Biscayne National Park Fishery Management Plan Reef Fishery Regulations and Science Plan Analysis

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EXECUTIVE SUMMARY

Located in southeastern Florida, 95% of Biscayne National Park (BNP) is underwater and includes 173,900 acres spanning from just south of Key Biscayne to just north of Key Largo, Florida. The health of BNP's resources, including reef fish populations, marine habitats, and coral reefs, is central to the future of fishing in Florida. Deep concern about BNP's marine fisheries and wildlife resulted in the promulgation of a Fishery Management Plan (FMP) whose Final Environmental Impact Statement (FEIS), released in 2014, proposed a 20% increase in the size-structured abundances of targeted reef fishes within the park. In June 2019, the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) released "Assessing the Efficacy of Fishery Management Changes Implemented for the Biscayne National Park Fishery Management Plan: A Science Plan Prepared by the National Park Service and the Florida Fish and Wildlife Conservation Commission" (Science Plan), which presented recommendations for monitoring targeted fisheries resources within BNP in order to assess the efficacy of park-specific regulations suggested in the FMP. The Science Plan considered target species divided into tiers, based on species routinely fished in the park and their potential to respond to proposed management actions.

FWC and NPS staff then collaborated on the development of draft fishery management regulations to be implemented by the FWC to fulfill the goals laid out in the FMP, fulfill the goals laid out in the FMP, such as the goal of increasing the size and abundance of target reef fish species in BNP by 20%, and other goals important to the future of BNP's resources. In December 2019, the FWC voted to approve a draft rule that included proposals to increase the minimum size limit for certain targeted finfish within BNP (a 20% increase in the minimum size limit for the majority of species), establish a 10-fish aggregate bag limit for select commonly targeted food and sport fish harvested or possessed inside the park, establish a trap-free zone near BNP headquarters, establish Coral Reef Protection Areas inside BNP where traps and lobstering would be prohibited, and establish inshore and offshore no-trawl zones within the park. These proposals were substantially weaker than those proposed at the July 2019 FWC Commission meeting and weaker still than those contemplated in the FMP FEIS. FWC Commissioners will vote on a final rule at the February 2020 FWC Commission meeting.

Given BNP's significance as America's largest marine national park and the economic, ecological, and cultural values of Biscayne, we conducted an independent science-based review of the Science Plan and proposed regulations. This analysis quantitatively assesses (1) the current status of select reef fish populations in BNP, (2) a minimum threshold for sustainability for select individual reef fish species, and (3) whether the proposed regulations that aim to increase the minimum size at first capture for target species by 20% will result in population metrics that equate to sustainability. We then compare the health of reef fish populations in BNP to the health of reef fish populations along the entirety of the Florida Reef Tract. Our analyses included a comparison of baseline (circa 2016) and current average size in the catch metrics. We used these data to determine whether the goal of reaching the 20% increases in size and abundance benchmarks would be met. Our analyses show that many of the Tier 1 species have been under considerable fishing pressures for some time. Further, there is serial overfishing of the snapper-grouper complex and some populations had less than 5% of the historical spawning biomass. Taken together, results of our review indicate that many of the park's targeted fish species require more creative and

effective regulations than what is currently being proposed, including regulations that specifically address the need to alleviate some of the fishing pressures in the park.

The Science Plan has several deficiencies that must be considered: additional data sources that circumscribes the reef fishery in BNP relative to the Florida Keys ecosystem and contextualizes the multi-stock analyses presented herein; observed declines of coral reefs and/or other spawning habitats within the park; confounding environmental factors such as water quality, marine debris, and climate change; the need for more frequent monitoring, occurring annually (vs. the proposed biennial monitoring); and a need to decrease the review period of data and regulations from the proposed seven years to every three years.

The proposed regulations as they stand are unlikely to eliminate overfishing, overcapitalization and severe fisheries' declines in BNP, and therefore should be improved upon in order to maximize efficacy for this economically and nationally important resource. We determined that a 20% increase in the observed average size in the catch would not be enough to lead to sustainable fish populations over the long-term. Whatever is done, it may take decades for recovery of some species. If FWC and NPS are genuinely committed to creating sustainable fish populations and meeting the spirit of BNP's enabling legislation to protect "a rare combination of terrestrial, marine, and amphibious life in a tropical setting of great natural beauty," then proposed fishery regulations must include a strategic combination of increased minimum size limits, fishing effort limits, and spatial closures such as the no-fishing marine reserves established in the Dry Tortugas, which have been shown to be especially effective, equitable, and enforceable means of meeting fishery management goals.

INTRODUCTION

Biscayne National Park (BNP) protects many different fishes and macroinvertebrates, often at different points in their life cycles, and is central to the future of fishing in Florida. Species such as mutton snapper, hogfish, black grouper, spiny lobster, pink shrimp, and stone crab are ecologically *and* economically important, supporting a vibrant recreational boating and fishing industry (Ault et al. 2005a, Lirman et al. 2019, Bryan and Ault 2019). Located in southeastern Florida, 95% of BNP is underwater and includes 173,900 acres spanning from just south of Key Biscayne to just north of Key Largo, Florida. BNP is a national treasure and protects an integral part of the third largest barrier reef ecosystem in the world. BNP is the United States' largest marine national park, created to protect "a rare combination of terrestrial, marine, and amphibious life in a tropical setting of great natural beauty" for present and future generations (16 U.S.C. 410gg). The park is also a significant economic driver, supporting a variety of economic and recreational activities, such as sportfishing, diving, snorkeling, and boating. According to an NPS report, in 2018, more than 450,000 visitors to BNP spent nearly $30.5 million, supporting 398 local jobs and generating more than $42 million for the local economy (Thomas et al. 2019).

In the interest of protecting one of America's most treasured national parks, and the health and sustainability of the broader marine ecosystem, there is strong public and scientific support for the implementation of science-based regulations and enhanced education-enforcement activities aimed at achieving sustainable fish populations in BNP. For more than 20 years, scientists have been publishing data that show the severe decline of BNP's fisheries and marine wildlife (Ault et al. 1998, 2001, 2007). As a result, deep public and scientific concerns about the future of BNP's fisheries prompted the development of BNP's Fishery Management Plan (FMP), which included a mandate to develop park-specific fishery management regulations for BNP designed to improve the park's fisheries by at least 20%.

In June 2019, the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) released "Assessing the Efficacy of Fishery Management Changes Implemented for the Biscayne National Park Fishery Management Plan: A Science Plan Prepared by the National Park Service and the Florida Fish and Wildlife Conservation Commission" (Science Plan), which includes recommendations for monitoring targeted fisheries resources within BNP in order to assess the efficacy of park-specific regulations implemented as part of the FMP. The Science Plan considered target species divided into tiers, based on species routinely fished in the park and their potential to respond to proposed management actions.

FWC and NPS staff also collaborated on the development of draft fishery management regulations to be implemented by the FWC to fulfill the goals laid out in the FMP, namely to increase the size and abundance of target reef fish species in BNP by 20%. At the July 18, 2019 FWC Commission meeting, FWC staff presented FWC Commissioners with a series of potential management options, including modifying size limits and bag limits, limiting spearfishing, creating coral reef protection areas, creating no-trap areas, creating no-trawl zones, and eliminating lobster mini-season. FWC staff then conducted three public workshops in August 2019 and three in October 2019 to gather public input on proposed management options. FWC staff modified proposed regulations based on public input, presenting FWC Commissioners with a draft rule at the December 2019 FWC Commission meeting. The draft rule included regulations to increase the minimum size limit for certain targeted finfish within BNP (a 20% increase in the minimum size limit for the majority of species), establish a 10-fish aggregate bag limit for select commonly targeted food and sport fish harvested or possessed inside the park, establish a trap-free zone near BNP headquarters, establish Coral Reef Protection Areas inside BNP where traps and lobstering would be prohibited, and establish inshore and offshore no-trawl zones within the park. These proposals were substantially weaker than those proposed at the July 2019 FWC Commission meeting and weaker still than those originally contemplated in the FMP FEIS. Commissioners voted to approve the draft rule. FWC Commissioners will vote on a final rule at the February 2020 FWC Commission meeting.

This analysis quantitatively assesses (1) the current status of select reef fish populations in BNP, (2) a minimum threshold for sustainability for select individual reef fish species, and (3) whether the proposed regulations that aim to increase the minimum size at first capture for target species by 20% will result in population metrics that equate to sustainability. We then compare the health of reef fish populations in BNP to the health of reef fish populations along the entirety of the Florida Reef Tract.

METHODS

This comprehensive analysis uses the scientifically rigorous multispecies assessment methods for data-limited fisheries of Ault et al. (1998, 2005b, 2009, 2019). This quantitative length-based risk analysis approach differs in mathematical scope and statistical depth compared to those included in the Science Plan. Additionally, our review incorporates a broader range of data and analyses than those considered in the Science Plan; for example, instead of only considering one to two data sources as the Science Plan does, our review takes five separate long-term data sources into account (i.e., Reef fish Visual Census (RVC), BNP Creel Survey, Commercial Trip Information Program (TIP), Headboats, and Marine Recreational Information Program (MRIP)). By analyzing a broader range of data and providing a more robust analysis of how fisheries may respond to the proposed regulations, our goal is to provide a science-based analysis that will constructively inform managers on regulations that will sustain BNP's reef fishery resources.

Demographic Parameters for Length-Based Risk Assessment Approach

The "data limited" length-based risk assessment (LBRA) approach of Ault et al. (2019) requires some basic species-specific life history demographic parameters: (i) the von Bertalanffy length dependent on age growth function; (ii) the allometric weight-length relationship; (iii) the oldest age (a_λ); and, (iv) the length at which 50% of individuals attain sexual maturity (L_m). For application to reef fishes in BNP, life history demographic parameters for grouper and snapper species were obtained from the comprehensive literature synthesis of Stevens et al. (2019) (c.f., **Table 1**).

Florida Coral Reef Fishes																				
Common	Species	a_λ	M	K	L_∞	L~A Fit	$L_{\infty(FL)}$	a_0	α	β	W_∞	W~L Fit	L_m	a_m	mos	L_c	a_c	mos	L_λ	W_λ
Groupers														**					**	
Black	*Mycteroperca bonaci*	33	0.09078	0.1432	1,334.00	TL	1,299.53	-0.9028	8.74750E-06	3.0843	35.13	FL	834	6.27	75	600	3.4222	41	1,289.41	34.30
Red	*Epinephelus morio*	29	0.10330	0.1251	829.00	FL	829.00	-1.2022	5.46000E-06	3.1800	10.43	FL	292	2.27	27	500	6.1852	74	810.05	9.69
Snappers																				
Gray	*Lutjanus griseus*	28	0.10699	0.1700	717.00	TL	676.19	-0.0250	7.22000E-06	3.1100	5.49	TL	230	2.25	27	250	2.6902	32	670.43	5.34
Hogfish	*Lachnolaimus maximus*	23	0.13025	0.1058	848.99	FL	848.99	-1.3290	9.50000E-05	2.7452	10.43	FL	177	0.88	11	300	2.7917	34	784.27	8.39
Lane	*Lutjanus synagris*	17	0.17622	0.1700	449.00	FL	449.00	-2.5900	5.92000E-05	2.8600	2.28	FL	240	1.91	23	200	0.8781	11	432.93	2.05
Mutton	*Lutjanus analis*	40	0.07489	0.1650	861.00	TL	799.05	-1.2300	1.47710E-05	3.0275	9.06	FL	323	1.91	23	400	2.9781	36	798.29	9.03
Schoolmaster	*Lutjanus apodus*	42	0.07133	0.1200	482.00	TL	482.00	-2.7900	9.26000E-06	3.1100	2.05	TL	200	1.68	20	250	3.3034	40	480.02	2.02
Yellowtail	*Ocyurus chrysurus*	23	0.13025	0.1330	618.00	TL	489.35	-3.1320	6.14000E-05	2.7790	1.83	FL	232	1.70	20	260	2.5660	31	476.09	1.70
Grunts																				
White grunt	*Haemulon plumieri*	18	0.16643	0.5200	323.1	TL	280.95	-0.5800	8.48881E-05	2.7500	0.46	FL	167	1.16	14	200	1.8130	22	280.94	0.46
Bluestriped	*Haemulon sciurus*	23	0.13025	0.3200	314.0	FL	314.00	-1.8000	9.30830E-06	3.1315	0.61	FL	205	1.51	18	210	1.6531	20	313.92	0.61
Other Reef Fishes																				
Great Barracuda	*Sphyraena barracuda*	19	0.15767	0.2600	1,236.4	FL	1,236.40	-0.7100	7.94000E-06	2.9670	11.86	FL	800	3.30	40	360	0.6136	7	1,230.73	11.70
Gray Triggerfish	*Balistes capriscus*	14	0.21398	0.1400	589.7	FL	589.70	-1.6600	2.16200E-05	3.0070	4.64	FL	211	1.50	18	300	3.4169	41	532.46	3.41

Table 1.- Population demographic parameters for groupers, snappers, grunts and other key reef fishes in the southern Florida/Biscayne National Park coral reef ecosystem.

The principal sampling data required for a given fish population are abundance-at-length compositions (used to estimate the indicator variable $\bar{L}$) and average length in the exploited phase of the population (i.e., the mean length of individuals $> L_c$, the minimum length of first capture regulated by the fishery). Length composition data were obtained from the National Oceanic and Atmospheric Administration's (NOAA) Southeast Fisheries Science Center from the following statistical sampling programs: (1) the Reef Fish Visual Census (RVC), a fishery-independent *in situ* diver survey (Smith et al. 2011); and (2) the BNP Creel Census, a dockside intercept survey of sportfishers from large charter boats (McDonough et al. 2019).

Estimates of $\bar{L}$ were computed using a survey design ratio-of-means estimator (Cochran 1977; Lohr 2010),

$$\bar{L}(t) = \frac{\bar{y}}{\bar{x}} = \frac{\frac{\sum_i y_i}{n}}{\frac{\sum_i x_i}{n}} \quad ,$$

following the formal definition of population average length (e.g., Ehrhardt and Ault 1992), where x_i is the number of fish measured in sample unit *i* (e.g., fishing trip), y_i is the summed lengths of measured fish in unit *i*, and *n* is number of sample units. Computations for variance of $\bar{L}$ followed Lohr (2010) (**Table 2**).

This information was then used to estimate population instantaneous total (*Z*), natural (*M*), and fishing (*F*) mortality rates following the published methods in Ault et al. (2019) used around the world (Ault et al. 2008, 2018; Nadon et al. 2015; Chong et al. 2019).

Numerical Length-Based Cohort Model

The numerical length-based cohort population model described in Ault et al. (2019) was tailored for data-limited situations and stochastic variation in parameters. The numerical model tracked cohort numbers-at-size (length and weight) over age and time. Model parameters are given in **Table 1**. For application in this study, the model time step Δt was monthly (12 equal periods for one year). Adapted for data-limited fisheries, model assumptions were: (1) average annual constant recruitment, apportioned evenly for each model time step; (2) knife-edged length at sexual maturity L_m; and (3) knife-edged gear selectivity at length L_c.

				BNP RVC						BNP Creel				Composite		
GROUPERS	**8/2/2019 8:31**	a_λ	M	**Lc**	**Lm**	**n**	**fish**	**Lbar**	**SE**	**n**	**fish**	**Lbar**	**SE**	**Avg Lbar**	**Avg SE**	**+20% Lbar**
Black	*Mycteroperca bonaci*	33	0.09078	600	834	200	1	800	0.00	6	10	690.00	28.69	690.00	28.69	**828.00**
Red	*Epinephelus morio*	29	0.10330	500	292	200	10	536.08	14.03	20	25	578.80	11.79	557.44	12.9585	**668.93**
SNAPPERS																
Gray	*Lutjanus griseus*	28	0.10699	250	230	200	396	275.79	7.62	240	916	304.16	3.27	289.98	5.8633	**347.97**
Hogfish	*Lachnolaimus maximus*	23	0.13025	300	177	200	298	327.79	4.97	101	364	351.04	2.87	339.42	4.0582	**407.30**
Lane	*Lutjanus synagris*	17	0.17622	200	240	200	139	210.62	16.94	2	4	212.50	2.50	211.56	12.1081	**253.87**
Mutton	*Lutjanus analis*	40	0.07489	400	323	200	22	448.08	22.59	45	62	502.10	12.95	475.09	18.4121	**570.11**
Schoolmaster	*Lutjanus apodus*	42	0.07133	250	200	200	102	291.3	7.49	21	33	329.70	18.73	310.50	14.2638	**372.60**
Yellowtail	*Ocyurus chrysurus*	23	0.13025	260	232	200	67	284.65	8.15	108	561	329.66	4.28	307.16	6.5093	**368.59**
GRUNTS																
White grunt	*Haemulon plumieri*	18	0.16643	200	167	200	2,525	226.81	3.14	128	378	235.50	2.33	231.16	2.7648	**277.39**
Bluestriped	*Haemulon sciurus*	23	0.13025	210	205	200	476	245.25	6.87	66	138	236.67	2.03	240.96	5.0655	**289.15**
OTHER REEF FISHES																
Great Barracuda	*Sphyraena barracuda*	19	0.15767	360	800	200	53	801.49	69.90	79	152	661.91	27.68	731.70	53.1610	**878.04**
Gray Triggerfish	*Balistes capriscus*	14	0.21398	300	211	200	9	309.81	9.71	7	8	331.25	8.66	320.53	9.2000	**384.64**

Table 2.- Composite average length in the exploitable phase (Lbar or $\bar{\mathrm{L}}$, FL mm) computations from the RVC and Creel data for the twelve key Biscayne National Park species considered in the Science Plan (McDonough et al. 2019).

Probabilistic Mortality Rates

Probabilistic total mortality (*Z*) was described using the statistical properties of the survey design average length estimates (i.e., normally distributed; Lohr, 2010). A normal $N(\mu, \sigma^2)$ probability density function was parameterized by setting $\mu = \bar{L}(\text{t})$ and $\sigma^2 = [SE(\bar{L}(\text{t}))]^2$, and then used to generate random deviates of average length. Random deviates of *Z* were computed from average length deviates. In a similar manner, probability distributions of natural mortality *M* were computed from corresponding probability distributions for maximum age a_λ. As demographic information has become more complete for Florida reef fishes over the past 20 or so years, the maximum observed age for many species has also increased, sometimes doubling or tripling in value. Thus, we considered the reported $\hat{a}_\lambda$ a minimum value with the uncertainty extending in one direction, i.e., to older ages.

Sustainability Analyses

Our procedure for establishing sustainability risk reference points was applied to BNP grouper, snapper, grunt and other reef fish species. The numerical cohort model was used to compute the Spawning Potential Ratio (SPR) at FMSY (i.e., $F = M$) for each species following Ault et al. (2019). The limit reference point for fishing mortality rate was established as $F_{REF} = F_{40\%SPR}$ for the 12 key species identified in the Plan, and the corresponding model predicted exploitable population biomass at F_{REF} was defined as B_{REF}.

RESULTS

We analyzed the BNP Creel database and compared that data to the BNP Reef Fish Visual Census (RVC) data. We ran the LBAR/REEFS risk analysis for data limited stocks using the algorithmic methods of Ault et al. (2014, 2019) for the 12 species identified in the Science Plan along with new demographic data (Nadon and Ault 2016; Stevens et al. 2019), and made the following conclusions.

Current Status of Select BNP Reef Fish Populations

To provide an accurate assessment of the current status of reef fish species in BNP, we analyzed available fisheries-dependent and -independent data for BNP for the 12 reef fish species identified in the Science Plan. Our analysis definitively showed that BNP fisheries are overfished and need improved regulations, supported by our findings below.

Spawning Potential Ratio is far below the minimum for sustainability for all 12 key reef fish species
To be considered minimally sustainable, the SPR, or ratio of fished to unfished spawning biomass, of a given species should exceed 0.40 or 40% of the unfished spawning stock biomass, depicted in Figure 1 below as the horizontal red line. <u>We found that all 12 species identified in the Science Plan are currently overfished in BNP (and throughout the entirety of the Florida Keys for that matter). Not one of the stocks analyzed was close to the standard for sustainability.</u> Black grouper and gray snapper, for instance, are so seriously overfished that they barely register on **Fig. 1**.

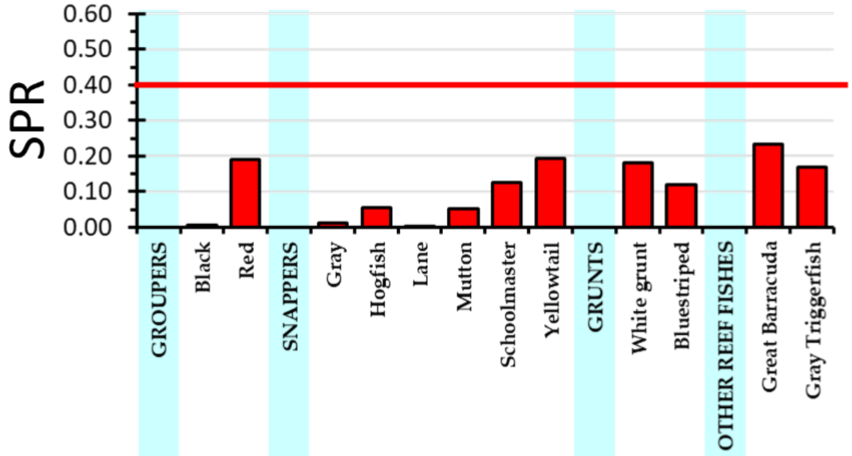

Figure 1.- Spawning potential ratio (SPR) for select reef fishes identified in the Science Plan (McDonough et al. 2019). Note: the minimum level for sustainability is indicated by the horizontal red line. All 12 species are currently well below the bare minimum SPR for sustainability in BNP.

Fishing effort and fishing pressure far exceed the maximum threshold for sustainability

Another way of assessing sustainability is by looking at fishing effort and fishing pressure on fish stocks. In terms of the fishing effort or fishing mortality (F), we considered the ratio of current F to the reference fishing mortality required to achieve an SPR of 40% (F_{ref}). For resource sustainability, this ratio should be less than or equal to a value of 1.0 (depicted by the horizontal green line). **Fig. 2** shows the ratio of current fishing effort to the fishing effort required for sustainability (i.e., 40% SPR) for each of the 12 species under consideration. Fig. 2 shows that fishing pressure on all fish species exceeds the maximum threshold for sustainability, and there is far too much fishing intensity on reef fish stocks in BNP. Excessive fishing pressure has dramatically reduced the average size and abundance of species such as lane and gray snapper, and black grouper.

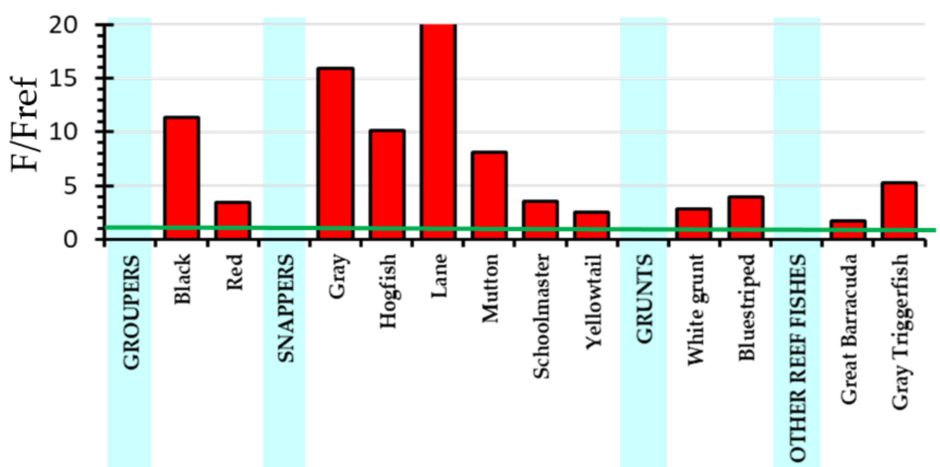

Figure 2.- Current fishing pressure on select reef fish species in BNP.

Over the years, excessive fishing pressure combined with inadequate fisheries regulations have led to substantial reductions in the average size of reef fish captured in BNP. **Table 3** illustrates the significant declines in the average weight of reef fish species, comparing the current average weight of fish caught now to what was caught a century ago in the nascent days of the fishery. The average weight of species like hogfish and gray snapper has declined by 80% compared to historical values.

	Average Weight (pounds)	
GROUPERS	**Historical**	**Current**
Black	35	11
Red	20	6
SNAPPERS		
Gray	5	1
Hogfish	5	1
Lane	1.0	0.3
Mutton	10	3
Schoolmaster	1.9	0.9
Yellowtail	2	1
GRUNTS		
White	0.5	0.4
Bluestriped	0.7	0.4
OTHER REEF FISHES		
Great Barracuda	24	13
Gray Triggerfish	2.0	1.0

Table 3.- Average weight $\overline{\mathrm{W}}$ in the exploited phase of the stock of current versus historical fish catches in Biscayne National Park for 12 species identified in the FWC/BNP draft Science Plan.

The average weight of reef fish captured within BNP has declined significantly from historical levels

One of the principal factors driving the decline of fish populations in BNP is the fact that most reef fish get little or no chance to spawn in their lifetime. Regulations to-date have not been based on sound science or a direct effort to ameliorate this "no chance to spawn" issue. **Fig. 4** illustrates that the minimum size of sexual maturity ($\mathrm{L_m}$) is close to or greater than the minimum size of first capture ($\mathrm{L_c}$), (determined by minimum size limits) for nearly all reef fish species under consideration. This means that most fish in BNP barely reach the size of sexual maturity and get little or no chance to spawn and reproduce, obviating any opportunity for fish stocks to reach sustainable levels.

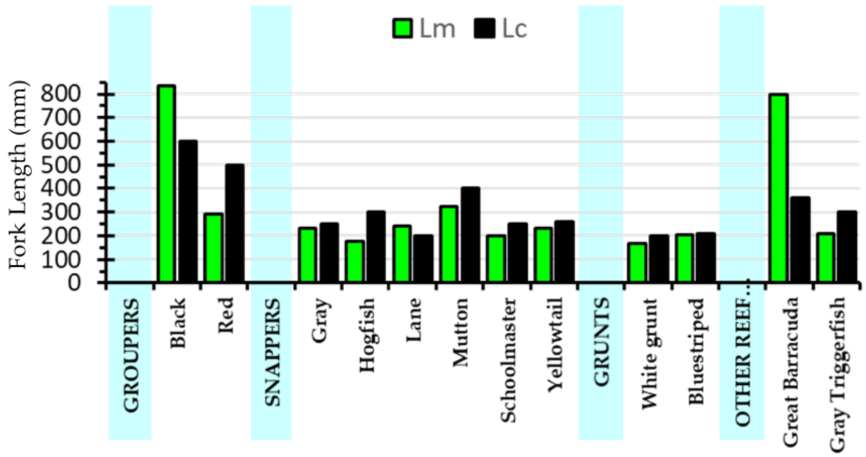

Figure 4.- Minimum size of sexual maturity (L_m, green bars) versus minimum size of first capture (L_c, black bars) for select reef fish species in Biscayne National Park.

Proposals to Increase Size Limits are Insufficient to Achieve Sustainability

Draft regulations proposed by the FWC include increasing the average size (in length) in the catch ($\bar{\mathrm{L}}$) by 20% for selected reef fish species in BNP. To accomplish this, without controlling for fishing effort, requires increasing the minimum size of first capture ($\mathrm{L_c}$). While this is a first step towards improvement of the health of reef fish populations in the park, on their own these proposed regulations are insufficient to achieve sustainability for nearly all species under consideration.

Fig. 5 compares the species' current $\mathrm{L_c}$ (red bars), the $\mathrm{L_c}$ required for the stock to be sustainable (green bars), and the $\mathrm{L_c}$ proposed by FWC in the Science Plan (gray bars). While the proposed regulations will move some populations, such as red grouper, closer to sustainability, **Fig. 5** also makes it clear that proposed regulations are insufficient to produce sustainable populations for species like mutton and gray snapper. Additionally, the FWC did not propose regulations for black grouper or great barracuda due to a purported lack of data, even though these stocks are some of the most overfished in the park. In contrast, using our innovative methods employed (see above) and data available from the State of Florida, NPS and National Marine Fisheries Service MFS sources, we were able to incorporate these species into our analyses.

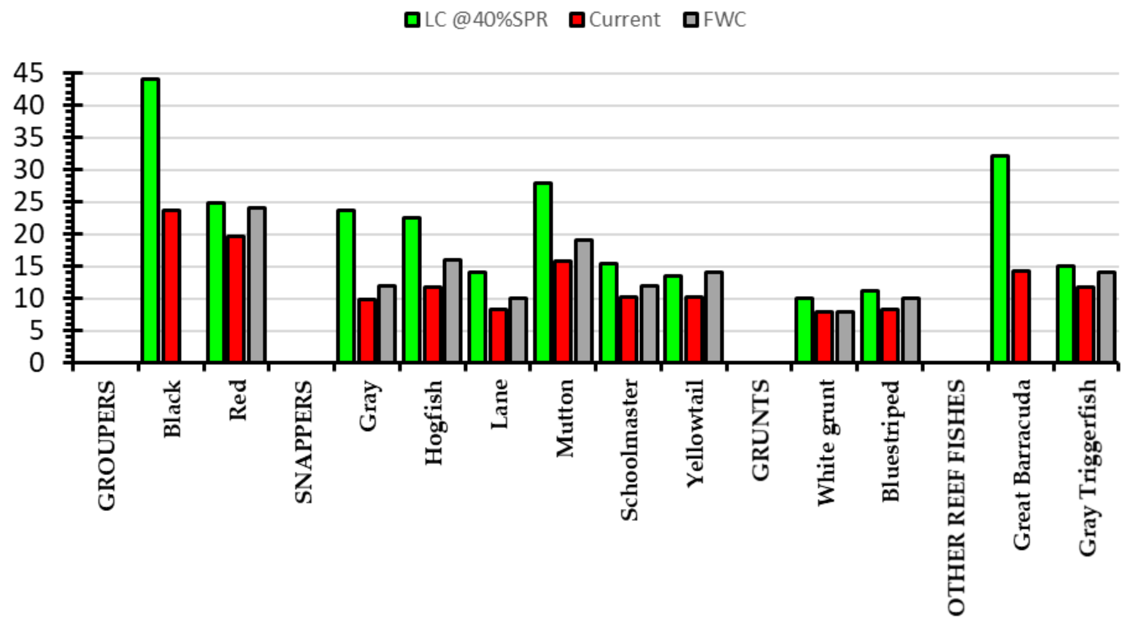

Figure 5.- Comparison of minimum lengths of first capture (L_c) of reef fish species required for sustainability (green bars), current (red bars), and those by proposed FWC regulations (gray bars).

Fishing Intensity and Fisheries Decline is Greater in BNP than in the Florida Keys

While reef fishery sustainability conditions in Biscayne National Park are worse than those observed in the broader Florida Keys reef fishery, it must be noted that 70% of the reef fish stocks in Florida Keys are serially overfished and considered not sustainable (**Fig. 6**). This decline has occurred in spite of more than 30 years of "traditional" fishery management policies and regulations. These similarities and differences have been pointed out before (Ault et al. 2002, 2009).

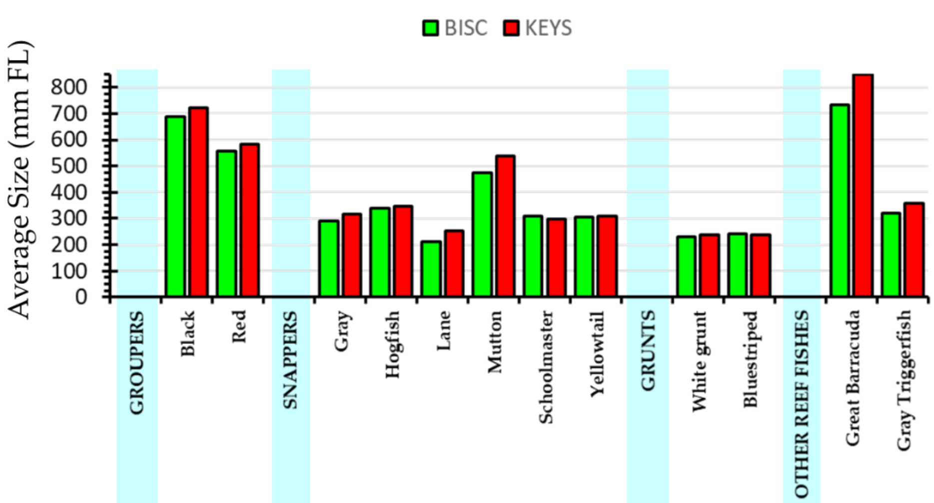

Figure 6.- Comparison of average size in the exploited phase $(\bar{L})$ of key reef fish in BNP (green bars), and the Florida Keys (red bars).

A probabilistic comparison of black grouper populations in the Florida Keys and BNP is shown in **Fig, 7.** Note that the average size $\bar{L}$ for black grouper (left-hand panels) in BNP is less than that observed in the Florida Keys. The right-hand panels of **Fig. 7** provide a computational translation of the average size $\bar{L}$ to the total mortality rate Z using the methods of Ault et al. (2019). The slightly larger $\bar{L}$ in the Keys translates to a substantially lower total mortality rate than observed in BNP.

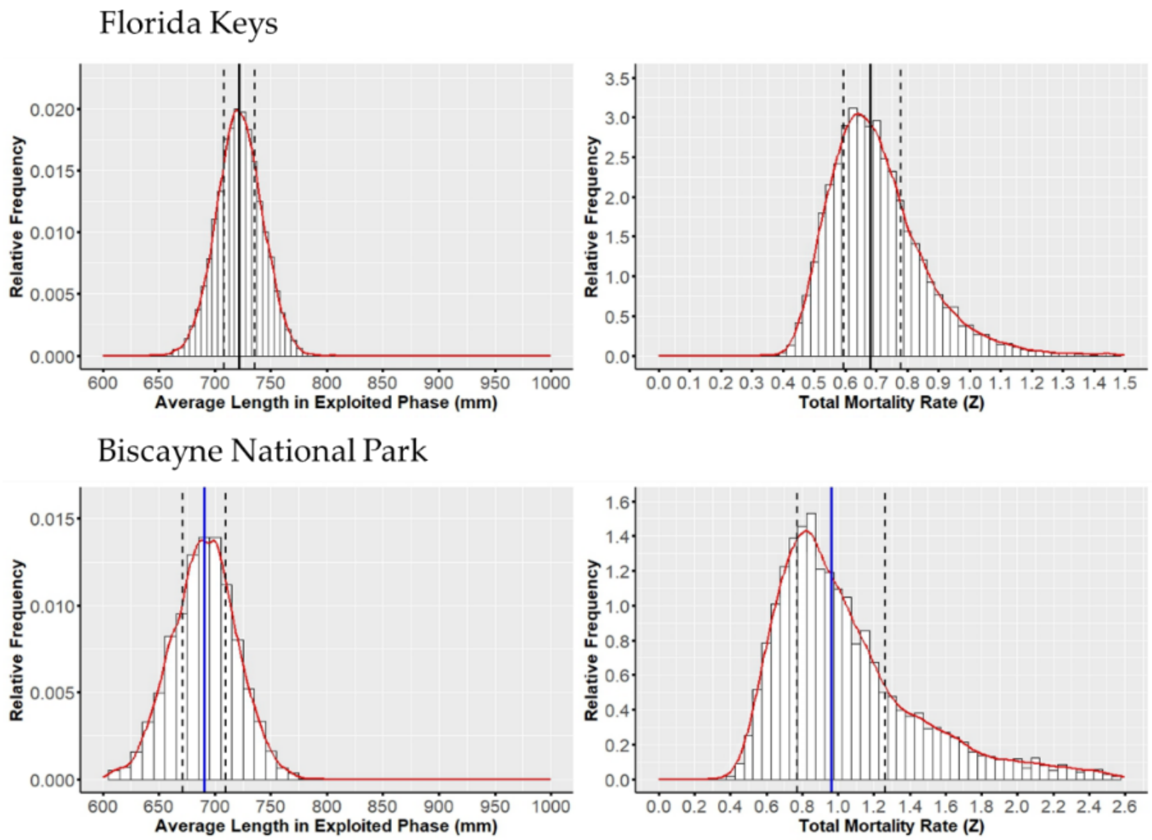

Figure 7.- Risk analysis comparisons of average length in the exploitable phase ($\bar{\mathrm{L}}$, left panels) and estimated total mortality rates (Z, right panels) for black grouper in the Florida Keys and Biscayne National Park. The solid vertical lines in the panels are the median (50% of the distribution lies to the left and right) of the statistical distribution, and the dashed vertical lines are the 1st and 3rd quartiles.

When the natural mortality rate M (e.g., Stevens et al. 2019) is factored into the estimates of total mortality rate Z (i.e., F = Z – M), this produces a statistical distribution of current fishing mortality rate F estimates (**Fig. 8**).

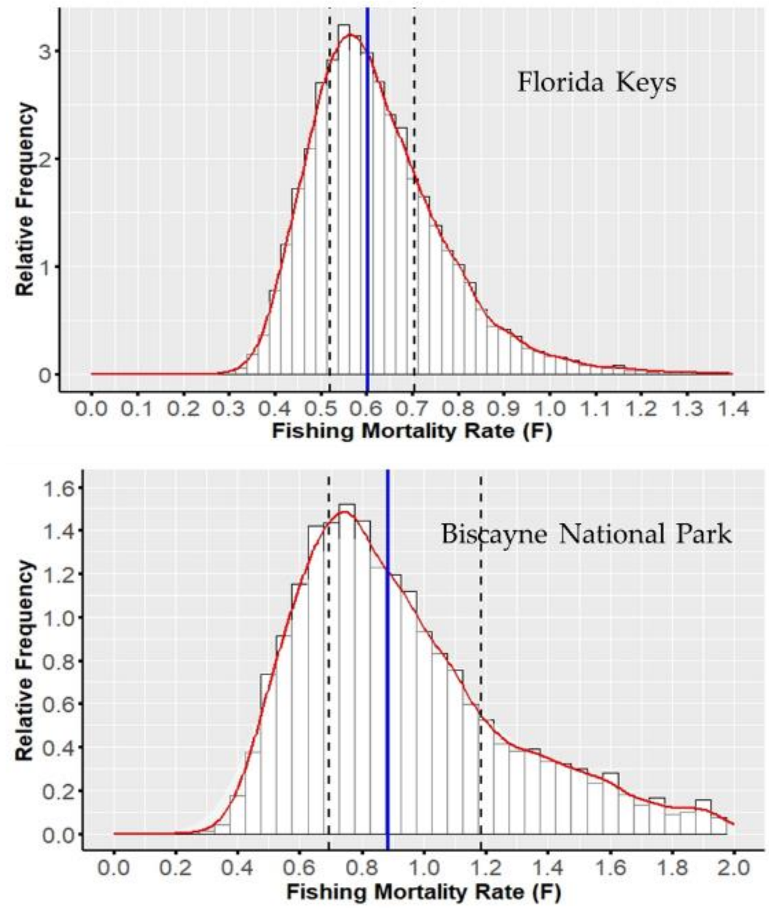

Figure 8.- Comparison of fishing mortality rate (F) distributions for black grouper in the Florida Keys and BNP. Blue solid vertical line is the median, and dashed vertical lines are the 1st and 3rd quartiles.

Fishing mortality rate, an important measure of the intensity with which a stock is being exploited, is compared above for black grouper between BNP and the Florida Keys. In **Fig. 8**, both the median and error variance of the BNP fishing mortality estimate are greater than that observed for the broader Florida Keys. This practically means that, while the uncertainty of the estimate is greater in BNP, the likelihood that fishing intensity and impacts within the park boundaries are also notably higher. This shows us that fishing intensity in BNP is a serious issue that needs to be managed.

To summarize, what these data and analyses show is that the intensity of fishing is greater in BNP than for those observed in the Florida Keys. However, neither BNP, nor the broader Florida Keys ecosystem is in good shape, even though traditional fishery management controls have been implemented over the past 30 years. More than 20 years of peer-reviewed publications support this conclusion (e.g., Ault et al. 1998, 2009). It is evident that traditional fishery management regulations have been largely ineffectual and other more strategic and science-based management measures must be implemented to curtail the substantial overfishing and to rebuild sustainable fisheries.

The risk consequences to reef fishery resource sustainability from the distribution of fishing mortality rate estimates shown in **Fig. 8** are presented in terms of the overfishing limit (OFL) and SPR, standard metrics used by national and international fishing management councils and commissions to evaluate resource sustainability (**Fig. 9**).

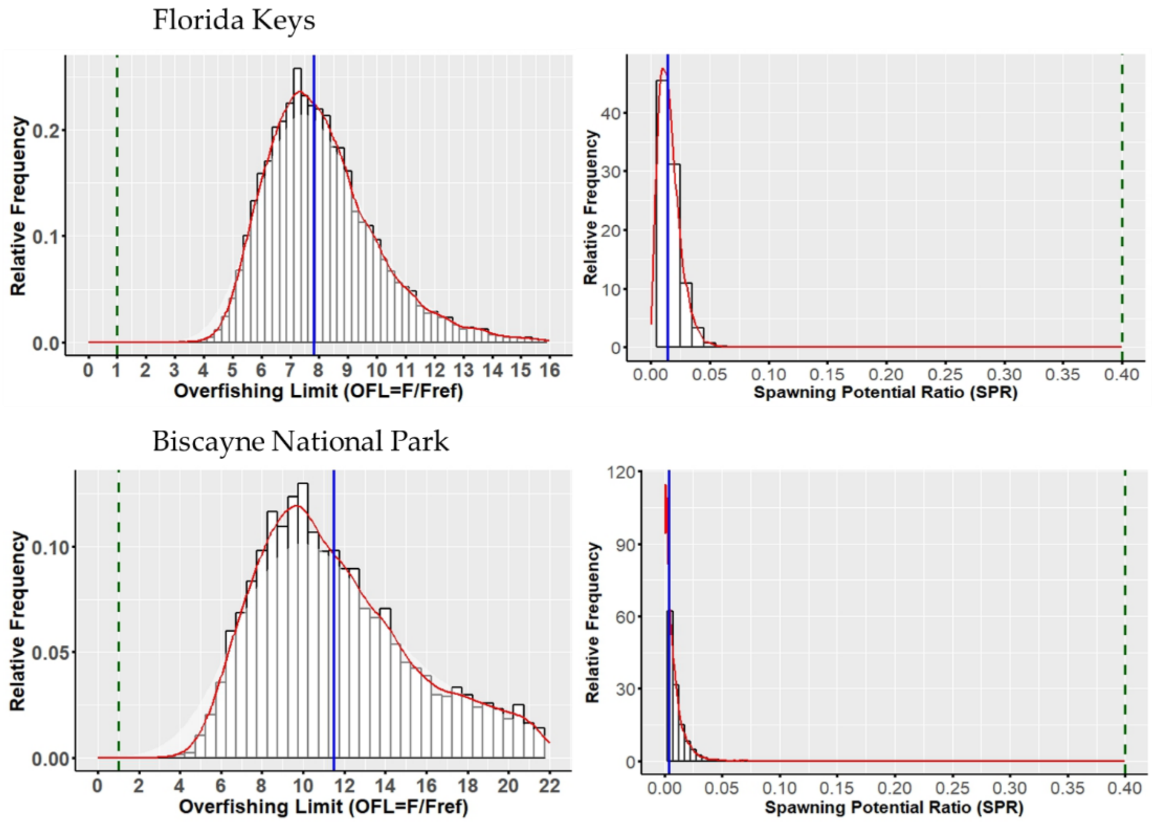

Figure 9.- Comparison of the overfishing limit (F/F_{ref}) and spawning potential ratio (SPR) for black grouper in the Florida Keys and Biscayne National Park. A sustainable fishery has a $\frac{F}{F_{ref}} < 1$ (dashed vertical line). In addition, a sustainable fishery has an SPR >0.4 (dashed vertical line).

Fig. 9 demonstrates that current fishing intensity in BNP is more than 10 times what is required for sustainable fisheries. Due to excessive exploitation pressure, the current stock spawning biomass for black grouper is less than 5% of their historical abundance. In this case, the probability of being at risk is 100%, and the probability of being in error in these calculations is zero. BNP and the Florida Keys reef fisheries have serious problems that must be addressed through effective and novel management strategy.

DISCUSSION

The draft fishery management proposals promulgated by the FWC, which include increases in size limits and habitat protections, are insufficient to fully address the substantial overfishing, overcapitalization and fisheries' declines in BNP. The analyses presented here show that a 20% increase in the observed average size in catch of reef fish is unlikely to lead to sustainable fish populations that are viable over the long-term. It is imperative to note that overfishing problems are not unique to BNP. Rather, overfishing and declining fish populations are systemic along the entire Florida Reef Tract, a problem that must be addressed now to prevent collapses in ecologically and economically vital fish populations throughout South Florida. If FWC and NPS are genuinely committed to creating sustainable fish populations in BNP over the long-term, then it is apparent that the regulations currently being considered by the FWC do not go nearly far enough.

The set of solutions to ameliorate these problems must, of course, include significant science-based measures to increase minimum size of capture L_c if there is no attempt to reduce fishing effort in the Park. The minimum size L_c limit will need to be dramatically increased, even above what has been proposed, to allow enough population spawning to achieve resource sustainability. However, in addition, the excessively high levels of fishing effort and fishing mortality experienced by the stocks need to also be greatly reduced. Accomplishing this will likely involve more creative uses of both fishery management variables (i.e., L_c and F). To achieve sustainable fish populations in BNP, the FWC and NPS must consider implementing the full range of science-based fishery management options outlined in the FMP FEIS, which include spatial closures, also known as marine reserves. FWC seems to consider marine reserves as overly restrictive and only to be tried after less restrictive measures have failed. In fact, they have! Less restrictive measures (i.e., fishing regulations specifically set by the FWC) have been in place for more than 25 years and the evidence clearly indicates serious overfishing in BNP and the entire Florida Keys ecosystem. The most practical solution to address this problem of chronic overfishing is a combination of increasing size limits, and placing limits on fishing effort and stock fishing mortality rates through spatial closures, i.e., marine reserve areas (Bohnsack and Ault 1996, Bohnsack et al. 2004, Meester et al. 2004).

The Dry Tortugas marine reserves, co-sponsored and supported by the State of Florida, NPS and NOAA, have been a shining example of partnership management success that has greatly benefitted the fisheries resources and the people of Florida (e.g., Ault et al. 2006, 2013). Ault et al. (2013) showed that 35-60% of the exploitable biomass of the top ten commercial grouper and snapper species for the Florida Keys are located within the network of marine reserves, which occupy only a small fraction of the total area of resource distribution. Clearly, marine reserves are a valid management tool that have also been successfully used by NOAA and FWC in the Florida Keys National Marine Sanctuary and Dry Tortugas National Park.

In addition to increasing size limits and implementing spatial closures, habitat protection measures are also key to protecting fisheries in BNP. In this regard, habitat protection methods including the strategic placement of no-trawl zones for commercial rollerframe trawls will result in significant benefits to BNP's fisheries. Commercial rollerframe trawls are extremely damaging to benthic habitat and result in significant bycatch of juvenile reef fishes that use Biscayne Bay as a primary natal grounds (Ault et al. 1999). No-fishing Coral Reef Protection Areas that protect the few healthy stands of coral remaining in BNP could also help protect critical habitat but need to be expanded in order to have a plausible effect.

The FMP Science Plan must also lay out a cost-effective, statistically reliable monitoring program that will enable managers to accurately assess the efficacy of regulations that are implemented. We recommend an adaptive management approach, involving an increase in sampling effort that presently occurs so that sampling is conducted annually, and a review of these results and the regulations every three to four years (Smith et al. 2011, Bryan et al. 2016). To ensure efficacy of the regulations, more regular assessments than what is proposed in the Science Plan must be implemented. Moreover, sufficient financial resources must be invested into the monitoring and review to ensure the success of FMP regulations. Finally, significant investments in public education and enforcement must also be made.

Enacting a more forward-looking strategy is key to protecting and restoring BNP's economically and ecologically valuable fisheries. Implementing conservation measures that include size limits, habitat protection, *and* a reduction in fishing pressure through the establishment of one or more marine reserves will ultimately preserve biodiversity, stimulate recreational and economic opportunities, build resource resilience to climate change, and strengthen the deep connections between our human communities and their maritime heritage. Without prudent action, we risk losing these natural assets. Preserving BNP's marine fisheries through implementation of science-based regulations focused on sustainability will protect BNP's marine fisheries and ensure constituency satisfaction for many generations to come.

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