SEDAR
Southeast Data, Assessment, and Review

SEDAR 84
Stock Assessment Report

US Caribbean Yellowtail Snapper – St. Thomas/ St. John

August 2025

SEDAR
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US Caribbean Yellowtail Snapper – St. Thomas/ St. John

SECTION I: Introduction

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Overview

SEDAR 84 addressed the stock assessment for US Caribbean Yellowtail Snapper – St. Thomas & St. John. 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 – St. Thomas & St. John 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

St. Thomas and St. John Yellowtail Snapper are managed under the St. Thomas and St. John 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 allowable biological catch and the annual catch limit are 93,634 and 88,952 pounds whole weight, respectively. In the U.S. Virgin Islands, recreational landings data are not available, so annual catch limits are based on commercial landings data. The annual catch limits apply to all harvest for the stocks and stock complexes in federal waters, whether commercial or recreational.

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. The size limit only applies to the U.S. Exclusive Economic Zone (EEZ), which is defined as the federal waters ranging from 3 to 200 nautical miles (5.6 – 370 kilometers) from the nearest coastline point of the U.S. Virgin Islands (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. No regulations exist for Yellowtail Snapper in territorial waters.

References

Crabtree, Roy E. (2019). Comprehensive Fishery Management Plan for the St. Thomas and St. John Exclusive Economic Zone Including Environmental Assessment, Regulatory Impact Review, and Fishery Impact Statement. https://repository.library.noaa.gov/view/noaa/45276

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/

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

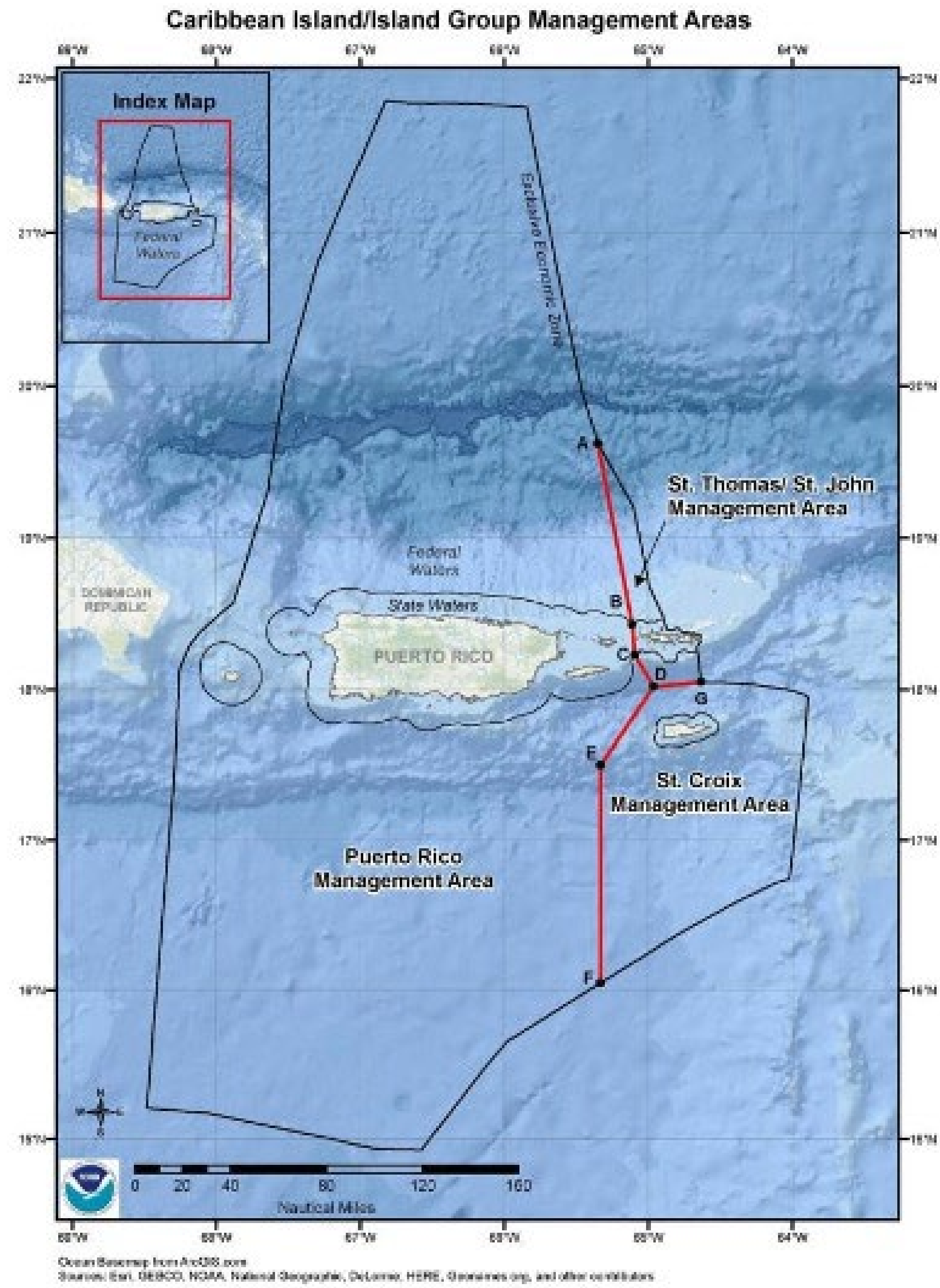

Figure 4.1 Jurisdictional boundaries of the Caribbean Fishery Management Council.

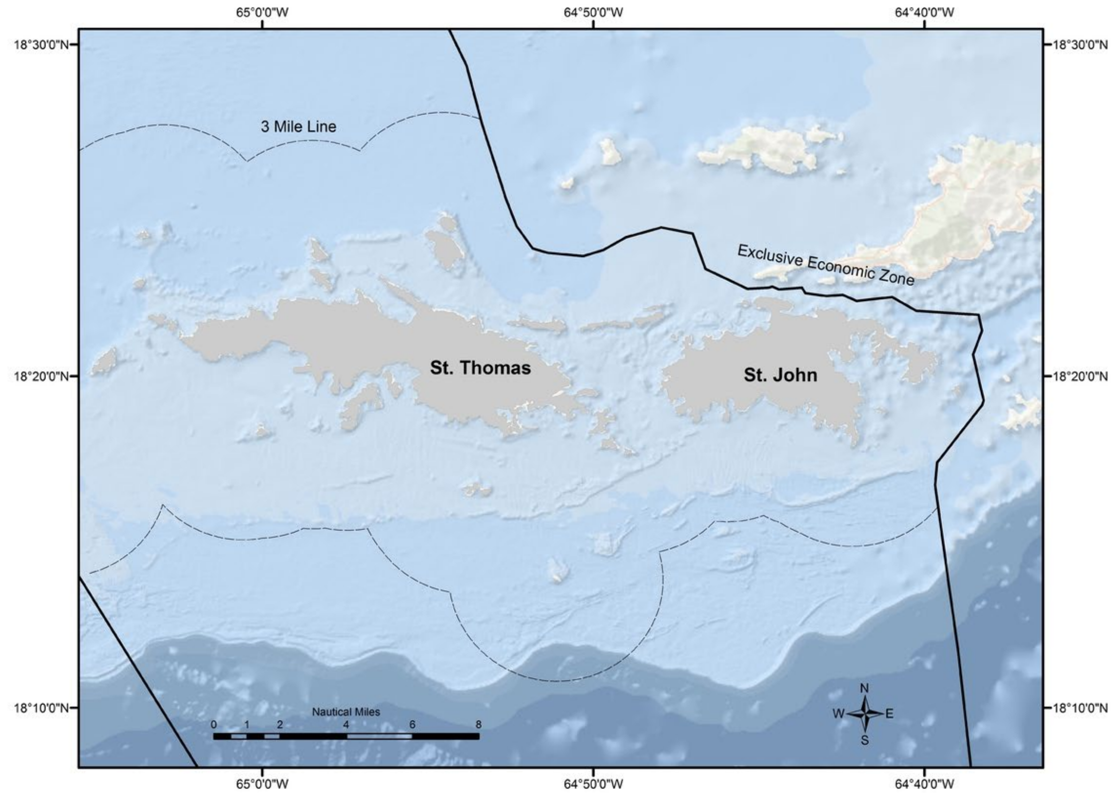

Figure 4.2: The U.S. Exclusive Economic Zone is defined as the federal waters ranging from 3 to 200 nautical miles (5.6 – 370 kilometers) from the nearest coastline point of the US Virgin Islands.

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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US Caribbean Yellowtail Snapper – St. Thomas/St. John

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
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M. Refik Orhun ....NMFS/SEFSC
Jesus M. Rivera-Hernández ....Univ SC
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Derek Soto ....

Staff

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

Workshop Observers

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

Data Process Webinar Observers
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Edwin Javier Arroyo..........
Rachal Banton..........
David Behringer..........
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Sophia Costa..........
Carly Daiek..........
Todd Gedamke..........MER Consultants
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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. Yellowtail Snapper life history data were provided in Shervette et al. (2024b).

2.2 Stock Definition and Description

The Yellowtail Snapper stock was defined by the CFMC Island-based Fishery Management Plan. The St. Thomas/St. John (SSTJ) stock is defined as the population within the U.S. Virgin Island's territorial waters; i.e., the island platforms of St. Thomas and St. John 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 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_∞ 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 with peak spawning from March-April.

A total of 454 female Yellowtail Snapper samples were evaluated for maturity and indicators of active spawning to use in estimating 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 Bertalanffy (VB) growth parameters for various length variables (Shervette et al. 2024). Figure 2.1 shows the fishery-dependent (FD) and fishery independent 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 on Use 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 show a reproduction peak from March to June, suggesting that the data can be combined.
- We are tentatively accepting 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.

Parameter	Definition	Management Strategy evaluation Stock Input	Real world data input	Units
L∞	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∞	Asymptotic weight	--	--	g
Lm	Length at maturity	L50	L50	mm FL
tm	Age at maturity	--	--	years
tλ	Maximum age	Max. age	Max. Age	years
Lλ	Mean length of Max age	--	--	mm FL
M	Natural mortality	M	Mort	year $^{-1}$
Sλ	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	$y = 0.00004x^{2.8642}$	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	1876	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 VBGF results. Parameter estimates are provided using FL and TL. Also provided are computed parameter estimates using to= -0.96 for comparison with the Caribbean study by Manooch and Drennon (1987) and using to= -1.93 for comparison with growth parameter estimates for Florida Yellowtail Snapper as reported in SEDAR 64.

Model	Loo**(mm)**	**K**	to	**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 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	$L_\infty/K/t_0$ 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. 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

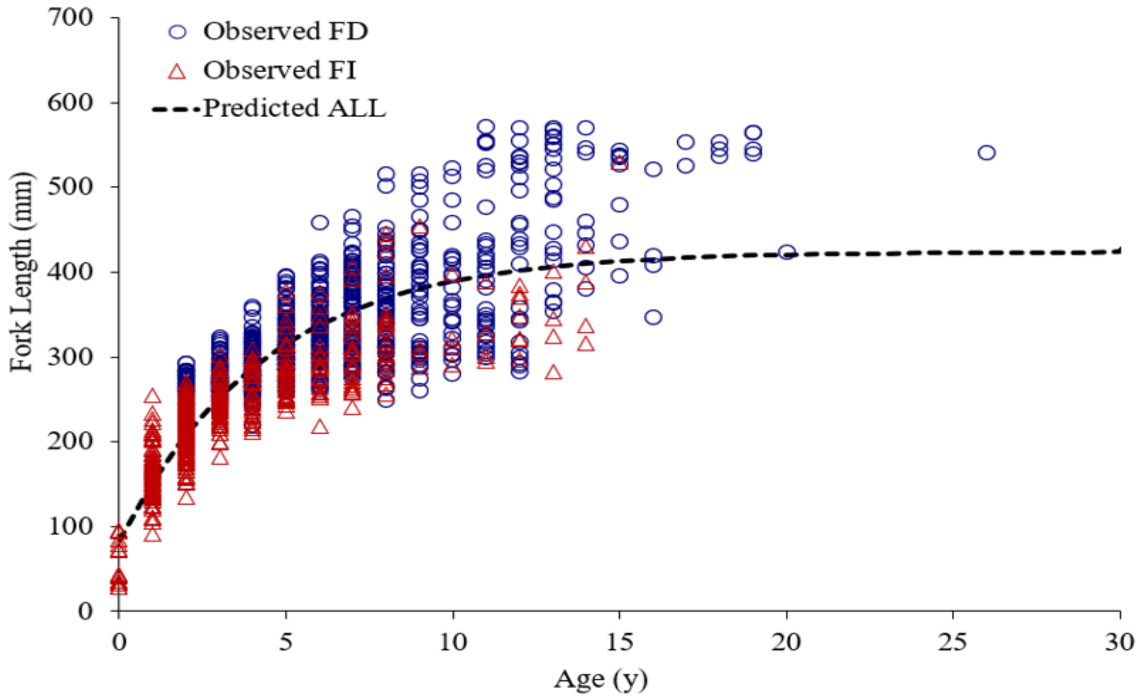

Figure 2.1 U.S. Caribbean Yellowtail Snapper length-at-age for FD and FI samples and van Bertalanffy growth based on t_0 = - 0.93.

3 Commercial Fishery Statistics

3.1 Commercial Landings

3.1.1 Overview

Commercial fishery landings in St. Thomas and St. John (STTJ) were obtained from self-reported fisher logbook data (Caribbean Commercial Logbook, CCL). Reporting of Yellowtail Snapper by species and fishing gear did not begin until July 2011 in the U.S. Virgin Islands, therefore, the first complete year of species-specific data is 2012. Logbook data is recorded by fishing year, which runs from July 1 through June 30 of the following year. However, data in this report are recorded in calendar year. Commercial fishery landings data for Yellowtail Snapper in STTJ were available for the calendar years 2012-2022 (Martinez et al. 2024). Commercial fishery landings in pounds of Yellowtail Snapper in STTJ by year and gear group are provided in Table 3.1.1.

3.1.2 Outlier removal

Outlier removal was conducted by using a mean and standard deviation method. If the landings of Yellowtail Snapper reported on a trip were greater than three standard deviations from the mean (i.e., 99.73% quantile), they 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). Due to the outlier removal, the yearly commercial landings for Yellowtail Snapper compiled in SEDAR84 may not match landings provided for previous SEDARs.

3.1.3 Snapper Fishery

Beginning in 1997 part of commercial landings were reported by species group (e.g., snappers, groupers, parrotfishes, surgeonfishes, etc.), and by gear (hook and line, gill net, SCUBA, trap, etc.). All commercial fishery data reports included species groups beginning in 2000. In July of 2011, commercial landings were reported by species and gear. Snapper complex (1997-2011) and species-specific snapper (2011-2022) landings are summarized in Table 3.1.3 and Figure 3.1.1. Note that landings prior to 2000 may be incomplete.

3.2 Commercial Discards

Commercial discards reported by calendar year were not significant (Martinez et al. 2024).

3.3 Commercial Effort

Commercial trips with reported Yellowtail Snapper landings per year were compiled from 2012 to 2022 (Table.3.3.1). The table includes the number of trips by year and fishing gear.

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).

3.4.2 Length Composition Sampling Intensity

The TIP data pertaining to Yellowtail Snapper in St. Thomas/St. John are comprised of 20,064 length observations across 1,078 unique port sampling interviews during the period 1983-2022. Of the Yellowtail Snapper measured, 19,927 are fork lengths (99.3%). Figure 3.4.1 displays the sample availability by year and gear. Plots and summary statistics of the currently available length frequency data of Yellowtail Snapper sampled from the predominant gears in St. Thomas/St. John are included in the working paper (Godwin et al. 2024).

3.4.3 Length Distributions

A variety of fishing gears were used by STTJ 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 2012 to 2022 (the years corresponding to species specific reporting of commercial landings data) are 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 plots of Yellowtail Snapper fork lengths collected across three or more unique interviews per gear groups across the time series (years with species specific commercial landings data) are summarized in Figures 3.4.2. Aggregated density plots of gears representing 2% or more of the samples are summarized in Figure 3.4.3.

3.4.4 Adequacy of Size Composition Data for Characterizing Catch

Due to reasonable levels of available data after 2012, TIP data can be considered to inform selectivity and annual population trends in the SEDAR 84 assessment pending an investigation into the comparison of interview and catch report quantities by gear groups and year. If the proportion of TIP trips interviewed compared to CCL trips reported by gear is low or highly variable, the workshop panel recommended combining TIP data across all years to inform commercial fleet selectivity, not annual population trends.

The landings data collected before 2012 were not species-specific, and current model configurations do not require length composition data before the first year of landings data. However, all length composition data should be supplied to the analytical team, allowing them to investigate other potential models. Further investigation into the filtering process will need to be executed to understand the high number of length and weight pairs flagged as possible outliers. As necessary, the analysts will communicate the high uncertainty across the measurement units associated with the TIP data for Yellowtail Snapper.

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 data (including data before 2012 and hindcast partitioning of landings recorded as species groups)
- Only use data starting in 2012, the first full year of species-specific reporting of the snapper group

Decision:
- Do not hindcast landings before 2012
- Provide a full-time series associated with the total landings of the snapper group over all years of available landings data

Rationale:
- Due to inconsistent levels of Yellowtail Snapper among all snappers after 2012, we cannot hindcast.

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

Options:
- Use one fleet (handline) while including an explanation of gears within the fleet.
- Use gear groups informed by the TIP data (handline, traps, and rod and reel) with others parsed in for modeling but separate for reporting.

Decision:
- Gear groups of “Fish Traps,” “Handline,” and “Rod and Reel” were established, with all other gears allocated to fleets proportionally.

Rationale:
- Results of GLM analyses of gear-specific size composition and expert opinion regarding gear similarities indicate three potential gear groups (Fish Traps, Handline, and Rod and Reel).
- The length data from all other gears was insufficient to characterize the size composition of the landings from those gears.

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

Options:
- Consider uncertainty around the landings (e.g. +/- 5% for 2016-present, +/-15% 2012-2015)
- Consider directional bias (e.g. + 5% for 2016-present, +15% 2012-2015)

Decision:

- Consider directional bias (e.g. + 5% for 2016-present, +15% 2012-2015)

Rationale:

- During 2012-2015, the commercial logbook forms lacked the option to select Yellowtail Snapper. Instead, fishermen had to write it in as an additional species. Inconsistent reporting of write-in species suggests underreporting in those years.
- From 2016 to now, Yellowtail Snapper appears on all logbook forms in the US Virgin Islands.

Issue 4: 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. For example, a significant jump in outliers could be attributed to the new style of fishing, indicating that these outliers are still valid trips.

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:

- Use the available reported discards data.
- Do not use the available reported discards data.
- Use expert opinion to inform estimates of discard mortality.
- Use discard mortality estimates in the published literature.

Decision:

- Discards of Yellowtail Snapper are assumed to be negligible, with minimal discard mortality.

  Rationale:
- Discarding is negligible within the Yellowtail Snapper STTJ fishery to the point that the mortality of discards is insignificant.
- Commercial logbook forms did not have species-specific discards before July 2015; therefore, discards before that time are unknown.

3.5.3 Adequacy of Length Composition Data

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

Options:
- Use filtered TIP lengths available by year from 1983 to 2022
- Use filtered TIP lengths available by year from 2012 to 2022
- Use filtered TIP lengths combined across years from 2012 to 2022 to inform selectivity
- Do not recommend using TIP lengths for any year

Decision:
- Use TIP data after 2012 to inform selectivity and annual population trends in SEDAR 84 assessment pending an investigation into comparing interview and catch report quantities by gear groups and year.
- Apply filtering based on the condition factor.
- Supply complete TIP time series for SEDAR 84 investigations.
- Investigate how the length-weight relationship varies by month and year (seasonality and reproduction).
- Try to obtain tagging research data on St. Thomas.
- Try to acquire the National Parks Service dataset for St. John. This dataset documents when fishing was allowed in the National Parks.
- Try to obtain the life history information from a 1987 age and growth study of Yellowtail Snapper.

Rationale:
- If the proportion of TIP trips interviewed compared to CCL trips reported by gear is low or highly variable, combine TIP data across all years to inform commercial fleet selectivity, not annual population trends.
- The landings data collected before 2012 were not species-specific, and current model configurations do not require length composition data before the first year of landings data. However, all length composition data should be supplied to the analytical team, allowing them to investigate other potential models.
- 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.

3.6 Commercial Statistics Tables

Table 3.1.1 Commercial landings of Yellowtail Snapper in St. Thomas/St. John from 2012-2022 reported in pounds by year and gear group.

Year	Handline	Other	Rod and reel	Traps	Total Landings
2012	22,813	7,392	192	2,854	33,251
2013	15,782	5,036	335	2,532	23,685
2014	20,982	5,872	668	3,739	31,261
2015	19,462	1,863	379	2,569	24,273
2016	20,835	2,564	900	3,735	28,034
2017	16,134	2,017	969	3,652	22,772
2018	15,521	1,023	468	4,365	21,377
2019	18,818	1,015	627	4,421	24,881
2020	21,246	376	844	3,990	26,456
2021	11,756	10	1,441	3,270	16,477
2022	12,565	27	1,953	3,439	17,984

Table 3.1.2 Comparison of commercial landings of Yellowtail Snapper in St. Thomas/St. John from 2012-2022 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)
2012	33,251	33,191	31,660	-0.2%	-4.8%
2013	23,685	22,260	22,215	-6.0%	-6.2%
2014	31,261	30,811	30,811	-1.4%	-1.4%
2015	24,273	22,356	23,588	-7.9%	-2.8%
2016	28,034	27,634	26,734	-1.4%	-4.6%
2017	22,772	22,315	21,707	-2.0%	-4.7%
2018	21,377	20,977	20,847	-1.9%	-2.5%
2019	24,881	24,401	24,109	-1.9%	-3.1%
2020	26,456	26,216	25,566	-0.9%	-3.4%
2021	16,477	16,477	16,078	0.0%	-2.4%
2022	17,984	17,834	17,489	-0.8%	-2.8%

Table 3.1.3 Commercial landings of all snapper species reported in St. Thomas/St. John from 1997-2022 by year. Note that landings prior to 2000 may be incomplete.

Year	Landings (lbs)
1997	12,721
1998	65,395
1999	127,568
2000	150,222
2001	175,734
2002	167,232
2003	160,215
2004	140,574
2005	151,595
2006	174,824
2007	156,015
2008	145,188
2009	143,604
2010	121,187
2011	76,193
2012	53,682
2013	35,889
2014	50,794
2015	40,053
2016	42,947
2017	35,367
2018	33,710
2019	35,052
2020	34,738
2021	24,486
2022	26,550

Table 3.3.1 Commercial trips that reported Yellowtail Snapper landings in St. Thomas/St. John from 2012-2022 reported by year and gear group.

Year	Handline	Other	Rod and reel	Traps	Total Trips
2012	435	48	12	352	847
2013	291	30	10	320	651
2014	309	38	15	309	671
2015	311	20	24	272	627
2016	409	17	55	389	870
2017	289	15	61	480	845
2018	253	22	38	513	826
2019	283	15	55	451	804
2020	292	5	45	495	837
2021	191	4	45	456	696
2022	190	4	74	435	703

Table 3.4.1 Generalized linear mixed model (GLMM) analysis summary results for the TIP data of Yellowtail Snapper fork lengths in St. Thomas/St. John from 2012 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. Gears that make up less than 2% are shaded in gray.

Gear	Mean	Estimated Marginal Mean	LCL	UCL	Group	Fish (n)	Interview (n)	Percentage	Gear Group
LINES HAND	32.14	3.44	3.42	3.47	2	7,353	210	85.93	Hand Line
POTS AND TRAPS; FISH	30.24	3.38	3.36	3.41	1	778	149	9.09	Traps
ROD AND REEL	34.43	3.58	3.51	3.64	3	174	15	2.03	Rod and Reel
REEL; ELECTRIC OR HYDRAULIC	31.23	3.51	3.39	3.64	1,2,3	139	5	1.62	Hand Line, Traps, or Rod and Reel
HAUL SEINES	30.05	3.44	3.34	3.54	1,2,3	81	8	0.95	Hand Line or Traps
ROD AND REEL; ELECTRIC (HAND)	33.15	3.44	3.32	3.57	1,2,3	20	4	0.23	Hand Line, Traps, or Rod and Reel
POTS AND TRAPS; SPINY LOBSTER	30.53	3.41	3.28	3.54	1,2,3	8	4	0.09	Hand Line, Traps, or Rod and Reel

3.7 Commercial Statistics Figures

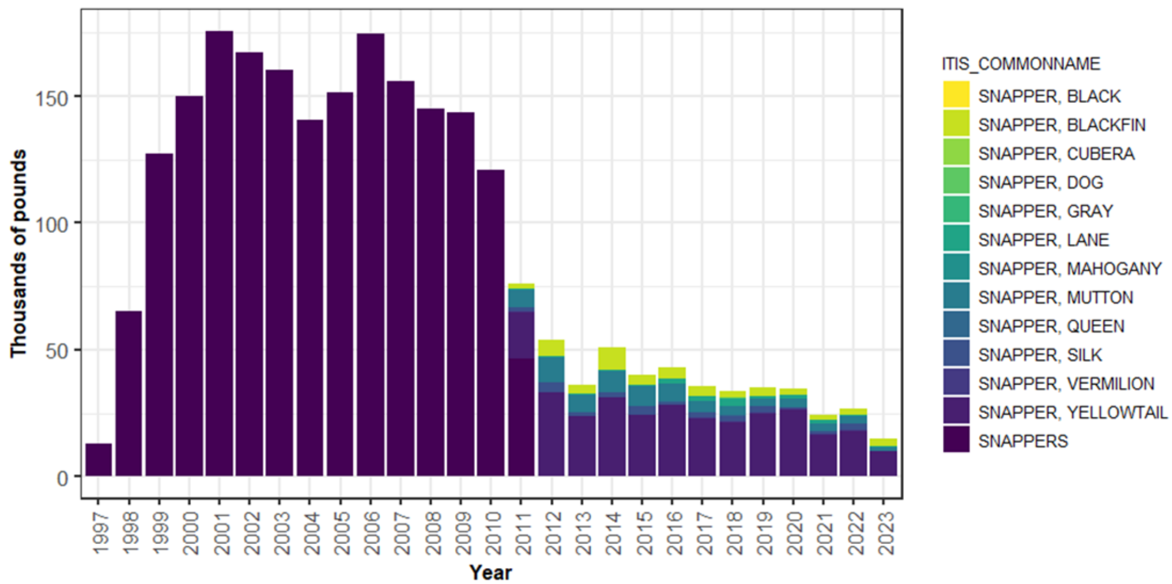

Figure 3.1.1 Commercial landings of all snapper species reported in St. Thomas/St. John from 1997-2022 by year.

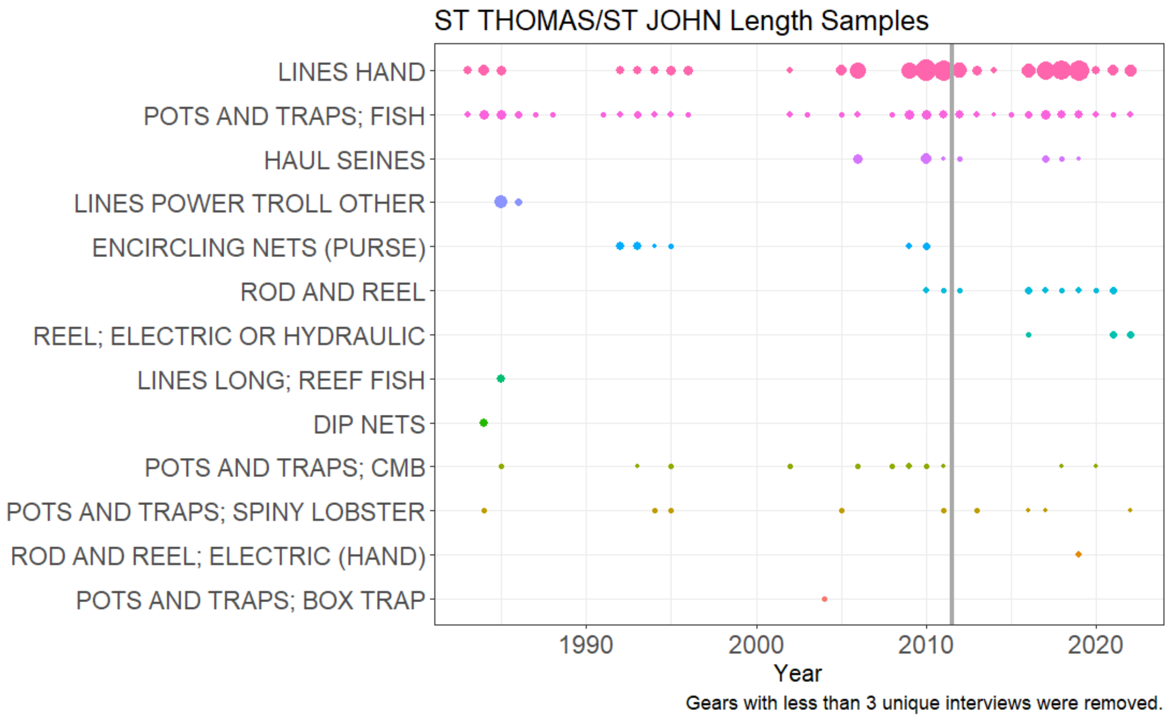

Figure 3.4.1 Plot showing relative number of Yellowtail Snapper in St. Thomas /St. John over time. Each point is color specific to the gear it represents. Gears are arranged from largest to smallest sample size of individual recorded lengths. Gray vertical line denotes the beginning of the truncated time series in 2012 (those years with species specific commercial landings data).

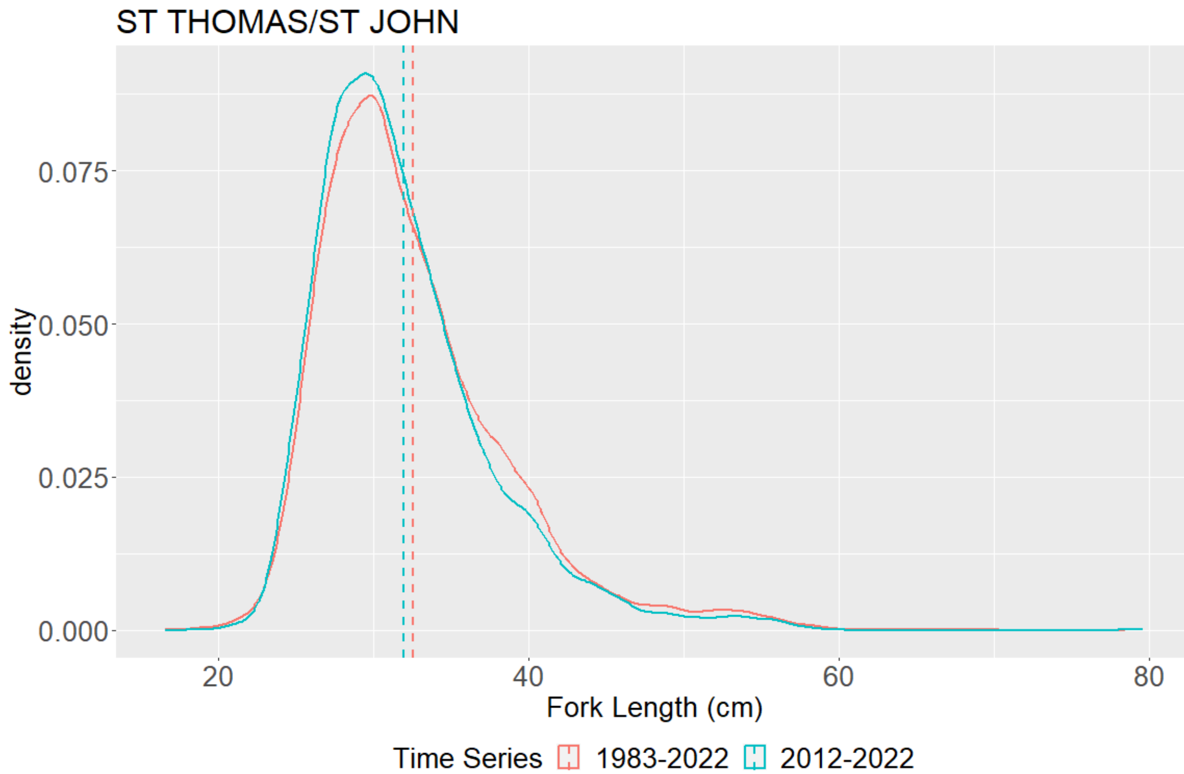

Figure 3.4.2 Aggregated density plot of lengths (cm) of Yellowtail Snapper in St. Thomas /St. John, all gears combined. Dotted line represents mean length. The period 1983-2022 includes all years with TIP data. The period 2012-2022 includes those years with corresponding species-specific commercial landings data.

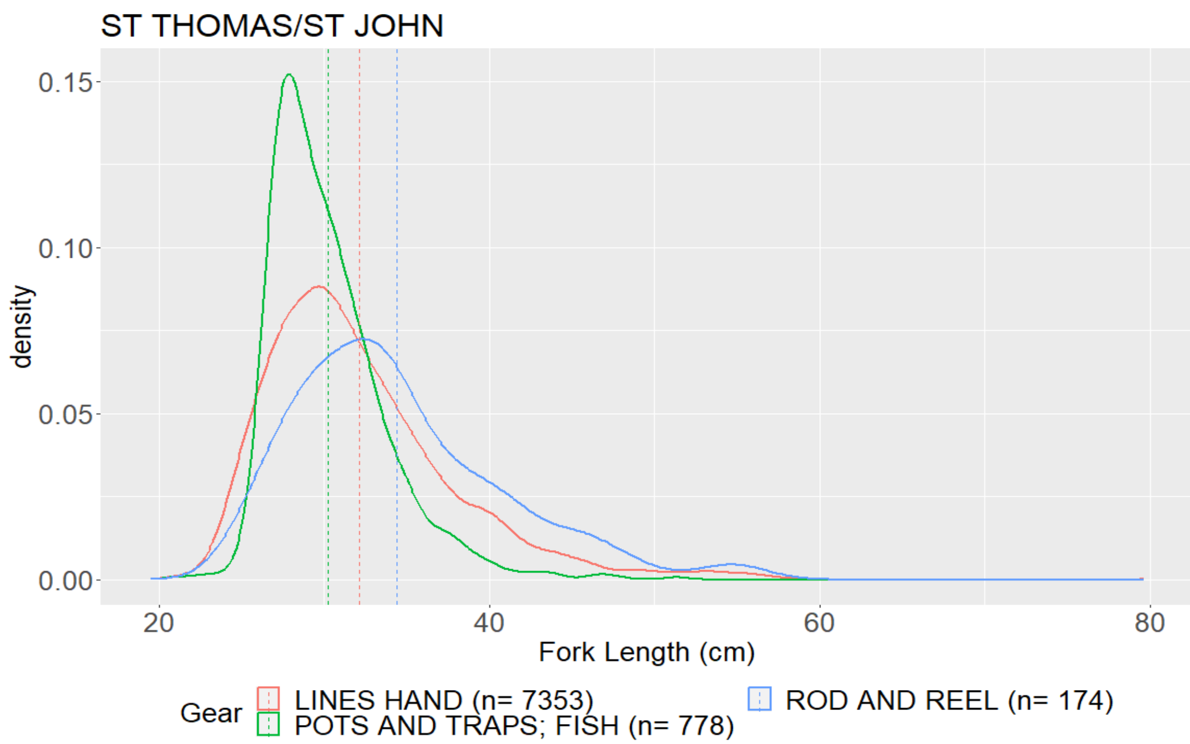

Figure 3.4.3 Aggregated density plot of lengths (cm) by gears with greater than 2% of total samples for Yellowtail Snapper in St. Thomas/St. John from 2012 to 2022. Dotted line represents mean length.

4 Recreational Fishery Statistics

4.1 Overview

U.S. Virgin Islands fishing tournament data were collected by the USVI Department of Planning and Natural Resources, Division of Fish and Wildlife staff serving as official weighmasters. Tournaments consist of kid's tournaments, spearfishing tournaments, and rod & reel/trolling tournaments. Data collected includes tournament name, date, vessel name, captain name, length of tournament, species landed, species weight, and species length.

Data were available for the years 2000-2022 from a total of 30 tournaments over the time series with data collected from 1-4 tournaments per year. A total of 1,074 Yellowtail Snapper were caught across all 30 tournaments. Of those observed fish, 671 were weighed and 198 lengths were measured. From 0 to 67 Yellowtail Snapper were measured per year and fewer than 10 fish were measured in 16 years of the 21 year time series (tournaments were not sampled in every year). From 0 to 206 Yellowtail Snapper were weighed per year with fewer than 10 fish weighed in 11 years of the time series.

4.2 SEDAR Panel Discussion of Recreational Landings Data for Assessment Analyses

Issue 1: Can tournament data inform recreational removals?

Options:
- Investigate tournament data from 2000-2022 further.
- Do not use the tournament data.

Decision:
- Do not use the tournament data. The limited tournament data available for Yellowtail Snapper in St. Thomas and St. John is considered negligible.

Rationale:
- Tournament data with Yellowtail Snapper is only available for 12 unique tournaments.
- Tournament data is a fraction of a percent of the commercial landings data; therefore, the utility of this data for the current analysis is negligible.
- Time series runs from 2000-2022, however years in which there are consecutive data are 2002-2003, 2010-2015, and 2019-2022 showing a lack of consistency across time.
- Across time series, there are 877 records in which lengths and/or weights cannot be verified due to a lack of units.
- Most data come from kid's tournaments which landed mainly juvenile and subadult yellowtail snapper.
- There is a lack of data for CPUE analysis due to the low number of records with gear type identified.
- Tournament data is negligible for this SEDAR; however, this dataset could be applicable to future SEDAR's.

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 these data or provide references that summarize the methods and data.

5.2 Review of Working Papers

SEDAR84-DW-15 (Grove et al. 2024): NCRMP FI Survey of Yellowtail Snapper (*Ocyurus chrysurus*) in St. Thomas/St. John, U.S. Virgin Islands, summarized NCRMP survey data for Yellowtail Snapper from 2014 to 2022.

5.3 National Coral Reef Monitoring Program - NCRCMP

5.3.1 Methods, Gears, and Coverage

This document outlines the data and methodologies used to estimate density and abundance-at-length compositions for the SEDAR84 Yellowtail Snapper Assessment for St. Thomas and St. John.

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 samples were reduced in St. Thomas and St. John in 2021 to 165 as a result of weather (Figure 5.3.1)

Two levels of calibration were needed to incorporate historical transect data. First, we analyzed the regionally restricted transect data from 2001 to 2011 in Virgin Island National Park and Virgin Islands Coral Reef National Monument in St. John. 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 (2017–2021). 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.

The National Coral Reef Monitoring Program (NCRMP) has a sampling depth limit of 30 m, and thus only represent shallow water fish populations. However, a majority of the fisheries areas, particularly on the northern and southern shelf of St. Thomas and St. John, are in depths between 30-65 m (Kadison et al., 2017). The Coral Reef Conservation Program (CRCP) funded a pilot survey to target the upper mesophotic habitats of St. Thomas and St. John from 2020–2022. The DCRMP program used NCRMP survey design and sampling methodologies for direct comparisons (Figure 5.3.2). For more details about the DCRMP program, data and sampling coverage see Grove et al. (in press).

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, ±1). 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). Time series indices and length frequency compositions were analyzed and presented separately for NCRMP and DCRMP surveys.

5.3.2 Sampling Intensity – Time Series

Sampling Intensity and the time series of the NCRMP reef survey in St. Thomas/St. John is illustrated in Table 5.3.1. 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.

The upper mesophotic zone DCRMP survey time series data from 2020 to 2022 is shown in Table 5.3.2. Here only habitat types are distinguished in the survey:

- Aggregate
- Patch
- Pavement

5.3.3 Size Data

Length size frequency distribution of Yellowtail Snapper population in St. Thomas and St, John from the NCRMP survey are shown for 2017, 2019, and 2021 in Figure 5.3.3 and for the DCRMP survey for the years 2020 to 2022 are shown in Figure 5.3.4

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 which also included the 2020-2022 from the DCRMP survey.

5.4 Fishery-Dependent Measures

5.4.1 Overview

US Caribbean commercial logbook (CCL) landings and effort were used to construct nominal indices of abundance. CCL data are self-reported. Species specific reporting in the U.S. Virgin Islands landings started in 2012 (1st full year) and the time series from 2012-2022 was considered. After calculating the proportion positive Yellowtail Snapper trips by gear group (Table 5.4.1) and examining the reported landings by gear group (Table 3.1.1), only hook & line gear had sufficient data to explore the construction of an index of abundance.

5.4.2 Methods of Estimation

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

- Hours fished
- Lines count

-Hooks per line count

The following units of effort considered

- Hook hours (hours fished * lines count * hooks per line count)
- Fishing lines hours (hours fished * lines count)
- Hooks per line hours (hours fished * hooks per line count)
- Hours fished

Based on the exploratory analysis of the relationship between CPUE (calculated as pounds of landed Yellowtail Snapper/unit of fishing effort; e.g., per hook hour, per hour fished, etc.) and effort (Figure 5.4.1). Hook hours was deemed as the most appropriate effort measure to calculate CPUE (Fig. 5.4.1)

5.4.3 Sampling Intensity

All commercial fishers are required to report landings and effort to CCL. CCL reporting is therefore considered to be census of commercial landings and fishing effort. Any underreporting has not been quantified.

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 were consistent throughout the time series, approximate 5 pounds of Yellowtail Snapper landed per hook hour fished (Figure 5.4.2). Nominal catch rates are shown; i.e., this CPUE series has not been standardized to account for fishing practices and other effects that may mask true trends in Yellowtail Snapper abundance.

5.4.6 Uncertainty and Measures of Precision

Coefficients of variance (CV) around the nominal CPUE index were rather were large throughout the time series (Figure 5.4.2).

5.5 SEDAR Panel Discussion of Indices Data for Assessment Analyses

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

Options:

- Use the density estimates and length composition data from 2013 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.

Decision:
- Use the NCRMP data from 2013 to 2022.
- Ensure the length at first capture used to define the exploited population aligns with the lengths observed in the port sampled data. (SEFSC TASK)
- Include the DCRMP information separately. Document caveat that there are other areas where larger fish can occur not captured in these surveys

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

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

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

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

Rationale:
- Time spent fishing does not necessarily translate to nominal CPUE, equating to where you could look at patterns over time. Experienced commercial fishermen know how to target the species effectively, which may differ from inexperienced fishermen. Therefore, we must include other aspects within the index to make it more representative.

5.6 Measure of Population Abundance Tables

Table 5.3.1 Number of reef fish visual survey sites by hard-bottom strata and depth categories per year from the reef fish visual surveys in the St. Thomas and St. John 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	6		1	8	1	2		1	5	1	**25**	**42**
2002	11	9	4	18	2	2			24	2	**72**	**105**
2003	16	6	8	19	9	22		3	23	3	**109**	**132**
2004	16	10	4	16	8	35		5	27	7	**128**	**119**
2005	26	6	9	13	6	30		6	25	7	**128**	**160**
2006	29	7	2	10	2	43		14	11	9	**127**	**176**
2007	29	10	5	13	3	41		9	11	8	**129**	**112**
2008	18		9	12	7	43		15	16	14	**134**	**171**
2009	27	6	13	8	3	46		9	14	6	**132**	**139**
2010	20	6	6	22	7	28		12	20	13	**134**	**127**
2011	27	5	9	11	9	43		11	9	9	**133**	**182**
2013	31	28	13	32	14	73	4	20	34	26	**275**	**601**
2015	21	13	17	25	15	62	1	29	48	24	**255**	**269**
2017	36	22	13	7	5	68	3	19	38	26	**237**	**802**
2019	49	39	13	19	14	88	4	32	36	28	**322**	**1428**
2021	17	22	4	15	6	56	1	7	24	13	**165**	**680**

Table 5.3.2 Number of DCRMP reef fish visual survey sites (left column) and number of Yellowtail Snapper (Ocyurus chrysurus) length observations (right column) by hard-bottom strata from the reef fish visual surveys in St. Thomas and St. John coral reef ecosystem (2020–2022).

	30 - 60 meters				
Year	**Aggregate**	**Patch**	**Pavement**	**Site Total**	**Length Total**
2020	75	48	39	**162**	**376**
2021	59	23	16	**98**	**258**
2022	33	21	35	**89**	**160**

Table. 5.4.1 Number trips that reported Yellowtail Snapper landings in St. Thomas/St. John by year and gear group expressed as a percentage of the total trips of Yellowtail Snapper landed by gear group and year.

Year	Traps (%)	Hook/line (%)	Dive (%)	Nets (%)
2012	22.0	70.6	2.1	27.1
2013	22.7	62.3	9.5	29.3
2014	22.8	69.5	1.5	22.2
2015	19.8	55.7	9.0	10.9
2016	26.1	56.7	3.9	9.2
2017	40.9	63.9	3.2	6.4
2018	49.5	60.6	3.4	9.4
2019	42.0	69.3	1.9	7.5
2020	41.6	76.8	0.0	4.2
2021	35.6	63.3	4.1	0.0
2022	35.8	49.1	2.4	1.1

5.7 Measure of Population Abundance Figures

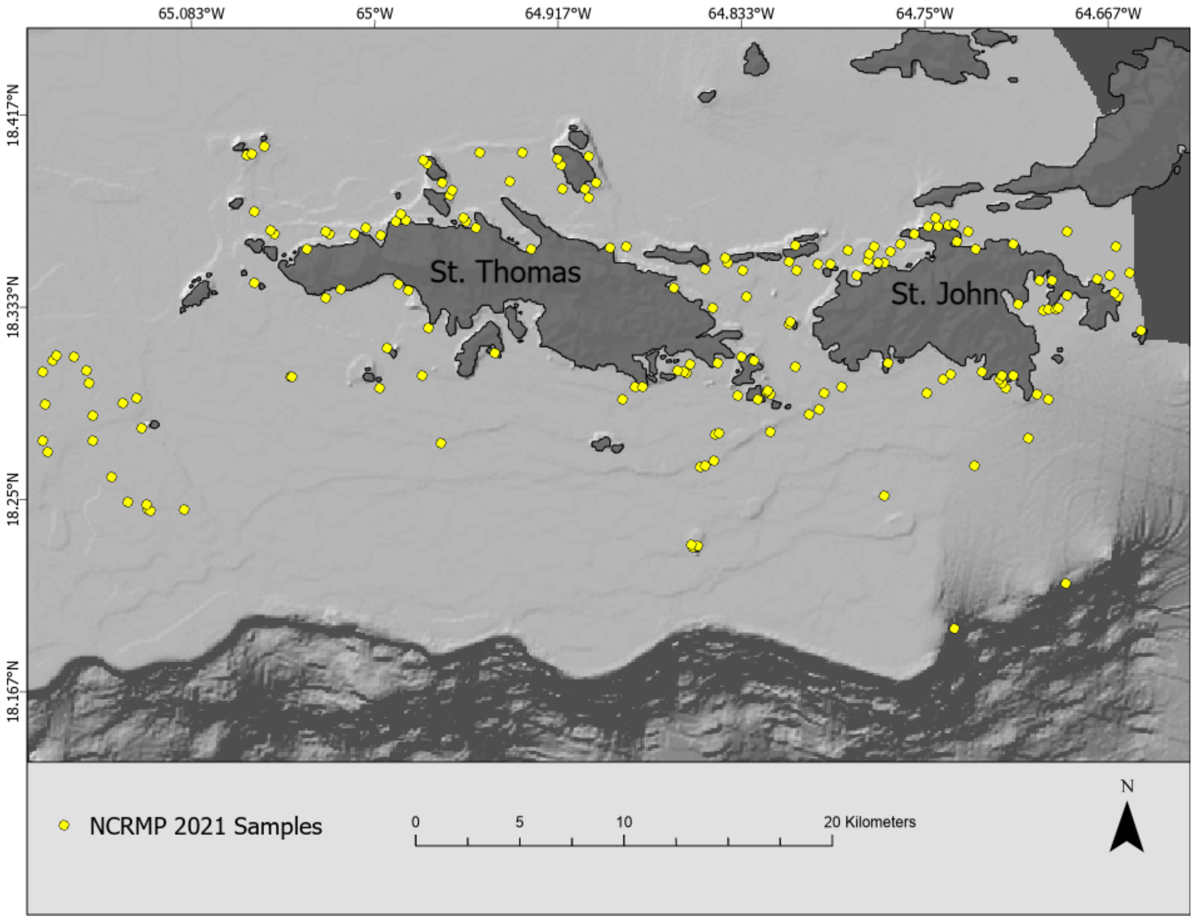

Figure 5.3.1 St. Thomas and St. John NCRMP sampling sites 2021 (n = 165).

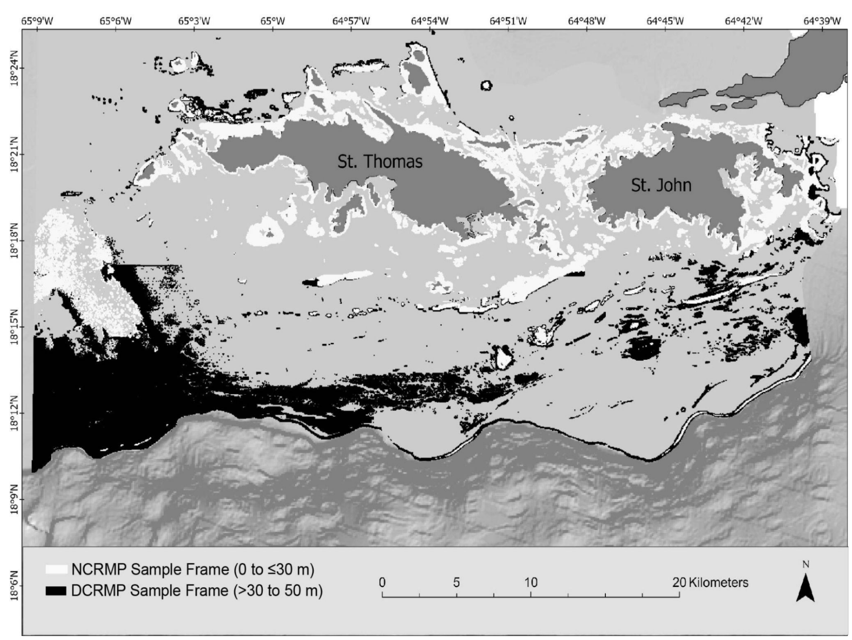

Figure 5.3.2 St. Thomas and St. John NCRMP (white) and DCRMP (black) sampling domain.

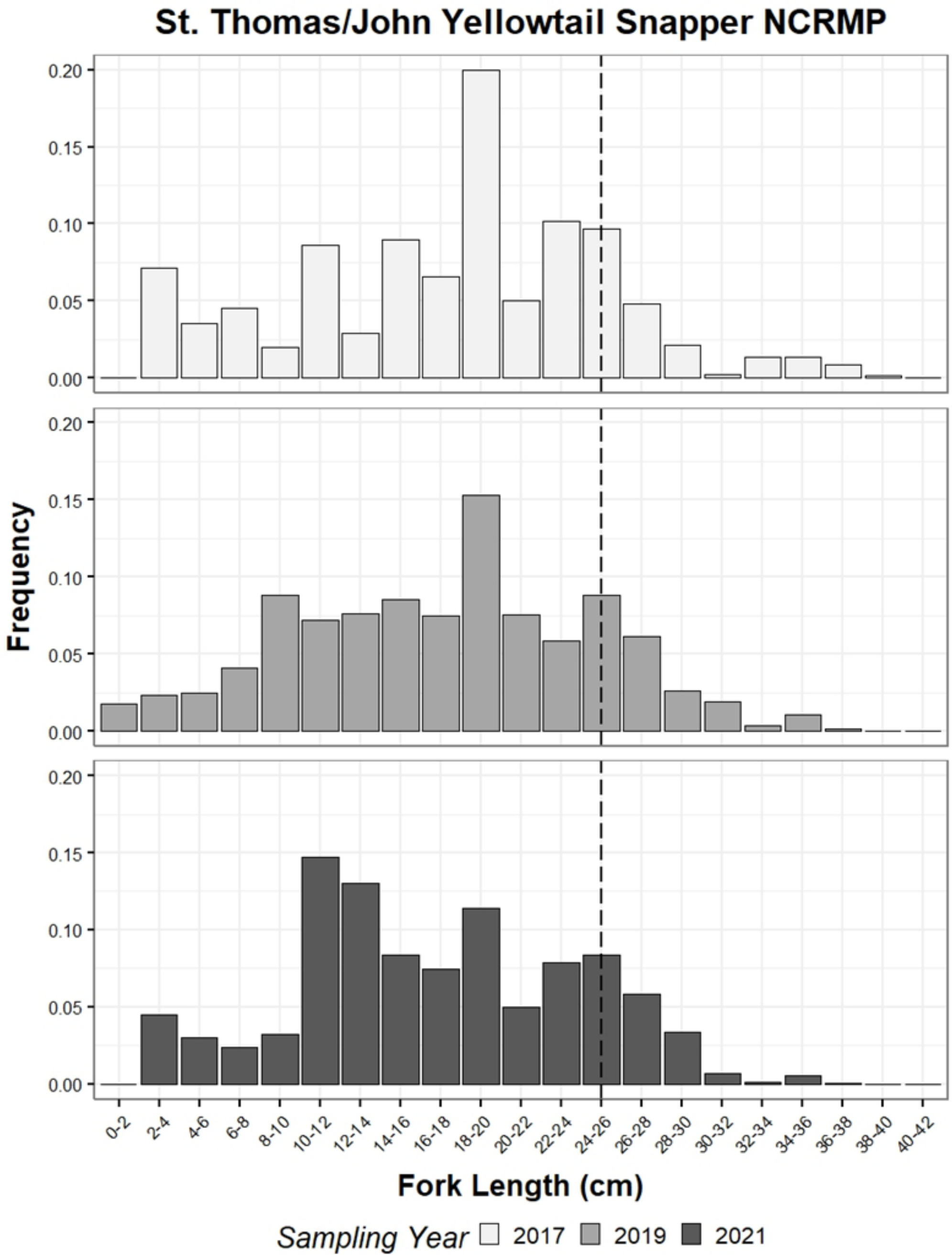

Figure 5.3.3 Yellowtail Snapper population size-frequency distribution at 2-cm bins from the 2017 - 2021 NCRMP RVC-SPC St. Thomas and St. John surveys. Vertical dashed line is length at capture (25.0 cm fork length).

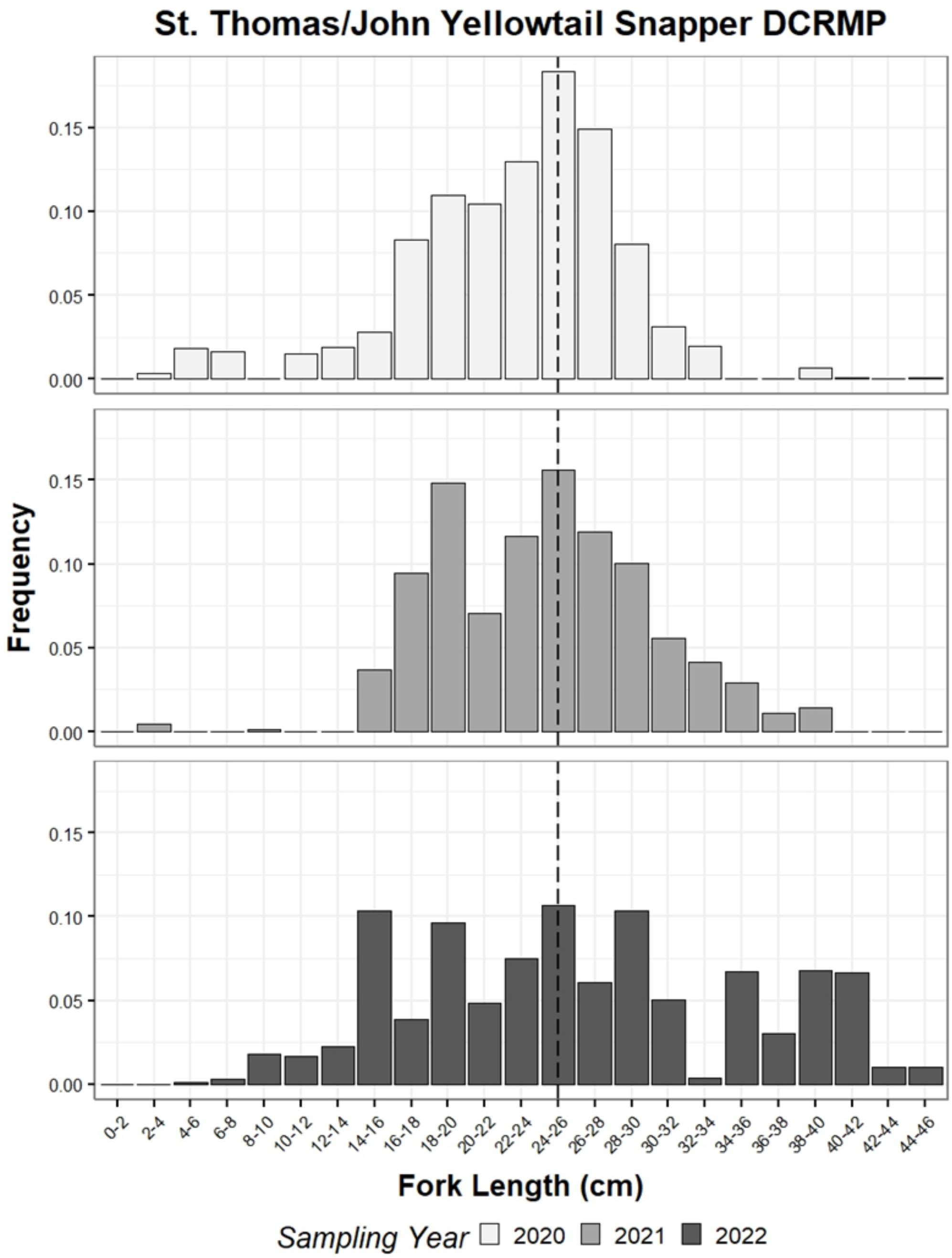

Figure 5.3.4 Yellowtail Snapper population size-frequency distribution at 2-cm bins from the 2020 - 2022 DCRMP RVC-SPC St. Thomas and St. John surveys. Vertical dashed line is length at capture (25.0 cm fork length).

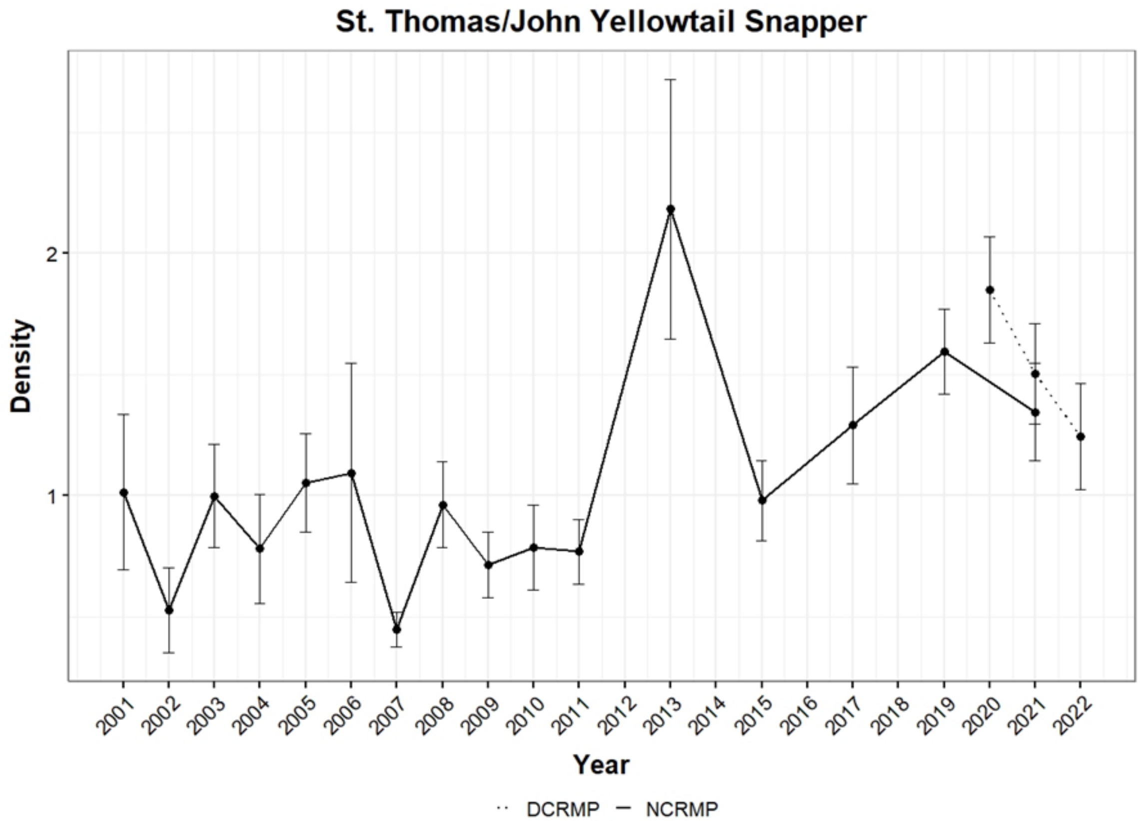

Figure 5.3.5 Time series (2001–2021) of Yellowtail Snapper (Ocyurus chrysurus) mean population density (number per 178 m2, ± SE) from the NCRMP (solid line) and DCRMP (dotted line) reef fish visual surveys in the St. Thomas and St. John coral reef ecosystem.

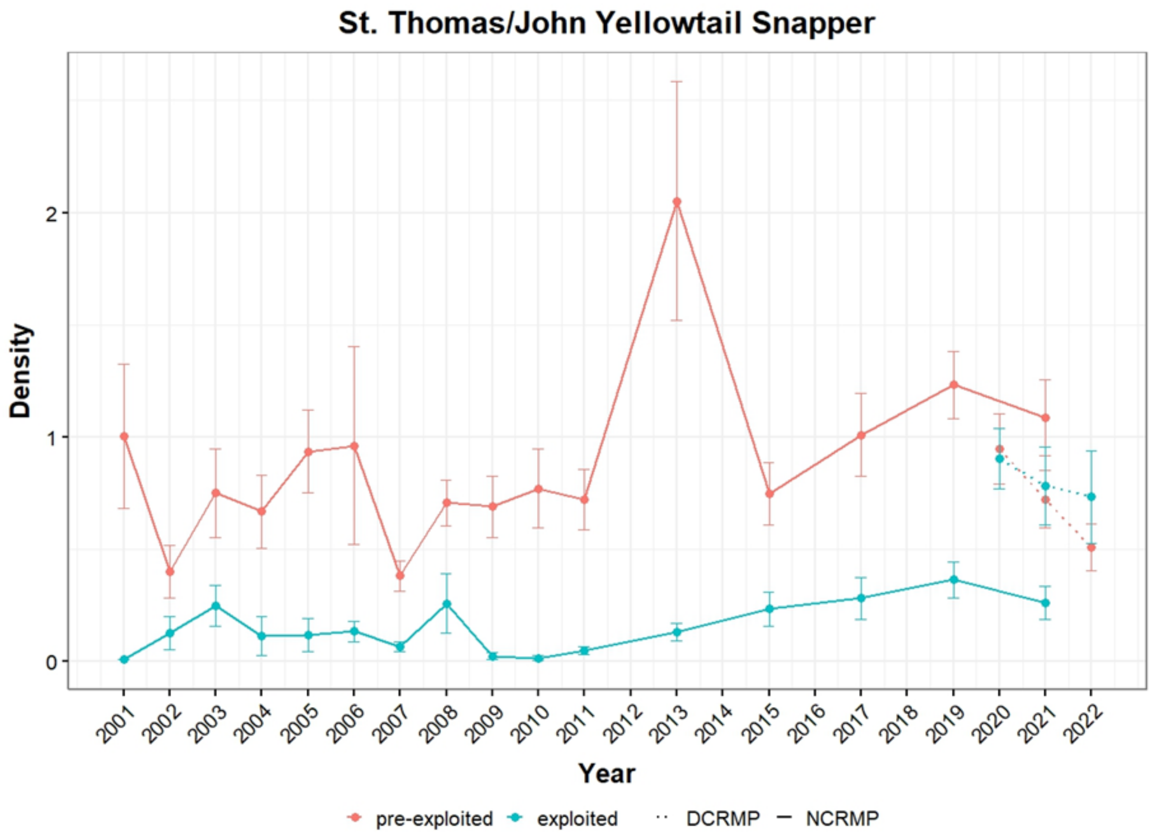

Figure 5.3.6 Time series (2001–2022) of Yellowtail Snapper (Ocyurus chrysurus) mean population density (number per 178 m2, ± SE) from the NCRMP (solid line) and DCRMP (dotted line) in the pre-exploited (blue, < 25 cm) and exploited (red, ≥ 25 cm) reef fish visual surveys in the St. Thomas and St. John coral reef ecosystem.

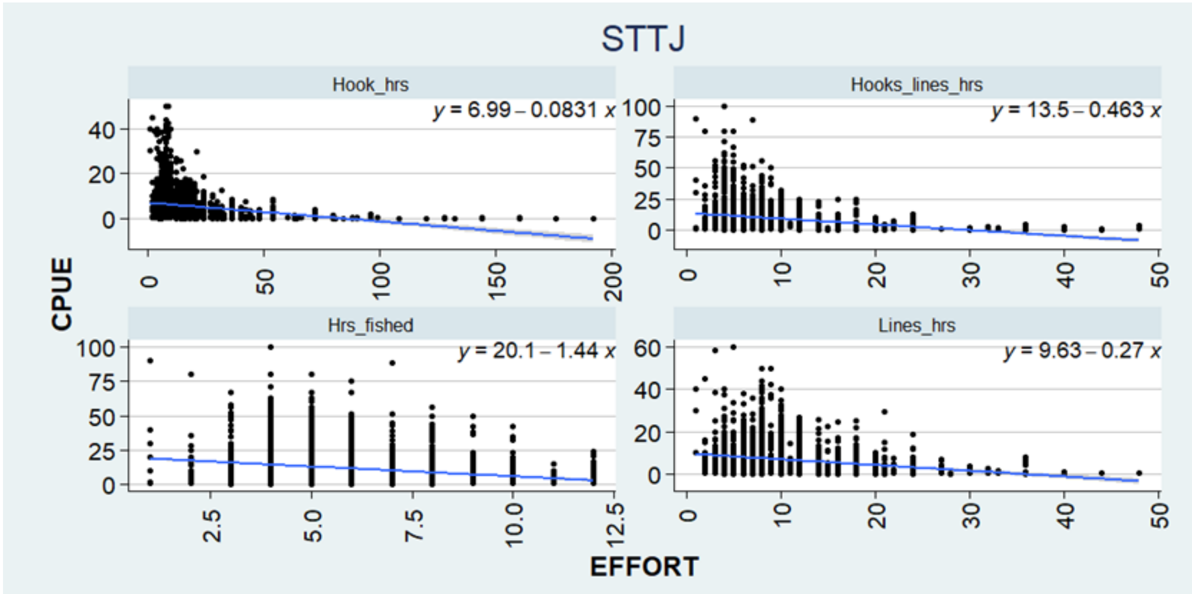

Figure 5.4.1 Exploratory analysis of different variables for suitability as a measure of effort. Hook hours (upper left) was chosen due to the minimal change in CPUE over increasing effort (hook hours); i.e., slope of the line is lowest (-0.0831).

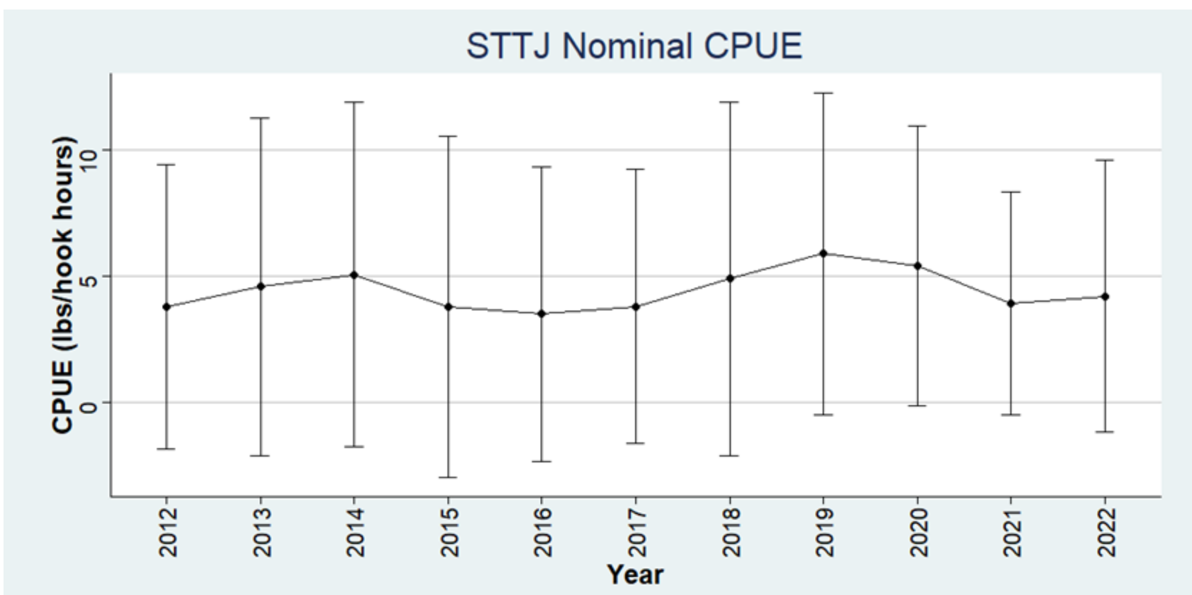

Figure 5.4.2 **N**ominal CPUE index in pounds per hook hours landed for the commercial Yellowtail Snapper fishery in the St. Thomas/St. John from 2012 to 2022,

6 SEDAR Panel Research Recommendations

6.1 Life History Research Recommendations

Issue 1: Are sufficient life history data available?

Research recommendations:

- 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 Recommendation

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 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 snappers 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.

6.2.2 Length Composition Research Recommendation

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.

6.3 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.

6.4 Measures of Population 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.

7 Literature Cited

Ault, JS, GA Diaz, SG Smith, J Luo, and JE Serafy. 1999. An efficient sampling survey design to estimate pink shrimp population abundance in Biscayne Bay, Florida. North American Journal of Fisheries Management 19: 696–712.

Ault, J, SG Smith, BL Richards, AJ Yau, BJ Langseth, JM O'Malley, CH Boggs, MP Seki, GT DiNardo. 2018. Towards fishery-independent biomass estimation for Hawaiian Islands deepwater snappers. Fisheries Research 208: 321-328.

Ault, JS, SG Smith, MW Johnson, LJW Grove. 2020. Gear calibration factors for U.S. Caribbean coral reef fish visual surveys. Final Technical Report on NOAA Grant No. NA15OAR4320064 SEFSC CREU. 56 p.

Beggerly, S, M Stevens, H Baertlein. 2022. Trip Interview Program Metadata. SEDAR74-DW-14. SEDAR, North Charleston, SC. 10pp.

Bryan, DR, AJ Atkinson, JS Ault, ME Brandt, JA Bohnsack, MW Feeley, ME Patterson, BI Ruttenberg, SG Smith, and BD Witcher. 2013. A cooperative multi-agency reef fish monitoring protocol for the U.S. Virgin Islands coral reef ecosystem. Natural Resource Report NPS/SFCN/NRR—2013/672. National Park Service, Fort Collins, Colorado.

Bryan, DR, SG Smith, JS Ault, MW Feeley, CW Menza. 2016. Feasibility of a region-wide probability survey for coral reef fish in Puerto Rico and the U.S. Virgin Islands. Marine and Coastal Fisheries 8(1): 135–146.

Cochran, WG. 1977. Sampling Techniques. Third edition, John Wiley and Sons, New York.

Charnow, E, H Gislason, JG Pope. 2012. Evolutionary assembly rules for fish life histories. Fish Fisheries Vo.14(2): 213-224.

Godwin, K, A Rios, K Dettloff. 2024. SEDAR 84 Trip Interview Program (TIP) Size Composition Analysis of Yellowtail Snapper (Ocyurus chrysurus) in St. Thomas/St. John, U.S. Caribbean, 1983-2022. SEDAR84-DW-10. SEDAR, North Charleston, SC. 10pp.

Grove, LJW, J Blondeau, JS Ault. 2024. Fishery-Independent Reef Fish Visual Survey Population Density and Length Composition for Yellowtail Snapper in St. Thomas/John. SEDAR84-WP-15. SEDAR, North Charleston, SC. 15pp.

Grove, LJW, J Blondeau, JS Ault. 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.

Grove, LJW, J Blondeau, JS Ault. 2021. National Coral Reef Monitoring Program's Reef Fish Visual Census Metadata for the U.S. Caribbean. SEDAR80-WP-02. SEDAR80, North Charleston, SC. 55 p.

Grove, LJW, J Blondeau, D Swanson, S Heidmann, SG Smith, M Johnson, V Brandtneris, S Sagarese, TB Smith. (in press). Expansion of an established fishery-independent survey into the US Virgin Islands' upper mesophotic zone: feasibility and management implications. Bulletin of Marine Science.

Hewitt, DA and JM Hoenig. 2005 Comparison of two approaches for estimating natural mortality based on longevity. Fishery Bulletin of the United States of America, 103, 433-437.

Kadison, E, M Brandt., R Nemeth, J Martens, J Blondeau, T Smith. (2017). Abundance of commercially important reef fish indicates different levels of over-exploitation across shelves of the U.S. Virgin Islands. PLOS ONE 12(7)

Law, AM. 2007. Simulation modeling and analysis. Fourth edition, McGraw Hill, New York. Lohr, SL. 2010. Sampling: Design and Analysis. Second edition, Brooks/Cole, Boston.

Martínez, S, K Johnson, MR Orhun. 2024. SEDAR 84 Commercial fishery landings of Yellowtail Snapper (Ocyurus chrysurus) in St. Thomas and St. John, US Caribbean, 2012-2022. SEDAR84-DW-02. SEDAR, North Charleston, SC. 15pp.

Robson, DS. 1966. Estimation of the relative fishing power of individual ships. ICNAF Research Bulletin 3: 5–15.

Shervette, V, J Rivera-Hernandez, Noemi Pena Alvarado. 2024. U.S. Caribbean Yellowtail Snapper Population Demographics, Growth, and Reproductive Biology: Addressing Critical Life History Gaps SEDAR84-WP-08. SEDAR, North Charleston, SC. 29 pp.

Southeast Data Assessment and Review (SEDAR) 46 SAR v2 2016. SEDAR 46 Stock Assessment Report Caribbean Data-Limited Species. April 2016, SEDAR, North Charleston, SC 373 pp. Available from https://sedarweb.org/documents/sedar-46-final-stock-assessment-report-caribbean-data-limited-species/

Smith, SG, JS Ault, JA Bohnsack, DE Harper, J Luo, and DB McClellan. 2011. Multispecies survey design for assessing reef-fish stocks, spatially explicit management performance, and ecosystem condition. Fisheries Research 109:25–41.

Then, AY., JM Hoenig, NMG Hall, A Hewitt. 2015. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. *ICES Journal of Marine Science*, Volume 72, Issue 1, January 2015, Pages 82–92, https://doi.org/10.1093/icesjms/fsu136.

Valle-Esquival, M, and G Díaz. 2004. 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). NOAA/NMFS/SEFSC Miami Laboratory SFD-2004/051 (SEDAR-8-DW-09). 48pp.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 84

US Caribbean Yellowtail Snapper – St. Thomas/St. John

SECTION III: Assessment Process Report

June 2025

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

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Assessment Process Report Summary

The SEDAR 84 St. Thomas and St. John 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 two reef fish surveys
- Fishery-independent indices of abundance from two reef fish surveys
- 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 fishery-independent 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. While these scenarios showed that key uncertainties can influence estimated productivity and biological reference points, nearly all models across the suite supported the conclusion that overfishing is not occurring and the stock is not overfished. A few sensitivity runs did indicate potential concern under specific combinations of assumptions, particularly with lower initial equilibrium catch and higher natural mortality.

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
J.J. Cruz-Motta	CFMC SSC, UPRM
Matt Damiano	NMFS/SEFSC
Sennai Habtes	USVI DPNR
Walter Keithly	SSC/LSU
Kevin McCarthy	NMFS/SEFSC
M. Refik Orhun	NMFS/SEFSC
Kyle Shertzer	NMFS/SEFSC
Virginia Shervette	Univ SC
Derek Soto	MER

Appointed Observers	
Carlos Farchette	Stakeholder - STX
Julian Magras	DAP STT/STJ

Observers	
Jerald S. Ault	Univ of Miami
Rachel Banton	NMFS/SEFSC
Sarah Beggerly	NMFS/SEFSC
David Behringer	NMFS/SEFSC
Jeremiah Blondeau	NMFS/SEFSC
Chip Collier	SAFMC Staff
Carly Daiek	NMFS/SEFSC
Katherine Godwin	UM-CIMAS
Jennifer Granneman	NOAA
Jay Grove	NMFS/SEFSC
Walter Ingram	NMFS/SEFSC
Stephanie Martinez-Rivera	NMFS/SEFSC
Maria McGirl	FWC
Jennifer Pytka	
Maggie Rios	USVI DPNR
Jesus M. Rivera-Herdández	Univ SC
Grisel Rodriguez-Ferrer	PR DNER
Wilson Santiago Soler	PR Fisheries Liaison

Observers	
Sarah Stephenson	NMFS/SEFSC
Joyah Watkins	Rice University

Staff	
Julie A. Neer	SEDAR
Liajay Rivera Garciá	CFMC Staff
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 Snapper St. Thomas and St. John 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, **bolded 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 two fishery-independent surveys of reef fish (Grove et al., 2024)
4. **Indices of abundance** from two fishery-independent surveys 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 two fishery-independent surveys.

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). Beginning in 1996, part of the commercial landings was reported by species groups (e.g., snappers, groupers, parrotfishes, surgeonfishes, etc.), and by gear (hook and line, gill net, SCUBA, trap, etc.). All commercial fishery data reports included species groups beginning in 1998. In July of 2011, commercial landings were reported by species and gear.

The handline gear group made up 72% of the reported landings catch of Yellowtail Snapper in St. Thomas and St. John. 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 2012 and 2022, respectively.**

It is important to note that the stock was not unexploited at the start year of the available catch time series. The commercial landings of all snapper species reported in St. Thomas and St. John in 2012 was undergoing a meaningful decline. Combined snapper landings dropped by over 55% in just one year, from 121,187 pounds in 2010 to 76,193 pounds in 2011, followed by another 30% decrease in 2012 (SEDAR (2024), Table 3.1.3). Initial F was estimated for the commercial fleet and a corresponding initial equilibrium catch. A common option to define reference point for the initial equilibrium catch is to use the geometric mean of the first three years of available catches. However, because of the decline preceding the start year of the assessment, the assessment panel agreed on using a value higher than the geometric mean of the first three years. **The initial equilibrium catch was configured in initial runs as 25 metric tons**, a little under twice the geometric mean of the catches from 2012 - 2014, which was 26.4 metric tons).

The input standard error for the landings was set to 0.3. When implemented with few data inputs, 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 reported by calendar year by Martínez Rivera et al. (2024) were minimal. Based on expert judgment and available information, discards of Yellowtail Snapper in the St. Thomas/St. John commercial fishery are considered negligible, with minimal associated mortality (SEDAR (2024)). Additionally, species-specific discard data were not collected in commercial logbooks prior to July 2015, leaving discards from earlier years unquantified. 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 (Godwin et al., 2024). The Trip Interview Program (TIP) manages data from the U.S. Virgin Islands collected by Division of Fish and Wildlife 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 St. Thomas and St. John included 20,064 length observations across 1,078 unique port sampling interviews.

Although the catch data can be separated into handline and non-handline related gears, 85% of the length measurements for St. Thomas and St. John Yellowtail Snapper from 2012-2022 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 compositions was based on the number of trips sampled**.

From 2012 - 2022, the data included 7,351 shore-based length measurements obtained across 208 trips. Two trips were flagged and removed as potential outliers with unusually large lengths. **Due to low sample sizes of both fish and trips, the fishery-dependent commercial fleet length composition data were collapsed across all years 2012-2022** by implementing the super-period approach in Stock Synthesis.

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 exists, it does not apply in USVI territorial waters extending from land to 3 nautical miles offshore. Discussion at the data workshop emphasized that the federal regulations does affect retention, however there are insufficient data on the lengths of discarded fish to inform length-based retention.

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 St. Thomas and St. John, NCRMP sampling began in 2001 and was conducted every year from 2001 to 2011 and then every other year starting in 2013. The data used in SEDAR 84 were from nonconsecutive years during 2013 - 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.

From 2020-2022, the Coral Reef Conservation Program (CRCP) funded a pilot survey to target the upper mesophotic habitats of St. Thomas and St. John. The Deep-NCRMP (DCRMP) has a sampling depth limit of 60 m (Grove et al., 2024).

Annual mean density and associated standard errors for NCMP and DCRMP 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 and DCRMP surveys in St. Thomas and St. John 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.

A large proportion of small fish were observed in the NCRMP survey. **The smallest two bins, (2 - 5 centimeters) and (5 - 8 centimeters), were collapsed into a single bin (2 - 8 centimeters).**

Since multiple fish can be observed during a single dive, individual lengths are not independent observations. **The relative model weighting of the NCRMP survey and DCRMP survey length compositions 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 32 centimeters fork length. Meanwhile, the length composition data also provided support that larger fish were available to the DCRMP. Over half of the lengths from the DCRMP survey were smaller than 26 centimeters fork length, and 98% were below 41 centimeters fork length. **Dome-shaped selectivity was explored for both the NCRMP and DCRMP surveys.**

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 observed 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 two fishery-independent surveys.

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 2012 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 25 metric tons.
  - The initial equilibrium catch was explored via likelihood profiling.
- The relative model weighting of the commercial fleet length compositions was based on the number of trips sampled.
- Due to low sample sizes, the fishery-dependent commercial fleet length composition data were combined across all years.

- 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 DCRMP index reflected larger fish than the NCRMP index.
- The surveys were configured as an index in numbers with a lognormal error distribution
- The relative model weighting of the surveys length compositions 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 smallest two bins, (2 - 5 centimeters) and (5 - 8 centimeters), were collapsed into a single bin (2 - 8 centimeters).
- The surveys were set up in the models with dome-shaped selectivity.

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 St. Thomas and St. John 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 compositions 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 compositions 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) dome-shaped selectivity, and (d) recruitment deviations. Additional model configurations were not pursued. For example, annual fishery-dependent length composition data were not considered due to low sample sizes.

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 **v4__m3__s1** refers to the fourth scenario (**v4**, which includes an index 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).

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 7.7).

4.2 Correlation Analysis

High correlation among parameters can lead to flat response surfaces and 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 across nearly all m2 model scenarios (Table 7.4). One particularly noteworthy correlation was between the estimates of initial fishing mortality (Initial F) and unfished recruitment (R0), which exceeded -0.99 in all models except for version v19_m2, where it was slightly lower but still substantial at -0.94.

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 25 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). This adjustment reduced the overly strong correlation between Initial F and R0 by relaxing the constraint on initial fishing mortality. The effects of increasing the standard error beyond 0.3 are discussed further in the sensitivity analyses section.

The v4_m2 and v4_m3 model scenarios showed high correlations (> 0.95) between the two parameters used to define the commercial fleet logistic selectivity: the length at peak selectivity and the width of the ascending limb. 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).

4.3 Evaluating Variance

To check for parameters with high variance, parameter estimates are reported with their resulting standard deviations. Table 7.7 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 key parameters are not being estimated with high precision. In particular, the coefficients of variation for initial fishing mortality are relatively high across all models, indicating considerable uncertainty in these estimates.

Figure 8.2 illustrates how the estimate 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 with annual fishery-independent length composition data (models v8_m3 and v19_m3) results in slightly higher values for both of these parameters. 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 7.5 shows this information and it is also plotted in Figures 8.3a and 8.3b.

Compared to the other m3 model scenarios, Model v19_m3 exhibited the highest initial depletion reflected in the lowest spawning biomass ratio (SSB Initial / SSB Unfished) reported in Table 7.5. This ratio is also plotted as a time series of total biomass relative to virgin spawning biomass in Figure 8.3a. The sensitivity runs described later further explore the uncertainty associated with 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 8.4).

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 2012–2022 catch data, as 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 (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. Additional justifications for further allowing the estimated initial equilibrium catch to differ from the assumed initial equilibrium catch of 25 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 (model scenarios v4_m2, and v8_m2), the predicted NCRMP and DCRMP indices are flat (Figures 8.5 and 8.6). In the model scenarios with estimated recruitment deviations (v19_m3), there is some a slight overall decline in the estimated indices. Notably, high uncertainty in the index was observed in 2013 of the NCRMP index (Figure 8.5).

4.5.3 Length Compositions

Figure 8.7 shows the cumulative fit across all years between the observed and predicted length composition for the model scenario that had aggregated length data (v4_m3). Figures 8.8 and 8.9 provide the cumulative and the year-specific length compositions for the model scenarios that included annual fishery-independent length data (v8_m3, and v19_m3).

Among the models with the annual fishery-independent length data (v8_m3, and v19_m3), the model with recruitment deviation being estimated (v19_m3), has improved fits to the annual NCRMP and DCRMP length composition data (Figure 8.9b). In the scenarios without recruitment deviations (v8_m3), the predicted NCRMP composition is identical across years and similar to cumulative fit when the length data were aggregated in model v4_m3. Finally, Figure 8.10 shows the observed and predicted mean length by year.

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. 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 8.11. All retrospectives show wide 95% confidence intervals. The retrospective pattern was most divergent in the scenario with recruitment deviations and annual fishery-independent length data, model v19_m2. In this scenario, the spawning biomass shows sensitivity to the removal of 2019 and 2018 data.

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 8.12 shows the profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for St. Thomas and St. John

Yellowtail Snapper across model scenarios (v4,_m3, v8_m3 and v19_m3). All models show conflicting signals and relatively poorly defined minimums, with a range of equally plausible values reflected by only small changes in likelihood. Figure 8.13 shows the corresponding change in the Maximum Sustainable Yield Proxy based on SPR 40% across the range of unfished recruitment values explored.

4.7.2 Initial Equilibrium Catch

Figure 8.14 shows the profile likelihood for the initial equilibrium catch for St. Thomas and St. John Yellowtail Snapper across model scenarios (v4_m3, v8_m3, and v19_m3). The models suggest improved fit associated with larger values of fixed initial equilibrium catch. Figure 8.14 shows the profile likelihood for the initial equilibrium catch for St. Thomas and St. John Yellowtail Snapper across model scenarios (v4_m3, v8_m3, and v19_m3). The profiles indicate improved model fit with larger fixed values of initial equilibrium catch. A few of the sensitivity runs, specifically two from the v4_m3 scenario and three from the v19_m3 scenario, appear as peaks or spikes in the likelihood profile. These reflect local minima where the model settled on alternative estimates of the DCRMP selectivity end parameter. Although they affect the smoothness of the profile, these peaks are not considered a concern for the overall analysis. Figure 8.15 shows the corresponding change in the MSY SPR 40% across the range of initial equilibrium catch values explored. This suggests that given further flexibility the initial equilibrium may be estimated higher. This was further examined through sensitivity runs further relaxing the information that informs the initial model conditions.

4.7.3 Steepness

Figure 8.16 shows the profile likelihood for the steepness parameter of the Beverton – Holt stock-recruit function for St. Thomas and St. John Yellowtail Snapper across model scenarios (v4_m3, v7_m3, and v19_m3). The lowest likelihoods are predominantly associated with the lowest values of steepness, driven by the fit to the length data. Figure 8.17 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 change to the derived quantities relative to the corresponding m3 sensitivity model configurations (Tables 7.6, 7.8, 7.9, and 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 showed the only slight differences from the corresponding m3 configurations. These differences included lower spawning stock biomass ratios, and higher fishing mortality ratios and similar equilibrium catch and estimates of maximum sustainable yield proxy (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. However, likelihood profiles (see

Section 4.7.2) showed improved fit at even higher 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, which are known to be difficult to resolve without longer time series. The m3_s3 sensitivities produced extremely higher estimates of initial catch and Maximum Sustainable Yield, lower fishing mortality ratios, and moderately high biomass ratios compared to the m3 models (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.

Figure 8.18 shows that the estimates and associated uncertainty for unfished recruitment (R0) and virgin spawning stock biomass in the m3_s3 sensitivity scenarios are shifted towards higher values compared to the m3 model results (See Figure 8.2). The time series of derived quantities for the m3_s3 scenarios are provided in Figure 8.19 and appear broadly similar to those from the m3 models shown in Figure 8.3, with the exception of the scale and notably higher uncertainty.

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 (Tables 7.6, 7.8, 7.9, and 7.10). As shown in Figure 8.20, the estimates and uncertainty for unfished recruitment (R0) and virgin spawning stock biomass in the m3_s4 models are also similar to those of the prior sensitivity plotted in Figure 8.18. The time series of derived quantities in Figure 8.21 indicate that the m3_s4 models converge on drastically higher spawning output and lower fishing mortality relative to the m3 scenarios.

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 St. Thomas and St. John. Across the wide range of scenarios explored, all model configurations consistently indicated that the stock is not overfished and that overfishing is not occurring (Table 7.10). However, diagnostics and sensitivity analyses revealed important caveats, primarily due to the strong influence of fixed parameter assumptions including initial conditions and growth.

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. 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, given the limited years of available data. However, the availability of fishery-independent length data from the NCRMP and DCRMP surveys 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:

- 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.

- At the data workshop, workshop participants emphasized that federal regulations do affect retention, however there were insufficient 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 St. Thomas St. John from 2012-2022 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 and Reel	Traps
2012	15.08	33,251	69%	22%	1%	9%
2013	10.74	23,685	67%	21%	1%	11%
2014	14.18	31,261	67%	19%	2%	12%
2015	11.01	24,273	80%	8%	2%	11%
2016	12.72	28,034	74%	9%	3%	13%
2017	10.33	22,772	71%	9%	4%	16%
2018	9.70	21,377	73%	5%	2%	20%
2019	11.29	24,881	76%	4%	3%	18%
2020	12.00	26,456	80%	1%	3%	15%
2021	7.47	16,477	71%	0%	9%	20%
2022	8.16	17,984	70%	0%	11%	19%
Total	122.67	270,451	72%	10%	3%	14%

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).

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 St. Thomas and St. John Yellowtail Snapper stock assessment.

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	v1	index + annual fishery-independent length data
Scenario	v4	index + dome-shaped selectivity
Scenario	v8	index + annual fishery-independent length data + dome-shaped selectivity
Scenario	v19	index + annual fishery-independent length data + dome-shaped selectivity + 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: St. Thomas and St. John Yellowtail Snapper correlations between estimated parameters across the m2 and 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
v4_m2	Initial F	Unfished Recruitment (R0)	-0.992
v4_m2	Commercial Selectivity Asend.	Commercial Selectivity Peak	0.963
v4_m3	Commercial Selectivity Asend.	Commercial Selectivity Peak	0.959
v8_m2	Initial F	Unfished Recruitment (R0)	-0.990
v19_m2	Initial F	Unfished Recruitment (R0)	-0.943

Table 7.5: St. Thomas and St. John 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 (v4_m3, v8_m3, and v19_m3). CV is calculated as the SD divided by the parameter estimate.

Derived Quantity	Scenario	Estimate	SD	CV
SSB Unfished (mt)	v4_m3	163.01	43.16	0.26
	v8_m3	186.18	45.96	0.25
	v19_m3	180.57	43.06	0.24
SSB Initial (mt)	v4_m3	42.85	20.47	0.48
	v8_m3	45.10	17.23	0.38
	v19_m3	25.66	9.91	0.39
Ratio SSB Initial:Unfished	v4_m3	0.26	0.13	0.48
	v8_m3	0.24	0.09	0.39
	v19_m3	0.14	0.07	0.46

Table 7.6: St. Thomas and St. John Yellowtail Snapper estimated initial equilibrium catch in metric tons by model scenario including across sensitivity runs. The input value was 25 metric tons with a standard error of 0.3.

Parameter	Scenario	v4	v8	v19
Commercial Equilibrium Catch	m2	25.01	25.01	25.02
	m3	30.95	35.44	35.84
	m3_s1	34.10	36.88	38.68
	m3_s2	31.14	35.09	34.93
	m3_s3	146.98	201.85	135.83
	m3_s4	130.99	186.93	116.44

Table 7.7: St. Thomas and St. John Yellowtail Snapper parameters, standard deviations (SD), and coefficient of variation (CV) by model scenario (v4_m3, v8_m3, and v19_m3). CV is calculated as the SD divided by the parameter estimate.

Parameter	Scenario	Estimate	SD	CV	Gradient
Commercial Selectivity Asend.	v4_m3	2.34	0.70	0.30	2.4e-05
	v8_m3	-5.69	5.93	-1.04	-3.7e-07
	v19_m3	-5.12	7.24	-1.41	-9.6e-07
Commercial Selectivity Peak	v4_m3	28.49	1.51	0.05	-2.6e-05
	v8_m3	25.43	2.25	0.09	-4.4e-06
	v19_m3	25.42	3.13	0.12	-7.5e-06
DCRMP Selectivity End	v4_m3	-0.34	0.33	-0.97	-1.6e-06
	v8_m3	-0.74	0.30	-0.41	-1.4e-06
	v19_m3	-0.93	0.32	-0.34	3.4e-06
DCRMP Selectivity Peak	v4_m3	18.42	0.49	0.03	1.1e-06
	v8_m3	18.76	0.55	0.03	-5.3e-06
	v19_m3	17.89	0.65	0.04	1.4e-05
DCRMP Selectivity Top	v4_m3	-1.21	0.17	-0.14	-4.9e-07
	v8_m3	-1.25	0.16	-0.13	-1.6e-05
	v19_m3	-1.17	0.15	-0.13	7.9e-06
Initial F	v4_m3	0.47	0.34	0.72	-6.2e-08
	v8_m3	0.50	0.28	0.56	-2.0e-07
	v19_m3	1.06	0.72	0.68	-9.7e-07
NCRMP Selectivity End	v4_m3	-1.91	0.25	-0.13	1.7e-07
	v8_m3	-1.78	0.24	-0.13	5.4e-06
	v19_m3	-1.93	0.24	-0.12	5.6e-06
NCRMP Selectivity Peak	v4_m3	8.21	0.31	0.04	-1.6e-05
	v8_m3	8.17	0.31	0.04	1.2e-06
	v19_m3	7.17	0.50	0.07	1.6e-05
	v4_m3	-0.70	0.04	-0.06	-1.2e-05

Parameter	Scenario	Estimate	SD	CV	Gradient
NCRMP Selectivity Top	v8_m3	-0.70	0.04	-0.06	1.2e-05
	v19_m3	-0.67	0.04	-0.06	4.5e-05
Unfished Recruitment (R0)	v4_m3	5.75	0.26	0.05	-1.1e-05
	v8_m3	5.88	0.25	0.04	3.2e-06
	v19_m3	5.85	0.24	0.04	9.5e-06

Table 7.8: St. Thomas and St. John Yellowtail Snapper derived quantities of the MSY proxy (based on SPR 40%) in metric tons by model scenario (v4_m3, v8_m3, and v19_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**
v4_m2	22.81	2.19	0.10
v4_m3	26.96	7.02	0.26
v4_m3_s1	28.59	7.30	0.26
v4_m3_s2	26.37	7.16	0.27
v4_m3_s3	121.44	143.28	1.18
v4_m3_s4	110.79	130.70	1.18
v8_m2	22.89	1.83	0.08
v8_m3	30.42	7.48	0.25
v8_m3_s1	31.27	7.64	0.24
v8_m3_s2	29.61	7.46	0.25
v8_m3_s3	165.21	189.76	1.15
v8_m3_s4	155.39	182.57	1.17
v19_m2	21.24	0.76	0.04
v19_m3	29.46	6.99	0.24
v19_m3_s1	30.85	7.23	0.23
v19_m3_s2	28.97	7.03	0.24
v19_m3_s3	110.19	128.86	1.17
v19_m3_s4	97.06	115.65	1.19

Table 7.9: St. Thomas and St. John Yellowtail Snapper derived quantities of the MSY proxy (based on SPR 40%) in pounds by model scenario (v4_m3, v8_m3, and v19_m3) and corresponding each model scenario's four sensitivity runs.

Scenario	**v4**	**v8**	**v19**
m2	50,291	50,470	46,826
m3	59,429	67,060	64,952
m3_s1	63,041	68,930	68,008
m3_s2	58,135	65,287	63,874
m3_s3	267,723	364,234	242,934
m3_s4	244,259	342,578	213,970

Table 7.10: St. Thomas and St. John 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 fishing mortality ratios that are below 0.75 are shown in red font.

Metric	Scenario	v4	v8	v19
F Current / F SPR 40%	m2	0.27	0.26	0.53
	m3	0.22	0.19	0.35
	m3_s1	0.21	0.18	0.32
	m3_s2	0.24	0.21	0.37
	m3_s3	0.04	0.03	0.07
	m3_s4	0.05	0.03	0.09
SSB 2022 / SSB SPR 40%	m2	1.60	1.61	0.82
	m3	1.65	1.70	0.92
	m3_s1	1.65	1.71	0.95
	m3_s2	1.56	1.61	0.88
	m3_s3	1.90	1.96	1.19
	m3_s4	1.80	1.87	1.15

8 Figures

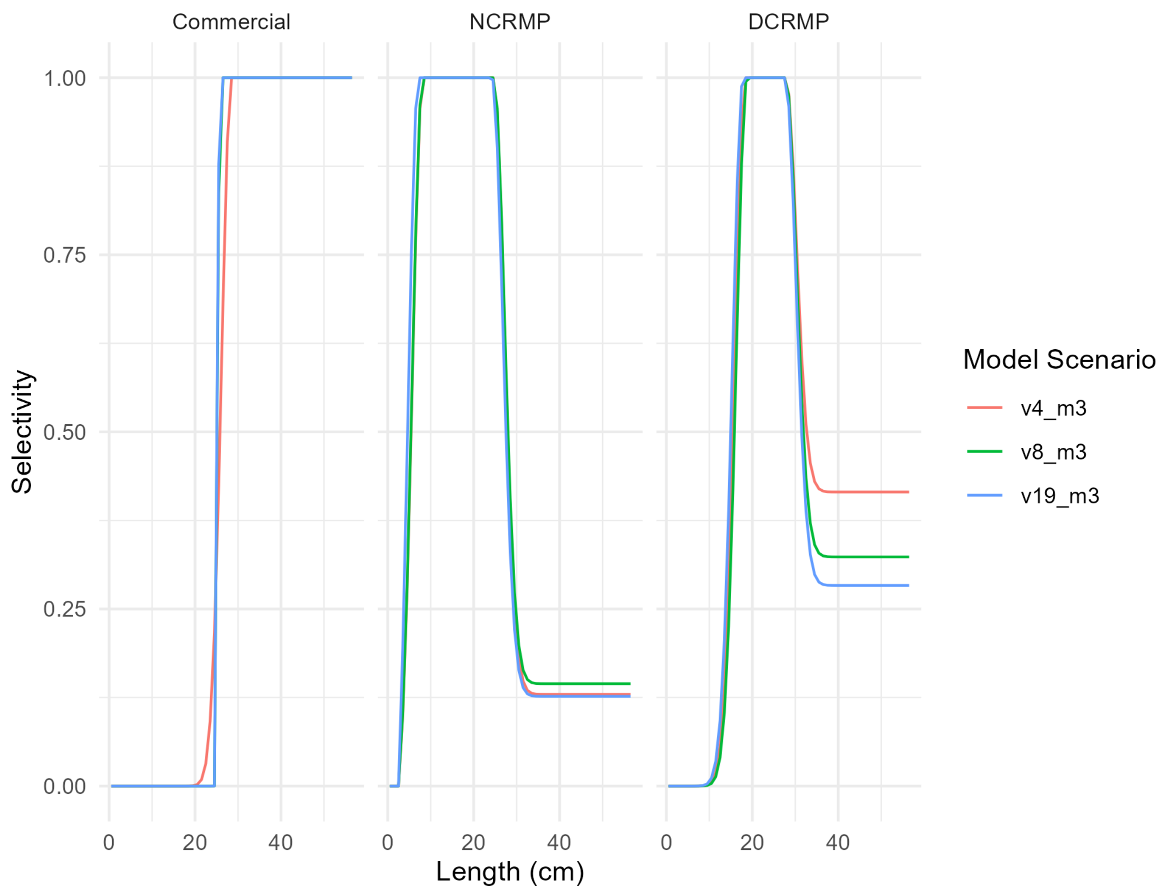
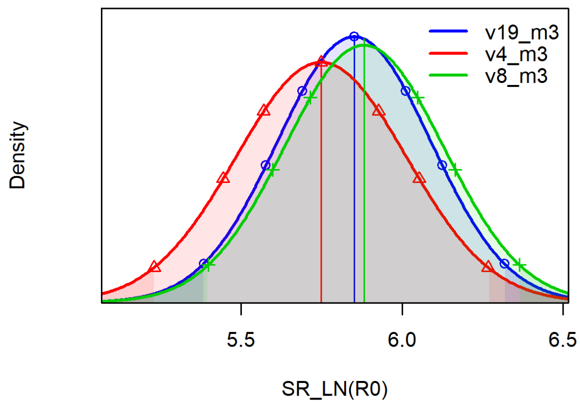
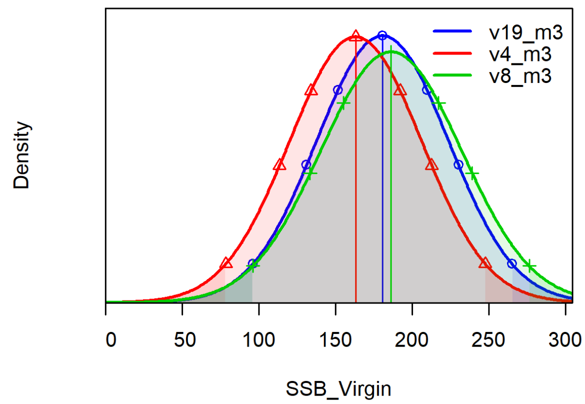


Figure 8.1: St. Thomas and St. John Yellowtail Snapper commercial fleet logistic selectivity and National Coral Reef Monitoring Survey (NCRMP) and Deep Coral Reef Monitoring Survey (DCRMP) domed selectivity across model scenarios (v4_m3, v8_m3, and v7_m3). Selectivity patterns reflect the probability that a fish of a given length will be caught by a particular fishing fleet or observed in a given survey.

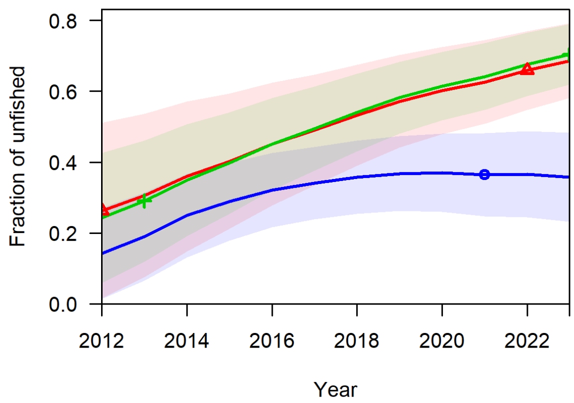


(a) Unfished recruitment

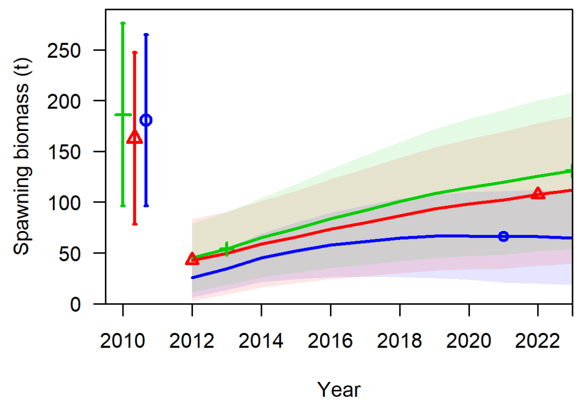


(b) Virgin Spawning Stock Biomass

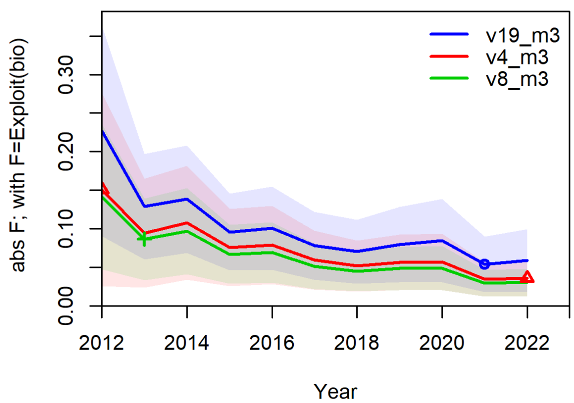
Figure 8.2: St. Thomas and St. John Yellowtail Snapper parameter distribution for (a) the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function and (b) virgin spawning stock biomass in metric tons across model scenarios (v4_m3, v8_m3, and v19_m3).



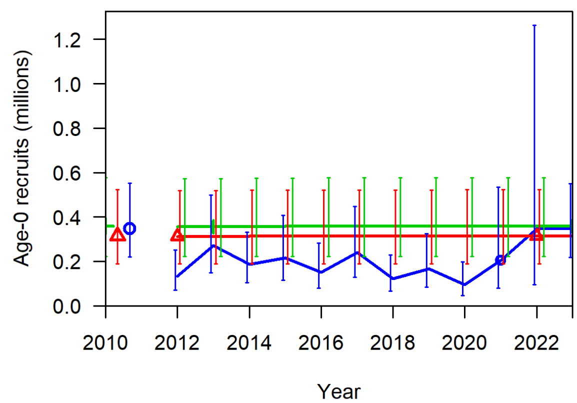
(a) Spawning Biomass Ratio



(b) Spawning Biomass

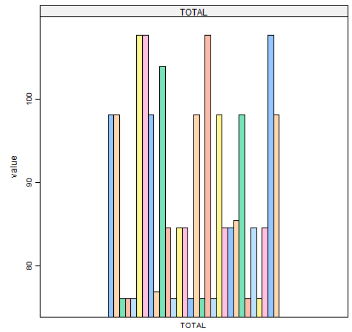


(c) Fishing Mortality

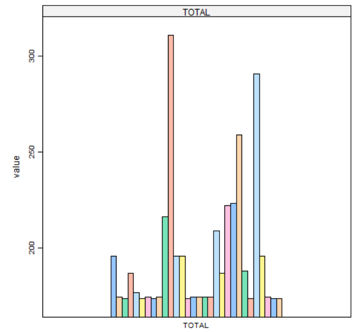


(d) Recruitment

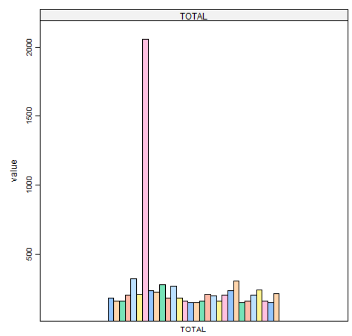
Figure 8.3: St. Thomas and St. John Yellowtail Snapper derived quantity time series across model scenarios (v4_m3, v8_m3, and v19_m3). Derived quantities plotted over time for (a) the relative spawning stock biomass (total biomass / virgin spawning stock biomass), (b) spawning stock biomass in metric 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 v4_m3

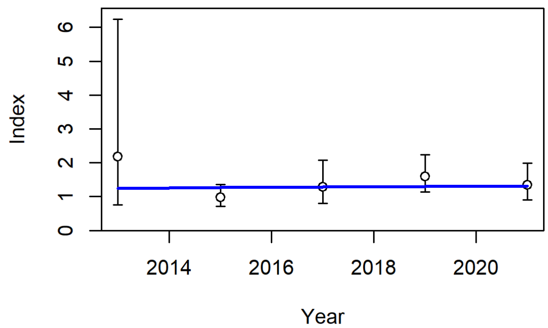


(b) Model v8_m3

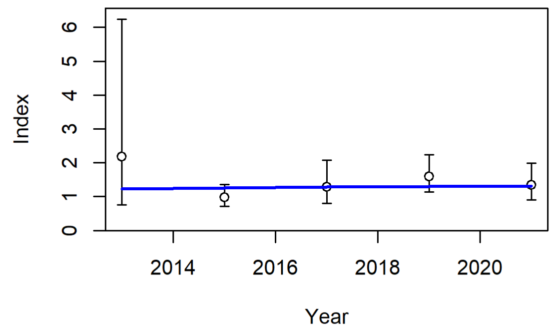


(c) Model v19_m3

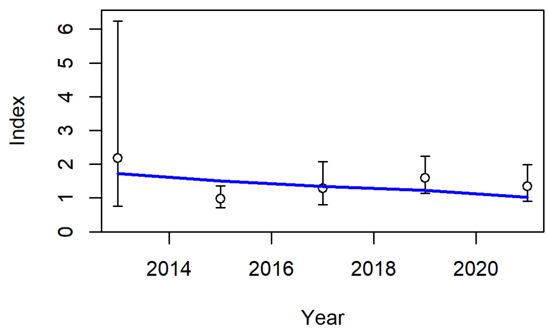
Figure 8.4: St. Thomas and St. John Yellowtail Snapper jitter analysis total likelihood across model scenarios (v4_m3, v8_m3, and v19_m3). Each panel gives the results of 30 runs of the corresponding model scenario where the starting parameter values for each run were randomly changed by 20% from each model's predicted values using a uniform distribution in cumulative normal space.



(a) v4_m3

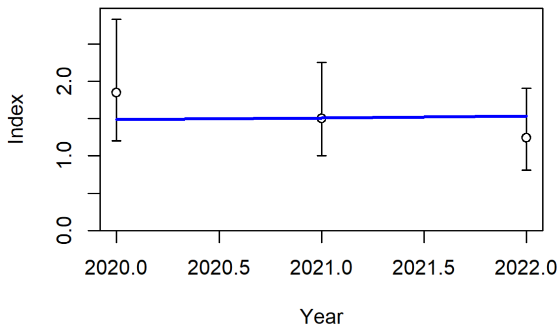


(b) v8_m3

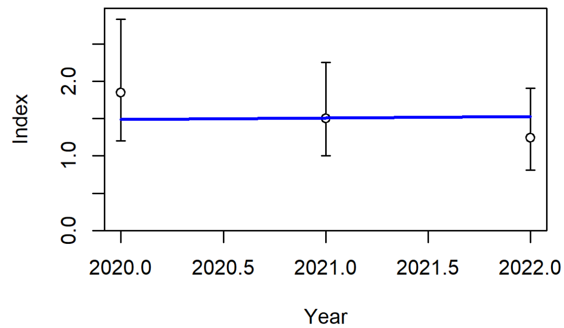


(c) v19_m3

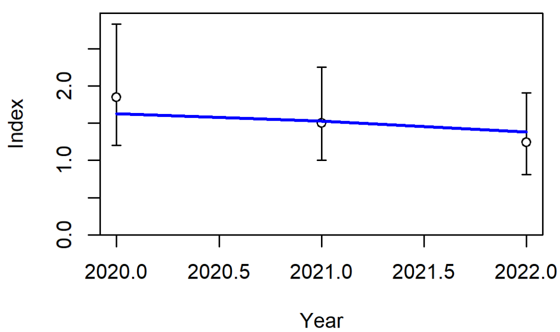
Figure 8.5: St. Thomas and St. John Yellowtail Snapper National Coral Reef Monitoring Program (NCRMP) observed (open circles) and predicted (blue line) indices of relative abundance and associated standard errors across model scenarios (v4_m3, v8_m3, and v19_m3). Error bars indicate a 95% uncertainty interval around observed index values based on the model assumption of lognormal error. Model scenarios v4_m3 and v8_m3 do not estimate recruitment deviations, while model scenarios v19_m3 does.



(a) v4_m3

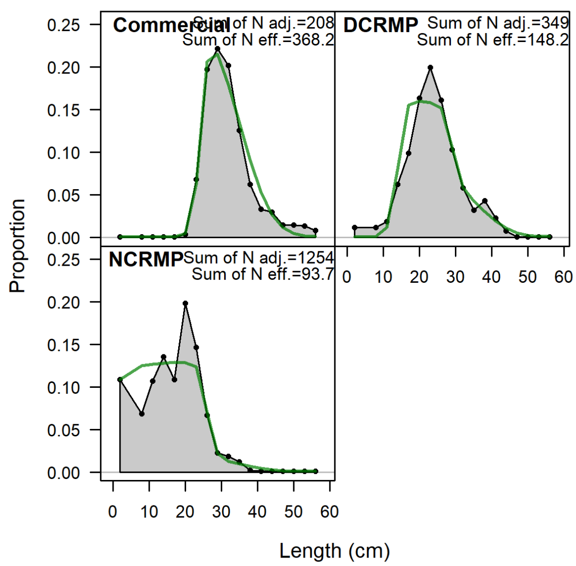


(b) v8_m3



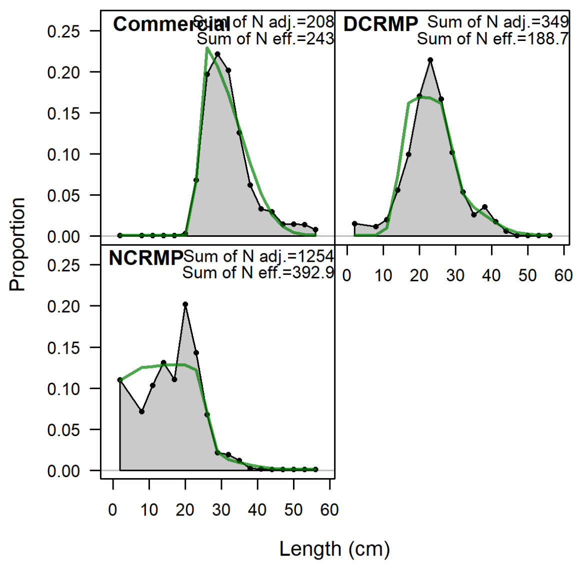
(c) v19_m3

Figure 8.6: St. Thomas and St. John Yellowtail Snapper Deep National Coral Reef Monitoring Program (DCRMP) observed (open circles) and predicted (blue line) indices of relative abundance and associated standard errors across model scenarios (v4_m3, v8_m3, and v19_m3). Error bars indicate a 95% uncertainty interval around observed index values based on the model assumption of lognormal error. Model scenarios v4_m3 and v8_m3 do not estimate recruitment deviations, while model scenarios v19_m3 does.

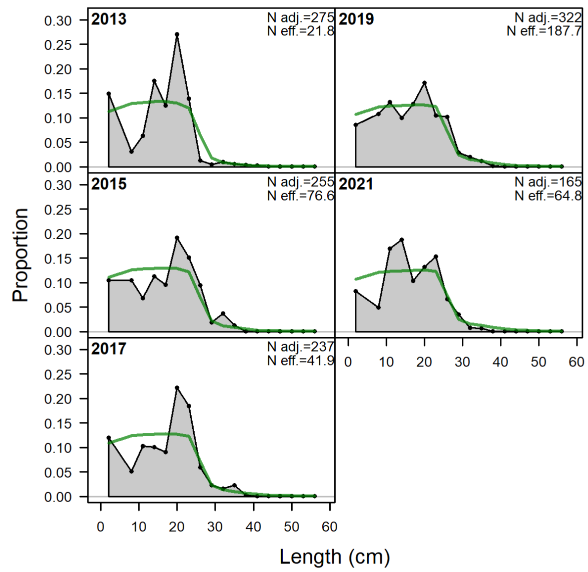


(a) v4_m3 across all years

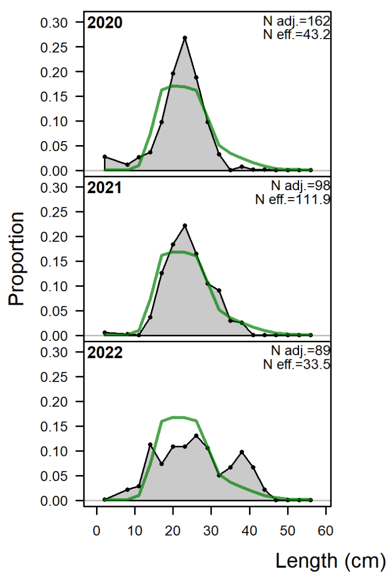
Figure 8.7: St. Thomas and St. John Yellowtail Snapper observed and predicted length distributions in centimeters aggregated across years for the Commercial (TIP), National Coral Reef Monitoring Survey (NCRMP) and Deep Coral Reef Monitoring Survey (DCRMP) length compositions for the (a) v4_m3 model scenario. 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. Since super years are utilized for the commercial fleet, NCRMP, and DCRMP survey in these model scenarios, the fits to annual data are not shown.



(a) v8_m3 across all years

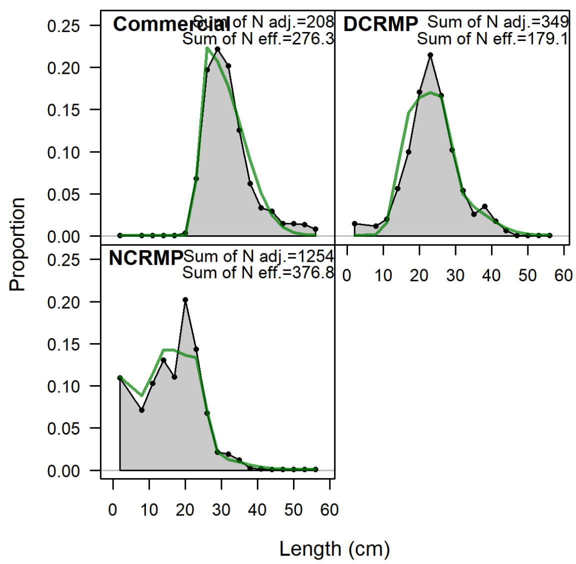


(b) v8_m3 NCRMP by year

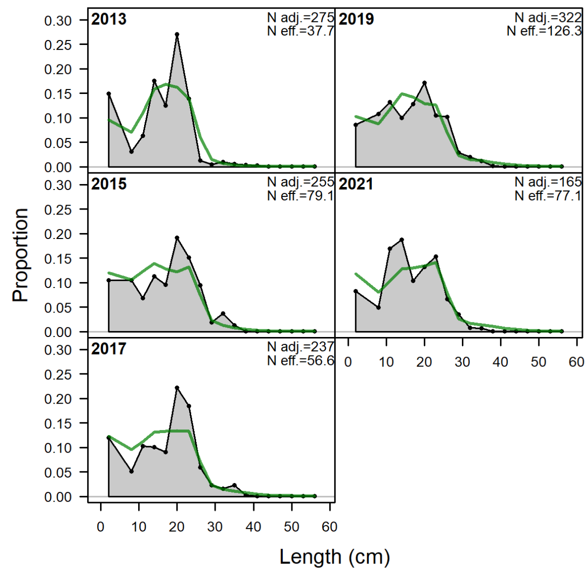


(c) v8_m3 DCRMP by year

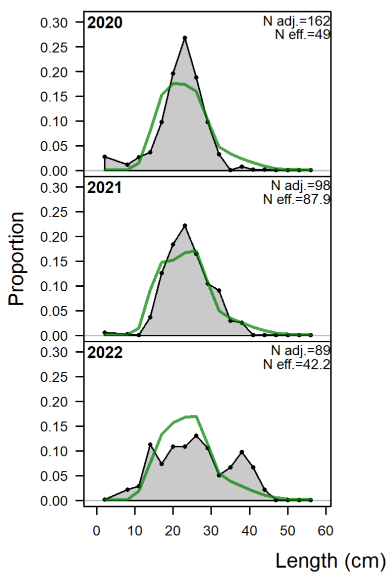
Figure 8.8: St. Thomas and St. John Yellowtail Snapper observed and predicted length distributions in centimeters (a) aggregated across years, (b) by year for the National Coral Reef Monitoring Survey (NCRMP), and (c) by year for the Deep Coral Reef Monitoring Survey (DCRMP) length compositions for the v8_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) v19_m3 across all years

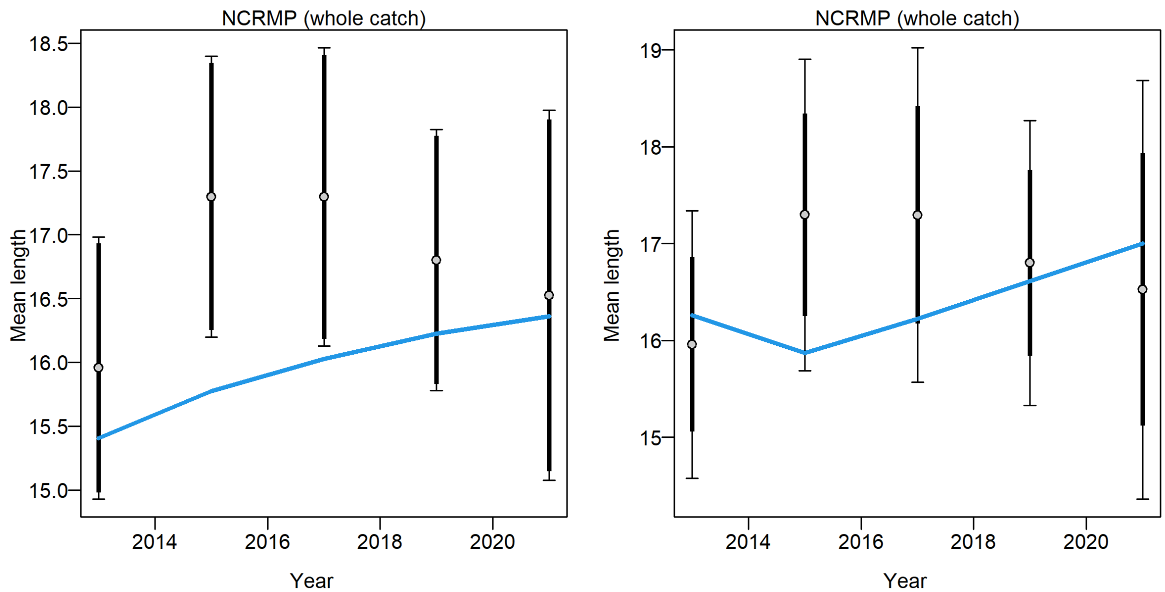


(b) v19_m3 NCRMP by year



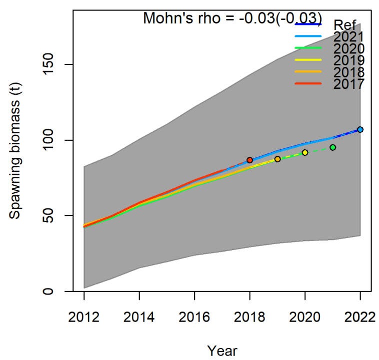
(c) v19_m3 DCRMP by year

Figure 8.9: St. Thomas and St. John Yellowtail Snapper observed and predicted length distributions in centimeters (a) aggregated across years, (b) by year for the National Coral Reef Monitoring Survey (NCRMP), and (c) by year for the Deep Coral Reef Monitoring Survey (DCRMP) length compositions for the v19_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.

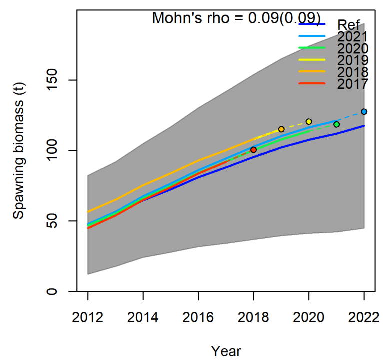


(a) v8_m3 (b) v19_m3

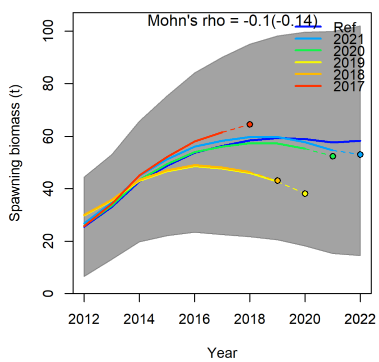
Figure 8.10: St. Thomas and St. John Yellowtail Snapper observed (open circles) and predicted (blue line) mean length in centimeters by year across model scenarios that include annual fishery-independent National Coral Reef Monitoring Survey (NCRMP) data without recruitment deviations (v8_m3) and with recruitment deviations (v19_m3).



(a) v4_m3

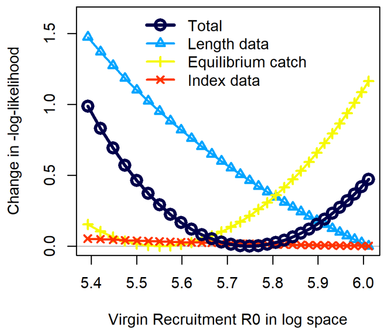


(b) v8_m3

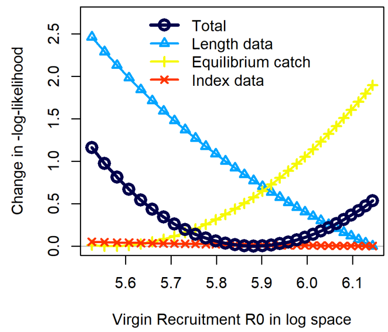


(c) v19_m3

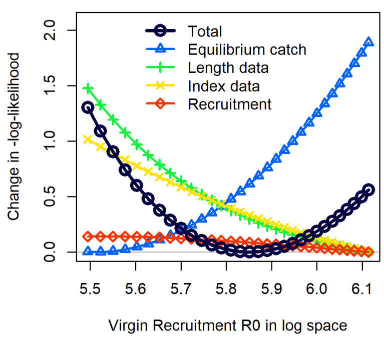
Figure 8.11: St. Thomas and St. John Yellowtail Snapper retrospective analysis of spawning stock biomass (SSB) conducted by refitting models after removing five years of observation, one year at a time sequentially. Mohn's rho statistics and the corresponding "hindcast rho" measure the severity of retrospective 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) v4_m3

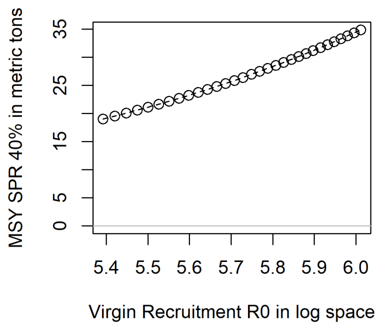


(b) v8_m3

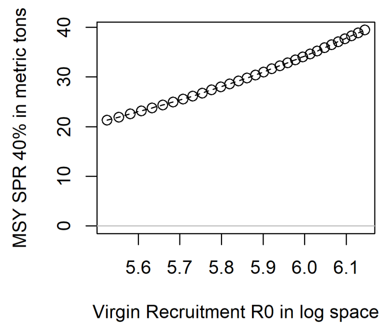


(c) v19_m3

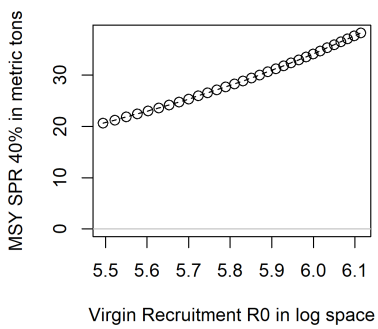
Figure 8.12: The profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for St. Thomas and St. John Yellowtail Snapper across model scenarios (v4_m3, v8_m3, and v19_m3). Each line represents the change in negative log-likelihood value 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) v4_m3

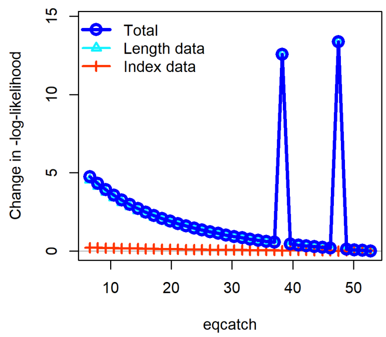


(b) v8_m3

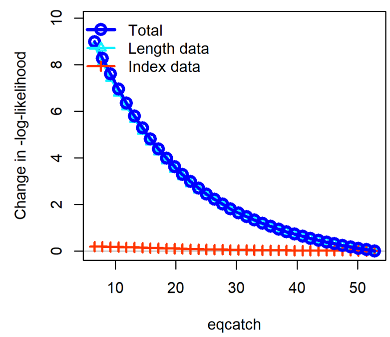


(c) v19_m3

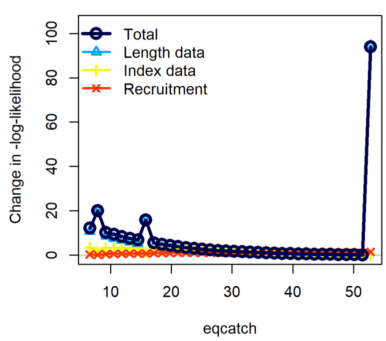
Figure 8.13: Estimates of the MSY proxy (based on SPR 40%) across the range of unfished recruitment values explored in the St. Thomas and St. John Yellowtail Snapper likelihood profile. These estimates, expressed in metric tons, are shown for model scenarios v4_m3, v8_m3, and v19_m3.



(a) v4_m3

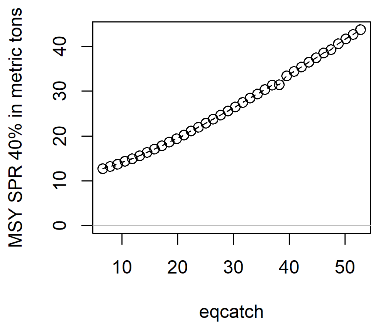


(b) v8_m3

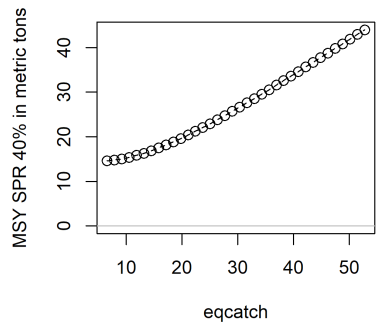


(c) v19_m3

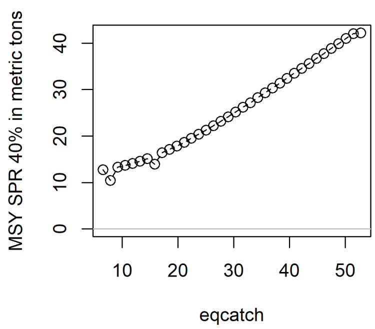
Figure 8.14: The profile likelihood for the fixed initial equilibrium catch for St. Thomas and St. John Yellowtail Snapper across model scenarios (v4_m3, v8_m3, and v19_m3). Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed equilibrium catch values tested in the profile diagnostic run.



(a) v4_m3

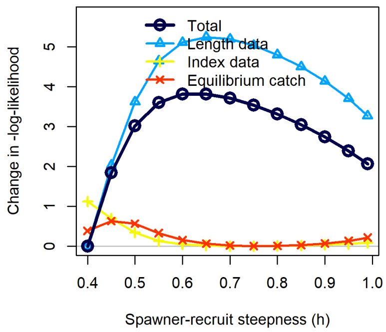


(b) v8_m3

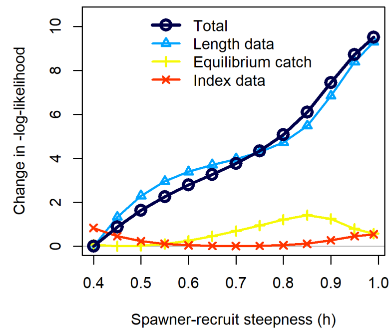


(c) v19_m3

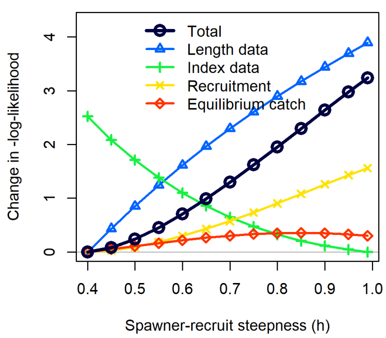
Figure 8.15: Estimates of the MSY proxy (based on SPR 40%) across the range of initial equilibrium catch values explored in the St. Thomas and St. John Yellowtail Snapper likelihood profile. These estimates, expressed in metric tons, are shown for model scenarios v4_m3, v8_m3, and v19_m3.



(a) v4_m3



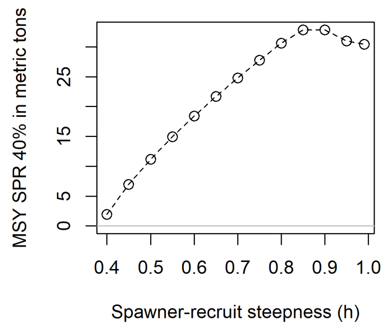
(b) v8_m3



(c) v19_m3

Figure 8.16: The profile likelihood for the steepness parameter of the Beverton – Holt stock-recruit function for St. Thomas and St. John Yellowtail Snapper across model scenarios (v4_m3, v8_m3, and v19_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.

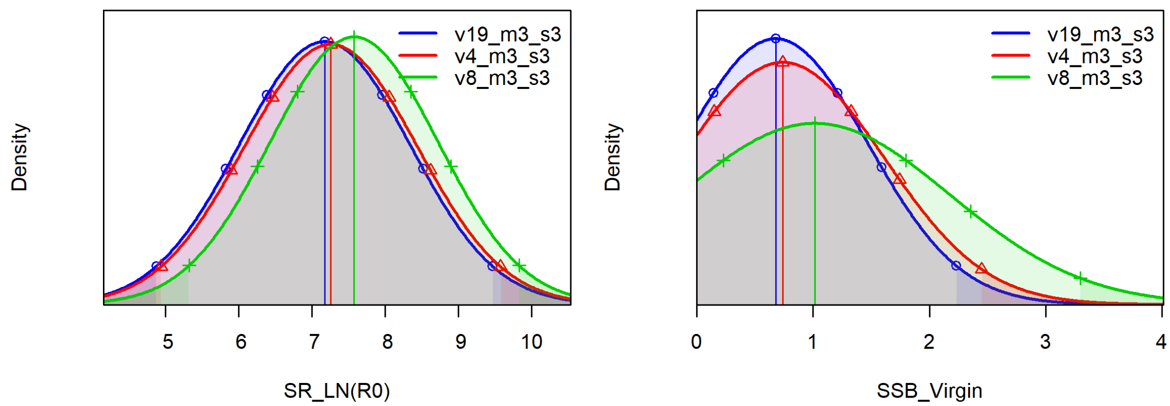
(a) v4_m3



(b) v8_m3

(c) v19_m3

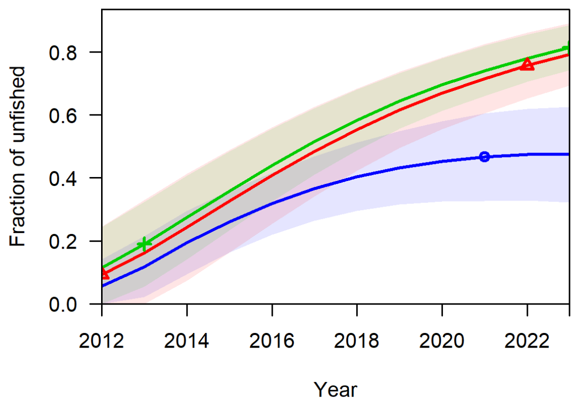
Figure 8.17: Estimates of the MSY proxy (based on SPR 40%) across the range of steepness values explored in the St. Thomas and St. John Yellowtail Snapper likelihood profile. These estimates, expressed in metric tons, are shown for model scenarios v4_m3, v8_m3, and v19_m3.



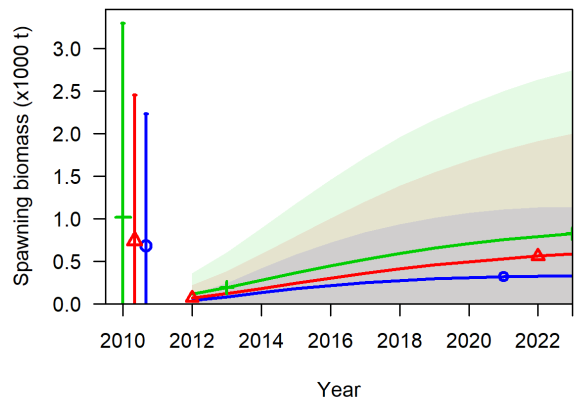
(a) Unfished recruitment (R0)

(b) Virgin Spawning Stock Biomass

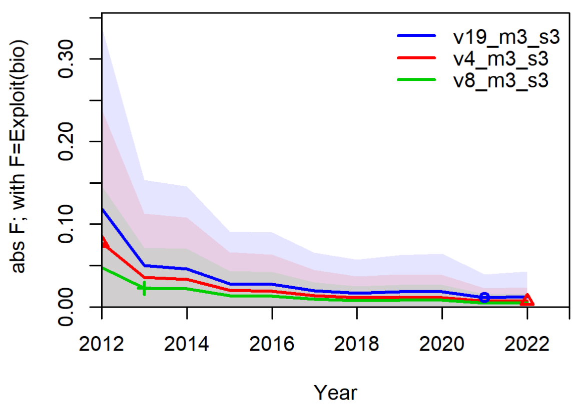
Figure 8.18: St. Thomas and St. John Yellowtail Snapper parameter distribution for (a) the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function and (b) virgin spawning stock biomass in metric tons across model scenarios (v4_m3_s3, v8_m3_s3, and v19_m3_s3).



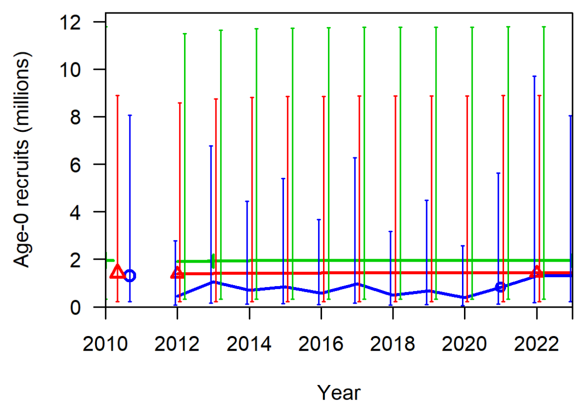
(a) Spawning Biomass Ratio



(b) Spawning Biomass

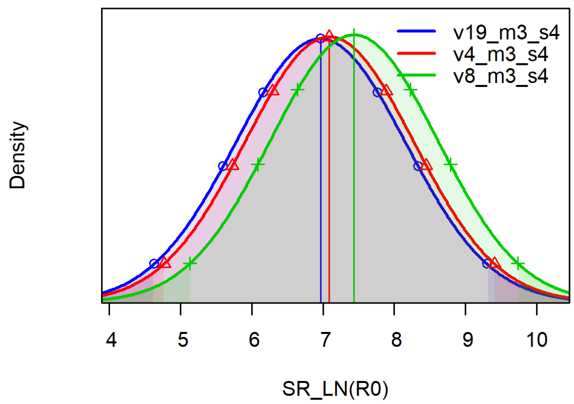


(c) Fishing Mortality

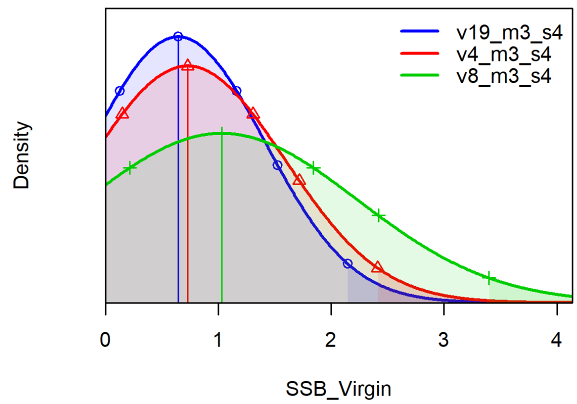


(d) Recruitment

Figure 8.19: St. Thomas and St. John Yellowtail Snapper derived quantity time series across model scenarios (v4_m3_s3, v8_m3_s3, and v19_m3_s3). Derived quantities plotted over time for (a) the relative spawning stock biomass (total biomass / virgin spawning stock biomass), (b) spawning stock biomass in 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.

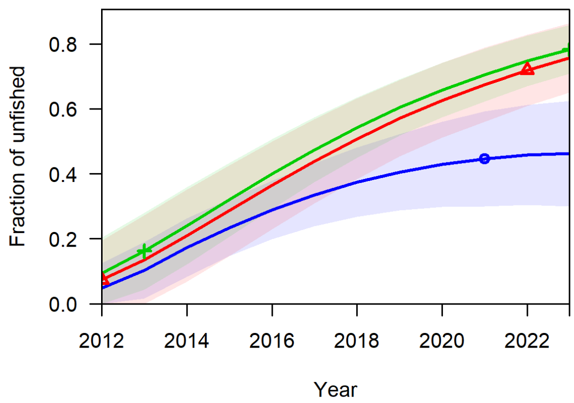


(a) Unfished recruitment (R0)

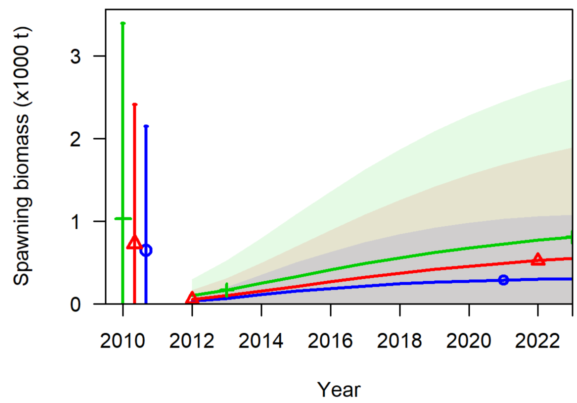


(b) Virgin Spawning Stock Biomass

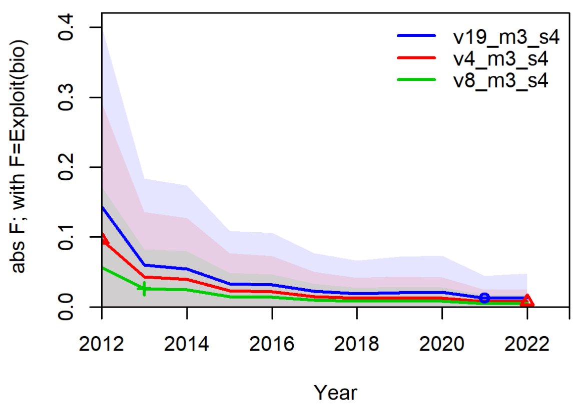
Figure 8.20: St. Thomas and St. John Yellowtail Snapper parameter distribution for (a) the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function and (b) virgin spawning stock biomass in metric tons across model scenarios (v4_m3_s4, v8_m3_s4, and v19_m3_s4).



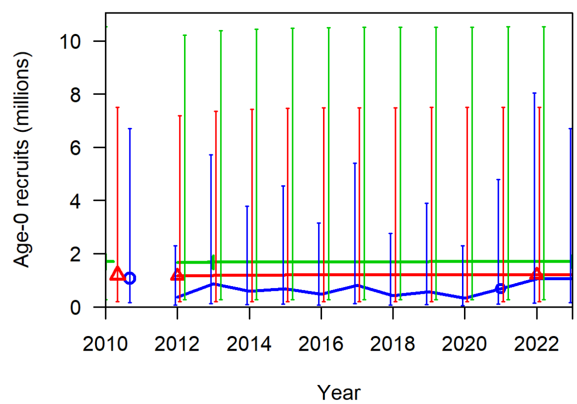
(a) Spawning Biomass Ratio



(b) Spawning Biomass



(c) Fishing Mortality



(d) Recruitment

Figure 8.21: St. Thomas and St. John Yellowtail Snapper derived quantity time series across model scenarios (v4_m3_s4, v8_m3_s4, and v19_m3_s4). Derived quantities plotted over time for (a) the relative spawning stock biomass (total biomass / virgin spawning stock biomass), (b) spawning stock biomass in 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.

References

Carvalho, F., Winker, H., Courtney, D., Kapur, M., Kell, L., Cardinale, M., Schirripa, M., Kitakado, T., Yemane, D., Piner, K. R., Maunder, M. N., Taylor, I., Wetzel, C. R., Doering, K., Johnson, K. F., & Methot, R. D. (2021). A cookbook for using model diagnostics in integrated stock assessments. *Fisheries Research*, *240*, 105959. https://doi.org/10.1016/j.fishres.2021.105959

Cope, J. (2024). *Stock assessment continuum tool*. https://github.com/shcaba/SS-DL-tool

Cope, J., & Hamel, O. S. (2022). Upgrading from M version 0.2: An application-based method for practical estimation, evaluation and uncertainty characterization of natural mortality. *Fisheries Research*, *256*, 106493. https://doi.org/10.1016/j.fishres.2022.106493

Godwin, K., Rios, A., & Dettloff, K. (2024). *SEDAR 84 Trip Interview Program (TIP) Size Composition Analysis of Yellowtail Snapper (Ocyurus chrysurus) in St. Thomas/St. John, U.S. Caribbean, 1983-2022* (SEDAR84-WP-10; p. 10). SEDAR. https://sedarweb.org/documents/sedar-84-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/

Grove, L. J. W., Blondeau, J., & Ault, J. (2024). *Fishery-Independent Reef Fish Visual Survey Population Density and Length Composition for Yellowtail Snapper in St. Thomas/John* (SEDAR84-WP-16; p. 15). SEDAR. https://sedarweb.org/documents/sedar-84-dw-16-fishery-independent-reef-fish-visual-survey-population-density-and-length-composition-for-yellowtail-snapper-in-st-thomas-john/

Grove, L. J. W., Blondeau, J., & Ault, J. S. (2021). *National Coral Reef Monitoring Program's reef fish visual census metadata for the U.S. Caribbean.* 55. https://sedarweb.org/documents/sedar-80-wp-02-national-coral-reef-monitoring-programs-reef-fish-visual-census-metadata-for-the-u-s-caribbean/

Hamel, O. S. (2015). A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. *ICES Journal of Marine Science*, *72*(1), 62–69. https://doi.org/10.1093/icesjms/fsu131

Hamel, O. S., & Cope, J. M. (2022). Development and considerations for application of a longevity-based prior for the natural mortality rate. *Fisheries Research*, *256*, 106477. https://doi.org/10.1016/j.fishres.2022.106477

Martínez Rivera, S., Johnson, K., & Orhun, M. R. (2024). *SEDAR 84 Commercial fishery landings of Yellowtail Snapper (Ocyurus chrysurus) in St. Thomas and St. John, US Caribbean, 2012-2022.* (SEDAR84-WP-02; p. 21). SEDAR. https://sedarweb.org/documents/sedar-84-dw-02-sedar-84-commercial-fishery-landings-of-yellowtail-snapper-ocyurus-chrysurus-in-st-thomas-and-st-john-us-caribbean-2012-2022/

Methot, R. D., & Wetzel, C. R. (2013). Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research*, *142*, 86–99. https://doi.org/10.1016/j.fishres.2012.10.012

Methot, R. D., Wetzel, C. R., Taylor, I. G., & Doering, K. (2020). Stock synthesis user manual: Version 3.30.15. *Northwest Fisheries Science Center (U.S.)*. https://doi.org/10.25923/5WPN-QT71

Ono, K., Licandeo, R., Muradian, M. L., Cunningham, C. J., Anderson, S. C., Hurtado-Ferro, F., Johnson, K. F., McGilliard, C. R., Monnahan, C. C., Szuwalski, C. S., Valero, J. L., Vert-Pre, K. A., Whitten, A. R., & Punt, A. E. (2015). The importance of length and age composition data in statistical age-structured models for marine species. *ICES Journal of Marine Science*, *72*(1), 31–43. https://doi.org/10.1093/icesjms/fsu007

Schemmel, E., Bohaboy, E. C., Kinney, M. J., & O'Malley, J. M. (2022). An assessment of sampling approaches for estimating growth from fishery-dependent biological samples. *ICES Journal of Marine Science*, *79*(5), 1497–1514. https://doi.org/10.1093/icesjms/fsac075

SEDAR. (2019). *SEDAR 57 Stock Assessment Report U.S. Caribbean Spiny Lobster*. 232. http://sedarweb.org/sedar-57

SEDAR. (2020). *SEDAR 64 Southeastern US Yellowtail Snapper final stock assessment report* (p. 457). SEDAR. https://sedarweb.org/documents/sedar-64-southeastern-us-yellowtail-snapper-final-stock-assessment-report/

SEDAR. (2022). *SEDAR 80 U.S. Caribbean Queen Triggerfish Puerto Rico final stock assessment report*. https://sedarweb.org/documents/sedar-80-us-caribbean-queen-triggerfish-puerto-rico-final-stock-assessment-report/

SEDAR. (2024). *SEDAR 84 U.S. Caribbean Yellowtail Snapper St. Thomas/St. John data workshop report* (p. 46). SEDAR. https://sedarweb.org/documents/sedar-84-us-caribbean-yellowtail-snapper-st-thomas-st-john-data-workshop-report/

Shertzer, K. W., Damiano, M. D., & Williams, E. H. (2024). Spawning Potential Ratio Can Provide Reference Points for Fishery Management That Are Robust to Environmental Variability. *Fishes*. https://doi.org/https://doi.org/10.3390/fishes9120497

Shervette, V. R., Rivera Hernández, J. M., & Peña Alvarado, N. (2024). *U.S. Caribbean Yellowtail Snapper Population Demographics, Growth, and Reproductive Biology: Addressing Critical Life History Gaps* (SEDAR84-WP-08; p. 29). SEDAR. https://sedarweb.org/documents/sedar-84-dw-08-u-s-caribbean-yellowtail-snapper-population-demographics-growth-and-reproductive-biology-addressing-critical-life-history-gaps/

Shervette, V. R., Rivera Hernández, J. M., & Zajovits, S. (2024). *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* (SEDAR84-WP-07; p. 22). SEDAR. https://sedarweb.org/documents/sedar-84-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/

Taylor, I. G., Doering, K. L., Johnson, K. F., Wetzel, C. R., & Stewart, I. J. (2021). Beyond visualizing catch-at-age models: Lessons learned from the r4ss package about software to

support stock assessments. *Fisheries Research*, *239*, 105924.
https://doi.org/10.1016/j.fishres.2021.105924

SEDAR

Southeast Data, Assessment, and Review

SEDAR 84

US Caribbean Yellowtail Snapper – St. Thomas/St. John

SECTION IV: Research Recommendations

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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:

- 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.
- At the data workshop, workshop participants emphasized that federal regulations do affect retention, however there were insufficient 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.

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.

1.3 LIST OF PARTICIPANTS

Review Panel

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Staff

Emily Ott... SEDAR
Graciela Garcia-Moliner ....CFMC Staff

Observers

Nathan Vaughan...SEFSC

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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.

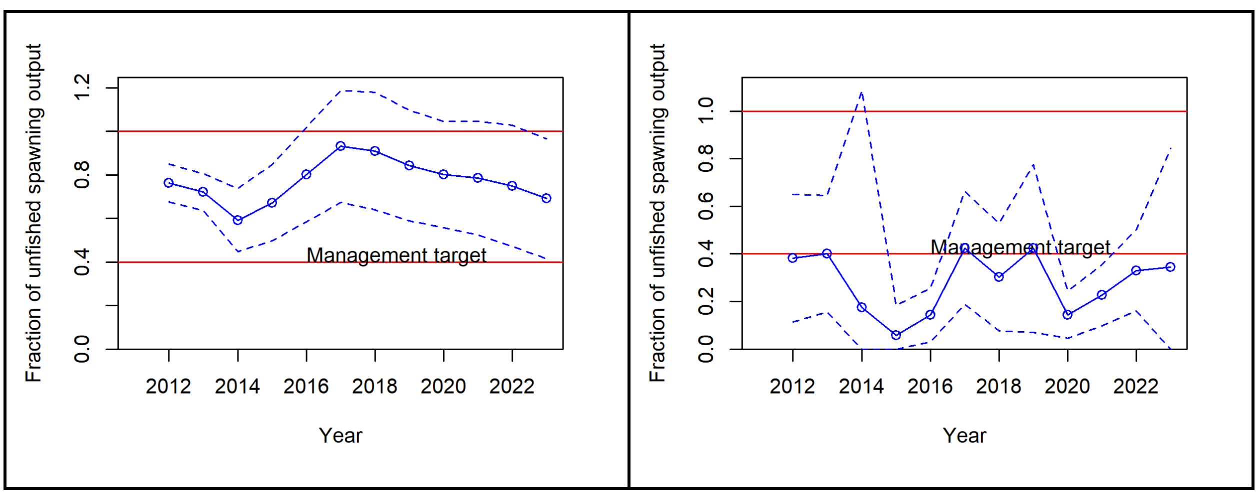

Figure 1 - Depletion level (i.e., fraction of unfished spawning output) estimated by the base run (STX_RW_1; left) and sensitivity run (STX_RW_2; right).

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.

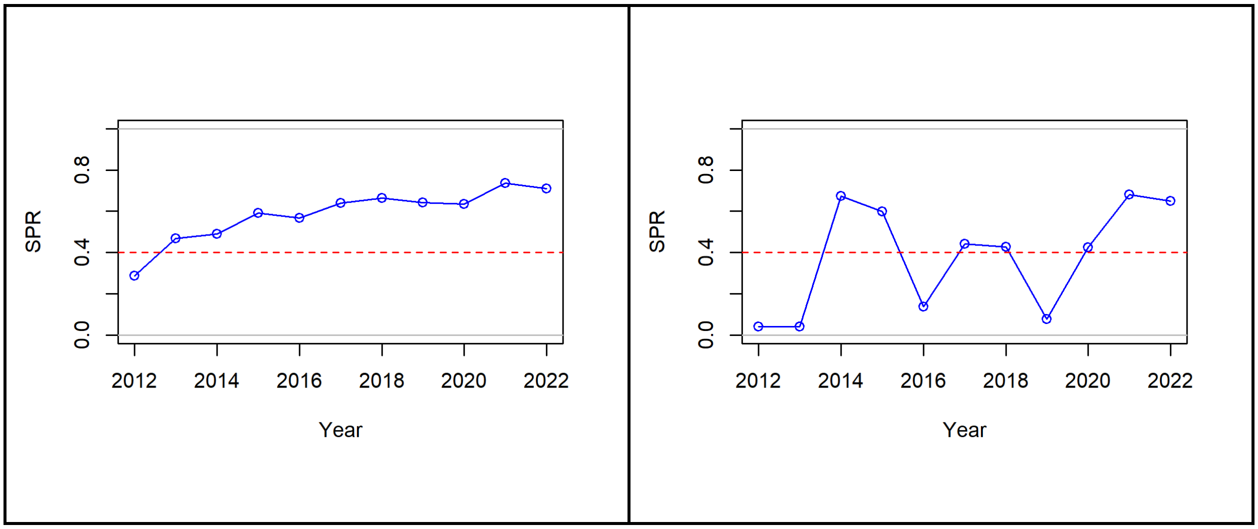

Figure 2 - Spawning Potential Ratio (SPR) estimated by the base run (STTJ_RW_1; left) and sensitivity run (STTJ_RW_2; right) .

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).

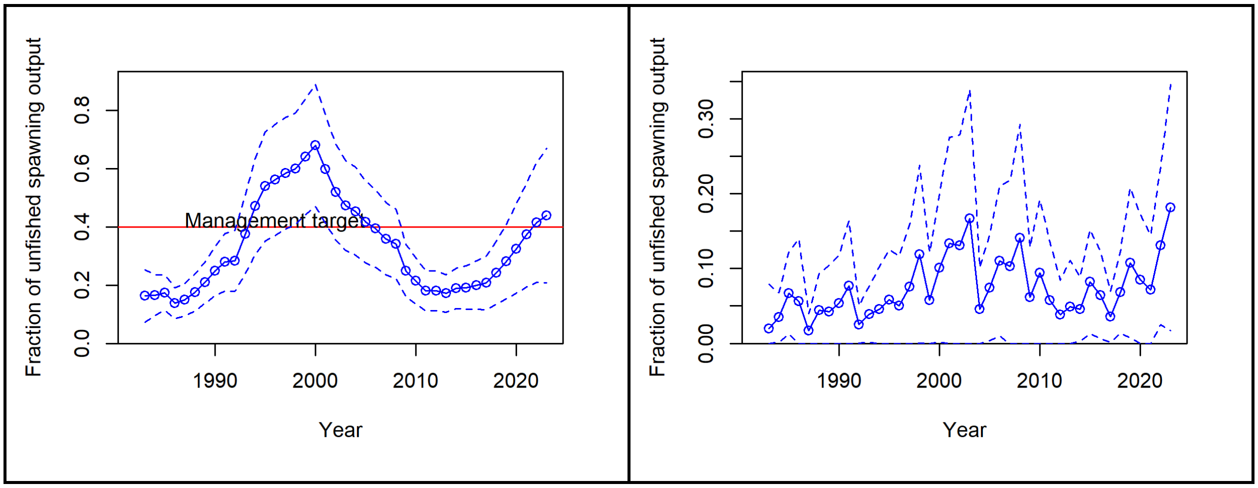

Figure 3 - Depletion level (i.e., fraction of unfished spawning output) estimated by the base run (PR_RW_1; left) and sensitivity run (PR_RW_2; right)

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 – St. Thomas and Saint John

SECTION VI: Post-Review Workshop Addenda

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Addendum

SEDAR 84 St. Thomas and St. John 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 St. Thomas and St. John, USVI.

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 St. Thomas and St. John, 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 exploratory model examined the use of a plus age group at age 12 to test whether grouping older fish into a terminal age class would affect model results. However, this adjustment had no meaningful impact on model behavior or outputs.

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. The results of the models with combined data for Puerto Rico and St. Thomas and St. John data are included in the Puerto Rico addendum.

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

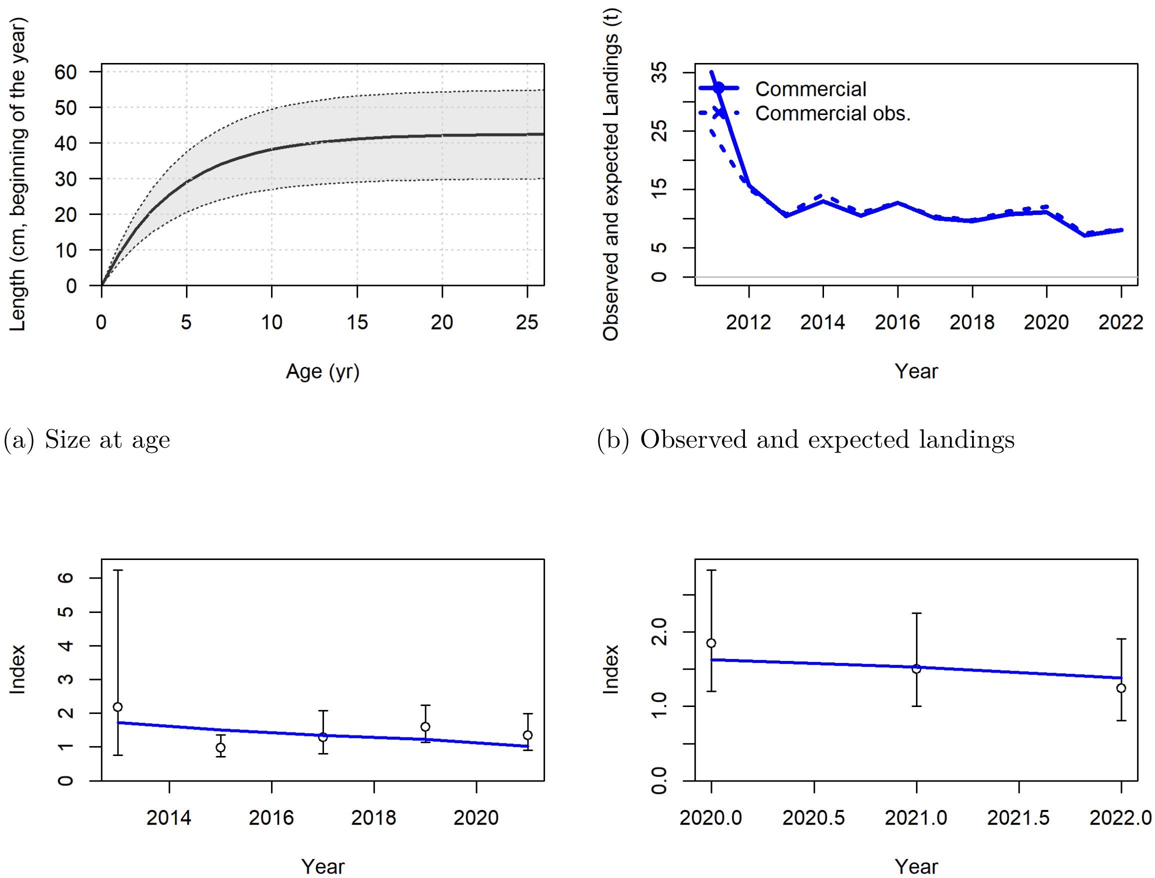
These analyses are exploratory and were conducted under panel direction during the SEDAR 84 Review Workshop. Further work is required to evaluate consequential assumptions, add sensitivity runs (e.g., steepness from FishBase), and ensure models are robust to uncertainty. Final recommendations and additional 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 St. Thomas and St. John.

Model	Description
STTJ_RW_1	Single Sex, F method 2, Catch SE = 0.3, and Corrected Survey SE
STTJ_RW_2	STTJ_RW_1 + Catch SE = 2 and Estimated Growth
STTJ_RW_3	STTJ_RW_1 + 12-year Age Plus Group
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



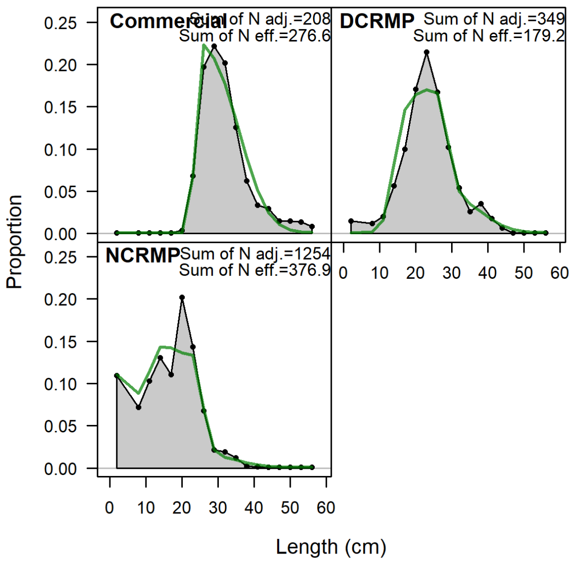
(a) Size at age

(b) Observed and expected landings

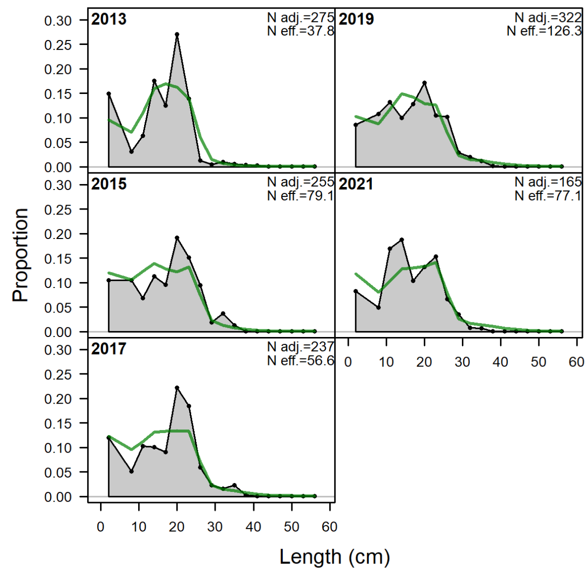
(c) Index NCRMP

(d) Index DCRMP

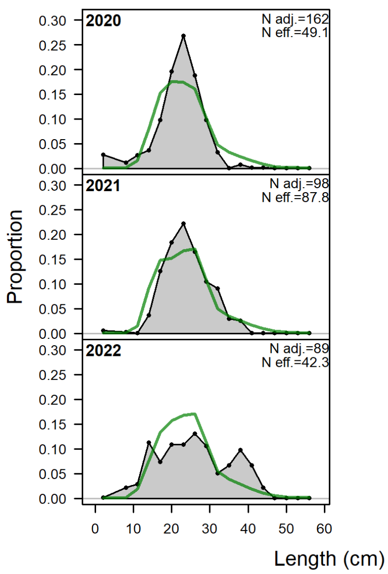
Figure 1: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_1 (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; (c) Fit to index data for the NCRMP survey.; and (d) Fit to index data for the DCRMP survey.



(a) Length fit aggregated across time

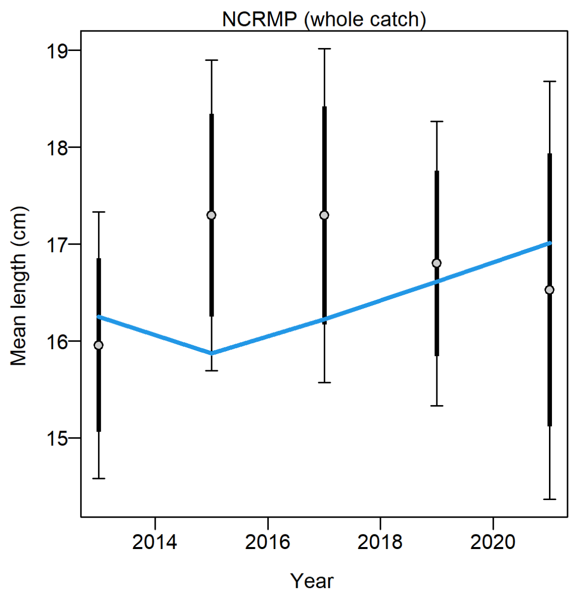


(b) Length comps NCRMP

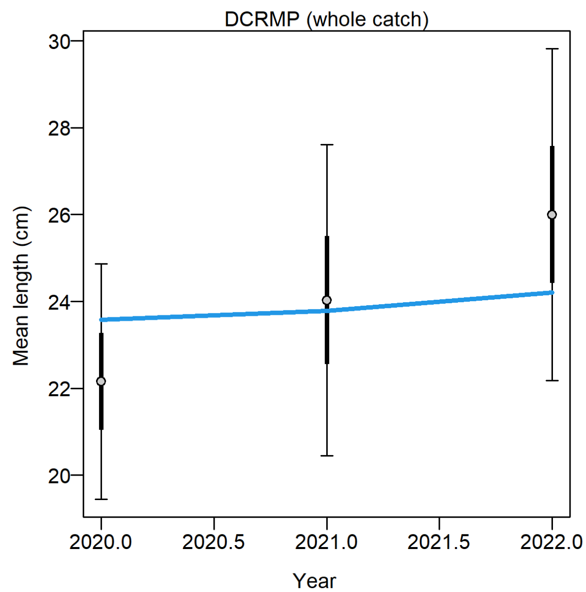


(c) Length comps DCRMP

Figure 2: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_1. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet; (b) observed and predicted length distributions in centimeters, by year for the NCRMP survey; and (c) observed and predicted length distributions in centimeters, by year for the 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.

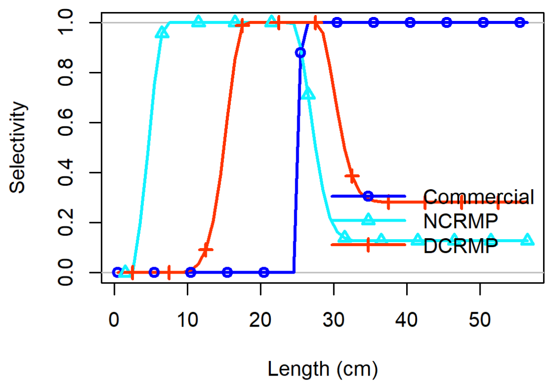


(a) Mean length NCRMP

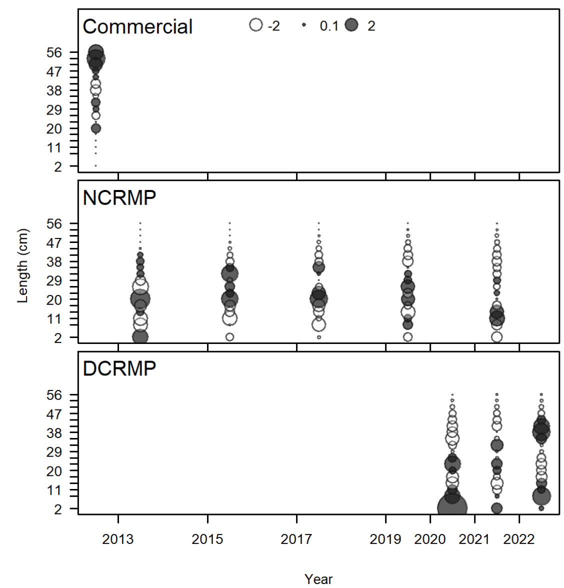


(b) Mean length DCRMP

Figure 3: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_1. Mean length for with 95% confidence intervals for (a) the NCRMP survey and for (b) the DCRMP.

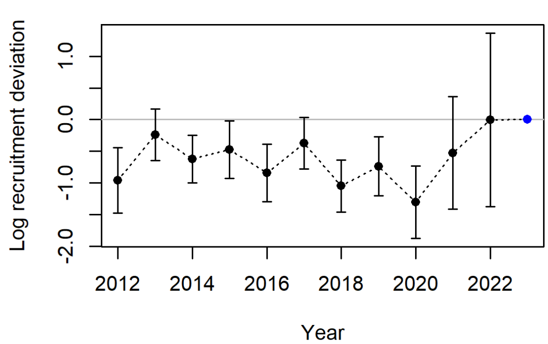


(a) Selectivity

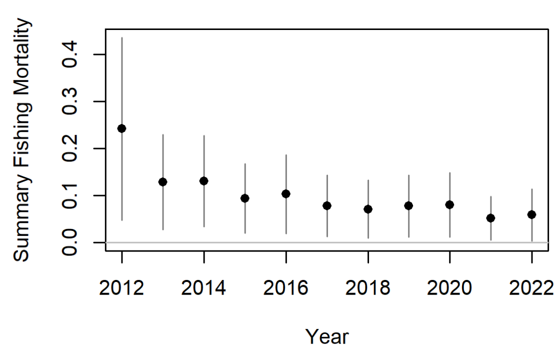


(b) Length fit

Figure 4: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_1. (a) selectivity at length by fleet; and (b) Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

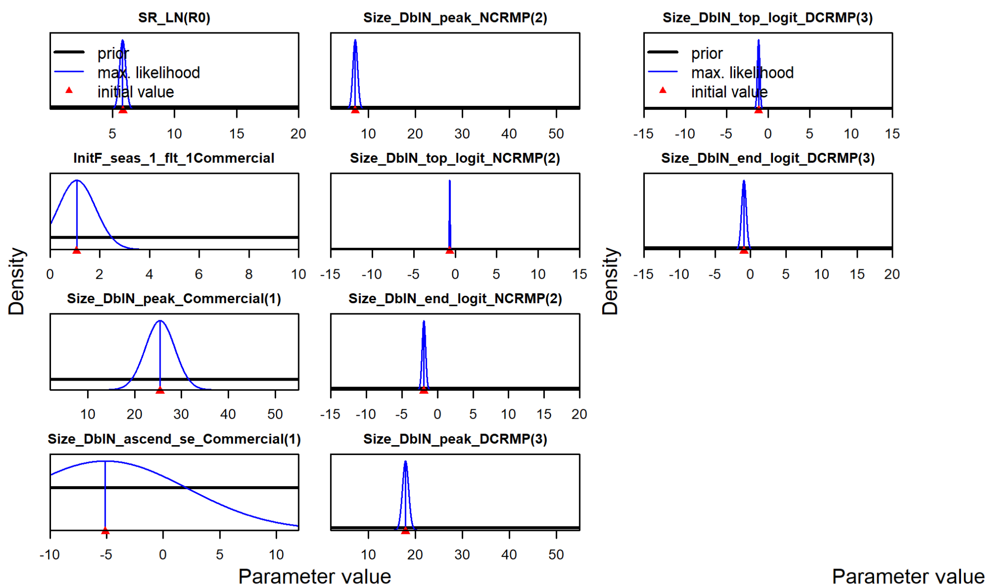


(a) Recruitment deviations



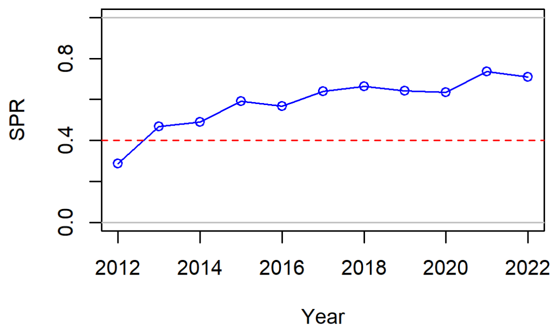
(b) Fishing Mortality

Figure 5: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_1 (a) Recruitment deviations with 95% intervals; and (b) fishing mortality (total biomass killed / total biomass).

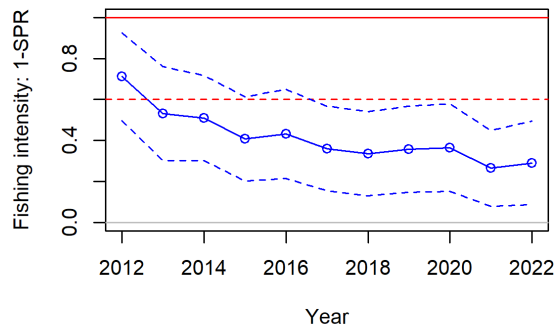


(a) Parameters pg. 1 of 2 (b) Parameters pg. 2 of 2

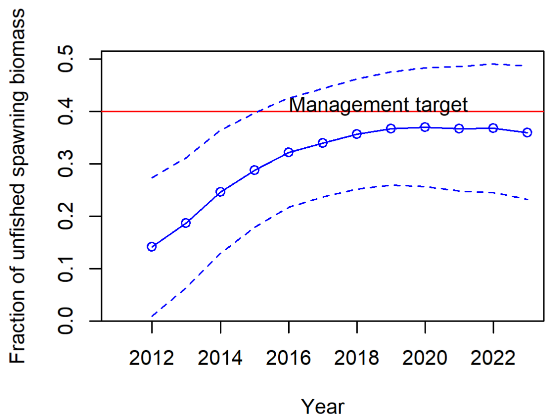
Figure 6: Parameter distribution plots for the St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_1.



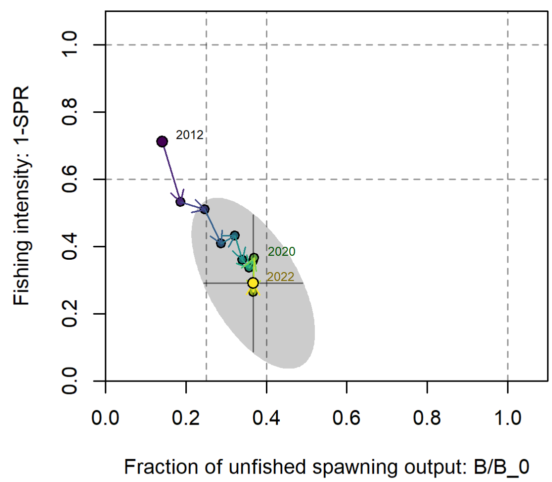
(a) SPR



(b) SPR Ratio

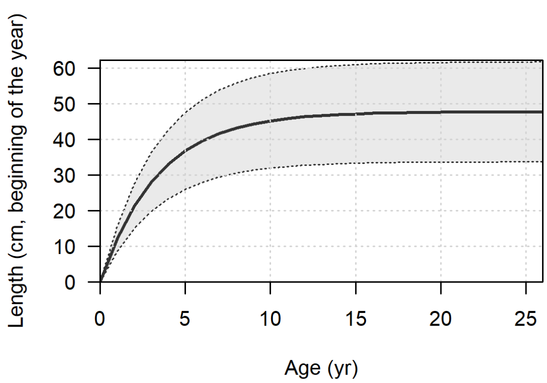


(c) Unfished ratio

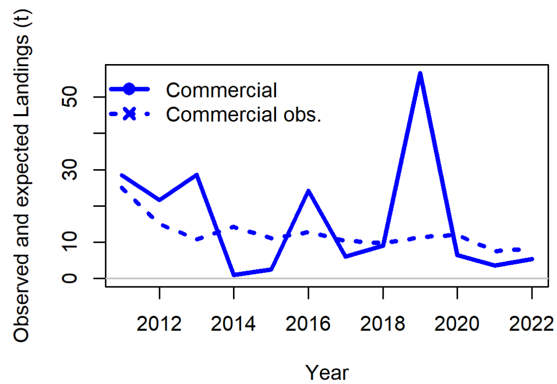


(d) SPR Phase

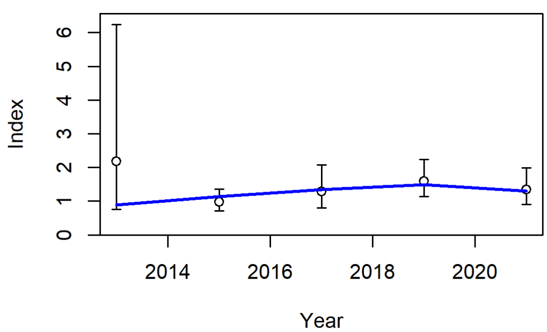
Figure 7: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_1. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4, (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass) with ~95% asymptotic intervals. Horizontal reference lines at 1 and 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: -0.58.



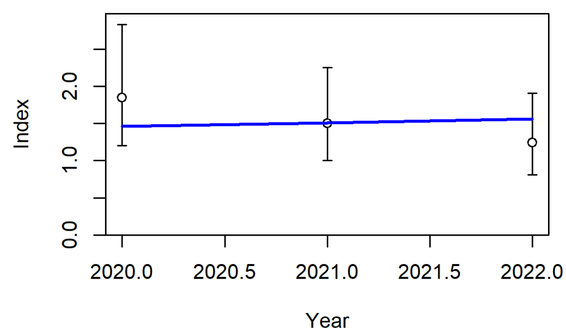
(a) Size at age



(b) Observed and expected landings

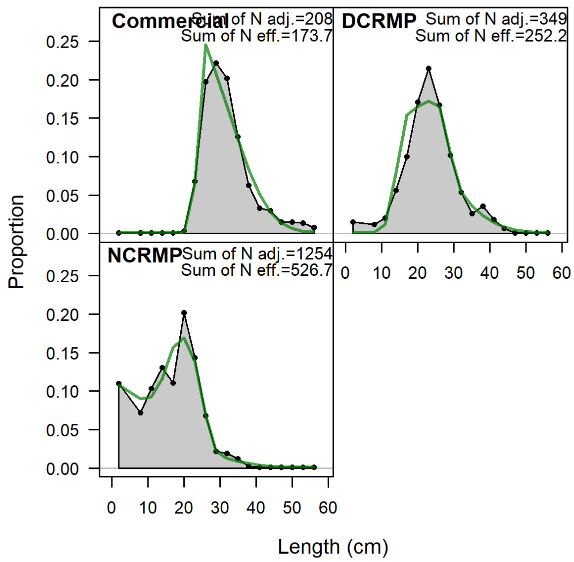


(c) Index NCRMP

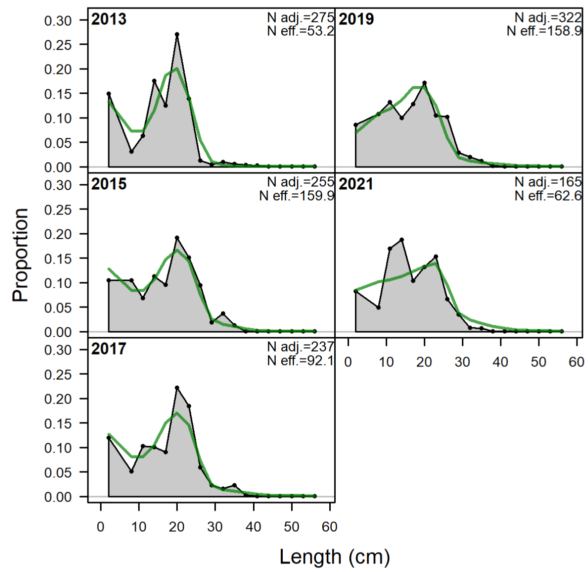


(d) Index DCRMP

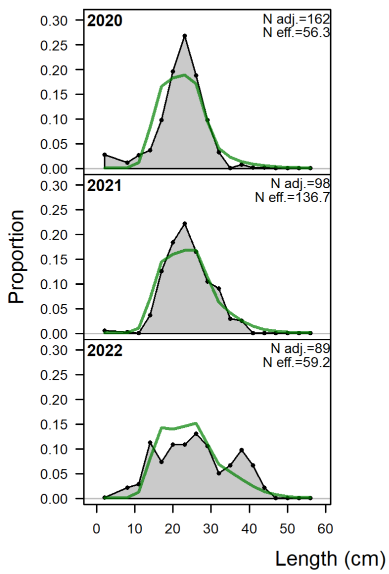
Figure 8: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_2. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; (c) Fit to index data for the NCRMP survey.; and (d) Fit to index data for the DCRMP survey.



(a) Length fit aggregated across time

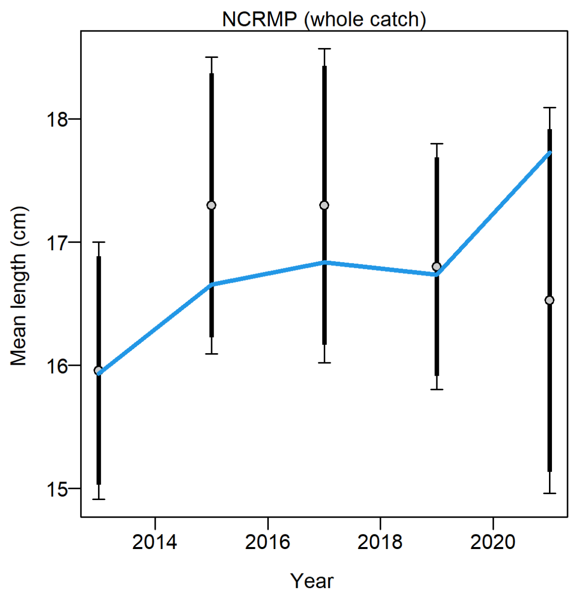


(b) Length comps NCRMP

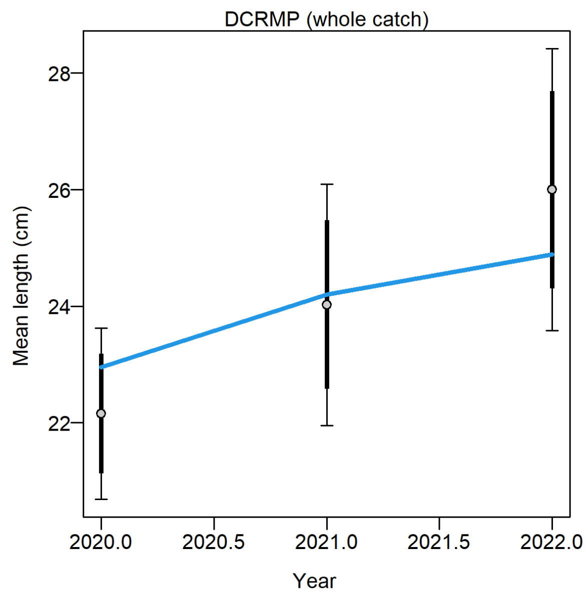


(c) Length comps DCRMP

Figure 9: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_2. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet; (b) observed and predicted length distributions in centimeters, by year for the NCRMP survey; and (c) observed and predicted length distributions in centimeters, by year for the 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.

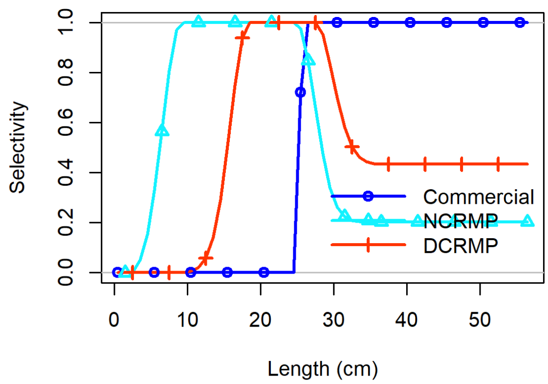


(a) Mean length NCRMP

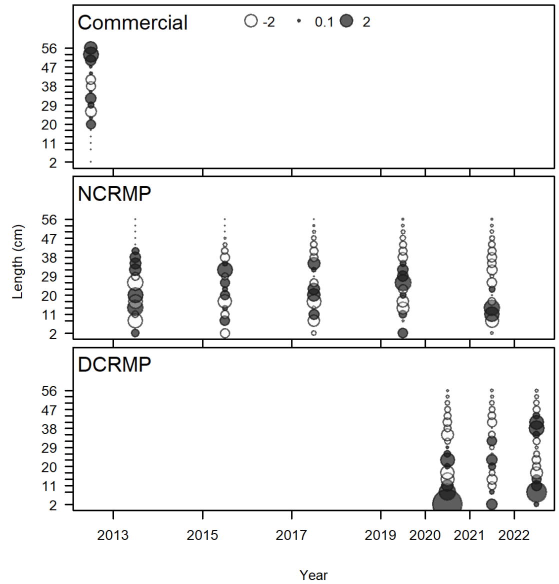


(b) Mean length DCRMP

Figure 10: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_2. Mean length for with 95% confidence intervals for (a) the NCRMP survey and for (b) the DCRMP.

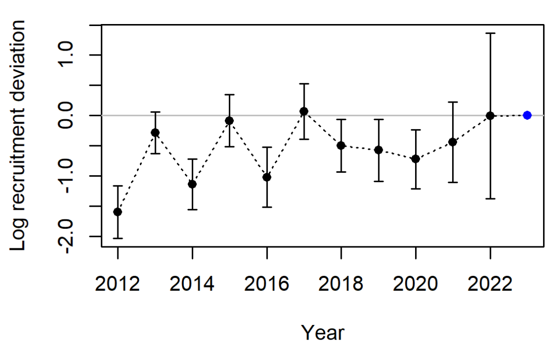


(a) Selectivity

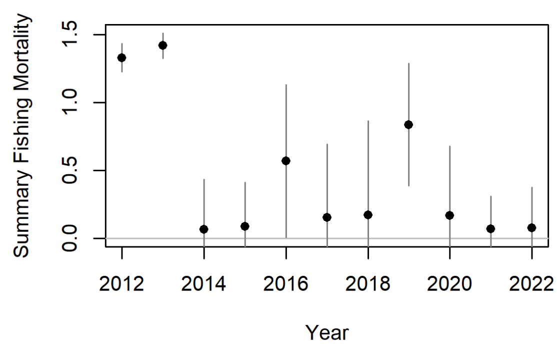


(b) Length fit

Figure 11: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_2. (a) selectivity at length by fleet; and (b) Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

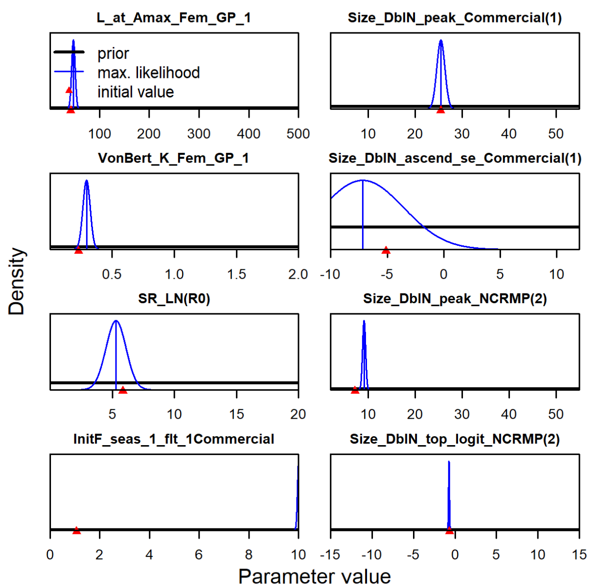


(a) Recruitment deviations

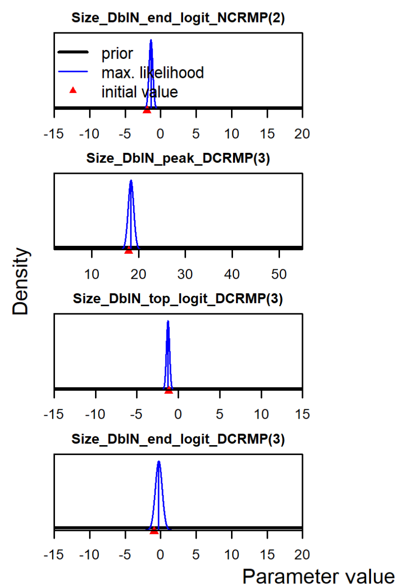


(b) Fishing Mortality

Figure 12: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_2 (a) Recruitment deviations with 95% intervals; and (b) fishing mortality (total biomass killed / total biomass).

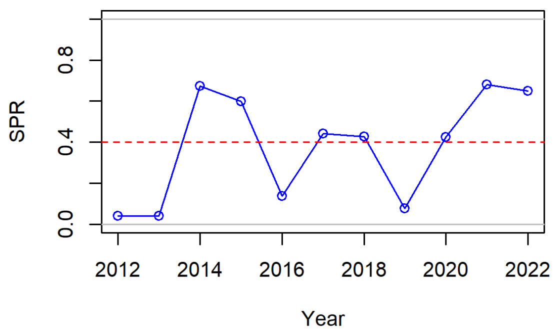


(a) Parameters pg. 1 of 2

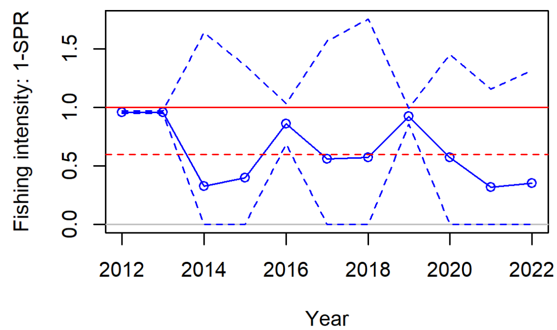


(b) Parameters pg. 2 of 2

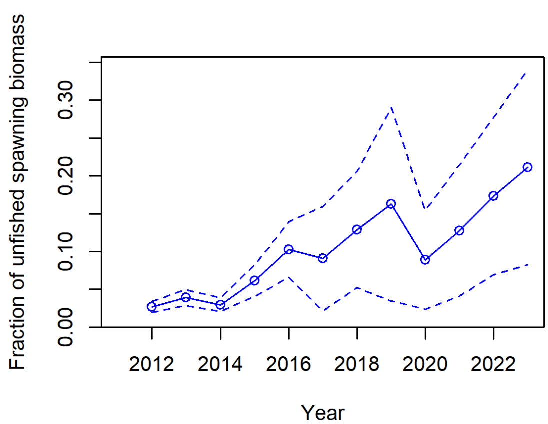
Figure 13: Parameter distribution plots for the St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_2.



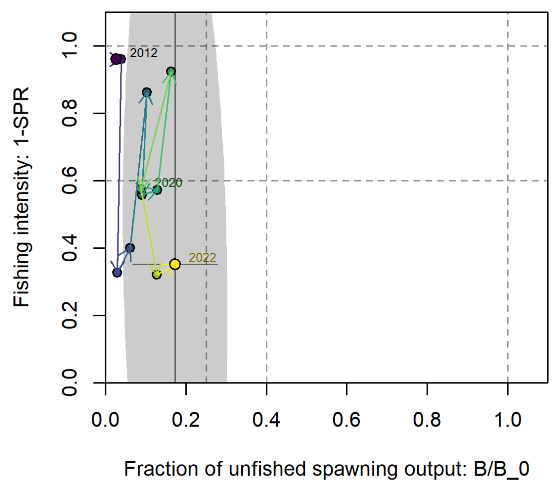
(a) SPR



(b) SPR Ratio

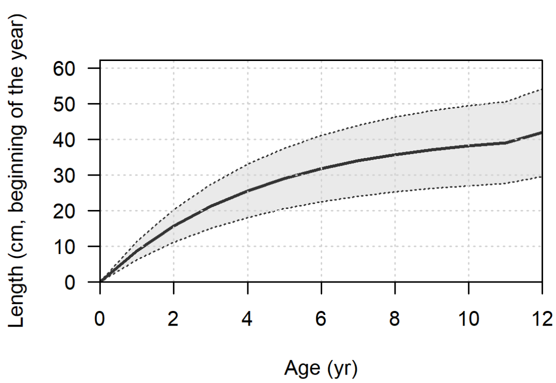


(c) Unfished ratio

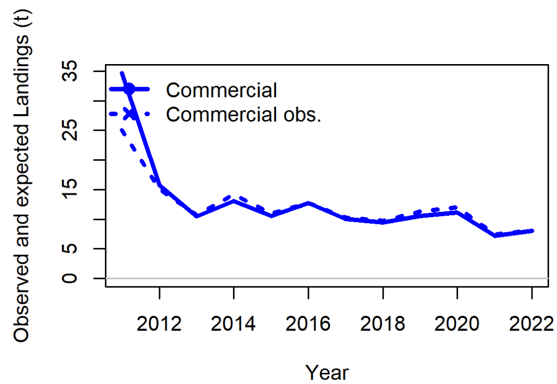


(d) SPR Phase

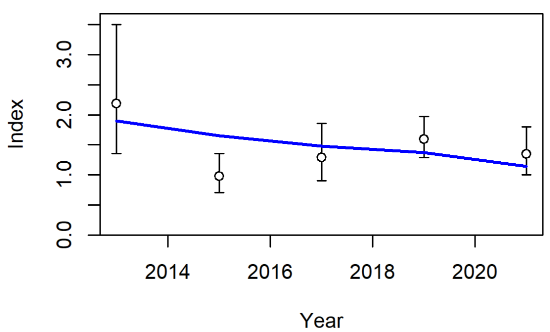
Figure 14: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_2. (a) Time series of SPR. Horizontal reference line is at SPR target: 0.4, (b) time series of 1-SPR. Horizontal reference lines 1 and at 1 - SPR target: 1 - 0.4 = 0.6; (c) the relative spawning stock biomass (total biomass / virgin spawning stock biomass) with ~95% asymptotic intervals. Horizontal reference lines at 1 and 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: -0.569.



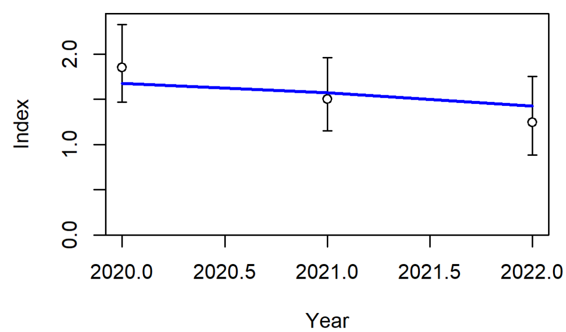
(a) Size at age



(b) Observed and expected landings

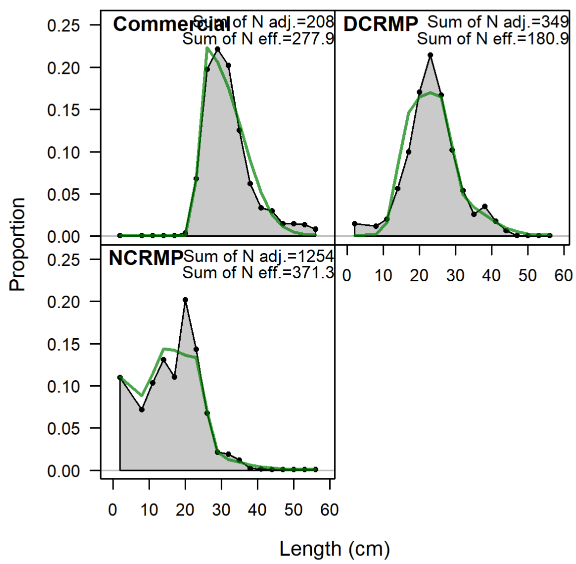


(c) Index NCRMP

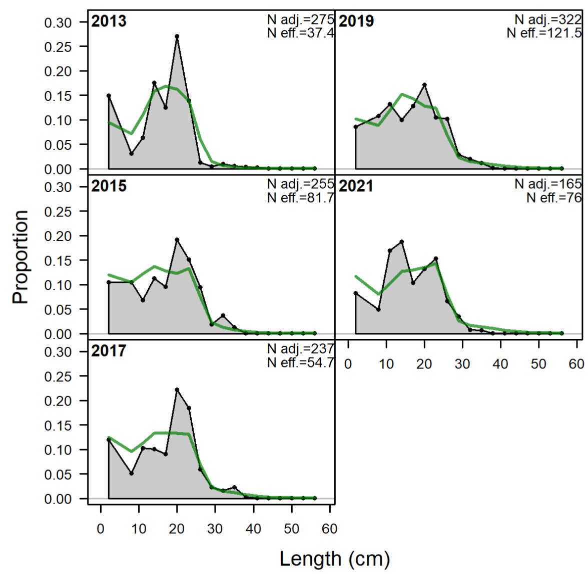


(d) Index DCRMP

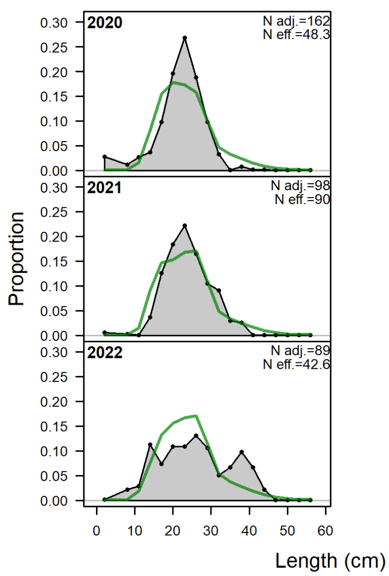
Figure 15: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_3. (a) Length at age in the beginning of the year (or season) in the final year of the model. Shaded area indicates 95% distribution of length at age around estimated growth curve; (b) observed and expected landings; (c) Fit to index data for the NCRMP survey.; and (d) Fit to index data for the DCRMP survey.



(a) Length fit aggregated across time

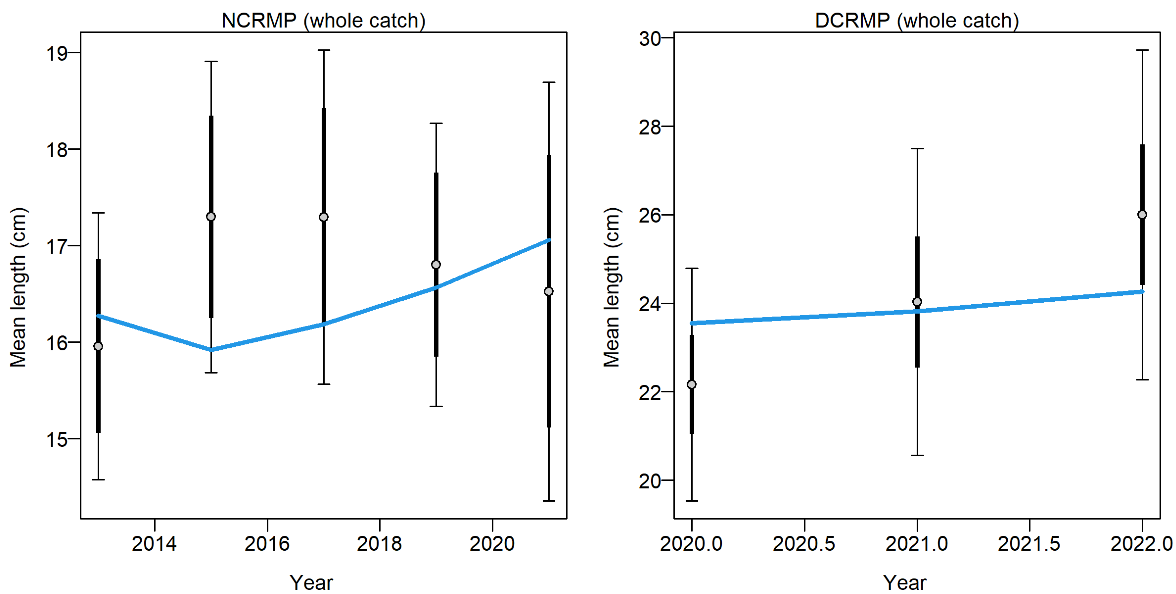


(b) Length comps NCRMP



(c) Length comps DCRMP

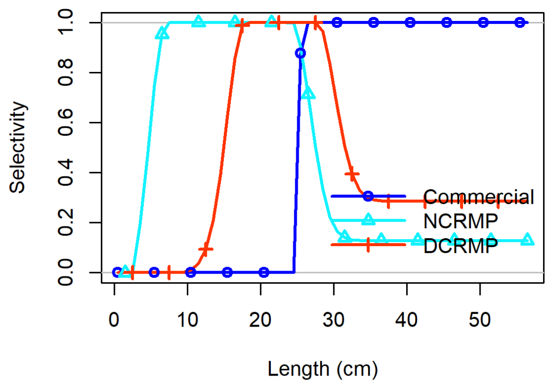
Figure 16: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_3. (a) Observed and predicted length distributions in centimeters, aggregated across time by fleet; (b) observed and predicted length distributions in centimeters, by year for the NCRMP survey; and (c) observed and predicted length distributions in centimeters, by year for the 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.



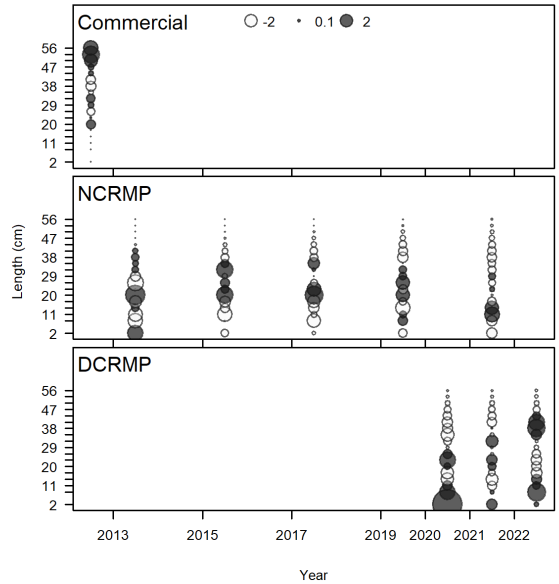
(a) Mean length NCRMP

(b) Mean length DCRMP

Figure 17: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_3. Mean length for with 95% confidence intervals for (a) the NCRMP survey and for (b) the DCRMP.

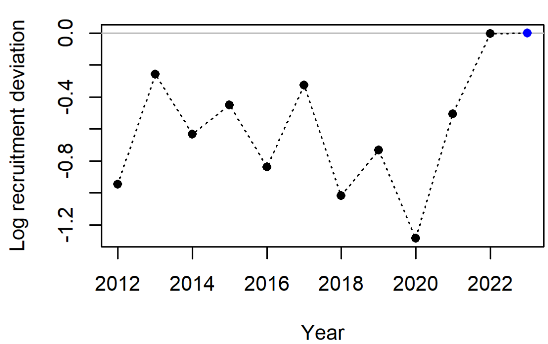


(a) Selectivity

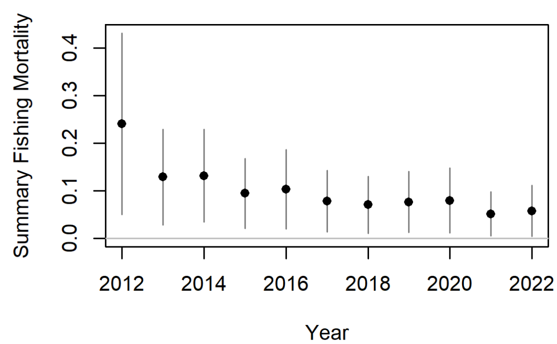


(b) Length fit

Figure 18: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_3. (a) selectivity at length by fleet; and (b) Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

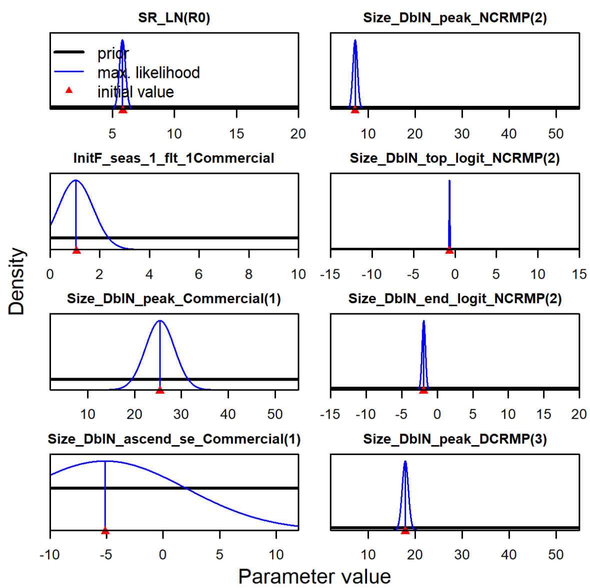


(a) Recruitment deviations

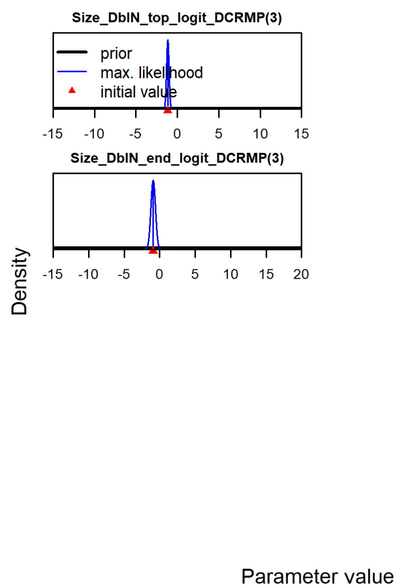


(b) Fishing Mortality

Figure 19: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_3. (a) Recruitment deviations with 95% intervals; and (b) fishing mortality (total biomass killed / total biomass).

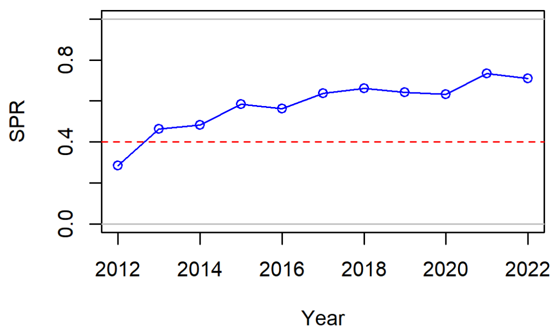


(a) Parameters pg. 1 of 2

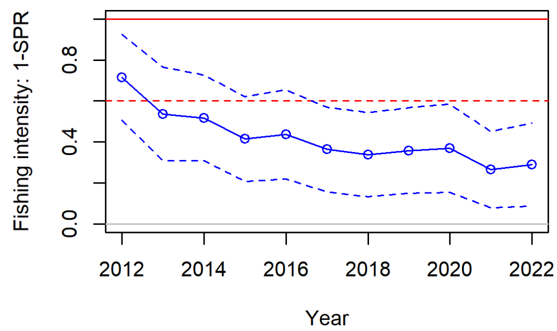


(b) Parameters pg. 2 of 2

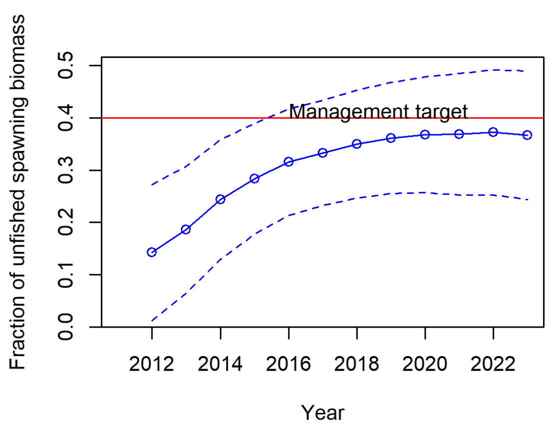
Figure 20: Parameter distribution plots for the St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_RW_3.



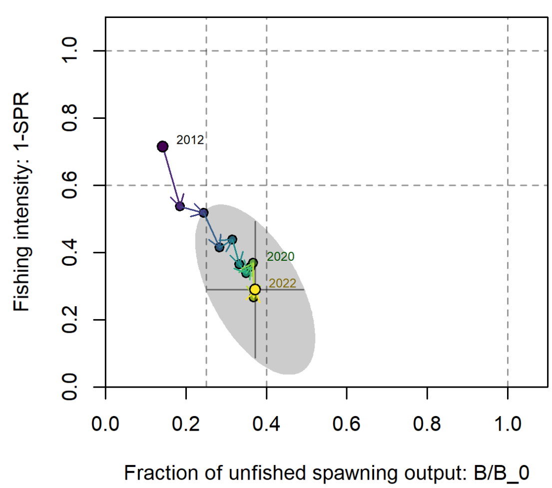
(a) SPR



(b) SPR Ratio



(c) Unfished ratio



(d) SPR Phase

Figure 21: St. Thomas and St. John Yellowtail Snapper Review Workshop Model STTJ_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) with ~95% asymptotic intervals. Horizontal reference lines at 1 and 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: -0.126.