SEDAR
Southeast Data, Assessment, and Review

SEDAR 35
Stock Assessment Report

U.S. Caribbean Red Hind

October 2014

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

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SECTION I: Introduction

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EXECUTIVE SUMMARY

SEDAR 35 addressed the stock assessment for U.S. Caribbean red hind. The assessment process consisted of an in-person data workshop, a series of assessment webinars, and a CIE desk review. The Data Workshop was held March11-13, 2013 in St. Thomas, USVI, the Assessment webinars were held between May and July 2014, and the Desk Review was conducted August-September 2014.

The Stock Assessment Report is organized into 5 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 three stages of the process (data, assessment, and review) can be found in Section IV for easy reference. Section V documents the discussions and findings of the Review Workshop (RW).

The final Stock Assessment Report (SAR) for the U.S. Caribbean red hind was disseminated to the public in October 2014. The Caribbean Fishery Management 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 November 2014 meeting, with the Council reviewing those recommendations at its next meeting, likely in in December 2014. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

During the assessment process several data and modeling topics received a lot of discussion. Those topics included:

- Recreational landings peak in 2005, and subsequent drop in 2006, for Puerto Rico: The analytic team investigated the issue and found that the high variability in landings and discards likely resulted from low numbers of intercepts (i.e. a fishing trip interviewed by a dockside port sampler) that reported Red Hind (6-42 intercepts per year). The high 2005 landings were primarily due to a high mean catch rate and high effort within a single stratum. No information indicated that the values were incorrect or should be adjusted.

- Variability in the Puerto Rico correction (expansion) factors: It was recommended that the data used to estimate the expansion factors be evaluated. In addition, it was recommended that the data be reviewed for possible limitations due to small sample size (number of intercepts). Raw data used to calculate the correction factors were available for only one year (2011). For all other years, data were only available in summary form. With only a single year of detailed data available, a thorough review of the calculation of correction factors could not be conducted.

- Use the spawning aggregation data as relative indices of abundance: Three spawning aggregation data sets were examined, however none were deemed appropriate for developing indices of abundance for a variety of reasons including a gap in time series, highly variable, and a limited time series.

- Yield-per-Recruit and Spawner-per-recruit analyses: These analyses was presented during the assessment process as a method to estimate fishing mortality reference points, assuming various F_{MSY} proxies. This allows you to compare the current fishing mortality estimates to reference points and determine the probability of the stock experiencing overfishing.

- Appropriate F_{MSY} proxies: Proxies discussed by the Panel included F_{MAX}, $F_{0.1}$, $F_{30\%}$, and $F_{40\%.}$ The discussion about whether to use F0.1 and FSPR30% (or FSPR40%) was centered on biological considerations and acceptable risk. The Panel agreed that the risk of recruitment overfishing outweighed the risk of growth overfishing and given the seasonal and spatial closures for Red Hind, F30% and F40% were reasonable FMSY proxies.

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 of Mexico, 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 series of webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final 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.

SEDAR 35 differed from the normal benchmark assessment process in that an in-person Review Workshop was not convened. Instead the SEFSC and Caribbean Council agreed to holding a desk review of the assessment, meaning three reviewers appointed by the Center for Independent Experts (CIE) where each prospered the assessment and supporting materials and each preformed their own independent review of the assessment and provided a report of their findings to SEDAR for inclusion in the final report. This modification of the Review Process was related to the limited data availability and assessment methods used during this process.

2. MANAGEMENT OVERVIEW

2.1. *Fishery Management Plan and Plan Amendments*

The U.S. Caribbean includes the islands of Puerto Rico and the U.S. Virgin Islands (USVI) including St. Thomas, St. John, and St. Croix. The state waters of Puerto Rico extend 9 nm from the shore and the state waters of the USVI extend 3 nm from shore. The following is a summary of the management measures that directly or indirectly have impacted the red hind (*Epinephelus guttatus*) fishery in the U.S. Caribbean exclusive economic zone (EEZ).

Measures in the original FMP, and in the amendments, that might affect red hind include changes to requirements for the constructions of traps (in both the Spiny Lobster and Reef Fish

FMPs), seasonal and/or area closures, gear restrictions, bag limits, and catch limits established through amendments to the Reef Fish FMP:

Description of Action	FMP/Amendment	Effective Date
Traps: construction and requirement for degradable panel	Spiny Lobster FMP	1985
Traps: construction and requirement for degradable panel; changes to mesh size	Reef Fish FMP/Amendment 1/Regulatory Amendment 1/Amendment 2/Technical Amendment/SFA	1985/1990/1991/1993/1994/2005
Seasonal area closures	Amendment 1/Amendment 2/ Amendment 3/Interim Rule/SFA	1990/1993/1996/1999/2005
No take Hind Bank Marine Conservation District	Coral FMP Amendment 1	1999
Seasonal Closure for Red Hind	Amendment 2/Regulatory Amendment 2/SFA/Regulatory Amendment 3	1993/1997/2005/2010
Gear Restrictions	SFA	2005
Annual Catch Limits/Accountability Measures	Amendment 5	2012
Bag Limit	Amendment 5	2012

Reef Fish FMP

The Council implemented the Reef Fish FMP (CFMC 1985; 50 FR 34850) in September of 1985. The Council implemented this FMP in an attempt to address the decreasing catches of shallow water reef species reported in the U.S. Caribbean. The FMP established the following management measures with respect to red hind:

1. **Fishery Management Units**
    - Identified the FMU to include 64 shallow water reef species distributed among 14 families as the most commonly landed species in Puerto Rico and the USVI. These 64 species accounted for 60 percent of the total finfish landings in the total area from shoreline to the edge of the insular platform.

2. **Management Reference Points**

- Identified the MSY and OY to be 7.7 million pounds (lbs) for the entire shallow water reef species FMU.
- Concluded that local fishermen were harvesting 100% of the OY. Therefore, there was no remaining harvest identified for foreign fishing.

3. **Gear**
   - Established a minimum mesh size for fish traps of 1 ¼ in to allow for the escape of juvenile fish.
   - Required a self-destruct panel (not smaller than the funnel opening of the trap) and/or self-destruct door fastening in fish traps.
   - Required owner identification and markings of traps, buoys, and boats in the EEZ. Allowed for:
     a. Marking/identification systems required by the Puerto Rico and USVI management agencies can be used by fishermen of those states to meet the federal marking requirements.
     b. If the state(s) eliminates the marking system or a fisherman will fish only in the U.S. Caribbean EEZ, an identification number and color code will be assigned by the NMFS Southeast Regional Director upon application.
   - Prohibited the hauling or tampering of another person's traps without owner's written permission, except by authorized enforcement officer to alleviate the theft of fish traps.
   - Prohibited the use of poisons, drugs, other chemicals, and explosives for fishing in the management area as these practices do not discriminate between species or species sizes and are detrimental to the environment.

Amendment 1

The Council implemented Amendment 1 to the Reef fish FMP (CFMC 1990a; 55 FR 46214) in December of 1990. The Council determined that more stringent management measures needed to be in place to achieve the goals of the Reef Fish FMP. Data from the Cooperative Fishery Statistics Program presented a continued downward trend in species composition and volume of landings. For example, the red hind populations in Puerto Rico were showing a decline in average size. To address these issues, the Council implemented the following measures:

1. **Gear Requirements**
   - Increased the minimum mesh size from 1¼ in to 2 in in the smallest dimension to further reduce bycatch of juveniles essential to the maintenance of the reef ecosystem balance.
   - Revised the data collection efforts to include the collection of socio-economic information on the different managed fisheries.

- Per request of the St. Thomas and St. John fishermen, the Council established a closed area off the southwest of St. Thomas to the harvest of red hind during its spawning season of December 1 through February 28 of each year. This area was known as the Hind Bank Marine Conservation District (Figure 1). The amendment prohibited the use of any and all fishing gear capable of capturing reef fish, such as fish traps, hook and line, bottom nets, and spear during the seasonal closure.

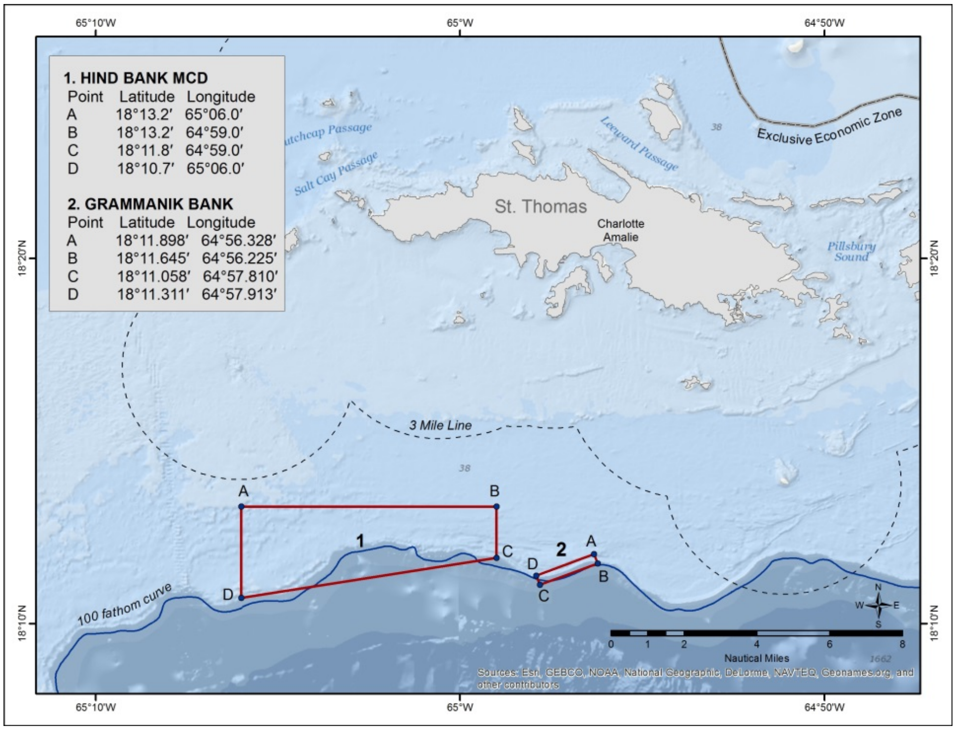


Figure 2.1 Map of the Hind Bank Marine Conservation District closed area (#1) off St. Thomas, USVI. Grammanik Bank (#2) seasonal area closure was established in 2004 to protect yellowfin grouper.

2. **Management Reference Points**
   - Defined overfishing and overfished for shallow water reef fish. A reef fish stock or stock complex is overfished when it is below the level of 20 percent of the spawning stock biomass per recruit that would occur in the absence of fishing. When a reef fish stock or stock complex is overfished, overfishing is defined as harvesting at a rate that is not consistent with a program that has been established to rebuild the stock or stock complex to the 20 percent spawning stock biomass per recruit level. When a reef fish stock or stock complex is not overfished; overfishing is defined as a harvesting rate that if continued would lead to a state of the stock or stock complex that would not at least allow a harvest of OY on a continuing basis.

3. **Essential Fish habitat**

- Described the characteristics of the habitat used by the stocks in the shallow water reef species FMU.

Regulatory Amendment 1

The Council implemented Regulatory Amendment 1 to the Reef Fish FMP (CFMC 1991; 56 FR 48755) in October 1991. In 1989, Hurricane Hugo hit Puerto Rico resulted in many fishermen losing fishing gear. The Small Business Administration provided loans to fishermen to assist in replacing lost gear including fish traps. However, instead of buying the required 2 in mesh wire they acquired square mesh wire of 1.5 in. The Council had to modify their minimum 2 in mesh size requirement to avoid further economic hardships to the fishermen. Therefore, the Council implemented the following requirements to compensate for the lack of smaller mesh size:

- Traps fabricated of bare hexagonal wire of 1.5 in in the smallest dimension or wire mesh of 2 in (bar measure) must have openings (8 x 8 in) on each of two opposing sides of the trap (excluding the top, bottom, and side with funnel opening). The fishermen need to cover the 8 x 8 in openings with a panel of wire of a mesh size no less than that of which the trap is constructed and attached with untreated jute of a maximum diameter of 1/8 in. The Access door may serve as one of the panels if it is hinged at the bottom and fastened with 1/8 in jute at the top so that the door would fall open when the fastener degrades. Jute used to secure the panels may not be wrapped or overlapped to extend degradation time.
- Traps constructed with square-mesh bare wire of 1.5 x 1.5 in must have openings of 9 x 9 inches covered with a panel of a mesh of no less than 2-in square-mesh wire on each of two opposing sides of the trap (excluding the top, bottom and side with funnel opening) and attached as described above. The Council disallowed the use of all 1.5-in square-mesh wire in the fishery by September 14, 1993.
- All wire mesh measurements are from center of strand to center of strand in accordance with manufacturers' specifications.
- Plastic traps and vinyl-coated wire traps must conform to the same mesh measurements and escape panel requirements for bare wire traps. The dimensions of the mesh openings in plastic and vinyl-coated wire traps must be equivalent to the mesh opening specifications for bare wire traps.

Amendment 2

The Council implemented Amendment 2 to the Reef Fish FMP (CFMC 1993; 58 FR 53145), in November of 1993. The growing concern by the Council about the scarce resources, protection to spawning aggregations, and extend the protection to other reef species not presently within the

FMU led to the development of this amendment. To address these concerns, the Council did the following:

1. **Fishery Management Unit**
   - The amendment also extended protection to the aquarium trade finfish species. The Council wanted to make sure that the increase in export of aquarium trade species and gears used to remove the species was not detrimental to the species populations, habitat, and the industry itself. Through this amendment, the Council prohibited the use of chemical substances or other destructive devices to harvest these species. Collectors could only use hand-held dip nets and slurp guns to collect the aquarium trade species.
   - Prohibited the harvest of red hind (*Epinephelus guttatus*) juveniles to allow for recovery.

2. **Management Reference Points**
   - Applied existing definitions of MSY and OY to all reef fish within the revised FMU, with the exception of marine aquarium finfish.
   - The MSY and OY of marine aquarium finfish remained undefined.

3. **Gear Requirements**
   - Required that the fish traps be constructed as follows:

     (a) Basic construction material must be of 1.5 in hexagonal mesh wire or 2.0 in square mesh wire;

     (b) The escape openings in the trap must be of at least 8x8 in and located on any two sides (except top, bottom, or side containing the funnel);

     (c) The access door may serve as an escape opening provided it meets all the requirements for a size and location, and is fastened in such a manner that the door will fall open when the fasteners degrade;

     (d) The panels covering the escapes openings must be of a mesh at least as large as the mesh used in constructing the trap, and fastened with untreated jute twine 1/8 in or less in diameter when traps are fitted with zinc anodes; or fastened with 18 gauge un-galvanized wire or 1/8 in untreated just twine (maximum diameter) if anodes are not used.

5. Seasonal Closures

- To protect the spawning of red hind, the Council established a closure December 1 through February 28 of each year. This measure would protect the red hind spawning aggregation off the west end of Puerto Rico. The area lays to the west of Tourmaline buoy, west of Mayaguez, Puerto Rico (Figure 2).

- To protect the spawning of red hind, the Council established a closure from December 1 through February 28 of each year. This measure would protect the red hind spawning aggregation off the east of St. Croix. The area lies to the extreme eastern end of Lang Bank (Figure 3).
- To protect the spawning aggregation of mutton snapper, the Council established a closure from March 1 through June 30 of each year. This measure indirectly protects the red hind during that time since all fishing is prohibited (Figure 3).

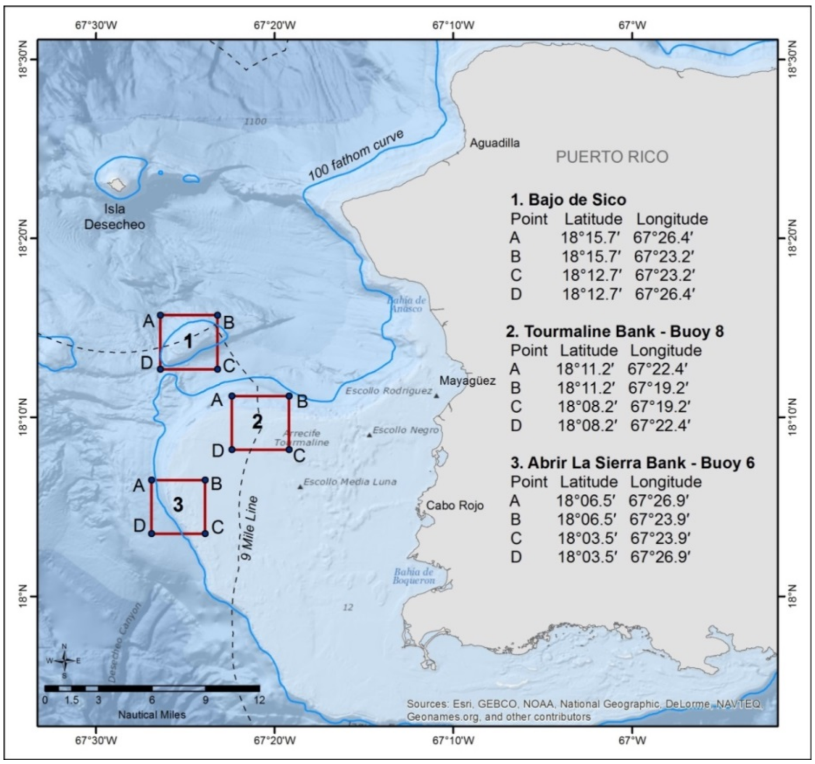


Figure 2.2 Map of the Tourmaline (#2) closed area off the west coast of Puerto Rico.

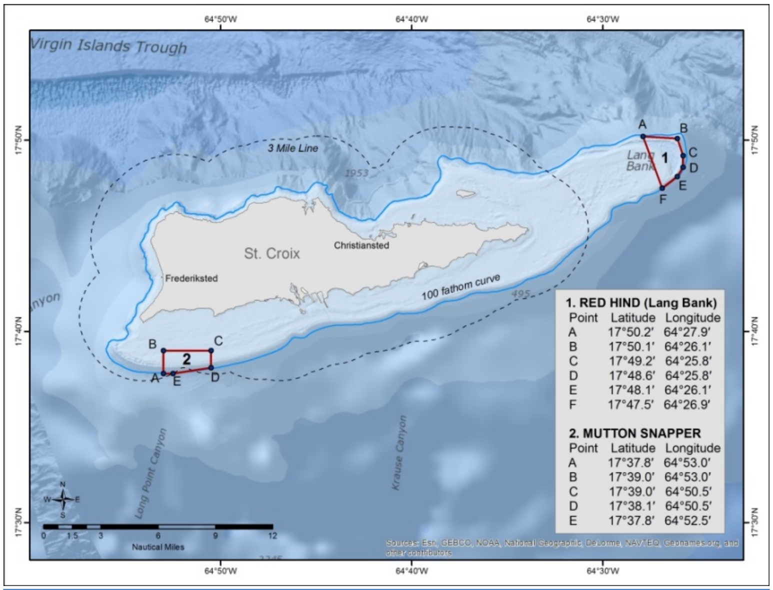


Figure 2.3 Map of the Red Hind Lang Bank (#1) and Mutton Snapper Spawning Aggregation Area (#2) closed area off St. Croix, USVI.

Technical Amendment

The Council implemented this technical amendment to the Reef Fish FMP (59 FR 11560), in April of 1994 to help clarify the minimum mesh size requirement for the fish traps in the U.S. Caribbean EEZ.

The amendment modified the regulations for measure the minimum allowable mesh size to be a measure between the centers of strands rather than the smallest dimension of the opening. The manufactures of the wire use the measurements between the centers of the strands as their standard measurements. Fishermen were using coated–wire fish traps with mesh constructed of this standard size. The difference between the industry standard bare wire and coated wire is approximately 0.23 in (5.84 mm) not considered significant for purposes of fishery conservation. The clarification included the following text:

> *.....Mesh size. A bare-wire fish trap used or possessed in the EEZ that has hexagonal mesh opening must have a minimum mesh size of 1.5 inches (3.8 cm), in the smallest dimension measures between centers of opposite strands. A bare-wire fish trap used or possessed in the EEZ that has other than hexagonal mesh openings or a fish trap of other than bare wire such as coated wire or plastic used or possessed in the EEZ must have a minimum mesh size of 2.0 inches (5.1 cm), in the smallest dimensions measures between centers of opposite strands…*

Regulatory Amendment 2

The Council implemented Regulatory Amendment 2 to the Reef Fish FMP (CFMC 1996; 61 FR 64485) in January 1997. The amendment reduced the size of the Tourmaline Bank closed area originally implemented in 1993, and established seasonal closures in two additional areas off the west coast of Puerto Rico (Abrir La Sierra Bank and Bajo de Sico).

The Council implemented this regulatory amendment based on recommendations by the fishermen in Puerto Rico to modify the size and limits of the Tourmaline Bank red hind close area. The fishermend argued that the red hind spawning aggregation was restricted to a 1.5 miles radious around Buoy 8/Tourmaline Bank and not most of the area west of this radious. In addition, the closed area limits precluded fishermen from moving and storing fish straps in the sandy bottom of the tourmaline bank during bad weather events. Furthermore, the Council considered the outcome of surveys showing continued decreases in the mean size of the red hind populations. The Council decided to adopt the following measures:

- Close the corresponding sections of the EEZ in all three (3) areas presented below to all fishing between December 1 and February 28 of each year.
    - One and a half (1.5) miles radius centered around a buoy to be deployed in the area known as "Bajo de Sico." (Figure 4)
    - One and a half (1.5) miles radius around Buoy 8 at Tourmaline Bank. (This is part of the area already closed but it allows for the use of the sandy area where red hinds are not found (Figure 4).
    - One and a half (1.5) miles radius around Buoy 6 at Abrir La Sierra Bank (Figure 4).

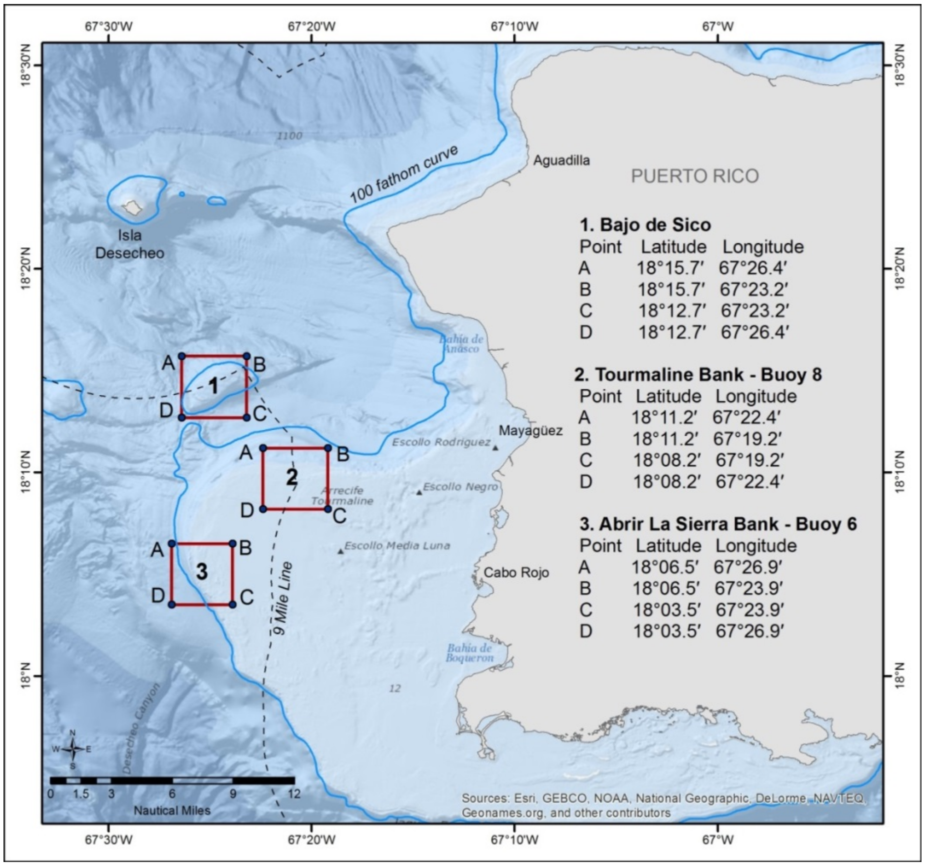


Figure 2.4 Map of the Bajo de Sico (#1) and Abrir La Sierra Bank (#3) closed areas off the west coast of Puerto Rico.

Amendment 1 to the Coral FMP

The Council implemented Amendment1 to the Coral FMP (CFMC 1999) in December 6, 1999, to protect important marine resources by establishing a year round closure at the Hind Bank Marine Conservation District (MCD). All fishing and anchoring are prohibited within the Hind Bank MCD.

Amendment 3

The Council implemented Amendment 3 to the Reef Fish FMP (CFMC 2005) in 2005 to address required provisions of the Magnuson-Stevens Fishery Conservation and Management Act (Caribbean SFA Amendment). The Council implemented the following measures:

1. **Gear Requirements**
   - Amended the current requirements for trap construction such that only one escape panel be required, which could be the trap door.

- This modified the regulation implemented through Regulatory Amendment 1, which required that each fish trap contains two degradable (escape) panels in addition to a self-destruct door fastening;
- Under this action, each fish trap must contain at least one degradable panel, which could be a self-destruct door fastening if the door was positioned on the side of the trap;
- The degradable panel had to be 8 x 8 in and with the mesh not smaller than the mesh of the trap;
- It also required that individual traps or pots have at least one buoy attached that floats on the surface; and
- Required that traps or pots tied together in a trap line have at least one buoy that floats at the surface at each end of the trap line;

- Prohibited the use of gillnets and trammel nets in the EEZ.
  - With the exception of those nets used for catching ballyhoo, gar, and flying fish. Nets used for the harvest of these species must be tended at all times.
- Prohibited the use of bottom tending gear (traps, pots, gillnets, trammel nets, bottom longlines) in the seasonally closed areas of Tourmaline, Bajo de Sico, Abrir la Sierra, Lang Bank, Mutton Snapper Spawning Aggregation Area, and Grammanik Bank.
- Required an anchor retrieval system for anyone fishing or possessing reef fish species.
- Prohibited the filleting of fish at sea.

2. Seasonal Closures

- Established a seasonal area closure in the area known as Grammanik Bank south of St. Thomas prohibiting all fishing from February 1 – April 30 of each year (Figure 1.1).
- Established seasonal closures (no fishing or possession) for Red hind from December 1 through the last day of February, each year.

3. Management Reference Points

- "In the absence of MSY estimates, the proxy for MSY will be derived from recent average catch (C), and from estimates of the current biomass (B_{CURR}/B_{MSY}) and fishing mortality (F_{CURR}/F_{MSY}) ratios as: $MSY = C/[(F_{CURR}/F_{MSY}) \times (B_{CURR}/B_{MSY})]$; where C is calculated based on commercial landings for the years 1997-2001 for Puerto Rico and 1994-2002 for the USVI, and on recreational landings for the years 2000-2001."
- "For each FMU sub-unit for which B_{CURR}/B_{MSY} and F_{CURR}/F_{MSY} have not been estimated through a stock assessment or other scientific exercise (i.e., stock status unknown), the following estimates will be used for the B_{CURR}/B_{MSY} and F_{CURR}/F_{MSY}

proxies: 1) For species that are not believed to be "at risk" based on the best available information, the F_{CURR}/F_{MSY} proxy is estimated as 0.75 and the B_{CURR}/B_{MSY} proxy is estimated as 1.25; 2) For species for which no positive or negative determination can be made on the status of their condition, the default proxies for F_{CURR}/F_{MSY} and B_{CURR}/B_{MSY} are estimated as 1.00; and 3) For species that are believed to be "at risk" based on the best available information, the F_{CURR}/F_{MSY} proxy is estimated as 1.50 and the B_{CURR}/B_{MSY} proxy is estimated as 0.75."

- "Set OY equal to the average yield associated with fishing on a continuing basis at F_{OY}; where $F_{OY} = 0.75F_{MSY}$."
- "Set MSST = B_{MSY}(1-c); where c = the natural mortality rate (M) or 0.50, whichever is smaller."
- "A) Specify an MSY control rule to define ABC = F_{MSY}(B). When the data needed to determine FMSY are not available, use natural mortality (M) as a proxy for F_{MSY}; and B) Specify an OY control rule to define target catch limits such that they equal F_{OY}(B)."
- In the case of a sub-unit with multiple M values, the lowest documented M value would be used in this formula to reduce the risk the most vulnerable species in a particular sub-unit would be overexploited. The specific MSST values that would be defined by this alternative in accordance with the preferred MSY alternatives are presented for each stock or complex in Table 1.

Table 2.1 Biological reference points and stock status determination criteria for the Reef Fish FMU subunits. Values in 1,000 pounds.

FMU	Status	MSY	OY	ABC/MFMT	Recent Catch	BMSY	BCURR/BMSY	MSST	BCURR/MSST	FMSY	FCURR/FMSY	M
Snapper 1	At risk	493	463	370	478	1,202	0.75	601	1.50	0.86	1.50	0.86
Snapper 2	Unknown (at risk)	151	142	151	151	516	1.00	289	1.79	0.44	1.00	0.44
Snapper 3	Unknown	542	508	542	542	2,403	1.00	1,682	1.43	0.30	1.00	0.30
Snapper 4	Unknown	365	342	365	365	2,214	1.00	1,771	1.25	0.20	1.00	0.20
Grouper 1	Overfished	2-25		-	25	20-190	<<1	18-171	<<.9	0.18	-0	0.18
Grouper 2	Overfished	2-11	1.88-23.44	-	7	40-120	<<1	38-114	<<.95	0.13	-0	0.13
Grouper 3	Unknown	158	1.88-10.31	158	158	1,045	1.00	857	1.22	0.18	1.00	0.18
Grouper 4	At risk	95	148	71	102	626	0.75	513	0.91	0.18	1.50	0.18
Grunts	Unknown	195	183	195	195	739	1.00	462	1.60	0.38	1.00	0.38
Goatfishes	Unknown	24	23	24	24	58	1.00	29	2.00	0.89	1.00	0.89
Porgies	Unknown	45	42	45	45	118	1.00	59	2.00	0.72	1.00	0.72
Squirrelfishes	Unknown	27	25	27	27	75	1.00	37	2.00	0.64	1.00	0.64
Tilefish	Unknown	3	3	3	3	11	1.00	6	1.72	0.42	1.00	0.42
Jacks	Unknown	310	291	310	310	1,283	1.00	860	1.49	0.33	1.00	0.33
Parrotfishes	At risk	304	285	228	312	1,053	0.75	600	1.32	0.43	1.50	0.43
Surgeonfish	Unknown	36	34	36	36	152	1.00	104	1.47	0.32	1.00	0.32
Triggerfish and Filefish	Unknown	196	184	196	196	939	1.00	686	1.37	0.27	1.00	0.27
Boxfish	Unknown	113	106	113	113	386	1.00	216	1.79	0.44	1.00	0.44
Wrasses	Unknown	67	63	67	67	341	1.00	255	1.33	0.25	1.00	0.25
Angelfish	Unknown	8	8	8	8	28	1.00	16	1.72	0.42	1.00	0.42
Aquarium Trade	Unknown	-	-	-	29,469		-	-	-	-	-	-

4. **Essential Fish Habitat**
    - Described and identified EFH according to functional relationships between life history stages of Council managed species and Caribbean marine and estuarine habitats.
    - Designate HAPCs in the Reef Fish and Coral FMPs based on confirmed spawning locations and on areas or sites identified as having particular ecological importance to managed species.
        a. Designated HAPCs in the Reef Fish FMP at the following areas based on the occurrence of confirmed spawning locations:
            i. I. Puerto Rico
                A. Tourmaline Bank/Buoy 8;
                B. Abrir La Sierra Bank/Buoy 6;
                C. Bajo de Sico; and
                D. Vieques, El Seco.

            ii. II. St. Croix
                A. Mutton snapper spawning aggregation area;
                B. East of St. Croix (Lang Bank).

            iii. III. St. Thomas
                A. Hind Bank MCD; and
                B. Grammanik Bank.

        b. Designated HAPC for the Reef Fish FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean reef fish species:
            i. Puerto Rico
                A. Hacienda la Esperanza, Manití;
                B. Bajuras and Tiberones, Isabela;
                C. Cabezas de San Juan, Fajardo;
                D. JOBANNERR, Jobos Bay;
                E. Bioluminescent Bays, Vieques;
                F. Boquerón State Forest;
                G. Pantano Cibuco, Vega Baja;
                H. Piñones State Forest;
                I. Río Espiritu Santo, Río Grande;
                J. Seagrass beds of Culebra Island (nine sites designated as Resource Category 1 and two additional sites); and
                K. Northwest Vieques seagrass west of Mosquito Pier, Vieques.

            ii. St. Thomas

A. Southeastern St. Thomas, including Cas Key and the mangrove lagoon in Great St. James Bay; and

B. Saba Island/Perseverance Bay, including Flat Key and Black Point Reef.

iii. St. Croix

A. Salt River Bay National Historical Park and Ecological Preserve and Marine Reserve and Wildlife Sanctuary;
B. Altona Lagoon;
C. Great Pond;
D. South Shore Industrial Area; and
E. Sandy Point National Wildlife Refuge.

Regulatory Amendment 3

The Council implemented Regulatory Amendment 3 to the Reef Fish FMP (CFMC 2010; 50 CFR Part 622) in December of 2010. The amendment modified the Bajo de Sico seasonal closure. The Bajo de Sico has been identified as an important spawning site, especially for red hind and possibly other resident groupers including Nassau and yellowfin, as well as an important foraging site for these and other Caribbean reef fish. The Bajo de Sico closed area has been described as a well-developed and diverse coral and sponge habitat that provides essential fish habitat for Caribbean reef fish. The purpose of the regulatory amendment was to protect red hind spawning aggregations and large snapper and grouper from directed fishing mortality. Primary management measures implemented through this amendment are as follows:

- Modified the original length of the yearly seasonal closure for Bajo de Sico of December 1 through the last day of February to October 1 through March 31;
- Prohibited fishing for or possession of Council-managed reef fish species in Bajo de Sico;
    - Fishing for highly migratory species (HMS), coastal migratory pelagics (dolphin, wahoo, jacks, and mackerel) and spiny lobster would be allowed all year.
- Prohibited anchoring year-round within Bajo de Sico closed area.

Amendment 5

The Council implemented Amendment 5 to the Reef Fish FMP (CFMC 2011; 76 FR 82404) in January of 2012 to address the new requirements of the 2007 reauthorization of the Magnuson-Stevens Act. The primary management measures implemented by this amendment were:

1. **Management Reference Points**

- Specified ACLs and AMs to prevent overfishing of species considered overfished or undergoing overfishing.
- Established management reference points: MSY and OY for managed species or species groups.
- Modified existing management measures as needed to constrain harvest to specified ACLs.
- Specified separate commercial and recreational annual catch limits in Puerto Rico based on the preferred management reference point time series.

The Magnuson-Stevens Act required that the Council to redefined the management reference points or proxies by 2010 for the species undergoing overfishing (snappers, groupers, parrotfish, and queen conch). For the commercial sector, the Council chose landings between 1988-2005 for Puerto Rico, 1999-2005 for St. Croix, and 2000-2005 for St. Thomas/St. John as the years of the best reliable landings data to use in modifying the existing management reference points. The Council also chose 2000-2005 as the years of best reliable landings data for the recreational sector of Puerto Rico (Table 2).

a. Maximum Sustainable Yield (MSY)

The Council updated the MSY established in the 2005 SFA Amendment to reflect the average of annual landings in Puerto Rico and the USVI based on the time series selected above as the years of best reliable landings data (Table 3).

b. Overfishing Limit (OFL)

The OFL value was a new Magnuson-Stevens Act requirement. The OFL was defined as the maximum rate of fishing a stock can withstand (MFMT) or maximum yield a stock can produce (OFL) annually, while still providing MSY on a continuing basis. The Council determined that the OFL for Puerto Rico and USVI would be equal to the MSY proxy.

In addition, the SSC determined that overfishing would occur if and when annual landings exceeded the OFL, unless the NMFS/SEFSC (in consultation with the Council and the SSC) determined the overage occurred because data collection/monitoring improved, rather than because landings actually increased.

c. Acceptable biological catch (ABC)

After the Council established the OFL they proceeded to established an ABC. The ABC is the range of acceptable catch for a species or species group. The ABC, as well as the OFL, were new Magnuson-Stevens Act requirements. The Council determined that the ABC would be equal to the OFL. Defining the ABC could entail applying a buffer to the OFL that represents an acceptable level of risk due to scientific uncertainty. However, the Council could also have set the ABC equal to OFL.

d. Annual Catch Limit

The ACL is the level of annual catch of a stock or stock complex that serves as the basis for invoking accountability measures. The Council applied a 15% percent uncertainty to the ABC to reduce the risk of exceeding the OFL if the ACL is exceeded. Reducing the likelihood of exceeding the OFL, reduces the risk of applying accountability measures which could reduce the fishing season to ensure that the ACL is not exceeded again, thereby ensuring that the OFL is not exceeded and therefore that overfishing is not a continuing problem.

Table 2.2 Summary of decisions made by the Council in modifying the management reference points for species consider overfished.

REFERENCE POINT	
Maximum Sustainable Yield	MSY proxy = average annual commercial landings from 1999-2005 for Puerto Rico and STX and from 2000-2005 for STT/STJ + average annual recreational catch from MRFSS during 2000-2005 for Puerto Rico.
Overfishing Threshold	OFL = MSY proxy; overfishing occurs when annual catches exceed the OFL, unless NMFS' Southeast Fisheries Science Center (in consultation with the Caribbean Fishery Management Council and its Scientific and Statistical Committee) determines the overage occurred because data collection/monitoring improved, rather than because catches actually increased.
Optimum Yield/Annual Catch Limit	OY = ACL = [OFL x (0.85)] for snapper and grouper
Optimum Yield/Annual Catch Limit	OY = ACL = [ABC specified by Scientific and Statistical Committee for parrotfish x (0.85)]
Optimum Yield/Annual Catch Limit	OY = ACL = 0 (Grouper Units 1 and 2, midnight parrotfish, blue parrotfish, rainbow parrotfish)

Table 2.3 Management reference points for species undergoing overfishing established in the 2010 Caribbean Annual Catch Limit Amendment. Values are in pounds (lbs). For the Puerto Rico recreational sector, numbers of individuals are in parenthesis.

<table>
<tr><th>Table 1.XFMU</th><th colspan="3">Puerto Rico Commercial</th><th colspan="3">Puerto Rico Recreational</th><th colspan="3">St. Thomas/St. John</th><th colspan="3">St. Croix</th></tr>
<tr><th></th><th>MSY=OFL</th><th>ABC=OFL</th><th>ACL=OY</th><th>MSY=OFL</th><th>ABC=OFL</th><th>ACL=OY</th><th>MSY=OFL</th><th>ABC=OFL</th><th>ACL=OY</th><th>MSY=OFL</th><th>ABC=OFL</th><th>ACL=OY</th></tr>
<tr><td>Queen Conch</td><td>403,349</td><td>403,349</td><td>0</td><td>N/A</td><td>N/A</td><td>0</td><td>1,649</td><td>1,649</td><td>0</td><td>107,720</td><td>107,720</td><td>50,000</td></tr>
<tr><td>Parrotfish</td><td>127,980</td><td>127,980</td><td>52,737</td><td>37,042</td><td>15,263</td><td>15,263
(9,118)</td><td>48,818</td><td>48,818</td><td>42,500</td><td>293,219</td><td>293,219</td><td>240,000</td></tr>
<tr><td>Snapper Unit 1</td><td>334,923</td><td>334,923</td><td>284,685</td><td>112,384</td><td>112,384</td><td>95,526
(83,197)</td><td rowspan="4">157,382</td><td rowspan="4">157,382</td><td rowspan="4">133,775</td><td rowspan="4">121,113</td><td rowspan="4">121,113</td><td rowspan="4">102,946</td></tr>
<tr><td>Snapper Unit 2</td><td>171,666</td><td>171,666</td><td>145,916</td><td>40,953</td><td>40,953</td><td>34,810
(7,862)</td></tr>
<tr><td>Snapper Unit 3</td><td>406,794</td><td>406,794</td><td>345,775</td><td>97,833</td><td>97,833</td><td>83,158
(78,024)</td></tr>
<tr><td>Snapper Unit 4</td><td>439,171</td><td>439,171</td><td>373,295</td><td>33,540</td><td>33,540</td><td>28,509
(27,866)</td></tr>
<tr><td>Grouper</td><td>208,839</td><td>208,839</td><td>177,513</td><td>90,839</td><td>90,839</td><td>77,213
(93,580)</td><td>60,999</td><td>60,999</td><td>51,849</td><td>35,806</td><td>35,806</td><td>30,435</td></tr>
</table>

N/A : Not Applicable

2. Accountability measures

The AMs are defined as management controls to prevent ACLs, including sector-specific ACLs (i.e., Puerto Rico commercial and recreational sectors), from being exceeded, and to correct or mitigate overages of the ACL if they occur (50 C.F.R. § 310(g)(1)). NMFS will trigger AMs as a result of catches exceeding ACLs unless NMFS' SEFSC (in consultation with the Council and its SSC) determines the overage occurred because data collection/monitoring improved rather than because catches actually increased.

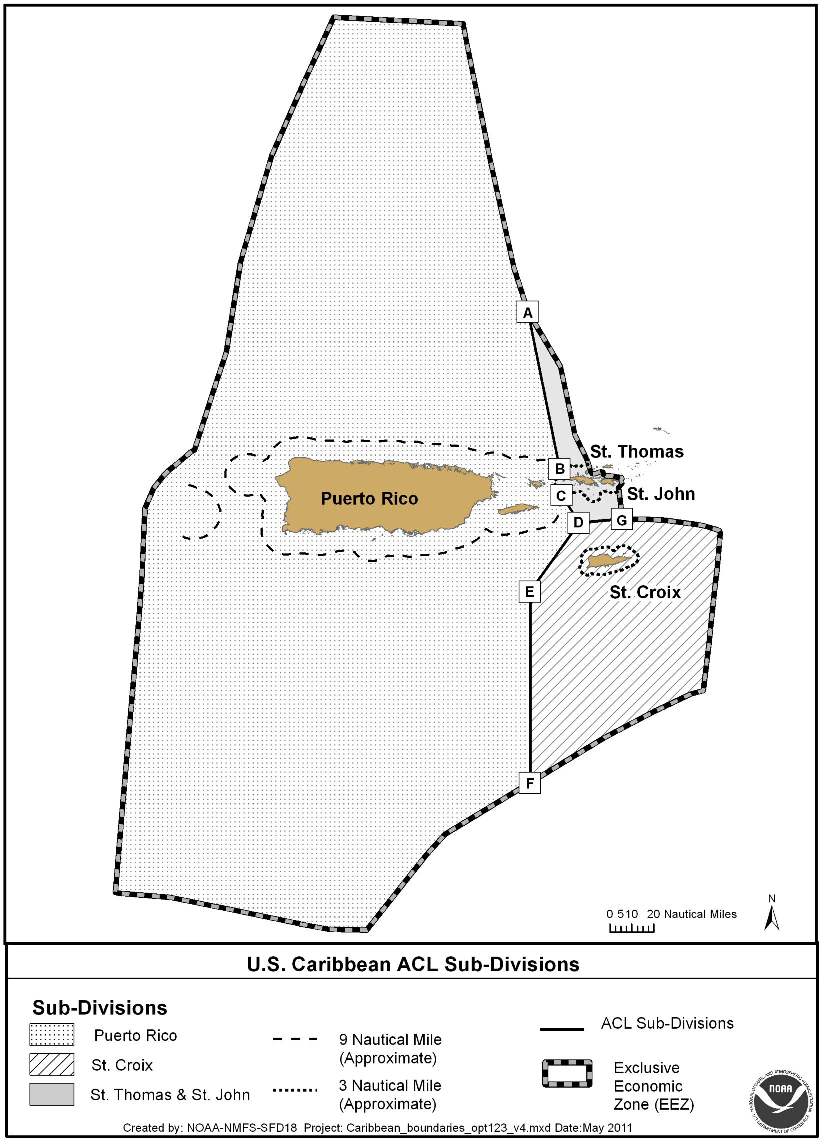
AMs will be trigger if a single year of landings effective beginning 2010, a 2-year average of landings effective 2011, then a 3-year running average of landings effective 2012 and thereafter (i.e., 2010, 2010-2011, 2010-2012, 2011-2013, etc.) exceed the established ACLs. If AMs are triggered, NMFS and the Council would reduce the length of the fishing season for that species or species group the year following the trigger determination by the amount needed to prevent such an overage from occurring again. The needed changes will remain in effect until modified.

3. Allocation of Reef Fish ACLs Among Island Management Areas;

The Council allocated the ACLs in the EEZ by island groups (i.e., Puerto Rico, St. Thomas/St. John, and St. Croix). Local fishers, the fishing community, and the local governments requested partitioning management among the described islands or island groups because of differences in culture, markets, gear, and seafood preferences. The Council used a mid-point or equidistant method for dividing the EEZ among islands (Figure 5).

4. Bag Limits

In this amendment, the Council established a recreational aggregate bag limit for snapper, grouper, and parrotfish of: five per fisher per day including not more than two parrotfish per fisher per day or six parrotfish per boat per day, and 15 aggregate snapper, grouper, and parrotfish per boat per day (would not apply to a fisherman who has a valid commercial fishing license).



Reference Point	Latitude	Longitude	Comments
A	19° 37’ 29”	65° 20’ 57”	Intersects with the International/EEZ boundary
B	18° 25’ 46.3015”	65° 06’ 31.866”	Intersects with the EEZ/Territorial boundary
C	18° 13’ 59.0606”	65° 05’ 33.058”	Intersects with the EEZ/Territorial boundary
D	18° 01’ 16.9636”	64° 57’ 38.817”	
E	17° 30’ 00.000”	65° 20’ 00.1716”	
F	16° 02’ 53.5812”	65° 20’ 00.1716”	
G	18° 03’ 03”	64° 38’ 03”	

Figure 2.5. Detailed boundaries, including the coordinates, for subdividing the U.S. Caribbean EEZ among islands (Puerto Rico, St. Croix) or island group (St. Thomas/St. John). Subdivisions were allocated using an equidistant approach that resulted in lines being spaced equally between the territorial waters of the neighboring islands (CFMC 2011a, 2011b).

2.2. Control Date Notices

The CFMC at its 130th meeting on March 24-26, 2009, established a control date of March 24, 2009, for every fishery managed by the Council, including GU3.

Subsequent to that action, the USVI began development of trap reduction programs and established a February 10, 2011, control date. At their August 2012 meeting, the Council discussed the ongoing development of trap reduction programs for the USVI, which if approved and implemented, will preserve and protect the historical and cultural fish trap sectors in a sustainable manner by reducing the total number of traps. To be consistent with the territorial regulations, the Council voted to update the previous control date of March 24, 2009, and establish a February 10, 2011, control date for the commercial trap sectors of the reef fish and spiny lobster fisheries of the U.S. Caribbean.

2.3. Management Program Specifications

The following is a summary of general information regarding management of red hind in the U.S. Caribbean:

Species	Red Hind
Management Unit	Grouper Unit 3
Management Unit Definition	Includes Coney (*Epinephelus fulvus*), Graysby (*Epinephelus cruentatus*), and Rock hind (*Epinephelus adscensionis*)
Management Entity	Caribbean Fishery Management Council
Management Contacts (SERO/CFMC)	William Arnold – SERO Graciela Garcia-Moliner - CFMC
Current Stock Exploitation Status	Unknown
Current Stock Biomass Status	Unknown

As described in the following table, the 2010 Caribbean Annual Catch Limit Amendment established reference points for all groupers (Values are in pounds (lbs). For the Puerto Rico recreational sector, numbers of individuals are in parenthesis.). This encompasses GU3, which includes Coney, Graysby, Red Hind, and Rock hind. Note that reference points were based upon commercial and recreational landings only. Although discards may occur in these fisheries, there has been no available method for estimating the extent of those discards.

Criteria	Puerto Rico Commercial	Puerto Rico Recreational	St. Thomas	St. Croix
MSY=OFL	208,839	90,839	60,999	35,806
ABC=OFL	208,839	90,839	60,999	35,806
ACL=OY	177,513	77,213 (93,580)	51,849	30,435

Stock Rebuilding Information

According to NOAA's Fish Stock Sustainability Index

(http://www.nmfs.noaa.gov/sfa/statusoffisheries/2013/second/Q2%202013%20Stock%20Status%20Tables.pdf), GU3 is considered to be unknown. Thus no rebuilding plan is required.

2.4. References

Caribbean Fishery Management Council (CFMC). 1981. Fishery management plan, final environmental impact statement, and regulatory impact review for the spiny lobster fishery of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 43 pp. + Appendices.

CFMC. 1985. Fishery management plan, final environmental impact statement, and draft regulatory impact review for the shallowwater reef fish fishery of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 69 pp. + Appendices.

CFMC. 1990a. Amendment number 1 to the fishery management plan for the shallow-water reef fish fishery, preliminary environmental assessment and regulatory impact review. Caribbean Fishery Management Council, San Juan, Puerto Rico. 51 pp. + Appendices.

CFMC. 1991. Regulatory amendment to the shallow water reef fish fishery management plan. Caribbean Fishery Management Council, San Juan, Puerto Rico. 24 pp. + Appendix.

CFMC. 1993. Amendment 2 to the fishery management plan for the shallow-water reef fish fishery of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 29 pp. + Appendices.

CFMC. 1996. Regulatory amendment to the fishery management plan for the reef fish fishery of Puerto Rico and the United States Virgin Islands concerning red hind spawning aggregation closures including a regulatory impact review and an environmental assessment. Caribbean Fishery Management Council, San Juan, Puerto Rico. 27 pp. + Appendices.

CFMC. 1999. Amendment number 1 to the fishery management plan for corals and reef associated plants and invertebrates of Puerto Rico and the United States Virgin Islands for establishing a marine conservation district, including regulatory impact review and initial regulatory flexibility analysis and a final supplemental environmental impact statement. Caribbean Fishery Management Council, San Juan, Puerto Rico. 47 pp. + Appendices.

CFMC. 2005. Comprehensive amendment to the fishery management plans (FMPs) of the U.S. Caribbean to address required provisions of the Magnuson-Stevens Fishery Conservation and Management Act: Amendment 2 to the FMP for the spiny lobster fishery of Puerto Rico and the U.S. Virgin Islands; Amendment 1 to the FMP for queen conch resources of Puerto Rico and the U.S. Virgin Islands; Amendment 3 to the FMP for the reef fish fishery of Puerto Rico and the U.S. Virgin Islands; Amendment 2 to the FMP for the corals and reef associated invertebrates of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 533 pp. + Appendices.

CFMC. 2010. Regulatory amendment to the fishery management plan for the reef fish fishery of Puerto Rico and the U.S. Virgin Islands modifying the Bajo de Sico seasonal closure including a regulatory impact review and an environmental assessment. Caribbean Fishery Management Council, San Juan, Puerto Rico. 198 pp. + Appendices.

CFMC. 2011. Amendment 2 to the FMP for the Queen Conch Fishery of Puerto Rico and the U.S. Virgin Islands and Amendment 5 to the Reef Fish Fishery Management Plan of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 523 pp + Appendices.

3. ASSESSMENT HISTORY AND REVIEW

Caribbean red hind have not been formally assessed prior to SEDAR 35.

4. REGIONAL MAPS

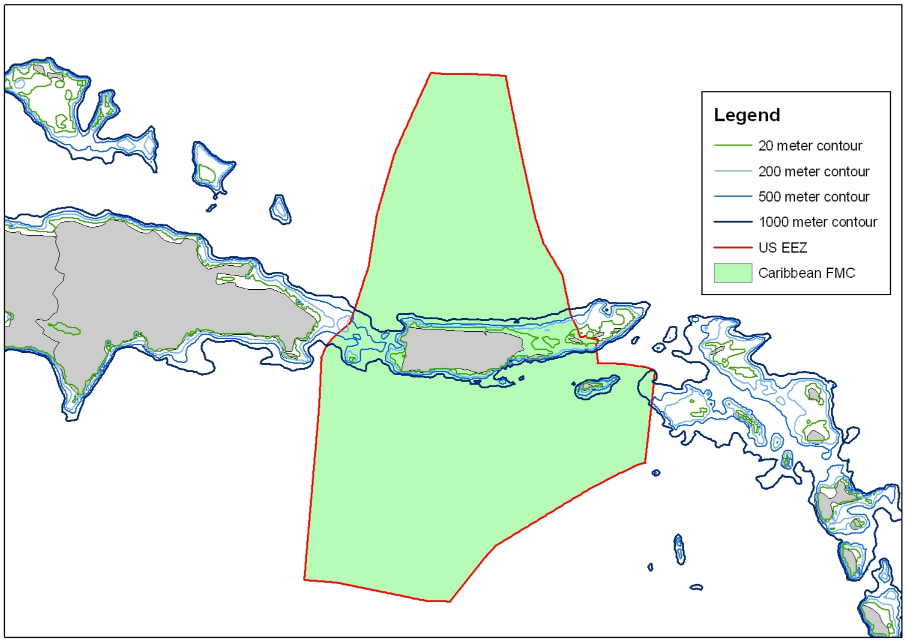


Figure 4.1. Caribbean management region including Council and EEZ Boundaries.

5. EXECUTIVE SUMMARY

To be added once the review is complete.

6. SEDAR ABBREVIATIONS

ABC	Allowable 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
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAM	Beaufort Assessment Model
BMSY	value of B capable of producing MSY on a continuing basis

CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
EEZ	exclusive economic zone
F	fishing mortality (instantaneous)
FMSY	fishing mortality to produce MSY under equilibrium conditions
FOY	fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
FMAX	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) 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)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey
MRIP	Marine Recreational Information Program
MSST	minimum stock size threshold, a 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
OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
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	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries Southeast Regional Office, National Marine Fisheries Service
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SS	Stock Synthesis
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
TPWD	Texas Parks and Wildlife Department
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 35

Caribbean Red Hind

SECTION II: Data Workshop Report

June 2014

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

Table of Contents

1 INTRODUCTION

1.1 Workshop time and place

The SEDAR 35 Data Workshop was held on March 11-13 in St. Thomas, USVI.

1.2 Terms of Reference

1. Review stock structure and unit stock definitions and consider whether changes are required.

2. Review, discuss, and tabulate available life history information.
    - Evaluate age, growth, natural mortality, and reproductive characteristics
    - Provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable.
    - Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.
3. Recommend discard mortality rates.
    - Review available research and published literature
    - Consider research directed at these species as well as similar species from the southeastern United States, U.S. Caribbean, and other areas.
    - Provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata.
    - Include thorough rationale for recommended discard mortality rates.
    - Provide justification for any recommendations that deviate from the range of discard mortality provided in the last benchmark or other prior assessment.
4. Provide measures of population abundance that are appropriate for stock assessment.
    - Consider and discuss all available and relevant fishery dependent and independent data sources.
    - Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
    - Provide maps of fishery and survey coverage.
    - Develop fishery and survey catch per unit effort indices by appropriate strata (e.g., age, size, area, and fishery) and include measures of precision and accuracy.
    - Discuss the degree to which available indices adequately represent fishery and population conditions.
    - Recommend which data sources are considered adequate and reliable for use in assessment modeling. Provide clear summary of indices not recommended and include justification for exclusion.
    - Complete the SEDAR index evaluation worksheet for each index considered.
    - Rank the available indices with regard to their reliability and suitability for use in assessment modeling.
5. Provide commercial catch statistics, including both landings and discards in both pounds and number.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species, spatial area, and fishery sector or gear.
    - Provide length and age distributions for both landings and discards if feasible.
    - Provide maps of fishery effort and harvest.
6. Provide recreational catch statistics, including both landings and discards in both pounds and number.

- Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species, spatial area, and fishery sector or gear.
- Provide length and age distributions for both landings and discards if feasible.
- Provide maps of fishery effort and harvest.

7. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.
8. 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

Workshop Panel

Meaghan Bryan……NMFS/SEFSC Miami
Walter Ingram……NMFS/SEFSC Pascagoula
Kevin McCarthy……NMFS/SEFSC Miami
Adyan Rios……NMFS/SEFSC Miami
Daniel Matos……PR DNER
Aida Rosario……PR DNER
Roy Pemberton……USVI DPNR
Tom Dolan……USVI DPNR
Richard Appeldoorn……University of Puerto Rico/CFMC SSC
Michelle Schärer……University of Puerto Rico
Rick Nemeth……University of the USVI

Council Representation

Tony Blanchard……CFMC

Observers

Jonathan Brown……DPNR/DFW

Staff

Julie Neer……SEDAR
Julia Byrd……SEDAR
Graciela García-Moliner……CFMC Staff
Kate Quigley……CFMC Staff
Patrick Gilles……NMFS/SEFSC Miami

Additional Participants via Webinars/Conference Calls

Shannon Cass-Calay .... NMFS Miami
Ron Hill .... NMFS Galveston
Tyler Smith .... Univ. of VI

1.4 List of Data Workshop papers and reference documents

Document #	Title	Authors	Date Submitted
Documents Prepared for the Data Workshop			
SEDAR35-DW-01	Monitoring of Commercially Exploited Fisheries Resources in Puerto Rico	Aida Rosario Jimenez	20 Sept 2013
SEDAR35-DW-02	Reef Fish Monitoring	Aida Rosario Jiménez, Verónica Seda Matos, and Noemí Peña-Alvarado	20 Sept 2013
SEDAR35-DW-03	Red hind data from Puerto Rico	Michelle Scharer, Michael Nemeth and Daniel Matos	3 March 2014
SEDAR35-DW-04	Abundance Indices of Red Hind Collected in Caribbean SEAMAP Surveys from Southwest Puerto Rico	G. Walter Ingrm	13 May 2014
Reference Documents			
SEDAR35-RD01	A Cooperative Multiagency Reef Fish Monitoring Protocol for the U.S. Virgin Islands Coral Reef Ecosystem, v. 1.00	David R. Bryan, Andrea J. Atkinson, Jerald S. Ault, Marilyn E. Brandt, James A. Bohnsack, Michael W. Feeley, Matt E. Patterson, Ben I. Ruttenberg, Steven G. Smith, Brian D. Witcher	
SEDAR35-RD02	Fishery independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puerto Rican EEZ	Jorge R. García-Sais, Jorge Sabater-Clavell, Rene Esteves, Milton Carlo	
SEDAR35-RD03	Portrait of the commercial fishery of red hind, *Epinephelus guttatus*, in Puerto Rico during 1992-1999	Daniel Matos-Caraballo	

SEDAR35-RD04	Portrait of the commercial fishery of red hind, *Epinephelus guttatus*, in Puerto Rico during 1988-2001	Daniel Matos-Caraballo, Milagros Cartagena-Haddock, and Noemi Pena-Alvarado
SEDAR35-RD05	Evaluation of seasonal closures of red hind, *Epinephelus guttatus* (Pisces: Serranidae), spawning aggregations to fishing off the west coast of Puerto Rico, using fishery-dependent and independent time series data	Anthony Robert Marshak
SEDAR35-RD06	Description of larval development of the red hind *Epinephelus guttatus*, and the spatio-temporal distributions of ichthyoplankton during a red hind spawning aggregations off La Parguera, Puerto Rico	Edgardo Ojeda Serrano
SEDAR35-RD07	Brief Summary of SEAMAP Data Collected in the Caribbean Sea from 1975 to 2002	G. Walter Ingram, Jr.
SEDAR35-RD08	Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection	Richard S. Nemeth
SEDAR35-RD09	Spatial and temporal patterns of movement and migration at spawning aggregations of red hind, *Epinephelus guttatus*, in the U.S. Virgin Islands	Richard S. Nemeth, Jeremiah Blondeau, Steve Herzlieb, and Elizabeth Kadison

2 LIFE HISTORY

This section details red hind life history characteristics compiled from a review of primary literature.

2.1 Stock Definition and Description

Red Hind are found in the tropical western Atlantic and are the most common species of the genus *Epinephelus* in the West Indies (Randal 1996). In Puerto Rico and the U.S. Virgin Islands, Red Hind are an important commercial species that are commonly taken by hook and line, fish trap, and speargun (Burnett-Herkes 1975, Sadovy et al. 1992). Red hind are monandric protogynous hermaphrodites, meaning that all fish begin life as females (Smith 1958, Sadovy et al. 1992, 1994). The reported depth range is from a few meters to more than 100 meters (Smith, 1958, Thompson and Munro 1974). Depth distribution and size are correlated, where smaller fish are generally found at shallower depths than larger fish (Sadovy et al. 1994, Thompson and Munro 1974). Although there is overlap in the size distributions by sex, males tend to be larger than females (Thompson and Munro 1974), and the majority of red hind closer to shore are female (Shapiro et al. 1993a).

2.2 Natural mortality

Published studies have used different methods for estimating natural mortality (*M)* of red hind. Ault et al. (2005) estimated *M* using information on the lifespan of red hind in the Florida Keys and methods from Alagaraja (1984). In Puerto Rico and St. Thomas, Sadovy and Figuerola (1992) calculated *M* using estimates of the Von Bertalanffy growth coefficient, *K*, and an equation developed from various tropical snappers and groupers by Ralston (1987). Thompson and Munro (1974) and Stevenson (1978) used length-frequency data from an unexploited part of Pedro Bank, Jamaica, and employed methods from Beverton and Holt (1956). The estimates of natural mortality from each study are provided in Table 2.8.1. Estimates of *M* ranged from 0.18 to 0.68.

2.3 Discard mortality

The literature review did not identify any published estimates of discard mortality rates for red hind. Notes from fishery-independent studies suggest that red hind are susceptible to some mortality associated with capture, both in traps (Thompson and Munro 1974) and by hook and line (Nemeth 2005) due to barotrauma.

2.4 Age & growth

Parameters associated with the Von Bertalanffy growth equation for red hind are included in Table 2.8.2. The reported ranges for L_∞, K, and t_0 were 471 to 601 mm total length (TL), 0.07 to 0.24 per year, and -4.69 to -0.44 years, respectively. In the US Caribbean, Sadovy et al. (1989) calculated a larger L_∞ and a lower K in St. Thomas compared to Puerto Rico.

2.5 Maturity and Reproduction

Red hind are monandric, protogynous hermaphrodites, meaning that they mature first as females and transition to males later in life (Smith 1958, Shapiro et al. 1993a, Sadovy et al. 1992, 1994). Few studies have estimated the lengths associated with female maturity or sexual transition. In Jamaica, macroscopic analyses by Thomson and Munro (1978) suggested that the average size for female maturity was less than or equal to 250 mm TL and that the mean size at sexual transition was 380 mm TL. In the US Caribbean, histological analyses by Sadovy et al. (1994) revealed a mean size at maturity of 215 mm TL, at an age of approximately 3 years (Sadovy et al. 1992).

Red hind spawn in aggregations at specific locations and at a specific time of the year. In the Caribbean, aggregations generally form along shelf edges from December to February, with peak activity in January (Shapiro 1993a, Colin et al. 1987, Nemeth 2007, Kadison et al. 2009). Spawning is associated with lunar phase (Shapiro 1993a, Colin et al. 1987, Kadison et al. 2009), periods of declining water temperature (Nemeth 2007) and tidal change, at depths where currents are weakest (Cherubin et al. 2011). At the aggregation sites, red hind form harems and spawning occurs in clusters of 2-7 fish (Shapiro et al. 1993b). Males patrol territories (Colin et al. 1987) and arrive earlier and stay longer at the site than females (Kadison et al. 2009, Nemeth 2007, Whiteman et al. 2005). Females are determinate spawners and may spawn more than once (Sadovy et al. 1994). Nemeth et al. (2007) estimated residence times of 13 and 1.5 days for males and females, respectively, and observed that larger females remained at the site longer than smaller females. Due to the arrivals and departures of individuals at the aggregation, densities, mean length, and sex ratios can vary over the course of the spawning period (Whiteman et al. 2005, Shapiro et al. 1993a, Beets and Friedlander 1998, Nemeth et al. 2007, Sadovy et al. 1994, Nemeth 2005).

2.6 Movements and migrations

Outside of the spawning season, red hind are scattered along reefs and reef patches (Shapiro et al. 1993b). Tag-recapture studies suggest that red hind have high site fidelity to a home reef (Lopez-Rivera and Sabat 2009) and can have overlapping home ranges (Shapiro et al. 1994). Red hind migrate to spawning locations and have been observed to migrate up to 18 km in Puerto Rico (Sadovy et al. 1992), and up to 33 km and 18 km in St. Thomas and St. Croix, respectively (Nemeth et al. 2007). Red hind captured and displaced from spawning aggregations have shown the ability to return to the site of first capture (Rosario and Fernandez 2001, Randal 1962 and Luckhurst 1998). Furthermore, red hind captured in consecutive years at the same spawning site suggest that the species may return annually to specific spawning aggregations (Luckhurst 1998).

2.7 Meristics & conversion factors

Since red hind have a rounded caudal fin, measurements of fork length are identical to measurements of total length. Equations for converting standard length to total length are provided in Table 2.8.3. The linear equations reported in different studies result in similar estimates of total length (Figure 2.9.1).

Length-weight relationships compiled from the literature review are detailed in Table 2.8.4. Among the studies with weights measured in grams and total length (or fork length) measured in mm, the reported range for the allometric growth parameter, *b*, was 2.84 – 3.23 and the range for the scaling parameter, *a*, was $4.14 \times 10^{-6} – 3.61 \times 10^{-5}$. The relationship between the reported values of *b* and the natural log of *a*, is plotted in Figure 2.9.2.

2.8 Tables

Table 2.8.1. Estimates of natural mortality (*M*) for Red Hind compiled from a review of the primary literature.

Citation	Estimated *M*	Method	Study Location	Study Years
Ault et al. 2005	0.18	Based on estimate of lifespan (Alagaraja 1984)	Florida Keys	1993-2002
Sadovy and Figuerola 1992	0.23	Based on estimate of growth coefficient, *k* (Ralston 1987)	Puerto Rico	1987-1989
Sadovy and Figuerola 1992	0.16	Based on estimate of growth coefficient, *k* (Ralston 1987)	St. Thomas	1987-1989
Stevenson 1978	0.59	Based on length-frequency data (Beverton and Holt 1956)	Puerto Rico	1973-1974
Thompson and Munro 1978	0.68	Based on length-frequency data (Beverton and Holt 1956)	Jamaica	1969-1973

Table 2.8.2. Estimates of the Von Bertalanffy growth equation parameters L_∞, *K*, and t_0 for Red Hind compiled from a review of the primary literature.

Citation	L_{inf}	K	t0	Method	n	Study Location	Study Years
Burnett-Herkes 1975 in Sadovy et al. 1992	507.0	0.1800	-0.440	Whole otoliths & length frequency	-	Bermuda	-
Potts and Manooch 1995	471.4	0.2000	-2.397	Sagittal otoliths	146	East US	1980-1992
Sale 1985	568.0	0.1190	-	Tagging	15	STJ	1959-1961
Sadovy et al. 1989	514.5	0.1013	-2.944	Sagittal otoliths	624	PR	1987-1989
Sadovy et al. 1989	601.0	0.0705	-4.690	Sagittal otoliths	162	STT	1987-1989
Thompson and Munro 1978	520.0	0.2400	-	Bi-monthly length-frequency	1475	Jamaica	1969-1973

Table 2.8.3. Equations for converting standard length to total length for Red Hind compiled from a review of the primary literature.

Citation	Equation	units	Length range (mm)	Sample Size	Study Location	Study Years
Beets and Friedlander 1992	24.7160 + 1.1080 * SL	mm	-	494	St. Thomas	1984-1988
Nemeth 2005	1.6415 + 1.1174 * SL	cm	-	230	St. Thomas	2000-2004
Sadovy et al. 1989	3.8600 + 1.2044 * SL	mm	170-490 FL*	36	Puerto Rico	1987-1989
Sadovy et al. 1989	24.4900 + 1.1101 * SL	mm	220-520 FL*	494	STT	1987-1989
Thompson and Munro 1978	1.8000 + 1.1900 * SL	cm	210-420 TL	230	Jamaica	1969-1973

Table 2.8.4. Length-weight relationships for Red Hind compiled from a review of the primary literature.

Citation	*a*	*b*	units	Length range (mm)	Sample Size	Study Location	Study Years
Beets and Friedlander 1992	1.47E-05	3.001	g, mm TL	196-535 TL	2651	St. Thomas	1984-1988
Beets and Friedlander 1992	1.95E-05	2.966	g, mm TL	178-496 TL	3073	St. Croix	1984-1988
Bohnsack and Harper 1988	8.55E-06	3.112	g, mm TL	139-255 TL	47	South FL	1985
Bohnsack et al. 1986	3.61E-05	2.839	g, mm FL	156-474 FL	723	Puerto Rico	1985
Bohnsack et al. 1986	8.40E-06	3.100	g, mm FL	205-545 FL	448	St. Thomas	1985
Bohnsack et al. 1986	4.14E-06	3.230	g, mm FL	208-500 FL	567	St. Croix	1985
Claro 2001	1.03E-02	3.120	g, cm FL	280-400 FL	15	Cuba	NA
Olsen and LaPlace 1978	2.90E-03	3.606	g, cm SL	120-430 SL	414	St. Thomas	1974-1976
Potts and Manooch 1995	1.80E-07	2.614	kg, mm TL	228-447 TL	96	East US	1980-1992
Rosario et al. 2004	7.24E-06	3.120	g, mm FL	107-398 FL	201	Puerto Rico	2000-2001
Sadovy et al. 1989	6.17E-06	3.140	g, mm TL	170-490 TL*	1619	Puerto Rico	1987-1989
Sadovy et al. 1989	2.09E-05	2.940	g, mm TL	220-520 TL*	493	St. Thomas	1987-1989
Thompson and Munro 1978	1.76E-02	2.960	g, cm TL	210-410 TL	189	Jamaica	1969-1973

*The range of lengths of fish used to obtain the length-weight relationship was inferred from the length-frequency histograms included in the publication.

2.9 Figures

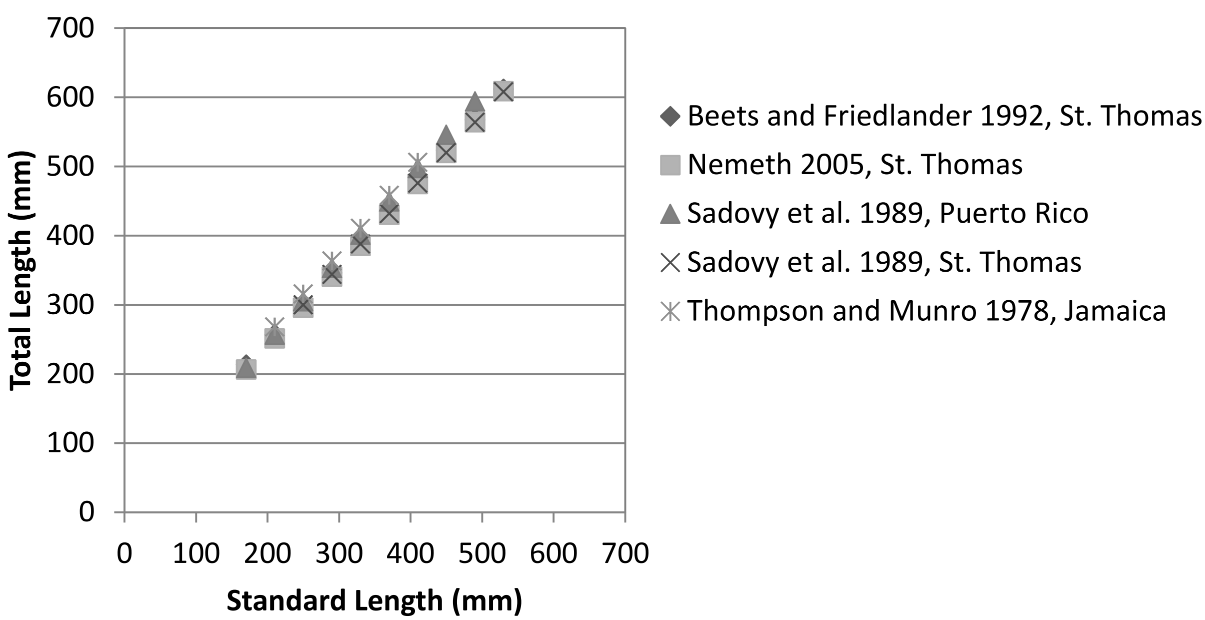


Figure 2.9.1. Plot of standard lengths converted to total lengths using the equations provided in Table 3.

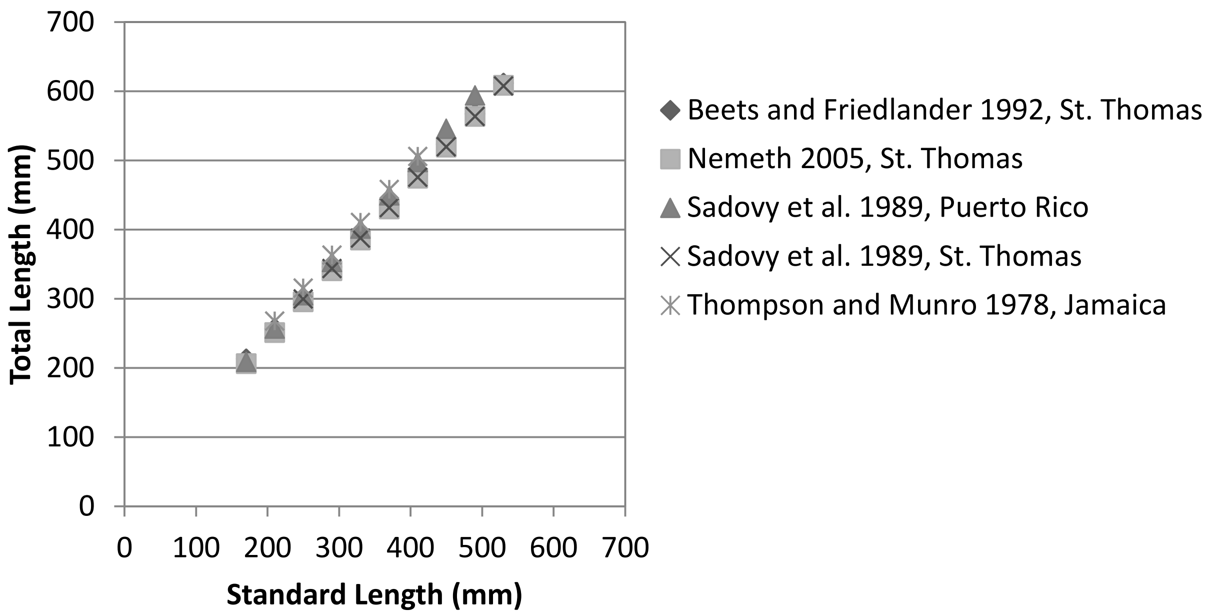


Figure 2.9.2. Plot of the allometric growth parameter, *b*, versus the natural log of the scaling parameter, *a*, for the length-weight conversions provided in Table 4.

3 PUERTO RICO FISHERY STATISTICS

3.1 Overview

Several fishery-dependent data sources from Puerto Rico were reviewed and discussed during the DW. These data sources include commercial fisheries statistics (i.e., catch and effort), biological sampling data from the Trip Interview Program (TIP), and recreational statistics from the Marine Recreational Fisheries Statistical Survey (MRFSS). Each of these data sources will be detailed in section 3 for Puerto Rico, section 4 for St. Thomas and St. John, and section 5 for St. Croix.

3.2 Commercial fishery statistics

3.2.1 Review of working papers

Working papers describing the commercial fisheries statistics or the biological sampling information were not produced for the data workshop. Commercial landings and biological sampling information were provided in oral presentations.

3.2.2 Commercial landings

Commercial fishery landings data for Puerto Rico were available from self-reported fisher logbooks/sales receipts for the years 1983-2012. Data were reported by species, fishing gear, and fishing center where the catch was landed. Puerto Rico commercial landings have been incompletely reported (Caribbean Fisheries Data Evaluation Final Report, 2009) and required use of correction/expansion factors to estimate total landings. For the years 2003 to 2012, correction/expansion factors have been coast-specific (north, south, east, and west). A single correction/expansion factor for all of Puerto Rico was developed and applied to the reported landings for years prior to 2003. Estimation of commercial fishery landings of earlier years used a single, island-wide, expansion factor.

Puerto Rico corrected/expanded landings were estimated for each reported trip as:
trip-specific reported landings*year-specific expansion factor

Yearly total estimated landings were the sum of all trip-specific corrected/expanded landings within each year. Estimation of landings for the most recent years (2003-2012) included year and coast-specific expansion factors. Reported landings were assigned to coast based upon the fishing center reported for a trip and the appropriate correction/expansion factor used to estimate landings. Red Hind landings have been reported by species in Puerto Rico beginning in 1986. Yearly total expanded Red Hind commercial fishery landings calculated for Puerto Rico are provided in Table 3.4.1. Puerto Rico expanded landings of Red Hind by gear and year are shown in Figure 3.5.1.A (plotted by gear) and B (plotted by coast). The numbers of trips with reported Red Hind landings are plotted in Figure 3.5.2 (by gear and year) and Figure 3.5.3 (by coast and year).

Data concerns noted during the workshop

The data workshop panel discussed, at length, possible reasons for the high 2005 Puerto Rico landings and the large drop in landings during 2006. It was noted that the 2005 estimated landings may have resulted primarily from a high correction/expansion factor calculated for the east coast of Puerto Rico. The panel recommended reviewing the data used for calculating correction/expansion factors for errors. In addition, those data will be reviewed for possible small sample size (number of intercepts) limitations. It was also suggested that landings data from the initial years of the time series were underreported. The data workshop panel recommended that commercial landings data prior to 1988 be excluded from the assessment.

3.2.3 Commercial discards

Commercial discard information for Red Hind is not available from Puerto Rico.

3.2.4 Commercial effort

Commercial effort, in numbers of reported fishing trips, is provided in Figures 3.5.2 and 3.5.3. Those totals include only those trips with reported landings of Red Hind. Correction/expansion factors do not exist for estimating total commercial fishing trips. Changes in effort (trips) may reflect changes in reporting and not changes in targeting alone.

3.2.5 Biological sampling

The Trip Interview Program (TIP) was initiated in 1983 to collect supplementary bio-statistical information from commercial fisheries in the South Atlantic of the US, the Gulf of Mexico, and the US Caribbean. The TIP is a port-sampling data collection program, where samplers are asked to record trip information including species-specific catch, and biological measurements, mainly lengths. The TIP length data were used during SEDAR 26 and 30 and applied to a mean-length estimation approach to evaluate relative changes in mortality over time for Queen Snapper, Silk Snapper, Redtail Parrotfish, Blue Tang, and Queen Triggerfish. This was done to determine overfishing status of these species. As these data have been the foundation of previous assessments in the US Caribbean, they were evaluated during the SEDAR 35 data workshop. More specifically, these data were evaluated to describe annual length-frequency distributions by gear type/fleet and island, identify the appearance of cohorts through time, and identify the length-at-recruitment (L_c) for each fleet. L_c is an important input parameter of the mean-length estimators.

A number of gear types are represented in the TIP database. Table 3.4.2 summarizes the gear types and their corresponding gear codes found in the TIP database associated with the Red Hind length data. The gear types were broadly reclassified as nets, pots and traps, vertical lines, longline and buoy gear, diving, or unspecified. The length data were evaluated for each gear type separately given potential selectivity differences among them. Lengths associated with unspecified gear were removed for the purposes of this evaluation. Length frequency plots and summary statistics to describe the distribution were generated. Length bins represent 10mm segments and are defined by the lower edge of the bin (e.g., lengths between 100mm and 109.999mm were included in the 100mm bin).

A total of 40,227 Red Hind lengths were measured in the US Caribbean between 1983 and 2013; 61.65% of the observations were from Puerto Rico. It should be noted that the 2012 and 2013 TIP data from Puerto Rico are incomplete as data are currently being entered. The majority of length observations were associated with the pot and trap, vertical line, and diving fleets (Tables 3.4.3 – 3.4.7, Figure 3.5.4). The majority of length observations from the pot and trap fleet were primarily from the 1980s (Table 3.4.3, Figures 3.5.4 and 3.5.5). The number of length observations from the vertical line fleet has been more consistent over time (Table 3.4.4, Figures 3.5.4 and 3.5.6). There were relatively few length observations from the diving fleet in the 1980s and 1990s, the majority of length observations were from the late 1990s (~1998) and the 2000s (Table 3.4.5, Figures 3.5.4 and 3.5.7). The number of annual length observations from the net fleet was relatively few in comparison to the pot and trap, vertical line, and diving fleets; a maximum of 80 lengths was observed in 2001 (Table 3.4.6). Very few Red Hind lengths were associated with the longline fleet (Table 3.4.7 and Figure 3.5.4).
Annual length-frequency plots are shown in Figures 3.5.5, 3.5.6, and 3.5.7 for the pot and trap, vertical line, and diving fleets, respectively. Annual mean length has increased since 1983 for the pot and trap and vertical line fleets (Tables 3.4.3 and 3.4.4, Figure 3.5.8). The increase associated with the pot and trap fleet is confounded with a decline in sample size. Mean length associated with the diving fleet has been relatively stable over time. Annual mean length of the Red Hind observed from the diving fleet was larger than the length at maturity (L_{mat} ~250mm, see Section 2) over the entire time series and larger than those from the pot and trap and vertical line fleets in the 1980s (Tables 3.4.3 – 3.4.5, Figure 3.5.8). Early in the time-series, the 1980s, the annual mean lengths observed from the pot and trap and vertical line fleets were closer to L_{mat} and then increased in the 1990s(Tables 3.4.3 – 3.4.4, Figure 3.5.8). Mean length was similar among the fleets starting in the mid-1990s and through the 2000s.

Although there has been a shift in the median and mean length associated with the pot and trap and vertical line fleets, the annual length frequency distributions were relatively stable over time for each (Figure 3.5.9). The annual length distributions associated with the diving fleet were also stable over time.

The annual length frequency distributions can also provide information about gear selectivity. Visual inspection of length-frequency distributions can be used to determine the size-at-recruitment (L_c) to the fishery where the mode of a well-defined distribution can represent L_c (Thorson and Prager 2011). The mode of each annual distribution was determined as well as the overall mode for each gear type. Overall, an estimate of L_c for the pot and trap fishery is ~281mm. This does not account for an apparent change in selectivity over time (Table 3.4.3). The mode was variable among years, but was generally larger after 1998 for the pot and trap (~320mm). A similar trend was apparent in the data from the vertical line fleet (Table 3.4.4). An overall estimate of L_c for the vertical line fishery is ~300mm. Given an apparent increase in mean size in 1998, an estimate of L_c prior to 1998 is ~280 mm and after 1998 is ~310mm. An overall estimate of L_c for the diving fleet is ~325mm (Table 3.4.5).

The DW panel suggested that we evaluate monthly trends in mean length. This was suggested because Red Hind are group spawners making them more vulnerable to fishing during spawning months. Trends in monthly mean length were evaluated to determine whether fishing activity during the spawning season influenced annual trends in length. Mean length was relatively stable among months within a given year for the pot and trap and vertical line fleets (Figure 3.5.10). Mean length in January within a given year from the diving fleet was generally higher than other months (Figure 3.5.10).

3.3 Recreational fishery statistics

3.3.1 Review of working papers

Working papers were not produced for the data workshop. Recreational landings and biological sampling information were provided in oral presentations.

3.3.2 Recreational landings

Recreational landings data were available for Puerto Rico from the Marine Recreational Fisheries Statistical Survey (MRFSS) for the period 2000-2013. Yearly landings of A and B1 (observed fish and fish reported as landed, respectively) are provided in Table 3.4.9 and in Figure 3.5.11.

Data concerns noted during the workshop

The data workshop panel discussed possible reasons for the high 2005 Puerto Rico recreational landings and the large drop in landings during 2006. The panel recommended reviewing the MRFSS data used for possible small sample size (number of intercepts) or very high catch rates that may also be due to small sample size. Such high catch rates may result in high landings estimates.

Examination of the MRFSS data revealed that the high estimated Red Hind landings in 2005 resulted from a combination of a relatively high number of Red Hind landed (68 A+B1) on only three intercepts and high estimated recreational fishing trips (91,438) in a single stratum of mode, area fished, and wave. Low estimated landings in 2006 were associated with few positive intercepts and few observed or reported Red Hind. Estimated number of Red Hind landed, CVs of landings estimates, estimated total number of recreational trips, number of intercepts with Red Hind landings, total intercepts, and reported number of Red Hind landed on positive trips are provided in Table 3.4.10. Yearly intercepts with Red Hind landings never exceeded 40 trips and were 10 or fewer trips during four years. The number of individual Red Hind landed on intercepted trips exceeds 100 fish during three years only (i.e., 2001, 2004, and 2005).

3.3.3 Recreational discards

Estimated MRFSS discards are provided in Table 3.4.11. Estimated discards vary greatly among years. That variability may be due to small numbers of intercepts. The data workshop panel recommended examining the data set to determine the adequacy of survey sample sizes. Estimated number of discarded Red Hind, CVs of discard estimates, estimated total number of recreational trips, number of intercepts with Red Hind discards, total intercepts, and reported number of Red Hind discarded on positive trips are provided in Table 3.4.12. The number of intercepts with reported Red Hind discards was very low (seven or fewer trips per year) and during two years no intercepted trips reported Red Hind discards. The number of discarded Red Hind (B2s) was also very low (20 or fewer fish per year).

3.3.4 Recreational effort

Yearly total estimated recreational effort (number of trips) was obtained through telephone surveys and is provided in Table 3.4.10. Yearly total recreational trips are plotted with estimated recreational landings in Figure 3.5.11. Total estimated recreational fishing effort (number of trips) has been decreasing over most of the time series. It has been suggested that this may be an artifact of the survey where only land line telephones have been included in the survey.

3.3.5 Biological sampling

The MRFSS program also collects biological information, which includes lengths and weights. The majority of length observations are from the following strata: private mode, state waters (Ocean <=10mi), and hook and line (Tables 3.4.13 – 3.4.16). Table 3.4.16 summarizes the annual number of measured lengths from the private mode, given that the majority of length observations are from this mode.

The overall length distribution from the private mode is bimodal with the first peak at ~240mm FL and the second peak at ~ 360mm FL (Figure 3.2.12). The annual length distributions are shown in Figure 3.5.13 and the distribution of observed lengths caught by the private mode and hook and line in state waters is shown in Figure 3.5.14. The distribution in Figure 3.5.14 is similar to Figure 3.5.12.

3.4 Tables

Table 3.4.1. Puerto Rico expanded commercial landings of Red Hind, 1986-2012. The data workshop panel recommended to review of correction/expansion factors, therefore, totals presented here should be regarded as preliminary. Landings of Red Hind prior to 1986 were not available in the data set.

Year	Red Hind
1986	589
1987	15,295
1988	51,548
1989	74,426
1990	77,353
1991	109,019
1992	70,071
1993	67,359
1994	44,904
1995	59,395
1996	75,139
1997	77,228
1998	70,514
1999	84,565
2000	107,785
2001	100,351
2002	94,340
2003	85,132
2004	89,928
2005	100,495
2006	31,352
2007	30,707
2008	39,640
2009	39,790
2010	47,174
2011	35,075
2012	52,541

Table 3.4.2. The gear codes found in the TIP database, the corresponding gear names, and the new gear names assigned to each.

Gear code	Gear name	New gear name
10	Haul seines	Nets
30	Encircling nets	Nets
60	Fyke and hoop nets	Nets
200	Entangling nets (gill) unspc	Nets
207	Trammel nets	Nets
550	Dip nets	Nets
551	Cast nets	Nets
660	Spears	Diving
750	By hand	Diving
751	Skin diving	Diving
752	By hand, diving gear	Diving
400	Lines long set with hooks	Longline and buoy
401	Buoy gear, vertical	Longline and buoy
403	Lines long, reef fish	Longline and buoy
130	Pots and trap, CMB	Pots and trap
139	Pots and trap, fish	Pots and trap
140	Pots and trap, spiny lobster	Pots and trap
182		Pots and trap
300	Rod and reel	Vertical line
303	Reel, electric or hydraulic	Vertical line
320	Lines power troll other	Vertical line
700	Lines hand	Vertical line
0		Unspecified
670		Unspecified
671		Unspecified

Table 3.4.3. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the pot and trap fleet in Puerto Rico. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Pots and traps	1983	220	240	270	278.3	306	631
	1984	260	241	267	274.3	300	1307
	1985	270	250	275	282.9	310	1262
	1986	260	230	266.5	273.3	307	1222
	1987	230	227.8	250	258.2	285	436
	1988	270	250	280	287	320	345
	1989	270	230	266.5	270.9	302	434
	1990	270	243	265	270.3	285	137
	1991	250	257	287	294.9	322	357
	1992	280	261.8	289	294	322	316
	1993	280	241	280	281.7	310	133
	1994	280	260.5	280	278.1	297.5	39
	1995	210	236	260	264.3	292	153
	1996	330	270	310	311.4	338	13
	1997	270	260.3	281	290.6	310	30
	1998	280	280	310	317.1	350	121
	1999	310	262	298	301.8	332.5	272

Table 3.4.3. continued

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Pots and traps	2000	310	280	310	317.1	360	191
	2001	280	275	295	308.1	340	237
	2002	270	272.5	299.5	305.8	332.2	184
	2003	270	275	300	316.5	343	177
	2004	280	283	310	318.9	344	297
	2005	370	354	372	377.7	404	35
	2006	320	315.5	328	316.1	347.5	19
	2007	340	302	342	340.3	372	81
	2008	360	284.2	347.5	314.1	366.8	16
	2009	270	249	274.5	297.8	323.5	22
	2010	280	291.8	297.5	320.5	329.2	8
	2011	310	295.5	325	318.9	352.8	110
	2012	270	313	340.5	352.5	368	6
	2013	270	272	272	272	272	1
Overall		-	246	280	285.2	315	8592

Table 3.4.4. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the vertical line fleet in Puerto Rico. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Vertical line	1983	270	237.2	270.5	274.7	293.2	38
	1984	270	250	290	297.1	340	129
	1985	310	265.2	295	300.2	326	170
	1986	270	253.5	300	305.3	350	262
	1987	260	262	295	295.1	325.8	694
	1988	280	248	287	291.3	330	561
	1989	270	236	275.5	285.6	317	176
	1990	260	250	285	295	333	419
	1991	250	263	310	316.3	366	788
	1992	270	262	300	305.6	340	521
	1993	320	276.5	312	314.8	350	347
	1994	320	290	322	319.3	355	221
	1995	310	260	300	307.4	349.2	238
	1996	320	259	280	285.3	312	61
	1997	270	242	272	290.1	322	175
	1998	310	276.5	310	318.9	356.5	211
	1999	300	284.2	330	331.9	380	582
	2000	300	280	318	319.9	360	371
	2001	300	271	305	313	350	478
	2002	280	288	330	328.2	365	533
	2003	320	300	336	344.5	380	697
	2004	310	300	340	346.4	385	546
	2005	320	320	351	350.4	388	419
	2006	310	308	350	354	399.2	584
	2007	320	300	332	342.4	375	214
	2008	360	300	347	346.2	390	403
	2009	350	302.5	350	346.4	392	379
	2010	300	312	350	353.8	399	289
	2011	300	278	324	323.2	372.5	92
	2012	380	295.8	355.5	349.6	388.2	52
	2013	370	332.2	371	365	391.2	60
Overall		-	275	319	322.5	365	10710

Table 3.4.5. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the diving fleet in Puerto Rico.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Diving	1983	370	379	379	379	379	3
	1984	310	318.5	333.5	344	359	4
	1985	310	308.8	324	334.6	355.5	28
	1986	350	359	395	384.8	410	13
	1987	360	308	330	328.4	365	19
	1988	340	300	340	338.9	370	66
	1989	430	340	380	371.9	420	60
	1990	370	325	370	368.9	415	159
	1991	330	305	345	346.4	385	211
	1992	310	300	335	339.5	377.5	130
	1993	290	283.8	320	324.1	352.5	56
	1994	320	308.5	330	333.4	354.5	27
	1995	350	292.5	310	321.2	350	27
	1996	270	285	330	325.4	380	61
	1997	300	312.5	357.5	358.4	398.8	34
	1998	290	290	320	322.6	360	164
	1999	310	299	347.5	345.4	390	172
	2000	370	280	335	327	377.5	251
	2001	280	285	320	327.7	368.5	171
	2002	280	280	305	318.8	350	224
	2003	280	300	328	338	370	81
	2004	310	305	330	332.4	366	229
	2005	310	289	310	317.4	333.5	271
	2006	310	301	326.5	333	366	240
	2007	340	310	330	329.4	350	133
	2008	350	300	355.5	336.6	405	206
	2009	290	290.5	319.5	328.6	360	114
	2010	320	300	325	331.5	360	405
	2011	310	310	335	338.5	362	719
	2012	360	319	351	350	374.2	120
	2013	-	-		-	-	-
	Overall	-	300	330	335	370	4398

Table 3.4.6. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the net fleet in Puerto Rico. The mode represents the length bin with the greatest number of observations

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Nets	1983	240	240.2	251	255	277.2	12
	1984	-	-		-	-	-
	1985	270	267.5	270	273.8	276.2	4
	1986	300	262	290	289.7	310	37
	1987	300	225	260	251.2	300	10
	1988	210	230	273	268.9	300	65
	1989	250	240	270	285.2	330	67
	1990	280	239.2	269	262.2	285.2	40
	1991	280	262	280	278.8	302	34
	1992	280	260	281	286.9	304	23
	1993	270	271.5	284.5	295.8	319.8	34
	1994	270	276	276	276	276	2
	1995	270	248.8	277.5	281.1	315	16
	1996	270	255.5	272.5	274	293.8	12
	1997	270	276.2	290	302.6	318.8	26
	1998	260	260	285	292.9	320	57
	1999	260	266.2	293.5	298.4	326.5	46
	2000	260	255	278	274.8	290	37
	2001	260	257.5	277	284.9	308	80
	2002	260	258.8	274	285.2	301.2	56
	2003	260	265.5	280.5	287.4	303.8	46
	2004	320	285	322	320.9	350	53
	2005	310	287.5	312.5	314.7	330	20
	2006	270	313	328.5	329.9	357.5	10
	2007	290	327	358	358	389	2
	2008	300	230.8	265.5	269.4	304.5	34
	2009	300	300	319	313	330	13
	2010	260	277.5	347.5	340.9	384.2	10
	2011	430	377	400	387.4	425	7
	2012	-	-		-	-	-
	2013	-	-		-	-	-
	Overall	-	260	282	288.4	315	853

Table 3.4.7. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the longline fleet in Puerto Rico. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Longline	1983	-	-		-	-	-
	1984	-	-		-	-	-
	1985	-	-		-	-	-
	1986	-	-		-	-	-
	1987	-	-		-	-	-
	1988	270	295	365	353.2	400	21
	1989	370	293	355	341.8	380	57
	1990	230	237.2	252	258.7	271.5	14
	1991	390	230	326	310.6	356	17
	1992	-	-		-	-	-
	1993	-	-		-	-	-
	1994	-	-		-	-	-
	1995	-	-		-	-	-
	1996	-	-		-	-	-
	1997	-	-		-	-	-
	1998	270	265	280	285.4	303	15
	1999	380	279	305	315.8	368	19
	2000	-	-		-	-	-
	2001	-	-		-	-	-
	2002	-	-		-	-	-
	2003	-	-		-	-	-
	2004	-	-		-	-	-
	2005	-	-		-	-	-
	2006	-	-		-	-	-
	2007	-	-		-	-	-
	2008	-	-		-	-	-
	2009	300	319.5	361	370.9	418.5	35
	2010	310	320	353	351.1	382	21
	2011	-	-		-	-	-
	2012	-	-		-	-	-
	2013	-	-		-	-	-
Overall		-	289.5	343	333.9	380	199

Table 3.4.8. Measures of central tendency and dispersion in the number of measured lengths by month in Puerto Rico.

Month	Lower_quartile	Median	Upper_quartile	Mean	SD
January	38.50	85.00	152.00	105.57	77.01
February	19.25	60.00	81.25	73.50	71.79
March	22.25	67.00	116.75	69.60	54.67
April	24.50	41.50	87.00	54.68	39.93
May	18.00	44.00	87.00	67.31	74.61
June	29.00	60.00	92.00	62.86	44.29
July	16.00	46.50	67.75	49.54	38.74
August	54.00	81.00	129.00	100.62	82.95
September	44.00	85.00	141.00	91.62	59.66
October	41.50	97.00	137.50	110.00	93.21
November	20.00	50.00	90.00	66.21	59.76
December	9.75	18.00	68.25	40.88	45.86

Table 3.4.9**.** Estimated recreational landings of Red Hind, 2000-2013. From Puerto Rico.

Year	Red Hind
2000	24,426
2001	49,967
2002	28,662
2003	38,359
2004	29,995
2005	110,149
2006	5,488
2007	47,176
2008	43,444
2009	11,144
2010	8,026
2011	6,192
2012	12,582
2013	859

Table 3.4.10. Estimated number of Red Hind landed, CVs of landing estimates, estimated number of recreational trips, numbers of intercepts with Red Hind landings, numbers of total intercepts, and the reported number of Red Hind landed on intercepted trips from Puerto Rico

Year	Estimated number of landed fish	Landings CVs	Estimated total trips	Intercepts with Red Hind landings	Total intercepts	Reported A+B1
2000	26,273	0.30	1,362,704	19	2,786	52
2001	58,411	0.26	1,411,943	40	3,168	140
2002	38,186	0.33	1,301,059	21	2,528	75
2003	35,652	0.30	1,111,405	24	2,979	93
2004	41,635	0.34	1,050,298	22	3,043	153
2005	111,681	0.75	866,723	26	1,831	142
2006	9,274	0.56	955,123	7	1,415	28
2007	32,939	0.36	1,080,097	19	2,108	55
2008	82,170	0.69	798,551	10	1,990	91
2009	14,903	0.31	636,151	20	2,616	72
2010	8,479	0.40	536,183	10	2,265	29
2011	5,314	0.44	424,587	13	2,389	40
2012	8,781	0.42	350,568	21	2,483	66
2013	1,278	0.62	511,001	4	1,125	14

Table 3.4.11. Estimated recreational discards of Red Hind, 2000-2013, from Puerto Rico.

Year	Red Hind discards (B2)
2000	12,237
2001	926
2002	2,965
2003	5,931
2004	652
2005	2,435
2006	5,280
2007	6,158
2008	0
2009	3,704
2010	0
2011	500
2012	1,637
2013	215

Table 3.4.12. Estimated number of Red Hind discarded, CVs of discard estimates, estimated number of recreational trips, numbers of intercepts with Red Hind discards, numbers of total intercepts, and the reported number of discarded Red Hind on intercepted trips from Puerto Rico.

Year	Estimated number of discarded fish	Discard CVs	Estimated total trips	Intercepts with Red Hind discards	Total intercepts	Reported B2
2000	12,237	0.65	1,362,704	4	2,786	19
2001	926	0.71	1,411,943	2	3,168	2
2002	2,965	1.00	1,301,059	1	2,528	4
2003	5,931	0.52	1,111,405	5	2,979	18
2004	652	0.70	1,050,298	3	3,043	3
2005	2,435	0.47	866,723	7	1,831	12
2006	5,280	0.87	955,123	2	1,415	2
2007	6,158	0.69	1,080,097	7	2,108	20
2008	0	0.00	798,551	.	1,990	0
2009	3,704	0.68	636,151	6	2,616	18
2010	0	0.00	536,183	.	2,265	0
2011	500	1.00	424,587	2	2,389	6
2012	1,637	0.57	350,568	5	2,483	12
2013	215	1.00	511,001	2	1,125	3

Table 3.4.13. Number of measured Red Hind lengths in Puerto Rico, 2000-2013 by mode.

Mode	Number of lengths
Shore	14
Charter boat	69
Private	419

Table 3.4.14. Number of measured Red Hind lengths in Puerto Rico, 2000-2013 by area.

Mode	Number of lengths
Inshore	18
<=10mi	421
>10mi	63

Table 3.4.15. Number of measured Red Hind length caught by the private mode by gear and area in Puerto Rico, 2000-2013.

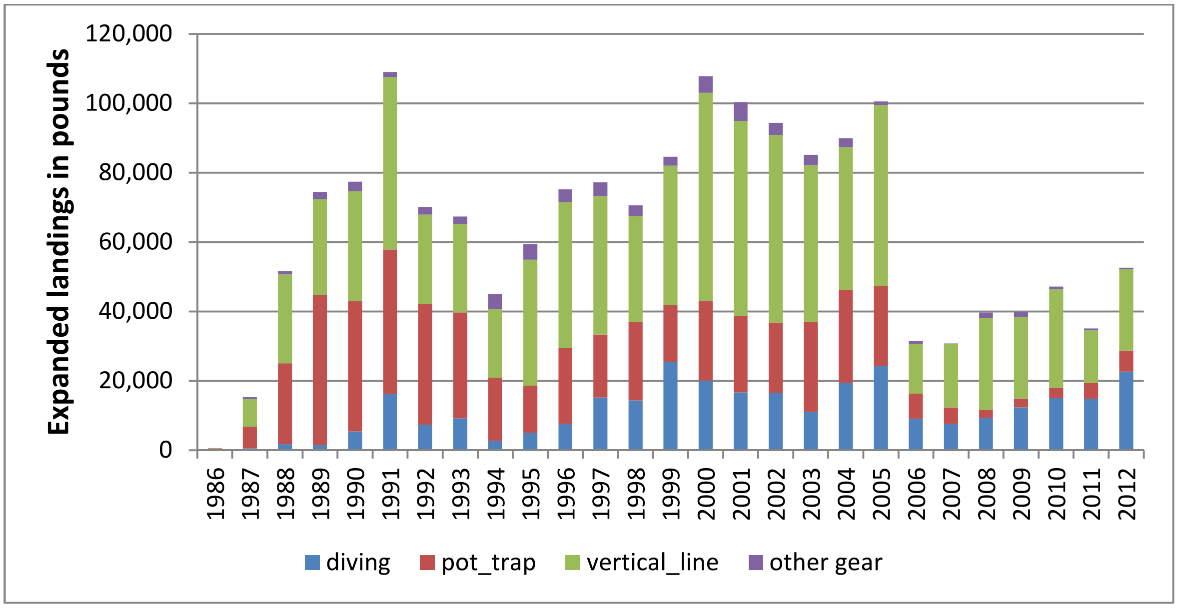
Gear	Area	Number of lengths
Hook and line	Inshore	2
Yo-yo	Inshore	7
Dip/A-frame net	Ocean<=10mi	2
Hand	Ocean<=10mi	9
Hook and line	Ocean<=10mi	253
Spear	Ocean<=10mi	8
Trap	Ocean<=10mi	2
Yo-yo	Ocean<=10mi	73
Dip/A-frame net	Ocean>10mi	4
Hook and line	Ocean>10mi	58
spear	Ocean>10mi	1

Table 3.4.16. Number of measured Red Hind lengths caught by the private mode by year in Puerto Rico.

Year	Number of lengths
2000	33
2001	73
2002	32
2003	40
2004	37
2005	78
2006	18
2007	14
2008	11
2009	20
2010	19
2011	8
2012	33
2013	3

3.5 Figures

A.



B.

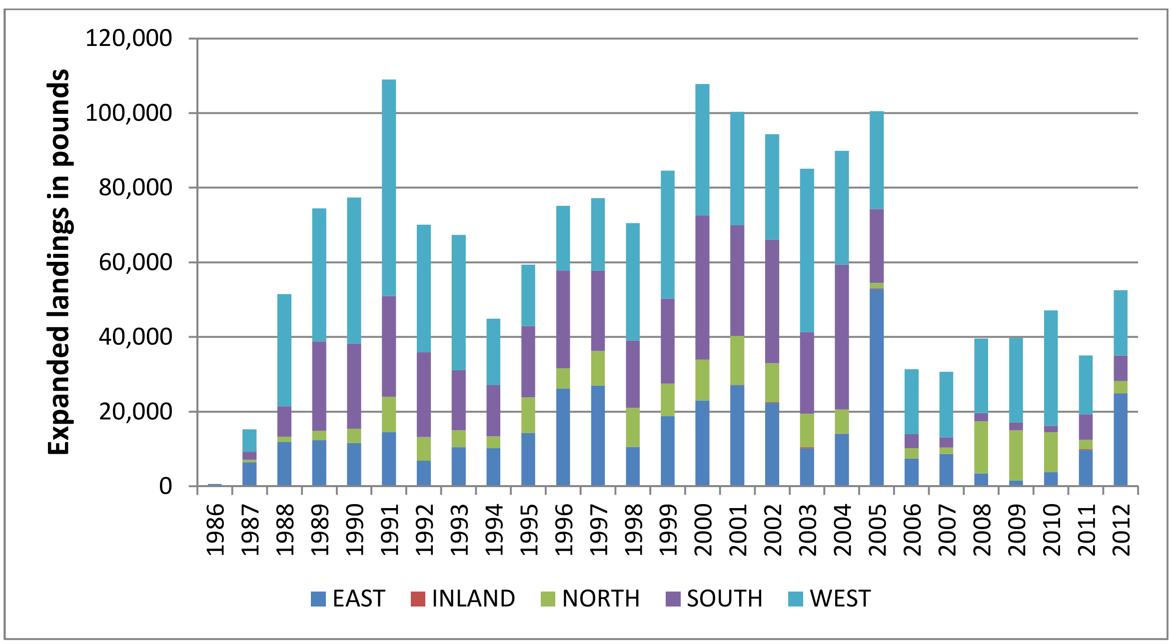


Figure 3.5.1. A. Puerto Rico yearly commercial fishery landings of Red Hind, expansion factors applied, by gear. B. Puerto Rico yearly commercial fishery landings of Red Hind, expansion factors applied, by coast.

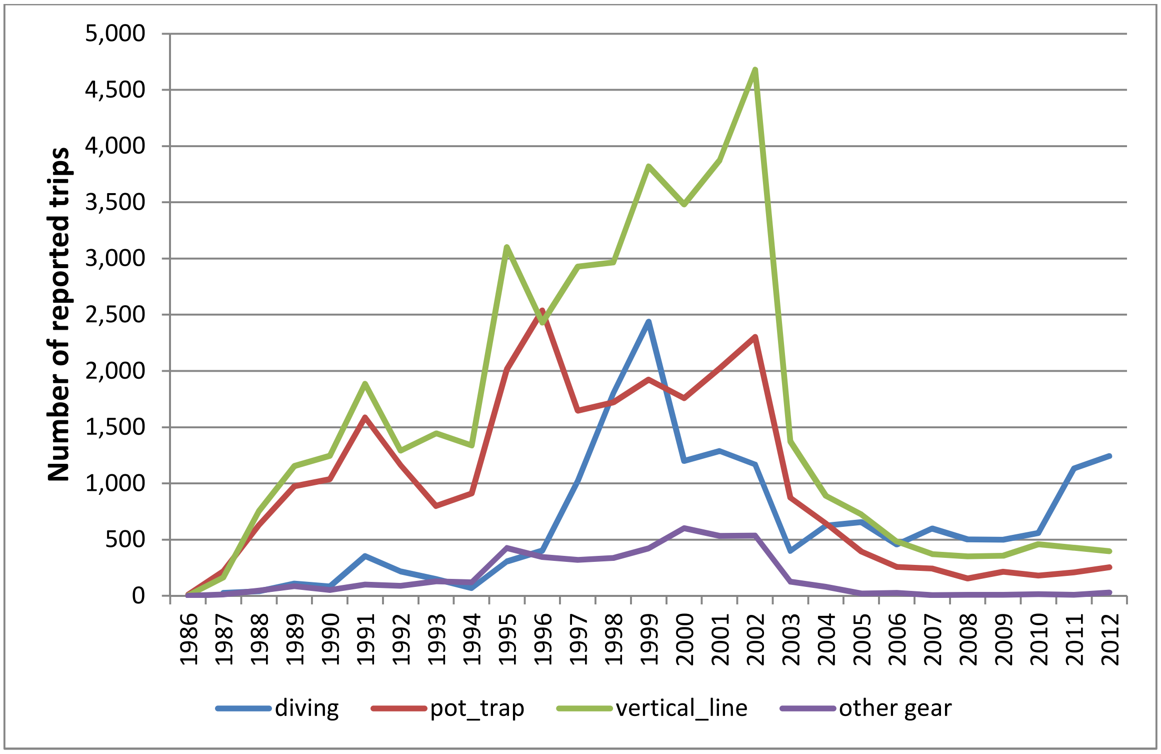


Figure 3.5.2. Puerto Rico reported yearly commercial fishing trips with Red Hind landings by gear.

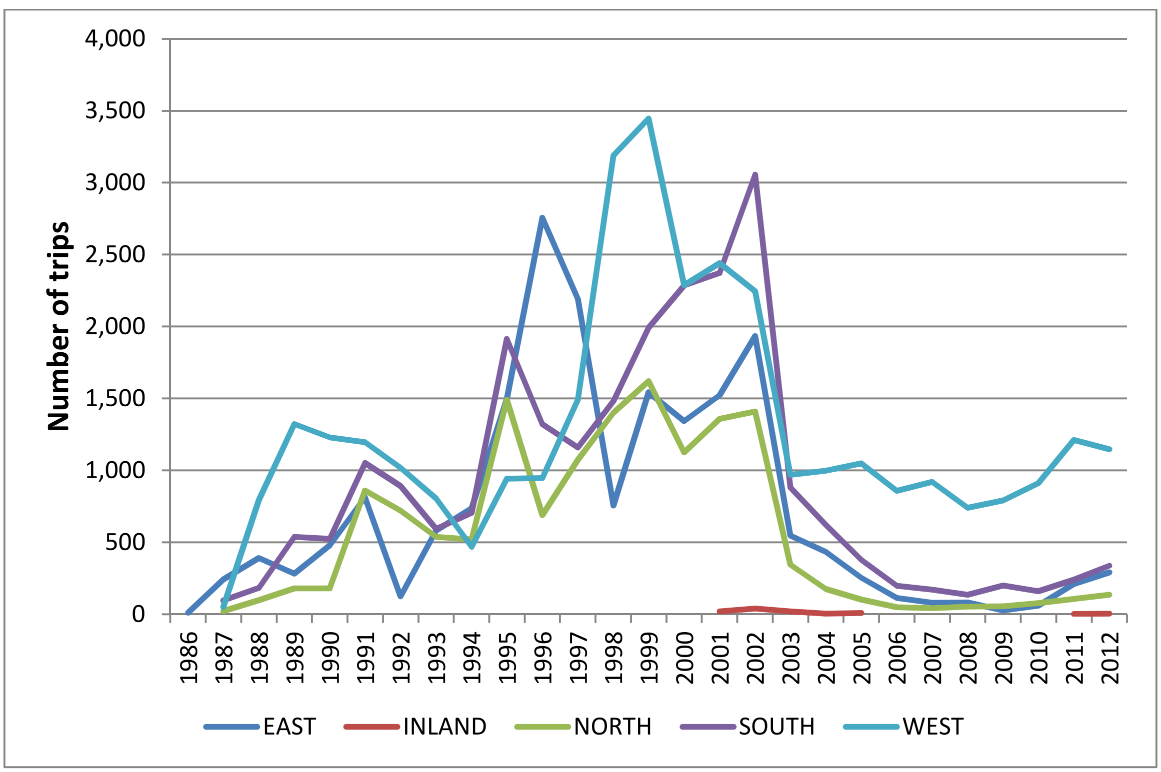


Figure 3.5.3. Puerto Rico reported yearly commercial fishing trips with Red Hind landings by coast.

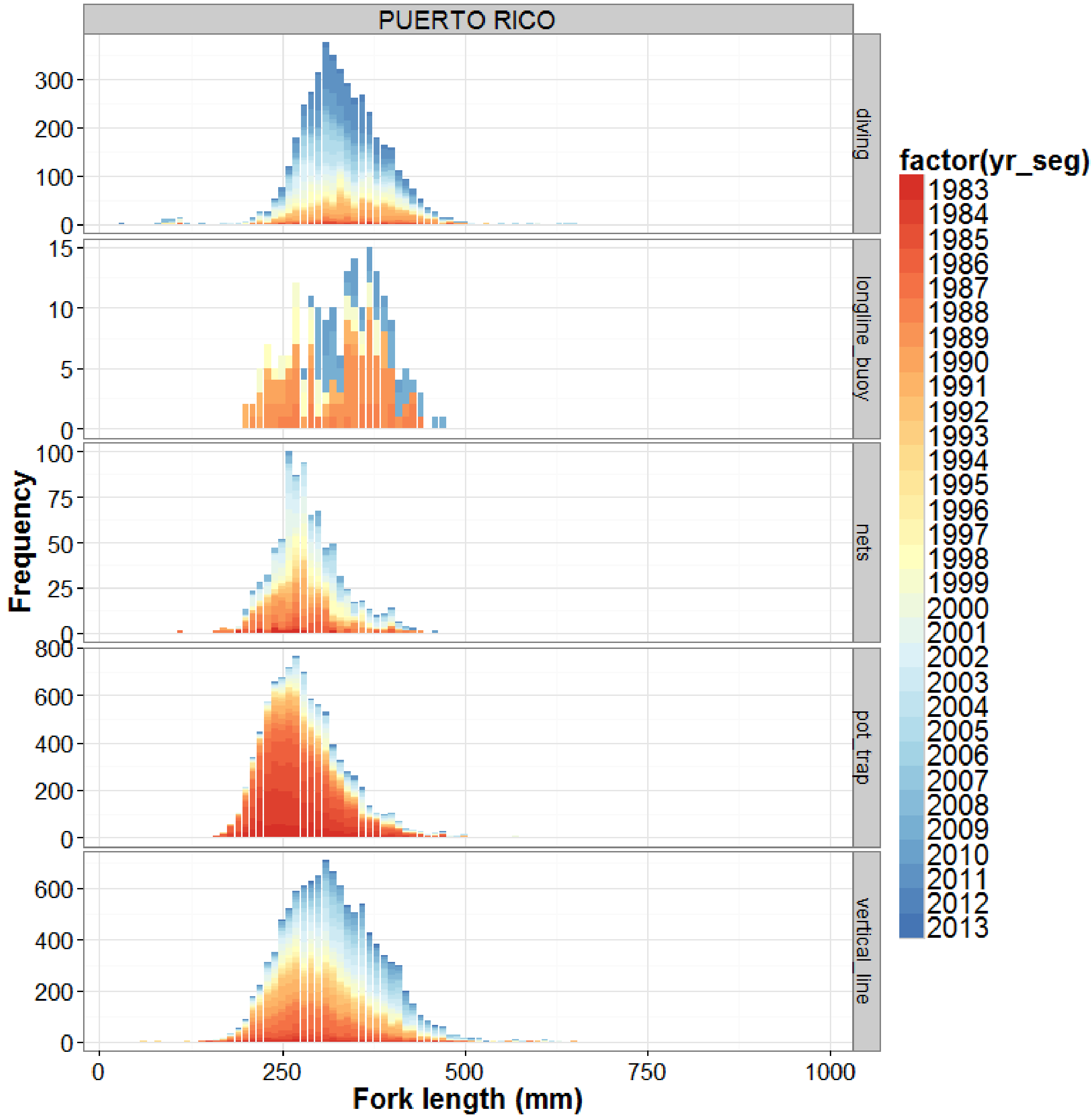


Figure 3.5.4. Length frequency distributions of Red Hind landed in Puerto Rico by year and gear type.

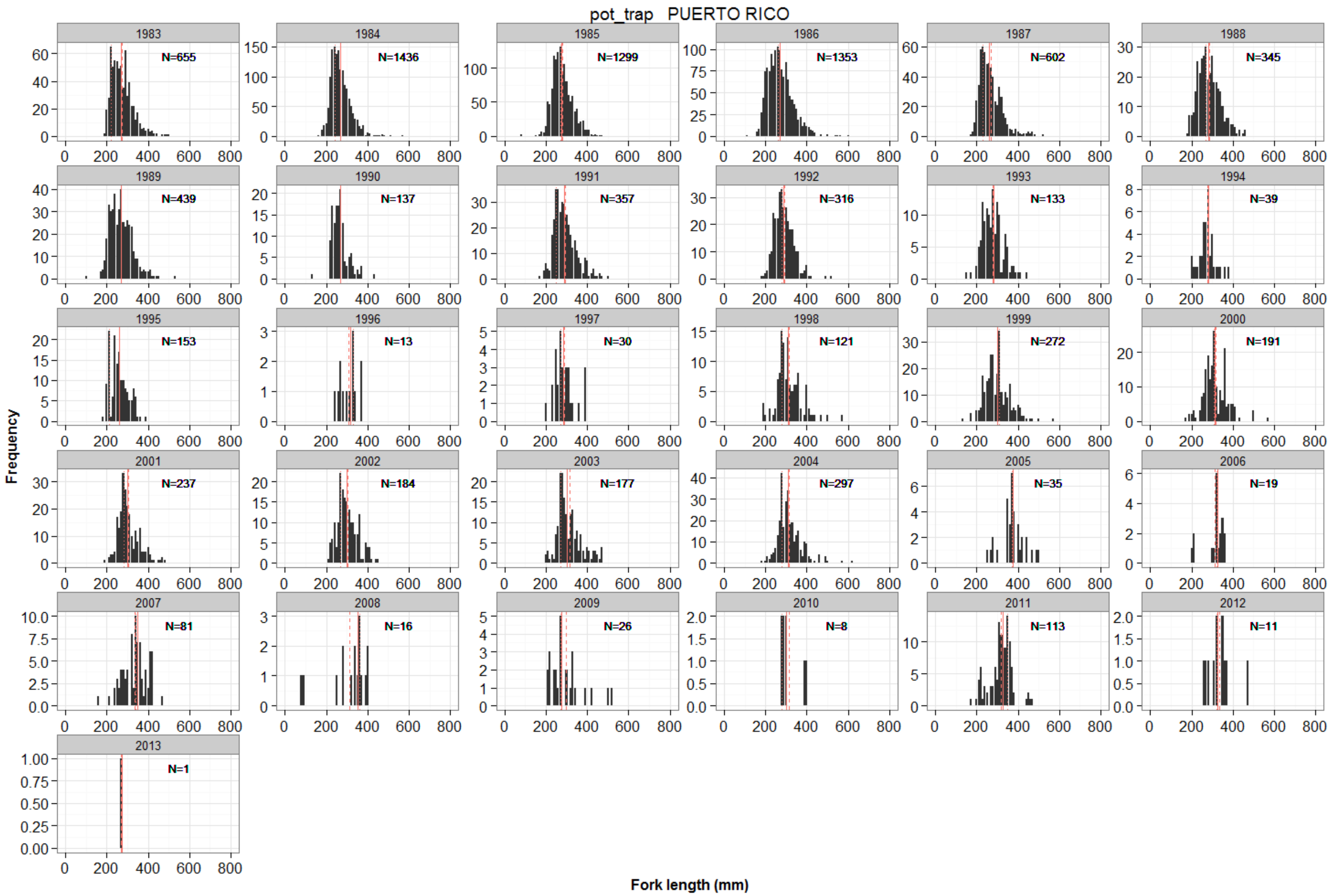


Figure 3.5.5. Annual length frequency distributions of measured Red Hind from the Puerto Rico pot and trap fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 3.2.3.

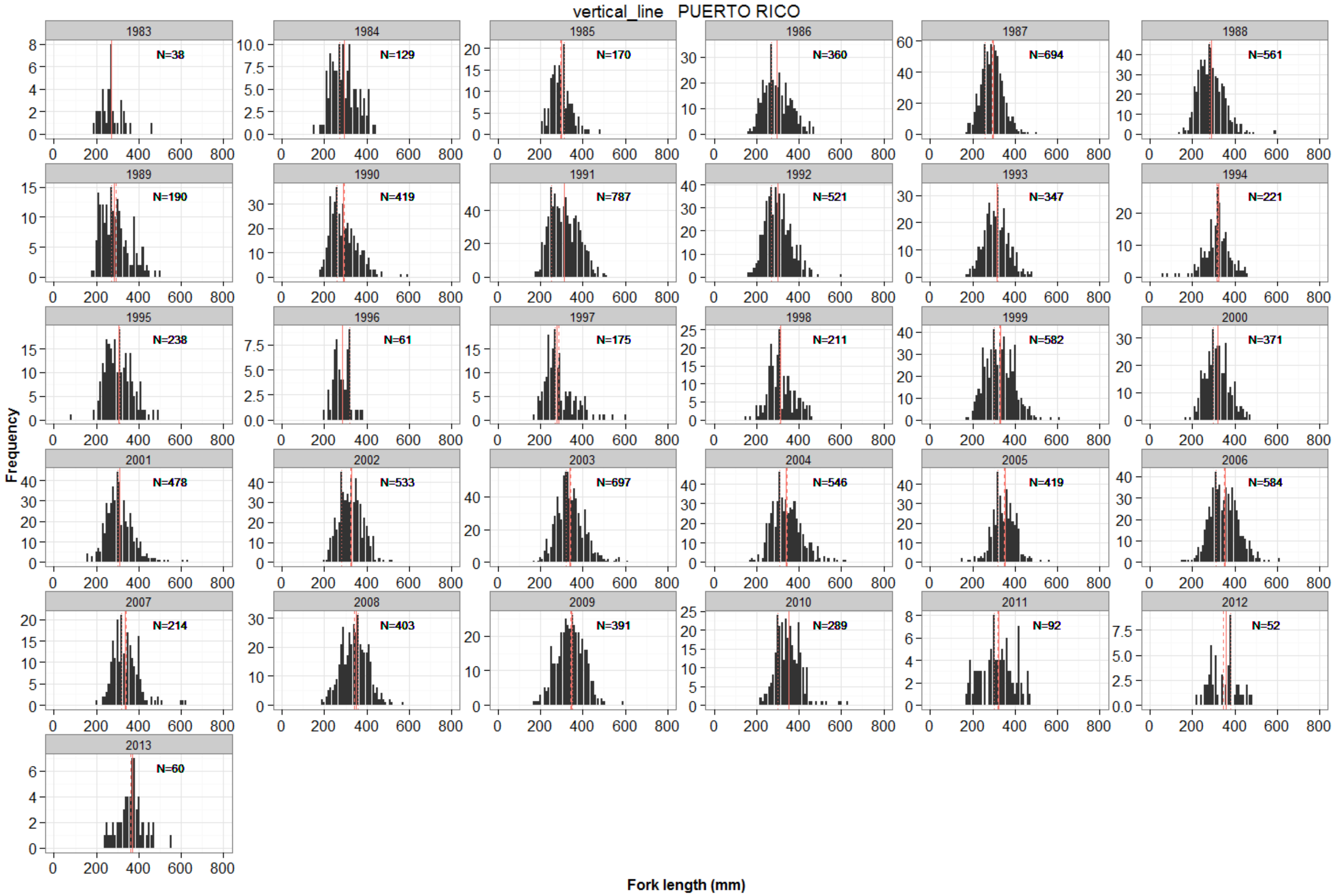


Figure 3.5.6. Annual length frequency distributions of measured Red Hind from the Puerto Rico vertical line fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 3.2.4.

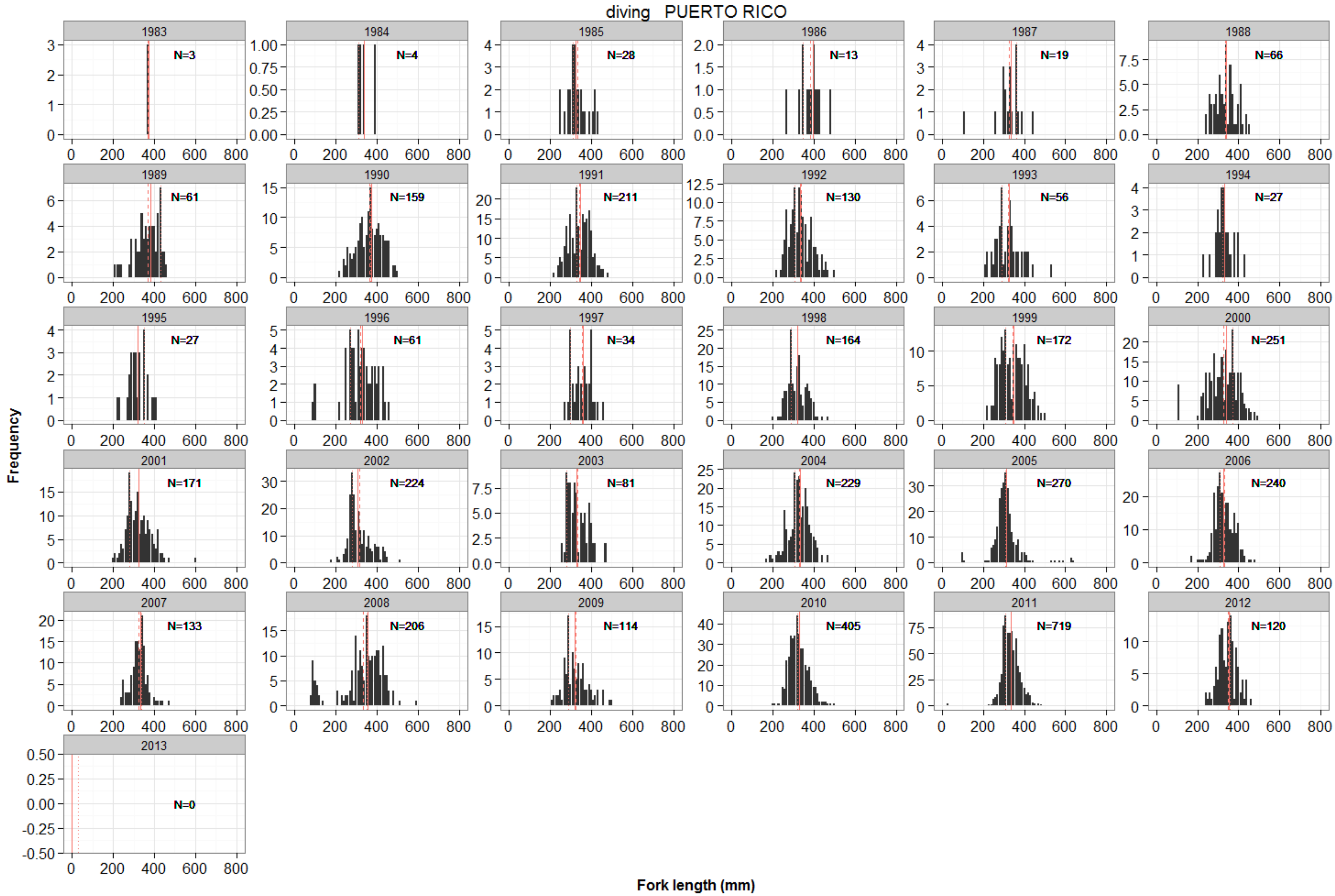


Figure 3.5.7. Annual length frequency distributions of measured Red Hind from the Puerto Rico diving fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 3.2.5.

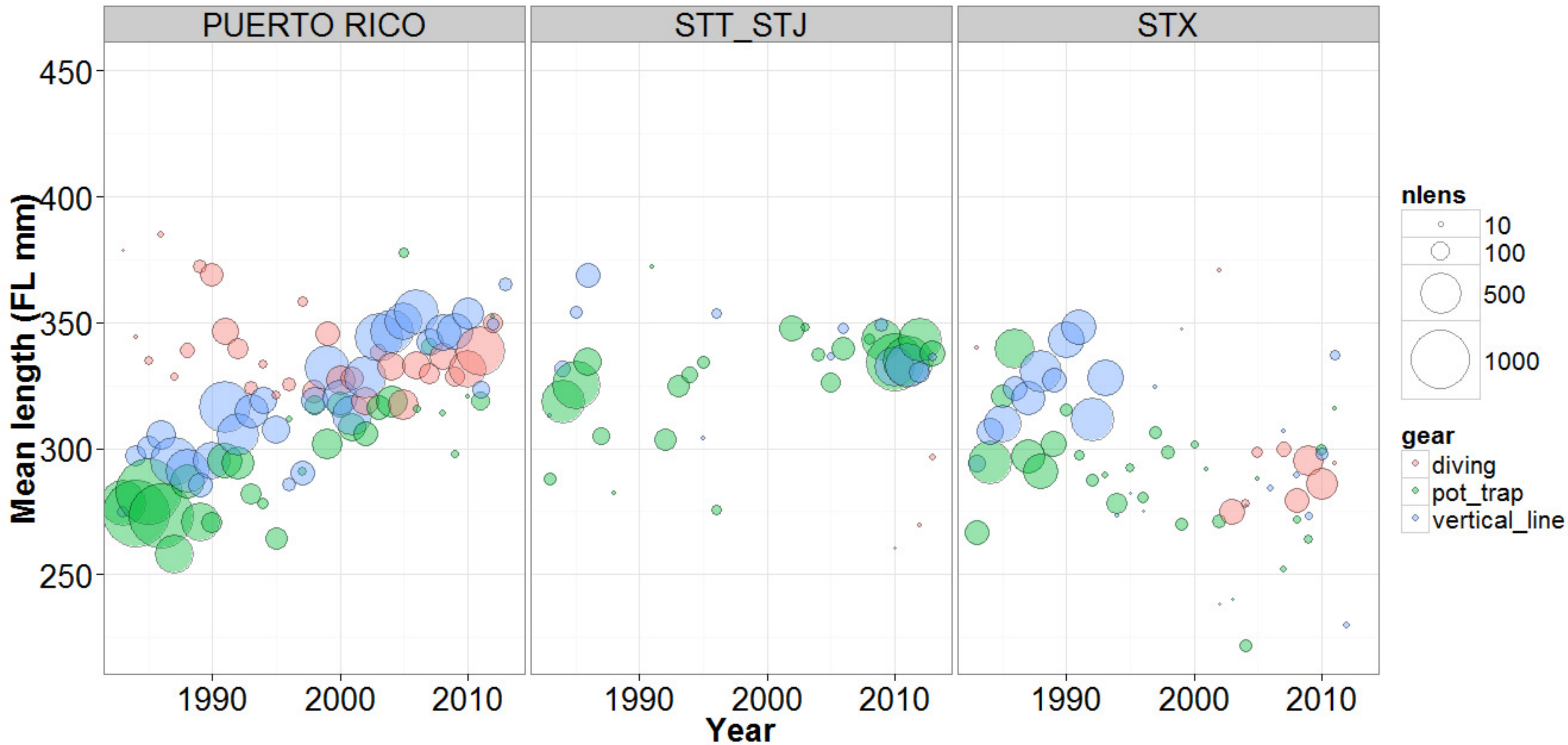


Figure 3.5.8. Mean length (FL mm) of Red Hind over time by island and gear type. Bubbles are scaled to reflect the annual number of lengths and color reflects the different gear types.

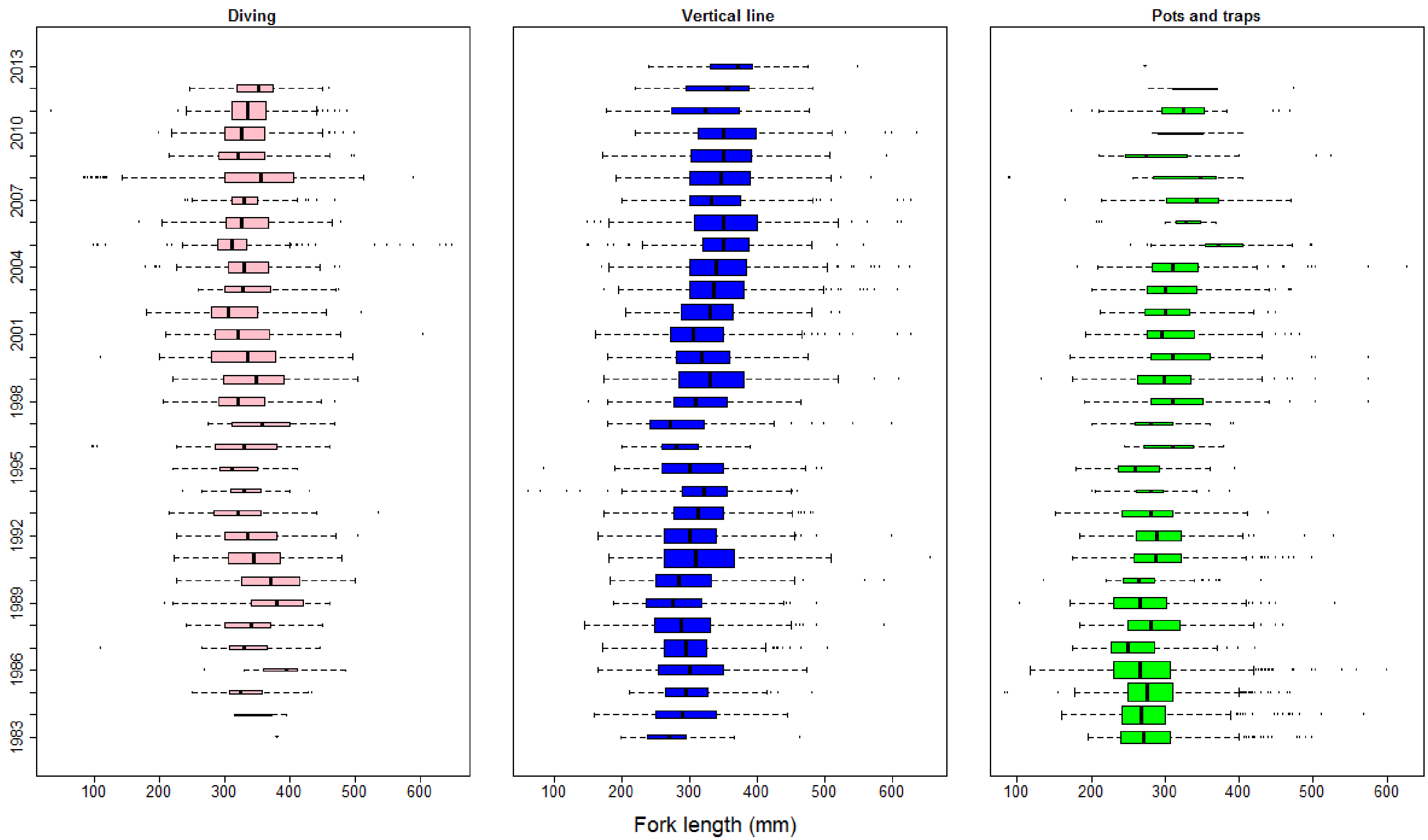


Figure 3.5.9. Boxplots of the annual length data from Puerto Rico by gear. The box represents 50% of the observations and includes the median. Box width was scaled to reflect the annual sample size, where the width was calculated as the square-root of the number of lengths in a given year.

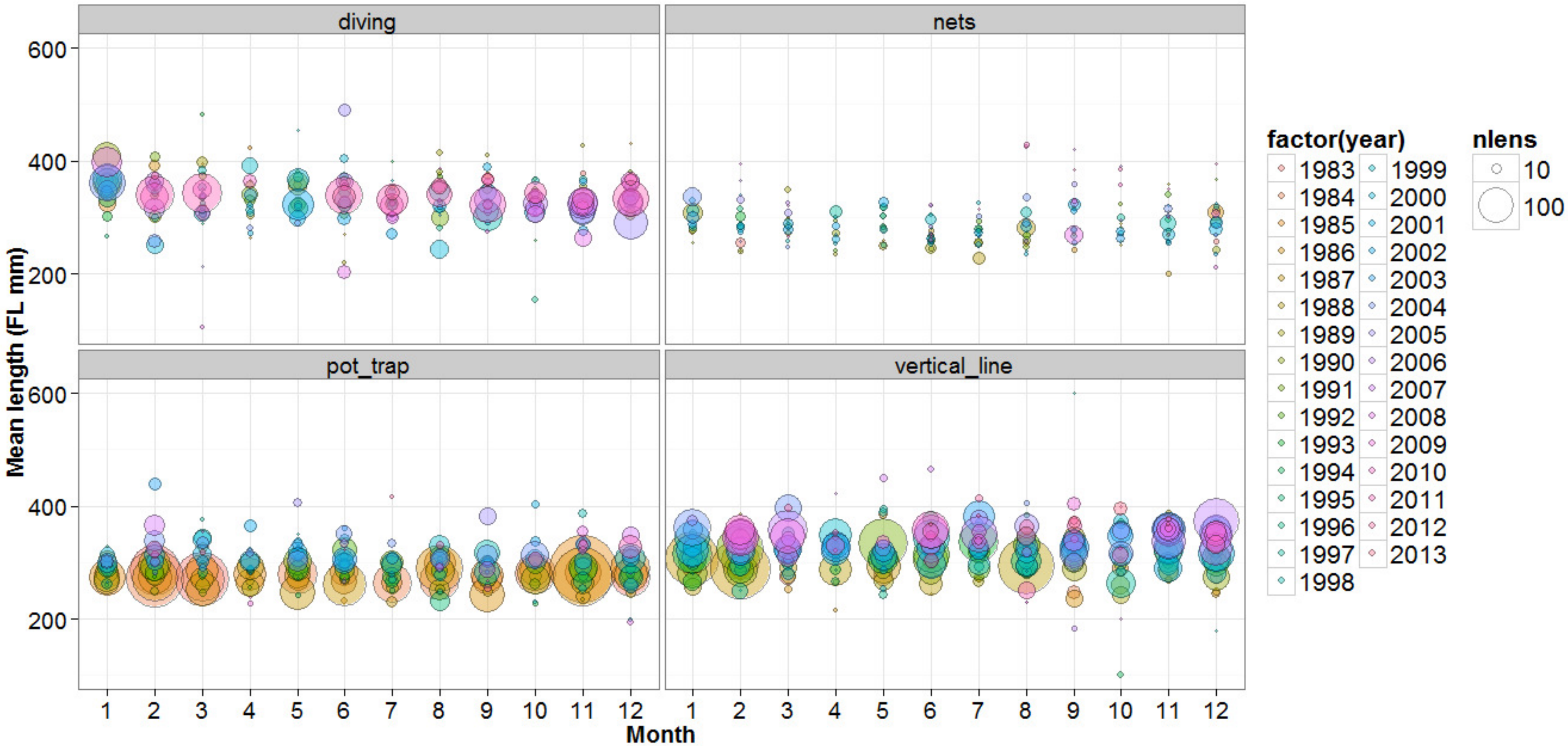


Figure 3.5.10. Monthly mean length by gear type and year. Bubbles are scaled to reflect the annual number of lengths and color reflects the year.

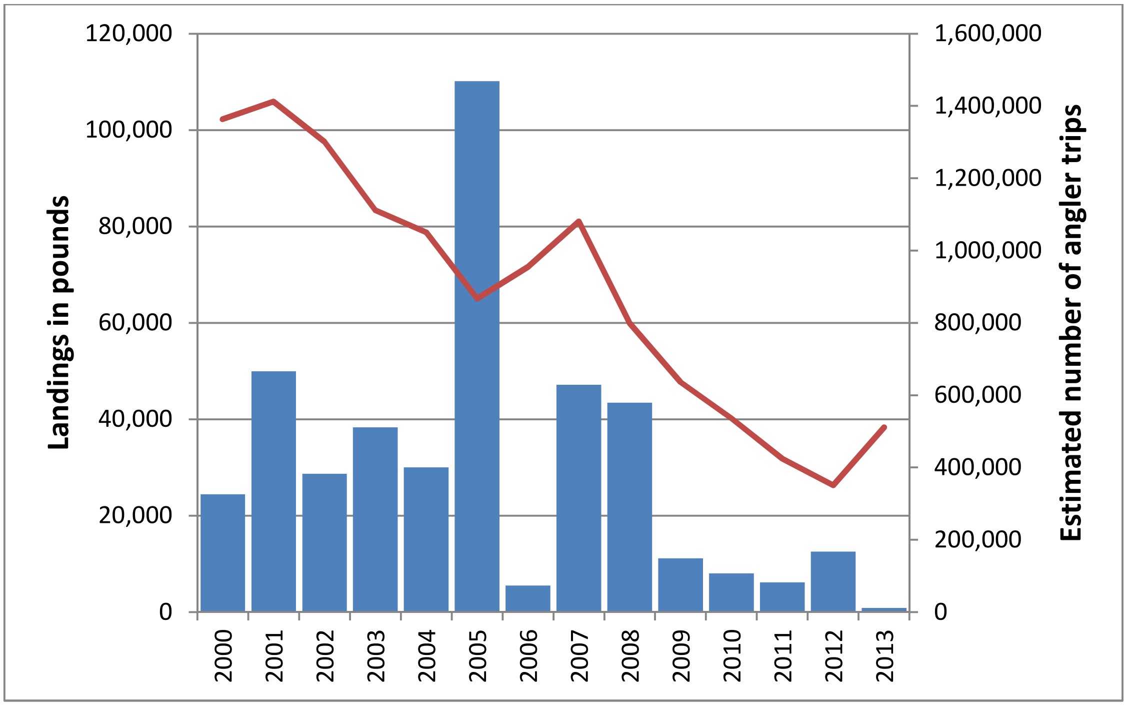


Figure 3.5.11. Red Hind recreational landings estimated using MRFSS data from Puerto Rico. Estimated landings plotted with estimated total recreational trips per year.

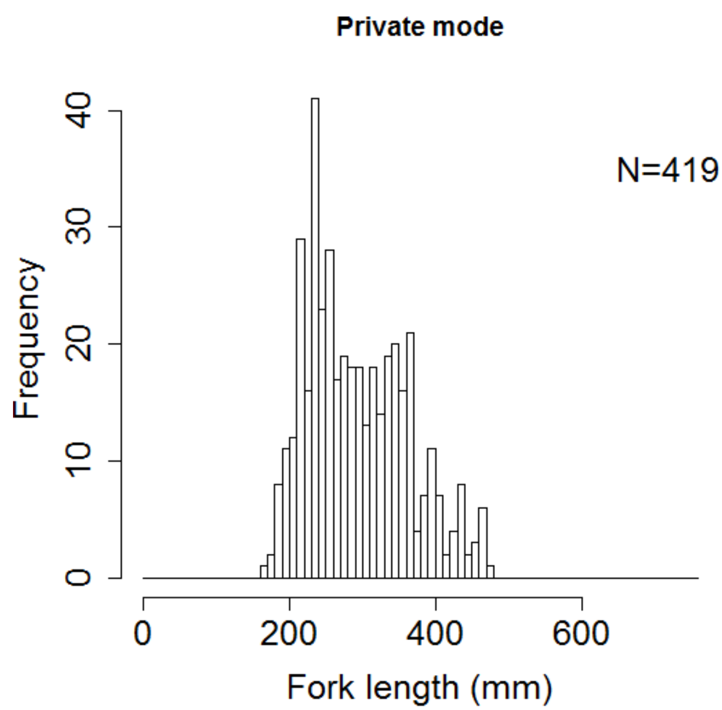


Figure 3.5.12. Length-frequency distribution of Red Hind caught by the private recreational mode in Puerto Rico, 2000-2013. Lengths are aggregated over all gear types and areas.

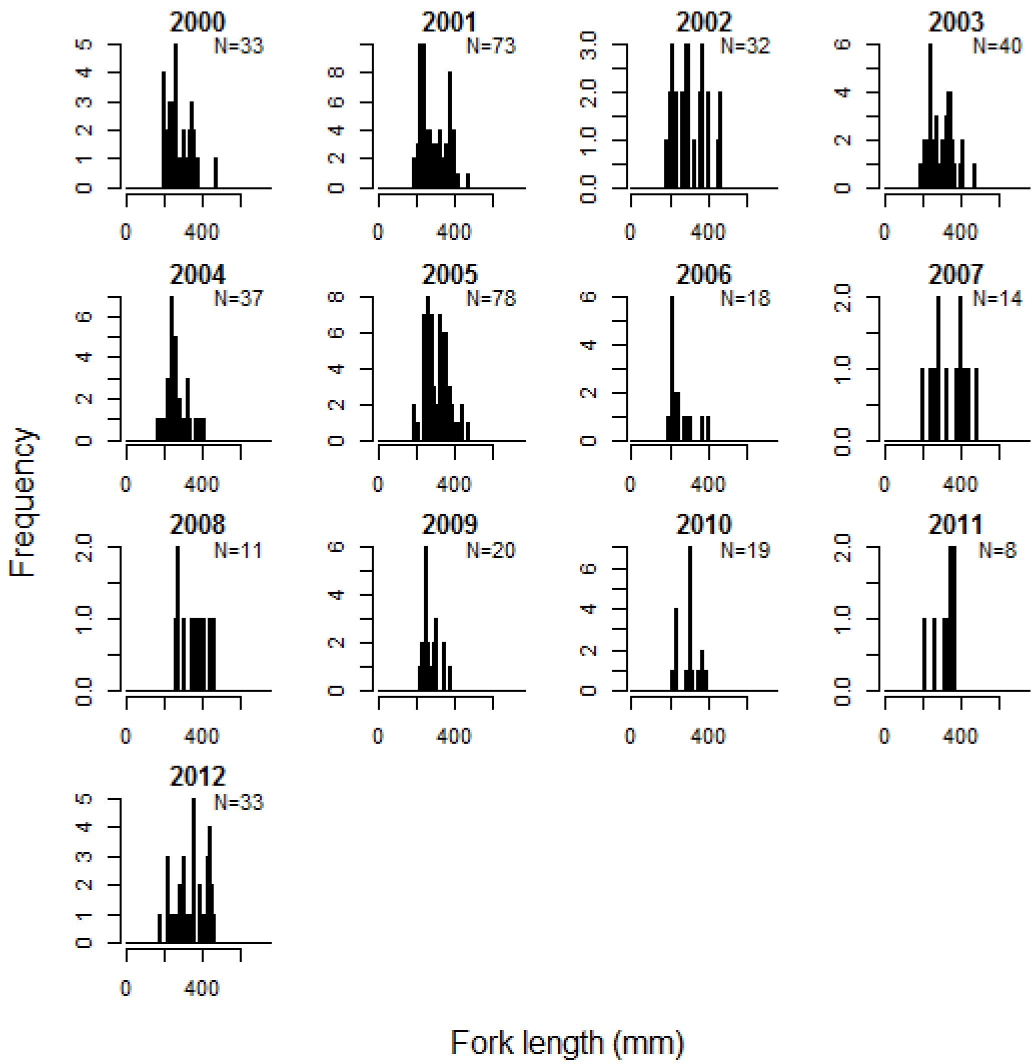


Figure 3.5.13. Annual length-frequency distribution of Red Hind caught by the private mode. All gear types and areas are included.

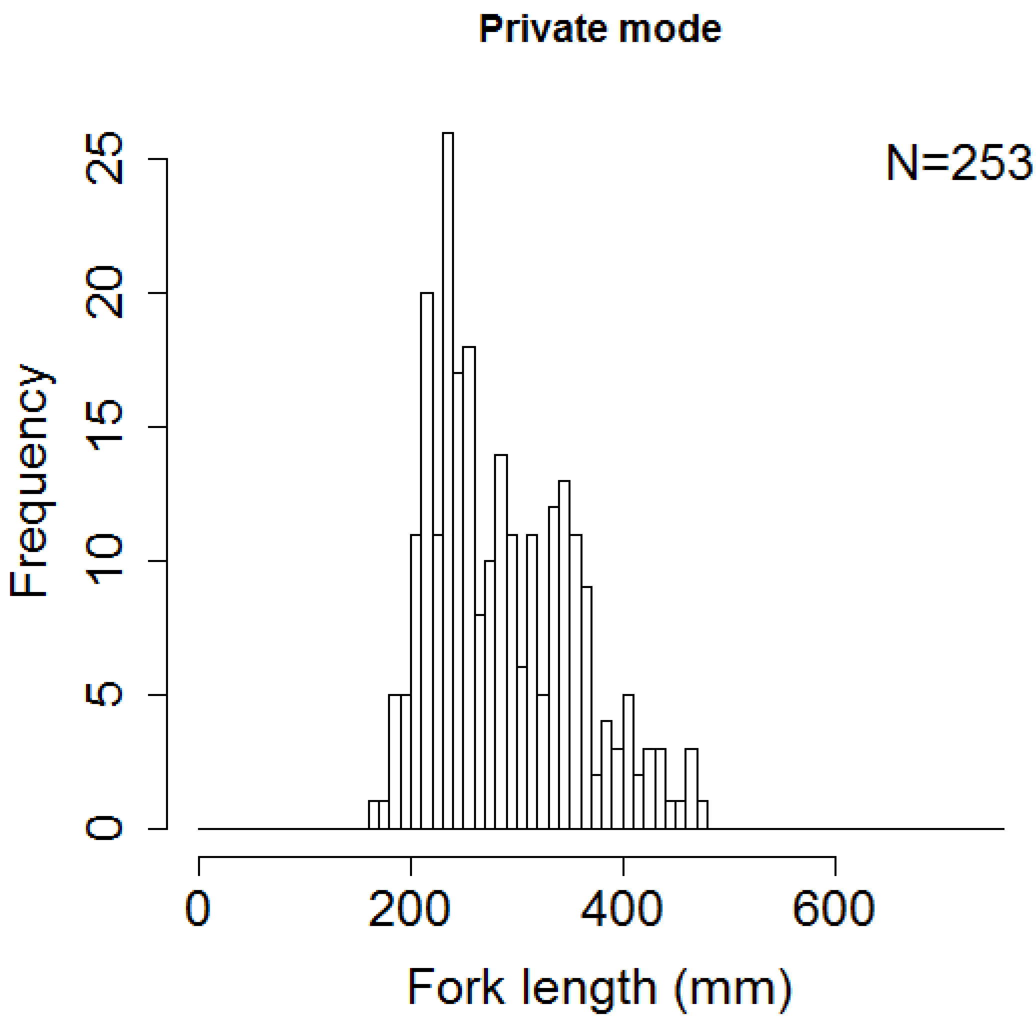


Figure 3.5.14. Length-frequency distribution of Red Hind caught by hook and line and the private recreational mode in state waters (Ocean<=10mi).

4 SAINT THOMAS AND SAINT JOHN FISHERY STATISTICS

4.1 Overview

Several sources of fishery-dependent data were evaluated and discussed at the DW. The main fishery-dependent data sources from St. Thomas include the commercial logbook database and TIP. Recreational data are not surveyed by MRFSS in St. Thomas, however, we did review data collected from the annual Mother's Day tournament in St. Thomas.

4.2 Red Hind commercial fishery statistics

4.2.1 Review of working papers

Working papers were not produced for the data workshop. Commercial landings and TIP information were provided in oral presentations.

4.2.2 Commercial landings

St. Thomas and St. John

In the US Virgin Islands logbook landings data from the islands of St. Thomas and St. John were compiled separately from St. Croix. Logbook reporting began in 1974. Landings were initially reported by gear type (e.g., net fish, hook fish, pot fish, and spear fish) and as either snapper/grouper or as other finfish during the period 1974-1995. Beginning in 1997 in St. Thomas/St. John, some landings data were reported by species group; (e.g., snappers, groupers, parrotfishes, surgeonfishes, etc.) and by gear (hook and line, gill net, SCUBA, trap, etc.). All commercial fishery data reports in St. Thomas/St. John included species group beginning in 2000. Species-specific data reporting began in July of 2011.

Available data for summing commercial landings of Red Hind were the self-reported logbook records from commercial fishers. In the US Virgin Islands landings have been assumed to be fully reported and no correction/expansion factors have been used. Landings could only be provided as grouper (all species combined) due to non-species specific reporting. Yearly landings data, as reported, were summed by species group and fishing gear and are provided in Table 4.4.1 and Figure 4.5.1. Red Hind landings are also provided for the years 2012-2013 when species specific data were available.

Data concerns noted during the workshop

The data workshop panel recommended no further exploration of the US Virgin Islands landings data.

4.2.3 Commercial discards

No commercial discard information for Red Hind was presented at the data workshop. Discard data have hot been consistently collected in the USVI.

4.2.4 Commercial effort

Commercial effort, in numbers of reported fishing trips, is provided in Figure 4.5.2 (St. Thomas/St. John). Those totals include trips with landings of Red Hind in addition to trips with landings of other grouper. The numbers of trips with Red Hind landings are also shown for the years 2012-2013. Changes in effort (trips) may reflect changes in reporting and not changes in targeting alone.

4.2.5 Biological sampling

A total of 40,227 Red Hind lengths were measured between 1983 and 2013, 18.35% were from St. Thomas and St. John. The majority of observed Red Hind lengths were associated with the pot and trap and vertical line fleets (Figure 4.5.3), The observations from the pot and trap fleet represents 76.4% of the Red Hind lengths measured in St. Thomas and St. John. Approximately 22.9% of the Red Hind was from the vertical line fleet and approximately 1% was associated with other gear types. Tables 4.4.2-4.4.6 provide a summary of sample size for each fleet and shows the years in which data are missing. Eight years (1989, 1990,1997-2001, and 2008) of length samples are missing from the pot and trap fleet and 16 years (1987-1991,1993,1994,1997-2001,2003,2004,2007,2008) of length samples are missing from the vertical line fleet (Tables 4.4.2 and 4.4.3).

Annual length-frequency plots are shown in Figures 4.5.4 and 4.5.5 for the vertical line and pot and trap fleets, respectively. The number of observed lengths associated with the pot and trap fleet was highly variable. Between 1984 and 1986 sample sizes were large, then varied and were generally small between 1991 and 2006, and increased between 2009-2013 (Table 4.4.2). Mean length was more variable and on average smaller earlier in the time-series than in the 2000s when mean length was stable (Table 4.4.2, Figure 4.5.5). Overall, the mean length of observed Red Hind from the pot and trap fleet was larger than the length at maturity (Table 4.4.2, Figures 4.4.6 and Section 3.5, Figure 3.5.8).

The number of lengths associated with the vertical line, in years with data, was highly variable (Table 4.4.5). Between 2010 and 2012 the number of observed lengths from the vertical line fleet increased substantially. Given the inconsistent sampling of Red Hind, it is difficult to comment on trends in mean length, but annual mean lengths are shown in Figure 4.5.7 compared to those from the pot and trap fleet.

The annual length frequency distributions were visually inspected to determine the length-at-recruitment (L_c) to the fishery where the mode of a well-defined distribution can represent L_c . The mode of each annual distribution was determined as well as the overall mode for each gear type. An estimate of L_c from the overall length-frequency distribution for the pot and trap fishery is ~300mm. The peak in the length frequency distribution for the 1980s-1990s is ~290mm, whereas in the 2000s the peak is ~310mm (Table 4.4.2, Figures 4.5.3 and 4.5.5).

Fishermen in attendance at the DW indicated that prior to the closure of Hind Bank, they primarily targeted Red Hind spawning aggregations from December through February. Trends in monthly mean length were evaluated to determine whether fishing activity during the spawning season influenced annual trends in length. Figure 4.5.7 shows monthly mean length by year for the pot and trap and vertical line fleets. Mean length was variable within months and among years. The influence of the spawning season on mean length is not apparent.

4.3 Recreational fisheries statistics

4.3.1 MRFSS

The MRFSS program currently does not collect data in St. Thomas or St. John.

4.3.2 Mothers Day Tournament

During the DW, Dr. Tom Dolan from the USVI DPNR presented data from the St. Thomas Mother's Day Tournament. These data were presented as an oral presentation; a DW working paper was not submitted to SEDAR.

The Mother's Day Tournament is a weight-based tournament that takes place annually in May. The tournament is held between 0530 and 1200 and only women are eligible for prizes. Handlines are the primary gear type used and there are no rules constraining hook size. Participants are allowed to use chum to attract fish. Although any species can be retained, the main target species is Queen Triggerfish, *Balistes vetula*.

Data from this tournament have been collected since 2000 and represent a total of 621 Red Hind. Data were not collected in 2004. Length information was not recorded in 2001 or 2005-2009. There was also mention of data inconsistencies in 2001. The main data collected include species-specific numbers, weight, and length and effort.

The data presented included length distributions as well as a nominal catch per unit effort (CPUE) series. Readers are referred to the presentation on the ftp site to view the presented data summaries. A summary of these data was given to the assessment analysts at the end of the meeting.

4.4 Tables

Table 4.4.1. Reported commercial landings of grouper (no expansion factors applied) from St. Thomas and St. John, 2000-2013.

Year	Grouper	Red Hind
2000	49,142	n/a
2001	54,273	n/a
2002	55,166	n/a
2003	65,332	n/a
2004	75,682	n/a
2005	66,343	n/a
2006	60,391	n/a
2007	52,540	n/a
2008	56,910	n/a
2009	68,602	n/a
2010	60,806	n/a
2011	53,170	n/a
2012	41,284	34,772
2013	23,128	20,376

Table 4.4.2. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the pot and trap fleet in St. Thomas and St. John.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Nlens
Pots and traps	1983	250	255	279	287.9	310.5	48
	1984	290	270	305	318.5	360	547
	1985	280	280	315	325.3	370	679
	1986	340	290.8	340	334.4	370	232
	1987	280	280	300	304.9	335	98
	1988	280	280	280	282.5	282.5	4
	1989	-	-	-	-	-	-
	1990	-	-	-	-	-	-
	1991	-	-	-	-	-	-
	1992	290	278.5	297	303.5	328.5	147
	1993	310	282.8	315	324.8	365.5	148
	1994	270	283.2	317	329.2	377.8	80
	1995	290	295.5	342	334.3	370	51
	1996	250	240	252	275.7	300	33
	1997	-	-	-	-	-	-
	1998	-	-	-	-	-	-
	1999	-	-	-	-	-	-
	2000	-	-	-	-	-	-
	2001	-	-	-	-	-	-
	2002	290	305	338	347.5	382.5	187
	2003	360	312.2	345.5	347.9	371.8	28
	2004	280	302	331	337.1	367.5	63
	2005	300	300	316.5	326.2	347.8	116
	2006	310	309	333	339.4	371.5	167
	2007	-	-	-	-	-	-
	2008	360	303.8	348.5	343.1	373.2	38
	2009	300	305	335	343.5	375.5	508
	2010	310	301.5	325	334.1	362	971
	2011	310	307	326	334.6	358	745
	2012	320	312.2	337	343.3	373.8	550
	2013	310	314	331.5	337.8	359.2	192
Overall							

Table 4.4.3. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the vertical line fleet in St. Thomas and St. John. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Vertical line	1983	330	280	315	312.8	330	9
	1984	280	291.5	322	331.4	353	75
	1985	380	323.8	377.5	354.4	398	50
	1986	380	345	365	368.6	392	181
	1987	-	-	-	-	-	-
	1988	-	-	-	-	-	-
	1989	-	-	-	-	-	-
	1990	-	-	-	-	-	-
	1991	-	-	-	-	-	-
	1992	450	450	450	450	450	1
	1993	-	-	-	-	-	-
	1994	-	-	-	-	-	-
	1995	250	287.5	313	304.2	329.8	4
	1996	310	313.8	341.5	353.6	395.5	32
	1997	-	-	-	-	-	-
	1998	-	-	-	-	-	-
	1999	-	-	-	-	-	-
	2000	-	-	-	-	-	-
	2001	-	-	-	-	-	-
	2002	260	260	260	260	260	1
	2003	-	-	-	-	-	-
	2004	-	-	-	-	-	-
	2005	360	298.2	347.5	336.8	370	18
	2006	330	316	348	347.5	378	43
	2007	-	-	-	-	-	-
	2008	-	-	-	-	-	-
	2009	370	317.8	357.5	349.1	379.8	56
	2010	280	289.2	330	332.4	370	474
	2011	280	290.5	327	333.1	375	587
	2012	300	290	315	329.9	352	128
	2013	330	314	336	336.1	365	25
	Overall						

Table 4.4.4. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the diving fleet in St. Thomas and St. John. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Diving	1983	-	-	-	-	-	-
	1984	380	380	380	380	380	1
	1985	-	-	-	-	-	-
	1986	-	-	-	-	-	-
	1987	-	-	-	-	-	-
	1988	-	-	-	-	-	-
	1989	-	-	-	-	-	-
	1990	-	-	-	-	-	-
	1991	-	-	-	-	-	-
	1992	-	-	-	-	-	-
	1993	-	-	-	-	-	-
	1994	-	-	-	-	-	-
	1995	-	-	-	-	-	-
	1996	-	-	-	-	-	-
	1997	-	-	-	-	-	-
	1998	-	-	-	-	-	-
	1999	-	-	-	-	-	-
	2000	-	-	-	-	-	-
	2001	-	-	-	-	-	-
	2002	-	-	-	-	-	-
	2003	-	-	-	-	-	-
	2004	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2006	-	-	-	-	-	-
	2007	-	-	-	-	-	-
	2008	-	-	-	-	-	-
	2009	-	-	-	-	-	-
	2010	220	230	235	260.3	278	3
	2011	-	-	-	-	-	-
	2012	260	261.5	267.5	269.5	275.5	4
	2013	230	246.2	284.5	296.2	353.5	12

Table 4.4.5. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the net fleet in St. Thomas and St. John. The mode represents the length bin with the greatest number of observations.

Gear type	**Year**	**Mode**	**25th percentile**	**Median**	**Mean**	**75th percentile**	**Number of lengths**
Nets	1983	-	-		-	-	-
	1984	300	292.5	302.5	323.3	372.5	12
	1985	-	-	-	-	-	-
	1986	-	-	-	-	-	-
	1987	-	-	-	-	-	-
	1988	-	-	-	-	-	-
	1989	-	-	-	-	-	-
	1990	-	-	-	-	-	-
	1991	-	-	-	-	-	-
	1992	260	263	263	263	263	1
	1993	-	-	-	-	-	-
	1994	-	-	-	-	-	-
	1995	200	279.8	352.5	352.5	425.2	2
	1996	-	-	-	-	-	-
	1997	-	-	-	-	-	-
	1998	-	-	-	-	-	-
	1999	-	-	-	-	-	-
	2000	-	-	-	-	-	-
	2001	-	-	-	-	-	-
	2002	-	-	-	-	-	-
	2003	-	-	-	-	-	-
	2004	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2006	290	299.5	303	303	306.5	2
	2007	-	-	-	-	-	-
	2008	-	-	-	-	-	-
	2009	-	-	-	-	-	-
	2010	-	-	-	-	-	-
	2011	-	-	-	-	-	-
	2012	-	-	-	-	-	-
	2013	-	-	-	-	-	-

Table 4.4.6. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the longline fleet in St. Thomas and St. John. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Longline	1983	-	-	-	-	-	-
	1984	-	-	-	-	-	-
	1985	250	280	320	329.3	365	13
	1986	-	-	-	-	-	-
	1987	-	-	-	-	-	-
	1988	-	-	-	-	-	-
	1989	-	-	-	-	-	-
	1990	-	-	-	-	-	-
	1991	-	-	-	-	-	-
	1992	-	-	-	-	-	-
	1993	-	-	-	-	-	-
	1994	-	-	-	-	-	-
	1995	-	-	-	-	-	-
	1996	-	-	-	-	-	-
	1997	-	-	-	-	-	-
	1998	-	-	-	-	-	-
	1999	-	-	-	-	-	-
	2000	-	-	-	-	-	-
	2001	-	-	-	-	-	-
	2002	-	-	-	-	-	-
	2003	-	-	-	-	-	-
	2004	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2006	230	261	286	286	311	2
	2007	-	-	-	-	-	-
	2008	-	-	-	-	-	-
	2009	-	-	-	-	-	-
	2010	-	-	-	-	-	-
	2011	-	-	-	-	-	-
	2012	-	-	-	-	-	-
	2013	-	-	-	-	-	-

Table 4.4.7. Measures of central tendency and dispersion in the number of measured Red Hind lengths in St. Thomas and St. John by month. Red Hind spawning occurs between December and February, with a peak in January (Nemeth 2005).

Month	Lower_quartile	Median	Upper_quartile	Mean	SD
January	18.75	25.50	72.00	57.17	74.16
February	9.00	23.00	57.25	59.00	89.34
March	16.00	31.00	85.00	64.38	73.87
April	6.00	16.50	39.25	38.88	60.87
May	19.00	37.00	103.00	88.00	106.08
June	7.00	17.00	67.00	76.54	116.55
July	8.00	13.00	45.50	26.00	25.09
August	18.25	24.00	41.75	30.33	20.95
September	13.00	23.00	40.50	33.27	28.41
October	12.50	29.00	55.25	38.58	37.87
November	10.00	21.00	38.00	34.56	37.14
December	12.50	47.00	76.75	44.42	34.37

4.5 Figures

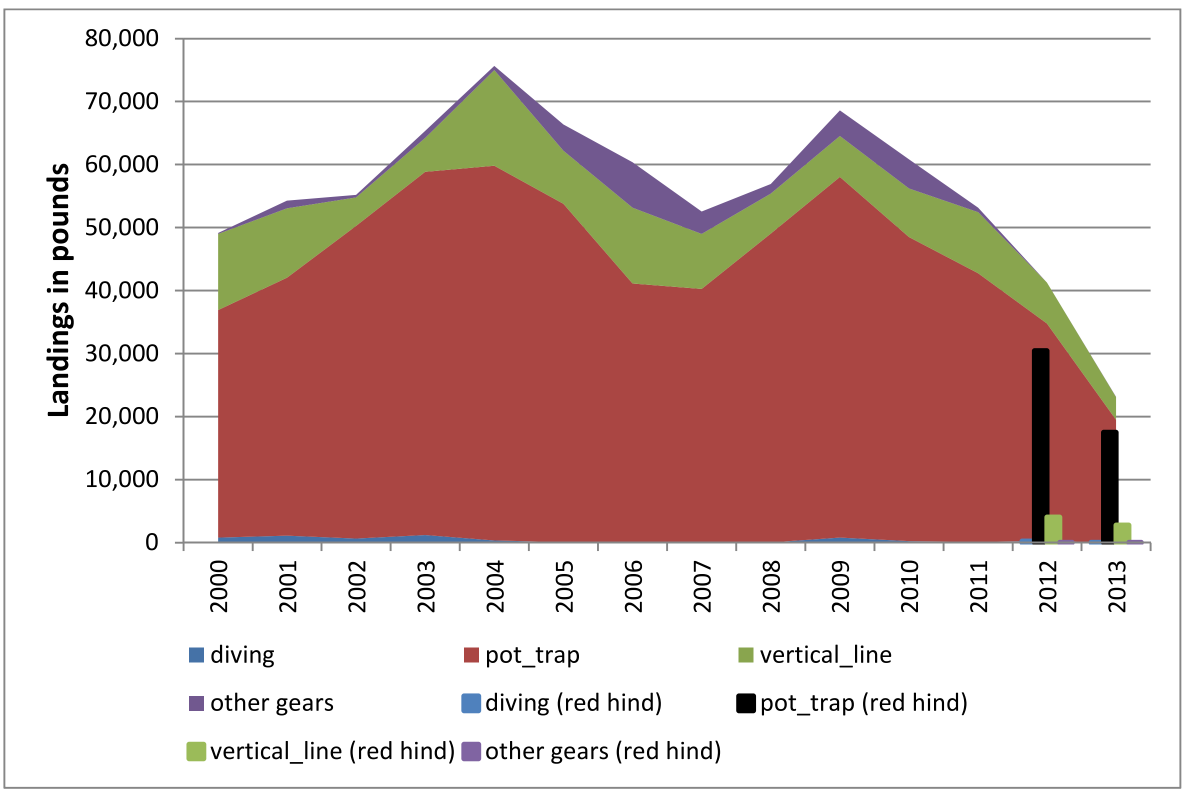


Figure 4.5.1. Yearly commercial landings of grouper as reported (no expansion factors applied) on fisher logbooks from St. Thomas and St. John by gear. Histogram (2012-13) shows Red Hind landings as reported by gear following introduction of species specific reporting forms.

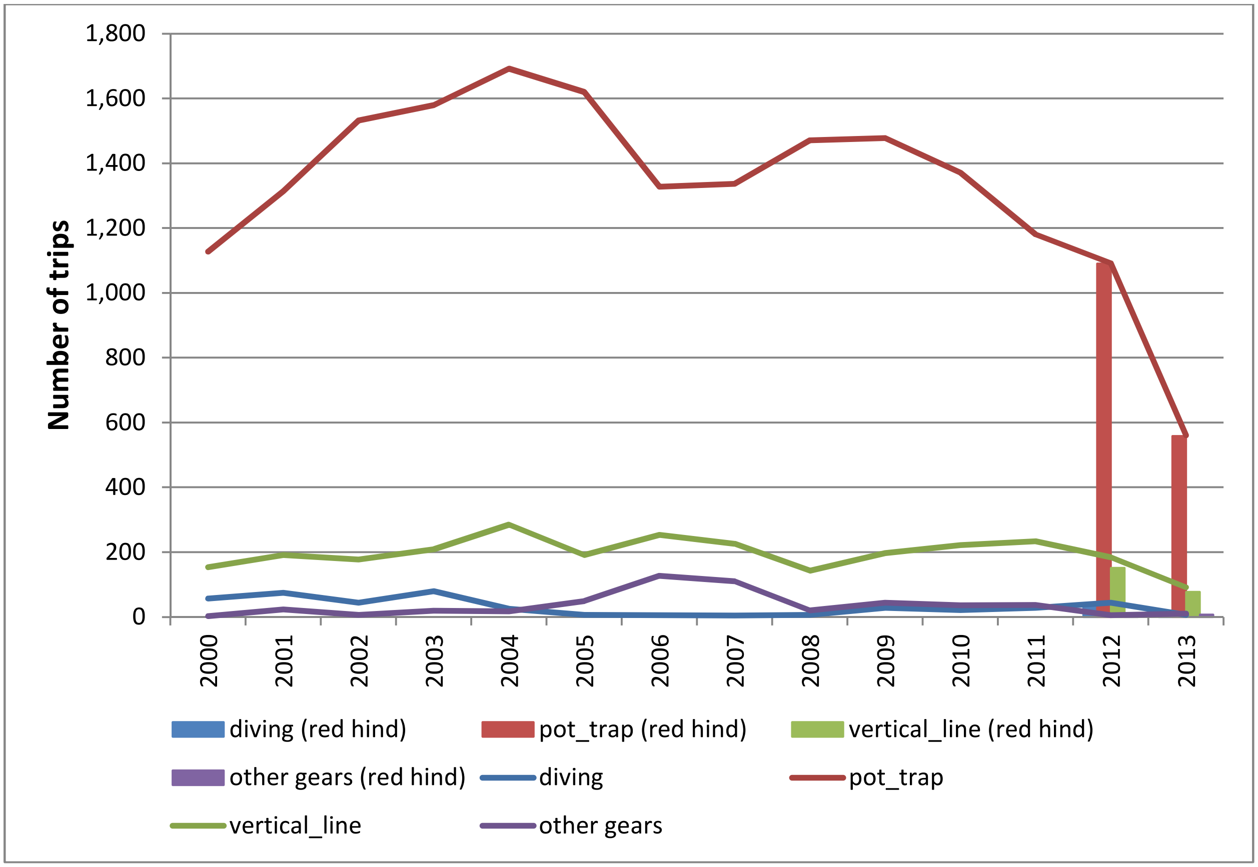


Figure 4.5.2. St. Thomas and St. John reported commercial fishing trips with grouper landings by gear and year. Histogram (2012-13) shows trips reporting Red Hind landings by gear following introduction of species-specific reporting forms.

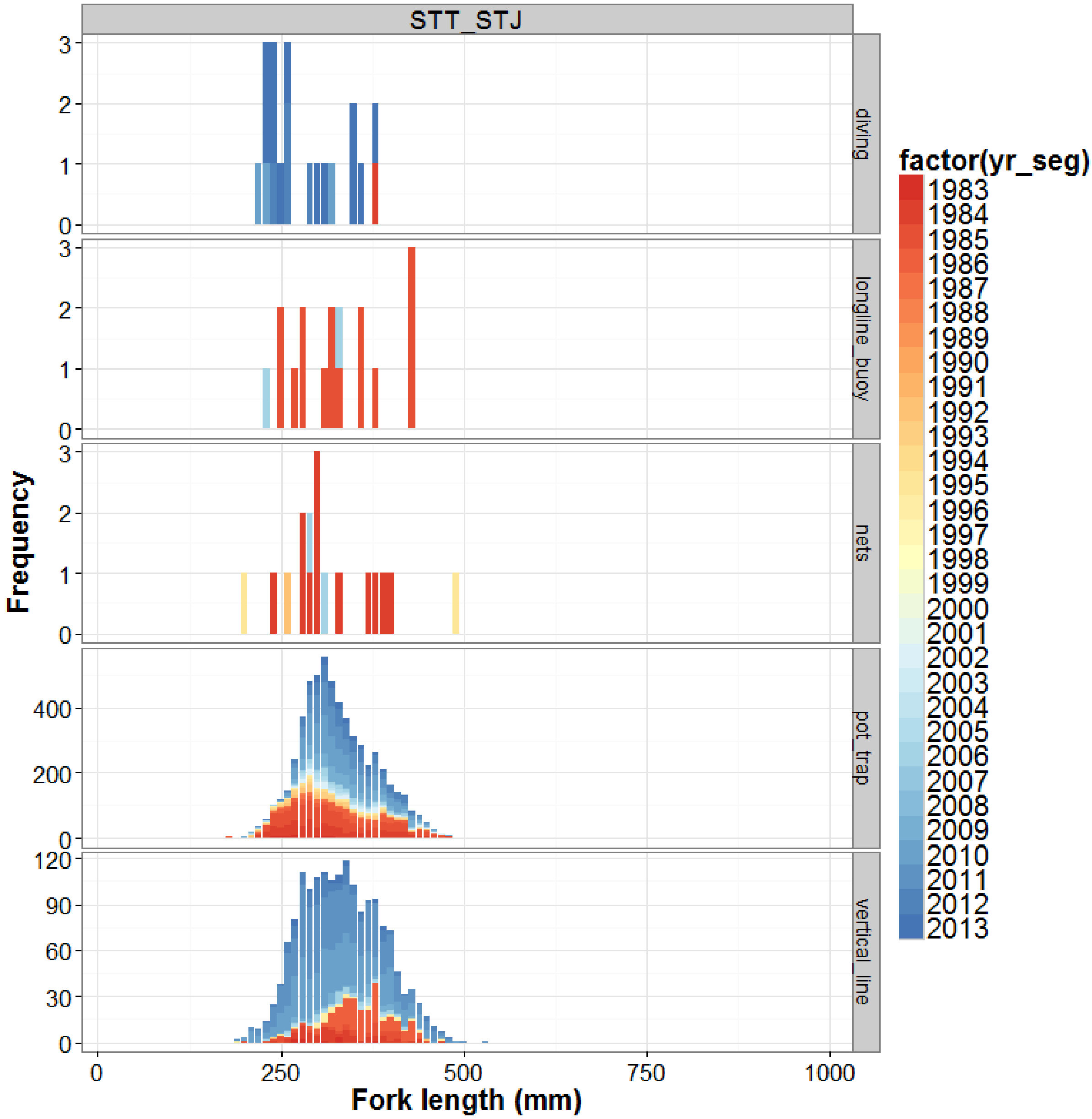


Figure 4.5.3. Length frequency distributions of Red Hind landed in St. Thomas and St. John by year and gear type.

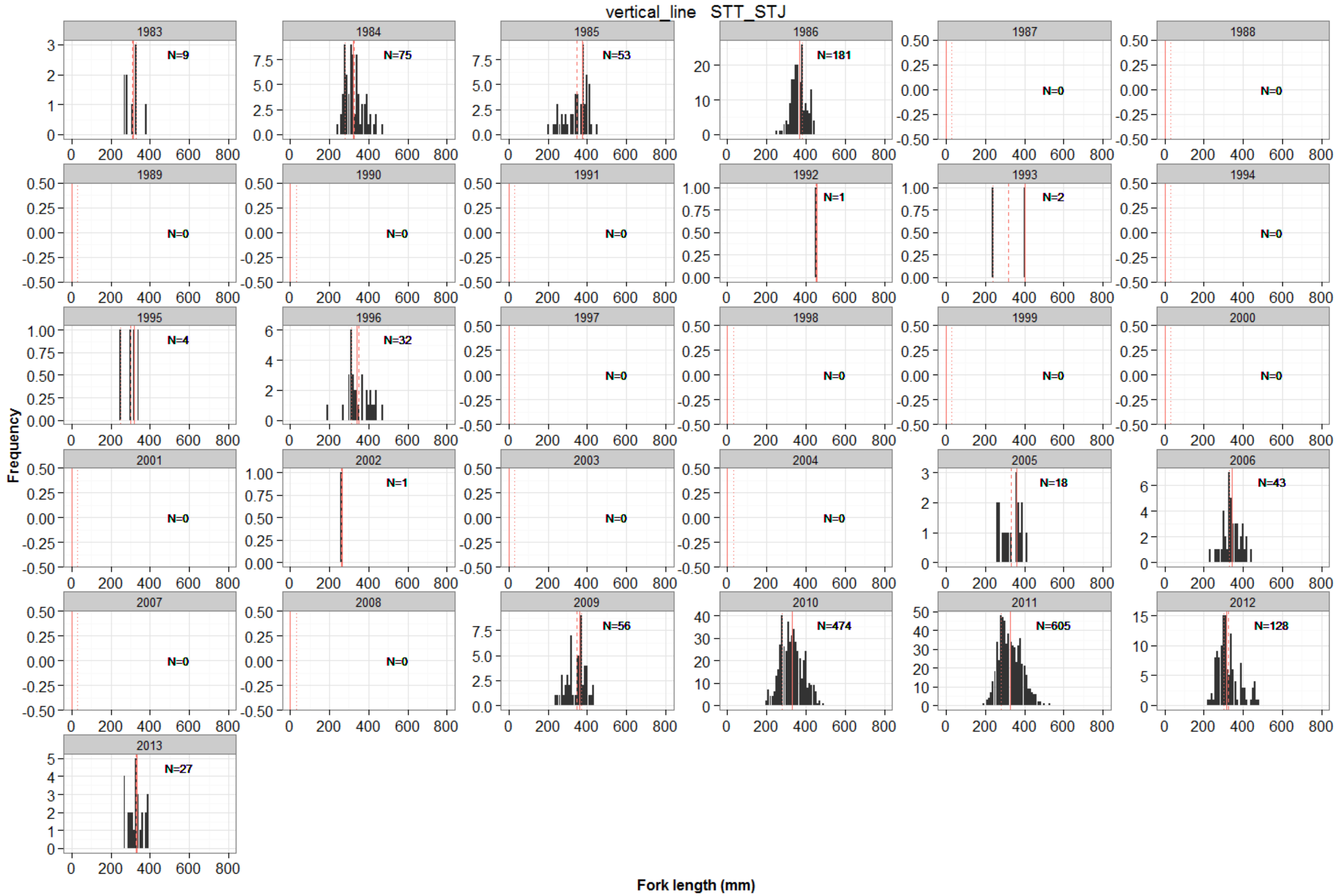


Figure 4.5.4. Annual length frequency distributions of measured Red Hind from the St. Thomas and St. John vertical line fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 4.2.2.

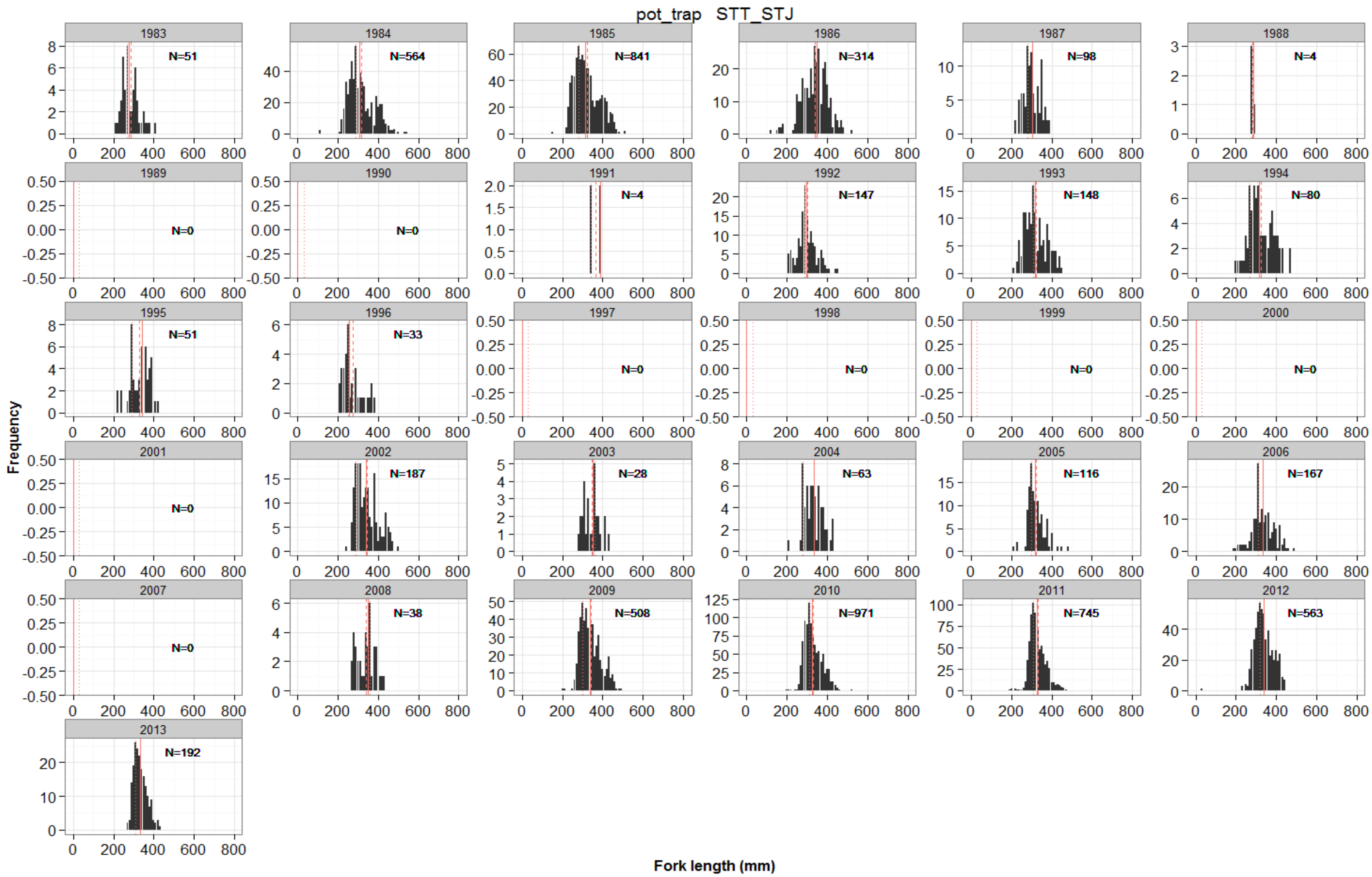


Figure 4.5.5. Annual length frequency distributions of measured Red Hind from the St. Thomas and St. John pot and trap fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 4.2.3.

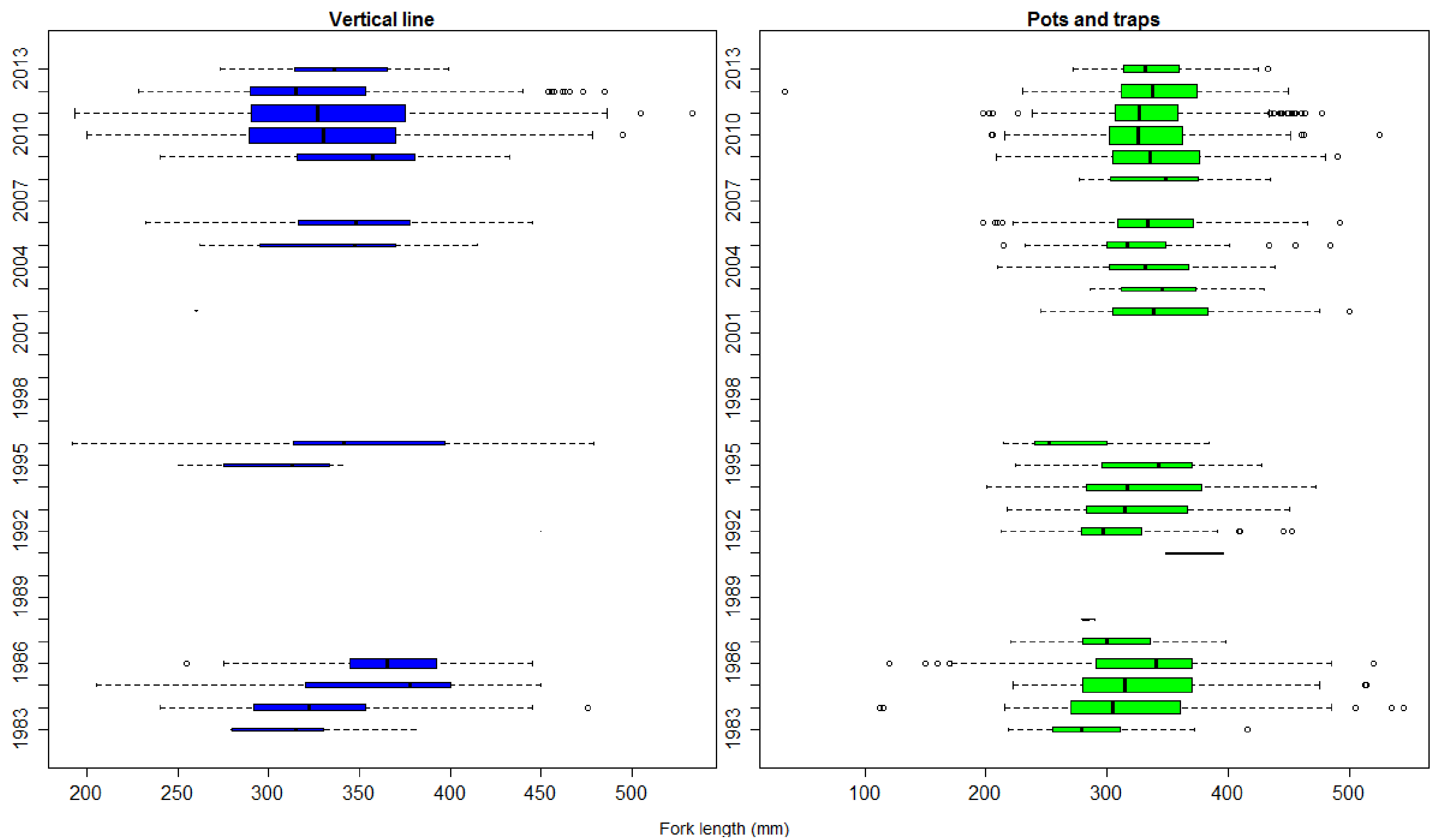


Figure 4.5.6. Boxplots of the annual length data from the St. Thomas and St. John vertical line and pot and trap fleets. The box represents 50% of the observations and includes the median. Box width was scaled to reflect the annual sample size, where the width was calculated as the square-root of the number of lengths in a given year.

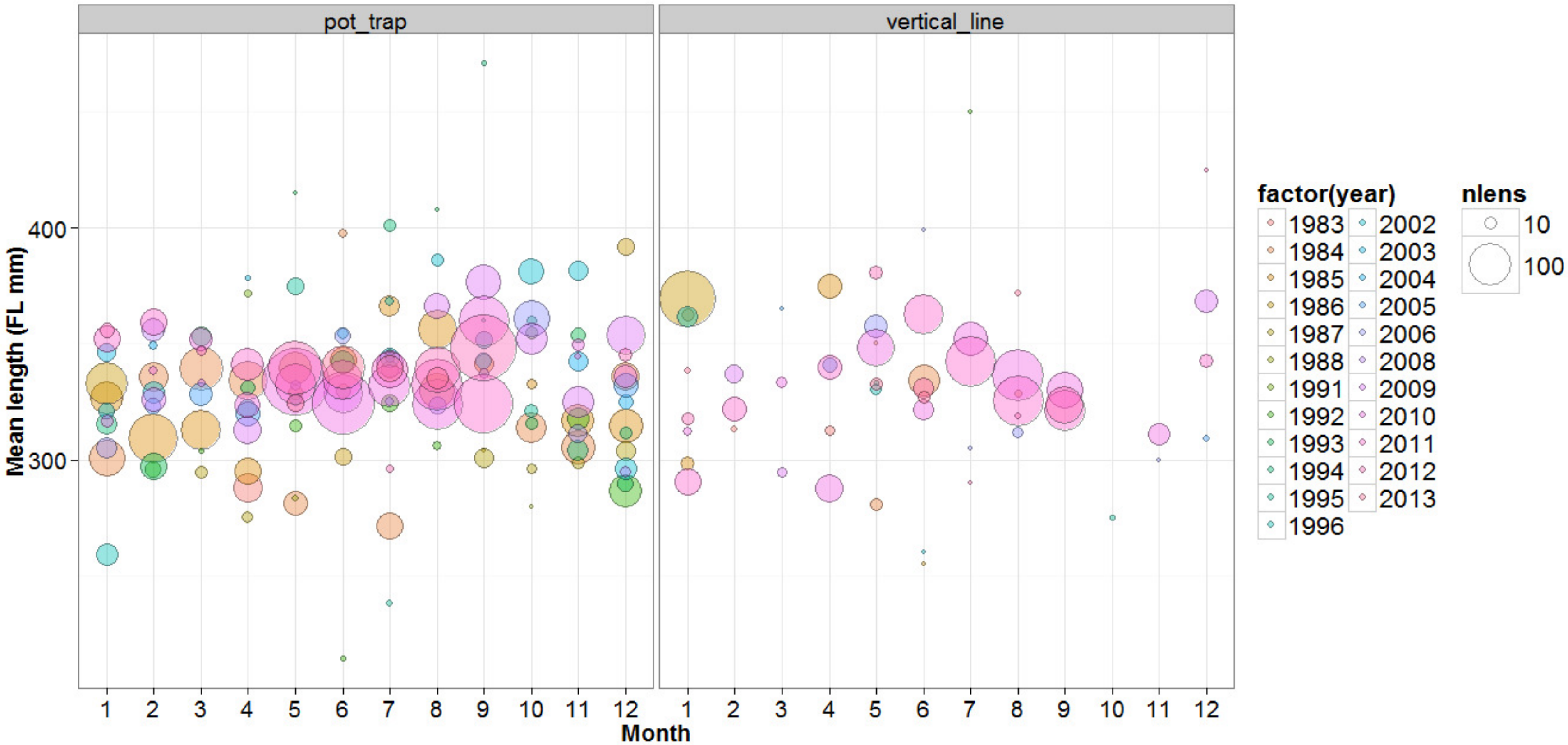


Figure 4.5.7. Monthly mean length by year and gear type. Bubbles are scaled to reflect the annual number of lengths and color reflects the year.

5 SAINT CROIX FISHERY STATISTICS

5.1 Red Hind commercial fishery statistics

5.1.1 Review of working papers

Working papers were not produced for the data workshop. Commercial landings and biological sampling information were provided in oral presentations.

5.1.2 Commercial landings

In the US Virgin Islands logbook landings data from the islands of St. Thomas and St. John were compiled separately from St. Croix. Logbook reporting began in 1974; however, landings were initially reported by gear type (e.g., net fish, hook fish, pot fish, and spear fish) and as either snapper/grouper or as other finfish during the period 1974-1995.

See the St. Thomas and St. John section for a brief description of the available landings data. In St. Croix some landings data were reported by species group beginning in 1995 and all landings were reported by species group beginning in 1998. Prior to July, 2011 landings could only be provided as grouper (all species combined) due to the non-species specific reporting by commercial fishers. In St. Croix, landings data were available for the years 1998-2013. Yearly landings data, as reported, were summed by species group (grouper) and fishing gear and are provided in Table 5.3.1 and Figure 5.4.1. Red Hind specific landings are provided for 2012-2013, the only full calendar years of species specific data.

Data concerns noted during the workshop

The data workshop panel recommended no further exploration of the US Virgin Islands landings data.

5.1.3 Commercial discards

Commercial discard information for Red Hind was not presented at the data workshop. Discard data have hot been consistently collected in the USVI.

5.1.4 Commercial effort

Commercial effort, in numbers of reported fishing trips, is provided in Figure 5.4.2. Those totals include trips with landings of Red Hind in addition to trips with landings of other grouper. The numbers of trips with Red Hind landings are also shown for the years 2012-2013. Changes in effort (trips) may reflect changes in reporting and not changes in targeting alone.

5.1.5 Biological sampling

A total of 40,227 Red Hind lengths were measured between 1983 and 2013, 20% (8056) of the observations were from St. Croix. The measured Red Hind lengths were primarily associated with the vertical line and the pot and trap fleets and represent 47.29% and 37.59% of the Red Hind lengths measured in St. Croix. The majority of these were observed early in the times series (Figure 5.4.3). Red Hind lengths associated with the diving fleet were not observed until the 2000s (Figure 5.4.3) and represent 13.84% of the Red Hind lengths measured in St. Croix. Lengths associated with the longline and net fleets represent a fraction of a percent of the total number of Red Hind lengths.

Annual length-frequency plots are shown in Figures 5.4.4 - 5.4.6 for the vertical line, pot and trap, and diving fleets, respectively. Figure 5.4.8 (right panel) shows the annual mean lengths for the pot and trap, vertical line, and diving fleets. Observed mean length from the pot and trap fleet increased between 1983 and 1986 and then declined. The decline was confounded with a severe reduction in sample size; the number of observed lengths was in the hundreds between 1983 and 1989 and then declined dramatically (Table 5.3.2, Figure 5.4.5). A similar pattern was observed for the vertical line fleet; however, the increase in mean length was between 1983 and 1990. The number of observed lengths from the vertical line fleet dropped off dramatically after 1993 obscuring any trend in mean length late in the time series (Table 5.3.3, Figure 5.4.4). The time-series of length observations from the diving fleet was short (2000-2001). Mean length from this fleet was stable and similar to the pot and trap and vertical line fleets during the same period of time. The annual length distributions from each of these fleets were fairly stable over time (Figure 5.4.7). There were no discernible cohort patterns in these length composition data.

The annual length frequency distributions were visually inspected to determine the size-at-recruitment (L_c) to the fishery where the mode of a well-defined distribution can represent L_c. The mode of each annual distribution was determined as well as the overall mode for each gear type. Overall estimates of L_c for the pot and trap fishery is ~274mm and from the vertical line fleet is ~ 283mm (Table 5.3.2, Figures 5.4.3 and 5.4.5). These peaks were driven by the observations from the 1980s and 1990s when sample size was large. An overall estimate of L_c for the diving fleet (2002-2011) is ~ 262mm.

Trends in monthly mean length were evaluated to determine whether fishing activity during the spawning season influenced annual trends in length. Figure 5.4.8 shows monthly mean length by year for the pot and trap and vertical line fleets. Mean length was variable within months and among years. The influence of the spawning season on mean length is not apparent for the diving or pot and trap fleet. There may have been some influence in the 1980s and early 1990s on the observed mean lengths from vertical line fleet.

5.2 Recreational fishery statistics

Recreational data are not available from St. Croix.

5.3 Tables

Table 5.3.1. Reported commercial landings of grouper (no expansion factors applied) from St. Croix, 1998-2013.

Year	Grouper	Red Hind
1998	18,219	n/a
1999	20,573	n/a
2000	23,807	n/a
2001	29,763	n/a
2002	44,505	n/a
2003	45,908	n/a
2004	47,301	n/a
2005	39,729	n/a
2006	35,235	n/a
2007	30,124	n/a
2008	29,585	n/a
2009	34,650	n/a
2010	29,117	n/a
2011	30,800	n/a
2012	29,853	17,221
2013	16,491	9,823

Table 5.3.2. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the pot and trap fleet in St. Croix. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Pots and traps	1983	280	231	270	266.5	298	173
	1984	260	260	288	294.7	323	553
	1985	290	279	305	320.5	360.2	168
	1986	430	290	335	339.3	390	471
	1987	300	260	290	297.1	330	335
	1988	270	257.2	282	290.9	307	370
	1989	280	275	295	301.8	325	198
	1990	280	285	300	315.3	338.5	48
	1991	290	277	295	297.6	314	31
	1992	330	262	283	287.5	315	49
	1993	270	272	295	289.5	310.5	12
	1994	260	245	270	277.8	302	136
	1995	250	265.5	280	292.3	315.8	30
	1996	270	250	275	280.3	310	43
	1997	260	272	290	306.3	330	53
	1998	290	270	293	298.2	312.5	55
	1999	210	225	257.5	270.2	311.2	52
	2000	260	257	269	301.8	355	19
	2001	270	260	275	291.7	300	9
	2002	280	245	270	271.1	290	59
	2003	230	235	240	240	245	2
	2004	200	208	220	221.8	237	51
	2005	280	277.5	285	288.1	301.2	8
	2006	-	-	-	-	-	-
	2007	240	237.5	240	251.9	260	15
	2008	260	250	265	271.9	280	17
	2009	250	250.2	260	263.9	284	28
	2010	280	280	291	299.3	319.5	38
	2011	310	290	310	316	315	5
	2012	-	-	-	-	-	-
	2013	-	-	-	-	-	-

Table 5.3.3. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the vertical line fleet in St. Croix. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Vertical line	1983	270	247.5	282.5	294.2	322.5	90
	1984	260	262.5	300	306.8	340	215
	1985	270	268	300	309.8	342	413
	1986	310	282	317.5	324	360	174
	1987	320	282	320	320.2	360	336
	1988	350	285	332	330.4	370	523
	1989	330	296	332	327	355	184
	1990	340	316	345	343.2	365.5	403
	1991	370	310	350	347.8	380	361
	1992	300	273	308	311.5	347	561
	1993	340	293	330	327.9	360	385
	1994	280	268.2	275	273.2	280	4
	1995	260	273.8	282.5	282.5	291.2	2
	1996	250	256.5	263	275	287.5	3
	1997	280	280	316	324.2	360.2	4
	1998	-	-	-	-	-	-
	1999	330	331	332	347.3	356	3
	2000	-	-	-	-	-	-
	2001	-	-	-	-	-	-
	2002	210	225.2	238.5	238.5	251.8	2
	2003	250	255	255	255	255	1
	2004	260	271.2	277.5	277.5	283.8	2
	2005	230	235	235	235	235	1
	2006	280	253.8	282.5	284.3	302.5	12
	2007	310	292.5	315	306.8	329.2	4
	2008	260	260	271	289.5	311.2	14
	2009	270	241.5	275	273.1	312.5	19
	2010	240	247	292	297.9	340	49
	2011	260	285	330	337.2	392.5	31
	2012	210	203.5	215	229.8	230	14
	2013	-	-	-	-	-	-

Table 5.3.4. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the diving fleet in St. Croix. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Diving	1983	280	302.5	330	340	367.5	4
	1984	-	-		-	-	-
	1985	-	-		-	-	-
	1986	-	-		-	-	-
	1987	-	-		-	-	-
	1988	-	-		-	-	-
	1989	-	-		-	-	-
	1990	-	-		-	-	-
	1991	-	-		-	-	-
	1992	-	-		-	-	-
	1993	-	-		-	-	-
	1994	-	-		-	-	-
	1995	-	-		-	-	-
	1996	-	-		-	-	-
	1997	-	-		-	-	-
	1998	-	-		-	-	-
	1999	-	-		-	-	-
	2000	-	-		-	-	-
	2001	-	-		-	-	-
	2002	280	302.5	322.5	370.8	342.5	6
	2003	250	250	270	274.6	295	197
	2004	230	237.5	270	277.9	320	24
	2005	280	270	295	298.2	330	45
	2006	310	315	315	315	315	1
	2007	250	258.2	291.5	299.6	326	70
	2008	240	245	270	279.5	308	185
	2009	260	260	285	294.8	320	281
	2010	290	260	281	286.2	302.2	296
	2011	230	267.5	300	294.2	325	6
	2012	-	-		-	-	-
	2013	-	-		-	-	-

Table 5.3.5. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the net fleet in St. Croix. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Nets	1983	-	-	-	-	-	-
	1984	-	-	-	-	-	-
	1985	430	380	400	401.5	430	13
	1986	-	-	-	-	-	-
	1987	-	-	-	-	-	-
	1988	-	-	-	-	-	-
	1989	-	-	-	-	-	-
	1990	-	-	-	-	-	-
	1991	-	-	-	-	-	-
	1992	-	-	-	-	-	-
	1993	350	327.5	355	337	355.5	3
	1994	-	-	-	-	-	-
	1995	210	230	250	241.7	257.5	3
	1996	-	-	-	-	-	-
	1997	280	280	280	280	280	1
	1998	-	-	-	-	-	-
	1999	-	-	-	-	-	-
	2000	320	320	320	320	320	1
	2001	-	-	-	-	-	-
	2002	280	280	280	279.4	285	5
	2003	280	281.2	282.5	282.5	283.8	2
	2004	270	230	260	267.2	275	13
	2005	280	257.5	280	267.2	280	6
	2006	-	-	-	-	-	-
	2007	-	-	-	-	-	-
	2008	-	-	-	-	-	-
	2009	-	-	-	-	-	-
	2010	-	-	-	-	-	-
	2011	-	-	-	-	-	-
	2012	-	-	-	-	-	-
	2013	-	-	-	-	-	-

Table 5.3.6. Measures of central tendency and dispersion in the observed annual length-frequency distributions from the longline fleet in St. Croix. The mode represents the length bin with the greatest number of observations.

Gear type	Year	Mode	25th percentile	Median	Mean	75th percentile	Number of lengths
Longline	1983	-	-	-	-	-	-
	1984	-	-	-	-	-	-
	1985	-	-	-	-	-	-
	1986	-	-	-	-	-	-
	1987	-	-	-	-	-	-
	1988	-	-	-	-	-	-
	1989	-	-	-	-	-	-
	1990	-	-	-	-	-	-
	1991	-	-	-	-	-	-
	1992	310	285.5	305	291.8	311.2	4
	1993	260	286	312	309	333.5	3
	1994	220	232.5	240	240	247.5	2
	1995	-	-	-	-	-	-
	1996	-	-	-	-	-	-
	1997	-	-	-	-	-	-
	1998	-	-	-	-	-	-
	1999	-	-	-	-	-	-
	2000	-	-	-	-	-	-
	2001	-	-	-	-	-	-
	2002	-	-	-	-	-	-
	2003	-	-	-	-	-	-
	2004	-	-	-	-	-	-
	2005	-	-	-	-	-	-
	2006	-	-	-	-	-	-
	2007	-	-	-	-	-	-
	2008	-	-	-	-	-	-
	2009	240	242	242	242	242	1
	2010	-	-	-	-	-	-
	2011	-	-	-	-	-	-
	2012	-	-	-	-	-	-
	2013	-	-	-	-	-	-

Table 5.3.7. Measures of central tendency and dispersion in the number of measured Red Hind lengths in St. Croix by month. Red Hind spawning season occurs from December to February.

Month	Lower_quartile	Median	Upper_quartile	Mean	SD
January	11.75	135.00	197.75	131.72	118.17
February	5.75	38.00	93.00	57.32	60.22
March	6.25	11.00	25.00	22.06	27.52
April	4.00	9.00	27.50	16.30	17.90
May	3.00	8.00	22.75	18.64	26.08
June	4.00	11.50	25.00	20.05	23.02
July	4.25	9.00	23.75	18.55	22.69
August	4.50	10.50	31.25	22.23	23.31
September	8.00	10.00	38.00	24.09	24.48
October	7.00	16.00	43.00	25.38	23.80
November	3.00	9.00	14.75	18.41	30.76
December	2.50	8.00	31.50	18.96	21.32

5.4 Figures

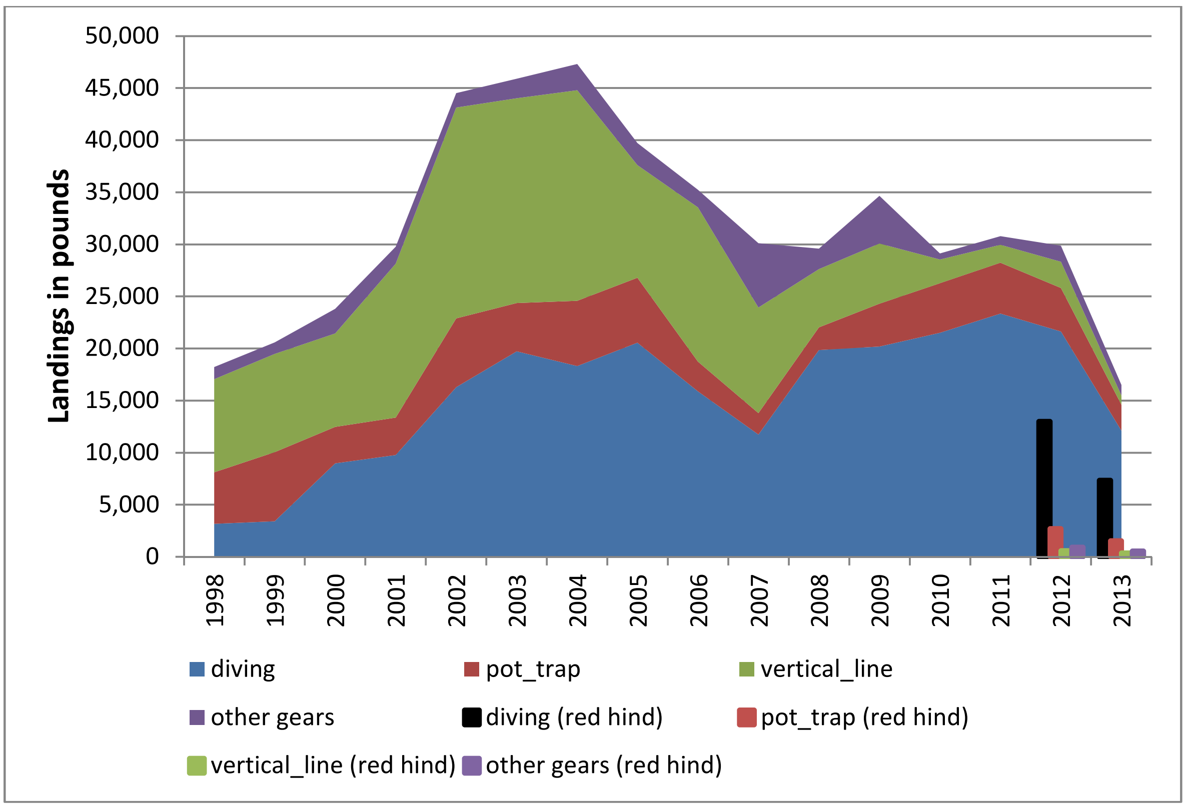


Figure 5.4.1 Yearly commercial landings of grouper as reported (no expansion factors applied) on fisher logbooks from St. Croix by gear. Histogram (2012-13) shows Red Hind landings as reported by gear following introduction of species-specific reporting forms.

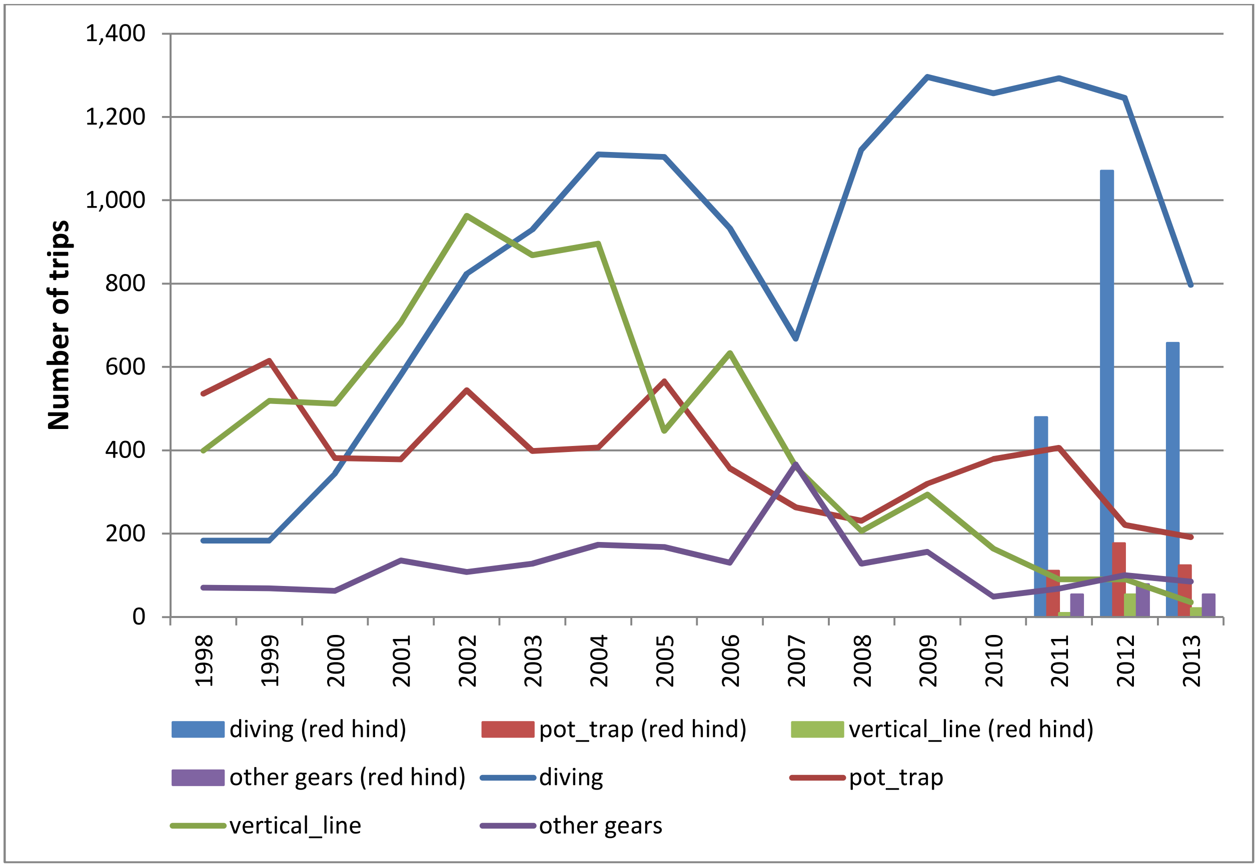


Figure 5.4.2. St. Croix reported commercial fishing trips with grouper landings by gear and year. Histogram (2012-13) shows Red Hind commercial trips reported by gear following introduction of species specific reporting forms.

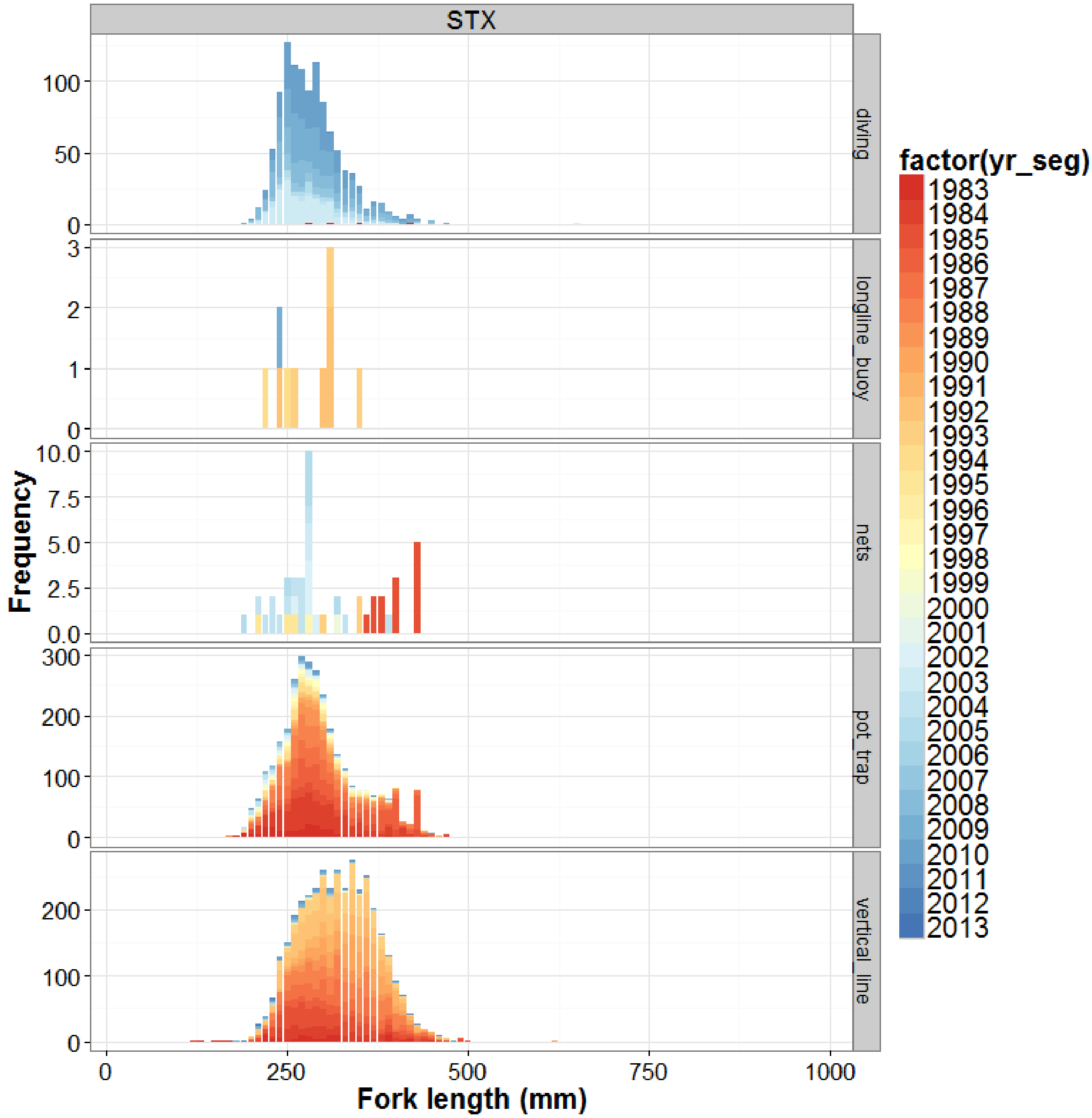


Figure 5.4.3. Length frequency distributions of Red Hind landed in St. Croix by year and gear type.

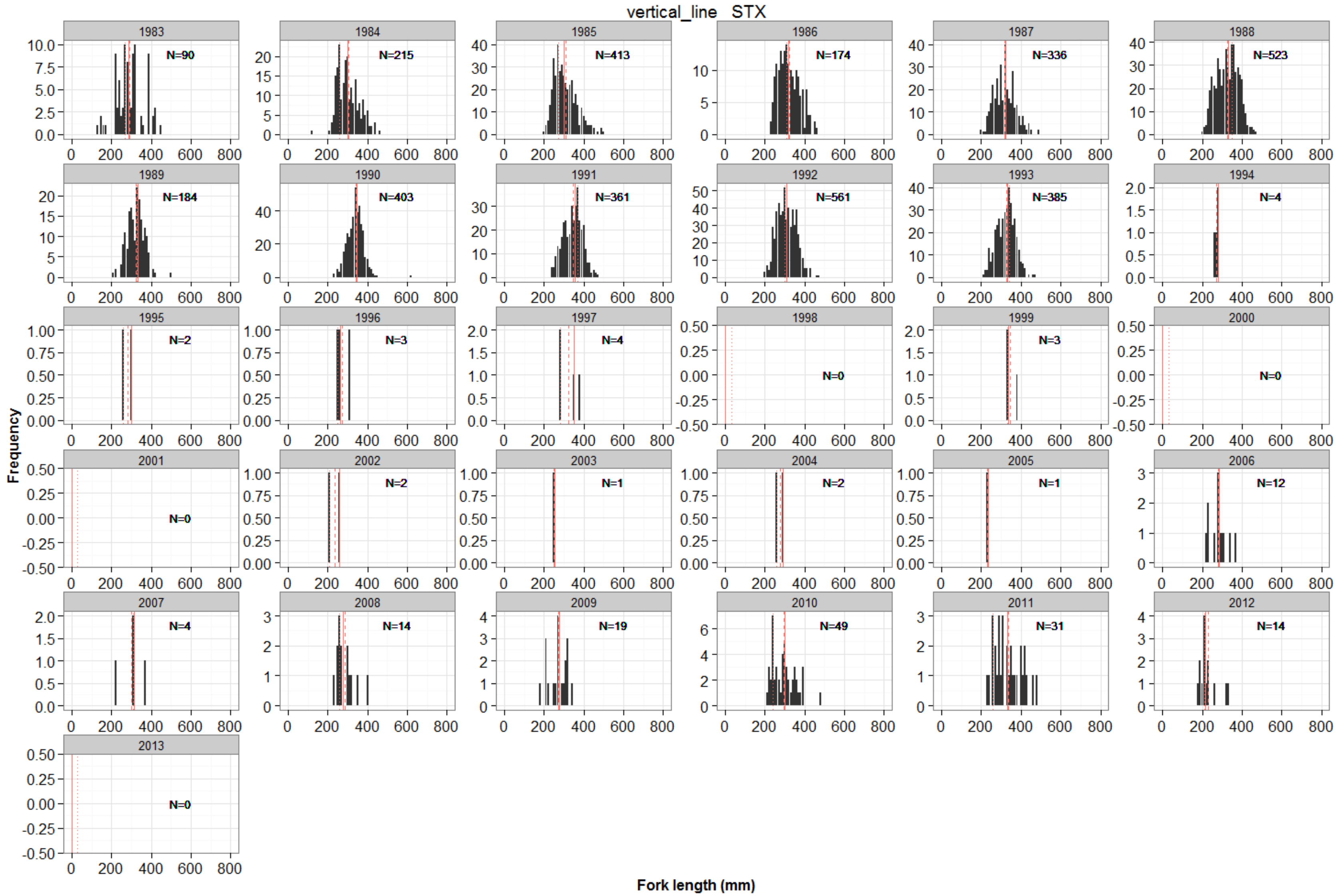


Figure 5.4.4. Annual length frequency distributions of measured Red Hind from the St. Croix vertical line fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 5.3.3.

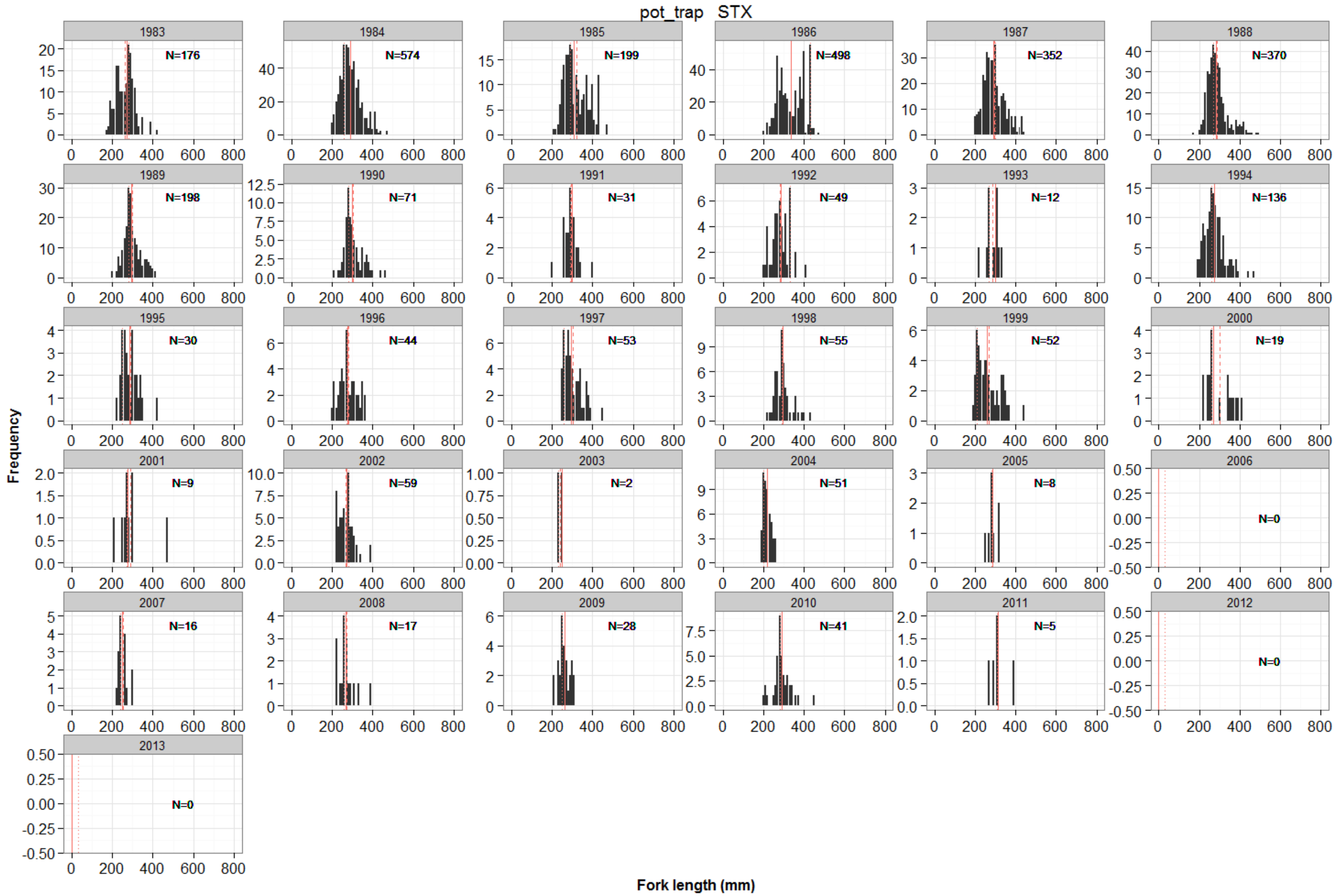


Figure 5.4.5. Annual length frequency distributions of measured Red Hind from the St. Croix pot and trap fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 5.3.2.

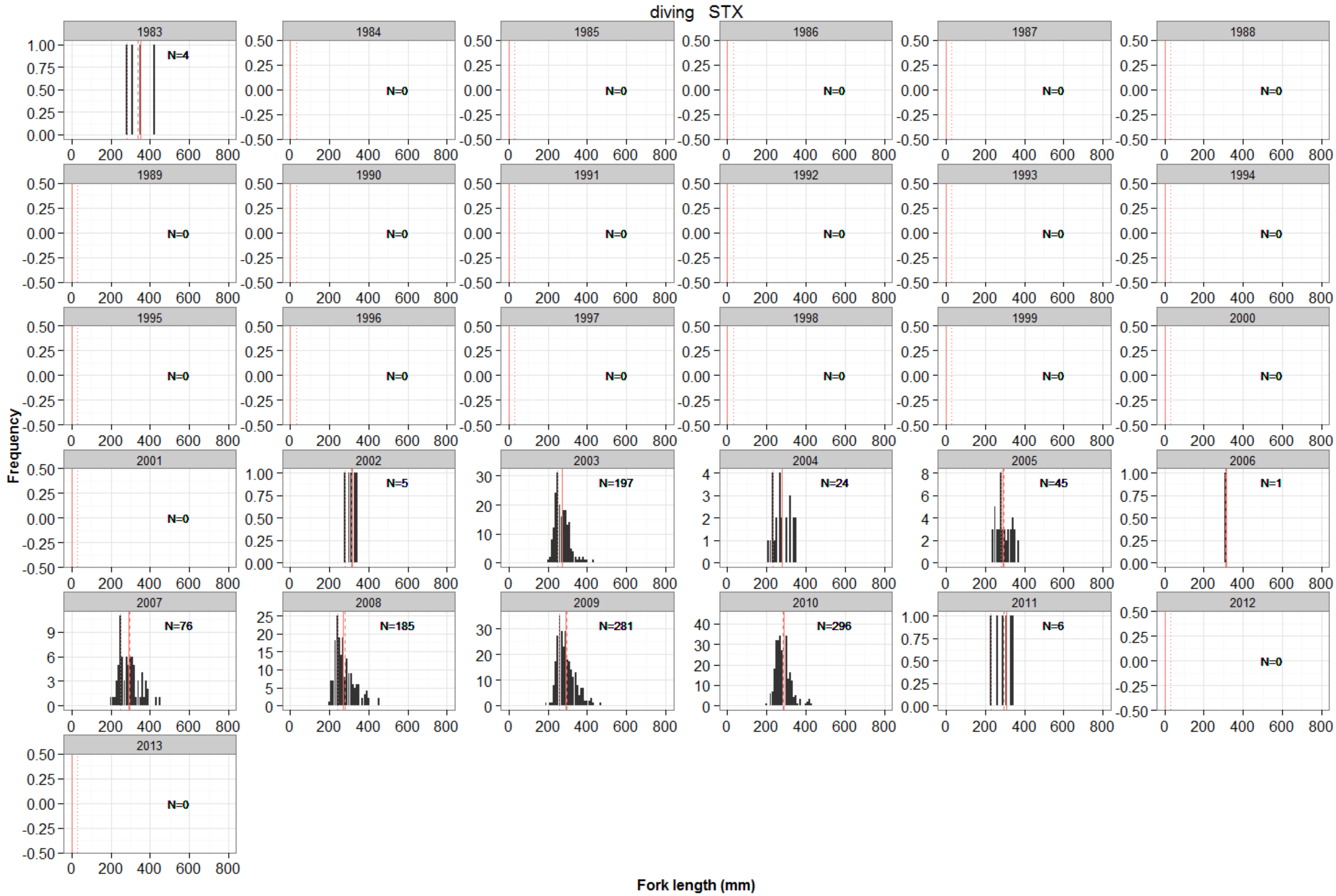


Figure 5.4.6. Annual length frequency distributions of measured Red Hind from the St. Croix diving fleet. Lengths are shown as fork length measured in millimeters. Annual sample sizes are shown in each panel also see Table 5.3.4.

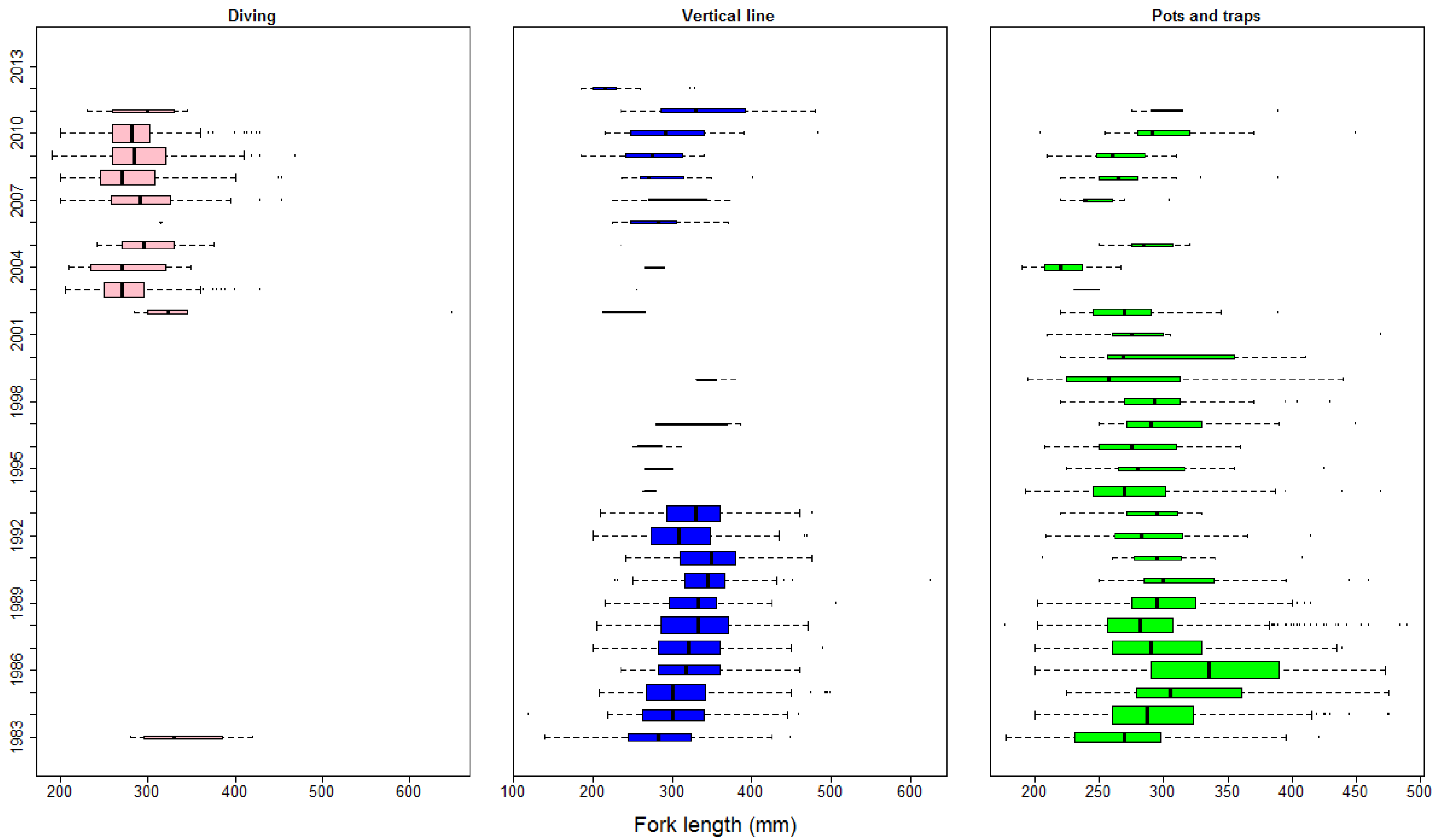


Figure 5.4.7. Boxplots of the annual length data from the St. Croix diving, vertical line, and pot and trap fleets. The box represents 50% of the observations and includes the median. Box width was scaled to reflect the annual sample size, where the width was calculated as the square-root of the number of lengths in a given year.

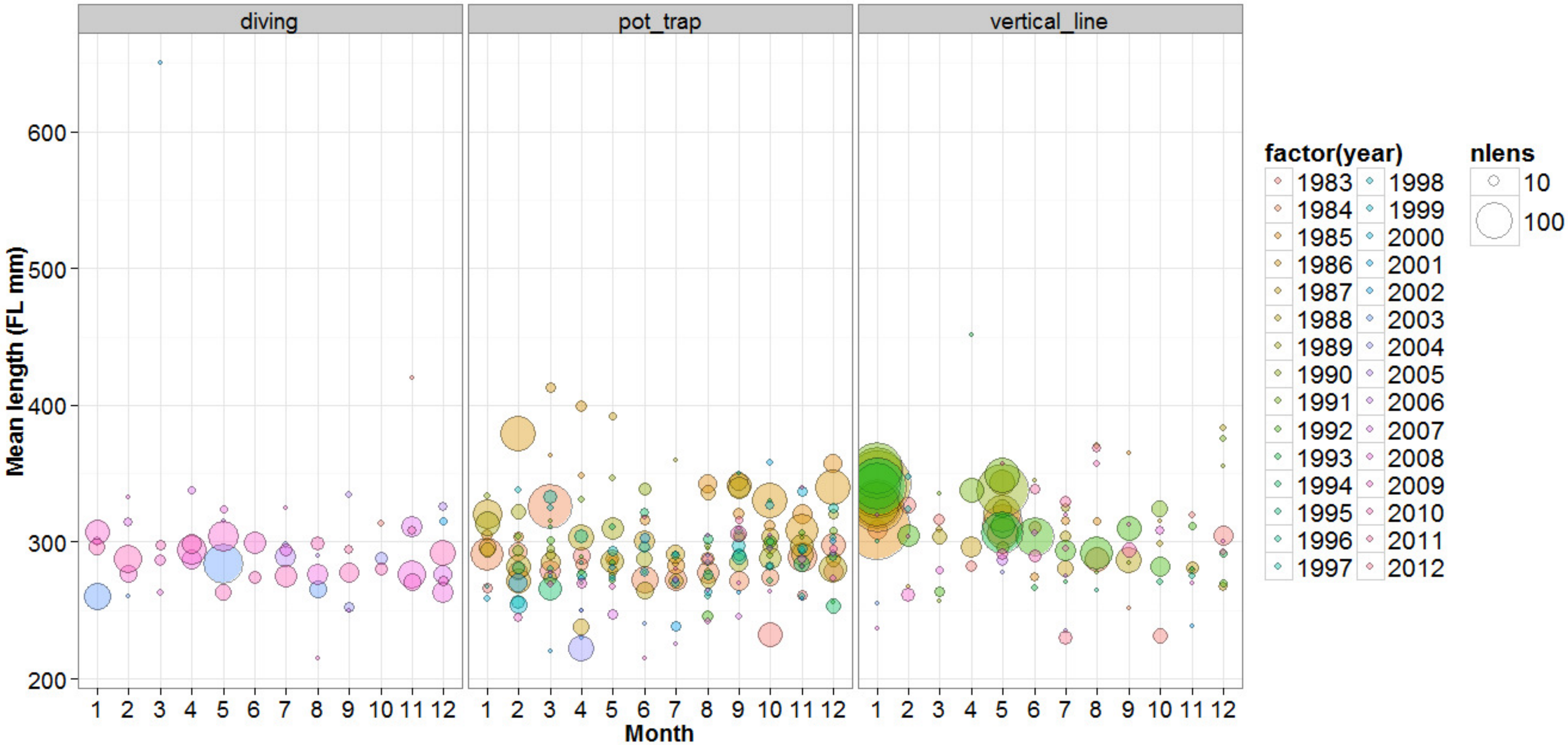


Figure 5.4.8. Mean length by month, year, and gear type. Bubbles are scaled to reflect the number of lengths and color reflects the year.

6 FISHERY-INDEPENDENT DATA SOURCES

6.1 Overview

The SEDAR 35 DW panel reviewed several fishery-independent data sources during the workshop. The following sections briefly summarize these data or provide references that summarize the methods and data.

6.2 Biogeography visual surveys

A data workshop report was not produced for these data and will be summarized in the following few sections.

6.2.1 General protocol

The National Ocean Service's (NOS) Biogeography Branch (BB) has conducted visual surveys in the US Caribbean since 1999. Initially the main goal of these surveys was to ground trough existing habitat maps and characterize the benthic habitat of this region. In 2000, the goal of the survey was extended to also characterize and quantify observed fish species and some invertebrate species associated with the benthos. Visual surveys were conducted by divers at randomly selected hard- and soft-bottom habitats. All surveys were done in less than 30m (~100ft) using a belt transect method. One diver swam along a 25m x 4m transect identifying and counting all fish species to the lowest taxonomic level. Lengths of each fish were recorded into 5cm length bins.

Readers of this report are referred to Menza *et al.* (2008) for a more complete and detailed description of the project objectives, the visual survey method, and survey site selection.

6.2.2 Puerto Rico

Visual surveys in Puerto Rico have been conducted since 2000. Table 6.7.1 summarizes the temporal extent of the surveys and Figures 6.8.1 and 6.8.2 show the spatio-temporal coverage. Sampling in Puerto Rico has been concentrated in the La Parguera and Guanica study areas. Sampling was generally conducted in August in Parguera-Guanica, except in 2001-2003 (Table 6.7.1). Surveys were conducted in January, May, and October in 2001, in February, June, and October in 2002, and in May and September in 2003. Surveys were also conducted in January in February in addition to August from 2005 until 2009. Vieques and Jobos Bay were two additional study areas that were surveyed in May, 2007 and June, 2009, respectively.

The proportion of Red Hind occurrence and the number of observed Red Hind was low in Puerto Rico (Table 6.7.2). The proportion ranged from 0.025 and 0.119 for the combined hard- and soft-bottom habitats (Table 6.7.2). Red Hind were primarily observed on hard-bottom habitats where the proportion of occurrence ranged between 0.042 and 0.164 (Table 6.7.3).

Figure 6.2.3 shows the size distribution of the 103 Red Hind observed in all Puerto Rico sampling areas and in hard- and soft-bottom habitats. The data were aggregated over all years because of the small annual sample sizes. The overall size range was between 12.5cm and 32.5cm. The majority, 77, was from Parguera-Guanica (Figure 6.8.4). Twenty-five Red Hind were observed in Vieques in 2007 and one was observed in Jobos Bay in 2009 (Figure 6.8.5). The size distribution in Vieques was skewed towards smaller Red Hind in comparison to the observed size distribution from Parguera-Guanica (Figure 6.8.4).

6.2.3 St. Croix

Visual surveys have been conducted in St. Croix since 2001. Table 6.7.5 summarizes the temporal extent of the survey and Figures 6.2.5 shows the spatio-temporal coverage. The majority of surveys in most years were conducted in Buck Island Reef National Monument (BUIS) and the East End Marine Park (EEMP). Surveys were completed in October in most years; however, in 2001 surveys were completed in February, August, and September and in 2012 surveys were completed in May.

The proportion of occurrence of Red Hind in BUIS ranged from 0.07 to 0.218 in all habitats and from 0.081 to 0.265 in hard-bottom habitat (Table 6.7.6). Although variable, there was a declining trend in the proportion of occurrence starting in 2008 in BUIS. The proportion of occurrence of Red Hind in the EEMP ranged from 0.051 to 0.275 in all habitats and from 0.096 to 0.338 in hard-bottom habitat (Table 6.7.6). The proportion of occurrence in sites in areas located outside the boundaries of BUIS and EEMP was higher, but this may be due to a very small number of sites surveyed (Tables 6.7.6 and 6.7.7).

Figure 6.8.6 shows the size distribution of the 592 Red Hind observed in all sampling areas and habitats. The overall size range was between 2.5cm and 41cm. This size range is wider than the size range observed in Puerto Rico. The majority of Red Hind were observed on hard-bottom habitats in BUIS (N=270 overall, N=254 on hard-bottom) and the EEMP (N=284 overall, N=282 on hard-bottom), since sampling intensity was highest in these areas over time (Tables 6.7.6 and 6.7.7). The size distributions from BUIS and EEMP were similar (Figure 6.8.7). A small number, 35, of Red Hind were observed in areas time. The size distribution in this zone is skewed towards smaller Red Hind than in BUIS and EEMP; however, this may be confounded due to the small sample size. One Red Hind was observed in Salt River Bay National Historical Park, SARI, in 2012 (Table 6.7.7).

6.2.4 St. John and St. Thomas

Visual surveys have been conducted in St. John since 2001. Table 6.7.8 summarizes the temporal extent of the survey and Figures 6.2.8 show the spatio-temporal coverage. The visual surveys were completed in July in most years (Table 6.7.8). In 2012, visual surveys were not conducted due to the expansion of spatial coverage in St. Croix and initiating surveys in St. Thomas. Surveys were carried out in the eastern end of St. Thomas in June, 2012 (Table 6.7.8 and Figure 6.8.8).

The proportion of occurrence of Red Hind in the Virgin Islands Coral Reef National Monument (VICR) ranged from 0.259 to 0.6 in all habitats and from 0.232 to 0.6 in hard-bottom habitat (Table 6.7.9). The proportion of occurrence of Red Hind in the Virgin Islands National Park (VIIS) ranged from 0.074 to 0.275 in all habitats and in hard-bottom habitat (Table 6.7.9). The proportion of occurrence in non-managed areas ranged from 0.112 to 0.338 in all habitats and from 0.095 to 0.306 in hard-bottom habitat.

Table 6.7.10 summarizes the number of Red Hind observed in the three management zones of St. John. A larger number of Red Hind were observed in areas outside the boundaries of VICR and VIIS. The number of Red Hind observed in VICR was generally larger than in VIIS. The overall size range of Red Hind observed in St. John was between 2.5cm and 45cm, which is similar to the observed range in St. Croix (Figure 6.8.9). The size distribution of Red Hind in areas located outside the VICR and VIIS was similar to the size distribution observed in VICR, whereas the size distribution from VIIS was skewed towards smaller Red Hind (Figure 6.8.10).

6.3 Red Hind underwater visual survey data from western Puerto Rico and Mona Island

Three data sets of underwater visual surveys from Puerto Rico were summarized by Dr. Michelle Schäarer-Umpierre. The first dataset pertained to a study that was designed to determine the spatial distribution and ontogenetic habitat utilization of coral reef fishes, including Red Hind around Mona Island in 2005. The second study that was presented was a partial replicate of the 2005 study that was conducted in 2010. The main goal of this study was to determine temporal changes in abundance of reef fishes including Red Hind in coral reef habitat in Mona Island. The third study represents a longer time-series, 2005-2012, and provides fish length and density information from underwater visual surveys (belt and roving transects) on two known spawning aggregation sites, Mona Island and Abrir la Sierra.

Readers are referred to SEDAR35-DW-03 for a complete description of the methods and data. The data from the ontogeny study and spawning aggregation study were made available to the assessment analysts.

6.4 Red Hind Bank, St. Thomas, USVI spawning aggregation data

The data from a long-term monitoring project, 1999-present, of the spawning aggregation on Red Hind Bank Marine Conservation District in St. Thomas were presented as an oral presentation at the DW by Dr. Rick Nemeth. Monitoring of the aggregation was done by conducting underwater visual surveys using 30m x 2m belt transects. All Red Hind were enumerated and their lengths were recorded in 10cm bins. Readers are referred to Nemeth (2005) and Nemeth *et al.* (2007) for a detailed explanation of the methods and the data available for assessment purposes. These data were made available to the assessment analysts at the end of the DW.

6.5 Mesophotic reef surveys in western Puerto Rico

In 2011 and 2012, fisheries independent visual surveys were conducted at 3 sites in Puerto Rico. The sites were Abrir La Sierra (ALS), Desecho Island (DES), and Bajo de Sico (BDS). Two or three different habitats were surveyed at each site. Reef tops, slope walls and rhodolith reefs were surveyed at ALS; slope walls, patch reefs and rhodolith reefs at DES; and rock reef promontories and rhodolith reef at BDS. Transects ranged in length from 200 to 500 meters at depths of 30-50 meters. At each transect two divers swam in parallel 6 meters apart and with the current. Eight transects were done in each habitat at each survey site, and in ALS, during each of three different seasons. The goals of the survey included to characterize species assemblages and to provide rough estimates of population size and stock status of various species based on observed densities and length-frequencies. In ALS, an additional goal was to infer seasonal variations, with particular interest on queen conch. Additional details about this survey can be found in the final report submitted to Caribbean Fishery Management Council (García-Sais et al. 2012).

Although red hind were observed in all habitats and at each of the three sites, the total number of observed individuals in the mesosphotic survey was low. Juveniles were observed at each site, but the majority of individuals sited were adults that measured 25-30cm in total length. At ALS, 95% of red hind length measurements were greater than or equal to 25cm, the reported of the length of first reproduction. The low numbers of red hind that were sighted in this survey may relate to the low proportion of surveyed habitat relative to total, the transect method, and to the cryptic nature of the species. Since only one year of data is available with relatively few total observations of red hind, the data from the Mesosphotic reefs in Puerto Rico were not deemed to be further investigated for use in the current assessment.

6.6 SEAMAP – C Survey

For the SEDAR 35, the time series of data between 1991 and 2011 were used to develop abundance indices for red hind for the U.S. Caribbean off the southwest coast of Puerto Rico. Initially, SEAMAP-C data were evaluated to determine the efficacy of their use for development of abundance indices of areas around both Puerto Rico and the U.S. Virgin Islands, using multiple gear-types (handline and traps) and catch data-types (catch in numbers or weight). Preliminary analyses indicated a sparseness of complete catch and effort for red hind in the USVI area, sparseness in the continuity of the time series of the trap data, and a higher variability in the weight data. Therefore, handline catch-per-unit-effort (CPUE) data in numbers of rind hind collected off the southwest coast of Puerto Rico were used to develop abundance indices. For details and results, please see SEDAR35-DW-04.

6.7 Tables

Table 6.7.1. Number of sites sampled in Puerto Rico by month and year.

		Month												
Region	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Parguera-Guanica	2000	-	-	-	-	-	-	-	31	-	-	-	-	31
	2001	28	-	-	-	36	-	-	-	-	38	-	-	102
	2002	-	56	-	-	-	48	-	-	-	-	-	60	164
	2003	-	-	-	-	77	-	-	-	77	-	-	-	154
	2004	-	-	18	59	-	-	-	76	-	-	-	-	153
	2005	39	38	-	-	-	-	-	80	-	-	-	-	157
	2006	9	70	-	-	-	-	-	80	-	-	-	-	159
	2007	80	-	-	-	-	-	-	80	-	-	-	-	160
	2008	27	53	-	-	-	-	-	80	-	-	-	-	160
	2009	27	53	-	-	-	-	-	80	-	-	-	-	160
	2010	-	-	-	-	-	-	-	114	-	-	-	-	114
	2011	-	-	-	-	-	-	-	79	-	-	-	-	79
	2012	-	-	-	-	-	-	-	45	38	-	-	-	83
Vieques	2007	-	-	-	-	75	-	-	-	-	-	-	-	75
Jobos Bay	2009	-	-	-	-	-	35	-	-	-	-	-	-	35

Table 6.7.2. The number of combined hard- and soft-bottom surveyed sites (those with Red Hind sightings and total) in Puerto Rico study areas by the NOS Biogeography team from 2000-2012 and the proportion of Red Hind positive sites overall.

	Number of sites with Red Hind sightings			Total number of surveyed sites			Overall		
Study area	Jobos Bay	Parguera-Guánica	Vieques	Jobos Bay	Parguera-Guánica	Vieques	Number of sites with Red Hind	Total	Proportion
Year									
2000	0	2	0	0	31	0	2	31	0.065
2001	0	5	0	0	102	0	5	102	0.049
2002	0	9	0	0	164	0	9	164	0.055
2003	0	5	0	0	154	0	5	154	0.032
2004	0	8	0	0	153	0	8	153	0.052
2005	0	8	0	0	157	0	8	157	0.051
2006	0	4	0	0	159	0	4	159	0.025
2007	0	6	22	0	160	75	28	235	0.119
2008	0	4	0	0	160	0	4	160	0.025
2009	1	9	0	35	160	0	10	195	0.051
2010	0	4	0	0	114	0	4	114	0.035
2011	0	6	0	0	79	0	6	79	0.076
2012	0	5	0	0	83	0	5	83	0.060

Table 6.7.3. The number of surveyed hard-bottom sites (those with Red Hind sightings and total) in Puerto Rico study areas by the NOS Biogeography team from 2000-2012 and the proportion of Red Hind positive sites overall. Survey sites represent hard and soft bottom habitats.

	Number of sites with Red Hind sitings			Total number of surveyed sites			Overall		
Study area	Jobos Bay	Parguera-Guánica	Vieques	Jobos Bay	Parguera-Guánica	Vieques	Number of sites with Red Hind	Total	Proportion
Year									
2000	0	2	0	0	28	0	2	28	0.071
2001	0	5	0	0	70	0	5	70	0.071
2002	0	9	0	0	100	0	9	100	0.090
2003	0	5	0	0	83	0	5	83	0.060
2004	0	7	0	0	109	0	7	109	0.064
2005	0	8	0	0	96	0	8	96	0.083
2006	0	4	0	0	96	0	4	96	0.042
2007	0	6	22	0	96	75	28	171	0.164
2008	0	4	0	0	82	0	4	82	0.049
2009	1	9	0	25	93	0	10	118	0.085
2010	0	4	0	0	66	0	4	66	0.061
2011	0	5	0	0	50	0	5	50	0.100
2012	0	5	0	0	41	0	5	41	0.122

Table 6.7.4. The number of observed Red Hind by study area in Puerto Rico and year for hard-bottom only and combined hard- and soft-bottom habitat.

	Hard-bottom only			
Year	Jobos Bay	Parguera- Guánica	Vieques	Total
2000	0	2	0	2
2001	0	5	0	5
2002	0	9	0	9
2003	0	5	0	5
2004	0	8	0	8
2005	0	8	0	8
2006	0	4	0	4
2007	0	6	25	31
2008	0	4	0	4
2009	1	9	0	10
2010	0	5	0	5
2011	0	5	0	5
2012	0	5	0	5
	Hard- and soft-bottom			
Year	Jobos Bay	Parguera- Guánica	Vieques	Total
2000	0	2	0	2
2001	0	5	0	5
2002	0	9	0	9
2003	0	5	0	5
2004	0	9	0	9
2005	0	8	0	8
2006	0	4	0	4
2007	0	6	25	31
2008	0	4	0	4
2009	1	9	0	10
2010	0	5	0	5
2011	0	6	0	6
2012	0	5	0	5

Table 6.7.5. Number of sites sampled in St. Croix by month and year.

		Month												
Region	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
St. Croix	2001	-	119	-	-	-	-	-	68	2	-	-	-	189
	2002	82	-	-	-	-	-	-	-	-	70	-	-	152
	2003	-	-	72	46	-	-	-	-	-	129	-	-	247
	2004	-	9	40	16	-	-	-	-	-	130	-	-	195
	2005	-	-	127	-	-	-	-	-	-	121	-	-	248
	2006	-	-	-	120	-	-	-	-	-	23	101	-	244
	2007	-	-	-	-	-	-	-	-	-	122	-	-	122
	2008	-	-	122	-	-	-	-	-	-	120	-	-	242
	2009	-	-	100	-	-	-	-	-	-	63	59	-	222
	2010	-	-	-	-	-	-	-	-	-	196	-	-	196
	2011	-	-	-	-	-	-	-	-	-	4	62	-	66
	2012	-	-	-	-	290	-	-	-	-	-	-	-	290

Table 6.7.6. The number of hard-bottom and hard- and soft-bottom surveyed sites in St. Croix management zones by the NOS Biogeography team from 2001-2012. The management zones are defined as: Buck Island – Buck Island Reef National Monument, EEMP – East End Marine Park, None – any site around St. Croix that is not within the other management zone boundaries, SARI – Salt River National Historic, which was surveyed in 2012.

	Number of sites with observed Red Hind							
Management Zone	Buck Island		EEMP		None		SARI	
Substrate	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall
Year								
2001	27	31	0	0	0	0	0	0
2002	25	30	0	0	0	0	0	0
2003	15	15	23	23	1	1	0	0
2004	11	12	9	9	1	1	0	0
2005	20	20	27	28	1	1	0	0
2006	26	26	32	33	1	1	0	0
2007	9	9	13	13	1	1	0	0
2008	21	22	24	24	0	0	0	0
2009	13	14	16	16	0	0	0	0
2010	4	4	7	7	0	0	0	0
2011	0	0	6	6	0	0	0	0
2012	6	7	10	10	14	15	1	1
	Total number of sites							
Management Zone	Buck Island		EEMP		None		SARI	
Substrate	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall
Year								
2001	120	189	0	0	0	0	0	0
2002	102	152	0	0	0	0	0	0
2003	81	139	76	107	1	1	0	0
2004	69	102	49	90	2	3	0	0
2005	88	121	80	121	2	6	0	0
2006	98	119	75	120	5	5	0	0
2007	49	63	39	58	1	1	0	0
2008	89	118	76	121	2	3	0	0
2009	86	111	64	108	2	3	0	0
2010	45	57	73	138	1	1	0	0
2011	0	0	42	66	0	0	0	0
2012	60	68	54	62	131	143	17	17

Table 6.7.6. continued.

	Proportion of Red Hind occurrence							
Management Zone	Buck Island		EEMP		None		SARI	
Substrate	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall
Year								
2001	0.225	0.164	-	-	-	-	-	-
2002	0.245	0.197	-	-	-	-	-	-
2003	0.185	0.108	0.303	0.215	1.000	1.000	-	-
2004	0.159	0.118	0.184	0.100	0.500	0.333	-	-
2005	0.227	0.165	0.338	0.231	0.500	0.167	-	-
2006	0.265	0.218	0.427	0.275	0.200	0.200	-	-
2007	0.184	0.143	0.333	0.224	1.000	1.000	-	-
2008	0.236	0.186	0.316	0.198	0.000	0.000	-	-
2009	0.151	0.126	0.250	0.148	0.000	0.000	-	-
2010	0.089	0.070	0.096	0.051	0.000	0.000	-	-
2011	-	-	0.143	0.091	-	-	-	-
2012	0.100	0.103	0.185	0.161	0.107	0.105	0.059	0.059

Table 6.7.7. The number of observed Red Hind by management zone and year in St. Croix for hard-bottom only and combined hard- and soft-bottom habitat.

Management Zone	**Buck Island**		**EEMP**		**None**		**SARI**	
Substrate	**Hardbottom**	**Overall**	**Hardbottom**	**Overall**	**Hardbottom**	**Overall**	**Hardbottom**	**Overall**
Year								
2001	37	42	0	0	0	0	0	0
2002	50	56	0	0	0	0	0	0
2003	18	18	34	34	8	8	0	0
2004	16	17	16	16	1	1	0	0
2005	37	37	48	49	1	1	0	0
2006	29	29	69	70	1	1	0	0
2007	12	12	21	21	1	1	0	0
2008	27	29	44	44	0	0	0	0
2009	16	17	18	18	0	0	0	0
2010	4	4	8	8	0	0	0	0
2011	0	0	11	11	0	0	0	0
2012	8	9	13	13	23	25	1	1
Total	254	270	282	284	35	37	1	1

Table 6.7.8. Number of sites sampled in St. John and St. Thomas by month and year.

		Month												
Region	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
St. John	2001	-	-	-	-	-	-	50	8	-	-	-	-	58
	2002	-	-	-	-	-	-	110	-	-	-	-	-	110
	2003	-	-	-	-	-	-	144	-	-	-	-	-	144
	2004	-	28	-	-	-	-	171	-	-	-	-	-	199
	2005	-	-	-	-	-	-	171	-	-	-	-	-	171
	2006	2	-	-	-	-	-	165	-	-	-	-	-	167
	2007	-	-	-	-	-	1	167	-	1	-	-	-	169
	2008	-	-	-	2	-	-	168	-	-	-	-	-	170
	2009	-	-	-	1	-	-	169	-	-	-	-	-	170
	2010	-	-	-	-	-	-	170	-	-	-	-	-	170
	2011	-	-	-	-	-	-	172	-	-	-	-	-	172
	2012	-	-	-	-	-	-	-	-	-	-	-	-	-
St. Thomas	2012	-	-	-	-	-	70	-	-	-	-	-	-	70

Table 6.7.9. The number of hard-bottom only and overall (hard- and soft-bottom) surveyed sites (those with observed Red Hind and total) in St. John management zones by the NOS Biogeography team from 2001-2011. St. John was not surveyed in 2012. The management zones are defined as: None – sites are outside the managed areas boundaries, VICR – Virgin Islands Coral Reef National Monument, and VIIS – Virgin Islands National Park.

	Number of sites with observed Red Hind					
Management Zone	None		VICR		VIIS	
Substrate	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall
Year						
2001	6	6	1	1	6	6
2002	15	16	6	6	9	12
2003	12	14	11	14	10	12
2004	21	27	13	16	4	4
2005	19	21	14	15	9	9
2006	22	25	15	21	11	11
2007	14	15	21	22	9	9
2008	21	21	16	18	6	6
2009	11	13	13	17	13	13
2010	12	13	13	15	7	7
2011	9	11	14	16	4	4
	Total number of surveyed sites					
Management Zone	None		VICR		VIIS	
Substrate	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall
Year						
2001	31	31	3	3	24	24
2002	54	55	10	10	40	45
2003	54	57	36	37	50	50
2004	84	88	56	57	54	54
2005	62	68	55	58	45	45
2006	73	74	45	53	40	40
2007	76	76	54	56	37	37
2008	80	81	55	55	34	34
2009	63	67	52	53	50	50
2010	77	78	49	51	41	41
2011	95	98	49	53	21	21

Table 6.7.9. continued.

	Proportion occurrence of Red Hind					
Management Zone	None		VICR		VIIS	
Substrate	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall
Year						
2001	0.194	0.194	0.333	0.333	0.250	0.250
2002	0.278	0.291	0.600	0.600	0.225	0.267
2003	0.222	0.246	0.306	0.378	0.200	0.240
2004	0.250	0.307	0.232	0.281	0.074	0.074
2005	0.306	0.309	0.255	0.259	0.200	0.200
2006	0.301	0.338	0.333	0.396	0.275	0.275
2007	0.184	0.197	0.389	0.393	0.243	0.243
2008	0.263	0.259	0.291	0.327	0.176	0.176
2009	0.175	0.194	0.250	0.321	0.260	0.260
2010	0.156	0.167	0.265	0.294	0.171	0.171
2011	0.095	0.112	0.286	0.302	0.190	0.190

Table 6.7.10. The number of observed Red Hind by management zone and year in St. John for hard-bottom only and combined hard- and soft-bottom habitat.

Management Zone	None		VICR		VIIS	
Habitat structure	Hardbottom	Overall	Hardbottom	Overall	Hardbottom	Overall
Year						
2001	10	10	2	2	9	9
2002	22	24	12	12	13	21
2003	18	22	18	21	15	17
2004	31	45	21	25	8	8
2005	27	29	18	22	17	17
2006	36	40	21	31	19	19
2007	20	21	28	30	20	20
2008	28	28	22	28	8	8
2009	19	23	20	31	27	27
2010	13	14	16	18	15	15
2011	13	15	15	20	5	5
Total	237	271	193	240	156	166

6.8 Figures

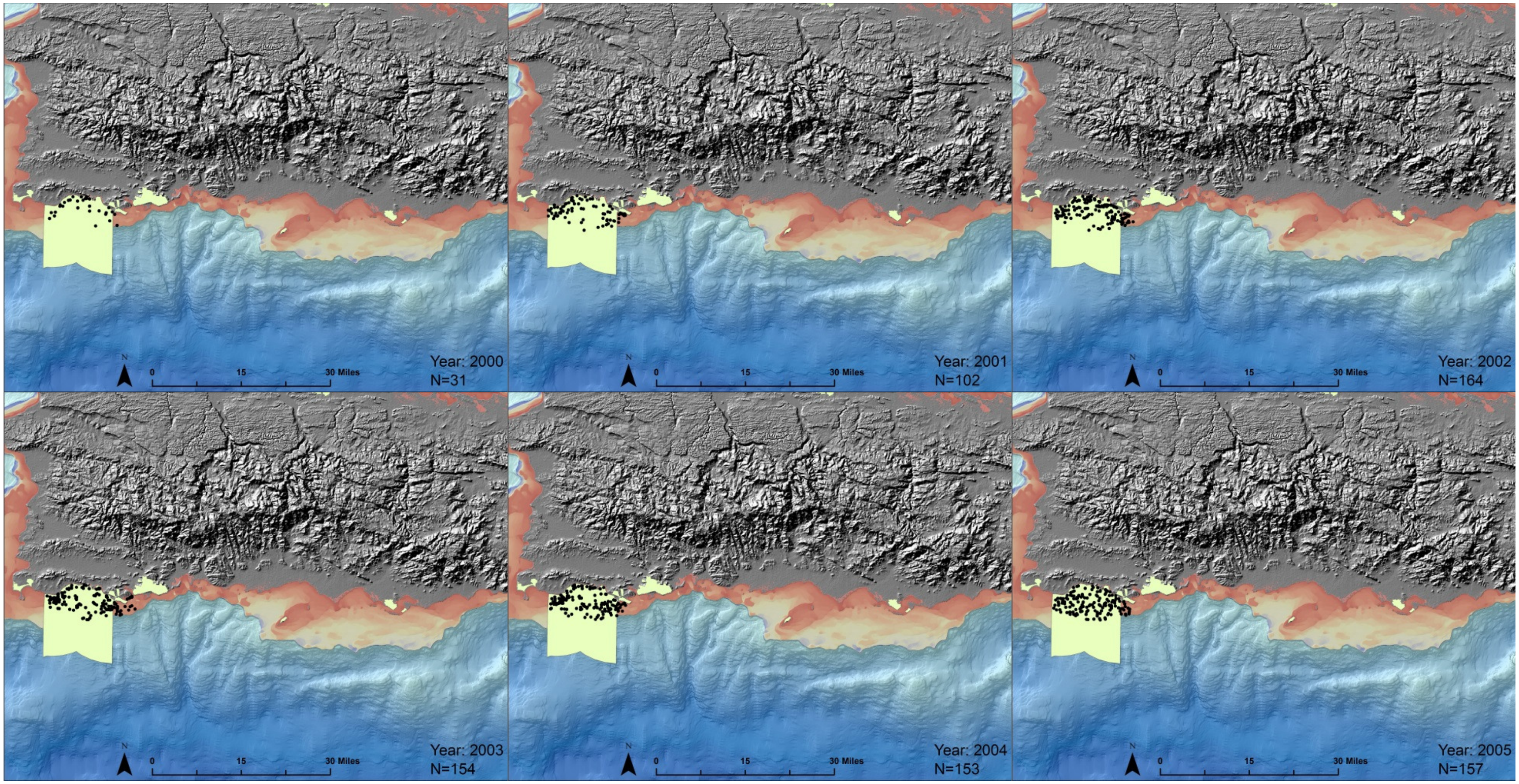


Figure 6.8.1. The annual spatial distribution of the Biogeography visual survey sites. Each panel represents a different year. N represents the annual number of survey sites. The black dots represent the survey sites. The western yellow areas are La Parguera Natural Reserve and Guánica State Forest. Sites surveyed in 2007 are shown in a separate figure.

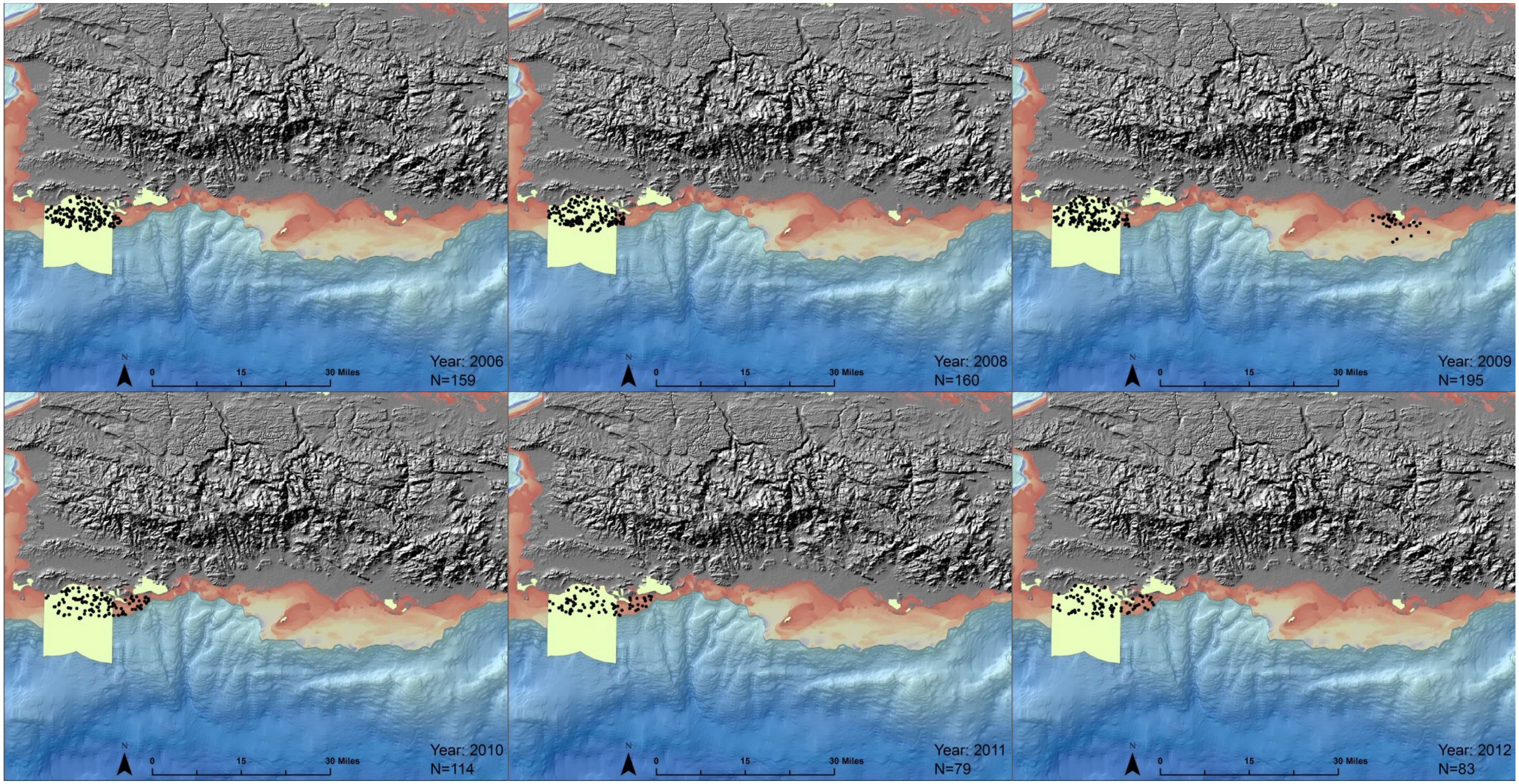


Figure 6.8.1 continued.

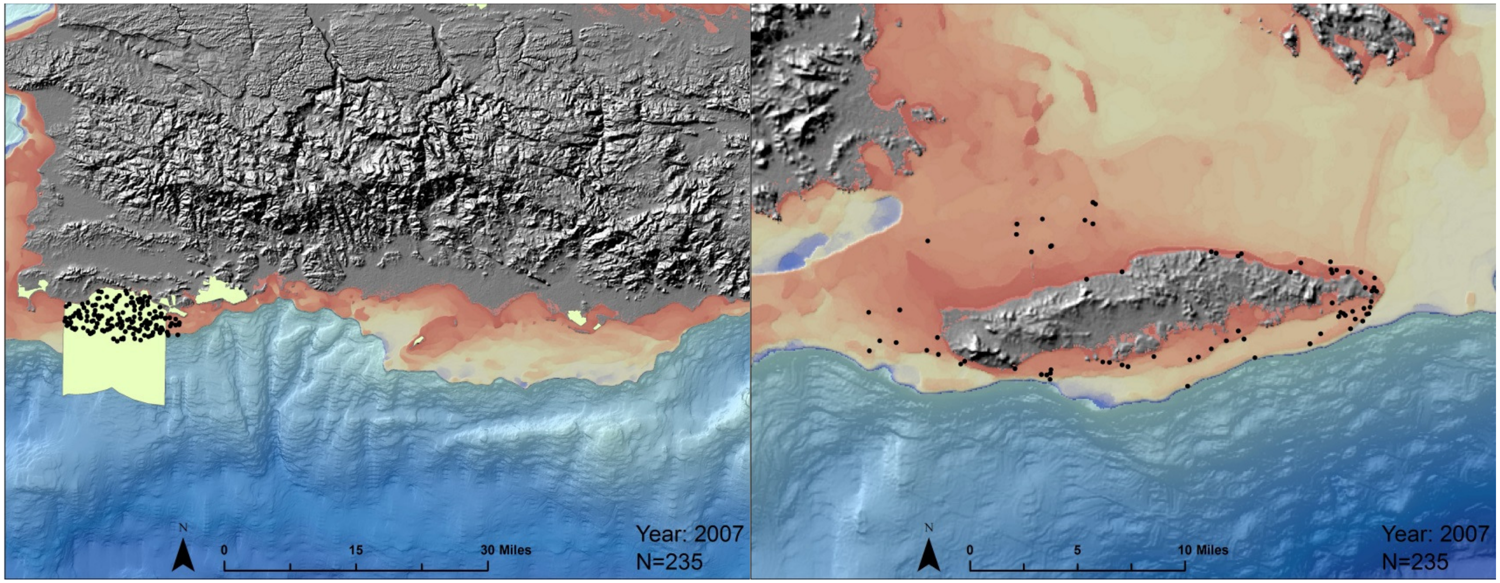


Figure 6.8.2. Biogeography survey sites in 2007. The left panel shows the survey sites in La Parguera and Guánica. The right panel shows the survey sites around Vieques, which was only surveyed in 2007. The black dots represent the survey sites.

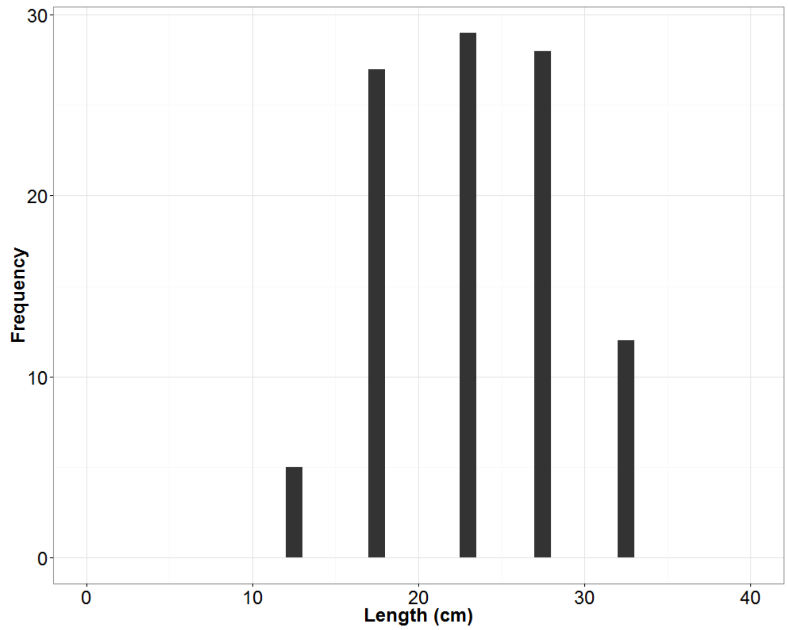


Figure 6.8.3. Length frequency distribution of red hind observed during visual surveys conducted by the NOS Biogeography team in Puerto Rico from 2000 to 2012. N = 103.

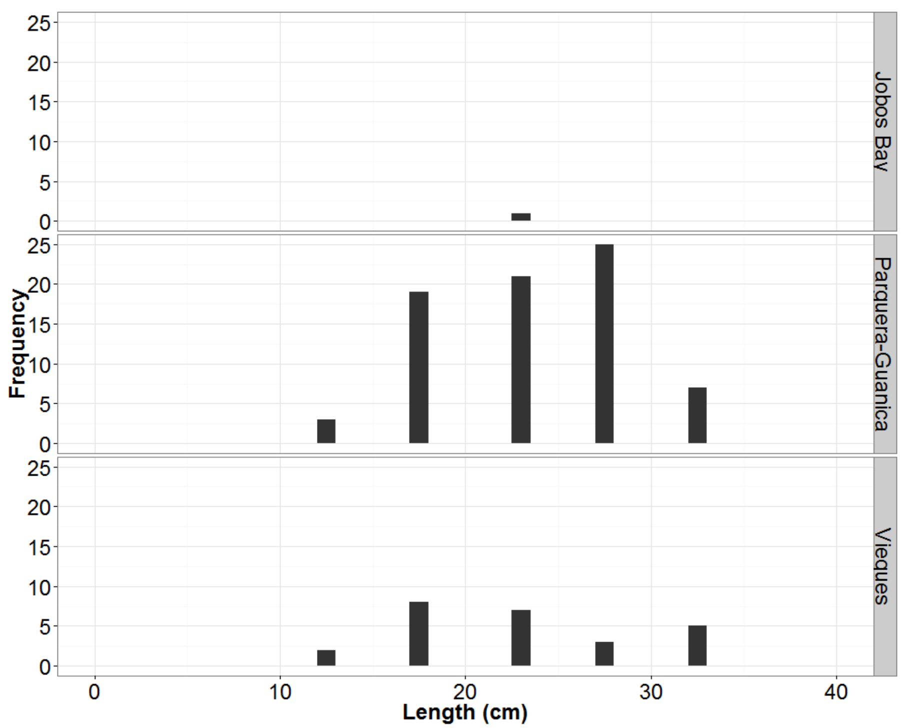


Figure 6.8.4. Length frequency distributions of red hind observed in three different study areas during visual surveys conducted by the NOS Biogeography team in Puerto Rico from 2000 to 2012. $N_{JobosBay}$=1, N_{PG}=77, $N_{Vieques}$=25.

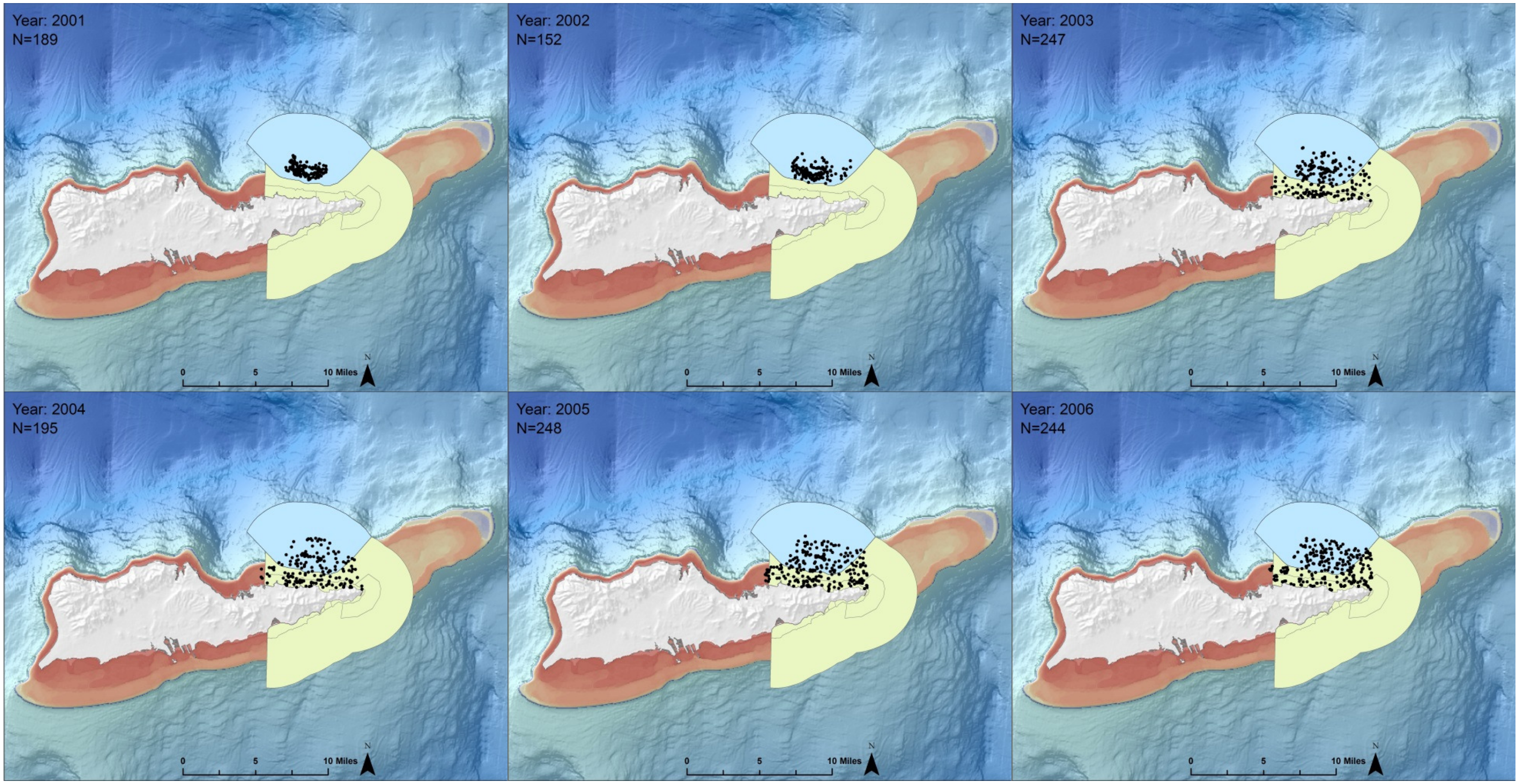


Figure 6.8.5. The annual spatial distribution of the Biogeography visual survey sites in St. Croix. Each panel represents a different year. N represents the annual number of survey sites. The black dots represent the survey sites. The blue area represents Buck Island National Monument and the yellow area represents the East End Marine Park.

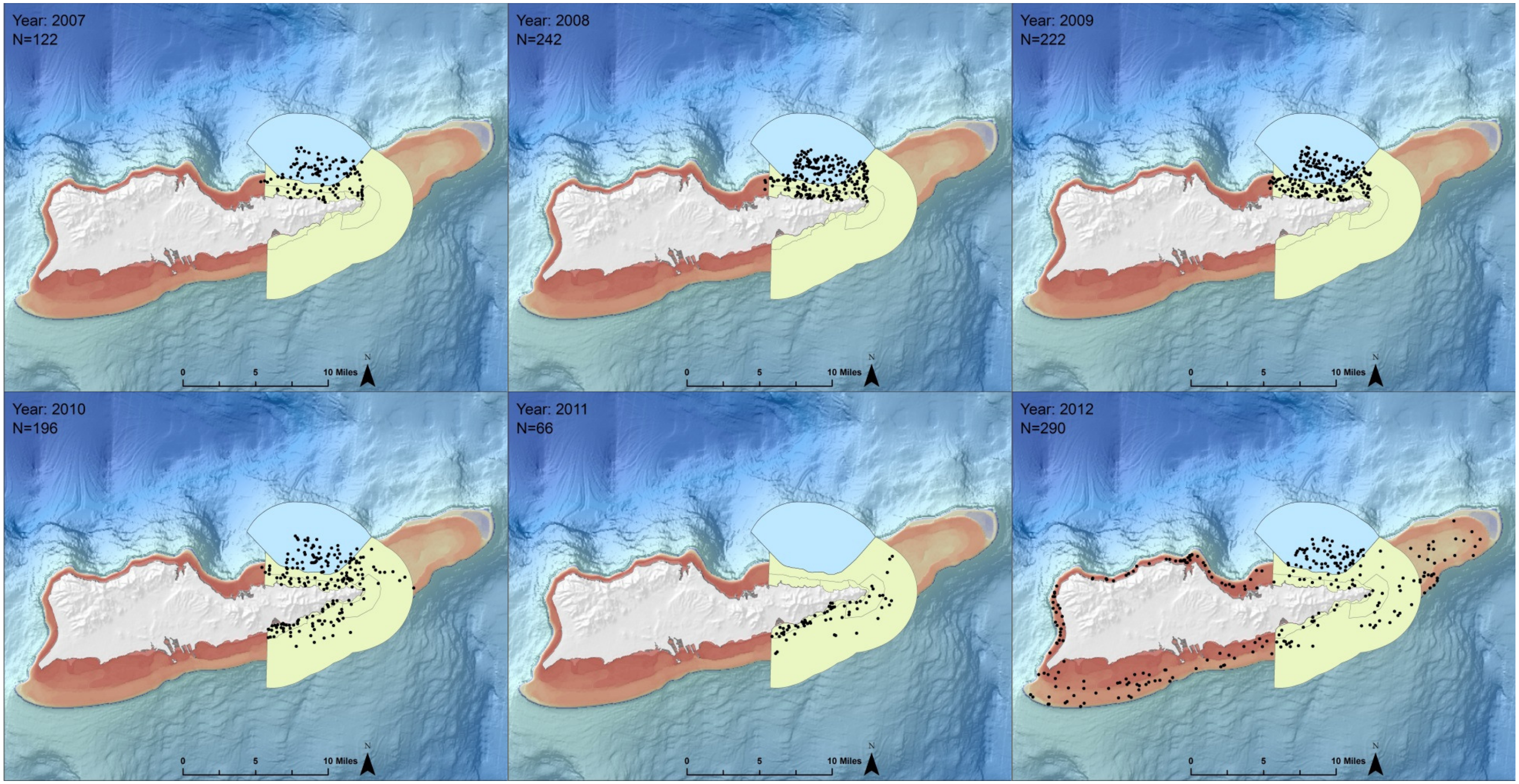


Figure 6.8.5. continued.

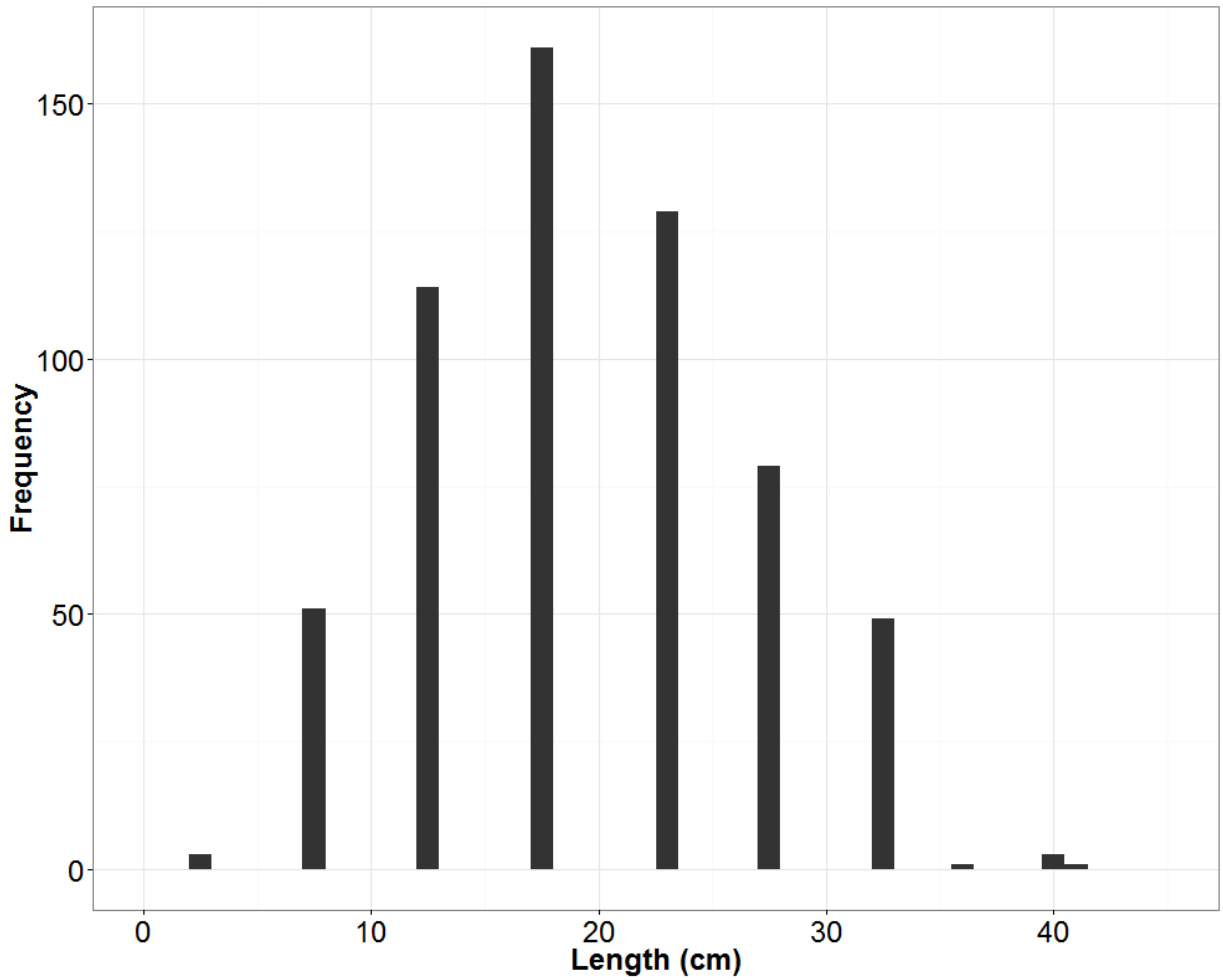


Figure 6.8.6. Length frequency distribution of red hind observed during visual surveys conducted by the NOS Biogeography team in St. Croix from 2001 to 2012. N = 592.

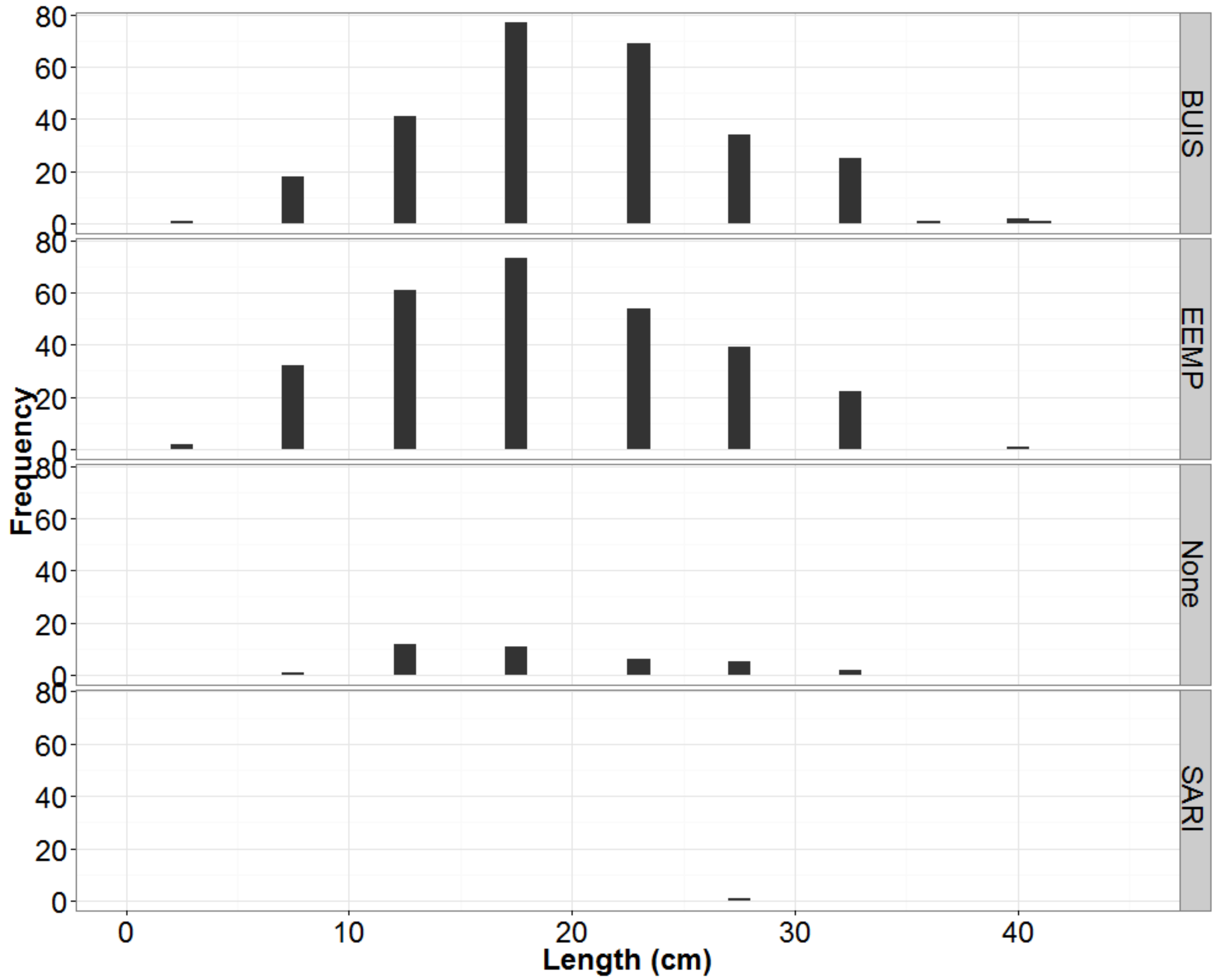


Figure 6.8.7. Length frequency distributions of red hind observed in four management zones during visual surveys conducted by the NOS Biogeography team in St. Croix from 2001 to 2012. N_{BUIS}=270, N_{EEMP}=284, N_{None}=37, and N_{SARI}=1.

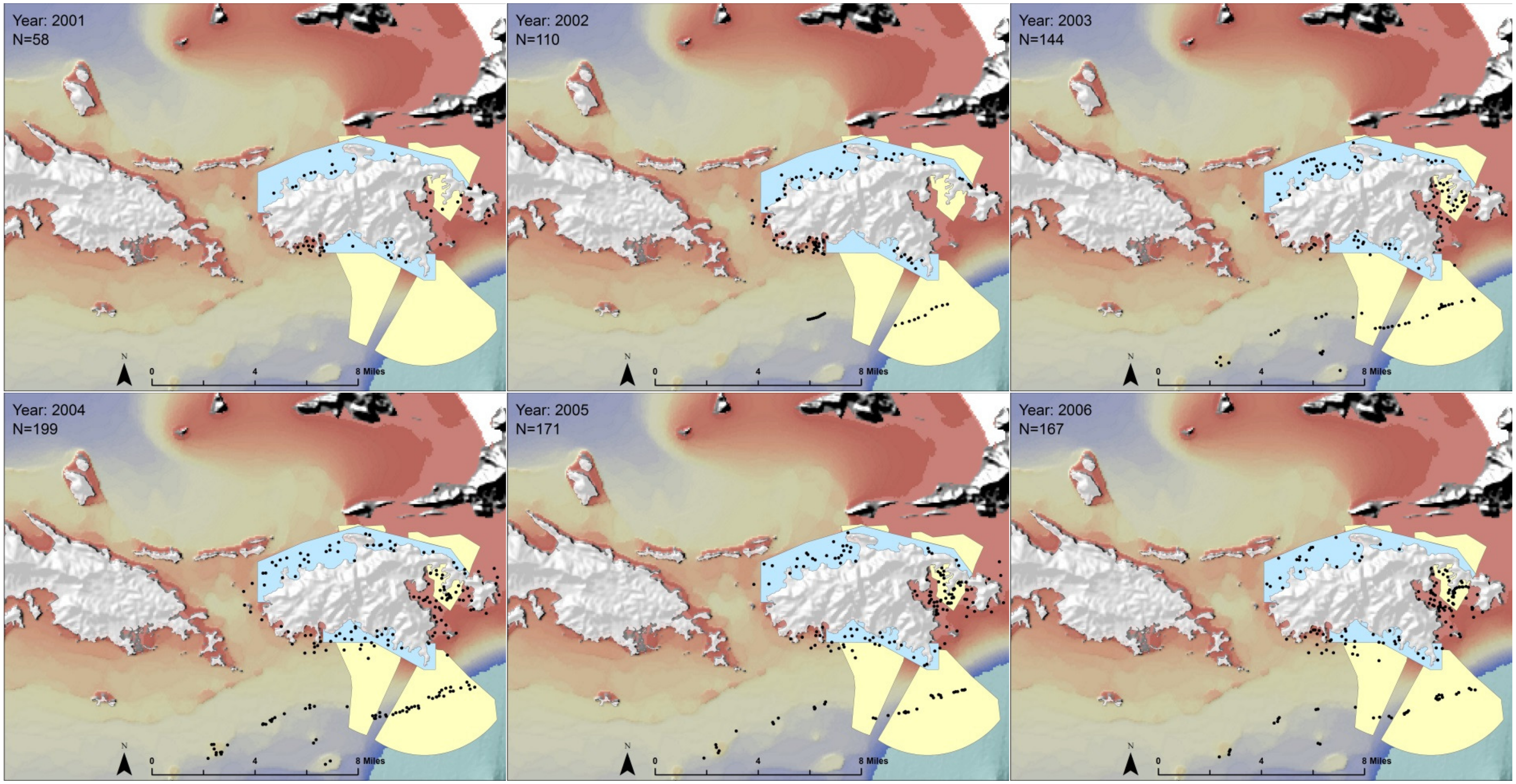


Figure 6.8.8. The annual spatial distribution of the Biogeography visual survey sites in St. John and in 2012 St. Thomas. Each panel represents a different year. N represents the annual number of survey sites. The black dots represent the survey sites. The blue area represents the Virgin Islands National Park and the yellow area represents the Virgin Islands Coral Reef National Monument.

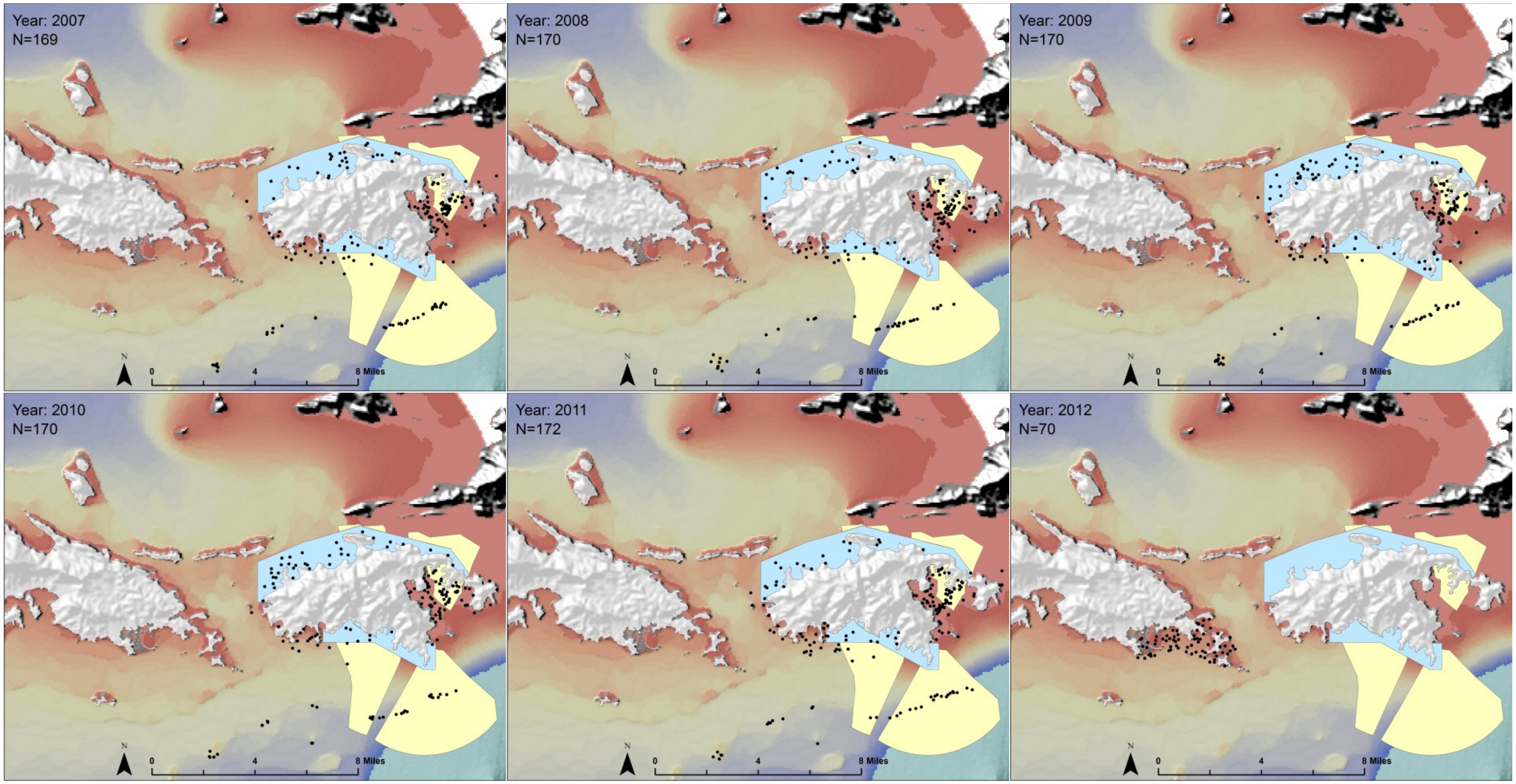


Figure 6.8.8. continued.

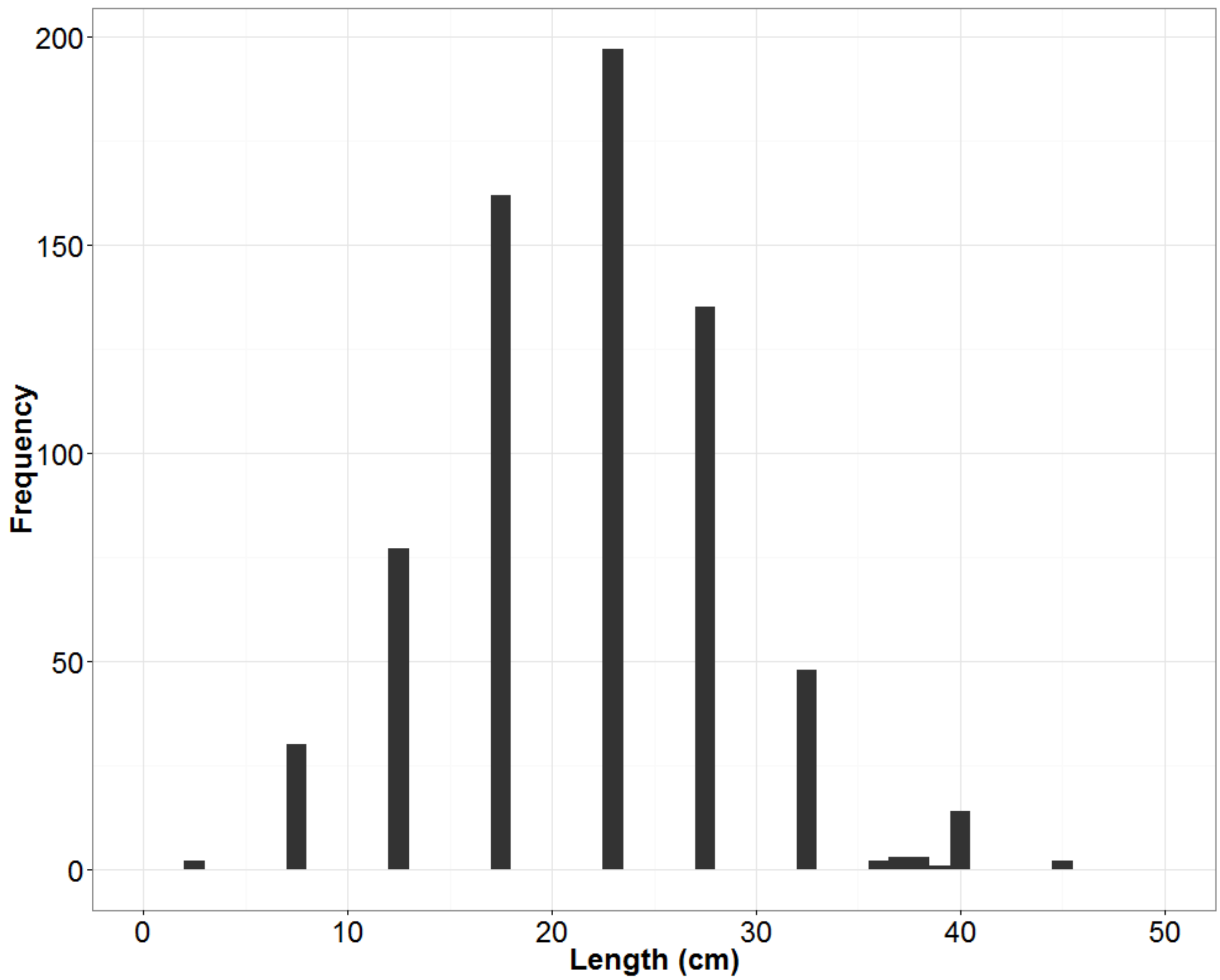


Figure 6.8.9. Length frequency distribution of red hind observed during visual surveys conducted by the NOS Biogeography team in St. John from 2001 to 2011. N = 677.

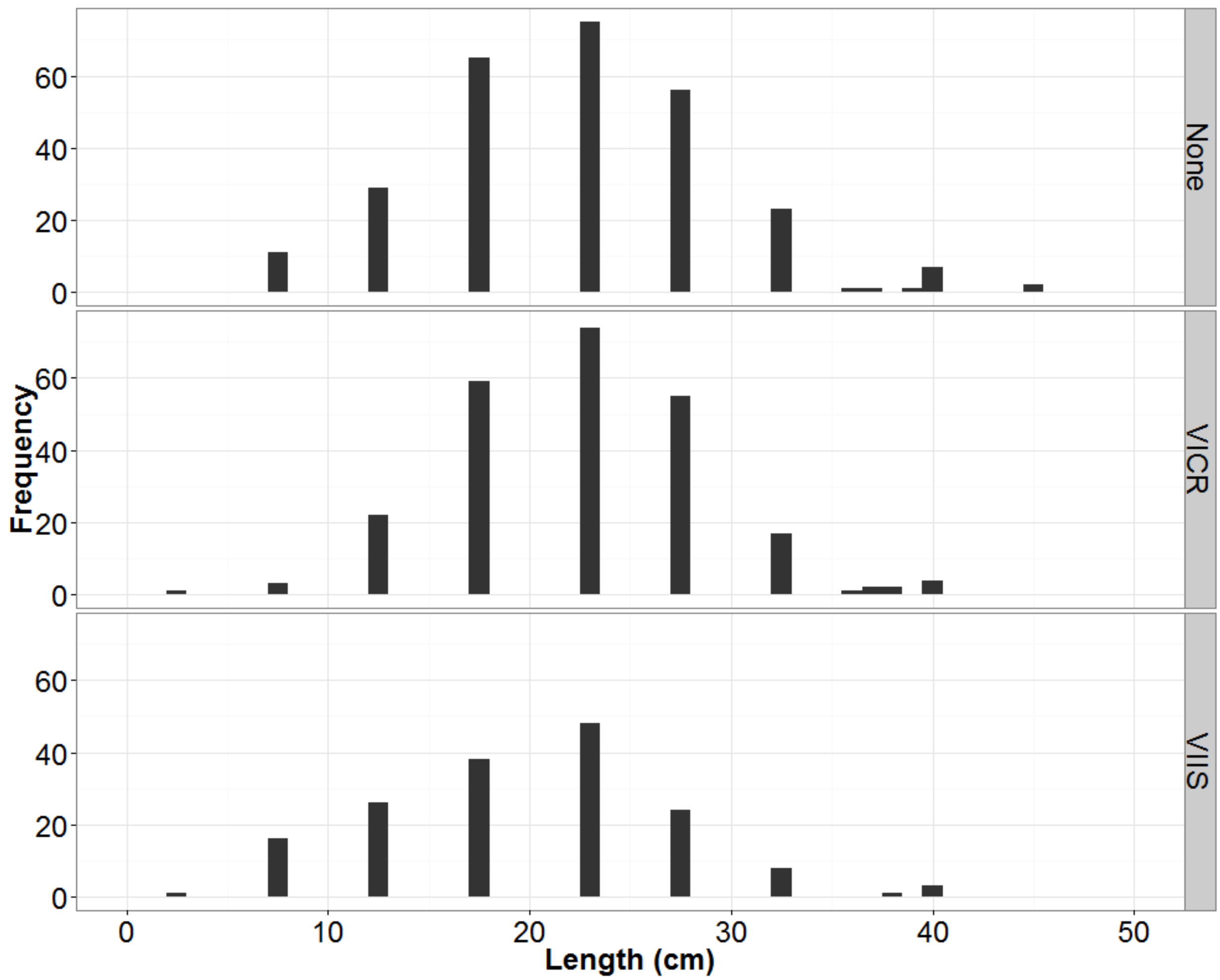


Figure 6.8.10. Length frequency distributions of red hind observed in three management zones during visual surveys conducted by the NOS Biogeography team in St. John from 2001 to 2011. N_{None}=271, N_{VICR}=240, and N_{VIIS}=166.

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 35

Caribbean Red Hind

SECTION III: Assessment Workshop Report

August 2014

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

Introduction

Workshop time and place

A series of webinars were held in lieu of an in-person assessment workshop. The webinars were held between May and July 2014.

Terms of reference

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

Several sources of data were updated after the data workshop: 1) the Marine Recreational Fisheries and Statistics Survey was reviewed to address concerns about a dramatic decline in recreational landings between 2005 and 2006, 2) the Trip Interview Program (TIP) data were reviewed to visually determine the length at which Red Hind, *Epinephelus guttatus*, recruit to the fishery for the fleets that were analyzed, 3) Puerto Rico's reported landings and effort data were processed to develop fishery-dependent relative indices of abundance for several fleets, 4) the SEAMAP-C length data were compared to the TIP length data to determine whether the SEAMAP-C lengths could be used as part of the mean length estimation analysis, 5) the data from three spawning aggregation visual surveys were reviewed. The data updates are summarized in the "Data review" section of this report.

2. Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.

The assessment approach is described in the "Modeling approach" section of this report. The approach is briefly summarized here.

The AW panel recommended that the analysts use a mean length estimator approach to obtain estimates of total mortality from length-frequency data from the diving, pot and trap, and vertical line fleets of Puerto Rico, the pot and trap fleet of St. Thomas, and the diving, pot and trap, and vertical line fleets of St. Croix. A comprehensive sensitivity analysis was conducted to evaluate the sensitivity of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. Fishing mortality was estimated using total mortality from the sensitivity analysis and natural mortality based on a maximum-age approach. To determine whether Red hind were experiencing overfishing, estimates of fishing mortality were compared to F_{MSY} proxies from yield-per-recruit and spawner-per-recruit analyses.

3. Provide estimates of stock population parameters, if feasible.

• Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as necessary to describe the population.

• Include appropriate and representative measures of precision for parameter estimates.

The AW Panel agreed that the length-frequency data from TIP are the most consistent source of species-specific information in the US Caribbean. A non-equilibrium mean length estimator approach was employed given the available data. This approach was used to estimate total mortality and the year of change, when such a change was supported by reductions in AIC. The estimates of total mortality were used to derive estimates of fishing mortality. The results from this analysis are presented in the "Model results: Mean length estimator and sensitivity analysis" section of this report.

4. Characterize uncertainty in the assessment and estimated values

• Consider uncertainty in input data, modeling approach, and model configuration.

• Provide a continuity model consistent with the prior assessment configuration, if one exists, updated to include the most recent observations. Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered.

• Consider other sources as appropriate for this assessment

• Provide appropriate measures of model performance, reliability, and 'goodness of fit'

• Provide measures of uncertainty for estimated parameters

A comprehensive sensitivity analysis was conducted to evaluate the sensitivity of and the uncertainty in the estimates of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. Additionally, when conducting the per-recruit analyses, uncertainties in the length-weight relationship and the estimate of maximum age were accounted for in the estimates of the F_{MSY} proxies.

5. Provide estimates of yield and productivity.

• Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.

Yield-per-recruit and spawner-per-recruit analyses were conducted and are outlined in the "Modeling approach: Per recruit analyses" section. The results of this analysis are summarized in the "Model results: Per recruit analyses" section of this report.

6. Provide estimates of population benchmarks or management criteria consistent with the available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.

• Evaluate existing or proposed management criteria as specified in the management summary

• Recommend proxy values when necessary

The mean length estimator approach does not provide estimates of population benchmarks such as *MSY*, F_{MSY}, or B_{MSY}. As such, F_{MSY} proxies, $F_{0.1}$, $F_{30\%}$, and F_{max} obtained from the yield-per-recruit and spawner-per-recruit analyses were considered. The AW Panel discussed concerns about growth overfishing versus recruitment overfishing, as well as the risk of sperm limitation given that Red Hind is a protogynous species. The AW Panel recommended that $F_{30\%}$ and $F_{40\%}$ be used as F_{MSY} proxies to which current fishing mortality could be compared. They also recommended that the Caribbean Fisheries Management Council's (CFMC) Statistical and Scientific Committee (SSC) review this decision with respect to the level of risk they deem appropriate for protogynous species.

7. Provide declarations of stock status relative to management benchmarks, or alternative data poor approaches if necessary.

Probabilities of overfishing are summarized in the "Model results: Per recruit analyses" section of this report.

8. Perform a probabilistic analysis of proposed reference points, stock status, and yield.

• Provide the probability of overfishing at various harvest or exploitation levels.

• Provide a probability density function for biological reference point estimates.

• If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.

Probabilities of overfishing are summarized in the "Model results: Per recruit analyses" section of this report.

9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:

A) If stock is overfished:

F=0, F=current, F=Fmsy, Ftarget

F=Frebuild (max that rebuild in allowed time)

B) If stock is overfishing

F=Fcurrent, F=Fmsy, F= Ftarget

C) If stock is neither overfished nor overfishing

F=Fcurrent, F=Fmsy, F=Ftarget

D) If data-limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice.

Due to the limited data available, a data poor methodology was attempted that does not include projections of stock dynamics. Therefore, projections were not conducted for this assessment.

10. Provide recommendations for future research and data collection.

• Be as specific as practicable in describing sampling design and sampling intensity.

• Emphasize items which will improve future assessment capabilities and reliability.

• Consider data, monitoring, and assessment needs.

Recommendations for future research can be found in the "Research recommendations" section of this report.

11. Complete the Assessment Workshop Report in accordance with project schedule deadlines (Section III of the SEDAR Stock Assessment Report).

This document serves as the Assessment Workshop report.

List of participants

Assessment workshop panel
Meaghan Bryan……………………………………………………………………………………………NMFS/SEFSC Miami
Kevin McCarthy…………………………………………………………………………………………NMFS/SEFSC Miami
Adyan Rios……………………………………………………………………………………………….…NMFS/SEFSC Miami
Daniel Matos………...PR DNER
Aida Rosario…….PR DNER
Roy Pemberton…….USVI DPNR
Tom Dolan………..USVI DPNR
Richard Appeldoorn……………………………………………………………………….University of Puerto Rico/CFMC SSC
Michelle Schärer…………………………………………………………………………………………..University of Puerto Rico

Attendees
Bill Arnold……NMFS SERO
Michael Larkin………………………………………………………………………………………………………..NMFS SERO

Staff
Julie Neer .... SEDAR
Graciela García-Moliner ....CFMC
Kate Quigley .... SEDAR
Shannon Cass-Calay .... NMFS Miami

Data review

Commercial landings

Puerto Rico

The Data Workshop Panel expressed concerns about unexpected variability in the Puerto Rico correction (expansion) factors, and recommended that the data used to estimate them be evaluated. In addition, it was recommended that the data be reviewed for possible limitations due to small sample size (number of intercepts). Raw data used to calculate the correction factors were available for only one year (2011). For all other years, data were only available in summary form. With only a single year of detailed data available, a thorough review of the calculation of correction factors could not be conducted. A brief summary of the methods used to calculate correction factors is presented below.

Correction/expansion factors are developed by the Puerto Rico Department of Natural and Environmental Resources by comparing landings in pounds observed during dockside sampling to landings reported by fishers in commercial logbooks. Correction factors have been calculated by coast (north, south, east, and west) since 2003, but during earlier years (1983-2002) a single correction factor was calculated for the entire island.

Information collected during 2011 includes species specific landings for each vessel sampled. Landings data for all species are pooled; therefore, correction factors are not species specific. Data are further pooled across vessels sampled, sampling dates, and sample sites within coasts. Commercial logbook data of all fishing trips reported from dates and sites corresponding to dockside sampling are also collected. Those logbook data are pooled similarly to the dockside sampling data. Logbook data from vessels that were not sampled are included in the calculation of correction factors. The coast specific correction factors are calculated as the proportion of reported landings in pounds to observed landings in pounds.

Recreational data

Puerto Rico

The Data Workshop Panel requested additional investigation of the variability among years in the Marine Recreational Fisheries and Statistics Survey (MRFSS) estimates of recreational landings. In particular, the very high landings in 2005 (approximately 110,000 pounds) followed by very low (5,500 pounds) landings in 2006 were of concern (Figure 1). MRFSS estimates of landings and discards are calculated using catch (or discard) rates from dockside intercepts and total fishing effort from telephone surveys. Rate and effort data are stratified by year, wave (two month periods within years, Jan-Feb, Mar-Apr, etc.), mode (private, headboat, shore based fishing), and area (10 miles or less from shore, >10 miles offshore). Landings and discards estimates are calculated within each stratum as:

*stratum specific landings (or discards) = stratum cpue (or discard rate)*stratum effort*

The high variability in landings and discards likely resulted from low numbers of intercepts (i.e. a fishing trip interviewed by a dockside port sampler) that reported Red Hind (6-42 intercepts per year). Total intercepts ranged from 1,125-3,168 per year. The high 2005 landings were primarily due to a high mean catch rate and high effort within a single stratum. The landings estimated for that stratum accounted for 81 percent of the estimated total recreational landings during 2005. Conversely, 2006 strata with high effort had no intercepts with Red Hind landings. Furthermore, strata that reported Red Hind landings also reported low effort, resulting in the very low estimated Red Hind landings during 2006.

USVI
Currently, the MRFSS data collection program does not operate in the USVI.

Fishery dependent relative indices of abundance
Data from self-reported fisher logbooks were examined to characterize abundance trends of Red Hind in Puerto Rico from 1990-2012 (SEDAR35-AW-01). Indices of abundance for the USVI were not pursued since species-specific data were only available after mid-2011.

Indices of abundance for Red Hind in Puerto Rico were developed separately for the diving, trap, and vertical line gear types. Catch per unit effort (CPUE) was calculated on an individual trip basis. CPUE was equal to the pounds of Red Hind landed on a given trip divided by the effort, where effort was the total hours on fishing grounds. The Stephens-MacCall approach (2004) was used to identify trips that targeted Red Hind and delta-lognormal modeling methods were used to estimate relative indices of abundance (Lo et al. 1992). Additional details on the standardization procedure and the resulting indices are included in SEDAR35-AW-01.

The resulting indices are reproduced in Figure 2. The indices exhibited wide confidence intervals and showed no overall directional trends in CPUE. However, similar trends across all three indices in the most recent years provide some support for an increasing CPUE at the end of the time series. Given that these indices are based on landings only and based on self-reported data of unknown accuracy, they were recommended as a qualitative supplement to the quantitative mean length analysis.

Fishery independent data

Spawning aggregation data
Three sources of spawning aggregation data were made available for this assessment. Spawning aggregation data from St. Thomas and St. Croix were made available by Dr. Rick Nemeth (Nemeth 2005, Nemeth *et al.* 2007*)* and data from Puerto Rico were made available by Dr. Michelle Schärer –Umpierre (Schärer *et al.* 2010).

During the first few assessment webinars much of the discussion was centered on these data. The primary objective of this data evaluation was to determine how to best use the spawning aggregation data to develop relative indices of abundance of the spawning population. To do so, the panel conducted a comprehensive evaluation of the within year and inter-annual sampling intensity over a number of spawning aggregation indicator variables (e.g. year, month, full moon phase, and winter solstice) to determine the sampling period in a given year that was most representative of the spawning population.

St. Thomas spawning aggregation data
The data from a long-term monitoring project, 1999-present, of the spawning aggregation on Red Hind Bank in St. Thomas were presented at the data workshop (DW) by Dr. Rick Nemeth and the data were made available after the DW. Monitoring of the aggregation was done by

conducting underwater visual surveys using 30m x 2m belt transects. All Red Hind were enumerated and their lengths were recorded in 10cm bins. Readers are referred to Nemeth (2005) and Nemeth *et al.* (2007) for a detailed explanation of the methods that were used.

Several suggestions for subsetting the data were discussed and evaluated during the assessment webinars. Initially, annual mean density was derived using all data within a given year. Upon closer inspection of the daily mean densities, the Panel agreed that this was inappropriate (Figure 3). The daily mean densities exhibited considerable variability from day to day. This would result from asynchronous arrivals to and departures from the aggregation. There was also considerable variability in the timing of the surveys. Table 1 - Table 3 summarize sampling intensity with respect to month, moon phase and winter solstice, all of which have been suggested to explain when Red Hind spawn. Sampling was mainly conducted in January and February (Table 1). In 2011-2013 sampling was only conducted on the January full-moon due to funding constraints. There were also some inconsistencies in sampling with respect to moon phase and winter solstice, which could explain some of the variability in the data (Table 2 and Table 3).

The Panel recommended using the annual maximum density to obtain an index of Red Hind spawning abundance from this data. This was deemed appropriate given the inherent inter-annual variability in the timing of the spawning aggregation and the variability in the timing of sampling. Using the peak density, regardless of when it occurs in a given year, should better reflect the potential spawning density than an average over a number of sampling days that may reflect the asynchronous arrival and departure of the individuals to the spawning site. This is of particular concern since there are suggestions of size-based variations in the occupation of spawning sites. The resulting density time-series shows considerable inter-annual variability with an alternating pattern of high and low density (Figure 4). In general, there was an increasing trend between in maximum density 2000 and 2007 followed by a decline, which coincided with a reduction in sampling intensity. The Panel agreed that given the caveats of the data that have been highlighted in this section, the resulting density estimates should be used as ancillary qualitative information rather than be incorporated into a quantitative stock assessment model.

St. Croix spawning aggregation data

The data were collected using the same methods as Nemeth (2005) and Nemeth *et al.* (2007). Visual surveys were conducted in 2004-2006 and 2014 on Red Hind Bank off of St. Croix, mainly in January (Table 4). A plot of daily mean density is shown in Figure 5. Given the large gap in the time-series, these data were not considered useful for the current assessment.

Mona Island and Abrir la Sierra, Puerto Rico spawning aggregation data

The spawning aggregation data from Puerto Rico was evaluated in the same manner as the data from St. Thomas. Underwater visual surveys were conducted from 2004-2012. The surveys were conducted as drift dives where survey tracks were recorded by GPS. Sampling occurred between November and May and varied among years. Readers are referred to SEDAR35-DW-09 and Schärer *et al.* (2010) for a complete description of the visual survey methods.

Table 5 summarizes the number of transects surveyed by month, year, and location. The years of sampling differed between Abrir la Sierra and Mona Island. Sampling in Abrir la Sierra started during the 2006-2007 spawning year, and sampling was carried out in all years except the 2007-2008 and the 2008-2009 spawning years. Sampling in Mona Island was initiated during the 2004-2005 spawning year and sampling was carried out in all years except the 2011-2012 spawning year. The month of sampling varied from year to year, but was most consistently collected January-March in Mona Island.

Figure 6 and Figure 7 summarize the daily mean density data for Mona Island and Abrir la Sierra, respectively. The number of sampling days was quite low in each year in Mona Island. The same is true for Abrir la Sierra; however, starting in 2010-2011 the number of sampling days in January and February increased and the resulting data more clearly indicate the days associated with peak spawning. Given the short temporal scale of this survey, these data were not recommended for use in a formal assessment model.

SEAMAP-C

The SEAMAP-C data were presented at the data workshop and were used to develop a relative index of aundance. The data used in the index were collected off the southwest of Puerto Rico between 1991 and 2011. Readers are referred to (SEDAR35-DW-04) for a detailed description of the data collection and index development.

The SEAMAP-C program collected length data in addition to catch-per-unit-effort data. The AW panel evaluated the length data during the first assessment webinar and compared them to the TIP length data. Most (93.85%) lengths were collected between 1991 and 1999 (Table 6). Subsequently, there was a decline in the number of annual lengths and a shift towards larger Red Hind (Figure 8). This shift towards larger Red Hind could be a symptom of small samples sizes and it was unknown to the panel whether sampling had changed at that time, e.g., the survey switched to using a larger hook size. Information about depths fished and fishing area type (i.e., marine protected area, MPA) were available, so the analysts evaluated whether the depth of fishing had changed over time and whether the proportion of sampled sites within MPAs had changed (Figure 9 and Figure 10). The mean depth of the survey stations was relatively constant over time (Figure 9) and the proportion of surveys sampling within MPAs had recently declined (Figure 10). Neither result helped to explain the observed shift towards larger Red Hind. One of the Panelists suggested that there may have been another change in sampling; however, this was never described or verified.

The SEAMAP-C length data were compared to the fishery-dependent length data from TIP (Figures 11-12). The comparison was complicated by the large difference in sample sizes between the two data sets during periods of spatial and temporal overlap (Figure 11). Comparing the peaks of the annual length-frequency distributions using all of the TIP Red Hind length data collected in Puerto Rico indicates that the selectivity of the SEAMAP-C survey generally resulted in a smaller modal length than the selectivity of vertical line fleet, except in 2005, 2006, and 2009 (Figure 12).

The Panel briefly discussed using the SEAMAP-C data for the mean length estimator. The Panel did not move forward with this recommendation given that the majority of samples were collected between 1991 and 1999 and samples are lacking from more recent years. Additionally, these data could not be combined with the TIP length data because the apparent difference in selectivity violated the assumptions of the model.

St. Croix trap study

A pilot trap study was conducted in 2010 in St. Croix. The main goals of this study were to develop a statistically sound survey of the entire St. Croix continental shelf by integrating information from existing habitat maps with local, historical fishing patterns and develop and execute a cooperative and cost-effective sampling program with the local fishing community. The survey was conducted in October, 2010 and provided a snap-shot of the St. Croix reef fish community. Readers are referred to Bryan *et al.* (2013) for a full description of the project and methods.

The AW Panel requested to see these data since Red Hind were the 9th most frequently captured species during this study. A total of 87 Red Hind were captured and all were captured on hard-bottom habitat. The length-data from this survey are shown in Figure 13. The smallest Red Hind captured was 14cm, the largest was 49cm, and the mean was 34 cm. The range of the length-frequency distribution was similar to that from the fishery-dependent length data, although the length distribution from this survey was not well defined due to the limited number of samples.

Trip Interview Program (TIP)

During the first webinar of the assessment webinar series the Panel reviewed the length data from TIP to determine the length-at-recruitment to the fishery. This will be fully described in the "Mean length estimator*:* Input parameters and data sources" section of the report.

Modeling approach

A three-stage approach was used to conduct this assessment. A brief overview will be given here and a more detailed description of each component will be described in the sections that follow.

(1) Since the length frequency data are currently the most temporally consistent source of species-specific information, a mean length estimator approach was used to estimate total mortality. Analyses were conducted separately for several island and gear combinations (Table 7). Initial analyses (base model) were done using estimates of the von Bertalanffy growth parameters that were from Sadovy *et al.* (1992). These growth parameters were compared to other published estimates and the Panel agreed that there was uncertainty about the growth relationship. Therefore, a sensitivity analysis was conducted to evaluate the influence of the growth parameters on the outcome of the mean length estimator and quantify uncertainty in the total mortality estimates.

(2) Fishing mortality estimates were derived from the total mortality estimates and estimates of natural mortality.

(3) A yield-per-recruit and spawner-per-recruit analysis was then conducted to evaluate stock status relative to fishing mortality.

Mean length estimator

Overview

Length frequency data from the NMFS Trip Interview Program, SEAMAP-C, and the NOS Biogeography visual survey database were evaluated for use. Samples sizes and temporal coverage of the TIP data were deemed adequate enough to attempt the analyses on a subset of the island and fleet combinations or strata (Table 7).

Model configuration and equations

For each stratum, total mortality (*Z*) estimates and changes in mortality were explored using a variant of the Beverton-Holt length-based mortality estimator (Beverton and Holt 1956, 1957). The Beverton-Holt mortality estimator has received widespread use, especially in data-limited situations, owing mainly to the minimal parameter inputs. They include the von Bertalanffy growth parameters, the growth coefficient (*K*) and the asymptotic length (L_∞), the so-called length of first capture (smallest size at which animals are fully vulnerable to the fishery and to the sampling gear), L_c, and the mean length of the animals ($\bar{L}$) larger than the length L_c:

$$Z = \frac{K(L_\infty - \bar{L})}{\bar{L} - L_c} \qquad (1)$$

There are six assumptions behind this method:

1. Growth is asymptotic with known parameters *K* and L_∞ that are constant over time.
2. No individual variability in growth.
3. Constant and continuous recruitment over time.
4. Mortality rate is constant with age for all ages $t > t_c$, where t_c is the age at first capture.
5. Mortality rate is constant over time.
6. Population is in equilibrium (i.e., enough time has passed following any change in mortality that mean length now reflects the new mortality level).

The method has been criticized, however, because the assumption of equilibrium (6) is very difficult to meet in the real world situations where any change in fishing pressure disrupts the equilibrium stable age distribution. In the case of increased fishing pressure, it takes time for the larger and older animals to be removed from the population and the mean length to decrease and reflect the current mortality rate. When fishing pressure is decreased, equilibrium takes even longer to achieve as only time will allow the smaller/ younger animals to grow and the mean length to increase and reflect the current mortality rate.

Gedamke and Hoenig (2006) developed an extension of the Beverton-Holt length-based mortality estimator for use in non-equilibrium situations. This method is attractive quantitatively because it requires minimal data that are commonly available and it does not require the assumption that catch rate is proportional to abundance. It allows for the broader application of a mean length analysis approach by removing an equilibrium assumption that is typically difficult to meet in real world situations. In addition, the transitional form of the model allows mortality estimates to be made within a few years of a change rather than having to wait for the mean lengths to stabilize at their new equilibrium level. In other words, as soon as a decline in mean length is detected, this model can be applied and the trajectory of decline can be used to estimate the new Z and how mean lengths will change over time.

The method is described in detail in Gedamke and Hoenig (2006) and will only be summarized briefly here. Like the Beverton and Holt estimator this extension requires only a series of mean length above the length at recruitment to the fishery, a user defined minimum size, and the von Bertalanffy growth parameters, so it can be applied in many data poor situations. Gedamke and Hoenig (2006) demonstrated the utility of this approach using both simulated data and an application to data for goosefish caught in the NEFSC fall groundfish survey.

The mean length in a population can be calculated *d* years after a single permanent change in total mortality from Z_1 to Z_2 yr^{-1} by the following equation:

$$\bar{L} = L_\infty - \frac{Z_1 Z_2 (L_\infty - L_c)\{Z_1 + K + (Z_2 - Z_1)\exp(-(Z_2 + K)d)\}}{(Z_1 + K)(Z_2 + K)(Z_1 + (Z_2 - Z_1)\exp(-Z_2 d))} . \quad (2)$$

Equation (2) was generalized to allow for multiple changes in the mortality rate over time. A maximum of two changes in total mortality was allowed. The algorithm was programmed in AD Model Builder in a maximum likelihood framework and used to estimate mortality rates from the observed mean lengths. A shell program was written in R to conduct a grid search of potential year(s) of change and also to conduct a sensitivity analysis to input parameters.

Models were run starting with the simplest model (i.e., no change in mortality) and then sequentially by adding an additional year of change and therefore increasing complexity (i.e., each year of change adds two parameters). Akaike information criterion with a correction for small sample size (AIC_c) was calculated for each scenario and will be referred to simply as AIC throughout the rest of this document. The change in AIC or ΔAIC was calculated to compare models. ΔAIC was calculated sequentially by subtracting the AIC of the more parsimonious model from the AIC of the less parsimonious model. When comparing models, a reduction of ΔAIC by more than 2 units was interpreted as strong support for the less parsimonious model.

Input parameters and data sources

The main input parameters for the mean length estimator are mean length, the length at which animals are fully vulnerable to the gear (L_c), and the von Bertalanffy growth parameters. The length data from the TIP database were used for this analysis to calculate annual mean length and determine L_c.

Annual length-frequency plots were constructed for each stratum that the Panel agreed had sufficient sample sizes. They were the diving, pot and trap, and vertical line fleets from Puerto Rico and St. Croix and the pot and trap fleet from St. Thomas. The gears were considered separately given their potential differences in selectivity. L_c was selected visually from the annual length-frequency distributions (Thorson and Prager, 2011) while considering the annual sample size. The highest L_c value over the time series was chosen as the input for initial analysis. Using the highest L_c value avoids violating model assumptions and the confounding of selectivity and mortality in the calculation of annual mean lengths. Annual mean lengths were calculated from lengths that were larger than L_c. Table 7 and Figure 14-Figure 16 summarize the chosen L_c values for each stratum.

The von Bertalannfy growth parameters, K and L_∞ that were used in the initial model runs were obtained from Sadovy *et al.* (1992).

Estimated parameters

The parameters estimated by the non-equilibrium length method as described above are total mortality rates (Z) and the year(s) of change. In this document, $Z_{current}$ or Z_{cur} is defined as the total mortality in the most recent time periods.

Uncertainty and measures of precision

A sensitivity analysis was conducted for each stratum. The analysis evaluated sensitivity in the estimates of total mortality and in the year(s) of change (if applicable) to changes in the growth parameters and values of L_c. The range of the growth parameters explored included four published estimates of asymptotic growth and the von Bertalanffy growth coefficient. A linear model was fit to these four points to define nine additional L_∞ and K parameter pairs (Figure 17). The 13 parameter pairs used for the sensitivity analysis are summarized in Table 8. The sensitivity range for L_c was determined for each individual stratum. The sensitivity of the mean length estimator to the selection of L_c was explored using two alternative assumptions, the value chosen by visual inspection and used in the initial analysis, and the average mode of the annual length-frequency distributions for each stratum.

Estimates of fishing mortality

Fishing mortality (F) was calculated using the equation ($F = Z\text{-}M$), where Z was the estimate of current total mortality from the mean length estimator and M was the estimate of natural mortality. An empirical estimate of natural mortality was not available; therefore, the AW Panel had a discussion to determine which natural mortality estimator was most appropriate for this assessment.

The Panel considered whether a maximum-age approach or a life-history invariants relationship should be used. Life-history invariant relationships rely on the von Bertalanffy growth coefficient. In general, the Panel agreed that given the uncertainty in the growth parameters, which are already accounted for in the sensitivity analysis, and given that maximum age estimates are generally more precisely known, it was prudent to use a maximum age approach.

Natural mortality was derived using two estimates of maximum age, 18 and 22 as reported in Sadovy *et al.* (1992) and Luckhurst *et al.* (1992). To estimate M, the regression approach presented by Hewitt and Hoenig (2006) was used, as the Hoenig (1983) approach requires making a subjective decision about the proportion of the population that survives to the maximum age.

Per recruit analyses

Yield-per-recruit (YPR) and spawner-per-recruit (SBPR) analyses using the Botsford incidence functions (Botsford, 1981) were conducted for each stratum to derive F_{MSY} proxies. These proxies were compared to the fishing mortality estimates from the sensitivity analyses to determine stock status with respect to fishing mortality. For each stratum, uncertainty in the growth parameters and L_c was propagated in using the same parameter combinations utilized in the sensitivity analyses.

Assumptions

Red Hind growth in millimeters fork length (FL mm) was assumed to follow the von Bertalanffy growth relationship, as was assumed in the mean-length estimator:

$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right), \tag{3}$$

where t is age and t_0 is the theoretical age where Red Hind would measure 0 mm. Mean weight at age, W_t, was assumed to follow the von Bertalanffy relationship and derived from the von Bertalanffy growth parameters and the length-weight power model:

$$W_t = W_\infty(1 - e^{-k(t-t_0)})^b \tag{4}$$

The asymptotic weight, W_∞, in equation (4) was derived using the length-weight power model and asymptotic length:

$$W_\infty = a{L_\infty}^b \tag{5}$$

The von Bertalanffy growth parameters used in this analysis were the same as those used in the sensitivity analysis and are shown in Table 8. The length-weight parameters used for this analysis were obtained from Sadovy *et al.* (1992) and Bohnsack and Harper (1986). The length-weight relationships from these two sources are shown in Figure 18 and all length-weight relationships that were considered are summarized in Table 9.

The Panel agreed that the uncertainty in the length-weight relationship should be accounted for in this analysis. Three relationships were chosen by the Panel for use. The Bohnsack and Harper length-weight relationships for St. Croix and Puerto Rico were used to define the upper and lower bounds of the length-weight relationship. The third mid-level relationship was defined using Sadovy's length-weight relationship for Puerto Rico.

Vulnerability-at-age, v_t, was assumed to have a knife-edge relationship at the age-at-recruitment to the fishery:

$$v_t = \begin{cases} 0, t < t_c \\ 1, t \geq t_c \end{cases}. \tag{6}$$

where t_c was derived from the von Bertalanffy growth equation. In equation (3) the mean length-at-age, L_t, was set equal to the length-at-full recruitment, L_c, and the equation was solved for age t_c:

$$t_c = \frac{\ln\left(\frac{-L_c}{L_\infty}+1\right)}{-k} + t_0. \tag{7}$$

Maturity-at-age, m_t, was assumed to have a knife-edge relationship at the age-at-maturity, a_{mat}:

$$m_t = \begin{cases} 0, t < t_{mat} \\ 1, t \geq t_{mat} \end{cases} \tag{8}$$

where a_{mat} was fixed at age 3 (Sadovy *et al.* 1992).

Mortality

The probability of surviving from one age to the next under fished and unfished conditions, or the survivorship of the species, is given by:

$$s_t = \begin{cases} 1, t = 1 \\ s_{t-1}e^{-(M+F_t)}, t > 1 \end{cases} \tag{9}$$

$$s_{o_t} = \begin{cases} 1, t = 1 \\ s_{o_{t-1}}e^{-M}, t > 1 \end{cases} \tag{10}$$

Equation (9) captures the effects of fishing mortality-at-age, $F_t = v_t F$, and natural mortality, M, on a species as it grows older and equation (10) captures only the effects of natural mortality. Natural mortality was derived as previously described using a maximum age-based approach.

Incidence functions

The equilibrium vulnerable biomass per recruit was obtained using:

$$\varphi_{vb} = \sum_{t=1}^{t=tmax} lx_t w_t v_t \tag{11}$$

(Botsford 1981, Walters and Martell 2004). The vulnerable biomass incidence function captures the effects of natural and fishing mortality over the lifetime of individuals. Yield per recruit (YPR) was predicted as the product of the exploitation rate and the lifetime vulnerable biomass:

$$YPR = (1 - e^{-F})\varphi_{vb}\,. \tag{12}$$

Spawning biomass per recruit under fished conditions was predicted as:

$$SPR = \sum_{t=1}^{t=tmax} lx_t w_t m_t\,. \tag{13}$$

Spawning biomass per recruit under unfished conditions was determined as:

$$SPR_o = \sum_{t=1}^{t=tmax} lxo_t w_t m_t. \tag{14}$$

F_{MSY} proxies

The fishing mortality rate that would achieve maximum sustainable yield, F_{MSY}, cannot be derived from a per recruit analysis; however, F_{MSY} proxies can be developed. Three proxies were considered by the panel; $F_{0.1}$, F_{max}, and $F_{SPR30\%}$.

$F_{0.1}$ and F_{max} are commonly used F_{MSY} proxies that are obtained from yield per recruit analyses. They are most often considered when growth overfishing is occurring since YPR accounts only for the mortality and weight of the species of interest. $F_{0.1}$ corresponds to the fishing mortality rate associated with the point on the yield curve with a slope that is ten percent of the slope at the origin and F_{max} corresponds to the fishing mortality rate that maximizes the yield per recruit curve. $F_{SPR30\%}$ corresponds to the fishing mortality rate that reduces the spawning biomass per recruit to 30% of the spawning biomass per recruit attained under unfished conditions. F_{SPR} based metrics are most often considered when there is a concern that recruitment overfishing is possible since SPR is a function of not only mortality and weight, but also maturity.

The AW Panel agreed that $F_{30\%}$ and $F_{40\%}$ were acceptable F_{MSY} proxies for Red Hind. The rationale behind this decision will be discussed in "Per recruit analyses*:* F_{MSY} proxies*"* section.

Probability of overfishing

Estimates of current fishing mortality, $F_{current}$, from the sensitivity analyses were compared to the recommended F_{MSY} proxies. More specifically, the ratio between $F_{current}$ and F_{MSY} proxies, which is often referred to as an F-ratio, was obtained to determine overfishing status for a given sensitivity run. The probability of overfishing integrated across all modeled sources of uncertainty was then determined. A normal distribution was assumed to describe the distribution of the results.

Model results

Mean length estimator and sensitivity analysis

Puerto Rico

The annual length distributions for the diving, pot and trap, and vertical line fleets in Puerto Rico are shown in Figure 19. The distributions of lengths larger than or equal to L_c are shown in Figure 20. The length distributions shown in Figure 20 were used to calculate annual mean length for Puerto Rico's diving, pot and trap, and vertical line fleets for the initial analysis.

Diving fleet

The model with strongest support based on AIC was the constant total mortality model, where total mortality was estimated at 0.312 (Table 10). Mean length remained relatively constant between 1983 and 2011, within a large outlier in 1995 (Figure 21).

The model supported by AIC was sensitive to the L_c values. The constant mortality model was supported by AIC for all sensitivity runs when L_c was equal to 370mm (Table 11 and Table 12). This was the value used for the base run and the results are in agreement with the initial runs. The model that assumed a single change in total mortality, where total mortality increased in 2008, was supported by AIC for all sensitivity runs when L_c was equal to 323 mm (Table 11 and Table 12).

The estimate of current total mortality was sensitive to the value of L_c and the von Bertalanffy growth parameters. The estimate of current total mortality was negatively correlated to the asymptotic length and positively correlated to the von Bertalanffy growth coefficient when L_c was equal to 323 mm (Figure

22). The total mortality estimates ranged between approximately 0.3 and 0.8, where 0.8 was an outlier. The relationship between the estimate of current total mortality and the von Bertalanffy growth parameters was dome shaped when L_c was equal to 370mm (Figure 22). Total mortality ranged between approximately 0.68 and 1.

Pot and trap fleet

The model with the strongest support based on AIC assumed a single change in total mortality (Table 10). Total mortality was predicted to decline in 1995 from 0.444 to 0.292. This represents a 34% decline in total mortality between steady states. Mean length was relatively stable between 1983 and 1995 (Figure 23). Mean length was predicted to change by approximately 12mm between the pre-1995 and post-1995 steady states.

The sensitivity results were similar between the two values of L_c. All sensitivity runs supported a single change in total mortality (Table 13). Total mortality was predicted to increase by approximately 32% and 36% on average when L_c was equal to 283mm and 310mm, respectively. In general, the sensitivity analysis indicated that total mortality changed sometime between 1993 and 1996 (Table 14). The majority of sensitivity runs supported that total mortality changed in 1994 or 1995.

The estimate of current total mortality was sensitive to the value of the von Bertalanffy growth parameters. The estimate of current total mortality was negatively correlated to the asymptotic length and positively correlated to the von Bertalanffy growth coefficient (Figure 24). The pattern and range in the estimates of total mortality was similar between the two values of L_c.

Vertical line fleet

The model strongly supported by AIC assumed a single change in total mortality (Table 10). Total mortality was predicted to decline in 1987 from 0.379 to 0.235. This represents a 61% decline in total mortality between steady states. Mean length was predicted to increase by 15mm between the pre-1987 and post-1987 steady states (Figure 25).

All sensitivity runs, except one, provided support for the model assuming a single change in total mortality, where total mortality was predicted to increase (Table 15). Total mortality was predicted to increase by 31% and 38%, on average, when L_c was equal to 298mm and 340mm, respectively. The year of change varied within and between the L_c values (Table 16). The majority of sensitivity runs for an L_c equal to 298mm supported an increase in total mortality in 1995 or 1996. The majority of sensitivity runs for an L_c equal to 340mm supported an increase in total mortality in 1994 or 1995.

The relationship between the estimate of current total mortality and the von Bertalanffy growth parameters was dome shaped for both values of L_c (Figure 26). The total mortality estimates were generally larger for the small L_c value. Estimates of total mortality ranged between approximately 0.19 and 0.58 for L_c equal to 298mm and 0.25 and 0.68 for L_c equal to 340mm.

St. Thomas/St. John

The annual length distributions for the pot and trap fleet in St. Thomas and St. John are shown in

Figure 27. The distributions of lengths larger than or equal to L_c are shown in Figure 28. The length distributions shown in Figure 28 were used to calculate annual mean length for the St. Thomas and St. John pot and trap fleet for the initial analysis.

Pot and trap fleet

The model strongly supported by AIC assumed a single change in total mortality (Table 17). Total mortality was predicted to increase in 1983, the first year of the time-series, from 0.270 to 0.390. The predicted change was a 44% increase between steady states.

The number of Red Hind lengths from the pot and trap fleet in St. Thomas and St. John was not consistent over time. The majority of lengths were collected within the first few years of the time-series or the last five years of the time-series (Figure 27 - Figure 29). Several years in 1990s and 2000s were associated with missing data or low sample sizes. The predicted change in mean length between the beginning of the time series and the last several years of data is approximately 15mm (Figure 29).

Trends in the size of red hind over time differed between the length distributions for all Red Hind and the truncated length distribution for Red Hind larger than L_c (Figure 27 and Figure 28). During 1983-1988, the trend suggests an increase towards larger Red Hind. However, when the data were truncated at L_c, the trend suggests a decline to smaller Red Hind (Figure 27 and Figure 28). This trend in the length-distributions was also exhibited between 1990 and 1995. During the 2000s there was a declining trend in length when the data were truncated at L_c. The trend was stable over this time-period for the larger dataset.

The sensitivity results were in agreement between the three values of L_c where the model assuming a single change in total mortality was supported by AIC for all sensitivity runs (Table 18). The average proportional change varied among the L_c values. Total mortality was predicted to increase by 38%, 64%, and 57% for the L_c values 302mm, 320mm, and 340mm, respectively (Table 18). The year of predicted change also varied among the L_c values, where a change in 2001, 2007, and 1983 was supported for the L_c values 302mm, 320mm, and 340mm, respectively (Table 19).

The estimate of current total mortality was negatively correlated with the asymptotic length and positively correlated with the von Bertalanffy growth coefficient (Figure 30). The range in total mortality for L_c equal to 302mm was between 0.34 and 0.93, for L_c equal to 320mm was between 0.45 and 1, and for L_c equal to 340mm was between 0.35 and 0.83.

St. Croix

The annual length distributions for the diving, pot and trap, and vertical line fleets from St. Croix are shown in Figure 31. The truncated length distributions, where the distributions represent the lengths that were at or larger than L_c are shown in Figure 32. The length distributions shown in Figure 32 were used to calculate annual mean length for the St. Croix fleets for the initial analysis.

The length-frequency distributions from the diving fleet were relatively stable overall and when truncated. The diving fleet time-series, 2002-2011, is shorter than the other two fleets (Figure 31 and Figure 32). The annual distributions of all the length data for the pot and trap fleet increased over the first four years and declined as sample size declined until 2007 when the length distributions began to increase. The truncated length declined over time; however, sample size was also greatly reduced. The trends for the vertical line fleet were similar to that of the pot and trap fleet.

Diving fleet

The time-series for the diving fleet was shorter than the others and started in 2002 with a terminal year of 2011. The model strongly supported by AIC was the constant total mortality model, where total mortality was estimated at 0.476 for the entire time-series (Table 20). Mean length remained relatively constant over the time series, except in 2002, which had small sample size and the highest mean length (Figure 33). All of the sensitivity runs strongly supported the constant total mortality model, regardless of the L_c value (Table 21). The estimates of total mortality were similar for both L_c values and were negatively correlated with asymptotic length and positively correlated with the von Bertalanffy growth coefficient (Figure 34).

Pot and trap fleet

The model strongly supported by AIC was the constant total mortality model, where total mortality was estimated at 0.295 (Table 20). Annual mean length was relatively constant over time (Figure 35). After 1989, the model over-estimated mean length except in 2001, 2008, and 2011. This corresponds to a reduction in annual sample, where between 1 and 13 measured lengths were included in mean length calculation (Figure 35).

Twelve out of thirteen sensitivity runs provided support for the single change model when L_c was equal to 277mm (Table 22). This was true for seven out of thirteen runs when L_c was equal to 340mm. An average increase in total mortality of 86% and 79% was predicted for the L_c equal to 277mm and L_c equal to 340mm, respectively. The change in total mortality was predicted to happen in 1986, regardless of L_c (Table 23). The other six runs for the L_c equal to 340mm supported the constant mortality model (Table 22). This is similar to the initial model run that used the same L_c. The initial model run overestimated annual mean length in most years from 1989 onward (Figure 35). This helps to explain why half of the sensitivity runs could also be explained by the model predicting a single increase in total mortality to describe the slightly lower mean length in those years.

The estimate of current total mortality was negatively correlated to asymptotic length and positively correlated with the von Bertalanffy growth coefficient when L_c was equal to 277mm. For the L_c equal to 340mm, the estimate of total mortality was similar, approximately 0.65, for asymptotic lengths between 450mm and 550mm and for von Bertalanffy growth coefficients between 0.12 and 0.24 (Figure 36). Total mortality was lower, between 0.4 and 0.27 at the higher end of asymptotic length and lower end of the von Bertalanffy growth coefficient (Figure 36).

Vertical line fleet

The model strongly supported by AIC assumed a single change in total mortality, where total mortality increased from 0.286 to 0.502 (Table 20). This represented a 75% increase in total mortality and corresponded to a 12mm decline in predicted mean length (Figure 37). There was a strong decline in mean length between 1983 and 1994. After 1994, sample size was reduced and mean length remained at similar levels to 1994, except for in 2011.

The results from the sensitivity analysis suggest that either the constant total mortality model or the model assuming a single change in total mortality was strongly supported by AIC depending on the L_c value (Table 24). The constant total mortality model was supported when L_c was equal to 287mm. A single increase in total mortality model was supported when L_c was equal to 350mm. On average, total mortality was predicted to increase by 64% between 1983 and 1985 (Table 24).

The estimate of current total mortality was negatively correlated to the asymptotic length and positively correlated with the von Bertalanffy growth parameter when L_c was equal to 287mm (Figure 38). The relationship was dome-shaped at the higher value of L_c.

Per recruit analyses

Figure 39 - Figure 41 show the yield per recruit and spawner per recruit curves for Puerto Rico, St. Thomas and St. John, and St. Croix Red Hind fisheries. The AW Panel evaluated these plots to determine the most appropriate F_{MSY} proxy to determine overfishing status. The majority of YPR curves were flat over a wide range of fishing mortality rates. This leads to unrealistically large F_{MAX} estimates. The Panel agreed that the use of F_{MAX} as the F_{MSY} proxy would be inappropriate for this reason.

The discussion about whether to use $F_{0.1}$ and $F_{SPR30\%}$ (or $F_{SPR40\%)}$ was centered on biological considerations and acceptable risk. The Panel agreed that the risk of recruitment overfishing outweighed the risk of growth overfishing and given the seasonal and spatial closures for Red Hind, $F_{30\%}$ and $F_{40\%}$ were reasonable F_{MSY} proxies. The panel also recommended that this decision be reconsidered by the Caribbean Fisheries Management Council's (CFMC) Statistical and Scientific Committee (SSC).

Figure 42 - Figure 44 show the distributions and cumulative probabilities of the F-ratios for the Puerto Rico, St. Thomas and St. John, and St. Croix Red Hind fisheries. These distributions and cumulative probabilities represent the aggregated outcomes of the per-recruit and fishing mortality estimates from the sensitivity analyses for all gear types.

The results indicate that the probability that Red Hind are experiencing overfishing in Puerto Rico is 25% and 40% when using $F_{30\%}$ and $F_{40\%}$, respectively, as the FMSY proxies (Figure 42). The probability of Red Hind experiencing overfishing in St. Thomas is 42% and 57% when using $F_{30\%}$ and $F_{40\%}$, respectively, as the F_{MSY} proxies (Figure 43). Lastly, the probability of Red Hind experiencing overfishing in St. Croix is 54% and 66% when using $F_{30\%}$ and $F_{40\%}$, respectively, as the FMSY proxies (Figure 44).

Discussion

Puerto Rico

Using the mean length estimator and conducting per recruit analyses resulted in two main outcomes: 1) the mean length estimator and sensitivity results from the analysis of Puerto Rico's pot and trap and vertical line fleet length data suggest that total mortality has declined, whereas, the analysis of the diving fleet's length data suggests total mortality has either remained constant or increased and 2)the resulting probability of overfishing for the Red Hind fishery in Puerto Rico was estimated to be 25% and 40% for $F_{30\%}$ and $F_{40\%}$ respectively.

Spawning aggregation data from Mona Island and Abrir la Sierra, the SEAMAP-C data, and self-reported catch and effort data were ancillary sources of information that were considered as part of this assessment. After evaluating the spawning aggregation data the Panel determined the most useful subset of these data included the last two years (2011 and 2012) of the Abrir la Sierra data. Given the small temporal scale of these data, comparisons cannot be made to the mean length estimator results. A standardized relative index of abundance was developed using the SEAMAP-C data (SEDAR35-DW-04). These data were collected from the west coast Puerto Rico using vertical lines, where CPUE declined over time (Figure 2 in SEDAR35-DW-04). If we were to assume that this index is representative of the Red Hind population of Puerto Rico and that standardized CPUE is proportional to abundance, this result would indicate abundance is declining and fishing mortality is increasing. This is contradictory to the mean length estimator result for the vertical line fleet, which suggested mortality declined. A fishery-dependent relative index of abundance was developed from the self-reported catch and effort data. The standardized indices were flat suggesting that abundance has not changed (Figure 2).

The results indicate that there is a low probability that Red Hind are experiencing overfishing in Puerto Rico. The main results from the mean length analysis suggest conflict dynamics among the fleets. The analyses of the pot and trap and vertical line fleets suggest that total and fishing mortality have declined, whereas, the analysis from the diving fleet suggests that total mortality remained constant or increased. These results are supported by the trends in effort for each fleet. The number of pot and trap and vertical line reported trips, overall and catching Red Hind, have declined by approximately 50% and 75%, respectively, since the early 2000s. The number of reported diving trips, overall and catching Red Hind, has increased by approximately 200% and 600%, respectively, since 1990 (Figure 45).

In the per-recruit analyses to develop overfishing probabilities, the fleets were assumed to be equally representative of the population. Without better spatially explicit data with respect to area and depth it is difficult ascertain whether this assumption is being met. Further complicating this analysis is the potential unknown component of mortality associated with the regulatory discards during the closed season for Red Hind. The landing of Red Hind is prohibited during December through February to protect the spawning stock. Fishing for other species is not prohibited during this time. Since it is well known the reef fisheries are inherently multispecies it is important to better understand whether the magnitude of incidental catch of Red Hind during the seasonal closure is a negligible component of mortality.

St. Thomas

Two main outcomes were provided by this analysis: 1) the mean length estimator and sensitivity results when applied to the St. Thomas pot and trap length data provided support for an increase in total mortality and 2) the per recruit analysis indicated that the probability of the St. Thomas Red Hind fishery experiencing overfishing was 42% and 57% when using $F_{30\%}$ and $F_{40\%}$, respectively.

The sensitivity runs were in agreement that total mortality increased. The timing of the increase was inconclusive given the sensitivity to the choice of L_c. One reason for this sensitivity is that the number of length samples was highly variable from year and to year, with an absence of samples for the majority of the 1990s and early 2000s. L_c is the main determinant of which data are included in the analysis since the mean length is a function of those lengths larger than L_c. With further reductions in the number of lengths during this time period, the model assuming a single change in total mortality could fit equally well over a range of change years.

Due to many years associated with low samples sizes of Red Hind length from St. Thomas, several sources of ancillary data were considered. The first was the Hind Bank spawning aggregation data presented in "St. Thomas spawning aggregation data" section. These data were evaluated with the purpose of developing a relative index of abundance for the spawning population. Annual density estimates were derived from these data. The panel agreed that using the maximum density was most representative of the spawning population. The resulting index lacked a clear trend and was characterized by considerable inter-annual variability (Figure 4). This was not unexpected; however, it was not possible to disaggregate to what degree this variability was explained by environmental covariates or sampling variability.

The reported landings and effort (i.e., number of trips) were also evaluated. Reported grouper (all grouper species) landings and effort have declined since approximately 2008 (Figure 46). Assuming that the number of trips is a reasonable measure of effort and catchability has been constant, this would indicate that fishing mortality has declined. As the theory indicates, as fishing mortality declines fish size will eventually increase. This is contradictory to the main result of the mean length estimator that mortality has increased due to a reduction in mean length.

It is important to note that during the data workshop there was a discussion about market demands dictating the size distribution of the landed Red Hind in the USVI. The fisherman from St. Thomas indicated that the market demand is for plate-sized fish, the average plate size fish in the United States is 27cm. Market driven selectivity generally leads to dome-shaped selectivity. If selectivity is truly dome-shaped this would violate the model assumption that selectivity is knife-edge at the length at recruitment. The violation of this assumption would lead to the over-estimation of fishing mortality. It is imperative that this issue of selectivity be addressed, if future US Caribbean assessments are to employ a mean length approach.

St. Croix

The mean length estimator and sensitivity results when applied to St. Croix's pot and trap and vertical line fleet length data predicted that total mortality has increased, whereas, the analysis of the diving fleet's length data indicates total mortality has either remained constant or increased. There was agreement among the sensitivity runs that the predicted increase in mortality occurred within a few years of the start of the time-series. The resulting probability of overfishing for the Red Hind fishery in St. Croix was estimated to be 54% and 66% for $F_{30\%}$ and $F_{40\%}$, respectively.

Sample size is a major concern associated with the length-frequency data from St. Croix. Red Hind caught by diving gear do not appear in the TIP database until 2002. Conversely, the sample sizes from the pot and trap and vertical line fleets are highest in the beginning of the time-series. As the number of samples declined, the length distributions were skewed towards smaller fish and the median was closer to the average plate size (Figure 31). It was not clear from the discussions when market demands altered size selectivity, but this may reflect a potential change in selectivity. Similar to St. Thomas, if selectivity is truly dome-shaped this violates the assumption of knife-edge selectivity and fishing mortality may be over-estimated.

Research recommendations

In the short term, US Caribbean stock assessments will continue to rely on mean-length estimation given the data currently available. The ability to use the mean-length estimator is contingent upon having length-frequency data that are temporally consistent and representative of the population and upon having reliable estimates of life history parameters, in particular, the von Bertalanffy parameters. Efforts should be made to review the current TIP sampling structure in Puerto Rico and in the USVI to ensure sampling is representative. Studies on basic life history (e.g., age-growth relationships, length/age-at-maturity) in the US Caribbean will greatly enhance the utility of the existing length-frequency data and should provide the greatest benefit to providing management advice in the short term. This should be placed as a top priority for key species.

Fishery-independent surveys should be considered as a top research priority for additional data collection. Fishery-independent surveys designed using a rigorous statistical framework will allow for the collection of species-specific catch and effort data that can be used to develop indices of abundance. Indices of abundance are used in stock assessments to inform models about how a population may be changing over time. Fishery-independent surveys can also be used to supplement existing programs by collecting age, length, weight, and reproductive data.

During the SEDAR 35 assessment workshop, and in previous assessment workshops in the US Caribbean, the fishermen from the USVI indicated that the size of landed fish is market driven for plate size fish. This may help to explain the relatively narrow size range of landed Red Hind. It also suggests that selectivity is dome-shaped, which violates the assumption of knife-edge selectivity in the mean-length model. One avenue of future research would be to expand the mean-length estimator to accommodate other selectivity patterns. Another avenue of research would be to quantify the selectivity patterns for the different gear types. During the data and assessment workshops, the Panel could not quantify discard rates nor could they ascertain the level of discard mortality. If discard mortality of larger fish is significant, the violation of the selectivity assumption may be moot. Efforts should be made to quantify discard and discard mortality rates for the US Caribbean fisheries.

Lastly, under the current management regime all US fisheries must be managed by annual catch limits (ACLs). In an ideal scenario, ACLs would be developed from estimates of abundance and sustainable yield. The mean length estimator does not provide these metrics. As such, it is essential that continued efforts to improve the data collection of fishery-dependent catch and effort statistics be made so that traditional biomass-based assessment approaches can be employed. Continued efforts to collect species-specific catch statistics will also be important in moving towards more traditional assessment approaches and for more precise monitoring of ACLs.

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Tables

Table 1. Sampling intensity by year and month for the St. Thomas spawning aggregation data.

Month	January		February		March		December	
Year	Days	Transects	Days	Transects	Days	Transects	Days	Transects
1999	-	-	-	-	-	-	1	5
2000	3	15	-	-	-	-	4	23
2001	14	75	6	30	-	-	1	17
2002	5	48	-	-	2	12	3	28
2003	6	42	4	29	-	-	1	9
2004	1	12	2	18	-	-	-	-
2005	4	39	-	-	-	-	3	27
2006	6	40	4	24	-	-	3	16
2007	13	116	2	24	-	-	3	36
2008	4	31	2	6	-	-	-	-
2009	3	30	1	7	-	-	-	-
2010	1	5	1	5	-	-	-	-
2011	1	9	-	-	-	-	-	-
2012	1	11	-	-	-	-	-	-
2013	1	3	-	-	-	-	-	-

Table 2. Sampling intensity by year and moon phase for the St. Thomas spawning aggregation data.

	Days before full moon														Full moon	Days after full moon			
Spawn year	**-14**	**-13**	**-12**	**-11**	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
1999-2000												1	1		2				
2000-2001	1	1				1				1	1	3	2	2	3	3	1	1	
2001-2002											1	1	2		1	1	1		1
2002-2003					1					2	2	3	2	1	2				
2003-2004							1								2			1	
2004-2005											1	1	1	1					
2005-2006											1	2	3	3	3	1			
2006-2007					1			1				1	1	2	3	2	2		
2007-2008										1		1		2	1	1	1		
2008-2009												1	1	1	1				
2009-2010																		1	
2010-2011															1				
2011-2012															1				
2012-2013															1				

Table 3. Sampling intensity by year and days within the winter solstice for the St. Thomas spawning aggregation data.

	Number of days after winter solstice													
Location	Before		0-10		11-20		21-30		31-40		41-50		50+	
Year	Days	Trans	Days	Trans	Days	Trans	Days	Trans	Days	Trans	Days	Trans	Days	Trans
1999			1	5										
2000	4	23					3	15						
2001			1	17	7	43	2	13	4	16	5	27	1	3
2002	3	28			1	7			4	41			2	12
2003	1	9					6	42					4	29
2004					1	12					1	12	1	6
2005	3	27							4	39				
2006	3	16			1	7	5	33					4	24
2007	2	28	1	8	6	57	2	10	4	37	2	24		
2008									4	31			2	6
2009					3	30					1	7		
2010					1	5					1	5		
2011							1	9						
2012					1	11								
2013									1	3				

Table 4. Sampling intensity by year and month for the St. Croix spawning aggregation visual survey.

	January		February	
Spawn year	Days	Transects	Days	Transects
2003-2004	2	25	4	44
2004-2005	7	72		
2005-2006	3	19	3	17
2013-2014	5	35	6	52

Table 5. Sampling intensity (number of surveyed transects) by year and month for the Puerto Rico spawning aggregation visual survey.

Area	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Abrir la Sierra	2006-2007			2					2
	2007-2008								
	2008-2009								
	2009-2010				4	2			6
	2010-2011	2	4	12	5				23
	2011-2012	2		18	10				30
Mona Island	2004-2005		4	8	1	4			17
	2005-2006	1		3	2	8			14
	2006-2007			9	9	8			26
	2007-2008			1	4	2			7
	2008-2009			6		7			13
	2009-2010			1	9	3	4	2	19
	2010-2011	1		9	2	5	4	1	22
	2011-2012								

Table 6. The number of Red Hind lengths collected annually by the SEAMAP-C survey.

Year	Number of lengths	Cumulative percent
1991	1310	15.14
1992	1755	35.42
1993	1256	49.94
1994	1340	65.42
1995	348	69.44
1996	-	-
1997	836	79.11
1998	645	86.56
1999	631	93.85
2000	135	95.41
2001	74	96.27
2002	-	-
2003	-	-
2004	94	97.35
2005	168	99.30
2006	8	99.39
2007	-	-
2008	-	-
2009	24	99.66
2010	18	99.87
2011	11	100.00

Table 7. List of island and fleet combinations that were applied to the mean length estimator and the length-at-recruitment, Lc, value identified by the assessment panel for the preliminary mean length estimator runs. Decisions about Lc were made by visually inspecting the annual length-frequency plots.

Island	Gear	Lc (FL mm)
Puerto Rico	Diving	370
	Pots and traps	310
	Vertical line	340
St. Thomas	Pot and traps	320
St. Croix	Diving	296
	Pots and traps	340
	Vertical line	350

Table 8. The sensitivity pairs of asymptotic length (L_∞) and the von Bertalanffy growth coefficient (K).

L_∞	K
665.1416	0.485611
632.702	0.510509
601	0.537438
601.845	0.536683
572.493	0.564199
514.5	0.627794
544.572	0.593126
518.013	0.623536
492.749	0.655506
471.4	0.685193
468.717	0.689115
520	0.621154
445.858	0.724446

Table 9. Length-weight relationship for Red Hind. The relationships highlighted in bold were used to account for uncertainty in this relationship when carrying out the per-recruit analyses.

Reference	Year(s) of sampling	Location	N	a	b	Units	Length range
Bohnsack et al. 1986	**Oct 1984 – Sep 1985**	**PR**	**723**	**3.60E-05**	**2.8386**	**mm FL, g**	**156 - 474**
		STT	448	8.40E-06	3.1001	mm FL, g	205 - 545
		STX	**567**	**4.14E-06**	**3.2304**	**mm FL, g**	**208 - 500**
Sadovy et al. 1992	**Sep 1987 – Jan 1989**	**PR**	**1619**	**6.17E-06**	**3.1422**	**mm TL, g**	**170 -490**
		STT	493	2.09E-05	2.9402	mm TL, g	220 – 520
Olsen and LaPlace 1978	Dec 1974 – Apr 1976	STT	414	2.90E-03	3.6060	cm SL, g	120-430
Potts and Manooch 1995	1980 - 1992	NC to DT	96	1.80E-07	2.6140	mm TL,kg	244 - 491
Thompson and Munro 1974	Nov 1969 – Mar 1973	Jamaica	189	1.76E-02	2.9600	cm TL g	21 - 41

Table 10. Mean length estimator results from the analysis of the Puerto Rico length data. The results in bold are associated with the model strongly supported by AIC.

Gear	Lc	VBK	L_Inf	Nchange	Npar	Nyrs	AIC	Δ AIC	LLIKE	Z	Z1	Δ Year 1	Z2	Δ Year 2	Z3
diving	**370**	**0.101**	**514.5**	**0**	**2**	**29**	**237.3**		**116.4**	**0.312**	**-**	**-**	**-**	**-**	**-**
	370	0.101	514.5	1	4	29	238.4	1.11	114.4	-	0.291	2008	0.692	-	-
	370	0.101	514.5	2	6	29	242.6	4.23	113.4	-	0.307	2003	0.154	2008	0.922
pot and traps	310	0.101	514.5	0	2	29	231.7		113.6	0.397	-	-	-	-	-
	310	**0.101**	**514.5**	**1**	**4**	**29**	**225.0**	**-6.63**	**107.7**	**-**	**0.444**	**1995**	**0.292**	**-**	**-**
	310	0.101	514.5	2	6	29	225.7	0.72	105.0	-	0.446	1996	0.245	2009	1.148
vertical line	340	0.101	514.5	0	2	29	218.8		107.2	0.263	-	-	-	-	-
	340	**0.101**	**514.5**	**1**	**4**	**29**	**209.0**	**-9.76**	**99.7**	**-**	**0.379**	**1987**	**0.235**	**-**	**-**
	340	0.101	514.5	2	6	29	213.3	4.27	98.7	-	0.381	1986	0.259	1999	0.212

Table 11. The influence of L_c on the supported model and the mean proportion change in total mortality if a model assuming a change in total mortality was supported when applied to the length data from the Puerto Rico diving fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	Nruns	Mean proportion change	Stdev
323	1	13	1.225	0.239
370*	0	13	0	0

Table 12. The influence of L_c on the year of change for supported models that assume a change in total mortality when applied to the mean length data from the Puerto Rico diving fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	**Nchange**	**ChangeYear1**	**ChangeYear2**	**Nruns**
323	1	2008	-	13
370*	0	-	-	13

Table 13. The influence of L_c on the supported model and the mean proportion change in total mortality if a model assuming a change in total mortality was supported when applied to the length data from the Puerto Rico pot and trap fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	Nruns	Mean proportion change	Stdev
283	1	13	-0.36	0.016
310*	1	13	-0.318	0.018

Table 14. The influence of L_c on the year of change for supported models that assume a change in total mortality when applied to the mean length data from the Puerto Rico pot and trap fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	ChangeYear1	ChangeYear2	Nruns
283	1	1995	-	6
		1994	-	6
		1993	-	1
310*	1	1996	-	3
		1995	-	8
		1994	-	2

Table 15. The influence of L_c on the supported model and the mean proportion change in total mortality if a model assuming a change in total mortality was supported when applied to the length data from the Puerto Rico vertical line fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	Nruns	Mean proportion change	Stdev
298	1	12	-0.38	0.023
	2	1	-0.276	-
340*	1	13	-0.314	0.036

Table 16. The influence of L_c on the year of change for supported models that assume a change in total mortality when applied to the mean length data from the Puerto Rico vertical line fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	ChangeYear1	ChangeYear2	Nruns
298	1	1997	-	1
		1996	-	6
		1995	-	4
		1994	-	1
298	2	1987	2000	1
340*	1	1994	-	7
		1995	-	3
		1987	-	2
		2000	-	1

Table 17. Mean length estimator results from the analysis of the St. Thomas pot and trap length data. The model in bold was strongly supported by AIC.

Lc	VBK	L_∞	Npars	Nyrs	AIC	ΔAIC	LLIKE	Z	Δ year 1	Z1	Z2	Δ year 2	Z3
340	0.0705	601	2	22	172.98		84.2	0.357	-	-	-	-	-
			4	**22**	**166.63**	**-6.35**	**78.1**	**-**	**1983**	**0.270**	**0.390**	**-**	**-**
			6	22	168.84	2.21	75.6	-	1984	0.251	0.922	1986	0.384

Table 18. The influence of L_c on model support and the mean proportion change in total mortality if a model assuming a change in total mortality was supported when applied to the St. Thomas pot and trap length data. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	Nruns	Mean proportion change	Stdev
302	1	13	0.379	0.071
320	1	13	0.643	0.072
340	1	13	0.57	0.135

Table 19. The influence of L_c on the year of change for supported models that assume a change in total mortality when applied to the mean length data from the St. Thomas pot and trap fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	ChangeYear1	ChangeYear2	Nruns
302	1	2007	0	1
		2001	0	10
		2008	0	1
		2000	0	1
320	1	2007	0	11
		2008	0	1
		2006	0	1
340	1	1983	0	13

Table 20. Mean length estimator results from the analysis of the St. Croix length data. Models in bold were strongly supported by AIC.

Gear	Lc	VBK	L_∞	Nchange	Npars	Nyrs	AIC	ΔAIC	LLIKE	Z	Δ year 1	Z1	Z2	Δ year 2	Z3
Diving	**296**	**0.1013**	**514.5**	**0**	**2**	**10**	**88.45**	**-**	**121.0**	**0.476**	**-**	**-**	**-**	**-**	**-**
				1	4	10	93.82	5.4	116.8	-	2009	0.422	2.142	-	-
				2	6	10	115.57	21.7	113.5	-	2004	0.528	0.209	2008	1.404
Pot and traps	**340**	**0.1013**	**514.5**	**0**	**2**	**22**	**195.57**	**-**	**95.5**	**0.295**	**-**	**-**	**-**	**-**	**-**
				1	4	22	193.96	-1.6	91.8	-	1986	0.269	0.497	-	-
				2	6	22	197.76	3.8	90.1	-	1983	0.315	0.001	1985	0.524
Vertical line	350	0.1013	514.5	0	2	18	140.71	-	67.95	0.425	-	-	-	-	-
				1	**4**	**18**	**136.07**	**-4.6**	**62.50**	**-**	**1983**	**0.286**	**0.502**	**-**	**-**
				2	6	18	138.03	2.0	59.20	-	1984	0.305	0.525	2007	0.001

Table 21. The influence of L_c on the supported model and the mean proportion change in total mortality if a model assuming a change in total mortality was supported when applied to the St. Croix diving fleet length data. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	Nruns	Mean proportion change	Stdev
264	0	13	-	-
296*	0	13	-	-

Table 22. The influence of L_c on the supported model and the mean proportion change in total mortality if a model assuming a change in total mortality was supported when applied to the St. Croix pot and trap fleet length data. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	Nruns	Mean proportion change	Stdev
277	1	12	0.857	0.054
	0	1	0	-
340*	1	7	0.794	0.124
	0	6	0	0

Table 23. The influence of L_c on the year of change for supported models that assume a change in total mortality when applied to the mean length data from the St. Croix plot and trap fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	ChangeYear1	ChangeYear2	Nruns
277	1	1986	0	12
340*	1	1986	0	7

Table 24. The influence of L_c on the supported model and the mean proportion change in total mortality if a model assuming a change in total mortality was supported when applied to the St. Croix vertical line fleet length data. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	Nruns	Mean proportion change	Stdev
287	0	13	0	0
350*	1	13	0.635	0.089

Table 25. The influence of L_c on the year of change for supported models that assume a change in total mortality when applied to the mean length data from the St. Croix vertical line fleet. Nchange is the number of assumed changes in total mortality and Nruns is the number of sensitivity runs.

Lc	Nchange	ChangeYear1	ChangeYear2	Nruns
287	0	-	-	13
350*	1	1984	-	7
		1985	-	4
		1983	-	2

Figures

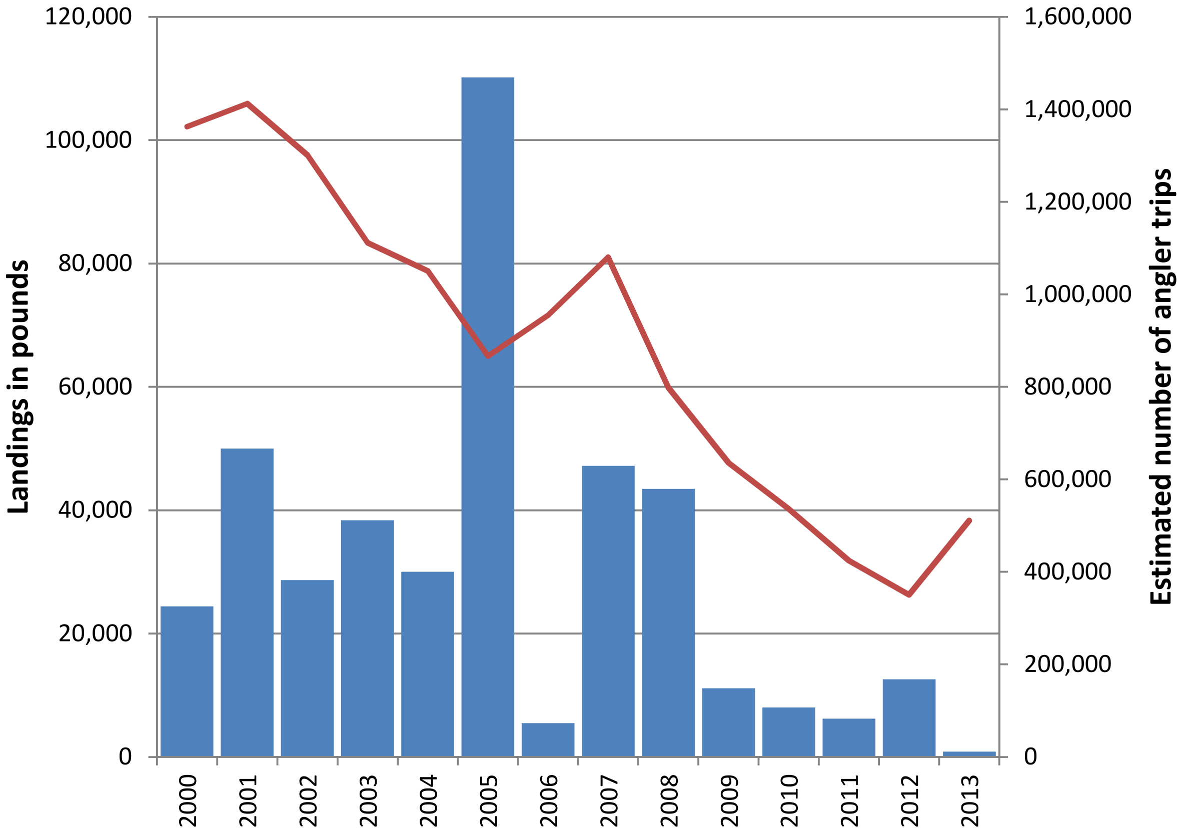


Figure 1. Puerto Rico Red Hind recreational landings estimated using MRFSS data. Estimated landings plotted with estimated total recreational trips per year.

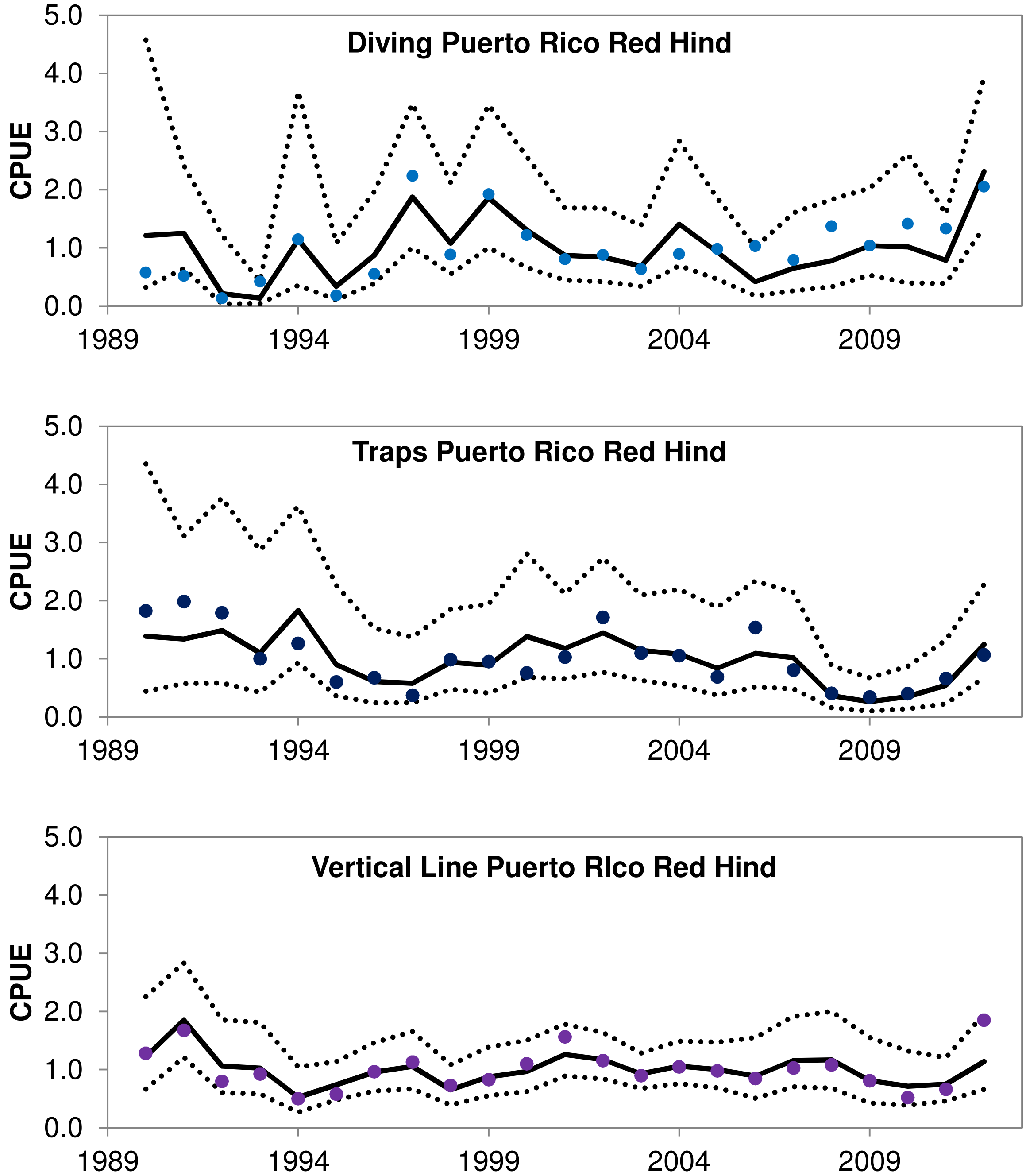


Figure 2. Nominal CPUE (points), standardized indices (solid lines), and the 95% confidence intervals (dotted lines) for Puerto Rico Red Hind from the diving, trap, and vertical line fisheries. The standardized index and nominal CPUE values were normalized by their respective means over the time series.

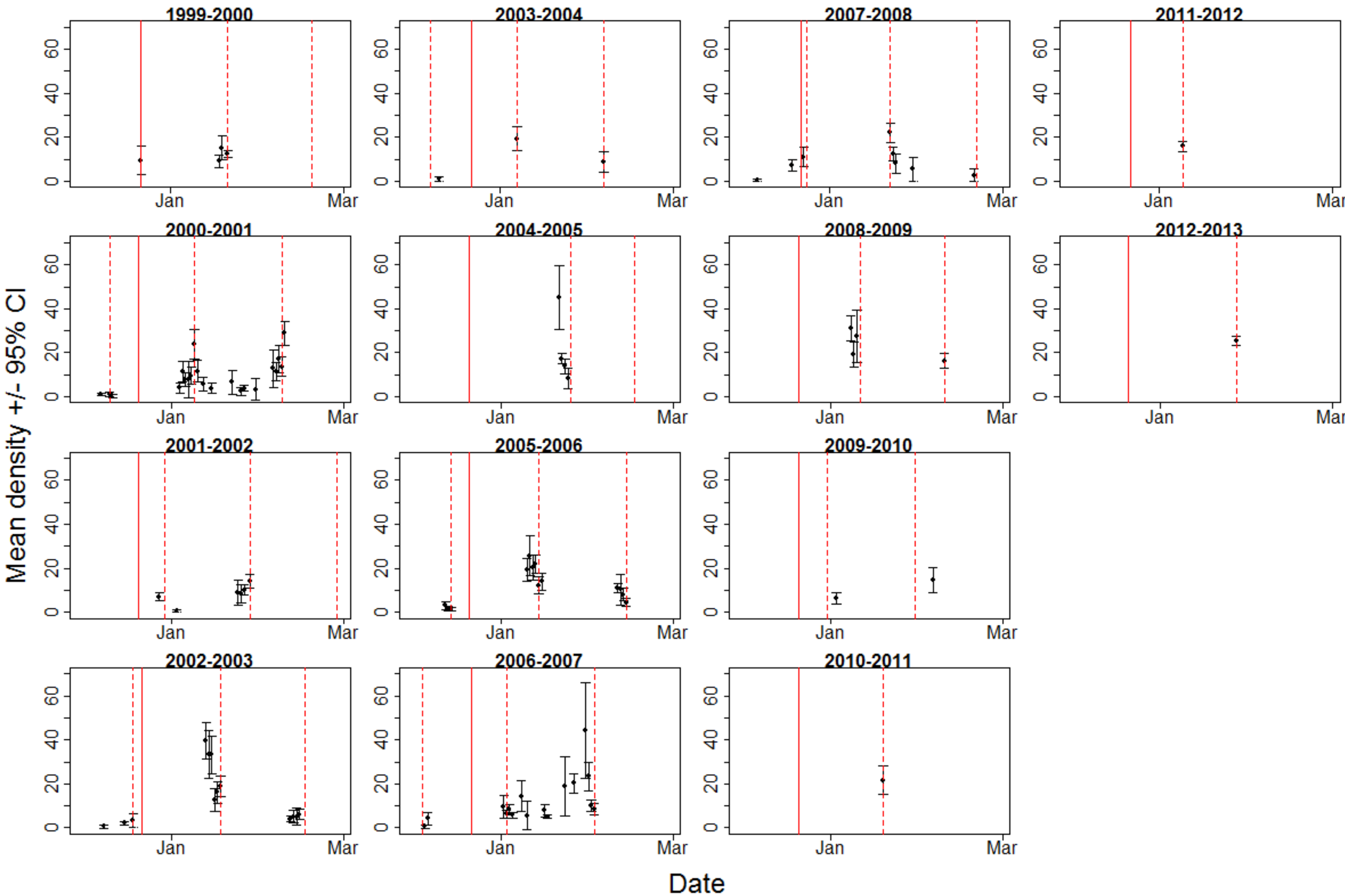


Figure 3. Daily mean density (individuals per 100m^2) and the 95% confidence intervals of the St. Thomas Hind Bank spawning aggregation data. Each panel represents a single spawning year. The dashed red lines represent the full moon in the corresponding month and the solid red line represents the winter solstice.

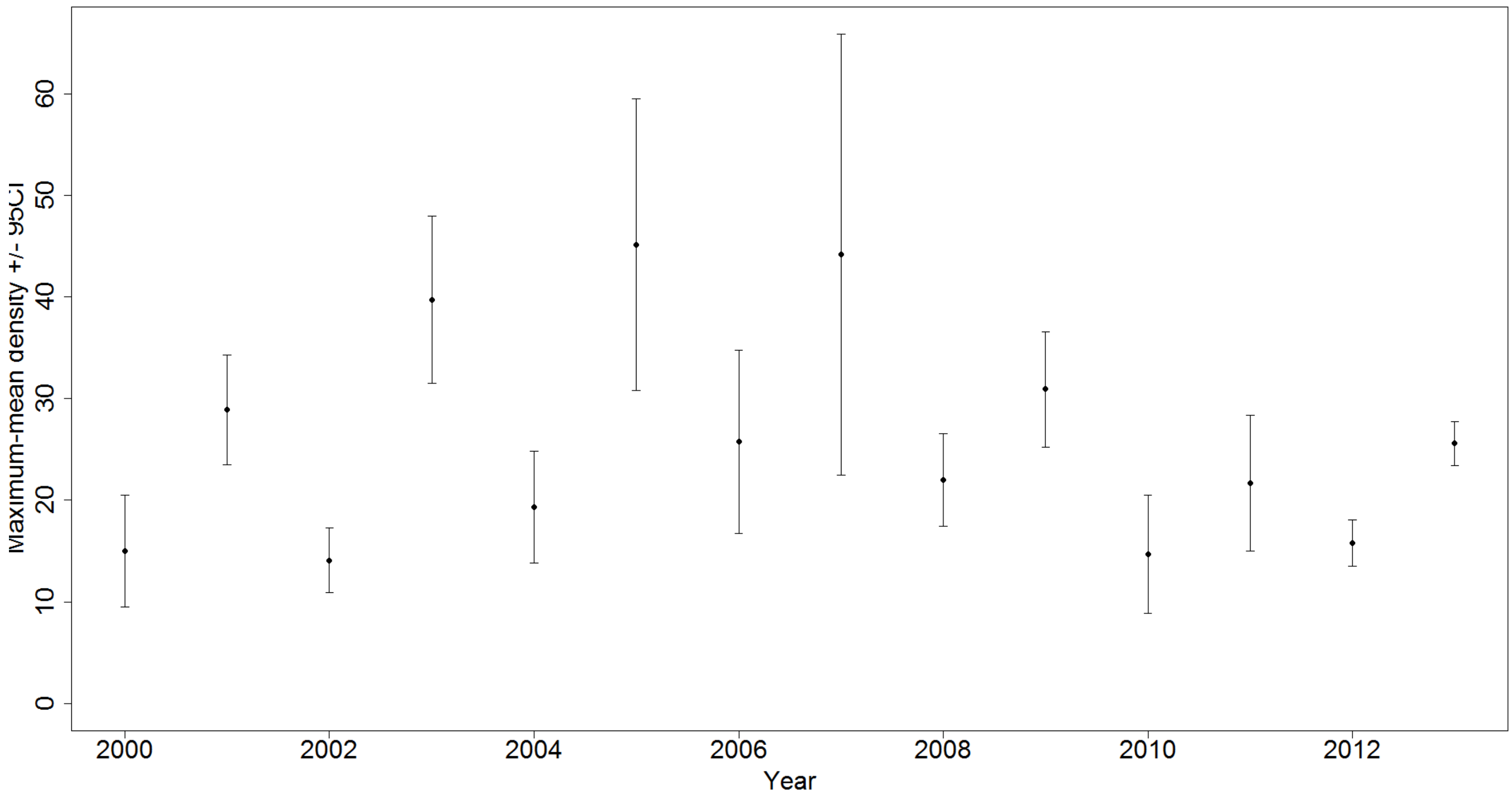


Figure 4. Maximum daily density (individuals per 100m^2) and the 95% confidence intervals of the St. Thomas Hind Bank spawning aggregation data.

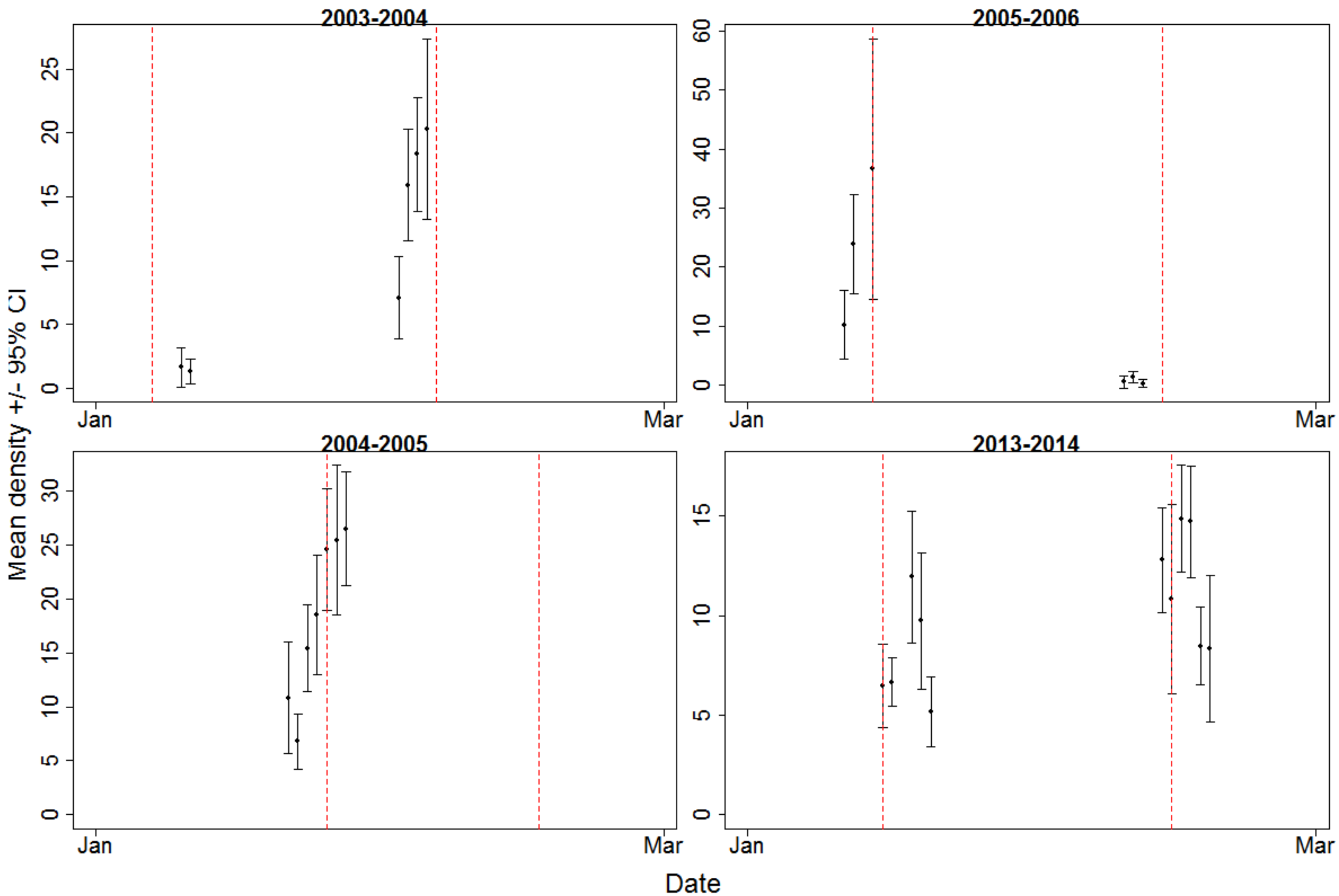


Figure 5. Daily mean density (individuals per 100m^2) and the 95% confidence intervals using the St. Croix spawning aggregation data. The red dashed line indicates the full-moon.

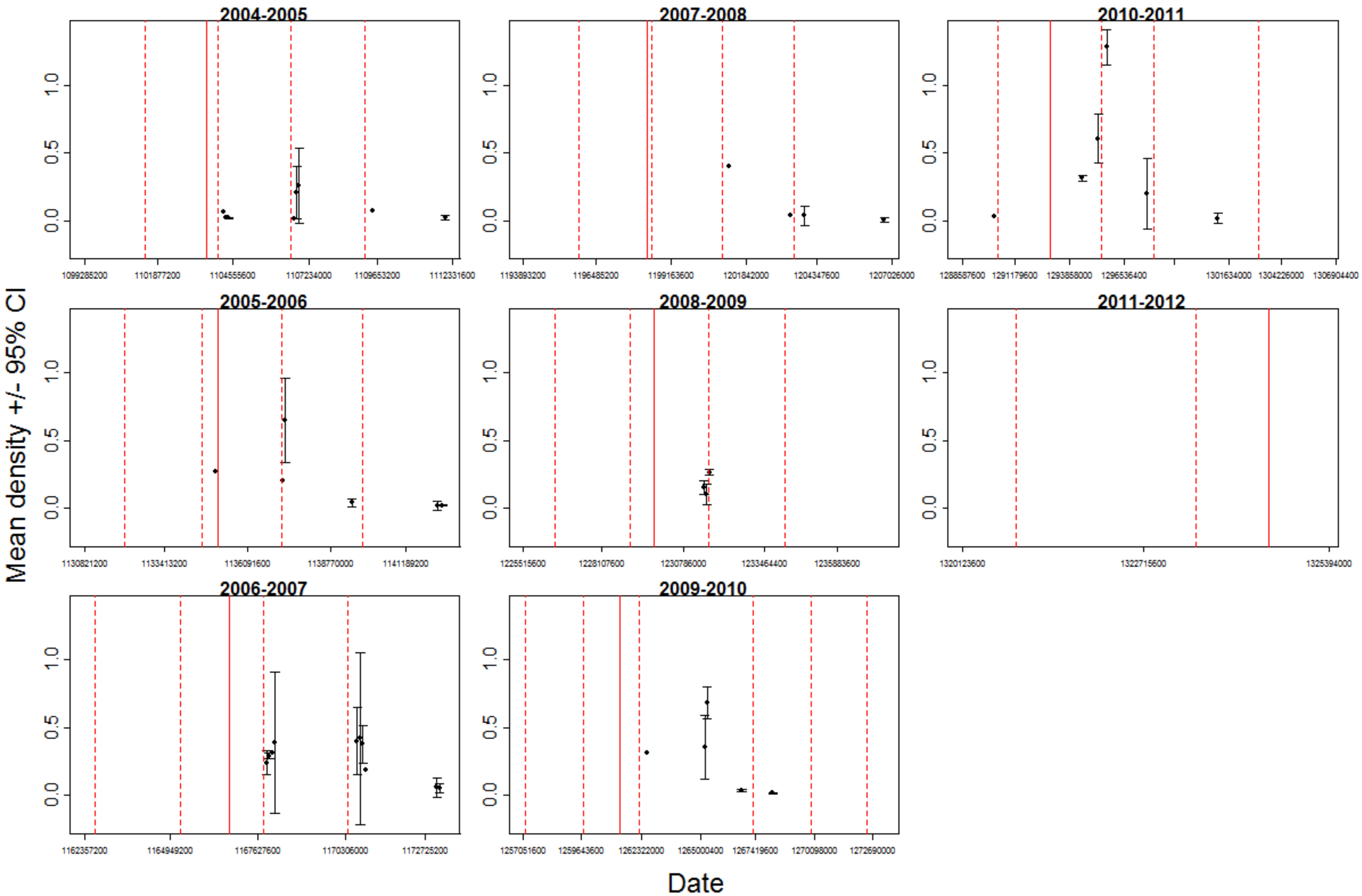


Figure 6. Daily mean density (individuals per 100m^2) of the Mona Island, Puerto Rico spawning aggregation. The dashed red lines represent the full moon in the corresponding month and the solid red line represents the winter solstice.

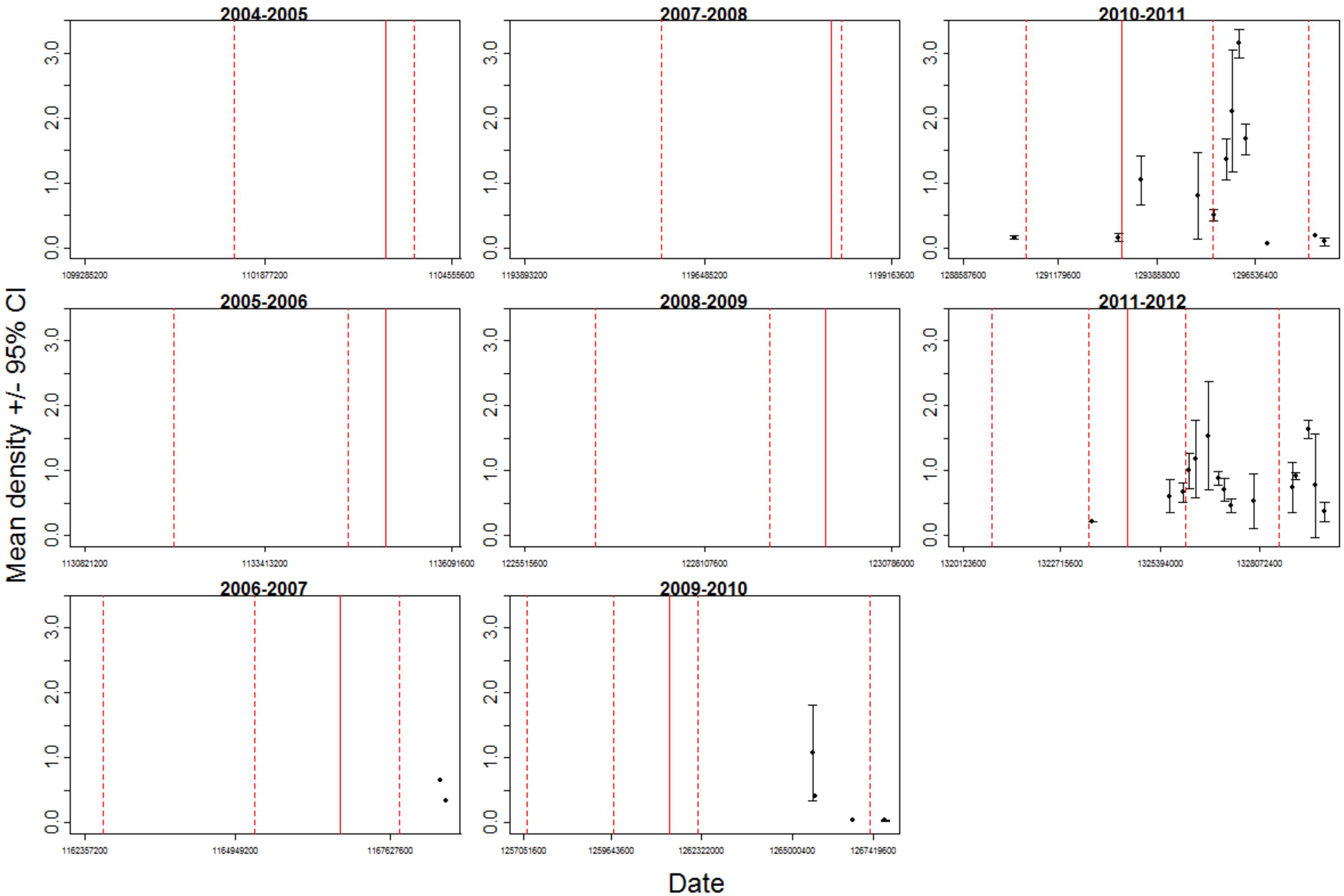


Figure 7. Daily mean density and the 95% confidence intervals of the Abrir la Sierra spawning aggregation. The dashed red lines represent the full moon in the corresponding month and the solid red line represents the winter solstice.

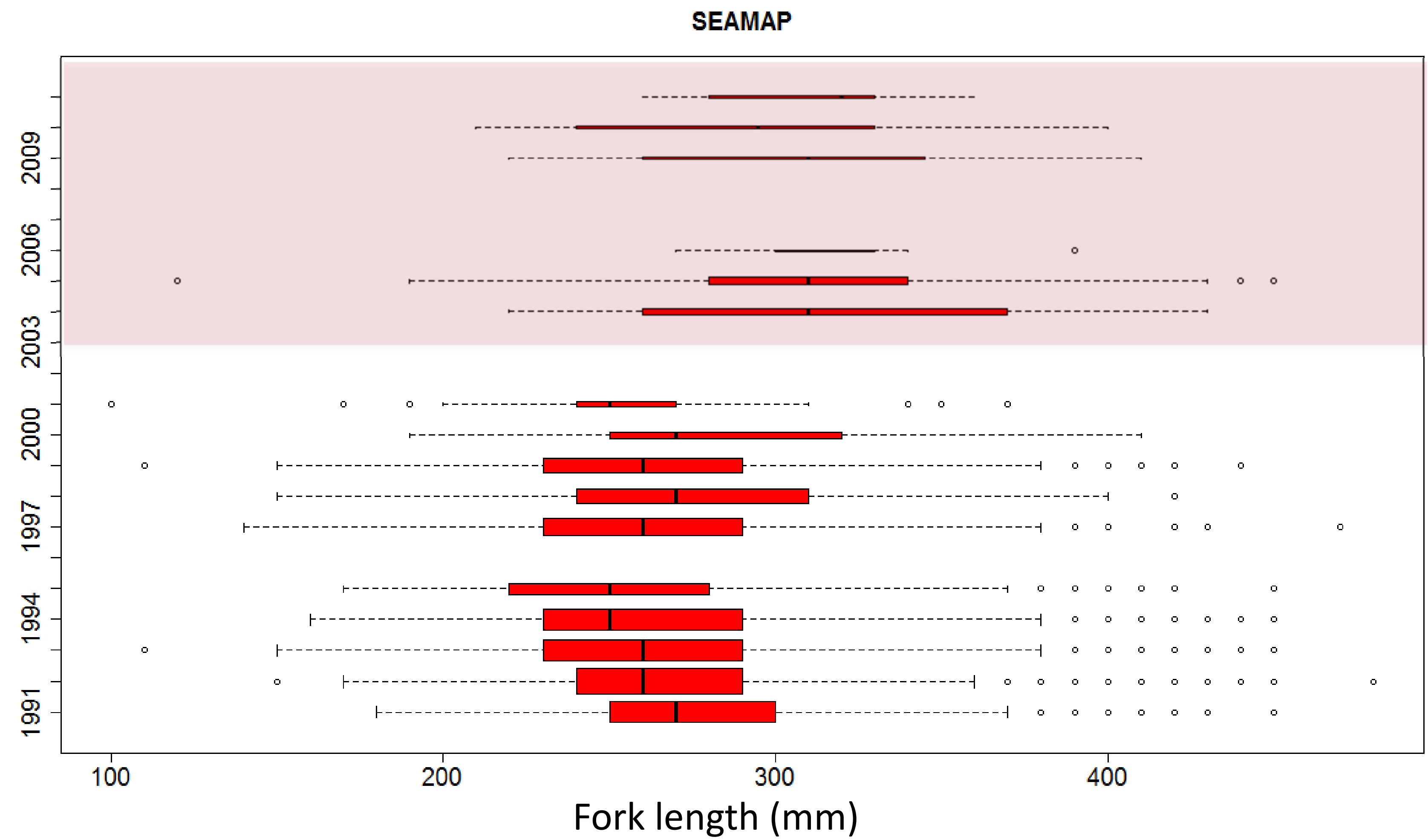


Figure 8. The Red Hind length-frequency from the SEAMAP-C survey. Length data were collected off the southwest coast of Puerto Rico by handlines. The boxplots represent the inter-quartile range, the open circles represent outliers, and the box width represents the relative sample size (box width is equal to the square-root of sample size). The shaded area highlights a shift towards larger Red Hind.

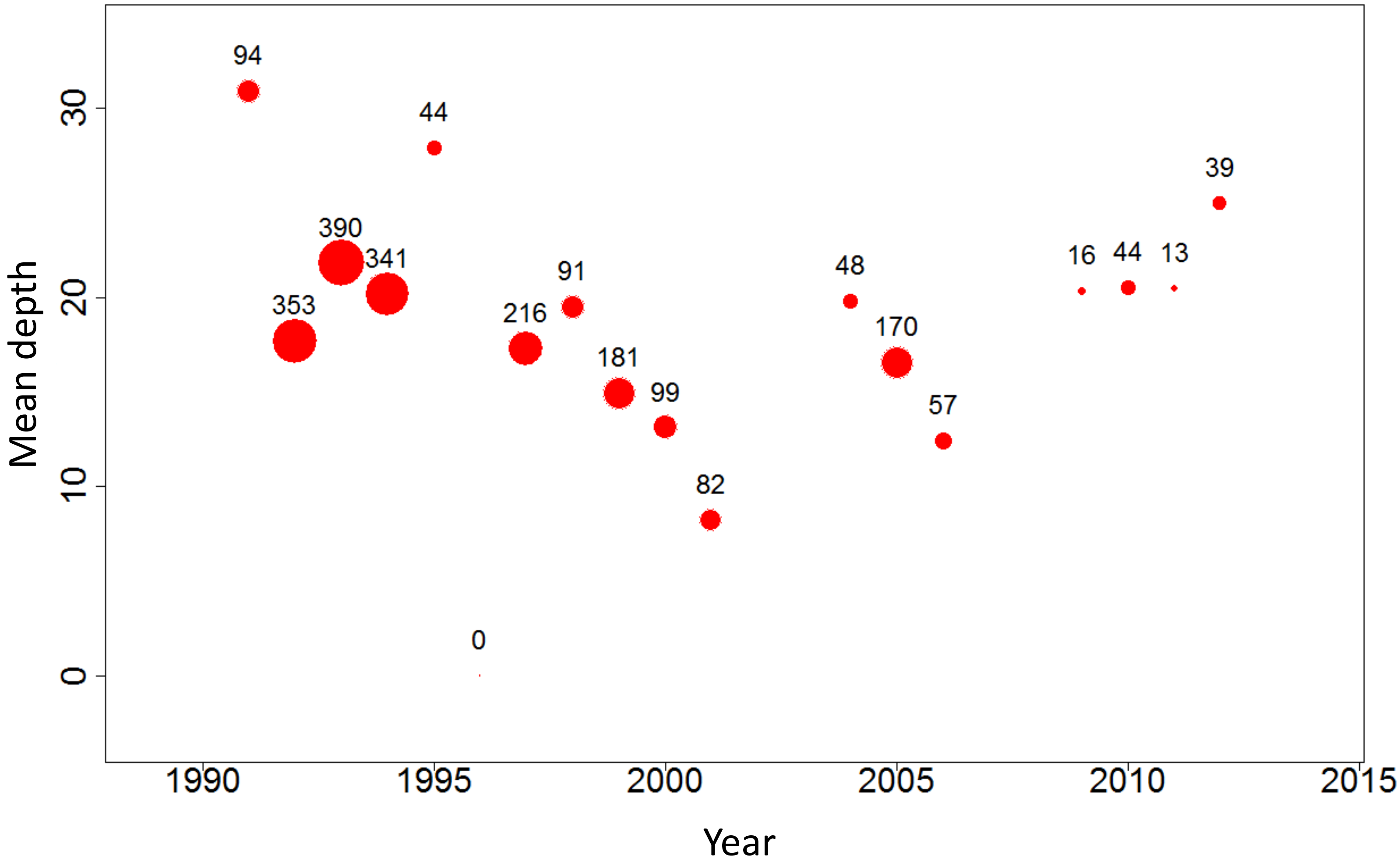


Figure 9. Mean depth of SEAMAP-C survey sites over time. The diameter of the bubble reflects sample size (the number of survey stations).

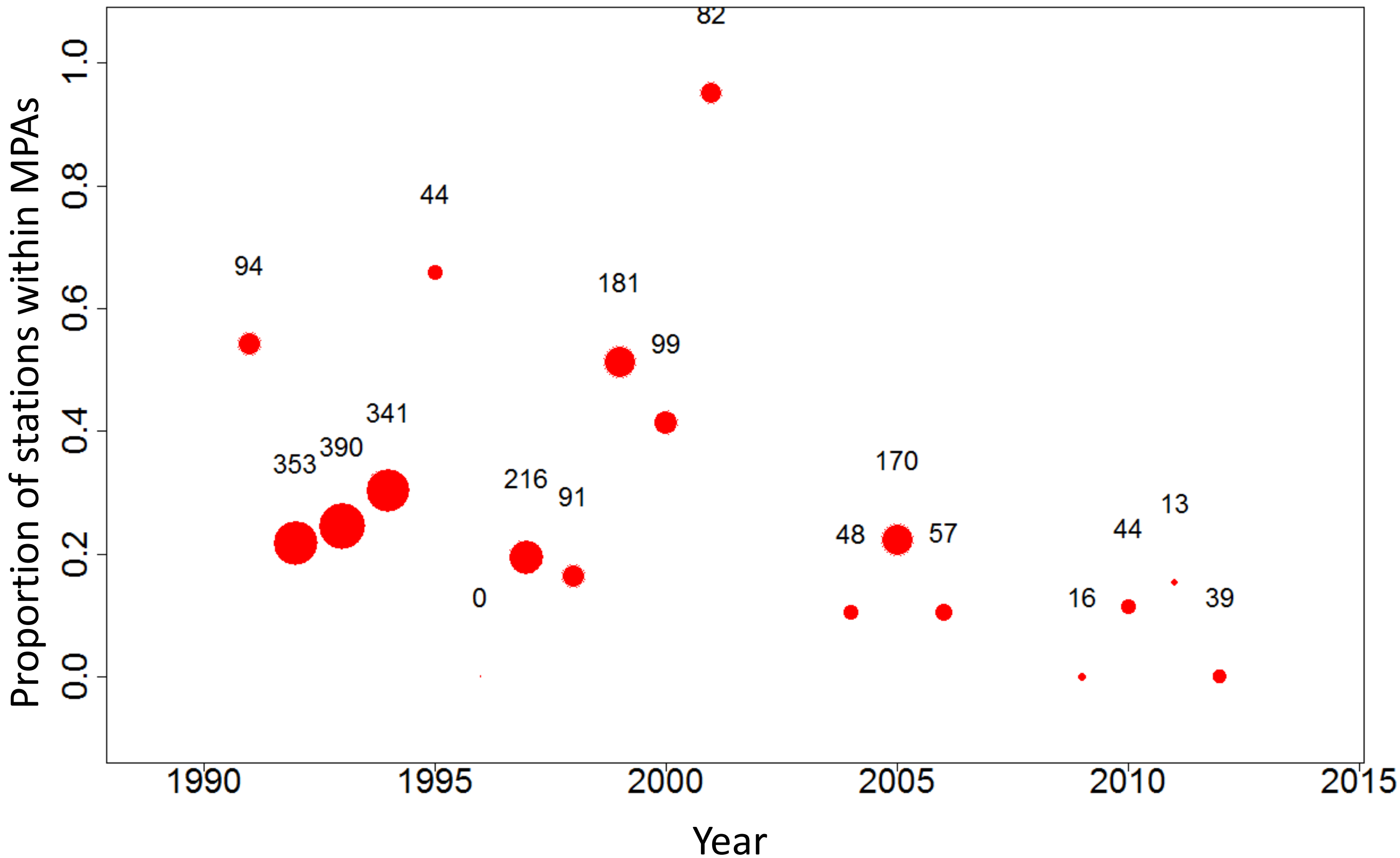


Figure 10. The proportion of SEAMAP-C survey stations within marine protected areas (MPAs) over time. The diameter of the bubble reflects sample size (the number of survey stations).

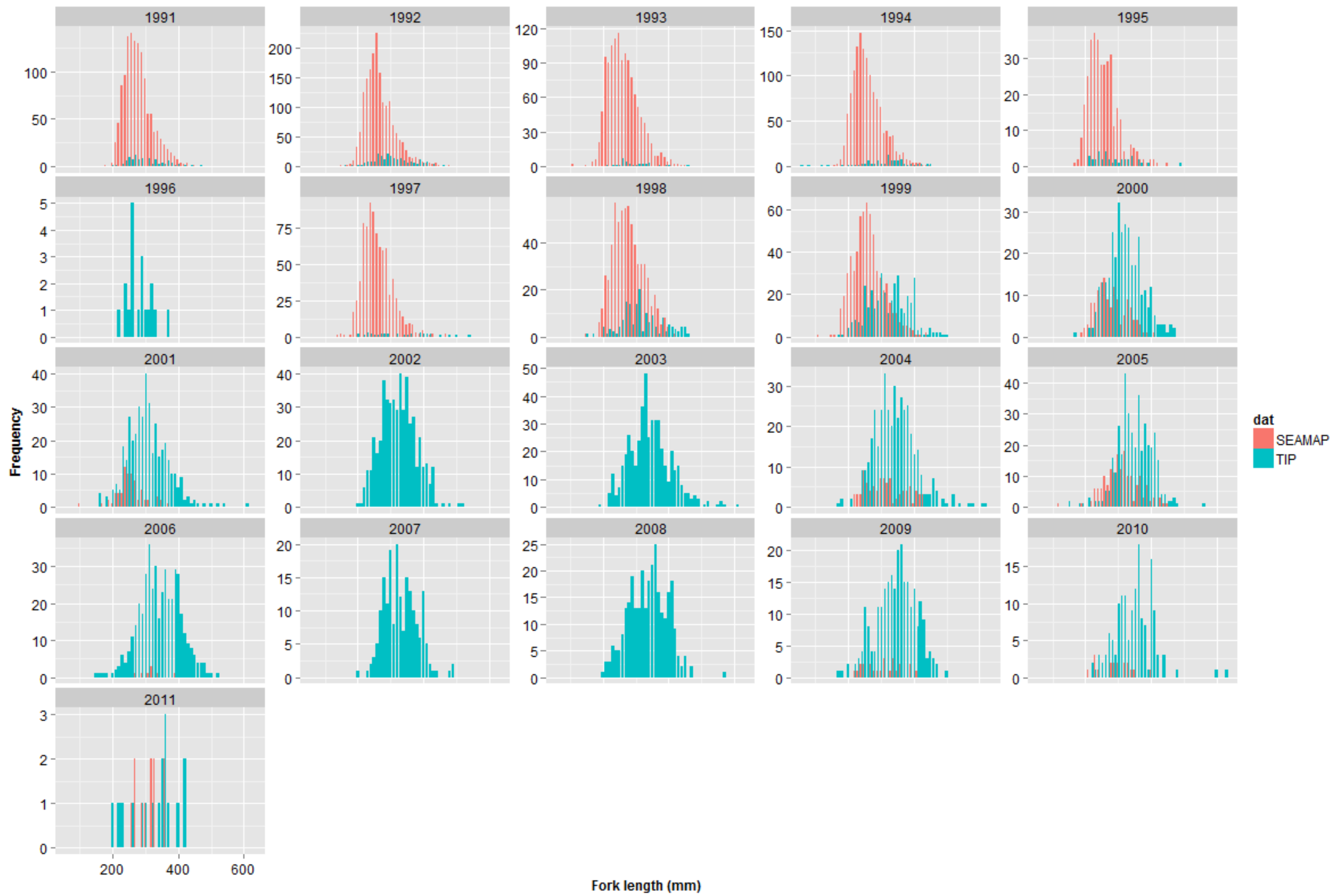


Figure 11. Comparison of the SEAMAP-C and TIP length frequency data. The TIP data were subset for the south and west coast counties.

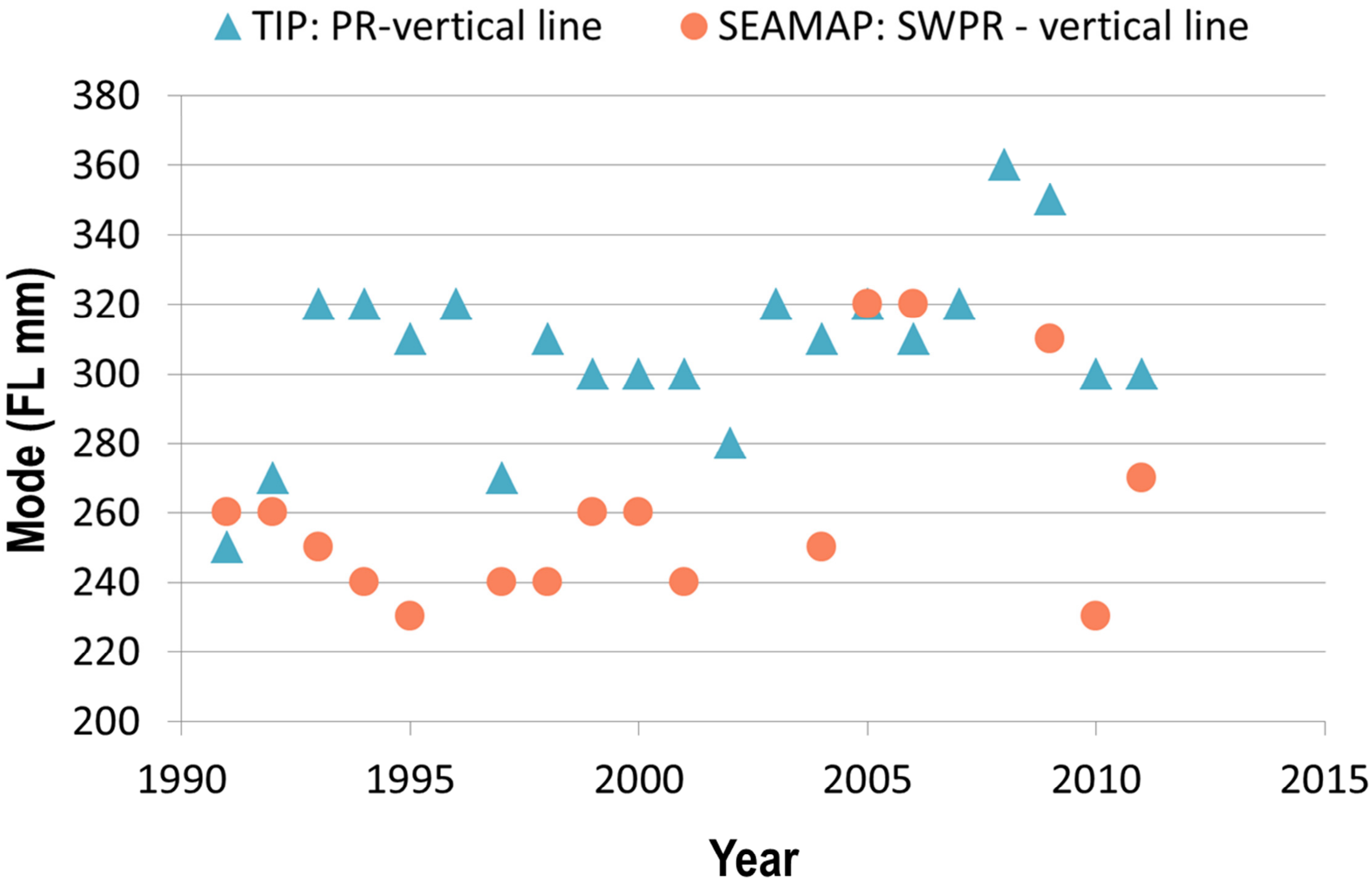


Figure 12. The annual modes (or peak of the annual length-frequency distributions) for the SEAMAP-C and TIP vertical line length-frequency data.

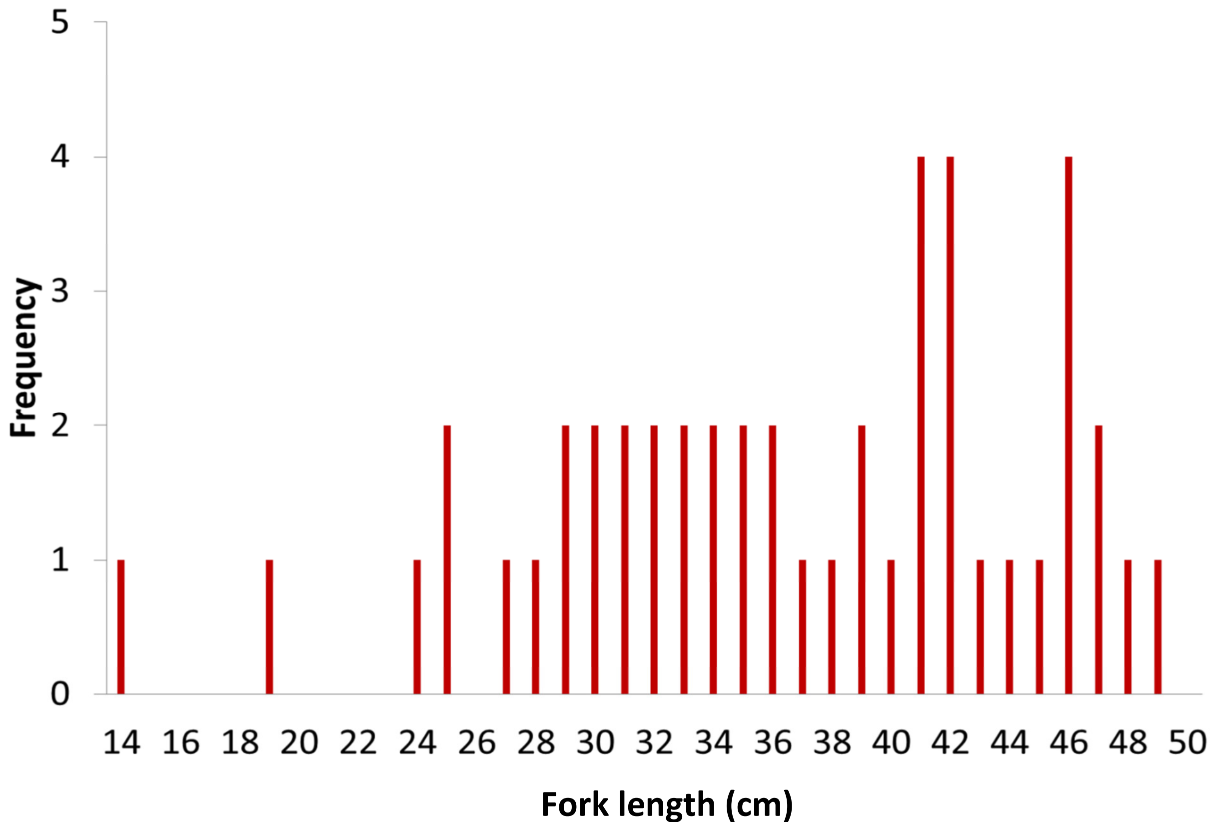


Figure 13. Red Hind length data from the St. Croix trap study.

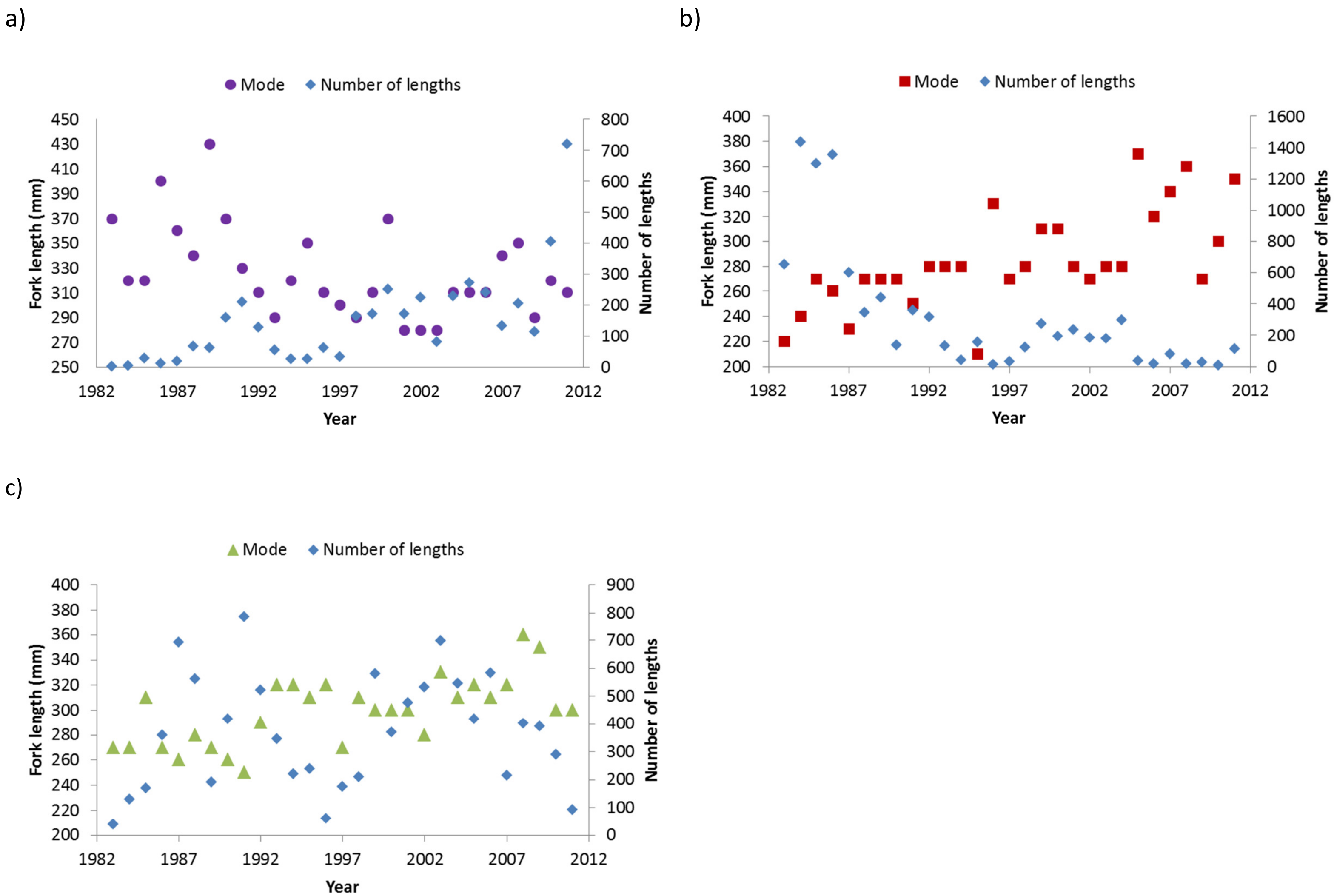


Figure 14. The peak value of the annual length frequency distributions used to identify the length at full recruitment, L_c, and the number of observed lengths for the a) diving, b) pot and traps, c) vertical line fleets in Puerto Rico.

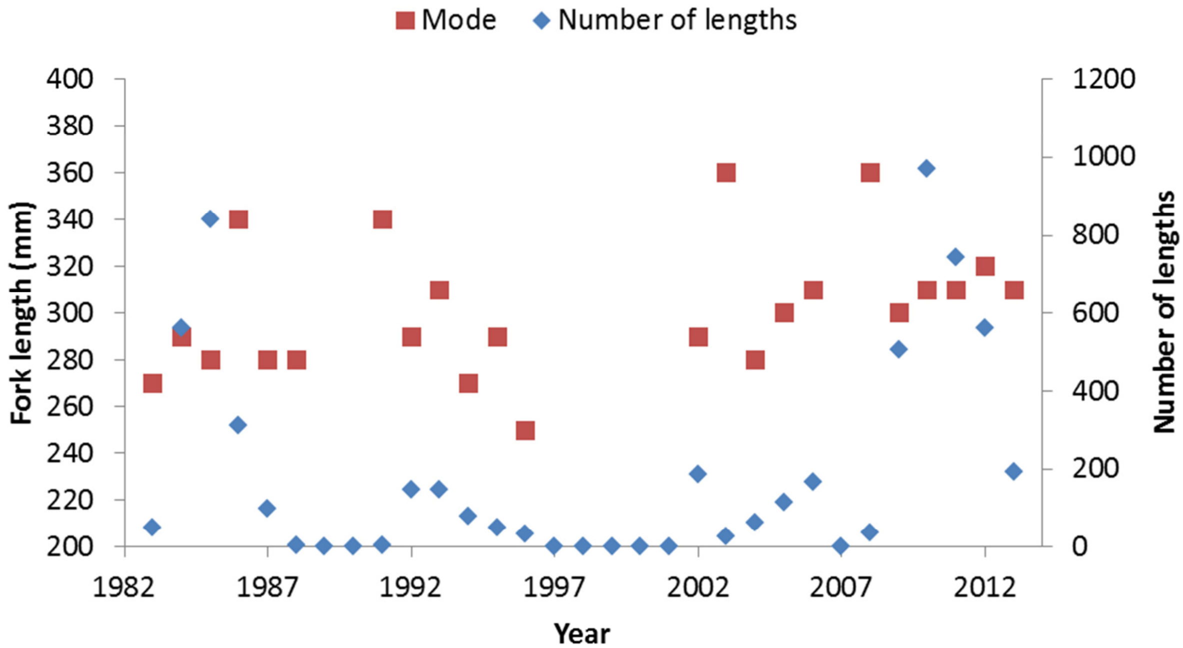


Figure 15. The peak of the annual length frequency distributions used to identify the length at full recruitment, L_c, and the number of observed lengths for the pot and trap fleet in St. Thomas.

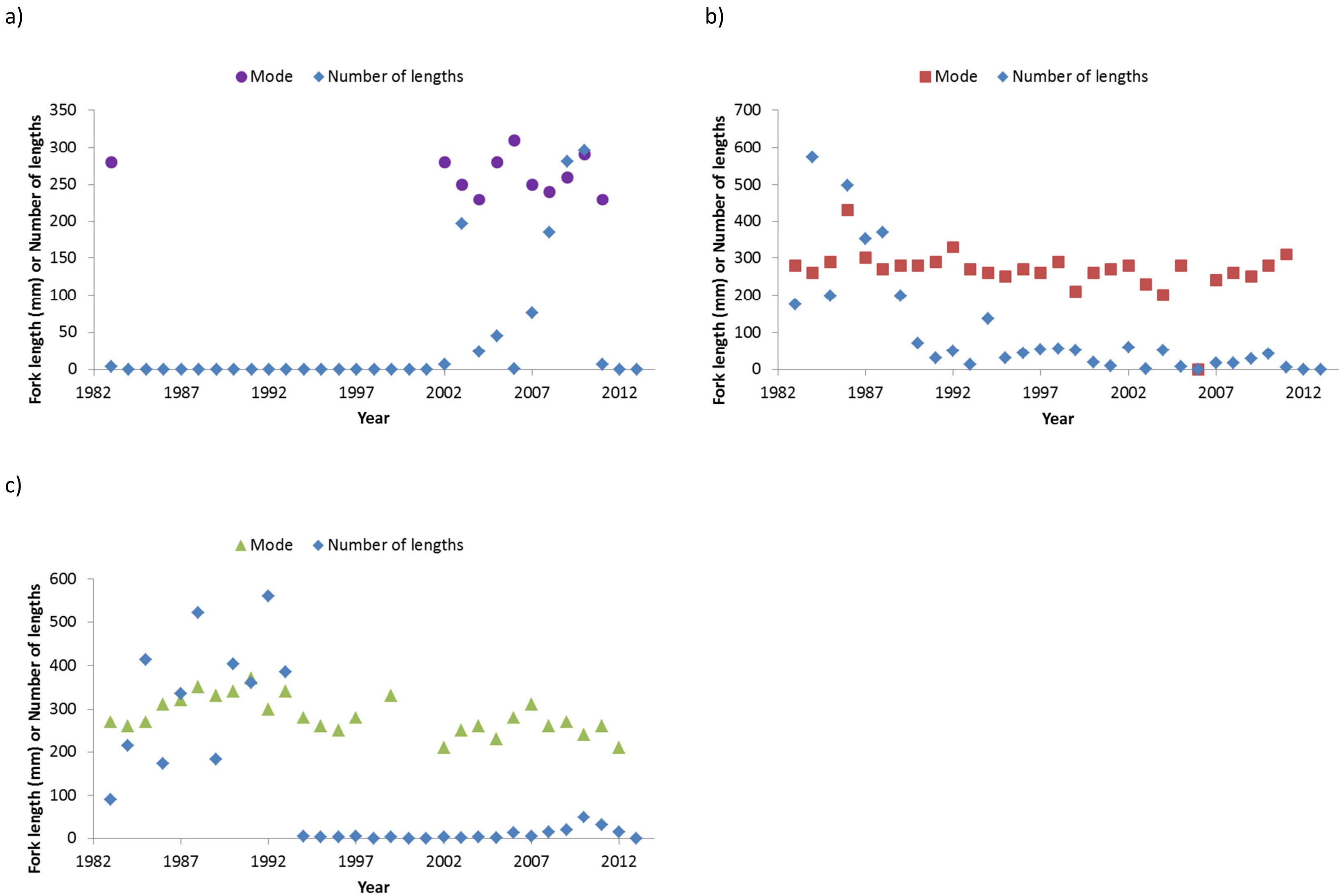


Figure 16. The peak of the annual length frequency distributions used to identify the length at full recruitment, L_c, and the number of observed lengths for the a) diving, b) pot and trap, and c) vertical line fleets in St. Croix.

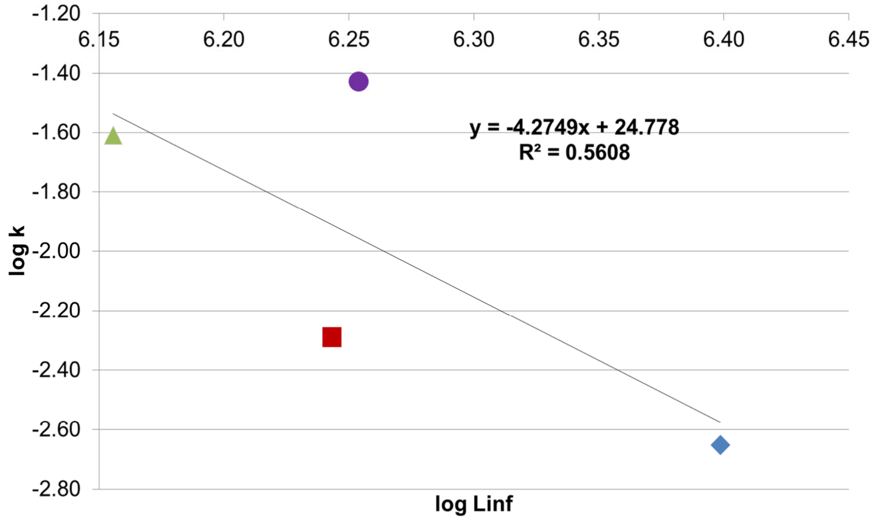


Figure 17. The linear model fit to the log transformed growth parameters found in the literature. The linear model was used to define nine additional parameter pairs.

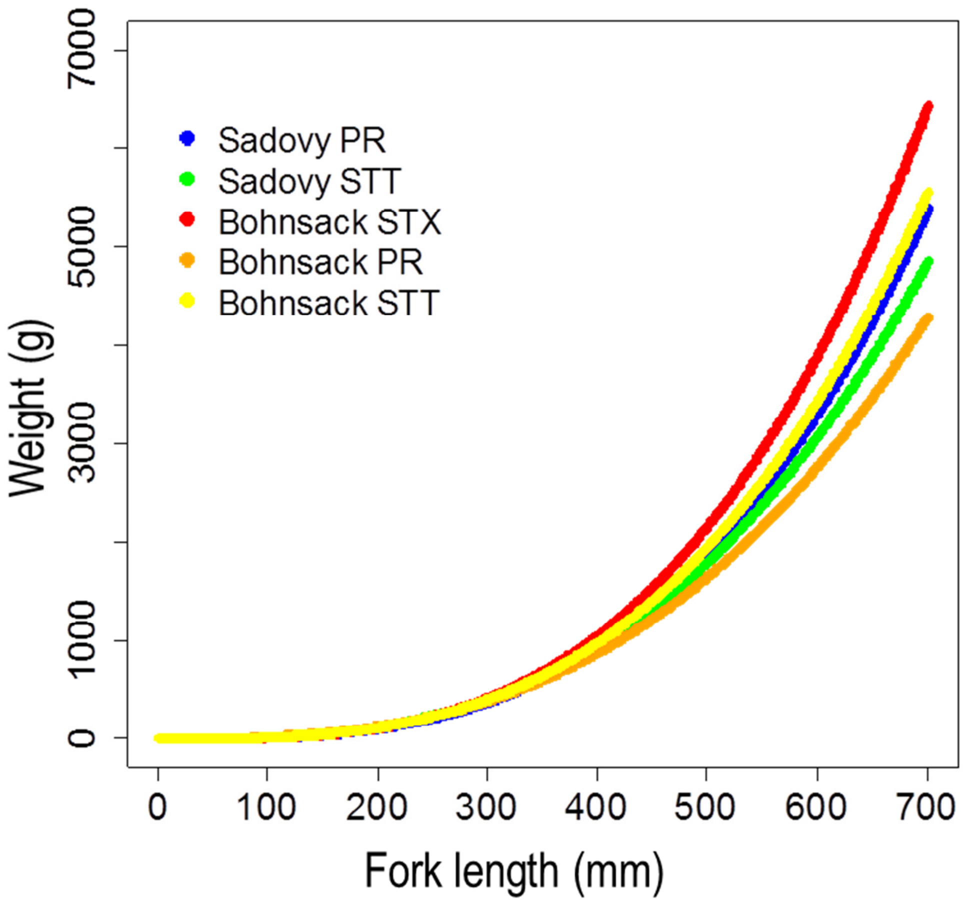


Figure 18. The length-weight relationships published in Sadovy *et al.* (1992) and Bohnsack and Harper (1986).

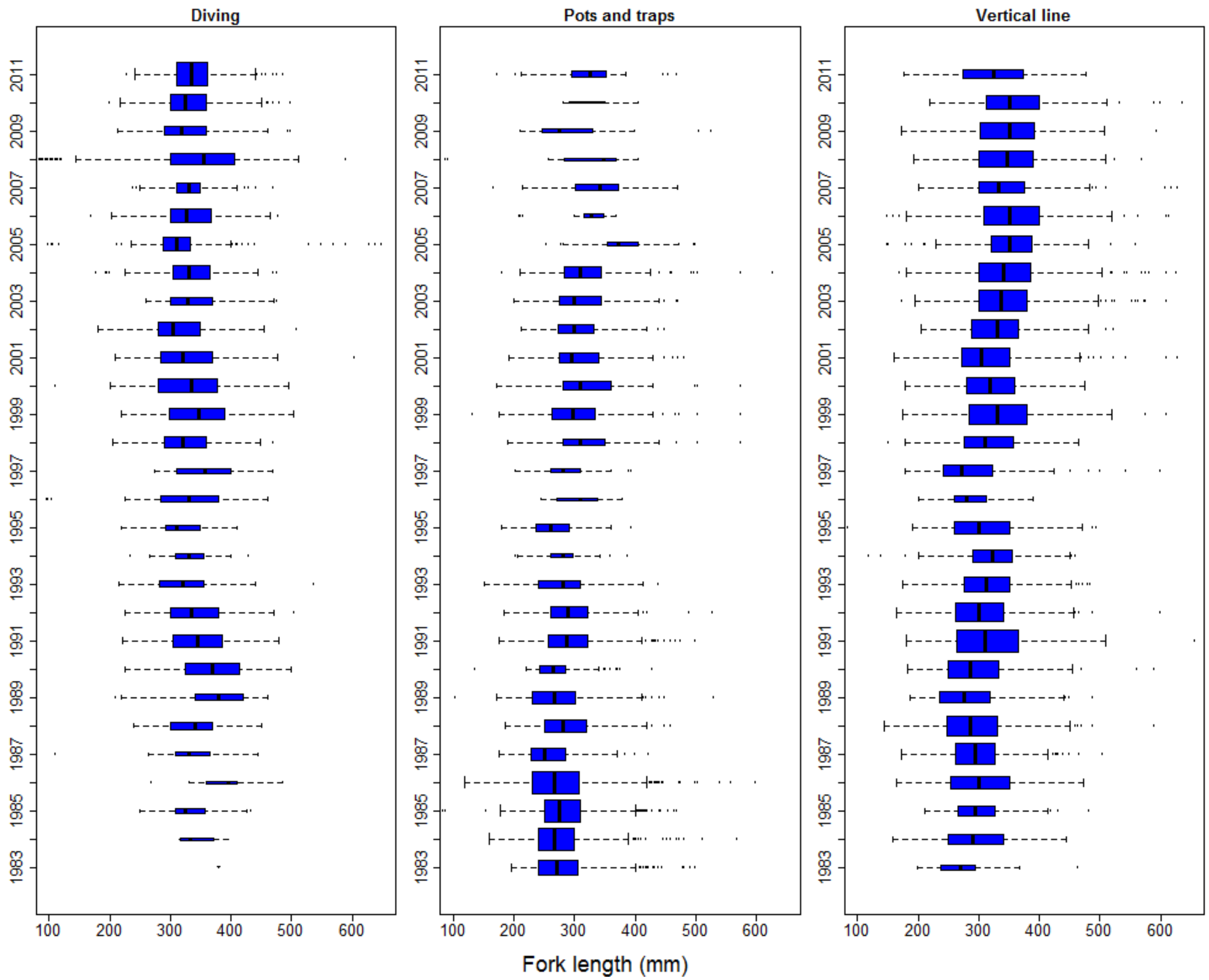


Figure 19. The annual length frequency distributions from the a) diving, b) pot and trap, and c) vertical line fleets in Puerto Rico. The box represents the inter-quartile range and the open circles represent the outliers. The box width indicates the annual sample size and was scaled as the square-root of the annual number of lengths.

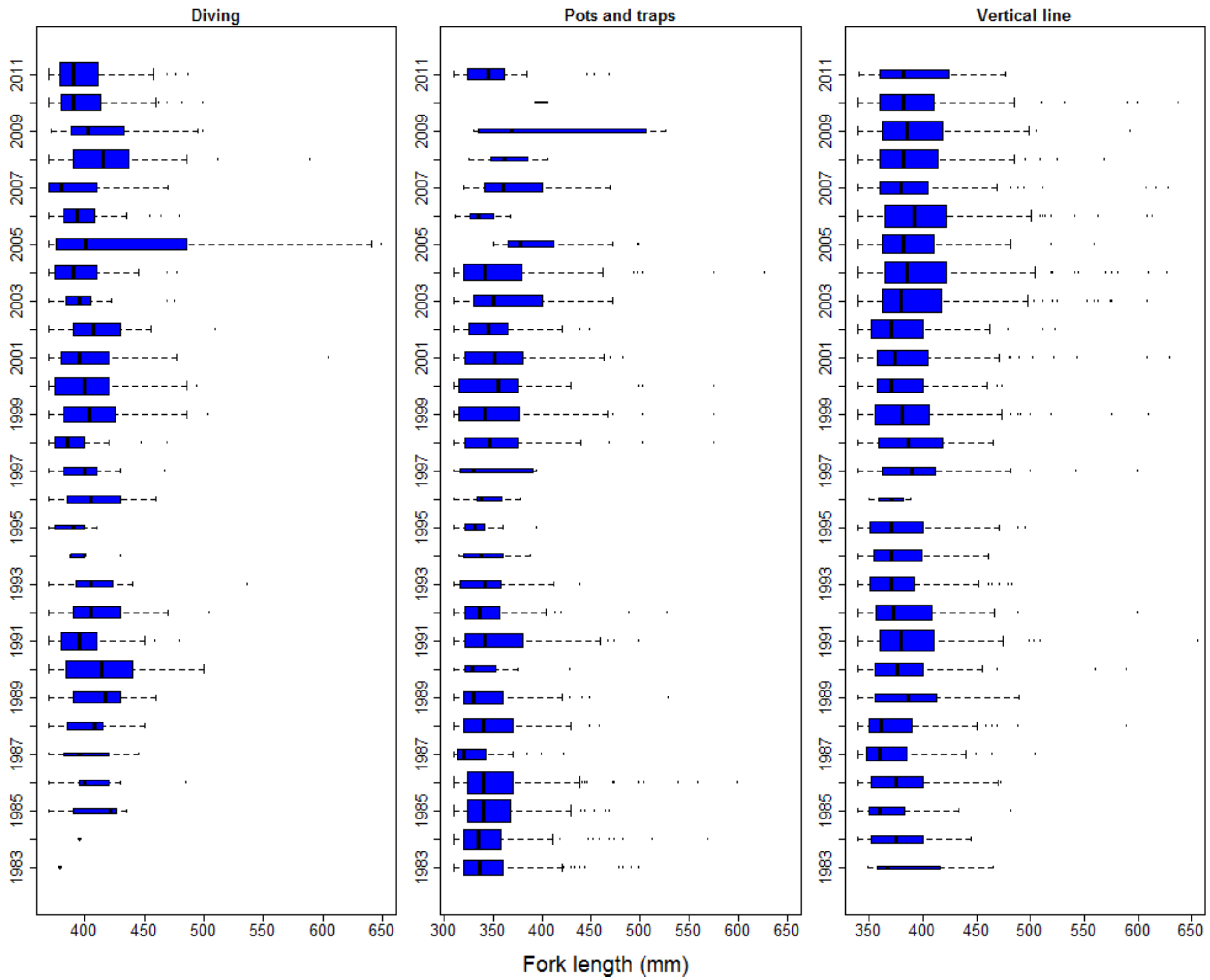


Figure 20. The annual length frequency distributions from the a) diving, b) pot and trap, and c) vertical line fleets in Puerto Rico where the lengths larger than or equal to the L_c are shown. The box represents the inter-quartile range and the open circles represent the outliers. The box width indicates the annual sample size and was scaled as the square-root of the annual number of lengths.

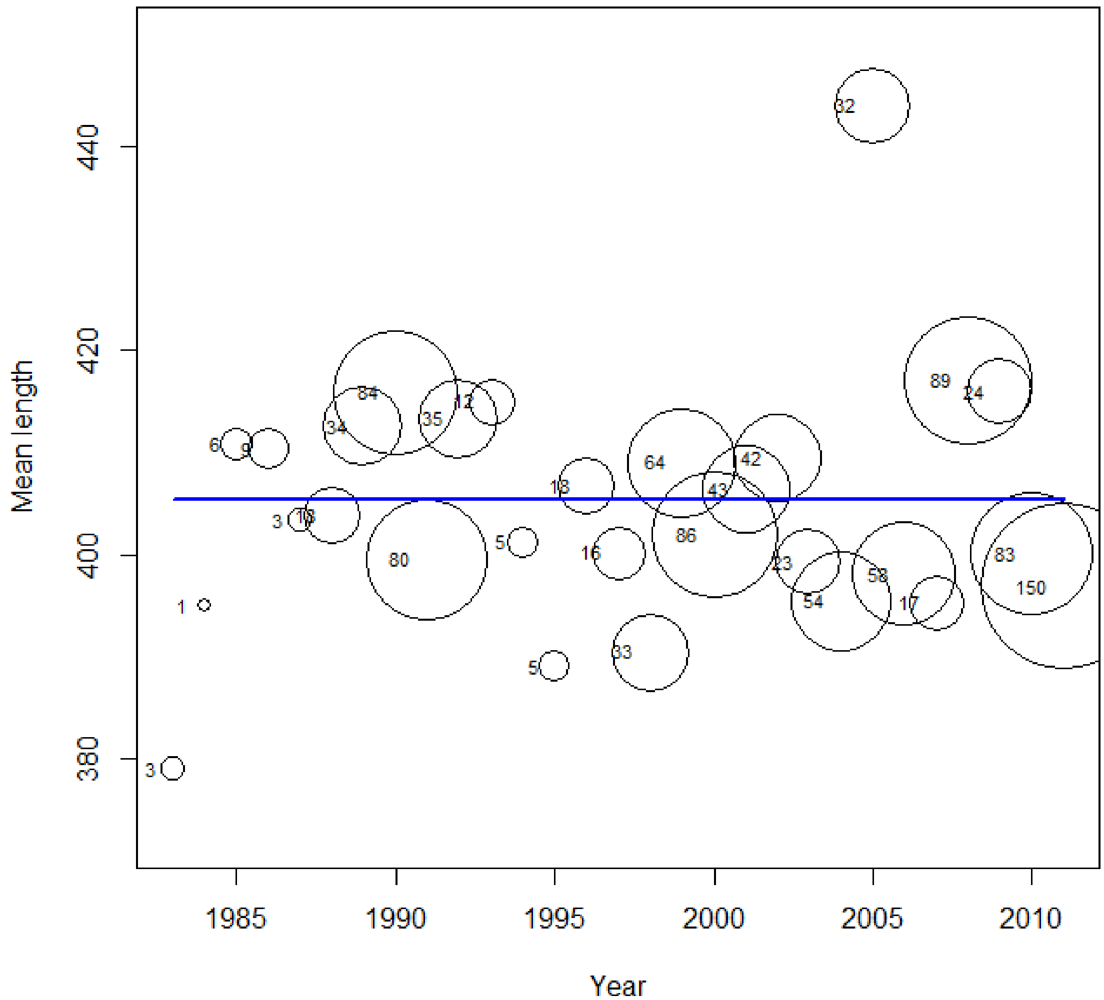


Figure 21. Model fit to the Puerto Rico diving fleet mean length data. The constant mortality model was strongly supported by AIC.

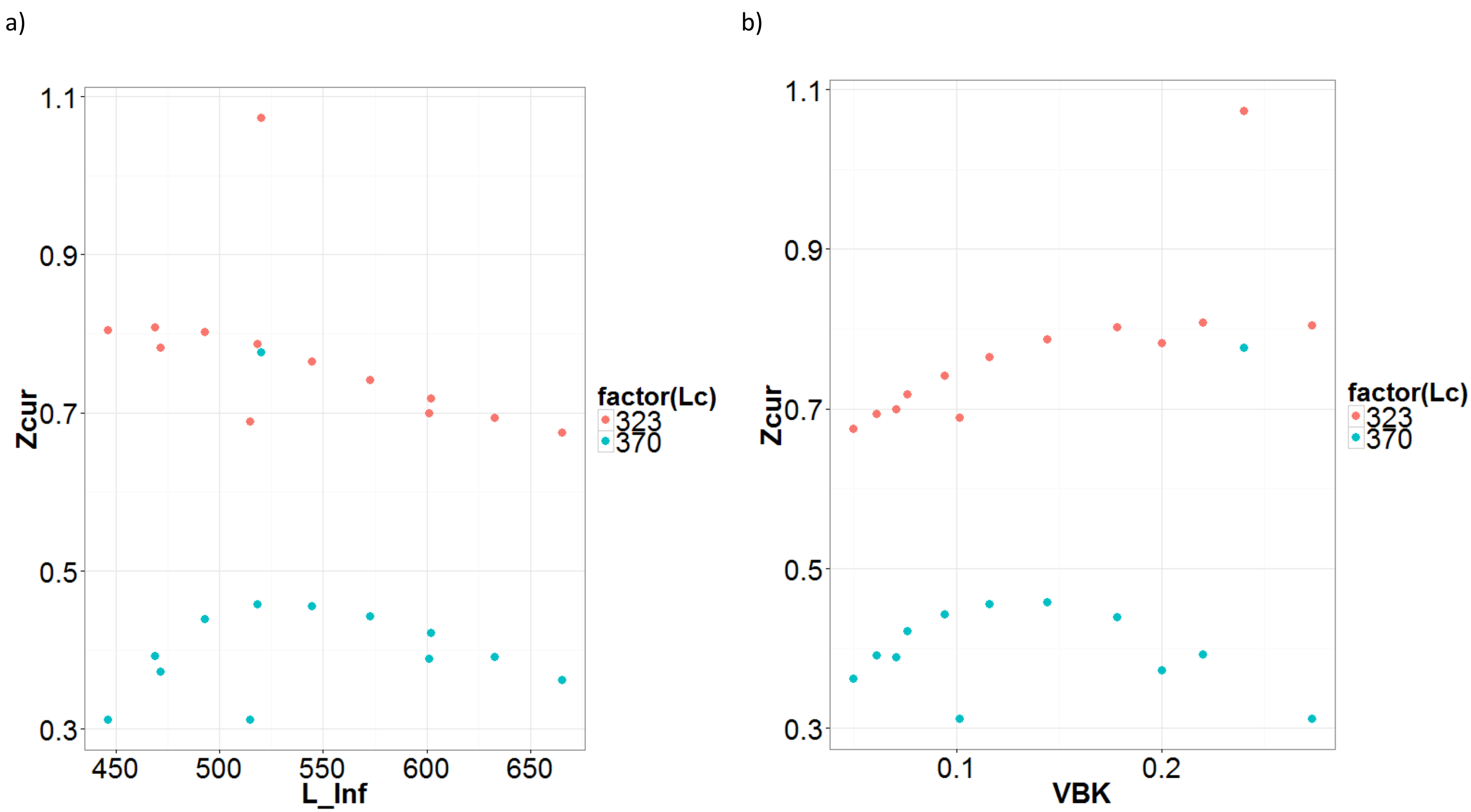


Figure 22. Sensitivity in the estimate of current total mortality (Zcur) from the analysis of the Puerto Rico diving fleet length data to a) asymptotic length and b) the von Bertalanffy growth coefficient.

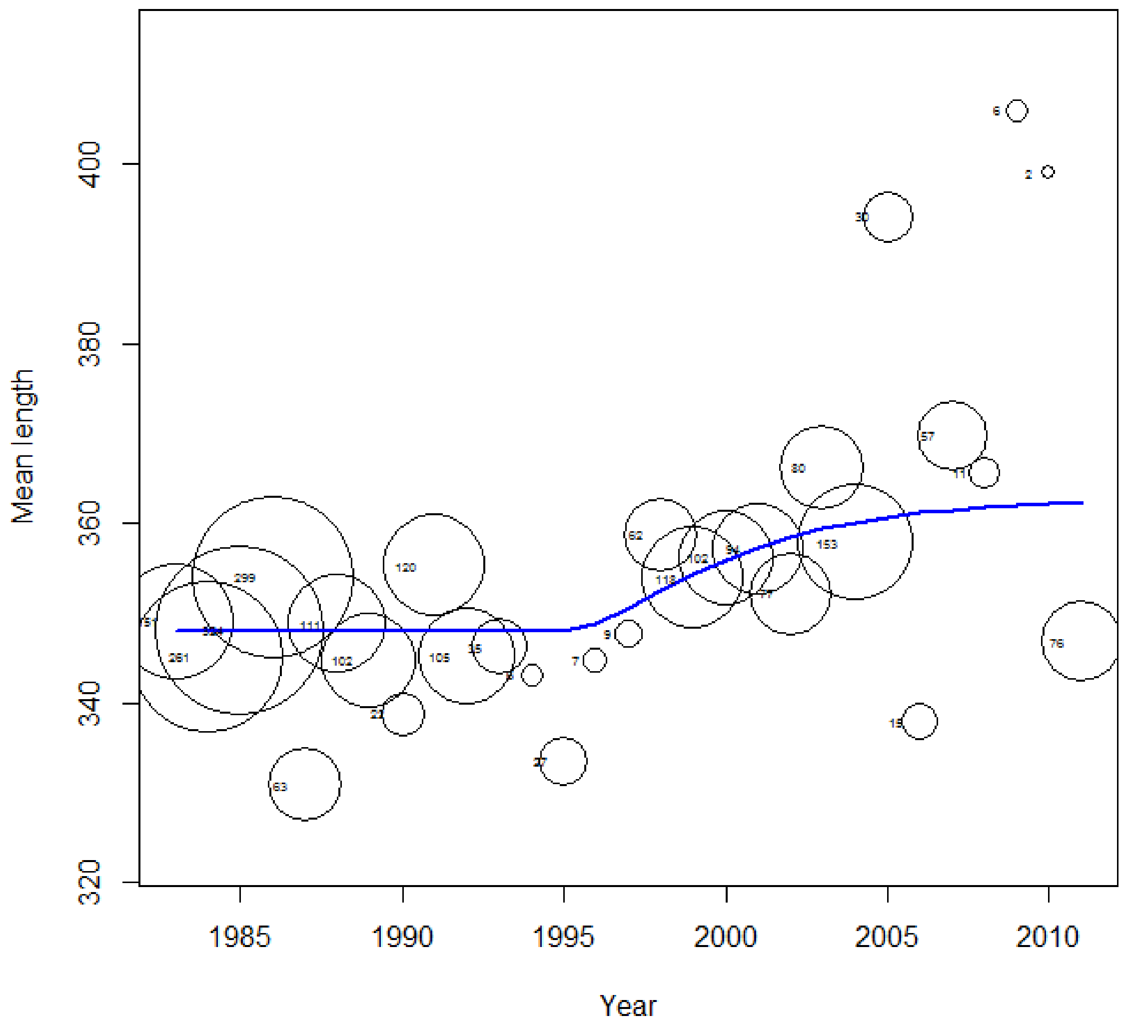


Figure 23. Model fit to the Puerto Rico pot and trap fleet mean length data. The model assuming a single change in total mortality was strongly supported by AIC.

a) b)

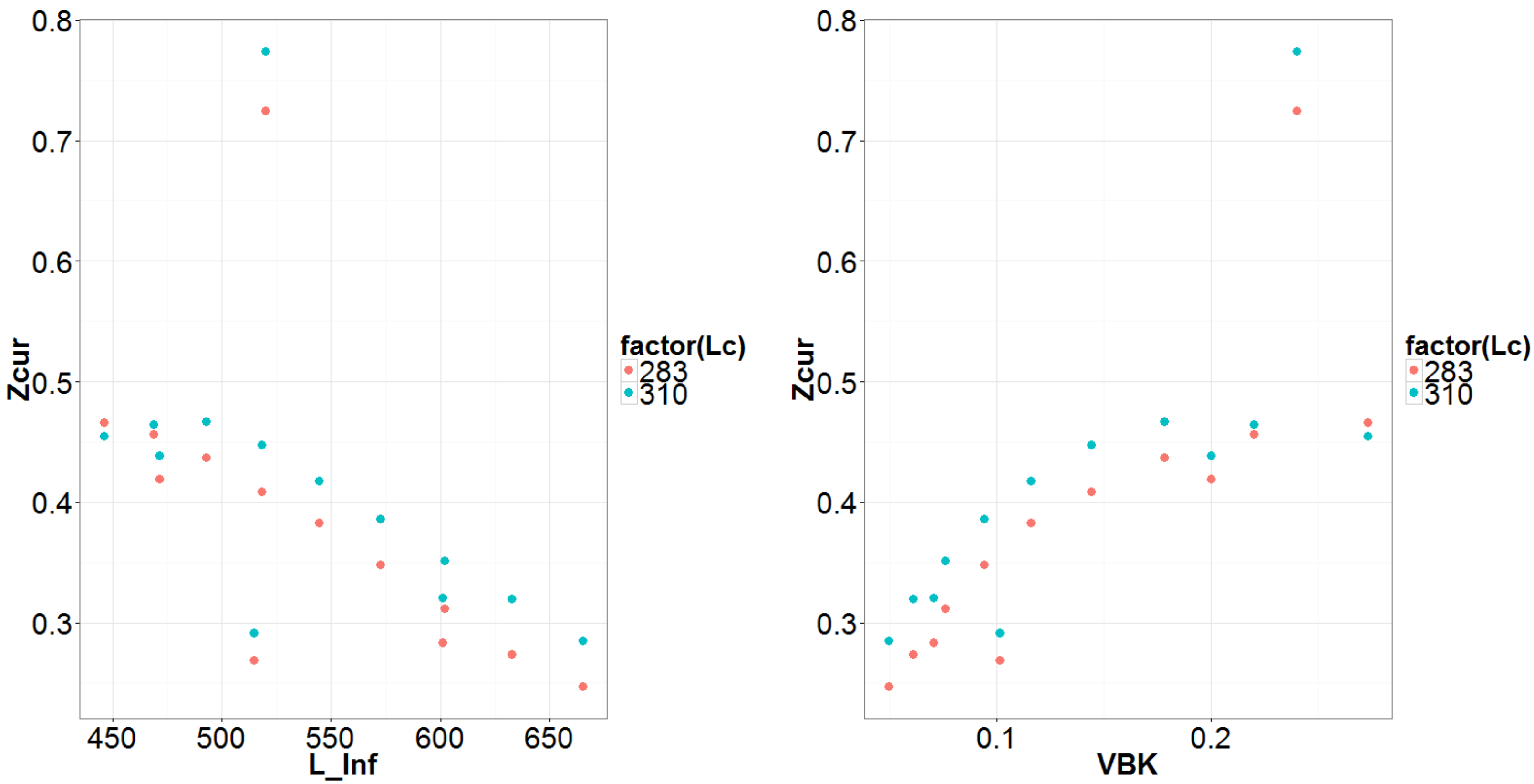


Figure 24. Sensitivity in the estimate of current total mortality (Zcur) from the analysis of the Puerto Rico pot and trap fleet length data to a) asymptotic length and b) the von Bertalanffy growth coefficient.

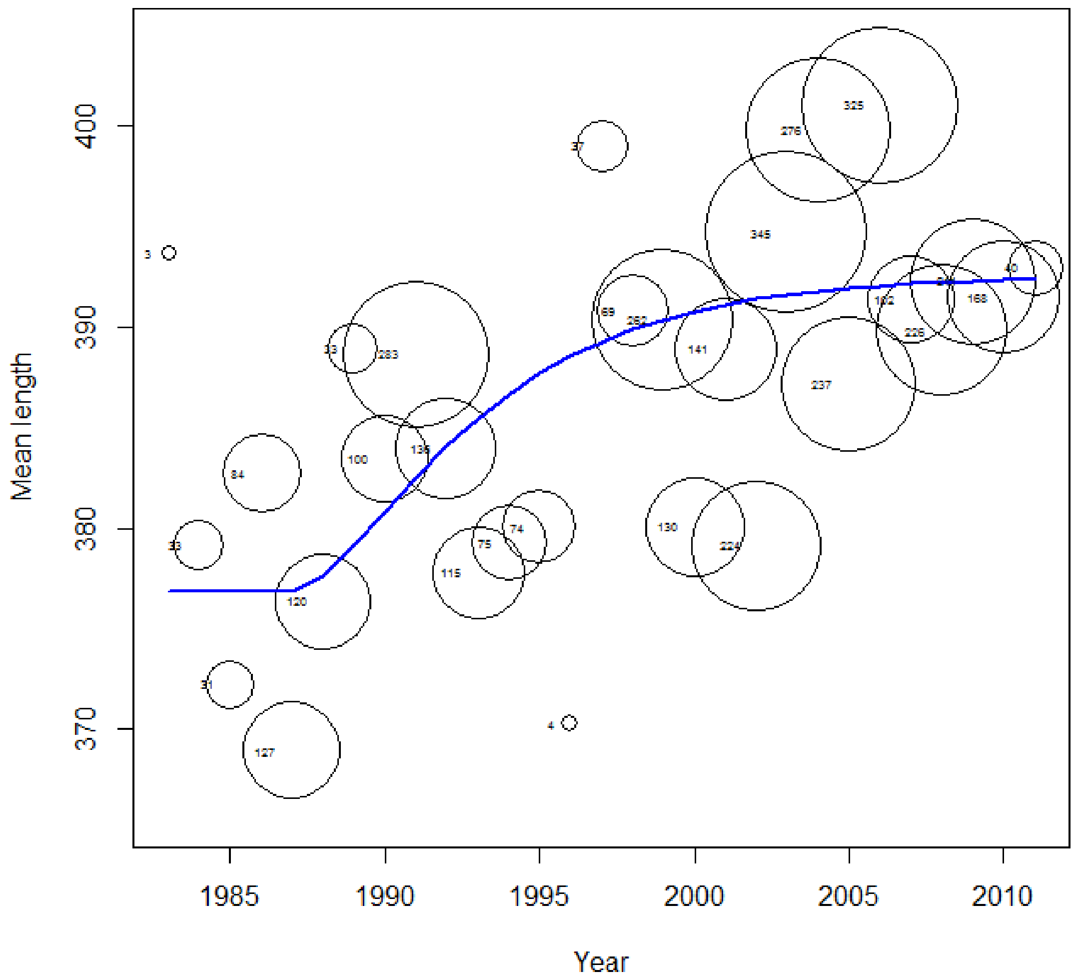
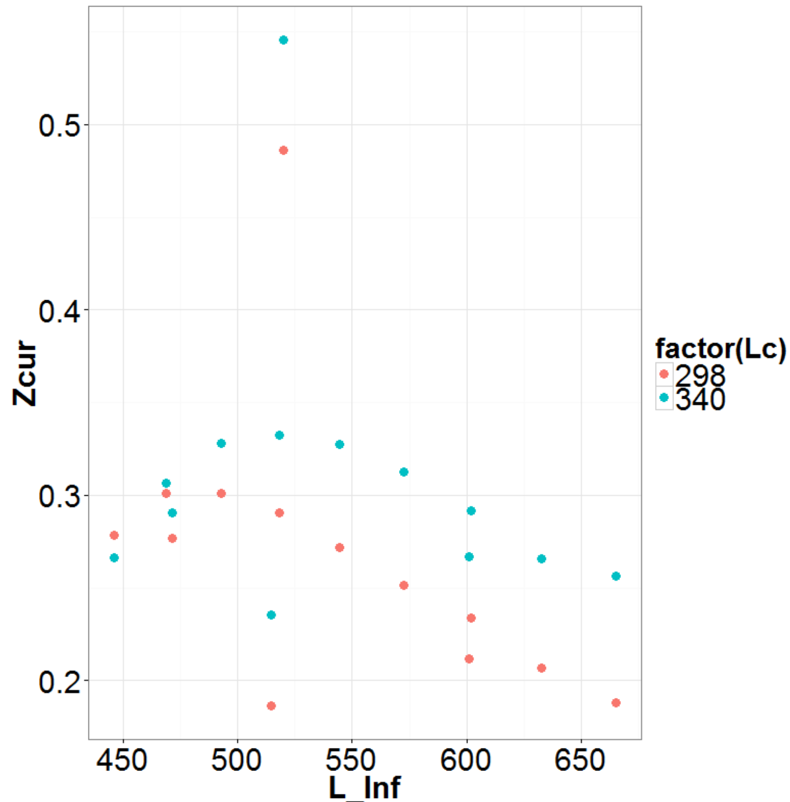


Figure 25. Model fit to the Puerto Rico vertical line fleet mean length data. The model assuming a single change in total mortality was supported by AIC

a)



b)

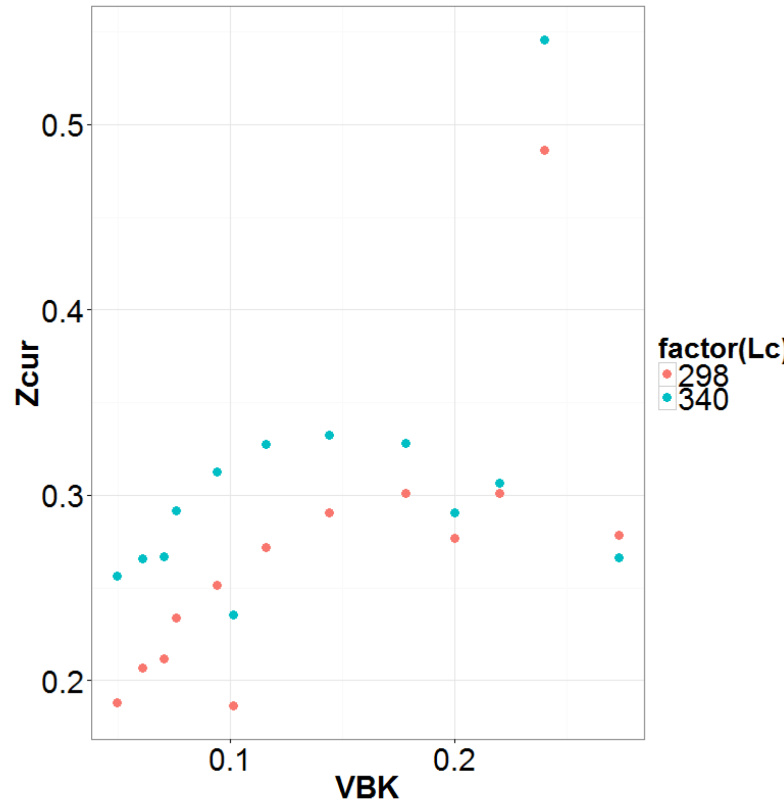


Figure 26. Sensitivity in the estimate of current total mortality (Zcur) from the analysis of the Puerto Rico vertical line fleet length data to a) asymptotic length and b) the von Bertalanffy growth coefficient.

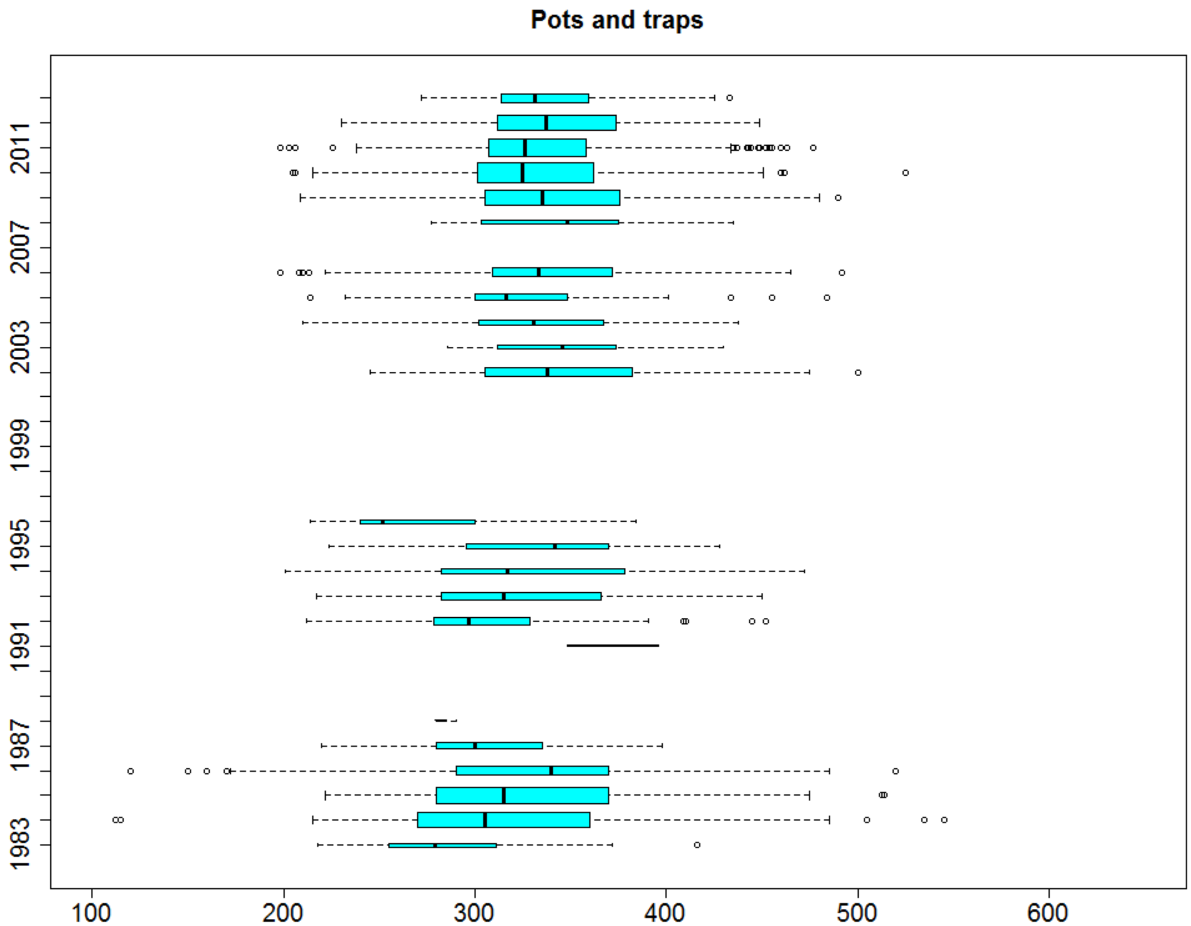


Figure 27. The annual length frequency distributions for the pot and trap fleet in St. Thomas. The box represents the inter-quartile range and the open circles represent the outliers. The box width indicates the annual sample size was scaled as the square-root of the annual number of lengths.

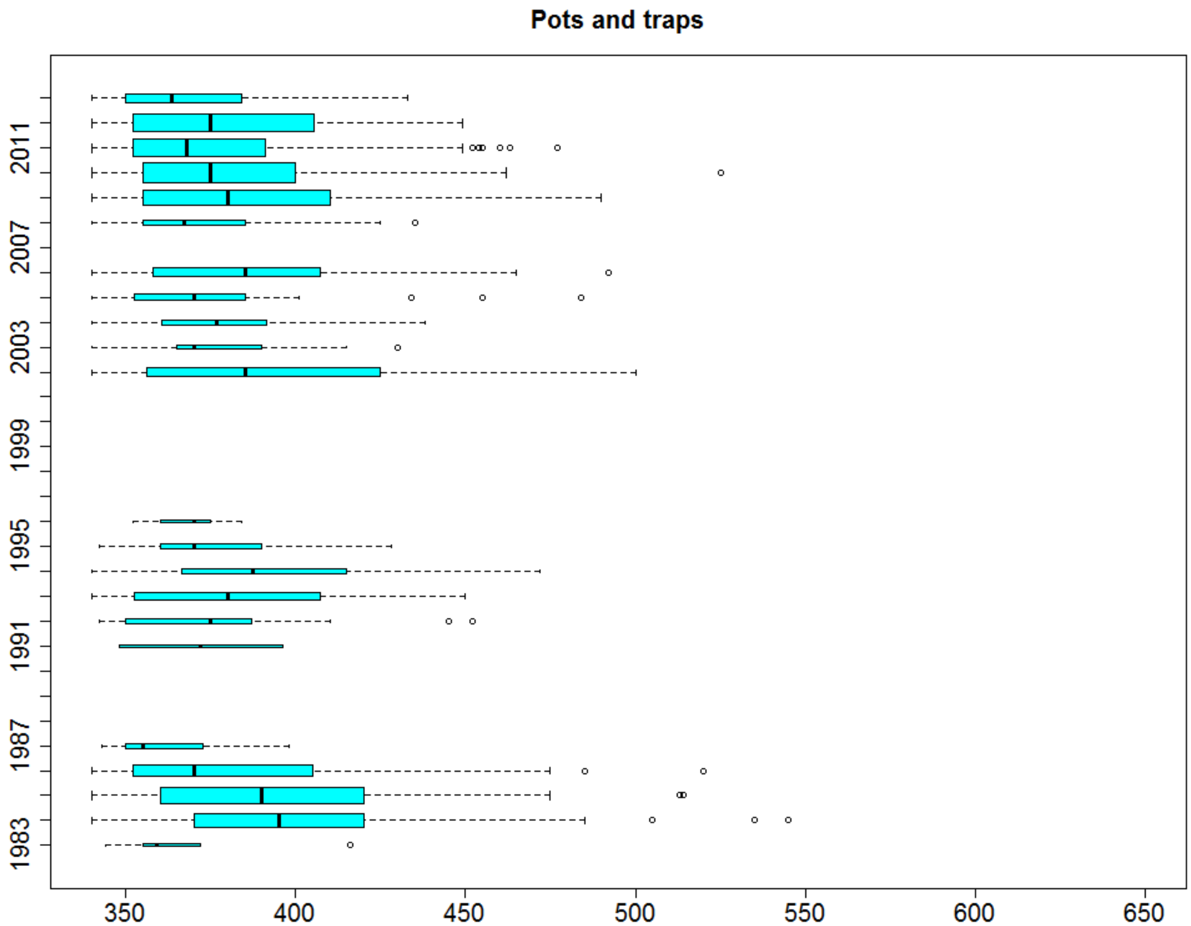


Figure 28. The annual length frequency distributions for pot and trap fleet in St. Thomas where the lengths larger than or equal to the L_c are shown. The box represents the inter-quartile range and the open circles represent the outliers. The box width indicates the annual sample size was scaled as the square-root of the annual number of lengths.

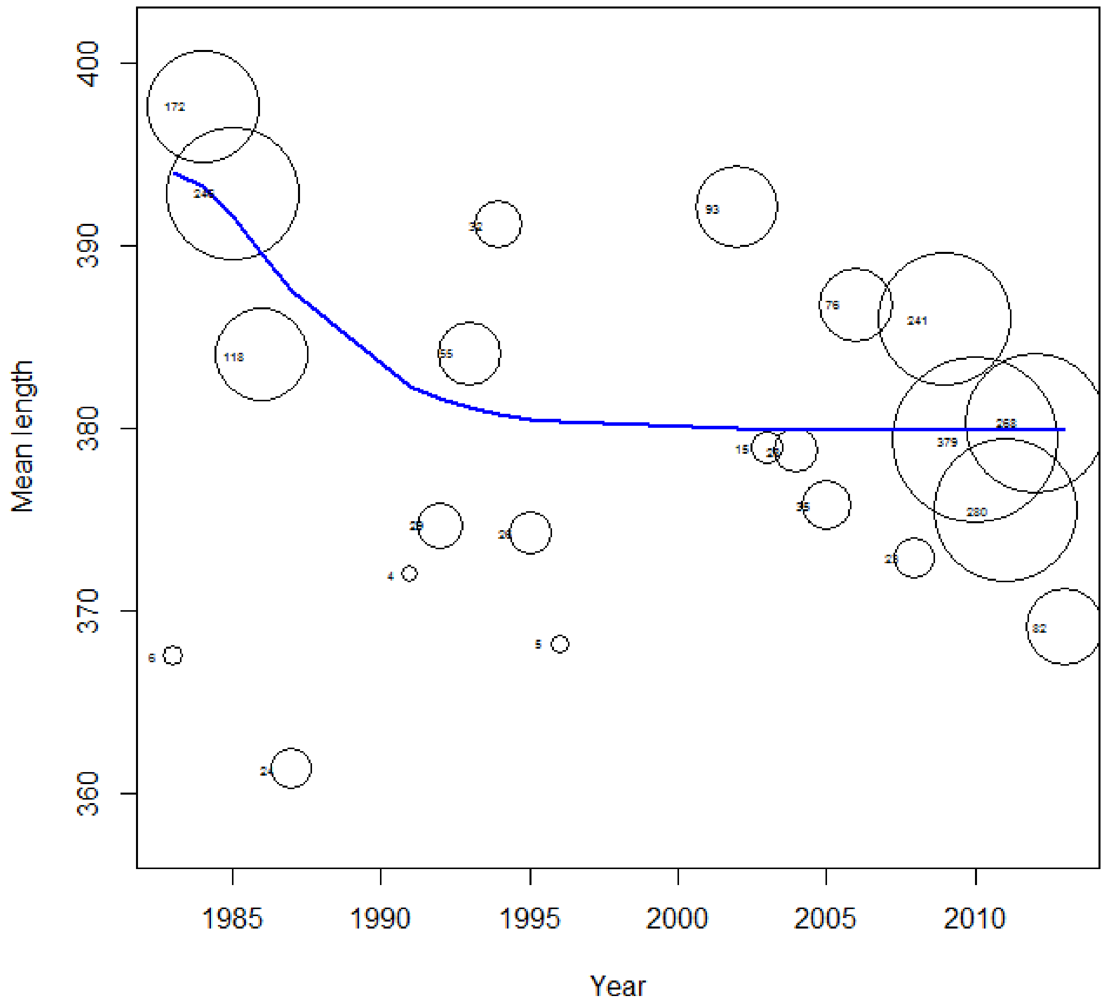


Figure 29. Model fit to the St. Thomas pot and trap fleet mean length data. The model assuming a single change in total mortality was supported by AIC .

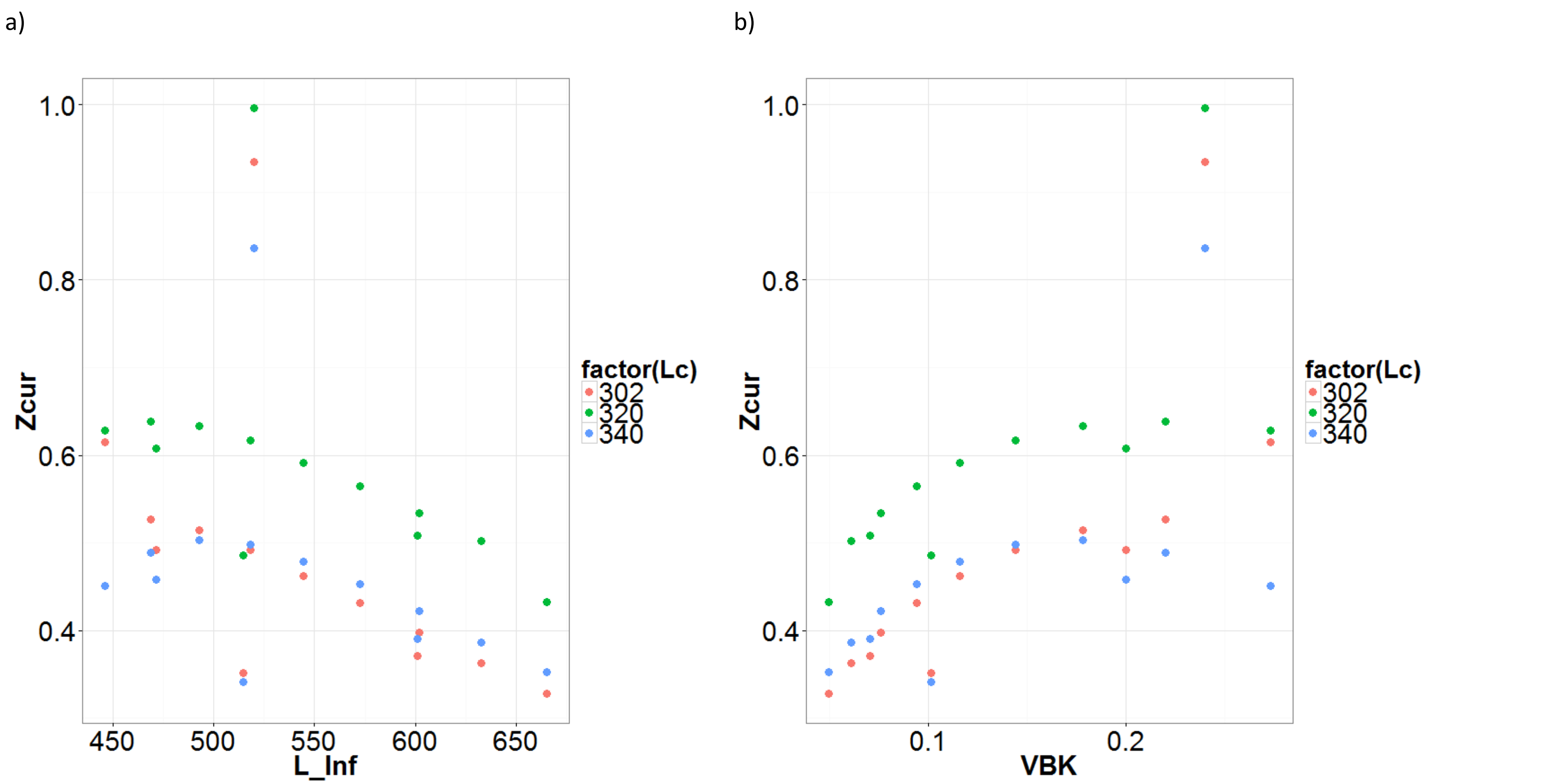


Figure 30. Sensitivity in the estimate of current total mortality (Zcur) from the analysis of the St. Thomas pot and trap fleet length data to a) asymptotic length and b) the von Bertalanffy growth coefficient.

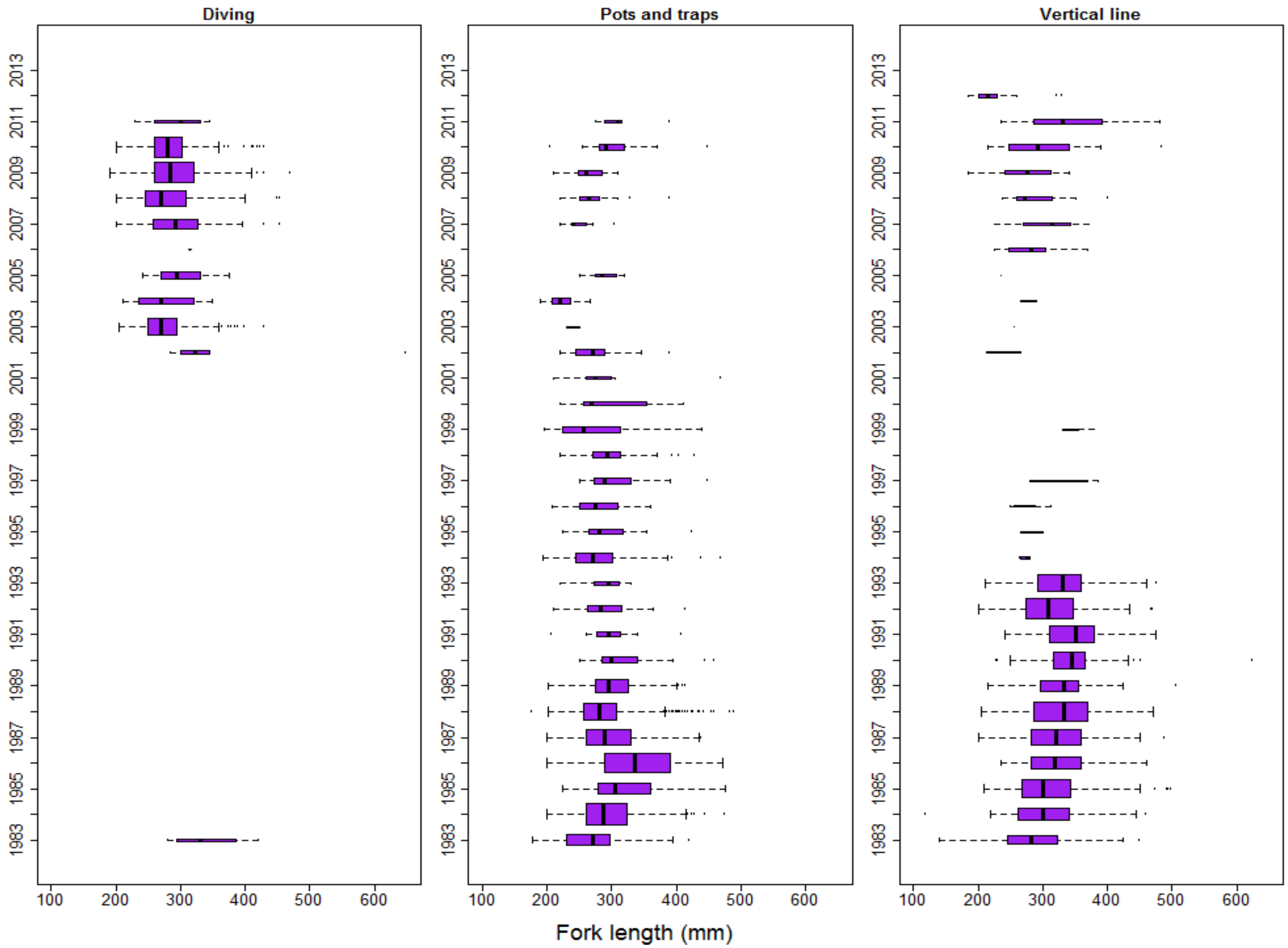


Figure 31. The annual length frequency distributions for the a) diving, b) pot and trap, and c) vertical line fleets in St. Croix. The box represents the inter-quartile range and the open circles represent the outliers. The box width indicates the annual sample size was scaled as the square-root of the annual number of lengths.

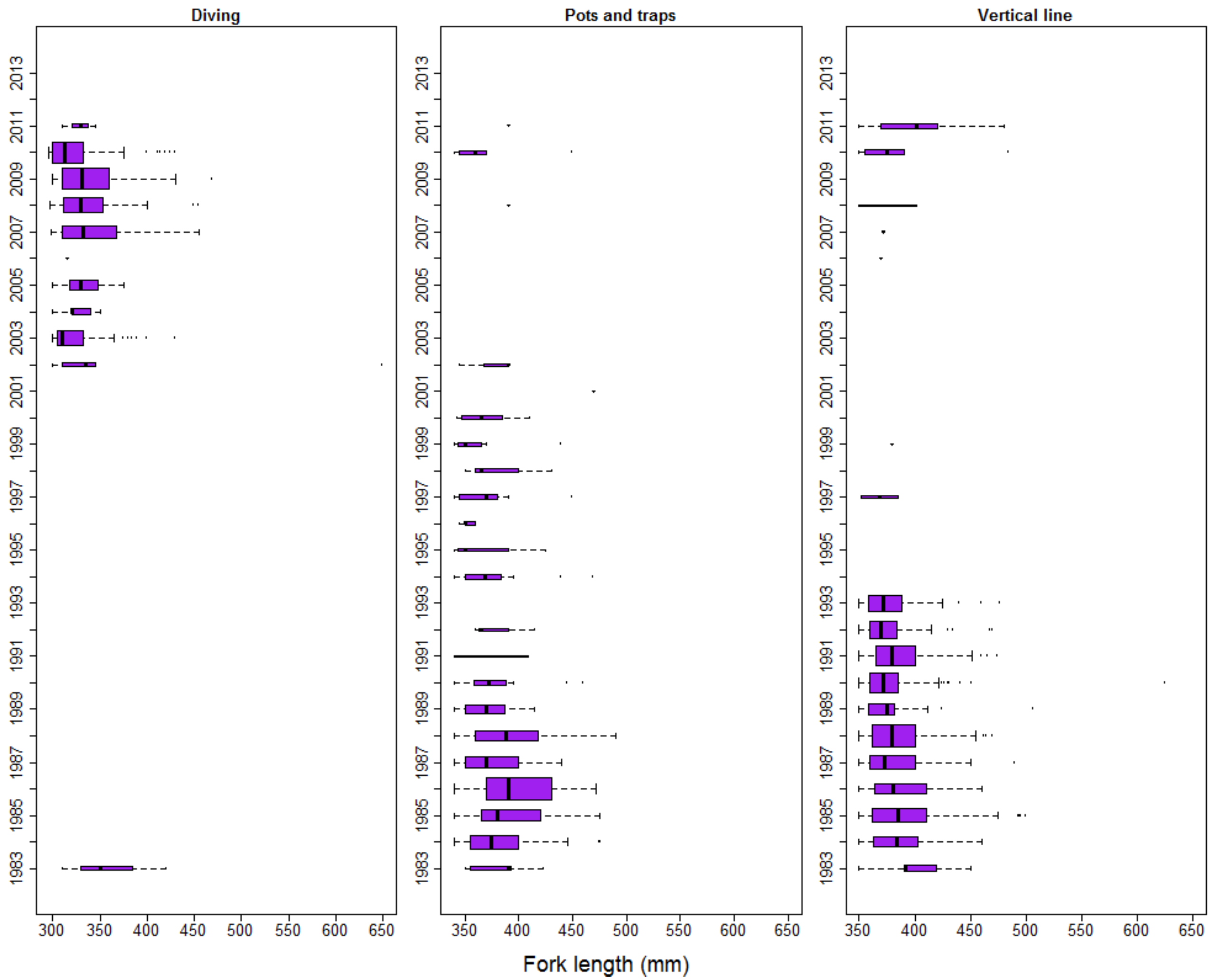


Figure 32. The annual length frequency distributions for the a) diving, b) pot and trap, and c) vertical line fleets in St. Croix where the lengths larger than or equal to the L_c are shown. The box represents the inter-quartile range and the open circles represent the outliers. The box width indicates the annual sample size was scaled as the square-root of the annual number of lengths.

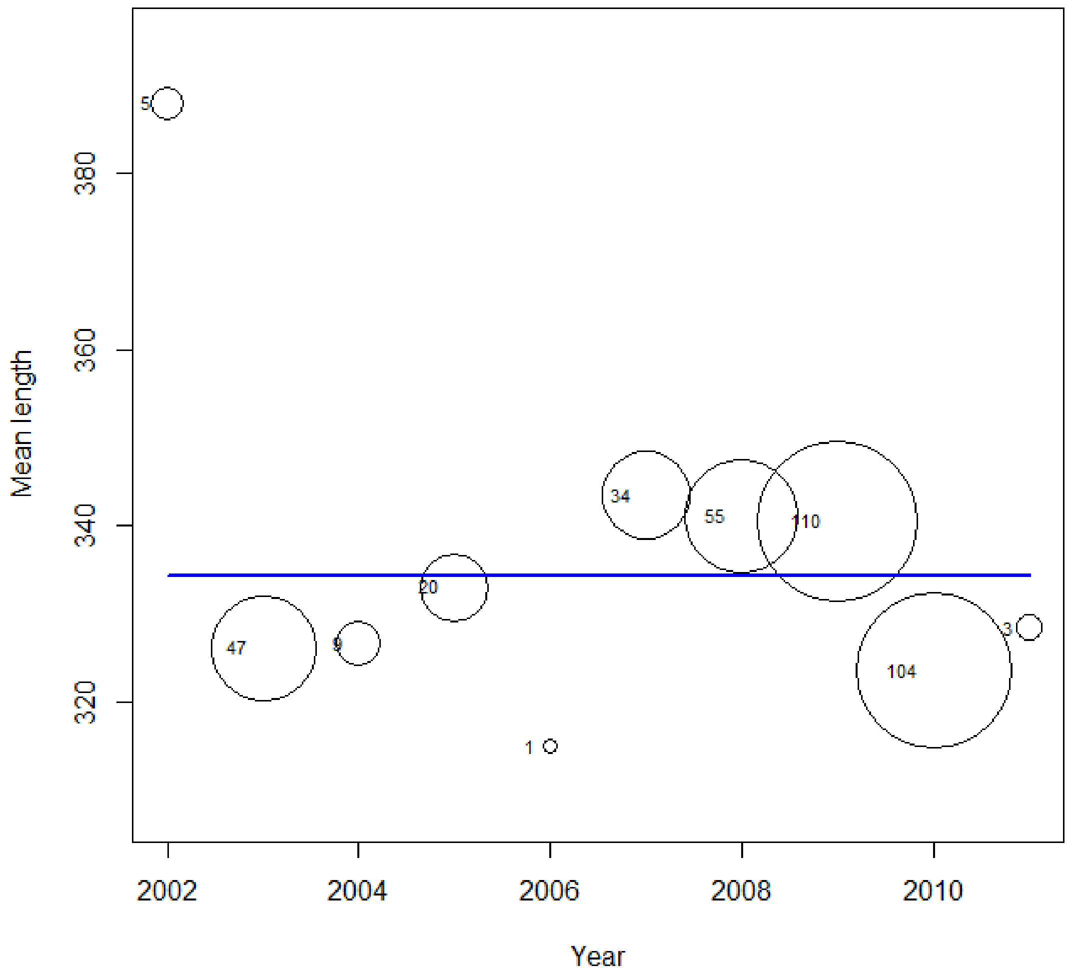


Figure 33. Model fit to the St. Croix diving fleet mean length data. The constant mortality model was supported by AIC.

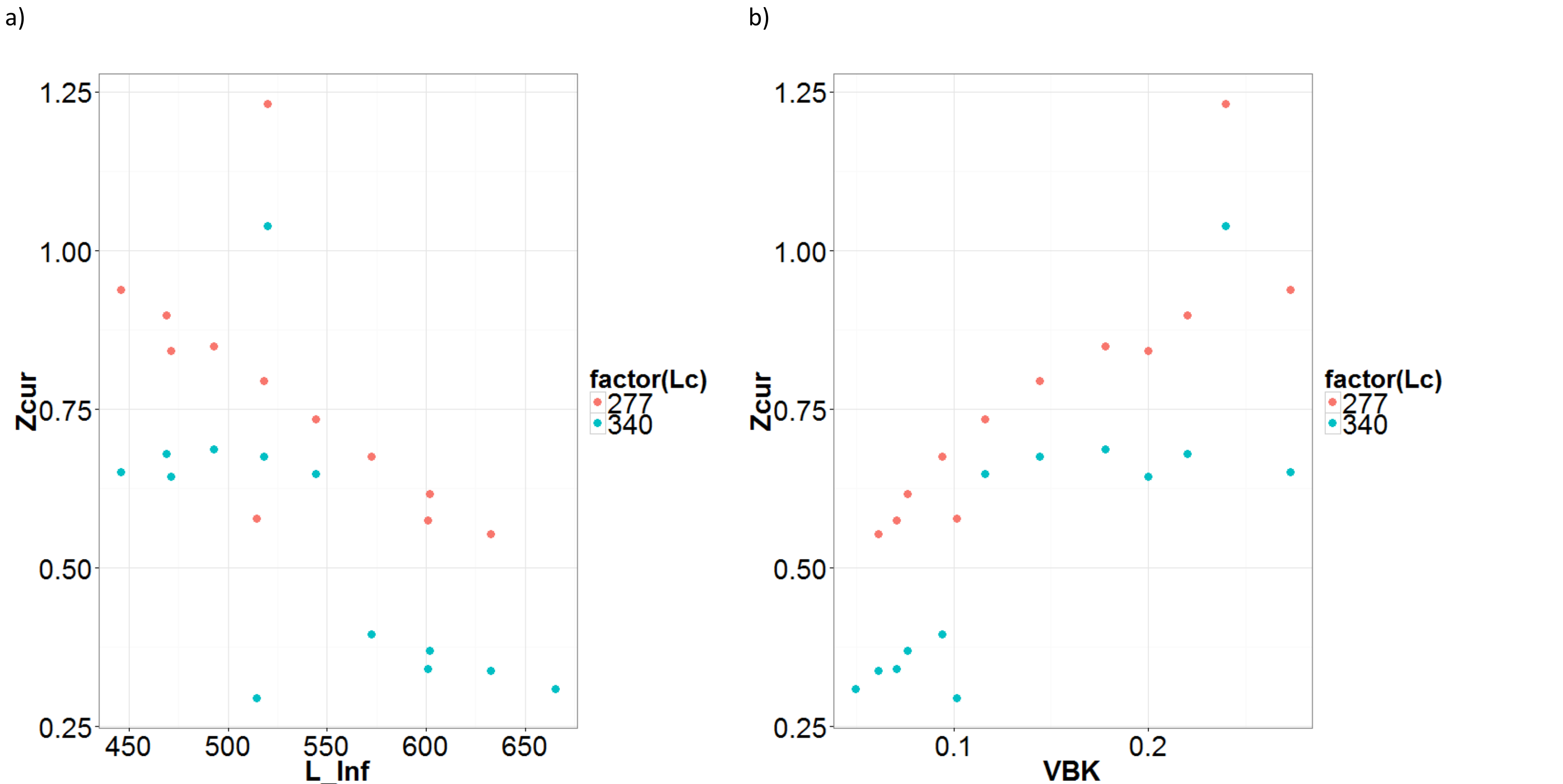


Figure 34. Sensitivity in the estimate of current total mortality (Zcur) from the analysis of the St. Croix diving fleet length data to a) asymptotic length and b) the von Bertalanffy growth coefficient.

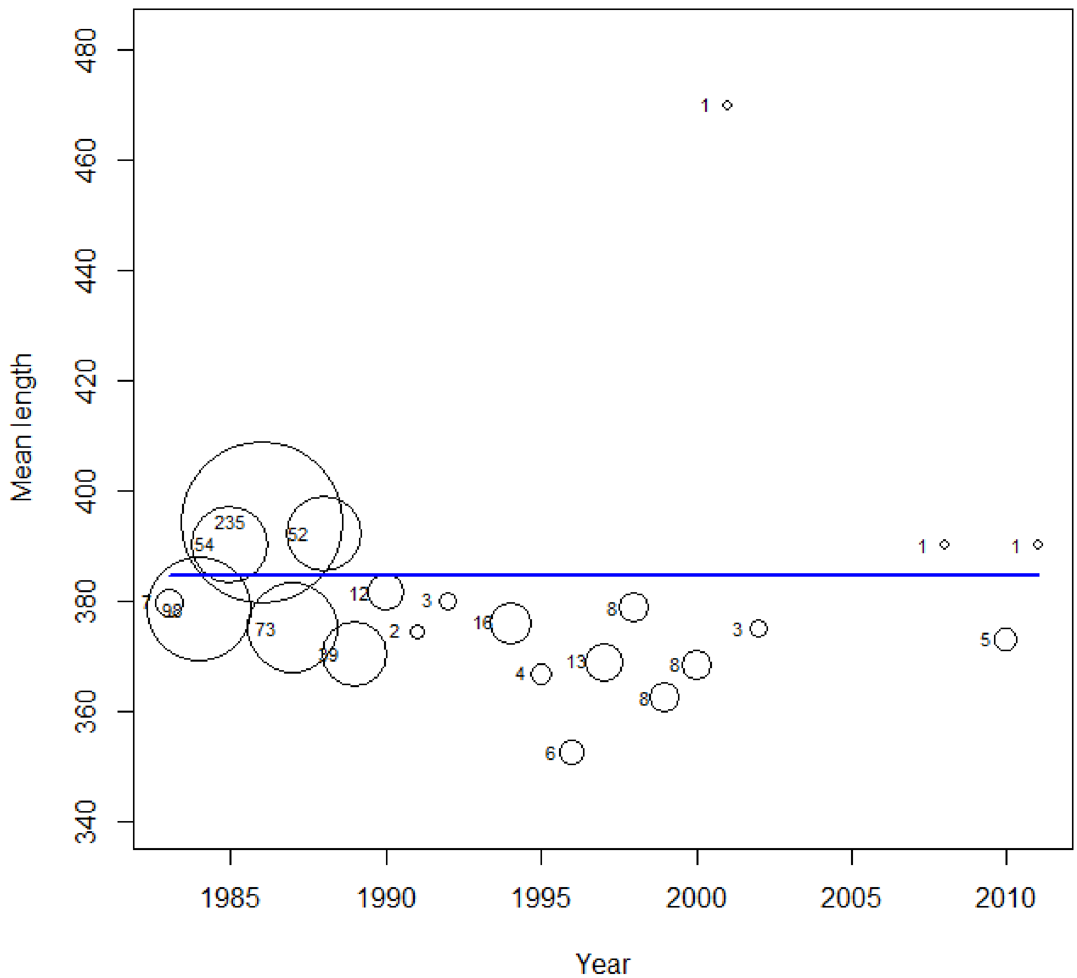


Figure 35. Model fit to the St. Croix pot and trap fleet mean length data. The constant mortality model was supported by AIC.

a) b)

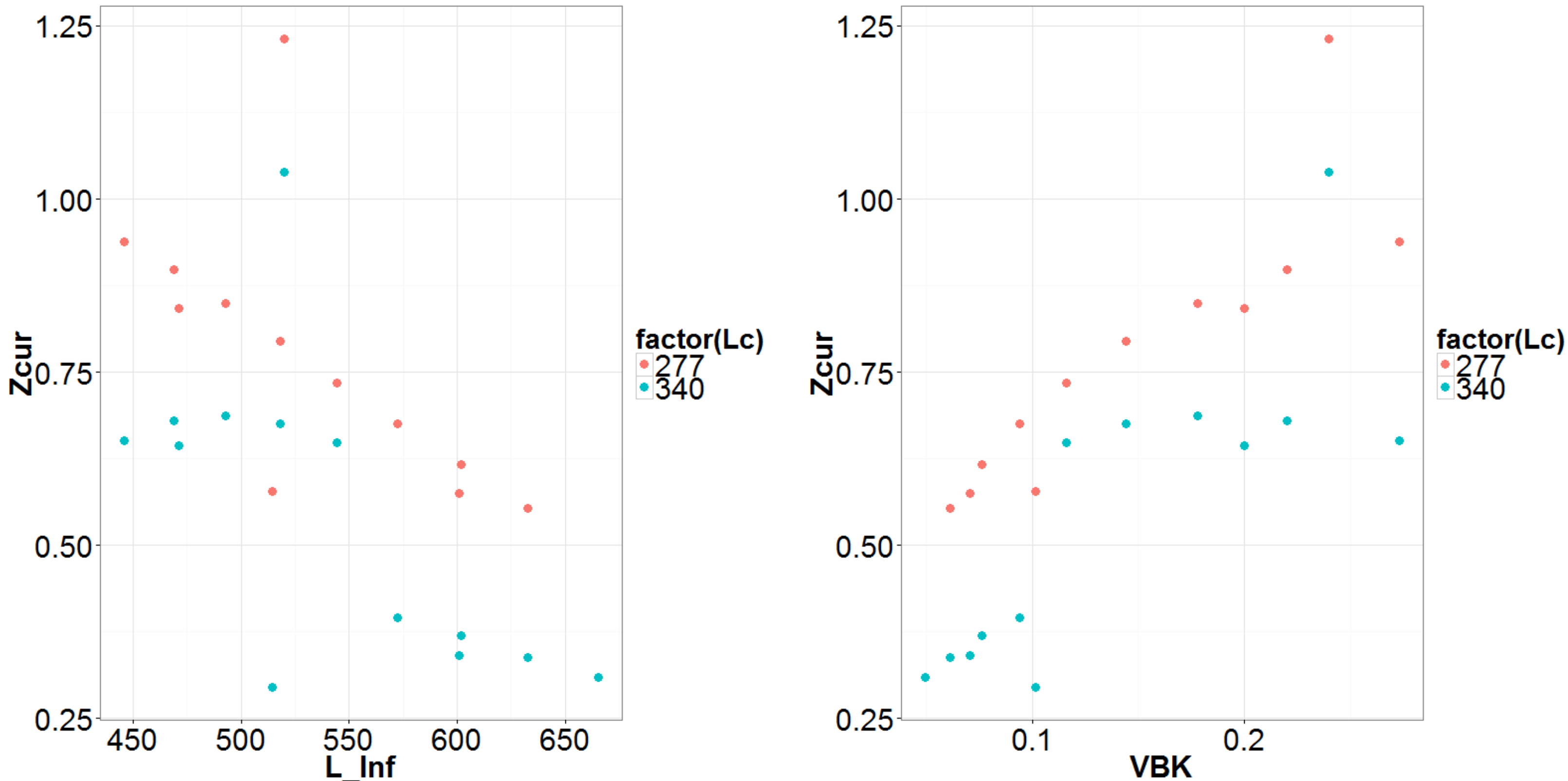


Figure 36. Sensitivity in the estimate of current total mortality (Zcur) from the analysis of the St. Croix pot and trap fleet length data to a) asymptotic length and b) the von Bertalanffy growth coefficient.

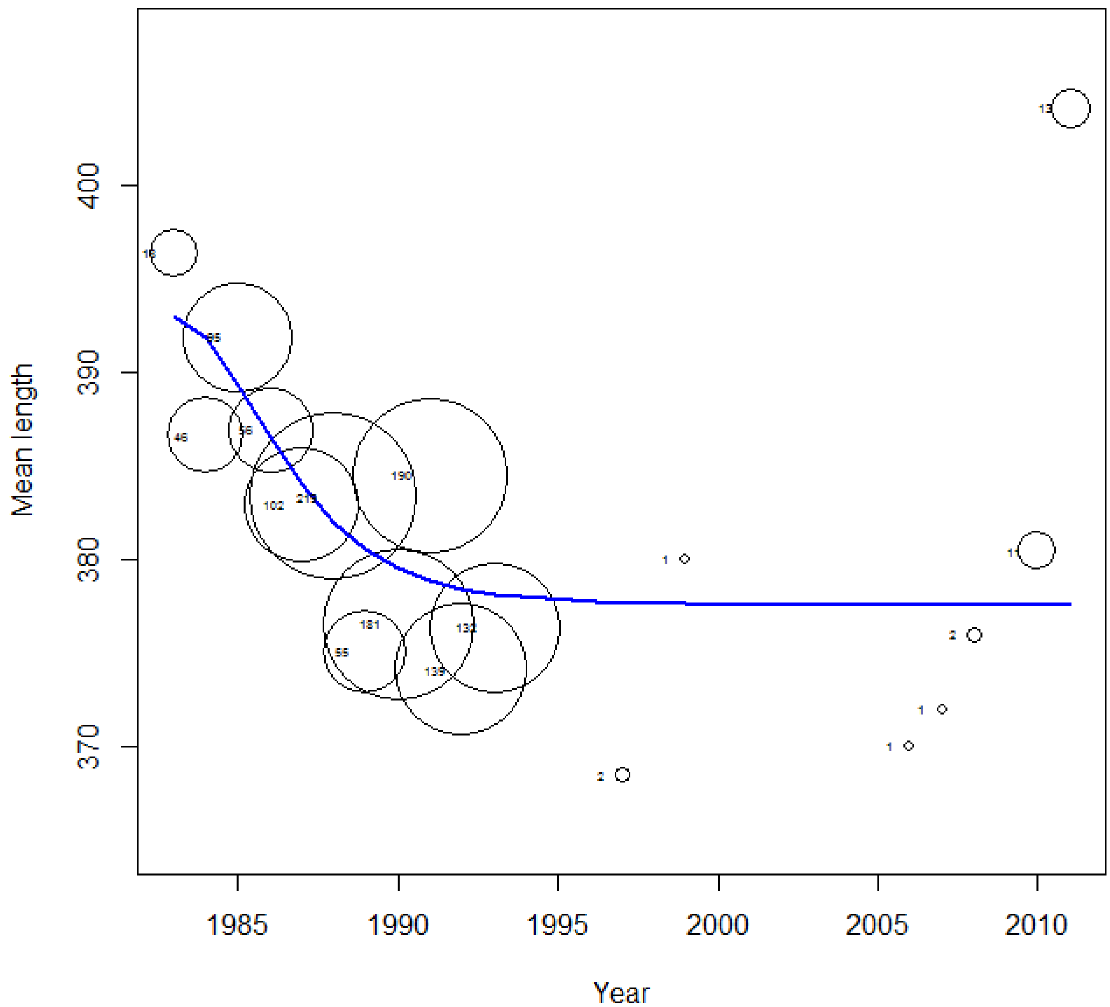


Figure 37. Model fit to the St. Croix vertical line fleet mean length data. The model assuming a single change in total mortality was supported by AIC.

a) b)

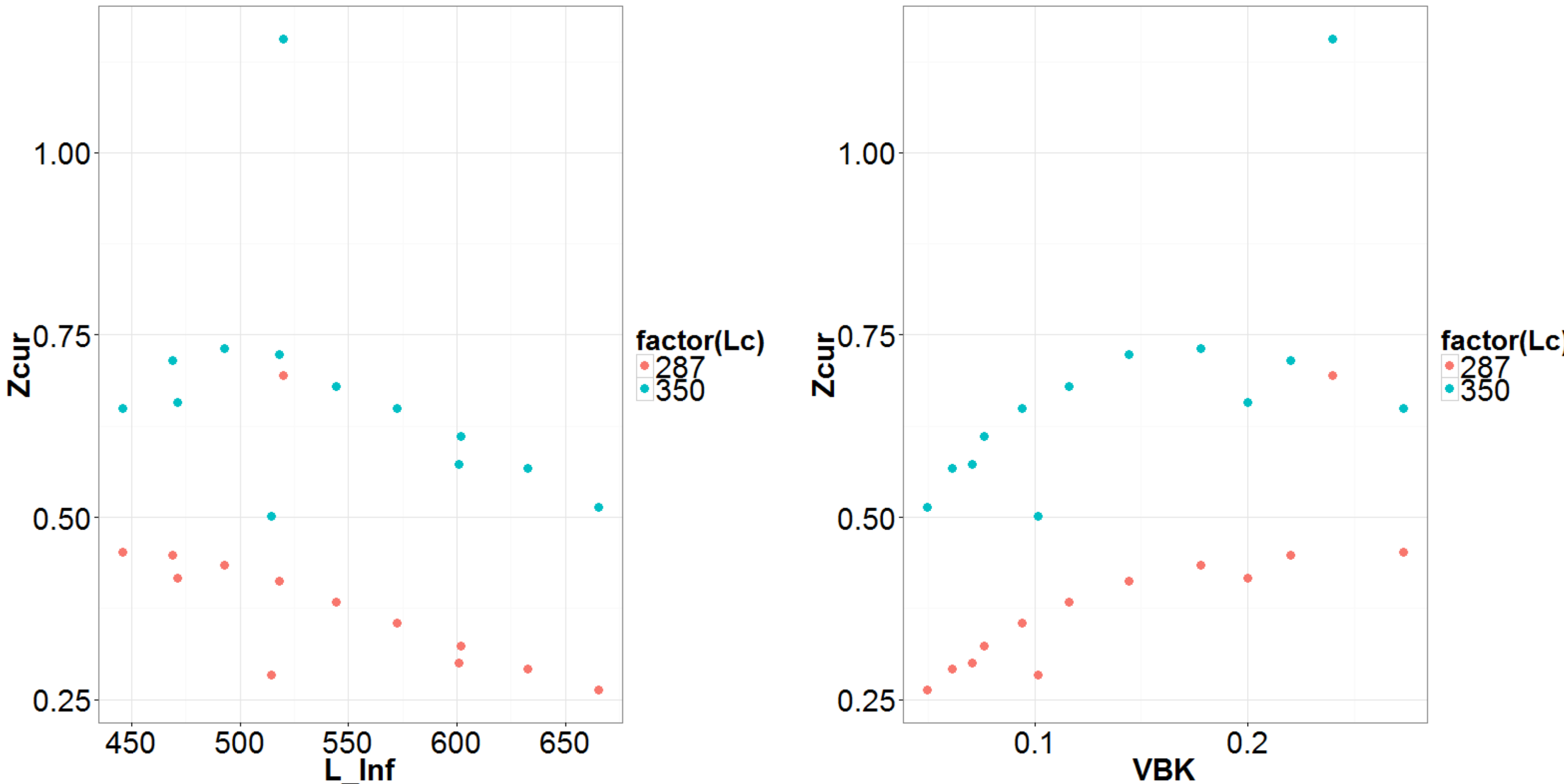


Figure 38. Estimates of current total mortality (Zcur) from the sensitivity analysis of the St. Croix vertical line fleet length data. Sensitivity to a) asymptotic length and b) the von Bertalanffy growth coefficient.

a) b)

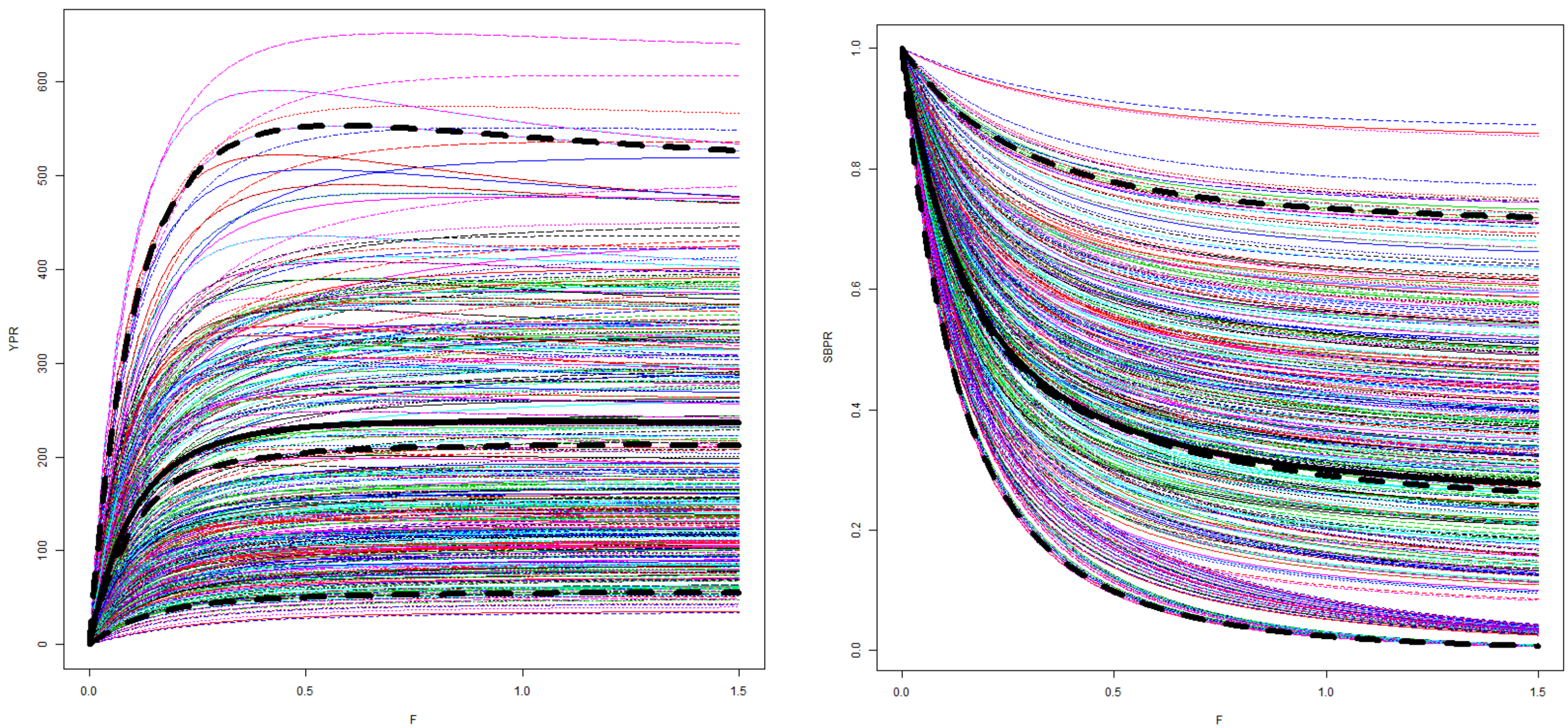
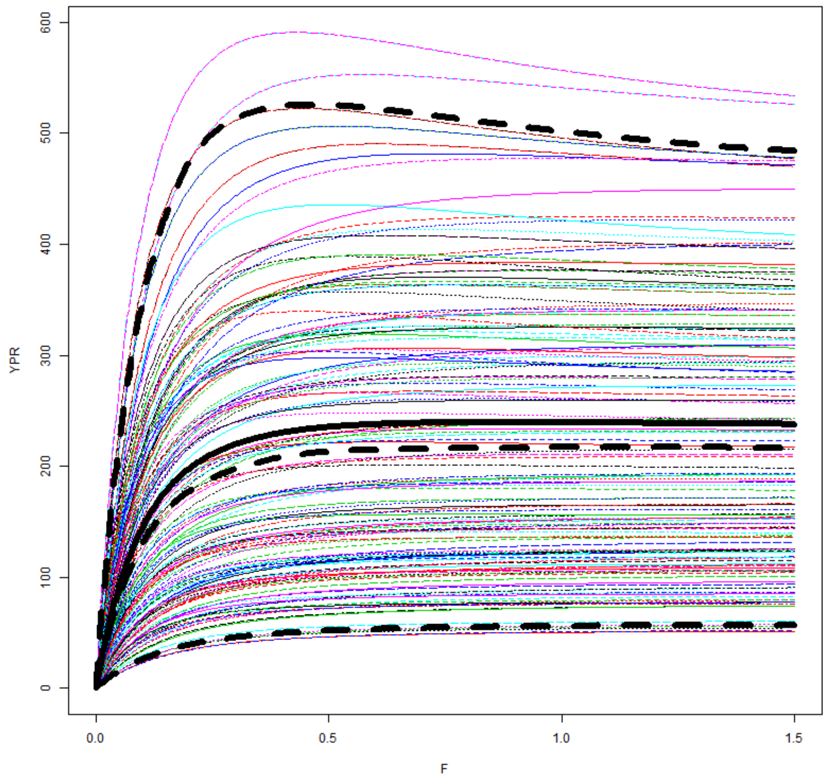


Figure 39. a) Yield per recruit and b)) the ratio between spawning biomass per recruit and spawning biomass per recruit under unfished conditions for the Puerto Rico Red Hind fishery. The colored lines represent individual YPR or SBPR curves for the diving, pot and trap, and vertical line fleets. The dashed lines represent the 95th percentile and the median, the solid line represents the mean relationship.

a) b)



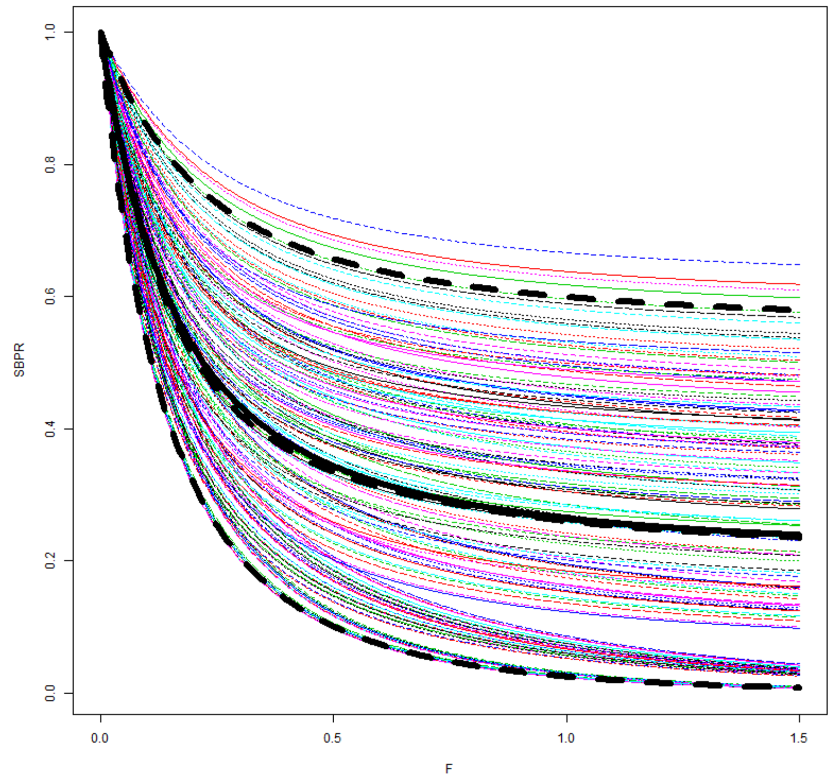


Figure 40. a) Yield per recruit and b) the ratio between spawning biomass per recruit and spawning biomass per recruit under unfished conditions for the St. Thomas Red Hind pot and trap fishery. The dashed lines represent the 95th percentile and the median, the solid line represents the mean relationship.

a) b)

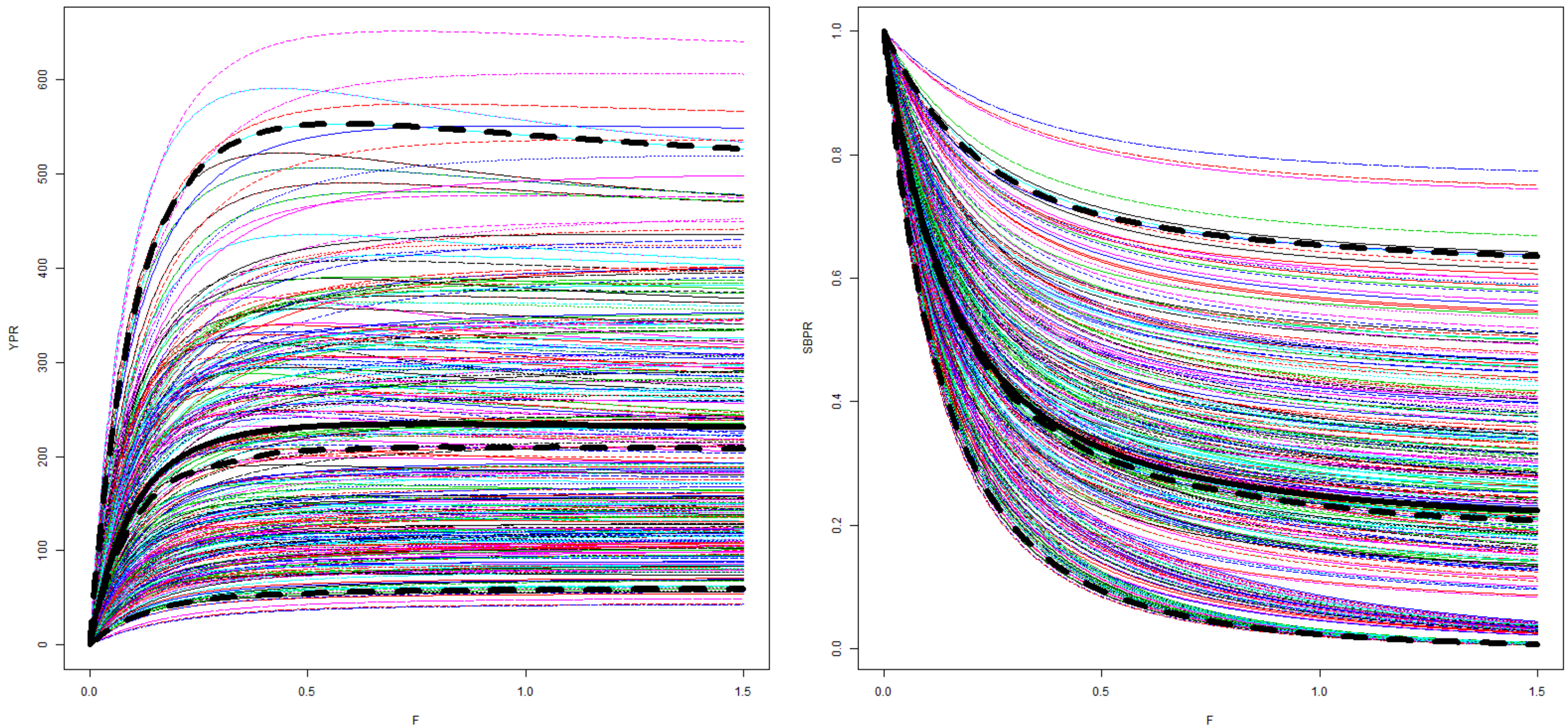


Figure 41. a) Yield per recruit and b) the ratio between spawning biomass per recruit and spawning biomass per recruit under unfished conditions for the St. Croix Red Hind fishery. The colored lines represent individual YPR or SBPR curves for the diving, pot and trap, and vertical line fleets. The dashed lines represent the 95th percentile and the median, the solid line represents the mean relationship.

a) b)

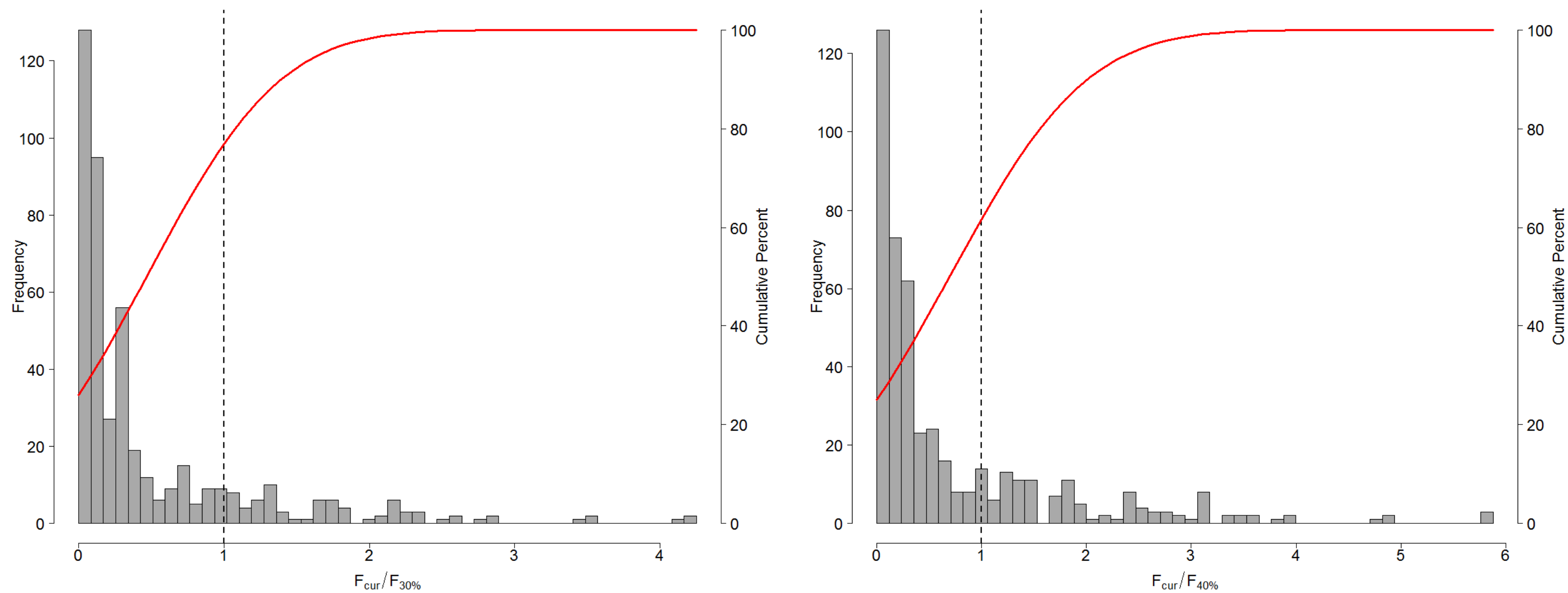


Figure 42. The frequency distribution (histogram) and cumulative probability (red line) of a) $F_{cur}/F_{30\%}$ and b) $F_{cur}/F_{40\%}$ for the Puerto Rico Red Hind fishery. The dashed vertical line shows where $F_{cur} = F_{30\%}$ or $F_{40\%}$.

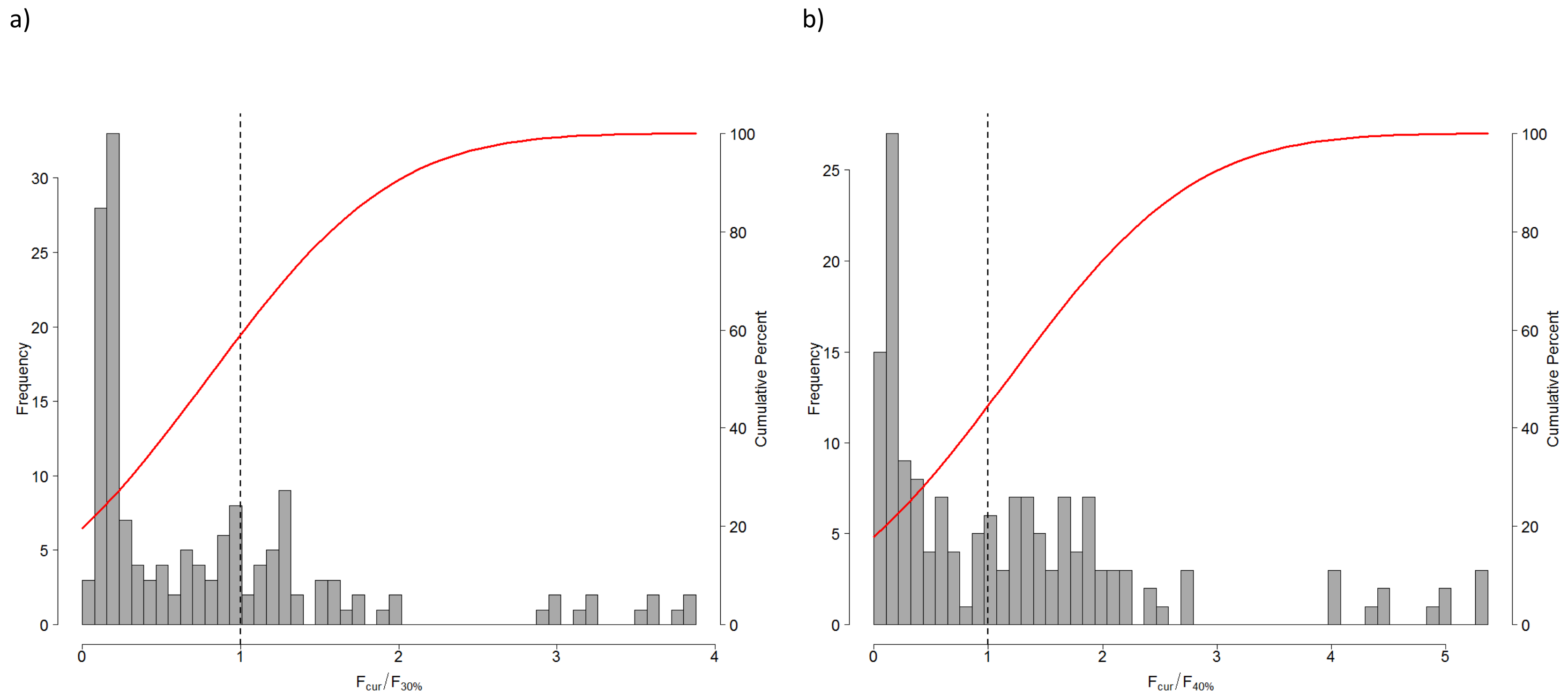


Figure 43. The frequency distribution (histogram) and cumulative probability (red line) of a)) $F_{cur}/F_{30\%}$ and b) $F_{cur}/F_{40\%}$ for the St. Thomas and St. John Red Hind fishery. The dashed vertical line shows where $F_{cur} = F_{30\%}$ or $F_{40\%}$.

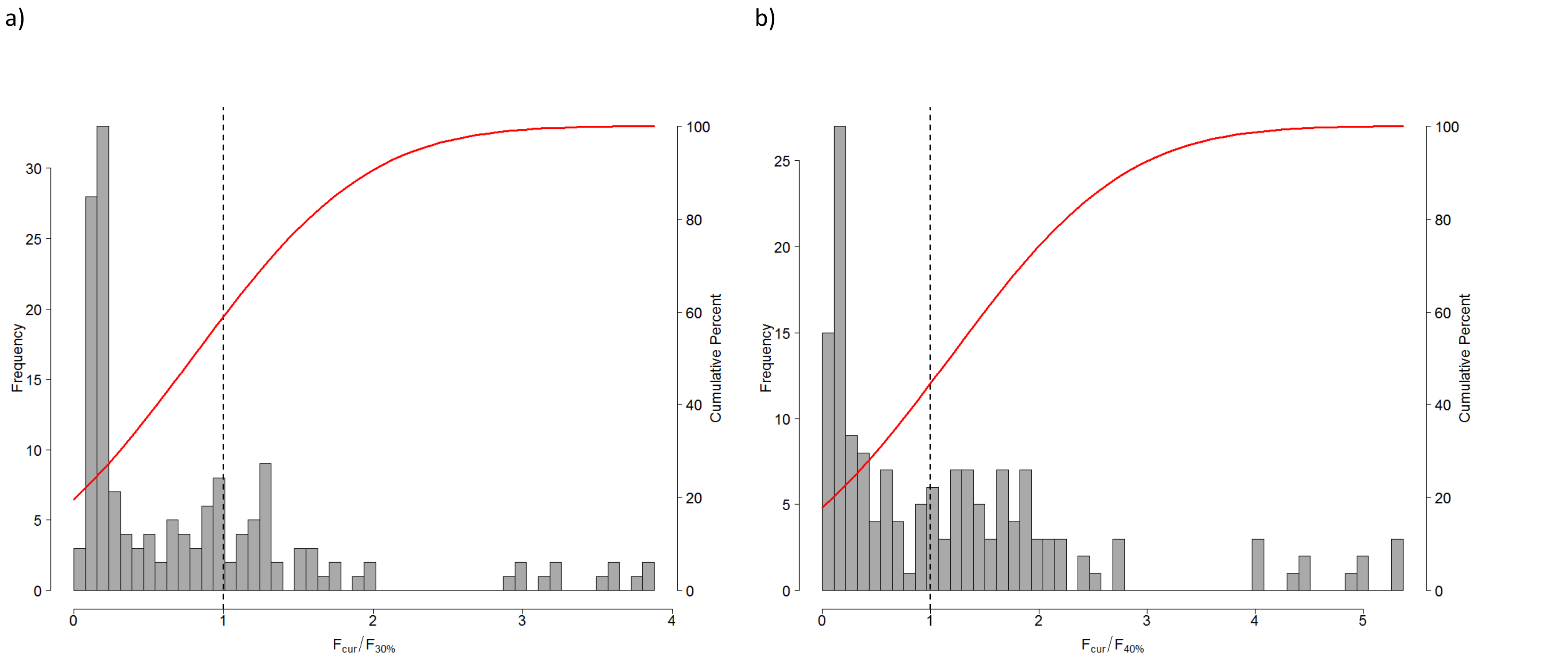
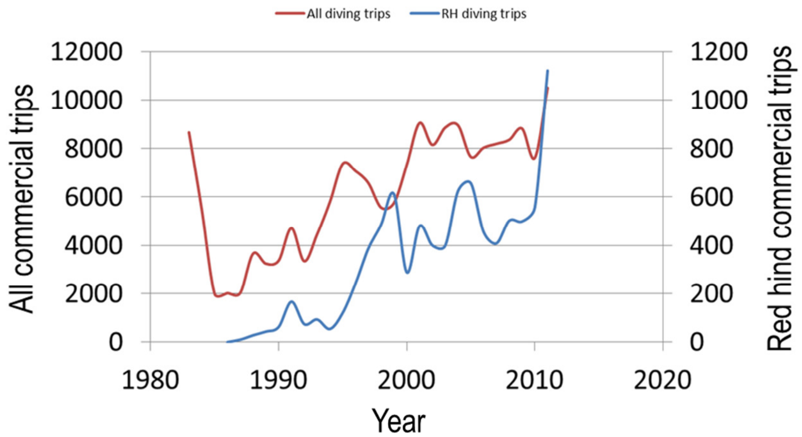
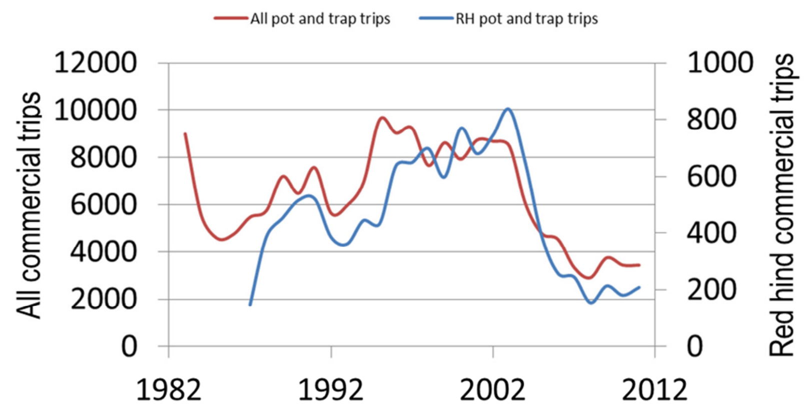


Figure 44. The frequency distribution (histogram) and cumulative probability (red line) of a) $F_{cur}/F_{30\%}$ and b) $F_{cur}/F_{40\%}$ for the St. Croix Red Hind fishery. The dashed vertical line shows where $F_{cur} = F_{30\%}$ or $F_{40\%}$.

a)



b)



c)

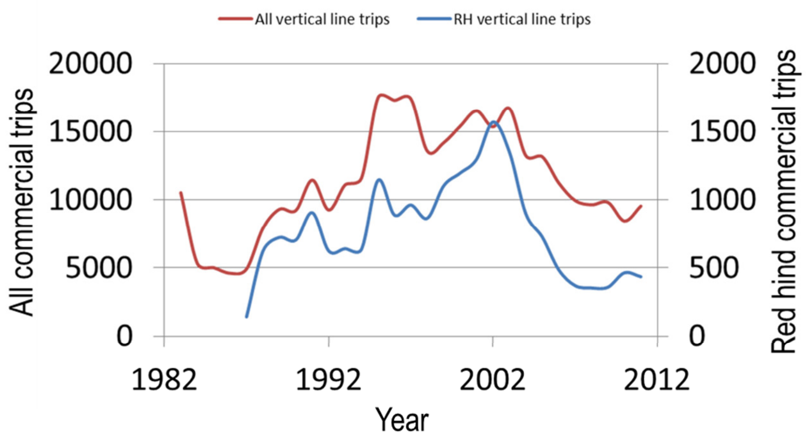
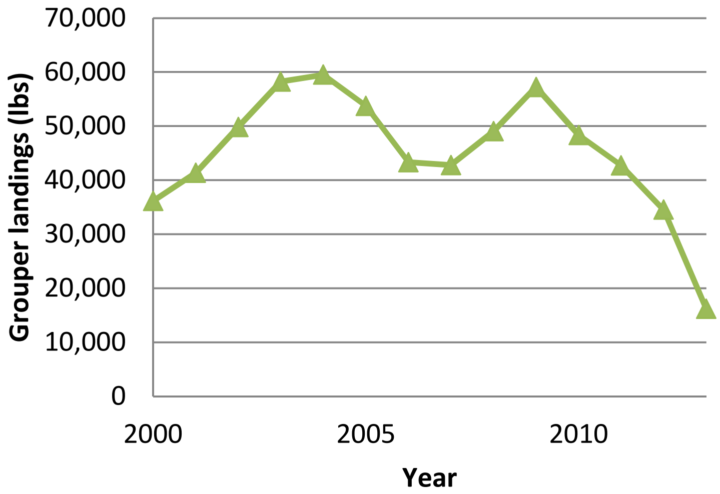


Figure 45. The total number of reported trips (red line) and the number of reported trips catching Red Hind (blue line) for the a) diving fleet, b) the pot and trap fleet, and c) the vertical line fleet in Puerto Rico.

a)



b)

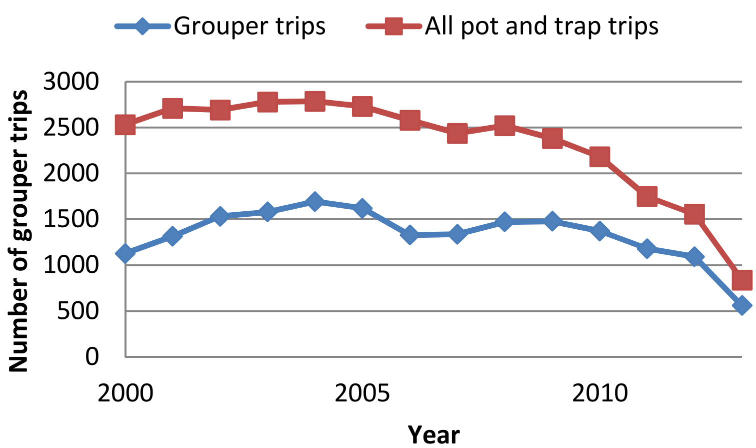


Figure 46. St. Thomas a) grouper landings in pounds and b) all pot and trap trips and grouper only trips from 2000-2013.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 35

Caribbean Red Hind

SECTION IV: Research Recommendations

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

1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

No specific recommendations were provided.

2. ASSESSMENT WORKSHOP RESEARCH RECOMMENDATIONS

In the short term, US Caribbean stock assessments will continue to rely on mean-length estimation given the data currently available. The ability to use the mean-length estimator is contingent upon having length-frequency data that are temporally consistent and representative of the population and upon having reliable estimates of life history parameters, in particular, the von Bertalanffy parameters. Efforts should be made to review the current TIP sampling structure in Puerto Rico and in the USVI to ensure sampling is representative. Studies on basic life history (e.g., age-growth relationships, length/age-at maturity) in the US Caribbean will greatly enhance the utility of the existing length-frequency data and should provide the greatest benefit to providing management advice in the short term. This should be placed as a top priority for key species.

Fishery-independent surveys should be considered as a top research priority for additional data collection. Fishery-independent surveys designed using a rigorous statistical framework will allow for the collection of species-specific catch and effort data that can be used to develop indices of abundance. Indices of abundance are used in stock assessments to inform models about how a population may be changing over time. Fishery-independent surveys can also be used to supplement existing programs by collecting age, length, weight, and reproductive data.

During the SEDAR 35 assessment workshop, and in previous assessment workshops in the US Caribbean, the fishermen from the USVI indicated that the size of landed fish is market driven for plate size fish. This may help to explain the relatively narrow size range of landed Red Hind. It also suggests that selectivity is dome-shaped, which violates the assumption of knife-edge selectivity in the mean-length model. One avenue of future research would be to expand the mean-length estimator to accommodate other selectivity patterns. Another avenue of research would be to quantify the selectivity patterns for the different gear types. During the data and assessment workshops, the Panel could not quantify discard rates nor could they ascertain the level of discard mortality. If discard mortality of larger fish is significant, the violation of the selectivity assumption may be moot. Efforts should be made to quantify discard and discard mortality rates for the US Caribbean fisheries.

Lastly, under the current management regime all US fisheries must be managed by annual catch limits (ACLs). In an ideal scenario, ACLs would be developed from estimates of abundance and sustainable yield. The mean length estimator does not provide these metrics. As such, it is essential that continued efforts to improve the data collection of fishery-dependent catch and effort statistics be made so that traditional biomass-based assessment approaches can be employed. Continued efforts to collect species-specific catch statistics will also be important in moving towards more traditional assessment approaches and for more precise monitoring of ACLs.

3. Research Recommendations from the CIE Reviewer Reports (Term of Reference 6)

Cardinale Recommendations

The Assessment team provides an exhaustive list for future data to be collected, which would notably improve the capability of assessing the status of the Caribbean red hind stock. However, I consider that the description of the additional research and future monitoring is not exhaustively presented and it could have been much more detailed and comprehensive.

The reviewer agrees with the Assessment team that priority should be to given to derive data which allows movement towards more traditional assessment approaches. However, the reviewer also considers that this could in part already be pursued by the Assessment team using other methods than the mean length analysis (see ToR 2 and ToR 3).

Additional Recommendations

• A virtual population analysis (VPA), assuming a steady state and combining different gears, should be used for selected combination of years, areas and gears in a future assessment of Caribbean red hind.

Dowling Recommendations

The research recommendations provided by the Assessment Workshop are:

--(top priority) Undertake studies on basic life history (e.g. age--growth relationships, length/age at maturity).

- Agree, in so much as these should reduce existing uncertainty – but are these realistic given the existing capacity? Why are not previous studies considered representative? Are there existing studies for the same species elsewhere that may be helpful?

--Review the current TIP sampling structure to ensure sampling is representative.

- Agree --but "representative" in what sense? Temporally, spatially, of the size structure of the total fished population, of the total fishing effort?
- I think this should rate as a higher priority than undertaking fishery--independent surveys. The priorities should be immediately focused on improving the input to, and outcomes, the existing assessment approach.

--top priority) undertake fishery-independent surveys that enable the development of abundance indices, and that collect age, length, weight and reproductive data.

- Fair enough – but again, are these realistic given the existing capacity?
- Moreover, this recommendation should be made in the context of the evaluations of the existing fishery independent data and/or survey protocols (e.g. the Mona Island and Abrir la Sierra (DW03) protocols and data had potential had the time series been longer).

--To expand the mean--length estimator to accommodate other selectivity patterns.

- I think this is an excellent recommendation.

--To quantify the selectivity patterns for the different gear types.

- I agree that this needs to be resolved, especially given the assumption of knife--edged selectivity underpinning the per--recruit analyses.

--To attempt to quantify discard and discard mortality rates.

- Agree that this would be useful, but how could this be achieved? Quantifying discarding is notoriously difficult.

- To continue to improve the data collection of fishery-dependent catch and effort statistics so that traditional biomass-based assessment approaches can be employed (and hence annual catch limits determined and monitored).

- I agree that this is a key priority.
- However, there is presumably no way to improve the quality of the historical catch and effort statistics, so the issue is also one of how best to work with the existing data.
- While it may be ideal to develop ACLs from estimates of abundance and sustainable yield, these are often unavailable. This does not preclude ACLs from being set. ACLs may be determined using simple empirical approaches, while acknowledging the increased risk associated with less information and certainty.

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

There are two arenas for research and monitoring. One is around improving the reliability and usefulness of the current assessment approach. This equates to narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing (and to introducing an overfished reference point threshold). The other is around improving the quality of information available into the future such that alternative approaches may be permitted.

Against the current assessment approach, I agree that

- Reviewing the TIP length data for representativeness (temporally, spatially, of the size structure of the total fished population, of the total fishing effort) is important. This should include a careful consideration of the TIP length data in the context of the other available length frequency information.
- Whether by improving the understanding of life history, and/or by reviewing the available information and parameters and weighting or narrowing these to a more plausible subset, working to reduce the range of mortality estimates is also important.

In addition, monitoring and research to resolve uncertainties around:

- --Stock structure in the context of the three regions considered (whether by genetic testing (expensive), tagging studies (expensive), or considering spawning migration (per RD09) and larval transport data (per RD06), and/or studies of dispersal, mixing and stock structure from similar species elsewhere) (i.e. are we treating the three regions as three separate stocks, to which different stock statuses and hence difference management apply?) and
- --Gear/fleet reconciliation within regions (i.e. what is the extent of overlap of the fishable sizes targeted/captured by the different gear/fleet types? To what extent can the data from each be combined?)

should be prioritized, so that the probabilities of overfishing are useful in a management context. Currently there are six sets of probabilities (3 regions x 2 overfishing threshold reference points), with each gear/fleet considered to contribute equally to the frequency distributions used to determine the probabilities. Ideally, there should be a recommended preferred reference point (that which is more precautionary, in the absence of other information), a better quantitative articulation of the extent to which the information from each gear/fleet contribute to the overall frequencies on which the probabilities of overfishing are based, and an increased confidence of how these should be applied in the context of what is understood about stock structure.

Additional work to determine:

- A suitable reference point corresponding to an overfished stock status
- A target reference point that could underpin management decision/control rules is also recommended.

Against improving the quality of information available into the future, such that alternative approaches may be permitted

- There is no clear indication given as to whether formal logbook reporting is possible (or exists), but it seems that the best means of obtaining uniform catch and effort data on which alternative assessments may be based (e.g. simple production models).

- A reconciliation of the fishery independent approaches should be undertaken with a view to recommending a monitoring program that will optimize the utility of the information obtained. (To what extent would the protocol described in RD01 be sufficient?) Recommendations should be pragmatic given the available resources and capacity.

Meanwhile, I encourage

- --Avoiding tossing out data for the sake of being overly Puritan. Even if time series of CPUE, for example, are not considered of adequate quality to enable a formal stock assessment, the data may be useful in informing simpler, more empirical assessments (e.g. Froese 2004; Dowling et al. 2008; Prince et al. 2012; Edwards et al. 2012; Erisman et al. 2014). At the very least, they give some notion of historical high catches, and size-based catch rates.
- --At least attempting to fit a production model to the two sets of standardized CPUE (AW01; DW04). Even if there proves to be inadequate contrast in the data, the attempt to use it in an assessment would still place emphasis on what is needed from future data collection protocols.

Finally, I strongly encourage that more effort be dedicated to considering approaches to developing ACLs. The Assessment Workshop avoided developing ACLs because the mean length estimator "does not provide these metrics" and "in an ideal scenario, ACLs would be developed from estimates of abundance and sustainable yield". However, the yield-per-recruit/spawner-per-recruit analyses provide F_{MSY} target reference point proxies that could be used in determining an ACL via simulated projections. Second, fisheries arguably do not require "traditional biomass based assessment approaches" in order to set ACLs. Catch time series, triggers (as reference point proxies) or reference points, and empirical decision/harvest control rules can all be used to set an interim ACL (e.g. Dowling et al. 2008; Prince et al. 2012; Dowling et al. 2014).

Provide recommendations on possible ways to improve the SEDAR process.

On the basis of the documents provided, I have the following recommendations:

--Link the Data Workshop Report more closely to the Assessment Workshop Report, so that

- Data are consistently summarized between each report, preferably via a commonly presented summary table
- There is improved clarity on how and whether data are used in the assessment. There is minimal detail regarding data in the Assessment Workshop Report. It would have been useful had the Data Workshop Report indicated whether and how each type/set of available data was used in the assessment, both as a summary sentence at the time of its presentation, and in an overall data summary table.

--Prior to circulating for review, cross--check reports to ensure that report reference lists are complete and that key papers are included as background reading (or at least links provided). Perhaps allowing slightly more time for completion of reports may assist with this.

--As a required part of the Assessment Workshop Report, provide historical context and past precedence for assessments previously undertaken. This was not provided in current reports. If not previous precedent exists, this should be explicitly stated.

Maravelias Recommendations

The following are some general suggestions and recommendations to improve the current status of the fishery.

A. Improve the fishery information management system. The Puerto Rico's fishery has been monitored through the Fisheries Statistics Project (FSP) continuously since 1967. The project aimed to provide fisheries data for the resources in the waters of Puerto Rico and scientific information to support management plans. Despite this FSP initiative, the lack of reliable official fishery statistics is evident and constitutes a considerable handicap for the assessments. It is important to improve the official state authority design, implementation and integration of the system to collect and compile statistical data from the entire national fisheries. This data collection system should ideally cooperate with other authorities e.g. the port authorities, the local customs offices, correspondents in municipalities and communities, villages. The primary objective should be to collect fishery-dependent info: catch, effort, discards, fleet, economic (cost, profit), social (e.g. employment, education) statistics. Following standard and common sampling protocols for all isles, fleets, gears, seasons and strata. Similar data, especially catches, effort, discards, costs and profits, can be collected regularly using onboard sampling, i.e. following the fishers during their fishing trips. This will provide more realistic data that could then be compared with port sampling, intercepts, TIP, logbooks.

B. Basic research could be promoted to study Red Hind biological parameters. This research preferably may include: age, growth, feeding, length/age-at-maturity, and fecundity to provide the fundamental knowledge that will support future assessments.

C. Fishery-independent surveys should be carefully designed and carried out in order to provide scientifically sound information and data to support stock assessment, fishery conservation and management. These ideally should cover the distribution of key species (including Red Hind) in all three studied regions, i.e. Puerto Rico, St Thomas/St John and St Croix. Such scientific surveys will provide abundance and biomass estimates but also additional size distribution, maturity, spawning season and areas, scales or otoliths for age and growth studies, stomach contents, fecundity information and they can target early-life stages and adult parts of the population. In addition a number of auxiliary data can be collected, e.g., oceanographic, seabed substrate, information on essential fish habitat of the species. These fishery-independent surveys will provide complete catch records in the area. Commercial vessels often discard many species and especially small fish (< MLS: minimum landing size), whereas research vessel surveys can provide information on the total species composition and size range available to the gear. The scientific information and data that will be collected will increase long-term economic and social benefits from the fisheries resources in the area. Once established, these surveys should be carried out routinely to support scientific monitoring of the living marine resources (e.g. annually or bi-annually).

D. Following the required provisions of the Magnuson-Stevens Fishery Conservation and Management Act, a number of management reference points for species undergoing overfishing were established by the 2010 Caribbean Annual Catch Limit Amendment 3. The Annual Catch Limit (ACL) is currently the main management tool and US fisheries should aim to specify ACLs and accountability measures, AMs, to prevent ACLs from being exceeded. Fishery-dependent catch, effort and discards statistics are urgently required to follow these provisions. As a first step, catch-based methods can be implemented that require only catch information. Biomass dynamic models can also be applied providing catch and effort data will become available. However, scientific advice to fishery managers needs to be expressed in probabilistic terms to convey uncertainty about the consequences of alternative harvesting policies. One avenue for future stock assessment could be to build informative prior probability distributions (priors) for r, K, q, M, F. Expert knowledge and the available fishery datasets may prove useful in building such priors. Then using a simple biomass dynamic model fitted to catch rate data, a risk assessment approach can be applied to evaluate the potential consequences of alternative ACLs. The benefit for the fishery from a probabilistic modeling method would be that uncertainties would have been considered but also estimates of biological risks of alternative ACL-policy options will be provided. This may serve as a basis for providing precautionary fishery management advice given the high degree of uncertainty.

E. Design and carry out gear selectivity studies aiming to disclose species' selectivity patterns and improve resource exploitation. This coupled with discard estimates from the fleet statistics and onboard scientific sampling will allow the assessment of discard mortality.

F. Improve the effectiveness of external partnerships with fishers, managers, scientists, conservationists, and other interested groups to build a balanced approach to meet common fisheries goals. This will ensure best buy-in of any future management measure.

G. Enforce stringent monitoring, control and surveillance mechanisms to restrict unregulated fishing in spawning aggregations that restrain stock recovery.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 35

U.S. Caribbean Red Hind

SECTION V: Review Report

October 2014

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

Table of Contents

1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 35 Peer Review Process was conducted via a CIE (Center for Independent Experts) Desk Review in lieu of a Panel Review Workshop. Three reviewers were selected by provided the CIE and provided with the assessment report and background materials. Each reviewer conducted a review of the material and produced an independent review report. Those reports are included below.

1.2 TERMS OF REFERENCE

1. Evaluate the data used in the assessment, addressing the following:
   a) Are data decisions made by the DW and AW sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and used consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

4. Evaluate the stock projections, addressing the following:

a) Are the methods consistent with accepted practices and available data?

b) Are the methods appropriate for the assessment model and outputs?

c) Are the results informative and robust, and useful to support inferences of probable future conditions?

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

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

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

- Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
- Provide recommendations on possible ways to improve the SEDAR process.

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

1.3 LIST OF PARTICIPANTS

CIE Reviewers

Massimiliano Cardinale .... CIE Reviewer
Natalie Anne Dowling .... CIE Reviewer
Christos Maravelias .... CIE Reviewer

2. CIE REVIEWER REPORTS

Center for Independent Experts (CIE) independent report of the SEDAR 35 Caribbean red hind assessment desk review

Dr. Massimiliano Cardinale

October 2014

Executive Summary

• This document is the individual CIE Reviewer report of the SEDAR 35 Caribbean red hind assessment conducted during August-September 2014 and provided at the request of the Center for Independent Experts (CIE) (see Attachment A).

• This report solely represents the view of the independent reviewer (Dr. Massimiliano Cardinale).

• The reviewer does not completely agree with all of the findings reported in the SEDAR 35 Caribbean red hind assessment report. Taking into account all available information, the reviewer considers that there is a high probability that Caribbean red hind is subject to overfishing. Findings that are reported in the SEDAR 35 Caribbean red hind assessment report are not necessarily fully repeated in this individual report. This report focuses on clarification of elements contained in the SEDAR 35 Caribbean red hind assessment report (including the Data Workshop Report and the backgrounds documents) and some additional views of the individual reviewer about how available data could have been better explored to derive more robust and alternative estimates of the exploitation rate and stock status of Caribbean red hind.

• The Assessment team addressed all the assigned terms of reference (TORs).

• The reviewer considers that the Assessment team has done a satisfactory job in carrying out the assessment, analysing all available data, modelling uncertainty and providing a full sensitivity analysis of both the data and the models. However, the reviewer considers that data for Caribbean red hind are underutilised and that more could have been done in terms of data analysis in order to derive estimates of exploitation rates and stock status for Caribbean red hind.

• Further recommendations aimed at improving the available data used in the Caribbean red hind assessment were made. These are mainly based on additional re-analysis and modelling of the original data set.

Introduction

SEDAR 35 Caribbean red hind assessment report and associated background documents containing detailed information on the data used in the assessment were provided to the independent reviewer (Dr. Massimiliano Cardinale) well in advance of the deadline scheduled for the 12th of September 2014. The report was reviewed at the request of the Center for Independent Experts (CIE) (see Attachment A).

Description of review activities

This review was undertaken by Dr. Massimiliano Cardinale as desk work during August-September 2014 at the request of the Center for Independent Experts (CIE) (see Attachment A).

Relevant documents (see bibliography, Attachment B) and background information were made available four weeks prior to the deadline through email and via a link to an ftp or SEDAR 35 website (http://www.sefsc.noaa.gov/sedar/Sedar_Documents.jsp?WorkshopNum=35&FolderType=Data). The assessment report was made available four weeks prior the deadline via a link to an ftp or SEDAR 35 website (http://www.sefsc.noaa.gov/sedar/Sedar_Documents.jsp?WorkshopNum=35&FolderType=Assessment). The documentation was reviewed prior to the deadline and the deadline was met. The background information and assessment report of Caribbean red hind was presented through several documents (see Attachment B). Background information relevant to this review is presented in a series of appendices, including: CIE Statement of Work (Attachment A); a bibliography (Attachment B), report format (Annex 1) and Terms of Reference (Annex 2). Comments included here are provided following the terms of reference (TORs) (Annex 2) and are those of the independent reviewer only. The list of main documents provided to the reviewer as background material is included in Attachment B.

Summary of findings

Main recommendations

1. Redefine the effective effort used to estimate CPUE trends in SEDAR35-AW-01 and SEDAR35-DW-04.

2. Redefine the models used to fit the self-reported fisher logbook (SEDAR35-AW-01) and the SEAMAP-C data (SEDAR35-DW-04).

3. Some of the data were underutilised, especially several of the length frequency distributions and some of the CPUE time series presented in SEDAR-RD-05, and should be explored in future assessments.

4. Conduct a statistical age estimation analysis of the total number of Caribbean red hind caught by length class to estimate the number of fish landed per age class for selected combination of areas, gears and years with a sufficient amount of length measurements (i.e. a general rule of thumb would be to use years with more than 150 or 200 individuals measured).

5. Explore different methodologies to derive yearly estimates of total mortality and F_{MSY} from the number of fish landed per length class in order to verify and confront the results obtained by the mean length analysis. A virtual population analysis (VPA) (e.g. VIT software) assuming a steady state (i.e. pseudo-cohort analysis) and combining the different gears could have been used for selected combination of years, areas and gears.

6. Conduct an YPR analysis that takes into account the effect of selectivity at size/age to estimate proxies of F_{MSY}.

7. Use time series of properly standardised CPUE data reported in SEDAR35-RD-05 as quantitative supplementary information of the mean length analysis.

8. The reviewer considers that the probabilities of current F being larger than the F_{MSY} proxy estimated for Puerto Rico, Saint Thomas and Saint John and Saint Croix (i.e. up to 40, 57 and 66%, respectively) are large enough to conclude that the stock of Caribbean red hind is undergoing overfishing in these areas.

9. Given that contrasting information was available for the trend in CPUE of Caribbean red hind, and that the assessment does not provide an estimate of the absolute biomass of the stock, the reviewer is unable to determine with certainty whether the stock of Caribbean red hind is currently overfished. However, the reviewer is of the opinion that more emphasis should be given to the SEAMAP-C time series and that, according to this data source, the stock of Caribbean red hind might be actually overfished.

10. A virtual population analysis (VPA), assuming a steady state (i.e. pseudo-cohort analysis) and combining different gears, should be used for selected combination of years, areas and gears in future assessments of Caribbean red hind.

11. More care should be devoted to the presentation of the results. The presentation of the available data and part of the assessment section is not clear and somewhat incomplete. There are several mistakes, especially in tables and figures, which complicate the evaluation of the assessment report (see details in answer under ToR 1).

ToRs

ToR1: Evaluate the data used in the assessment, addressing the following:

a) Are data decisions made by the Assessment Workshop sound and robust?

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

c) Are data applied properly within the assessment model?

d) Are input data series reliable and sufficient to support the assessment approach?

General comments

I consider the data used within the chosen assessment model (i.e. mean length analysis) as appropriate and uncertainty properly acknowledged and integrated. However, I found the presentation of the available data rather confusing and somewhat incomplete. Also, it is sometimes difficult to understand the link between the different times series presented. In particular, the TIP (Trip Interview Sampling) was used to estimate trends in average length of Caribbean red hind between 1983 and 2012 (in some cases up to 2011, depending on the gear and area), but it is not clear which is the relationship between the TIP and the SEAMAP-C program, which also sampled commercial red hind catches in the same area and during the same period.

Some of the models used to estimate trends in CPUE of the self-reported fisher logbooks data and the SEAMAP-C fisheries independent data could have been specified differently. Further, modelling results of the CPUE data contained in SEDAR35-DW-01 and SEDAR35-DW-04 should have been presented more thoroughly and in further detail.

Some of the available data were underutilised, especially the length frequency distribution and several of the CPUE time series presented in SEDAR RD-05.

Specific comments

Commercial landings data

Landings of Caribbean red hind from Puerto Rico have been adjusted for incomplete reporting using so called expansion factors to estimate the total actual landings. It is however unclear, both from the assessment report and from the background documents, how the expansion factors have been estimated, what is the source of the factors, how large are the factors and if they vary between years and for the different areas and gears. As a minimum, the yearly expansion factor used to estimate the total landings should have been presented in a table of the report.

Fisheries-dependent and fisheries-independent data

SEDAR35 Section II (Data Workshop Report; page 75) states that preliminary analysis of SEAMAP-C fishery independent data indicates a "sparseness of complete catch and effort data for red hind in the USVI area sparseness in the continuity of the time series of the trap data, and a higher variability in the weight data. Therefore, hand-line catch-per-unit-effort (CPUE) data in numbers of rind hind collected off the southwest coast of Puerto Rico was used to develop abundance indices of the red hind population." I can agree with the choice to not use data from USVI for the reasons stated in the document (i.e. SEDAR35-DW-04), but the Assessment team should add one or two figures or tables to substantiate this choice or at least should refer to a document where USVI data are reported. I initially assumed that the underlying data presented in SEDAR35-DW-04 were those reported in SEDAR-RD-05 but after a more careful analysis of both documents, I cannot see a direct correspondence between the data contained in SEDAR-RD-05 and SEDAR35-DW-04. It is indeed unclear what is the relationship between these two different data sets that otherwise seem to be apparently collected in the same area, during approximately the same time and by the same project (SEAMAP-C). Indeed the presentation of the available data is somewhat confusing. I had difficulties to understand the difference between the SEAMAP-C fisheries-dependent data presented in SEDAR-RD-05 and the standardized catch rates presented in SEDAR-AW-01. Moreover, there are complete data series reported in SEDAR RD-05 (e.g. figure 17, page 46), which are not mentioned in the assessment report and were apparently not used.

The standardized catch rates presented in SEDAR AW-01 are defined as self-reported, while time series of CPUE presented in SEDAR-RD-05 are derived from a direct sampling of the commercial catches during SEAMAP-C. This will reinforce the idea that time series reported in SEDAR-RD-05 are a valuable source of information and should be used. Again, the presentation of the available data is somewhat confusing and the choice of some of the data used for the assessment of Caribbean red hind is debatable. The Assessment team gives more relevance to the self-reported catch and effort data time series, while I would be in favour of the SEAMAP-C data due to the uncertainty (e.g. misreporting, discards, imprecision when data are collected by self-sampling) generally associated with self-reported catch data from the fisheries. Interestingly, the Assessment team also defines the self-reported catch and effort data "…of unknown accuracy" but then rely on them for the trend in stock abundance and for inferring on the status of Caribbean red hind. Also, I cannot categorically exclude that I have partially mixed up the time series but the way the data are presented certainly does not help the reader to understand the difference between them.

The effort of the self-reported fisher logbooks is described in total number of hours fished (SEDAR35-AW-01). While number of hours fished might be in theory a good proxy of the effective effort for spearfishing (i.e. although targeting is an issue with spearfishing CPUE data, see also answer under ToR 3), I doubt it reflects the effective effort for the hooks and line fishing and more so for the trap fisheries. From the report, it seems that the number of gears (i.e. traps and hooks) used is available, and thus a more correct way to define the effective effort would be to use the number of hours fished times the number of traps for the fish pots and trap fisheries and the number of hours fished times the number of hooks for the hook and line fisheries.

I do not understand the reason why interaction effects were added as random factor in the model presented in SEDAR35-AW-01. An explanatory line would be beneficial here. It would also be relevant to add the first model for which the reduction in deviance per degrees of freedom is less than 1% in Table 4. More residuals plots should have been presented, as for example the distribution and the autocorrelation of the residuals. Also, the kind of distribution used for the delta models in SEDAR35-DW-04 should be reported, the y-axis in figure 2 of SEDAR35-DW-04 should indicate the unit of measure of the CPUE, and the unit of measure of CPUE should also have been indicated in table 7, 8 and 9 of SEDAR35-AW-01.

In general, the presentation of the results reported in SEDAR35-DW-04 needs to be improved. The distribution of the modelled CPUE and the proportion of positive trips are missing. As for SEDAR35-AW-01, more residuals plots should have been presented as for example the distribution and the autocorrelation of the residuals. As the Assessment team used a backward stepwise approach based on AIC, at least the first model for which the AIC does not decrease should be shown in the table.

Recreational data for Caribbean red hind are also presented but they are too sparse for allowing any kind of analysis. In this context, the reviewer agrees with the evaluation made by the Assessment team.

Data and assessment presentation

I found the presentation of the different data sources and part of the assessment section somewhat incomplete. Here I report a series of issues with the data presentation, which complicated the evaluation of the assessment of Caribbean red hind. A misperception in the data presentation arises when comparing figures of the mean length and model fit presented in Section III (Assessment Workshop Report) with tables reported in Section II (Data workshop report). For example (but this applies also to other combination of gears and areas), I expected that the number of lengths (which I interpret as number of individuals) in Table 5.3.2 of the Section II (Data workshop report) should match the numbers associated with the bubbles in Figure 35 of Section III (Assessment Workshop Report). This is obviously not the case, which makes the evaluation of the effect of the sample size on the analysis problematic.

In figure 5.4.2 of Section II (Data workshop report), it appears that Caribbean red hind specific effort data are available from 2011 while the text states that species-specific landings reporting obligation started in 2012 (Figure 5.4.1).

In Section III (Assessment Workshop Report), table 8 is somewhat confusing as it reports a range of values of k between 0.48 and 0.72, while Table 2.8.2 in Section II and sensitivity analysis figures in the Assessment Workshop report indicate a range of values used for the sensitivity analysis roughly between 0.05 and 0.30.

The text for the diving fleet analysis in Section III (Assessment Workshop Report), reports a total mortality for L_c equal to 370 mm ranging between 0.68 and 1, while the values in Figure 22 are between 0.30 and 0.50.

The lines of the 95% CI in the legend of figure 4, 5 and 6 in SEDAR35-AW-01 are wrong as they should be dashed lines and not thick lines.
The caption in Table 1 in SEDAR35-DW-04 is not correct as it reports data for red snapper collected by long lines in the Gulf of Mexico (or at least it indicates so).

Modelling issues

Depth in SEDAR35-AW-04 model should have been treated as a continuous variable and not as a factor. It is not clear if this was actually the case in the fitted model. Moreover, CPUEs reflect several aggregated cohorts, with the same cohorts contained in successive years. Thus, a smoother would be more suitable here to model the year effect for both models (SEDAR35-AW-01 and SEDAR35-DW-04), although I recognise that missing years in the time series of the SEAMAP-C data (SEDAR35-DW-04) might represent an issue. Finally, the interaction factor between the main effects should have been tested also in the SEDAR35-DW-04 model as done for the SEDAR35-AW-01 model.

The analysis presented in figures 9 and 10 of Section III (Assessment Workshop Report), should be improved and made easier to present if a modelling approach, including other factors than simply a year effect, was used to estimate the changes in depth over time in the SEAMAP-C program.

Recommendations:

- Redefine the effective effort used to estimate CPUE trends in SEDAR35-AW-01 and SEDAR35-DW-04.
- Redefine the models used to fit the self-reported fisher logbook (SEDAR35-AW-01) and the SEAMAP-C data (SEDAR35-DW-04).
- Some of the data were underutilised, especially several of the length frequency distributions and some of the CPUE time series presented in SEDAR-RD-05, and should be explored in future assessments.

ToR2: Evaluate the methods used to assess the stock, taking into account the available data.
a) Are methods scientifically sound and robust?
b) Are assessment models configured properly and used consistent with standard practices?

The methodology (i.e. Gedamke and Hoenig 2006 method also defined as "mean length analysis") used to estimate Z has been applied correctly and I consider it as a robust and appropriate alternative for deriving estimates of exploitation rate given the available data. However, biological sampling showed in general that length frequency distributions of Caribbean red hind were characterized by the presence of several modes. Clearly, the length frequency distributions contain information on the age structure of the population, which are in part underutilized when using the Gedamke and Hoenig 2006 method. Moreover, given the numerous changes in the management of the species during the analysed period (e.g., introduction of closed areas to protect the spawning aggregation in 1996 off the west coast of Puerto Rico) and in the fisheries, differences in catchability between sexes, the influence of the market on the size of Caribbean red hind targeted by the fisheries and many others, the observed changes in average size of the catches might not be simply an effect of changes in total mortality but could be an artefact of changes in fishing practices and fishing selectivity linked to modifications in management regulations. In this case, other approaches should have been used in conjunction with the Gedamke and Hoenig (2006) method to derive alternative estimates of exploitation rate for Caribbean red hind and allow for comparison.

For several combinations of areas, gear and years, the data are sufficient to estimate the yearly total number of fish caught by length class for the different areas and gears. A method defined as statistical age estimation (beside the more simple knife-edge slicing method, which can be also used here) has recently been developed (see Kell and Kell, 2011; Scott et al., 2011) to generate age structured data from length frequency distribution (LFD) data and VBF growth curve parameters to be used in stock assessment (e.g., ICES 2014). The method is very flexible and offers a sophisticated framework for converting numbers at length to numbers at age as well as estimating the mean length at age of the different cohorts by assuming different distributions of the length data (i.e. Gaussian, gamma and lognormal).

Age data derived by the slicing methods (i.e. knife-edge slicing and statistical slicing) can be used to derive estimates of total mortality using VIT software (Lleonart & Salat, 2000), which can also be used when a single year of LFD and growth parameters are available. The method is extensively used in similar data situation as for several Mediterranean stocks (e.g. STECF 2012) and stocks in the North East Atlantic (e.g. ICES 2014). VIT conducts a virtual population analysis (VPA) assuming a steady state (also known as pseudo-cohort analysis). This is a rather strong assumption for species, like small pelagics, with highly fluctuating abundance due to both variable recruitment and relatively low number of age classes, but it is a much more supported assumption for demersal fish such as Caribbean red hind for which the population is made up by several age classes. As it requires knowledge of the catches over one year only (Lleonart & Salat, 2000) it might be used for years, areas and species for which the data allows for such an analysis. In addition to the above mentioned data, VIT requires a set of biological information such as growth parameters, length-weight relationship, natural mortalities and percentage mature by size or age, and proportions caught by each fishing gear (when available but not strictly necessary). Such information is available for Caribbean red hind and is reported in SEDAR35 documents.

The use of a pseudo-cohort analysis would allow obtaining an alternative and possibly more robust estimate of Z (and F assuming that M is known) from the same data and also to compare Z estimated with VIT against those derived using Gedamke and Hoenig (2006) method. Another feature of the VIT is that it allows for the combination of different gears within the same model, which would also allow estimating partial F for the different gears, an important piece of information from a management perspective. Therefore, I consider that VIT estimates of F would be crucial to better evaluate the results obtained from the Gedamke and Hoenig (2006) method.

I also consider that the mean length analysis does not explicitly account for selectivity, which has a large impact on estimates of F and F_{MSY}. The use of VIT would also allow for conducting a yield per recruit (YPR) analysis and derive estimates of F_{MSY} (using $F_{30\%}$ and $F_{40\%}$ as a proxy), taking into account selectivity at size/age. A YPR analysis based on selected yearly catch at age data from collected length frequency distributions would be a valuable piece of information to verify estimates of F and F_{MSY} obtained from the mean length analysis. It can be argued that for several years, sample size of Caribbean red hind is too low to conduct such kind of analysis. However, this also applies to the estimation of the average length used in the Gedamke and Hoenig (2006) method and constitutes a further argument for combining different approaches to estimate Z. It would also allow for a more thorough utilisation of the available data, especially for those years for which a large number of individual length data are available.

In general, I consider that the reader is left with the doubt that much more could have been done with the same kind of data and that the Assessment team should have at least explored the possibility of using different methodologies to derive alternative estimates of exploitation rates and F_{MSY} than those obtained using the Gedamke and Hoenig (2006) method. The same concerns were expressed by the reviewer in a previous evaluation (February 2013) of two other commercial species caught in the same area (i.e. Caribbean queen triggerfish and Caribbean blue tang) but apparently they were not considered by the Assessment team for the Caribbean red hind stock.

Recommendations:

- Conduct a statistical age estimation analysis (e.g. knife-edge slicing and/or statistical slicing sensu Scott et al., 2011) of the total number of Caribbean red hind caught by length class to estimate the number of fish landed per age class for selected combination of areas, gear and years with sufficient amounts of length measurements (a general rule of thumb would be to use years with more than 150 or 200 individuals measured).

- Explore different methodologies to derive estimates of total mortality from the estimated number of fish landed per age class in order to verify and confront the results obtained by the mean length analysis. A virtual population analysis (VPA) (e.g.

VIT software) assuming a steady state and combining the different gears should have been used for selected combination of years, areas and gears.

- Conduct an YPR analysis to estimate proxies of F_{MSY} that takes into account the effect of selectivity at age.

- Use time series of appropriately standardised CPUE data reported in SEDAR35-RD-05 as quantitative supplementary information for the mean length analysis.

ToR3: Evaluate the assessment findings with respect to the following:

a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
b) Is the stock overfished? What information helps you reach this conclusion?
c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

I consider that estimates of exploitation rates of Caribbean red hind are consistent with the input data and assessment model (i.e. Gedamke and Hoenig 2006 method) used by the Assessment team but that the Assessment team should have explored also different methodologies to derive estimates of total mortality and proxies of F_{MSY} (see details in the answer given for ToR2). I also consider that, due to the effect of the numerous changes that occurred in the fisheries and in the management of the species during the analysed period (see answer in Tor1 for details), observed changes in average length of the catches might be in part an artefact of changes in fishing practices linked to modifications in management regulations more than a direct effect of fishing mortality. In this case, a different methodology to estimate trends in F would be necessary. Moreover, the use of CPUE estimated from self-reported fisheries-dependent data in the case of a changing fishery is contradictory and, in this specific situation, the reviewer considers that more emphasis should have been given to the SEAMAP-C data.

The reviewer also considers that a probability up to 40% of Caribbean red hind in Puerto Rico being currently overfished cannot be considered low (i.e. as stated in the Section III Assessment Workshop Report). Also, the reviewer considers that estimated probabilities for Saint Thomas and Saint John and Saint Croix (i.e. up to 57 and 66%, respectively) are large enough to conclude that the stock of Caribbean red hind is undergoing overfishing in these areas.

The shift from traps and pots and vertical lines to spearfishing is alarming, as this kind of fishery has generally a much higher efficiency than the traps and pots and/or the hook and vertical lines fisheries for species as Caribbean red hind. Most importantly, spearfishing has an inherently technological creep linked to targeting, which implies that CPUE might suffer from the hyper-aggregation phenomenon. Contrasting information was available for the trend in CPUE of Caribbean red hind. SEDAR35-DW-04 reported a large decline in CPUE, based on the SEAMAP-C data, while self-reported fisher logbook data presented in SEDAR-AW-01 shows a rather stable trend with a tendency to increase in the last years of the time series. On the other hand, several time series reported in SEDAR35-RD-05 (i.e. figures 5, 6, 7, 8, 16, 17 and 21) show a large decline in CPUE. The Assessment team gave more relevance to the self-reported catch and effort data time series (i.e. SEDAR-AW-01), while I would be in favour of the SEAMAP-C data due to the uncertainty (e.g. misreporting, discards, etc.) generally associated with self-reported catch data from fisheries. As hypothesized by Marshak in SEDAR35-RD-05, an increase in the mean length of the population could also be the results of failure in recruitment. The mean length analysis alone is unable to distinguish this scenario from a more optimistic situation where the mean size increases as fishing mortality declines. Therefore, given the considerations presented above, a different methodology should have bene applied to the data to verify and confront the results obtained by the mean length analysis.

Recommendations

- The reviewer considers that estimated probabilities of current F being larger than proxy of F_{MSY} for Puerto Rico, Saint Thomas and Saint John and Saint Croix (i.e. up to 40, 57 and 66%, respectively) are large enough to conclude that the stock of Caribbean red hind is undergoing overfishing in these areas.
- Given that contrasting information was available for the trend in CPUE of Caribbean red hind, and that the assessment does not provide an estimate of the absolute biomass of the stock, the reviewer is unable to determine with certainty whether the stock of Caribbean red hind is currently overfished. However, the reviewer is of the opinion that more emphasis should have been given to the SEAMAP-C time series and that, according to this data, the stock of red hind might be actually overfished.

ToR 4: Evaluate the stock projections, addressing the following:
a) Are the methods consistent with accepted practices and available data?
b) Are the methods appropriate for the assessment model and outputs?
c) Are the results informative and robust, and useful to support inferences of probable future conditions?
d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Tor4 deals with the stock projections, which were not carried out by the assessment team due to data restrictions.

Recommendations

None

ToR 5: Consider how uncertainties in the assessment, and their potential consequences, are addressed.
a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
b) Ensure that the implications of uncertainty in technical conclusions are clearly stated

As the Assessment team correctly pointed out, the keys parameters for the method currently used to assess Caribbean red hind are the von Bertalanffy growth curve parameters and the L_c, which are used to estimate M and F (and proxies of F_{MSY}). The reviewer agrees with the evaluation made by the Assessment team and the treatment of the uncertainty in the key parameters of the mean length analysis. Also, the probabilistic way of analysing the occurrence of overfishing is adequate and generally nicely presented.

A minor issue was found in Section III (Assessment Workshop Report). It is unclear from the current text how the L_c values used in the sensitivity analysis and in the evaluation of the uncertainty were selected by visual inspection. I consider that it would have been more appropriate to conduct a sensitivity analysis on the effect of the L_c values based on the CI of the average length mode estimated for each gear and reported in Figure 14, 15 and 16.

Recommendations

None

ToR 6: Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

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

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

The Assessment team provides an exhaustive list for future data to be collected, which would notably improve the capability of assessing the status of the Caribbean red hind stock. However, I consider that the description of the additional research and future monitoring is not exhaustively presented and it could have been much more detailed and comprehensive.

The reviewer agrees with the Assessment team that priority should be to given to derive data which allows movement towards more traditional assessment approaches. However, the reviewer also considers that this could in part already be pursued by the Assessment team using other methods than the mean length analysis (see ToR 2 and ToR 3).

Recommendations

- A virtual population analysis (VPA), assuming a steady state and combining different gears, should be used for selected combination of years, areas and gears in a future assessment of Caribbean red hind.

ToR 7: Provide guidance on key improvements in data or modelling approaches which should be considered when scheduling the next assessment.

See comments under ToR 2 and 3.

Recommendations

- See recommendations under ToR 2 and 3.

Others

More care should have been devoted to the presentation of the results. The presentation of the available data and part of the assessment section is rather confusing and often incomplete. There are several mistakes, especially in tables and figures, which complicate the evaluation of the assessment report (see details in answer under ToR 1).

Conclusions

The Assessment team should be commended for their effort, timing and correctness in the use of the assessment methodologies. However, I consider that some of the available data are underutilised and that the report suffers sometime from the inaccuracy in the way the data, the methods and the results are presented. Also, the lack of alternative estimates of Z beside these coming from the Gedamke and Hoenig (2006) method makes it difficult to fully evaluate the results. A series of recommendations on how the data utilisation could be improved and how alternative estimates of the exploitation rates could have been produced have been given under the specific ToRs. Nevertheless, the reviewer considers that, given the available information, the Caribbean red hind stock in Puerto Rico, Saint Thomas and Saint John and Saint Croix should be considered as subject to overfishing. Instead, given that contrasting information was available for the trend in CPUE of Caribbean red hind, and that the assessment does not provide an estimate of the absolute biomass of the stock, the reviewer is unable to determine with certainty whether the stock of Caribbean red hind is currently overfished. However, the reviewer is of the opinion that more emphasis should have been given to the SEAMAP-C time series and that, according to these data, the stock of Caribbean red hind might be overfished. Finally, the reviewer considers that a virtual population analysis (VPA), assuming a steady state (i.e. pseudo-cohort analysis) and combining different gears, should be used for selected combination of years, areas and gears in a future assessment of the Caribbean red hind stock in Puerto Rico, Saint Thomas and Saint John and Saint Croix.

Basic data and model framework were presented through documents and circulated well in advance of the review. The presence of a *Glossary* and an *Acronyms* list at the end of the document greatly facilitated the reading of the report and was greatly appreciated by the reviewer.

Reference list

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Lleonart, J. and Salat, J., 2000. VIT (version 1. 1): Software for fishery analysis. User's manual. On line: http//www.faocopemed.org/es/activ/infodif/vit.htm.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Assessment of Mediterranean Sea stocks – part 1 (STECF 12-19). (eds. Cardinale M. (Chairman) Osio C. & Charef A.). 2012. Publications Office of the European Union, Luxembourg, EUR 25602 EN, JRC 76735, 502 pp.

Scott F, Osio G, Cardinale M 2011. Comparison of age slicing methods - Working Document in support to the STECF Expert Working Group 11-12 Assessment of Mediterranean Sea stocks - part II. EUR 25054 EN. Luxembourg.

Appendix A: List of main documents provided as background material

SEDAR 35
Caribbean Red Hind
Workshop Document List

Document #	Title	Authors	Date Submitted
Documents Prepared for the Data Workshop			
SEDAR35-DW-01	Monitoring of Commercially Exploited Fisheries Resources in Puerto Rico	Aida Rosario Jimenez	20 Sept 2013
SEDAR35-DW-02	Reef Fish Monitoring	Aida Rosario Jiménez, Verónica Seda Matos, and Noemí Peña-Alvarado	20 Sept 2013
SEDAR35-DW-03	Red hind data from Puerto Rico	Michelle Scharer, Michael Nemeth and Daniel Matos	3 March 2014
SEDAR35-DW-04	Abundance Indices of Red Hind Collected in Caribbean SEAMAP Surveys from Southwest Puerto Rico	G. Walter Ingram, Jr.	13 May 2014
Documents Prepared for the Assessment Process			
SEDAR35-AW-01	Standardized Catch Rates for Red Hind from the Commercial Diving, Trap, and Vertical Line Fisheries in Puerto Rico	Adyan Rios	8 August 2014
Final Stock Assessment Reports			
SEDAR35-SAR1	Caribbean Red Hind		
Reference Documents			
SEDAR35-RD01	A Cooperative Multiagency Reef Fish Monitoring Protocol for the U.S. Virgin Islands Coral Reef Ecosystem, v. 1.00	David R. Bryan, Andrea J. Atkinson, Jerald S. Ault, Marilyn E. Brandt, James A. Bohnsack, Michael W. Feeley, Matt E. Patterson, Ben I. Ruttenberg, Steven G. Smith, Brian D. Witcher	
SEDAR35-RD02	Fishery independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puerto Rican EEZ	Jorge R. García-Sais, Jorge Sabater-Clavell, Rene Esteves, Milton Carlo	
SEDAR35-RD03	Portrait of the commercial fishery of	Daniel Matos-Caraballo	

	red hind, *Epinephelus guttatus*, in Puerto Rico during 1992-1999	
SEDAR35-RD04	Portrait of the commercial fishery of red hind, *Epinephelus guttatus*, in Puerto Rico during 1988-2001	Daniel Matos-Caraballo, Milagros Cartagena-Haddock, and Noemi Pena-Alvarado
SEDAR35-RD05	Evaluation of seasonal closures of red hind, *Epinephelus guttatus* (Pisces: Serranidae), spawning aggregations to fishing off the west coast of Puerto Rico, using fishery-dependent and independent time series data	Anthony Robert Marshak
SEDAR35-RD06	Description of larval development of the red hind *Epinephelus guttatus*, and the spatio-temporal distributions of ichthyoplankton during a red hind spawning aggregations off La Parguera, Puerto Rico	Edgardo Ojeda Serrano
SEDAR35-RD07	Brief Summary of SEAMAP Data Collected in the Caribbean Sea from 1975 to 2002	G. Walter Ingram, Jr.
SEDAR35-RD08	Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection	Richard S. Nemeth
SEDAR35-RD09	Spatial and temporal patterns of movement and migration at spawning aggregations of red hind, *Epinephelus guttatus*, in the U.S. Virgin Islands	Richard S. Nemeth, Jeremiah Blondeau, Steve Herzlieb, and Elizabeth Kadison

Appendix B: Statement of Work for Dr. Massimiliano Cardinale

External Independent Peer Review by the Center for Independent Experts

SEDAR 35 Caribbean red hind assessment review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: SEDAR 35 will be a compilation of data, benchmark assessments of the stocks, and an assessment review conducted for Caribbean red hind. The review is responsible for ensuring that the best possible assessment is provided through the SEDAR process and will provide guidance to the SEFSC to aid in their review and determination of best available science, and when determining if the assessment is useful for management. The stocks assessed through SEDAR 35 are within the jurisdiction of the Caribbean Fishery Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Experience with data-limited assessment methods is desirable. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project

Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs cannot be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than September 12, 2014, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

4 August 2014	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
18 August 2014	NMFS Project Contact sends the CIE Reviewers the report and background documents
25 August through 12 September 2014	Each reviewer conducts an independent peer review as a desk review
12 September 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
26 September 2014	CIE submits the CIE independent peer review reports to the COTR
30 September 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

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Support Personnel:

Allen Shimada
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
Allen Shimada@noaa.gov Phone: 301-427-8174

William Michaels
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
mshivlani@ntvifederal.com Phone: 305-968-7136

Key Personnel:

NMFS Project Contact:

Julie A. Neer, SEDAR Coordinator
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405
Julie.Neer@safmc.net Phone: 843-571-4366

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed. The CIE independent report shall be an independent peer review of each ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: List of main documents provided as background material for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 35 Caribbean red hind assessment review

1. Evaluate the data used in the assessment, addressing the following:
   a) Are data decisions made by the Assessment Workshop sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and used consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?
   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
   a) Are the methods consistent with accepted practices and available data?
   b) Are the methods appropriate for the assessment model and outputs?
   c) Are the results informative and robust, and useful to support inferences of probable future conditions?
   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods

- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.

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

CENTER FOR INDEPENDENT EXPERTS (CIE) INDEPENDENT PEER REVIEW REPORT

SEDAR 35 STOCK ASSESSMENT REPORT: U.S. CARIBBEAN RED HIND

Natalie Anne Dowling, Ph.D.

OCTOBER 2014

CONTENTS:

EXECUTIVE SUMMARY

This report comprises an impartial and independent peer review of the SEDAR 35 stock assessment undertaken for Caribbean Red Hind, a grouper species. The assessment focuses on three locations: Puerto Rico, and St Thomas/St John and St Croix in the U.S. Virgin Islands.

The Assessment Workshop Report is the third of three sections of the SEDAR 35 report. The other two sections comprise an Introduction and the Data Workshop Report. There was minimal cross-referencing or linkage between the report sections. The management history of the fishery provided in the Introduction is barely mentioned in the subsequent sections.

There is no mention of previous stock assessments having been undertaken for this species, whether in these or other regions, and as such, no notion of past precedence.

There was no attempt to define the assumed stock structure for purposes of the assessment. At a minimum, a consideration of the area covered by the analyses, versus the potential of the species for movement and mixing (per RD09), would have been useful. The lack of specification of stock structure assumptions also brings into question the reliability of spawner-per-recruit based reference points.

There is a range of historical fishery dependent and independent data available for the fishery, including several time series of catch rates, for which two CPUE standardisations were attempted in order to obtain proxy abundance indices. These were considered to be inappropriate for use in a formal stock assessment, and were considered only briefly and in a qualitative sense in the Discussion section of the report. Most of the other data was short-term or temporally patchy, and/or associated with low sample sizes.

There was little attempt to compare or reconcile data from different gear/fleets, different regions and sectors (i.e. commercial, recreational, survey), nor to consider time series in the context of the management history (i.e. significant changes in management that may have affected observed trends).

- It would have been highly useful to have seen the extent to which trends were consistent across these categories.
- At a minimum, it would have been useful to have seen time series of mean length presented for all available length information, as this is what was used in the assessment. Ideally, such comparisons should have been made for the available catch, CPUE and survey abundance information, also. As it stands, it is very difficult to grasp the overall picture: Are things different in a different area and/or under a different gear/survey protocol? Or a different sector (commercial/recreational/independent survey)? Or for a different data set in the same area?

The Caribbean Red Hind Assessment Workshop focused on using length frequency data obtained from a port-sampling data collection program, termed the Trip Interview Program, to obtain estimates of total mortality via a mean-length estimator. A simple mean-length estimator was fitted to the most temporally consistent source of length data to obtain estimates of total mortality. Fishing mortalities were obtained by subtracting estimated natural mortality, and compared to overfishing reference points derived from standard spawner-biomass-per-recruit estimates. There were two Fmsy proxy reference points, and therefore six separate probabilities of overfishing (two for each of three regions) were calculated.

These methodologies appear sound and consistent with the best available assessment approaches based on length data. The mean-length estimator is a current acknowledged approach for estimating total mortality from length distribution data. It does not assume equilibrium population dynamics. It appears to have been properly configured and used consistent with standard practices (e.g. Edwards et al. 2012; Erisman et al. 2014).

The following should be noted:

- The assumptions of constant recruitment and mortality associated with the mean-length estimator, are not given consideration. The history of the fishery should be acknowledged in this context.
- Knife-edged vulnerability was assumed for the per-recruit analyses, but not considered in terms of the data.
- The definition of size-at-recruitment to the fishery, Lc, was vague.
- Very little detail was provided on the derivation of natural mortality estimates.
- Sources of uncertainty in the assessment methods were not investigated quantitatively. Temporal inconsistencies in terms of sampling size were mentioned throughout the report, together with their possible impact on length distributions, but there was no direct suggestion as to how to reconcile these.
- It is mentioned that the size of fish in the USVI may be market driven for plate size, suggesting that the selectivity may be dome shaped, which is in violation of the assumption of knife-edged selectivity in the mean-length estimator. Expanding the mean-length estimator to accommodate other selectivity patterns should be undertaken.

A sensitivity analysis was undertaken by fitting mortalities under a range of combinations of life history parameters and length of first capture. Beyond the suite of sensitivity scenarios, and providing resultant probabilities of overfishing, the report did not critically review or evaluate its approach, or consider its findings in a managerial context (as per Assessment Workshop TOR 7).

The technical conclusions are three sets of probabilities of overfishing. These have been presented with no implications of uncertainty, or (with the exception of recommending studies on basic life history) recommendations regarding narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing. Specifically, the implications of:

- the breadth of the ranges of Z (and hence the uncertainty in stock status) in terms of the efficacy of the overfishing probabilities in a management context
- having separate sets of probabilities for each of the three regions, without specifying what is assumed about stock structure

- the equal consideration/contribution of all sensitivity runs in calculating the probabilities of overfishing
- the lack of recommendation regarding the preferred choice of overfishing reference point

are not explicitly considered.

Against the current assessment approach, the outcomes for each gear/fleet should be reconciled within regions (i.e. what is the extent of overlap of the fishable sizes targeted/captured by the different gear/fleet types? To what extent can the data from each be combined?), so that the probabilities of overfishing are useful in a management context. Currently each gear/fleet is considered to contribute equally to the frequency distributions used to determine the probabilities. Ideally, there should be a better quantitative articulation of the extent to which the information from each gear/fleet contribute to the overall frequencies on which the probabilities of overfishing are based. Additionally, the assessment results showed variation in Z estimates and temporal trends between gear/fleet types at the same location. The obvious response would be to consider whether this is due to differences in selectivity, whereby the different fleets/gears are targeting different sizes of the stock.

It appears that the Workshop participants undertook the assessment on the basis that the approach was appropriate for the best available data source, and simply reported on this and its outcomes. While the assessment approach may be the best scientific information available, the report provides little more than the technical details and a brief consideration of the outcomes.

My remaining concerns with the Assessment Workshop Report are summarized as follows:

- The presentation of available data across the three sections of the SEDAR-35 report was difficult to navigate, both within and between reports. A simple summary table of the available information (source, location, type of data, fishery in/dependent, time series, and indicating what was provided to the Assessment Group, and what was actually used) allowing for ready comparison would have been highly useful.
- Prior to circulating for review, reports should be cross-checked to ensure that report reference lists are complete and that key papers are included as background reading (or at least links provided).
- Generally, the data decisions appear sound and robust, but, particularly where data have been excluded, these could have been better justified. I also recommend not being overly hasty in discarding data. Even if time series of CPUE, for example, are not considered of adequate quality to enable a formal stock assessment, the data may be useful in informing simpler, more empirical assessments (e.g. Froese 2004; Dowling et al. 2008; Prince et al. 2012; Edwards et al. 2012; Erisman et al. 2014). At the very least, they give some notion of historical high catches, and size-based catch rates.
    - With the exception of the direct comparison of TIP length data and SEAMAP-C length data, there was little effort made to reconcile i) the TIP data across the different locations and gear/fleet types, let alone across ii) the various sources of length data, or iii) the other available data. As a minimum, some

qualitative consideration of how the TIP estimates of mean length and Lc vary between gear types and location, and what this may mean for the interpretation of stock status, would have been highly useful.

  - Alternatively, a clear justification of why stock status estimates will differ according to gear type and location, and why this is acceptable in the context of using these for management purposes, could have been provided.
  - Reviewing the TIP length data for representativeness (temporally, spatially, of the size structure of the total fished population, of the total fishing effort) is important. This should include a careful consideration of the TIP length data in the context of the other available length frequency information.

- No alternative assessment approaches were reviewed or considered. I recommend attempting to reconcile length-based methods with production models and/or other assessment approaches, either via a review of approaches, attempting to fit a production model to existing CPUE time series, and/or or better justifying the current approach. Even acknowledging the supposed problems with the two standardized CPUE indices (AW01; DW04), and the St Thomas spawning aggregation density time series, it still would have been of interest to have at least attempted to have fitted a simple production model to these.

- There was no estimated reference point corresponding to a threshold for an overfished state of the stock (however "stock" is defined), nor justification for the lack of this. Limit reference points often correspond to 20% of unfished biomass, B_0, so a crude approximation could be made that the probability of being overfished equates to the probability that $F_{cur} > F_{SPR20\%}$.

- The probabilities of overfishing were determined from frequency distributions that embraced a large range of possible fishing mortalities. Whether by improving the understanding of life history, and/or by reviewing the available information and parameters, weighting or narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing should be a key priority for future assessments.

- The same concerns regarding the large range of values of Z apply to the large range in the estimates of $F_{30\%}$ and $F_{40\%}$ (per Figures 39-41). There should be a recommended preferred reference point (that which is more precautionary, in the absence of other information).

- The report concluded that it was unlikely that overfishing was occurring for Caribbean red hind in Puerto Rico, despite probabilities of 25% and 40%. This conclusion is highly subjective and lacks direct justification.

- The probabilities of overfishing according to the $F_{30\%}$ and $F_{40\%}$ proxies for F_{msy}, are, I believe, high enough to be of concern that overfishing is indeed occurring, particularly for St Thomas/St John and St Croix, where the lowest probability is 42%. There is no discussion of a minimum reference probability above which some decision rule is invoked or further investigation is required, but even the lowest probability of overfishing of 25% for Puerto Rico should warrant some attention.

- The interpretation of the results relative to the other sources of available input data (as per the Assessment Workshop Report's Discussion section) is questionable in various ways.
- It was stated that the mean length estimator approach does not include projections of stock dynamics, and that these were therefore not conducted. There exists adequate life history and catch information that a simulation-based management strategy evaluation (MSE) model could have been developed, incorporating a length-based assessment. A simulation-based MSE could be developed, to facilitate projections and undertake a risk analysis by applying decision rules according to the probabilities of overfishing, and thus determine the relative importance of resolving the range of mortalities contributing to these probabilities.
- The Assessment Workshop argues that the mean length estimator approach precludes the setting of ACLs. However, direct estimates of abundance and sustainable yield are not required to set a recommended ACL. I strongly encourage that more effort be dedicated to considering approaches to developing ACLs. Catch time series, triggers (as reference point proxies) or reference points, and empirical decision/harvest control rules can all be used to set an interim ACL.

BACKGROUND

This report comprises an impartial and independent peer review of the SEDAR 35 stock assessment undertaken for Caribbean Red Hind, a grouper species. The assessment focuses on three locations: Puerto Rico, and St Thomas/St John and St Croix in the U.S. Virgin Islands.

The Assessment Workshop Report is the third of three sections of the SEDAR 35 report; the other two sections comprise an Introduction and the Data Workshop Report. There was minimal cross-referencing or linkage between the report sections. The management history of the fishery provided in the Introduction is scarcely mentioned in the subsequent sections.

There is no mention of previous stock assessments having been undertaken for this species, whether in these or other regions, and as such, no notion of past precedence.

There is also no indication of assumptions regarding stock structure.

There is a range of historical fishery dependent and independent data available for the fishery, including several time series of catch rates, for which two CPUE standardisations were attempted in order to obtain proxy abundance indices. These were considered to be inappropriate for use in a formal stock assessment, and were considered only briefly and in a qualitative sense in the Discussion section of the report. Most of the other data was short-term or temporally patchy, and/or associated with low sample sizes.

There was little attempt to compare or reconcile data from different gear/fleet sectors and different regions, nor to consider time series in the context of the management history (i.e. significant changes in management that may have affected observed trends).

The assessment approach focused on using length frequency data obtained from a port-sampling data collection program, termed the Trip Interview Program, to obtain estimates of total mortality via a mean-length estimator. Fishing mortalities were obtained by subtracting estimated natural mortality, and compared to overfishing reference points derived from spawner-biomass-per-recruit estimates. A sensitivity analysis was undertaken by fitting mortalities under a range of combinations of life history parameters and length of first capture.

These methodologies appear sound and consistent with the best available assessment approaches based on length data.

No alternative assessment approaches were reviewed or considered.

The outcomes equate to six values for the probability of overfishing occurring, with two values (each corresponding to an alternative threshold reference point) for each of the three locations. There was no estimate corresponding to whether the stock (however this is defined) is overfished. There was no attempt to reconcile the outcomes between areas and between gear/fleet types – the latter are assumed to contribute equally to the overall frequency distribution from which the overfishing probability was derived.

The probabilities were determined from frequency distributions that embraced a large range of possible fishing mortalities. Narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing should be a key priority for future assessments.

The report concluded that it was unlikely that overfishing was occurring for Caribbean red hind in Puerto Rico, despite probabilities of 25% and 40%. This conclusion was apparently based upon the fact that a proxy abundance index time series (DW04) supposedly contradicts the mean length results in suggesting an increase in F for the vertical line fleet, and upon the fact that the results from mean length analyses suggested conflicting dynamics between the fleets, in terms of temporal trends in predicted Z. Neither of these justify a “no overfishing” conclusion.

The probabilities of overfishing according to the $F_{30\%}$ and $F_{40\%}$ proxies for F_{msy}, are, I believe, high enough to be of concern that overfishing is indeed occurring, particularly for St Thomas/St John and St Croix, where the lowest probability is 42%. There is no discussion of a minimum reference probability above which some decision rule is invoked or further investigation is required, but even the lowest probability of overfishing of 25% for Puerto Rico should warrant some attention. This is regardless of the temporal trends in Z predicted by the mean length estimators. While low sample sizes were a problem, particularly for the USVI regions, this should be even more reason to respond in a precautionary manner, to probabilities of overfishing that are already high.

It was stated that the mean length estimator approach does not include projections of stock dynamics, and that these were therefore not conducted. There exists, however, adequate life history information to have developed a simulation-based management strategy evaluation model that would have enabled stock projections to have been modelled. This would also have provided a framework via which to evaluate and establish target reference points and ACLs.

DESCRIPTION OF THE INDIVIDUAL REVIEWER'S ROLE IN THE REVIEW ACTITIVIES

I was approached by the Center for Independent Experts (CIE), following a recommendation from colleague, Dr. Ana Parma from the Centro Nacional Patagónico of Argentina.

My background is in management strategy evaluation (MSE) and the development of formal harvest strategies (monitoring, assessment, decision/harvest control rules) for data-poor species and fisheries. I was project officer on the development of the Australian Commonwealth Harvest Strategy Guidelines and led the development, finalisation and implementation of harvest strategies for all Commonwealth data-poor stocks. I subsequently secured and led two contracts for the FAO developing guidelines for harvest strategy development in data-poor contexts.

While the majority of my work is not focused on stock assessments per se, via my extensive experience with data poor harvest strategies, I have a strong awareness of the ranges of assessment approaches and options available in a data poor context.

I have never been actively involved in assessments of red hind or other grouper species either in the Caribbean or elsewhere.

SUMMARY OF FINDINGS FOR EACH TERM OF REFERENCE

Annex 2: Terms of Reference for the Peer Review

SEDAR 35 Caribbean Red Hind Assessment Desk Review

NB lack of page numbering in the assessment report will make referencing difficult.

1. **Evaluate the data used in the assessment, addressing the following:**
   a) **Are data decisions made by the Assessment Workshop sound and robust?**

Generally, the data decisions do appear sounds and robust, but, particularly where data have been excluded, could have been better justified. There were numerous available time series of standardized catch rates, fishery independent survey abundances, and catch, which were not used directly in the formal assessment, yet the rationale behind this decision was not discussed in detail.

A typical example is where the fishery independent St Thomas spawning aggregation data have been described, and maximum densities used to obtain an index of spawning abundance. The report states, "given the caveats…that have been highlighted in this section, the resulting density estimates should be used as ancillary qualitative information, rather than be incorporated into a quantitative stock assessment model". Yet, the caveats mostly pertained to the use of mean rather than maximum density.

Similarly, the SEAMAP-C time series of standardized CPUE proxy abundance indices (per SEDAR35-DW-04) were referred to briefly, but the main focus of the SEAMAP-C data discussion pertained to the length data. The rationale for the standardized CPUE time series not being uptaken was not provided.

Better justification was provided for the decision not to use the fishery-dependent CPUE-based abundance indices developed for Puerto Rico (SEDAR35-AW-01) ("…based on self-reported data of unknown accuracy"), but the argument that the indices are based on landings only and therefore should be excluded partially on this basis does not seem to make sense: all CPUE indices are based on landings. I also disagree with the conclusion that these indices showed "no overall directional trends in CPUE" – I feel that the lack of detectable trends is a result of the scale of the y-axis that was chosen to include the broad confidence interval values.

The rationale for excluding the St Croix spawning aggregation data and the Mona Island and Abrir la Sierra, Puerto Rico spawning aggregation data are sound, but the potential of the latter should have been noted explicitly.

Moreover, even acknowledging the supposed problems with the two standardized CPUE indices, and the St Thomas spawning aggregation density time series, it still would have been of interest to have at least attempted to have fitted a simple production model to these. This is of especial relevance given that the mean length methods used do not enable projections of stock dynamics. Even if the abundance indices are unreliable and/or there was inadequate contrast to enable a production model to be fitted, the attempt to have done so would have flagged more strongly the potential value of collecting robust CPUE and/or density information.

The updating of the several data sources as per point 1 of the Assessment Workshop Terms of References appears appropriate and thorough.

More generally, I found the presentation of available data across the three sections of the SEDAR-35 report highly difficult to navigate, both within and between reports. A simple summary table of the available information (source, location, type of data, fishery in/dependent, time series, and indicating what was provided to the Assessment Group, and what was actually used) allowing for ready comparison would have been highly useful (in fact, in order to help try to grasp the data landscape, I undertook this task myself).

It would also have been helpful had the order and groupings of the presentation of data been consistent between the Data Workshop Report and the Assessment Workshop report. Links to working papers and reference documents were not always made explicitly (e.g. the "St Croix trap study" cites Bryan et al. (2013) which is presumably RD01 (yet RD01 states that it describes a protocol for belt visual surveys, so the reader is left confused – particularly as this reference [along with many others] is not listed in the reference list of the report).

Of greater concern was that there was very little effort made across both reports to attempt to reconcile in any detail the data trends and inferences between gear/effort types, location and sector (i.e. commercial, recreational, survey). This applies both within and between data types. It would have been highly useful to have seen the extent to which trends were consistent across these categories.

At a minimum, it would have been useful to have seen time series of mean length presented for all available length information, as this is what was used in the assessment. Figure 3.5.8 in the Data Workshop Report shows this, but only for the TIP length frequency information, and Figures 11 and 12 in the Assessment Workshop Report compare the TIP and SEAMAP-C length-frequency information. It would have been useful to have seen this for all sources of length information (including the SEAMAP-C surveys, the NOS Biogeography Visual Survey Database, and that from DW03, RD02, RD03 and RD04). Ideally, such comparisons should have been made for the available catch, CPUE and survey abundance information, also. As it stands, it is very difficult to grasp the overall picture: are things different in a different area and/or under a different gear/survey protocol? Or a different sector (commercial/recreational/independent survey)? Or for a different data set in the same area?

Aside from a cursory attempt to reconcile the Fmsy-based probabilities of overfishing with recent trends in CPUE, there was no attempt made to compare the different types of data, to ascertain whether they were reinforcing or apparently contradicting each other in terms of what they suggested regarding the status of the stock.

It would also have been useful to have understood the difference between minimum/mean length of capture from the length frequency data, and the length at maturity, in terms of age. That is, how many spawning seasons (if any) do red hind experience before becoming vulnerable to fishing gear?

I do agree that it was appropriate to choose a mean-length estimator approach on the basis that length frequency data are currently the most temporally consistent source of species-specific information.

The Assessment Workshop report states "Annual length-frequency plots were constructed for each stratum that the Panel agreed has sufficient sample sizes". While the issues around sample sizes were touched on in the Data Workshop report, the criteria for a "sufficient" sample size are not explicitly presented.

Finally, there was no attempt to define what constituted a stock, for purposes of the assessment, nor were any assumptions specified regarding stock structure. This would have provided a context for how results could or should be reconciled across regions and/or gear/fleet types. At a minimum, a consideration of the area covered by the analyses, versus the potential of the species for movement and mixing (per RD09, which indicated red hind were capable of spawning migrations of up to 33km), would have been useful.

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Uncertainties in:

- the von Bertalanffy growth parameters
- the values of Lc
- the length-weight relationship
- maximum age (used to derive M)

are acknowledged and considered in sensitivity tests around the estimates of total mortality and the years in which this changes. Von Bertalanffy, maximum ages and length-weight parameters were based on those reported in the literature.

Ideally, the suite of sensitivity analyses undertaken could have been summarized clearly in a table illustrating the total number of combinations/scenarios.

I am not convinced of the value of fitting a linear model to the growth parameters reported in the literature, so as to obtain an additional nine parameter pairs. The relationship between the pairs of reported parameters does not seem significantly linear (Figure 17, r^2 = 0.5608; significance value not reported). Moreover, the addition nine parameter pairs are interpolations within the range of those reported in the literature. As such, the inference adds more uncertainty while not providing new values outside the range of those from the literature. It would have been simpler and more sensible to have only used the four reported sets of values found in the literature.

The definition of size-at-recruitment to the fishery, Lc, was vague and this was a significant concern. Page 15 of the Data Workshop Report states, "visual inspection of length-frequency distributions can be used to determine the size-at-recruitment (Lc) to the fishery where the mode of a well-defined distribution can represent Lc".

- It seems strange to me that the mode, as opposed to some lower percentile, is assumed to represent Lc. The mode would surely represent more the prime size of capture rather than the first size of capture. According to Gedamke and Hoenig

(2006), on whose paper and equation the mean length model was based (noting also that this citation did not appear in the reference list of the report, nor as a reference document), Lc is the "smallest size at which animals are fully vulnerable to the fishery and the sampling gear". The Assessment Report, under "Assumptions", refers to Lc only as "the length at full recruitment". I still do not see how the mode of sampled lengths from the catch equates to Lc as per Gedamke and Hoenig's (2006) definition.

- The same page also states, "The mode of each annual distribution was determined as well as the overall mode for each gear type". Was the overall mode determined by averaging the annual modes, or combining the data across years and taking the mode of this combined distribution? The former gives equal weighting to each year; the latter down-weights years with lower sample sizes.

The Assessment Workshop report states, "Lc was selected visually from the annual length-frequency distributions while considering the annual sample size" – how was the sample size considered? Also, "The highest Lc value over the time series was chosen…(this) avoids violating model assumptions and the confounding of selectivity and mortality in the calculation of annual mean lengths" – I don't follow this. Why/how? Then, "mean lengths were calculated from lengths larger than Lc" – this makes no sense to me. If Lc is the modal length, as per the Data Workshop report, then this would only leave the upper percentiles of sampled lengths from which to obtain a mean – which seems contradictory to the definition of the latter. I then refer to Gedamke and Hoenig (2006) who state that "mean length" is in fact the mean length of animals larger than Lc – in which case the definition provided makes sense (assuming Lc is indeed the modal length in the sampled catch). However, it is not clear if this is the mean length of animals larger than Lc in the population, or in the fishable population. These definitions need to be carefully clarified and explained.

Further, in terms of the sensitivity analysis, the Assessment Workshop report states, "The sensitivity of the mean length estimator to the selection of Lc was explored using two alternative assumptions, the value chosen by visual inspection and used in the initial analysis, and the average mode of the annual length-frequency distributions for each stratum". But does not the "visual inspection" equate to the identification of the mode? Without clarity on how these modes were combined across years to obtain the Lc based on "visual inspection", it is difficult to understand how this differs from taking "an average mode of the annual length frequency distributions". This needs to be clarified.

Moreover, it would seem more appropriate to test sensitivity to a range of Lc values derived from the alternative available sources of length-frequency data.

c) Are data applied properly within the assessment model?

See the above concerns regarding the definition and derivation of Lc and mean length. These need to be clarified. Incidentally, the reference to Thorson and Prager (2011) against the statement "Lc was selected visually from the annual length-frequency distribution" doesn't add anything – this paper, among other things, is about how the use of logistic catch curves relaxes the assumption of knife-edge selectivity, and eliminates the need to select this age visually from observed catch data. The citation doesn't add confidence regarding, or provide clarification of, how Lc was selected visually.

The assumptions of constant recruitment and mortality associated with the mean length estimator, are not given consideration. The history of the fishery should be acknowledged in this context: there have been many management changes pertaining to spatial and seasonal closures, and to gear. There have also been temporal changes in the length-frequency distribution/mean length for several gear/area strata. Whether these have corresponded to management changes has not been investigated. However, given the management changes and the changes in length, some consideration should have been given regarding the extent to which recruitment and mortality could be assumed to have been constant.

Knife-edged vulnerability was assumed for the per-recruit analyses– but is this suggested by the data? Moreover, if this is considered to be the case, then the mean length estimator would be more consistent with the per-recruit analyses if a lower percentile of the length distribution was used to calculate Lc – i.e. if a fish of a certain minimum size has been caught by the gear, regardless of in what relative proportion, this size is assumed to be that at which the species is fully recruited to the fishery.

Otherwise, the data appear to have been applied properly within the mean length estimator and the per recruit analyses.

d) Are input data series reliable and sufficient to support the assessment approach and findings?

I question the representativeness of the TIP length information (the only source used for the assessment), in the following ways:

- Under the "SEAMAP-C" section of the Assessment workshop report, it is stated, "selectivity of the SEAMAP-C survey resulted in a smaller modal length than the selectivity of the vertical line fleet". While the TIP information is derived from a fishery-dependent port-based interview program, how certain is it that the selectivities that correspond to each of the TIP gear types may be considered to be representative?
- There was no attempt to standardize for the variability in sample sizes between years. If mean length and Lc estimates are time invariant, this is not particularly important, but if estimates of Lc in particular vary between years, and so does sample size (and/or external factors such as management measures pertaining to gear changes or spatial closures), then this should be considered when combining the time series of data within each stratum to obtain an overall estimate of Lc. (There was an acknowledgement of the possible effect of the Hind Bank (St Thomas) closure on mean length, but the influence of spawning season on mean length was not apparent). The issue of inter-annual sample size variability persists across the three locations (Puerto Rico, St Thomas, St Croix), but taking pages 14-15 of the Data Workshop Report describe the Puerto Rico TIP data as an example:
    - o The sample sizes were very low for all gears other than the vertical line.
    - o The increases in annual mean length since 1983 for the pot and trap, and vertical line fleets: do these correspond to management measures pertaining to gear/selectivity? What is the impact, if any, on Lc?

- There appears to have been some kind of regime shift c.1998 for the pot and trap, and vertical line fleets corresponding to shifts in modal mean length. Possible reasons for this were not investigated in detail. Various (over all, pre-1988, post-1998) estimates of Lc were made as a result, but neither correspond to those used in the sensitivity analyses in the Assessment Report.

With the exception of the direct comparison of TIP length data and SEAMAP-C length data, there was little effort made to reconcile i) the TIP data across the different locations and gear/fleet types, let alone across ii) the various sources of length data, or iii) the other available data. As a minimum, some qualitative consideration of how the TIP estimates of mean length and Lc vary between gear types and location, and what this may mean for the interpretation of stock status, would have been highly useful. This would have considered the length statistics in the context of the gear selectivity and stock structure assumptions (noting that there is no discussion of stock structure across any of the reports). Alternatively, a clear justification of why stock status estimates will differ according to gear type and location, and why this is acceptable in the context of using these for management purposes, could have been provided. For example, if the probabilities of overfishing at one location are greater for one gear type than another in the same location, different control rules can be applied to each gear type accordingly. However, there remains the question of how these probabilities are reconciled to form an overall estimate of the status of the stock (presuming the gears are targeting the same stock). Conversely, if the probabilities of overfishing for the same gear type are different between areas, area-specific control rules can be imposed, but this will again depend on what is assumed about stock structure.

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

a) Are methods scientifically sound and robust?

I have no problem with the mean length estimator method. I like that Gedamke and Hoenig (2006) get around the assumption of equilibrium population dynamics. This appears to the standard current acknowledged approach for estimating total mortality from length distribution data, accounting to non-equilibrium conditions (e.g. Edwards et al. 2012; Erisman et al. 2014).

The yield- and spawner-biomass-per-recruit calculations were standard.

As such, both the mean length estimator, and the per recruit analysis appear to me to be sound and robust, with the assumptions of each clearly stated.

However, while citations are made in the text, there are generally no full references given for key papers pertaining to the Methods. Specifically, I refer to

- Gedamke and Hoenig (2006) (extension of Beverton-Holt length-based mortality estimator)
- Thorson and Prager (2011) (visual selection of Lc from length-frequency distributions)
- Hewitt and Hoenig (2006); Hoenig (1983) (regression approach to estimate M)

- Botsford (1981); Walters and Martell (2004) (equilibrium vulnerable biomass-per-recruit)
- Menza et al. (2008) (fishery independent data)

I appreciate that the Assessment Working Group had to complete their report within a small window of time. However, it is ironic that these references, which were arguably the most critical in terms of underpinning the chosen methodology, were omitted from the reference list. I find it also somewhat bewildering that a 200 page report of survey protocols that collected data that was not used in the assessment (RD01) and a similarly large PhD thesis focusing largely on larval development (RD06) were included as reference documents, yet core references such as those listed did not even make it into the reference list of the report, let alone be included as reference documents.

Very little detail was provided on the derivation of natural mortality estimates. The previous studies on which the calculation was based are cited but do not appear in the reference list, nor in the list of background documents. These equations should appear (particularly given that the relatively well-known von Bertanlanffy growth equations are presented), if only in an appendix. Kenchington (2013) provides natural mortality estimators for information-limited fisheries; it would have been useful to have better understood the method chosen and why this was chosen over other alternatives.

b) Are assessment models configured properly and used consistent with standard practices?

The mean length estimator appears to have been properly configured and used consistent with standard practices (e.g. Edwards et al. 2012; Erisman et al. 2014).

There are some issues with the notation pertaining to the yield- and spawner-biomass-per-recruit calculations:

- K should be uppercase in equation 4.
- Equation 8: a_{mat}, not t_{mat}, or change a_{mat} to t_{mat} in the text
- Equations 9 and 10: s_t and s_{ot} seem to have been replaced with x_t and x_{ot} in equations 13 and 14 – this needs to be consistent
- Equation 11: use single letters for subscripts, i.e., not "*vb*"
- Equations 11,13,14: What is *l*?
- Equation 14: "*o*" needs to be subscripted to *x* (or *s*, as the case may be)

Otherwise these appear to have been properly configured and used consistent with standard practices.

c) Are the methods appropriate for the available data?

The methods appear to be appropriate for the available data, given that length-frequency data are currently the most temporally consistent source of species-specific information.

However, the Methods section of the Assessment Workshop report jumps straight from data evaluations to a description of the modelling approach. More context would have been appreciated, vis-à-vis

- A concluding summary of the available data, leading into a consideration of
- Available assessment options given the data and its quality, presented as a brief review. This should include both methods that pertain to the range of available data (particularly as the chosen length-based methods excludes stock projections, but acknowledging that other data were rejected for various reasons), and those that pertain to length data only.
- Background on (if)/how the species has been assessed in the past.
- Hence, greater justification for the chosen approach.

As it stands, the report reads as, "The length data were the most temporally consistent source of species-specific information, so a mean length estimator was used". The reader is left to wonder whether other approaches were even considered, and whether perhaps there is a historical precedent of this type of analysis having been undertaken, and, as such, an attitude of complacency. Perhaps it is merely a case of knowledge of the fishery and its history and assessment approaches being assumed known – but if so, there is a lot of knowledge that is assumed.

No explicit consideration was given regarding alternative assessment approaches. Erisman et al. (2014) provide various options for assessing stocks (for species forming spawning aggregations) using simple metrics based on catch length composition.

- Other methods that could have been used to evaluate stock status include
    - Assessment from Froese's (2004) indicators of sustainability. Froese (2004) suggested that management could be based on three size-based indicators and their target reference points: (i) percentage of mature fish in the catch, with 100% as target (Pmat); (ii) percent of fish of optimum length (i.e. the length where the number of fish in a given unfished year class, multiplied by their mean individual weight, is maximum and where thus the maximum yield and revenue can be obtained.) in the catch, with 100% as target (Popt); and (iii) percentage of large fish in the catch (Pmega), with 0% as target and 30–40% being acceptable if there is no upper size limit for the fishery.
    - Spawning potential ratio (SPR) analyses: SPR is the ratio of the total fecundity of the fished population under a given exploitation rate, to the total fecundity of the unfished population.
    - (possibly) SAFE: A Sustainability Assessment for Fishing Effects (SAFE): a fishing mortality based method that can quantify the effects of fishing on sustainability for large numbers of species with limited data (Zhou *et al.* 2009)
    - (possibly) production models – as stated above: even acknowledging the supposed problems with the two standardized CPUE indices, and the St Thomas spawning aggregation density time series, it still would have been of interest to have at least attempted to have fitted a simple production model to these. This is of especial relevance given that the mean length methods

used do not enable projections of stock dynamics. Even if the abundance indices are unreliable and/or there was inadequate contrast to enable a production model to be fitted, the attempt to have done so would have flagged more strongly the potential value of collecting robust CPUE and/or density information.

- The Assessment Workshop report seems to skirt around the issue of setting Annual Catch Limits (ACLs), arguing that the mean length estimator approach precludes this. However, one arguably does not need direct estimates of abundance and sustainable yield to set a recommended ACL (although obviously the ACL becomes more defensible the more that is understood about the stock). Methods that could have been used to set ACLs include, but are not limited to:
    - Froese's (2004) size-based sustainability indicators
    - Simple, empirical catch/CPUE- time series-based regression methods – e.g. RD04 has a good catch time series
    - and/or traffic light, CUMSUM control indices, or hierarchical decision trees – indicators could include changes in catch composition, landings and size of landings, as per RD04. Also, RD04 has a historical (1988-2001) time series corresponding to a heavily fished period, which could be used to inform reference points for indicators.

3. **Evaluate the assessment findings with respect to the following:**

    a) **Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?**

The assessment findings are limited to estimates of fishing mortality and spawner biomass per recruit.

In the absence of any information regarding stock structure (or assumptions regarding same), the first question is whether the results should be interpreted as each of the three areas/regions equating to a separate stock. On the basis of the manner in which the results are presented, I will assume this to be the case, but this is an issue that should be clarified in the report.

Total mortality estimates are provided by location, and, correspondingly, probabilities of overfishing (across all crosses of sensitivity analyses [13x,von Bertalanffy pairs, 2x Lc, 3x length-weight relationship, 2x M] and gear/fleet types) against each of two F_{MSY} proxies: $F_{30\%}$ and $F_{40\%.}$

It would have been useful if something similar to the following summary table had been provided:

Location and gear/fleet type	Z estimates: most strongly supported by AIC	Lc	Z ranges	Pr(overfishing)
Puerto Rico: diving	0.312	370mm 323mm	0.68-1.0 0.3-0.8	Using $F_{30\%}$: 25% Using $F_{40\%}$: 40%
Puerto Rico: pot and trap	34% decline in 1995 from 0.444 to 0.292	283mm 310mm	Avg. increase of 32% (from what to what?) Avg. increase of 36%(from what to what?)	
Puerto Rico: vertical line	61% decline in 1987 from 0.379 to 0.235	298mm 340mm	Avg. increase of 31% (range 0.19-0.58) Avg increase of 38% (range 0.25-0.68)	
St Thomas/ St John: pot and trap	44% increase in 1983 from 0.270 to 0.390	302mm 320mm 340mm	Avg increase of 38% (range 0.34-0.93) Avg increase of 64% (range 0.45-1.0) Avg increase of 57% (range 0.35-0.83)	Using $F_{30\%}$: 42% Using $F_{40\%}$: 57%
St Croix: diving	0.476	264mm 296mm	Similar for both Lc values	Using $F_{30\%}$: 54% Using $F_{40\%}$: 66%
St Croix: pot and trap	0.295	277mm 340mm	Avg increase of 86% (no range given) Avg increase of 79% (range 0.27-0.65)	
St Croix: vertical line	75% increase from 0.286 to 0.502	287mm 350mm	Constant Z; no values given Avg. increase of 64%	

Are these estimates reliable? On the basis of the consistently large ranges of possible mortality values (and the large range in the $F_{30\%}$, $F_{40\%}$ values to which they were compared), probably not. The fact that some of the Z estimates include values of 1.0 is also of concern.

I don't know if there is some manner in which the suite of possible mortality values arising from the sensitivity analyses can somehow be weighted, or reduced – e.g., are there combinations of input values for Lc, von Bertalanffy parameters, natural mortality and length-weight parameters that are more biologically plausible/consistent than others? (e.g. growth parameters with a lower L_∞ may be more likely to be associated with a lower Lc value). (Also, less weighting could be given to runs where von the Bertalanffy parameters have been inferred from linear regression). The combinations that are weighted more highly could perhaps have a greater relative representation in the frequency distributions that are used to determine the probabilities of overfishing. Alternatively, those combinations that are considered less plausible could be omitted from the pool of values.

I assume that the numbers of lines on each of the panels of Figures 39-41, and the summed frequencies in Figures 42-44 equate to 13 von Bertalaffy parameter pairs x 2 Lc values x 3 length-weight relationships x 2 natural mortality values x (1 or 3) fleet types = 176 (St Thomas) or 528 (Puerto Rico and St Croix). If so, this should be explicitly stated. (I assume that "like was compared with like" in calculating the ratios for F_{cur} (from the mean length estimator) relative to $F_{30\%}$ and $F_{40\%}$ (from the YPR, SPR analyses), in terms of the population and Lc parameters).

Even if we assume that the values of F are reliable for each area and gear/fleet stratum, there remains:

i) the issue of some contradictions in trends in Z for different sensitivity runs, and/or differences in timing for changes in Z

ii) the issue of the variation in Z estimates and temporal trends between gear/fleet types at the same location.

Beside the above suggestion of assigning relative plausibilities to the different sensitivity combinations, and acknowledging the issue of frequently low sample sizes, I have no suggestions as to how to reconcile i).

Regarding ii), the obvious response would be to consider whether this is due to differences in selectivity, whereby the different fleets are targeting different sizes of the stock. Certainly for Puerto Rico, and, to a lesser extent, St Croix, there is little overlap in the Lc values for the diving fleet and those for the pot and trap, and vertical line fleets, which may help to explain the contradictory trends in Z. Given that M is invariant of the gear/fleet type, the differences in Z are solely due to fishing mortality. Where these differ between gear/fleets, emphasis should be put on those gears/fleets with the highest relative effort, and/or those that are targeting the larger, more fecund individuals (or else very small individuals $< L_{mat}$, but this does not seem to have occurred for red hind). For Puerto Rico, the diving sector appears to target larger individuals than the other gear types, but for St Croix, the diving sector appears to target smaller individuals.

Due to the large number of combinations of scenarios considered, it is difficult to determine whether estimates of total mortality are consistent with input data and population biology characteristics.

- There is a frequently observed negative correlation between estimated current total mortality and asymptotic length, and positive correlation between estimated current total mortality and the von Bertalanffy growth coefficient. These trends should be the inverse of each other: a larger L_∞ goes along with a lower K, corresponding to a slow-growing, less productive stock that ultimately reaches a larger maximum size. However, for a given mean length and Lc, I would have thought a slow-growing, less productive stock would experience a higher total mortality than that for a fast-growing, more productive stock (i.e. one with a lower L_∞ and higher K) – and indeed this is suggested by equation (1) (the equilibrium Beverton-Holt estimator). The relationship between total mortality and the von Bertalanffy parameters was sometimes dome-shaped, which suggests that total mortality is lower at the extremes of von Bertalanffy parameter combinations.
- There was no consistent trend of estimated Z being higher or lower for higher or lower values of Lc.
- There was often an interaction between Lc and the von Bertlanffy growth parameters in terms of the nature of the relationship between the estimated Z and each of L_∞ and K.

Then, there are issues associated with the interpretation of the results relative to the other sources of available input data (as per the Assessment Workshop Report's Discussion section):

- For Puerto Rico, the estimated temporal changes in mortality for the vertical line fleet were compared to the CPUE standardization undertaken using SEAMAP-C data (DW04) for the same fleet. The latter suggests abundance is declining, and this is assumed to equate to an increase in fishing mortality. This may not be the case: fishing mortality could in fact be declining in response to low abundance. Moreover, the conclusion cannot be drawn that "This is contradictory to the mean length estimator result for the vertical line fleet, which suggests mortality declined". It does not follow that low abundance equals high fishing mortality in the same time period. There is typically a lag between fishing mortality and the response in terms of abundance. Low abundance indices can follow a period of high fishing mortality, and in the time during which abundance is low, fishing mortality may subsequently ease in response to this, such that the population then recovers.
- Again for Puerto Rico, it is stated that the fishery dependent relative abundance indices (per AW01) were "flat, suggesting that abundance has not changed". I disagree; I believe the mean trend appears flat due to the scales of the y-axes that are accommodating the confidence intervals.
- Again for Puerto Rico, it is stated that effort has declined for the pot and line and the vertical trap fleets, corresponding to a modelled decline in Z and F, while diving effort for red hind has increased, corresponding to no change or an increase in Z. These correlations do make sense.
- For St Thomas, it is concluded that, because reported landings and effort have declined since 2008, this equates to a decline in fishing mortality, and an eventual increase in fish size. This is interpreted to be contradictory to the result from the mean length estimator, which suggests that mortality has increased due to a

reduction in mean length. This supposed contradiction is shaky: there is no consideration of time frame for recovery of mean length. Moreover, there is a temporal mismatch in the comparisons: the modelled decline in mean length is based on a time series from ~1983 to ~2012, during which mean length declined from the mid-1980s, but remained relatively constant since ~1995. Thus the modelled increase in mortality corresponds to a time long prior to the declines in landings and effort in 2008.

b) Is the stock overfished? What information helps you reach this conclusion?

There was no reference point corresponding to a threshold for an overfished state.

I don't particularly follow the rationale of "The discussion about whether to use $F_{0.1}$ and $F_{SPR30\%}$ (or $F_{SPR40\%}$) was centered on biological considerations and acceptable risk. The Panel agreed that the risk of recruitment overfishing outweighed the risk of growth overfishing, and given the seasonal and spatial closures for red hind, $F_{30\%}$ and $F_{40\%}$ were reasonable F_{MSY} proxies". This doesn't make much sense unless it is put in the context of the sentence from the "Modelling approach" section: "F_{SPR} based metrics are most often considered when there is a concern that recruitment overfishing is possible since SPR is a function of not only mortality and weight, but also maturity". The two sections describing the choice of reference points (in the "Modelling approach" and "Results" sections) should be combined.

Second, the rationale for including both $F_{30\%}$ and $F_{40\%}$ as F_{MSY} proxies, was not made clear – was the intention that F< $F_{40\%}$ would correspond to growth overfishing, and F< $F_{30\%}$ to recruitment overfishing? Presumably $F_{0.1}$ was excluded because it was obtained from yield per recruit analysis and so did not embrace recruitment overfishing. Thirdly, none of the "Per recruit analysis" section of the Results section justifies the lack of choice of reference point for an overfished stock status.

In a broad-brush sense, limit reference points often correspond to 20% of unfished biomass, B_0, so a crude approximation could be made that the probability of being overfished equates to the probability that $F_{cur} > F_{SPR20\%}$.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

The probabilities of overfishing according to the $F_{30\%}$ and $F_{40\%}$ proxies for F_{msy}, are, I believe, high enough to be of concern that overfishing is indeed occurring, particularly for St Thomas/St John and St Croix, where the lowest probability is 42%. There is no discussion of a minimum reference probability above which some decision rule is invoked or further investigation is required, but even the lowest probability of overfishing of 25% for Puerto Rico should warrant some attention. This is regardless of the temporal trends in Z predicted by the mean length estimators. While low sample sizes were a problem, particularly for the USVI regions, this should be even more reason to respond in a precautionary manner, to probabilities of overfishing that are already high.

Point evaluations of overfishing/no overfishing for each of the reference case scenarios would have been useful.

The report conclusion that, for Puerto Rico, "The results indicate that there is a low probability that Red Hind are experiencing overfishing" is highly subjective and lacks direct justification. It appears to be based upon the fact that a proxy abundance index time series (DW04) supposedly contradicts the mean length results in suggesting an increase in F for the vertical line fleet, and upon the fact that the results from mean length analyses suggested conflicting dynamics between the fleets, in terms of temporal trends in predicted Z. Neither of these justify a "no overfishing" conclusion. Indeed, it was the diving sector that suggested Z was constant or increasing with time, and it is this sector that appears to target larger fish for Puerto Rico. An increase in Z on a larger (more fecund) sector of the population is cause for concern.

In terms of temporal changes, it should be reiterated that values for M are fixed temporally such that any predicted changes in Z are directly attributed to changes in F.

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

There is no stock-recruitment relationship provided, nor estimates of steepness.

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

While $F_{30\%}$ and $F_{40\%}$ are proxies for F_{msy}, there no reference point or proxy that corresponded to a threshold for an overfished state.

The same concerns regarding the large range of values of Z apply to the large range in the estimates of $F_{30\%}$ and $F_{40\%}$ (per Figures 39-41): it is difficult to know which (if any) among these are the more plausible. In the "Modelling Approach" section of the report, the sentence "The probability of overfishing integrated across all modelled sources of uncertainty was then determined" is vague and does not specify precisely how this integration was performed. I assume all sensitivity combinations contributed to the frequency distributions presented in Figures 42-44.

Again, I assume that "like was compared with like" in calculating the ratios for F_{cur} (from the mean length estimator) relative to $F_{30\%}$ and $F_{40\%}$ (from the YPR, SPR analyses), in terms of the population and Lc parameters. However, aside from the ambiguous sentence, "…the ratio between $F_{current}$ and F_{MSY} proxies….was obtained to determine overfishing status for a given sensitivity run", this is not clarified in the text: it is possible that only the mean or median $F_{30\%}$ and $F_{40\%}$ were used in the ratio calculations.

The lack of specification of stock structure assumptions also brings into question the reliability of spawner-per-recruit based reference points. If the fish captured by the various gear/fleets are generally above the size of maturity, then presumably they collective contribute to the spawner biomass. Yet separate spawner-per-recruit estimates are presented for each gear/fleet combination. Better justification for this needs to be provided.

As stated earlier, even acknowledging the supposed problems with the two standardized CPUE indices, and the St Thomas spawning aggregation density time series, it still would have been of interest to have at least attempted to have fitted a simple production model to these. This is of especial relevance given that the mean length methods used do not enable projections of stock dynamics. Even if the abundance indices are unreliable and/or there was inadequate contrast to enable a production model to be fitted, the attempt to have done so would have flagged more strongly the potential value of collecting robust CPUE and/or density information. If production models were able to be fitted, estimates of biomass-based reference points can be inferred from these.

Moreover, there exists adequate life history and catch information that a simulation-based management strategy evaluation (MSE) model could have been developed, incorporating a length-based assessment. The simulation could then have been used to have selected an appropriate $F_{x\%}$, as per Edwards et al. (2012) (and associated references under the “reference points” section of this paper). As it stands, there is no attempt made to recommend the use of $F_{30\%}$ over $F_{40\%}$, or vice-versa.

I acknowledge that the time and/or required to develop an MSE may have been exceeded that available, but it would be of value to have flagged this as a future recommendation.

4. **Evaluate the stock projections, addressing the following:**
   a) **Are the methods consistent with accepted practices and available data?**
   b) **Are the methods appropriate for the assessment model and outputs?**
   c) **Are the results informative and robust, and useful to support inferences of probable future conditions?**
   d) **Are key uncertainties acknowledged, discussed, and reflected in the projection results?**

Against their terms of reference, the Assessment Workshop surmises, “Due to the limited data available, a data poor methodology was attempted that does not include projections of stock dynamics. Therefore, projections were not conducted for this assessment”.

As stated immediately above, I believe there exists enough life history information and catch data that a simulation-based operating model could have been built and projections conducted in the context of a Management Strategy Evaluation (MSE) framework. This could have been a simple model, but it would at least have provided a platform for undertaking projections (thereby inferring future conditions), and for selecting appropriate reference points.

Even for data-poor cases, Australian examples (e.g., Dichmont and Brown, 2010; Dowling, 2011; Haddon, 2011; Klaer and Wayte, 2011; Plaganyi et al., 2013) indicate that a formal MSE enables objective performance evaluation, robustness testing, and detecting responses that cannot be intuitively anticipated.

5. **Consider how uncertainties in the assessment, and their potential consequences, are addressed.**

- **Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods**

The methods used to evaluate uncertainty are limited to undertaking sensitivity runs embracing population (i.e. life history parameter) uncertainty. Specifically, uncertainties in:

- the length at full recruitment, Lc (up to 2 values per area and gear/fleet stratum)
- von Bertalanffy growth parameters (13 sets of values)
- the length-weight relationship (3 sets of values)
- natural mortality (2 values)

were considered.

While these sensitivity runs certainly embrace the population–based uncertainty relevant to the required inputs for the assessment approach, they resulted in a large range of Z-values from the mean-length estimator and large ranges of $F_{\%SPR}$ based reference points, conferring uncertainty to the resultant probabilities of overfishing.

However, short of recommending studies on basic life history, there were not suggestions around how to narrow the range of estimated mortalities, or what subset of the range was considered most plausible.

As stated against TOR 3a) above, I don't know if there is some manner in which the suite of possible values arising from the sensitivity analyses could somehow be weighted, or reduced – e.g., are there combinations of input values for Lc, von Bertalanffy parameters, natural mortality and length-weight parameters that are more biologically plausible/consistent than others? (e.g. growth parameters with a lower L_∞ may be more likely to be associated with a lower Lc value). (Also, less weighting could be given to runs where the von Bertalanffy parameters have been inferred from linear regression, rather than empirically derived). The combinations that are weighted more highly could perhaps have a greater relative representation in the frequency distributions that are used to determine the probabilities of overfishing. Alternatively, those combinations that are considered less plausible could be omitted from the pool of values considered.

In the Discussion section for Puerto Rico, it was mentioned that "Further complicating this (per-recruit) analysis is the potential unknown component of mortality associated with the regulatory discards during the closed season for red hind….it is important to better understand whether the magnitude of incidental catch of red hind during the seasonal closure is a negligible component of mortality." There was no attempt to incorporate some hypothetical estimate of discard mortality within the per-recruit analyses.

As stated against TOR 1b) above, I was confused about the following statement: "The sensitivity of the mean length estimator to the selection of Lc was explored by using two alternative assumptions, the value chosen by visual inspection and used in the initial analysis, and the average mode of the annual length-frequency distributions for each stratum". How do these differ? Surely the value chosen by visual inspection should equate to the mode?

No specification or discussion regarding stock structure, or assumptions around the same, was provided.

There was little evaluation of uncertainty in the data sources or the assessment methods themselves. In terms of data sources, as stated against TOR 1d) above,

- there was no attempt to standardize for the variability in sample sizes between years within the TIP data.
- with the exception of the direct comparison of TIP length data and SEAMAP-C length data, there was little effort made to reconcile i) the TIP data across the different locations and gear/fleet types, let alone ii) the various sources of length data, or iii) the other available data. As a minimum, some qualitative consideration of how the TIP estimates of mean length and Lc vary between gear types and location, and what this may mean for the interpretation of stock status, would have been highly useful.

The Discussion section mentioned the following issues pertaining to data sources, but the report did not attempt to address these:

- Re: Puerto Rico:
    - "In the per-recruit analyses to develop overfishing probabilities, the fleets were assumed to be equally representative of the population. Without spatially explicit data with respect to area and depth it is difficult (to) ascertain whether this assumption is being met". Relative effort would also have been useful in this context.
    - Discards in Puerto Rico during closed season possibly affecting mortality (as mentioned above).
- Re: St. Thomas/St. John:
    - The Hind Bank spawning aggregation data index was considered as a source of ancillary data because of many years with low sample sizes of red hind length from St. Thomas. This index lacked a clear temporal trend and was characterized by inter-annual variability, but the report stated that it was not possible to disaggregate the degree to which the variability was explained by environmental covariates or sampling variability.
- Re: St. Croix
    - Low sample size was a major concern with the length-frequency data.
- Re: St. Thomas/St. John and St. Croix
    - Possibly market-driven demands affecting size distribution and hence selectivity. As market-driven selectivity is generally dome-shaped, this would violate the assumption of knife-edged selectivity in the per recruit analysis.

In terms of the assessment methods themselves, sources of uncertainty were not investigated quantitatively. The "Research Recommendations" section states that "the ability to use the mean-length estimator is contingent upon having length-frequency data that are temporally consistent and representative of the population, and upon having reliable estimates of life history parameters". Temporal inconsistencies in terms of sampling size were mentioned throughout the report, together with their possible impact on length distributions, but there was no direct suggestion as to how to reconcile these.

It is also mentioned that the size of fish in the USVI may be market driven for plate size, suggesting that the selectivity may be dome shaped, which is in violation of the assumption of knife-edged selectivity in the mean-length estimator. Expanding the mean-length estimator to accommodate other selectivity patterns was suggested as future research, rather than attempted within the current workshop.

- **Ensure that the implications of uncertainty in technical conclusions are clearly stated.**

The technical conclusions are three sets of probabilities of overfishing. These have been presented with no implications of uncertainty, or (with the exception of recommending studies on basic life history) recommendations regarding narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing. Specifically, the implications of:

- The breadth of the ranges of Z (and hence the uncertainty in stock status) in terms of the efficacy of the overfishing probabilities in a management context
- Having separate sets of probabilities for each of the three regions, without specifying what is assumed about stock structure
- The equal consideration/contribution of all sensitivity runs in calculating the probabilities of overfishing
- The lack of recommendation regarding the preferred choice of overfishing reference point

are not explicitly considered.

As a secondary point, I have some issues the CPUE standardisations undertaken in DW04 and AW01, and the manner in which these were undertaken. I have made some brief points in my appended notes against each of the working papers/reference documents (Appendix 3).

6. **Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.**

The research recommendations provided by the Assessment Workshop are:

- (top priority) Undertake studies on basic life history (e.g. age-growth relationships, length/age at maturity).
    - Agree, in so much as these should reduce existing uncertainty – but are these realistic given the existing capacity? Why are not previous studies considered representative? Are there existing studies for the same species elsewhere that may be helpful?
- Review the current TIP sampling structure to ensure sampling is representative.
    - Agree - but “representative” in what sense? Temporally, spatially, of the size structure of the total fished population, of the total fishing effort?
    - I think this should rate as a higher priority than undertaking fishery-independent surveys. The priorities should be immediately focused on improving the input to, and outcomes, the existing assessment approach.

- (top priority) undertake fishery-independent surveys that enable the development of abundance indices, and that collect age, length, weight and reproductive data.
    - Fair enough – but again, are these realistic given the existing capacity?
    - Moreover, this recommendation should be made in the context of the evaluations of the existing fishery independent data and/or survey protocols (e.g. the Mona Island and Abrir la Sierra (DW03) protocols and data had potential had the time series been longer).
- To expand the mean-length estimator to accommodate other selectivity patterns.
    - I think this is an excellent recommendation.
- To quantify the selectivity patterns for the different gear types.
    - I agree that this needs to be resolved, especially given the assumption of knife-edged selectivity underpinning the per-recruit analyses.
- To attempt to quantify discard and discard mortality rates.
    - Agree that this would be useful, but how could this be achieved? Quantifying discarding is notoriously difficult.
- To continue to improve the data collection of fishery-dependent catch and effort statistics so that traditional biomass-based assessment approaches can be employed (and hence annual catch limits determined and monitored).
    - I agree that this is a key priority.
    - However, there is presumably no way to improve the quality of the historical catch and effort statistics, so the issue is also one of how best to work with the existing data.
    - While it may be ideal to develop ACLs from estimates of abundance and sustainable yield, these are often unavailable. This does not preclude ACLs from being set. ACLs may be determined using simple empirical approaches, while acknowledging the increased risk associated with less information and certainty.

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

There are two arenas for research and monitoring. One is around improving the reliability and usefulness of the current assessment approach. This equates to narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing (and to introducing an overfished reference point threshold). The other is around improving the quality of information available into the future such that alternative approaches may be permitted.

Against the current assessment approach, I agree that

- Reviewing the TIP length data for representativeness (temporally, spatially, of the size structure of the total fished population, of the total fishing effort) is important. This should include a careful consideration of the TIP length data in the context of the other available length frequency information.

- Whether by improving the understanding of life history, and/or by reviewing the available information and parameters and weighting or narrowing these to a more plausible subset, working to reduce the range of mortality estimates is also important.

In addition, monitoring and research to resolve uncertainties around:

- Stock structure in the context of the three regions considered (whether by genetic testing (expensive), tagging studies (expensive), or considering spawning migration (per RD09) and larval transport data (per RD06), and/or studies of dispersal, mixing and stock structure from similar species elsewhere) (i.e. are we treating the three regions as three separate stocks, to which different stock statuses and hence difference management apply?) and
- Gear/fleet reconciliation within regions (i.e. what is the extent of overlap of the fishable sizes targeted/captured by the different gear/fleet types? To what extent can the data from each be combined?)

should be prioritized, so that the probabilities of overfishing are useful in a management context. Currently there are six sets of probabilities (3 regions x 2 overfishing threshold reference points), with each gear/fleet considered to contribute equally to the frequency distributions used to determine the probabilities. Ideally, there should be a recommended preferred reference point (that which is more precautionary, in the absence of other information), a better quantitative articulation of the extent to which the information from each gear/fleet contribute to the overall frequencies on which the probabilities of overfishing are based, and an increased confidence of how these should be applied in the context of what is understood about stock structure.

Additional work to determine:

- A suitable reference point corresponding to an overfished stock status
- A target reference point that could underpin management decision/control rules

is also recommended.

Against improving the quality of information available into the future, such that alternative approaches may be permitted

- There is no clear indication given as to whether formal logbook reporting is possible (or exists), but it seems that the best means of obtaining uniform catch and effort data on which alternative assessments may be based (e.g. simple production models).
- A reconciliation of the fishery independent approaches should be undertaken with a view to recommending a monitoring program that will optimize the utility of the information obtained. (To what extent would the protocol described in RD01 be sufficient?) Recommendations should be pragmatic given the available resources and capacity.

Meanwhile, I encourage

- Avoiding tossing out data for the sake of being overly Puritan. Even if time series of CPUE, for example, are not considered of adequate quality to enable a formal stock assessment, the data may be useful in informing simpler, more empirical assessments (e.g. Froese 2004; Dowling et al. 2008; Prince et al. 2012; Edwards et al. 2012; Erisman et al. 2014). At the very least, they give some notion of historical high catches, and size-based catch rates.

- At least attempting to fit a production model to the two sets of standardized CPUE (AW01; DW04). Even if there proves to be inadequate contrast in the data, the attempt to use it in an assessment would still place emphasis on what is needed from future data collection protocols.

Finally, I strongly encourage that more effort be dedicated to considering approaches to developing ACLs. The Assessment Workshop avoided developing ACLs because the mean length estimator "does not provide these metrics" and "in an ideal scenario, ACLs would be developed from estimates of abundance and sustainable yield". However, the yield-per-recruit/spawner-per-recruit analyses provide F_{MSY} target reference point proxies that could be used in determining an ACL via simulated projections. Second, fisheries arguably do not require "traditional biomass based assessment approaches" in order to set ACLs. Catch time series, triggers (as reference point proxies) or reference points, and empirical decision/harvest control rules can all be used to set an interim ACL (e.g. Dowling et al. 2008; Prince et al. 2012; Dowling et al. 2014).

- **Provide recommendations on possible ways to improve the SEDAR process.**

On the basis of the documents provided, I have the following recommendations:

- Link the Data Workshop Report more closely to the Assessment Workshop Report, so that
    - Data are consistently summarized between each report, preferably via a commonly presented summary table
    - There is improved clarity on how and whether data are used in the assessment. There is minimal detail regarding data in the Assessment Workshop Report. It would have been useful had the Data Workshop Report indicated whether and how each type/set of available data was used in the assessment, both as a summary sentence at the time of its presentation, and in an overall data summary table.

- Prior to circulating for review, cross-check reports to ensure that report reference lists are complete and that key papers are included as background reading (or at least links provided). Perhaps allowing slightly more time for completion of reports may assist with this.

- As a required part of the Assessment Workshop Report, provide historical context and past precedence for assessments previously undertaken. This was not provided in the current reports. If not previous precedent exists, this should be explicitly stated.

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

As stated above, in terms of the available data provided to the assessment workshop via the Data Workshop Report:

- The data were presented in such a way that it was difficult to navigate. A clear summary table of available data including their attributes, whether fishery dependent/independent, available time series, associated references, and how/whether used in the assessment, would have helped enormously.

In terms of the presentation of data/information in the Assessment Workshop Report:

- A clearer presentation of input data, as per the above-suggested summary table, would have been highly useful.
- Sensitivity combinations should be presented clearly in a table format that is easy to follow, and such that the number of crosses in explicitly stated.

Regarding the efficacy of the modelling approaches, and as stated previously, I recommend considering:

- Establishing a reference point threshold corresponding to an overfished state.
- Establishing a target reference point such that a ACL can be set using the current assessment approach, via empirical decision/control rules (e.g. slope-to-target) (Prince et al. 2012; Dowling et al. 2014).
- Undertaking a simulation-based MSE, to facilitate projections and undertake a risk analysis by applying decision rules according to the probabilities of overfishing, and thus determine the relative importance of resolving the range of mortalities contributing to these probabilities.
- Reconciling length-based methods with production models or other assessment approaches, either via a review of approaches, attempting to fit a production model to existing CPUE time series, and/or or better justifying the current approach. There is no indication as to whether assessments have been undertaken previously for this species, and if so, whether there is a precedent for the use of the mean-length estimator. While the mean-length estimator approach used appears sound, this is used as an excuse to avoid projections (when these could have been undertaken using simulations), the setting of ACLs and of target and overfished reference points.
- The application of results in a management context – how useful and informative are the outcomes? What are possible decision rules that could applied?

CONCLUSIONS AND RECOMMENDATIONS

The Caribbean Red Hind Assessment Workshop applied a simple mean-length estimator to the most temporally consistent source of length data to obtain estimates of total mortality. Fishing mortalities were obtained by subtracting estimated natural mortality, and compared to overfishing reference points derived from standard spawner-biomass-per-recruit estimates. There were two Fmsy proxy reference points, and therefore six separate probabilities of overfishing (two for each of three regions) were calculated.

The mean-length estimator is a current acknowledged approach for estimating total mortality from length distribution data, and does not assume equilibrium population dynamics. It appears to have been properly configured and used consistent with standard practices (e.g. Edwards et al. 2012; Erisman et al. 2014).

The following should be noted, however:

- The assumptions of constant recruitment and mortality associated with the mean length estimator, are not given consideration. The history of the fishery should be acknowledged in this context: there have been many management changes pertaining to spatial and seasonal closures, and to gear. There have also been temporal changes in the length-frequency distribution/mean length for several gear/area strata. Whether these have corresponded to management changes has not been investigated. However, given the management changes and the changes in length, some consideration should have been given regarding the extent to which recruitment and mortality could be assumed to have been constant.
- Knife-edged vulnerability was assumed for the per-recruit analyses– but is this suggested by the data?
- The definition of size-at-recruitment to the fishery, Lc, was vague.
- Very little detail was provided on the derivation of natural mortality estimates.
- Sources of uncertainty in the assessment methods were not investigated quantitatively. The "Research Recommendations" section states that "the ability to use the mean-length estimator is contingent upon having length-frequency data that are temporally consistent and representative of the population…". Temporal inconsistencies in terms of sampling size were mentioned throughout the report, together with their possible impact on length distributions, but there was no direct suggestion as to how to reconcile these.
- It is mentioned that the size of fish in the USVI may be market driven for plate size, suggesting that the selectivity may be dome shaped, which is in violation of the assumption of knife-edged selectivity in the mean-length estimator. I agree that expanding the mean-length estimator to accommodate other selectivity patterns should be undertaken.

Beyond undertaking a suite of sensitivity scenarios, and providing probabilities of overfishing, the report did not critically review or evaluate its approach, or consider its findings in a managerial context (as per Assessment Workshop TOR 7).

The technical conclusions are three sets of probabilities of overfishing. These have been presented with no implications of uncertainty, or (with the exception of recommending studies on basic life history) recommendations regarding narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing. Specifically, the implications of:

- The breadth of the ranges of Z (and hence the uncertainty in stock status) in terms of the efficacy of the overfishing probabilities in a management context,
- Having separate sets of probabilities for each of the three regions, without specifying what is assumed about stock structure,
- The equal consideration/contribution of all sensitivity runs in calculating the probabilities of overfishing,
- The lack of recommendation regarding the preferred choice of overfishing reference point

are not explicitly considered.

Against the current assessment approach, the outcomes for each gear/fleet should be reconciled within regions (i.e., what is the extent of overlap of the fishable sizes targeted/captured by the different gear/fleet types? To what extent can the data from each be combined?), so that the probabilities of overfishing are useful in a management context. Currently each gear/fleet is considered to contribute equally to the frequency distributions used to determine the probabilities. Ideally, there should be a better quantitative articulation of the extent to which the information from each gear/fleet contribute to the overall frequencies on which the probabilities of overfishing are based. Additionally, the assessment results showed variation in Z estimates and temporal trends between gear/fleet types at the same location. The obvious response would be to consider whether this is due to differences in selectivity, whereby the different fleets/gears are targeting different sizes of the stock.

It appears that the Workshop participants undertook the assessment on the basis that the approach was appropriate for the best available data source, and simply reported on this and its outcomes. While the assessment approach may be the best scientific information available, the report provides little more than the technical details and a brief consideration of the outcomes.

My remaining concerns with the Assessment Workshop Report are summarized (and reiterated from the above section) as follows, with recommendations as appropriate:

- General presentation
    - The presentation of available data across the three sections of the SEDAR-35 report was difficult to navigate, both within and between reports. A simple summary table of the available information (source, location, type of data, fishery in/dependent, time series, and indicating what was provided to the Assessment Group, and what was actually used) allowing for ready comparison would have been highly useful.
    - The Data Workshop Report should be linked more closely to the Assessment Workshop Report, so that there is improved clarity on how and whether data are used in the assessment.

- Prior to circulating for review, reports should be cross-checked to ensure that report reference lists are complete and that key papers are included as background reading (or at least links provided). While citations were made in the text, there were generally no full references given for key papers pertaining to the assessment methods.

- The report lacks context in terms of data decisions and historical precedence regarding previous assessments.
    - The Methods section of the Assessment Workshop report jumps straight from data evaluations to a description of the modelling approach. More context would have been appreciated in order to have provided greater justification for the chosen approach.
    - As a required part of the Assessment Workshop Report, historical context and assessments previously undertaken should be explicitly described.
    - Generally, the data decisions do appear sounds and robust, but, particularly where data have been excluded, these could have been better justified. I also recommend not being hasty to discard data for the sake of being overly Puritan. Even if time series of CPUE, for example, are not considered of adequate quality to enable a formal stock assessment, the data may be useful in informing simpler, more empirical assessments (e.g. Froese 2004; Dowling et al. 2008; Prince et al. 2012; Edwards et al. 2012; Erisman et al. 2014). At the very least, they give some notion of historical high catches, and size-based catch rates.
    - With the exception of the direct comparison of TIP length data and SEAMAP-C length data, there was little effort made to reconcile i) the TIP data across the different locations and gear/fleet types, let alone across ii) the various sources of length data, or iii) the other available data. As a minimum, some qualitative consideration of how the TIP estimates of mean length and Lc vary between gear types and location, and what this may mean for the interpretation of stock status, would have been highly useful.
    - Alternatively, a clear justification of why stock status estimates will differ according to gear type and location, and why this is acceptable in the context of using these for management purposes, could have been provided.
    - Reviewing the TIP length data for representativeness (temporally, spatially, of the size structure of the total fished population, of the total fishing effort) is important. This should include a careful consideration of the TIP length data in the context of the other available length frequency information.

- There was no attempt to define what constituted a stock for purposes of the assessment, nor were any assumptions specified regarding stock structure.
    - Are we to treat the three regions as three separate stocks, to which different stock statuses and hence difference management apply?
    - At a minimum, a consideration of the area covered by the analyses, versus the potential of the species for movement and mixing (per RD09), would have

been useful. A priority for monitoring and research should be to resolve the issues of stock structure across the three regions considered (whether by genetic testing (expensive), tagging studies (expensive), or considering spawning migration (per RD09) and larval transport data (per RD06), and/or studies of dispersal, mixing and stock structure from similar species elsewhere).

  - The lack of specification of stock structure assumptions brings into question the reliability of spawner-per-recruit based reference points. If the fish captured by the various gear/fleets are generally above the size of maturity, then presumably they collective contribute to the spawner biomass. Yet separate spawner-per-recruit estimates are presented for each gear/fleet combination. Better justification for this needs to be provided.

- Both within and between data types, and for assessment outcomes, there was little attempt to reconcile the data trends and/or inferences between gear/effort types, location and sector (i.e. commercial, recreational, survey).
  - It would have been highly useful to have seen the extent to which trends were consistent across these categories.
  - At a minimum, it would have been useful to have seen time series of mean length presented for all available length information, as this is what was used in the assessment. Ideally, such comparisons should have been made for the available catch, CPUE and survey abundance information, also. As it stands, it is very difficult to grasp the overall picture: are things different in a different area and/or under a different gear/survey protocol? Or a different sector (commercial/recreational/independent survey)? Or for a different data set in the same area?
  - Aside from a cursory attempt to reconcile the Fmsy-based probabilities of overfishing with recent trends in CPUE, there was no attempt made to compare the different types of data, to ascertain whether they were reinforcing or apparently contradicting each other in terms of what they suggested regarding the status of the stock.

- No alternative assessment approaches were reviewed or considered. Erisman et al. (2014) provide various options for assessing stocks (for species forming spawning aggregations) using simple metrics based on catch length composition.
  - Other methods that could have been used to evaluate stock status include
    - Assessment from Froese's (2004) size-based indicators of sustainability
    - Spawning potential ratio (SPR) analyses
    - (possibly Sustainability Assessment for Fishing Effects (SAFE)(Zhou *et al.* 2009)
    - (possibly) production models
  - I recommend attempting to reconcile length-based methods with production models or other assessment approaches, either via a review of approaches,

attempting to fit a production model to existing CPUE time series, and/or better justifying the current approach. There is no indication as to whether assessments have been undertaken previously for this species, and if so, whether there is a precedent for the use of the mean-length estimator. While the mean-length estimator approach used appears sound, this is used as an excuse to avoid projections (when these could have been undertaken using simulations) and the setting of ACLs and of target and overfished reference points.

    - Even acknowledging the supposed problems with the two standardized CPUE indices (AW01; DW04), and the St Thomas spawning aggregation density time series, it still would have been of interest to have at least attempted to have fitted a simple production model to these. This is of especial relevance given that the mean length methods used do not enable projections of stock dynamics. Even if the abundance indices are unreliable and/or there was inadequate contrast to enable a production model to be fitted, the attempt to have done so would have flagged more strongly the potential value of collecting robust CPUE and/or density information.
    - Against improving the quality of information available into the future, such that alternative approaches may be permitted:
        - There is no clear indication given as to whether formal logbook reporting is possible (or exists), but it seems that the best means of obtaining uniform catch and effort data on which alternative assessments may be based (e.g. simple production models);
        - A reconciliation of the fishery independent approaches should be undertaken with a view to recommending a monitoring program that will optimize the utility of the information obtained. (To what extent would the protocol described in RD01 be sufficient?) Recommendations should be pragmatic given the available resources and capacity.

- There was no estimated reference point corresponding to a threshold for an overfished state of the stock (however "stock" is defined), nor justification for the lack of this.
    - Limit reference points often correspond to 20% of unfished biomass, B_0, so a crude approximation could be made that the probability of being overfished equates to the probability that $F_{cur} > F_{SPR20\%}$.
- The probabilities of overfishing were determined from frequency distributions that embraced a large range of possible fishing mortalities. Whether by improving the understanding of life history, and/or by reviewing the available information and parameters, weighting or narrowing the range of mortality estimates and so increasing the certainty around the probability of overfishing should be a key priority for future assessments.
    - Short of recommending studies on basic life history, there were no suggestions of how to narrow the range of estimated mortalities, or what subset of the range was considered most plausible.

- Point evaluations of overfishing/no overfishing for each of the reference case scenarios would have been useful.
- Are there combinations of input values for Lc, von Bertalanffy parameters, natural mortality and length-weight parameters that are more biologically plausible/consistent than others? The combinations that are weighted more highly could perhaps have a greater relative representation in the frequency distributions that are used to determine the probabilities of overfishing. Alternatively, those combinations that are considered less plausible could be omitted from the pool of values.

- The same concerns regarding the large range of values of Z apply to the large range in the estimates of $F_{30\%}$ and $F_{40\%}$ (per Figures 39-41):
  - It is difficult to know which (if any) among these are the more plausible.
  - In the "Modelling Approach" section of the report, the sentence "The probability of overfishing integrated across all modelled sources of uncertainty was then determined" is vague and does not specify precisely how this integration was performed. I assume all sensitivity combinations contributed to the frequency distributions presented in Figures 42-44.
  - There should be a recommended preferred reference point (F_{msy} proxy) (that which is more precautionary, in the absence of other information).
- The report concluded that it was unlikely that overfishing was occurring for Caribbean red hind in Puerto Rico, despite probabilities of 25% and 40%. This conclusion is highly subjective and lacks direct justification. It was apparently based upon the fact that a proxy abundance index time series (DW04) supposedly contradicts the mean length results in suggesting an increase in F for the vertical line fleet, and upon the fact that the results from mean length analyses suggested conflicting dynamics between the fleets, in terms of temporal trends in predicted Z. Neither of these justify a "no overfishing" conclusion.
  - Indeed, it was the diving sector that suggested Z was constant or increasing with time, and it is this sector that appears to target larger fish for Puerto Rico. An increase in Z on a larger (more fecund) sector of the population is cause for concern.
- The probabilities of overfishing according to the $F_{30\%}$ and $F_{40\%}$ proxies for F_{msy}, are, I believe, high enough to be of concern that overfishing is indeed occurring, particularly for St Thomas/St John and St Croix, where the lowest probability is 42%. There is no discussion of a minimum reference probability above which some decision rule is invoked or further investigation is required, but even the lowest probability of overfishing of 25% for Puerto Rico should warrant some attention. This is regardless of the temporal trends in Z predicted by the mean length estimators. While low sample sizes were a problem, particularly for the USVI regions, this should be even more reason to respond in a precautionary manner, to probabilities of overfishing that are already high.

- The interpretation of the results relative to the other sources of available input data (as per the Assessment Workshop Report's Discussion section) is questionable in the following ways:
    - For Puerto Rico, the estimated temporal changes in mortality for the vertical line fleet were compared to the CPUE standardization undertaken using SEAMAP-C data (DW04) for the same fleet. The latter suggests abundance is declining, and this is assumed to equate to an increase in fishing mortality. This may not be the case: fishing mortality could in fact be declining in response to low abundance. Moreover, the conclusion cannot be drawn that "This is contradictory to the mean length estimator result for the vertical line fleet, which suggests mortality declined". It does not follow that low abundance equals high fishing mortality in the same time period. There is typically a lag between fishing mortality and the response in terms of abundance. Low abundance indices can follow a period of high fishing mortality, and in the time during which abundance is low, fishing mortality may subsequently ease in response to this, such that the population then recovers.
    - It is stated that the fishery dependent relative abundance indices for Puerto Rico (per AW01) were "flat, suggesting that abundance has not changed". I disagree; I believe the mean trend appears flat due to the scales of the y-axes that are accommodating the confidence intervals.
    - For St Thomas, it is concluded that, because reported landings and effort have declined since 2008, this equates to a decline in fishing mortality, and an eventual increase in fish size. This is interpreted to be contradictory to the result from the mean length estimator, which suggests that mortality has increased due to a reduction in mean length. This supposed contradiction is shaky: there is no consideration of time frame for recovery of mean length. Moreover, there is a temporal mismatch in the comparisons: the modelled decline in mean length is based on a time series from ~1983 to ~2012, during which mean length declined from the mid-1980s, but remained relatively constant since ~1995. Thus the modelled increase in mortality corresponds to a time long prior to the declines in landings and effort in 2008
- It was stated that the mean length estimator approach does not include projections of stock dynamics, and that these were therefore not conducted.
    - There exists adequate life history and catch information that a simulation-based management strategy evaluation (MSE) model could have been developed, incorporating a length-based assessment. A simulation-based MSE could be developed, to facilitate projections and undertake a risk analysis by applying decision rules according to the probabilities of overfishing, and thus determine the relative importance of resolving the range of mortalities contributing to these probabilities. This could be a simple model, but it would provide a platform for undertaking projections (thereby inferring future conditions), and for establishing and evaluating overfished and target reference points and ACLs. It could also be used to

select an appropriate $F_{x\%}$: there is no attempt made to recommend the use of $F_{30\%}$ over $F_{40\%}$, or vice-versa.

- The Assessment Workshop argues that the mean length estimator approach precludes the setting of ACLs. However, direct estimates of abundance and sustainable yield are not required to set a recommended ACL.
    - I strongly encourage that more effort be dedicated to considering approaches to developing ACLs. The Assessment Workshop avoided developing ACLs because the mean length estimator "does not provide these metrics", and "in an ideal scenario, ACLs would be developed from estimates of abundance and sustainable yield". However, the yield-per-recruit/spawner-per-recruit analyses provide F_{MSY} target reference point proxies that could be used in determining an ACL via simulated projections. Fisheries arguably do not require "traditional biomass based assessment approaches" in order to set ACLs. Catch time series, triggers (as reference point proxies) or reference points, and empirical decision/harvest control rules can all be used to set an interim ACL (e.g. Dowling et al. 2008; Prince et al. 2012; Dowling et al. 2014).
    - Methods that could have been used to set ACLs include, but are not limited to:
        - Froese's (2004) size-based sustainability indicators
        - Simple, empirical catch/CPUE- time series-based regression methods
        - and/or traffic light, CUMSUM control indices, or hierarchical decision trees.

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APPENDIX 1: BIBLIOGRAPHY OF MATERIALS PROVIDED FOR REVIEW

SEDAR 35

Caribbean Red Hind

Workshop Document List

Document #	Title	Authors	Date Submitted
Documents Prepared for the Data Workshop			
SEDAR35-DW-01	Monitoring of Commercially Exploited Fisheries Resources in Puerto Rico	Aida Rosario Jimenez	20 Sept 2013
SEDAR35-DW-02	Reef Fish Monitoring	Aida Rosario Jiménez, Verónica Seda Matos, and Noemí Peña-Alvarado	20 Sept 2013
SEDAR35-DW-03	Red hind data from Puerto Rico	Michelle Scharer, Michael Nemeth and Daniel Matos	3 March 2014
SEDAR35-DW-04	Abundance Indices of Red Hind Collected in Caribbean SEAMAP Surveys from Southwest Puerto Rico	G. Walter Ingram, Jr.	13 May 2014
Documents Prepared for the Assessment Process			
SEDAR35-AW-01	Standardized Catch Rates for Red Hind from the Commercial Diving, Trap, and Vertical Line Fisheries in Puerto Rico	Adyan Rios	8 August 2014
Final Stock Assessment Reports			
SEDAR35-SAR1	Caribbean Red Hind		
Reference Documents			
SEDAR35-RD01	A Cooperative Multiagency Reef Fish Monitoring Protocol for the U.S. Virgin	David R. Bryan, Andrea J. Atkinson, Jerald S. Ault, Marilyn E. Brandt,	

	Islands Coral Reef Ecosystem, v. 1.00	James A. Bohnsack, Michael W. Feeley, Matt E. Patterson, Ben I. Ruttenberg, Steven G. Smith, Brian D. Witcher
SEDAR35-RD02	Fishery independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puerto Rican EEZ	Jorge R. García-Sais, Jorge Sabater-Clavell, Rene Esteves, Milton Carlo
SEDAR35-RD03	Portrait of the commercial fishery of red hind, *Epinephelus guttatus*, in Puerto Rico during 1992-1999	Daniel Matos-Caraballo
SEDAR35-RD04	Portrait of the commercial fishery of red hind, *Epinephelus guttatus*, in Puerto Rico during 1988-2001	Daniel Matos-Caraballo, Milagros Cartagena-Haddock, and Noemi Pena-Alvarado
SEDAR35-RD05	Evaluation of seasonal closures of red hind, *Epinephelus guttatus* (Pisces: Serranidae), spawning aggregations to fishing off the west coast of Puerto Rico, using fishery-dependent and independent time series data	Anthony Robert Marshak
SEDAR35-RD06	Description of larval development of the red hind *Epinephelus guttatus*, and the spatio-temporal distributions of ichthyoplankton during a red hind spawning aggregations off La Parguera, Puerto Rico	Edgardo Ojeda Serrano
SEDAR35-RD07	Brief Summary of SEAMAP Data Collected in the Caribbean Sea from 1975 to 2002	G. Walter Ingram, Jr.
SEDAR35-RD08	Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection	Richard S. Nemeth
SEDAR35-RD09	Spatial and temporal patterns of movement and migration at spawning aggregations of red hind, *Epinephelus guttatus*, in the U.S. Virgin Islands	Richard S. Nemeth, Jeremiah Blondeau, Steve Herzlieb, and Elizabeth Kadison

APPENDIX 2: COPY OF THE CIE STATEMENT OF WORK

Attachment A: Statement of Work for Dr. Natalie Dowling

External Independent Peer Review by the Center for Independent Experts

SEDAR 35 Caribbean Red Hind Assessment Desk Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: SEDAR 35 will be a compilation of data, benchmark assessments of the stocks, and an assessment review conducted for Caribbean red hind. The review is responsible for ensuring that the best possible assessment is provided through the SEDAR process and will provide guidance to the SEFSC to aid in their review and determination of best available science, and when determining if the assessment is useful for management. The stocks assessed through SEDAR 35 are within the jurisdiction of the Caribbean Fishery Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Experience with data-limited assessment methods is desirable. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer revie

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs cannot be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.

1) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
2) No later than September 12, 2014, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

4 August 2014	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact

18 August 2014	NMFS Project Contact sends the CIE Reviewers the report and background documents
25 August through 12 September 2014	Each reviewer conducts an independent peer review as a desk review
12 September 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
26 September 2014	CIE submits the CIE independent peer review reports to the COTR
30 September 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov)

Support Personnel:

Allen Shimada
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
Allen Shimada@noaa.gov Phone: 301-427-8174

William Michaels
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
mshivlani@ntvifederal.com Phone: 305-968-7136

Key Personnel:

NMFS Project Contact:

Julie A. Neer, SEDAR Coordinator
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405
Julie.Neer@safmc.net Phone: 843-571-4366

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review

   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 35 Caribbean Red Hind Assessment Desk Review

1. Evaluate the data used in the assessment, addressing the following:
   e) Are data decisions made by the Assessment Workshop sound and robust?
   f) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   g) Are data applied properly within the assessment model?
   h) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   d) Are methods scientifically sound and robust?
   e) Are assessment models configured properly and used consistent with standard practices?
   f) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   f) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   g) Is the stock overfished? What information helps you reach this conclusion?
   h) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   i) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   j) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
   e) Are the methods consistent with accepted practices and available data?
   f) Are the methods appropriate for the assessment model and outputs?
   g) Are the results informative and robust, and useful to support inferences of probable future conditions?
   h) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
   - Ensure that the implications of uncertainty in technical conclusions are clearly stated.
6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

APPENDIX 3: ADDITIONAL NOTES

Summary table of working papers and reference documents

Document	Author	Location	Timeframe	Nature of data	Notes
DW01	Jiminez	Puerto Rico (S&E Coast)	1987-88	fishery dependent	19.9% of #s sampled = red hind
DW02	Jiminez	Puerto Rico	2009	Fishery dependent	15.6% of weight sampled = red hind Size composition by station varied by area & depth Fisher experience influenced CPUE - Both of these should thus be considered in CPUE standardisation!
DW03	Scharer-Umpierre	Puerto Rico Mona Island Abrir la Sierra (size distn only)	2005 2010 2005-2012:	Fishery independent – diver visual census Passive acoustic monitoring + dive surveys	Transect & roving survey snapshots: low abundance Adult red hind at Mona Island most commonly observed over low coral cover and medium structural relief Effect of reserves wrt density Size distribution from 2 spawning sites 2005 spatial distn & habitat utilisation 2010: temporal changes in abundance at Mona Island 2005-2012: length and density info from uw visual surveys from 2spawning aggregation sites
DW04	Walter-Ingram, Jr	SW Puerto Rico	1991-2011 with gaps 2002-04 inclusive, 2007-09, 2012-	SEAMAP survey Handline CPUE only used	CPUE standardisation by year, spawning season, spawning aggregation area, depth BUT - No interactions - No fisher experience (relevant if data collected by sub-contracting skippers) - Need finer area term

					- RD08 suggest size and density and therefore biomass increase by >60% following permanent closure in 1999 – not accounted for - Effect of depth not removed in standardised index
AW01	Rios	Puerto Rico	1990-2012 (species-specific data only since mid 2001)	Commercial – self-reported fisher logbooks	Separate CPUE standardisation for each gear type by year, coast, season with 2-way interactions - No depth, fisher experience
RD01	Bryan et al	USVI	2010 snapshot	Reef belt visual surveys	Cooperative multiagency reef fish monitoring protocol for USVI - To what data does this link? Referred to as "StCroix trap study" in assessment report
RD02	Garcia-Sais et al	Puerto Rico (3 sites) -Abris la Sierra - Isla Desecheo - Bajo de Sico	2011-2012	Fishery independent surveys of exploited fish and shellfish	Length-frequency (p 53, 76, 78, 80, 83, 85) Density, population size (p 26, 28, 37, 39, 42, 43) NB page 1SEAMAP C since 1992 – notes narrow spatial and temporal coverage P53 "Red hind presented modal size (30cm) just > size at 1st reproduction (25cm – though see RD04 below))which may be indicative of high fishing pressure on this species" (may also reflect size at which not cryptic/targeting or spawning aggregations; will also depend on growth rate and age – how long does it take to grow that extra 5cm so how many spawnings?) P2 low abundance, migratory behaviour and large home range imply large geographical scale survey required for population stock assessment
RD03	Matos-Carabello	Puerto Rico	1992-1999	Commercial data: Commonwealth of Fisheries Statistics Project (program with Puerto Rico's Department of Natural & Environmental Resources)	CPUE, length-frequency Figure 3 CPUE – why not standardise this? Could input to a production model

RD04	Matos-Carabello	Puerto Rico	1988-2001	Commercial data: Commonwealth of Fisheries Statistics Project (program with Puerto Rico's Department of Natural & Environmental Resources)	P354 cites Sadovy and Figuerola as 215mm min length maturity Before 1987, red hind reported in the grouper category Overfishing symptoms = catch composition changes, decrease in landings, decrease in size l/f distributions 1988-2011 (at 1st glance mode length looks similar (~280-320mm) to that of later years) Figure 1 = decent catch time series 1988-2000 High fishing pressure during this period 1995 closures: increased landings of larger fish 1995-98 relative to 1992-94
RD05	Marshak	Puerto Rico	1988-2006	SEAMAP C And fishery dependent data	Evaluation of 1996 seasonal closures - CPUE initially thought to increase within aggregations - Subsequent increase in effort led to decrease in CPUE - Increase in average length in both data types, but due to limited recruitment - Closure initially effective but changes in fishing strategy overrode recovery SEAMAP C CPUE Figs 5,6,7,8,17,18,21
RD06	Ojeda Serrano	Puerto Rico		Biological	Larval development and spatio-temporal distributions of ichthyoplankton – retention could be local or up to 60km downstream
RD07	Walter-Ingram	Puerto Rico and USVI	1975-2002	2-pager overview of SEAMAP	1975-84: most was longline sampling, but couldn't standardise because of lack of knowledge of LL hooks per set (but could assume common number of hooks per set) Catch rates for each area-gear combination (1991-2002??) – fish trap and handline. Only latter used in CPUE standardisation of DW04

RD08	Nemeth	St Thomas, USVI	1999-2004 (closed seasonally in 1990; permanently in 1999)	Tag and release fishing and fish survey transects	Population response of a spawning aggregation - Should take this closure as a regime shift in GLM - Also tag studies inform movement - Recovery with respect to mean length gives idea of lag between fishing impact and mean length and could therefore help inform assessment in reconciling trend in CPUE indices and mean length trends (Fig 5-7) - Could density estimates be used in some kind of assessment for spawning biomass? Suggests size and density and thus biomass increased by <60% following permanent closure in 1999 – this should somehow be accounted for. Cited page 74 Data Workshop Report as source of l/f info
RD09	Nemeth et al	USVI St Thomas St Croix	1999-2006	Fishery independent scuba surveys, draft fishing and fish traps to determine arrival/departure from spawning sites; then focused density estimates using belt transects. Tag and release to determine migration.	STT 6-33km spawning migrations from area of 500km^2; STC 5-18km from area of 90km^2 Implies there is an important interaction effect between time of year (spawning season) and area (if latter is a spawning area) Striking similarities between STT and STX in timing, movement and migrations re: spawning aggregations Risk of hyperstability Cited page 74 Data Workshop Report as source of l/f info

GENERAL NOTES AGAINST EACH WORKING PAPER/REFERENCE DOCUMENT/REPORT SECTION

DW01:

- Should be stated upfront that this is a fishery dependent monitoring program
- How was relative abundance inferred from catch?
- Line 3: population fluctuations *in availability*
- Last line: was the species composition the same for both coasts?

DW02:

- Background?? How many sampling periods? What fishery/gears? (hook and line – stated later) Define "stations" and other terms

DW03:

- P1: whether data is fishery independent or dependent should be explicitly stated.
- P1 visual estimation of fish size – is this reliable?
- P2 What is "landscape composition"?
- P3 "frequency of occurrence" relative to what? 3.9% - from both belt transects and roving surveys? 25 individuals across 613 belt transects
- P4 this paragraph should lead the Results; 1st sentence is not a sentence
- P4 why weren't data collected at the spawning aggregation site?
- P4 "latter data" = 2010, 2011??
- P4 "Supposed protection" = 1st mention of reserves
- P6 are the belt transects and roving surveys same as those in part 1? Or different?
- P6 "NTZ" – what is this? 1st use
- P6 Methodology – what years?
- P7 "a potential reserve effect" of what?
- P8 why is it important to obtain data yearly? This won't improve any single abundance estimate.
- P9 by "fieldwork" – is this referring to the dive surveys?
- P10 That the sampling times were pooled needs to be in the Methods
- P10 where do the length estimates come from? I thought this section pertained to acoustic monitoring
- P11 p=0.00 – not really, surely?!

- P11 last paragraph: “Data collected from 2005 to 2012” – does this mean acoustic survey data?

DW04:

- P1 why does higher variability in weight data matter?
- Were skippers sub-contracted to undertake cruises? If so, their experience will be an important factor and should be a GLM explanatory variable.
- P1 notation: “c” also used for CPUE
- Equation 3 reduces to c/(1+c) How is this a vector of the presence/absence?
- P2 How large are the MPAs? Should a finer scale area term be used?
- P2 ***** In generating the standardised CPUE abundance indices, the effect of depth should be removed as a confounding variable. Standardised CPUE abundance indices should only be functions of time and area.
- I would have expected an interaction effect between spawning season and aggregation area, especially given RD09’s finding re: spawning migration
- RD08 suggests size and density (and therefore biomass) increases by over 60% on spawning grounds following permanent closure in 1999. This should somehow be accounted for.
- Figure 2 (Std CPUE indices) – some context ito history of fishery – when did it commence? Closures implemented (show with vertical line)

AW01

- Not used in assessment; species-specific data only available after mid-2001
- Are the effort units appropriate for the gear?
- To identify trips that targeted red hind, could have also used Principal Component Analysis or Cluster Analysis and identified those clusters with an appreciable red hind catch composition.
- Additional confounding factors? What is being filtered out from standardised signal? Not much different from nominal.
- DISAGREE that standardised indices show no overall directional trends – this is a function of the scale of the y-axis.
- Comparison by gears?
- One overall index with gear as a factor explanatory variable?
- Why would the GLM with the interaction term between year and coast not converge? (Table 6)
- Caption for Figures 1-3c is vague

SECTION I: Introduction

Up front should be species name and description

What is area of fishery/relevance to the assessment? What is the presumed stock structure? That is, what are we dealing with in terms of the assessment?

A map of the entire area of relevance would have been good.

Some of the management actions should be incorporated in GLMs or at least flagged temporally on plots. There have been many knife-edged regime changes.

P7 Where is the socio-economic information?

NB P8 overfished, overfishing definitions

P10 1993 prohibited juvenile harvest – should check l/f information per DW04 (available since 1991) to evaluate impact

P13 1999 first full closure

P14 spawning season closure

P14-15 management reference points (few comments but nothing noteworthy)

P2-17 HAPCs?? Not in glossary

P2-17 Lists confirmed spawning locations

P2-19 overfishing limit "maximum rate of fishing a stock can withstand while still providing MSY on a continuing basis" – I don't get this. Still needs to provide MSY, but above this cannot provide MSY – by definition! Since MSY is itself a proxy, this is not precautionary.

P22 reducing length of fishing season does not necessarily reduce catch, as effort can be condensed across a shorter season. The decision rule as to when to resume the original season length is not specified.

SECTION II: Data Workshop Report

Main concern is the lack of attempt to compare/reconcile data from different gear sectors and regions – i.e. what is the overall picture? Are things different in a different area and/or under a different gear? Or a different sector (commercial/recreational/independent survey)?

Summary tables indicating what was provided to the Assessment Group, and what was actually used, would have been helpful.

Summary of ALL available length-frequency information – from where, what years – as per Fig 3.5.8 but for the different data sources, would have been helpful.

General – would be good to have summary table of ALL data sources, types and what is used in assessment – latter also flagged at end of each section

P8 What is the assumed stock structure? Single or multiple?

P8 natural mortality 0.18-0.68 is a huge range

P8 avg size female maturity 250mm or 215mm (3years) TL, mean size at sexual transition 380mm TL – how does this compare to mean length? (see also RD02 "red hind presented a modal size just above the size at first reproduction")

P9 ?? stock-recruitment relationship?? ??steepness??

P9 movement/spawning migrations as per RD09 (18-33km) plus high site fidelity to a home reef. Upshot for stock structure assumption?

P9 large range in length-weight relationship parameters

PUERTO RICO

P13 Puerto Rico commercial red hind landings from 1986

P13 how is expansion factor determined?

P13-14 Trip Interview Program (TIP) described – identifying Lc (but never specific on exactly how – the very minimum size, or some lower percentile, or what?)

P14 TIP <1500 indiv red hind lengths pa on average

P14 Figure 3.5.6, 3.5.7 show very low numbers

P14 TIP is the increase in mean length significant? Confounded with decline in sample size, but may it also correspond to management measures re: gear/selectivity?

P15 TIP shift in median and mean length for pot and trap, vertical line gears ~1998 suggests some kind of regime shift- fig 3.5.8 p 35. Gear-type specific (pot-trap and vertical line); suggests could be to do with gear controls, also fig 3.5.9 p36

P15 why would mean length be affected during spawning season relative to rest of year? May be more heavily fished in spawning season but in same relative length proportion, especially if Lc> spawning size. And what about spatial closures in spawning areas?

P15 recreational landings estimated how? From intercepts?

P15 both commercial and recreational showed peak in 2005 landings followed by large drop in 2006.

P16 what is a “wave”?

P16 reliability of recreational discard info?

P16 how well do rec fisher participants in phone surveys recall the number of trips they undertook?

P16 how does the recreational data compare with the commercial data? Doesn’t seem to be big changes over time

For me, the recreational fishing sampling is so low as to be negligible, so for purposes of assessment not that useful, especially not l/f data UNLESS this is markedly different from the commercial data. Recreational catch could possibly be included, e.g. in an operating model MSE context.

P26 only 19 of 2786 recreational intecepts had red hind landings.

P31 fig 3.5.4 significant changes in gear over time. Depending on time series used in assessment, beware standardised CPUE if from one gear only (which it is)

ST THOMAS & ST JOHN

P41 St Thomas and St John (previous was Puerto Rico) How does the commercial catch, effort compare to that of Puerto Rico?

P42 how small was the small sample size from 1991-2006?

P42 figures should have a vertical line showing length at maturity

P42 again, how does mean length compare to that in Puerto Rico?

P42 as per Puerto Rico, why should mean length be affected by fishing activity in spawning season?

P43 Should I bother checking the ftp site to look at the St Thomas Mother’s Day Tournament info?

P52 fig 4.5.4 etc. what are the red vertical lines?

Pg 54 fig 4.5.6 difficult to compare vertical line, pot and trap l/f info with different x-axis scales

ST CROIX

P56 St Croix – again, what % of Puerto Rico’s catch does this represent?

P57 fig 5.4.8 should be 5.4.7

P57 influence in early 1980s and 90s on observed mean lengths from vertical line fleet difficult to see

P72 Fishery independent data – how does this compare to the fishery-dependent data. Bottom line: how representative do we believe each data source to be?

P72 Biogeography visual surveys – only used for l/f? abundance? Say so up front.

P72 Menza et al (2008) not in reading materials – how/was this used?

P72 why were Puerto Rico visual surveys undertaken in August?

P72 proportion of red hind relative to what? Number of surveyed sites? Is this an appropriate metric?

P73 visual survey size ditributions based on <10 individuals. Inference re: skewed toward smaller red hind is useless

P73 why October sampling in St Croix compared to August for Puerto Rico?

P73 Size range 2.5-41cm. How binned?

P73 St John & St Thomas visual survey July – different timing again to St Croix and Puerto Rico.

P74 Proportion of red hind in St John/St Thomas visual surveys much higher than other 2 regions.

Summary table across all 3 regions and sub-sites would have been good.

P74 DW03 summarised – 2005, and 2005-2012 data made available to assessment analysts

P74 RD08 and RD09 cited here in context of available source of l/f info. BUT I have concerns wrt what these 2 papers show wrt increase in biomass post-closure and re: spawning migrations, and factoring these into GLM standardisations of CPUE.

P75 mentions RD02 (big survey protocol) 2011, 2012 fishery indep visual survey – but total number of observed red hind low. Since only one year data with relatively few observations of red hind, not used.

P75 Why isn't cryptic nature of the species mentioned earlier?!

P75 summaries SEAMAP-C per DW04 (& RD07) – although from both Puerto Rico and USVI, and for multiple gear types, emphasises only handline CPUE (in numbers) off SW Puerto Rico only, used in standardisations.

SECTION III ASSESSMENT REPORT

Commerical landings: Puerto Rico – concern about expansion factors BUT still have a time series of catch

Recreational data Puerto Rico: reporting coverage as % would have been preferable (NB none in USVI)

AW01: fishery dependent CPUE indices (from self-reported logbooks) – only Puerto Rico; species specific data for USVI only available since 2011. Separate indices by gear (diving, trap, vertical line). States shows "wide confidence intervals and no overall directional trend" disagree with latter; artefact of scale due to CIs. "Recommended as a qualitative supplement to the quantitative meanL analysis" – in what way?! Why not attempt a production model while acknowledging limitations?

Fishery-independent data

- Spawning aggregation data
    - DW03 Puerto Rico (3 sets)
        - Short temporal scale – not recommended for use in formal assessment: agree, but note potential of each
    - RD08, RD09 St Thomas, St Croix
    - Tried to develop relative abundance indices for spawning population
        - St Thomas – used annual max density. Resultant time series showed inter-annual variability and again "given caveats highlighted in this section" (?) have used as ancillary qualitative info – why?!? Could have again tried production model. No attempt to reconcile this to CPUE trends.
        - St Croix – too large a gap in time series: agree
- SEAMAP-C
    - Why were relative abundance indices not discussed, or justified why not used to fit production model?
    - Discussed length data and compared these to TIP data. Post 1999 decline in number of annual lengths and shift to larger red hind (NB corresponded with first permanent closures – p13 Section 1 - why not mention this?) Examined changes in sampling methods but not changes affecting commercial fishing.
    - Also, suggests mean depth of survey stations relatively constant over time (Figure 9) but I disagree – decrease then increase
    - Selectivity of SEAMAP-C resulted in smaller modal length than vertical line fleet
    - Did not use SEAMAP-C data for mean length estimator as most data in 1990s and lacking from recent years; could not be combined with TIP data because of differences in selectivity would have violated model assumptions – agree
- St Croix trap study – per RD01 document
    - Says was 2010 pilot trap study but RD01 says visual belt survey - ??
    - 89 red hind captured; range of lengths similar to fishery –dependent length data

Table 6 – best to plot these

Figures 16 is missing its secondary axis

Figure 21: Circles and numbers are what? Does the line equate to the modelled values and the circles to the data, and the numbers the sample size?

Center for Independent Experts (CIE) External Independent Peer Review

SEDAR 35 Caribbean Red Hind Assessment Desk Review

Dr. Christos Maravelias

October 2014

CONTENTS:

1. EXECUTIVE SUMMARY

The Caribbean Red Hind, *Epinephelus guttatus,* is one of most important commercial species in Puerto Rico and USVI. It is characterized by a long lifespan, slow growth, a protogynous hermaphrodite sexual strategy and short-term annual spawning aggregations that make them highly vulnerable to overexploitation. Intensive fishing during the 1970s led to continually decreasing annual catches during the 1980s, resulting in low landings in the 1990s. Numerous studies have reported red hind as an overfished species.

For the purposes of the current Red Hind assessment various sources of fishery-dependent and fishery-independent datasets have been considered. Several of them were characterized as having substantial gaps in the time-series, unknown levels of uncertainty, high variability and low sampling size. As a result there were not included further in the analysis.

The assessment was performed using length frequency data from Puerto Rico and USVI. These were the most temporally consistent sources of species-specific information, thus, were considered the best available Red Hind datasets. The non-equilibrium mean-length estimator approach was undertaken in this assessment to provide estimates of total mortality. A detailed deterministic sensitivity analysis was conducted to evaluate the sensitivity of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. The fishing mortality was estimated using total mortality from the sensitivity analysis and natural mortality based on a maximum-age approach. The assessment methodology followed here provided estimates for total mortality, fishing mortality and Lc. The analysis couldn't provide stock population parameters such as MSY, biomass, abundance, F_{MSY}, B_{MSY}, selectivity etc. To remedy this, F_{msy} proxies (i.e. $F_{30\%}$ and $F_{40\%}$) from yield-per-recruit and spawner-per-recruit analyses were considered. Estimated probabilities of overfishing were respectively: 25% and 40% for Puerto Rico, 42% and 57% for St Thomas and 54% and 66% for St Croix. These probabilities indicated that the Red Hind stock has, on average, a 32.5%–60% risk of experiencing overfishing. The findings were consisted with the increased total mortality estimates for St Thomas, St Croix and Puerto Rico (diving fleet only). It needs to be underlined that the current findings were based on the analysis of TIP datasets only. Due to the limitations of the approach and of the sampling quality/quantity there have been no quantitative estimates of important stock population parameters. Therefore the estimated overfishing probabilities can only be used as indicative of the status of the population. The increasing trend in total mortality estimates can also serve as an indicator of an increased exploitation pattern. An important issue that weakens the reliability of the current estimates and restricts their use to support status inferences is the reported market driven selectivity. This merits further investigation.

A number of recommended actions could be advanced to support the fisheries in the US Caribbean. A first priority could be the promotion of basic fish biology research (e.g. age, growth, diet studies, length/age-at-maturity, fecundity) to provide the fundamental knowledge that will support future assessments. The introduction of fishery-independent surveys in order to provide scientifically sound information and data to support stock assessment, fishery conservation and management is also considered top priority. In order to disclose species' selectivity patterns and improve resource exploitation, gear selectivity studies should be carried out. These gear experiments coupled with discard estimates from the fleet statistics and onboard scientific sampling will help the assessment of discard mortality. It is also imperative to improve the existing fisheries data collection system. The data sampling programme should ideally collect fishery-dependent information in all major fishing ports, villages, landing sites etc. Catches, effort, discards, economic (e.g. costs, profits) and social (e.g. employment, education) information could be collected on site from representative samples of each gear, fleet and fishery. Similar data, especially catches, effort, discards, costs and profits can be collected regularly using onboard sampling, i.e. following fishers during their fishing trips. It is essential that the diverse fisheries datasets are standardized, integrated and comparable in order to be of use to assessment analysis.

Overall, the current findings are considered the best scientific information available.

2. BACKGROUND

The Caribbean Red Hind, *Epinephelus guttatus,* is a commercially important species in Puerto Rico and USVI. It has been targeted mainly after the collapse of *Epinephelus striatus* and yellow-fin grouper (*Mycteroperca venenosa)* spawning aggregations in 1970s and ’80s. Red hind contributed 70 to 99% of the total catch of fin fish landed in the Virgin Islands between 1987 and 1992 (Cummings et al. 1997; cited in Nemeth et al 2005). Nemeth et al (2007) reported that by the late 1980s an evaluation of the red hind stock around St. Thomas showed dramatic decreases in average length and an extremely skewed female-to-male sex ratio (15:1) of the spawning population (Beets & Friedlander 1992; ct Nemeth et al 2005) suggesting a disproportional harvest of large males (Sadovy & Figuerola 1992). Other studies also provided evidence that the species was overfished (Sadovy & Figuerola 1992).

The Red Hind is a monadric protogynous hermaphrodite species. It changes sex from female to male at 32–38 cm total length (Sadovy et al. 1992; Nemeth 2005) and reaches maximum length and age at 50–55 cm and 11–22 years (Sadovy et al. 1992). It forms large spawning aggregations from Dec. to Feb. and spawning occurs during the full moon. These spawning aggregations consist of small haremic groups with one male defending three to five females and spawning occurs in pairs 1–2 m above the reef (Shapiro et al. 1993). Sadovy et al. (1994b) found that *E. guttatus* females are determinate spawners and spawn more than once during the course of the annual spawning season. The local fishermen are well aware of this spawning behavior, making the species susceptible to high exploitation rate. As a result the species became an extremely vulnerable target to various gears and fisheries with negative results to its reproduction.

Nemeth et al. (2005) reported that unregulated fishing on aggregations may have contributed to a 65–95% decline of commercial grouper landings in Puerto Rico and Bermuda, respectively (Sadovy and Figuerola 1992; Sadovy et al. 1992; Luckhurst 1996; cited in Nemeth et al. 2005). Less dramatic, but equally important to reproductive output, are the subtle effects of fishing on spawning aggregations of protogynous species such as decreased average fish size, smaller size at sexual transformation and altered male:female sex ratio (Coleman et al. 1996; cited in Nemeth et al. 2005).

The Council implemented in 1985 a Reef Fish FMP to address the decreasing catches of reef species in the US Caribbean. The current FMP of Reef Fish, affecting Red Hind, includes technical measures such as: gear restrictions, seasonal/area closures, catch limits, bag limits, changes to requirements for the constructions of traps. In 1990 the Council introduced Amendment 1 with more stringent management measures to be implemented in the Reef Fish FMP. This was due to continued decreasing trends in species composition and volume of landings, including Red Hind species. A further Amendment 2 was put in place in 1993. In 2005 the Council enacted Amendment 3 to address the required provisions of the Magnuson-Stevens Fishery Conservation and Management Act. The Magnuson-Stevens Act required the Council to redefine the management reference points. The fisheries are to be managed under Annual Catch Limits (ACLs) and accountability measures (AM) that will ensure preventing ACLs from being exceeded. In the absence of MSY estimates, the

Over Fishing Limit (OFL) will use MSY proxy that will be derived from recent average annual landings (Section1_Intro_S35_red_hind).

Puerto Rico's fishery has been monitored through the Fisheries Statistics Project (FSP) continuously since 1967. The project aimed to provide fisheries data for the resources in the waters of Puerto Rico and scientific information to support management plans. Indeed, there are various sources of fishery-dependent and fishery-independent information regarding Red Hind in the Caribbean. Unfortunately, most of them suffer from substantial gaps in time-series, unknown levels of uncertainty, high variability, low sampling size, and misreporting. As a result these fishery datasets are not comparable and cannot be of direct use in the stock assessment process. They can only serve as qualitative indicators. Currently the best available source of Red Hind data to perform a stock assessment in Puerto Rico and USVI is the length frequency data.

3. DESCRIPTION OF REVIEWER'S ROLE IN THE REVIEW ACTIVITIES

Various pre-review preparations were carried out that were deemed necessary in order to conduct the best possible review. Firstly, in early August 2014, three weeks prior to the start of the review process, a number of key publications and material were searched for and downloaded from web databases regarding the Red Hind species in the Caribbean. This included also the CIE web site. Their detailed study enabled the reviewer to get familiar with the species' biology, ecology and fishery in Puerto Rico and USVI.

Secondly, the NMFS Project Contact provided additional background material and reports in advance of the peer review. These included reference documents RD01-09, working papers DW01-04 and AW01 that helped me get acquainted with the characteristics and research carried out so far on the US Caribbean Red Hind.

All three Report Sections provided were subsequently studied thoroughly.

Initially the Report Section_I was read ("Section1_Intro_S35_red_hind") to get an overview of the governance and fishery system that is currently in place in US Caribbean and which the Red Hind fishery follows.

Then the "SectionII_S35_RedHind_DW_Report" was examined. The specific work presented the outcome of the Data Workshop Report where all of the available data sources were reviewed. This enabled understanding the advantages and disadvantages of the available datasets and their suitability (or not) for stock assessment.

Subsequently, the "SectionIII_S35_AW_report" was critically reviewed. The biological parameters, the available datasets, the compilation of input data, the statistics and methods, the equations, the models' configurations and assumptions, the uncertainty, the results, the stock population benchmarks, the proxy values, the overfishing probabilities and recommendations were scrutinized. The strong and weak points of every step of the assessment were evaluated and highlighted. Each ToR was considered and addressed. Additional recommendations and priorities alongside the ones provided by the Assessment workshop were proposed for US Caribbean Red Hind fisheries.

4. SUMMARY OF FINDINGS FOR EACH TOR

SEDAR 35 Caribbean Red Hind Assessment Desk Review

1. Evaluate the data used in the assessment, addressing the following ToRs:

    a) Are data decisions made by the Assessment Workshop sound and robust?

Data review-Commercial landings-Puerto Rico
A number of correction factors have been calculated in order to allow the use of commercial landings. These factors were either coast specific (2003 and afterwards) or single for the entire island (for the period 1983-2002).

The raw data used to calculate the correction factors were available for one year only (2011). These correction factors were subsequently used to all years. This entailed a high degree of uncertainty in the calculation of commercial landings data.

Further, the available information collected during 2011 included species-specific landings for each vessel sampled. The landings' data for all species were pooled; therefore, correction factors were not species specific. The data were further pooled across vessels sampled, sampling dates, and sample sites within coasts.

These datasets, containing species-specific landings details, are quite informative. Developing species-specific correction factors (for example only for species of interest such as the red hind or target species) could have been advantageous for carrying out the red hind assessment. These red hind-specific factors could have produced more precise estimators. Fishing capacity, effective effort and capacity utilization differs between the vessels of a fleet, not to mention within fleets (e.g. vertical line, pots and traps). Fishers' behavior is mainly driven by profit. There are various target species in these fisheries among them of primary interest is red hind.

Pooling all fishing trips, all species landings and all logbook data irrespective of their catch composition results in an overall correction factor for the entire fishery that may well not represent the commercial landings or effort targeted to a specific species of interest, e.g. red hind.

The decisions of the panel to utilize the fishery dependent relative indices of abundance from self-reported fisher logbooks and fishery independent spawning aggregation data as qualitative information are justifiable and robust. Likewise, the panel rightly omitted the spawning aggregation data from St. Croix and Puerto Rico from the current assessment. The decision to exclude the SEAMAP-C data due to the lack of recent year samples and different selectivity was also correct.

    b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Several concerns have been correctly raised by the DWP with regard to variability and occasionally small sample size of various data sources. These included PR commercial and recreational landings. The issue with the collection of recreational data is also reported: "MRFSS estimates of landings and discards were calculated using catch (or discard) rates from dockside intercepts and total fishing effort from telephone surveys." It is not immediately clear the precision level of the intercepts, how representative these interviews were with regard to the respective fleet/vessels, and how the telephone surveys were conducted (e.g. coverage, questions asked, degree of genuine answers, false reporting etc). As a result evaluating the level of data uncertainties becomes problematic.

Overall the panel has acknowledged most of the data uncertainties.

c) Are data applied properly within the assessment model?

The data have been applied correctly within the chosen assessment model.

d) Are input data series reliable and sufficient to support the assessment approach and findings?

The commercial logbook data of all fishing trips were reported from dates and sites that corresponded to the dockside samples collected. Consequently the logbook data were pooled similarly to the dockside sampling data. Logbook data from vessels that were not sampled were also included in the calculation of correction factors. The coast specific correction factors were calculated as the proportion of reported landings in pounds to observed landings in pounds.

It is often that logbook data suffer from misreporting and false reporting. MRFSS dockside intercepts ideally should have been designed to cover a representative sample of the fishery. Here the total intercepts range was provided, i.e. 1125-3168 per year. This is a highly variable sampling number of intercepts and no explanation is provided with regard to this observed variability. This implies an adaptable sampling protocol rather than a stratified sampling with predetermined and fixed number of samples per gear, fleet, fishery, area, depth zone, month, year. The report supports the opposite: ‘Rate and effort data are stratified by year, wave (two month periods within years, Jan-Feb, Mar-Apr, etc.), mode (private, headboat, shore based fishing), and area (10 miles or less from shore, >10 miles offshore). Landings and discards estimates are calculated within each stratum as: stratum specific landings (or discards) = stratum cpue (or discard rate)*stratum effort.

Fishery dependent relative indices of abundance
Data from self-reported fisher logbooks were examined to characterize abundance trends of Red Hind in Puerto Rico from 1990-2012 (SEDAR35-AW-01). The approach followed here, CPUE calculated on an individual trip basis, is recommended for similar datasets and could have also been utilized on other data sources e.g. commercial landings in PR. These datasets suffer from accuracy issues and the report correctly recommends them as a qualitative index of information only.

Fishery independent data

Spawning aggregation data

There is no sampling either in Feb (since 2010) or in Dec (since 2007) in St. Thomas. Even in January the number of sampling days and transects after 2009 has dramatically declined to reach in 2013: 1 sampling day and 3 transects (Table 1). It would have been beneficial for the assessment if the informative data series up to 2007-2009 continued at the same sampling intensity in recent years. Typically, the quality of the sampling typically improves in terms of sampling intensity in recent years; the opposite trend is observed in St. Thomas. The report attributes that to funding constraints. In St. Croix and Puerto Rico, the sampling intensity (number of surveyed transects) of spawning aggregation visual surveys has remained relatively stable.

As mentioned above, the observed constraints in several of the data series and their quality, compromised their direct input and use in the assessment approach. The TIP data were less problematic and reasonably reliable and sufficient to support the analysis performed.

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

   a) Are methods scientifically sound and robust?

This is a typical data-limited stock. The length frequency data were the most temporally consistent source of species-specific information. In order to assess the stock, the panel proposed and used the non-equilibrium mean length estimator approach for estimating total mortality and the maximum age approach for estimating natural mortality. The non-equilibrium B-H length based mortality estimator (Gedamke and Hoenig 2006) is an appealing method to deal with length data. It relaxes the assumption of the catch rate being proportional to abundance. Its use is considered appropriate.

There were two positive points for the current analysis: a) the fact that analyses were conducted separately for several island and gear combinations (as shown in Table 7) and b) since the panel realized that there was uncertainty about the growth relationship parameters of red hind, it conducted a sensitivity analysis to evaluate the influence of the growth parameters on the outcome of the mean length estimator and quantify uncertainty in the total mortality estimates.

There are some weak points of the length based mortality estimator as highlighted by Gedamke and Hoenig (2006). Firstly, the method does not make use of the information contained in the variability of length measurements within a year (i.e., the sample variance) thus this is not used in the estimation of mortality rates and change points. That is, under high mortality, there are few large fish and thus the variance in length decreases with increasing mortality rate. An expression for the variance of length measurements as a function of the mortality and growth parameters and the years of change could have been derived and incorporated in the likelihood function as suggested by Gedamke and Hoenig (2006). Secondly, the application of the particular method should consider the possibility of a trend in mean length arising from a particularly large or small year-class. Thirdly, the method assumes constant recruitment over the time series being analyzed. If recruitment varies directly with the stock size, then the model in its current form will underestimate the magnitude of any change in mortality.

   b) Are assessment models configured properly and used consistent with standard practices?

The configuration of the models used annual length-frequency plots for each stratum for the diving, pot and trap, and vertical line fleets from Puerto Rico, St. Croix and pot and trap fleet from St. Thomas. The Lc values chosen for each stratum were presented in Table 7 and Figures 14-16. Relevant information is also presented in Section II: Data Workshop Report. A closer examination of the figures 14-16 reveals that:

a) for Puerto Rico and diving fleet and years 1983, 1984,
b) PR, pot and traps, years 2008, 2010, 2012,
c) St Croix, pot and traps, years 2001, 2003, 2005, 2011,
d) St Croix, vertical line, years 1994-2006,

the annual length frequency distributions, Lc, Mode, were derived from less than 10 specimens of red hind (providing the interpretation is correct). In several of these years the number of lengths measured are 1 or 2. This makes the configuration of the models problematic, as it is difficult for someone to accept a species' annual LFD that is derived from 1 single specimen's measurement. For example in St. Croix vertical line, the Data Workshop Report uses an overall estimate for Lc ~283mm (DWR page 57). It is noted that this peak was driven by the observation from the 1980s and 1990s when sample size was large. This proves that 20 years old data were essentially used in this fleet and extrapolated for the purposes of this assessment. How well do the 20-year old data capture the annual length frequency distribution of the species in recent years, e.g. 2012? How informative could be the Lc and mode used, with regard to the current fishing mortality of the stock? Is Lc of the 1990s similar to the Lc in 2012? Is the fishery exploitation regime comparable? Did any changes in gear selectivity occur? What about technological creep and fishing efficiency? If there have been documented changes in gear selectivity and technological creeping over the last 20 years (more than likely) then the datasets should have been standardized somehow prior to their analysis. Evidently, this raises a number of questions for the adequacy of the model configuration as applied.

On a positive side the assessment models have been used consistent with the international standard practices.

c) Are the methods appropriate for the available data?

The non-equilibrium extension of B-H length based mortality estimator is considered appropriate for the available data. It could have been useful if the analysis has also considered ways to address the weak points of the methodology mentioned in 2a.

The maximum age approach to estimate natural mortality using the regression analysis of Hewitt and Hoenig (2006) is also appropriate for the current data available.

Two fundamental assumptions of the methods used are: a) the red hind growth follows the von Bertalanffy growth model and b) the Sadovy's length-weight relationship (1992) describes adequately the species' growth, as this was considered appropriate to define the mid-level L-W relationship. With regard to a) there is increasing evidence in the literature that the von Bertalanffy GF may not be always the best available to describe the growth of a particular species and should not be used a priori as a panacea. Regarding b) it may have been worth investigating the possibility that the length-weight relationship (among other parameters used, e.g. α_{mat}) may have altered 20+ years after the initial work of Sadovy et al (1992).

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

    a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

The only stock population parameters estimates that were derived from this assessment were the:

a) Total mortality, Z, with the use of the non-equilibrium mean length estimator (and the year of change)
b) Fishing mortality, F, by subtracting from total mortality the natural mortality estimates derived from the maximum-age approach.

Since a number of other stock population parameters could not be extracted from the applied methodology, F_{msy} proxies from yield-per-recruit and spawner-per-recruit analyses were considered.

A substantial part of the model results section was devoted to the analysis of the sensitivity in the estimates of total mortality and in the year of change to changes in the growth parameters and values of Lc. The majority of YPR curves were flat over a wide range of fishing mortality rates. This leads to unrealistically large F_{MAX} estimates. The Panel agreed that the use of F_{MAX} as the F_{MSY} proxy would be inappropriate for this reason. Given that the risk of recruitment overfishing outweighed the risk of growth overfishing and the spatiotemporal closures for Red Hind the use of $F_{30\%}$ and $F_{40\%}$ was considered acceptable.

Puerto Rico

Fishery-independent standardized relative indices of abundance have been developed for the vertical line fishery of the southwest coast of Puerto Rico using the SEAMAP-C data (1991-2011). Initial results indicated that the abundance was declining and that the fishing mortality was increasing, which contradicted the mean length estimator result for the vertical line fleet. The fishery-dependent relative index of abundance that was further developed, i.e. *Scaled Index:* the abundance index scaled to a mean of one over the time series (Figure 2 of S35-DW-04) suggested that abundance remained stable. This particular dataset suffered from a number of issues: A) poor coverage of the last decade. Specifically since 2001, only 2005-06 and 2010-11 were available. B) Its geographic coverage is also restricted to the southwest coast of Puerto Rico. C) It focused on vertical line gear, which represents only a part of the exerted fishing effort and mortality on Red Hind stock by the local fishery (pots and traps, diving).

The AW report results indicated a low probability of Red Hind experiencing overfishing in Puerto Rico. Yet, conflicting trends among the fleets were evident. Pot and traps and vertical line fleets pointed to a decrease in total and fishing mortality. The diving fleet results testified for the opposite, i.e. total mortality remained stable or increased. It is not immediately clear which exploitation pattern is representative of the stock status in terms of abundance and biomass. The panel correctly draws attention to the number of annual reported trips per gear. Pot and traps and vertical line trips have declined dramatically since the early 2000s by 50% and 75% respectively. It is worth noticing that Figure 45 shows several years with all port and traps trips being less (?) than the targeted Red Hind pot and traps trips. In contrast, diving trips increased by approximately 600%. This may imply that the diving fleet may well be more representative of the current stock status as sample size is notably larger in recent years. If that is the case then the per-recruit analyses used to develop overfishing probabilities may have to be adjusted. The reason is that the per-recruit analysis assumed fleets to be an equal representation of the population. This point requires additional research in the future.

Abundance and biomass estimates could also suffer from the omission of the discards component of the catch. The multispecies nature of the reef fisheries inevitable lead to incidental catches of Red Hind during the seasonal closure period.

St Thomas

The main source of data used for the purposes of the current assessment was the pot and trap data. The findings of the present assessment were: 1) the mean length estimator and sensitivity results indicated an increase in total mortality due to a reduction in mean length and 2) the per recruit analysis indicated that the probability of the St. Thomas Red Hind fishery experiencing overfishing was 42% and 57% when using F30% and F40%, respectively.

The lack of eight years of data, especially in late 80s-early 90s and late 90s-early 2000s (Table 4.4.2 of SEDAR 35-Secion II-DWR), had a bearing in the consistency of the reported results.

The panel correctly considered other sources of data but these proved even less informative for Red Hind assessment. For example the maximum density approach to St Thomas spawning aggregation data was characterized by considerable inter-annual variability and lack of clear trend.

An important issue that further undermines the reliability of the current estimates and restricts their use to support status inferences is the reported market driven selectivity. This is usually associated with dome-shaped selectivity, which contradicts the knife-edge selectivity assumption made for Lc. The panel highlights the importance of this matter as it may results in over-estimating fishing mortality.

St Croix

Similarly to the other two areas (Puerto Rico and St Thomas), the mean length estimator and follow up sensitivity analysis gave slightly different results between fleets. More precisely, the mean length estimator and sensitivity results when applied to St. Croix's pot and trap and vertical line fleet length data predicted that the total mortality increased, whereas, the analysis of the diving fleet's length data indicated that total mortality has either remained constant or increased.

The results of the assessment are best seen bearing in mind the limitations of the sampling. Especially, in terms of quality, intensity and sample size of the available datasets. This prevents the current findings from supporting robust status inferences and promoting management decisions. Specifically the majority of the pot and traps and vertical line samples were observed early in the time series. From mid 1990s the number of lengths measured dropped dramatically. In contrast the diving fleet data were from 2002 onwards.

b) Is the stock overfished? What information helps you reach this conclusion?

There is no definite information indicating that the stock is overfished. The AW panel has used a wide range of data sources from various fleets, gears and areas. In several of them there have been signs of overfishing in the past such as the decreased size of Red Hind in pot and trap fishery in St Thomas in 1990-95 and in 2000s.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

The results of the per recruit analysis indicated that the stock of Red Hind in Puerto Rico had the lowest probability of overfishing compared to the other USVI species' stocks. The estimated probabilities were 25% and 40% for $F_{30\%}$ and $F_{40\%}$ respectively.

The per recruit analysis indicated that the probability of the St. Thomas Red Hind fishery experiencing overfishing was 42% and 57% when using $F_{30\%}$ and $F_{40\%}$, respectively. Both these probability estimations are relatively high and should be considered.

The St Croix Red Hind per recruit analysis suggested that the species' probability of overfishing was 54% and 66% (shouldn't it be 40% and 56% instead?) of reported values of when using $F_{30\%}$ and $F_{40\%}$, respectively. Both these probability estimations are considerably high and should be followed up closely.

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

The stock recruitment relationship derived from the data analysis was partly informative. As already mentioned, the majority of YPR curves were flat over a wide range of fishing mortality rates, thus unrealistically large F_{MAX} estimates could be generated. However, the distributions and cumulative probabilities presented in Figures 42-44 constituted the aggregated outcomes of the per-recruit analysis and fishing mortality estimates from the sensitivity runs. These distributions and cumulative probabilities enabled the estimates of population benchmarks such as the proxy values of $F_{cur}/F_{30\%}$ and $F_{cur}/F_{40\%}$.

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

The estimated probabilities of overfishing ranged from 25-66% for different proxies and islands. These were based on the analysis of TIP datasets that were considered the best available to perform the mean length estimator approach. Due to the limitations of the approach and of the sampling data quality/quantity there have been no quantitative estimates of important stock population parameters such as abundance, biomass, fishing mortality etc. The overfishing probabilities can only be used as early indicators of the status of the population. The increasing trend in total mortality estimates can also serve as indicator of an increased exploitation pattern.

A limited dataset ana1ysis using scuba diver assessments and covering the period 1999-2004 and only the Red Hind Bank MCD (in St Thomas) provided early indications for recovery. More precisely, the work from Nemeth et al (2005; 2007) used as indicators the average size of Red Hind and the maximum male size. When compared with their respective values before the permanent closure, the average size of red hind increased during the seasonal closure period (10 cm over 12 yr). The maximum total length of male red hind increased by nearly 7 cm following permanent closure. The scientists also reported that average density and biomass of spawning red hind increased by over 60% following permanent closure whereas maximum spawning density more than doubled.

4. Evaluate the stock projections, addressing the following:
    a) Are the methods consistent with accepted practices and available data?
    b) Are the methods appropriate for the assessment model and outputs?
    c) Are the results informative and robust, and useful to support inferences of probable future conditions?
    d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

According to S35_AW report, ToR no 9, page 7 it is clearly stated that:

"Due to the limited data available, a data poor methodology was attempted that does not include projections of stock dynamics. Therefore, projections were not conducted for this assessment".

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

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

An important part of the current assessment report has been devoted to evaluating the sensitivity of and the uncertainty in the estimates of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. These estimated uncertainties were carried further, in the yield per recruit analysis and thus, were embedded in the estimates of the F_{MSY} proxies. This is considered a strong point of the work. So are the clear statements of the implications of the studied uncertainties to the conclusions of this study.

The sensitivity analysis was performed separately for each stratum. The linear model fitted to the four published estimates of von Bertalanffy growth parameters was subsequently used to generate nine additional pairs of K and $L\infty$. These were essential in order to perform the follow up sensitivity analysis. One point here is that the fit of the linear model was marginally adequate (R^2=0.5608). This should have been discussed as well as its likely effect on the sensitivity analysis of the uncertainty of the growth parameters, especially since the sensitivity pairs of asymptotic length and von Bertalanffy growth coefficient were used further in the per-recruit analysis.

Typically, there are six types of uncertainty related to sources of risk in a fisheries setting: those associated with process, observation, model, estimation, implementation and institutions (see Francis & Shotton, 1997). Briefly, *process* uncertainty is defined as the underlying stochasticity in the population dynamics such as the variability in recruitment. *Observation* uncertainty originates from the process of data collection (e.g. inadequate data collection systems and deliberate misreporting), through measurement and sampling error (as we observe a sample and not the entire population). *Model* uncertainty is due to the lack of complete information on the population and community dynamics of the system. Usually fisheries' scientists and managers use mathematical models, i.e. a conceptual set of equations describing (or at least attempts to) how populations and fisheries change over time. Lack of information in building such models causes: a) structural uncertainty (e.g. shape of Stock/Recruit relationship), b) parameter (e.g. is Natural Mortality M 0.2 or 0.3) uncertainty, and c) error structure uncertainty. *Estimation* uncertainty is linked with the process of parameter estimation (that requires data and model) and as such is derived from some or all of the three above types. *Implementation* uncertainty refers to the extent of successful implementation of management policies. *Institutional* uncertainty relates to problematic interaction of interested parties (scientists, fishers, economists, etc.) composing the management process (Francis & Shotton, 1997).

The last two types of uncertainty, i.e. implementation and institutional, are of no immediate interest to any assessment working group. However, the first four types of uncertainty could have a direct impact in any species assessment, here the Red Hind Assessment. Stochasticity in the populations dynamics such as the variability in recruitment, observation uncertainty due to problematic data collection programmes (observed here), model uncertainty (e.g. uncertainty in the Y/R shape), or uncertainty in parameter estimates (here only uncertainty in the growth parameters was considered) e.g. uncertainty in natural mortality or maturity-at-age or vulnerability-at-age values are only few of the forms of uncertainty that someone could have additionally considered.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
- Provide recommendations on possible ways to improve the SEDAR process.

All research recommendations made by the AW panel are appropriate and in the right direction.

The AW panel concluded that in the near future the mean length estimator will continue to form the basic methodology for US Caribbean stock assessments. They also recommended that effort should be directed to basic fish biology research (e.g. age, growth, diet studies, length/age-at-maturity, fecundity) to provide the knowledge that will support future assessments. This is, and must be, indeed the top priority for key species. Even if these research priority areas cannot be covered within available financial resources from fisheries or public authorities, a carefully designed university programme can help on this direction. For example, a number of relevant research topics can be advanced for M.Sc or PhD dissertations and these will provide, with minimum cost and in a short period, the missing biological information.

Fishery-independent surveys were also recommended as a top research priority. Such surveys should be carefully designed and cover the entire distribution of the key species in all three studied regions, i.e. Puerto Rico, St Thomas/St John and St Croix. A rigorous sampling programme should be put in place, preferably using the same vessel(s) and gear specifications. Alternatively similar vessels/gears can be used providing that these should be standardized at some stage. This will allow for direct and meaningful comparisons to be made.

Sampling should allow for a sufficient number of samples to be taken in and out of closed areas, fishing grounds, spawning and nursery grounds. Samples should include not only catches and discards of key species but also fish biology (length, weight, age, diet, reproductive), oceanographic (temperature and salinity profiles) and seabed substrate data.

Selectivity experiments using commercial gear can also assist in disclosing species' selectivity patterns. This coupled with discard estimates from the fishery will allow the assessment of discard mortality.

In the specific fishery a substantial lack of key biological parameters is obvious. Guidelines for filling these gaps have been provided earlier. At the same time it is evident that various sources of fishery-dependent information is available. Some of these datasets are short, others are longer, a few have yearly gaps, a number of them are recent, and several are older. All these indicate what is common in fisheries all over the world: rigorous (and therefore expensive) fisheries sampling programmes were seldom the priority. Yet, there is information in these datasets and the AW panel had tried to use this.

The existing data collection programme should be improved. Following standard and common sampling protocols for all isles, fleets, gears, seasons and strata. This sampling programme should collect fishery-dependent info in all major fishing ports, villages, landing sites etc. Catches, effort, discards, economic (e.g. costs, profits), social (number of fishers, sex, education etc) information could be collected on site from representative samples of each gear and fishery. Similar data, especially catches, effort, discards, costs and profits, can be collected regularly using onboard sampling, i.e. following the fishers during their fishing trips. This will provide more realistic data that could then be integrated and compared with port sampling, intercepts, TIP, logbooks. For example self-reported logbooks or TIPs usually suffer from misreporting and false reporting. Such a data collection framework programme will shortly result in datasets that will allow for meaningful inferences to be made also utilizing the past data.

Expert local ecological knowledge, participatory stakeholders' involvement, use of already available datasets such as those explored here and even spatial back filling (imputing) of missing catches may all aid to this end.

I have no remarks with regard to the SEDAR process as it is well-organized and efficient.

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

According to section I page 14: ‘The Council implemented Amendment 3 to the Reef Fish FMP (CFMC 2005) in 2005 to address required provisions of the Magnuson-Stevens Fishery Conservation and Management Act (Caribbean SFA Amendment).’ Among the measures that the Council implemented were management reference points that rely on recent average catch. Recently there has been growing interest in the use of methods for estimating overfishing thresholds and setting catch limits for stocks with limited data. The so-called catch-based methods have generally been employed where insufficient data exist for determining an OFL using more sophisticated methods (Carruthers et al 2014).

The Red Hind fishery dependent data available suffered from limitations (e.g. landings only) and unknown accuracy. Still it would be interesting to apply any of the proposed catch-based methods to obtain management reference points such as OFL, ABC, ACL, OY and F_{MSY} and compare these with those derived from the present analysis. Obviously, there may be considerable uncertainty regarding the inputs to the methods. Adding appropriate error components could simulate the imperfect knowledge of these quantities. Another avenue of research could be to use these early datasets as priors for a Bayesian approach as new data are collected.

A minor technicality: it was difficult, in places, to follow up all the different datasets in DW and AW, especially which ones were finally used for the full assessment, which ones were only qualitatively used and which ones were not considered. A simple table with the various data sources which show the advantages, disadvantages and importantly their level of use (or not) would have greatly facilitated the review process.

5. CONCLUSIONS

There are various sources of fishery-dependent and fishery-independent information regarding Red Hind in the Caribbean. Most of them suffer from substantial gaps in the time-series, unknown levels of uncertainty, high variability, low sampling size, and misreporting. As a result they cannot be of direct use to the stock assessment process but only serve as qualitative indicators.

Currently the best available source of Red Hind data to perform a stock assessment in Puerto Rico and USVI is the length frequency data. The non-equilibrium mean-length estimator approach was undertaken in this assessment to provide estimates of total mortality. A detailed deterministic sensitivity analysis was conducted to evaluate the sensitivity of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. Then the fishing mortality was estimated using total mortality from the sensitivity analysis and natural mortality based on a maximum-age approach. The assessment methodology followed here provided estimates for total mortality, fishing mortality and Lc. On a negative side it couldn't deliver stock population parameters such as MSY, biomass, abundance, F_{MSY}, B_{MSY}, selectivity etc. These parameters could have been used as reference points and population benchmarks and thus facilitate buy-in of scientific advice in support to policy.

In order to clarify whether Red hind was experiencing overfishing, estimates of fishing mortality were compared to F_{MSY} proxies from yield-per-recruit and spawner-per-recruit analyses namely $F_{30\%}$ and $F_{40\%}$. Probabilities of overfishing were provided for $F_{30\%}$ and $F_{40\%}$ respectively: 25% and 40% for Puerto Rico, 42% and 57% for St Thomas and 54% and 66% for St Croix. These probabilities and their associated risk indicate that the Red Hind stock has, on average, a 32.5%–60% risk of experiencing overfishing and therefore is being exploited unsustainably. Such a high fishing pressure upon larger males within aggregations has been suggested to result in sperm limitation and unbalanced male:female ratio. These findings are in agreement with estimated increases in total mortality for St Thomas and St Croix. In Puerto Rico the trend in total mortality was unclear: pot, traps and vertical line fleets exhibited decreasing total mortality whereas the diving fleet increasing Z values. However, in Puerto Rico there was an issue with sampling intensity in recent years and representative sampling of the population. Evidently, stringent harvest control management procedures, including more effective monitoring, surveillance and enforcement, will be required to return the stock to sustainable levels of exploitation. Future management procedures should be designed to lower the risk of high harvest rates and to promote stock recovery when stock size is low, thus reducing the risk of over exploitation.

When someone considers the results of this assessment, the person should always take into account the limitations of the sampling scheme. Only the TIP data were used for this assessment. Various other data sources existed but were not fully used due to various shortcomings. Evidently there is an issue with regard to how well the TIP data are representing the population. A key aspect in model development that is related to sampling error is that of representative sampling. This is because even if the particular model applied here fitted the present data set, this does not necessarily imply that the model also described adequately the entire Red Hind population. This restricts the current findings from supporting status inferences and promoting management decisions. Still total mortality estimates, Lc and overfishing probabilities can be utilized as early indicators of stock status.

6. RECOMMENDATIONS

The following are some general suggestions and recommendations to improve the current status of the fishery.

A. Improve the fishery information management system. The Puerto Rico's fishery has been monitored through the Fisheries Statistics Project (FSP) continuously since 1967. The project aimed to provide fisheries data for the resources in the waters of Puerto Rico and scientific information to support management plans. Despite this FSP initiative, the lack of reliable official fishery statistics is evident and constitutes a considerable handicap for the assessments. It is important to improve the official state authority design, implementation and integration of the system to collect and compile statistical data from the entire national fisheries. This data collection system should ideally cooperate with other authorities e.g. the port authorities, the local customs offices, correspondents in municipalities and communities, villages. The primary objective should be to collect fishery-dependent info: catch, effort, discards, fleet, economic (cost, profit), social (e.g. employment, education) statistics. Following standard and common sampling protocols for all isles, fleets, gears, seasons and strata. Similar data, especially catches, effort, discards, costs and profits, can be collected regularly using onboard sampling, i.e. following the fishers during their fishing trips. This will provide more realistic data that could then be compared with port sampling, intercepts, TIP, logbooks.

B. Basic research could be promoted to study Red Hind biological parameters. This research preferably may include: age, growth, feeding, length/age-at-maturity, and fecundity to provide the fundamental knowledge that will support future assessments.

C. Fishery-independent surveys should be carefully designed and carried out in order to provide scientifically sound information and data to support stock assessment, fishery conservation and management. These ideally should cover the distribution of key species (including Red Hind) in all three studied regions, i.e. Puerto Rico, St Thomas/St John and St Croix. Such scientific surveys will provide abundance and biomass estimates but also additional size distribution, maturity, spawning season and areas, scales or otoliths for age and growth studies, stomach contents, fecundity information and they can target early-life stages and adult parts of the population. In addition a number of auxiliary data can be collected, e.g., oceanographic, seabed substrate, information on essential fish habitat of the species. These fishery-independent surveys will provide complete catch records in the area. Commercial vessels often discard many species and especially small fish (< MLS: minimum landing size), whereas research vessel surveys can provide information on the total species composition and size range available to the gear. The scientific information and data that will be collected will increase long-term economic and social benefits from the fisheries resources in the area. Once established, these surveys should be carried out routinely to support scientific monitoring of the living marine resources (e.g. annually or bi-annually).

D. Following the required provisions of the Magnuson-Stevens Fishery Conservation and Management Act, a number of management reference points for species undergoing overfishing were established by the 2010 Caribbean Annual Catch Limit Amendment 3. The Annual Catch Limit (ACL) is currently the main management tool and US fisheries should aim to specify ACLs and accountability measures, AMs, to prevent ACLs from being exceeded. Fishery-dependent catch, effort and discards statistics are urgently required to follow these provisions. As a first step, catch-based methods can be implemented that require only catch information. Biomass dynamic models can also be applied providing catch and effort data will become available. However, scientific advice to fishery managers needs to be expressed in probabilistic terms to convey uncertainty about the consequences of alternative harvesting policies. One avenue for future stock assessment could be to build informative prior probability distributions (*priors*) for *r, K, q, M, F*. Expert knowledge and the available fishery datasets may prove useful in building such priors. Then using a simple biomass dynamic model fitted to catch rate data, a risk assessment approach can be applied to evaluate the potential consequences of alternative ACLs. The benefit for the fishery from a probabilistic modelling method would be that uncertainties would have been considered but also estimates of biological risks of alternative ACL-policy options will be provided. This may serve as a basis for providing precautionary fishery management advice given the high degree of uncertainty.

E. Design and carry out gear selectivity studies aiming to disclose species' selectivity patterns and improve resource exploitation. This coupled with discard estimates from the fleet statistics and onboard scientific sampling will allow the assessment of discard mortality.

F. Improve the effectiveness of external partnerships with fishers, managers, scientists, conservationists, and other interested groups to build a balanced approach to meet common fisheries goals. This will ensure best buy-in of any future management measure.

G. Enforce stringent monitoring, control and surveillance mechanisms to restrict unregulated fishing in spawning aggregations that restrain stock recovery.

APPENDIX 1: BIBLIOGRAPHY OF MATERIALS PROVIDED FOR REVIEW

SEDAR35-DW-01 Monitoring of Commercially Exploited Fisheries Resources in Puerto Rico
SEDAR35-DW-02 Reef Fish Monitoring
SEDAR35-DW-03 Red hind data from Puerto Rico
SEDAR35-DW-04 Abundance Indices of Red Hind Collected in Caribbean SEAMAP Surveys from Southwest Puerto Rico

SEDAR35-AW-01 Standardized Catch Rates for Red Hind from the Commercial Diving, Trap, and Vertical Line Fisheries in Puerto Rico

SEDAR35-RD01 A Cooperative Multiagency Reef Fish Monitoring Protocol for the U.S. Virgin Islands Coral Reef Ecosystem, v. 1.00
SEDAR35-RD02 Fishery independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puerto Rican EEZ
SEDAR35-RD03 Portrait of the commercial fishery of red hind, Epinephelus guttatus, in Puerto Rico during 1992-1999
SEDAR35-RD04 Portrait of the commercial fishery of red hind, Epinephelus guttatus, in Puerto Rico during 1988-2001
SEDAR35-RD05 Evaluation of seasonal closures of red hind, Epinephelus guttatus (Pisces: Serranidae), spawning aggregations to fishing off the west coast of Puerto Rico, using fishery-dependent and independent time series data
SEDAR35-RD06 Description of larval development of the red hind Epinephelus guttatus, and the spatio-temporal distributions of ichthyoplankton during a red hind spawning aggregations off La Parguera, Puerto Rico
SEDAR35-RD07 Brief Summary of SEAMAP Data Collected in the Caribbean Sea from 1975 to 2002
SEDAR35-RD08 Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection
SEDAR35-RD09 Spatial and temporal patterns of movement and migration at spawning aggregations of red hind, Epinephelus guttatus, in the U.S. Virgin Islands

Section1_Intro_S35_red_hind
SectionII_S35_RedHind_DW_Report_with_disclaimer_watermark
SectionIII_S35_AW_report_with_watermark

Additional bibliography used for the review:

Beets J, Friedlander A. 1992. Stock analysis and management strategies for red hind, *Epinephelus guttatus*, in the U.S. V. I. Proc 42nd Gulf Caribb Fish Inst 42: 66–79.

Carruthers, T.R., Punt, A., Walters, C.J., MacCall, A., McAllister, M.K., Dick, E.J., Cope, J. 2014. Evaluating methods for setting catch limits in data-limited fisheries. Fisheries Research 153: 48-68.

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Francis, R.I.C.C., and Shotton, R. 1997. "Risk"in fisheries management: a review. Canadian Journal of Fisheries and Aquatic Sciences, 54: 1699-1715.

Gedamke T. and Hoenig J.E. 2006. Estimating Mortality from Mean Length Data in Nonequilibrium Situations, with Application to the Assessment of Goosefish. Transactions of the American Fisheries Society 135: 476–487. DOI: 10.1577/T05-153.1

Sadovy Y, Figuerola M. 1992. The status of red hind fishery in Puerto Rico and St. Thomas, as determined by yield-per-recruit analysis. Gulf Caribb Fish Inst 42: 23–38.

Sadovy Y, Figuerola M, Roman A. 1992. Age and growth of red hind *Epinephelus guttatus* in Puerto Rico and St. Thomas. Fishery Bulletin 90: 516–528.

Sadovy, Y., A. Rosario, and A. Roman. 1994. Reproduction in an aggregating grouper, the red hind, *Epinephelus guttatus*. Environmental Biology of Fishes 41: 269-286.

Shapiro DY, Sadovy Y, McGehee MA (1993) Size, composition, and spatial structure of the annual spawning aggregation of the red hind, *Epinephelus guttatus* (Pisces: Serranidae). Copeia 2:399–406

APPENDIX 2: A COPY OF THE CIE STATEMENT OF WORK

Statement of Work for Dr. Christos Maravelias

External Independent Peer Review by the Center for Independent Experts

SEDAR 35 Caribbean Red Hind Assessment Desk Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: SEDAR 35 will be a compilation of data, benchmark assessments of the stocks, and an assessment review conducted for Caribbean red hind. The review is responsible for ensuring that the best possible assessment is provided through the SEDAR process and will provide guidance to the SEFSC to aid in their review and determination of best available science, and when determining if the assessment is useful for management. The stocks assessed through SEDAR 35 are within the jurisdiction of the Caribbean Fishery Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Experience with data-limited assessment methods is desirable. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs cannot be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than September 12, 2014, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be

written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

4 August 2014	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
18 August 2014	NMFS Project Contact sends the CIE Reviewers the report and background documents
25 August through 12 September 2014	Each reviewer conducts an independent peer review as a desk review
12 September 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
26 September 2014	CIE submits the CIE independent peer review reports to the COTR
30 September 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting

Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Support Personnel:

Allen Shimada
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
Allen Shimada@noaa.gov Phone: 301-427-8174

William Michaels
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
mshivlani@ntvifederal.com Phone: 305-968-7136

Key Personnel:

NMFS Project Contact:

Julie A. Neer, SEDAR Coordinator
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405
Julie.Neer@safmc.net Phone: 843-571-4366

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 35 Caribbean Red Hind Assessment Desk Review

1. Evaluate the data used in the assessment, addressing the following:
   e) Are data decisions made by the Assessment Workshop sound and robust?
   f) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   g) Are data applied properly within the assessment model?
   h) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   d) Are methods scientifically sound and robust?
   e) Are assessment models configured properly and used consistent with standard practices?
   f) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   f) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   g) Is the stock overfished? What information helps you reach this conclusion?
   h) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   i) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   j) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
   e) Are the methods consistent with accepted practices and available data?
   f) Are the methods appropriate for the assessment model and outputs?
   g) Are the results informative and robust, and useful to support inferences of probable future conditions?
   h) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

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

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.