Analyses of Commercial Parrotfish Landings in the U.S. Caribbean
NOAA National Marine Fisheries Service
Southeast Regional Office
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Introduction

Parrotfish are both a culturally and ecologically significant species in the Caribbean. They are harvested throughout the U.S. Caribbean with the majority of commercial landings coming from St. Croix. Parrotfish are herbivorous grazers that remove algae, which enhances settlement and survival of coral recruits (Brock 1979; Mumby 2006; Burkepile and Hay 2010). Their ecological role has become more relevant in the past 30 years due to the Caribbean-wide decline of longspine urchin (*Diadema antillarum*) in the 1980s (Mumby 2006).

In recent years, the Caribbean Fishery Management Council (CFMC) has approved several regulations to directly or indirectly reduce parrotfish harvest. In November 2005, a prohibition of gill and trammel nets was implemented in federal waters (50 CFR Parts 600 and 622). A compatible regulation was implemented in state waters of the U.S. Virgin Islands (USVI) in July 2006 (V.I.C. Title 12, Chapter 9A, 321-1), but, the Commonwealth of Puerto Rico did not enact similar regulations in state waters. Amendment 5 to the CFMC's Reef Fish Fishery Management Plan (FMP) was implemented on January 30, 2012, and prohibited the harvest of blue (*Scarus coeruleus*), midnight (*Scarus coelestinus*), and rainbow (*Scarus guacamaia*) parrotfish. These are the three largest parrotfish species that occur in the U.S. Caribbean and are considered to be the most vulnerable to overharvest because of their large body size, high susceptibility to spear gear and fish traps, and relatively low resilience.

The Magnuson-Stevens Reauthorization Act of 2006 required regional fishery management councils under federal management to implement annual catch limits (ACLs) and accountability measures (AMs) for all stocks undergoing overfishing by 2010. The CFMC implemented ACLs for parrotfish in Amendment 5 to the CFMC's Reef Fish FMP (CFMC 2010). ACLs were implemented for each island based on 85% of the average parrotfish landings from 1999 to 2005. Commercial ACLs for Puerto Rico and St. Thomas were set at 52,737 and 42,500 lbs, respectively. ACLs were set below the acceptable biological catch set by the Statistical and Scientific Committee to account for uncertainty, ecological factors, and other concerns. The proposed ACLs for Puerto Rico and St. Thomas are similar to the average landings from 2006 to 2008; however, St. Croix's ACL (240,000 lbs) is lower than the average landings from 2006 to 2008 (402,744 lbs). Thus, modifications to harvest strategies are needed to reduce landings to ensure the ACL is not exceeded. This report evaluates reductions in commercial landings projected from imposing minimum and maximum size limits, slot limits, and trip limits.

Data Sources

Two different datasets were used to estimate landings reductions associated with a variety of management schemes: 1) the National Marine Fisheries Service Southeast Fisheries Science Center's (SEFSC) Trip Interview Program (TIP) and 2) the commercial landings data for the U.S. Caribbean, which consists of the USVI Department of Planning and Natural Resources

(DPNR) commercial catch record (CCR) and Puerto Rico's Department of Natural and Environmental Resources (DNR) sales receipts. TIP data were accessed on January 5, 2011 from the SEFSC's data files. These data were collected by port samplers that interviewed fishermen and measured their catch. TIP provides information on the length and numbers of parrotfish species landed, gear used, and information on the fishing trip (e.g., date sampled, location sampled, and a variety of information on fishing effort (e.g. soak time, number of lines, number of traps). In some cases the TIP sampling may only provide a sub-sample of the total catch. USVI CCR and PR DNR trip data were accessed on March 17, 2011, from the SEFSC's data files, and provided fishermen reported catch for each trip, and included landings (in pounds whole weight) by general family name (parrotfish) with information on the fishing trip (i.e., date landed or sold, location fished, and capture gear). Landings data by individual parrotfish species are not available in the USVI or Puerto Rico, but have been recommended as part of the U.S. Caribbean Commercial Data Improvement project recently undertaken by the SEFSC, USVI DPNR, Puerto Rico DNR, NOAA Fisheries Service, CFMC and territory and commonwealth fishers.

Methods

Size Limits

Size limit analyses were conducted using available U.S. Caribbean TIP data for each island (St. Croix and St. Thomas = 2008-2010; Puerto Rico = 2006-2008). Samples were aggregated across years by island to increase sample sizes when determining reductions in landings associated with various size limits, and details on pooling the data across years are provided in **Appendix A**. TIP length data were recorded using fork length (*FL*) or total length (*TL*) in cm. Since the majority of the parrotfish data were in fork length (91%), all total lengths were converted to fork length using equation 1:

$$FL = \alpha * TL \qquad (1)$$

where *FL* is fork length in cm, α is a conversion parameter, and *TL* is total length in cm. Although landings data have not always been reported to species level for parrotfish, routinely the TIP data provide information on species. Data from TIP indicates seven different parrotfish species have been recorded in the samples. Length conversion parameters are shown in **Table 1**. Princess (*Scarus taeniopterus*), striped (*Scarus croicensis*) and redband (*Sparisoma aurofrenatum*) parrotfish did not require a conversion because they have truncated tails (i.e. fork length equals total length).

Table 1.- Total length to fork length conversion parameters for four parrotfish species using the equation FL=α*TL.

Common Name	*Genus species*	α	Source
Queen Parrotfish	*Scarus vetula*	0.967	Fishbase on 4/22/2011
Redfin Parrotfish	*Sparisoma rubripinne*	0.920	Fishbase on 4/22/2011
Redtail Parrotfish	*Sparisoma chrysopterum*	0.901	Molina (2005)
Stoplight Parrotfish	*Sparisoma viride*	0.903	Fishbase on 4/22/2011

After all lengths were standardized to fork length they were converted to weight following equation 2:

$$WT = aFL^b \quad (2)$$

where WT is weight in grams, *a* and *b* are weight-length conversion parameters. Weight-length conversion parameters are shown in **Table 2**. All weight conversions are in whole weight.

Table 2.- Fork length to total weight conversion parameters for seven parrotfish species using the equation: $WT=a(FL)^b$ where weight is grams and fork length is in mm, except for queen parrotfish where the fork length is in cm.

Common Name	Genus species	a	b	Source
Princess Parrotfish	*Scarus taeniopterus*	0.010	1.875	Bohnsack and Harper (1988)
Queen Parrotfish	*Scarus vetula*	0.025	2.921	Marks and Klomp (1988)
Redband Parrotfish	*Sparisoma aurofrenatum*	8.4E-05	2.744	Bohnsack and Harper (1988)
Redfin Parrotfish	*Sparisoma Rubripinne*	1.3E-05	3.064	Bohnsack and Harper (1988)
Redtail Parrotfish	*Sparisoma chrysopterum*	0.00089	2.319	Bohnsack and Harper (1988)
Stoplight Parrotfish	*Sparisoma viride*	3.7E-05	2.905	Bohnsack and Harper (1988)
Striped Parrotfish	*Scarus croicensis*	1.3E-05	3.055	Bohnsack and Harper (1988)

All the fork lengths were converted to inches and proportional reductions in landings were estimated for a range of minimum size limits, maximum size limits, and slot limits from 8 to 15 inches FL. The size limit analysis followed the method of Chih (2003) but did not include measurement error or release mortality. Measurement error information was not available because the CFMC has never imposed size limits on parrotfish, and no information is currently available for release mortality of parrotfish of the U.S. Caribbean. Release mortality was assumed to be zero and support for imposing this assumption seems reasonable since the majority of the parrotfish landings are caught with diving (spear) and trap gears, and gill nets are prohibited. Spears are thought to have very little bycatch of parrotfish (Soldo et al. 2007) and the traps were deployed primarily in shallow water (<30 feet).

The percent reduction of parrotfish from the size limits were calculated in terms of weight by using the corresponding weight for each fish's length. The weight of parrotfish below a minimum size limit was calculated using equation 3:

$$R_1 = C - G \quad (3)$$

where R_1 is the summed weight of all fish below a size limit, *C* is the total weight of all the fish measured, and *G* is the weight of fish measured that were greater than or equal to the minimum size limit. The weight of parrotfish above a maximum size limit was calculated using equation 4:

$$R_2 = C - H \quad (4)$$

where R_2 is the summed weight of all the fish above a size limit, *C* is the total weight of fish measured, and *H* is the weight of fish measured that were less than the maximum size limit. The

percent reductions in landings were calculated for a given minimum size limit (*MN*), maximum size limit (*MX*), and slot limit using equations 5-7:

$$MN = (R_1/C)*100 \quad (5)$$

$$MX = (R_2/C)*100 \quad (6)$$

$$SL = MN + MX \quad (7)$$

where *MN* is the percent reduction from a minimum size limit, *MX* is the percent reduction from a maximum size limit, *SL* is the percent reduction in landings from a slot limit, R_1 is the weight of parrotfish below a minimum size limit, R_2 is the weight of parrotfish above a maximum size limit, and *C* is the total weight of parrotfish measured in the TIP database.

The percent reductions for each island were calculated with respect to gear then weighted by the percentage of commercial landings by gear. This weighted reduction was calculated with equations 8-10:

$$WRMN = \sum_{i=1}^{n} MNG_i * LG_i \quad (8)$$

$$WRMX = \sum_{i=1}^{n} MXG_i * LG_i \quad (9)$$

$$WRSL = WRMN + WRMX \quad (10)$$

where WRMN is the weighted percent reduction in landings for a minimum size limit, MNG is the percent reduction from the minimum size limits for gear *i*, LG is the percentage of landings caught by gear *i*, WRMX is the weighted percent reduction in landings for a maximum size limit, MXG is the maximum size limit percent reduction for gear *i*, and WRSL is the weighted percent reduction for a slot limit.

Trip Limits

The U.S. Caribbean's USVI CCR and PR DNR trip ticket landings data from 2000 to 2008 contained 39,815 parrotfish records in St. Croix, 18,223 parrotfish records in St. Thomas, and 22,690 parrotfish records in Puerto Rico (80,728 total). The U.S. Caribbean landings data were used to evaluate reductions in landings from trip limits. A range of trip landings limits were considered ranging from 10 to 500 pounds. The estimated reduction in catch per trip was estimated using equation 11:

$$P = T - L \quad (11)$$

where P is the projected landings removed for a given trip limit, T is the total landings for a trip, and L is the imposed trip landings limit. All three variables are in pounds whole weight. P and T were summed for all trips and percent reductions associated with trip limits (*PRT*) were calculated using equation 12:

$$PRT = (P/T)*100. \quad (12)$$

The trip limit percent reductions for each island were calculated with respect to gear then weighted by the percentage of commercial landings by gear. This weighted reduction was calculated with equation 13:

$$WRTL = \sum_{i=1}^{n} PRT_i * LG_i \quad (13)$$

where WRTL is the weighted percent reduction in landings for a trip limit, PRT is the percent reduction from the trip limits for gear i, and LG is the percentage of landings caught by gear i.

Combination Size and Trip Limits

Percent reductions in landings were calculated for a combination of size/slot limits and trip limits using equations 14-16:

$$CR_1=1-(1-WRMN)*(1-WRTL) \quad (14)$$

$$CR_2=1-(1-WRMX)*(1-WRTL) \quad (15)$$

$$CR_3=1-(1-WRSL)*(1-WRTL) \quad (16)$$

where CR_1 is the combined weighted percent reductions in landings from both the minimum size limit and trip limit, CR_2 is the combined weighted percent reductions in landings from both the weighted maximum size limit and trip limit, and CR_3 is the combined weighted percent reductions in landings from both the slot limit and trip limit.

Results

TIP Catch Length Sample Data

The majority of U.S. Caribbean TIP parrotfish samples (2000-2010) were from St. Croix (n=16,683) followed by Puerto Rico (n=14,648) then St. Thomas (n=1,591). Rainbow (n=44), blue (n=10), and midnight parrotfish (n=2), were removed from the dataset since their harvest is prohibited (Amendment 5). Six redband and two redtail parrotfish were removed because they had lengths greater than 10 percent larger than the maximum size reported by Robins et al. (1986), and were greater than 3 standard deviations from the mean parrotfish length for the species. Records not identified to a specific parrotfish species (n=426) were also removed.

USVI CCR and PR trip ticket landings data

The U.S. Caribbean landings dataset from 2000 to 2008 included 39,815 parrotfish records in St. Croix, 18,223 parrotfish records in St. Thomas, and 22,690 parrotfish records in Puerto Rico (80,728 total). Available trip ticket data indicates U.S. Caribbean parrotfish landings from 2000-2008 peaked in 2006 (**Figure 1**). The gears that produced the majority of the landings were diving, traps, and gill nets (**Figure 2**). Despite the prohibition of gill and trammel nets in 2005 (50 CFR Parts 600 and 622) there still were landings from these gears in 2006 and 2007.

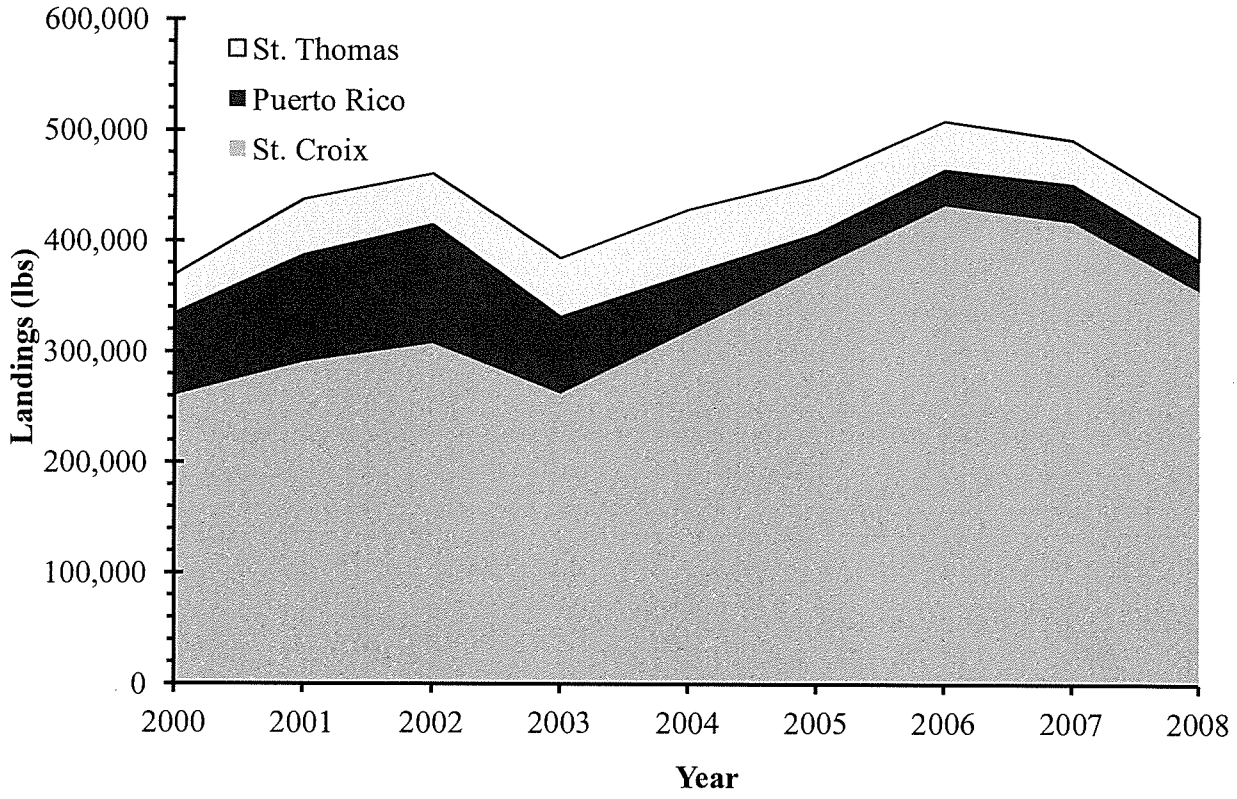

Figure 1.- Annual parrotfish landings for each U.S. Caribbean island from 2000 to 2008 (Source U.S. Caribbean landings dataset).

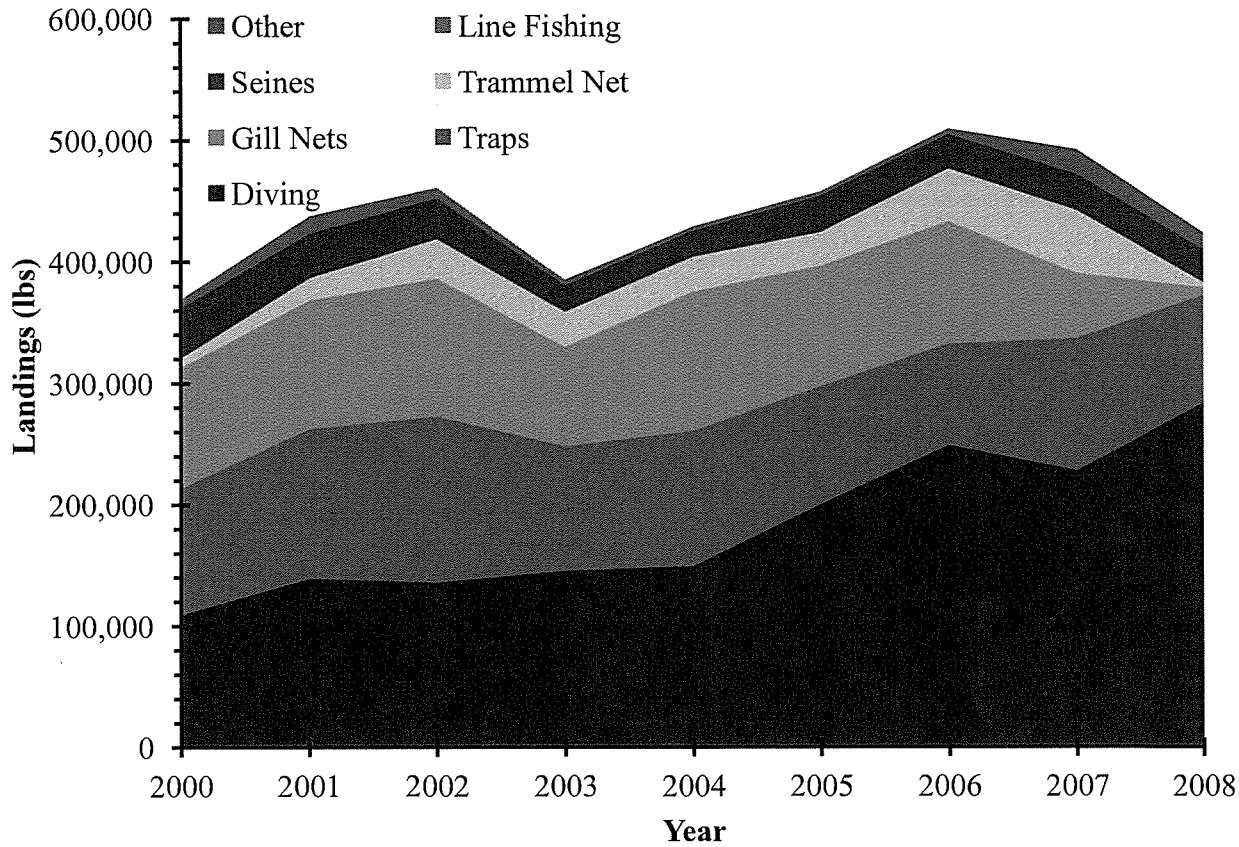

Figure 2.- Annual parrotfish landings from all U.S. Caribbean islands by gear type from 2000 to 2008 (Source U.S. Caribbean landings dataset). The "Other" category is composed of cast nets, spears, and unknown gear types.

Size Limit Analysis

St. Croix

Size limit analyses for St. Croix were based on the last three years of TIP data (2008 to 2010). The data from this period produced 59% of the TIP records and 35% of the TIP samples across the time period 2000 to 2010. Also, these years are more likely to represent current harvesting practices. A large reduction in landings (>50%) was estimated for either minimum size limits ≥12 inches FL or maximum size limits ≤11 inches FL (**Table 3**). **Table 4** provides a range of estimated percent reductions in landings for several combinations of minimum and maximum size limits (i.e., 'slot limits').

Table 3.- Percent reductions in parrotfish landings (pounds and percentage) for minimum and maximum size limits applied to St. Croix TIP data for the years 2008 to 2010. The reductions were calculated in terms of parrotfish weight (lbs) with respect to gear. Then the reductions were weighted by the percentage of landings for each gear type. The numbers listed under "lbs" in the minimum size column represent variable G in equation 3, and the numbers listed under "lbs" in the maximum size column represent variable H for equation 4. Variable C in equations 3 and 4 is the "No Limit" value (5,496 pounds).

Size Limit	Minimum size		Maximum Size	
(inches FL)	lbs	%	lbs	%
No Limit	5,496		5,496	
8	37	0.7	5,459	99.3
9	382	7.0	5,114	93.0
10	1069	19.4	4,427	80.6
11	2347	42.7	3,149	57.3
12	4081	74.2	1,415	25.8
13	5079	92.4	417	7.6
14	5352	97.4	144	2.6
15	5442	99.0	54	1.0

Table 4.- Weighted percent reductions in parrotfish landings (in lbs) for various slot limits created from St. Croix TIP data for the years 2008 to 2010.

	Maximum Size (inches FL)							
Minimum Size (inches FL)	8	9	10	11	12	13	14	15
8	-	93.7	81.2	58.0	26.4	8.3	3.3	1.7
9		-	87.5	64.2	32.7	14.6	9.6	8.0
10			-	76.7	45.2	27.0	22.1	20.4
11				-	68.5	50.3	45.3	43.7
12					-	81.8	76.9	75.2
13						-	95.0	93.4
14							-	98.4

St. Thomas

Size limit analyses for St. Thomas were based on the last three years of TIP data (2008 to 2010). This time period had the majority of the TIP records (61%) and samples (68%) from 2000 to 2010. Also, these years likely represent current harvesting conditions. A large reduction in landings (>50%) was estimated for minimum size limits ≥12 inches FL or maximum size limits ≤ 11 inches FL (**Table 5**). **Table 6** provides a range of estimated percent reductions in landings for combinations of minimum and maximum size limits (i.e., 'slot limits').

Table 5.- Percent reductions in parrotfish landings (pounds and percentage) for minimum and maximum size limits applied to St. Thomas TIP data for the years 2008 to 2010. The reductions were calculated in terms of parrotfish weight (lbs) with respect to gear. Then the reductions were weighted by the percentage of landings for each gear type. The numbers listed under "lbs" in the minimum size column represent variable G in equation 3, and the numbers listed under "lbs" in the maximum size column represent variable H for equation 4. Variable C in equations 3 and 4 is the "No Limit" value (1,059 pounds).

Size Limit	Minimum size		Maximum Size	
(inches FL)	lbs	%	lbs	%
No Limit	1,059		1,059	
8	2	0.1	1,057	99.9
9	17	1.6	1,042	98.4
10	136	12.8	923	87.2
11	474	44.7	585	55.3
12	837	79.0	222	21.0
13	1,008	95.2	51	4.8
14	1,041	98.3	18	1.7
15	1,051	99.2	8	0.8

Table 6.- Weighted percent reductions in parrotfish landings for various slot limits created from St. Thomas TIP data for years 2008 to 2010.

	Maximum Size (inches FL)							
Minimum Size (inches FL)	8	9	10	11	12	13	14	15
8	-	98.5	87.3	55.4	21.1	5.0	1.9	0.9
9		-	88.8	56.9	22.6	6.4	3.3	2.4
10			-	68.1	33.8	17.7	14.6	13.6
11				-	65.7	49.5	46.4	45.5
12					-	83.8	80.7	79.8
13						-	96.9	96.0
14							-	99.1

Puerto Rico

Size limit analyses were conducted using 2006-2008 TIP data, which accounted for 17% of the total TIP records and 18% of the total parrotfish records during 2000-2009. Large reduction in landings (>50%) were estimated for either minimum size limits ≥12 inches FL or maximum size limits ≤ 11 inches FL (**Table 7**). **Table 8** provides a range of estimated percent reductions in landings for various combinations of minimum and maximum size limits (i.e., 'slot limits').

Table 7.- Percent reductions in parrotfish landings (pounds and percentage) for minimum and maximum size limits applied to Puerto Rico TIP data for the years 2006 to 2008. The reductions were calculated in terms of parrotfish weight (lbs) with respect to gear. Then the reductions were weighted by the percentage of landings for each gear type. The numbers listed under "lbs" in the minimum size column represent variable G in equation 3, and the numbers listed under "lbs" in the maximum size column represent variable H for equation 4. Variable C in equations 3 and 4 is the "No Limit" value (2,377 pounds).

Size Limit	Minimum size		Maximum Size	
(inches FL)	lbs	%	lbs	%
No Limit	2,377		2,377	
8	13	0.6	2,364	99.4
9	72	3.0	2,305	97.0
10	316	13.3	2,061	86.7
11	729	30.7	1,648	69.3
12	1,403	59.0	974	41.0
13	2,053	86.4	324	13.6
14	2,288	96.2	89	3.8
15	2,347	98.7	30	1.3

Table 8.- Weighted percent reductions in parrotfish landings for various slot limits created from Puerto Rico TIP data for years 2006 to 2008.

	Maximum Size (inches FL)							
Minimum Size (inches FL)	8	9	10	11	12	13	14	15
8	-	97.5	87.3	69.9	41.5	14.2	4.3	1.8
9		-	89.8	72.4	44.0	16.7	6.8	4.3
10			-	82.6	54.3	26.9	17.0	14.6
11				-	71.6	44.3	34.4	31.9
12					-	72.7	62.8	60.3
13						-	90.1	87.6
14							-	97.5

Size limit restrictions have the potential to impact each parrotfish species in a different way. Relative impacts depend primarily on the size distribution and population abundance of each parrotfish species. The most common parrotfish species in the most recent available TIP data for all three areas (St. Croix 2008-2010, St. Thomas 2008-2010, Puerto Rico 2006-2008) were redtail, stoplight, and redband parrotfish (**Table 9**). A box plot of the size composition for each species (**Figure 3**) shows the majority of the parrotfish lengths in the catch are relatively similar.

Table 9.- Percentage of TIP records by species for each island for the most recent data (St. Croix 2008-2010, St. Thomas 2008-2010, and Puerto Rico 2006-2008). Numbers in parenthesize are sample size.

	Princess	Queen	Redband	Redfin	Redtail	Stoplight	Striped
St. Croix	1.4 (87)	0.2 (13)	7.9 (463)	5.6 (329)	49.4 (2,907)	35.5 (2,090)	0.0 (0)
St. Thomas	0.7 (7)	0.2 (2)	0.8 (8)	3.6 (38)	45.8 (485)	48.9 (518)	0.1 (1)
Puerto Rico	4.8 (116)	4.8 (115)	0.4 (9)	1.7 (42)	38.1 (923)	50.2 (1,213)	0.0 (0)
All Three Islands	2.2(210)	1.4 (130)	5.1 (480)	4.4 (409)	46.1 (4,315)	40.8 (3,821)	0.01 (1)

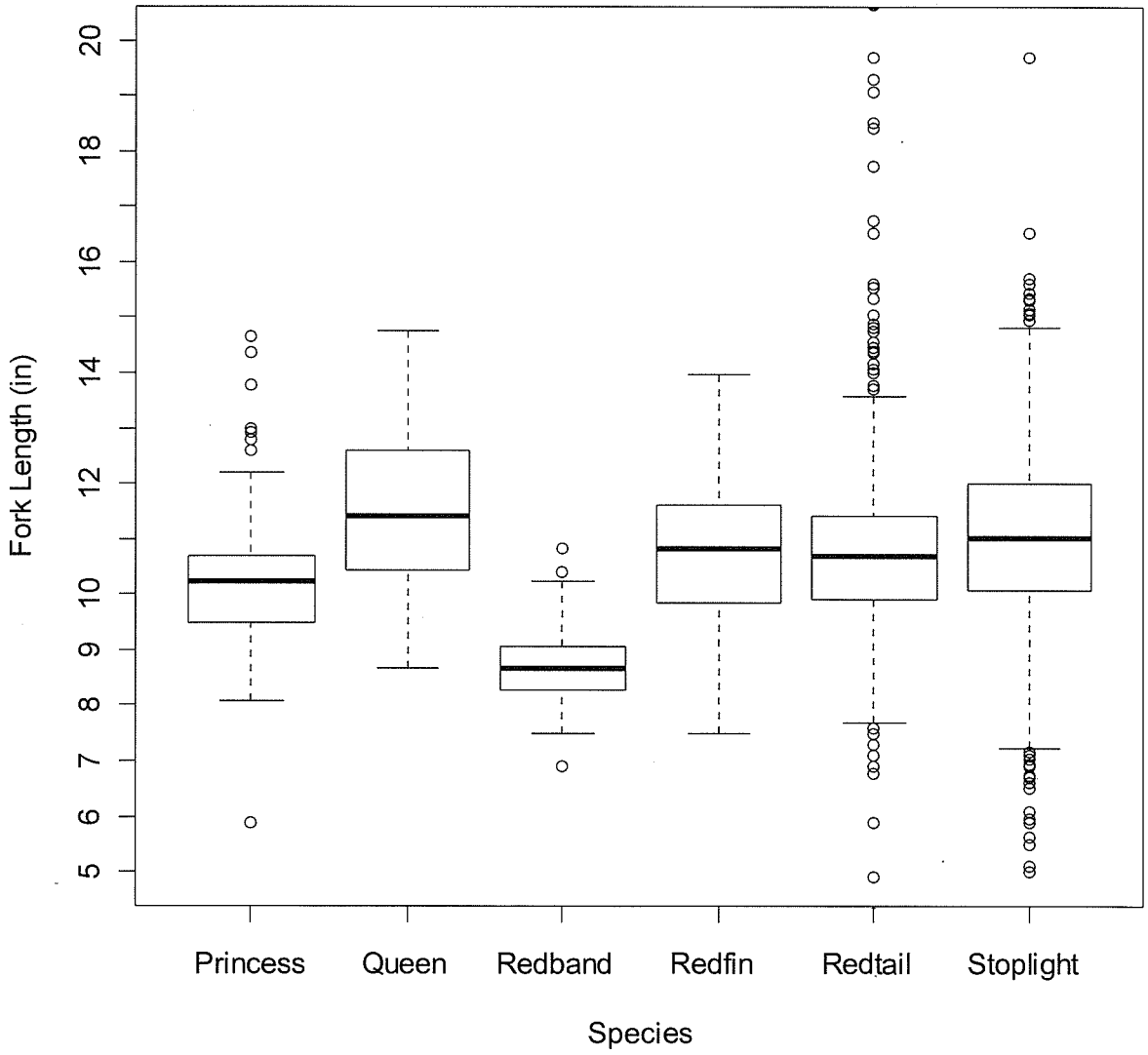

Figure 3.- Box plot of the size of each parrotfish species created from the most recent TIP data for all three islands (St. Croix 2008-2010, St. Thomas 2008-2010, and Puerto Rico 2006-2008). Striped parrotfish were not included in the boxplot because there was only one record in the most recent data.

Trip Limit Analysis

St. Croix

The annual landings data from St. Croix (2007 and 2008) accounted for 19% of the records and 21% of the landings by weight (lbs) between 1998 and 2009. The average, minimum, and maximum parrotfish landings per trip were 86, 1, and 2,996 pounds for 2007, and 78, 1, and 905 pounds for 2008. A trip limit analysis estimated large reductions in landings (>50%) occurred at trip limits of 60 pounds or less (**Table 10**). Trip limits imposed in St. Croix would have the greatest impact on parrotfish collected with dive gear (**Table 11**), which may also include spear and net gears.

Table 10.- Percent reductions in parrotfish landings (pounds and percentage) for various trip limits applied to St. Croix landings data for 2007 and 2008 (n=9,449 trips). The reductions were calculated in terms of parrotfish weight (lbs) with respect to gear. Then the reductions were weighted by the percentage of landings for each gear type. The numbers listed under "Landings (lbs) Reduction" represent variable P in equation 11. Variable T in equation 11 is the "No Limit" value of 774,888 pounds.

Trip Limit	Landings (lbs) Reduction	Percent Reduction
No Limit	774,888	
10	683,700	88.2
20	604,992	78.1
30	539,216	69.6
40	482,008	62.2
50	432,091	55.8
60	389,124	50.2
70	352,723	45.5
80	321,209	41.5
90	293,796	37.9
100	269,509	34.8
150	194,548	25.1
200	140,732	18.2
300	59,437	7.7
400	16,866	2.2
500	5,533	0.7

Table 11.- Percent reductions in parrotfish landings (pounds and percentage) for each gear based on St. Croix landings data for 2007 and 2008. The numbers listed under "Landed (lbs)" represent variable P in equation 11. Variable T in equation 11 is the "No Limit" value for each gear.

	Castnet		Diving		Traps		Line Fishing		Seine Net		Trammel Net		Gillnet	
Trip Limits (lbs)	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction
No Limit	1,906		491,820		104,589		22,333		55,559		45,128		53,326	
10	1,466	76.9	432,322	87.9	83,034	79.4	17,705	79.3	54,089	97.4	43,858	97.2	50,971	95.6
20	1,034	54.2	376,252	76.5	69,704	66.6	14,030	62.8	52,619	94.7	42,588	94.4	48,654	91.2
30	630	33.1	327,423	66.6	61,115	58.4	11,083	49.6	51,149	92.1	41,318	91.6	46,364	86.9
40	312	16.4	284,411	57.8	54,969	52.6	8,322	37.3	49,689	89.4	40,048	88.7	44,084	82.7
50	131	6.9	247,250	50.3	49,877	47.7	5,894	26.4	48,229	86.8	38,778	85.9	41,813	78.4
60	48	2.5	216,149	43.9	45,058	43.1	3,877	17.4	46,769	84.2	37,508	83.1	39,556	74.2
70	5	0.3	190,690	38.8	40,446	38.7	2,555	11.4	45,309	81.6	36,238	80.3	37,306	70.0
80	0	0.0	169,473	34.5	36,005	34.4	1,762	7.9	43,849	78.9	34,968	77.5	35,066	65.8
90	0	0.0	151,615	30.8	31,814	30.4	1,292	5.8	42,389	76.3	33,698	74.7	32,876	61.7
100	0	0.0	136,225	27.7	28,146	26.9	963	4.3	40,939	73.7	32,428	71.9	30,696	57.6
150	0	0.0	95,471	19.4	18,069	17.3	345	1.5	33,789	60.8	26,178	58	20,646	38.7
200	0	0.0	70,056	14.2	11,305	10.8	80	0.4	26,758	48.2	19,988	44.3	12,471	23.4
300	0	0.0	30,397	6.2	4,095	3.9	0	0.0	13,959	25.1	9,041	20.0	1,991	3.7
400	0	0.0	6,277	1.3	1,550	1.5	0	0.0	6,395	11.5	2,553	5.7	70	0.1
500	0	0.0	2,496	0.5	800	0.8	0	0.0	3,620	6.5	1,069	2.4	0	0.0

St. Thomas

The annual landings data from St. Thomas (2007 and 2008) accounted for 18% of the records and landings in weight (lbs) during 2000-2009. The average, minimum, and maximum parrotfish landings per trip were 24, 1, and 145 pounds for 2007, and 24, 2, and 200 pounds for 2008. A trip limit analysis estimated large reductions in landings (>50%) occurred at a trip limit of 10 pounds (**Table 12**). Trip limits imposed in St. Thomas would have the greatest impact on parrotfish collected with traps (**Table 13**).

Table 12.- Percent reductions in parrotfish landings (pounds and percentage) for various trip limits applied to St. Thomas landings data for 2007 and 2008 (n=3,366 trips). The reductions were calculated in terms of parrotfish weight (lbs) with respect to gear. Then the reductions were weighted by the percentage of landings for each gear type. The numbers listed under "Landings (lbs) Reduction" represent variable P in equation 11. Variable T in equation 11 is the "No Limit" value of 79,788 pounds.

Trip Limit	Landings (lbs) Reduction	Percent Reduction
No Limit	79,788	
10	50,073	62.8
20	33,291	41.8
30	22,794	28.5
40	15,345	19.2
50	9,726	12.2
60	5,564	7.0
70	3,128	3.9
80	1,871	2.3
90	1,247	1.6
100	935	1.2
150	156	0.2
200	0	0.0
300	0	0.0
400	0	0.0
500	0	0.0

Table 13.- Percent reductions in parrotfish landings (pounds and percentage) for each gear based on St. Thomas landings data for 2007 and 2008. The numbers listed under "Landed (lbs)" represent variable P in equation 11. Variable T in equation 11 is the "No Limit" value for each gear.

	Diving		Traps		Line Fishing		Seine Net	
Trip Limits (lbs)	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction
No Limit	827		77,944		800		213	
10	491	59.4	49,212	63.1	259	32.4	137	64.3
20	252	30.5	32,850	42.1	142	17.8	80	37.6
30	132	16.0	22,494	28.9	85	10.6	50	23.5
40	65	7.9	15,161	19.5	60	7.5	20	9.4
50	20	2.4	9,641	12.4	40	5.0	0	0.0
60	10	1.2	5,531	7.1	20	2.5	0	0.0
70	0	0.0	3,083	4.0	10	1.3	0	0.0
80	0	0.0	1,863	2.4	0	0.0	0	0.0
90	0	0.0	1,283	1.6	0	0.0	0	0.0
100	0	0.0	930	1.2	0	0.0	0	0.0
150	0	0.0	165	0.2	0	0.0	0	0.0
200	0	0.0	0	0.0	0	0.0	0	0.0
300	0	0.0	0	0.0	0	0.0	0	0.0
400	0	0.0	0	0.0	0	0.0	0	0.0
500	0	0.0	0	0.0	0	0.0	0	0.0

Puerto Rico

The annual landings data (2008 and 2009) from Puerto Rico accounted for 13% of the records and 8% of the landings by weight (lbs) during 1998 to 2009. The average, minimum, and maximum parrotfish landings per trip were 51, 2, and 5,000 pounds for 2008, and 31, 1, and 1,383 pounds for 2009. A trip limit analysis estimated large reductions in landings (>50%) occurred at a trip limit of 10 pounds (**Table 14**). Trip limits imposed in Puerto Rico would have the greatest impact on parrotfish collected with traps (**Table 15**).

Table 14.- Percent reductions in parrotfish landings (pounds and percentage) for various trip limits applied to Puerto Rico landings data for 2008 and 2009 (n=3,709 trips). The reductions were calculated in terms of parrotfish weight (lbs) with respect to gear. Then the reductions were weighted by the percentage of landings for each gear type. The numbers listed under "Landings (lbs) Reduction" represent variable P in equation 11. Variable T in equation 11 is the "No Limit" value of 56,487 pounds.

Trip Limit lbs	Landings (lbs) Reduction	Percent Reduction
No Limit	56,487	
10	29,309	54.6
20	18,104	35.2
30	12,899	25.6
40	9,515	19.2
50	7,112	14.6
60	5,373	11.2
70	4,092	8.6
80	3,146	6.7
90	2,469	5.3
100	1,961	4.3
150	716	1.8
200	385	1.0
300	0	0
400	0	0
500	0	0

Table 15.- Percent reductions in parrotfish landings (pounds and percentage) for each gear based on Puerto Rico landings data for 2008 and 2009. The numbers listed under "Landed (lbs)" represent variable P in equation 11. Variable T in equation 11 is the "No Limit" value for each gear.

	Diving		Traps		Line Fishing		Seine Net		Trammel Net		Gillnet	
Trip Limits (lbs)	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction	Landed (lbs)	% Reduction
No Limit	16,148		13,238		13,253		1,669		6,833		5,346	
10	7,668	47.5	4,868	36.8	8,463	63.9	895	53.6	5,172	75.7	2,243	42.0
20	4,101	25.4	2,032	15.3	6,100	46.0	488	29.2	3,883	56.8	1,500	28.1
30	2,732	16.9	1,088	8.2	4,637	35.0	369	22.1	2,953	43.2	1,120	21.0
40	1,987	12.3	485	3.7	3,630	27.4	309	18.5	2,224	32.5	880	16.5
50	1,460	9.0	148	1.1	2,882	21.7	250	15.0	1,672	24.5	700	13.1
60	1,049	6.5	26	0.2	2,274	17.2	200	12.0	1,254	18.4	570	10.7
70	776	4.8	5	0.0	1,776	13.4	150	9.0	942	13.8	443	8.3
80	575	3.6	0	0.0	1,437	10.8	105	6.3	691	10.1	338	6.3
90	419	2.6	0	0.0	1,192	9.0	70	4.2	531	7.8	257	4.8
100	299	1.9	0	0.0	1,014	7.7	50	3.0	397	5.8	201	3.8
150	21	0.1	0	0.0	585	4.4	0	0.0	100	1.5	10	0.2
200	0	0.0	0	0.0	335	2.5	0	0.0	50	0.7	0	0.0
300	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
400	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
500	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Combination Size and Trip Limit Analyses

Minimum size, maximum size, and slot limit results were combined with trip limit results to determine percent reductions in landings for each island (**Tables 16, 17, 18,** and **19**). A range of sizes ranging from 8 to 14 inches FL were chosen to provide a variety of estimated percent reductions in landings. Trip limits of 10 to 50, 100, 150, and 200 pounds were chosen because they provided a variety of estimated percent reductions in landings for each island (**Tables 10, 12,** and **14**).

Table 16.- Weighted percent reductions in parrotfish landings for minimum and maximum size limits combined with various trip limits for St. Croix.

		Trip Limit (lbs)							
		10	20	30	40	50	100	150	200
	8	88.3	78.2	69.8	62.5	56.1	35.2	25.6	18.7
	9	89.0	79.6	71.7	64.8	58.9	39.3	30.3	23.9
Min Size (in)	10	90.5	82.4	75.5	69.6	64.4	47.5	39.7	34.1
	11	93.2	87.5	82.6	78.3	74.7	62.6	57.1	53.1
	12	97.0	94.4	92.2	90.3	88.6	83.2	80.7	78.9
	10	97.7	95.7	94.1	92.6	91.4	87.3	85.4	84.1
	11	95.0	90.6	87.0	83.9	81.1	72.2	68.0	65.1
Max Size (in)	12	91.2	83.7	77.4	71.9	67.2	51.6	44.4	39.3
	13	89.1	79.8	71.9	65.1	59.2	39.8	30.8	24.4
	14	88.5	78.7	70.4	63.2	57.0	36.5	27.1	20.3

Table 17.- Weighted percent reductions in parrotfish landings for minimum and maximum size limits combined with various trip limits for St. Thomas.

		Trip Limit (lbs)							
		10	20	30	40	50	100	150	200
	8	62.9	41.9	28.6	19.3	12.3	1.3	0.3	0.1
	9	63.4	42.7	29.7	20.5	13.6	2.8	1.8	1.6
Min Size (in)	10	67.6	49.3	37.7	29.6	23.5	13.9	13.0	12.8
	11	79.4	67.8	60.5	55.3	51.5	45.4	44.8	44.7
	12	92.2	87.8	85.0	83.1	81.6	79.3	79.1	79.0
	10	95.2	92.5	90.8	89.6	88.7	87.3	87.2	87.2
	11	83.4	74.0	68.0	63.9	60.7	55.8	55.4	55.3
Max Size (in)	12	70.6	54.0	43.5	36.1	30.6	21.9	21.1	21.0
	13	64.6	44.6	31.9	23.1	16.4	5.9	5.0	4.8
	14	63.4	42.8	29.7	20.6	13.7	2.9	1.9	1.7

Table 18.- Weighted percent reductions in parrotfish landings for minimum and maximum size limits combined with various trip limits for Puerto Rico.

		Trip Limit (lbs)							
		10	20	30	40	50	100	150	200
	8	54.8	35.6	26.0	19.7	15.1	4.9	2.4	1.6
	9	56.0	37.2	27.8	21.7	17.2	7.3	4.8	4.0
Min Size (in)	10	60.6	43.8	35.5	30.0	26.0	17.0	14.9	14.2
	11	68.5	55.1	48.4	44.0	40.8	33.7	31.9	31.4
	12	81.4	73.4	69.5	66.9	65.0	60.8	59.8	59.4
	10	94.0	91.4	90.1	89.3	88.7	87.3	87.0	86.8
	11	86.1	80.1	77.2	75.2	73.8	70.7	69.9	69.6
Max Size (in)	12	73.2	61.8	56.1	52.3	49.6	43.5	42.1	41.6
	13	60.8	44.0	35.7	30.3	26.3	17.4	15.2	14.5
	14	56.3	37.6	28.4	22.3	17.9	7.9	5.5	4.7

Table 19.- Weighted percent reductions in parrotfish landings for slot limits and trip limits for all three islands.

	Slot Limit (inches)	Trip Limit (lbs) 10	20	30	40	50	100	150	200
St. Croix	8 to 12	91.3	83.9	77.6	72.2	67.5	52.0	44.9	39.8
	8 to 14	88.6	78.8	70.6	63.4	57.3	36.9	27.6	20.9
	10 to 14	90.8	82.9	76.3	70.5	65.6	49.2	41.6	36.2
St. Thomas	8 to 12	70.7	54.1	43.6	36.3	30.7	22.1	21.3	21.1
	8 to 14	63.5	42.9	29.8	20.7	13.8	3.0	2.1	1.9
	10 to 14	68.2	50.3	38.9	31.0	25.0	15.6	14.7	14.6
Puerto Rico	8 to 12	73.5	62.1	56.5	52.8	50.1	44.1	42.6	42.1
	8 to 14	56.6	38.0	28.8	22.7	18.3	8.5	6.1	5.3
	10 to 14	62.3	46.2	38.3	33.0	29.2	20.6	18.6	17.9

Discussion

The CFMC recently implemented ACLs for all federally managed species. Based on ACLs recommended for parrotfish, reductions in landings will likely be required in St. Croix to prevent the ACL from being exceeded, and accountability measures from being triggered. The ACL for St. Croix is 40% lower than the average landings for 2006-2008 (CFMC 2010). Assuming previous year's landings are a reasonable predictor of future landings trends, a 40% reduction in landings could be accomplished with a minimum or maximum size of 11 inches (**Table 3**). These management measures could aid in decreasing the landings below the recommended ACL level given all other factors remaining constant (e.g., fisher behavior, fishing effort and distribution).

Evaluation of size limit data in these analyses suggested most parrotfish sampled through the TIP program were ≤ 12 inches FL (**Figure 3**). Size limits can potentially reduce harvest as well as reduce fishing mortality, protect immature fish and increase yield-per-recruit from a fish stock, assuming discard mortality is low. Size limits can also minimize recruitment overfishing, which can lead to a stock biomass level below maximum yield. Minimum size limits have the potential to increase productivity of a stock by allowing the fish to spawn before being harvested. Parrotfish become mature at a range of lengths varying spatially and across species. A literature review provided a range of lengths at maturity for U.S. Caribbean parrotfish from ~6 to 11 inches FL (Robertson and Warner 1978; Koltes 1993). A minimum size limit has the potential to improve the redband parrotfish stock because the majority of their harvests were below the size at maturity (~9.25 inches, Randall 1963) (**Figure 3**).

Another consideration of minimum size limits is the potential to cause fishermen to remove the larger fish, which produce exponentially more eggs than smaller fish (Bohnsack, 1990). Also, the absence of larger and older spawning stock may lower recruitment by preventing parrotfish from living long enough to survive through periods when conditions are poor for offspring survival (Hawkins and Roberts 2003), especially since the maximum ages of parrotfish species in the current catch range from only 3 to 7 years (Molina-Urena 2005). An additional consideration is all Caribbean parrotfish are protogynous hermaphrodites, changing sex from females to males. Generally, minimum size limits will protect the females but shift fishing pressure upon the males. This makes them highly susceptible to overfishing. Chronic removal of the male

parrotfish will dramatically decrease sperm availability and act as a limiting factor during mating (Clua and Legendre 2008). Another consideration is the reproductive behavior since male parrotfish maintain harems. The reproduction of the entire harem will be interrupted when a male is harvested, thus seriously reducing the reproductive output as seen by hogfish (*Lachnolaimus maximus*) (McBride and Johnson 2007). Also, parrotfish must reach a genetically determined size threshold before they can become males (Warner 1988; Clua and Legendre 2008). If fishing prevents individuals from growing large enough to undergo sex change then the population could become non-reproductive. Hawkins and Roberts (2003) examined parrotfish populations in Jamaica and the Dominican Republic and discovered fishing pressure eliminated stoplight and queen parrotfish males to the point where the population depends on recruitment from distant sources. Minimum size limits also have the potential to alter the balance of the species since each parrotfish species will be impacted differently. This could be counterproductive to ecosystem health.

Implementing a maximum size limit could help prevent the removal of older, larger fish in the population. Larger parrotfish are more likely to be male. Imposing a maximum size limit increases male survival and could prevent interruption of spawning harems. A maximum size limit of 11 inches for St. Croix was estimated to reduce landings by 42% (**Table 1**) and can, potentially, decrease the current landings below the proposed ACL level. However, the continued removal of small fish, which are primarily females, could hamper spawning success. Additionally, a maximum size limit will only lead to a sustainable fishery if individuals live long enough to reach the maximum size limit.

Any minimum and maximum size limits need to consider socioeconomic impacts. There may be a range of parrotfish sizes that are more preferred in the markets.

There are a range of slot limits that can potentially reduce St. Croix parrotfish landings to the ACL level, which are highlighted in **Table 20.** In addition to the potential impacts of minimum and maximum size limits discussed earlier, a slot limit has the potential to protect females with a minimum size limit and the males with a maximum size limit.

Table 20.- Weighted percent reduction of parrotfish landings for various slot limits created from St. Croix TIP data for years 2008 to 2010. Cells highlighted in yellow have a reduction in landings of 40 percent or greater.

	Maximum Size (inches FL)							
Minimum Size (inches FL)	8	9	10	11	12	13	14	15
8	-	93.7	81.2	58.0	26.4	8.3	3.3	1.7
9		-	87.5	64.2	32.7	14.6	9.6	8.0
10			-	76.7	45.2	27.0	22.1	20.4
11				-	68.5	50.3	45.3	43.7
12					-	81.8	76.9	75.2
13						-	95.0	93.4
14							-	98.4

Parrotfish have become one of the most important reef fish species-groups harvested in St. Croix (Toller 2007). The use of gill and trammel nets was prohibited in St. Croix in 2006 in both state

and federal waters, however these gears were used after 2006 (**Figure 2**). Additionally, 70% of scuba landings are mis-reported (Toller 2007) because gill nets were used in combination with scuba gear. Toller (2007) analyzed St. Croix parrotfish landings and determined a cut-off threshold of 162.5 pounds to separate net-scuba from scuba-only landings. Therefore, a potential regulation to eliminate illegal netting is to set a trip limit below 162 pounds. A 150 pound trip limit can potentially reduce landings by 25%.

Finally, the results are based on the data available and assumptions used. Analyses assume the parrotfish length frequency distribution of the TIP dataset is representative of the catch, however, the TIP dataset has some caveats. The sampling depends on volunteer fishermen allowing a biologist to measure and count their catch. This volunteer option may bias the TIP data and could prevent the dataset from being an accurate representation of the overall catch. Additionally, fishermen involved in illegal activity will likely not participate. This issue was discussed at a SEDAR workshop in January of 2009 addressing non-reporting as a significant concern for Caribbean catch statistics. Another limitation of the TIP data is flaws in the sampling design with nonrandom sampling potentially biasing the results.

Analyses also assume fishermen will fully comply with size limits and no measurement error will occur. Retention of parrotfish below or above specified size limits would reduce the reductions estimated in this report. Additionally, trip limit reductions do not account for shifts in fishing effort or other behavior changes. If fishermen take more fishing trips to compensate for more restrictive trip limits, then reductions summarized herein are overestimated. The analysis is also affected by potential biases associated with sampling, such as spatial and temporal differences in sampling intensity over time.

In summary size limits and trip limits could potentially reduce parrotfish landings to levels equal to or less than the ACL set by the CFMC. If size limits are to be considered as a measure for reducing landings to meet the ACL, then parrotfish reproductive biology should be considered as size and slot limits may differentially affect female and male parrotfish. Trip limits could reduce landings, but would decrease the efficiency of fishermen that frequently produce large landings.

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Appendix A: Annual estimates of harvest reductions by island for various minimum size limits.

The majority of the recent data years did have sufficient TIP samples (>300) in each year to estimate reductions in harvest without pooling data. The only exception was St. Thomas in 2008 which only had 35 samples. **Tables A1, A2,** and **A3** show the annual percent reductions in harvest by island for minimum size limits, and compares weighted versus unweighted mean percent reductions across years. The unweighted mean gave equal weight to each year and the weighted means were calculated with the total pounds in a year given as the weighting factor. The consistency in the percent reductions across years justified the pooling of years.

Table A1.- Percent reductions in parrotfish landings (pounds and percentage) for minimum size limits applied to St. Croix TIP data for the years 2008 to 2010. The reductions were calculated in terms of parrotfish weight (lbs) for each year. The total weight for each year is the annual pounds of parrotfish sampled by TIP with no implemented size limit. The numbers under the "lbs" column for each year are the pounds of fish sampled by TIP that would not have been harvested if a minimum size limit was in place. Unweighted and weighted mean percent reductions for all three years were calculated with the annual total weights as the weighting factor.

	Year	2008		2009		2010		Unweighted	Weighted
	Total Weight	1,564 lbs		1,574 lbs		2,358 lbs		Mean %	Mean %
		lbs	%	lbs	%	lbs	%	Total = 5,496 lbs	
Minimum Size	8	17	1.1	9	0.6	7	0.3	0.7	0.6
	9	145	9.3	90	5.7	131	5.6	6.9	6.7
	10	346	22.1	285	18.1	437	18.5	19.6	19.4
	11	754	48.2	654	41.6	1,008	42.7	44.2	44.0
	12	1,199	76.7	1,128	71.7	1,750	74.2	74.2	74.2
	13	1,455	93.1	1,417	90.1	2,164	91.8	91.7	91.7
	14	1,538	98.4	1,508	95.8	2,290	97.1	97.1	97.1
	15	1,558	99.6	1,555	98.8	2,317	98.2	98.9	98.8
	16	1,558	99.6	1,570	99.8	2,327	98.7	99.4	99.3
	17	1,558	99.6	1,570	99.8	2,330	98.8	99.4	99.3
	18	1,558	99.6	1,570	99.8	2,333	98.9	99.4	99.4
	19	1,558	99.6	1,570	99.8	2,336	99.1	99.5	99.4
	20	1,564	100	1,574	100	2,340	99.2	99.7	99.7

Table A2.- Percent reductions in parrotfish landings (pounds and percentage) for minimum size limits applied to St. Thomas TIP data for the years 2008 to 2010. The reductions were calculated in terms of parrotfish weight (lbs) for each year. The total weight for each year is the annual pounds of parrotfish sampled by TIP with no implemented size limit. The numbers under the "lbs" column for each year are the pounds of fish sampled by TIP that would not have been harvested if a minimum size limit was in place. Unweighted and weighted mean percent reductions for all three years were calculated with the annual total weights as the weighting factor.

Year	2008		2009		2010		Unweighted Mean	Weighted Mean %
Total Weight	35 lbs		332 lbs		692 lbs			
	lbs	%	lbs	%	lbs	%	Total = 1,059 lbs	
8	0	0	1	0.3	5	0.7	0.3	0.6
9	0	0	5	1.5	40	5.8	2.4	4.3
10	0	0	40	12	142	20.5	10.8	17.2
11	8	22.9	151	45.5	346	50	39.5	47.7
12	32	91.4	253	76.2	573	82.8	83.5	81.0
13	35	100	311	93.7	668	96.5	96.7	95.7
14	35	100	325	97.9	685	99	99.0	98.7
15	35	100	329	99.1	691	99.9	99.7	99.7
16	35	100	332	100	692	100	100	100.0
17	35	100	332	100	692	100	100	100.0
18	35	100	332	100	692	100	100	100.0
19	35	100	332	100	692	100	100	100.0
20	35	100	332	100	692	100	100	100.0

Table A3.- Percent reductions in parrotfish landings (pounds and percentage) for minimum size limits applied to Puerto Rico TIP data for the years 2006 to 2008. The reductions were calculated in terms of parrotfish weight (lbs) for each year. The total weight for each year is the annual pounds of parrotfish sampled by TIP with no implemented size limit. The numbers under the "lbs" column for each year are the pounds of fish sampled by TIP that would not have been harvested if a minimum size limit was in place. Unweighted and weighted mean percent reductions for all three years were calculated with the annual total weights as the weighting factor.

	Year	2006		2007		2008		Unweighted	Weighted
	Total Weight	1,333 lbs		404 lbs		638 lbs		Mean %	Mean %
		lbs	%	lbs	%	lbs	%	Total = 2,377 lbs	
Minimum Size	8	10	0.7	1	0.3	8	1.3	0.8	0.8
	9	63	4.7	3	0.9	21	3.3	3.0	3.7
	10	259	19.4	35	8.8	121	19	15.7	17.5
	11	575	43.1	116	28.7	281	44	38.6	40.9
	12	958	71.8	223	55.2	463	72.5	66.5	69.1
	13	1,244	93.2	334	82.6	585	91.7	89.2	90.9
	14	1,306	97.9	359	89	608	95.2	94.0	95.6
	15	1,326	99.3	387	95.7	616	96.6	97.2	97.9
	16	1,331	99.7	389	96.2	624	97.7	97.9	98.5
	17	1,331	99.7	394	97.5	626	98.1	98.4	98.8
	18	1,331	99.7	394	97.5	626	98.1	98.4	98.8
	19	1,331	99.7	397	98.2	629	98.6	98.8	99.1
	20	1,331	99.7	397	98.2	638	100	99.3	99.4

Appendix B: Number of parrotfish TIP samples by island and by gear.

Table B1.- The number of parrotfish TIP samples by island and gear.

	Gear					
	Diving	Nets	Spear	Trap	Hook & Line	Total
St. Croix (2008-2010)	1,240	173	3,529	929	0	5,871
St. Thomas (2008-2010)	0	83	0	999	3	1,085
Puerto Rico (2006-2008)	66	2,287	0	39	26	2,418

Response to SEFSC comments on Caribbean parrotfish analysis
March 8, 2012

All comments provided by the SEFSC on December 8, 2011, were addressed. Below is a brief explanation of major changes made to the analysis in response to SEFSC comments.

Comment 1: Size selectivity will be different for each gear type. Therefore, size limits need to be evaluated with respect to gear type. Additionally, percent reductions should be weighted by catch or TIP sample sizes.

Response: Size limit analyses were adjusted and recalculated with respect to gear to address differences in gear selectivity. Reductions by gear were weighted by total reported annual landings by gear type to generate weighted size limit reduction estimates.

Comment 2: Indicate reasons why only the most recent 3-years are used in the analysis.

Response: The most recent 3-years were used because they reflect current harvesting practices in the fishery. Text has been added to the document indicating the reasons the three most recent years were chosen for analysis.

Comment 3: It was recommended that lengths be converted to weights before calculating the percent reduction in harvest to get a more accurate and "true" percent reduction of the landings.

Response: The percent reductions from the size limits were redone and calculated in terms of weight (lbs) by converting each length to weight. The methods section of the report was rewritten to discuss this addition to the methods.

Comment 4: Include additional discussion on potential biases of the TIP dataset.

Response: Biases of the TIP data are included in the Discussion section of the report. Specific biases discussed include: TIP samples may not be representative of the entire catch of the fishery due to non-random sampling of volunteer fisherman and illegal harvest.

Comment 5: State the average landings and range of landings per trip across the time series.

Response: The average, minimum, and maximum trip landings for each island and year of data were added to the trip limit results section.

Comment 6: Combining size limits with trip limits is not appropriate since the size limits are based on length and not stratified by gear type.

Response: The size limits were converted to weight and stratified by gear type making the combinations of size and trip limits a better representation of harvest changes expected to occur.

Comment 7: Include a table of the number of parrotfish samples in the TIP data by island and gear.

Response: Table B1 in Appendix B was added to the document. This table provides the number of parrotfish samples in the TIP data by island and gear.

Comment 8: It was recommended that outliers greater or less than 3 standard deviations from the mean be removed.

Response: A total of 8 large parrotfish considered to be outliers were removed because they were greater than 3 standard deviations from the mean.