

SEDAR

Southeast Data, Assessment, and Review

SEDAR 91 Stock Assessment Report

US Caribbean Spiny Lobster – St. Thomas/ St. John

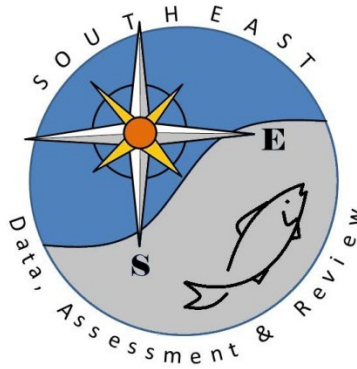
September 2025

SEDAR
4055 Faber Place Drive, Suite 201
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SEDAR



Southeast Data, Assessment, and Review

SEDAR 91

US Caribbean Spiny Lobster – St. Thomas/ St. John

SECTION I: Introduction

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Overview

SEDAR 91 addressed the stock assessment for US Caribbean Spiny Lobster – St. Thomas & St. John. The process consisted of an in-person Data Workshop, with several webinars before and after the workshop and a series of assessment webinars. The Review Workshop was cancelled because the center for independent experts (CIE) were not able to participate in the review of the assessment. The assessment was conducted by the SEFSC.

The Stock Assessment Report is organized into 4 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.

The final Stock Assessment Report (SAR) for US Caribbean Spiny Lobster – St. Thomas & St. John was disseminated to the public in September 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 September 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

A Management History Database is being compiled, cataloged, and standardized by the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), the Southeast Fisheries Science Center (SEFSC) Fisheries Statistics and Sustainable Fisheries Divisions in collaboration with the Cooperative Institute for Marine and Atmospheric Studies (CIMAS) of the University of Miami.

The Management History Database effort involves:

- Identifying Federal Register documentation associated with management actions affecting federally managed species throughout the Gulf of Mexico, South Atlantic, and U.S. Caribbean regions.
- Creating standardized records specifying the Fishery Management Plan (FMP), species, jurisdiction, and fishing sector (commercial and recreational) to which each management action is applied.

Once complete, the goal of the database is to provide a comprehensive and standardized record of published management actions to increase the efficiency of fisheries stock assessments, ACL monitoring, and ecosystem approaches. However, the database is still in development and is not yet available to the public. The intention of this working paper is not to replace current management history documents but to provide complementary tables of cited regulations.

We queried a prototype of the database for records related to Caribbean Spiny Lobster. The records associated with bag limits, size limits, prohibited gear, and closures were reviewed and are summarized here.

Table 1. Recreational bag limit regulations contained within the Management History Database for Caribbean Spiny Lobster.

| Region Affected | Fishery | Start Year | Effective Date | End Date | Bag Limit | FR Reference(s) | Amendment Number or Rule Type |
|-----------------|--------------|------------|----------------|----------|-----------------------|-----------------------------|-------------------------------|
| Caribbean | Recreational | 2012 | 01/30/2012 | Ongoing | 3 per person per day | 76 FR 82413 | Final Amendment 5 |
| | | 2012 | 01/30/2012 | Ongoing | 10 per vessel per day | 76 FR 82413 | Final Amendment 5 |

Table 2. Size limit regulations for the commercial fishery and recreational and commercial fisheries combined (All) contained within the Management History Database for Caribbean Spiny Lobster.

| Region Affected | Fishery | Start Year | Effective Date | End Date | Size Limit | Length Type | FR Reference(s) | Amendment Number or Rule Type |
|-----------------|------------|------------|----------------|----------|-------------------------|-------------------------|-----------------------------|-------------------------------|
| Caribbean | All | 1985 | 01/01/1985 | Ongoing | 3.5 inches ¹ | Minimum Carapace Length | 49 FR 50049 | Final Original FMP |
| Caribbean | Commercial | 2009 | 02/11/2009 | Ongoing | 6 ounce ² | Tail Weight | 74 FR 1148 | Final Amendment 4 |

¹Size limit applies to non-egg-bearing spiny lobster

²Size limit applies to imported spiny lobster

Table 3. Gear restrictions for commercial and commercial and recreational fisheries combined (All) contained within the Management History Database for Caribbean Spiny Lobster.

| Region Affected | Fishery | Gear Type | Start Year | Effective Date | End Date | Gear/Harvesting Restrictions | FR Reference(s) | Amendment Number or Rule Type |
|-----------------|---------|--------------------------|------------|----------------|------------|--|-----------------------------|-------------------------------|
| Caribbean | All | All | 2005 | 11/28/2005 | Ongoing | Prohibited fileting fish at sea | 70 FR 62073 | Final |
| | | | | | | Reef fish vessels required to recover anchor by its crown | | |
| | | Explosives | 1985 | 01/01/1985 | Ongoing | Prohibited for spiny lobster | 49 FR 50049 | Final Original FMP |
| | | Gillnets or Trammel Nets | 2005 | 11/28/2005 | Ongoing | Prohibit gillnets or trammel net for reef species ¹ | 70 FR 62073 | Final Amendment 2 |
| | | Hookah ² | 1997 | 01/13/1997 | Ongoing | Prohibited hookah gear for harvesting conch | 61 FR 65481 | Final Original FMP |
| | | Poison | 1985 | 01/01/1985 | Ongoing | Prohibited for spiny lobster | 49 FR 50049 | Final Original FMP |
| | | Pots and Traps | 1985 | 01/01/1985 | 09/19/1991 | Include one degradable panel and/or door | 49 FR 50049 | Final Original FMP |
| | | | 1986 | 09/22/1986 | 09/13/1991 | Minimum mesh size 1 ¼” | 50 FR 34850 | Final Original FMP |
| | | | 1991 | 09/14/1991 | Ongoing | Minimum mesh size 2” | 55 FR 46214 | Final Amendment 1 |

| Region Affected | Fishery | Gear Type | Start Year | Effective Date | End Date | Gear/Harvesting Restrictions | FR Reference(s) | Amendment Number or Rule Type |
|-------------------------------------|------------|---------------------------|------------|----------------|------------|--|--|-------------------------------|
| | All | Pots and Traps | 1991 | 09/20/1991 | 11/14/1993 | Include two degradable panels on opposite sides | 56 FR 48755 | Final |
| | | | 1993 | 11/15/1993 | 11/27/2005 | Include two degradable panels (sides no longer specified) | 58 FR 53145 | Final Amendment 2 |
| | | | 2005 | 11/28/2005 | Ongoing | Include one degradable panel | 70 FR 62073 | Final |
| | | Slurp Gun and Dip Nets | 1993 | 11/15/1993 | 11/28/2005 | Allow only slurp gun and hand-held dip nets for aquarium trade | 58 FR 53145 70 FR 62073 | Final Amendment 2 Final |
| | | Spear | 1985 | 01/01/1985 | Ongoing | Prohibited for spiny lobster | 49 FR 50049 | Final Original FMP |
| | Commercial | Spear | 2010 | 12/02/2010 | Ongoing | Allow spear fishing for reef fish in the commercial sector | 75 FR 67247 | Final Regulatory Amendment |
| Caribbean Closed areas ³ | All | Bottom gears ⁴ | 2005 | 11/28/2005 | Ongoing | Prohibited year-round | 70 FR 62073 | Final |
| Caribbean Bajo de Sico | All | Anchoring | 2010 | 12/02/2010 | Ongoing | Anchoring by fishing vessels prohibited year-round | 75 FR 67247 | Final Regulatory Amendment |

¹Gill nets and trammel nets used to fish other species must be tended at all times

²Lang Bank (St. Croix) only starting 11/28/2005

³Bajo de Sico, Abrir La Sierra, Tourmaline, Mutton Snapper Spawning Aggregation Area, Lang Bank, Hind Bank Marine Conservation District, and Grammanik Bank

⁴Pots, traps, bottom longlines, gillnets, trammel nets

Table 4. Closure regulations for Caribbean Spiny Lobster contained within the Management History Database.

| Region Affected | Start Year | End Year | Start Day | End Day | Restriction During Closure | FR Reference(s) | Amendment Number or Rule Type |
|--|-------------------|-----------------|------------------|----------------|-----------------------------------|-----------------------------|--------------------------------------|
| Caribbean Red Hind Spawning Aggregation West of Puerto Rico - Abrir La Sierra Bank | 1996 | 1996 | 12/7 | 12/31 | All fishing prohibited | 61 FR 64485 | Final Regulatory Amendment |
| | 1997 | Ongoing | 1/1 | 2/28 | All fishing prohibited | 61 FR 64485 | Final Regulatory Amendment |
| | 1997 | Ongoing | 12/1 | 12/31 | All fishing prohibited | 61 FR 64485 | Final Regulatory Amendment |

| Region Affected | Start Year | End Year | Start Day | End Day | Restriction During Closure | FR Reference(s) | Amendment Number or Rule Type |
|--|------------|----------|-----------|---------|----------------------------------|-----------------------------|-------------------------------|
| Caribbean Red Hind Spawning Aggregation West of Puerto Rico - Bajo De Sico | 1996 | 1996 | 12/7 | 12/31 | All fishing prohibited | 61 FR 64485 | Final Regulatory Amendment |
| | 1997 | 2010 | 1/1 | 2/28 | All fishing prohibited | 61 FR 64485 | Final Regulatory Amendment |
| | 1997 | 2009 | 12/1 | 12/31 | All fishing prohibited | 61 FR 64485 | Final Regulatory Amendment |
| | 2010 | 2010 | 12/2 | 12/31 | Fishing for reef fish prohibited | 75 FR 67247 | Final Regulatory Amendment |

| Region Affected | Start Year | End Year | Start Day | End Day | Restriction During Closure | FR Reference(s) | Amendment Number or Rule Type |
|--|-------------------|-----------------|------------------|----------------|-----------------------------------|-----------------------------|--------------------------------------|
| Caribbean Red Hind Spawning Aggregation West of Puerto Rico - Bajo De Sico | 2011 | Ongoing | 1/1 | 3/31 | Fishing for reef fish prohibited | 75 FR 67247 | Final Regulatory Amendment |
| | 2011 | Ongoing | 10/1 | 12/31 | Fishing for reef fish prohibited | 75 FR 67247 | Final Regulatory Amendment |
| Caribbean Grammanik Bank Reef Fish Fishery Management Area | 2005 | Ongoing | 2/1 | 4/30 | All fishing prohibited | 70 FR 62073 | Final Amendment 2 |
| Caribbean Hind Bank Marine Conservation District (MCD) Reef Fish Fishery Management Area | 1989 | 1989 | 12/6 | 12/31 | All fishing prohibited | 54 FR 50624 | Emergency Interim Rule |

| Region Affected | Start Year | End Year | Start Day | End Day | Restriction During Closure | FR Reference(s) | Amendment Number or Rule Type |
|---|-------------------|-----------------|------------------|----------------|-----------------------------------|-----------------------------|--------------------------------------|
| Caribbean Hind Bank Marine Conservation District (MCD) Reef Fish Fishery Management Area | 1990 | 1999 | 1/1 | 2/28 | All fishing prohibited | 54 FR 50624 | Emergency Interim Rule |
| | 1990 | 1999 | 12/1 | 12/31 | All fishing prohibited | 55 FR 46214 | Final Amendment 1 |
| | 2000 | Ongoing | 1/1 | 12/31 | All fishing prohibited | 64 FR 60132 | Final |
| Caribbean Mutton Snapper Spawning Aggregation Reef Fish Fishery Management Area | 1994 | Ongoing | 3/1 | 6/30 | All fishing prohibited | 58 FR 53145 | Final Amendment 2 |
| Caribbean Red Hind Spawning Aggregation East of St. Croix Reef Fish Fishery Management Area | 1993 | Ongoing | 12/1 | 12/31 | All fishing prohibited | 58 FR 53145 | Final Amendment 2 |

| Region Affected | Start Year | End Year | Start Day | End Day | Restriction During Closure | FR Reference(s) | Amendment Number or Rule Type |
|---|------------|----------|-----------|---------|----------------------------|-----------------------------|---------------------------------------|
| Caribbean Red Hind Spawning Aggregation East of St. Croix Reef Fish Fishery Management Area | 1994 | Ongoing | 1/1 | 2/28 | All fishing prohibited | 58 FR 53145 | Final Amendment 2 |
| Caribbean Red Hind Spawning Aggregation West of Puerto Rico - Tourmaline Bank | 1993 | Ongoing | 12/1 | 12/31 | All fishing prohibited | 58 FR 53145 | Final Amendment 2 |
| | 1994 | Ongoing | 1/1 | 2/28 | All fishing prohibited | 58 FR 53145 | Final Amendment 2 |
| Caribbean St. Croix Management Area | 2013 | 2013 | 12/19 | 12/31 | All fishing prohibited | 78 FR 18247 | Temporary Rule Accountability Measure |
| | 2016 | 2016 | 12/10 | 12/31 | All fishing prohibited | 81 FR 34283 | Temporary Rule Closure |
| Caribbean Puerto Rico Management Area | 2017 | 2017 | 9/7 | 9/30 | All fishing prohibited | 82 FR 31489 | Temporary Rule Closure |
| | 2021 | 2021 | 8/22 | 9/30 | All fishing prohibited | 86 FR 40787 | Temporary Rule Closure |
| | 2022 | 2022 | 7/12 | 9/30 | All fishing prohibited | 87 FR 38008 | Temporary Rule Closure |

3 ASSESSMENT HISTORY AND REVIEW

Previous stock assessments for US Caribbean spiny lobster have attempted to quantify stock status using both traditional as well as data-limited stock assessment procedures. Morris et al. (2004) and also SEDAR (2005A) provide assessment histories that summarize various traditional assessments, e.g. stock production analyses (ASPIC), CPUE examinations, yield per recruit, landings and length frequency. During SEDAR 46, a data-limited management strategy evaluation was conducted to simulation-test mean-length, indicator-based control rules (2016). A table of past assessment model applications can be found in the SEDAR 57 Final Stock Assessment Report (2019). SEDAR 57 was the first application of Stock Synthesis 3.0 (SS3) in the US Caribbean (2019). During SEDAR 57, the Saint Thomas/St. John spiny lobster stock assessment models were subject to numerous sensitivity analyses including assumptions related to natural mortality, growth, and selectivity (SEDAR, 2019). The St. Thomas/St. John assessment models developed during SEDAR 57 were fit to catch time series and length composition information from dive and pot/trap fisheries; this is considered a data-limited to moderate implementation of SS3. SEDAR 57 resulted in a satisfactory stock status determination for providing management advice (2019). A data-only update was conducted in 2022 to provide ABCs and ACLs through May, 2025. One new data stream became available following the SEDAR 91 Data Workshop in November 2024: the SEAMAP-C dive survey (2021-2023). However, due to low sample size ($n = 57$), the Assessment Workshop Panel did not recommend fitting the model to those data.

REGIONAL MAPS

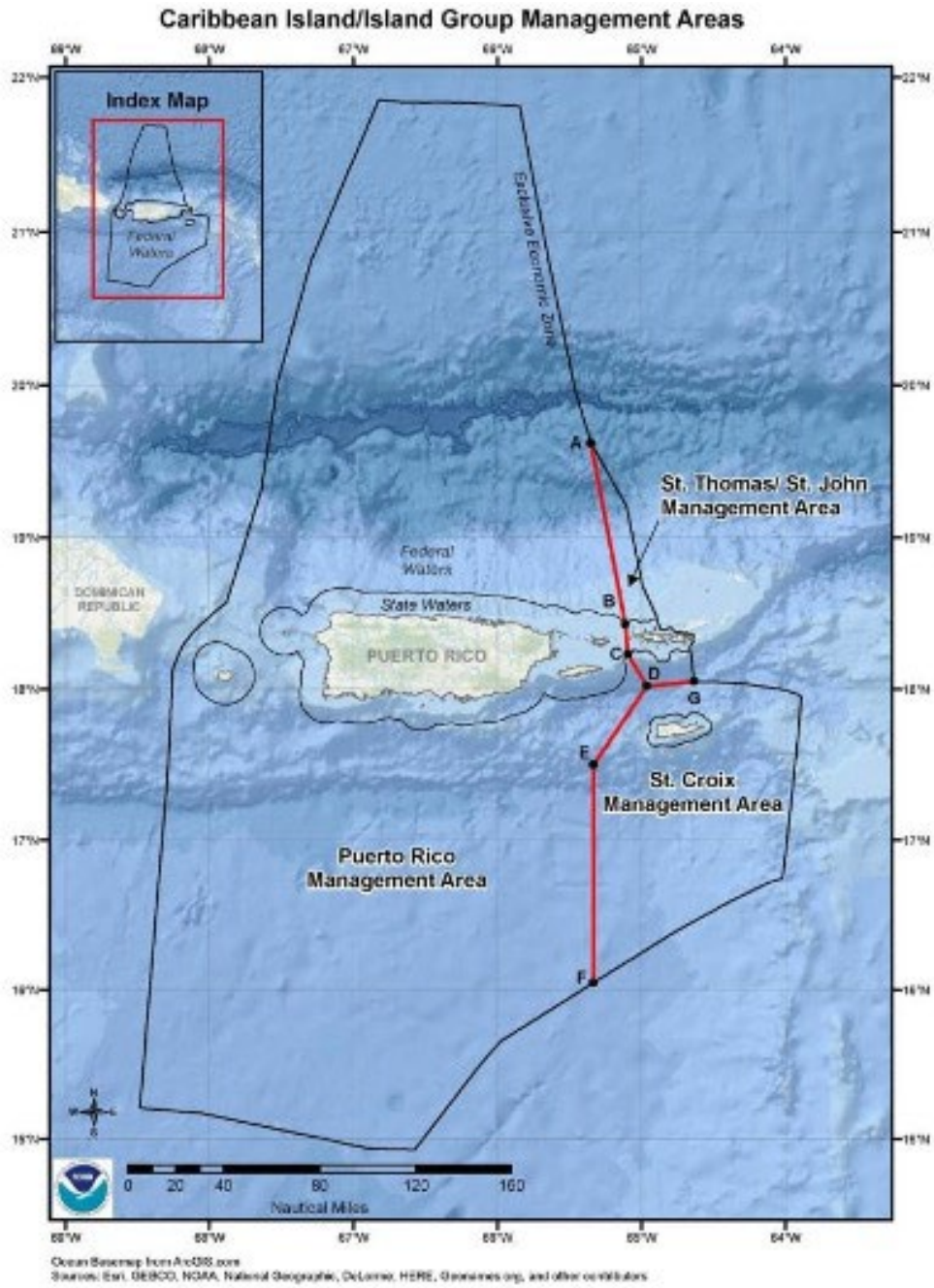


Figure 4.1 Jurisdictional boundaries of the Caribbean Fishery Management Council.

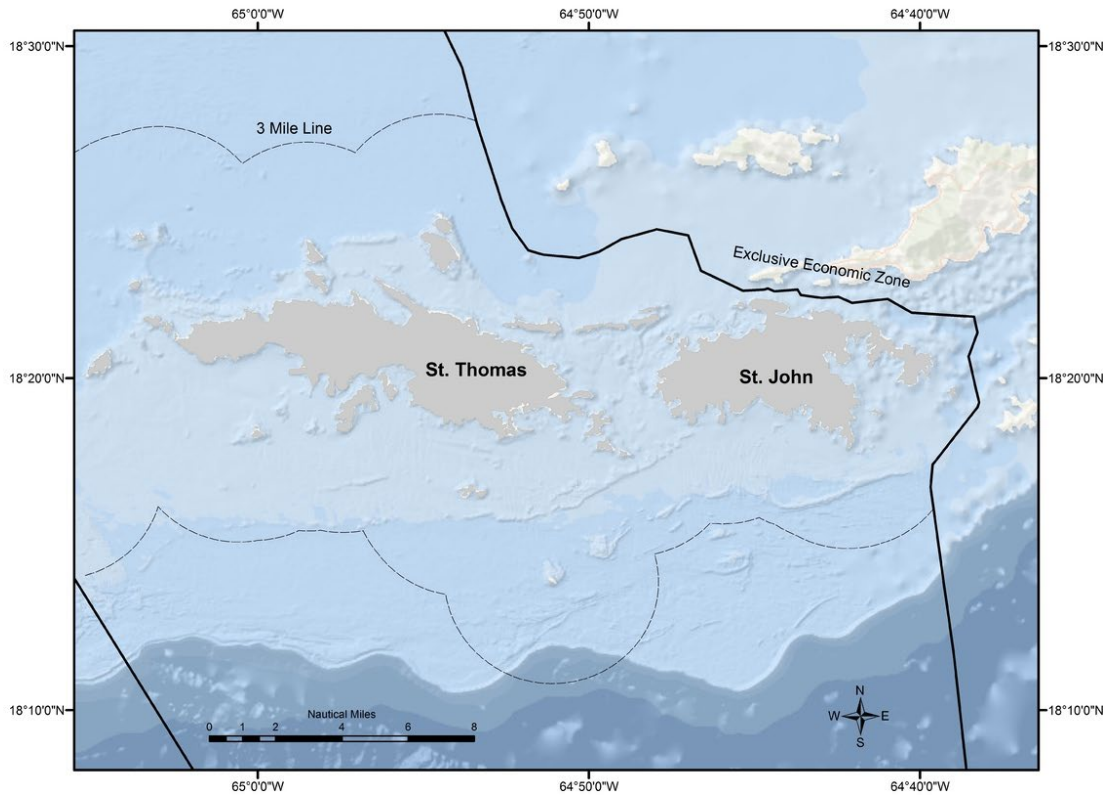


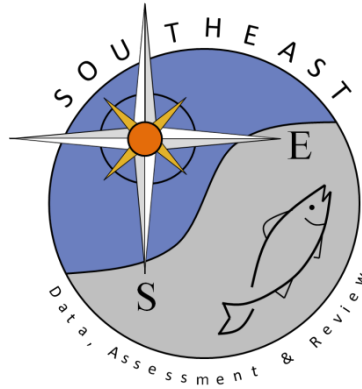
Figure 4.2: The U.S. Exclusive Economic Zone is defined as the federal waters ranging from 3 to 200 nautical miles (5.6 – 370 kilometers) from the nearest coastline point of the US Virgin Islands.

4 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, F_{max} |
| 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 Spiny Lobster St. Thomas and St. John

SECTION II: Data Workshop Report

January 2025

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1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 91 Data Workshop was held November 13-15, 2024, in St Thomas, USVI. In addition to the in-person workshop, a series for webinars were held before (June and October 2024) the meeting.

1.2 TERMS OF REFERENCE

Data Workshop Terms of Reference:

1. 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
 - e. Include data through at least 2022.
2. 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.
3. 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

| | |
|----------------------------------|----------------------|
| Matt Damiano (Lead Analyst)..... | NMFS/SEFSC |
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| Daniel Matos-Caraballo..... | PR DNER |
| Kevin McCarthy | NMFS/SEFSC |
| Maggie Rios..... | USVI DPNR |
| M. Refik Orhun..... | NMFS/SEFSC |
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 Sarah Stephenson..... SERO
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 Cindy Grace-McCaskey
 Kimberly Johnson.....NMFS/SEFSC
 May Lehmensiek.....
 Jesus Leon
 Martha Prada..... DRNA
 Vanessa Ramirez.....
 Noemi Peña AlvardPR DNER
 Aida Rosario.....PR DNER

1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERENCE DOCUMENTS

| Document # | Title | Authors | Date Submitted |
|---|---|---|----------------|
| Documents Prepared for the Data Workshop | | | |
| SEDAR91-DW-01 | Summary of participatory modeling workshops to understand ecological, social and economic dimensions of the U.S. Virgin Islands lobster fishery | Juan Agar, Mandy Karnauskas, Kelsi Furman, Matt McPherson, Manoj Shivlani | 11/1/2024 |
| SEDAR91-DW-02 | Summary of participatory modeling workshops to understand ecological, social and economic dimensions of the Puerto Rican lobster fishery | Mandy Karnauskas, Juan Agar, Matt McPherson, Kelsi Furman, Manoj Shivlani | 11/1/2024 |
| SEDAR91-DW-03 | PR/DNER/Commercial Fisheries Statistics Program Report Signs of the Abundance of Spiny Lobster <i>Panulirus argus</i> Observed by Commercial Landings Reported during 2014-2023 | Daniel Matos-Caraballo, Jesús León-Fernández, Luis A. Rivera-Padilla, and Wilson Santiago-Soler | 11/15/2024 |
| SEDAR91-DW-04 | SEDAR 91 Trip Interview Program (TIP) Size Composition Analysis of Caribbean Spiny Lobster (<i>Panulirus argus</i>) in Puerto Rico, U.S. Caribbean, 1981-2023 | Katherine Godwin, Adyan Rios | 11/20/2024 |
| SEDAR91-DW-05 | SEDAR 91 Trip Interview Program (TIP) Size Composition Analysis of Caribbean Spiny Lobster (<i>Panulirus argus</i>) in St. Thomas/St. John, U.S. Caribbean, 1981-2023 | Katherine Godwin, Adyan Rios | 11/20/2024 |
| SEDAR91-DW-06 | SEDAR 91 Trip Interview Program (TIP) Size Composition Analysis of Caribbean Spiny Lobster (<i>Panulirus argus</i>) in St. Croix, U.S. Caribbean, 1981-2023 | Katherine Godwin, Adyan Rios | 11/20/2024 |
| SEDAR91-DW-07 | SEDAR 91 Commercial Landings of Caribbean Spiny Lobster (<i>Panulirus argus</i> , <i>Panulirus guttatus</i>) in Puerto Rico, US Caribbean, 1983-2023 | M. Refik Orhun, Katherine Godwin, Kim Johnson, and Stephanie Martínez Rivera | 11/24/2024 |

| | | | |
|----------------------------|---|---|------------|
| SEDAR91-DW-08 | SEDAR 91 Commercial Landings of Caribbean Spiny Lobster (<i>Panulirus argus</i>) in St. Thomas and St. John, US Caribbean, 1975-2023 | M. Refik Orhun, Katherine Godwin, Kim Johnson, and Stephanie Martínez Rivera | 11/24/2024 |
| SEDAR91-DW-09 | SEDAR 91 Commercial Landings of Caribbean Spiny Lobster (<i>Panulirus argus</i>) in St. Croix, US Caribbean, 1975-2023 | M. Refik Orhun, Katherine Godwin, Kim Johnson, and Stephanie Martínez Rivera | 11/24/2024 |
| Reference Documents | | | |
| SEDAR91-RD01 | On the productivity and technical efficiency of the Puerto Rican queen conch <i>Aliger gigas</i> fishery | Juan Agar and Daniel Solis | 10/9/2024 |
| SEDAR91-RD02 | Socio-economic Profile of the Small-scale Dive Fishery in the Commonwealth of Puerto Rico | Juan J. Agar and Manoj Shivlani | 10/9/2024 |
| SEDAR91-RD03 | Determining the age-size relationship of <i>Panulirus argus</i> in the southwest area of Puerto Rico | Ana G. Medina Martinez | 10/9/2024 |
| SEDAR91-RD04 | Annual Juvenile Recruitment of Spiny Lobsters, <i>Panulirus Argus</i> (Decapoda, Palinuridae), in a Shallow Seagrass Bed and a Deeper Hard Bottom off Western Puerto Rico | Nilda M. Jiménez, Ernest H. Williams, Jr. and Aida Rosario | 10/10/2024 |
| SEDAR91-RD05 | Patterns of Spiny Lobster (<i>Panulirus argus</i>) Postlarval Recruitment in the Caribbean: A CRTR Project | Mark J. Butler IV, Angela M. Mojica, Eloy Sosa-Cordero, Marines Millet and Paul Sanchez-Navarro | 10/10/2024 |
| SEDAR91-RD06 | Developing a population assessment for Caribbean spiny lobster <i>Panulirus argus</i> in the United States Virgin Islands: lessons learned | Lee Richter ¹ and Michael W Feeley ² | 11/7/2024 |
| SEDAR91-RD07 | Estimate of In-water Size Structure of Spiny Lobsters in St. Thomas | Tyler B. Smith, Sarah L. Heidmann, Rosmin S. Ennis, Viktor W. Brandtneris, Adeline Shelby, | 11/7/2024 |

| | | | |
|--------------|---|--|------------|
| | | Jeremiah Blondeau | |
| SEDAR91-RD08 | Displaced juvenile and subadult Caribbean spiny lobsters show strong orientation toward home dens | Michael J. Childress a,*, Coral Holt a, Rodney D. Bertelsen b | 11/14/2024 |
| SEDAR91-RD09 | Ocean acidification disrupts the orientation of postlarval Caribbean spiny lobsters | Philip M. Gravinese, Heather N. Pag, Casey B. Butler, Angelo Jason Spadaro, Clay Hewett, Megan Considine, David Lankes & Samantha Fisher | 11/14/2024 |
| SEDAR91-RD10 | Relationships between postlarval settlement and commercial landings of Caribbean spiny lobster (<i>Panulirus argus</i>) in Florida (USA) | Emily Hutchinson, Thomas R. Matthews, Gabrielle F. Renchen | 11/14/2024 |
| SEDAR91-RD11 | Gastric mill ossicles record chronological age in the Caribbean spiny lobster (<i>Panulirus argus</i>) | Emily Hutchinson, Thomas R. Matthews, Erica Ross, Samantha Hagedorn, Mark J. Butler IV, | 11/14/2024 |
| SEDAR91-12 | Spiny Lobster SEAMAP Program Survey 2021-23 | Department of Natural and Environmental Resources | 11/14/2024 |
| SEDAR91-13 | Progress Report: Independent fishery data collection for lobster (<i>Panulirus argus</i>) and conch (<i>Lobatus gigas</i>) under the SEAMAP-C program | Juan J. Cruz Motta | 11/14/2024 |

2. Life History

2.1 Overview

No new life history information was available for the SEDAR Panel to discuss during the data workshop. Therefore, sections 2.2-2.6 were carried over from SEDAR 57.

2.2 Stock Definition and Description

The Caribbean spiny lobster (hereafter referred to as spiny lobster), occurs in the Caribbean Sea, the Gulf of Mexico and the Western Central and South Atlantic Ocean. North Carolina marks its northernmost limit whereas Brazil marks its southernmost limit (Bliss 1982). The spiny lobster occurs from the extreme shallows of the littoral fringe to depths exceeding 100 meters (Kanciruk 1980; Munro 1974). CFMC (1981) reports that its distribution off Puerto Rico extends to the edge of the shelf, which is described as the 100–fathom contour (183 meters). Shallow areas with mangroves and seagrass (*Thalassia testudinum*) beds serve as nursery areas where available (Munro 1974). Generally, spiny lobsters move offshore when they reach reproductive size (Phillips et al. 1980). These animals are primarily carnivores, and serve as the major benthic carnivores in some ecosystems (Kanciruk 1980), feeding upon smaller crustaceans, mollusks and annelids (Cobb and Wang 1985).

2.3 Meristic & Conversion factors

Length-weight conversions were estimated using the Trip Interview Program (TIP) database. TIP records were filtered according to island platform (Puerto Rico, St. Thomas/St. John, and St. Croix). Records were further filtered such that retained records consisted only of those with paired length-weight measurements that had reported units of measure (e.g., mm or kg) and corresponding measurement type (e.g., carapace length or whole weight). A subsequent evaluation of data entry and/or measurement errors led to the removal of 55 records for St. Thomas/St. John (Table 2.1).

Length-weight relationships were fit as log-linear functions in the R statistical computing software (Quinn and Deriso 1999, R Development Core Team 2012). The relationship for length (mm CL) to weight (kg whole weight) is:

$$W = aL^b$$

Model fitting was carried out using linear regression on the log transformed equation:

$$\log(W) = \log(a) + b * \log(L)$$

Analyses were carried out separately for males, females, and for both sexes combined. Resulting L-W relationships are found in Table 2.2. For St. Thomas/St. John, a total of $n=11,723$ L-W observations were available from TIP (n male=6,692; n female=5,031) from 1980 to 2017 (Fig. 2.1). The largest individual by length was 203.2 mm CL (3.175 kg), while the largest individual by weight was 4.7 kg (200 mm CL). Carapace length to weight conversion for St. Thomas/St. John spiny lobsters are shown in Table 2.2.

2.4 Natural Mortality

During SEDAR 8, various sources are referenced with respect to natural mortality, including Olsen and Koblic 1975, Medley and Ninnes 1996, and FAO 2001. Natural mortality was specified at 0.36 for adult lobsters and used for all ages during SEDAR 8. During SEDAR 46 (Spiny lobster St. Thomas/St. John and St. Croix), consideration was given to natural mortality estimates from tagging studies, with estimates typically occurring between 0.26 and 0.44 year⁻¹ for adult spiny lobster, with the most reliable estimates suggested to be in the range of 0.30 to 0.40 (FAO 2001). A point estimate of 0.34, calculated from a variant of Pauly's equation, is also widely reported (Cruz et al. 1981). Point estimates based on longevity were also considered, but require evidence of maximum age, which is difficult to obtain for lobsters (Kanciruk 1980). This issue is reinforced by additional statements made by Olsen and Koblic (1975). Further discussion about spiny lobster longevity can be found on pg 27, SEDAR 46, Data and Assessment Workshop report (SEDAR 2016). Several spiny lobster stock assessments in the Caribbean have used 0.34 to 0.36 year⁻¹ in base model runs (Cruz 2001; Gongora 2010; SEDAR 2005; Babcock et al. 2014). During the SEDAR 57 data workshop, participants identified a mark-recapture dataset from a study undertaken by the St. Thomas Fishermen's Association (Olsen et al. 2017). Analysts determined obtaining an estimate of natural mortality from this study for use in the assessment was not feasible; this was potentially due to an underestimate of reporting practices stated by Olsen et al. (2017), which resulted in an unreasonably high ($M > 2.0$ per year) estimate of natural mortality (see SEDAR 57 Final Assessment Report).

2.5 Reproduction

Die (2005) estimated a logistic maturity curve from TIP prior to 1990, when landing of egg bearing females was permitted. Data from Puerto Rico and St. Thomas/St. John were aggregated for the purpose of model fitting. Two model parameterizations were considered, in both cases, length at 50% maturity were similar being either 91 mm or 92 mm CL.

For SEDAR 8 (2005), fecundity-at-length was obtained for Cuba spiny lobster (FAO 2001):

$$E = 0.5911L^{4.5677}$$

where E is number of eggs and L is carapace length in mm.

2.6 Age and Growth

During SEDAR 8, von Bertalanffy growth curves for males and females were obtained from Leon et al. (1994) for Cuba (SEDAR 2005). Since SEDAR 8, several additional publications have become available for von Bertalanffy growth curves from regions such as Cuba, Puerto Rico, and Mexico (Table 2.3). Also, during SEDAR 46 (Spiny lobster St. Thomas/St. John & St. Croix), von Bertalanffy growth parameters from Leon et al. (1995) were reviewed, noting similar values used in other stock assessment (i.e., Gongora 2010; Babcock et al. 2014). These point estimates were also compared to a more recent study by Leon et al. (2005) and analyses in SEDAR 46 were based on a single growth curve for both sexes. During the SEDAR 57 data workshop, participants identified a mark-recapture dataset from a study undertaken by the St. Thomas Fishermen's Association (Olsen et al. 2017). During SEDAR 57, analysts determined that obtaining a growth curve from this study for use in the assessment was not feasible. This

was due to an absence of the largest size classes in the data set, though results verified that growth in Puerto Rico (Table 2.3) was generally consistent with growth in St. Thomas/St. John (see SEDAR 57 Final Assessment Report).

Table 2.1. Records manually removed from St. Thomas/St. John TIP prior to L-W model fitting.

| L | W | Sex | L | W | Sex |
|--------|-------|-----|--------|-------|-----|
| 114.3 | 0.003 | F | 63.5 | 0.003 | M |
| 101.6 | 0.002 | F | 88.9 | 0.002 | M |
| 107.95 | 0.003 | F | 88.9 | 0.002 | M |
| 107.95 | 0.003 | F | 120.65 | 0.003 | M |
| 88.9 | 0.002 | F | 120.65 | 0.004 | M |
| 107.95 | 0.003 | F | 127 | 0.004 | M |
| 82.55 | 0.002 | F | 114.3 | 0.003 | M |
| 114.3 | 0.003 | F | 114.3 | 0.002 | M |
| 107.95 | 0.003 | F | 95.25 | 0.002 | M |
| 101.6 | 0.002 | F | 101.6 | 0.002 | M |
| 101.6 | 0.002 | F | 107.95 | 0.002 | M |
| 114.3 | 0.003 | F | 95.25 | 0.002 | M |
| 127 | 0.004 | F | 107.95 | 0.002 | M |
| 152.4 | 0.007 | F | 101.6 | 0.002 | M |
| 133.35 | 0.004 | F | 101.6 | 0.002 | M |
| 120.65 | 0.003 | F | 95.25 | 0.002 | M |
| 133.35 | 0.004 | F | 95.25 | 0.002 | M |
| 95.25 | 0.002 | F | 158.75 | 0.006 | M |
| 88.9 | 0.002 | F | 146.05 | 0.006 | M |
| 95.25 | 0.002 | F | 114.3 | 0.003 | M |
| 120.65 | 0.003 | F | 133.35 | 0.004 | M |
| 114.3 | 0.003 | F | 107.95 | 0.002 | M |
| 82.55 | 0.002 | F | 101.6 | 0.002 | M |
| 120.65 | 0.003 | F | 114.3 | 0.003 | M |
| 107.95 | 0.002 | F | 120.65 | 0.003 | M |
| 88.9 | 0.002 | F | 101.6 | 0.002 | M |
| 101.6 | 0.002 | F | 107.95 | 0.003 | M |
| 101.6 | 0.002 | F | | | |

Table 2.2 Fitted conversion functions from length (mm CL) to weight (kg whole weight) for St. Thomas/St. John.

| Island platform | Year | n | a | b |
|----------------------------|-----------|-------|-----------|-------|
| St. Thomas/St. John | | | | |
| Males | 1980-2017 | 6692 | 3.548E-05 | 2.204 |
| Females | 1980-2017 | 5031 | 4.889E-05 | 2.138 |
| Males + Females | 1980-2017 | 11723 | 4.166E-05 | 2.171 |

Table 2.3 von Bertalanffy growth parameters, noting values used in SEDARs 8 and 46 (i.e., Leon et al. (1995)) and with emphasis on studies that have been subsequently produced.

| Study | Region/Country | Source | Sex | L_{∞} (mm) | K |
|---|-----------------|------------------|----------|----------------------|------|
| Leon et al. (1995) | Cuba | Length frequency | M | 184 | 0.24 |
| | | | F | 155 | 0.22 |
| Leon et al. (2005) | Cuba | Length frequency | Both | 184 | 0.24 |
| Mateo (2004) | Puerto Rico | Length frequency | M (1999) | 197 | 0.24 |
| | | | M (2000) | 195 | 0.24 |
| | | | F (1999) | 191 | 0.25 |
| | | | F (2000) | 185 | 0.23 |
| Velazquez- Abunader et al. (2015) | Mexico, Yucatan | Length frequency | M | 203 | 0.28 |
| | | | F | 189 | 0.34 |

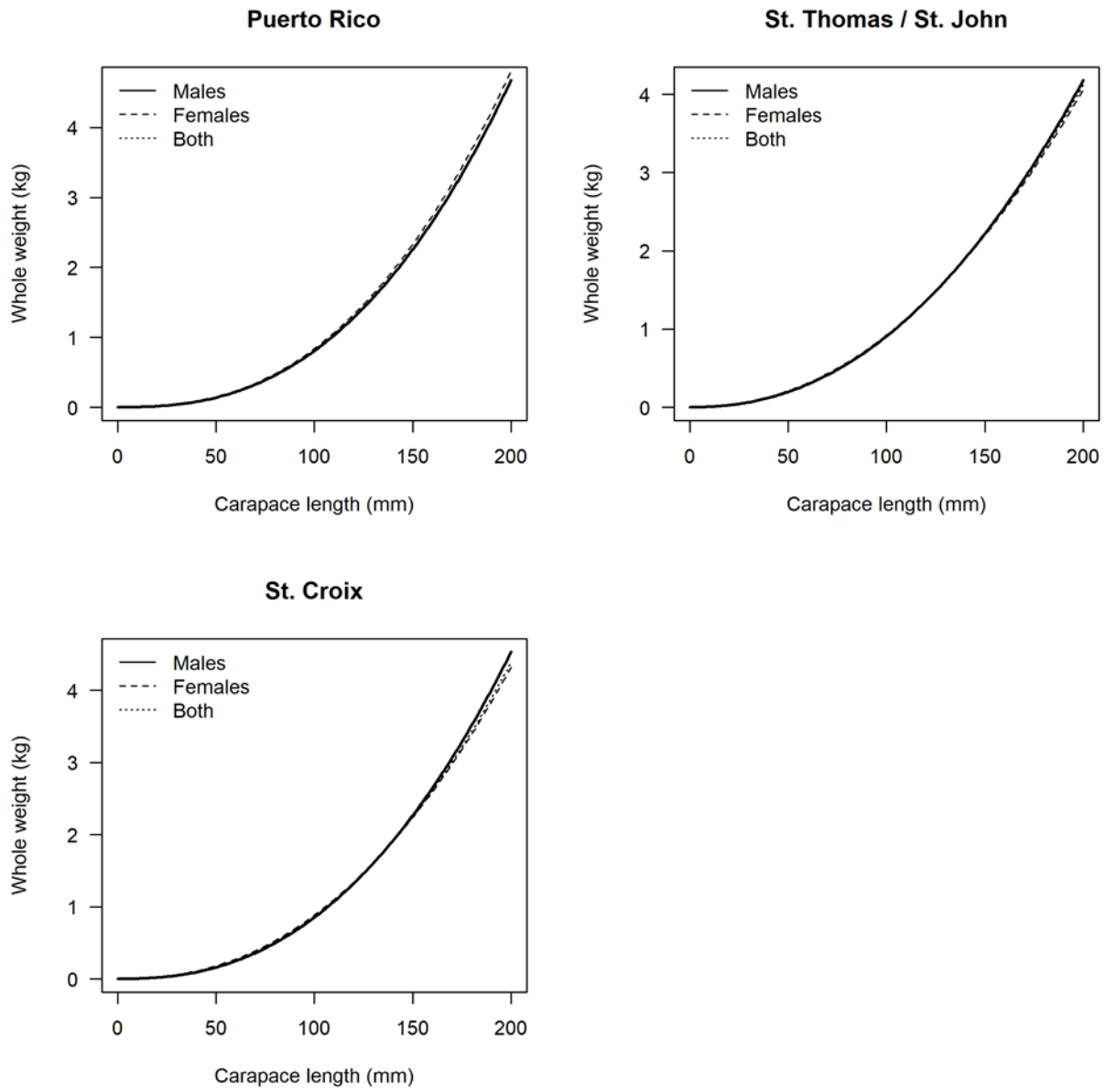


Figure 2.1 Length-weight curves for spiny lobster of Puerto Rico, St. Thomas/St. John, and St. Croix.

3. Commercial Fishery Statistics

3.1 Biological Sampling

3.1.1 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 the 1980s with frequent updates in best practices; the latest being in 2017. Data are collected by trained shore-based samplers (Beggerly et al., 2022).

3.1.2 Length Composition Sampling Intensity

The TIP data pertaining to Caribbean Spiny Lobster in St. Thomas/St. John consists of 15,921 length observations across 699 unique port sampling interviews (Figure 3.1.1). Of the Caribbean spiny lobster measured, 15,904 were carapace length observations (99.9%). Plots and summary statistics of the currently available length frequency data of Caribbean spiny lobster sampled from the predominant gears in St. Thomas/St. John are included in the working paper Godwin et al. 2024.

3.1.3 Length Distributions

A variety of fishing gears were used by St. Thomas/St. John commercial fishers to catch Caribbean spiny lobster. A generalized linear mixed model (GLMM) was fit to TIP data to compare mean size composition among gear types. The purpose of the analysis was to identify gear groups among the commercial fishing gears with groups based upon Caribbean spiny lobster size composition. Gears with size compositions that were not significantly different were assigned to the same gear group. The analysis identified no difference among gear specific size compositions and the gears with nonconfidential data are provided in Table 3.1.1. Summary statistics produced by the GLMM analysis of the available length frequency data from 1981 to 2023 are also included in Table 3.1.1. Gear groups were identified based on GLMM analysis using a gamma-distributed dependent variable and a covariate to account for changes in mean size over time. Random effects for interview ID and categorical year were included to account for non-independence of observations.

The aggregated density plot for all gears combined of Caribbean spiny lobster carapace lengths collected across the time series 1981-2023 are summarized in Figure 3.1.2. Aggregated density plots of Caribbean spiny lobster landed by nonconfidential gears are summarized in Figure 3.1.3.

3.1.4 Adequacy of Size Composition Data for Characterizing Catch

The available TIP size composition data can be used to inform selectivity; however, it is not certain that sample sizes are sufficient to identify annual population trends in the SEDAR 91 assessment models.

A weight-length analysis was not conducted to identify outliers in the TIP data. A cutoff of 2.5cm minimum and 25cm maximum length was implemented to remove notable outliers in the TIP dataset (Godwin et al 2024).

Decisions:

- Consider TIP data to inform selectivity in the assessment models and allow the assessment analyst to explore the data for any evidence of annual population trends.
- Supply complete TIP time series for use in SEDAR 91 investigations.
- Compare aggregated length density of SEAMAP-C data with that of TIP data.

3.2 Commercial Landings

3.2.1 Overview

Commercial fishery landings in St. Thomas/St. John, referred to as “STTJ”, were obtained from self-reported fisher logbook data (Caribbean Commercial Logbook, CCL). Classification of Caribbean Spiny Lobster by species began in 1974, which was a partial year (Valle-Esquivel and Díaz 2004). Commercial fishery landings data for Caribbean Spiny Lobster in STTJ were available for the years 1975-2023.

3.2.2 Outlier Analysis

An outlier analysis was conducted by using a mean and standard deviation method. If the landings of Caribbean Spiny Lobster reported on a trip were greater than three standard deviations from the mean (i.e., 99.73% quantile), they were marked for removal from the dataset. Outliers were identified for each gear group across all years. Total landings with and without outliers are shown in Figure 3.2.1 and the percent change in landings with outliers removed is shown in Table 3.2.1.

Decisions:

- SEDAR 91 Panel decided to use the St. Thomas and St. John commercial landings without removing the outliers.
- Panel recommended using the landings time series starting in 1975.

3.2.3 St. Thomas/St. John Caribbean Spiny Lobster Fishery

Logbook data are recorded by fishing year, which runs from July 1 through June 30 of the following year. However, data in this report are provided by calendar year. STTJ’s Caribbean Spiny lobster fishery is dominated by traps as the major gear and accordingly, gears are grouped into diving and traps and all other gears are merged with the trap data in a “traps all” gear group following the protocol of the prior Caribbean Spiny Lobster assessment and its update (SEDAR 57, 2019; SEDAR 57 Update, 2022) shown in Orhun et al. (2024). The commercial landings were presented in pounds by year and fishing gear group are shown in Table 3.2.2.

3.3 Commercial Discards

Species-specific commercial discard reporting began in July 2003 and the first full year of reporting was 2004 in the USVI for Caribbean Spiny Lobster. Commercial discards were infrequently reported by fishers. Plenary group discussion resulted in the recommendation that discard mortality be considered minimal.

Decision:

- Discard mortality of spiny lobster was considered minimal and therefore represent a very minor source of mortality due to fishing (as per SEDAR 57)

3.4 Commercial Effort

Commercial trips with reported Caribbean Spiny Lobster landings per year and gear group were compiled from 1975 to 2023 (Table 3.4.1).

Table 3.1.1 GLMM analysis summary results for St. Thomas/St. John TIP Caribbean Spiny Lobster lengths(cm) from 1981 to 2023. The column titled “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. Only nonconfidential data shown.

| Gear | Mean | Estimated Marginal Mean | LCL | UCL | Group | Lobster (n) | Interview (n) | Percentage |
|----------------------------------|-------------|--------------------------------|------------|------------|--------------|--------------------|----------------------|-------------------|
| POTS AND TRAPS; SPINY LOBSTER | 10.90 | 2.42 | 2.40 | 2.45 | 1 | 9,285 | 197 | 60.03 |
| POTS AND TRAPS; FISH | 11.44 | 2.42 | 2.40 | 2.45 | 1 | 3,969 | 330 | 25.66 |
| POTS AND TRAPS; CMB | 10.96 | 2.42 | 2.38 | 2.46 | 1 | 1,129 | 49 | 7.30 |
| BY HAND; DIVING GEAR | 11.39 | 2.43 | 2.39 | 2.47 | 1 | 644 | 55 | 4.16 |

Table 3.2.1 Comparison of all reported landings and landings after outlier removal of commercial landings of Caribbean Spiny Lobster in pounds for St. Thomas/St. John.

| Year | Landings (lbs.) | Landings outlier removed (lbs.) | Difference (%) |
|-------------|------------------------|--|-----------------------|
| 1975 | 6,795 | 6,795 | 0.0 |
| 1976 | 6,741 | 6,741 | 0.0 |
| 1977 | 19,461 | 19,461 | 0.0 |
| 1978 | 58,311 | 50,501 | 13.4 |
| 1979 | 29,385 | 27,815 | 5.3 |
| 1980 | 36,089 | 30,429 | 15.7 |
| 1981 | 38,068 | 38,068 | 0.0 |
| 1982 | 36,662 | 35,094 | 4.3 |
| 1983 | 36,140 | 36,140 | 0.0 |
| 1984 | 35,976 | 34,156 | 5.1 |
| 1985 | 29,357 | 29,357 | 0.0 |
| 1986 | 23,637 | 23,637 | 0.0 |
| 1987 | 40,666 | 37,406 | 8.0 |
| 1988 | 54,679 | 54,136 | 1.0 |
| 1989 | 58,856 | 57,768 | 1.8 |
| 1990 | 77,836 | 68,581 | 11.9 |
| 1991 | 54,798 | 53,758 | 1.9 |
| 1992 | 86,413 | 84,073 | 2.7 |
| 1993 | 83,260 | 82,007 | 1.5 |
| 1994 | 61,774 | 61,774 | 0.0 |
| 1995 | 67,392 | 67,392 | 0.0 |
| 1996 | 87,932 | 87,932 | 0.0 |
| 1997 | 95,094 | 95,094 | 0.0 |
| 1998 | 73,715 | 72,727 | 1.3 |
| 1999 | 75,828 | 73,675 | 2.8 |
| 2000 | 76,151 | 76,030 | 0.2 |
| 2001 | 89,707 | 88,242 | 1.6 |
| 2002 | 115,973 | 114,048 | 1.7 |
| 2003 | 135,290 | 133,014 | 1.7 |
| 2004 | 133,982 | 132,852 | 0.8 |
| 2005 | 124,641 | 124,641 | 0.0 |
| 2006 | 136,028 | 133,232 | 2.1 |
| 2007 | 119,640 | 117,904 | 1.5 |
| 2008 | 110,465 | 110,465 | 0.0 |
| 2009 | 115,761 | 113,663 | 1.8 |
| 2010 | 114,572 | 108,700 | 5.1 |
| 2011 | 84,301 | 82,896 | 1.7 |
| 2012 | 83,156 | 82,641 | 0.6 |
| 2013 | 84,514 | 83,976 | 0.6 |
| 2014 | 92,260 | 92,173 | 0.1 |
| 2015 | 109,454 | 109,454 | 0.0 |
| 2016 | 121,695 | 120,755 | 0.8 |
| 2017 | 91,913 | 90,711 | 1.3 |
| 2018 | 86,708 | 84,078 | 3.0 |
| 2019 | 98,609 | 97,694 | 0.9 |

| | | | |
|-------|-----------|-----------|-----|
| 2020 | 94,333 | 94,008 | 0.3 |
| 2021 | 101,108 | 100,501 | 0.6 |
| 2022 | 104,905 | 101,273 | 3.5 |
| 2023 | 123,027 | 120,001 | 2.5 |
| Total | 3,823,058 | 3,747,469 | 2.0 |

Table 3.2.2 Commercial landings of Caribbean Spiny Lobster in pounds by gear group that reported Caribbean Spiny Lobster landings in St. Thomas/St. John.

| YEAR | TOTAL TRAPS LBS | TOTAL DIVING ALL LBS | GRAND TOTAL LBS |
|-------------|----------------------------|---------------------------------|--------------------------------|
| 1975 | 4,908 | * | * |
| 1976 | 5,404 | 1,337 | 6,741 |
| 1977 | 14,964 | * | * |
| 1978 | 50,524 | * | * |
| 1979 | 25,868 | 3,517 | 29,385 |
| 1980 | 30,989 | 5,100 | 36,089 |
| 1981 | 34,919 | 3,149 | 38,068 |
| 1982 | 33,612 | 3,050 | 36,662 |
| 1983 | 32,614 | 3,526 | 36,140 |
| 1984 | 30,889 | 5,087 | 35,976 |
| 1985 | 25,557 | 3,800 | 29,357 |
| 1986 | 19,020 | 4,617 | 23,637 |
| 1987 | 35,319 | 5,347 | 40,666 |
| 1988 | 48,681 | 5,998 | 54,679 |
| 1989 | 55,554 | 3,302 | 58,856 |
| 1990 | 58,707 | 19,129 | 77,836 |
| 1991 | 46,060 | 8,738 | 54,798 |
| 1992 | 82,558 | 3,855 | 86,413 |
| 1993 | 77,816 | 5,444 | 83,260 |
| 1994 | 58,116 | 3,658 | 61,774 |
| 1995 | 63,646 | 3,746 | 67,392 |
| 1996 | 82,722 | 5,210 | 87,932 |
| 1997 | 90,299 | 4,795 | 95,094 |
| 1998 | 70,484 | 3,231 | 73,715 |
| 1999 | 70,619 | 5,209 | 75,828 |
| 2000 | 71,605 | 4,546 | 76,151 |
| 2001 | 82,136 | 7,571 | 89,707 |
| 2002 | 104,071 | 11,902 | 115,973 |
| 2003 | 125,641 | 9,649 | 135,290 |
| 2004 | 130,759 | 3,223 | 133,982 |
| 2005 | 121,759 | 2,882 | 124,641 |
| 2006 | 132,513 | 3,515 | 136,028 |
| 2007 | 116,855 | 2,785 | 119,640 |
| 2008 | 108,042 | 2,423 | 110,465 |
| 2009 | 111,599 | 4,162 | 115,761 |
| 2010 | 112,833 | 1,739 | 114,572 |
| 2011 | 81,994 | 2,307 | 84,301 |
| 2012 | 81,766 | 1,390 | 83,156 |
| 2013 | 83,349 | 1,165 | 84,514 |
| 2014 | 91,337 | 923 | 92,260 |
| 2015 | 108,170 | 1,284 | 109,454 |
| 2016 | 119,817 | 1,878 | 121,695 |

| | | | |
|------|---------|-------|---------|
| 2017 | 86,728 | 5,185 | 91,913 |
| 2018 | 81,004 | 5,704 | 86,708 |
| 2019 | 97,247 | 1,362 | 98,609 |
| 2020 | 92,683 | 1,650 | 94,333 |
| 2021 | 99,403 | 1,705 | 101,108 |
| 2022 | 102,582 | 2,323 | 104,905 |
| 2023 | 120,545 | 2,482 | 123,027 |

* Confidential data by year and gear were removed. Total landings (lbs.) of confidential data is 14,171.

Table 3.4.1 Number of commercial trips by gear group that reported Caribbean Spiny Lobster landings in St. Thomas/St. John.

| YEAR | TRIPS TRAPS | TRIPS DIVING ALL | TOTAL TRIPS |
|-------------|--------------------|-----------------------------|------------------------|
| 1975 | 212 | * | * |
| 1976 | 176 | 24 | 200 |
| 1977 | 407 | * | * |
| 1978 | 612 | * | * |
| 1979 | 547 | 97 | 644 |
| 1980 | 462 | 72 | 534 |
| 1981 | 543 | 95 | 638 |
| 1982 | 510 | 85 | 595 |
| 1983 | 474 | 154 | 628 |
| 1984 | 394 | 227 | 621 |
| 1985 | 527 | 162 | 689 |
| 1986 | 439 | 169 | 608 |
| 1987 | 518 | 194 | 712 |
| 1988 | 670 | 182 | 852 |
| 1990 | 640 | 139 | 779 |
| 1991 | 813 | 147 | 960 |
| 1992 | 805 | 164 | 969 |
| 1993 | 1,244 | 146 | 1,390 |
| 1994 | 1,079 | 206 | 1,285 |
| 1995 | 945 | 184 | 1,129 |
| 1996 | 904 | 146 | 1,050 |
| 1997 | 1,025 | 162 | 1,187 |
| 1998 | 1,136 | 202 | 1,338 |
| 1999 | 1,033 | 101 | 1,134 |
| 2000 | 1,068 | 153 | 1,221 |
| 2001 | 1,053 | 165 | 1,218 |
| 2002 | 1,180 | 232 | 1,412 |
| 2003 | 1,288 | 295 | 1,583 |
| 2004 | 1,451 | 253 | 1,704 |
| 2005 | 1,615 | 102 | 1,717 |
| 2006 | 1,524 | 81 | 1,605 |
| 2007 | 1,395 | 100 | 1,495 |
| 2008 | 1,352 | 76 | 1,428 |
| 2009 | 1,353 | 100 | 1,453 |
| 2010 | 1,277 | 120 | 1,397 |
| 2011 | 1,180 | 76 | 1,256 |
| 2012 | 985 | 77 | 1,087 |
| 2013 | 958 | 54 | 1,062 |
| 2014 | 902 | 39 | 1,012 |
| 2015 | 961 | 68 | 941 |
| 2016 | 1,048 | 96 | 1,144 |
| 2017 | 838 | 144 | 982 |
| 2018 | 694 | 112 | 806 |
| 2019 | 821 | 46 | 867 |

| | | | |
|------|-----|----|-------|
| 2020 | 948 | 66 | 1,014 |
| 2021 | 986 | 81 | 1,067 |
| 2022 | 912 | 89 | 1,001 |
| 2023 | 862 | 81 | 943 |

* Confidential data by year and gear were removed. Total number of trips of confidential data is 258.

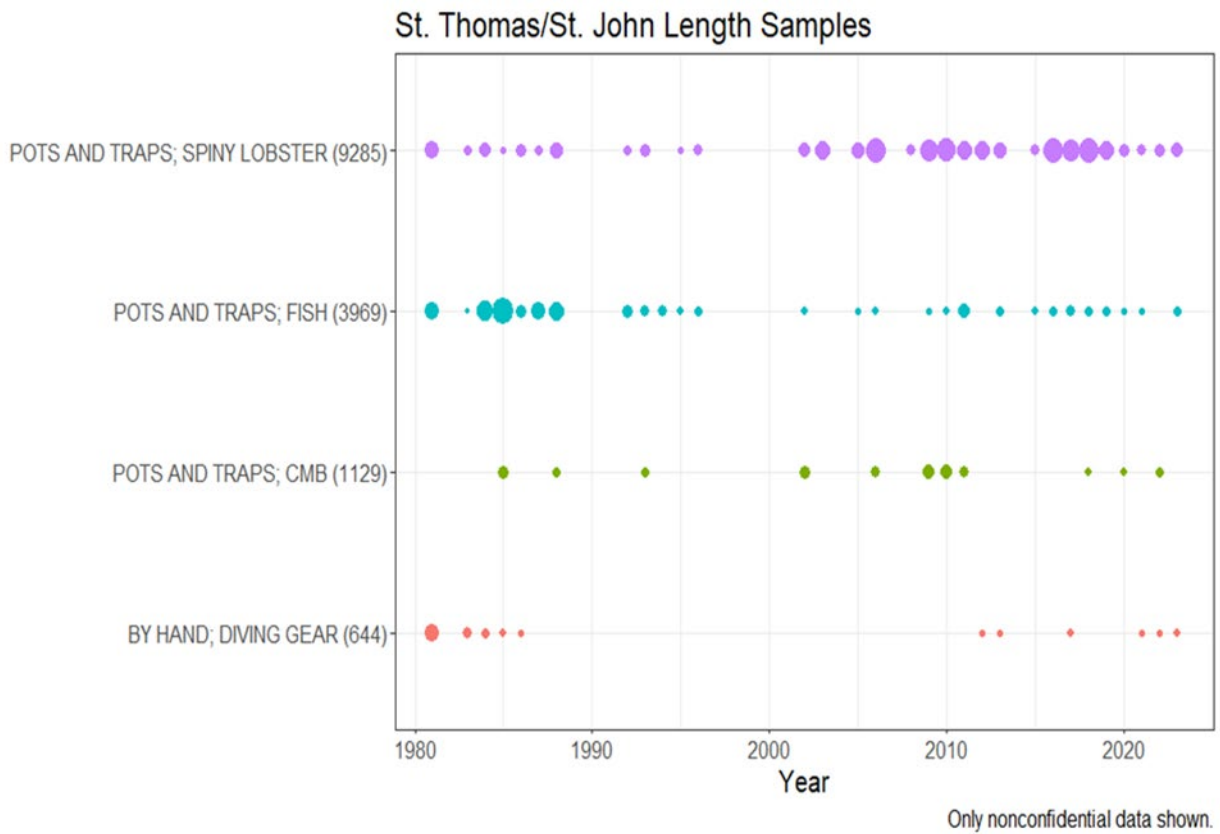


Figure 3.1.1 Plot showing relative number of Caribbean Spiny Lobster lengths in St. Thomas/St. John across time collected. Each point is color specific to the gear it represents. Gears are arranged from most to least abundant.

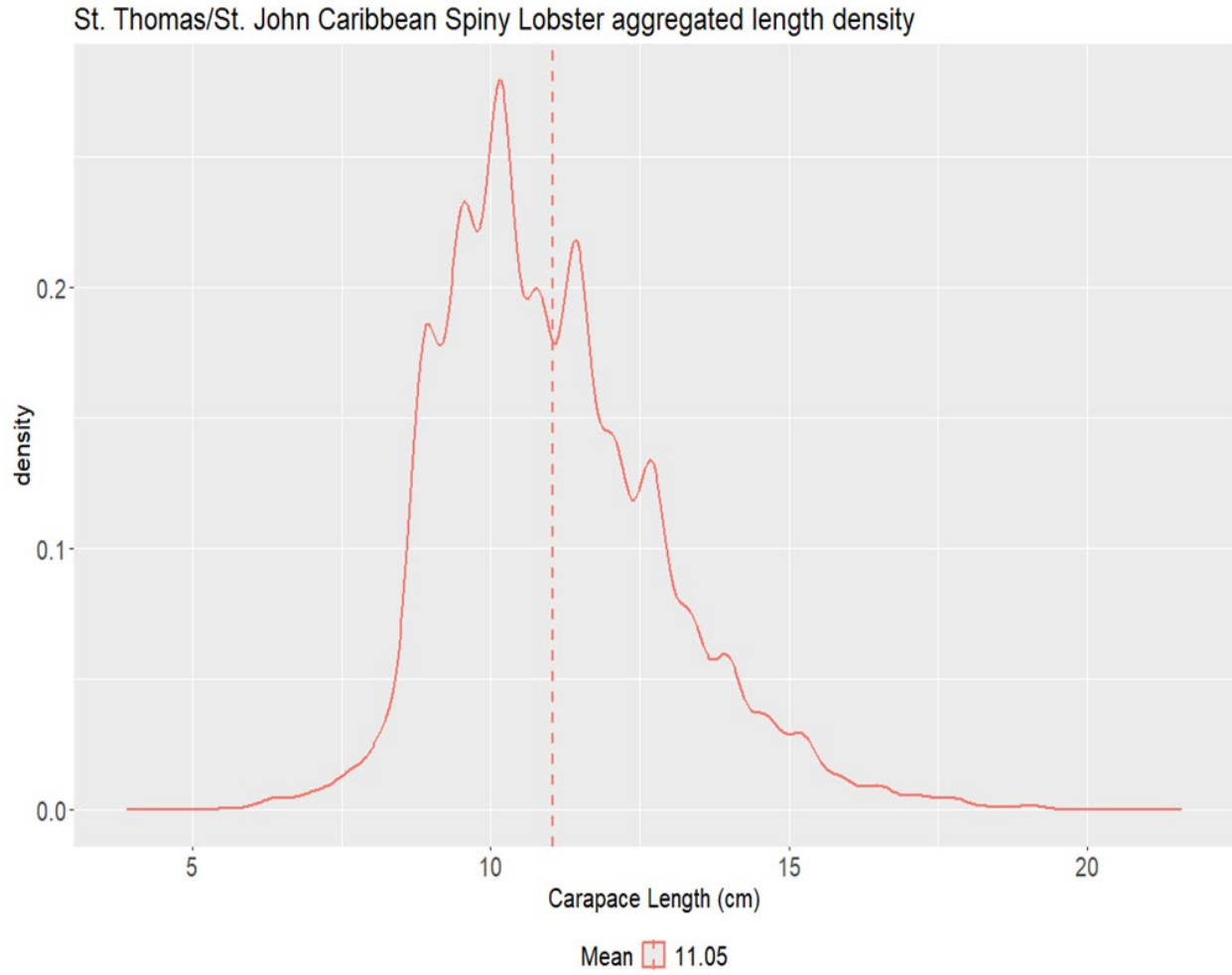


Figure 3.1.2 Aggregated density plot of lengths(cm) of Caribbean Spiny Lobster in St. Thomas/St. John, all gears combined. Dotted line represents mean length.

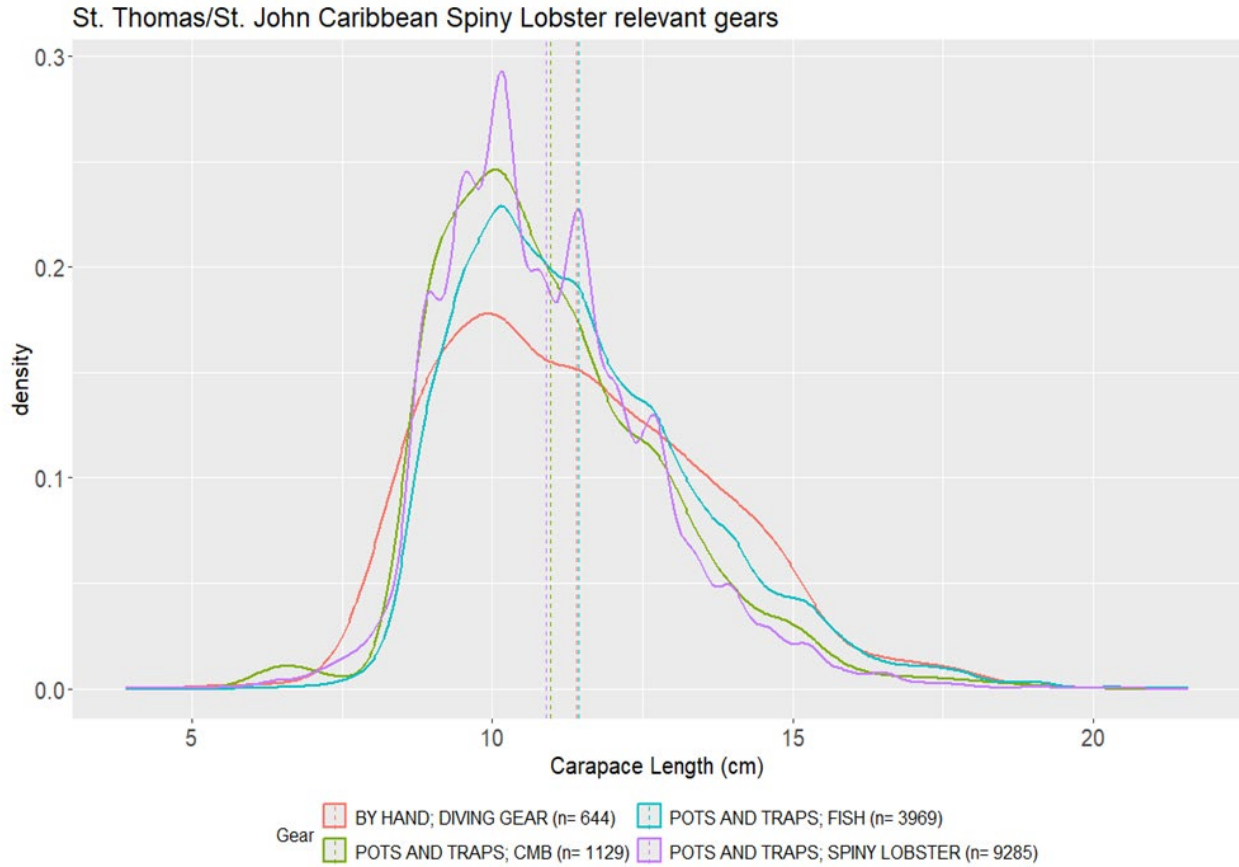


Figure 3.1.3 Aggregated density plot of lengths(cm) of nonconfidential gears recorded for Caribbean Spiny Lobster in St. Thomas/St. John from 1981 to 2023. Dotted line represents mean length. Mean lengths can be found in **Table 3.1.1**.

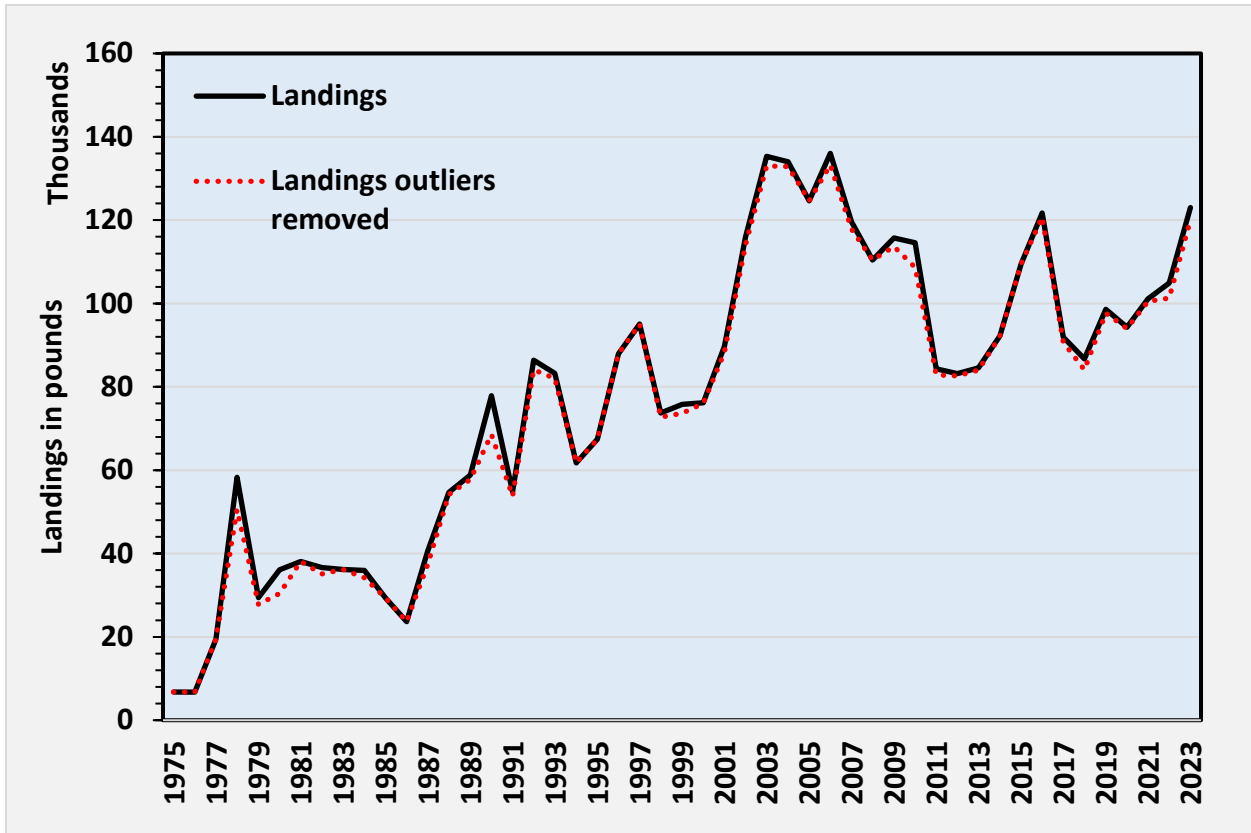


Figure 3.2.1 Commercial landings of Caribbean Spiny Lobster landings of St. Thomas/St. John with and without the outliers removed.

4. Recreational Fishery Statistics

There are currently no data available on recreational landings in St. Thomas/St. John.

5. Measures of Population Abundance

5.1 Overview

The panel was presented with summaries of the fishery-independent research conducted by The University of the Virgin Islands in cooperation with the Southeast Fisheries Science Center (RD-05), and by the National Park Service in Buck Island Reef National Monument and Salt River National Historical Park in St. Croix, US Virgin Islands and St. John, US Virgin Islands (RD-06). The panel discussed concerns about using data collected from the two studies for indices of relative abundance, principally due to short time series, small spatial extent of the studies, and small sample sizes, and recommended they not be considered for use in either the STX or STTJ assessment models.

6. Research Recommendations

-When developing new research projects, consider how those projects can be designed to include data collection and/or analyses that would inform ecosystem models and analyses. The original objectives of the project should not be compromised, however.

6.1 Life History Research Recommendation

- Life history studies focused on the US Caribbean – generate region-specific parameters for growth, fecundity, natural mortality.
- Look for ongoing growth/aging work via SEAMAP-C
- Merge selectivity studies, life history data collection, and fishery-independent survey frameworks to determine how to get best data for stock assessment

6.2 Commercial Fishery Statistics

6.2.1 Length Composition Research Recommendations

- Compare SEAMAP-C to TIP size composition to better inform gear selectivity.

6.2.2 Commercial Landings Research Recommendations

- Track number of fishers per year in relation to annual landings.
- Support connectivity studies consider spiny lobster as one stock vs. by island (metapopulation).
- Investigate weak/lack of correlation between TIP and landings data.
- Conduct a supplemental exploratory analysis to look at the STTJ trap CPUE in lbs./trap/hour.
- Investigate species associations with spiny lobster.
- Demand analysis: look at price per pound (survey), market preferences, trends and correlation with landings, and for all islands.
- Market survey to determine whether the size of the lobster being landed is a response to the market preference/availability.
- Increase funding for port samplers to improve TIP data collection in PR and USVI.
- Propose new gear type of “diving on traps” in TIP reports (larger conversation to be had among those collecting and collating data).
 - a) Recommended this be a conversation including all jurisdictions,
 - b) Periodically review gears on forms to ensure they are accurate

6.2.3 Discards and Discard Mortality Research Recommendations

- Discard information in the catch reports doesn’t allow data on length or sex in current reporting schema

6.3 Indices Research Recommendations

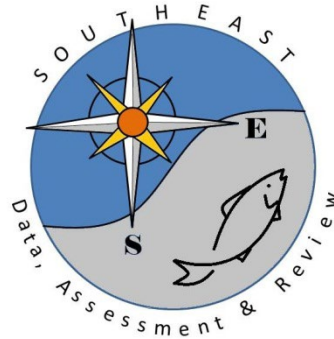
- The panel recommended moving forward with planned lobster trap surveys in the US Virgin Islands.

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 91

US Caribbean Spiny Lobster – St. Thomas/St. John

SECTION III: Assessment Process Report

August 2025

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

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1. EXECUTIVE SUMMARY

The SEDAR 91 St. Thomas/St. John spiny lobster (*Panulirus argus*) stock assessment workshop consisted of four webinars between January 2025 and April 2025. 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
- Life history information carried over from the SEDAR 57 and SEDAR 57 update assessments

The assessment used Stock Synthesis, a statistical catch-at-age model (Methot et al., 2020). Stock Synthesis V3.30.12 models were fit to annual catch time series and annual length composition information for two fleets: dive and trap/pot fisheries and two sexes: females and males. Model development included stepwise fitting to catch and length composition sequentially, i.e., catch and then catch and length models were built, to ensure an analytical understanding of data impacts on model results. Three sensitivity analyses were conducted: two selectivity sensitivities in which each fleet selectivity was assigned a logistic (“flat-topped”) pattern, which was fixed or estimable, respectively, and one length-weight relationship selectivity in which female and male length-weight relationship parameters were set to US Caribbean regional estimates.

Model diagnostics assessed convergence, fit, and consistency using gradients, residuals, likelihood profiles, hindcast cross-validation, and jitter analyses. Those diagnostics illustrated that despite the models’ relative lack of flexibility with respect to parameter estimation, the model estimates were consistent and relatively robust.

Sensitivity analyses determined that fleet selectivity is dome-shaped for both dive and trap/pot fisheries. Initializing exponential logistic selectivity models with flat-topped selectivity patterns and allowing the model to estimate selectivity parameters resulted in the same dome-shaped selectivity patterns estimated when selectivity models were initialized as

dome-shaped. This suggests that the length composition information can inform fleet selectivity parameter estimation. Island-specific and US Caribbean region-wide estimates of length-weight parameters produced similar population dynamics for St. Thomas/St. John spiny lobster.

1.1 Background

US Caribbean spiny lobster (*Panulirus argus*) is a marine invertebrate that inhabits pelagic, nearshore vegetation, and coral reef habitats throughout its life history. Spiny lobsters inhabit the southeast US coast, Gulf of America, and greater Caribbean region. The St. Thomas/St. John fishery targets adult spiny lobster on reef habitats.

2. INTRODUCTION

2.1 Workshop Time and Place

The SEDAR 91 Assessment Workshop was held via webinars from January to April 2025.

2.2 Terms of Reference

Assessment Process 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. Characterize uncertainty in the assessment and estimated values.
 - a. Consider uncertainty in input data, modeling approach, and model configuration.
 - b. Provide appropriate measures of model performance, reliability, and ‘goodness of fit’.
 - c. Provide measures of uncertainty for estimated parameters and derived quantities such as biological reference points and stock status if feasible.
3. 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.
4. 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 F_0
 - ii. Project $F_{Rebuild}$
5. Provide recommendations for future research and data collection.
6. Provide an Assessment Workshop Report to address these Terms of Reference and fully document the input data and results.

2.3 List of Participants

Assessment Panel

| | |
|-----------------------------------|------------|
| Matt Damiano (Lead Analyst) | NMFS/SEFSC |
| Kevin McCarthy..... | NMFS/SEFSC |
| Erik Williams | NMFS/SEFSC |
| Jason Cope | NMFS/NWFSC |

Appointed Observers

| | |
|----------------------|-------------------|
| Nelson Crespo | CFMC Industry Rep |
| Julian Magras | CFMC Industry Rep |
| Gerson Martinez..... | CFMC Industry Rep |

Observers

| | |
|--------------------------------|----------------|
| Adyan Rios..... | NMFS/SEFSC |
| Juan Agar | NMFS/SEFSC |
| Mandy Karnauskas..... | NMFS/SEFSC |
| Maria Lopez-Mercer | NMFS/SEFSC |
| Stephanie Martinez Rivera..... | NMFS/SEFSC |
| Sarah Stephenson | NMFS/SEFSC |
| Katherine Godwin..... | UM-CIMAS |
| Rachel Banton..... | UM-CIMAS |
| Sarah Beggerly..... | NMFS/SEFSC |
| M. Refik Orhun..... | NMFS/SEFSC |
| Sennai Habtes..... | USVI DPNR |
| Maggie Rios | USVI DPNR |
| J.J. Cruz-Motta..... | CFMC SSC, UPRM |
| Hannah Jacobs | UM |

Manuel Coffill-Rivera.....University of South AL
 Veronica Seda MatosPR DNER
 Aida RosarioPR DNER
 Daniel Matos-CaraballoPR DNER
 Wilson Santiago Soler..... PR Fisheries Liaison
 Cristina OlanCFMC Staff

Staff

Emily Ott..... SEDAR
 Julie A. Neer SEDAR
 Graciela Garcia-MolinerCFMC Staff

2.4 List of Assessment Process Working Papers and Reference Documents

| Document # | Title | Authors | Date Submitted |
|--|--|--|-----------------|
| Documents Prepared for the Assessment Process | | | |
| SEDAR91-AP-01 | Summary of Management Actions for Caribbean Spiny Lobster 1985-2023 | Gaitlyn Malone | 31 January 2025 |
| Reference Documents | | | |
| SEDAR91-RD14 | Catch curve stock-reduction analysis: an alternative solution to the catch equations | James Thorson, Jason Cope | |
| SEDAR91-RD15 | Accounting for variable recruitment and fishing mortality in length-based stock assessments for data-limited fisheries | Merill Rudd, James Thorson | |
| SEDAR91-RD16 | A 50-Year Reconstruction of Fisheries Catch in Puerto Rico | Richard Appeldoorn, Isle Sanders, Leonie Farber | |
| SEDAR91-RD17 | Final stock assessment and fishery evaluation (SAFE) report for the workshop on spiny lobster resources in the U.S. Caribbean San Juan, Puerto Rico, September 11-13, 1990 | James Bohnsack, Stephen Meyeres, Richard Appeldoorn, Jim Beets, Daniel Matos, To | |
| SEDAR91-RD18 | Reflections of the way life used to be: Anthropology, History and the Decline of the Fish Stocks in Puerto Rico | Manuel Valdés-Pizzini | |

2.5 Stock Structure and Management Unit

St. Thomas/St. John spiny lobster is managed under the St. Thomas/St. John Fishery Management Plan (Crabtree, 2019). In 2023, the Caribbean Fisheries Management Council

transitioned from regional species-based to island-specific species-based fisheries management (Figure 9.1). The management measures in the new island-based fishery management plans became effective on October 13, 2022.

The St. Thomas/St. John spiny lobster stock is managed as an independent population. Catch limits for St. Thomas/St. John spiny lobster are based on a tiered acceptable biological catch (ABC) control rule; it is currently managed under Tier 3: acceptable assessment available, using the models developed during SEDAR 57 (2019) and SEDAR 57 update (2022) processes. The most recent annual catch limit (ACL) was 133,207 lbs., whole weight.

A SEDAR 91 Assessment Process working paper summarizes federal management actions for spiny lobster in St. Thomas/St. John (Malone, 2025). On January 1, 1985, a 3.5-inch carapace length federal size limit was instituted as part of the original fishery management plan. The size limit applies to the U.S. Exclusive Economic Zone (EEZ) surrounding St. Thomas/St. John, which is defined as the federal waters ranging from 3 to 200 nautical miles (nm) (5.6 – 370 kilometers [km]) from the nearest coastline point of the U.S. Virgin Islands (Figure 9.1).

3. DATA INPUT AND MODEL CONFIGURATIONS

3.1 Modeling Framework

Stock Synthesis V3.30.12 was the modeling approach applied in the current SEDAR 91 assessment because of compatibility with the available data and consistency with standard practices.

SS3 is a statistical catch-at-age model that uses a population model, an observation model, and an estimation model that applies a likelihood function in the estimation process (Methot et al., 2020). 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 SS3 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). SS3 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. 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.

3.2 Data Informed Modeling Decisions

The data available for use in the current assessment are documented in the SEDAR 91 US Caribbean spiny lobster St. Thomas/St. John Data Workshop Report (SEDAR, 2025). Provided here is a summary of those data with a focus on the associated model configurations explored using *SS3*. 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 (Orhun et al., 2024)
2. **Length compositions** from shore-based port sampling (Godwin and Rios., 2024)

Based on the available data, the assessment was configured with one area, one season, two sexes, and two commercial fleets.

3.3 Commercial Fleet Data

3.3.1 Catch

Commercial fishery landings in St. Thomas/St. John (STTJ) were obtained from self-reported fisher logbook data (Caribbean Commercial Logbook, CCL) (Orhun et al. 2024). Commercial fishery landings data for Caribbean spiny lobster in STTJ were available for the years 1975-2023 (Figures 9.2 and 9.3). Potential outliers were discussed during the Data Workshop and the decision was made to retain them as valid trips.

In the SEDAR 91 *SS3* 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. Catches are assumed to be approximately known with a standard error of 0.01 for each fleet.** The years of the available species-specific self-reported commercial fisher logbook landings and effort data determined the start and end years of the *SS3* models. **The start and end years of the model were 1975 and 2023,**

respectively. Although it is considered likely that fishing for spiny lobster occurred prior to 1975, the magnitude of catches is considered negligible. Therefore, **the model assumes that the stock is in an unexploited state during the first year.**

3.3.2 Size Composition and Quantile Analyses

Gear-specific annual length frequencies for the commercial fleet came from the commercial shore-based port-sampling Trip Interview Program (Godwin and Rios, 2024). The Puerto Rico Department of Natural and Environmental Resources (PR DRNA), as part of the Trip Interview Program (TIP), collects length and weight data from lobsters landed by commercial fishing vessels, along with information about fishing areas and gears. Data collection began in the 1980s and are available for STTJ spiny lobster during 1981-2023.

Data availability and sample sizes vary over time and by fleet. Overall, there are more years of data available with higher sample sizes for the pot/trap fishery. Data for both fleets are generally sparse with several missing years, but the dive fleet has smaller sample sizes (Figure 9.3). **The relative model weighting of each commercial fleet's length compositions was based on the number of trips sampled.** From 1981 - 2023, the TIP data contain 15,921 length observations across 699 unique port sampling interviews. **The Trip Interview Program length compositions of the commercial fleets were assumed to be representative of the total catch.** Although non-commercial fishing is reported to occur, it is assumed to be constant over time.

An analysis of the length composition quantiles was conducted for each fleet by sex to determine the relative estimability of fishing mortality and recruitment deviations (Figures 9.4:9.7). Weighted 10th, 25th, 50th, 75th, and 90th quantiles for female (Figure 9.4) and male (Figure 9.5) lobster were estimated per year for each fishery and each sex (Akinshin 2023). Weighted quantiles in the dive fishery over time are centered consistently around the average size of spiny lobster with little or no trend. Missing years of data create some artificial peaks and valleys in the time series. Weighted quantiles for female (Figure 9.6) and male (Figure 9.7) lobster in the pot/trap fishery over time show some resolution around the median size. Despite the small contrast in the pot/trap fishery weighted quantile estimate, annual recruitment deviations are unlikely to be estimable, and weighted quantile analyses for both fleets suggest that fishing has not had an effect on the overall size structure of the population.

An exponential logistic function (Equation 1, Methot et al. 2020) was used to model the relative vulnerability of capture by length for the pot/trap fleet (Figure 9.8):

$$\text{Selectivity} = \frac{e^{2^{\text{nd}} \text{ limb} * 1^{\text{st}} \text{ limb} * (\text{asymptote} - \text{length})}}{1 - 2^{\text{nd}} \text{ limb} (1 - e^{1^{\text{st}} \text{ limb} * (\text{asymptote} - \text{length})})} \quad (1).$$

The three-parameter exponential logistic function can be used to model both dome and logistic and flat-topped selectivity patterns. The pot/trap fleet is the dominant fishery for STTJ spiny lobster. The missing years in the time series of dive fleet length composition, however, make estimation of dive fleet selectivity infeasible. Therefore, the dive fleet exponential logistic parameters are assumed to mirror those of the pot/trap fleet (Figure 9.8), as they were in SEDAR 57 (2019). Additionally, a fixed time-varying knife-edged retention function was included to model the minimum-size limit and retention of male spiny lobsters in the pot/trap fishery; this model assumes that discarding of under-sized lobster occurs following the implementation of the size limit (2000), but that no mortality from discarding occurs (Figure 9.9).

The initial exponential logistic function parameters estimated for the pot/trap fleet assume a dome-shaped selectivity pattern. The exponential logistic function requires three parameters: a 1st limb, an asymptote (peak), and a 2nd limb. Due to the low resolution (contrast) in the length composition weighted quantiles estimates, the Assessment Panel requested a model in which the exponential logistic is initialized with a logistic/flat-topped selectivity and then allowed to estimate all three selectivity parameters. An additional sensitivity was explored in which the exponential logistic function parameters were fixed to a logistic selectivity pattern. The dive fishery selectivity was assumed to mirror the pot/trap fleet selectivity.

3.4 Life History Parameters

The life history data used in the assessment included an island-specific length-weight conversion estimated from 11,723 length-weight observations in the TIP data. No other empirical life history information was used in the model. See the STTJ Data Workshop Report for additional detail. Based on the available information, **the spiny lobster population was modeled from age 0 through age 15, which was treated as a plus group, and from 5 to 250-millimeters (mm) carapace length, in 5-mm bins. Note that only lobsters 51 mm or larger were observed in the TIP**

data.

3.4.1 Growth

The SS3 growth formulation requires five parameters:

1. Length at the youngest age
2. Length at the maximum age
3. Von Bertalanffy growth parameter (K)
4. Coefficient of variation at the youngest age
5. Coefficient of variation at the maximum age

Based on feedback from the Data Workshop, growth model parameters were carried over from SEDAR 57 with no recommended changes. Von Bertalanffy growth function parameters were sex-specific and assumed fixed. Length at the youngest age was fixed at 5 mm for both males and females, and the length at the maximum age was fixed at 155 and 184 mm, respectively. K was fixed at 0.22 and 0.24 for males and females, respectively. The coefficient of variation at the youngest age was set to 0.1, and oldest age at 0.043 for both males and females. These parameters remain unchanged from SEDAR 57 (2019). Note that the length at maximum age for each sex is treated as an average by the model; larger lobsters have been observed in the data and can be estimated by the model. No alternative growth models were explored for STTJ spiny lobster.

3.4.2 Length-Weight Conversion

The relationship between weight in kilograms and carapace length in millimeters was estimated using a linear regression on the log-transformed exponential equation fit to the TIP data. **The length-weight relationship for males was $W = 3.55 \times 10^{-5} * L^{2.204}$ and was $W = 4.90 \times 10^{-5}$ millimeters. * $L^{2.138}$ for females with weight (W) in kilograms and length (L) in millimeters.** Note that SS3 assumes that inputs are in centimeters. However, length data and life history relationships are input and parameterized using millimeters, respectively, SS3 will produce consistent results. This was the approach in both SEDAR 57 and the update (SEDAR 2019, 2022). Also note that length-related SS3 outputs will automatically generate figures with centimeter units, but for the purposes of this assessment, should be interpreted in millimeters.

One sensitivity model was explored for the length-weight relationship. Length-weight parameters for the entire US Caribbean region were estimated using the log-

scale linear regression method described in the STTJ Data Workshop Report (SEDAR 2025), but applied to data from STTJ during 1980-2024. The sensitivity analysis applied these regional length-weight parameter estimates to determine if there were population-level differences when island-specific vs. regional estimates of length-weight parameters are applied. **The regional length-weight relationship for males was $W = 1.1 \times 10^{-5} * L^{2.44}$, and was $W = 9.4 \times 10^{-6}$ millimeters. * $L^{2.475}$ for females with weight (W) in kilograms and length (L) in millimeters.**

3.4.3. Maturity and Fecundity

Maturity was modeled as a logistic function and parameters were treated as fixed inputs to the model. Parameter estimates for maturity were estimated using TIP data prior to 1990 when landing egg bearing females was allowed (Die 2005). **The fecundity of spiny lobster is modeled as a power function** with parameter estimates from Cuba spiny lobster (FAO 2001):

$$E = 0.5911L^{4.5677}$$

where E is number of eggs and L is carapace length in mm. **Fecundity parameters were treated as fixed inputs to the model.**

3.4.4 Stock Recruitment

A Beverton-Holt stock-recruit function was used to parametrize the relationship between spawning output and resulting recruitment of age-0 lobster. 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 (R_0 ; estimated in log space) represents the asymptote or unfished recruitment levels.
- The variance term (σ_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 (R_0) 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. **Due to the low contrast in length composition data, annual deviations from the stock-recruit function were not estimated.** A sensitivity run indicated that recruitment deviations cannot be estimated well and resulted in nearly identical estimates of the four model parameters. Steepness and R_0 were explored via likelihood profiling.

3.4.5 Maximum Age and Natural Mortality

Natural mortality was treated as a fixed model input set to 0.34: the same value used in SEDAR 57 (2019). This value is based on a point estimate calculated from a variant of Pauly's equation (Cruz et al. 1981). Past considerations of natural mortality are discussed in the Data Workshop Report Section 2.4.

Empirical estimates of natural mortality (M) can be derived using life history information such as longevity, growth, and maturity. The Assessment Panel recommended that the Natural Mortality Tool (Cope & Hamel, 2022) be used to determine if 0.34 is still a reasonable value for natural mortality. Parameters for maximum age, the Von Bertalanffy growth parameter (K), and asymptotic size (L_∞), for females and males that are used in the current assessment were treated as inputs to the Natural Mortality Tool to obtain values of M from various empirical estimators. Maximum age was assumed to be 16 to approximate the age 15 plus group, and a lognormal coefficient of variation of 0.2 was included for uncertainty. The empirical estimators can be broken into two groupings: those based on maximum age ("Then_nls," "Then_lm," "Hamel_Amax") and those based on the von Bertalanffy growth function ("Then_VGBF," "Hamel_k," "Jensen_k1," "Jensen_K2"; see Cope and Hamel, 2022 for additional details on estimators). The average estimated natural mortality across estimators was very close to 0.34 for both sexes (Figures 9.10, 9.11), and therefore no changes to the fixed parameter input were considered.

3.5 Summary of Data-Informed Modeling Configurations

Based on the available data, the assessment was configured with one area, one season, two sexes, and two commercial fleets. SS3 models were configured using annual commercial catch time series and size compositions by fleet.

3.5.1 Commercial Fleet

- The catch was input as biomass (in metric tons) and was treated as if it occurred over the calendar year.
- The start and end years of the model were 1975 and 2023, respectively.
- The input standard error for the landings was set to 0.01.
- 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 fleets were assumed to be representative of the total catch.
- An exponential logistic function was used to model the relative vulnerability of capture by length for the pot/trap fleet.
- The dive fleet selectivity was assumed to mirror the pot/trap selectivity.
- A sensitivity run was conducted in which the exponential logistic function parameters were initialized with a logistic selectivity pattern and only the ascending limb was estimated, i.e., the logistic pattern is fixed.
- A sensitivity run was conducted in which the exponential logistic function was initialized with a logistic selectivity pattern and allowed to estimate all three selectivity parameters.
- The assessment assumed a time-varying retention function for the pot/trap fishery, but assumed no mortality from discards.

3.5.2 Life History

- The spiny lobster population was modeled from age 0 through age 15, which was treated as a plus group, and from 5 to 250-millimeters carapace length, in 5-millimeter bins.
- Growth parameters for females and males were treated as fixed model inputs and carried over from SEDAR 57.
- Coefficients of variation for younger and older ages were initially set to 0.1 and 0.043 for both sexes.
- The length-weight relationship for male lobster was $W = 3.55 \times 10^{-5} L^{2.204}$, and $W = 4.9 \times 10^{-5} L^{2.138}$ for female lobster, with weight in kilograms and length in millimeters.
- A natural mortality value of 0.34 was used in the initial model runs.

- Maturity was modeled as a logistic function and fecundity was modeled as a power function with parameters treated as fixed model inputs.
- A Beverton-Holt stock-recruit function was used to parametrize the relationship between spawning output and resulting recruitment of age-0 lobster.
- Sigma R and steepness were fixed at 0.7 and 0.99, respectively.
- In model configurations, annual deviations from the stock-recruit function were not estimated.
- A sensitivity run was conducted in which regional length-weight parameter estimates were applied instead of the STTJ island-specific parameters.

4 STOCK ASSESMENT MODEL RESULTS

SS3 models were configured using annual commercial catch time series and size compositions by fleet.

4.1 Overview

The SEDAR 91 model is essentially a data-only update from the SEDAR 57 update assessment, however, important life history parameters such as natural mortality and the length-weight relationship were re-evaluated and determined to be appropriate. Excluding the SEAMAP-C dive survey data, there were no additional data introduced during SEDAR 91 beyond updated landings and length composition time series, and the assessment workshop panel did not recommend any deviation from other SEDAR 57 life history assumptions, or any further sensitivity analyses related to life history. The stock assessment analyst investigated alternative stock assessment modeling frameworks designed specifically for marine invertebrates, however, the lack of an index of relative abundance for spiny lobster precluded the application of alternative frameworks to SS3. Therefore, the SS3 models remain the best benchmark stock assessment approach for US Caribbean spiny lobster.

This report summarizes and discusses the results of four stock assessment models: the *base* model described in Section 3, two sensitivities that explore logistic selectivity patterns, and one sensitivity to explore an alternate parameterization of the length-weight relationships by sex (Table 8.1). The *selex1* model refers to the sensitivity in which the exponential logistic function is initialized with a logistic selectivity pattern and the asymptote and 2nd limb parameters are fixed for the pot/trap fleet, and *selex2* refers to the model in which the logistic selectivity pattern is initialized but all three

parameters are estimated within the model. Finally, the *lw* model refers to the sensitivity analysis in which the length-weight relationship parameters were set to region-level estimates for female and male lobster, respectively.

4.1 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.

4.2 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 (Table 8.2).

4.3 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. No high correlations (correlation coefficients greater than 0.95 or less than -0.95) were observed. Correlations between all selectivity parameters were

moderate in the *base* model (Table 8.3).

4.4 Evaluating Variance

To check for parameters with high variance, parameter estimates are reported with their resulting standard deviations. Table 8.2 presents the model-estimated values and standard deviations for the main active parameters. Selectivity parameters for the base model were estimated with precision, although the probability density of the 1st limb of the exponential logistic function demonstrates some uncertainty (Figure 9.12). Log-scale R_0 was estimated with relative precision (Table 8.2)).

4.5 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. Furthermore, jitter analyses, when jittered at appropriately high values, can provide insight into whether a more optimal solution space exists, i.e., a lower total negative log-likelihood. For this assessment, a jitter value of 0.5 was applied to the starting values, and 40 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), the jitter analysis also performed well, indicating that all models converged to a similar solution (Figure 9.14). Importantly, no jitter runs produced a lower likelihood than the best fit already identified for each model.

4.7 Residual Analysis

The primary approach to investigate model performance was a residual analysis of model fit to each data set. 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.

4.7.1 Catch

SS3 uses a hybrid implementation of Pope's approximation to internally tune the model such that fishing mortality need not be an estimated parameter, but an internally-tuned coefficient to produce values of fishing mortality associated with a perfect fit to catch data (Figure 9.13c) (Richard Methot, NOAA Fisheries Directorate, personal communication). Therefore, observed and predicted catches match more or less exactly.

4.7.2 Length compositions

Figure 9.15 shows the cumulative fit across all years between the observed and predicted length composition for the base model by sex, and Figures 9.16 and 9.17 show the individual fits to length composition by year for the dive and pot/trap fleets, respectively. Note that SS3 assumes that length composition data are in centimeters (cm) and generate plots to this effect; all measurements are in mm. Cumulative fits were reasonable with some overestimation of 100 mm females (Figure 9.15); this pattern was likely driven by poor model fits to data during years with low sample sizes (Figure 9.16, 9.17). Years in which sample sizes were sufficiently large resulted in close fits to the length composition data (Figure 9.16, 9.17).

4.8 Retrospective Analysis

A retrospective analysis is a helpful approach for investigating the consistency of terminal year model estimates (e.g., SSB) 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 size 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 for SSB are plotted in Figure 9.18, which shows no evidence of a retrospective pattern.

4.9 Hindcast Cross-validation

Hindcast cross-validation uses SS3's forecast file to calculate the expected values of the observed data based on forward projections (Carvalho et al. 2021), which can be used to test the model's ability to predict mean values; e.g., length composition, by projecting a number of years backward from the terminal year. Model prediction ability is diagnosed with mean absolute square error (MASE) scores. Scores less than 1.0 indicate some predictive ability while values of 1.0 or greater indicate that the model performs equivalently with a random walk model; i.e., does not have predictive ability. Hindcast cross-validation was applied to the length composition data for each commercial fleet (*base* model only). MASE scores indicate that the model can predict mean length composition for both pot/trap and dive fleets (Figure 9.19).

4.10 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). However, due to the small number of parameters estimated in the model, and extensive sensitivity analyses conducted during SEDAR 57 (2019), profiles were exclusively explored for unfished recruitment (R_0) and steepness.

4.10.1 Unfished Recruitment (R_0)

Figure 9.20 shows the profile likelihood for the natural log of the unfished recruitment

parameter of the Beverton – Holt stock-recruit function for STTJ spiny lobster (*base* model only). The base model log-scale R_0 profile indicates a well-defined minimum occurring at the base model estimate of R_0 (Table 8.2).

4.10.2 Steepness

Figure 9.21 shows the profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for STTJ spiny lobster (*base* model only). The base model steepness profile indicates that 0.99 is the global minimum parameter value, though this is a common result when the model does not contain much information on the steepness parameter (thus why it goes to the bound in estimation).

4.11 Sensitivity Runs

Two sensitivity analyses were conducted to determine the estimability of selectivity. *Selex1* explored initializing the pot/trap fleet's exponential logistic function with parameters that generate a logistic selectivity pattern, and treats the asymptote and 2nd limb parameters as fixed inputs. *Selex2* explored initializing the dive fleet's exponential logistic function with parameters that generate a logistic selectivity pattern, but allows the model to estimate all three parameters. Estimated selectivity patterns each of the SEDAR 91 models (*base*, *selex1*, *selex2*) are provided in Figure 9.8. Despite the low resolution in the median quantiles of the length composition data, the exponential logistic function in *selex2* estimates nearly identical parameters as the base model, resulting in the same dome-shaped selectivity pattern (Figure 9.8).

One sensitivity was conducted in which the length-weight parameters were fixed at the US Caribbean region-wide estimates for males and females. The *lw* sensitivity resulted in nearly identical population dynamics to those of the *base* and *selex2* models (Tables 8.2, 8.4, 8.5; Figure 9.22). *Lw* sensitivity selectivity parameters were identical, but R_0 was slightly higher than that of the *base* (Table 8.2). The estimated MSY proxy yield was less than the *base* model (Table 8.4), but did not result in a different stock status (Table 8.5).

5 DISCUSSION

This assessment presents four model configurations, using an integrated framework and several model diagnostics in order to characterize the stock status of spiny lobster in STTJ. Overall, the results broadly indicate that overfishing is not occurring and the stock is not

overfished (Figure 9.13a, Table 8.5). The *base* model is a relatively inflexible application of a data-limited length-based integrated statistical-catch-at-age model. There are only four parameters being estimated, and there are several sources of uncertainty in the data and model. These include the low contrast in the length composition demonstrated by the median quantile analyses; the lack of lobsters smaller than 51 mm in the length composition data to anchor the model predictions for lobsters between 5-46 mm; the lack of an index of relative abundance; and the use of fixed parameters for most model functions. However, despite the limitations of the available data and rigidity of the model, model diagnostics suggest that the results are generally robust to alternative model specifications. In other words, the model is not allowed to change much, but when it does, the answer (i.e., solution) does not change. Due to the assumption that the model begins when the fishery began, estimates of unfished biomass and initial biomass do not differ (Table 8.6).

The SEDAR 91 model for STTJ spiny lobster is essentially a data-only update of a data-only update (SEDAR 57 update assessment); the model has already been subjected to a host of analyses designed to test the sensitivity of the model to uncertainty in the landings data, and the influence of critical life history function parameters such as growth and natural mortality during SEDAR 57 (2019). Sensitivities from SEDAR 57 not explicitly analyzed during SEDAR 91 nonetheless hold for SEDAR 91 because the underlying SS3 model framework is identical.

This assessment is, however, an advancement in terms of determining the extent to which the TIP data are informative to model: for example, the *selex2* model results suggest that there is enough information content for dome-shaped selectivity to be estimated. Additionally, the median quantile analyses suggest that fishing has not had an effect on the size structure of the STTJ spiny lobster population over time. Magnitude of biomass remains somewhat uncertain (Figure 9.13b), although R_0 was estimated with relative precision (Table 8.2).

The models assume a Beverton-Holt stock-recruitment relationship with a steepness value of 0.99 – this effectively decouples spawning stock biomass and recruitment and defaults to a “null” stock-recruitment relationship (Brooks, 2024), allowing the stock to be very productive at very low stock sizes. This is a reasonable assumption given the open nature of the population to outside recruitment sources. Assuming this null relationship, coupled with the inability to reliably estimate annual recruitment deviations (Figure 9.13d) from the TIP data, R_0 becomes the most influential model parameter with respect to magnitude of the stock (scale) and stock status in the terminal year; alternative steepness

values do not alter the value of R_0 greatly, nor stock status (sensitivity not summarized here). In addition to the precision with which R_0 was estimated for the *base* model, the likelihood profile for R_0 indicates a well-defined minimum (Figure 9.20). The total likelihood associated with *selex1* was larger and therefore a less probable solution than the *base* model, *selex2*, or *lw* model. The *lw* model however, resulted in a nearly identical, though slightly higher total likelihood. Given that the *lw* model also resulted in identical stock status (Table 8.5; Figure 9.22), and similar selectivity parameter estimates, it is possible that using region-level estimates of length-weight parameters results in an equally probable solution.

There are several avenues for future US Caribbean spiny lobster research worth considering. Continued collection of length composition data from the SEAMAP-C dive survey, or sampling efforts focused on collecting information on juvenile or sub-adult lobster, will be important to provide the model information on smaller lobsters that are either not vulnerable to the gear of the fishery, or caught and discarded for being undersized. Further investigation into age structure of Caribbean spiny lobster via gastric ossicle mills, such studies conducted by Hutchinson et al. (2024) and Medina Martinez (2024), provide a specific age-length key for spiny lobster should length-based statistical catch-at-age models continue to be the primary tool for assessing stock status. Given the generally discrete growth process of marine invertebrate, i.e., molting, should future analysts wish to consider a size-based assessment, there are generalized and lobster-specific frameworks available. For example, the Alaska Fisheries Science Center developed A Generalized Size-Based Assessment Modeling Approach for Alaskan Crab Stocks (GMACS) that may be worth applying to spiny lobster should an index of relative abundance become available in the future. Multiple stock assessment methods for Northeast American lobster (*Homarus americanus*) are also currently in development, but require an index of relative abundance (Burton Shank, NEFSC, personal communication), and would similarly benefit from more information on smaller lobsters.

Other sources of uncertainty suggest that US Caribbean spiny lobster may also benefit from a management strategy evaluation (MSE) approach. MSE is warranted when uncertainty threatens the efficacy of the current management approach (Walter et al. 2023). The magnitude of non-commercial harvest in STTJ waters remains highly uncertain, and that harvest remaining stable over time is a fundamental assumption of the SEDAR 91 model. MSE would offer an appropriate means of testing this assumption, and a simulated non-commercial fleet and associated selectivity in the operating models could be informed by expert opinion. Additionally, should local ecological knowledge-based data streams

such as an index of relative perceived abundance (Shaff et al. 2023) become available, MSE is an appropriate framework for testing their utility in future stock assessment. Furthermore, environmental drivers of lobster population dynamics and the effects of market dynamics on the fisheries were primary concerns identified during participatory modeling in the US Virgin Islands (Agar et al. 2024). The effects of environmental nonstationarity on the performance of management procedures can be tested using MSE, as can the effects of market dynamics on fishing (Damiano et al., *in prep*).

6 RESEARCH RECOMMENDATIONS

- Continue the SEAMAP-C data collection program for collecting spiny lobster size composition data.
- Consider the use of management strategy evaluation to explore the uncertainty in non-commercial catches.

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8 TABLES

Table 8.1: Summary of models for SEDAR 91.

| Stage | Code | Model description |
|-------------|---------------|--|
| Initial | <i>base</i> | Model fit to catch and length composition data updated through 2023; all model parameters remain unchanged from SEDAR 57 |
| Sensitivity | <i>selex1</i> | Model exponential logistic function for dive fishery is initialized with logistic selectivity pattern; only first limb parameter allowed to estimate |
| Sensitivity | <i>selex2</i> | Model exponential logistic function for dive fishery is initialized with logistic selectivity pattern; all three parameters are allowed to estimate |
| Sensitivity | <i>lw</i> | Same as the <i>base</i> model but uses the length-weight parameters estimated for the entire US Caribbean region |

Table 8.2: St. Thomas/St. John spiny lobster parameters, standard deviations (SD), and coefficient of variation (CV) by model scenario (*base*, *selex1*, *selex2*, *lw*). CV is calculated as the SD divided by the parameter estimate.

| Parameter | Scenario | Estimate | SD | CV | Gradient |
|---------------------------------------|-----------------|-----------------|-----------|-----------|-----------------|
| Dive selectivity 1 st limb | <i>base</i> | 0.170 | 0.022 | 0.130 | -1.8e-07 |
| | <i>selex1</i> | 0.048 | 0.001 | 0.021 | 2.8e-06 |
| | <i>selex2</i> | 0.170 | 0.022 | 0.130 | 3.1e-06 |
| | <i>lw</i> | 0.170 | 0.022 | 0.130 | 1.1e-07 |
| Dive selectivity asymptote | <i>base</i> | 0.39 | 0.008 | 0.021 | -1.8e-07 |
| | <i>selex1</i> | NA | NA | NA | NA |
| | <i>selex2</i> | 0.39 | 0.008 | 0.021 | 8.1e-06 |
| | <i>lw</i> | 0.39 | 0.008 | 0.021 | 1.5e-07 |
| Dive selectivity 2 nd limb | <i>base</i> | 0.10 | 0.034 | 0.34 | -1.5e-07 |
| | <i>selex1</i> | NA | NA | NA | NA |
| | <i>selex2</i> | 0.10 | 0.034 | 0.34 | 7.2e-07 |
| | <i>lw</i> | 0.10 | 0.034 | 0.34 | 6.8e-09 |
| Unfished Recruitment (R0) | <i>base</i> | 5.58 | 0.11 | 0.02 | 1.3e-06 |
| | <i>selex1</i> | 5.35 | 0.02 | 0.004 | -2.6e-07 |
| | <i>selex2</i> | 5.58 | 0.11 | 0.02 | 7.2e-07 |
| | <i>lw</i> | 5.62 | 0.11 | 0.02 | -3.7e-07 |

Table 8.3: St. Thomas/St. John spiny lobster correlations between estimated parameters for the *base* model scenario.

| Scenario | Estimated Parameter | | Correlation Coefficient |
|-------------|---------------------------------------|---------------------------------------|-------------------------|
| <i>base</i> | Dive selectivity 2 nd limb | Dive selectivity 1 st limb | -0.810 |
| <i>base</i> | Dive selectivity asymptote | Dive selectivity 1 st limb | -0.634 |
| <i>base</i> | Dive selectivity asymptote | Unfished Recruitment (R0) | -0.456 |
| <i>base</i> | Dive selectivity 2 nd limb | Unfished Recruitment (R0) | 0.454 |
| <i>base</i> | Dive selectivity 2 nd limb | Dive selectivity asymptote | 0.295 |
| <i>base</i> | Dive selectivity 1st limb | Unfished Recruitment (R0) | 0.074 |

Table 8.4: St. Thomas/St. John spiny lobster derived quantities of the MSY proxy (based on SPR 30%) in metric tons for the *base* model and *selex1* and *selex2*, and *lw* selectivities. CV is calculated as the SD divided by the parameter estimate.

| Scenario | MSY Proxy | SD | CV |
|-----------------|------------------|-----------|-----------|
| <i>base</i> | 58.93 | 5.68 | 0.10 |
| <i>selex1</i> | 50.51 | 1.14 | 0.02 |
| <i>selex2</i> | 59.07 | 5.70 | 0.10 |
| <i>lw</i> | 58.76 | 5.61 | 0.10 |

Table 8.5: St. Thomas/St. John spiny lobster fishing mortality rate and spawning stock biomass ratios relative to the rate and biomass of the stock associated with the MSY proxy (based on SPR 30%) for the *base* model, and *selex1* and *selex2*, and *lw* sensitivities. The relative fishing mortality ratio is expressed as a three-year geometric mean of the annual fishing mortality rates for 2021-2023 divided by the fishing mortality rate associated with MSY SPR 30%. The relative stock biomass ratio is expressed as the 2023 spawning biomass divided by the spawning stock biomass at MSY SPR 30%.

| Metric | Scenario | Value |
|------------------------|-----------------|--------------|
| F Current / F SPR 30% | <i>base</i> | 0.16 |
| | <i>selex1</i> | 0.64 |
| | <i>selex2</i> | 0.16 |
| | <i>lw</i> | 0.63 |
| SSB 2023 / SSB SPR 30% | <i>base</i> | 1.55 |
| | <i>selex1</i> | 1.31 |
| | <i>selex2</i> | 1.55 |
| | <i>lw</i> | 1.56 |

Table 8.6: St. Thomas/St. John spiny lobster derived quantities for unfished and initial spawning stock biomass in metric tons (mt) along with standard deviations (SD) and coefficient of variation (CV) for the *base* model. CV is calculated as the SD divided by the parameter estimate.

| Derived Quantity | Scenario | Estimate | SD | CV |
|-----------------------------|-----------------|-------------------|--------------------|-----------|
| SSB Unfished (mt) | <i>base</i> | 9.3×10^7 | 9.83×10^6 | 0.11 |
| SSB Initial (mt) | <i>base</i> | 9.3×10^7 | 9.83×10^6 | 0.11 |
| Ratio SSB Initial: Unfished | <i>base</i> | 1.0 | NA | NA |

9 FIGURES

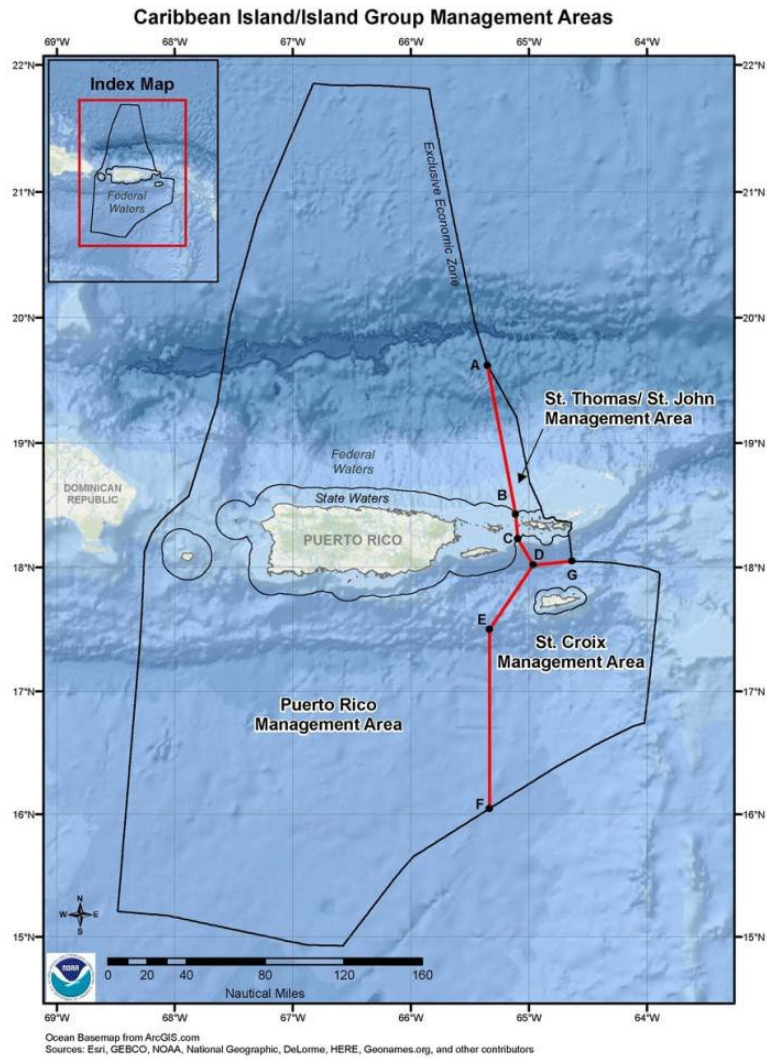


Figure 9.1: Jurisdictional boundaries of the Caribbean Fishery Management Council.

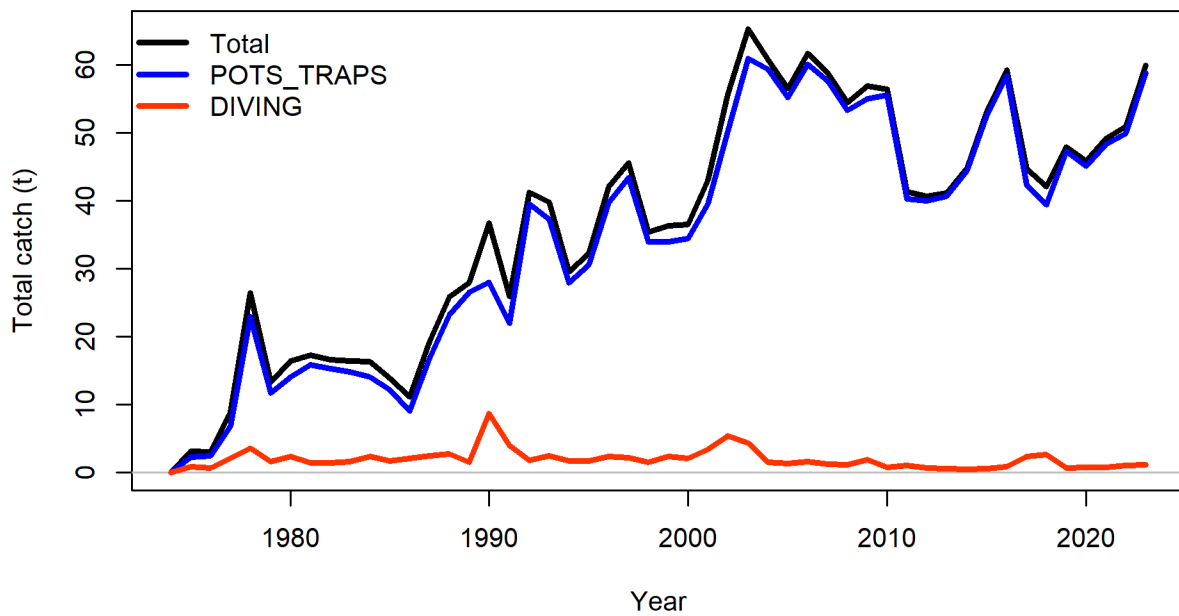


Figure 9.2: St. Thomas/St. John spiny lobster landings (mt) during 1975-2023 by fleet: dive (blue), pot/trap (red), total (black).

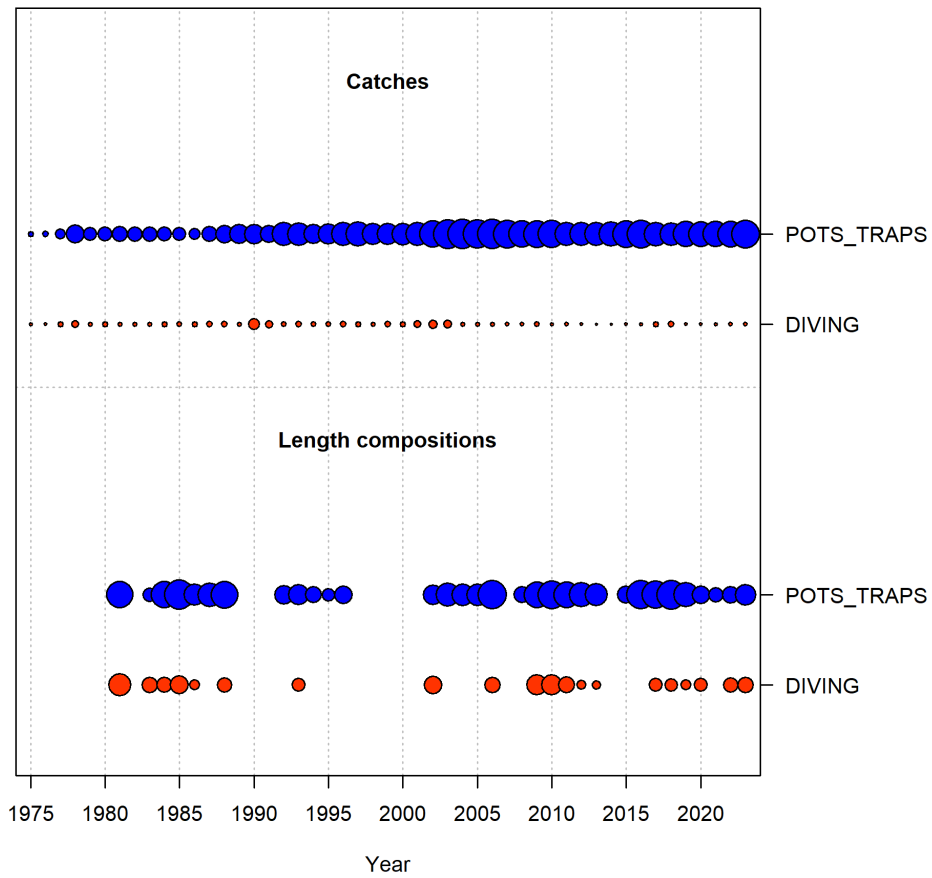


Figure 9.3: St. Thomas/St. John spiny lobster catch (top) and length composition (bottom) data by fleet: dive (red), pot/trap (blue); circle size is indicative of the magnitude of catches (top) and sample sizes (bottom), respectively.

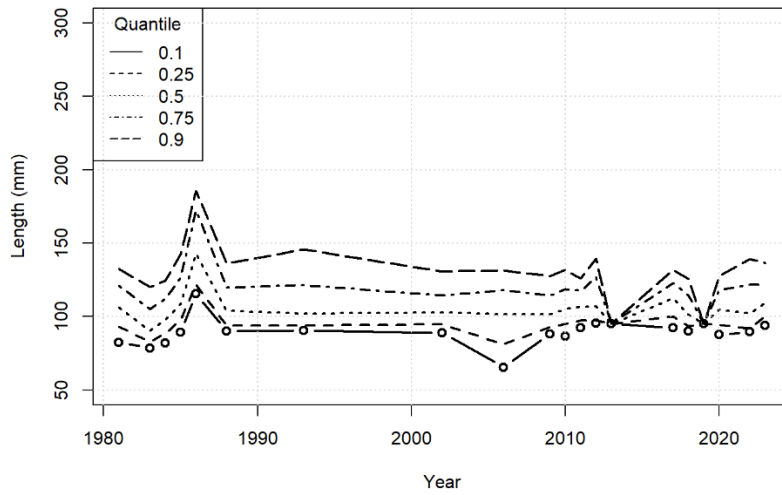


Figure 9.4: Weighted 10th, 25th, 50th, 75th, and 90th quantiles of length composition data (mm) for female St. Thomas/St. John spiny lobster in the dive fishery during 1981-2023.

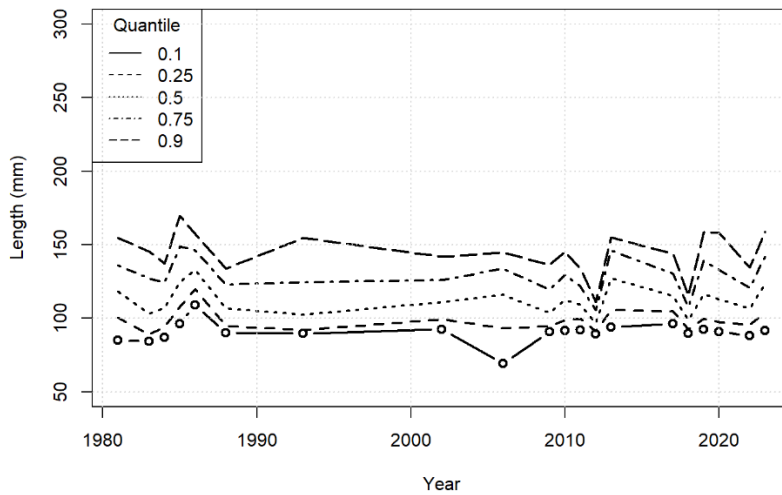


Figure 9.5: Weighted 10th, 25th, 50th, 75th, and 90th quantiles of length composition data (mm) for male St. Thomas/St. John spiny lobster in the dive fishery during 1981-2023.

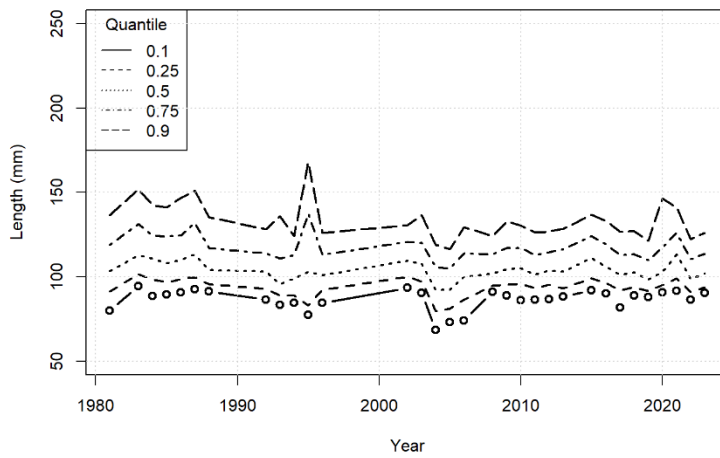


Figure 9.6: Weighted 10th, 25th, 50th, 75th, and 90th quantiles of length composition data (mm) for female St. Thomas/St. John spiny lobster in the pot/trap fishery during 1981-2023.

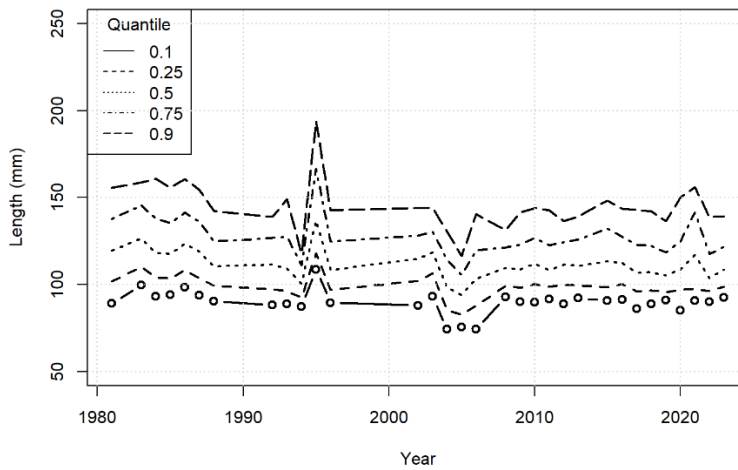
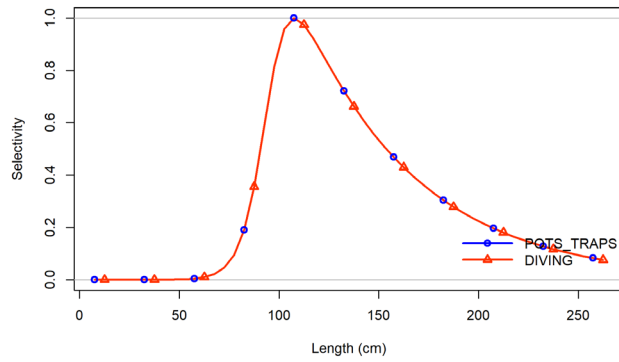
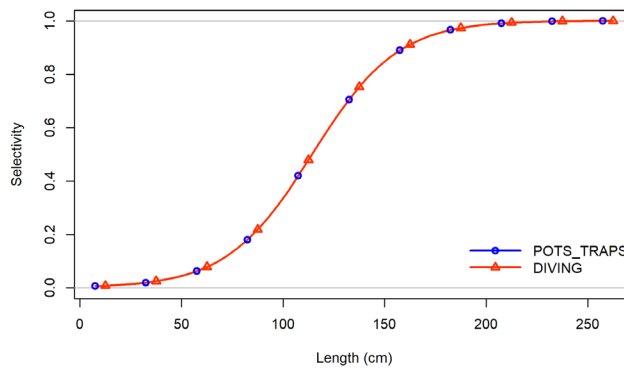


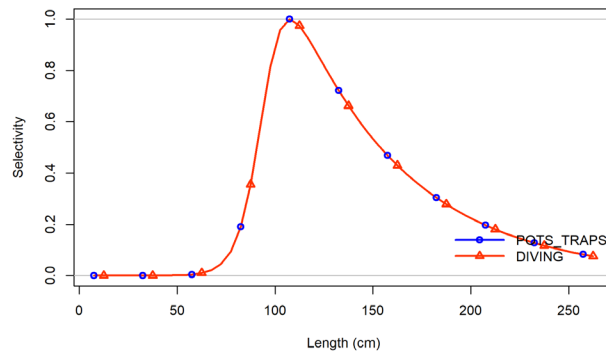
Figure 9.7: Weighted 10th, 25th, 50th, 75th, and 90th quantiles of length composition data (mm) for male St. Thomas/St. John spiny lobster in the pot/trap fishery during 1981-2023.



(base)



(selex1)



(selex2)

Figure 9.8: St. Thomas/St. John spiny lobster fleet selectivity by model scenario: *base* (top), *selex1* (middle), *selex2* (bottom), and by fleet: dive (red), pot/trap (blue). See Table 8.1 for model name descriptions

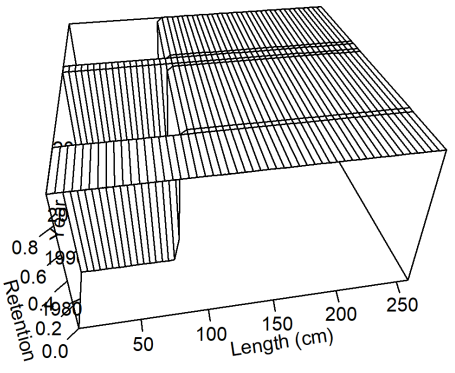
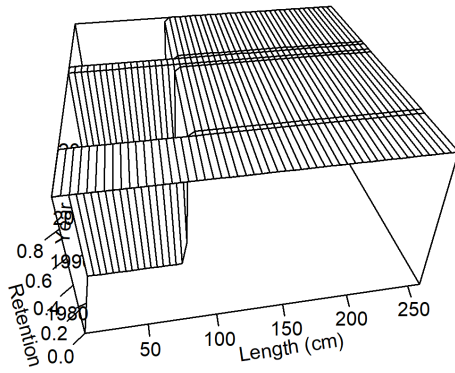


Figure 9.9: Time-varying retention curve surface for the first time-block (front) and second time-block (back) for female (top) and male (bottom) St. Thomas/St. John spiny lobster during 1981 (front left) – 2023 (back left).

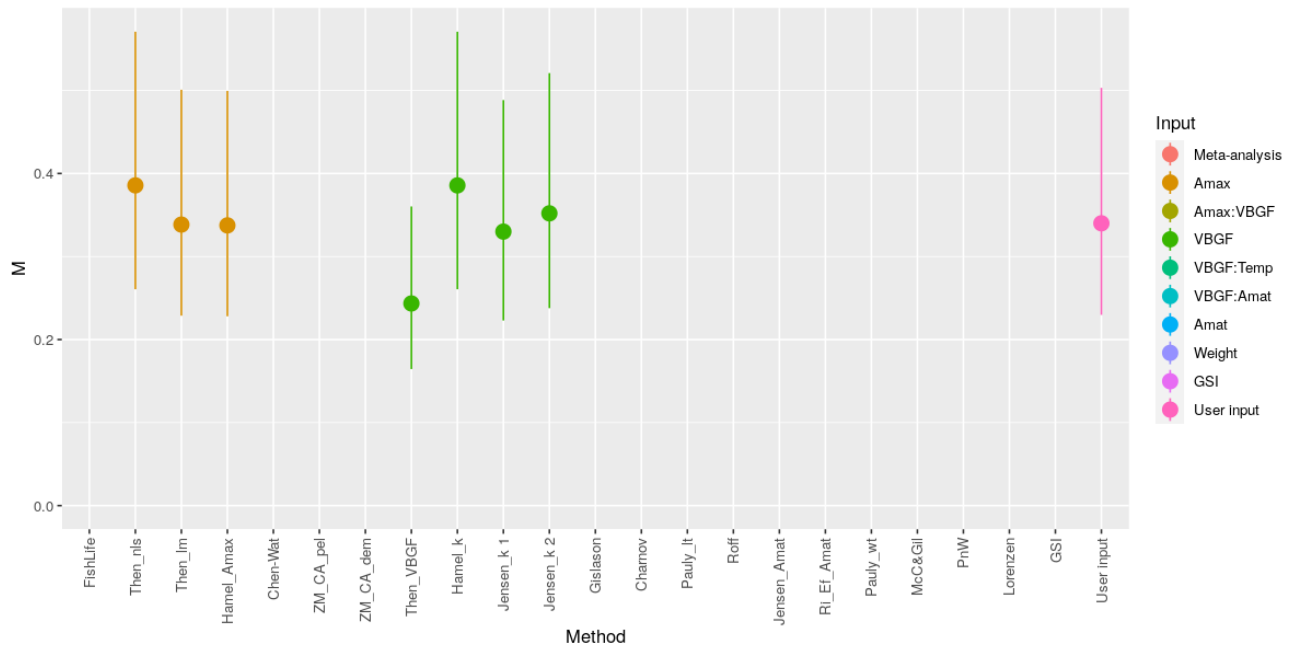


Figure. 9.10: Empirical estimates of natural mortality (M) based on maximum age and von Bertalanffy parameters for female Caribbean spiny lobster.

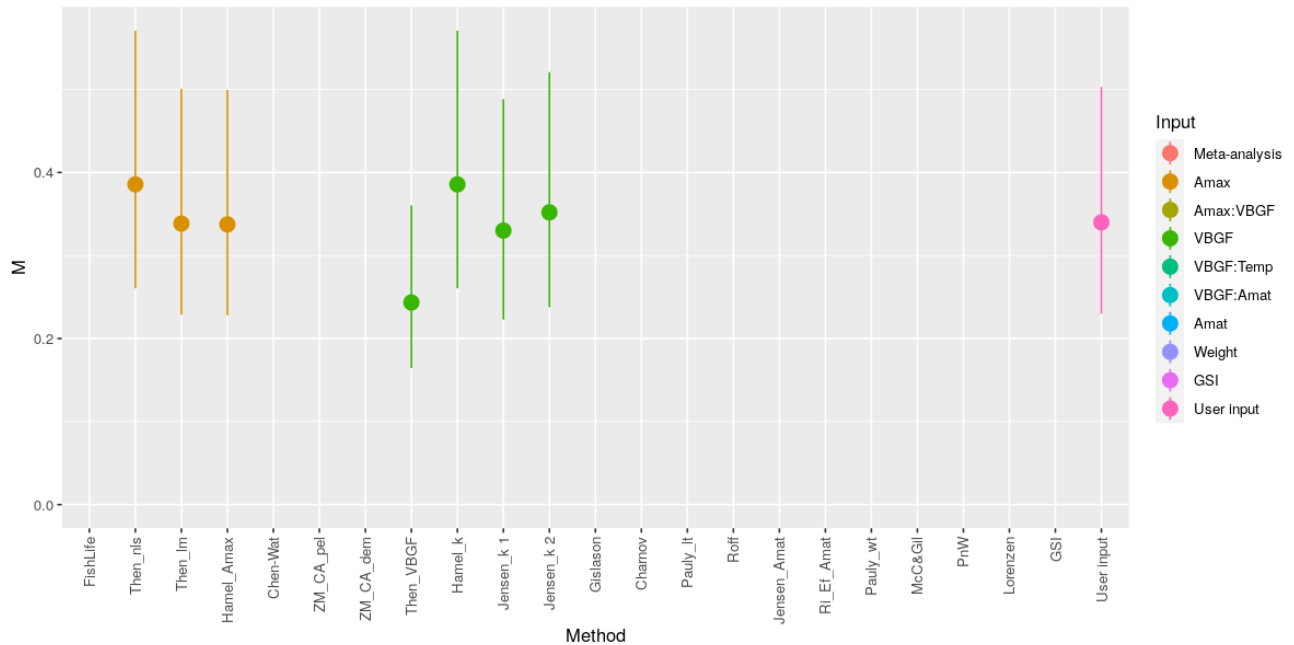


Figure 9.11: Empirical estimates of natural mortality (M) based on maximum age and von Bertalanffy parameters for male Caribbean spiny lobster.

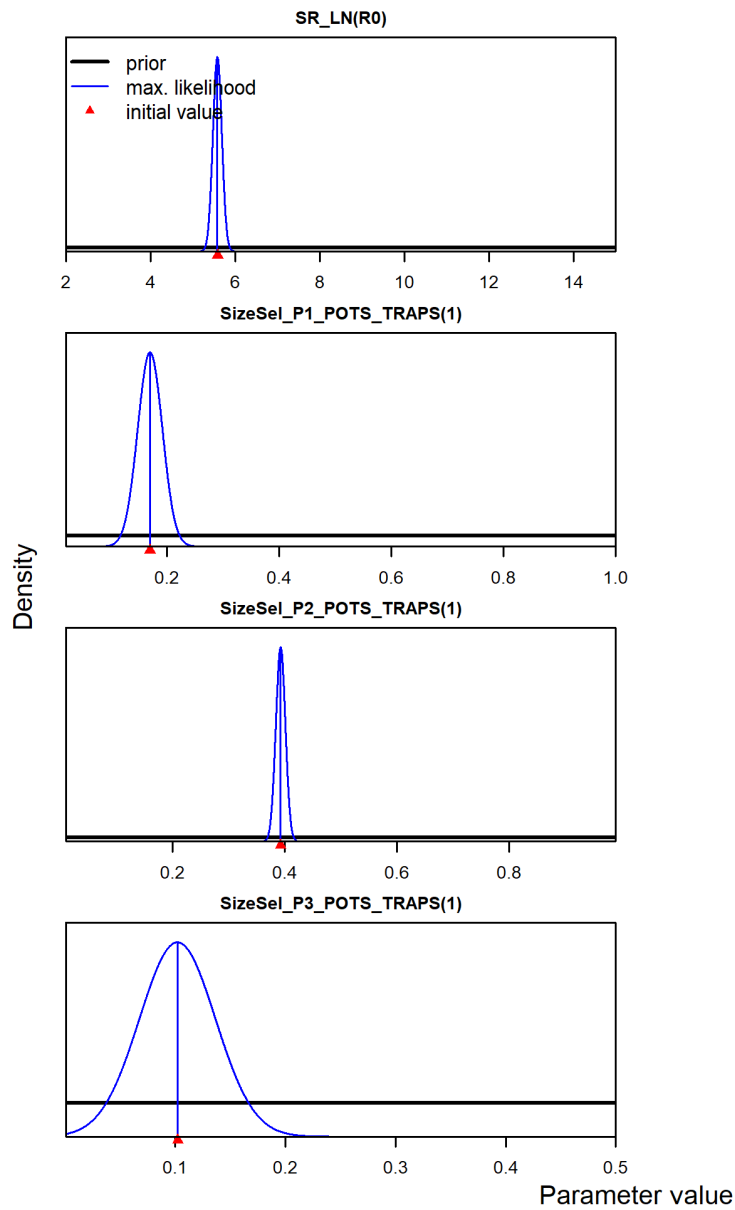
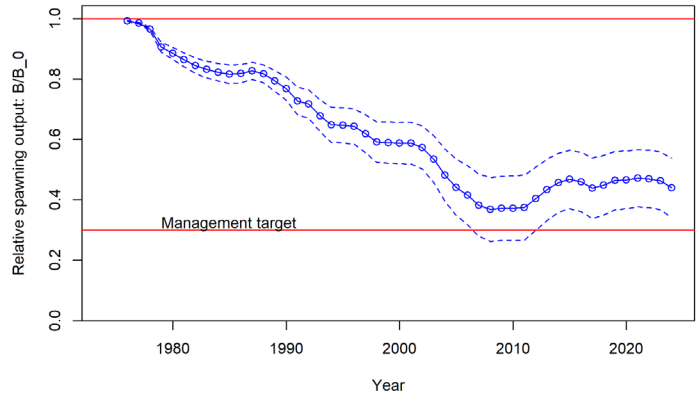
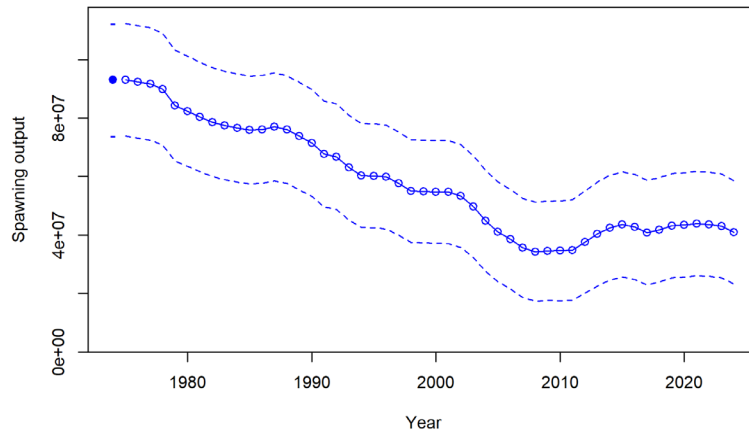


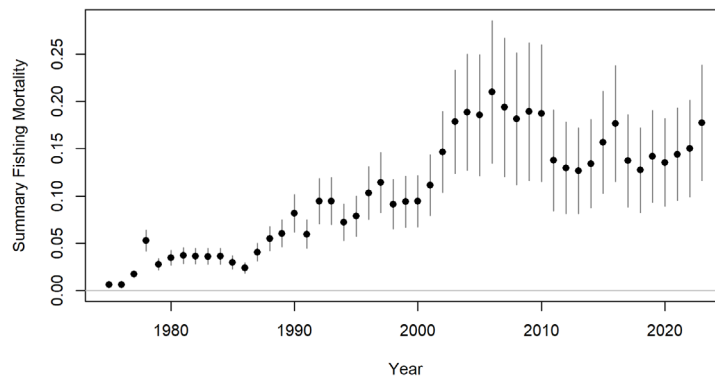
Figure 9.12: St. Thomas/St. John spiny lobster parameter distribution for, in descending order, the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function, the 1st limb parameter of the exponential logistic selectivity function for the pot/trap fleet, the asymptote parameter of the exponential logistic selectivity function for the pot/trap fleet, and the 2nd limb parameter of the exponential logistic selectivity function for the pot/trap fleet



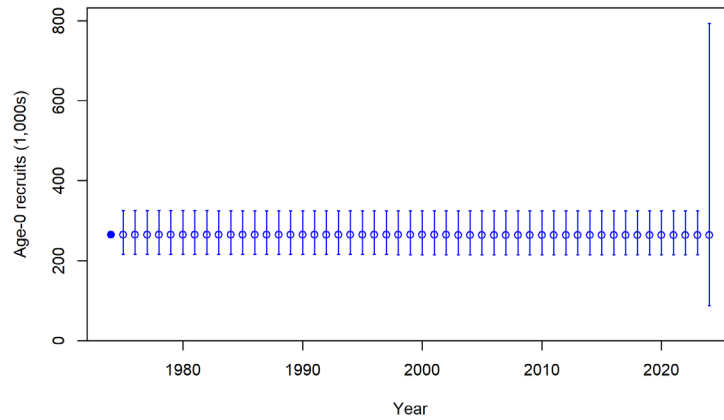
a. Spawning Biomass Ratio



b. Spawning Biomass



c. Fishing Mortality



d. Recruitment

Figure 9.13: St. Thomas/St. John spiny lobster derived quantity time series from the *base* model. Derived quantities plotted over time for (a) the spawning biomass ratio (total biomass / unfished spawning stock biomass), (b) spawning stock biomass in metric tons, (c) fishing mortality (total biomass killed / total biomass), (d) and recruitment in thousands of fish. The dashed lines and vertical bars in the derived quantities time series represent 95% confidence intervals.

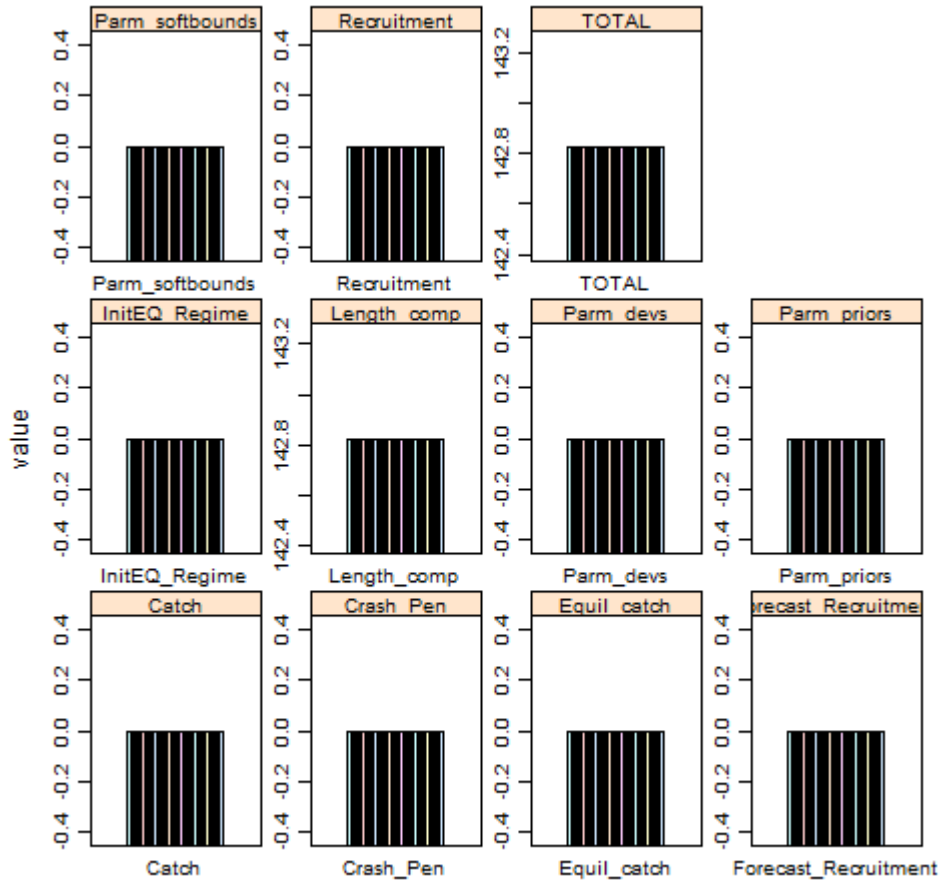


Figure 9.14: St. Thomas/St. John spiny lobster jitter analysis total likelihood for the *base* model. Each panel gives the results of 40 runs of the corresponding model scenario where the starting parameter values for each run were randomly changed by 50% from each model's predicted values using a uniform distribution in cumulative normal space.

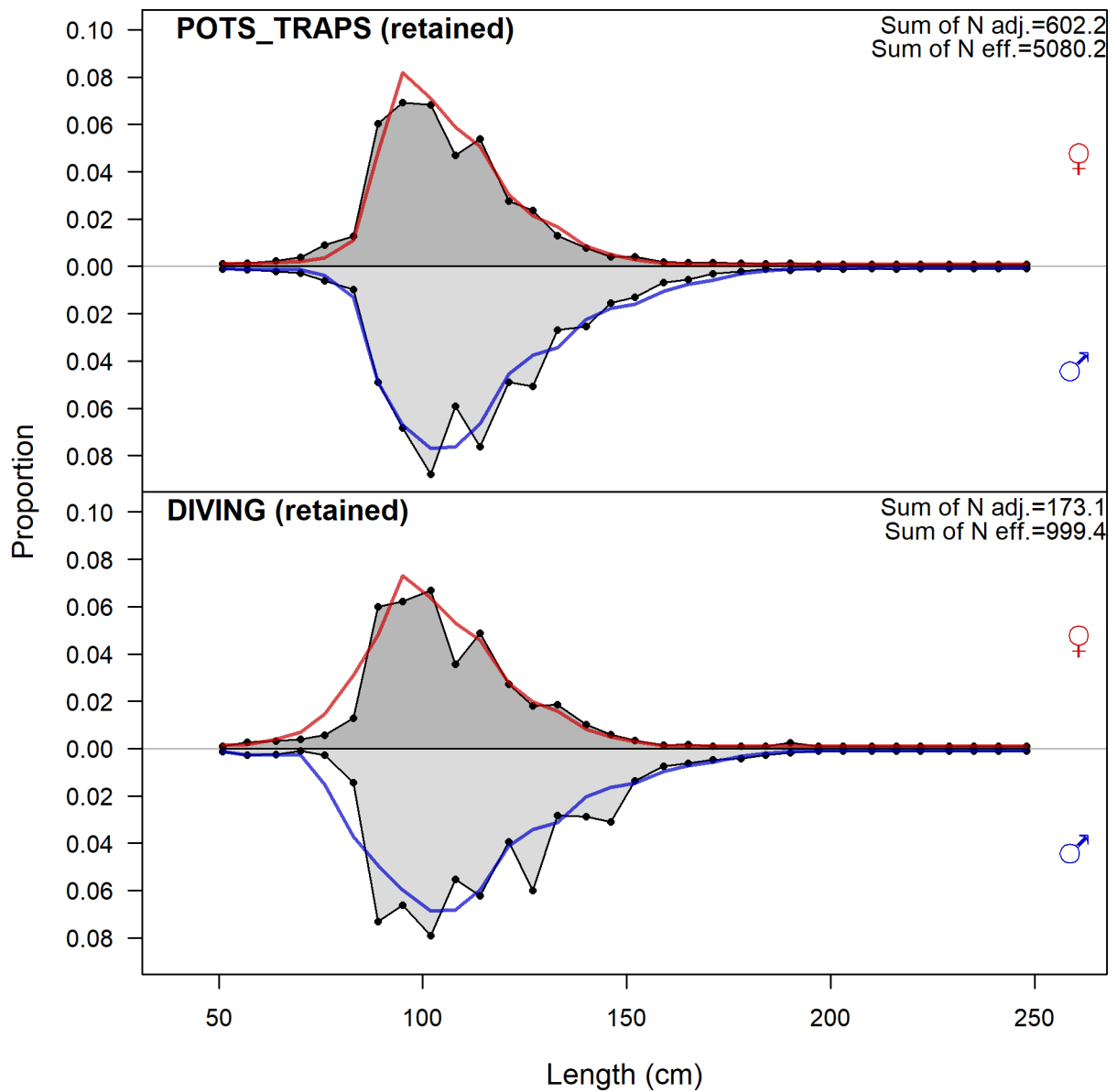


Figure 9.15: St. Thomas/St. John spiny lobster observed and predicted length distributions in millimeters. Red and blue solid lines represent predicted length compositions, while gray regions represent observed length compositions. The effective sample sizes used to weight the length composition data are provided by N adj (the input sample size) and N eff (the calculated effective sample size) and are shown in the upper right corners.

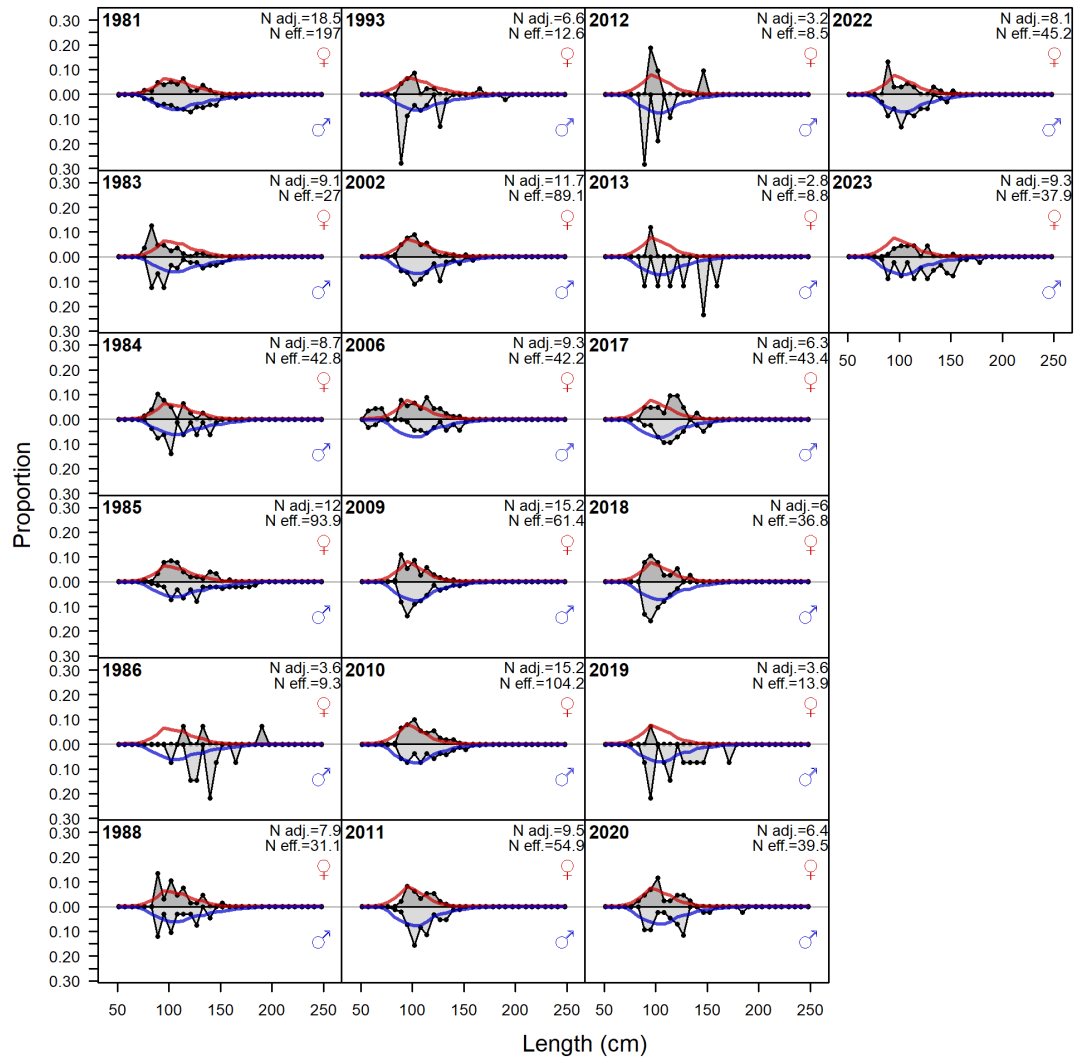


Figure 9.16: St. Thomas/St. John spiny lobster observed (grey) and predicted (solid line) dive fleet length composition by individual year and sex: females (red) and males (blue).

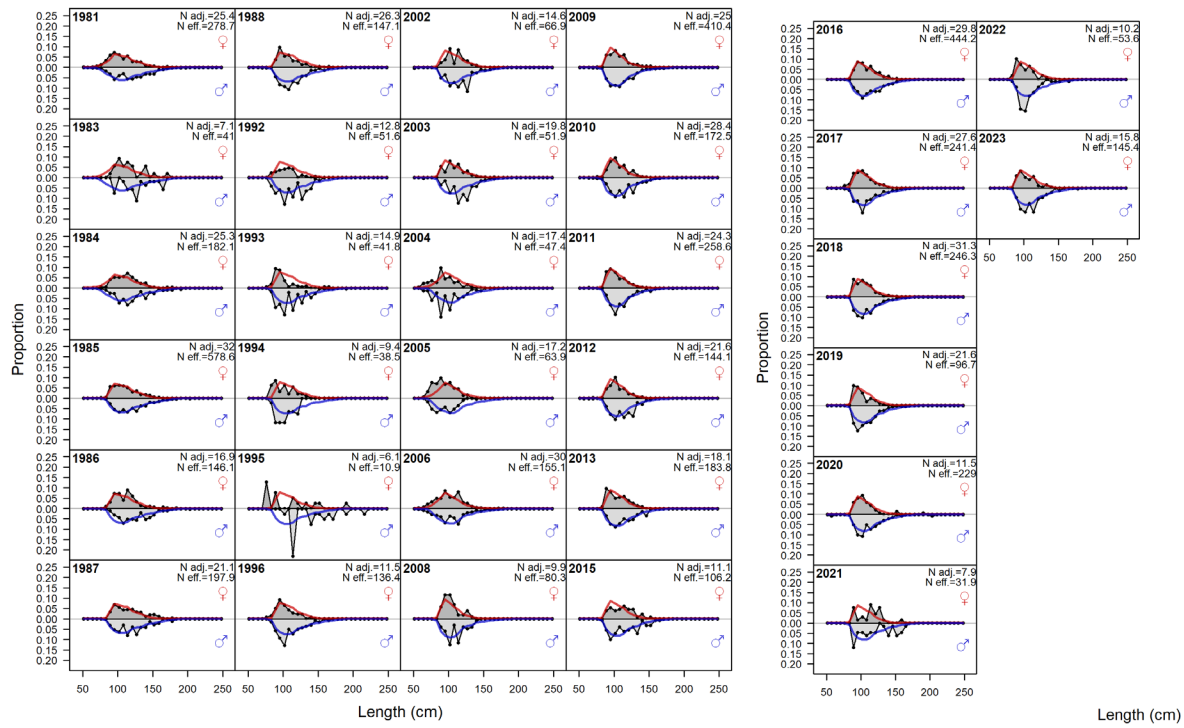


Figure 9.17: St. Thomas/St. John spiny lobster observed (grey) and predicted (solid line) pot/trap fleet length composition by individual year and sex: females (red) and males (blue).

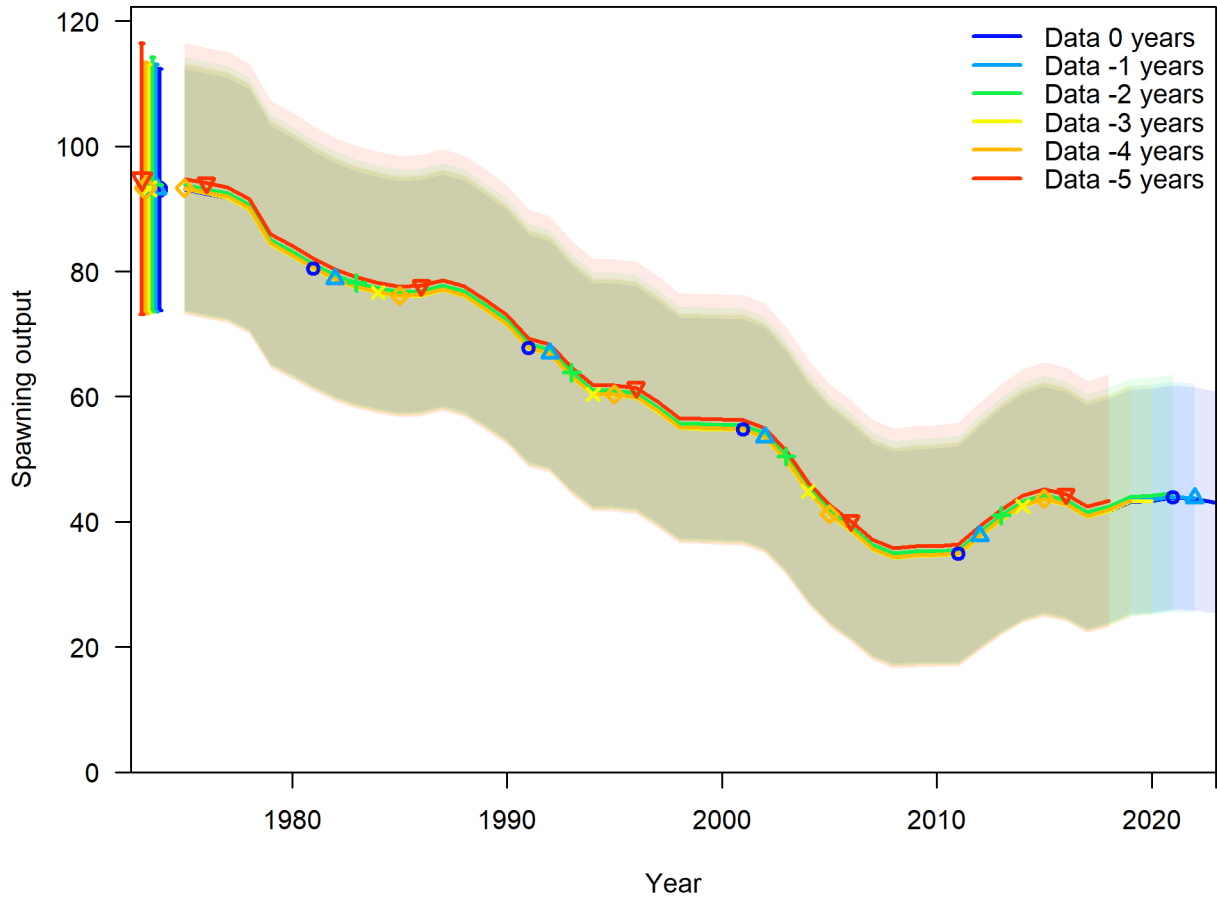


Figure 9.18: St. Thomas/St. John spiny lobster retrospective analysis of spawning stock biomass (SSB) (*base model*) conducted by refitting models after removing five years of observation, one year at a time sequentially. Grey shaded areas are the 95% confidence intervals.

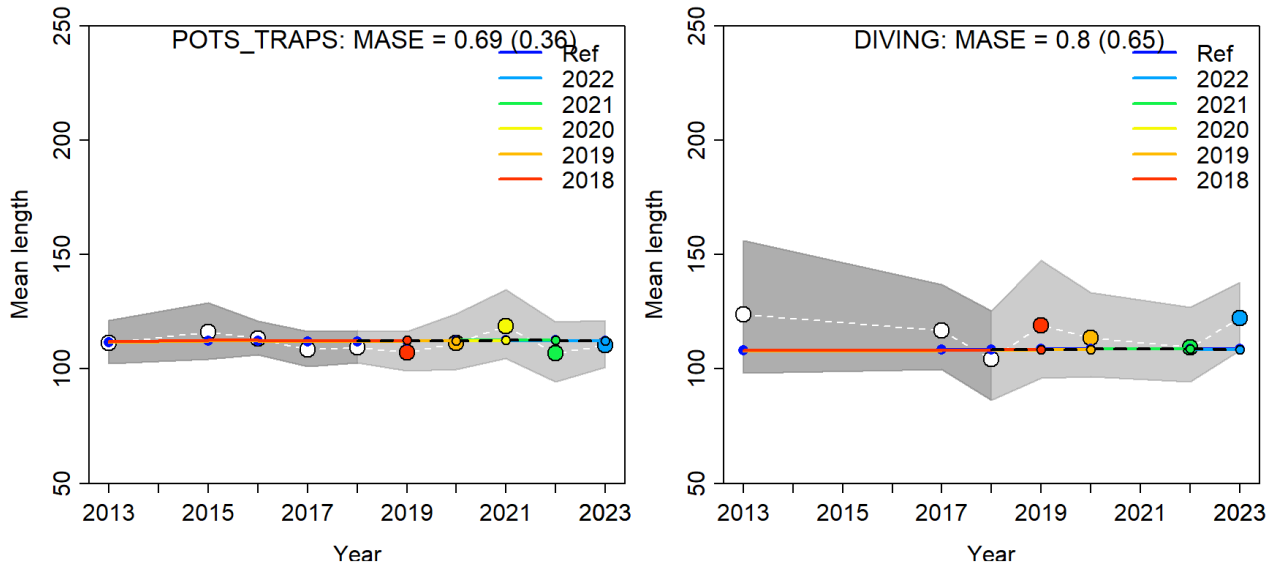


Figure 9.19: St. Thomas/St. John spiny lobster hindcast cross-validation plots of mean absolute scaled error (MASE) from hindcast model prediction of length composition time series by fleet: pot/trap fleet (left) and dive fleet (right).

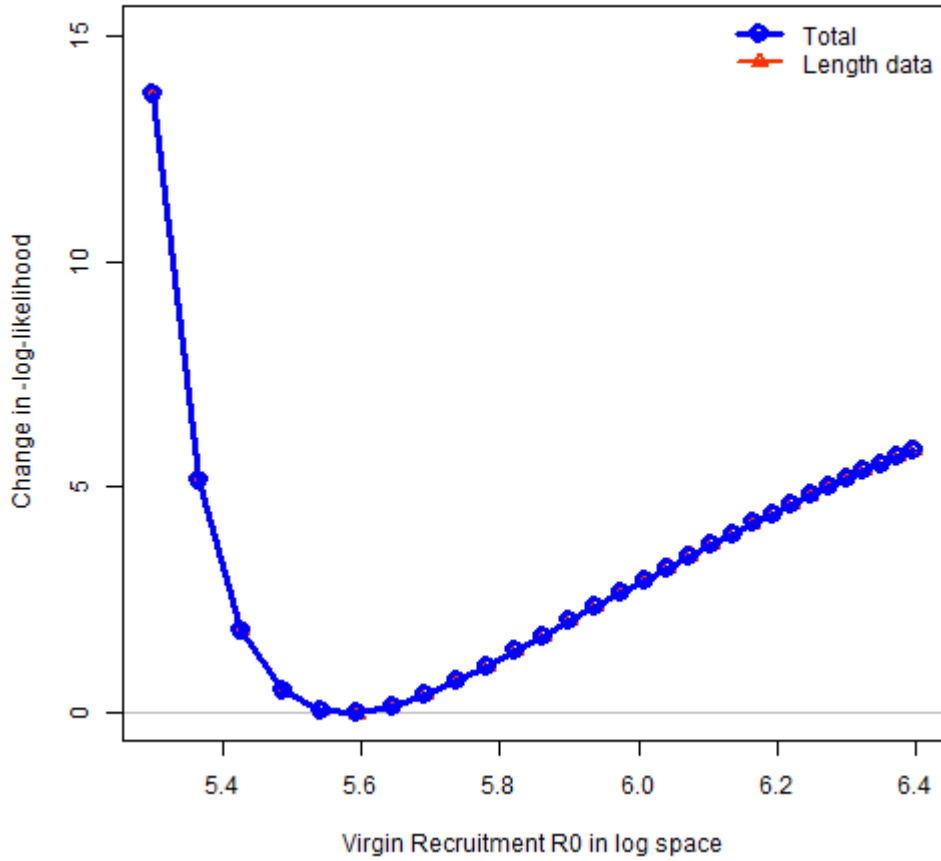


Figure 9.20: The profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for St. Thomas/St. John spiny lobster (*base* model). Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed unfished recruitment values tested in the profile diagnostic run.

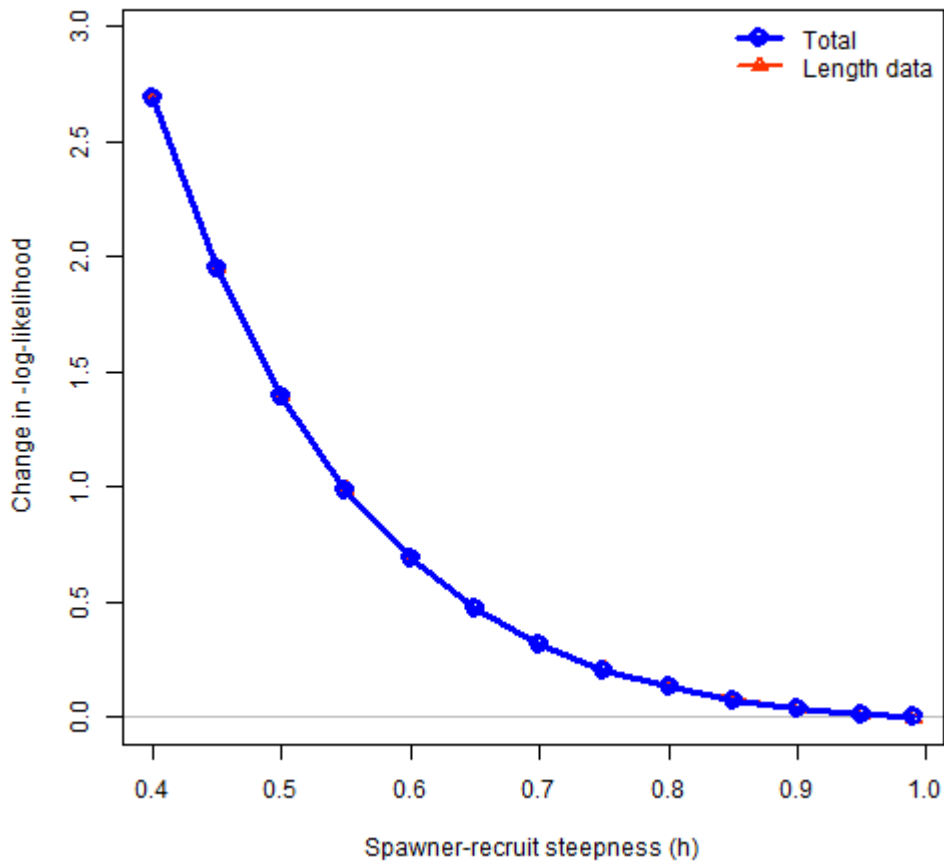
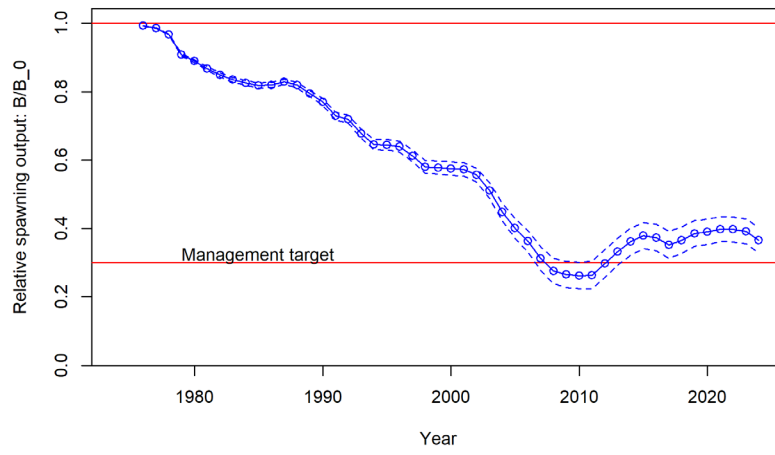
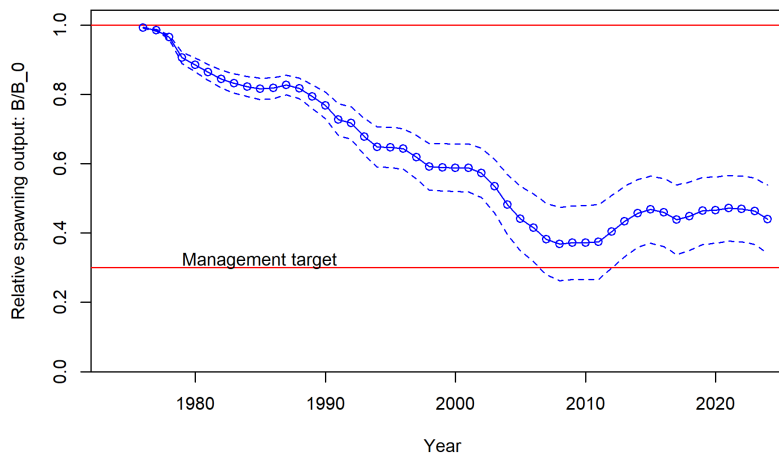


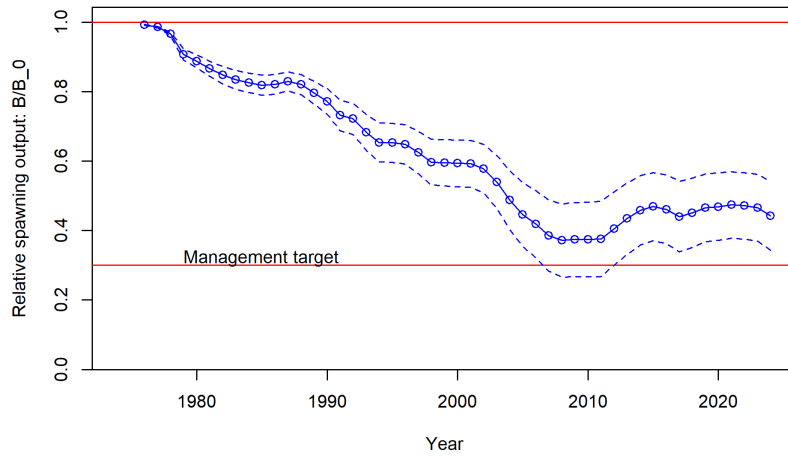
Figure 9.21: The profile likelihood for the steepness parameter of the Beverton – Holt stock-recruit function for St. Thomas/St. John spiny lobster (*base* model). Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed steepness values tested in the profile diagnostic run.



(selex 1)

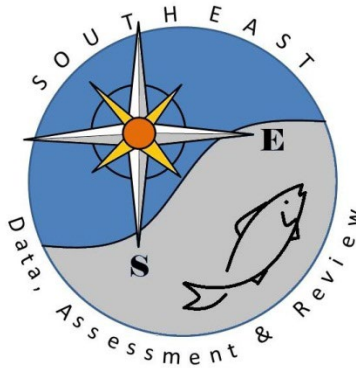


(selex 2)



(lw)

Figure 9.22: St. Thomas/St. John spiny lobster estimated relative spawning output (biomass/unfished biomass) from *selex1* (top) and *selex2*, and *lw* sensitivities.



SEDAR

Southeast Data, Assessment, and Review

SEDAR 91

US Caribbean Spiny Lobster – St. Thomas / St. John

SECTION IV: Research Recommendations

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

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1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

-When developing new research projects, consider how those projects can be designed to include data collection and/or analyses that would inform ecosystem models and analyses. The original objectives of the project should not be compromised, however.

1.1 LIFE HISTORY RESEARCH RECOMMENDATIONS

- Life history studies focused on the US Caribbean – generate region-specific parameters for growth, fecundity, natural mortality.
- Look for ongoing growth/aging work via SEAMAP-C
- Merge selectivity studies, life history data collection, and fishery-independent survey frameworks to determine how to get best data for stock assessment

1.2 COMMERCIAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

1.2.1 Length Composition Research Recommendations

- Compare SEAMAP-C to TIP size composition to better inform gear selectivity.

1.2.2 Commercial Landings Research Recommendations

- Track number of fishers per year in relation to annual landings.
- Support connectivity studies consider spiny lobster as one stock vs. by island (metapopulation).
- Investigate weak/lack of correlation between TIP and landings data.
- Conduct a supplemental exploratory analysis to look at the STTJ trap CPUE in lbs./trap/hour.
- Investigate species associations with spiny lobster.

- Demand analysis: look at price per pound (survey), market preferences, trends and correlation with landings, and for all islands.
- Market survey to determine whether the size of the lobster being landed is a response to the market preference/availability.
- Increase funding for port samplers to improve TIP data collection in PR and USVI.
- Propose new gear type of “diving on traps” in TIP reports (larger conversation to be had among those collecting and collating data).
 - a) Recommended this be a conversation including all jurisdictions,
 - b) Periodically review gears on forms to ensure they are accurate

1.2.3 Discards and Discard Mortality Research Recommendations

- Discard information in the catch reports doesn’t include data on length or sex in current reporting schema

1.3 RECREATIONAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

No research recommendations were provided.

1.4 MEASURES OF POPULATION ABUNDANCE RESEARCH RECOMMENDATIONS

- The panel recommended moving forward with planned lobster trap surveys in the US Virgin Islands.

2. ASSESSMENT PROCESS RESEARCH RECOMMENDATIONS

- Continue the SEAMAP-C data collection program for collecting spiny lobster size composition data.
- Consider the use of management strategy evaluation to explore the uncertainty in non-commercial catches.

3. REVIEW PANEL RESEARCH RECOMMENDATIONS

The Review Workshop was cancelled so there were no review panel research recommendations compiled.