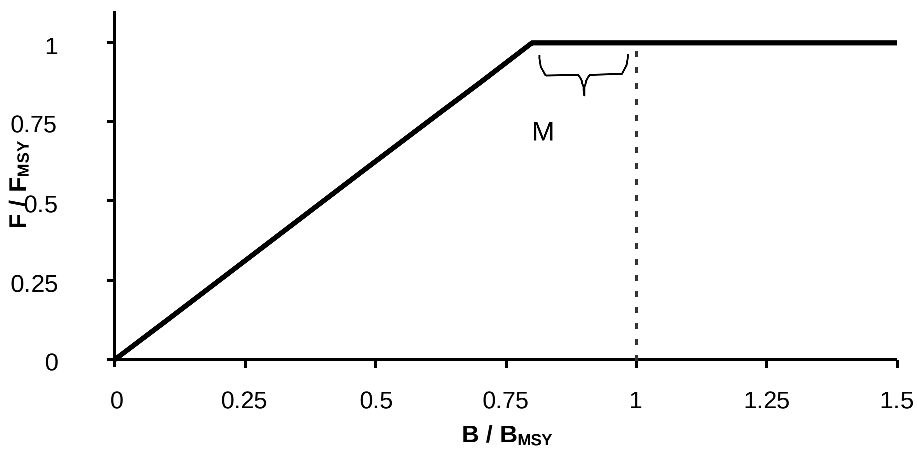
Tab B, No. 10
9/29/2015

Minimum Stock Size Threshold (MSST) and Maximum Sustainable Yield (MSY) Proxy for Reef Fish Stocks



Options Paper
for an Amendment
to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico

October 2015

This is a publication of the Gulf of Mexico Fishery Management Council Pursuant to National Oceanic and Atmospheric Administration Award No. NA10NMF4410011.

This page intentionally blank

ABBREVIATIONS USED IN THIS DOCUMENT

Council	Gulf of Mexico Fishery Management Council
FMP	Fishery Management Plan
GMFMC	Gulf of Mexico Fishery Management Council
Gulf	Gulf of Mexico
M	Instantaneous Rate of Natural Mortality
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MFMT	Maximum fishing mortality threshold
MSST	Minimum stock size threshold
MSY	Maximum sustainable yield
NMFS	National Marine Fisheries Service
NS1	National Standard 1 guidelines
OY	Optimum yield
SEDAR	Southeast Data, Assessment and Review
SPR	Spawning potential ratio

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

1.1 Background

What Actions Are Being Proposed?

This Amendment to the Fishery Management Plan for the Reef Fish Fishery of the Gulf of Mexico proposes to modify the definition of minimum stock size threshold (MSST) for select reef fish species with a low (less than 0.10, 0.15, 0.20, or 0.25) natural mortality rate, and to consider setting a default definition of MSST for all stocks in the reef fish fishery management unit.

Who is Proposing the Action?

The Gulf of Mexico Fishery Management Council (Council) is proposing the action. The Council develops the amendment and submits it to the National Marine Fisheries Service (NMFS) who publishes a rule to implement the amendment on behalf of the Secretary of Commerce. NMFS is an agency in the National Oceanic and Atmospheric Administration within the Department of Commerce.

Why are the Council and NMFS Considering Action?

This amendment would define (or re-define) the MSST for select reef fish species with low natural mortality rates to reduce the likelihood of the stock entering an overfished status due to normal year-to-year fluctuations in biomass levels. MSST is a biomass level set below the level corresponding to maximum sustainable yield (MSY) to allow for fluctuations in abundance while maintaining the capability to produce MSY on a continuing basis. The current definition of MSST used by the Council for most stocks where it has been defined is $(1-M)*B_{MSY}$ (or proxy for B_{MSY}) or $0.5* B_{MSY}$ (or proxy), whichever is greater. M is the natural mortality rate and B_{MSY} (or proxy) is the biomass or biomass proxy when the stock is at the maximum sustainable yield (MSY) level and considered to be rebuilt. This can be measured in terms of female spawning stock biomass, total (male plus female) spawning stock biomass, or estimated spawning stock egg production. Using this formula, the buffer between MSY and MSST is very small for long-lived stocks that have a low M. Such stocks tend to have smaller natural fluctuations in abundance than high-M stocks, but even small fluctuations in biomass due to natural variations not related to fishing mortality may cause a stock to vary between an overfished or not overfished condition based on current definitions. When a species is identified as overfished, the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) requires that a plan be implemented to rebuild the stock. Redefining MSST for species with low natural mortality rates would help to prevent unnecessary overfished designations when small drops in biomass are due to natural variation in recruitment or other environmental variables, and ensure that rebuilding plans are applied to stocks when truly appropriate.

This amendment would also consider establishing a default MSST for all reef fish stocks in the management unit. A previous attempt was made to define MSST as a certain spawning potential ratio (SPR) level for all reef fish species in the Generic Sustainable Fisheries Act Amendment (GMFMC 1999) was rejected by NMFS. Subsequent to that action, the Council began to define MSST and other status determination criteria for stocks as they were assessed, but only if needed in order to establish a rebuilding plan for overfished stocks. MSSTs have not been set for stocks without assessments or assessed stocks that were not in need of a rebuilding plan. Consequently, MSST has been defined for only 5 of the 31 species in the reef fish fishery management unit (Table 1.2).

Gulf of Mexico Fishery Management Council

- Responsible for conservation and management of fish stocks
- Consists of 17 voting members, 11 of whom are appointed by the Secretary of Commerce, the National Marine Fisheries Service Regional Administrator, and 1 representative from each of the 5 Gulf states marine resource agencies
- Responsible for developing fishery management plans and amendments, and for recommending actions to National Marine Fisheries Service for implementation

National Marine Fisheries Service

- Responsible for conservation and management of fish stocks
- Responsible for compliance with federal, state, and local laws
- Approves, disapproves, or partially approves Council recommendations
- Implements regulations

1.2 Purpose and Need

The purpose for the action is set MSST for reef fish stocks taking into consideration natural mortality rates, and to establish MSST for all stocks in the reef fish fishery management unit.

The need for the proposed action is to comply with the National Standard 1 guidelines requiring that stocks have an MSST while giving consideration to preventing reef fish stocks with low natural mortality rates from frequently alternating between overfished and non-overfished conditions due to natural variation in recruitment and other environmental factors.

1.3 History of Management

Following passage of the Sustainable Fisheries Act of 1996, the National Marine Fisheries Service (NMFS) published updated National Standard Guidelines that included the introduction of status determination criteria. The updated guidelines for National Standard 1 (NS1) described maximum fishing mortality threshold (MFMT) to determine when overfishing is occurring, and minimum stock size threshold (MSST) to determine when a stock is overfished. The NS1 guidelines further required that each fishery management plan (FMP) must specify, to the extent possible, objective and measurable status determination criteria for each stock or stock complex covered by that FMP and provide an analysis of how the status determination criteria were chosen and how they relate to reproductive potential.

In 1999, the Council submitted its Generic Sustainable Fisheries Act Amendment (GMFMC 1999), in which it attempted to define MSST and MFMT along with other biological reference points of maximum sustainable yield (MSY) and optimum yield (OY) for stocks under management. All of the definitions were based on static[1] spawning potential ratio (SPR). For reef fish stocks, the amendment proposed the following MFMT and MSST definitions (Table 1.1).

[1] SPR is a measure of reproductive capability, but is measured in two different ways. Static SPR is a measure of spawning-per-recruit relative to the level of spawning-per recruit that would occur in the absence of fishing. It is analogous to yield-per-recruit and is the level of spawning that would occur at equilibrium if fishing occurred at the same rate and selectivity pattern. Transitional SPR is a measure of spawning production per recruit in a given year relative to the spawning production that would have occurred in that year if there had been no fishing. Static SPR is directly related to fishing mortality and can be used as a measure of overfishing. Transitional SPR can be used to indicate how close the age structure of a stock is to being rebuilt, but does not necessarily correlate to absolute biomass levels (GMFMC 1996). Although these terms have fallen out of common use, phrases such as “a mortality rate of 30% SPR” or “yield when fishing at 30% SPR” refer to static SPR.

Table. 1.1. Proposed MSY, OY, MFMT, and MSST definitions in the Generic Sustainable Fisheries Amendment.

Stock	MSY	OY	MFMT	MSST
Nassau grouper Jewfish (goliath grouper)	50% static SPR	50% static SPR	Fishing mortality rate equivalent to 50% static SPR	To be implemented by framework measure as estimates of BMSY and MSST are developed by NMFS, the Reef Fish Stock Assessment Panel, and the Council.
Red snapper	26% static SPR	36% static SPR	Fishing mortality rate equivalent to 26% static SPR	
All other reef fish stocks	30% static SPR	40% static SPR	Fishing mortality rate equivalent to 30% static SPR	

On November 17, 1999, NMFS notified the Council that, while it approved the definitions of MFMT based on static SPR, it disapproved all SPRs submitted as proxies for MSY, OY and MSST because SPR is not biomass-based and is not an acceptable proxy for biomass reference points.

All stocks have an MFMT from the Generic Sustainable Fisheries Act Amendment or as later modified. Other status determination criteria and biological reference points were adopted on a stock-by-stock basis as stocks were assessed, but only if the stock was determined to be in need of a rebuilding plan. Stocks for which MSST has been adopted are shown in Table 2.1.

Table 1.2. Stocks with status determination criteria assigned.

Stock	MFMT	MSST	MSY	Source
Gag	F_{MAX}	(1-M)*femaleSSB_{MAX} (M = 0.15)		Amendment 30B (GMFMC 2008a)
Red grouper	$F_{30\% SPR}$	(1-M)* SSfemale gonad wt_{MSY} (M = 0.2)		Secretarial Amendment 1 (GMFMC 2004a)
Red snapper	$F_{26\% SPR}$	(1-M)*B_{MSY} (M = 0.094277)		Amendment 27 (GMFMC 2007)
Vermilion snapper	F_{MSY} (no proxy)	(1-M)*B_{MSY} (M = 0.25)	Yield at F_{MSY}	Amendment 23 (GMFMC 2004b)
Gray triggerfish	$F_{30\% SPR}$	(1-M)*egg$SSB_{30\% SPR}$ (M = 0.27)		Amendment 30A (GMFMC 2008b)
Greater amberjack	$F_{30\% SPR}$	(1-M)*B_{MSY} (M = 0.25)		Secretarial Amendment 2 (GMFMC 2002)

Note: Amendment 23 did not define an MSY proxy for vermilion snapper. It specified that SDC were to be based on the actual MSY estimate. The proxy SEDAR 9 and SEDAR 9 update assessments, however, used a proxy based on 30% SPR.

Several other reef fish species have had stock assessments, but were not in need of rebuilding plans (or in the case of goliath grouper, harvest was already prohibited), and therefore were not assigned status determination criteria. These stocks include mutton snapper, lane snapper, yellowedge grouper, goliath grouper, black grouper, tilefish, and hogfish.

CHAPTER 2. MANAGEMENT ALTERNATIVES

2.1 Action 1 – Define (or re-define) Minimum Stock Size Threshold for Species in the Reef Fish Fishery Management Unit

Alternative 1: No Action. MSST for species that have a defined specification will not be changed. MSST will remain undefined for species that do not have a definition specified.

Alternative 2: MSST = (1-M)*B_{MSY} (or proxy)

Alternative 3: MSST = (1-M)*B_{MSY} (or proxy) or 0.75*B_{MSY} (or proxy), whichever is less.

Alternative 4: MSST = 0.75*B_{MSY} (or proxy), for all stocks.

Alternative 5: MSST = 0.50*B_{MSY} (or proxy), for all stocks.

<u>Discussion</u>:

Stocks with a low natural mortality rate can end up with an MSST that is only slightly below the B_{MSY} (or proxy) spawning stock biomass level. In such situations it can be difficult to determine if a stock is actually below MSST due to imprecision and accuracy of the data. In addition, natural fluctuations in stock biomass levels around the B_{MSY} level may temporarily drop the spawning stock biomass below MSST, although analysis from the Southeast Fisheries Science Center (SEFSC) suggests that this is unlikely except at very low natural mortality rates (see below). Setting a wider buffer between B_{MSY} or proxy) and MSST can avoid these issues. In addition, setting a wider buffer can allow a greater opportunity for management to end a decline in a stock that is approaching an overfished condition and rebuild the stock without the constraints imposed by a rebuilding plan that is required if the stock drops below MSST and is declared overfished. However, if a stock does drop below MSST and is declared overfished, a more restrictive rebuilding plan may be needed than if there were a narrower buffer between B_{MSY} and MSST. Thus, the decision of where to set MSST requires a balance between conservation and management flexibility.

Under **Alternative 1**, only six of the 31 stocks in the Reef fish Fishery Management Plan currently have MSST defined. Those stocks are: gag, red grouper, red snapper, vermilion snapper, gray triggerfish, and greater amberjack (Table 1.2) For each of these stocks, MSST = (1-M)*B_{MSY} (or proxy). The natural mortality rate (M) for these stocks ranges from 0.09 to 0.25, so the resulting MSST values range from 75% to 91% of the B_{MSY} proxy. For the remaining 25 stocks, MSST is undefined and would need to be established on a case by case basis.

Alternative 2 sets MSST for all stocks at (1-M)*B_{MSY} (or proxy). This is often the de facto MSST used to determine overfished status, but has been formally adopted in an FMP amendment only for stocks in need of a rebuilding plan. Stock that have not been assessed, and stock that have been assessed and found not to be in need of a rebuilding plan, have not had the MSST established. Natural mortality rates have been estimated for 14 of the 31 reef fish stocks in the

Gulf of Mexico (Table 2.1). These estimates range from a low of 0.073 (yellowedge grouper) to a high of 0.28 (greater amberjack), , so the resulting MSST values range from 72% to 91% of the B_{MSY} (or proxy). An additional 14 stocks have natural mortality estimates from other regions, either in the published literature or in SEDAR assessments done for South Atlantic stocks (Table 2.2). The SEFSC and the SSC would need to determine if these estimates are applicable to the Gulf stocks or if separate Gulf estimates are needed. Three stocks have no published estimates of natural mortality (Table 2.2).

Alternative 3 sets MSST at 0.75*B_{MSY} (or proxy) for all stocks that have M = 0.25 or less. Stocks with M greater than 0.25 would use the (1-M)*B_{MSY} formula, which would result in a wider buffer between B_{MSY} and MSST for those stocks with M greater than 0.25.

Mutton snapper (M=0.11)	Vermilion snapper (M=0.25)	Black grouper (M=0.136)
Red snapper (M=0.094)	Yellowedge grouper (M=0.073)	Gag (M-0.134)
Lane snapper (M=0.11-0.24)	Goliath grouper (M=0.12)	Tilefish (M=0.13)
Yellowtail snapper (M=0.194)	Red grouper (M=0.14)	Hogfish (M=0.179)

In addition, there are 14 reef fish stocks that have natural mortality rates estimated from regions other than the Gulf and 3 stocks that have no estimate of natural mortality (Table 2.2). Until estimates of natural mortality for the Gulf of Mexico are available, these stocks will be considered to have an unknown mortality in this region and will be included in the low mortality category. These stocks include:

Queen snapper (M=0.33-0.843)	Speckled hind (M=0.15-0.20)	Goldface tilefish (M=n/a)
Blackfin snapper (M=0.23-0.73)	Warsaw grouper (M=0.08)	Blueline tilefish (M=0.10)
Cubera snapper (M=0.15)	Snowy grouper (M-0.12)	Lessor amberjack (M=n/a)
Gray snapper (M=0.18-0.43)	Yellowmouth grouper (M=0.14-0.24)	Almaco jack (M=n/a)
Silk snapper (M=0.19-0.86)	Scamp (M=0.14-0.15)	Banded rudderfish (M=0.41)
Wenchman (M=0.44)	Yellowfin grouper (M=0.20)	

All of the above stocks (29 of 31) would have MSST = 0.75*B_{MSY} (or proxy). The only stocks not subject to this level are gray triggerfish (M=0.27) and greater amberjack (M-0.28). For these stocks, MSST would be equal to 0.73*B_{MSY} and 0.72*B_{MSY} respectively.

Alternative 4 sets MSST 0.75*B_{MSY} (or proxy) for all reef fish stocks. This would set MSST at the 0.75 level for all 31 stocks in the FMP including gray triggerfish and greater amberjack.

Alternative 5 sets MSST 0.75*B_{MSY} (or proxy) for all reef fish stocks. This would set MSST at the 0.75 level for all 31 stocks in the FMP.

If any species are added to the management unit, or if the estimate of M is changed in a peer-review report or SEDAR assessment for any existing species in the management unit, the intent of this action is that MSST will be set based on the most recent estimate of M and the preferred alternative specified in this action.

Evaluation of the Likelihood of Stocks Falling Below MSST Due to Natural Fluctuations

The SEFSC evaluated the probability that spawning stock will fall below the MSST in the absence of overfishing when MSST = (1-M)*B_{MFMT} versus other MSST reference points (Appendix A). This analysis was requested by the interdisciplinary planning team during preparation of this amendment. The analysis modeled three stocks using different proxies for MFMT (F_{MSY} for bluefin tuna, F_{MAX} for vermilion snapper and $F_{30\%\ SPR}$ for gray triggerfish). For these stocks, estimated natural mortality (M) ranged from 0.14 to 0.27. In the model, abundance was varied randomly while the stock was fished at MFMT. Results showed that fewer than 5% of the model runs resulted in spawning stock levels below MSST at either (1-M)*B_{MFMT} or 0.75*B_{MSY}. None of the model runs resulted in spawning stock levels below MSST at 0.50*B_{MSY}. These results indicate that for the stocks examined, (1-M)*B_{MFMT} appears to be a sufficient buffer against stocks dropping below MSST due to natural fluctuations. However, lower values of M did result in higher probabilities of the stock dropping below MSST despite not experiencing overfishing. As a result, the relationship may breakdown for very small levels of M less than 0.1, in which case adopting an MSST of at least 0.9*B_{MFMT} may be appropriate for stocks with M less than 0.1.

Table 2.1. Reef fish species with natural mortality estimates from stock assessments for the Gulf of Mexico stock.

Common Name	Scientific Name	M	Source
		Snappers	
Mutton snapper	*Lutjanus analis*	0.11	SEDAR 15A (2008)
Red snapper	*Lutjanus campechanus*	0.094277	SEDAR 31 (2013)
Lane snapper*	*Lutjanus synagris*	0.30 0.11-0.24	Ault et al. (2005) Johnson et al. (1995)
Yellowtail snapper	*Ocyurus chrysurus*	0.194	O'Hop et al. (2012)
Vermilion snapper	*Rhomboplites aurorubens*	0.25	SEDAR 9 (2006a)
		Groupers	
Yellowedge grouper	*Hyporthodus flavolimbatus*	0.073	SEDAR 22 (2011a)
Goliath grouper	*Epinephelus itajara*	0.12	SEDAR 23 (2011b)
Red grouper	*Epinephelus morio*	0.14	SEDAR 12 (2007)
Black grouper	*Mycteroperca bonaci*	0.136	SEDAR 19 (2010)
Gag	*Mycteroperca microlepis*	0.134	SEDAR 33 (2014a)
		Tilefishes	
Tilefish	*Lopholatilus chamaeleonticeps*	0.13	SEDAR 22 (2011c)
		Other Species	
Hogfish	*Lachnolaimus maximus*	0.179	Cooper et al. (2013)
Greater amberjack	*Seriola dumerili*	0.28	SEDAR 33 (2014b)
Gray triggerfish	*Balistes capriscus*	0.27	SEDAR 9 (2006b)

* Lane snapper: Ault et al. (2005) estimated M=0.30 for lane snapper in the Florida Keys. Johnson et al. (1995) reported a range of M estimates from 0.11 to 0.24 for lane snapper from the northern Gulf of Mexico.

Table 2.2. Reef fish species with no estimate of Gulf of Mexico natural mortality. Natural mortality estimates, where shown, are for stocks from other regions, primarily the Florida Keys, U.S. south Atlantic, or Caribbean.

Common Name	Scientific Name	M	Source
		Snappers	
Queen snapper	*Etelis oculatus*	0.843 0.33-0.76	Murray and Moore (1992) Bryan et al. (2011)
Blackfin snapper	*Lutjanus buccanella*	0.23 0.73	Ault et al. (1998) Tabash and Sierra (1996)
Cubera snapper	*Lutjanus cyanopterus*	0.15	Ault et al. (1998)
Gray (mangrove) snapper	*Lutjanus griseus*	0.25 0.18-0.43	Ault et al. (2005) Burton (2000)
Silk snapper	*Lutjanus vivanus*	0.23 0.19-0.86 0.86	Ault et al. (1998) Bryan et al. (2011) Tabash and Sierra (1996)
Wenchman	*Pristipomoides aquilonaris*	0.44	Froese and Pauly (2014a)
		Groupers	
Speckled hind	*Epinephelus drummondhayi*	0.20 0.15	Ault et al. (1998) Ziskin (2008)
Warsaw grouper	*Hyporthodus nigritus*	0.08	Ault et al. (1998)
Snowy grouper	*Hyporthodus niveatus*	0.12	SEDAR 36 (2013)
Yellowmouth grouper	*Mycteroperca interstitialis*	0.14-0.24*	Burton et al. (2014)
Scamp	*Mycteroperca phenax*	0.15 0.14	Potts and Brennan (2001) Ault et al. (2005)
Yellowfin grouper	*Mycteroperca venenosa*	0.20	Ault et al. (2005)
		Tilefishes	
Goldface tilefish	*Caulolatilus chrysops*	n/a	
Blueline tilefish	*Caulolatilus microps*	0.10	SEDAR 32 (2013)
		Jacks	
Lesser amberjack	*Seriola fasciata*	n/a	
Almaco jack	*Seriola rivoliana*	n/a	
Banded rudderfish	*Seriola zonata*	0.41	Froese and Pauly (2014b)

* For Yellowmouth grouper, Burton et al. (2013) gave age specific natural mortality rates calculated three ways, but did not provide an average. The values in this table are the range of average values for each method for the adult age groups (ages 3 to 31).

2.2 Action 2 – MSY Proxies

Alternative 1: No Action.

Alternative 2: MSY proxy = the yield when fishing at $F_{30\%\ SPR}$, except for those stocks listed in Alternative 4 (if selected).

Alternative 3: MSY proxy = the yield when fishing at $F_{40\%\ SPR}$, except for those stocks listed in Alternative 4 (if selected).

Alternative 4: Regardless of the alternative selected above, the following stocks shall have MSY defined as shown below.

Exceptions:

Gag:	MSY proxy = the yield when fishing at F_{MAX}. (Amendment 30B)
Red grouper:	MSY proxy = the yield when fishing at $F_{30\%\ SPR}$. (Secretarial Amendment 1)
Red snapper:	MSY proxy = the yield when fishing at $F_{26\%\ SPR}$. (Amendment 27)
Vermilion snapper:	MSY proxy = the yield when fishing at F_{MSY}. (SEDAR 9 Update Assessment)
Gray triggerfish:	MSY proxy = the yield when fishing at $F_{30\%\ SPR}$. (Amendment 30A)
Greater amberjack:	MSY proxy = the yield when fishing at $F_{30\%\ SPR}$. (Secretarial Amendment 2)
Goliath grouper:	MSY proxy = the yield when fishing at $F_{50\%\ SPR}$. (SEDAR 23)

Discussion:

Alternative 1 leaves the MSY undefined except for the six stocks listed in Table 1.2 (gag, red grouper, red snapper, vermilion snapper, gray triggerfish, and greater amberjack). The MSY proxy for the remaining stocks would need to be established on a case by case basis as an assessment is conducted or sufficient biological information is attained to allow a specification of MSY of MSY proxy.

Note: for vermilion snapper, Amendment 23 (2004) specified that the actual MSY estimate was to be used rather than a proxy. However, the most recent vermilions snapper assessments (SEDAR 9 2006b and SEDAR 9 Update 2011) used a proxy of yield at $F_{30\%\ SPR}$. Under **Alternative 1** there would be no proxy for vermilion snapper; the actual estimate of MSY would be used as specified in Amendment 23. **Alternatives 2 and 3** would adopt a proxy of yield at $F_{30\%\ SPR}$ or $F_{40\%\ SPR}$ unless vermilion snapper is retained as an exception under **Alternative 4**.

Alternative 2 sets the MSY proxy at the yield when fishing at $F_{30\%\ SPR}$. This would apply to all reef fish stocks except those listed in Alternative 4 (if that alternative is adopted along with **Alternative 2**). Under the Generic Sustainable Fisheries Act Amendment (GMFMC 1999), and MFMT overfishing threshold of $F_{30\%\ SPR}$ was adopted for most reef fish stocks. Those stocks with a different MFMT are listed in **Alternative 4**. **Alternative 3**, if adopted in conjunction with **Alternative 4**, would set MSY proxies that are consistent with the current MFMT proxies.

Alternative 3 sets the MSY proxy at the yield when fishing at $F_{40\%\ SPR}$. This would apply to all reef fish stocks except those listed in **Alternative 4** (if that alternative is adopted along with

Alternative 3). Under the Generic Sustainable Fisheries Act Amendment (GMFMC 1999), and MFMT overfishing threshold of $F_{30\%\ SPR}$ was adopted for most reef fish stocks. Those stocks with a different MFMT are listed in **Alternative 4**. **Alternative 3** is inconsistent with most of the current MFMT proxies. It would result in an MSY proxy and MSST that are more conservative than the MFMT at $F_{30\%\ SPR}$. An additional action to re-define MFMT for most reef fish stocks would be needed to restore consistency between MFMT, MSST, and MSY proxies.

Alternative 4 is intended to be adopted in combination with either **Alternative 2** or **Alternative 3**. It defines specific stocks that have a different MSY proxy that was either defined in an earlier amendment or utilized in a recent SEDAR stock assessment. **Alternative 4** would assure that those proxies are retained.

CHAPTER 10. REFERENCES

Ault, J.S., J.A. Bohnsack, and G.A. Meester. 1998. A retrospective (1979-1996) multispecies assessment of coral reef fish stocks in the Florida Keys. Fishery Bulletin 96(3):395-414 . http://fishbull.noaa.gov/963/ault.pdf

Ault, J. S., S.G. Smith, and J.A. Bohnsack. 2005. Evaluation of average length as an estimator of exploitation status for the Florida coral-reef fish community. ICES Journal of Mar. Sci. 62:417-423.
http://icesjms.oxfordjournals.org/content/62/3/417.full.pdf

Bryan, M.D., M. Lopez, and B. Tokotch. 2011. A review of the life history characteristics of silk snapper, queen snapper, and redtail parrotfish. SEDAR26-DW-01. Sustainable Fisheries Division Contribution No. SFD-2011-008. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida. 41 p.
http://www.sefsc.noaa.gov/sedar/download/S26_DW_01.pdf?id=DOCUMENT

Burton, M.L. 2000. Age, growth, and mortality of gray snapper, *Lutjanus griseus*, from the east coast of Florida. Fishery Bulletin 99:254–265.
http://fishbull.noaa.gov/992/bur.pdf

Burton, M.L. , J.C. Potts, and D.R. Carr. 2014. Age, growth, and mortality of Yellowmouth grouper from the southeastern United States. Marine and Coastal Fisheries: Dynamics: Management, and Ecosystem Science, 6:1, 33-42, DOI: 10.1080/19425120.2013.866998
http://dx.doi.org/10.1080/19425120.2013.866998

Cooper, W., A. Collins, J. O'Hop, and D. Addis. 2013. The 2013 Stock Assessment Report for Hogfish in the South Atlantic and Gulf of Mexico (SEDAR 37). Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, St. Petersburg, Florida.
http://www.sefsc.noaa.gov/sedar/download/SEDAR37_Hogfish_SAR.pdf?id=DOCUMENT

Froese, R. and D. Pauly. Editors. 2014a and b. FishBase. World Wide Web electronic publication.
www.fishbase.org, version (08/2014).
a. Wenchman:
http://www.fishbase.se/PopDyn/KeyfactsSummary_2v2.php?ID=198&GenusName=Pristipomoides&SpeciesName=aquilonaris&vStockCode=212&fc=323
b. banded rudderfish:
http://fishbase.sinica.edu.tw/PopDyn/KeyFactsSummary_2v2.php?ID=1008&GenusName=Seriola&SpeciesName=zonata&vStockCode=1024&fc=314

GMFMC. 1996. An evaluation of the use of SPR levels as the basis for overfishing definitions in the Gulf of Mexico finfish fishery management plans. Gulf of Mexico Fishery Management Council, Tampa, Florida. 46 p

GMFMC. 1999. Generic sustainable fisheries act amendment, includes environmental assessment, regulatory impact review, and initial regulatory flexibility analysis. Gulf of Mexico Fishery Management Council, Tampa, Florida. http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/Generic%20SFA%20amendment%201999.pdf

GMFMC. 2002. Secretarial Amendment 2 to the Reef Fish Fishery Management Plan to set greater amberjack sustainable fisheries act targets and thresholds and to set a rebuilding plan includes environmental assessment and regulatory impact review. Gulf of Mexico Fishery Management Council. Tampa, Florida. http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/Secretarial-Amendment-2-RF.pdf

GMFMC. 2004a. Secretarial amendment 1 to the reef fish management plan to set a 10-year rebuilding plan for red grouper, with associated impacts on gag and other groupers includes environmental assessment, regulatory impact review and final regulatory flexibility analyses. Gulf of Mexico Fishery Management Council. Tampa, Florida. http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/Secretarial-Amendment-1-RF.pdf

GMFMC. 2004b. Final amendment 23 to the reef fish fishery management plan to set vermilion snapper sustainable fisheries act targets and thresholds and to establish a plan to end overfishing and rebuild the stock, including a final supplemental environmental impact statement and regulatory impact review. Gulf of Mexico Fishery Management Council. Tampa, Florida. http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/VS%2023%20Oct%20Final%2010-21-04%20with%20Appendix%20E.pdf

GMFMC. 2007. Final amendment 27 to the reef fish fishery management plan and amendment 14 to the shrimp fishery management plan including supplemental environmental impact statement, regulatory impact review, and regulatory flexibility act analysis. Gulf of Mexico Fishery Management Council. Tampa, Florida. 490 pp with appendices. http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/Final%20RF%20Amend%2027-%20Shrimp%20Amend%2014.pdf

GMFMC. 2008a. Final Amendment 30B: gag – end overfishing and set management thresholds and targets. Red grouper – set optimum yield, TAC, and management measures, time/area closures, and federal regulatory compliance including environmental impact statement, regulatory impact review, and regulatory flexibility act analysis. Gulf of Mexico Fishery Management Council, Tampa, Florida. http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/Final%20Amendment%2030B%2010_10_08.pdf

GMFMC. 2008b. Final reef fish amendment 30A: greater amberjack – revised rebuilding plan, accountability measures; gray triggerfish – establish rebuilding plan, end overfishing, accountability measures, regional management, management thresholds and benchmarks including supplemental environmental impact statement, regulatory impact review, and regulatory flexibility act analysis. Gulf of Mexico Fishery Management Council. Tampa, Florida. http://www.gulfcouncil.org/docs/amendments/Amend-30A-Final%20208.pdf

Johnson, Allyn G., L. Alan Collins, John Dahl, and M. Scott Baker, Jr., 1995. Age, growth, and mortality of Lane Snapper from the northern Gulf of Mexico. Proc. Annu. Conf. Southeast Assoc. Fish and Wildl. Agencies. 49:178-186. http://www.seafwa.org/resource/dynamic/private/PDF/JOHNSON-178-186.pdf

Kenchington, T.J. 2008. The natural mortality rate of gag grouper: a review of estimators for data-limited fisheries. Unpublished manuscript, Gadus Associates. 31 p. http://www.sefsc.noaa.gov/sedar/download/S19_RD27_Kenchington%20Mortality%20Estimators%20Summary.pdf?id=DOCUMENT

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology 49:627-647.

Murray, P.A. and E.A. Moore. 1992. Recruitment and exploitation rate of *Etelis oculatus* Val. in the St. Lucian fishery. In: Proceedings of the Forty-Second Annual Gulf and Caribbean Fisheries Institute, Charleston, South Carolina. Page 262. http://procs.gcfi.org/pdf/gcfi_42-27.pdf

O'Hop, J., M. Murphy, and D. Chagaris. 2012. The 2012 stock assessment report for yellowtail snapper in the South Atlantic and Gulf of Mexico (SEDAR 27). Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, St. Petersburg, Florida. http://www.sefsc.noaa.gov/sedar/download/YTS_FWC_SAR.pdf?id=DOCUMENT

Potts, J.C. and K. Brennan. 2001. Trends in catch data and static SPR values for 15 species of reef fish landed along the southeastern United States. Report for South Atlantic Fishery Management Council, Charleston, SC. 42pp. http://www.sefsc.noaa.gov/sedar/download/SEDAR4_DW_28.pdf?id=DOCUMENT

Restrepo, V. R., G. G. Thompson, P. M. Mace, W. L. Gabriel, L. L. Low, A. D. MacCall, R. D. Methot, J. E. Powers, B. L. Taylor, P. R. Wade, and J. F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum NMFS-F/SPO-31. NOAA, National Marine Fisheries Service, Silver Spring, Maryland. http://www.nmfs.noaa.gov/sfa/NSGtkgd.pdf

SAFMC. 2011. Comprehensive annual catch limit amendment for the south Atlantic region. South Atlantic Fishery Management Council, North Charleston, South Carolina. 691 p. http://safmc.net/Meetings/SSCMeeting/SSCBBApril2012/Comp%20ACL%20Am%20101411%20FINAL.pdf

SEDAR 9. 2006a. Stock assessment report Gulf of Mexico vermilion snapper. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 9. 2006b. Stock assessment report Gulf of Mexico gray triggerfish. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 12. 2007. SEDAR12-Complete Stock Assessment Report 1: Gulf of Mexico Red Grouper. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/

SEDAR 15A. 2008. Stock assessment report 3 (SAR 3) South Atlantic and Gulf of Mexico mutton snapper. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 19. 2010. Stock assessment report Gulf of Mexico and South Atlantic black grouper. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 22. 2011a. Stock assessment report Gulf of Mexico yellowedge grouper. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 22. 2011b. Stock assessment report Gulf of Mexico tilefish. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 23. 2011. Stock assessment report South Atlantic and Gulf of Mexico goliath grouper. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 31. 2013. Stock assessment report Gulf of Mexico red snapper. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 32. 2013. Stock assessment report South Atlantic blueline tilefish. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 33. 2014a. Gulf of Mexico gag stock assessment report. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 33. 2014b. Gulf of Mexico greater amberjack stock assessment report. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

SEDAR 36. 2013. Stock assessment report South Atlantic snowy grouper. Southeast Data, Assessment, and Review. North Charleston, South Carolina. http://www.sefsc.noaa.gov/sedar/.

Tabash, F.A.B. and L.M. Sierra. 1996. Assessment of Lutjanus vivanus in the north Caribbean coast of Costa Rica. NAGA, The ICLARM Quarterly, October, 1996. Pp. 48-51.
http://www.worldfishcenter.org/Naga/na_2126.pdf

Ziskin, G.L. 2008. Age, growth and reproduction of speckled hind, *Epinephelus drummondhayi*, off the Atlantic coast of the southeast United States. A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science in Marine Biology. Graduate School of the College of Charleston. 120 p.
http://www.safmc.net/managed-areas/pdf/Ziskin2008_SHthesis.pdf

APPENDIX A.

A Preliminary Analysis of the Probability that the Spawning Stock will Fall Below the Minimum Stock Size Threshold in the Absence of Overfishing

Clay E. Porch
Southeast Fisheries Science Center

The Interdisciplinary Planning Team charged with developing a Minimum Stock Size Threshold amendment to the Reef Fish FMP requested an analysis be conducted to determine the likelihood of stock biomass levels falling below the minimum stock size threshold (MSST) for reasons other than overfishing. This document presents the results of preliminary analyses based on the assessments of three stocks with very different life history strategies: vermilion snapper, gray triggerfish and western Atlantic Bluefin tuna. These stocks were chosen because the forecasting software used in those assessments was easily modified to accommodate the request, however more species will be analyzed as time permits.

The basic approach to quantifying the probability that a stock would fall below a prescribed level of MSST without undergoing overfishing involves stochastic projections of the long-term abundance of the stock when it is subject to fishing at the maximum fishing mortality threshold (MFMT) used to define the overfishing limit (F_{MSY} for Bluefin, F_{MAX} for vermilion snapper and $F_{30\%}$ for gray triggerfish). Stochasticity was introduced by incorporating estimates of parameter uncertainty and lognormally-distributed random deviations in recruitment as specified in the assessment documents referenced below. Populations were found to reach a dynamic equilibrium within 150 years, therefore it was safe to assume that any transient effects resulting from the stock starting somewhere above or below MSST would be negligible by the final year of the projection. The fraction of the projections where the biomass in the final year falls below the biomass at MSY (or proxy) was then tabulated in the form of cumulative frequency distributions (Figure 1).

In all three examples fewer than 5% of the runs resulted in spawning stock levels below the fraction (1-M) of the long-term spawning biomass level associated with MFMT (B_{MFMT}). In these examples M ranges between 0.14 and 0.27, so it was also true that 5% or fewer of the runs resulted in spawning stock levels below 0.75*B_{MFMT}. None of the runs resulted in spawning stock levels below 0.5*B_{MFMT}.

The probability of classifying a stock as overfished when MSST is defined as (1-M)* B_{MFMT} appears to change inversely with M. For example, if the value of M assumed for vermilion snapper is increased from 0.25 to 0.5, the probability that the stock would be classified as overfished decreased from 4% to near zero (Figure 2). Conversely, if the value of M assumed for vermilion snapper is decreased from 0.25 to 0.05, the probability that the stock would be classified as overfished increased to 37%.

In conclusion, the MSST definition (1-M)* B_{MFMT} appears to be a sufficient buffer against classifying any of the three stocks examined as overfished merely as a consequence of natural fluctuations in year-class strength. Only a small percentage of the projections resulted in levels of spawning biomass below this level. The reason for this is that the extent to which year-class fluctuations result in fluctuations in spawning biomass generally decreases with the number of year classes in the population, and the number of year-classes in the population in turn generally increases with decreasing M. This relationship may breakdown for very small levels of M < 0.1, in which case one might wish to adopt a definition for MSST that does not exceed $0.9*B_{MFMT}$, e.g.,

$$MSST = MIN[1-M, 0.9]*B_{MFMT} .$$

The present analysis could be expanded to allow for fluctuations in the natural mortality rate, growth and other population parameters, in which case it might be expected that the probability of dipping below any given level of MSST due to natural fluctuations would increase. This implies that a somewhat larger buffer might be appropriate. The levels mentioned during the IPT discussions included $0.75*B_{MFMT}$ and $0.5*B_{MFMT}$ (the latter being the lowest level allowed under the current NS1 guidelines). While further analyses are needed to indicate the level of natural variability required to support buffers as low as $0.5*B_{MFMT}$ in general, the current work suggests that at least for longer-lived stocks (low M) the degree of uncertainty would need to increase a great deal for such a low threshold to be appropriate. Ortiz et al. (2010) point out that setting a limit well below B_{MFMT}, while having the desirable quality of increased statistical power for detecting whether a stock has been overexploited, also carries with it the danger of extended time periods for management actions required for rebuilding. The current requirement under Magnuson-Stevens Fishery Conservation and Management Act to take immediate actions to stop overfishing should mitigate against this danger of falling too far below B_{MFMT}, or to put it another way, causes buffers as low as $0.5*B_{MFMT}$ to have no meaningful effect on the management of long-lived animals

References

ICCAT. 2015. Report of the 2014 Atlantic Bluefin Tuna Stock Assessment Session. ICCAT Collected volume of Scientific Papers 178 pp. http://www.iccat.int/en/meetings.asp

Linton, B. Cass-Calay, S. and C. E. Porch. 2011. An Alternative SSASPM Stock Assessment of Gulf of Mexico Vermilion Snapper that Incorporates the Recent Decline in Shrimp Effort. 17 pp. http://sedarweb.org/docs/suar/Final%20Vermilion%20Snapper%20Update%20with%20addendum.pdf

Ortiz, M., Cass-Calay, S. L. and G. P. Scott. 2010. A Potential Framework for Evaluating the Efficacy of Biomass Limit Reference Points in the Presence of Natural Variability and Parameter Uncertainty: An Application to Northern Albacore Tuna (Thunnus alaunga). Collect. Vol. Sci. Pap. ICCAT, 65(4): 1254-1267 (2010)

SEDAR 9 Update Stock Assessment Report Gulf of Mexico Gray Triggerfish. 2011. http://sedarweb.org/docs/suar/2011%20Update%20Assessment%20Report%20for%20SEDAR9%20GoM%20Gray%20Triggerfish.pdf

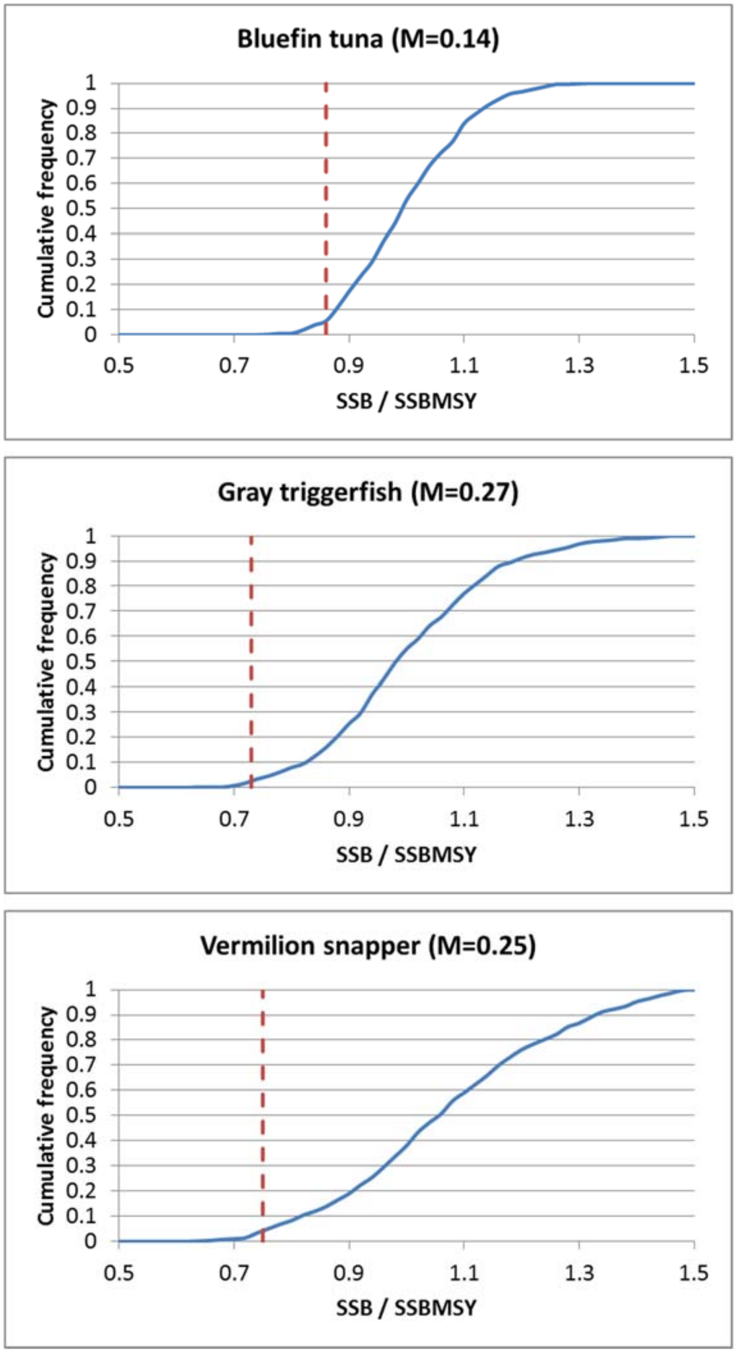


Figure 1 (Appendix A). Cumulative probability distributions of the spawning biomass in the last year of the projection relative to the equilibrium spawning biomass associated with MFMT for each of the three species. The dashed vertical line represents the quantity 1-M.

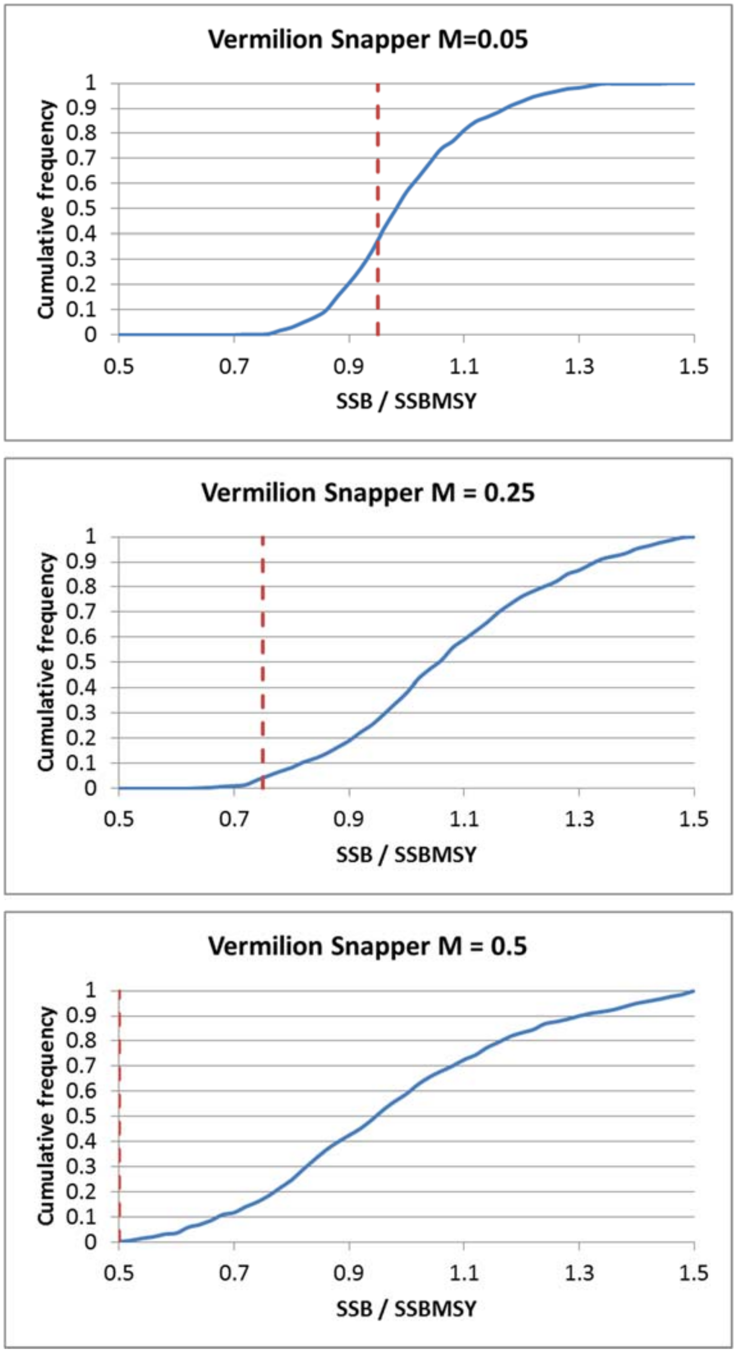


Figure 2 (Appendix A). Cumulative probability distributions of the spawning biomass in the last year of the projection relative to the equilibrium spawning biomass associated with MFMT for vermilion snapper assuming 3 different levels of M. The dashed vertical line represents the quantity 1-M.