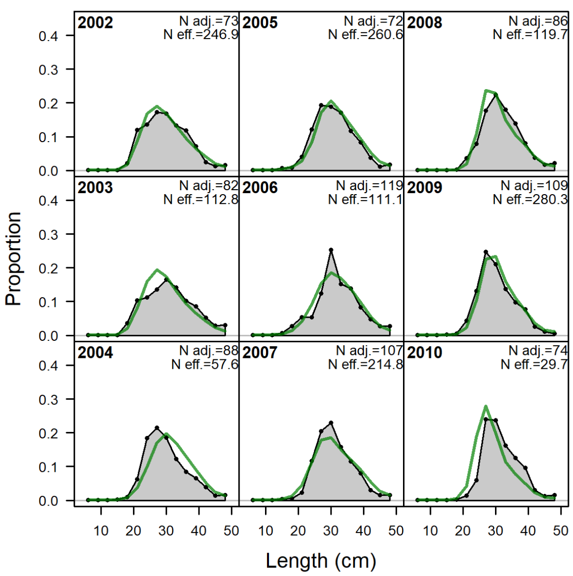
Figure 52: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).



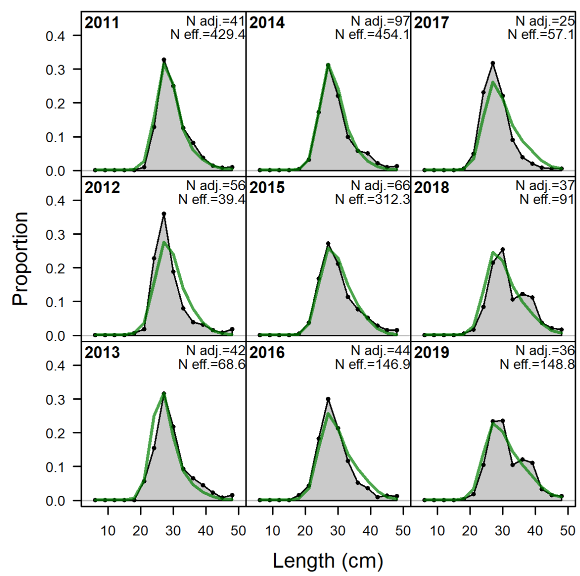
(a) Length comps PR Commercial pg. 1 of 5



(b) Length comps PR Commercial pg. 2 of 5

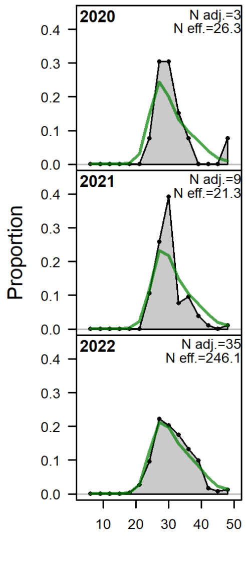


(c) Length comps PR Commercial pg. 3 of 5

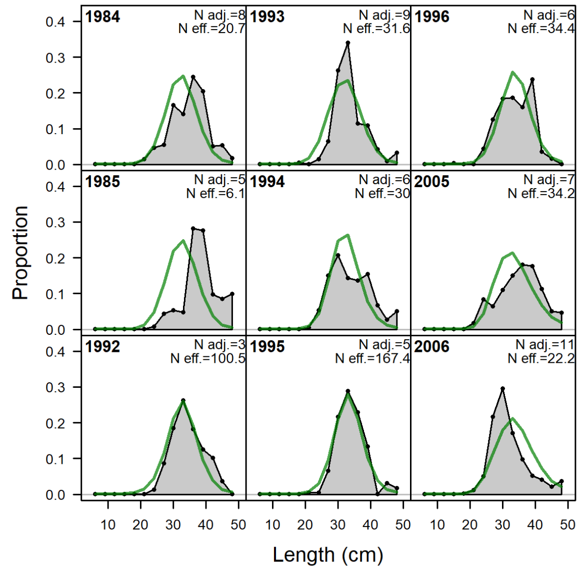


(d) Length comps PR Commercial pg. 4 of 5

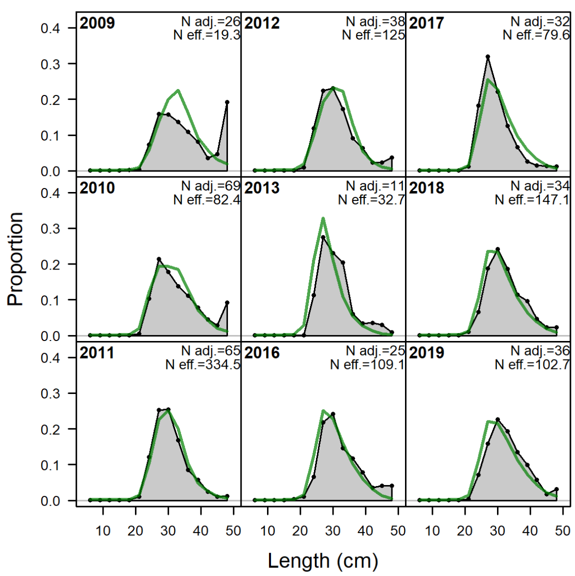
Figure 53: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Observed and predicted length distributions in centimeters, by year for the Puerto Rico commercial fleet.



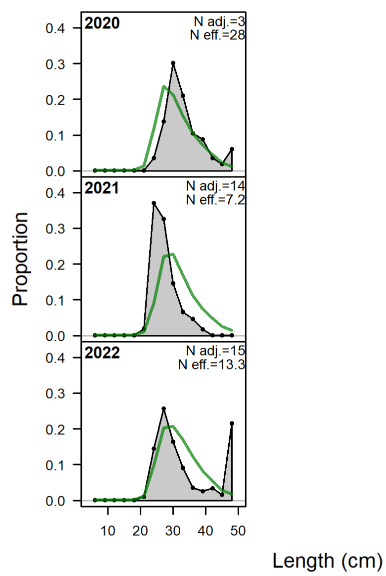
(a) Length comps PR Commercial pg. 5 of 5



(b) Length comps STTJ Commercial pg. 1 of 3

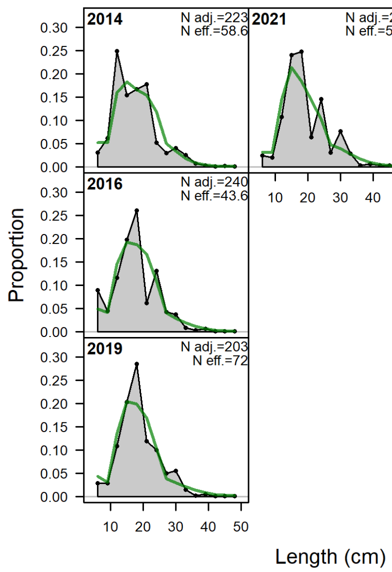


(c) Length comps STTJ Commercial pg. 2 of 3

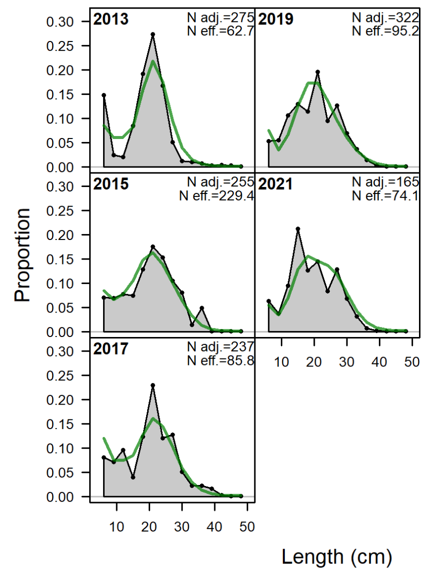


(d) Length comps STTJ Commercial pg. 3 of 3

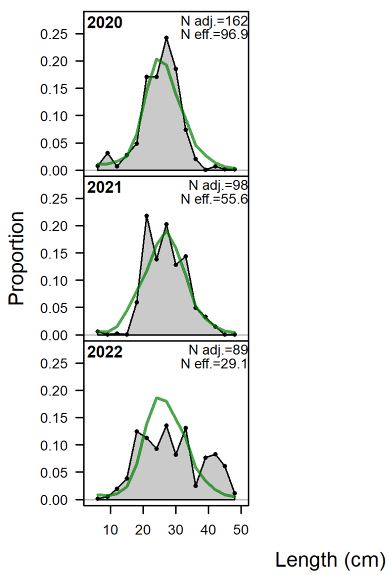
Figure 54: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Observed and predicted length distributions in centimeters, by year for (a) the Puerto Rico commercial fleet (continued); and (b-d) the St. Thomas and St. John Commercial Fleet. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



(a) Length comps PR NCRMP

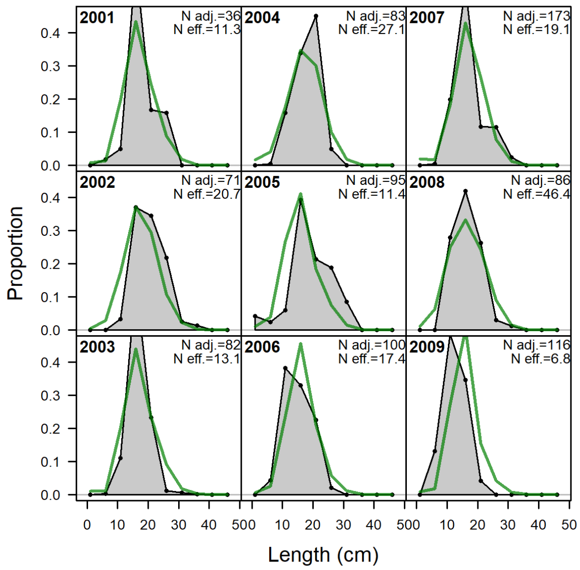


(b) Length comps STTJ NCRMP

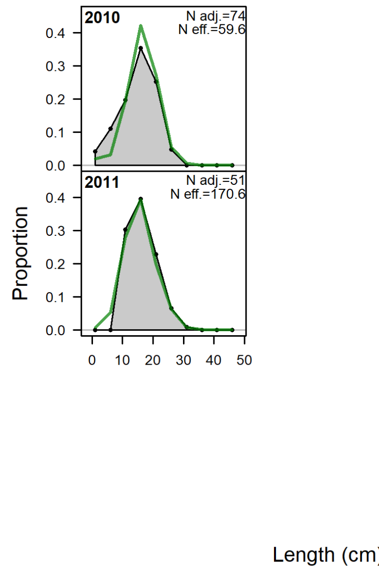


(c) Length comps STTJ DCRMP

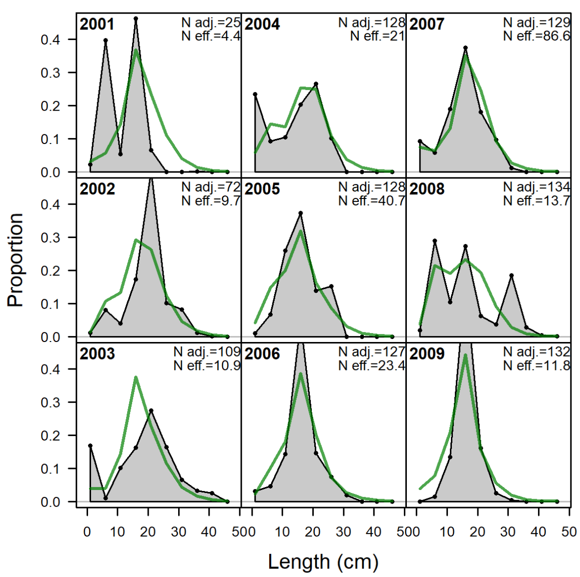
Figure 55: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Observed and predicted length distributions in centimeters, by year for (a) the Puerto Rico NCRMP survey; (b) the St. Thomas and St. John NCRMP survey; and (c) the St. Thomas and St. John DCRMP survey. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



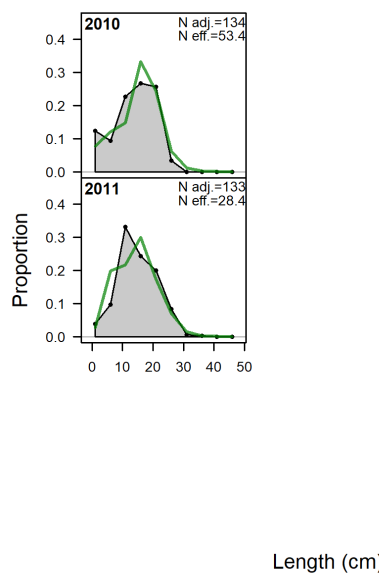
(a) Length comps PR La Parguera pg. 1



(b) Length comps PR La Parguera pg. 2

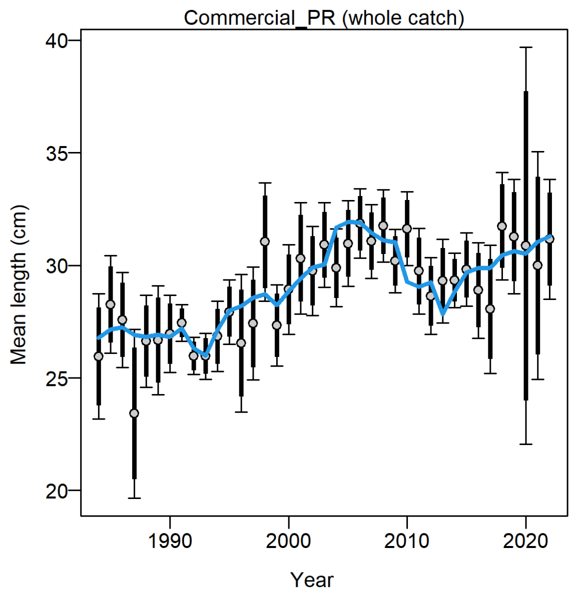


(c) Length comps STJ pg. 1

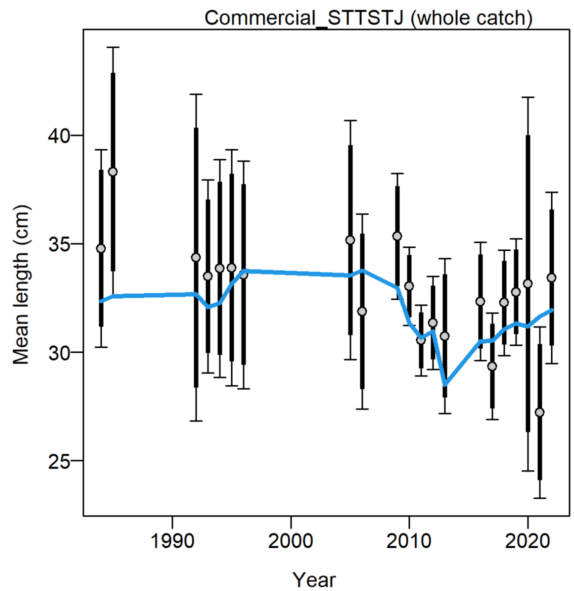


(d) Length comps STJ pg. 2

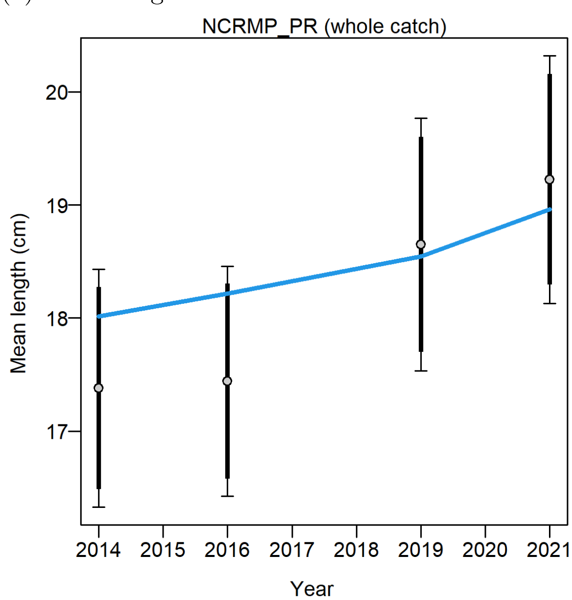
Figure 56: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Observed and predicted length distributions in centimeters, by year for (a-b) the Puerto Rico La Parguera survey; and (c-d) St. John survey. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



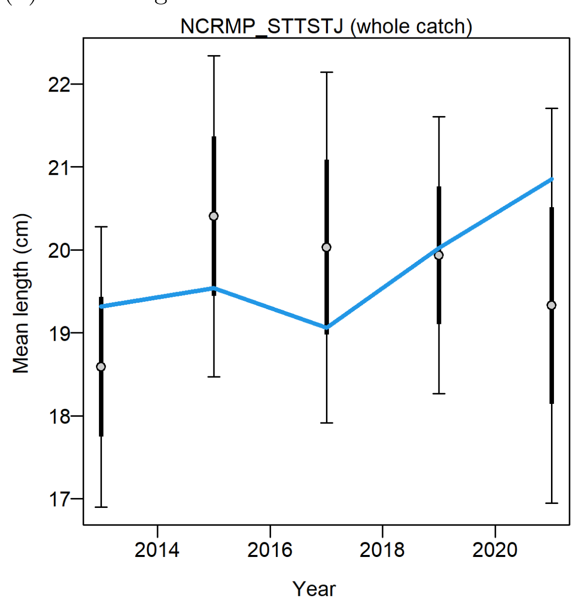
(a) Mean length PR Commercial



(b) Mean length STTJ Commercial

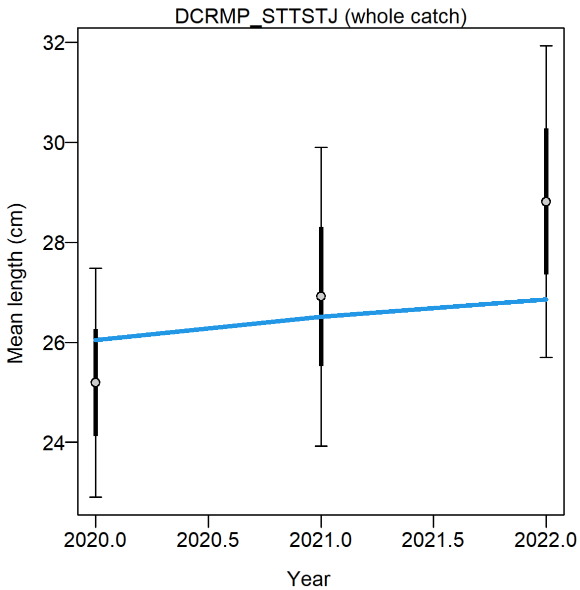


(c) Mean length PR NCRMP

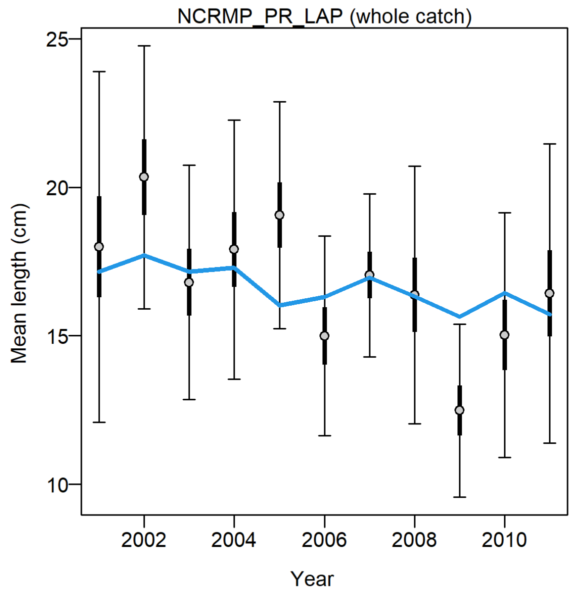


(d) Mean length STTJ NCRMP

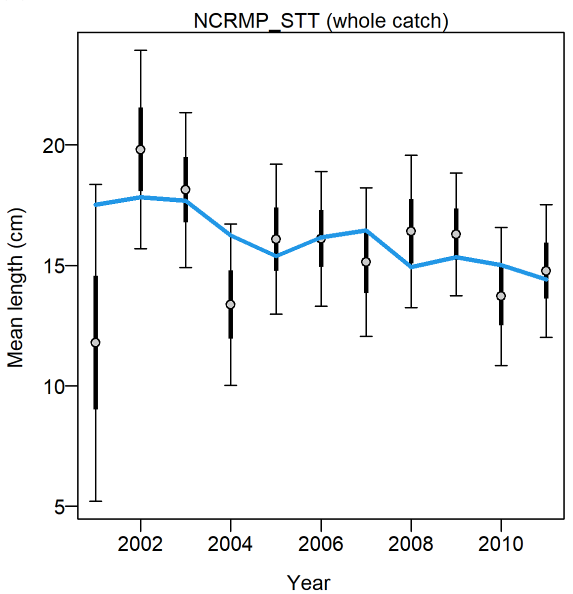
Figure 57: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Mean length for with 95% confidence intervals for (a) the Puerto Rico commercial fleet, (b) the St. Thomas and St. John commercial fleet, (c) the Puerto Rico NCRMP survey, and (d) the St. Thomas and St. John NCRMP survey.



(a) Mean length STTJ DCRMP

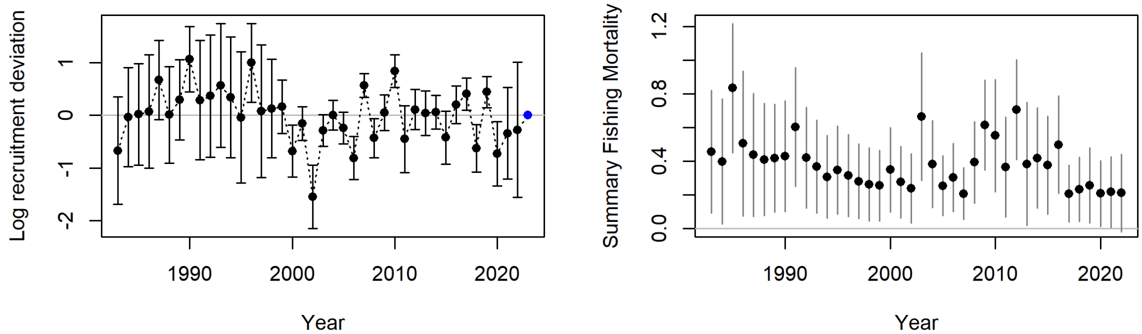


(b) Mean length PR La Parguera



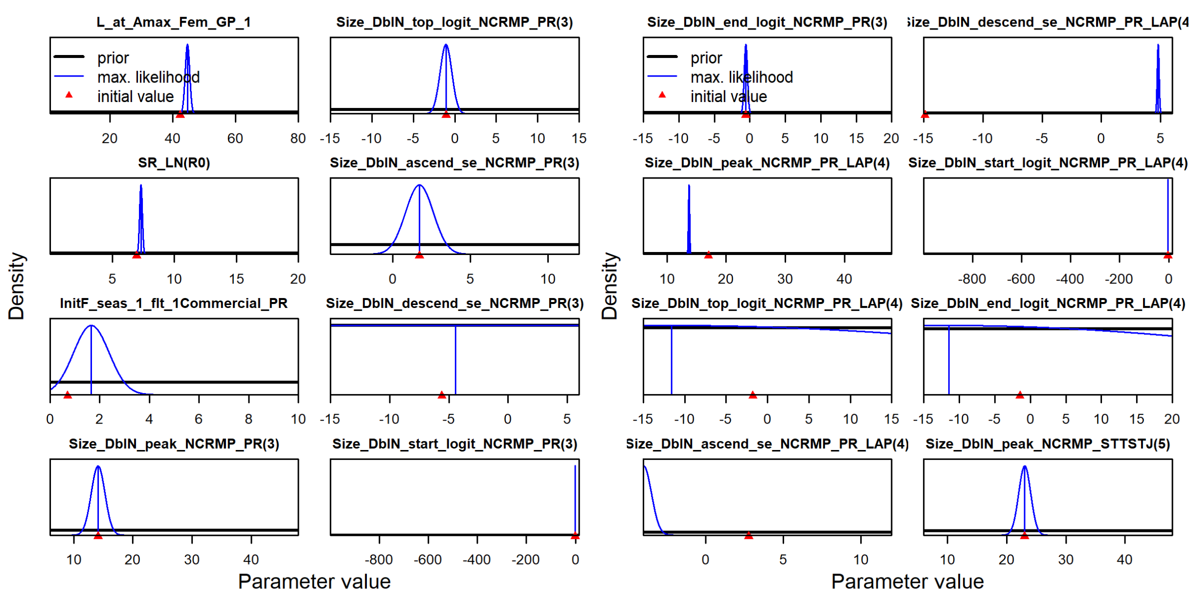
(c) Mean length STJ

Figure 58: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. Mean length for with 95% confidence intervals for (a) the Saint Thomas and St. John DCRMP survey, (b) the Puerto Rico La Parguera survey, and (c) the St. John survey.



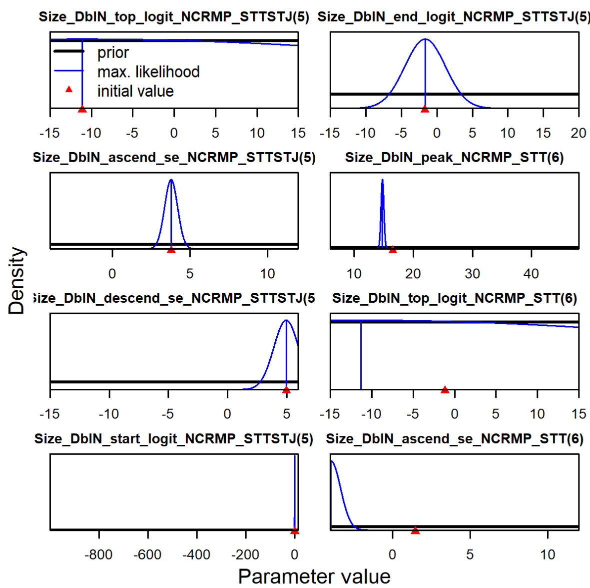
(a) Recruitment deviations (b) Fishing Mortality

Figure 59: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. (a) Recruitment deviations with 95% intervals; and (b) fishing mortality (total biomass killed / total biomass).

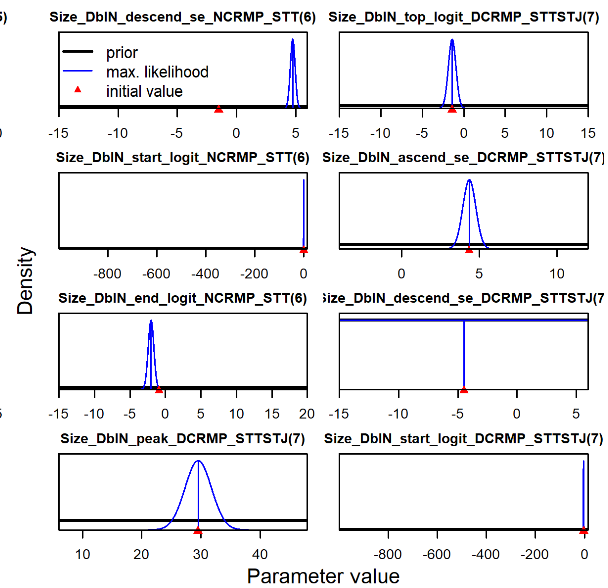


(a) Parameters pg. 1 of 5 (b) Parameters pg. 2 of 5

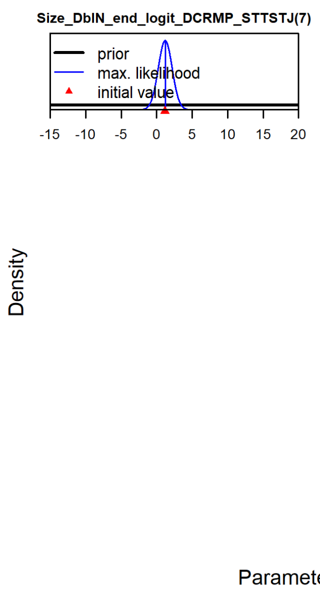
Figure 60: Parameter distribution plots for the Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2.



(a) Parameters pg. 3 of 5

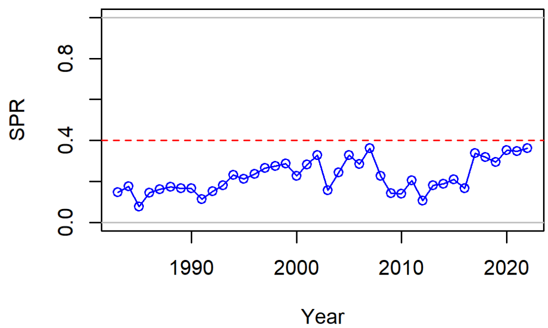


(b) Parameters pg. 4 of 5

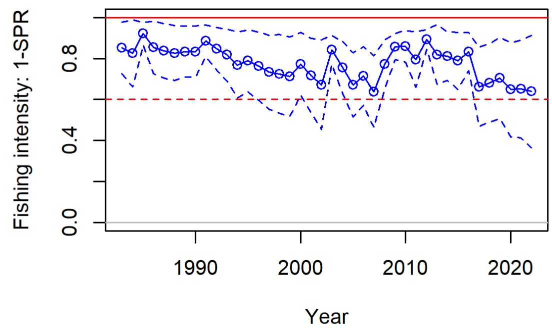


(c) Parameters pg. 5 of 5

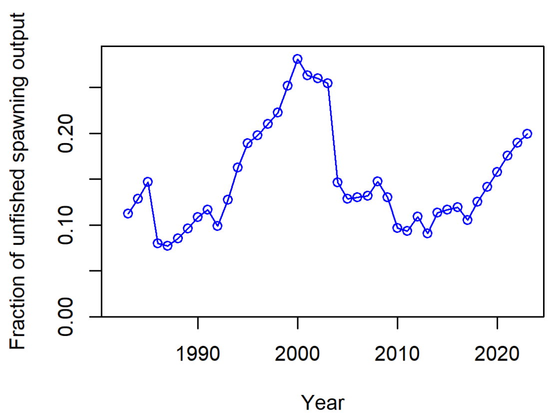
Figure 61: Parameter distribution plots for the Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2 (continued).



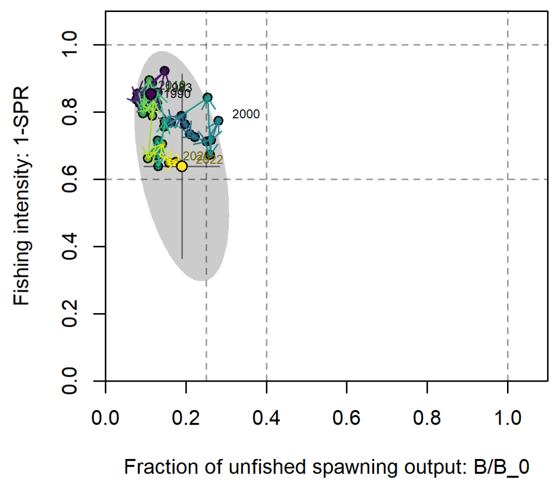
(a) SPR



(b) SPR Ratio



(c) Unfished ratio



(d) SPR Phase

Figure 62: Puerto Rico Yellowtail Snapper Review Workshop Model PR_STTJ_RW_2. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4; (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass) with ~95% asymptotic intervals; and (d) phase plot of biomass ratio vs. SPR ratio where warmer colors (red) represent early years and colder colors (blue) represent recent years. Lines through the final point show 95% intervals based on the asymptotic uncertainty for each dimension. The shaded ellipse is a 95% region which accounts for the estimated correlation between the two quantities: -0.416.