U.S. Caribbean Stoplight Parrotfish St. Croix, USVI

Outline

I. Introduction & Background
II. Data & Methods
III. Assessment Results
IV. Discussion & Uncertainties
V. Conclusions & Recommendations

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I. Introduction & Background

- Maps
- Current Management
- Management History
- Stock Complexes
- Assessment History

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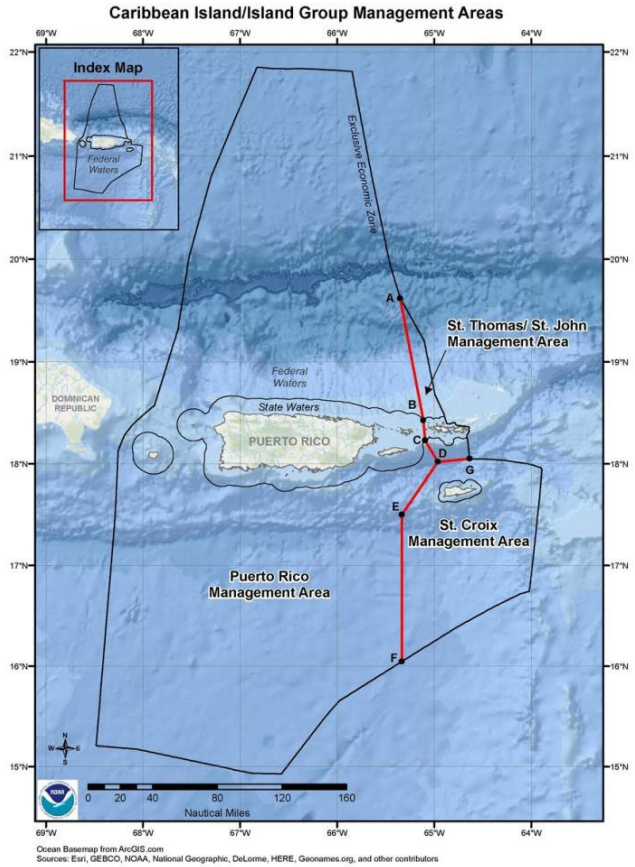
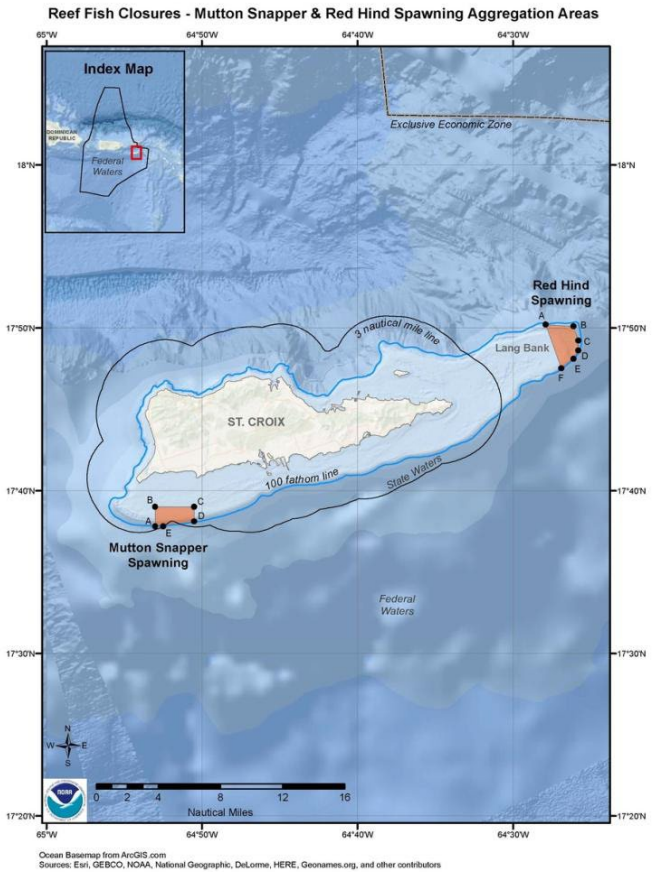


U.S. Caribbean



St. Croix Management Area

Current Management

- Island-based fishery management plans effective as of October 2022
  - St. Croix Fishery Management Plan
  - Annual Catch Limits for Stocks and Stock Complexes
- 2022 ACL for St. Croix Parrotfish 2— 72,365 lbs
  - *2000-2010 reference; 2012-2016 ratio*
  - Based on commercial landings but applies to all harvest
  - Landings of indicator stocks are combined to monitor compliance
  - Accountability measures apply to all stocks in the complex if ACL is exceeded

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Management History

- Federal Waters
  - 2005 FMP comprehensive amendment and ban of gillnets and trammel nets
  - 2012 Prohibited Blue, Midnight, and Rainbow parrotfish
  - 2012 ACL for St. Croix Parrotfish 240,000 lb *(1999-2005 reference)*
  - 2013 9-inch size limit for parrotfishes, except redband
- Territorial Waters
  - 2008 Buy-back/ban of gillnets and trammel nets

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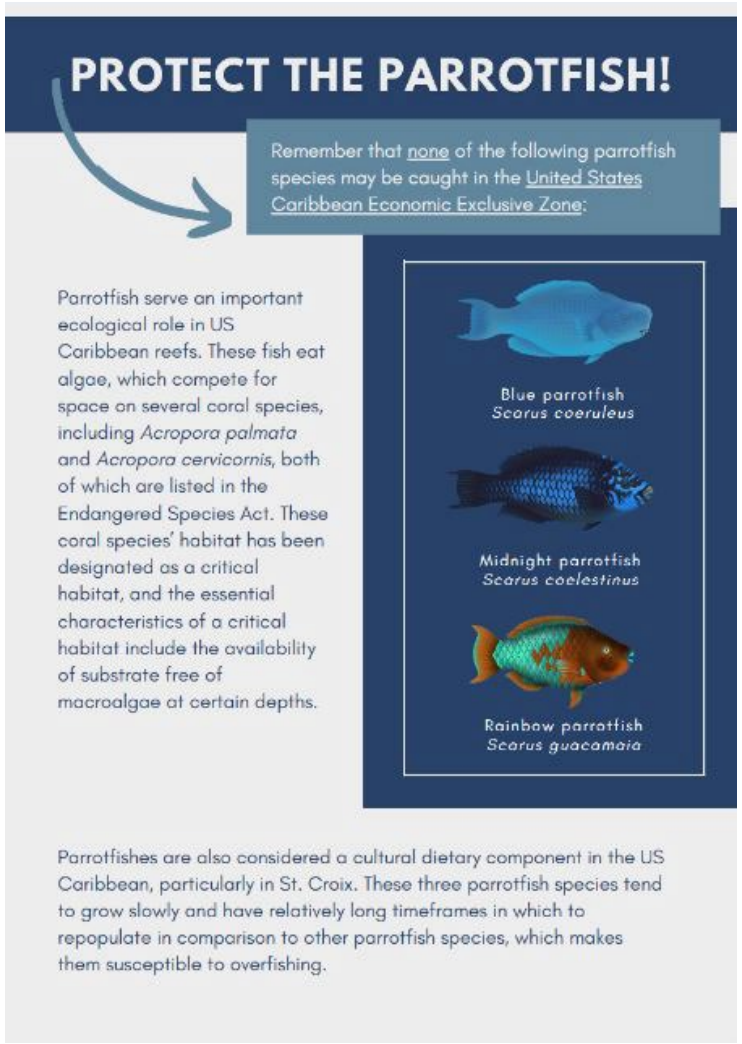
Stock Complexes

- Parrotfish 1— Blue, Midnight, and Rainbow parrotfish **Prohibited 2012**
- Parrotfish 2— Princess, Queen, Redband, **Redfin**, Redtail, **Stoplight**, Striped parrotfish



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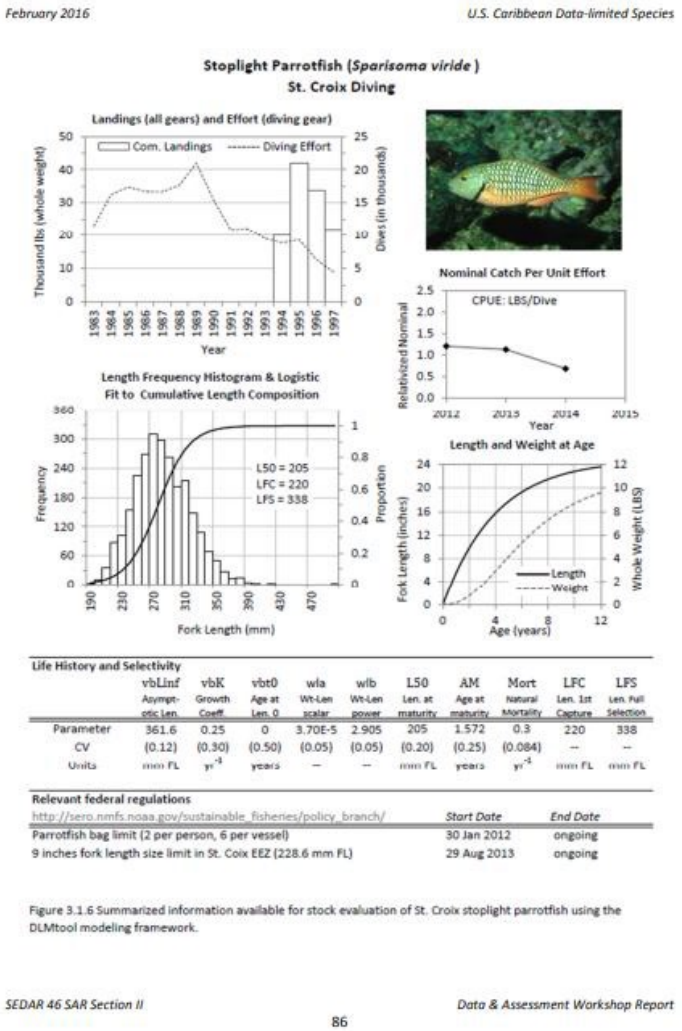
Assessment History

- A 2016 assessment (SEDAR 46) used data-limited methods but was not used for management advice



February 2016 U.S. Caribbean Data-limited Species

Stoplight Parrotfish (*Sparisoma viride*)
St. Croix Diving

Landings (all gears) and Effort (diving gear)

Com. Landings ------ Diving Effort

Thousand lbs (whole weight) / Dives (in thousands) / Year

Nominal Catch Per Unit Effort

CPUE: LBS/Dive

Relativized Nominal / Year

Length Frequency Histogram & Logistic Fit to Cumulative Length Composition

L50 = 205
LFC = 220
LFS = 338

Frequency / Proportion / Fork Length (mm)

Length and Weight at Age

Length
Weight

Fork Length (inches) / Whole Weight (LBS) / Age (years)

Life History and Selectivity

	vbLinf Asymptotic Len.	vbK Growth Coeff	vbt0 Age at Len. 0	wla Wt-Len scalar	wlb Wt-Len power	L50 Len. at maturity	AM Age at maturity	Mort Natural Mortality	LFC Len. 1st Capture	LFS Len. Full Selection
Parameter	361.6	0.25	0	3.70E-5	2.905	205	1.572	0.3	220	338
CV	(0.12)	(0.30)	(0.50)	(0.05)	(0.05)	(0.20)	(0.25)	(0.084)	--	--
Units	mm FL	yr^{-1}	years	--	--	mm FL	years	yr^{-1}	mm FL	mm FL

Relevant federal regulations

http://sero.nmfs.noaa.gov/sustainable_fisheries/policy_branch/	Start Date	End Date
Parrotfish bag limit (2 per person, 6 per vessel)	30 Jan 2012	ongoing
9 inches fork length size limit in St. Coix EEZ (228.6 mm FL)	29 Aug 2013	ongoing

Figure 3.1.6 Summarized information available for stock evaluation of St. Croix stoplight parrotfish using the DLMtool modeling framework.

SEDAR 46 SAR Section II 86 Data & Assessment Workshop Report

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II. Data & Methods

- Data Sources Overview
- Data Workshop Outcomes
- Post-Data Workshop Outcomes
- Modeling Approach
- Assessment Methodology
- Assessment Overview
- Data Sources

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Data Sources Overview

1. **Landings** from self-reported commercial fisher logbooks
2. **Length compositions** from shore-based port sampling
3. **Length compositions** from a fishery-independent survey of reef fish
4. **Index of abundance** from a fishery-independent survey of reef fish
5. **Life history information** from otolith analysis and gonad histology

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Data Workshop Outcomes

- Use life history data made available in SEDAR working papers.
- Only use commercial landings data starting in 2012.
- Identify and flag outliers.
- Utilize the various diving gears to establish a SCUBA gear group.
- Assume commercial discards are negligible.
- Utilize TIP lengths from 2012 to 2022 to inform selectivity.
- Use the NCRMP Stoplight Parrotfish data for STX from 2012 to 2022.
- Do not consider the fishery-dependent information for an abundance indices.

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Post-Data Workshop Outcomes

- Life history working paper finalized (SEDAR84-AP-01)
- Assessment panel accepted landings outliers retained as valid trips

Modeling Approach

- 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.
- 40% SPR used as a proxy for MSY.
- Tools for working with Stock Synthesis
  - r4ss: Create plots and tables of Stock Synthesis output and functions to work with Stock Synthesis in R.
  - ss3diags: Run advanced diagnostics for Stock Synthesis models.
  - Stock Assessment Continuum Tool (previously the SS-DL-tool) a shiny app that includes Extended Simple Stock Synthesis and Simple Stock Synthesis in its functionality.

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Assessment Method

- Began with data-limited models using super-period length compositions
  - Steepness fixed at 0.99
  - Sigma R fixed at 0.7
- Model progression tracked biological/data complexities:
  - m1: Hermaphroditism
  - m2: Continuous recruitment
  - m3: Increased catch uncertainty
- Progressed to data-moderate models incorporating:
  - Abundance indices
  - Annual fishery-independent length compositions
  - Recruitment deviations

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Model Development

- Labels (e.g., v1_m3_s4) reflect version, complexity, and sensitivity runs
- **Model v7_m3** proposed to inform catch advice (*index + annual fishery-independent length data + rec deviations*)

Stage	Code	Sequential modeling steps
Initial	ct	model initialized with continuum tool (ct)
Initial	m1	ct + hermaphroditism and 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	b	annual fishery-independent length data
Scenario	v1	index + annual fishery-independent length data
Scenario	v3	index + recruitment deviations
Scenario	v7	index + annual fishery-independent length data + recruitment deviations
Sensitivity	s1	higher CV on growth young
Sensitivity	s2	higher age and lower m
Sensitivity	s3	one sex (age-based fecundity = maturity * weight * sex ratio)
Sensitivity	s4	higher catch uncertainty
Sensitivity	s5	s2 + s4
Sensitivity	s6	s2 + s3 + s4

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Assessment Overview

- Stock Assessment Continuum Tool used to build initial models
- Models configured with 1 area, 1 fleet, and 1 survey; 2012—2022
- Sensitivities tested using:
  - Longevity-based natural mortality
  - Growth variability (CV on growth)
  - Hermaphroditism parameterization
  - Uncertainty in initial equilibrium catch
- Diagnostics included:
  - Gradients, residuals, likelihood profiles
  - Retrospectives and jitter analyses

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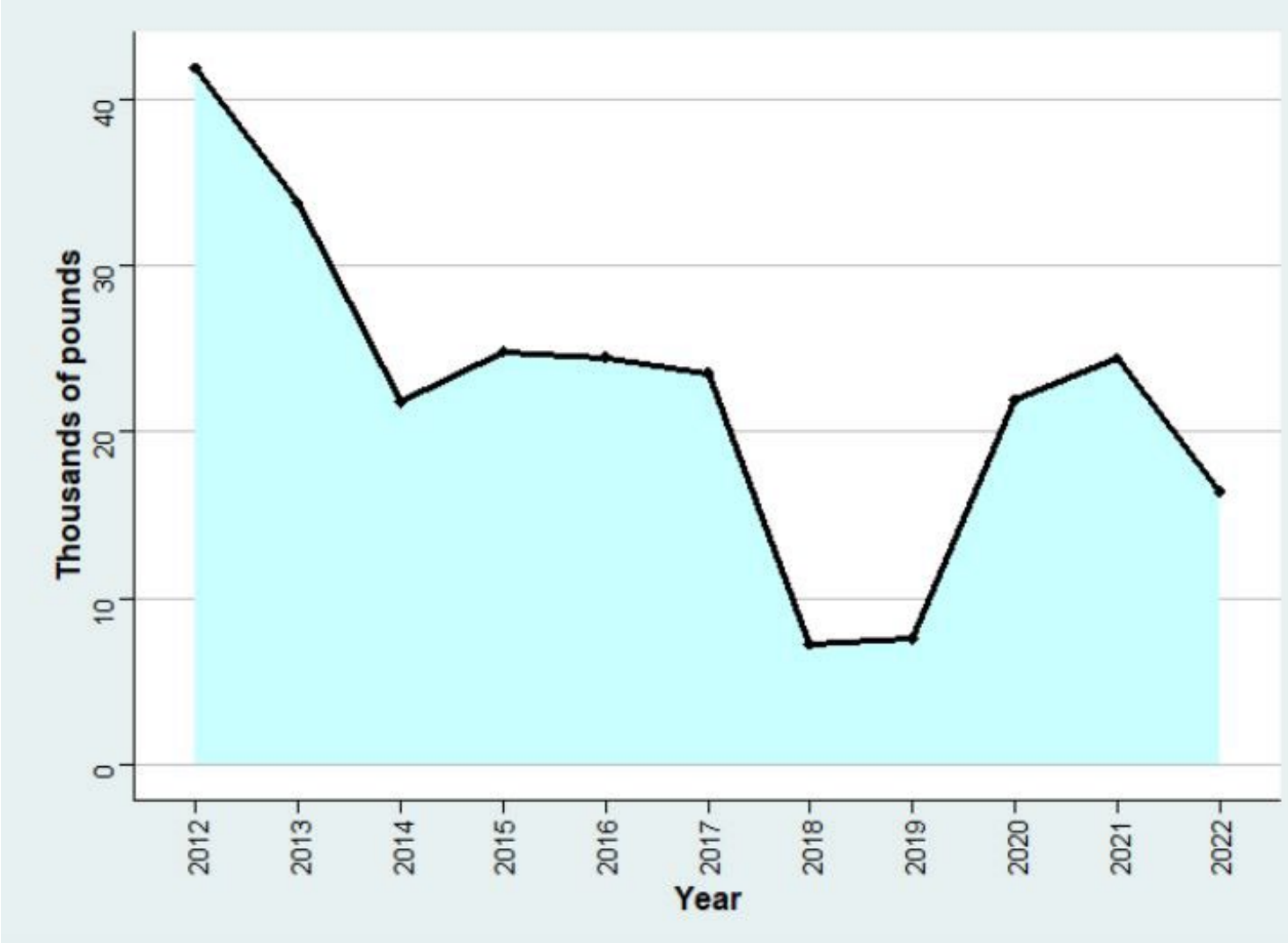
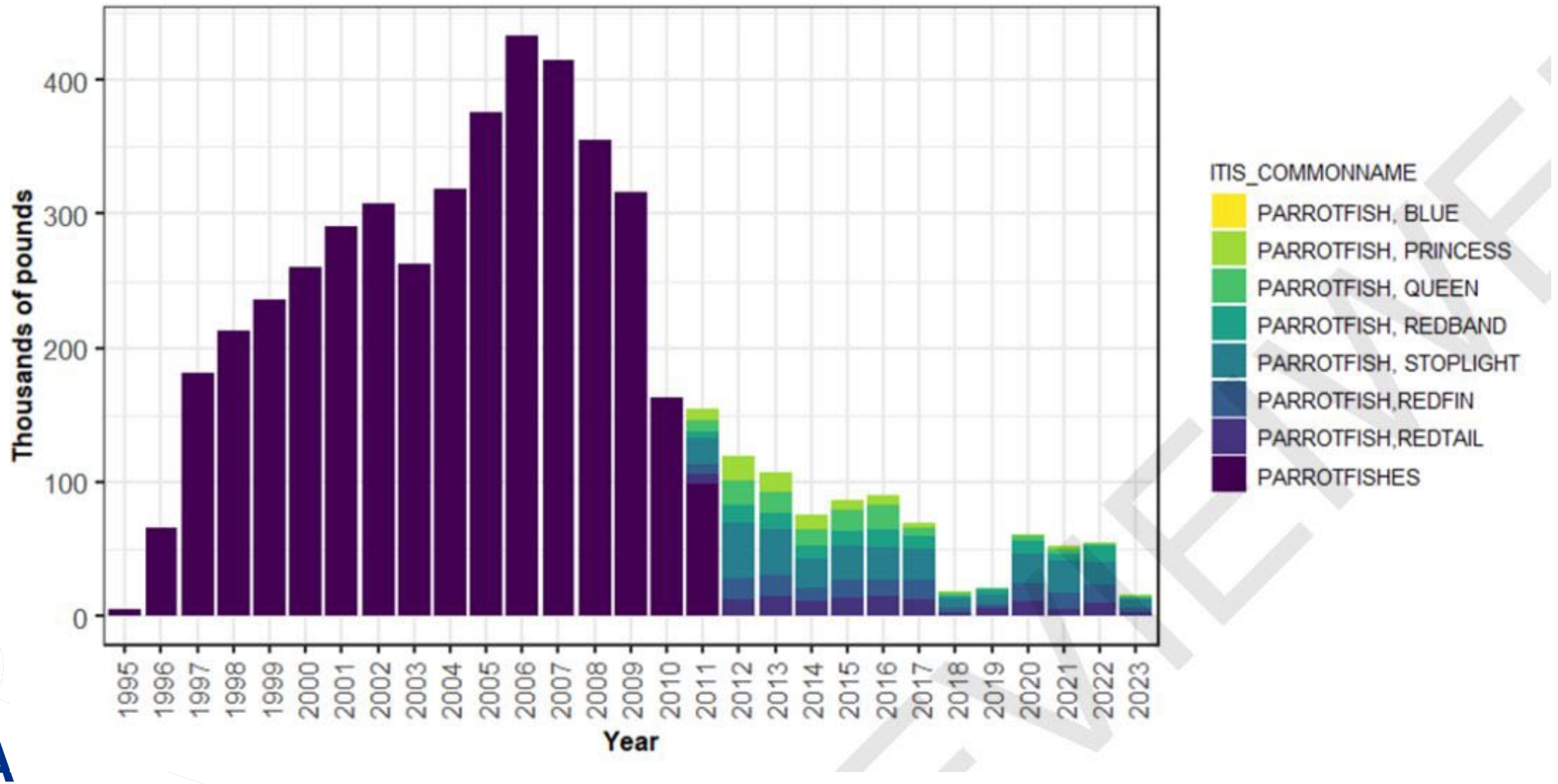
1. Landings from self-reported commercial logbooks

Caribbean Commercial Logbook Program





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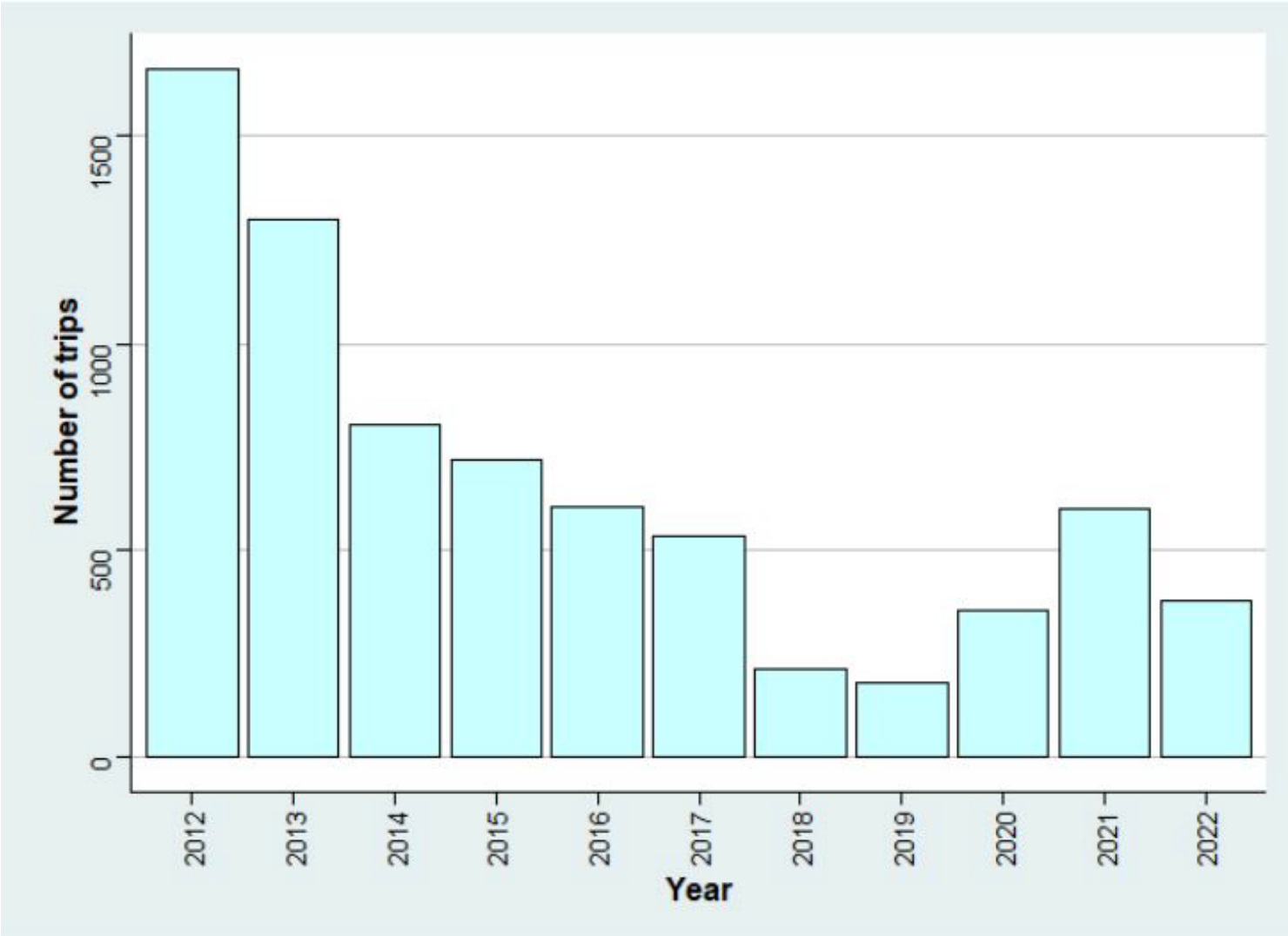
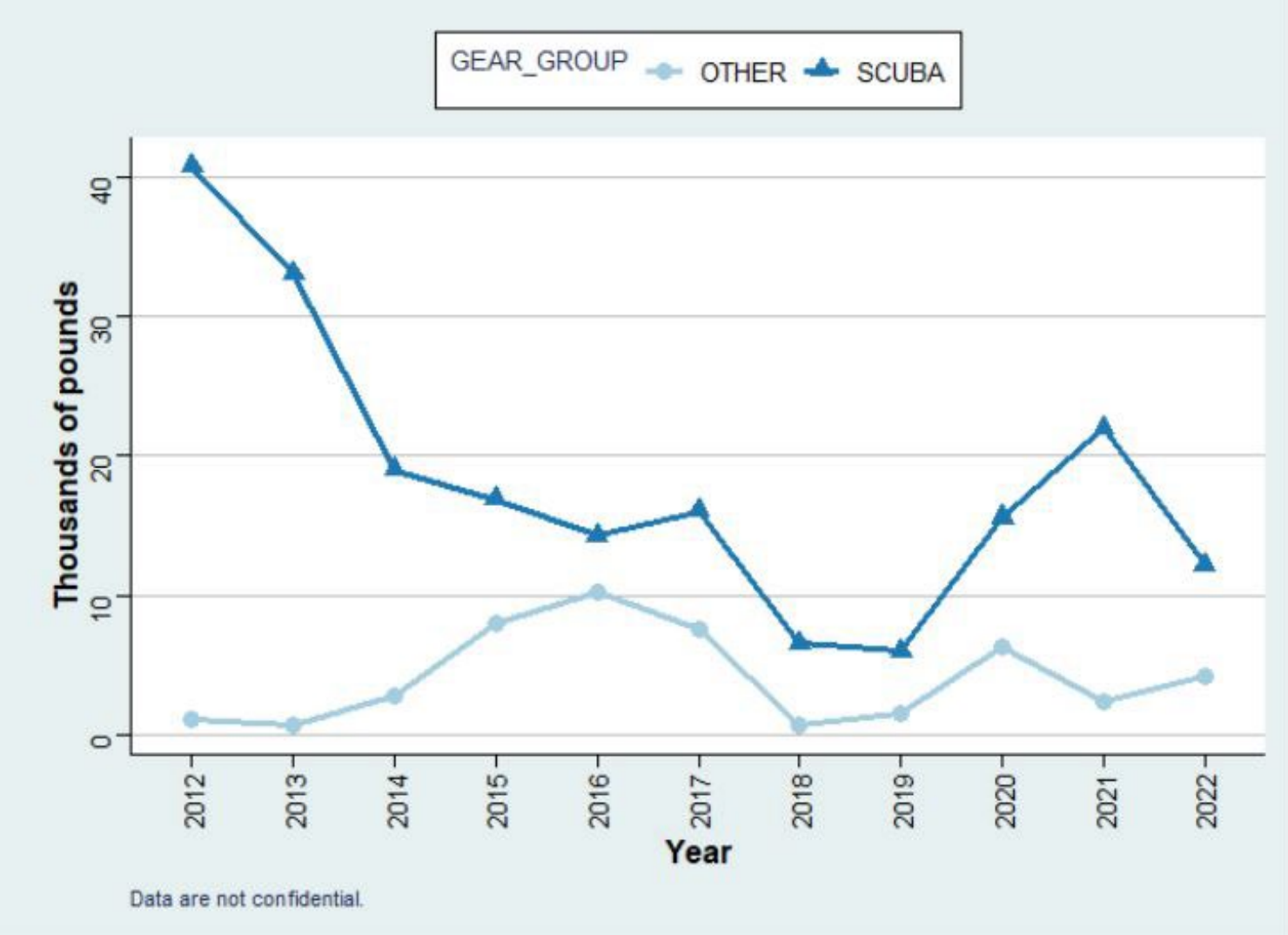

Number of trips
0
500
1000
1500
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Year


GEAR_GROUP
OTHER
SCUBA
Thousands of pounds
0
10
20
30
40
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Year
Data are not confidential.

2. Length compositions from shore-based port sampling

Trip Interview Program

- 98% of TIP length data (2012–2022) came from diving gear.
  - 1,033 length measurements from 66 trips.
- Used to inform length-based selectivity for the commercial fleet.
- Multiple lengths per trip; non-independent observations.
- Model weighting based on number of sampled trips.

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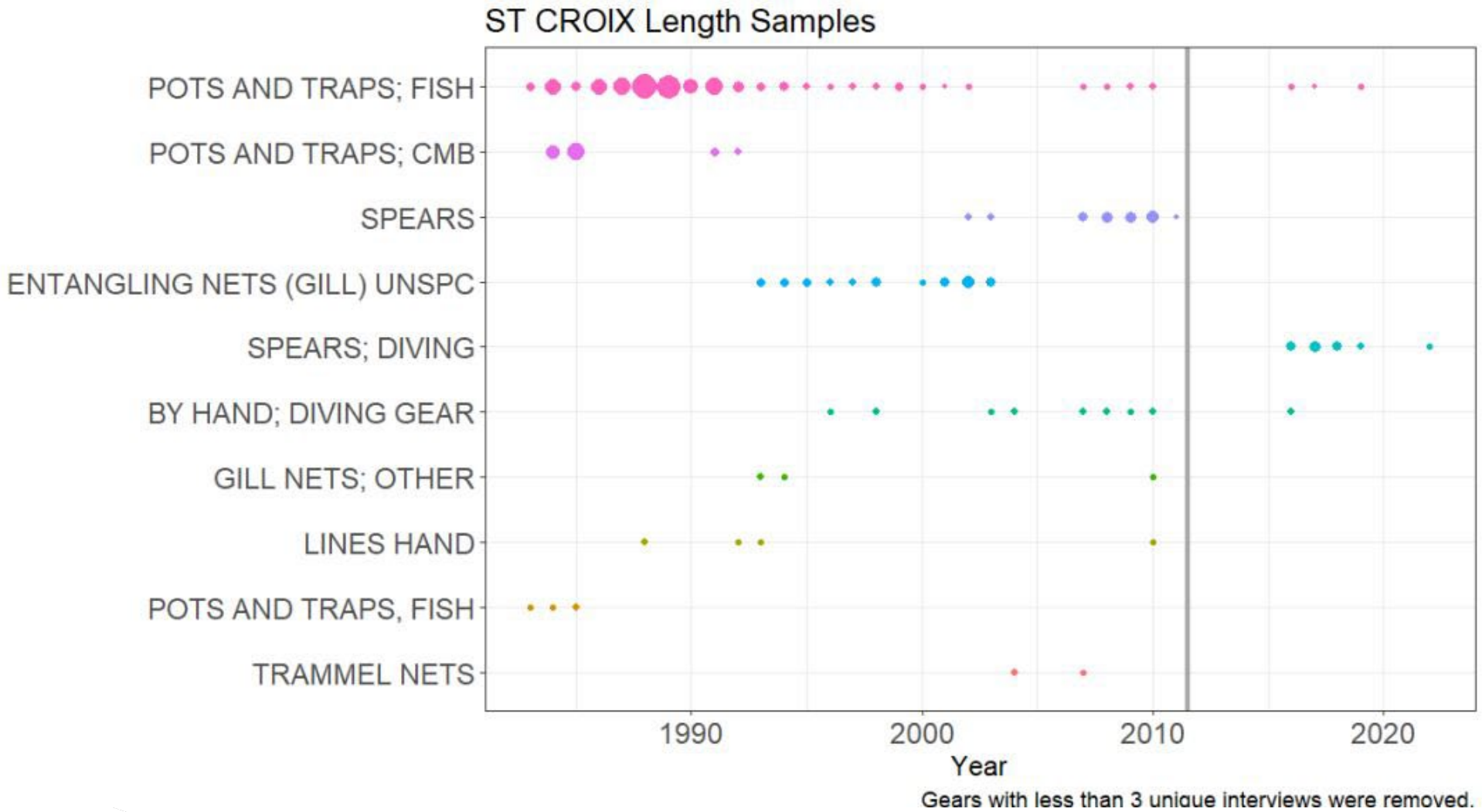
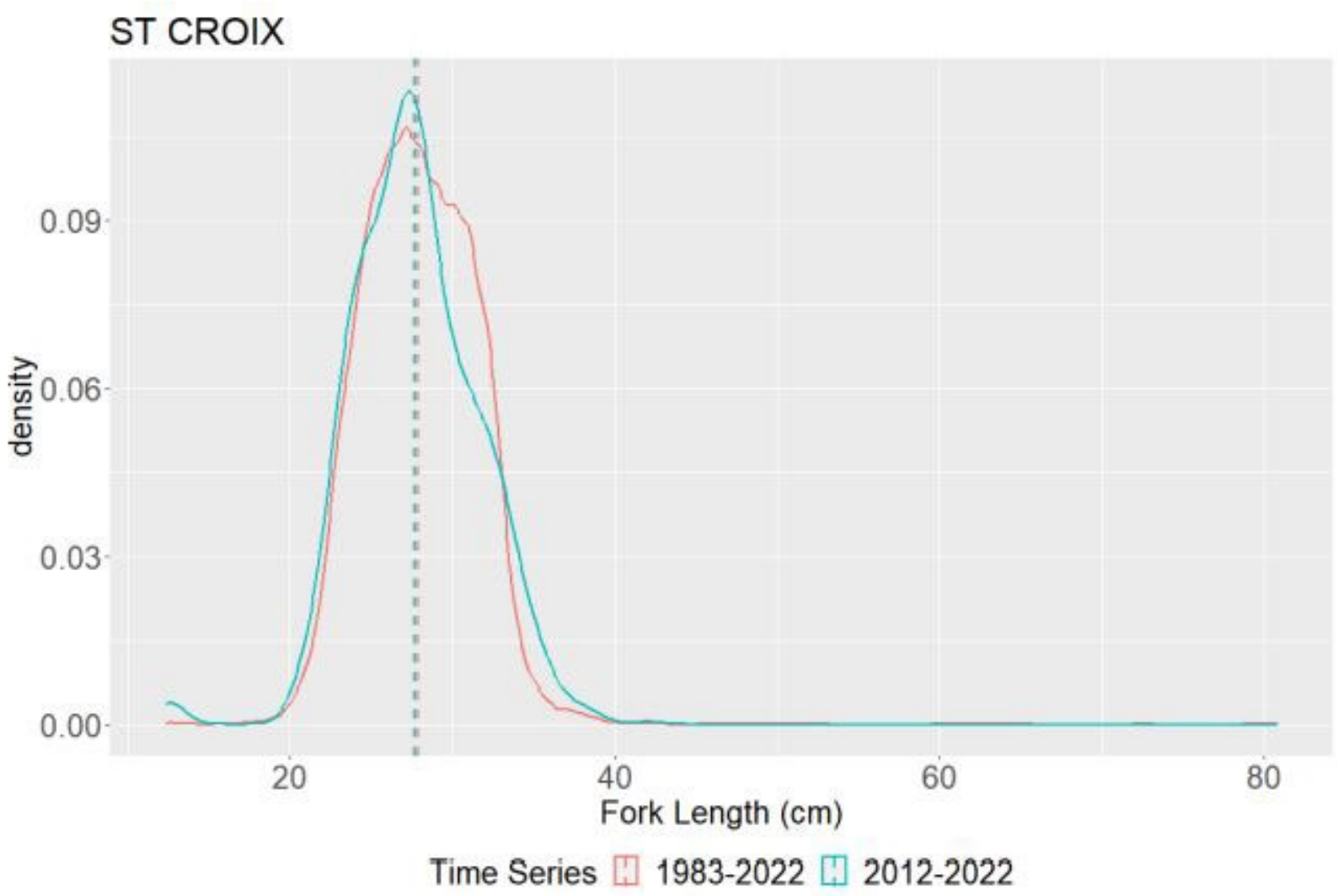
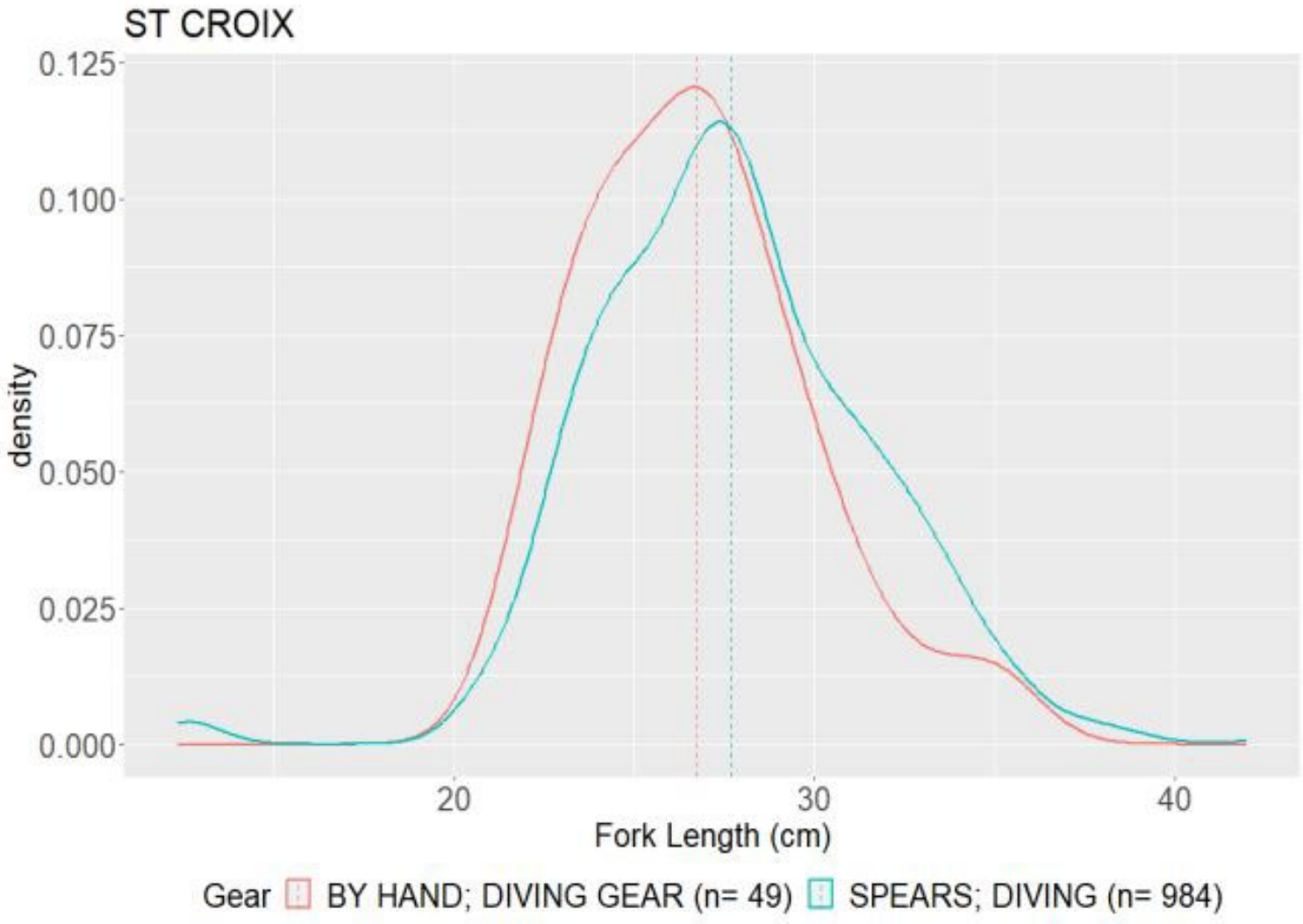


NOAA FISHERIES


ST CROIX
density
0.09
0.06
0.03
0.00
20
40
60
80
Fork Length (cm)
Time Series
1983-2022
2012-2022


ST CROIX
0.125
0.100
0.075
0.050
0.025
0.000
density
20
30
40
Fork Length (cm)
Gear
BY HAND; DIVING GEAR (n= 49)
SPEARS; DIVING (n= 984)

3. Length compositions from a fishery-independent survey of reef fish

National Coral Reef Monitoring Program

- Regionally restricted transect data from 2001 to 2011.
- Belt transect (2001–2015); Stationary point count (2017–2021).
- Multiple lengths per dive; non-independent observations.
- The relative model weighting based on the number of paired dives.

	0 - 12 meters					12 - 30 meters						
Year	Aggregate	Bedrock	Patch	Pavement	Coral/Rock	Aggregate	Bedrock	Patch	Pavement	Coral/Rock	Site Total	Length Total
2001	12		14	35	12			9	2	2	**86**	**376**
2002	7		15	21	10			8	14	1	**76**	**318**
2003	38	6	13	72	7	3		3	21	2	**165**	**455**
2004	23	4	14	46	9	2		4	7	5	**114**	**413**
2005	43	4	17	46	11	9	1	7	25	7	**170**	**485**
2006	34	2	18	48	20	6		13	38	6	**185**	**400**
2007	13	1	14	23	5	1		7	24	2	**90**	**230**
2008	16		27	62	3	5		12	35	7	**167**	**344**
2009	15		23	61	9	4		8	32	5	**157**	**277**
2010	17		15	38	5	3		2	33	5	**118**	**344**
2011	3			19					17	2	**41**	**86**
2012	15	5	13	64	6	35		19	79	26	**262**	**492**
2015	15	4	14	47	17	33		19	75	15	**239**	**444**
2017	11	1	14	33	5	46		19	47	5	**181**	**810**
2019	29	8	32	46	10	74		35	72	8	**314**	**1116**
2021	14		19	19	2	43		12	35	4	**148**	**694**

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	0 - 12 meters					12 - 30 meters						
Year	Aggregate	Bedrock	Patch	Pavement	Coral/Rock	Aggregate	Bedrock	Patch	Pavement	Coral/Rock	Site Total	Length Total
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2011	3			19					17	2	**41**	**86**
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2015	15	4	14	47	17	33		19	75	15	**239**	**444**
2017	11	1	14	33	5	46		19	47	5	**181**	**810**
2019	29	8	32	46	10	74		35	72	8	**314**	**1116**
2021	14		19	19	2	43		12	35	4	**148**	**694**

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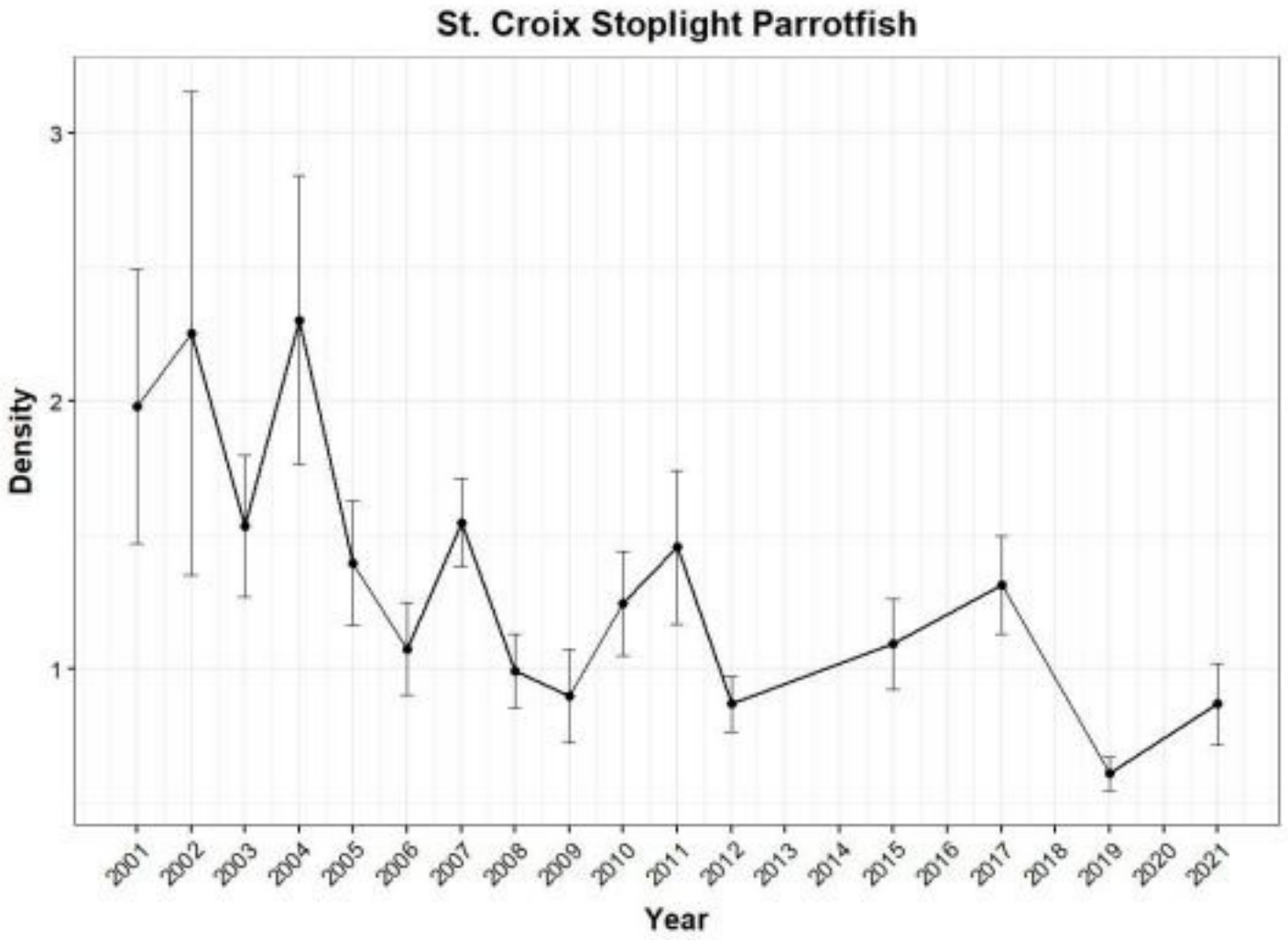
4. Index of abundance from a fishery-independent survey of reef fish



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5. Life history information

- Lengths
  - 1,801 samples from 2013-2023 and across the U.S. Caribbean
  - Males (304 mm FL) were significantly larger than females (259 mm FL) and transitioning (258 mm FL)
  - Very few females greater than 351 mm FL
  - Maximum length 433 mm FL
- Ages
  - 1,649 aged fish
  - Oldest fish (20 y) female

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5. Life history information

- Sexual maturity and reproductive phase
  - 1,765 stoplight parrotfish gonads
  - Females and males spawning capable year-round
  - Not all females appear to transition to males
  - Females are more dominant through age-3
  - Similar proportions of females and males ages 4-15

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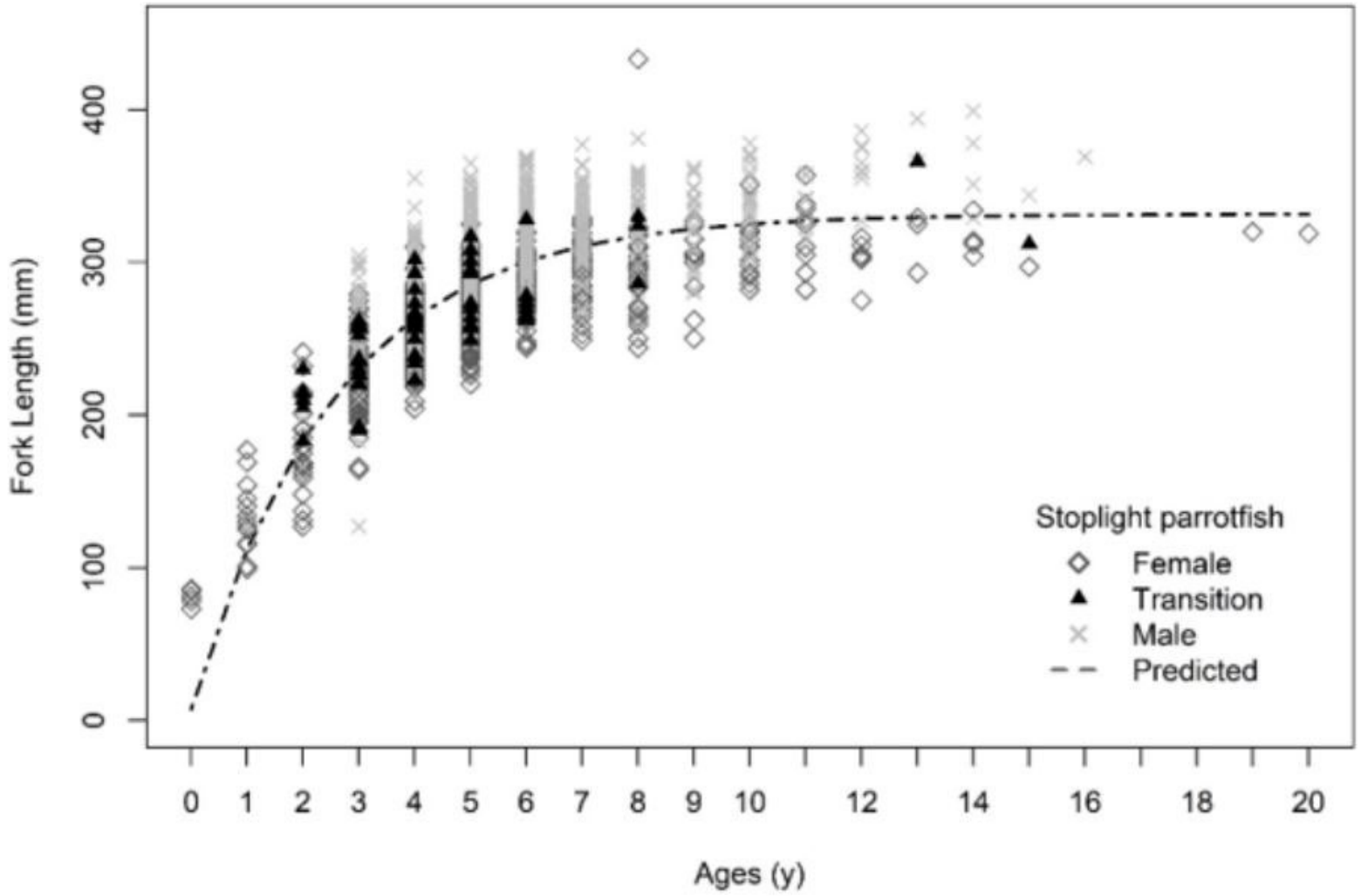
Growth


Fork Length (mm)
0
100
200
300
400
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20
Ages (y)
Stoplight parrotfish
Female
Transition
Male
Predicted

Growth

Model	N	L_∞ (mm)	K	t_0
FL mm t_0-fixed	1649	332 (328 - 335)	0.39 (0.35 - 0.41)	-0.06*
FL mm	1649	338 (328 - 335)	0.33 (0.31 - 0.36)	−0.52 (−0.72 - −0.35)
SL mm t_0-fixed	1649	287 (282-290)	0.38 (282-290)	-0.06*
SL mm	1649	297 (286-300)	0.33 (0.31-0.36)	−0.40 (−0.59 - −0.23)

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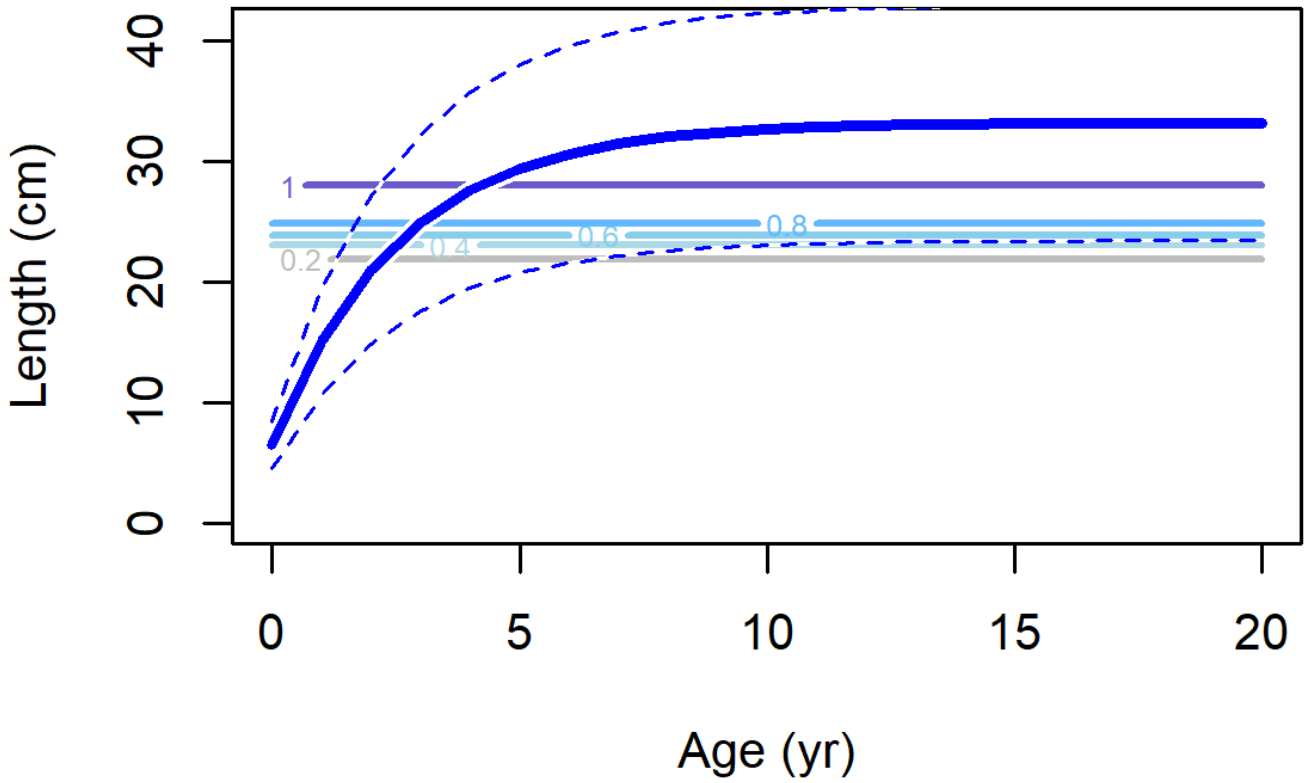
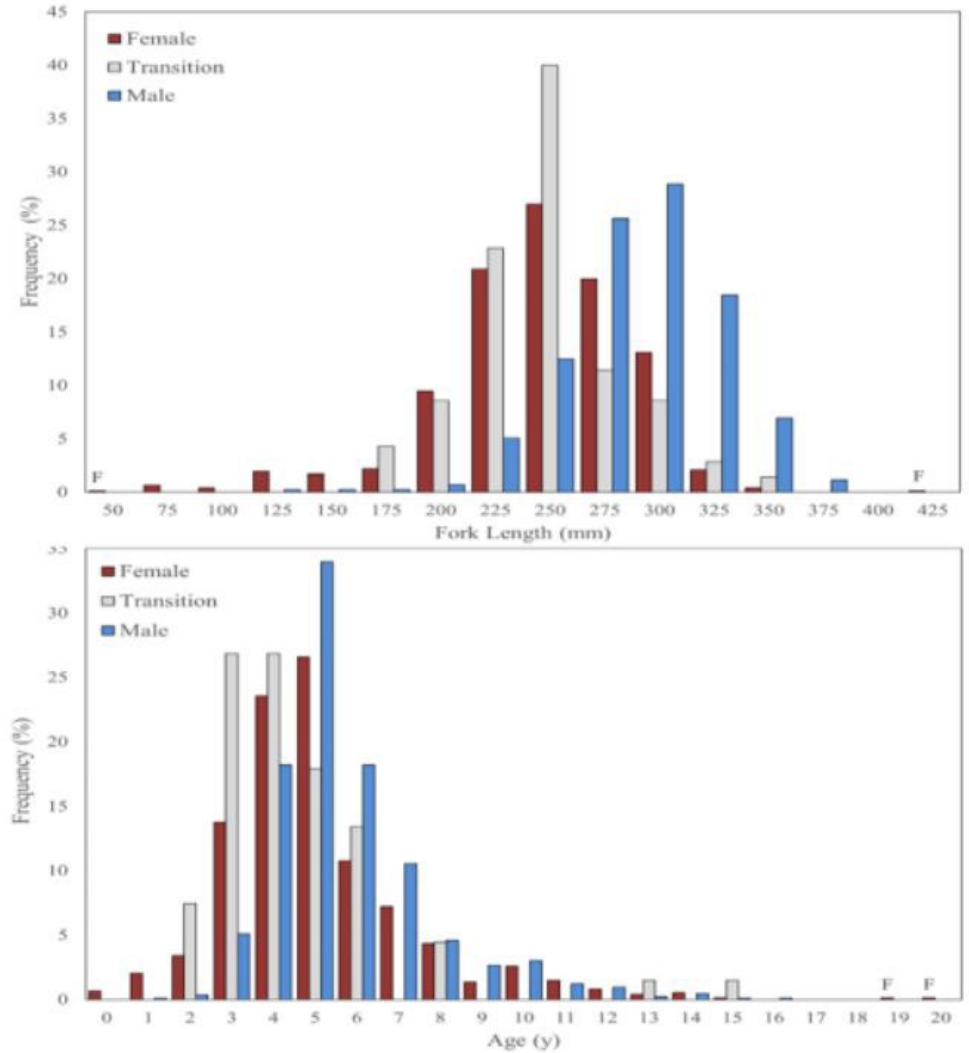
Growth



Maturity and Hermaprhoditism

Parameter	n	Estimate
Sexual Maturity		
LM_{50}	768	153 (140 - 165)
AM_{50}	731	1.6 (1.4 - 1.9)
Transition		
LT_{50}	1637	279 (275 - 282)
AT_{50}	1558	4.5 (3.4 - 5.3)

Maturity and Hermaprhoditism



Natural Mortality

Input Source	Input Type	Input	M	Method
Survival curve	Maximum age	30	**0.180**	Hamel_Amax
SEDAR84-AP-01	Maximum age	20	**0.270**	Hamel_Amax
Meta-analysis	Scientific name	*Sparisoma viride*	0.397	FishLife
Choat et al. (2003)	Maximum age	12	0.450	Hamel_Amax
Choat et al. (2003)	Maximum age	9	0.600	Hamel_Amax
SEDAR84-AP-01	Growth (k)	0.39	0.604	Hamel_k
SEDAR84-AP-01	Growth (k)	0.39	0.585	Jensen_k 1
SEDAR84-AP-01	Growth (k)	0.39	0.624	Jensen_k 2
SEDAR84-AP-01	Growth (L_∞, k)	33.2, 0.39	0.576	Then_VBGF
SEDAR84-AP-01	Growth (k)	0.33	0.512	Hamel_k
SEDAR84-AP-01	Growth (k)	0.33	0.495	Jensen_k 1
SEDAR84-AP-01	Growth (k)	0.33	0.528	Jensen_k 2
SEDAR84-AP-01	Growth (L_∞, k)	33.8, 0.33	0.573	Then_VBGF
SEDAR84-AP-01	Age at 50% maturity	1.6	1.030	Jensen_Amat
SEDAR84-AP-01	Age at 50% maturity	1.6	0.924	Ri_Ef_Amat

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III. Assessment Results

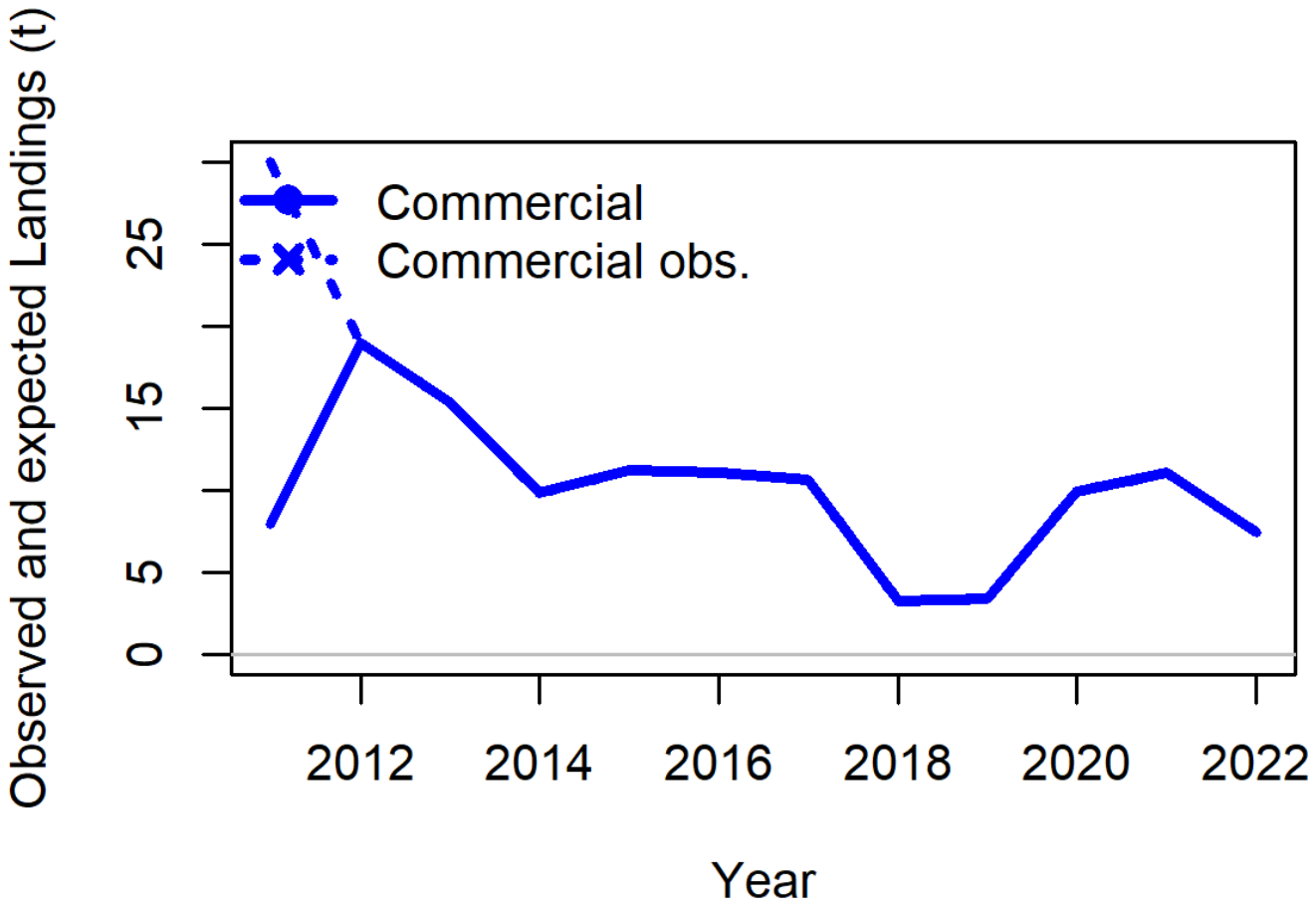
Model Scenario m3_v7

1. Convergence - OKAY
2. Correlation Analysis - OKAY
3. Variance - OKAY
4. Jitter Analysis - OKAY
5. Residual Analysis
6. Retrospective Analysis
7. Likelihood Profiles (3)
8. Sensitivities (6)

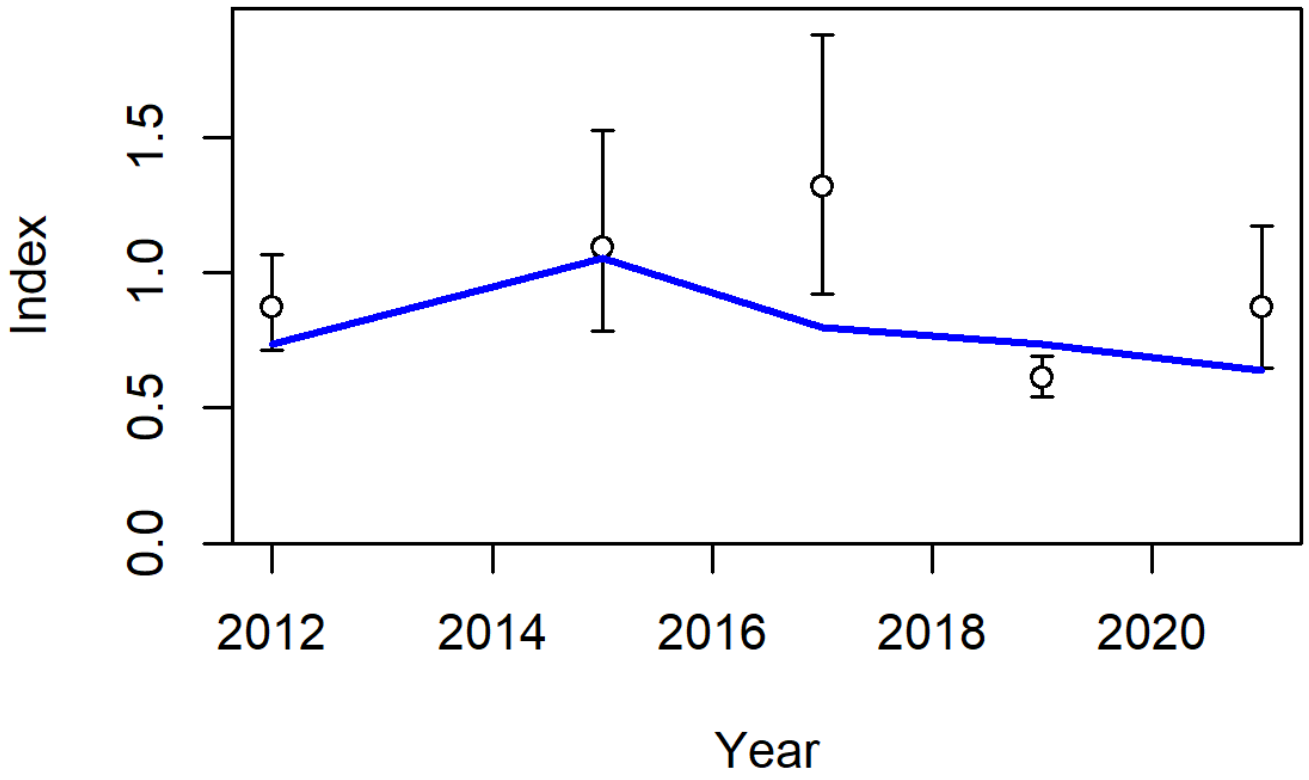
5. Residual Analysis

- Catch
- Indices
- Length Compositions

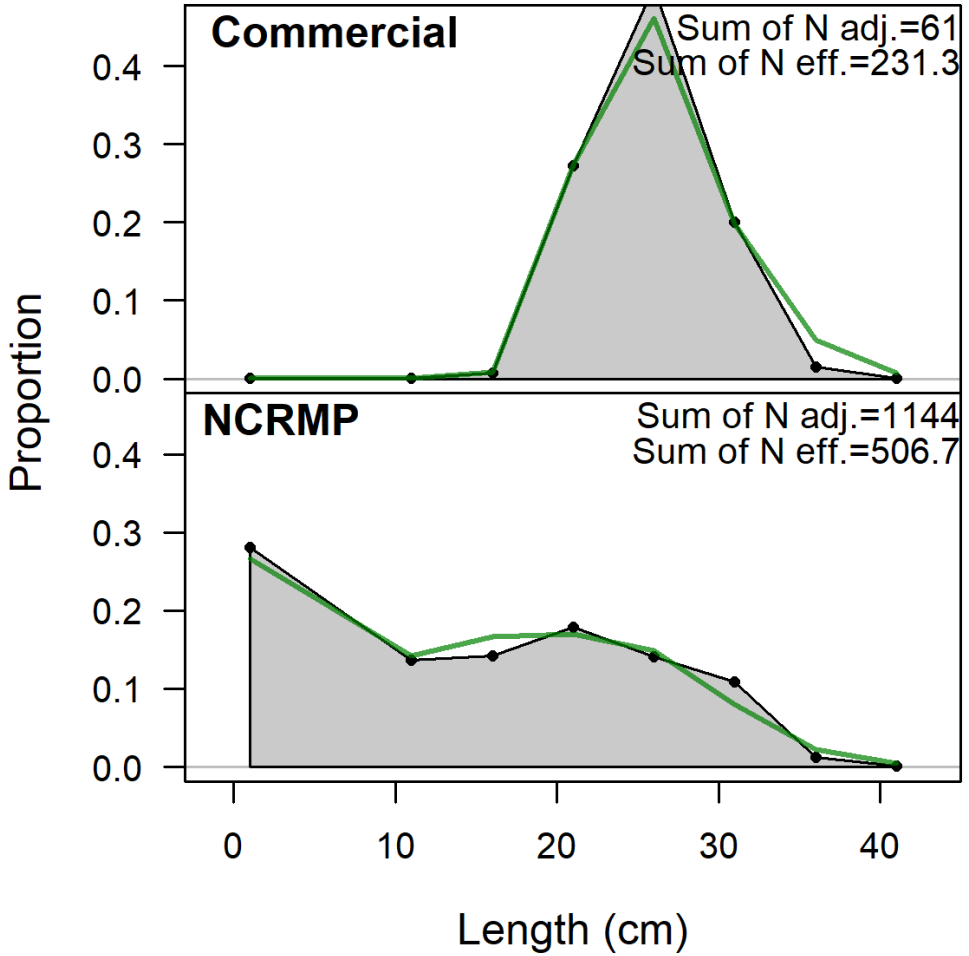
Catch

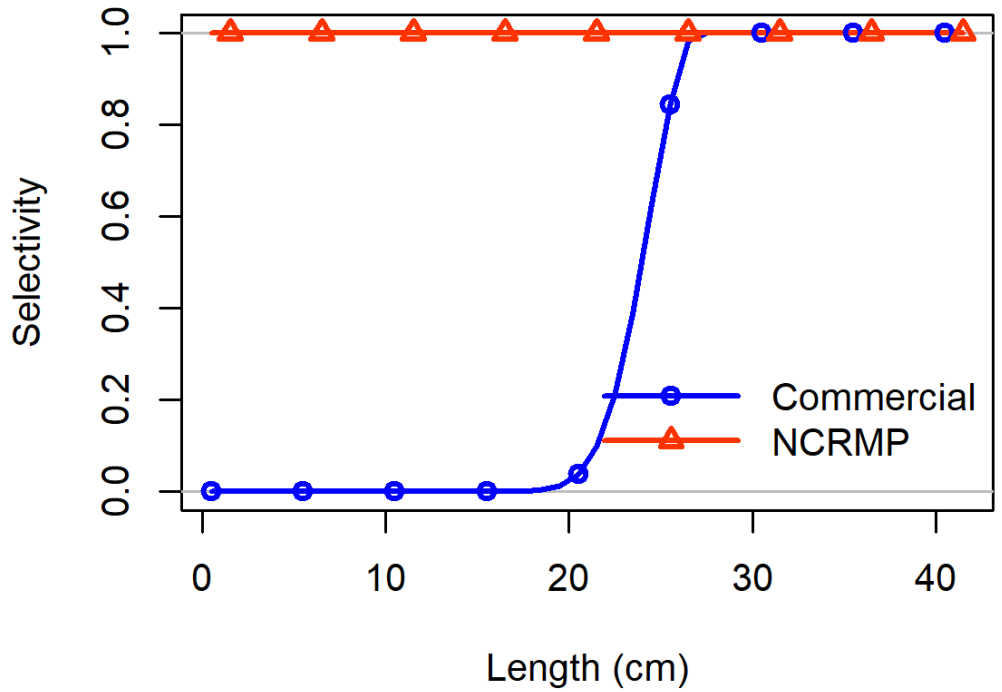

Observed and expected Landings (t)
0
5
15
25
Commercial
Commercial obs.
2012
2014
2016
2018
2020
2022
Year

Index

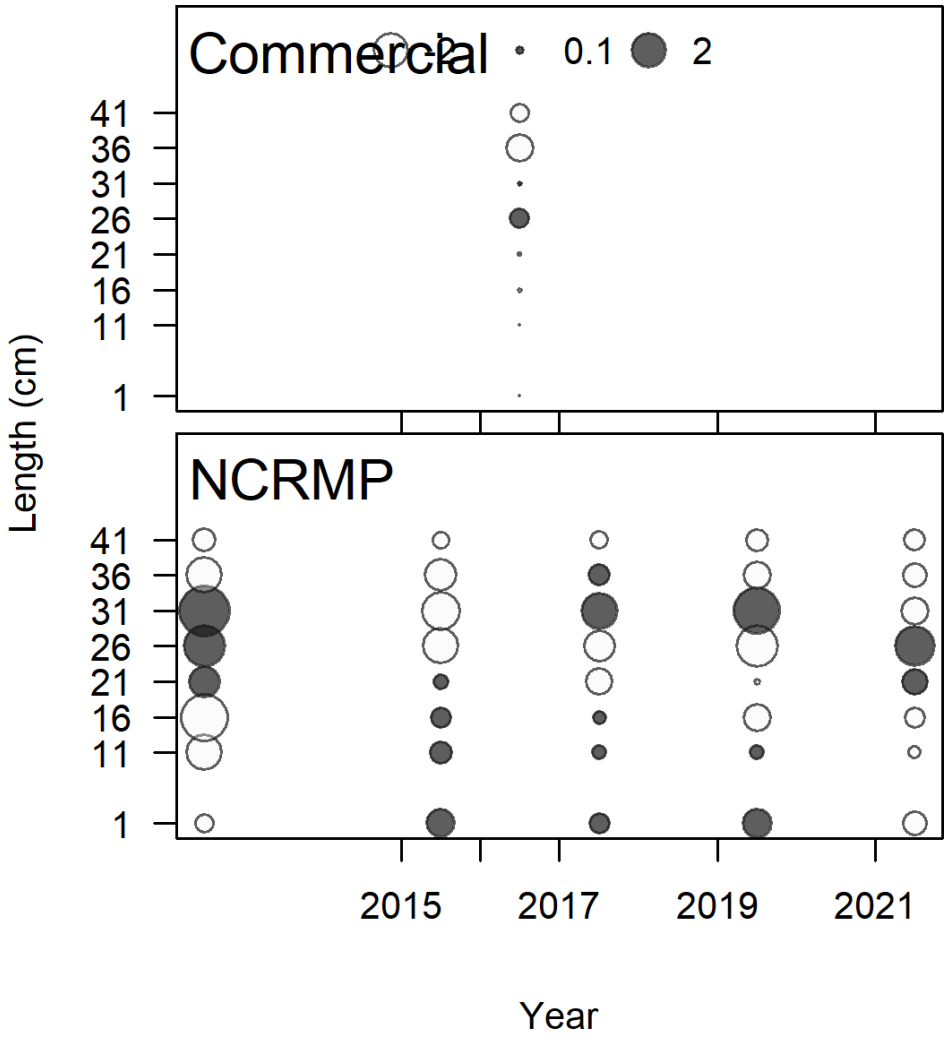


Length Compositions

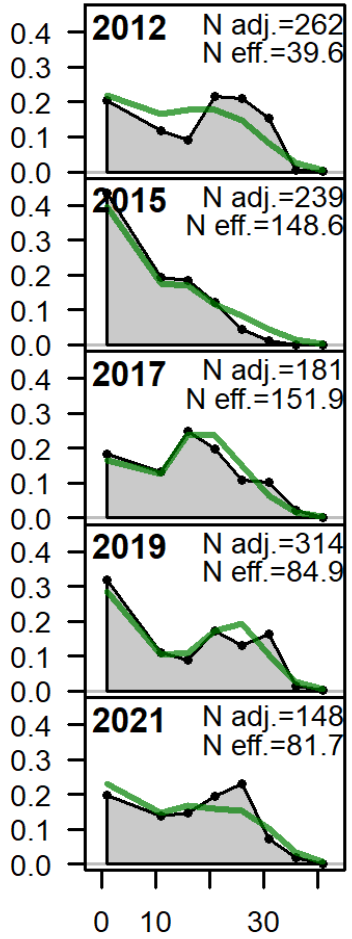


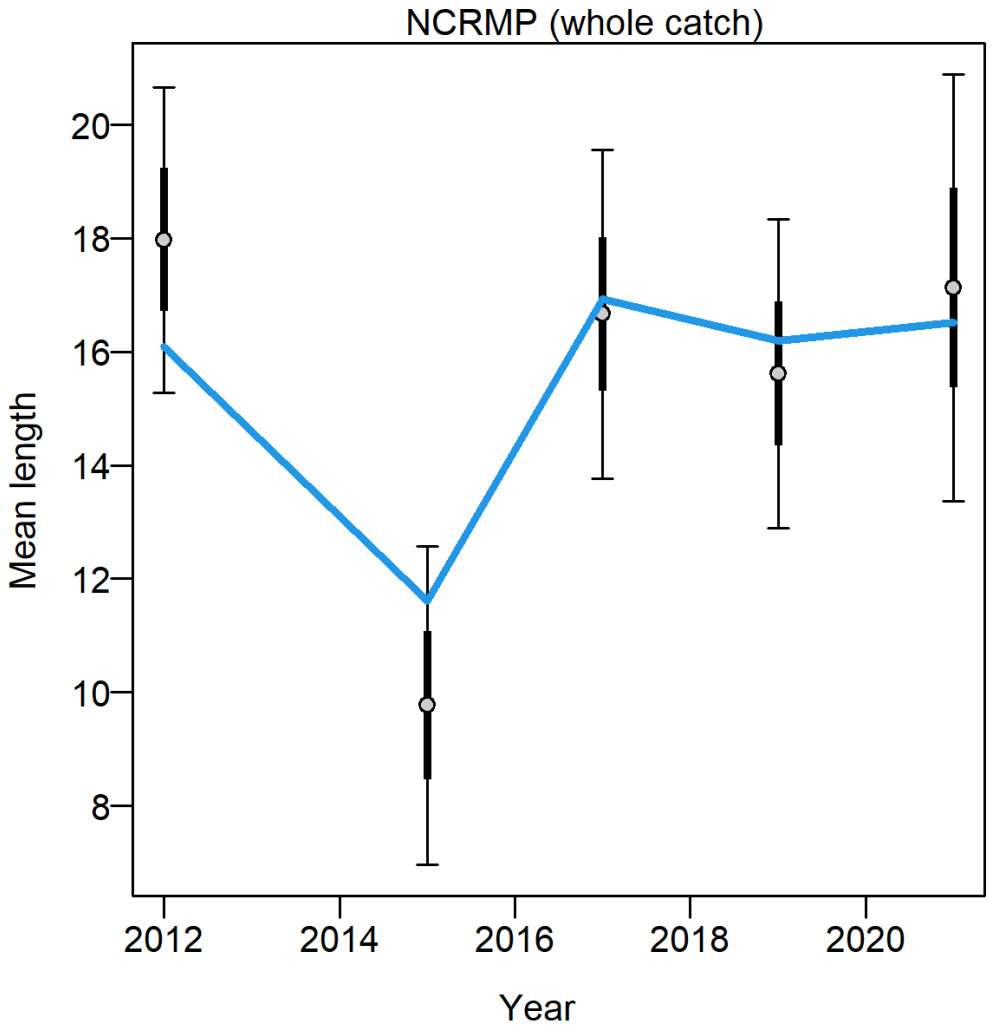


Length Compositions

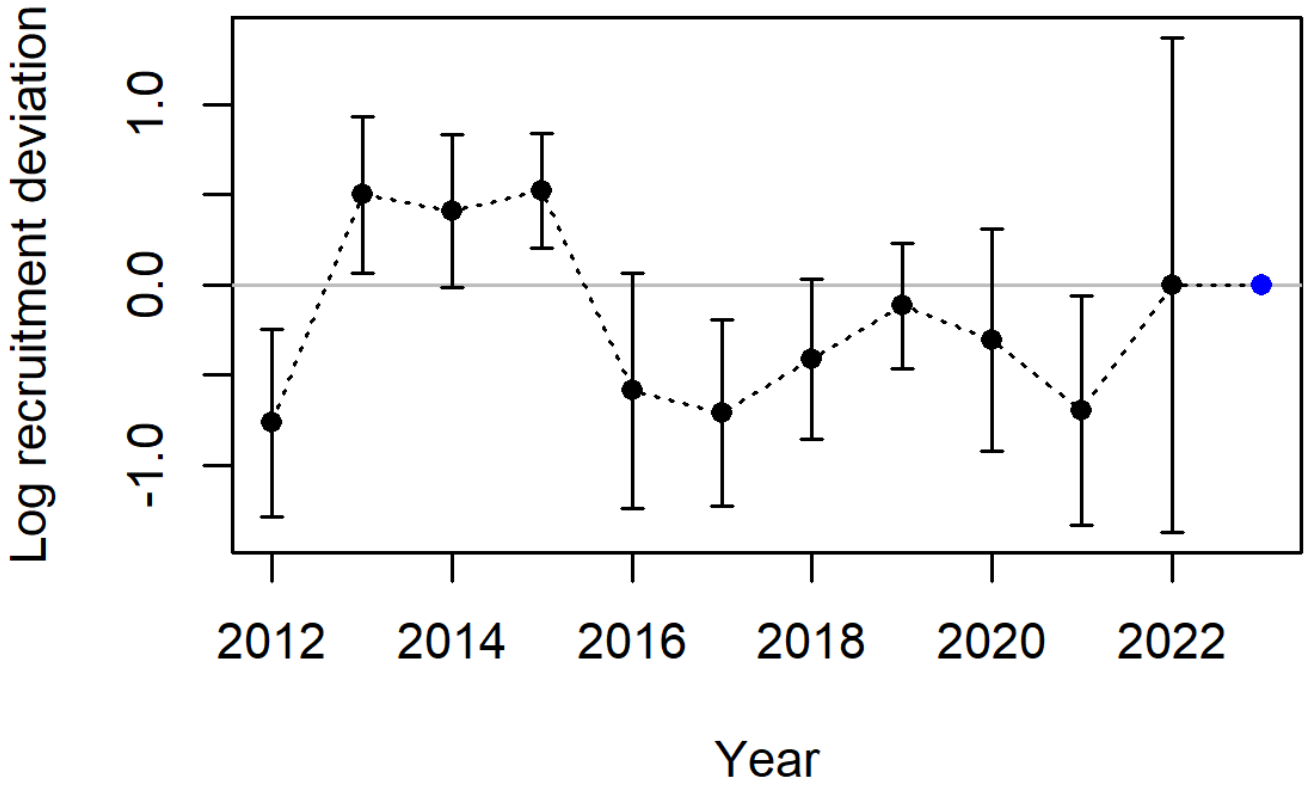


Length Compositions

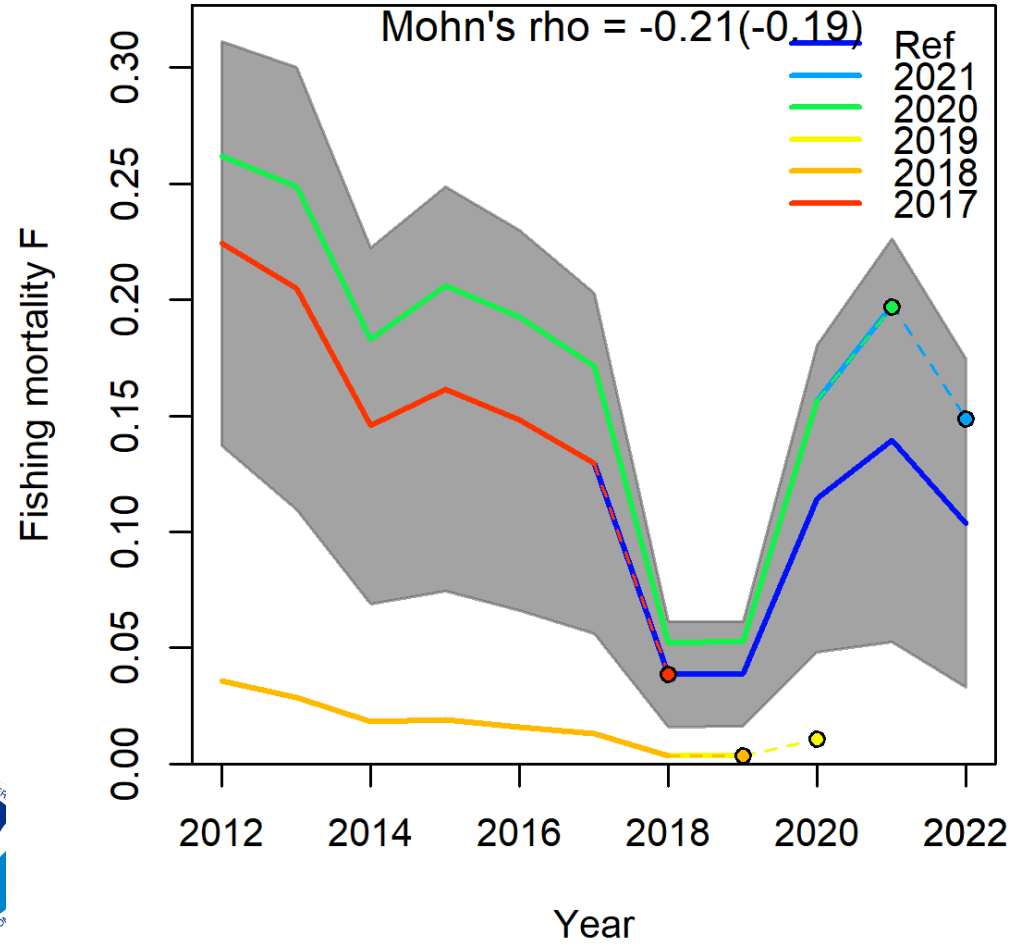


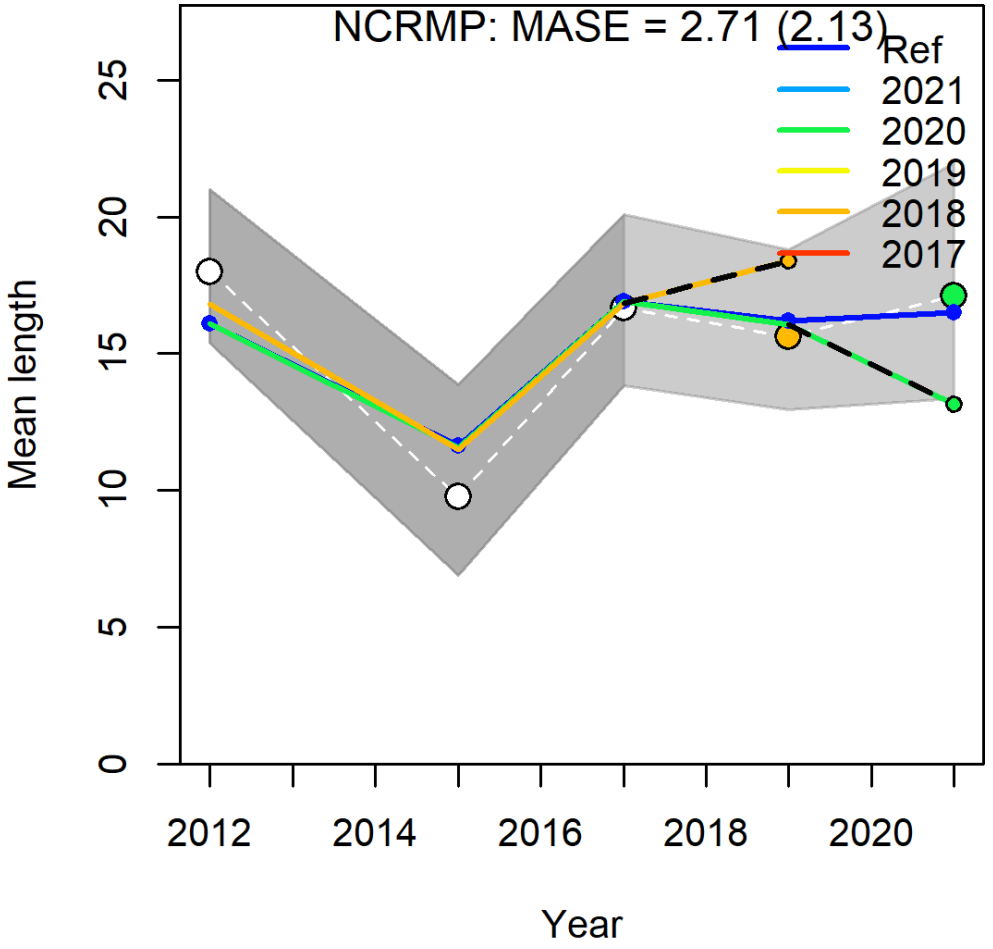


Recruitment Deviations



6. Retrospective Analysis

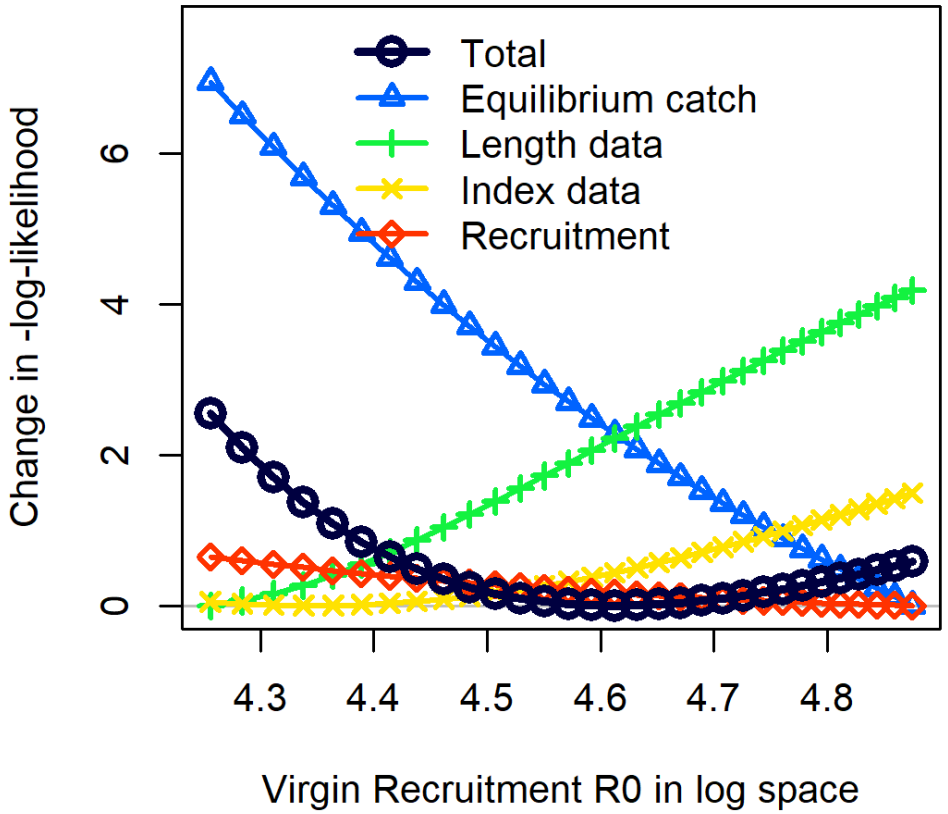


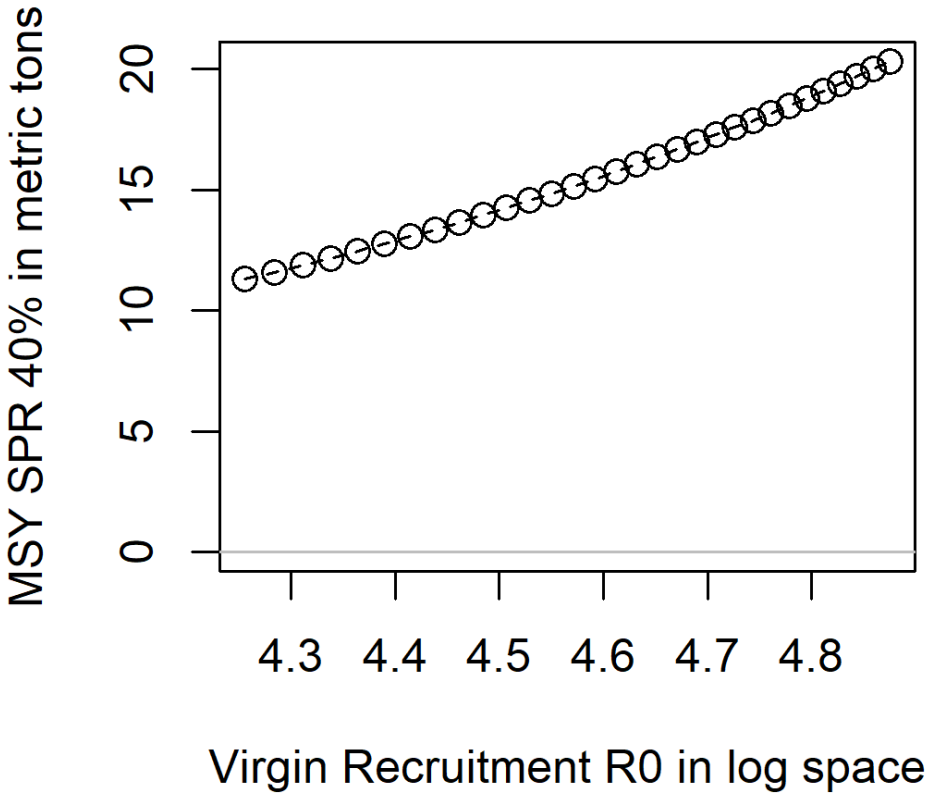


7. Likelihood Profiles

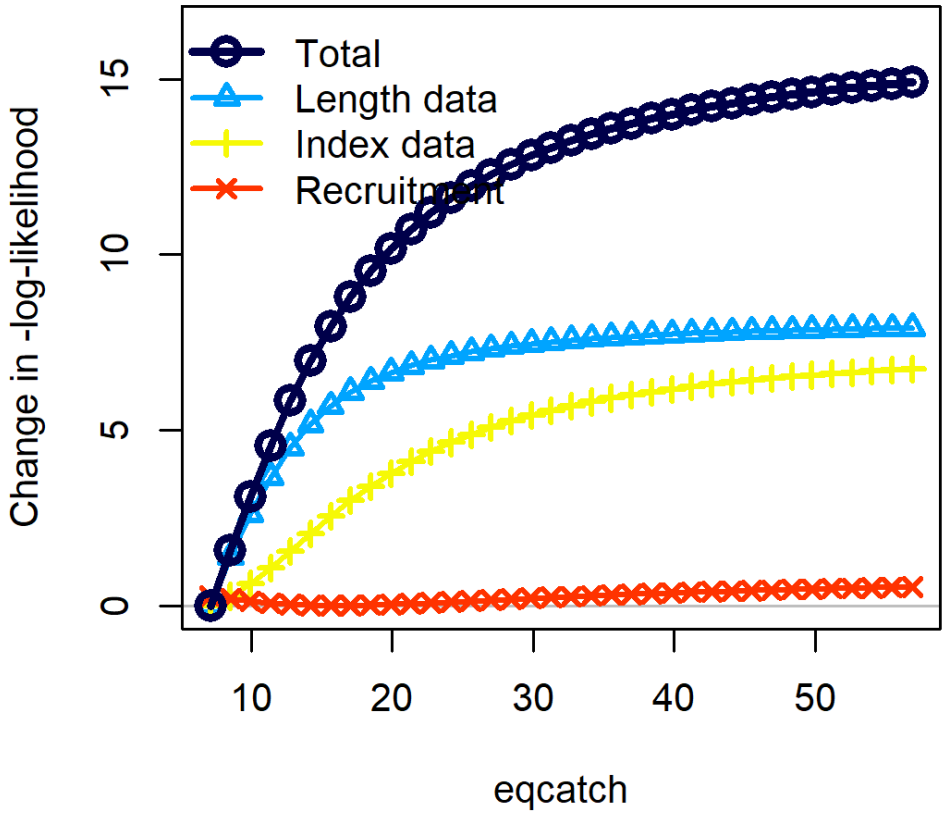
- Unfished Recruitment
- Initial Equilibrium Catch
- Steepness

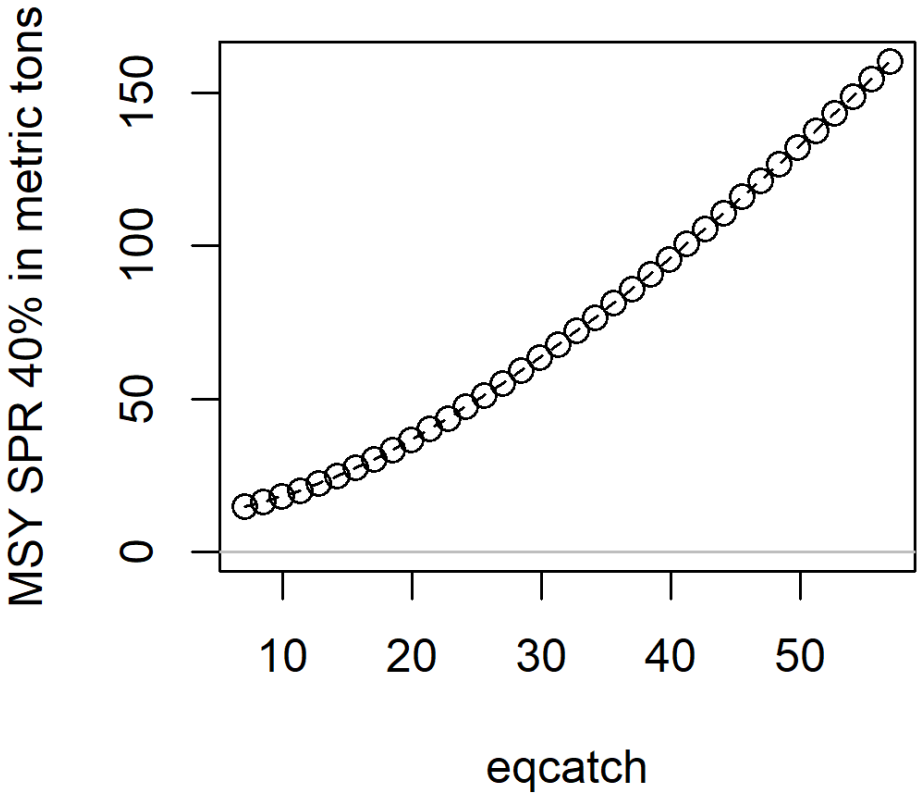
Unfished Recruitment



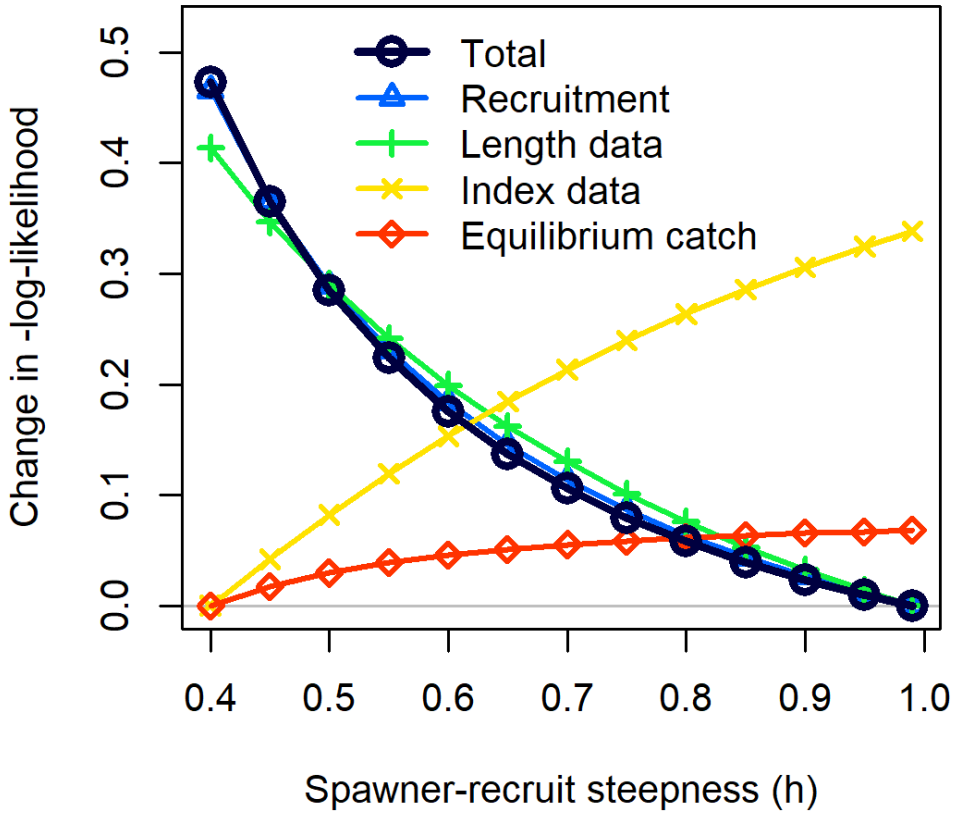


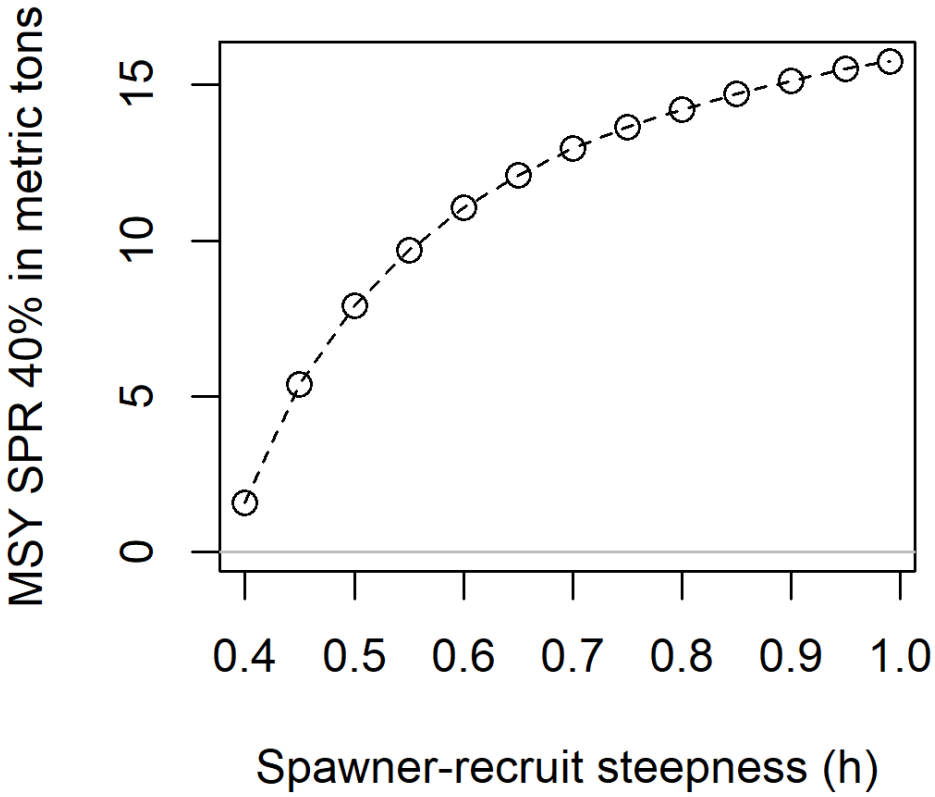
Initial Equilibrium Catch





Steepness


Change in -log-likelihood
0.0
0.1
0.2
0.3
0.4
0.5
Total
Recruitment
Length data
Index data
Equilibrium catch
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Spawner-recruit steepness (h)


MSY SPR 40% in metric tons
0
5
10
15
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Spawner-recruit steepness (h)

8. Sensitivities

- s1 Growth CV increased from 0.15 to 0.25.
- s2 Natural Mortality
- s3 Single Sex Model
- s4 Standard Error on Catch
- s5 Standard Error on Catch and Natural Mortality
- s6 Single Sex Model, Standard Error on Catch, and Natural Mortality

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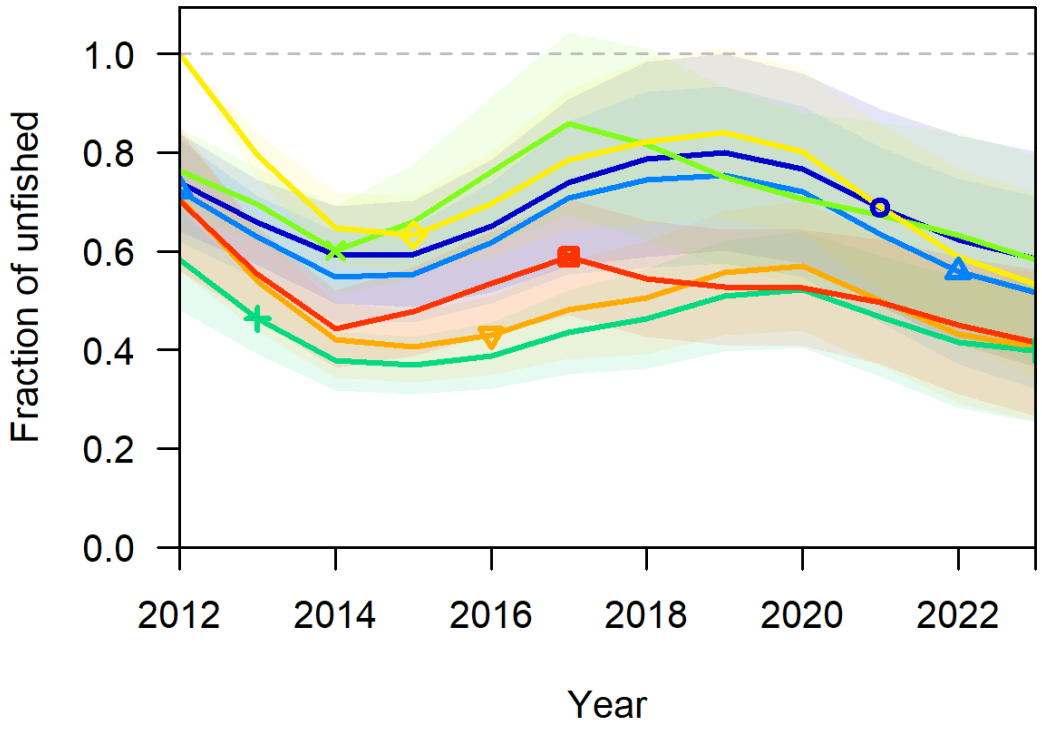
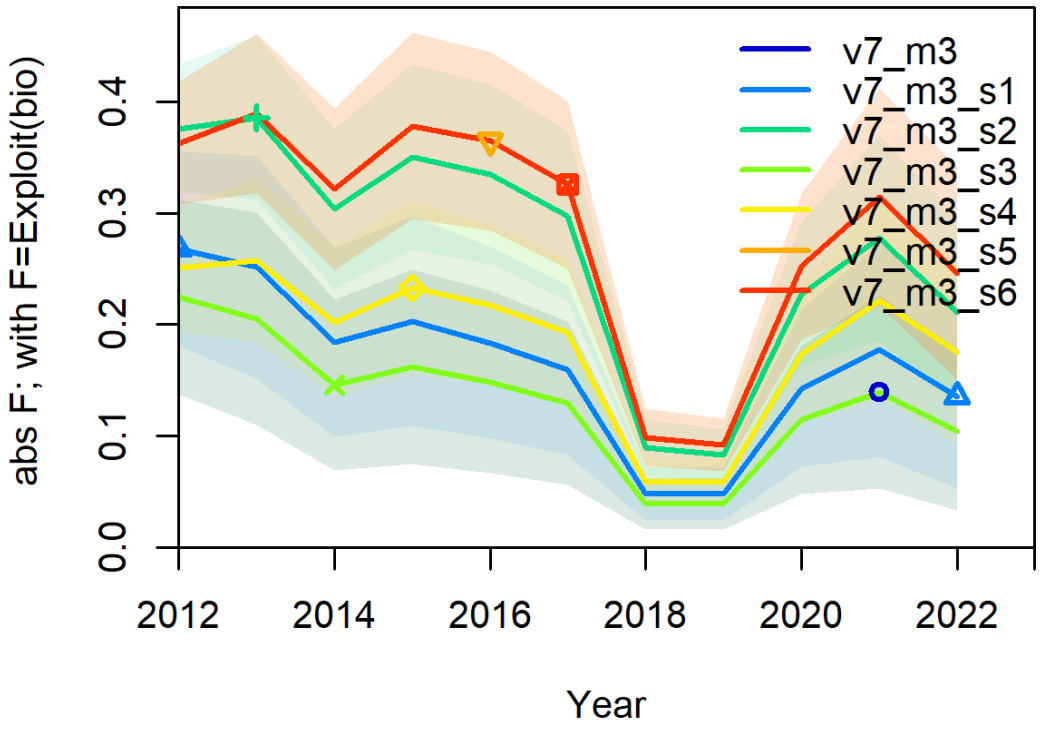
8. Sensitivities





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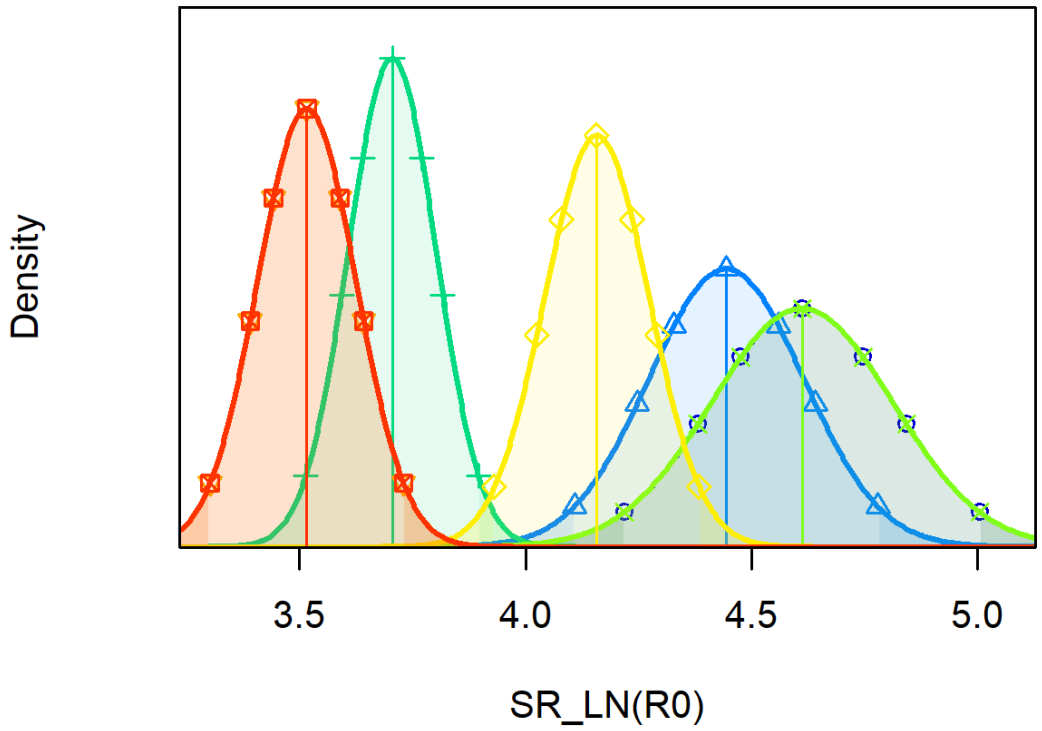
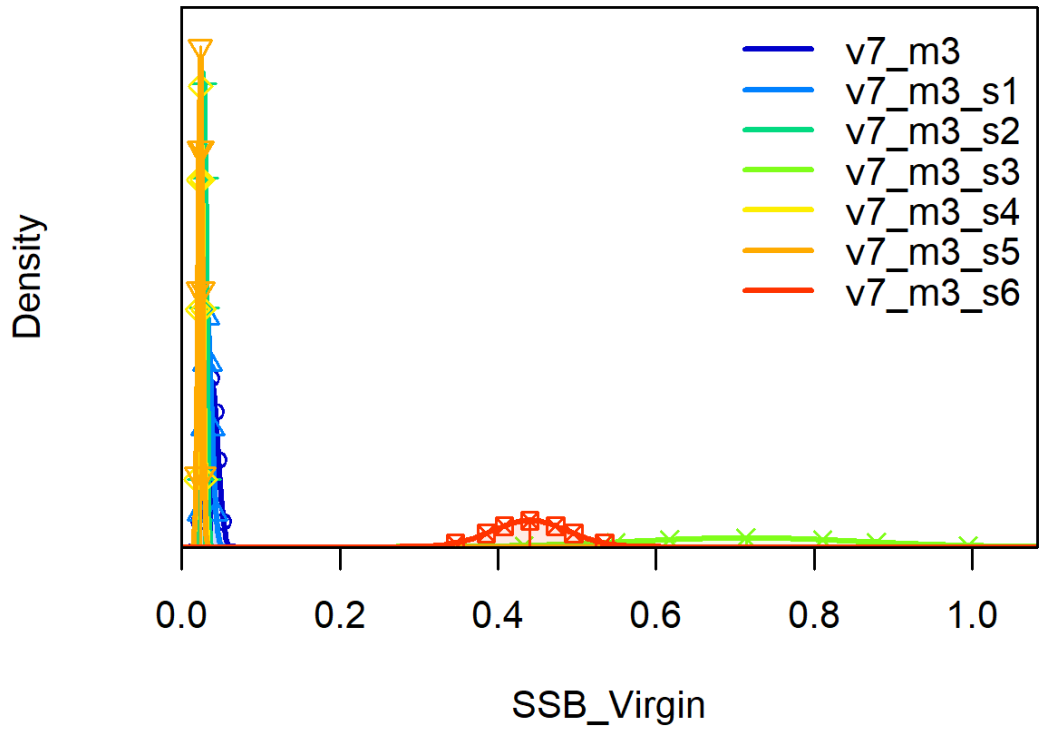
8. Sensitivities





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IV. Discussion & Uncertainties

- Assessment uses a stepwise, scenario-based framework to explore uncertainty
- Natural mortality and initial catch are highly influential in model outcomes
- Short time series (2012-2022) and coarse length bins (2012 & 2015)
- Recruitment deviations are uncertain but improved by fishery-independent data

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V. Conclusions & Recommendations

Key Findings

- Model indicates no overfishing and not overfished
- Only one sensitivity (m3_s6) showed potential overfishing status
- Initial catch conditions are a major source of uncertainty
- Results are robust across models but limited by low-contrast data

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Assessment Research Recommendations

- Reevaluate use of combined indicator species for setting ACLs
- Consider larger-scale stock definitions due to high larval connectivity
- Expand modeling to reflect regional metapopulation dynamics
- Continue long-term monitoring with 1-cm length resolution
- Decouple initial condition from long-term sustainable yields
- Support development of ensembles to capture uncertainty
- Promote scenario testing for other Caribbean species

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Data Workshop Research Recommendations

Life History

- Optimize sample sizes
- Ensure adequate coverage of small and large fish

Length Composition

- Increase TIP sample size and improve trip coverage (e.g., night fishing)
- Link TIP and CCL via integrated data system
- Investigate weight-at-length trends and trip-level representativeness
- Develop a more holistic sampling strategy

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Data Workshop Recommendations (cont.)

- Commercial Landings
- Investigate trends in effort, gear, and environmental drivers
- Explore hindcasting and develop gear grouping and outlier flagging tools
- Discards & Mortality
- Quantify **shark depredation** and discard mortality
- Promote discard reporting through outreach and education

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Data Workshop Recommendations (cont.)

- Fishery-Independent (NCRMP)
  - Investigate changes across consistent sites (e.g., Buck Island);
  - Investigate habitat change and expand to seagrass/mangrove areas
  - Explore unsurveyed turbid regions
- Fishery-Dependent Indices
  - Apply ecosystem lens to fisher targeting behavior
  - Filter out lobster/conch-only trips
  - Examine effort vs. catch disconnect in dive data

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The End

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1. Convergence

- Positive definite Hessian, indicating local optimal fit
- No parameters were bounded, suggesting unconstrained optimization
- Parameter gradients were small (all < 0.001), supporting convergence

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2. Correlation Analysis

- No correlations greater than 0.95 or less than -0.95
- Moderately high correlations (> 0.90) commercial fleet logistic selectivity
  - length at peak selectivity
  - width of the ascending limb

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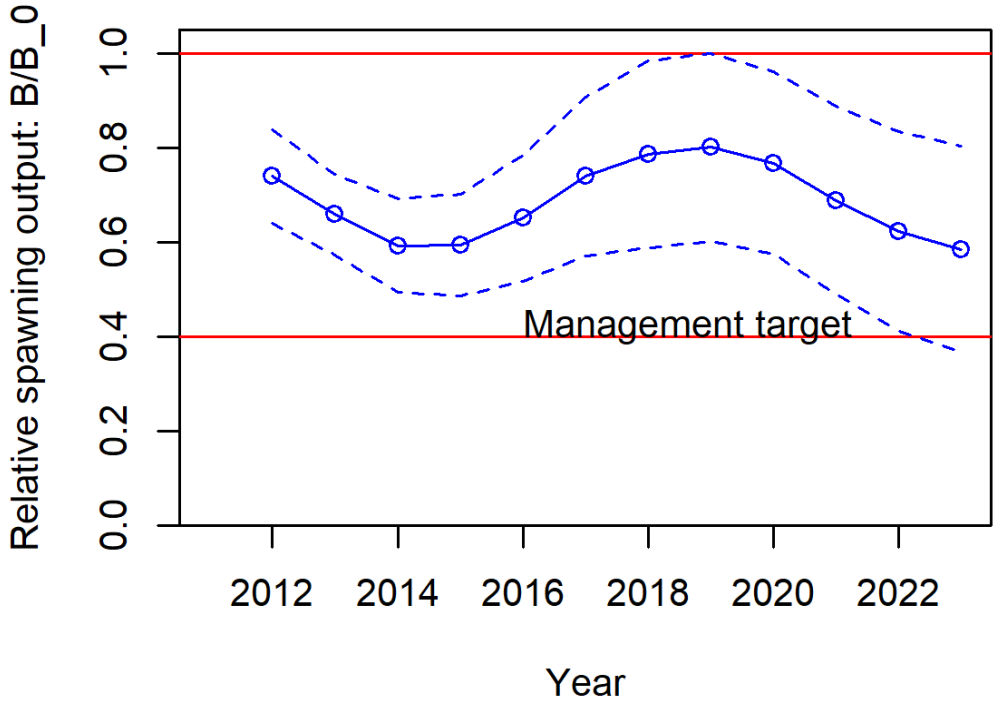
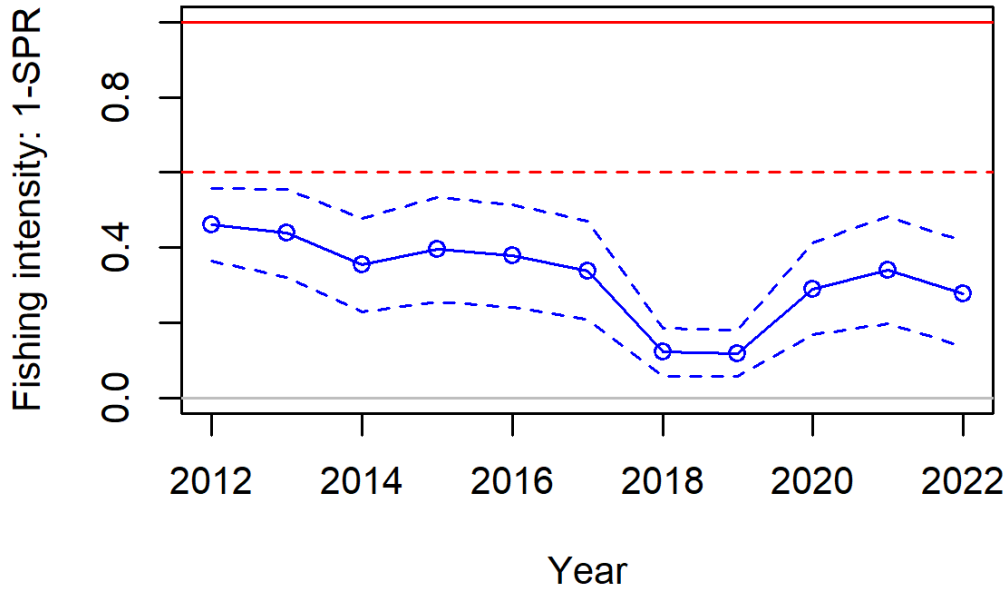
3. Variance





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4. Jitter Analysis