SCIENTIFIC COMMITTEE
SEVENTEENTH REGULAR SESSION

ELECTRONIC MEETING
11-19 August 202021

FUTURE STOCK PROJECTIONS OF OCEANIC WHITETIP SHARKS IN THE WESTERN AND CENTRAL PACIFIC OCEAN

WCPFC-SC17-2021/SA-IP-21

Joel Rice[1], Felipe Carvalho[2], Mark Fitchett[3], Shelton Harley[4] and Asuka Ishizaki

[1] Rice Marine Analytics (ricemarineanalytics@gmail.com),
[2] NOAA Pacific Islands Fisheries Science Center
[3] Western Pacific Regional Fishery Management Council
[4] Ministry of Primary Industry, New Zealand

Future Stock Projections of Oceanic Whitetip Sharks in the Western and Central Pacific Ocean

Joel Rice[5], Felipe Carvalho[6], Mark Fitchett[7], Shelton Harley[8] and Asuka Ishizaki[3]
July 24th, 2020

Abstract

The updated stock assessment for oceanic whitetip shark presented to the 15th WCPFC Science Committee (Tremblay-Boyer et al., 2019) showed that the stock was overfished and undergoing overfishing, but also highlighted a small reduction in stock depletion, with increases in recruitment and a reduction in fishing mortality relative to reference points under certain catch scenarios. However, since oceanic whitetip sharks are late-maturing and fishing mortality on juveniles is high, uncertainty remains as to the level of effectiveness of the non-retention measure active for the last 4 years of the assessment (CMM-2011-04 non-retention of the species, and CMM 2014-05 a ban on wiretrace or sharklines) and the impact of the CMM on the timeline for recovery. In parallel, Hutchinson and Bigelow (2019) presented new results quantifying post-release mortality for oceanic whitetip shark that were not available at the time the 2019 stock assessment was completed. The stock assessment characterized the uncertainty in the data and model parameters via a structural uncertainty grid where multiple (648) combinations of data and parameter values were used to show the range of plausible uncertainty to the inputs. This study uses a representative subset of the structural uncertainty in the assessment (108 runs) based on the updated post-release mortality values. Future projections for the 2019 WCPO oceanic whitetip stock assessment are completed to assess the impacts of recent conservation and management measures future fishing mortality on recovery timelines, using updated estimates of post-release mortality. We demonstrate the effect of a range of post assessment (2017 and on) catch trends on the estimates of population growth rate. Population projections are carried forward to estimate the mean time and probability of the population reaching thresholds of 50%, 25%, and 12.5% of current (2016) biomass levels.

1. Introduction

Oceanic whitetip (OCS) sharks were first assessed in 2012 (Rice and Harley 2012), where the stock in the Western and Central Pacific Ocean (WCPO) was found to be overfished and that overfishing was occurring. Based in part on the 2012 assessment conservation and management measure (CMM) CMM2011-04 became active in 2013, enacting a no-retention measure for OCS for WCPFC Members, Cooperating Non-Members and Participating Territories (CCMs). Additional CMMs have been

[5] Rice Marine Analytics (ricemarineanalytics@gmail.com),
[6] NOAA Pacific Islands Fisheries Science Center
[7] Western Pacific Regional Fishery Management Council
[8] Ministry of Primary Industry, New Zealand

implemented on the species, based in part on Bromhead et al. (2013) showing the effect of shark lines on the catch rate of OCS and other shark species. Following the non-retention of oceanic whitetips in 2013, a ban of 'shark lines in longline fisheries' via CMM-2014-05 came into force, becoming fully effective July 1, 2015.

Recently the OCS stock assessment was updated and presented to SC15 (Tremblay-Boyer et al 2019), which showed that the stock was overfished and undergoing overfishing, but also highlighted a small reduction in stock depletion, and positive trends in recruitment from 2013 to the terminal year and improvement with respect to fishing mortality (F-based) reference points under certain catch scenarios. However, since oceanic whitetip sharks are late-maturing and fishing mortality on juveniles is high (see Tremblay-Boyer et al 2019, for details on the biology and recent mortality), uncertainty remains as to the effectiveness of the non-retention measure active for the last years of the assessment (since implementation of CMM-2011-04) and the resulting timeline for recovery. In parallel, Hutchinson and Bigelow (2019; SC15-EB-WP-04) presented new results quantifying post-release mortality (PRM) for oceanic whitetip shark that were not available at the time the assessment was completed. Projections were completed to illustrate the potential effect of these CMMs on the oceanic whitetip stock in the WCPO.

Population projections for 2017-2031 were completed using Stock Synthesis (Methot & Wetzel 2013). This study uses a 15-year projection window under the assumption that is enough to capture the ongoing change of stock status following management measures given that estimates of the generation time for OCS are between 5 and 8 years. The projection horizon should allow the work to quantify the expected timeline for recovery for this stock, and could also inform short- to medium-term recovery plans. As with many shark stock assessments there is substantial uncertainty regarding historical catches due to underreporting and historical non-reporting of non-target species. The 2019 assessment (Tremblay-Boyer et al 2019) considered uncertainty in the catch as well as in natural mortality, historical fishing mortality (initial depletion), recruitment (via steepness and recruitment deviations), growth and maturity via a structural uncertainty grid in which every combination of the values is run, for more information see Tremblay-Boyer et al 2019. This report uses the majority of the uncertainty scenarios presented in the assessment. It focuses the recommendations on axes of uncertainty that substantially affect the outcomes on and those scenarios that most closely represent the new information on post-release mortality (PRM, SC15-EB-WP-04) for oceanic whitetip shark. This study relies on the assumption that the 2019 stock assessment adequately represents a suite of plausible population dynamics for oceanic whitetip shark in the WCPO. In particular the study assumes that future changes in recruitment do not compromise the quality of the projections.

2 Methods.

Future projections based on the 2019 WCPO oceanic whitetip stock assessment were carried out using the Stock Synthesis forecast module. The forecast period was implemented with the same model configurations from the 2019 stock assessment of OCS (Tremblay-Boyer et al, 2019). A range of future catch scenarios was implemented to represent the uncertainty regarding the effects of recent CMMs, their impacts as implantation has increased and to incorporate change in fishing effort in the core habitat area of OCS. Future catch scenarios that span the plausible influence of mitigation measures implemented are considered, along with a zero-catch scenario.

Representative Runs from the 2019 Assessment

The 2019 assessment used a structural uncertainty approach to explore the alternative states of nature that are plausible for the biology and catch history given the available information. The results along the axes of uncertainty were weighted to given an overall prediction of the stock status and related uncertainty. The axes of uncertainty contained two levels for growth and fecundity, three for the initial F (fishing mortality prior to the start of the model), three levels for steepness, three for natural mortality, two for the recruitment deviation and six for the catch estimates.

Catch estimates used in the assessment model for OCS run between 1995 and 2016, the full assessment considered two different catch trajectories that were estimated with three different levels of PRM (for a total of six catch scenarios). The catch scenarios used in the assessment were estimated using a Bayesian model (Tremblay and Neubauer 2019) and were based on the median (50^{th} quantile) estimate and the 90^{th} quantile. Both scenarios were considered with three levels of PRM, a 100% mortality on all catches independently of discard status, a 25% mortality on discards and a 25% mortality on individuals released alive (total discard mortality of 43.75% =0.25+0.25*0.75), and a 25% mortality on discards (0% mortality on live release). For details regarding the catch estimation and implementation of the PRM scenarios please see (Tremblay and Neubauer 2019, and Tremblay-Boyer et al, 2019).

Recent studies of PRM for pelagic sharks have been carried out by the National Marine Fisheries Service Pacific Islands Fisheries Science Center, whereby Hutchinson. and Bigelow, (2019) have estimated a value of 13% for PRM with a 33.6% discard rate mortality for a total mortality of 42.23% (=0.336 + 0.13 *0.664) for oceanic whitetip sharks. This study uses only the catch estimates from the assessment that include a 25% mortality on discards and a 25% mortality on individuals released alive due to the similarity of the Hutchinson and Bigelow (2019) estimate of total mortality (42.23%) and the intermediate value used in the assessment (43.75%). Further given the minimal effect that changes in sigma r (i.e. constraining penalty for the estimates of recruitment deviations) had on the results this study only considers those runs with sigma r values of 0.1.

Post Assessment Catch Estimation for OCS.

Following the introduction of CMM-2011-04 (non-retention of the species, became fully effective in 2013) estimated catches have declined (Tremblay and Neubauer 2019). Onboard fisheries observer data from the WCPO indicates that this is due to increased discard rates in the longline and purse seine fishery occurring over the last few years as the CMM was more widely adopted. Additionally longline effort in the WCPO has declined in recent years, from a high of approximately 11 hundred million hooks to 8 hundred million hooks in 2017 (https://www.wcpfc.int/public-domain). For projection purposes, it is helpful to have realistic levels of catch, especially during the intervening years between the terminal model year and the present. The goal was to simulate increased adoption of the CMM over the years between the terminal year of the model and the current year (i.e. 2017-2020), after which the values are projected forward at a constant level. Catch estimates from 2017 – 2020 were estimated by reducing annual total catch using two scalar that are representative of the average annual percent reduction from 2013-2014, 2014-2015, and 2015-2016 (10% and 20%%). The catch was set constant at the 2020 estimated values for 2021 through 2031 (Table 1). For illustration purposes model runs with the terminal years catch of 2016 (status quo), were also projected, along with a zero-catch scenario. These catch levels are also consistent with catch trajectories of oceanic whitetip sharks through 2018 as estimated by Peatman and Nicol (2020; SC16-ST-IP-11)

Population Projections

Population projections were carried out in the Stock Synthesis forecast module assuming the catch calculated in the previous section. Estimates of mean time the population reaching thresholds of 50%, 25%, and 12.5% of current (2016) abundance were based on the population projections and aggregated by forecast catch scenarios (with the exception of the zero-catch scenario in which biomass only increased). Biomass and recruitment trajectories in the final years of the model varied from decreasing to increasing depending on the specific values for the biology and catch scenarios assumed in the model run.

3 Results

The population is projected to increase at a moderate pace over the projection period under the zero-catch scenario, as well as for many of the models under the projected status quo, 10% and 20% decrease catch scenarios. This is in concert with a decline in catches that began in 2011 (Figure 1) and stabilized as the CMM came into force in 2013, assuming a gradual adoption of the measure. The average annual change from 2018-2028 shows that the majority of the population trajectories are increasing (Table 2, Figure 3). The estimate of the mean and median time (in years) from the end of the assessment period to the population reaching thresholds of 50%, 25% and 12.5% of the 2016 biomass is shown in Table 2, and Figure 8. The average time to 50% of the 2016 biomass levels is approximately 10, 15, and 16 years for the 2016, 10% decline and 20% decline catch scenarios (respectively). Population projections under a 20% decline in catches for the years 2017-2020 show that the in the majority of the simulations the population is increasing. After the projection period of 2-3 generation times (16 years) the population is at or greater than its 2016 values (Table 3, Figures 3-7).

The reaction of the model to the catch scenarios is dependent on the model configuration, i.e. the models with higher natural mortality or steepness result in a population that is more readily able to rebound from a depleted status (Figure 4 and 5). The growth curve parameterization in the assessment considered values by two different studies (Joung et al. 2016 and Seki et al 1996), with the results based on the Seki parameterization showing a greater ability to rebound under all catch scenarios (Figure 5).

Acknowledgements

The authors would like to thank Ian Taylor and Michelle Scully for assistance with Stock Synthesis and high throughput computing. The authors acknowledge the National Oceanic and Atmospheric Administration and the Council's funding support through 20-ADMN-##.

4 References

Bromhead, D., J. Rice and S. Harley. (2013) Analyses of the potential influence of four gear factors (leader type, hook type, “shark” lines and bait type) on shark catch rates in WCPO tuna longline fisheries. WCPFC-SC9-2013/EB-WP-02

Joung, S.-J.; Chen, N.-F.; Hsu, H.-H., & Liu, K.-M. (2016). Estimates of life history parameters of the oceanic whitetip shark, Carcharhinus longimanus, in the western North Pacific Ocean. Marine Biology Research, 12(7), 758–768.

Hutchinson, M. and Bigelow, K. (2019). Quantifying Post Release Mortality Rates of Sharks Incidentally Captured in Pacific Tuna Longline Fisheries and Identifying Handling Practices to Improve Survivorship. WCPFC-SC15-2019/EB-WP-04 (Rev.01). WCPFC-SC15-2019/SA-WP-06. Report to the WCPFC Scientific Committee. Fifteenth Regular Session, 12–20 August 2018, Pohnpei, Federated States of Micronesia.

McCracken, M. (2019). American Samoa Longline Fishery Estimated Anticipated Take Levels for Endangered Species Act Listed Species. PIFSC Data Report DR-19-028. Issued 06 June 2019 https://doi.org/10.25923/b8gs-j441

McCracken, M. (2019b). Hawaii Permitted Deep-set Longline Fishery Estimated Anticipated Take Levels for Endangered Species Act Listed Species and Estimated Anticipated Dead or Serious Injury Levels for the Listed Marine Mammals. PIFSC Data Report DR-19-011https://doi.org/10.25923/brkr-c471

McCracken, M. (2018). Hawaii Permitted Shallow-set Longline Fishery Estimated Anticipated Take Level for Endangered Species Act Listed Species. PIFSC Data Report DR-18-014. https://doi.org/10.25923/9qy7-wz62

Methot Jr, R. & Wetzel, C. R. (2013). Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research, 142, 86–99.

Peatman, T, and Nicol, S. (2019). Updated longline bycatch estimates in the wcpowcpfc-sc16-2020/st-ip-11. Report to the WCPFC Scientific Committee. Fifteenth Regular Session, 12–20 August 2018, Pohnpei, Federated States of Micronesia.

Tremblay-Boyer, Laura; Felipe Carvalho; Philipp Neubauer; Graham Pilling (2019). Stock assessment for oceanic whitetip shark in the Western and Central Pacific Ocean, 98 pages. WCPFC-SC15-2019/SA-WP-06. Report to the WCPFC Scientific Committee. Fifteenth Regular Session, 12–20 August 2018, Pohnpei, Federated States of Micronesia.

Tremblay-Boyer, L. & Neubauer, P. (2019). Data inputs to the stock assessment for oceanic whitetip shark in the Western and Central Pacific Ocean. WCPFC-SC15/SA-IP-XX. Report to the Western and Central Pacific Fisheries Commission Scientific Committee. Fifteenth Regular Session, 12–20 August 2018, Pohnpei, Federated States of Micronesia.

Rice, J. & Harley, S. (2012). Stock assessment of oceanic whitetip sharks in the western and central Pacific Ocean. WCPFC-SC8-2012/SA-WP-06 Rev 1. Report to the Western and Central Pacific Fisheries Commission Scientific Committee. Eighth Regular Session, 7–15 August, 2012, Busan, Korea.

Seki, T.; Taniuchi, T.; Nakano, H., & Shimizu, M. (1998). Age, growth and reproduction of the oceanic whitetip shark from the Pacific Ocean. Fisheries Science, 64(1), 14–20.

5 Tables

Table 1. Estimated catches (in 1000's of individuals) used in the assessment (High PRM 0.75, Median PRM 0.75) for the years 2012-2016, along with calculated values for 2017-2020 based on zero catch in 2017 and based on an average annual percent reduction in catch from 2016 of 10% and 20%. Estimates from 2020 were carried forward to 2031.

	Forecast at zero catch			Forecast at 2016 Levels	
	High PRM	Median PRM		High PRM	Median PRM
	0.75	0.75		0.75	0.75
2012	233	112	2012	233	112
2013	111	54	2013	111	54
2014	111	46	2014	111	46
2015	115	48	2015	115	48
2016	87	38	2016	87	38
2017	0	0	2017	87	38
2018	0	0	2018	87	38
2019	0	0	2019	87	38
2020	0	0	2020	87	38
2021	0	0	2021	87	38
2022	0	0	2022	87	38

	Forecast at a 10% decline			Forecast at a 20% decline	
	High PRM	Median PRM		High PRM	Median PRM
	0.75	0.75		0.75	0.75
2012	233	112	2012	233	112
2013	111	54	2013	111	54
2014	111	46	2014	111	46
2015	115	48	2015	115	48
2016	87	38	2016	87	38
2017	78	34	2017	69	30
2018	70	31	2018	56	24
2019	63	28	2019	44	20
2020	57	25	2020	36	16
2021	57	25	2021	36	16
2022	57	25	2022	36	16

Table 2. Mean and median annual change for the reference set of models for the years 2018-2028. These values are calculated under three different future catch scenarios, the 2016 values, the 2016 values with a 10% decline, and the 2016 catches with a 20% decline.

	Future Catch Scenario		
	2016	10% Decline	20% Decline
Mean	-13.3%	-0.4%	4.2%
Median	-14.6%	-1.2%	3.3%

Table 3. Time to 50% and 25% and 12.5% of the 2016 biomass levels for the reference set of runs based on three future catch scenarios. Values of "16" indicate that the population biomass was greater than 50% or 25% of the 2016 values at the end of the projection period (2031).

Future Catch Scenario	Percent of 2016 Biomass	Mean	Standard Deviation	Median
2016 catch	12.5%	13.8	1.8	14.0
2016 catch	25%	12.7	2.4	12.0
2016 catch	50%	10.6	3.2	10.0
10% Decline	12.5%	16.0	0.0	16.0
10% Decline	25%	15.9	0.4	16.0
10% Decline	50%	15.1	1.6	16.0
20% Decline	12.5%	16.0	0.0	16.0
20% Decline	25%	16.0	0.0	16.0
20% Decline	50%	16.0	0.0	16.0

6 Figures

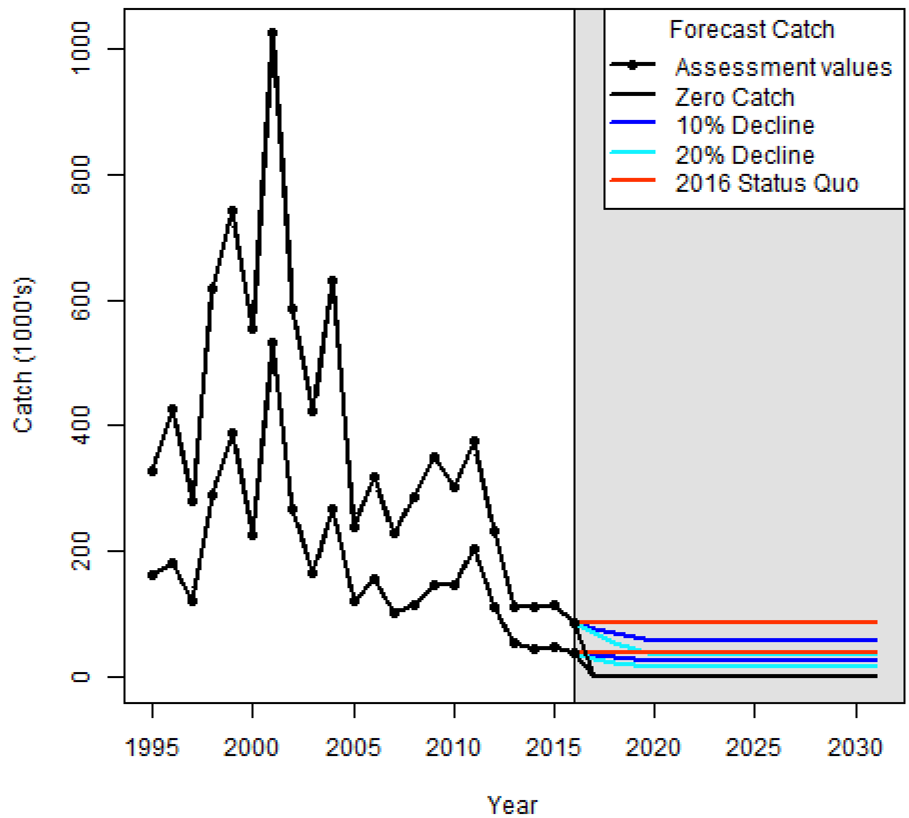

Figure 1. Assessment catch values (dotted line) under the High Catch PRM 0.75 (upper line) and Median Catch PRM 0.75 scenarios with forecast catch under zero catch, the 10 %, 20% decline and 2016 status quo catch scenarios.

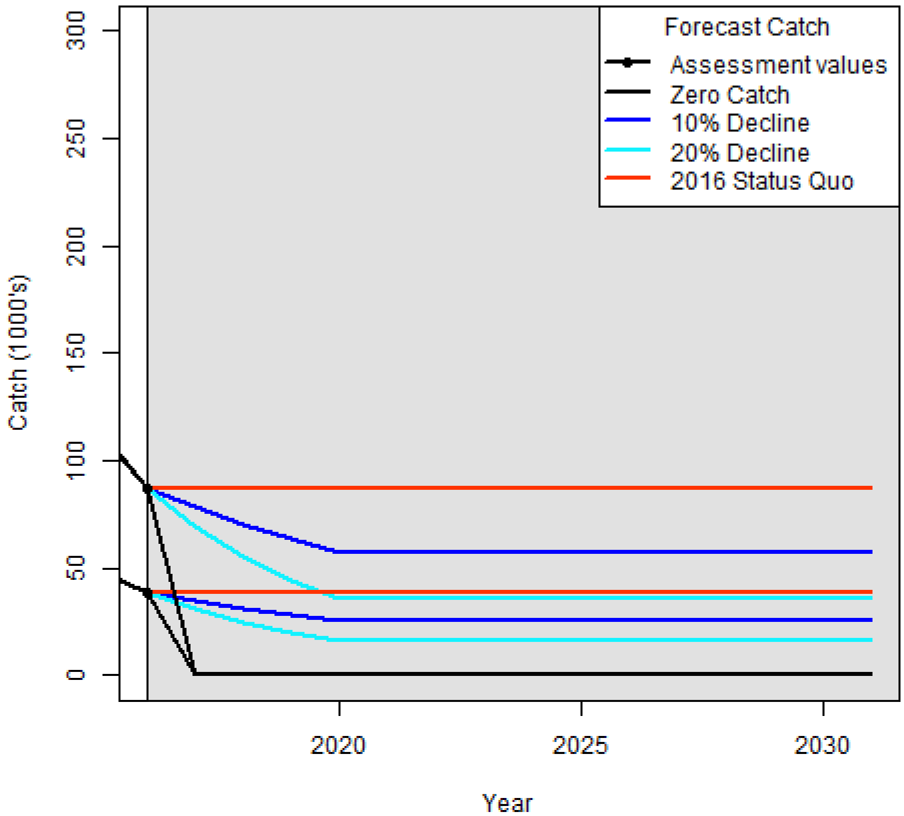

Figure 2. A close-up comparison of the projected catch values during the forecast period (shaded portion of the graph).

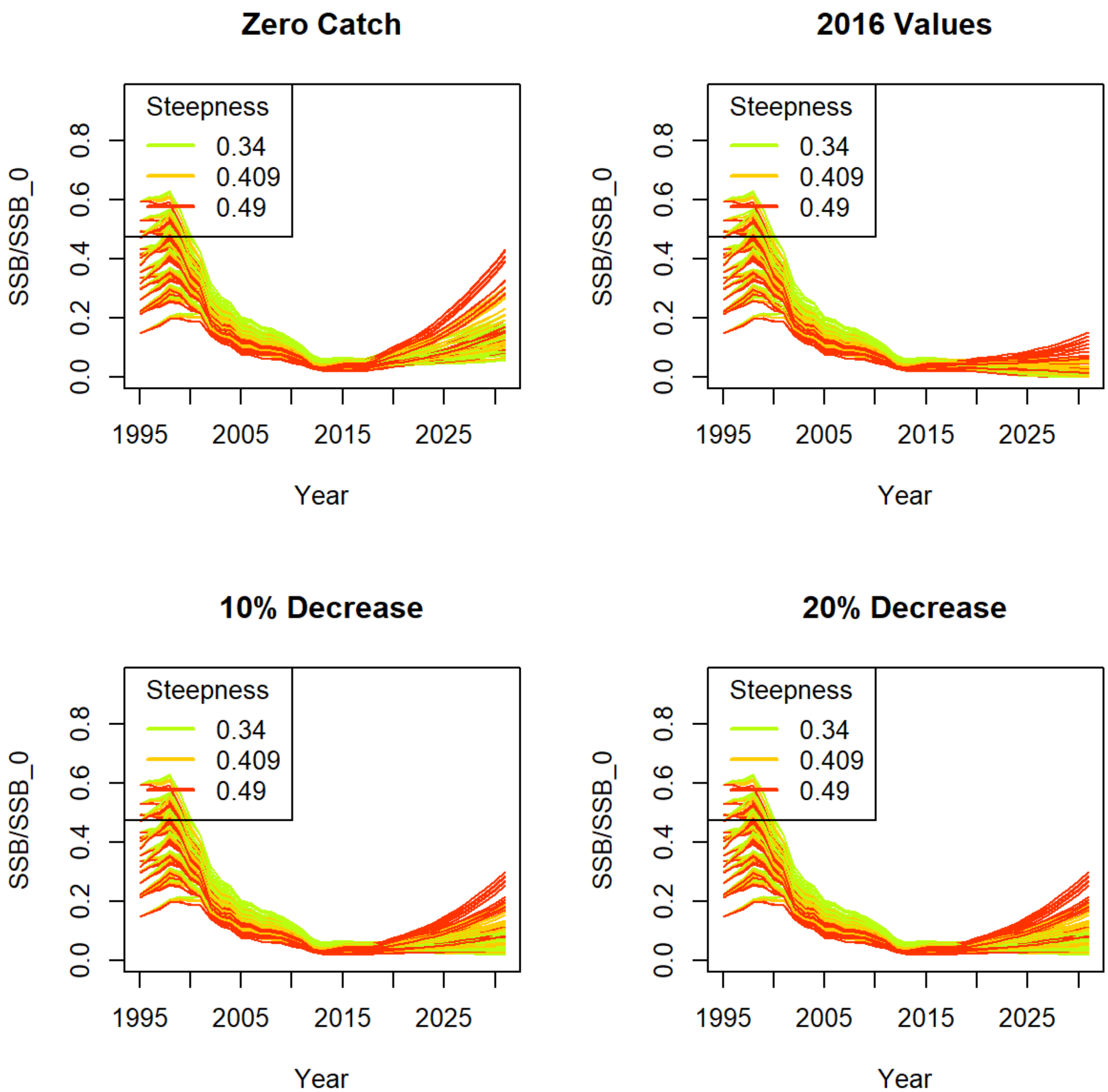

Figure 3. Projected biomass depletion under zero catch scenario, the 2016 status quo catch a 10% decline from 2016 and a 20% decline from 2016. Colors indicate steepness values assumed in the assessment as part of the structural uncertainty grid.

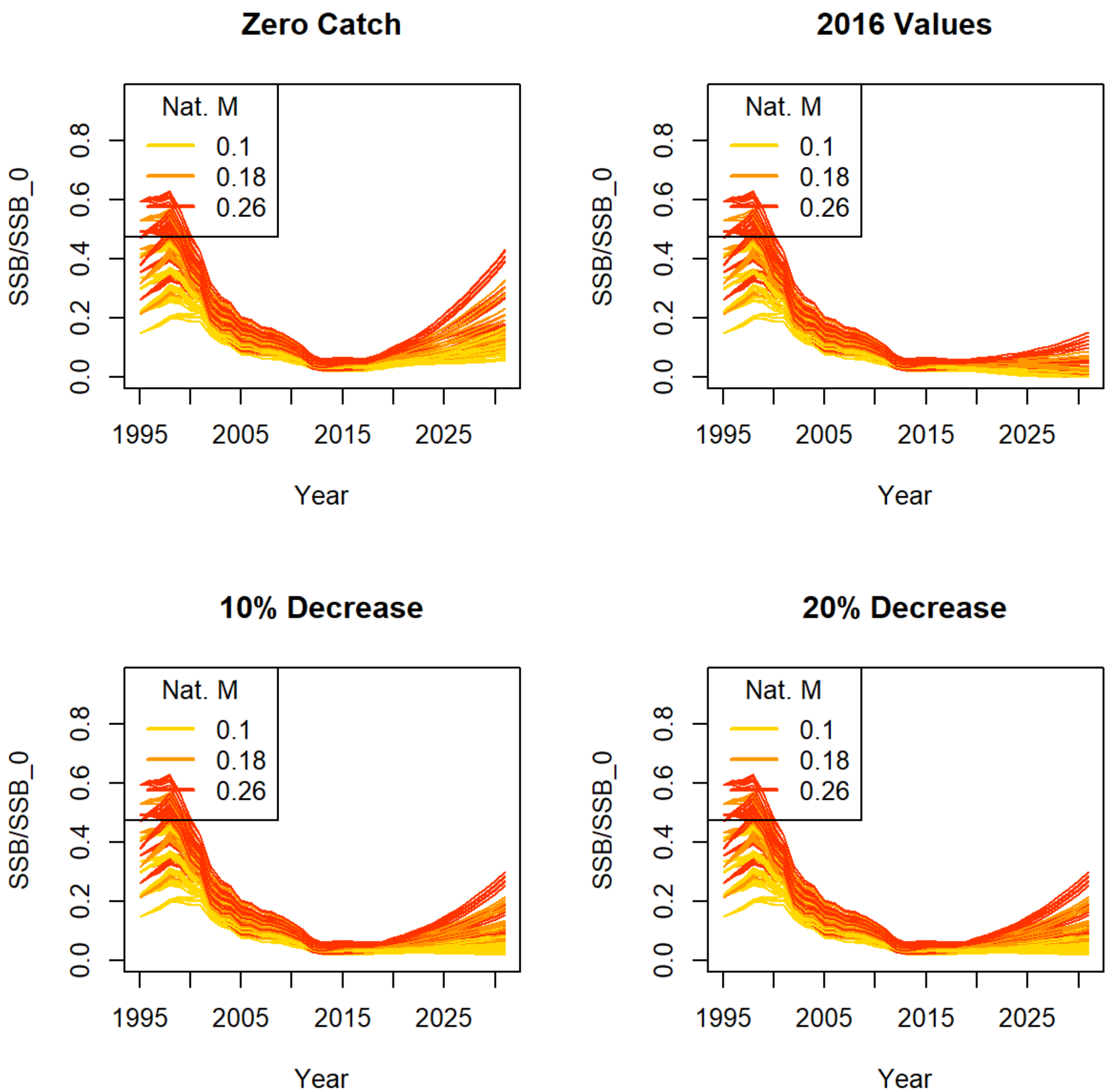

Figure 4. Projected biomass depletion under zero catch scenario, the 2016 status quo catch a 10% decline from 2016 and a 20% decline from 2016. Model runs are colored by the natural morality values

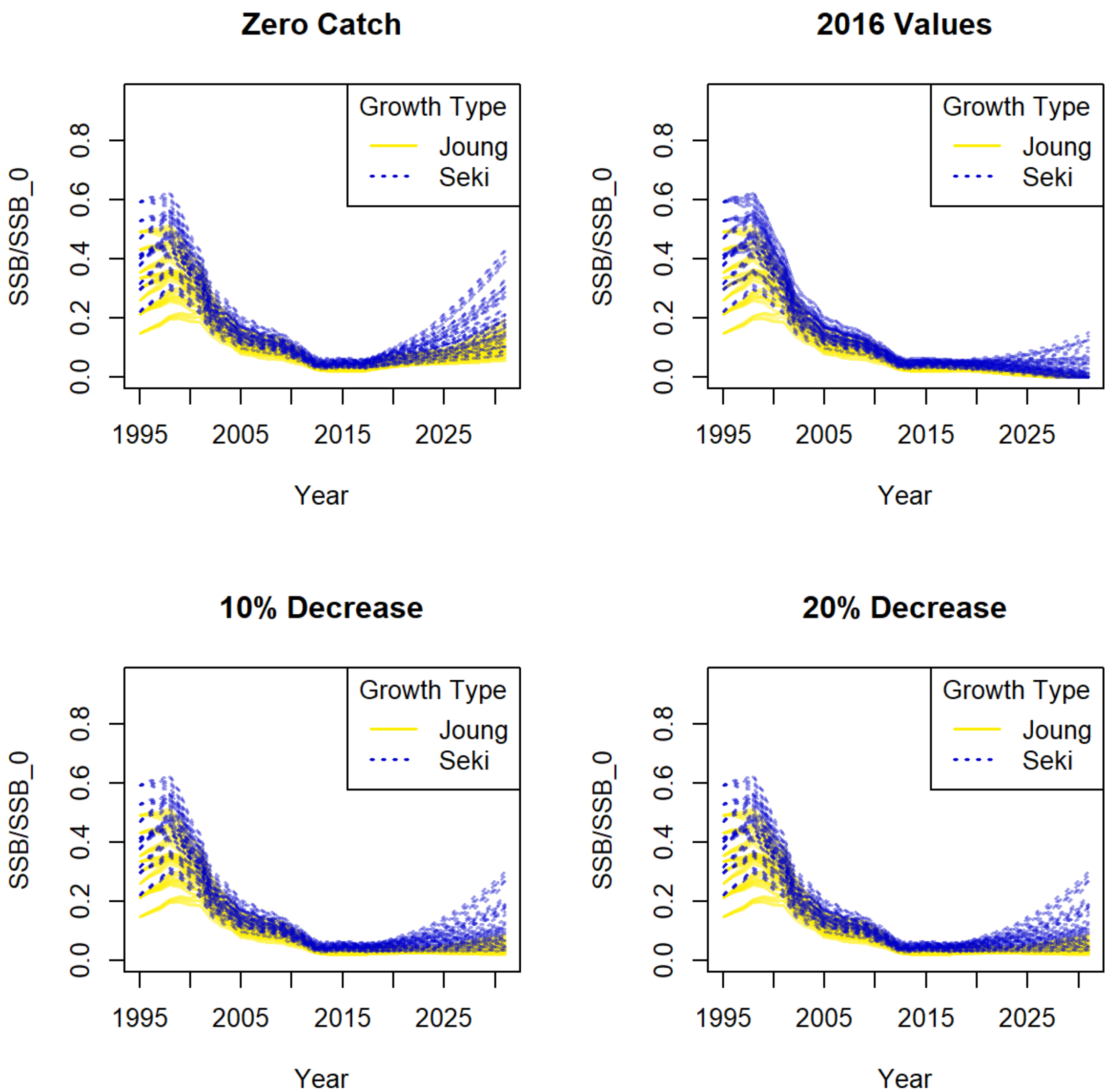

Figure 5. Projected biomass depletion under zero catch scenario, the 2016 status quo catch a 10% decline from 2016 and a 20% decline from 2016. Model runs are colored by the growth curve used.

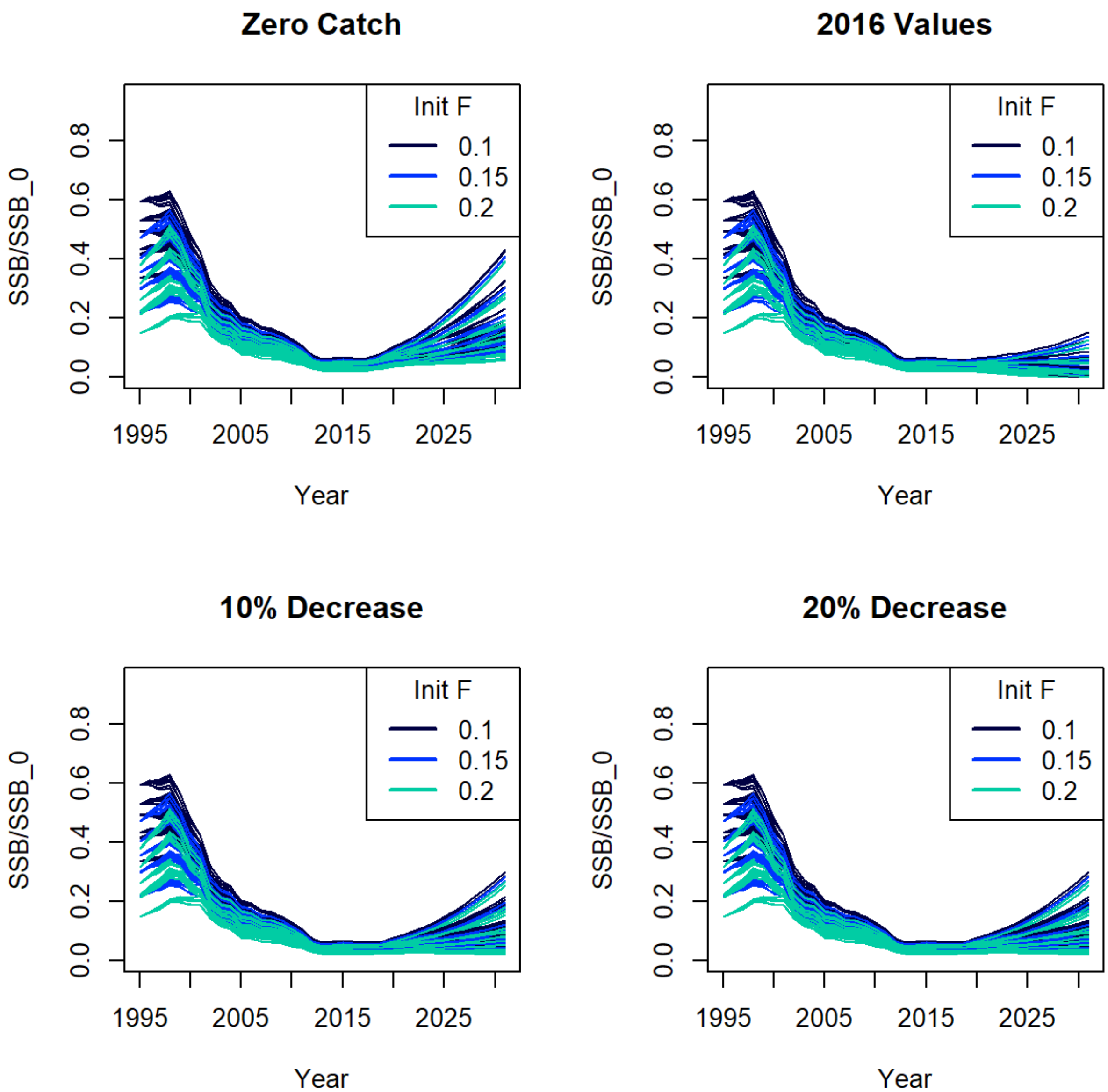

Figure 6. Projected biomass depletion under zero catch scenario, the 2016 status quo catch a 10% decline from 2016 and a 20% decline from 2016.Model runs are colored by the initial depletion used.

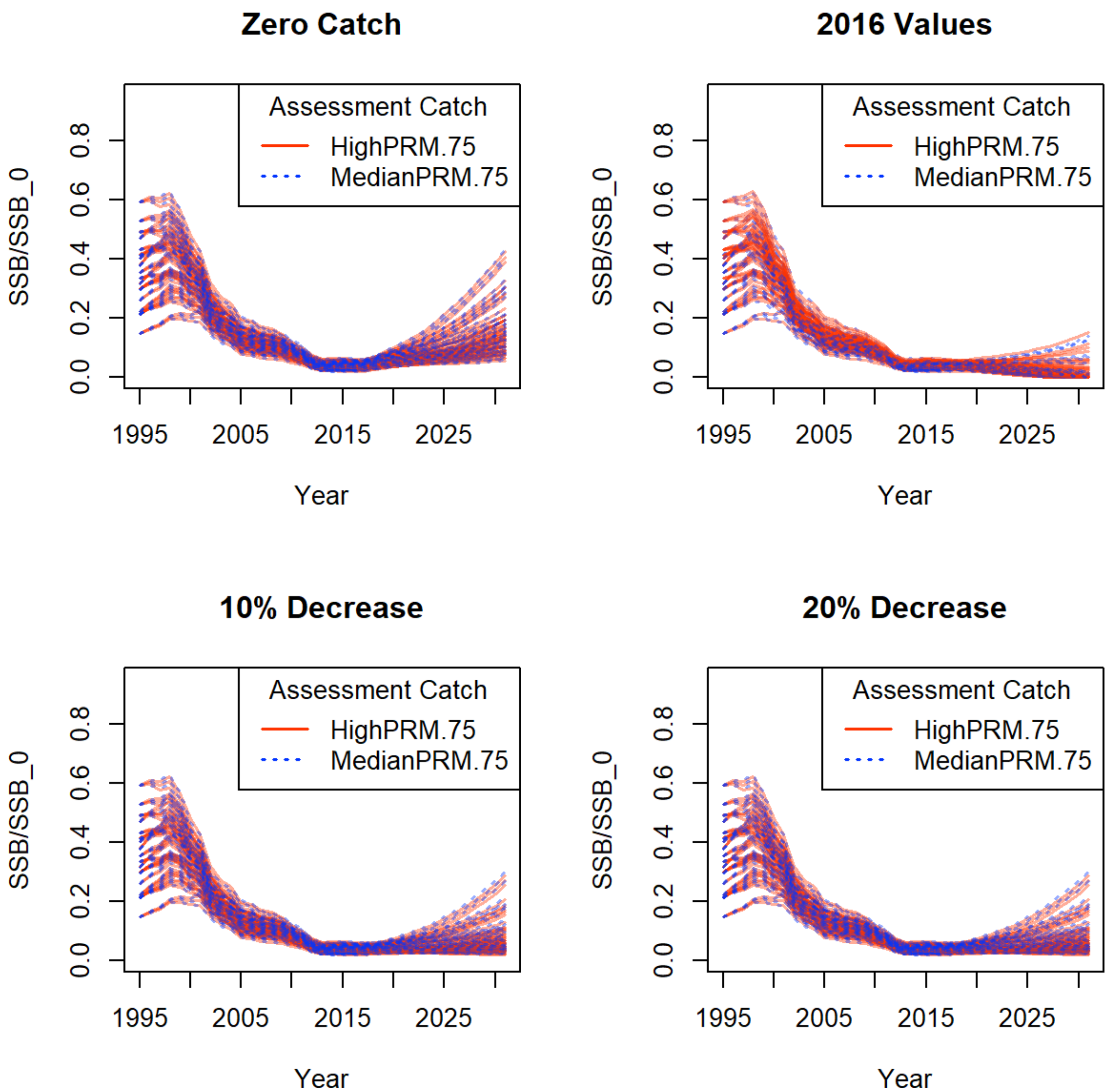

Figure 7. Projected biomass depletion under zero catch scenario, the 2016 status quo catch a 10% decline from 2016 and a 20% decline from 2016. Model runs are colored by the catch trajectory used.

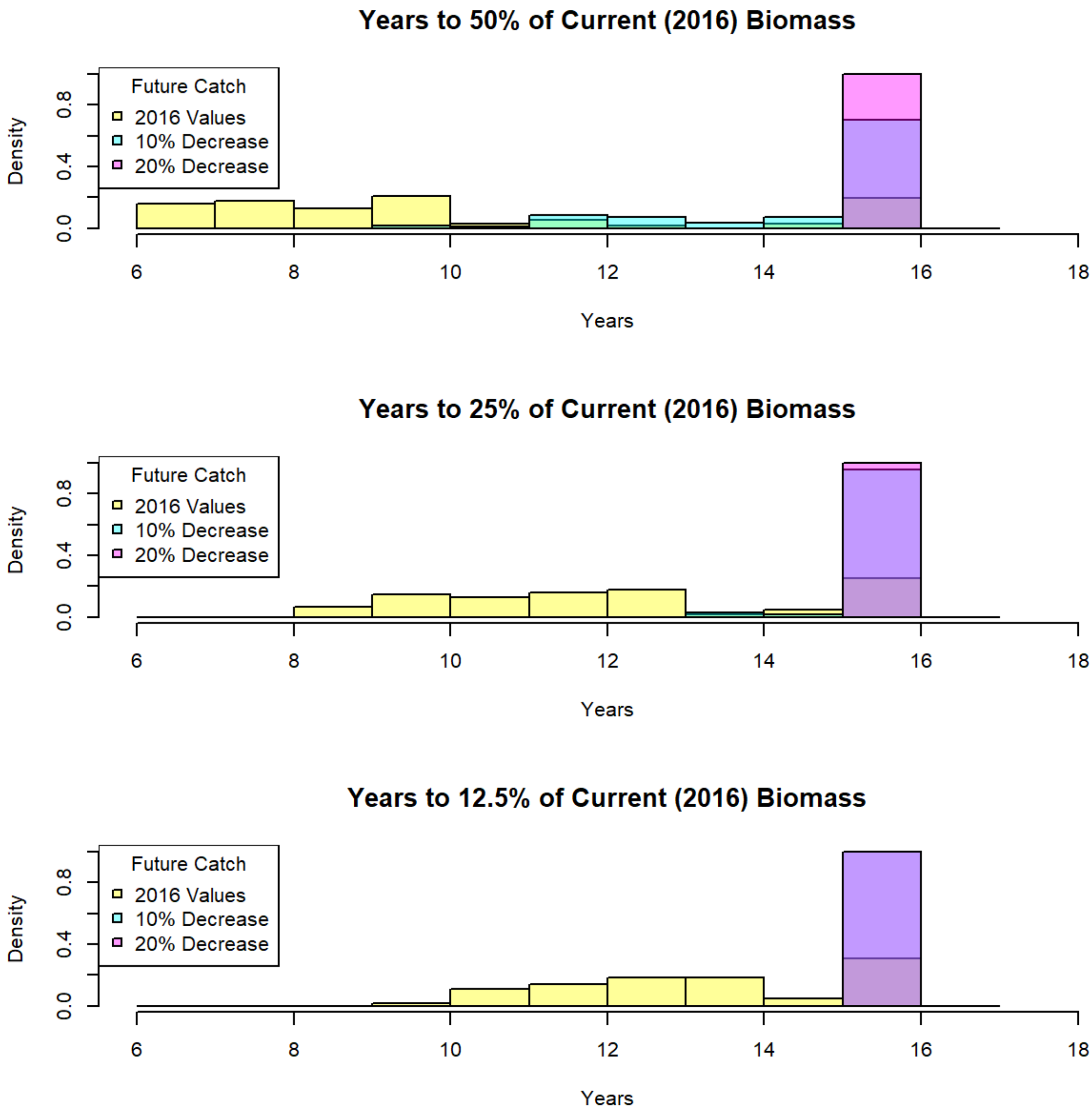

Figure 8. Time in years to biomass depletion to percentages of the 2016, (50%, 25% and 12.5%. Model runs are colored by the catch trajectory used.