Blue Marlin Stock Assessment and Stock Status and Conservation Information For WCPFC SC

ISC Billfish Working Group

Hirotaka Ijima, Chair
Michelle Sculley, lead modeler

Overview

- **Review of the 2016 Benchmark Stock Assessment**
- **2021 Assessment Data and Model**
  - **Blue Marlin Life History Information**
  - **Fishery Definitions and Selectivity Modeling**
  - **Catch, Standardized CPUE, and Size Composition Data**
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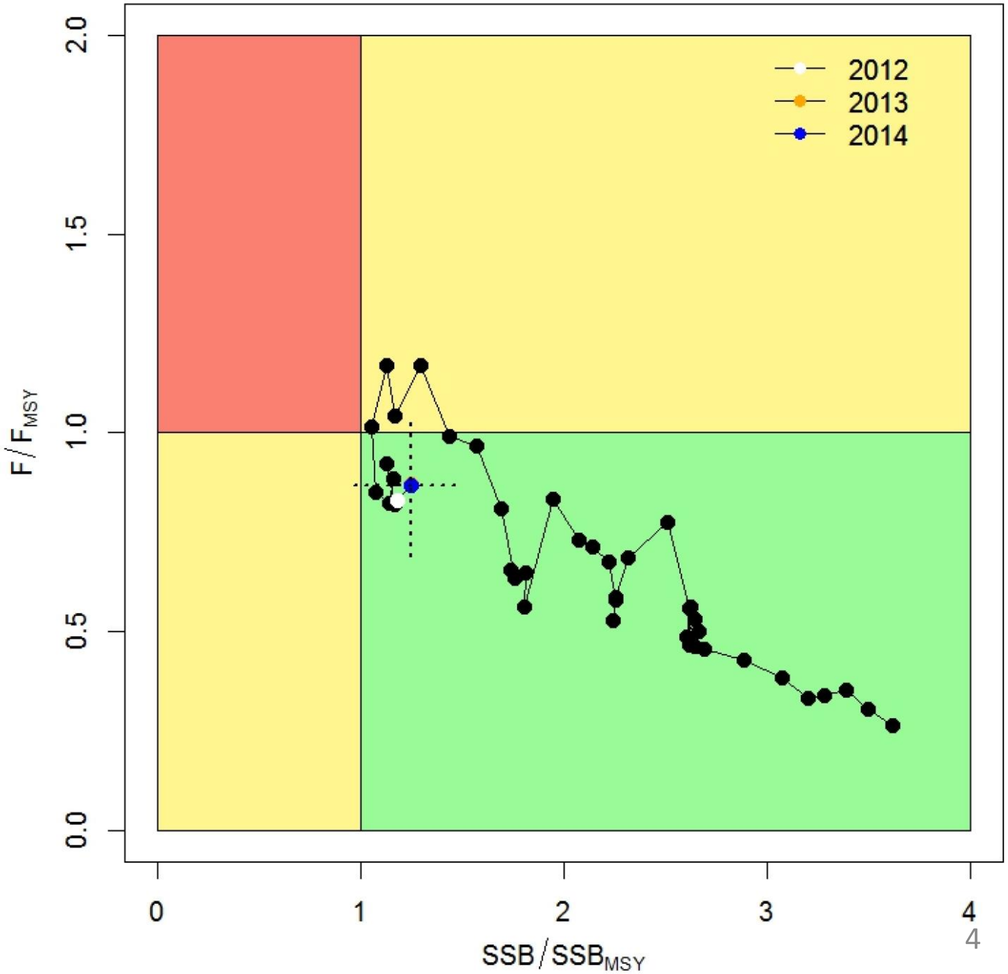
Review of the 2016 Benchmark Stock Assessment

2016 Stock Assessment Summary

Pacific BUM was not experiencing overfishing and was not overfished relative to MSY-based reference points.

- Stock Synthesis 3.24 model (ISC 2016)
- SSB_{2014} = 24,809 mt (25 % above SSB_{MSY})
- F_{2014} = 0.28 (12% below F_{MSY})



Pacific Blue Marlin
Benchmark Stock Assessment

Assessment Data and Models

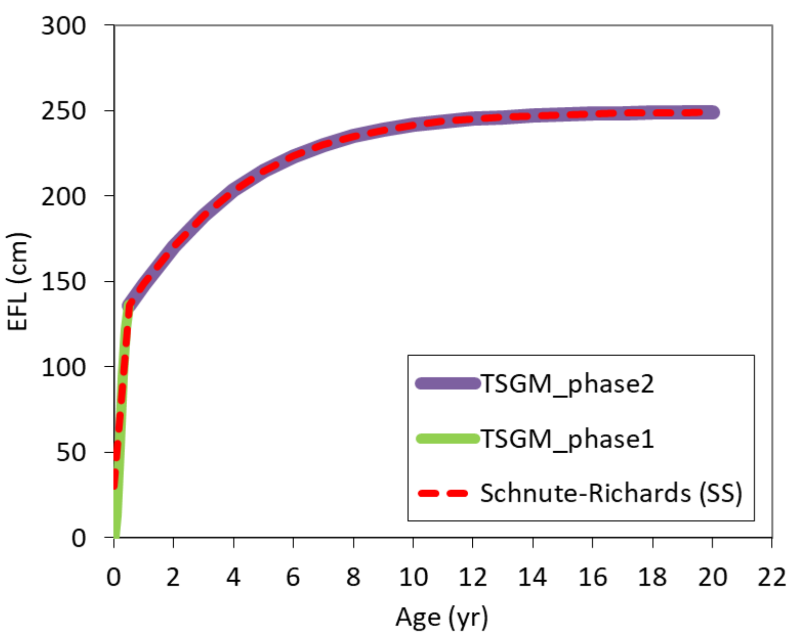
Outline 2021 Pacific Blue Marlin Benchmark Stock Assessment

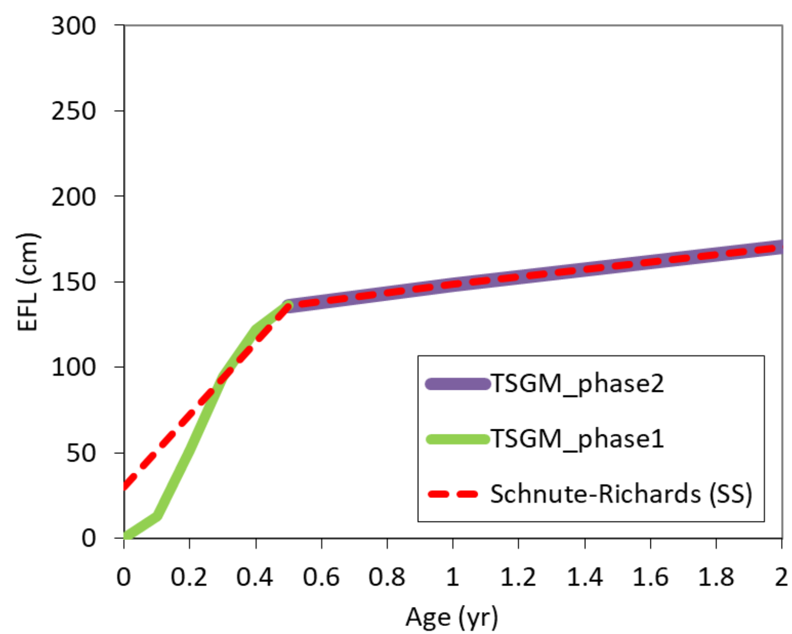
- Collaboration work with ISC, IATTC, and SPC.
- Read modeler: Dr. Michelle Sculley
- Data preparatory meeting: 6-7th, 10, 13th November 2020 held by webinar
- Stock assessment meeting: 6-10th, 13th April 2021 held by webinar

Pacific Blue Marlin
Life History Information

New BUM Growth Curve

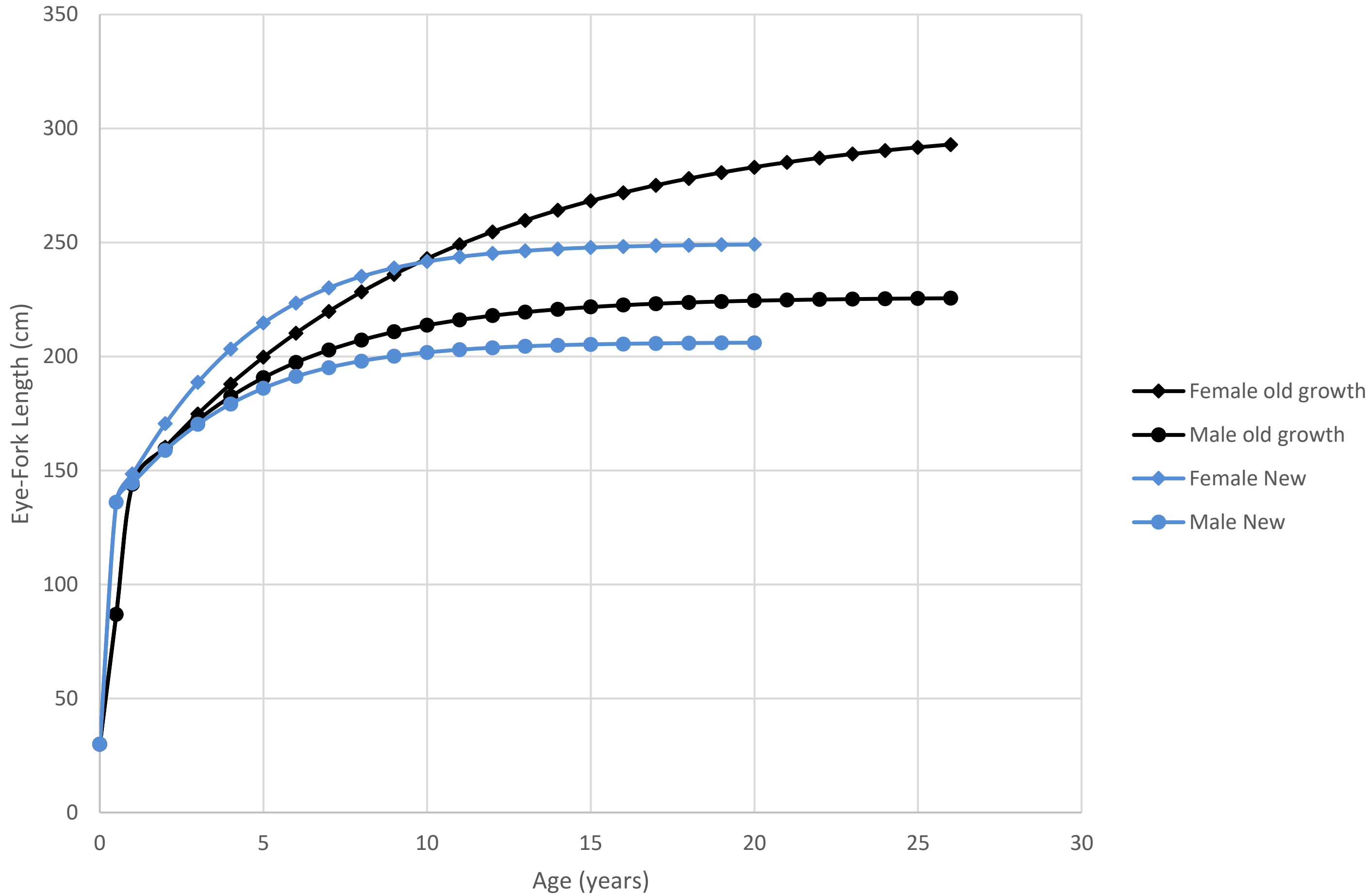
- Chang et al. 2020 presented a growth curve incorporating otolith and fin spine samples from Japan and Chinese Taipei and radio-carbon dating from USA.
- 2-Stanza growth curve with L_{inf} much smaller than the previous growth curve used in the 2016 assessment due to a lack of very large fish in the sample, but was very informative for the growth of small fish.
- To approximate this curve, a Schnute-Richards growth curve was used for fish >0.5 years, and linear growth for fish age 0-0.5 years.





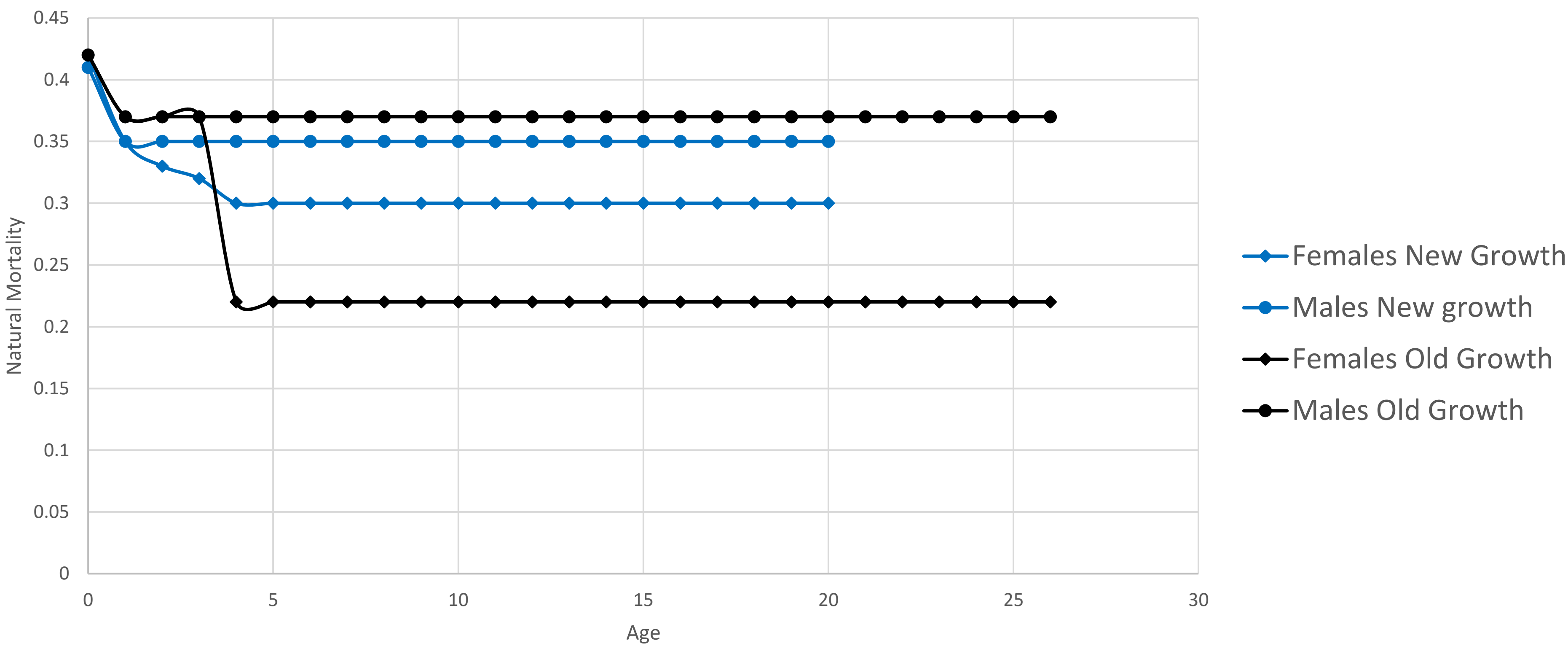
BUM Growth Curves

- The 2016 assessment growth curve (“old growth”) was a Von Bertalanffy curve.
- Without sufficient evidence to discard either growth curve, the WG developed assessment models with each growth curve and used model diagnostics to determine which model to use.



BUM Natural mortality at age

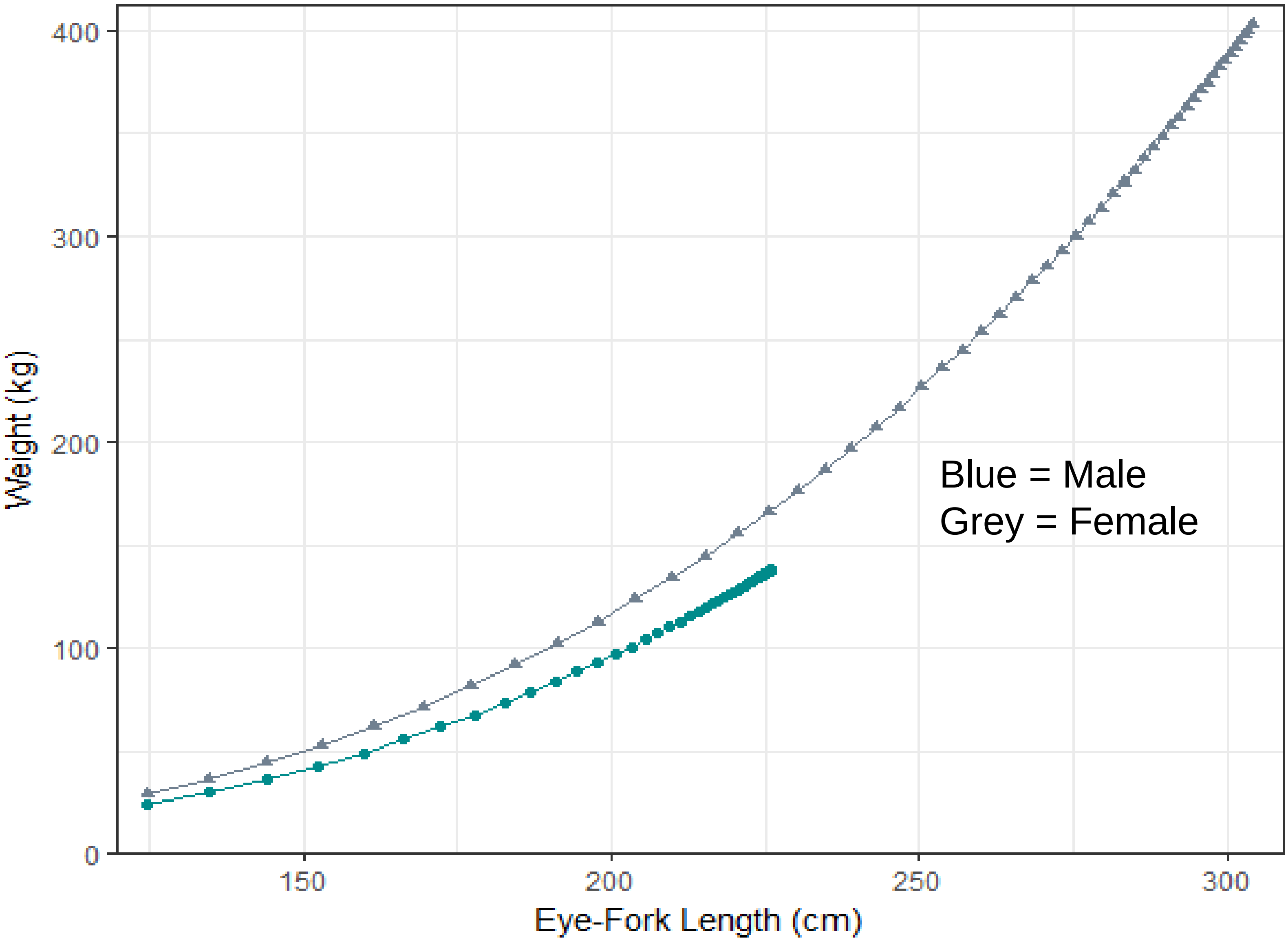
Brodziak 2021 estimated natural mortality at age using the new growth curve.



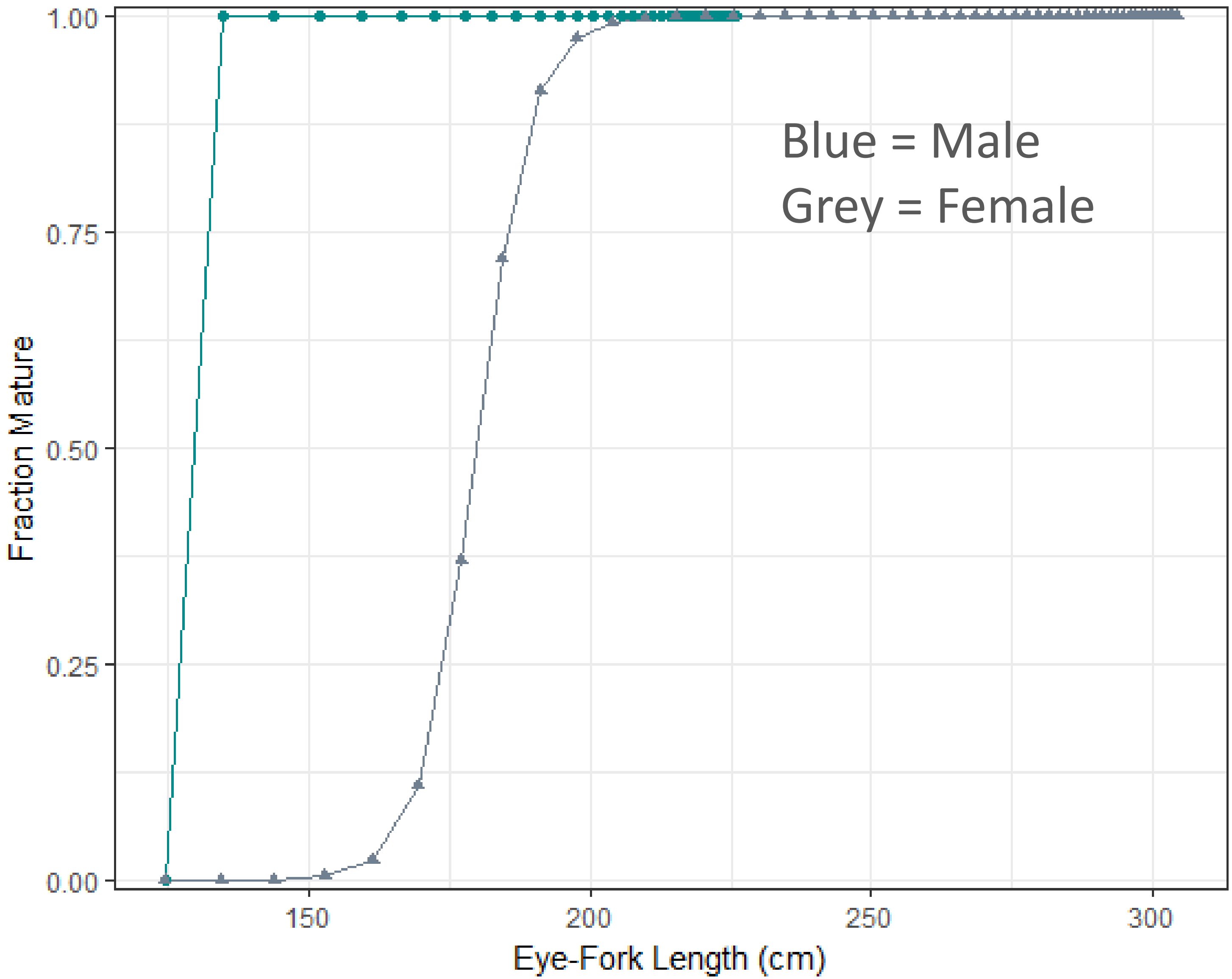
All other life history parameters were the same

Parameter	Old Growth	New Growth
Female weight-length alpha	1.84E-05	1.84E-05
Female weight-length beta	2.956	2.956
Female Length at 50% maturity	179.76	179.76
Female slope of maturity ogive	-0.2039	-0.2039
Fecunditiy	Proportional to spawning biomass	Proportional to spawning biomass
Male weight-length alpha	1.37E-05	1.37E-05
Male weight-length beta	2.975	2.975
Spawning season	2	2
Steepness	0.87	0.87
sigmaR (rescaled)	0.6	0.4

Pacific Blue Marlin Weight at Length



Pacific Blue Marlin Probability of Maturity at Length

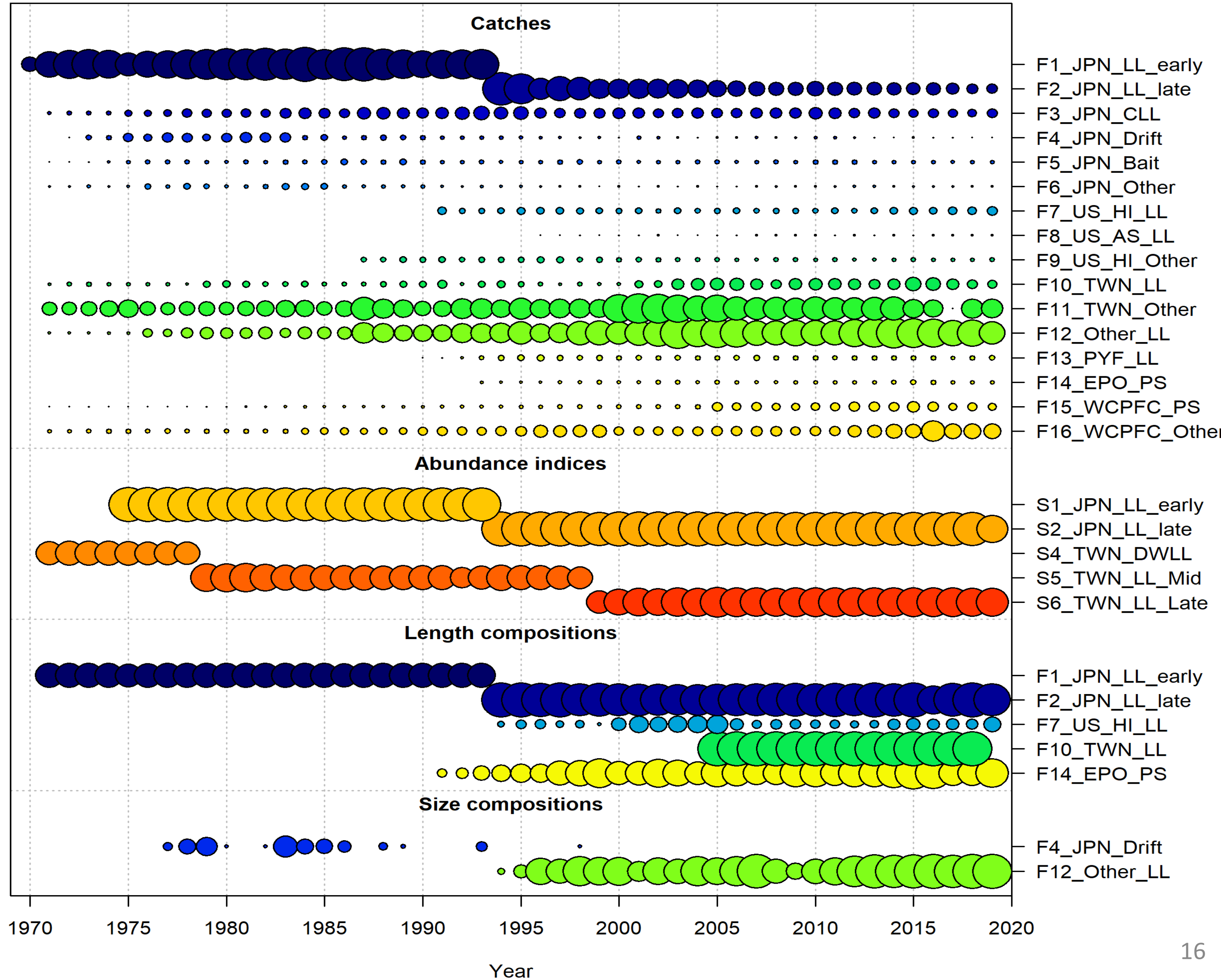


Definition of Pacific Blue Marlin Fisheries

Pacific Blue Marlin Fleets

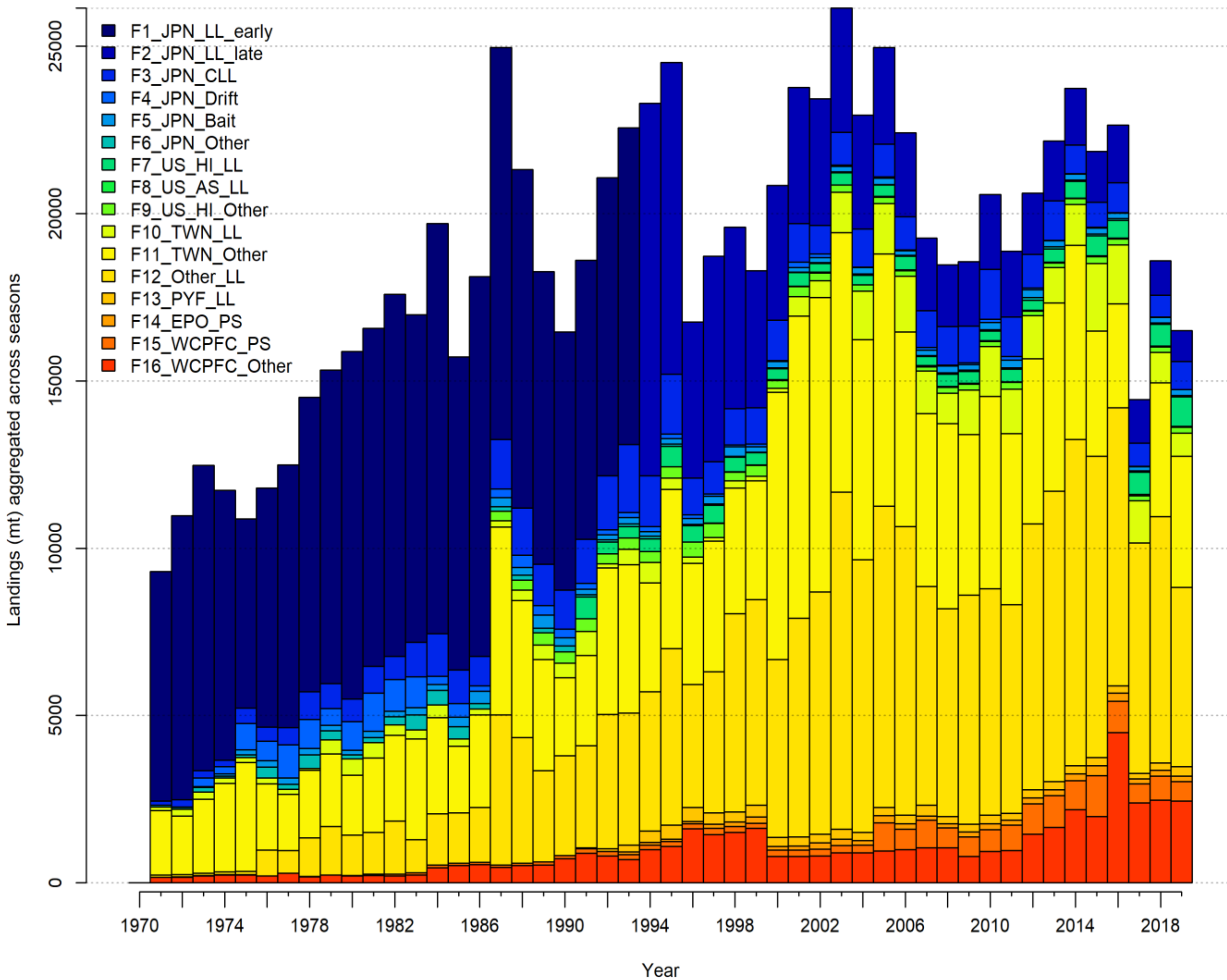
Length Comp – Used?	Relative Abundance Index – Used?	Fleet Name	Time Series
F1 – Y	S1 – Y	JPNEarlyLL	1971-1993
F2 - Y	S2 - Y	JPNLateLL	1994-2019
F3 - N	-	JPNCLL	1971-2019
F4 – Y	-	JPNDRIFT	1971-2019
F5 – N	-	JPNBait	1971-2019
F6 – N	-	JPNOth	1971-2019
F7 – Y	S3 - N	HWLL	1991-2019
F8 – N	-	ASLL	1996-2019
F9 – N	-	HWOth	1975-2017
F10 – Y	S4, S5, S6 - Y	TWNLL	1987-2019
F11 – N	-	TWNOth	1971-2019
F12 – Y	-	OthLL	1971-2019
F13 – N	-	PYFLL	1971-2019
F14 – Y	-	EPOPS	1990-2019
F15 – N	-	WCPFCPS	1993-2019
F16 – N	-	WCPFCOth	1971-2019

Temporal Coverage of Catch, Abundance Index, and Size Composition Time Series By Fleet



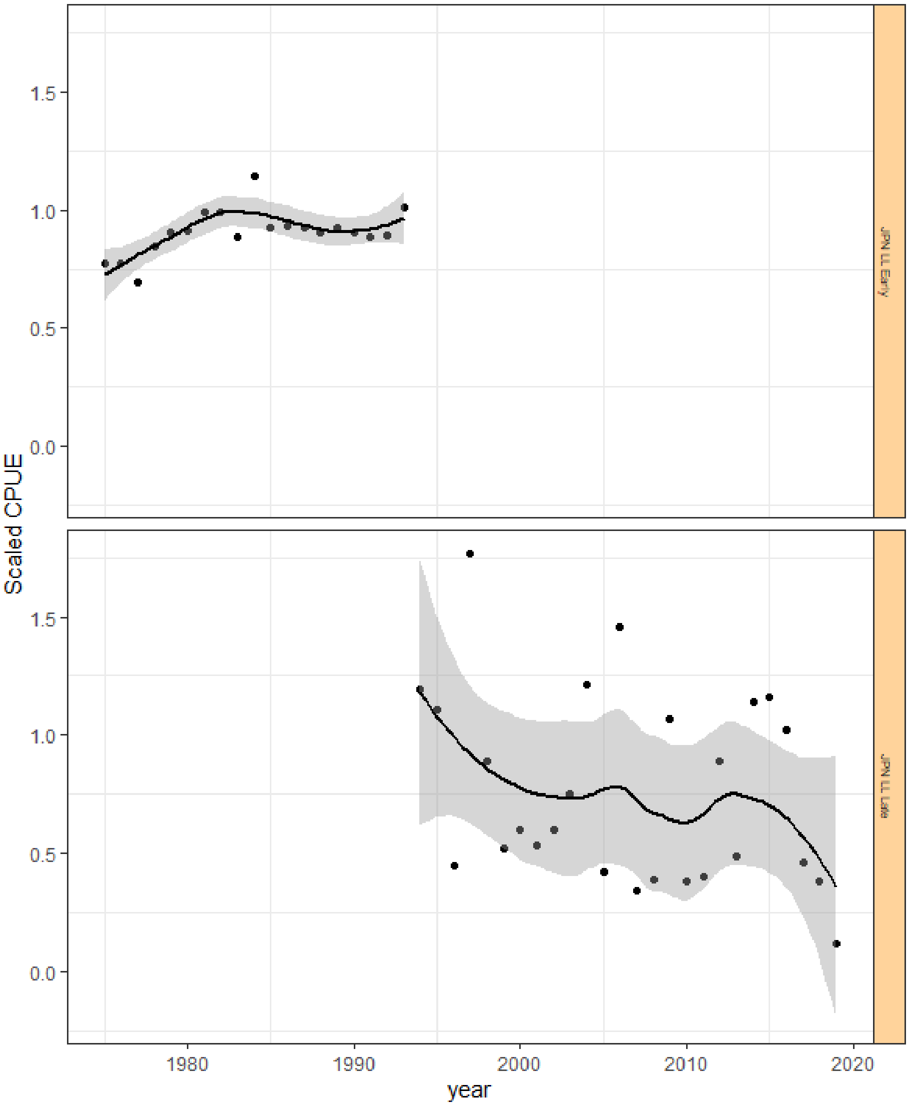
Pacific Blue Marlin Catch Data

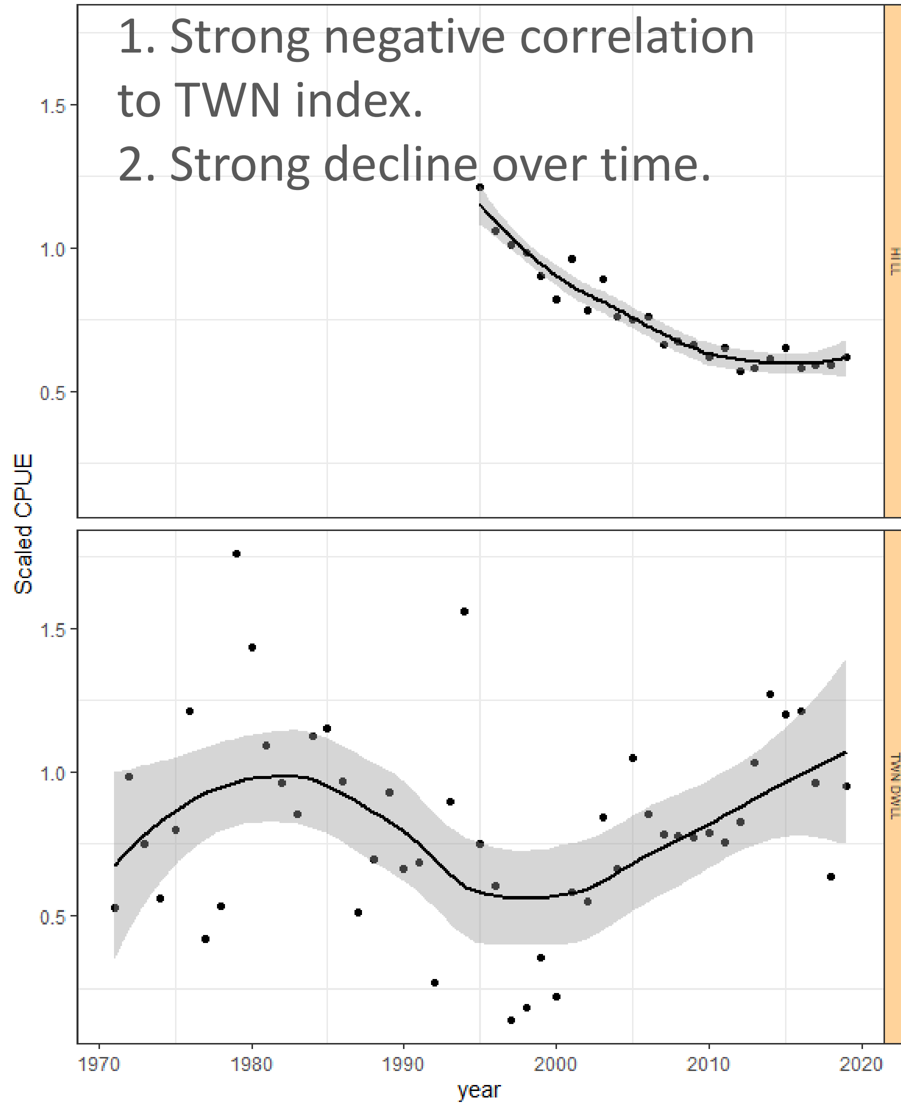
- Catches are assumed to be well reported.
- Catch data for 1971 to 2019 were gathered from all available fleets and sources.



Relative Abundance Indices Based on Standardized Catch-Per-Unit Effort

Standardized CPUE by Fleet

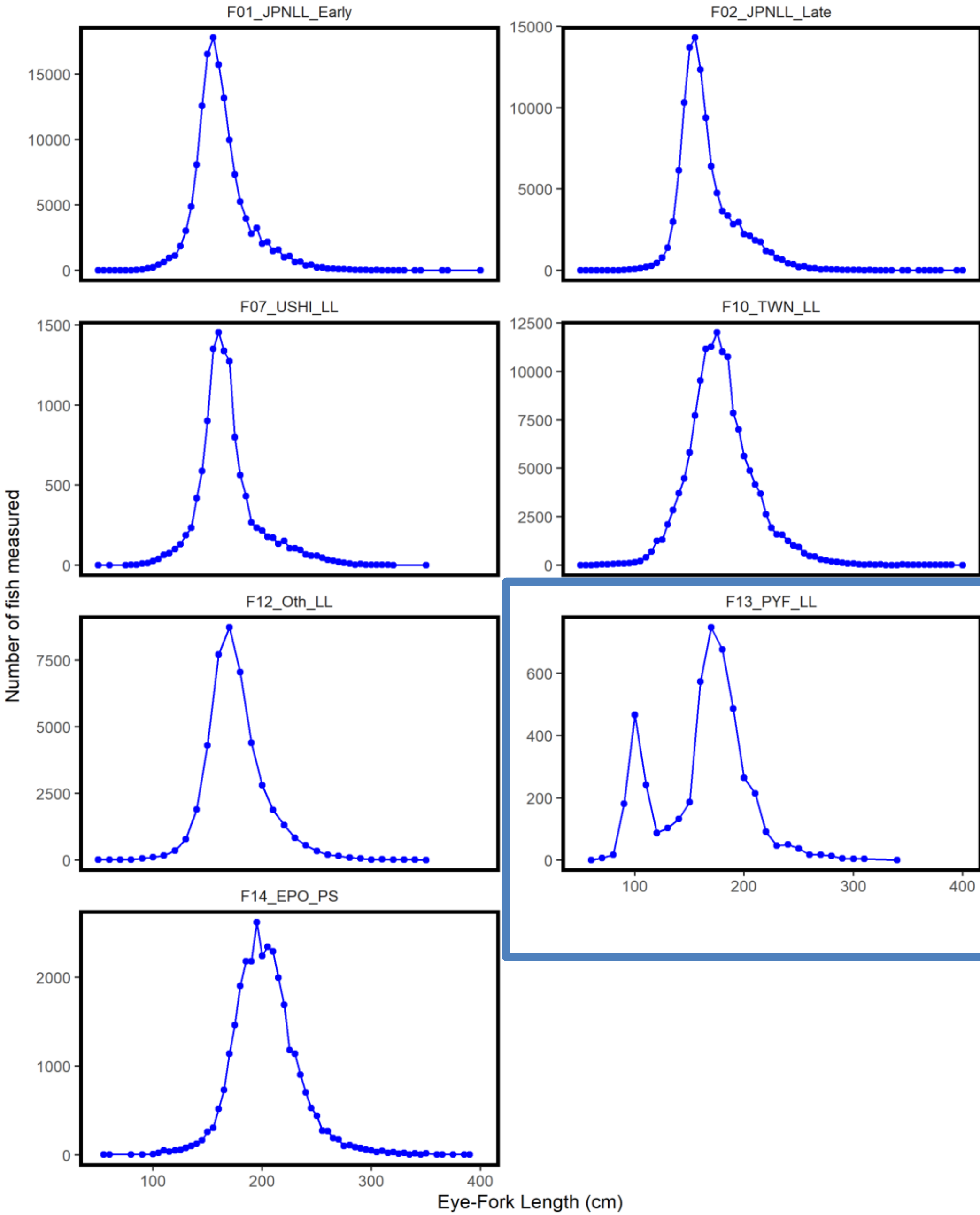


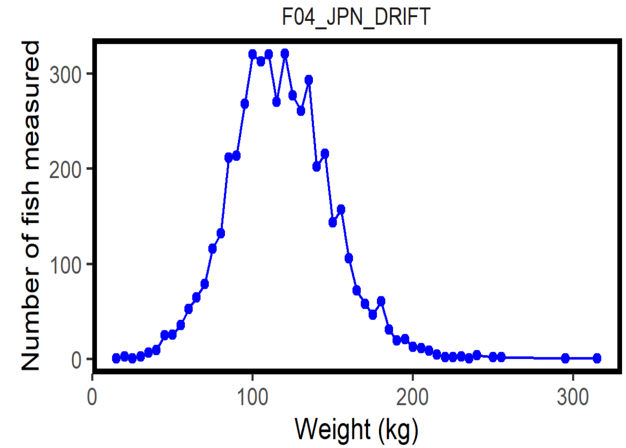


1. Strong negative correlation to TWN index.
2. Strong decline over time.

Size Composition Data

Aggregated Size Composition Data By Fleet





French Polynesia longline catch accounted for <8% of the total catch in the fishery, and required an additional 18 parameters to fit.

Assessment Modeling Approach

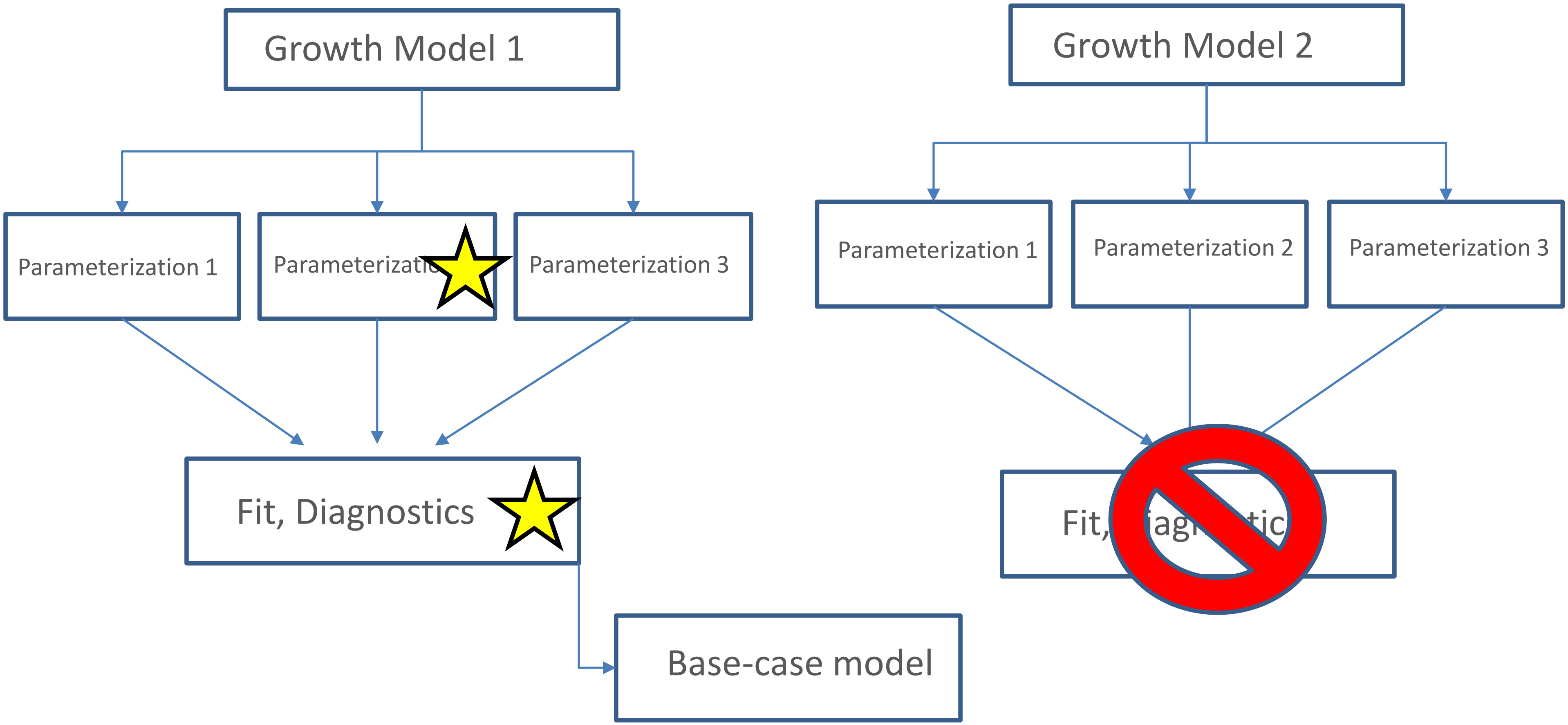
- 2021 benchmark assessment used the Stock Synthesis 3.30 assessment model in a maximum likelihood estimation framework with some parameter constraints for fishery selectivity parameters.

- A large number of candidate model configurations for both the old growth and new growth curves were explored and evaluated with various model diagnostics.

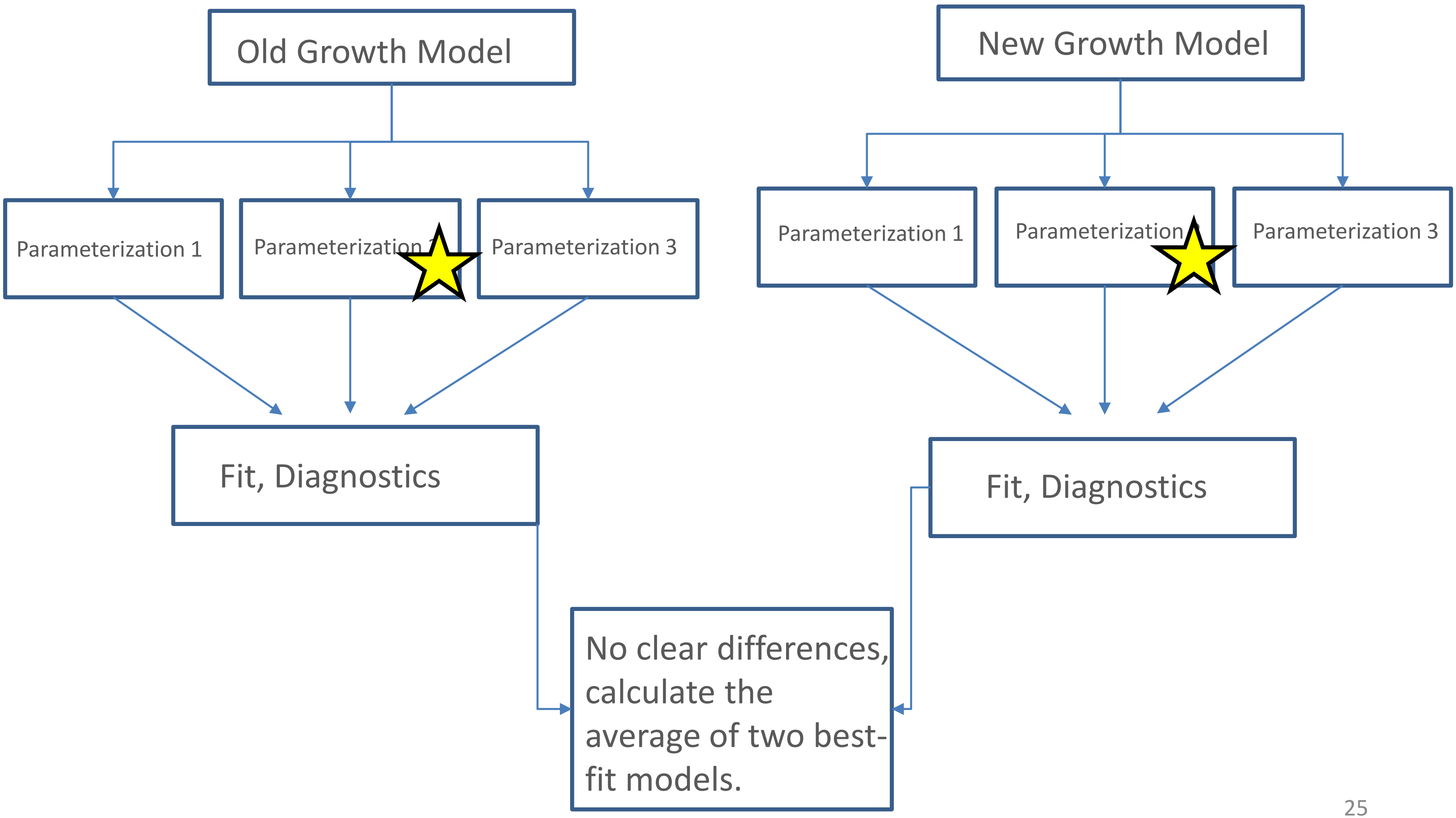
- The 2021 stock status was based upon the best fitting model of each of the growth models.

- Other than the difference in growth curve and natural mortality, the two models were treated the same: data, fishery selectivity, data weighting, etc. were consistent between the two models.

Status Quo modeling approach



2021 modeling approach



List of the model parameterization

Base-case	Run	Model Change
Yes	1	Drop 1990 size comp for F14 EPO PS
Yes	2	Drop 1992-1993 (first two years) of F12 other LL
Yes	3	Keep TWN as scaled to mean, split into three indices
Yes	4	Start new growth early recruitment at 1961
Yes	5	Down weight JPN LL length composition using 0.5 variance adjustment value, use time block 1971-1974.
Yes	6	Down weight HI LL length composition using 0.5 variance adjustment value, use time block 1994-2004.
No	7	Down weight JPN LL late length composition using 0.5 variance adjustments value.
No	8	Down weight (add variance to) JPN LL Late CPUE (add ~0.2 based upon RMSE) – based on Francis method
No	9	Change prior of steepness, mean 0.87, sd 0.05, Full Beta prior
No	10	Drop JPN S2

Data Observation Models

Abundance Indices

- Lognormal observation errors set for abundance indices.
- log(SE) = sqrt(log(1+CV^2)) for the individual CPUE standardizations.
- Values of log(SE) < 0.20 were rescaled to set log(SE) = 0.20.

Size Composition Data

- Multinomial observation errors for size composition data.
- Size compositions with fewer than 25 individuals measured were removed.
- Effective sample size was number of fish measured/10, with all year/quarters greater than 50 set to 50.
- Weight composition data were binned such that a bin was approximately equal to a bin of 5cm in length.

Blue Marlin Fishery-Specific Selectivity Assumptions

Fleet	Selectivity Function
F1 JPN LL Early	**4-parameter cubic spline**
F2 JPN LL Late	**3-parameter cubic spline***
F3 JPN CLL	Mirror F2
F4 JPN DRIFT	**Double normal**
F5 JPN Bait	Mirror F2
F6 JPN Oth	Mirror F2
F7 HW LL	**3-parameter cubic spline***
F8 AS LL	Mirror F7
F9 HW Oth	Mirror F7
F10 TWN LL	**Double normal**
F11 TWN Oth	Mirror F10
F12 Oth LL	**Double Normal**
F13 PYF LL	Mirror F12
F14 EPO PS	**Asymptotic logistic**
F15 WCPFC PS	Mirror F14
F16 WCPFC Oth	Mirror F10
S1 JPN LL Early	Mirror F1
S2 JPN LL Late	Mirror F2
S4 TWN LL Early	Mirror F10
S5 TWN LL Mid	Mirror F10
S6 TWN LL Late	Mirror F10

*Indicates selectivity was time-varying Mirror fleet = fisheries with similar fishery selectivity patterns.

Estimation of Recruitment Deviations From Stock-Recruitment Curve

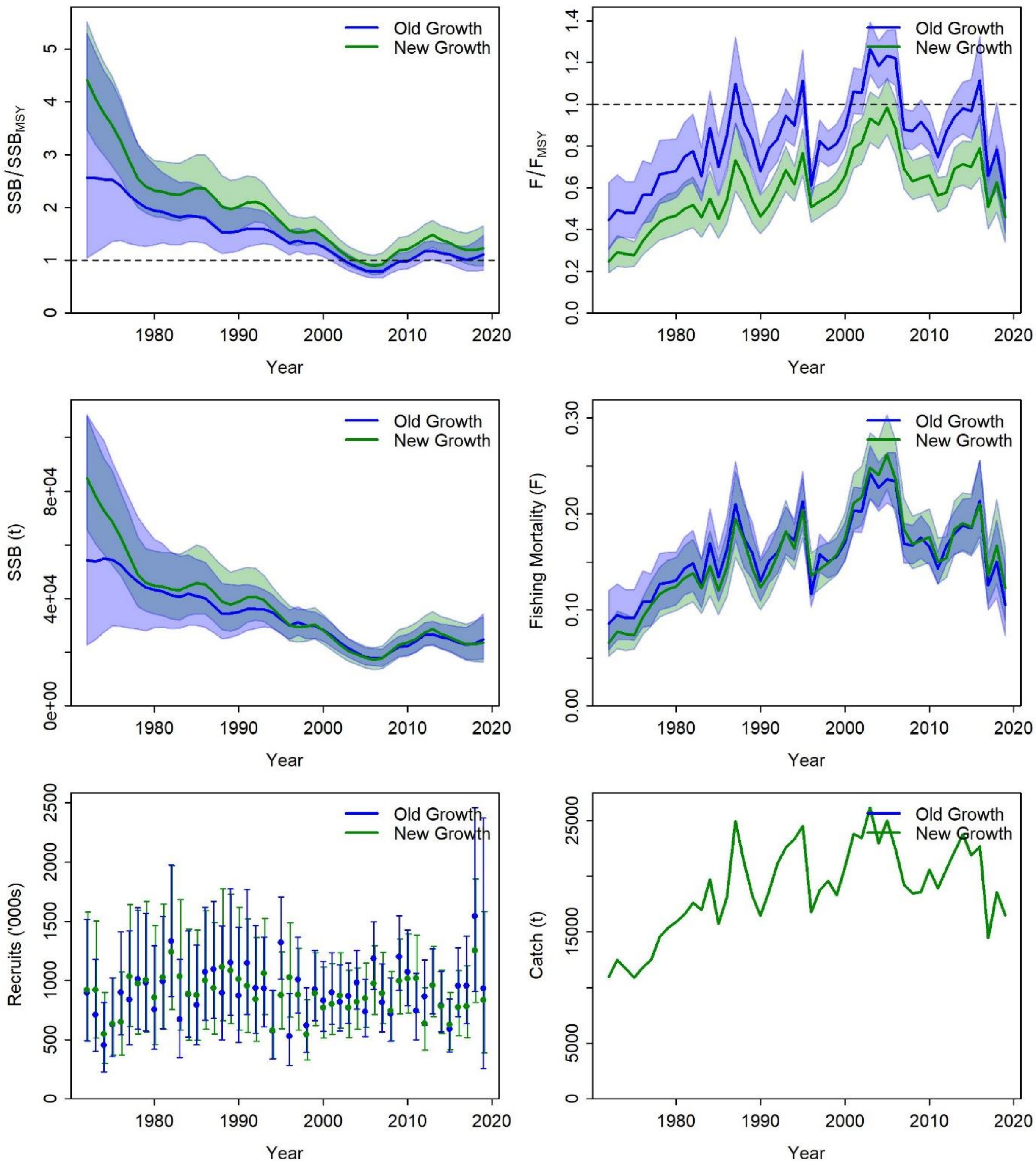
- Recruitment was estimated during 1971-2019 (with bias adjustment) and used the expected recruitment value from the estimated stock-recruitment curve for 2019
- Recruitment variability (σ_R, the standard deviation of log-recruitment) was fixed at $\sigma_R = 0.6$ for the old growth model, and rescaled to 0.4 for the new growth model based upon model outputs. Rescaling σ_R was not suggested by the old growth model outputs.

MODEL RESULTS AND DIAGNOSTICS COMPARISON

Diagnostics comparison

Diagnostic	Old Growth	New Growth
Likelihood profile	✓	
Fit to CPUE	✓	✓
CPUE Runs test	✓	✓
CPUE Hind casting	✓	✓
Fit to Length/Weight Comp	✓	✓
Length Comp Runs test	✓	
Length Comp Hind casting	✓	✓
Retrospective Analysis		✓
ASPM		✓
Jitter Analysis	✓	✓
	8	8

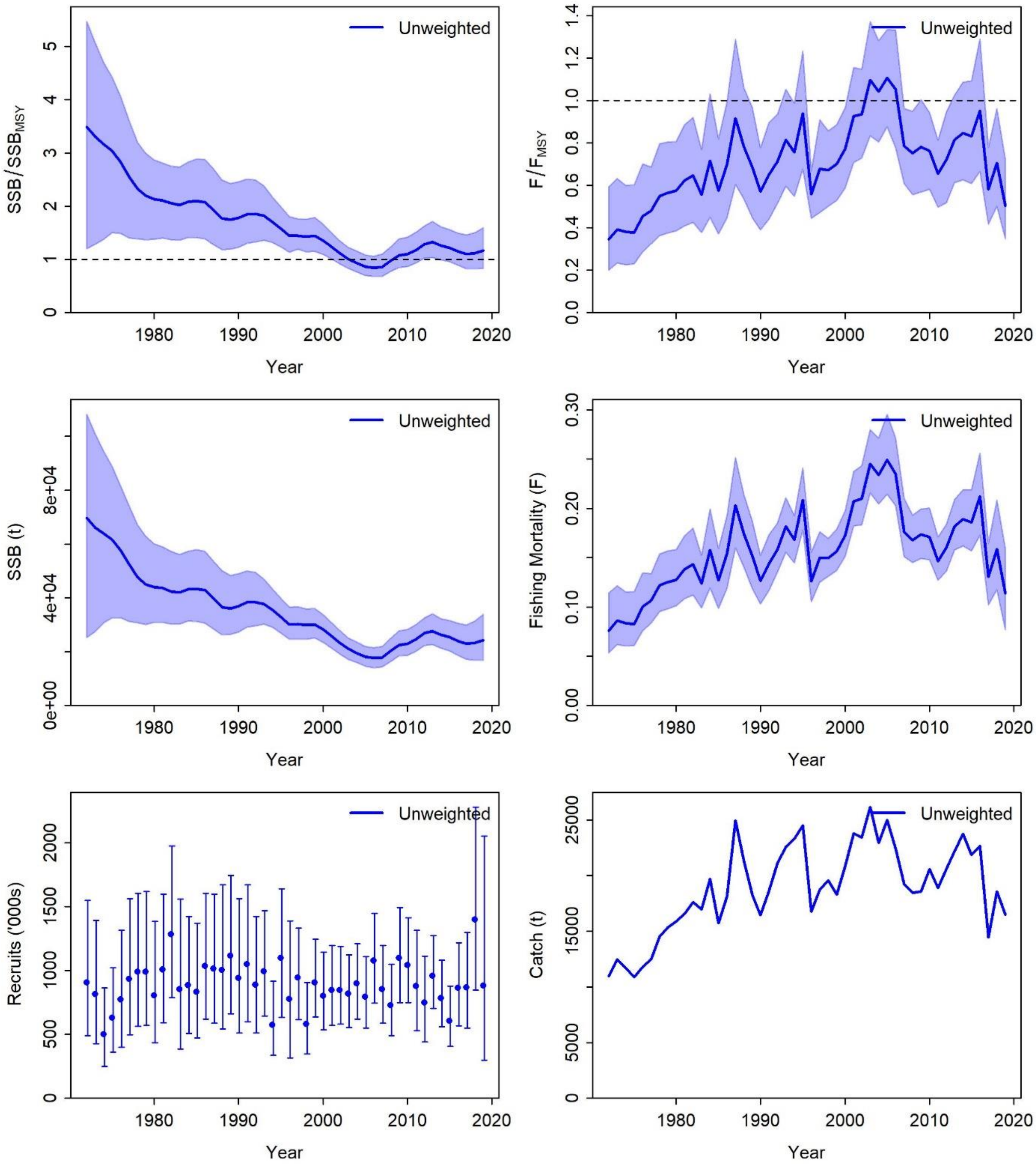
Check indicates which model had the better diagnostic, both models checked indicate that the diagnostics equally indicated good/poor fit to the data.



Old Growth
New Growth
SSB/SSB$_{MSY}$
Year
F/F$_{MSY}$
SSB (t)
Fishing Mortality (F)
Recruits ('000s)
Catch (t)

Model Averaging

- 10,000 draws from a multivariate log-normal (MVLN) distribution for each model were averaged with equal weighting.
- The draws were used to obtain the probability distributions around SSB/SSB_{MSY} and F/F_{MSY}.
- The mean and 95% confidence intervals were then calculated from the combined MVLN draws to produce final estimates of SSB, F, SSB_{MSY}, F_{MSY}, and recruitment.
- This method was also used to combine model projections.



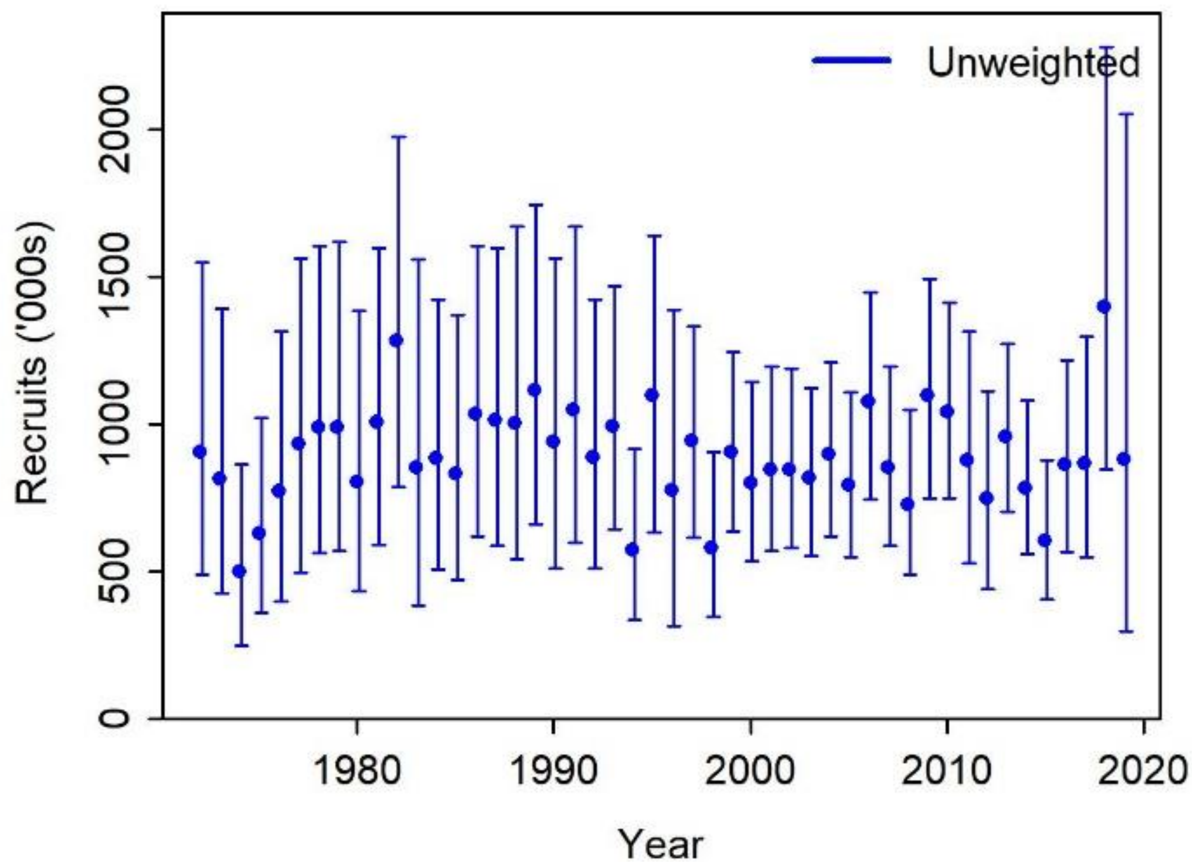
Unweighted means both models have equal weights.

Stock Status and Conservation Information

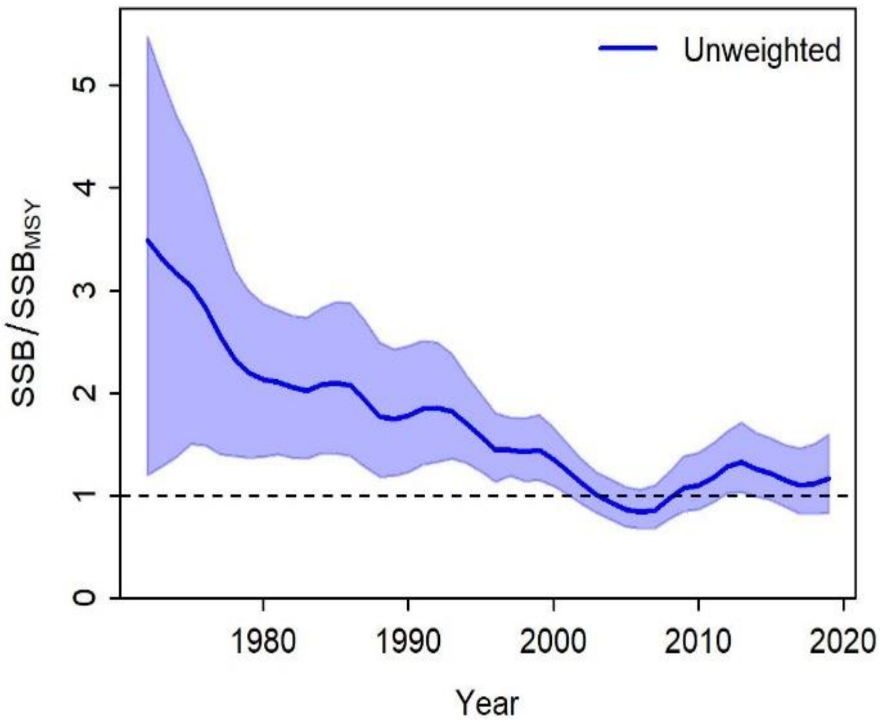
Pacific Blue Marlin Reference Points

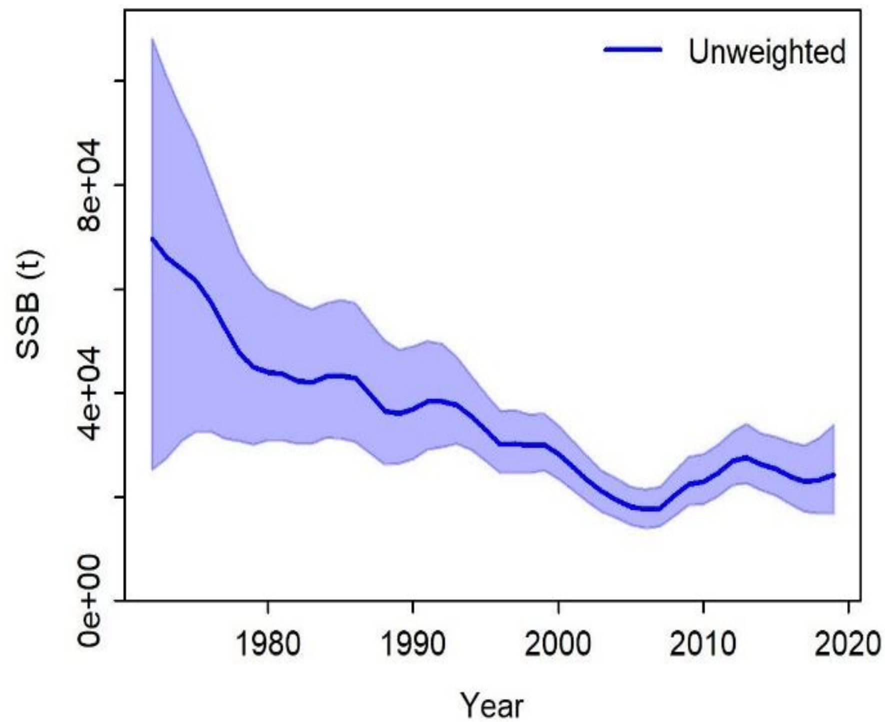
Reference Point	Estimate
F_{MSY} (age 1-10)	0.23
F_{2019} (age 1-10)	0.11
$F_{20\%SSB0}$	0.18
SSB_{MSY}	20,677 mt
SSB_{2019}	24,241 mt
$SSB_{20\%SSB0}$	20,729 mt
MSY	24,600 mt
$C_{2017-2019}$	16,512 mt
SPR_{MSY}	17%
SPR_{2019}	34%
$SPR_{20\%SSB0}$	23%

Pacific Blue Marlin Recruitment



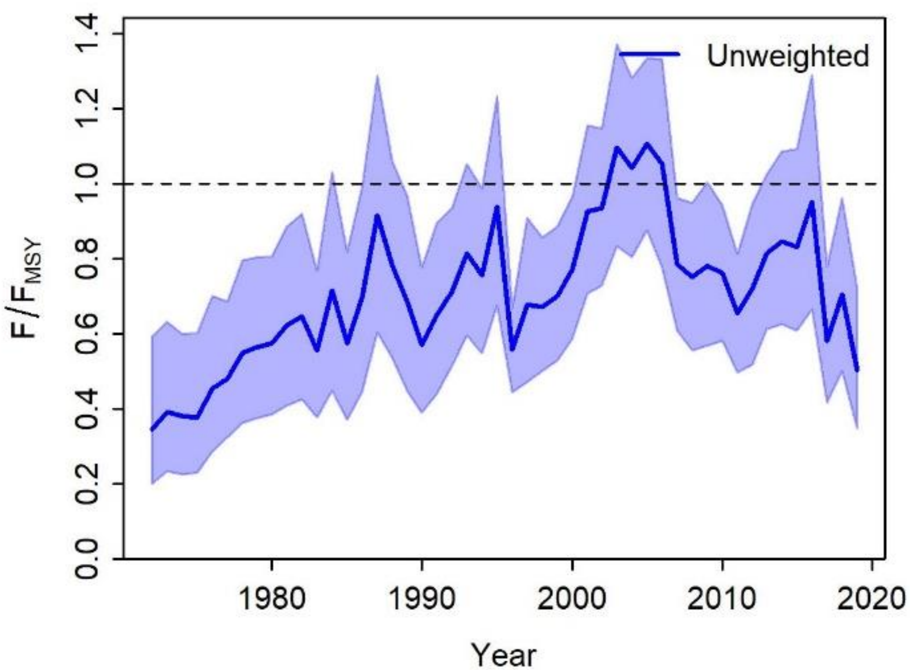
Pacific Blue Marlin Spawning Biomass

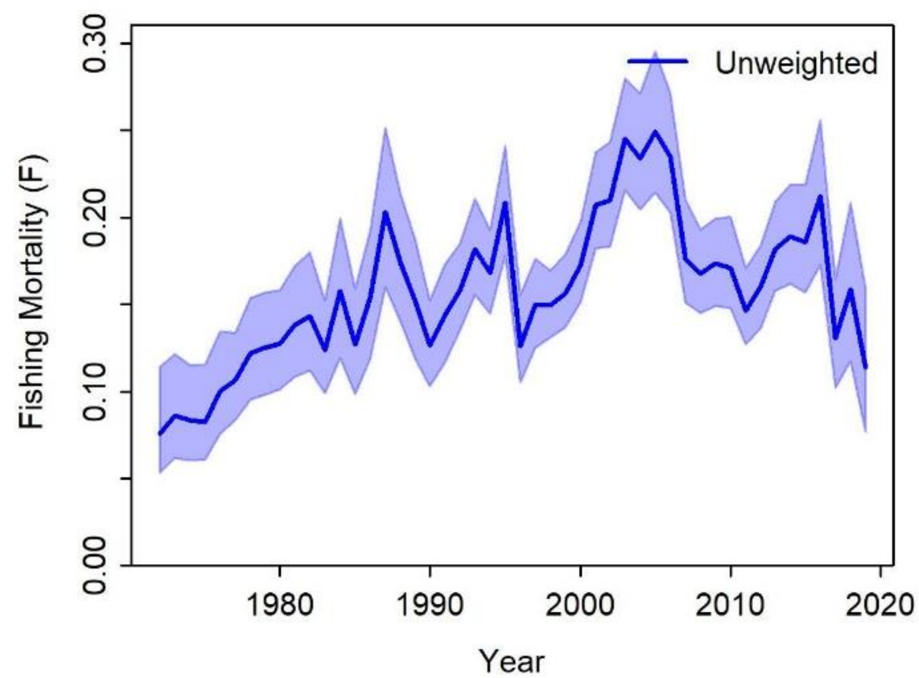




- Estimates of population biomass and spawning biomass show a decline from 1975 to about 2005 followed by a moderate increasing trend from 2005 to 2019
- Current spawning biomass exceeds SSB$_{MSY}$ and was only below SSB$_{MSY}$ from 2003-2006.

Pacific Blue Marlin Fishing Mortality

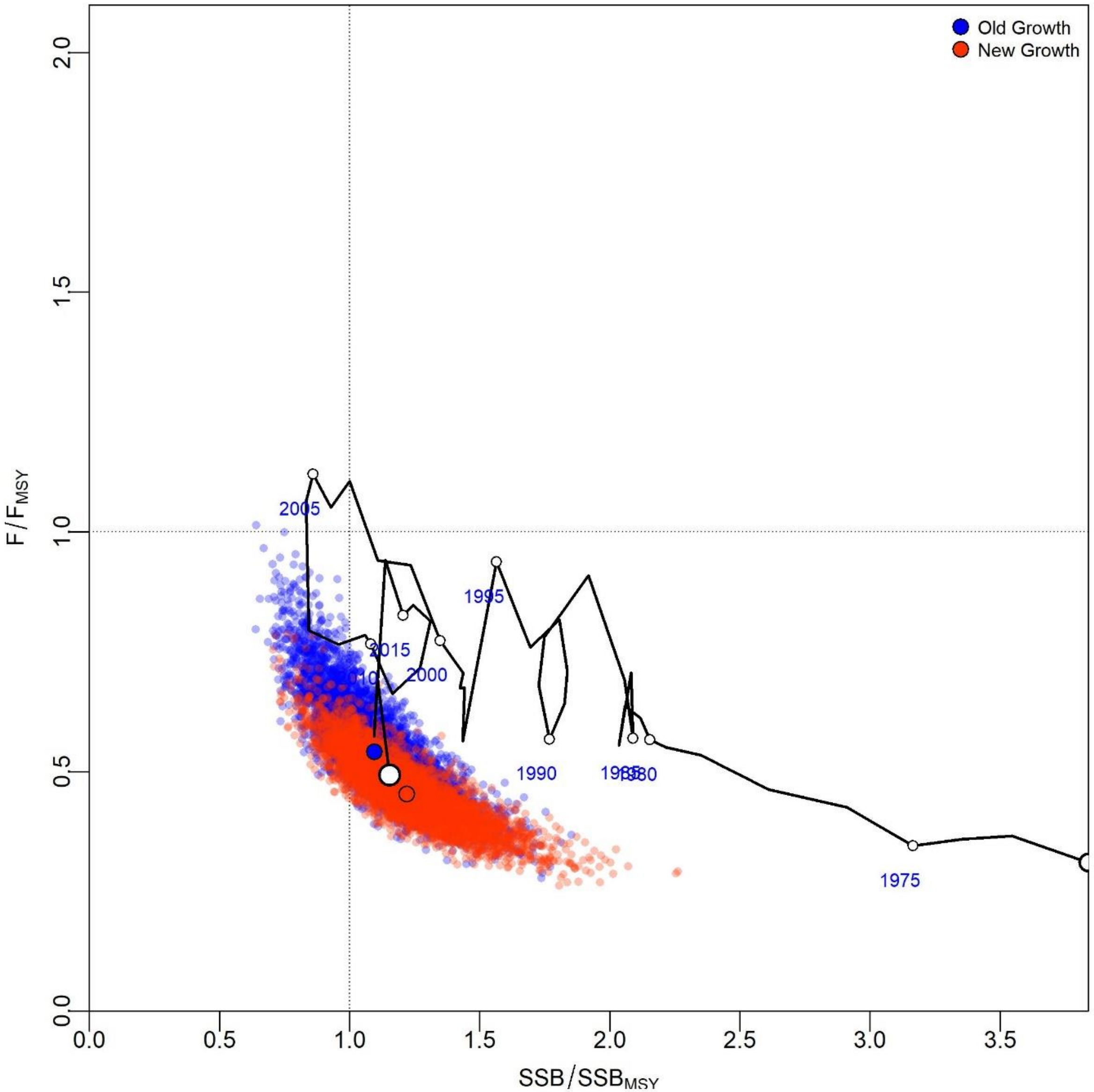




Information on Stock Status

- **Female spawning stock biomass was estimated to be 24,241 mt in 2019, or about 17% above SSB_{MSY} and 17% above $20\%SSB_0$**
- **Fishing mortality on the stock (average F, ages 1 to 10) averaged roughly F = 0.13 during 2016-2019, or about 40% below F_{MSY} and 28% below $F_{20\%SSB0}$**
- **Blue marlin stock status from the ensemble model indicates that relative to MSY-based reference points, overfishing was very likely not occurring (>90% probability) and Pacific blue marlin is likely not overfished (81% probability).**

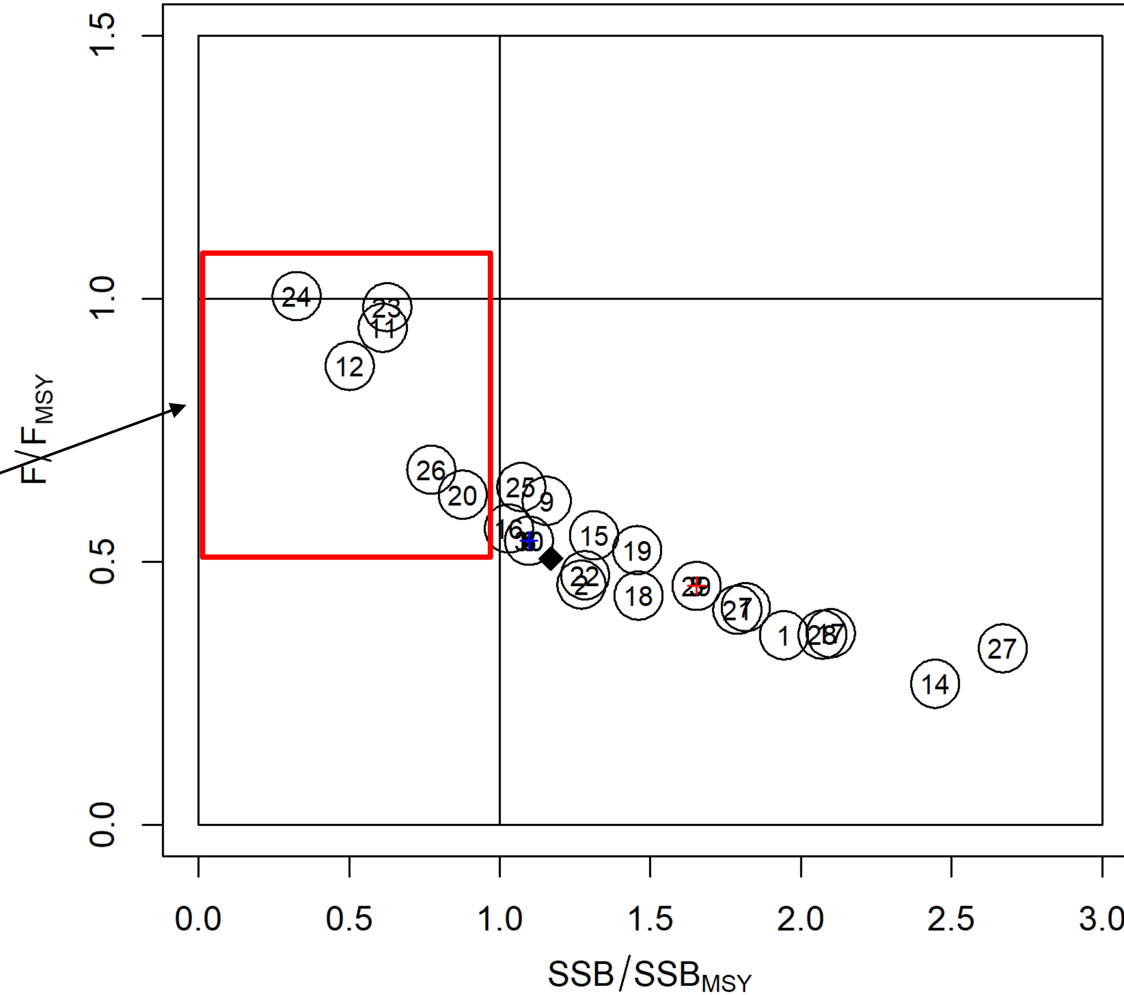
Pacific Blue Marlin Kobe Plot
Relative to MSY-Based Reference Points



Kobe Plot for 2019 Sensitivity Results

- Old Growth Model
- New Growth Model
- Ensemble Model

Sensitivity runs on L_{inf} and steepness



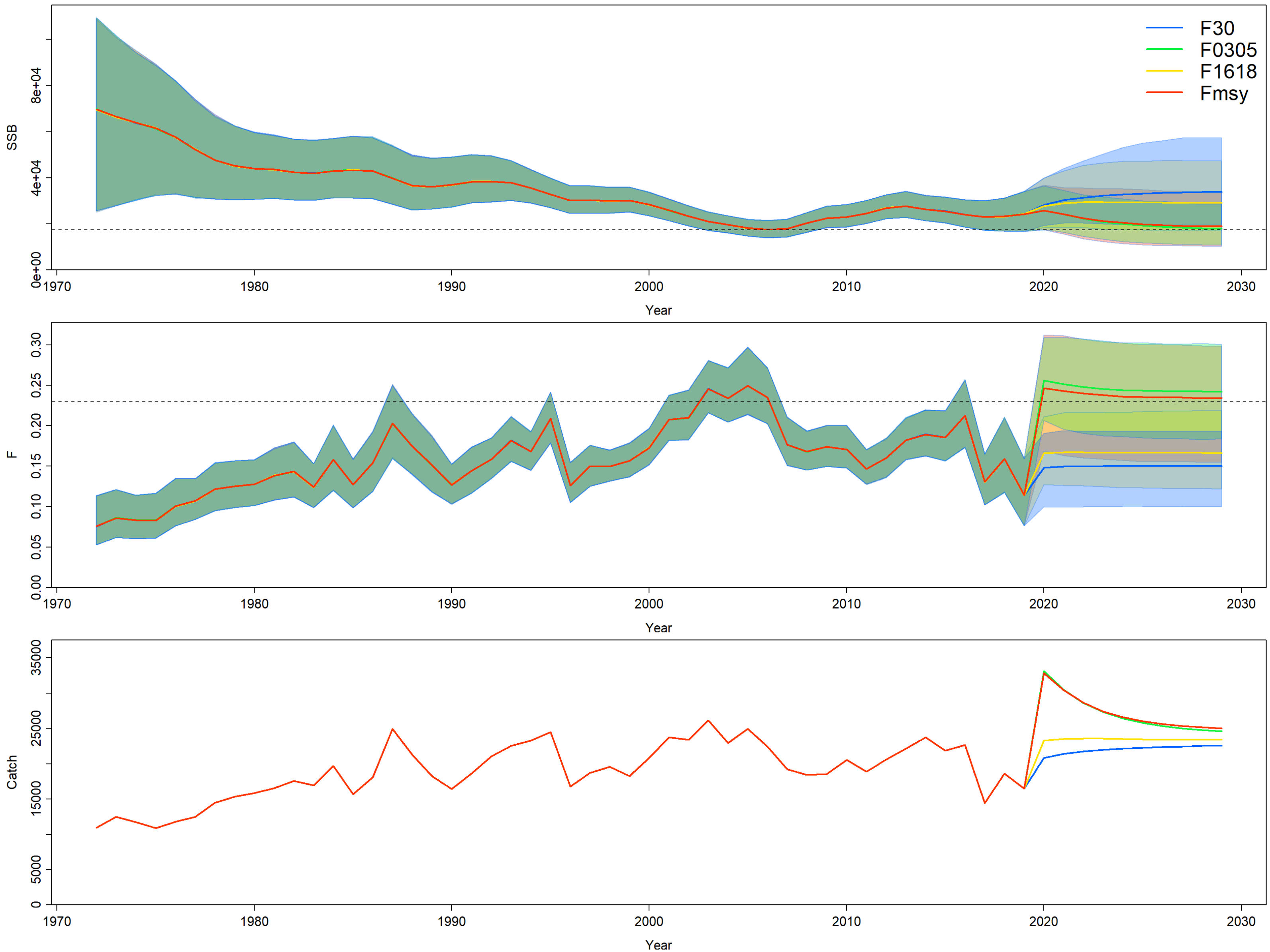
Future projection of BUM stock

- Stock projections were conducted for 2020-2029 using the deterministic forecasts through SS3.
- Projections were run for each growth model and the results averaged together in the same manner as the model ensemble.

Pacific Blue Marlin Stock Projections

- Four future harvest scenarios were analyzed:
  - F Status Quo Scenario with $F = F_{2016-2019}$
  - F at MSY Scenario with $F = F_{MSY}$
  - F High Scenario with $F = F_{2003-2005}$
  - F Low Scenario with $F = F_{30\%}$

Pacific Blue Marlin Stock Projections

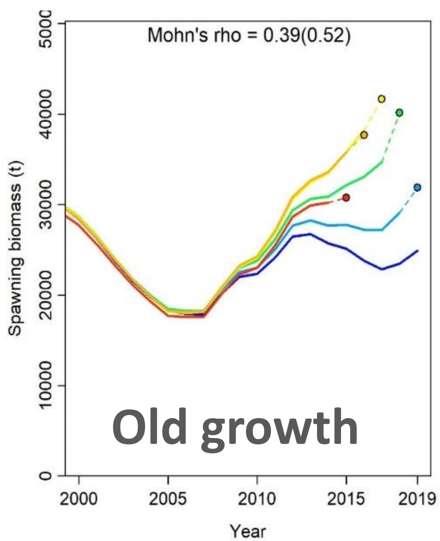


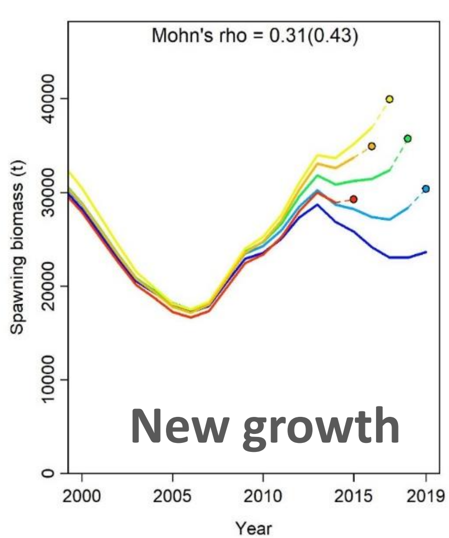
Conservation Information

- The Pacific blue marlin stock has produced annual yields of around 18,800 mt per year since 2019, or about 90% of the MSY catch amount
- There is no evidence of excess fishing mortality above F_{MSY} ($F_{2016-2019}$ is 40% of F_{MSY}) or substantial depletion of spawning potential (SSB_{2019} is 17% above SSB_{MSY})

Conservation Information

- **It is important to note that there are no currently agreed upon reference points for the Pacific blue marlin stock and that retrospective analyses show that the assessment model appears to overestimate spawning stock biomass in recent years**
- **Overall, the Pacific blue marlin stock was not likely overfished and was not likely experiencing overfishing relative to MSY-based or 20% of unfished spawning biomass-based reference points**





Conservation Information

- The results show that projected female spawning biomasses would be expected to increase under $F_{status\ quo}$ and $F_{30\%}$ harvest scenarios and decline to SSB_{MSY} under High F and F_{MSY} harvest scenarios. The probability of the stock being overfished or overfishing to occur by 2029 under each harvest scenario is low.

Special Comments

- **It was noted that there was uncertainty regarding the choice of BUM growth curve that led to the ensemble model approach for this assessment.**
- **It was recommended that biological sampling to improve life history parameter estimates continue to be collected and ISC countries participate in the BILLWG International Biological Sampling program to improve those estimates.**

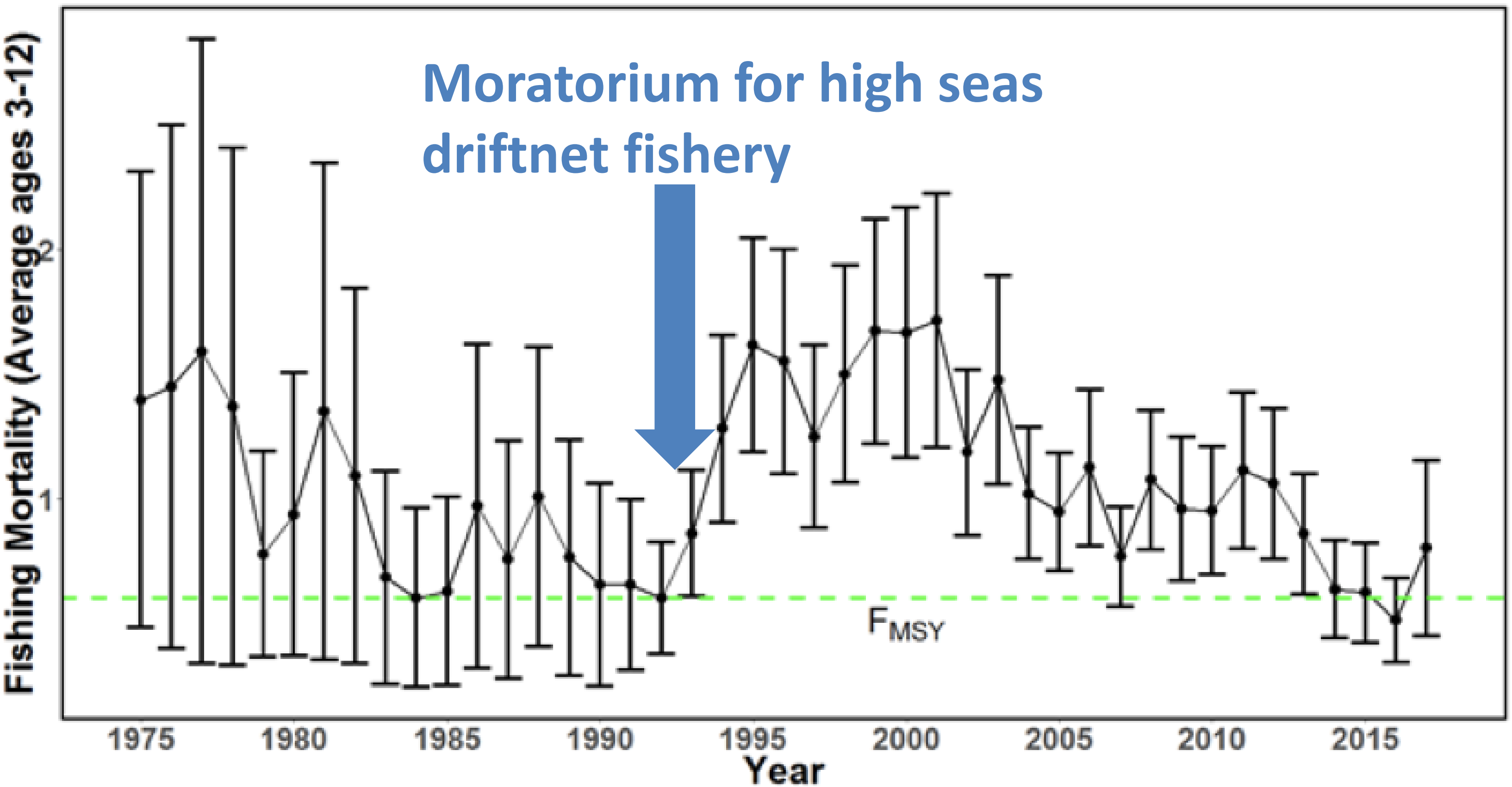
Answers to the request from WCPFC commission

i) examine differences between ISC stock assessment catch estimates by CCM and WCPFC catch estimates, and work with the Scientific Services Provider to provide an assessment of the shortcomings

The WG discussed the working paper ISC/21/BILLWG-01/05 and concluded that WCPFC Japanese longline fishery statistics and the output from SS are similar. These two catch weights were estimated using different methods and therefore the values differ slightly.

SPC noted that for longline fisheries where the catch is recorded as numbers it is not surprising that when converted to biomass (mt) the WCPFC biomass catch estimates and the SS biomass catch estimates are different. This is due to the different approach taken for converting numbers to biomass for the WCPFC catch estimates and for the stock assessment, whether it is SS or MFCL. The WCPFC catch estimates are converted from numbers to biomass using a simple conversion using the average weight of the individuals caught on that trip or within the reporting strata. In the stock assessment, the catch in biomass is a product of the numbers caught, the fishery selectivity function, and the weight-at-age of individuals. Though these methods will produce catch estimates in biomass that are similar, **it is reasonable and expected that some differences will exist.** When conducting the stock assessment it is important to account for potential conversion error by using the catch in the original recorded units, which for longline fisheries is in terms of numbers.

ii) provide explanation why the striped marlin stock decreased and the fishing mortality increased after a drastic decrease in fishing effort by high seas driftnet fisheries in the early 1990s



The WG group discussed why the fishing mortality increases in 1994 despite the loss of large catch from the Japanese driftnet. The WG members that this could be caused by multiple factors: 1.) The model assumes that the selectivity for Japanese driftnet catches in 1975-1993 have the same selectivity as those in the Japanese coastal driftnet fishery from 1994 to 2017, although there is no size data available from 1975-1993. This selectivity targets large adult striped marlin, which means that the model is assuming the majority of the catch from 1975 to 1993 is large adult fish. In 1994, the majority of the catch is from CCM longline fleets, which catch predominately juvenile striped marlin. This assumed shift from catching large adults to small juveniles would result in an increase in fishing mortality even if the overall catch has decreased. 2.) The CPUE time series has a break in 1993 to 1994, which could be driving a shift in the model results due to a lack of continuity. 3.) The Japanese logbook data also change their reporting requirements in 1993 to 1994, which could contribute to the shift in fishing mortality, **however not all CCMs agreed that this would drive the change in fishing mortality.**

The WG noted that excluding data prior to 1994 in the MLS assessment was explored in the 2019 assessment meeting. The WG compared two models that started in 1994. A sensitivity run fixing the initial equilibrium catch (run 22, MLS SAR, ISC 2019, Figure 3 a) showed no difference in the base-case model results. In contrast, estimating the initial equilibrium catch (Model 2 in the Carvalho, et al. 2019, Figure 3 b) resulted in the same trend but produced different estimates of initial population size. **One WG member noted that SSB_0 was strongly associated with the initial equilibrium catch. However, the WG did not have strong information to justify setting the initial catch (5,000mt). The WG agreed to estimate the initial equilibrium catch in the stock assessment model, and agreed that differences due to starting year were likely driven by the uncertainty in catches before 1993.**

iii) develop a roadmap to address the issues identified in the latest stock assessment by ISC

The WG suggested that the WG revise the work plan to assess WCNPO striped marlin in 2022 and postpone commencement of the NP swordfish assessment to 2023 to address many of the concerns both presented in this meeting and highlighted in the 2019 MLS SAR. For example, there were concerns about providing a rebuilding plan in 2021 and then reassessing the stock in 2022. However, it was noted that **the rebuilding plan would be updated after each assessment**, and that the rebuilding plan should be presented to managers noting that the WG plans to run a new benchmark assessment in 2022 and also plans to update the rebuilding plan accordingly.