Coastal Pelagic Species Management Team Presentation on the Pacific Sardine Rebuilding Plan
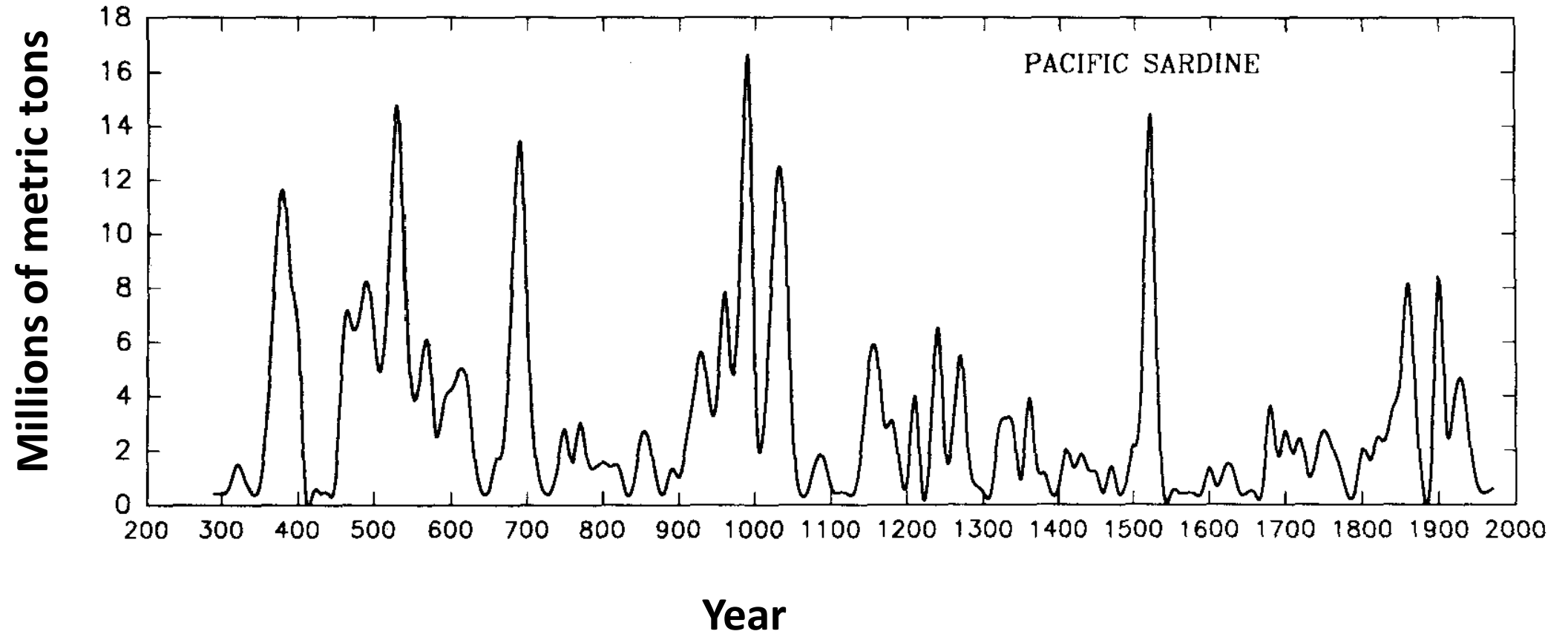
OUTLINE

- Historical Perspective

- Modeling

- CPSMT Recommendations and Rationale

Reconstruction of Historical Sardine Biomass
modified from Baumgartner et al. 1992 (CalCOFI Reports) to remove anchovy

Discussion – (slide presented by Dr. Kevin Hill to SSC)

- Long-term 'equilibrium' conditions do not exist for CPS (Baumgartner et al. 1992), so long-term projections are not realistic;

- Sardine will rebound once environmental drivers favor recruitment/survival;

- No environmental data exists to project the population forward for decades;

- Steepness caveats:
    - Steepness in SS based on only 14 paired estimates; h is poorly estimated, so is fixed at a low value for assessment purposes;
    - Steepness might be lower during poor environmental conditions, but steepness in Clupeiformes is generally considered to be much higher (e.g. h=0.72, Thorson et al.). Likelihood profile/fits for h could also be due to SS model misspecification.
    - Steepness profile (median h=0.4) locks productivity into a low state indefinitely;

- Projections assume that 100% of ABC is taken – not realistic given recent catch history

Inclusion of uncertainty

- High recruitment variability ($\sigma R = 1.2$)
- Two productivity 'states of nature' considered:
  - SB_0 based on recruits from 2005-18 and 2010-18
- Uncertainty in Mexico catch: constant tonnage vs. rate
- Additional uncertainty in spawner-recruit calculations: Profiled a range of Beverton-Holt steepness parameters (h=0.30 to 0.80)
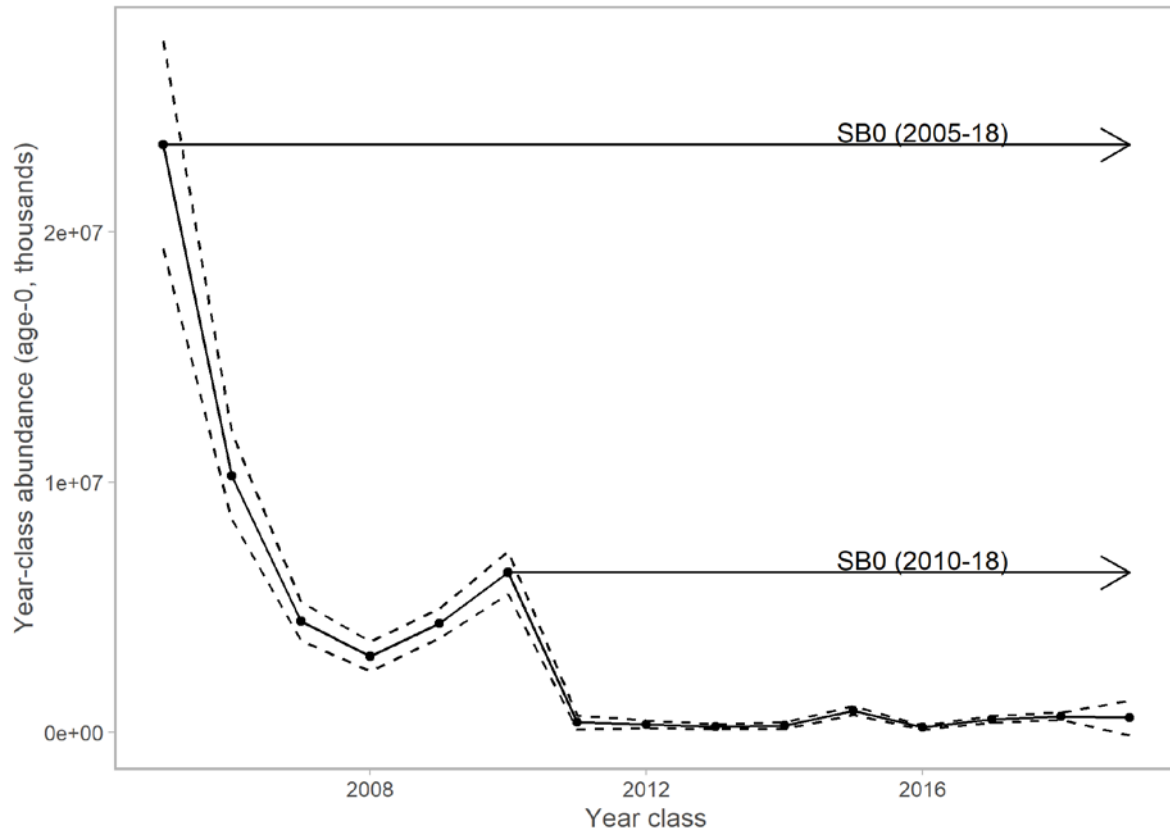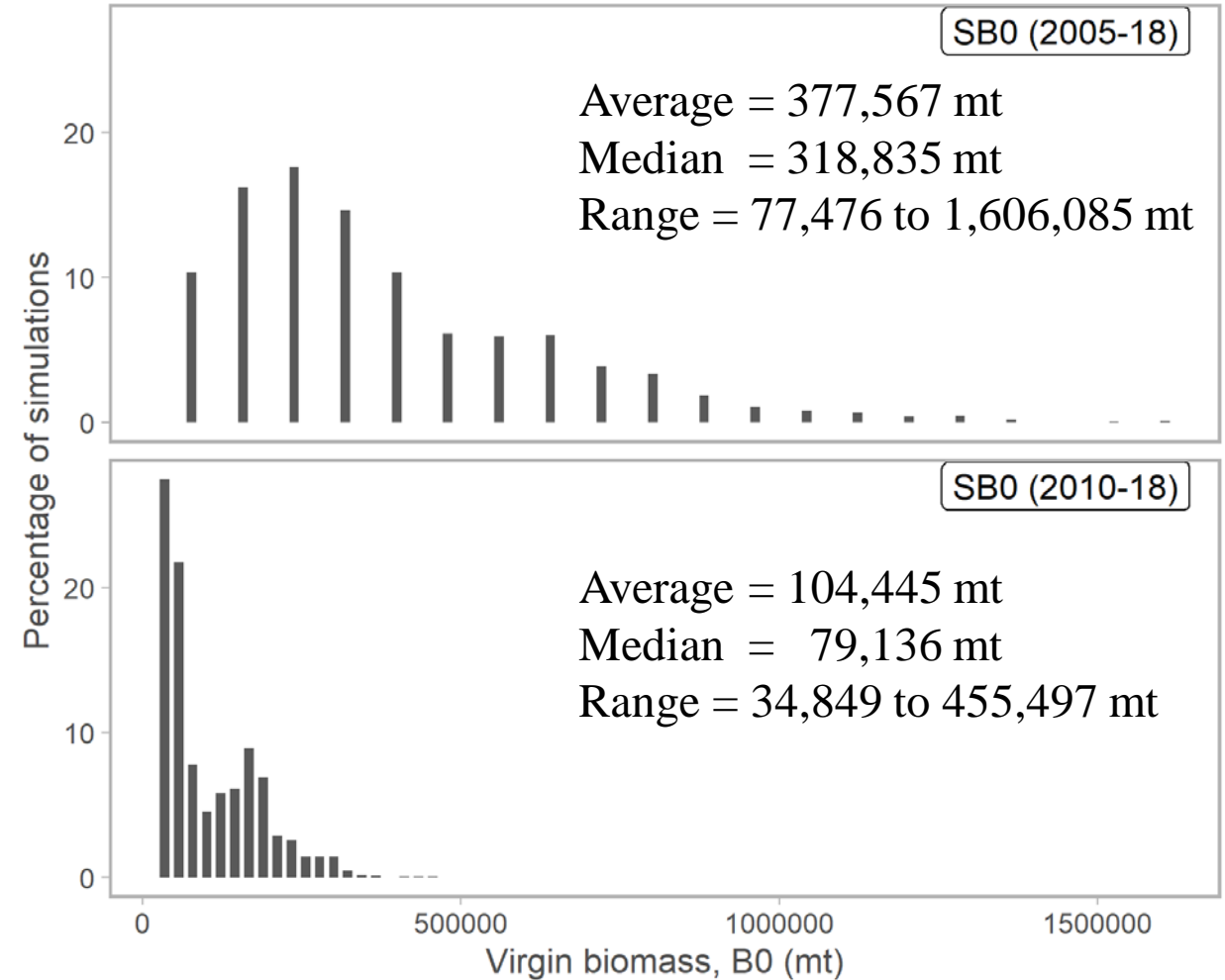
Rebuilding calculations: Definition of SB_0

Figure 4. Virgin spawning biomass (SB_0) for the two states of nature.

SB0 (2005-18)

Average = 377,567 mt
Median = 318,835 mt
Range = 77,476 to 1,606,085 mt

SB0 (2010-18)

Average = 104,445 mt
Median = 79,136 mt
Range = 34,849 to 455,497 mt

Rebuilding calculations: Definition of rebuilt

- Stock is deemed 'rebuilt' when there is a greater than 50% probability of the stock achieving SB_{MSY}.

- $SB_{\mathrm{MSY}} = SB_0 * 0.365$ (the target depletion level)

- Use of multiple recruitments to provide a range of SB_0 values results in a range of rebuilding targets (SB_{MSY}) for each simulation.

Table 4. MSY references points and relative probabilities over the profiled range of steepness for two productivity states of nature.

$SB_{0(2005\text{-}18)}$						$SB_{0(2010\text{-}18)}$					
Steepness	E_{MSY}	Median Catch (mt)	SB_{MSY} (mt)	Target Depletion	Relative Probability	Steepness	E_{MSY}	Median Catch (mt)	SB_{MSY} (mt)	Target Depletion	Relative Probability
0.30	0.075	16,112	162,286	0.42983	19%	0.30	0.075	4,465	44,975	0.43062	19%
0.35	0.110	22,791	155,613	0.41213	17%	0.35	0.110	6,307	43,066	0.41233	17%
0.40	0.150	28,880	143,687	0.38057	15%	0.40	0.150	7,990	39,751	0.38059	15%
0.45	0.190	34,538	134,826	0.35710	13%	0.45	0.190	9,554	37,296	0.35710	13%
0.50	0.230	39,897	127,896	0.33870	11%	0.50	0.230	11,037	35,379	0.33870	11%
0.55	0.280	45,058	117,800	0.31200	9%	0.55	0.280	12,464	32,587	0.31200	9%
0.60	0.330	50,109	110,394	0.29240	7%	0.60	0.330	13,861	30,538	0.29240	7%
0.65	0.390	55,125	101,953	0.27000	5%	0.65	0.385	15,249	28,588	0.27370	5%
0.70	0.455	60,198	94,656	0.25070	3%	0.70	0.455	16,652	26,184	0.25070	3%
0.75	0.535	65,423	86,664	0.22950	1%	0.75	0.535	18,098	23,974	0.22950	1%
0.80	0.640	70,942	77,650	0.20570	0%	0.80	0.640	19,624	21,480	0.20570	0%
		$SB_0=$	377,567	0.36500 <-Wtd Value				$SB_0=$	104,445	0.36500 <-Wtd Value	
	Average $SB_{MSY}=$	137,812					Average $SB_{MSY}=$	38,122			

Median SB_{MSY} = **116,374 mt**
Range: **28,279 to 586,221 mt**

Median SB_{MSY} = **28,885 mt**
Range: **12,720 to 166,256 mt**

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	Average $SB_{MSY}=$	137,812			

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Range: 28,279 to 586,221 mt

(Right table, partially obscured) $SB_{0(2010-18)}$

Steepness		Median	SB_{MSY} (mt)		Relative Probability
					17%
					15%
0.45					13%
0.50					11%
0.55					9%
0.60					7%
0.65					5%
					3%
			21,4..		0%

$SB_0=$ 104,445

$SB_{MSY}=$ 38,122

Median $SB_{MSY} =$ 28,885 mt
Range: 12,720 to 166,256 mt

Rebuilding calculations: Alternative harvest strategies

- Rebuilding analyses explored three US harvest alternatives, with two approaches to modeling Mexico's harvest: constant catch and constant rate.

- US rate = 0.18 (Alt 1); no future data to inform E_{MSY}, so static value from the MSE was used.

- US rate = 0.00 (Alt 2); zero take.

- US rate = 0.05 (Alt 3) was the Council's request for a reduced harvest scenario.

> For the constant Mexico harvest rate runs, strategies were:
> Alt 1: Total E=0.2202 (where US E=0.1216 and Mexico E=0.0986)
> Alt 2: Total E=0.0986 (where US E=0.0000 and Mexico E=0.0986)
> Alt 3: Total E=0.1486 (where US E=0.0500 and Mexico E=0.0986)

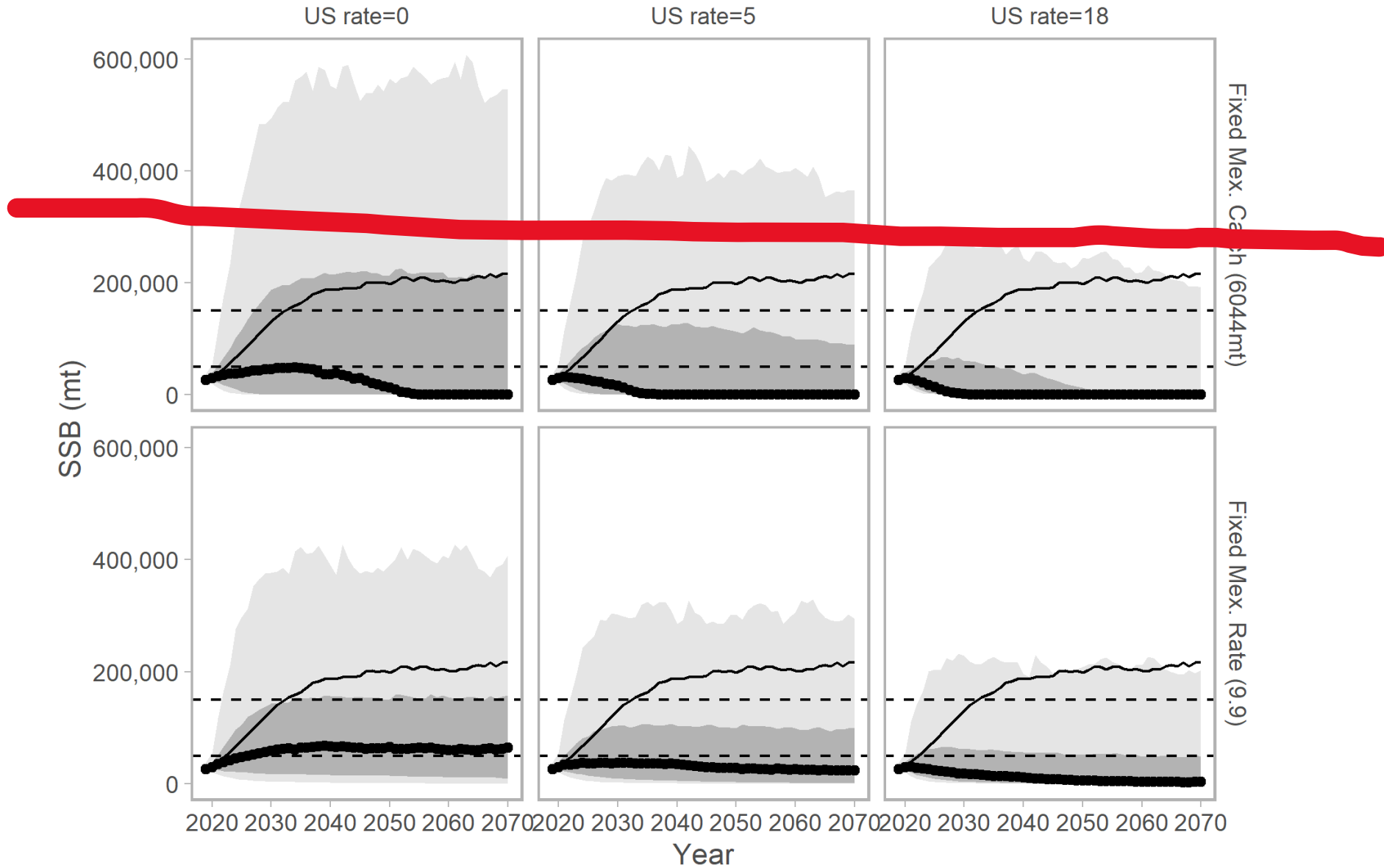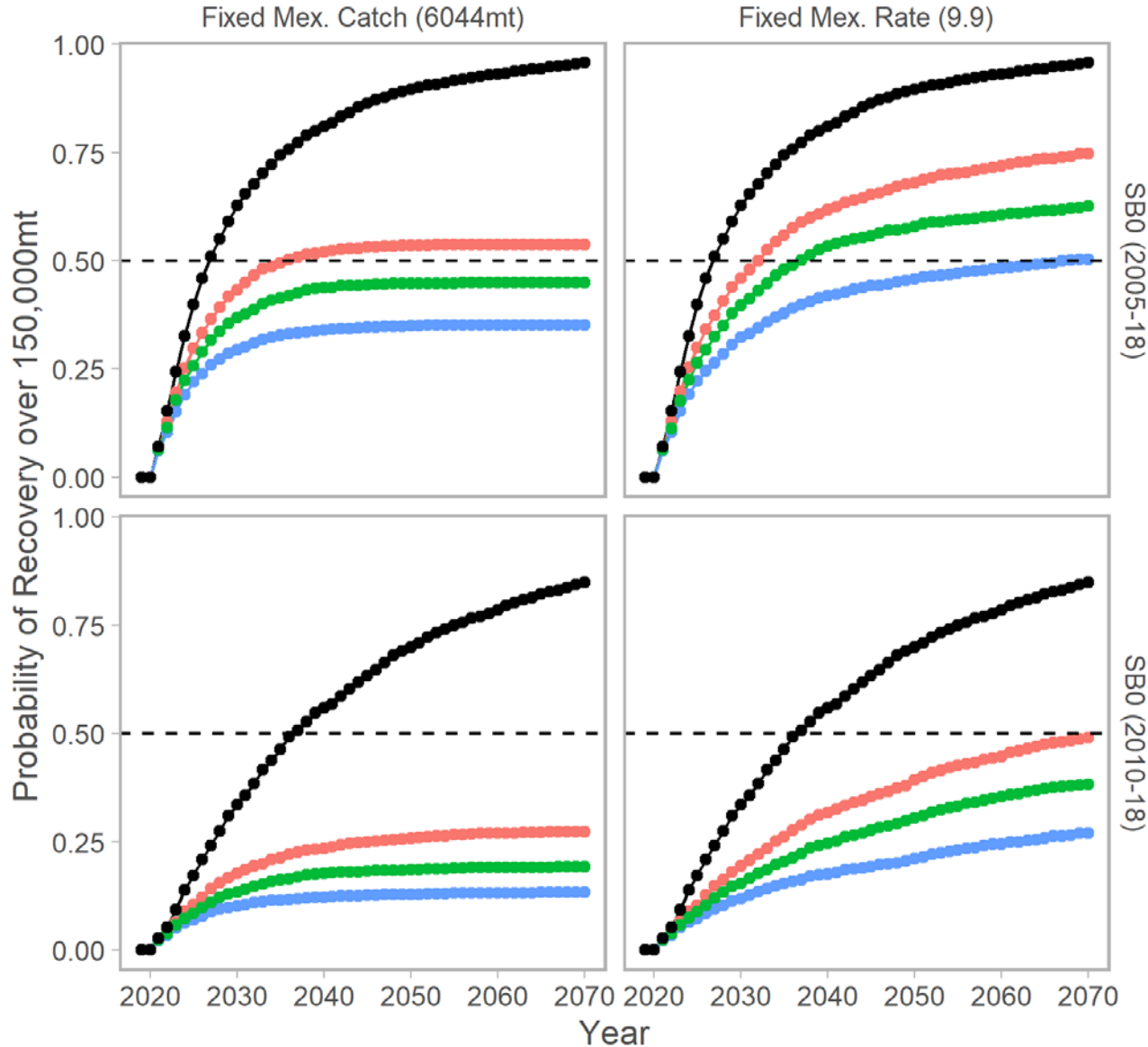# Figure 9. Projected spawning stock biomass (mt) for $SB_{0(2005-18)}$ scenario.

Figure 7b. Probabilities of recovery to the 150,000 mt Cutoff threshold. See also Tables 8 and 9.

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service | modified from slide presented to SSC by Dr. Kevin Hill

CPSMT Recommendations for Sardine Rebuilding Plan

- Alternative 1 – Status Quo

  - Rebuilding Target = 150,000 mt 1+biomass

  - T_{min} = 12 years (based on Rebuilder model projection for zero U.S. fishing rate)
  - T_{max} = 24 years (based on NS 1 guidelines method of doubling T_{min})
  - T_{target} = 14 years

Rationale for Recommendations

- Based on more than <u>just</u> modeling results

  - Historical information on sardine abundance

  - Historical information on range of sardine recruitment and population dynamics

  - Historical information on sardine fishery

  - An understanding of the modeling, its assumptions, and uncertainty

Rationale for Recommendations

- Based on more than <u>just</u> modeling results

  - Examination of how to utilize modeling results for real world decision making

  - Socio-economics of fishing industry and communities it supports
    - Both other alternatives may have substantial negative effects

  - Under status quo management average recent harvest = ~2,200 mt
    - Only 472 mt of which are NSP
    - Very different from what was modeled

150,000 mt 1+biomass Rebuilding Target

- Modeling results for SB_{msy} provide a very wide range of values

- The median value for SB_{msy} was 116,374 mt

- The 'equivalent' of 150,000 mt of 1+biomass is 121,650 mt SB
  - Note that this SB estimate is based on data output from the 2020 assessment
  - Similar to median SB_{msy} estimate

- SB_{msy} is a moving target that depends on stock productivity

150,000 mt 1+biomass Rebuilding Target

- 1+biomass is the same metric as both the overfished threshold and the results reported by annual stock assessments
  - Conversion of 1+biomass to SB is not simple or straightforward

- Alignment should facilitate tracking progress toward rebuilding
  - Helps avoid confusion over different biomass metric/units

- 150,000 mt 1+biomass is reasonable analog to B_{msy} for rebuilding
  - Equivalent SB is slightly above median SB_{msy} for model deemed most informative for prevailing environmental conditions, therefore represents a rebuilding level consistent with producing MSY
  - Established level for which a target fishery can occur

Timelines for Rebuilding

- Historical information suggests it may take some time before the stock rebounds and environmental conditions will be a primary driver

- U.S. management actions are implemented only in the U.S.
  - There are no international agreements for this transboundary stock

- T_{min} is based on median result from zero U.S. fishing model

- T_{max} is based on the doubling T_{min} method provided in NS 1 guidelines

Timelines for Rebuilding

- Status quo U.S. harvest of NSP has averaged 0.6% of 1+biomass

- T_{target} of 14 years is halfway between median zero fishing rate and U.S. 5% fishing rate model projection times for rebuilding

- CPSMT examined two other model runs
  - Constant rate U.S. harvest of 2,200 mt/year Rebuilder model = 17 years
  - Compound interest rate for more productive stock (30% annual increase) = 8 years

CPSMT Conclusions and Recommendations for Sardine Rebuilding Plan

- Alternative 1 – Status Quo

  - T_{min} = 12 years

  - T_{max} = 24 years

  - T_{target} = 14 years

  - Rebuilding Target = 150,000 mt 1+biomass

Questions?

Photo courtesy of NOAA