Science, Service, Stewardship

Agenda Item F.3.a
Supplemental NMFS Presentation 1
March 2018

Assessing the effects of climate change on U.S. West Coast sablefish productivity and on the performance of alternative management strategies

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March 10, 2018

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PFMC

Sablefish

Understanding climate drivers of recruitment and the interaction between climate and fishing is a priority

1. Sea level – recruitment relationship has been the subject of previous research and debates during scientific review of assessment products for management.
2. Forecast and/or hindcast stock productivity.
3. Testing the robustness of management strategies to climate variability and change.

Why Should We Care About Uncertainty in Future Climate and Management Strategy Evaluation?

PFMC: Uncertainty in future environmental conditions of the California current ecosystem should be considered a significant source of uncertainty in all projections of stock status.

IPCC GCMs can provide relevant projections of future long term environmental conditions.

MSE is a **STRATEGIC** planning tool can be used to:

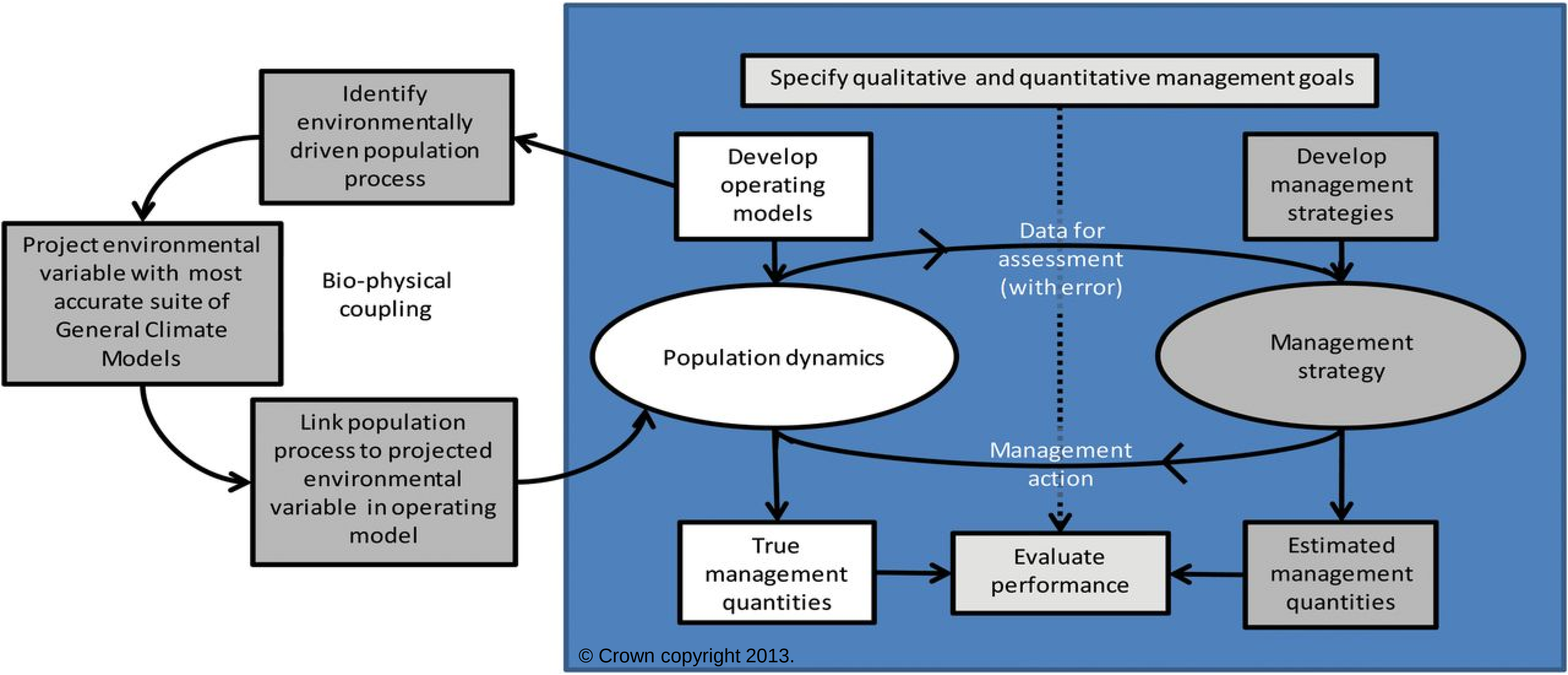
evaluate the robustness of control rules to potential long term trends in recruitment-climate relationships.

understand and evaluate trade-offs of a range of management policies.

Multi-decadal forecasts of sablefish productivity could provide long term strategic advice to allow fishers and managers to plan for and respond to shifts in productivity.

Goals

1. MSE assess the robustness of harvest control rules to decadal scale climate driven changes in recruitment.
2. Evaluate future decadal scale trends in sablefish productivity.



André E. Punt et al. ICES J. Mar. Sci. 2014;71:2208-2220

Physical Processes

Recruitment is driven by pelagic life stage feeding conditions.

Feeding conditions are driven by horizontal transport.

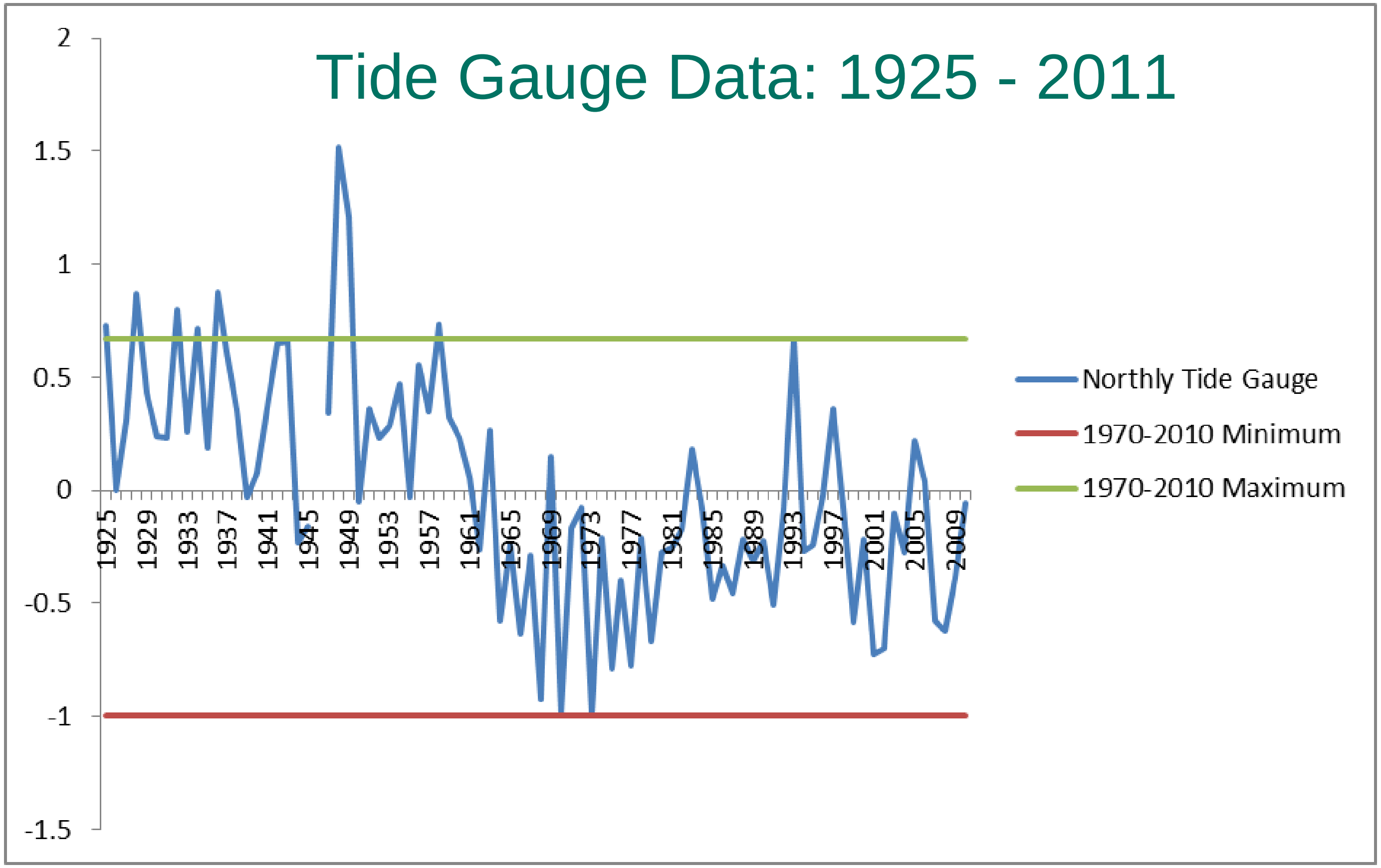
Sea level indexes horizontal transport.

Average

April-June Mean

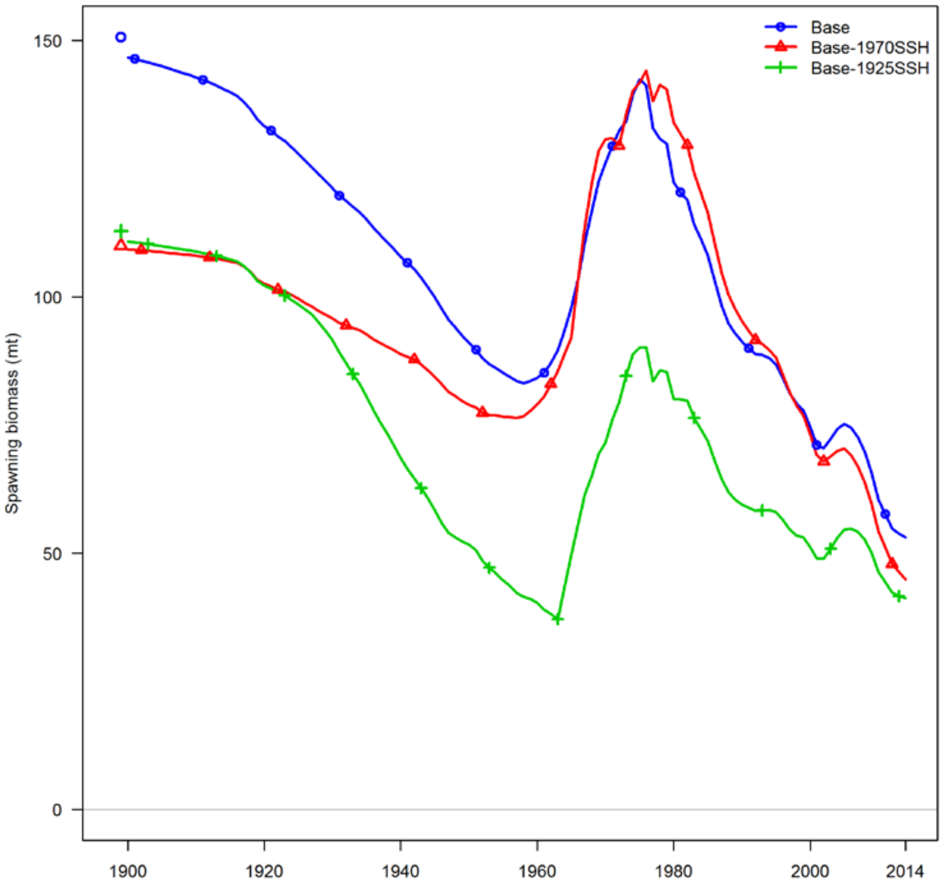
40-49 ºN

Explains ~36% Recruitment Variability

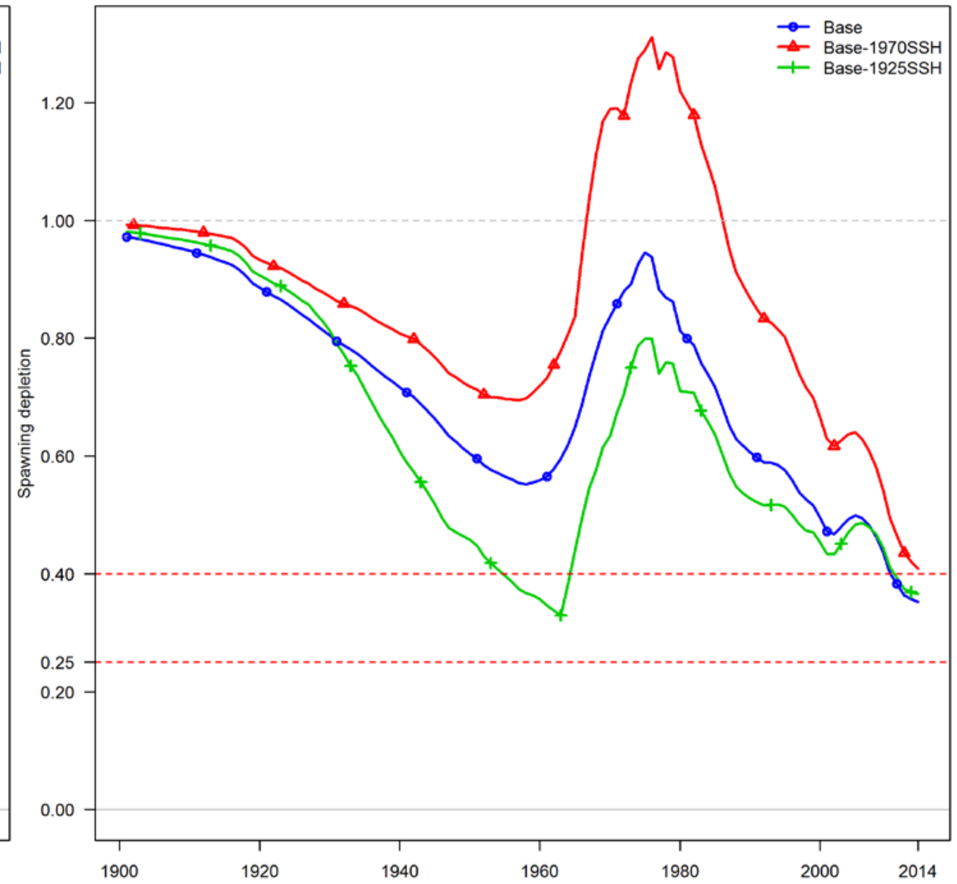


2015 Stock Assessment Sensitivity: Conditioning the Operating Model

Spawning Biomass



Spawning Depletion



Year

Year

Base – No SSH

Base – SSH 1970, No estimated additional SD

Base – SSH 1925, No estimated additional SD

Management Strategy Evaluation Framework

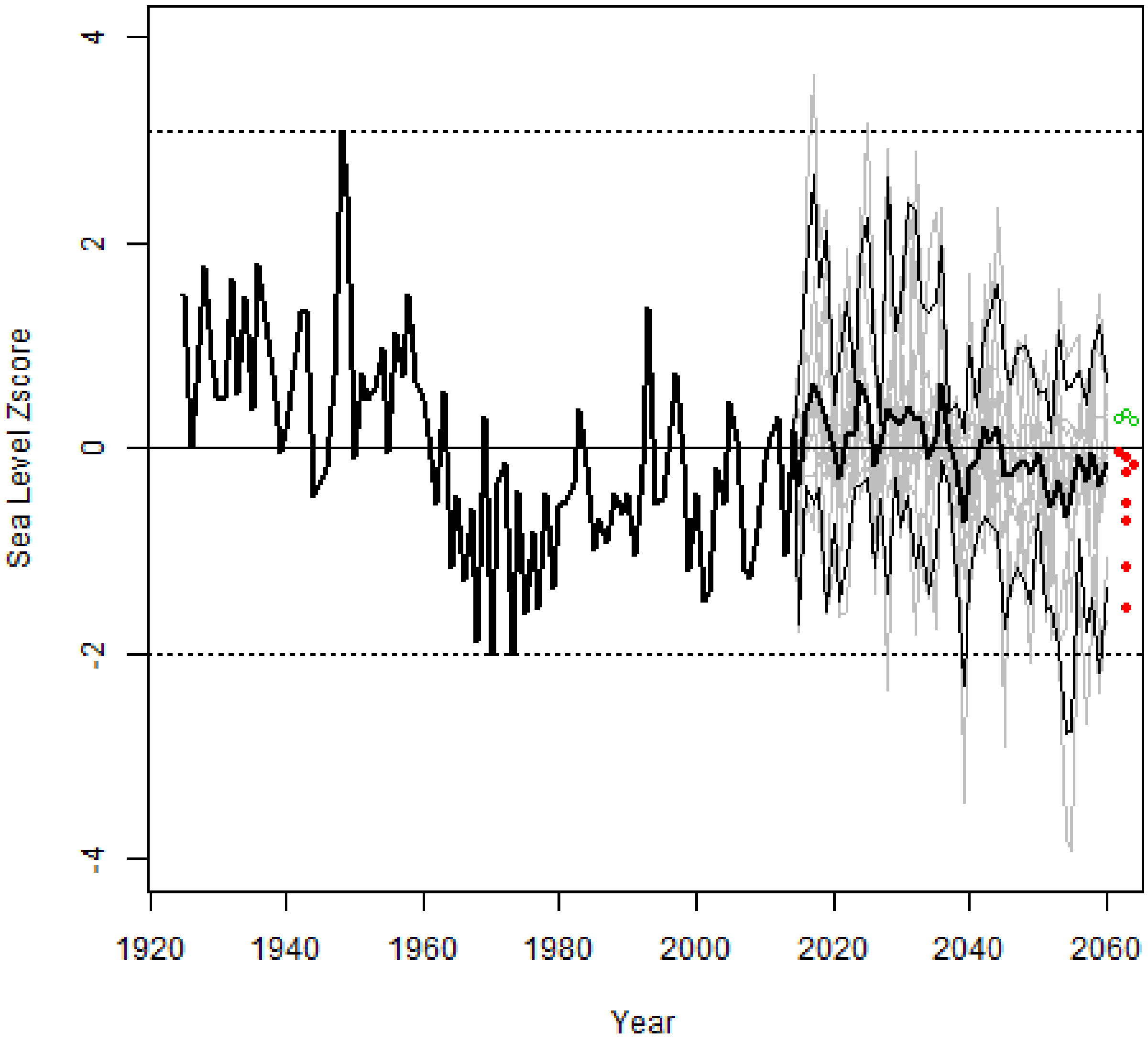
Operating Model – Representation of the ‘True’ System

- **SL** - northern California Current
  - SL data beginning during 1925
  - 11 CMIP 5 GCMs from 2015 forward
- **SL-recruitment relationship** explains 36% of the variability in recruitment deviations in the OM

Estimation Model

- **Annual Management** period: 2015-2060
- **2015** update stock assessment
  - SL used as a survey index of recruitment beginning 1925
  - IPCC SL 2015 forward

Sea Level Tide Gauge and GCM Outputs

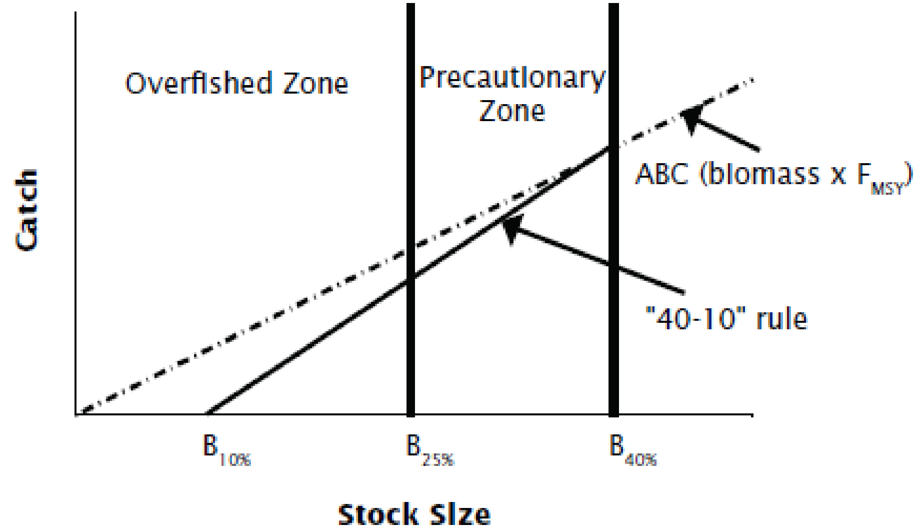


Management strategy: Harvest Control Rules

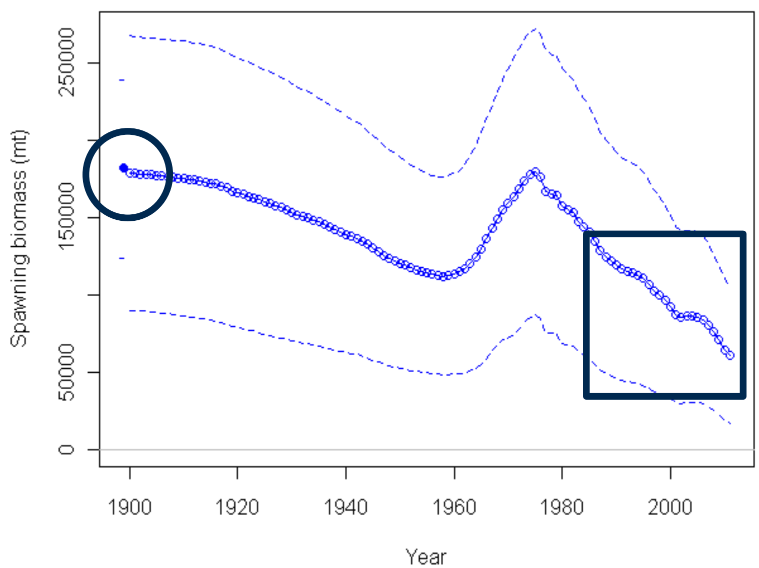
1. No fishing

2. **40-10 rule**

   Static reference points



3. Dynamic Bo 40-10 rule
   - Spawning biomass in the absence of fishing
   - 35 year moving window



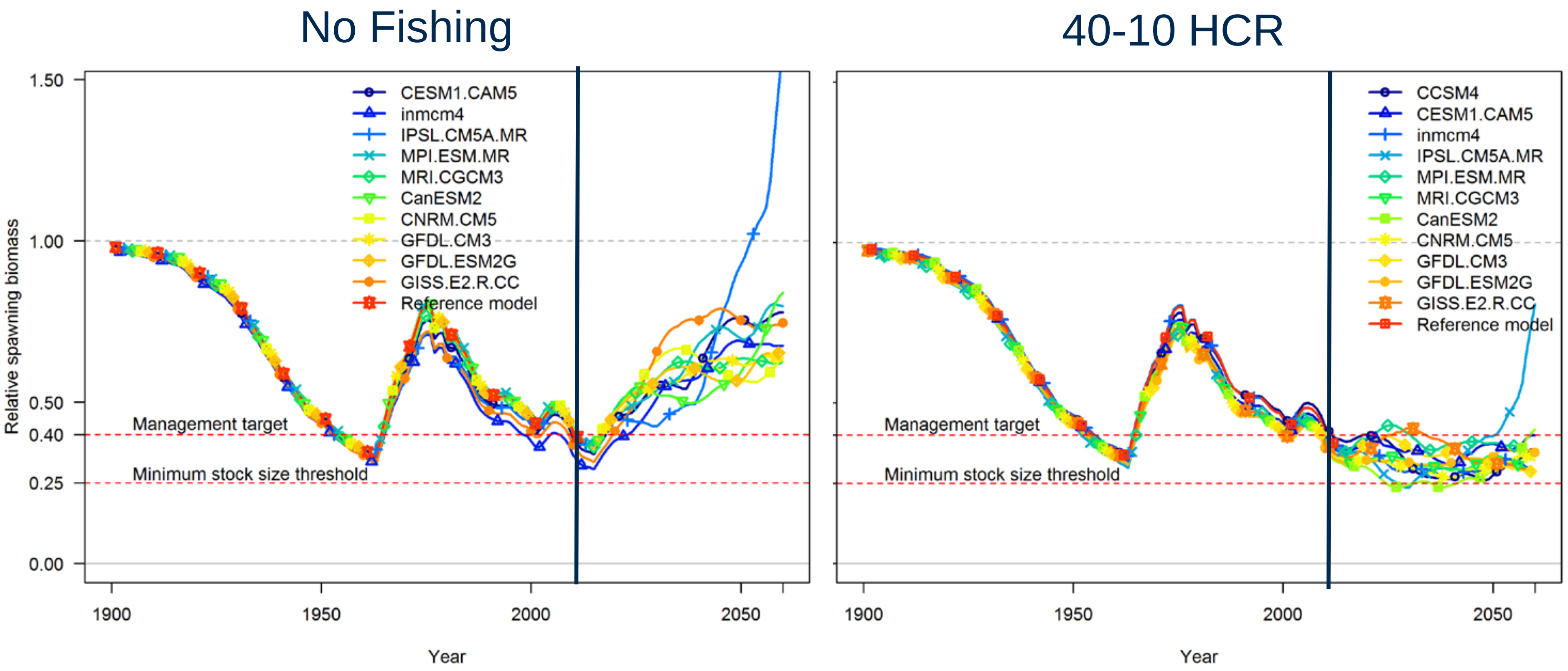
Performance Metrics

Projected time series: spawning biomass, stock depletion, catches

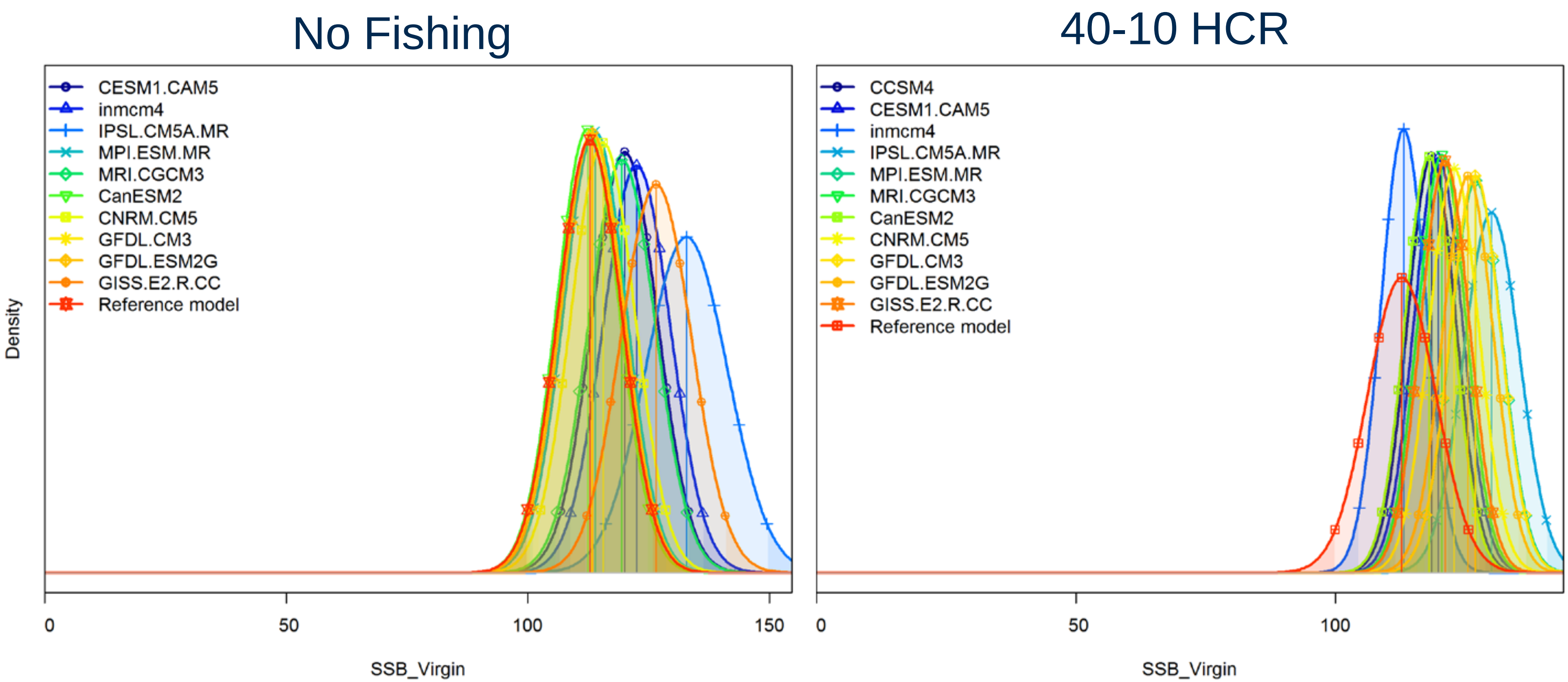
Distributions: estimated unfished biomass and unfished recruitment, and historical (1925 to 2014) and projected (2015-2060) spawning biomass and recruitment

Proportion of the time that historical (1925 to 2014) and projected (2015-2060) spawning biomass is below the true (OM) 25% and 10% levels of B_0 (reference run).

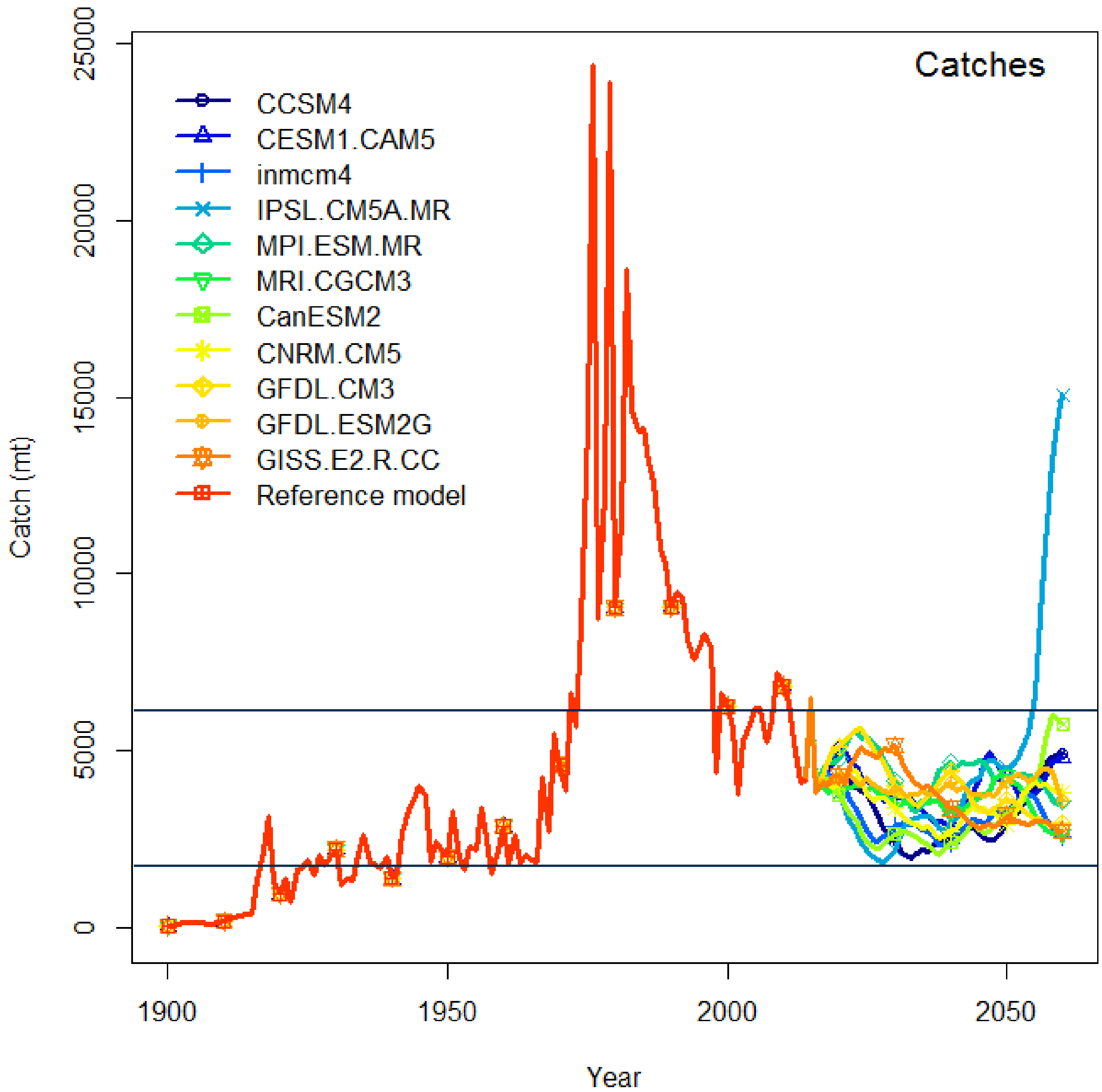
MSE Results: Time Series of Stock Depletion



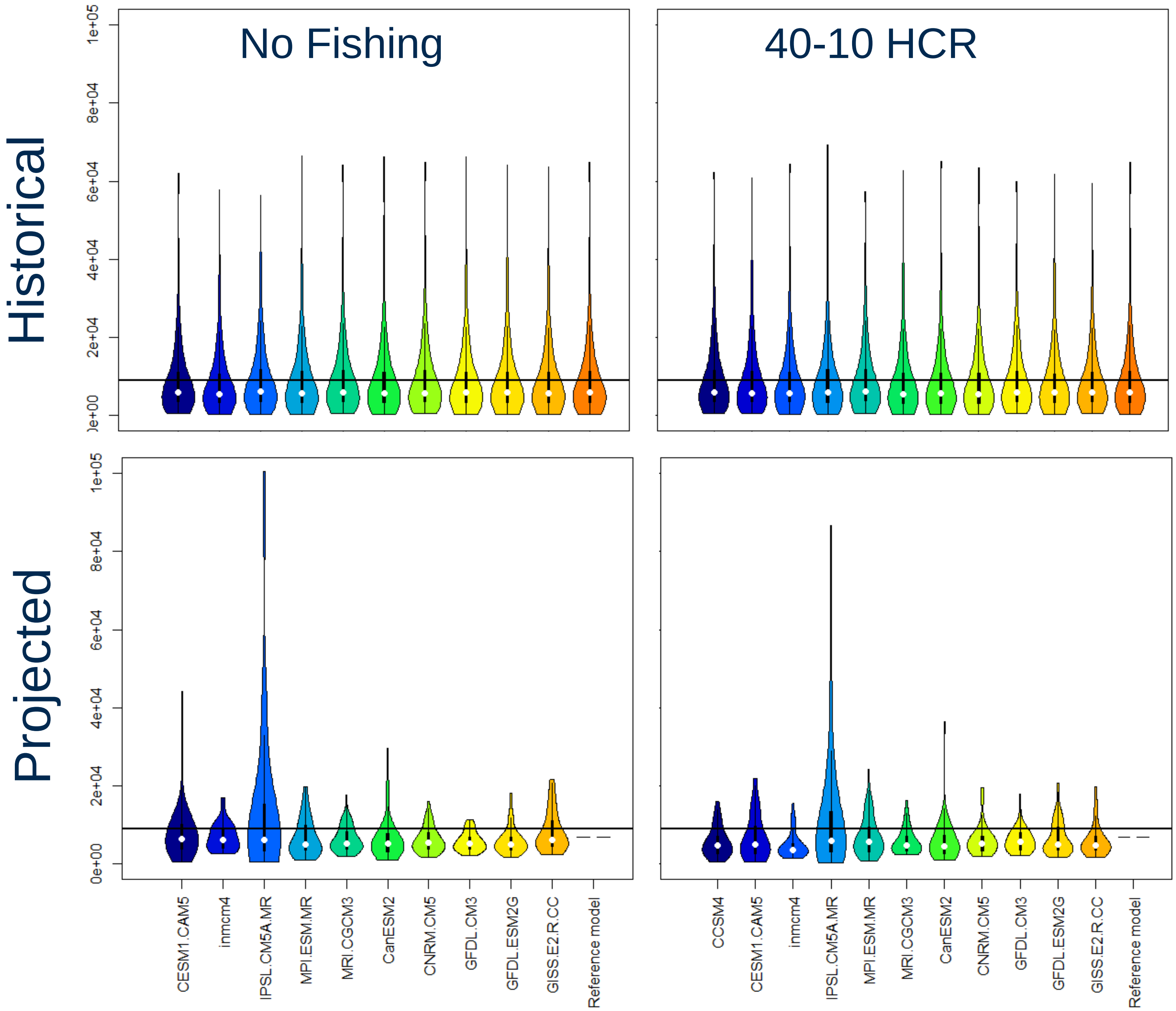
MSE Results: Distribution of Unfished Spawning Biomass



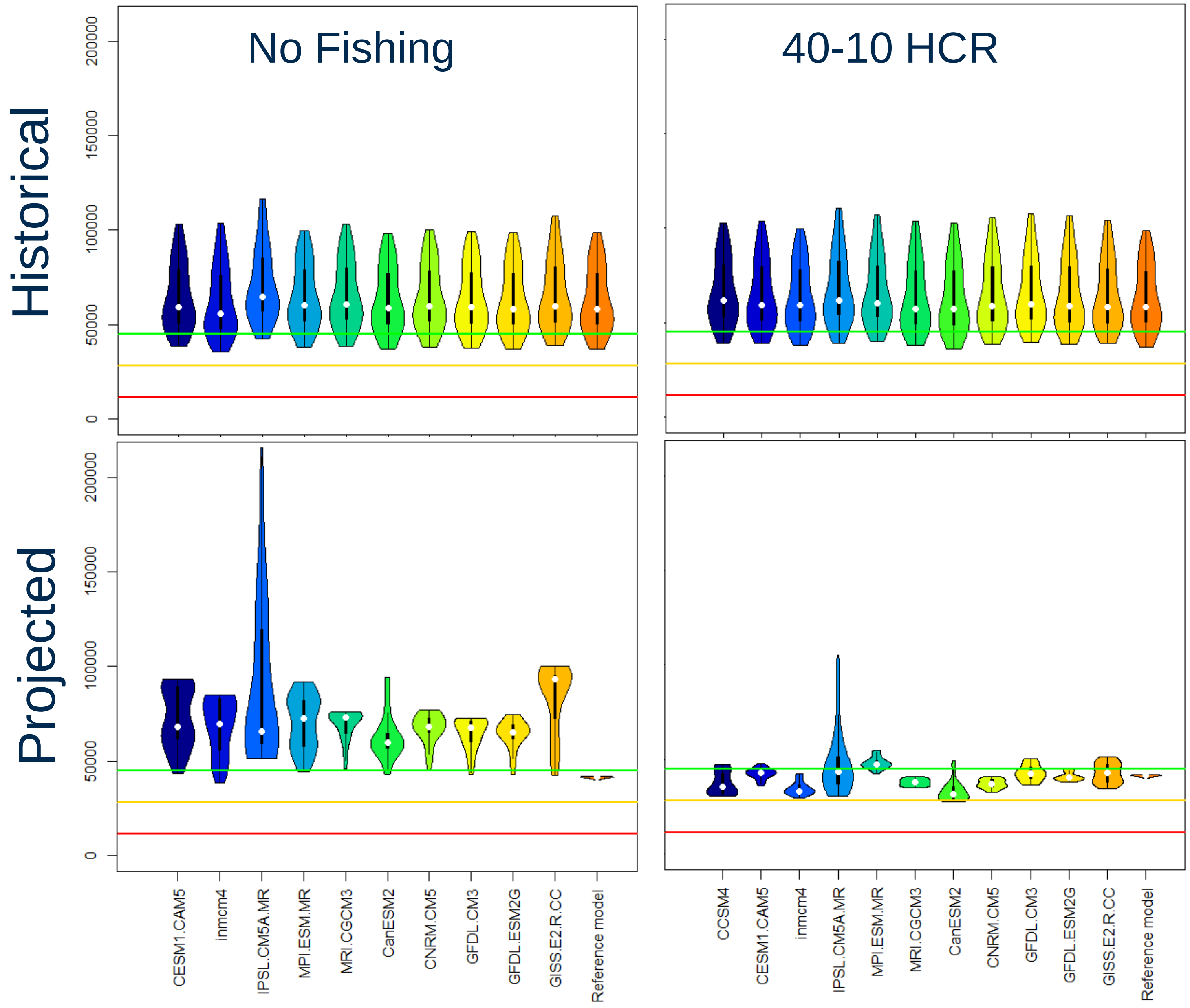
MSE Results: 40-10 Catches



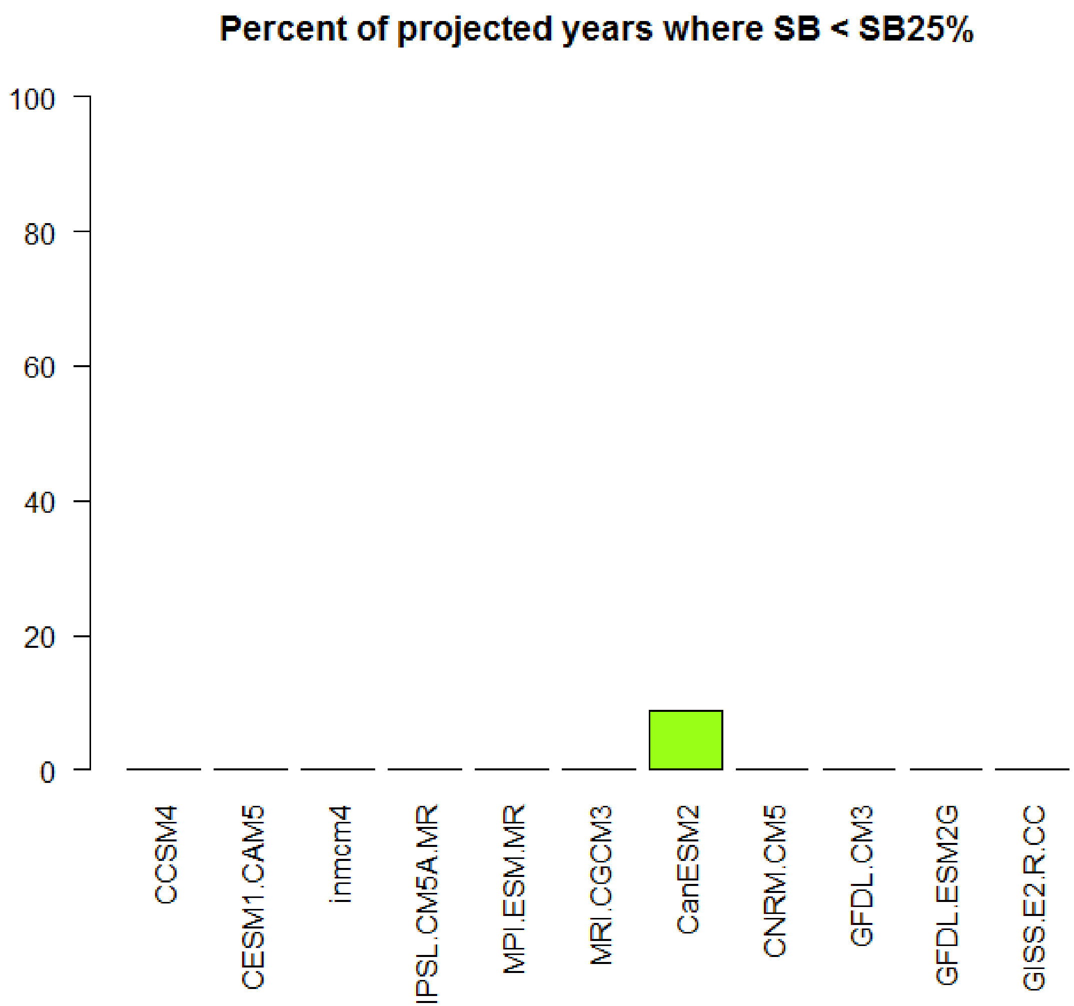
MSE Results: Recruitment distribution versus management target



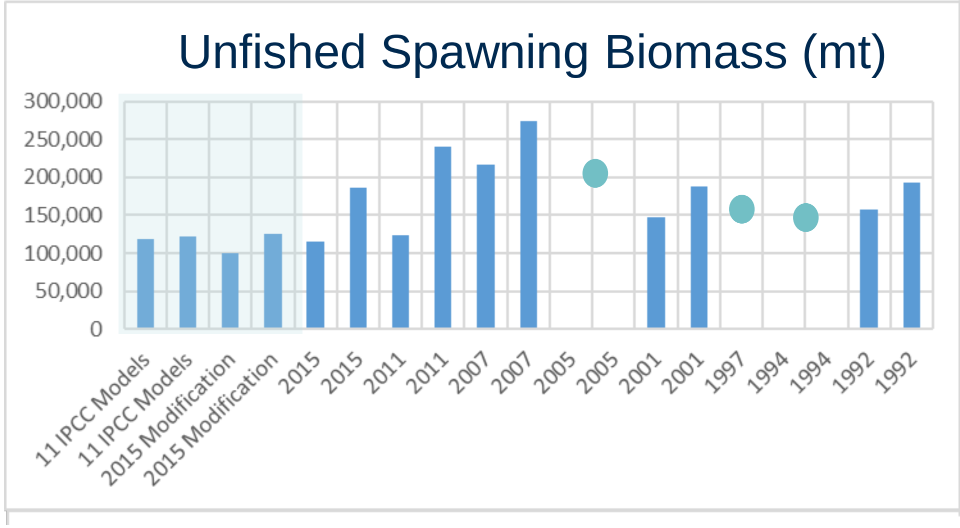
MSE Results: Spawning biomass (mt) distribution versus management target

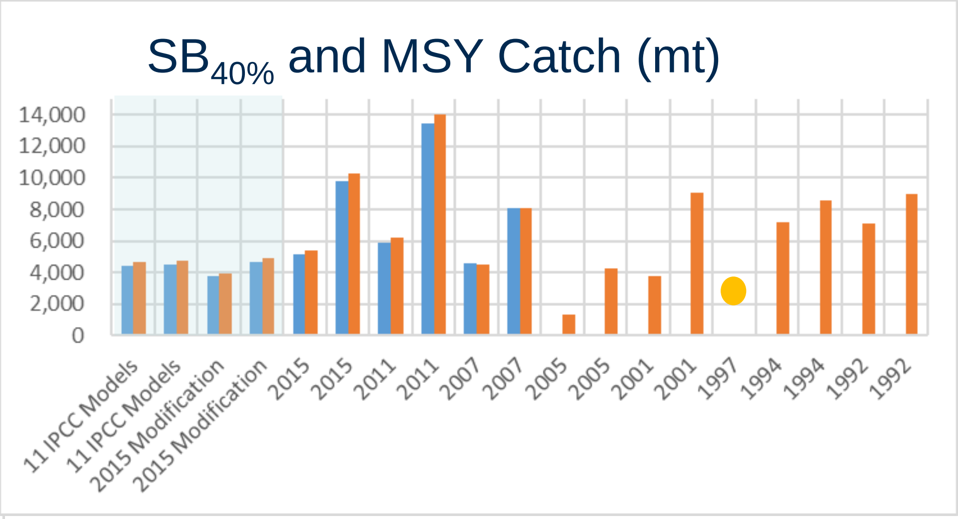


MSE Results: Proportion of years SB < 25% under 40-10



Past and Projected Reference Point Ranges





The two sets of bars for each model year provide the lower and upper range of uncertainty presented for each assessment.

Circles represent point estimates from assessments that did not present uncertainty.

Shaded boxes are values from this study.

Conclusions

Future sablefish recruitment is likely to:

- fall within the range of past observations
- exhibit decadal trends that result in recruitment levels that persist at lower levels (~ 2040) followed by higher levels (~2040 - 2060)

GCMs capture long term sea level trends but less natural variability

Both HCRs:

- Prevent fishery closures
- Project declining, then stabilizing or slightly increasing spawning biomass and catch trends
- Maintain the stock in the precautionary zone
  - SPR rate and target biomass are inconsistent policies
- Future MSY Catches ~4100-5100 mt

Conclusions

Both 40-10 and Dynamic B0 HCRs trigger stock rebuilding plans occasionally

Dynamic B0 HCR:

May be more robust to potential future climate change due to the ability to track decadal scale changes in productivity

But performs similarly to the 40-10 HCR given the implementation of a long moving window

Could be risk prone in cases where fishing pressure is causing biomass declines, allowing higher catches at low stock sizes due to reference points shifting lower through time.

Recommend presenting a combination of both static and dynamic B_0 reference points to fishery managers

Future Directions

Funding

- **NMFS-Sea Grant** fellow in population dynamics, pending
- **DFO** 2 year post-doc or researcher, awarded

Stakeholder input is fundamental to define and evaluate alternative MSE frameworks that are viable and possible to implement

Input regarding alternative:

- Management objectives
- Management strategies
- Performance Metrics
- Operating models: fishery and population dynamics

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Sablefish

Widely distributed across the NE Pacific

Winter deep water spawners

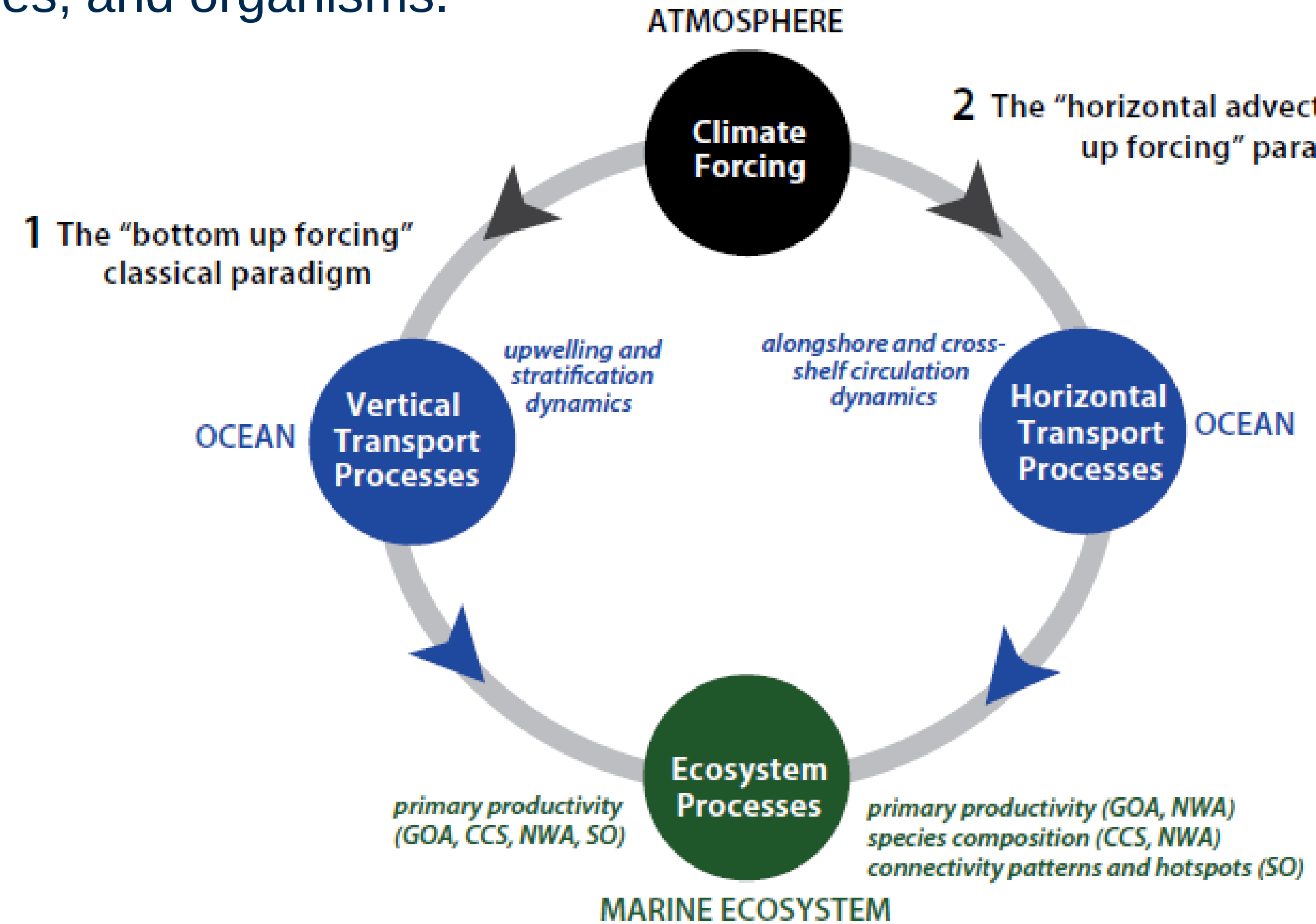
Pelagic larvae offshore, migrate inshore to settle as demersal juveniles

Rapid growth, reaching full size and maturity within a decade, long lived

Commercially valuable target fishery

US GLOBEC:
The horizontal-advection bottom-up forcing paradigm

Large-scale climate forcing drives regional changes in alongshore and cross-shelf ocean transport, directly impacting the transport of nutrients, water masses, and organisms.

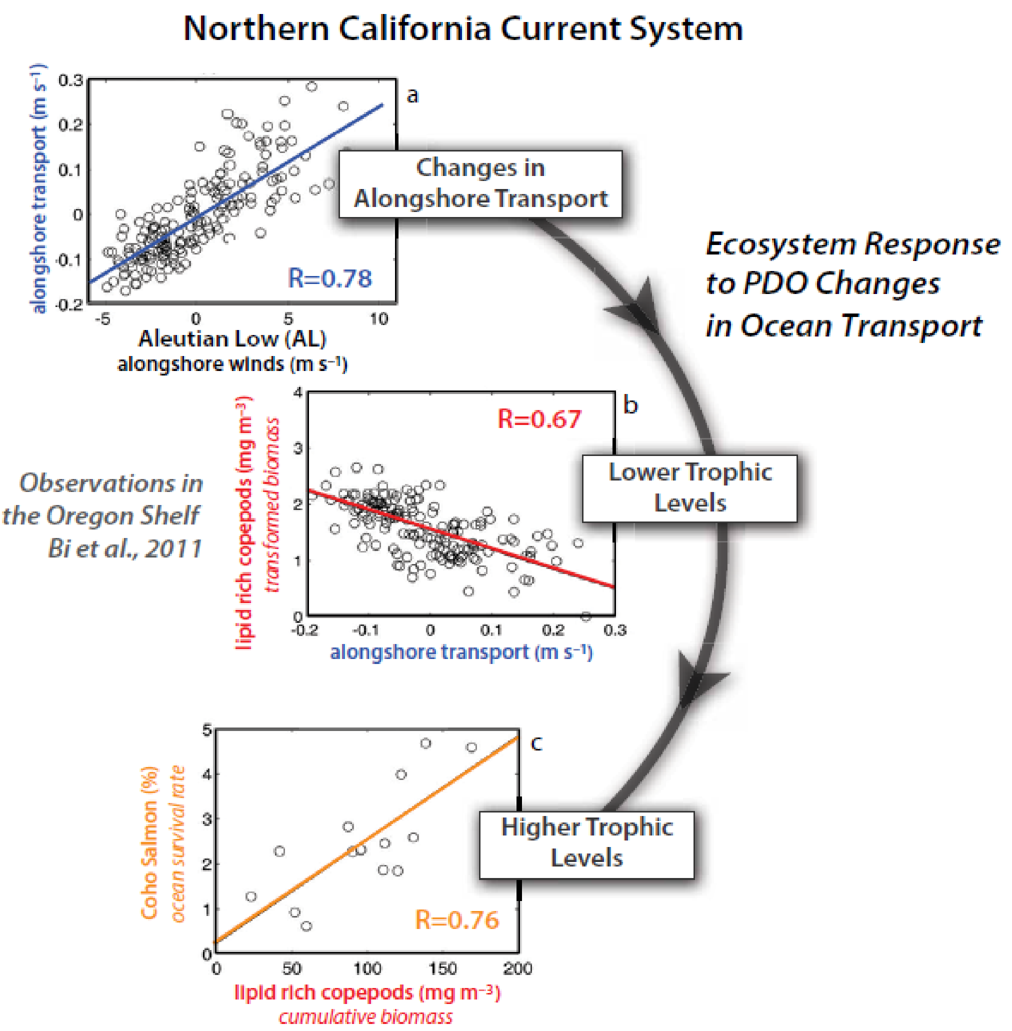


Di Lorenzo, et al. 2013. *Oceanography* 26(4):22–33.

US GLOBEC:
The horizontal-advection bottom-up forcing paradigm

Large-scale climate forcing drives regional changes in alongshore and cross-shelf ocean transport, directly impacting the transport of nutrients, water masses, and organisms.

A mechanistic framework through which climate variability and change alter sea surface height (SSH), zooplankton community structure, and sablefish recruitment, all of which are regionally correlated.



Di Lorenzo, et al. 2013. *Oceanography* 26(4):22–33.

GCMs

CMIP3

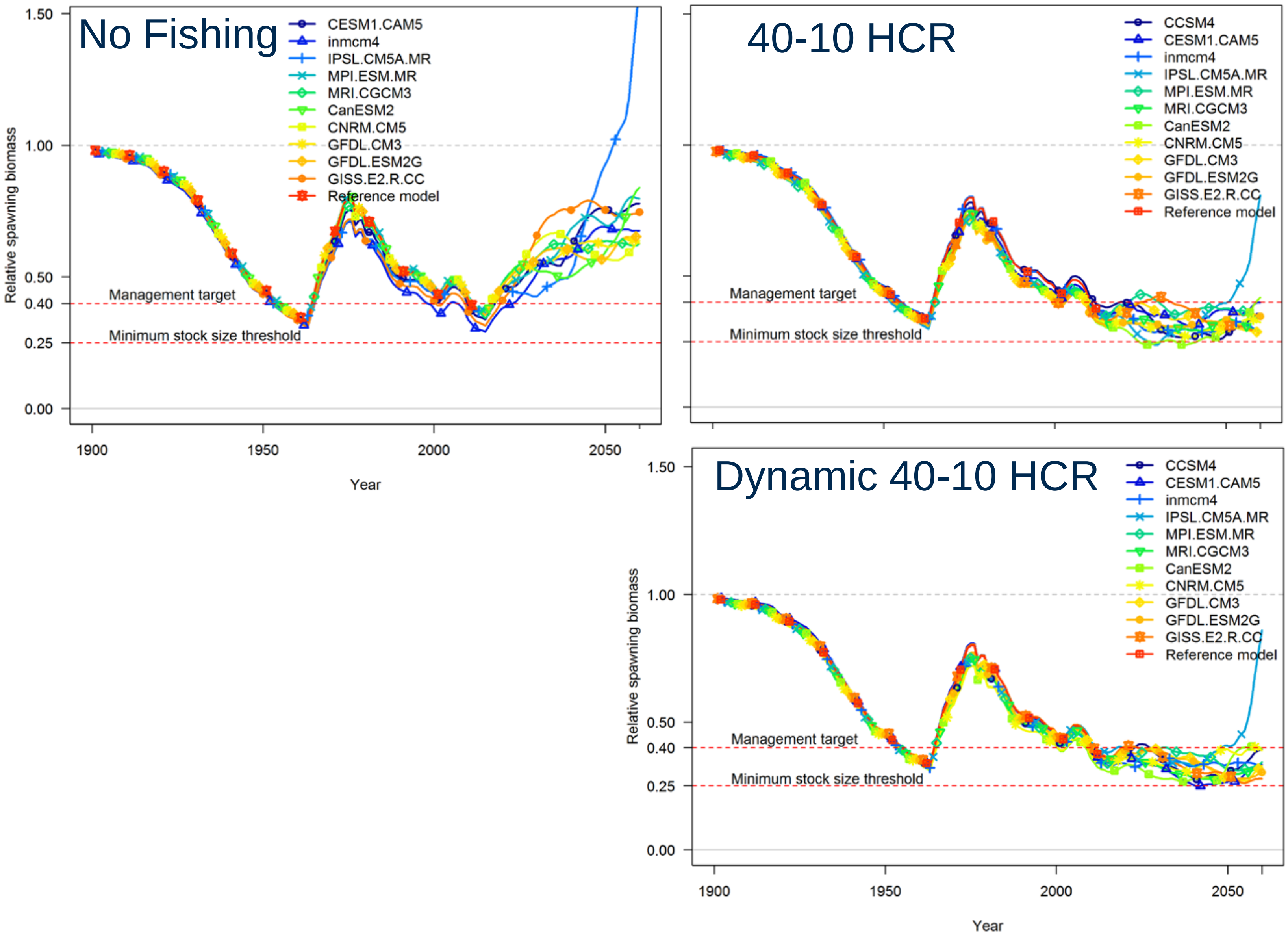
Overland and Wang 2007

CMIP5

Rupp et al 2013

CMIP5-RCP8.5 (11)
CCSM4
CanESM2
GFDL.CM3
GFDL.ESM2G
Inmcm4
IPSL.CM5A.MR
MPI.ESM.MR
MRI.CGCM3
CNRM.CM5
GISS.E2.R.CC
CESM1.CAM5

MSE Results: Time Series of Stock Depletion



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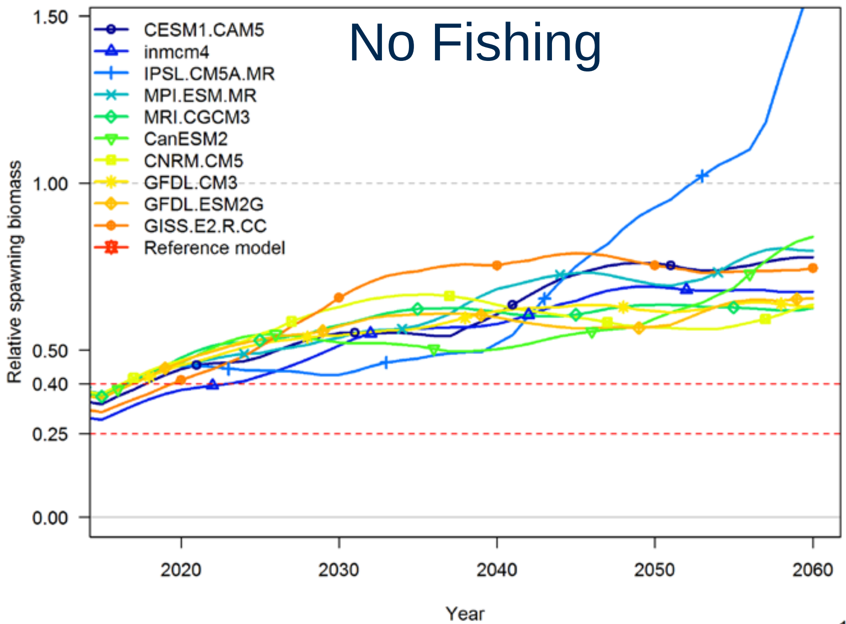
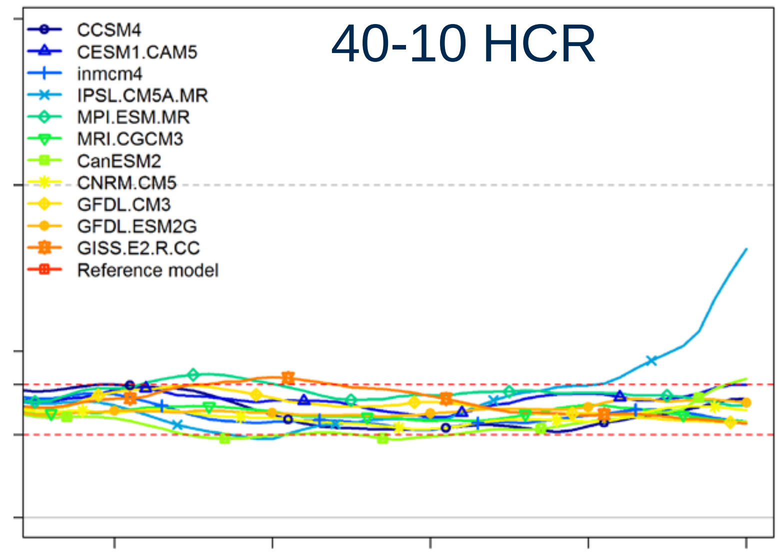
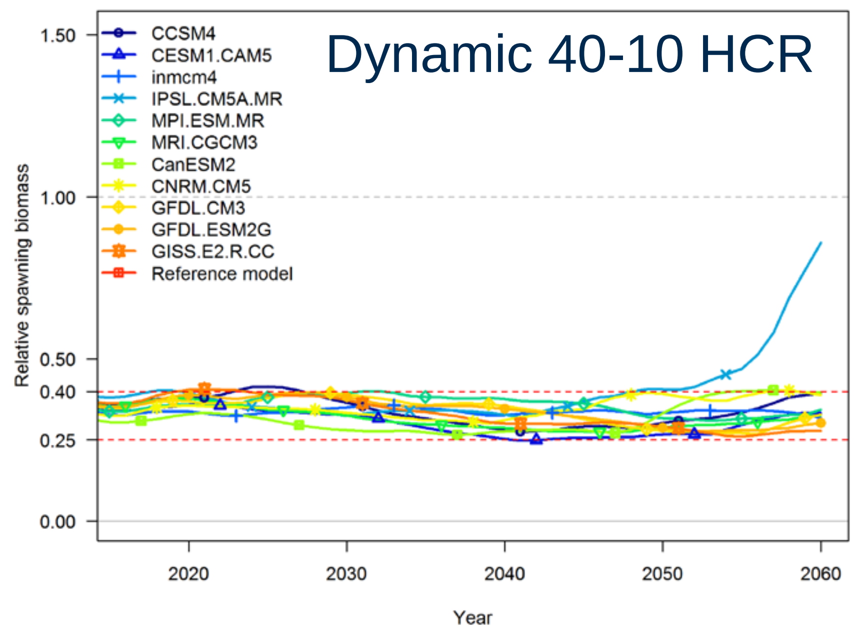
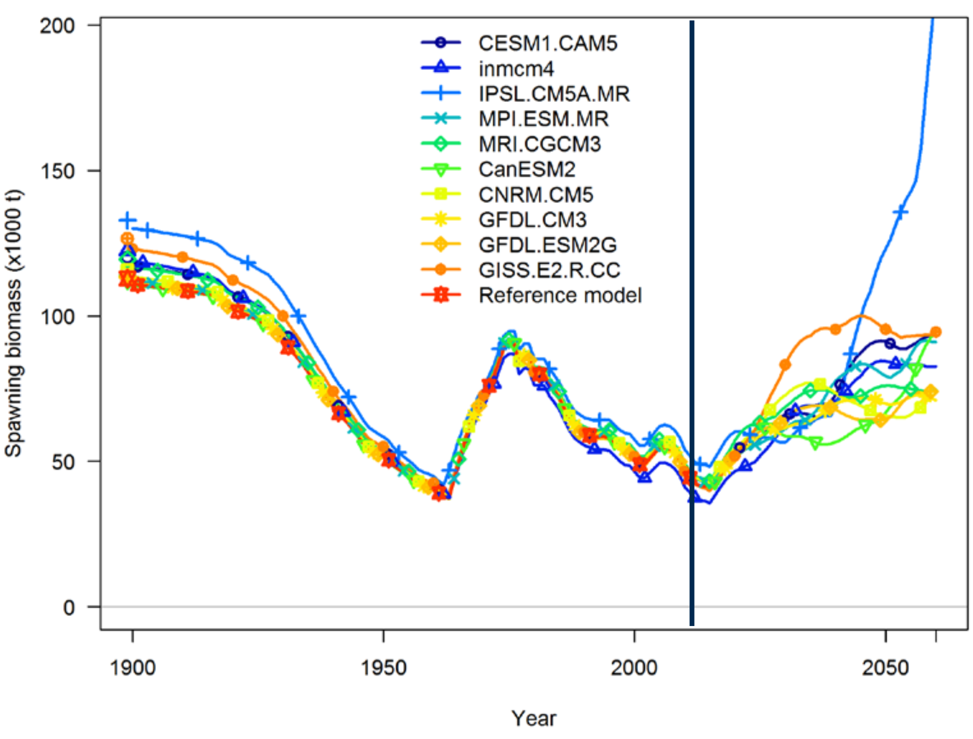




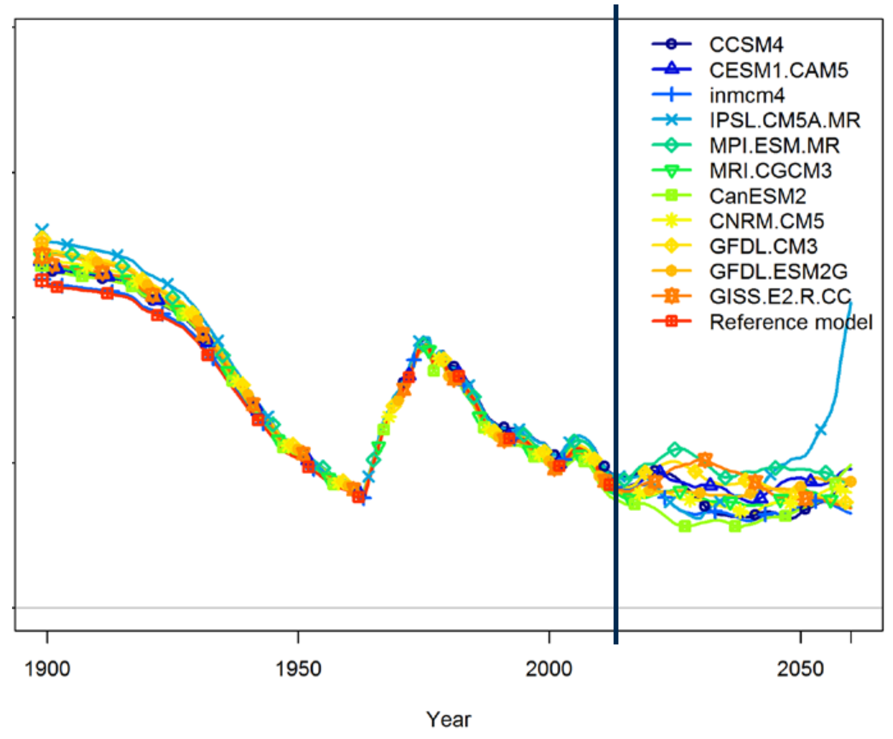


MSE Results: Time Series of Spawning Biomass

No Fishing



40-10 HCR



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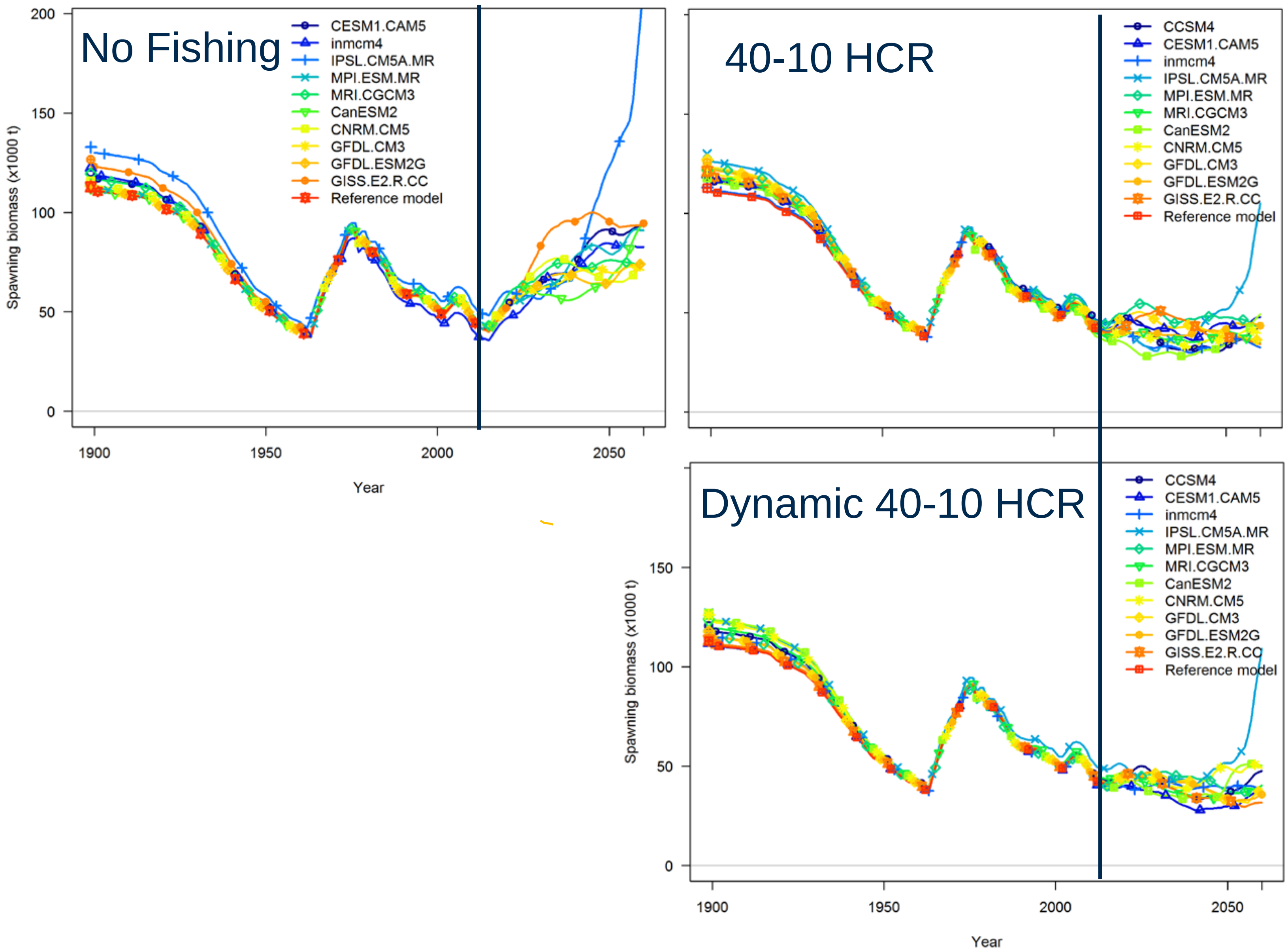
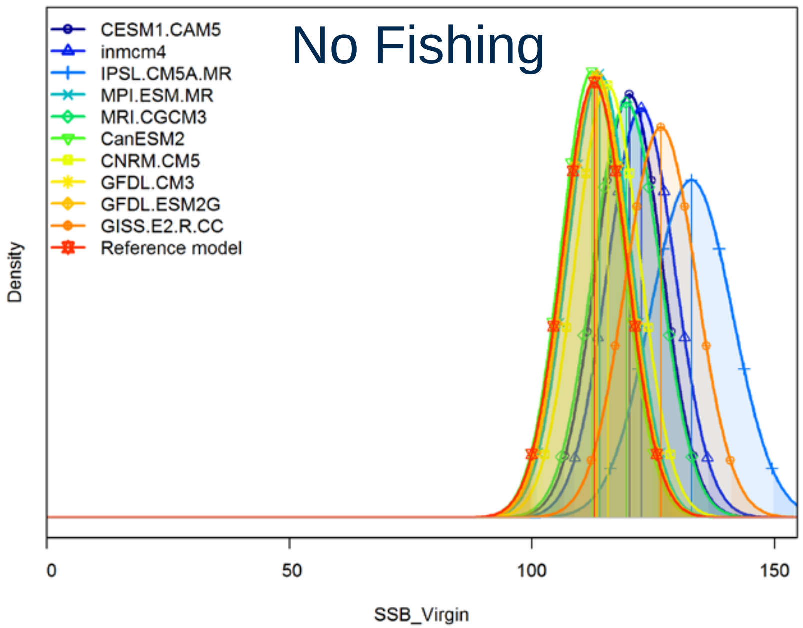
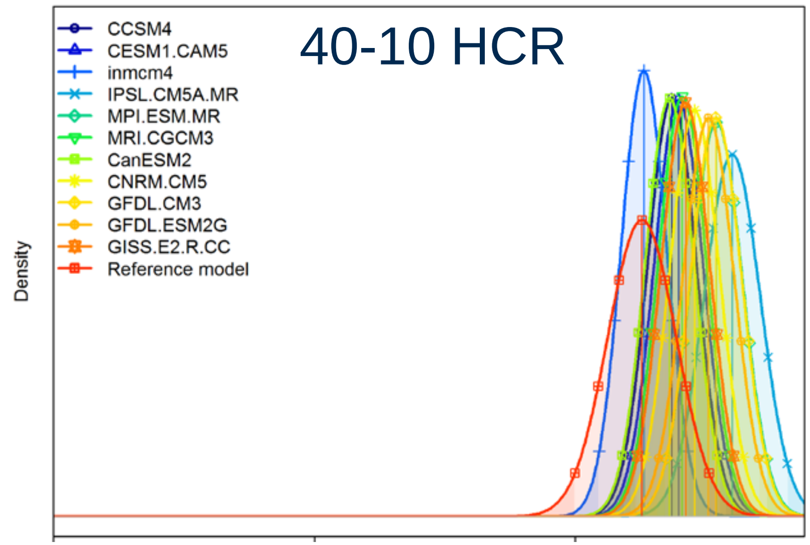
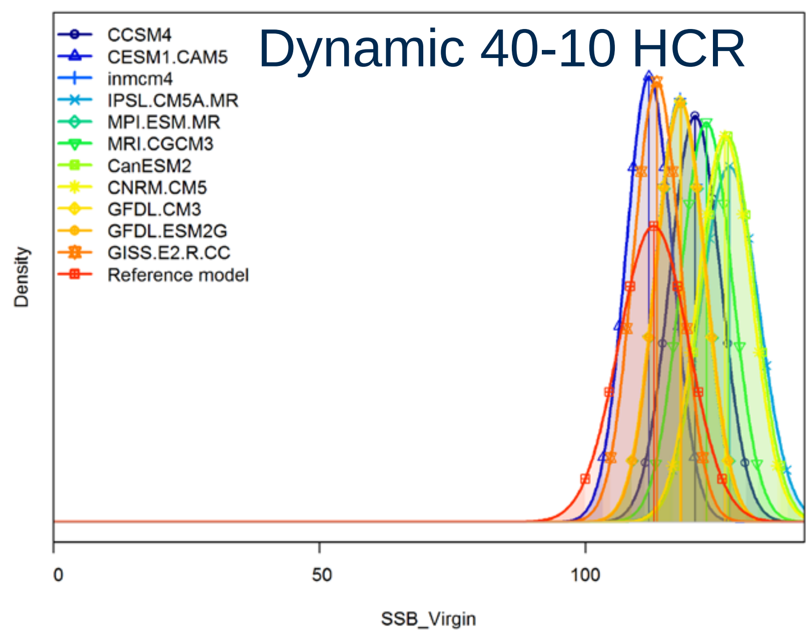


MSE Results: Distribution of Unfished Spawning Biomass

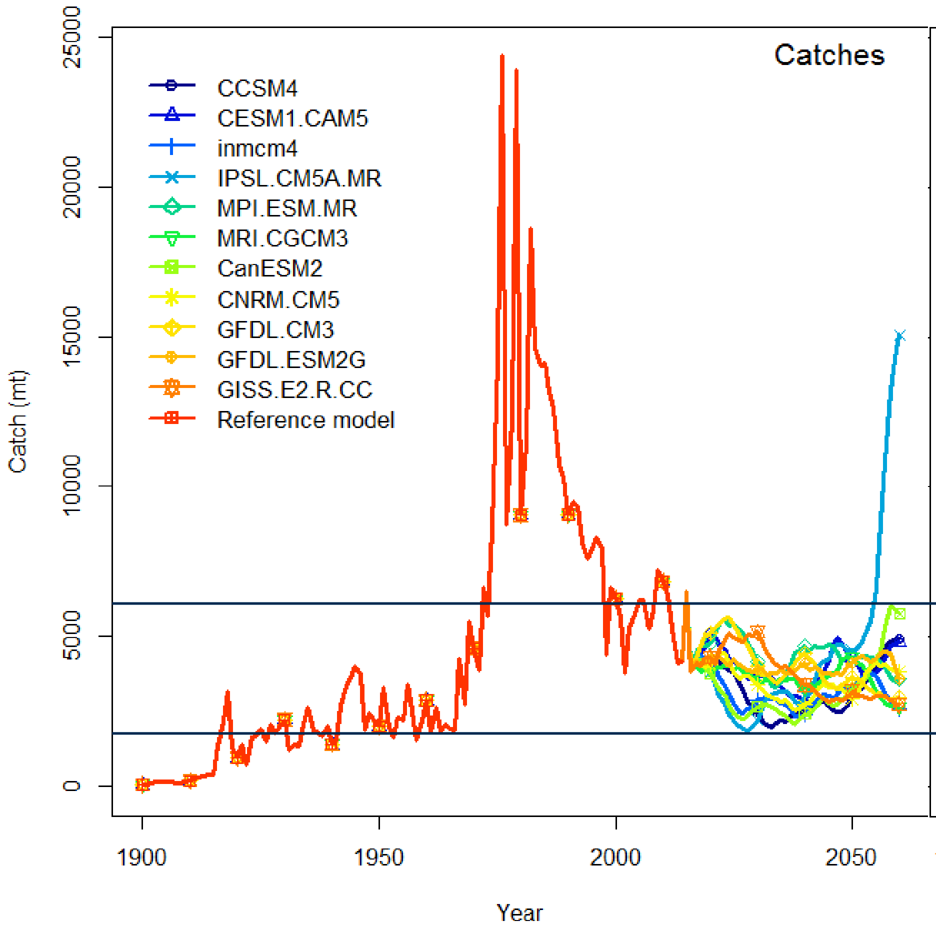




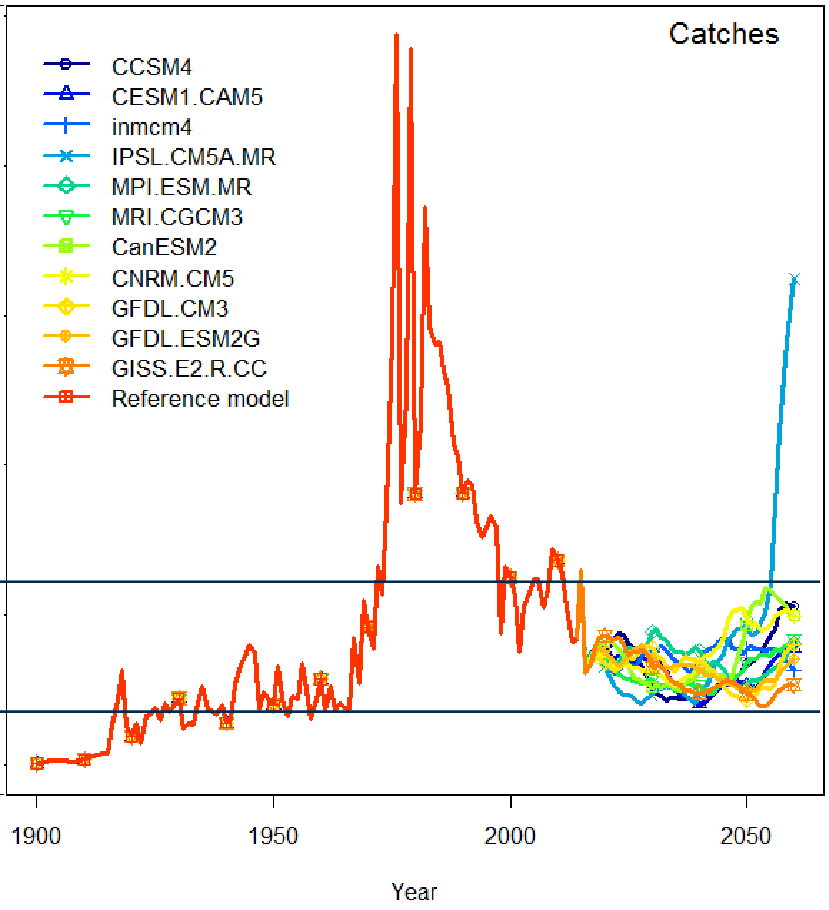


MSE Results: Catches

40-10 HCR

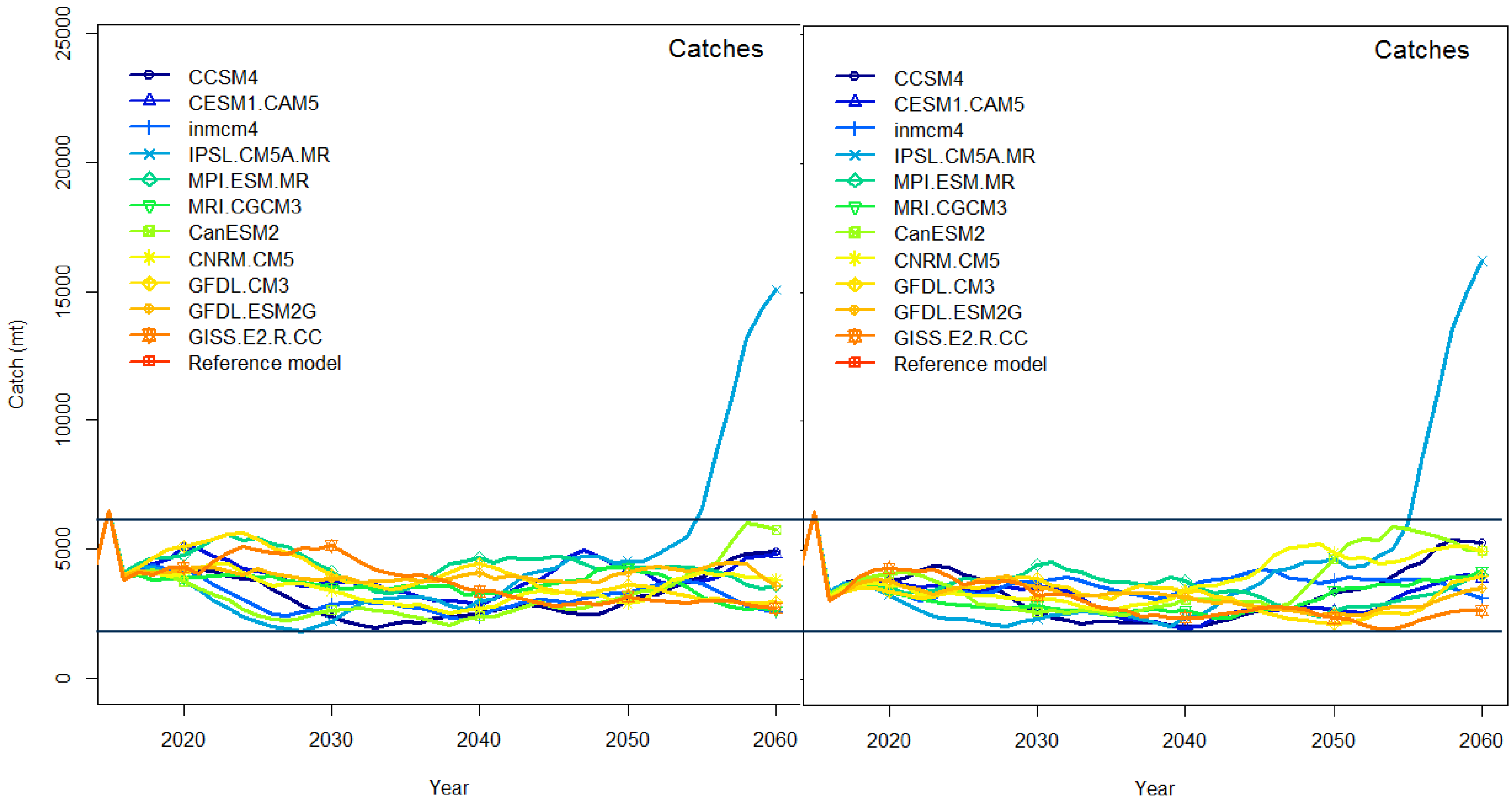


Dynamic 40-10 HCR

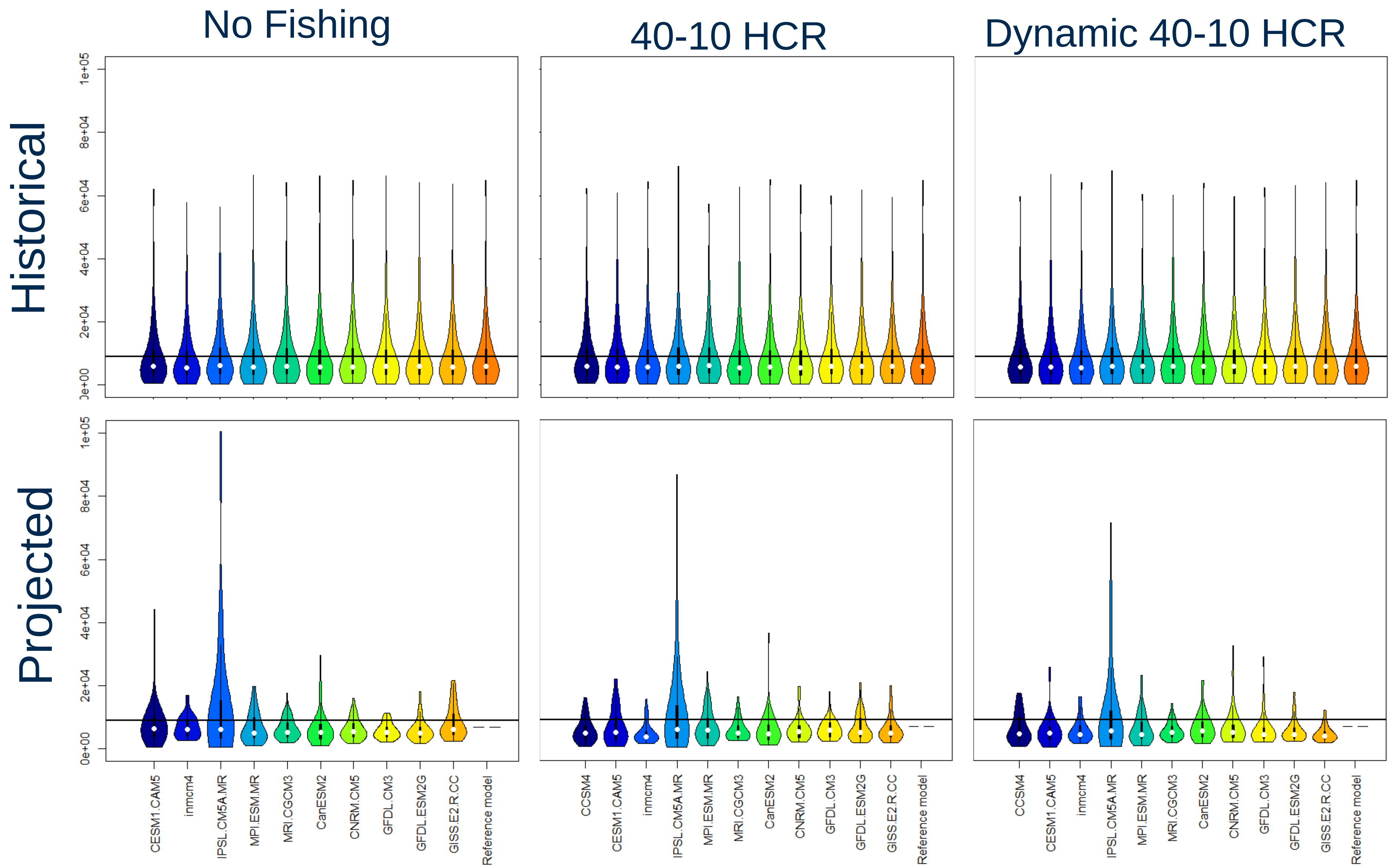


MSE Results: Catches

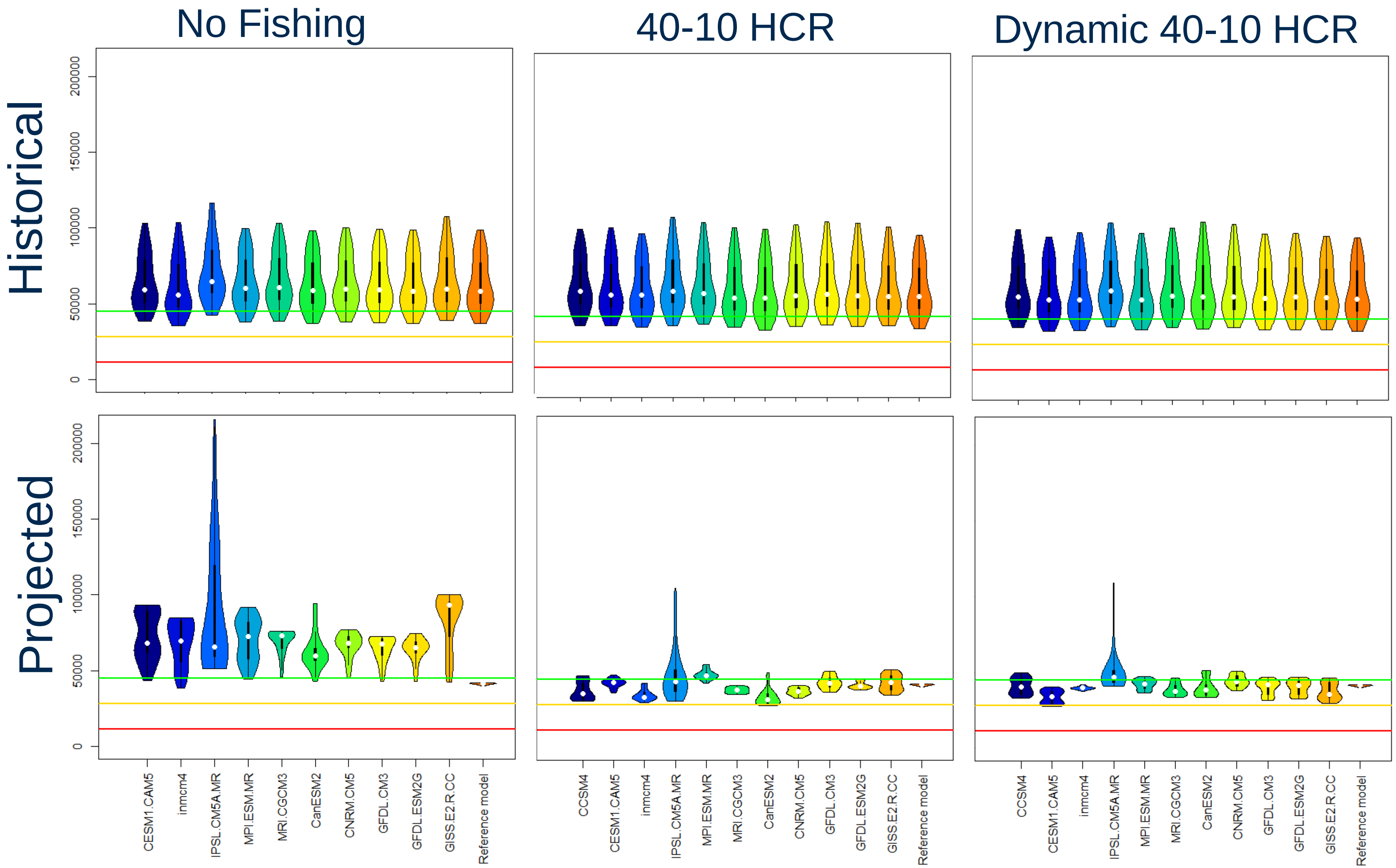
40-10 HCR　　　　Dynamic 40-10 HCR



MSE Results: Recruitment distribution versus management target

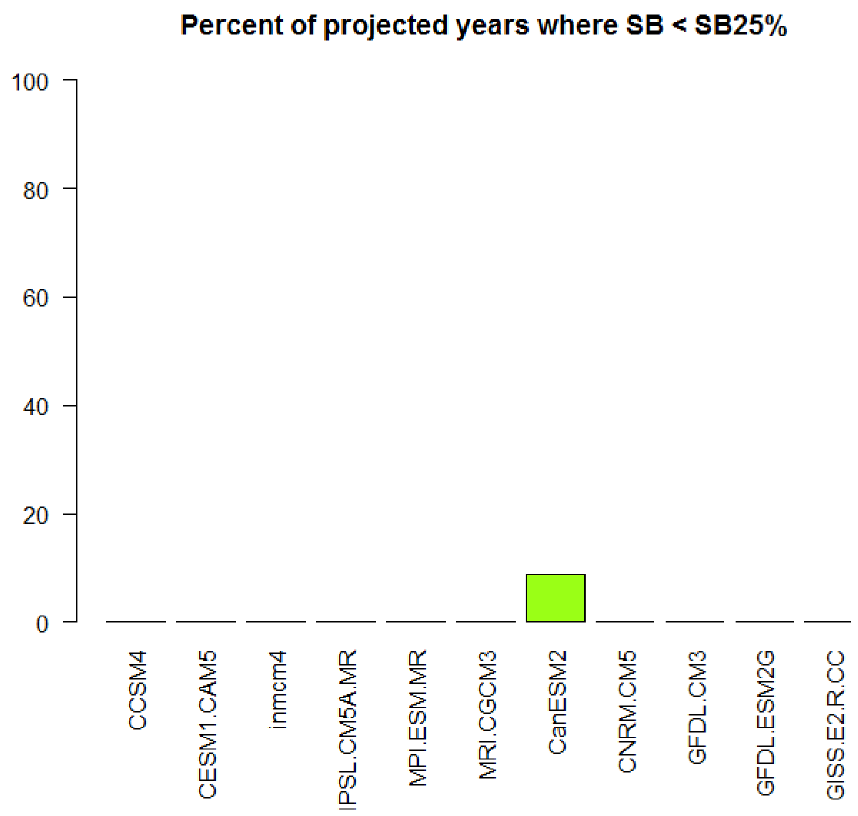


MSE Results: Spawning biomass (mt) distribution versus management target

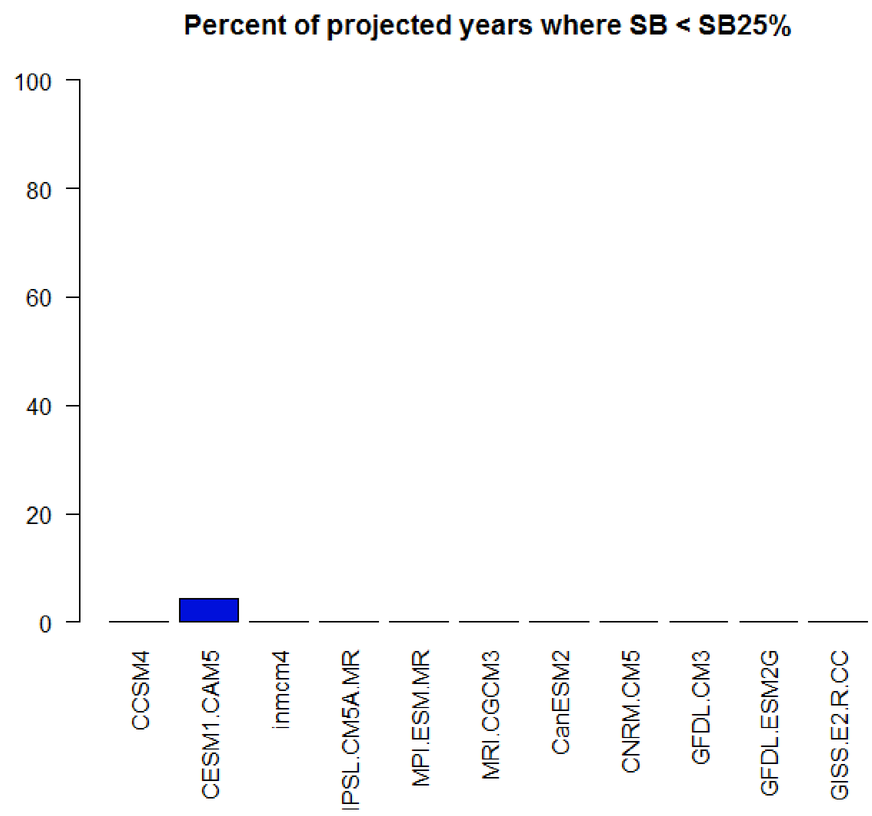


MSE Results: Proportion of years below management limit and fishery closure

40-10 HCR



Dynamic 40-10 HCR



Reference Points

	No Catch		40-10 HCR	
	Average	Standard Deviation	Average	Standard Deviation
Unfished recruitment (millions)	9.262	0.492	9.408	0.405
Unfished spawning biomass (mt)	118,958	6,738	122,154	4,921
Spawning biomass at 40% Unfished spawning biomass (mt)	47,584	2,695	48,862	1,968
Catch at 40% Unfished spawning biomass (mt)	4,417	242	4,505	193
Spawning Biomass at MSY (mt)	34,823	1,993	35,811	1,434
Catch at MSY (mt)	4,630	252	4,721	203
Spawing biomass 2015-2024 (mt)	51,122	3,488	42,214	4,523
Spawning biomass 2051-2060 (mt)	87,741	26,051	42,795	10,580
Ratio of biomass 2015-2024 to Unfished spawning biomass	43.1%	3.2%	34.6%	3.5%
Ratio of biomass 2051-2060 to Unfished spawning biomass	73.1%	17.2%	34.9%	7.5%

Reference Points

	No Catch		40-10 HCR		Dynamic Unfished Biomass 40-10 HCR	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Unfished recruitment (millions)	9.262	0.492	9.408	0.405	9.247	0.400
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Catch at 40% Unfished spawning biomass (mt)	4,417	242	4,505	193	4,426	197
Spawning Biomass at MSY (mt)	34,823	1,993	35,811	1,434	35,149	1,526
Catch at MSY (mt)	4,630	252	4,721	203	4,639	206
Spawing biomass 2015-2024 (mt)	51,122	3,488	42,214	4,523	43,145	3,084
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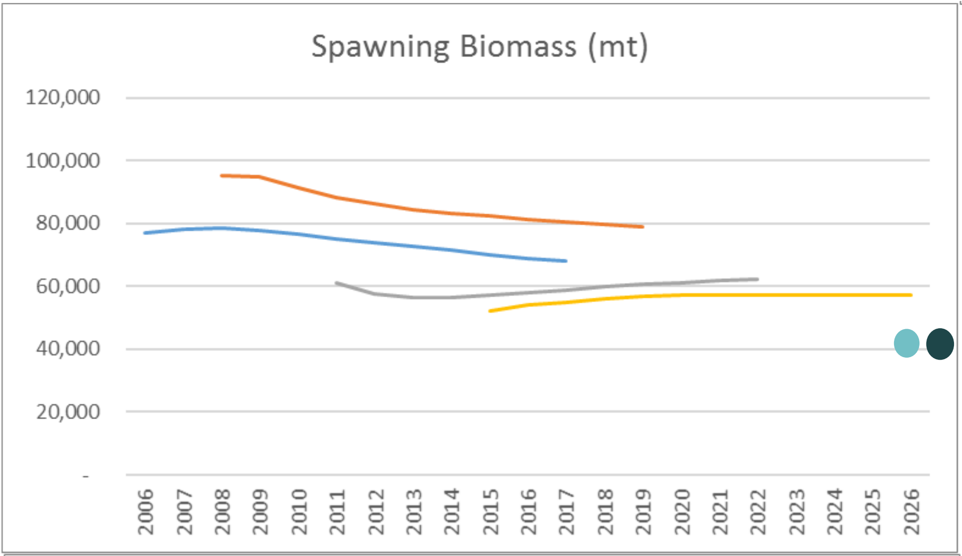
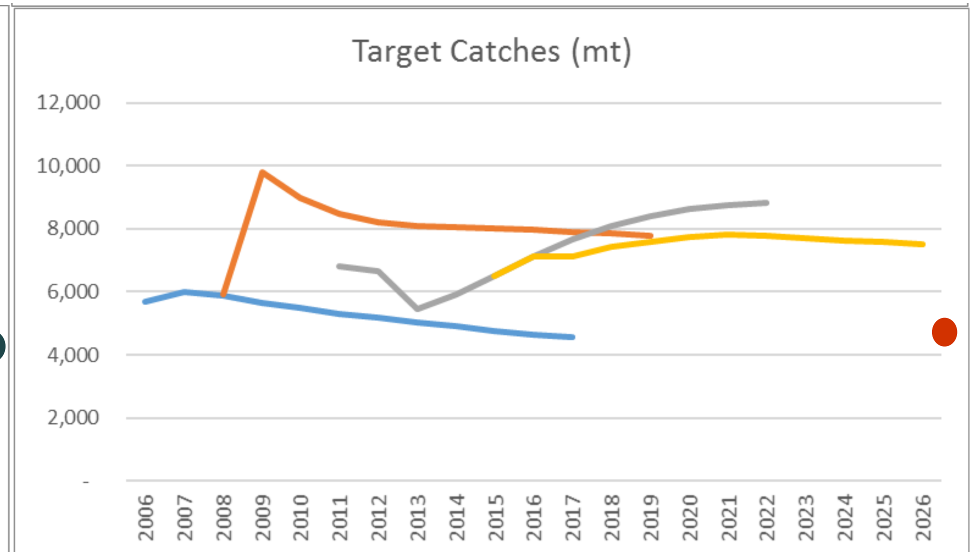
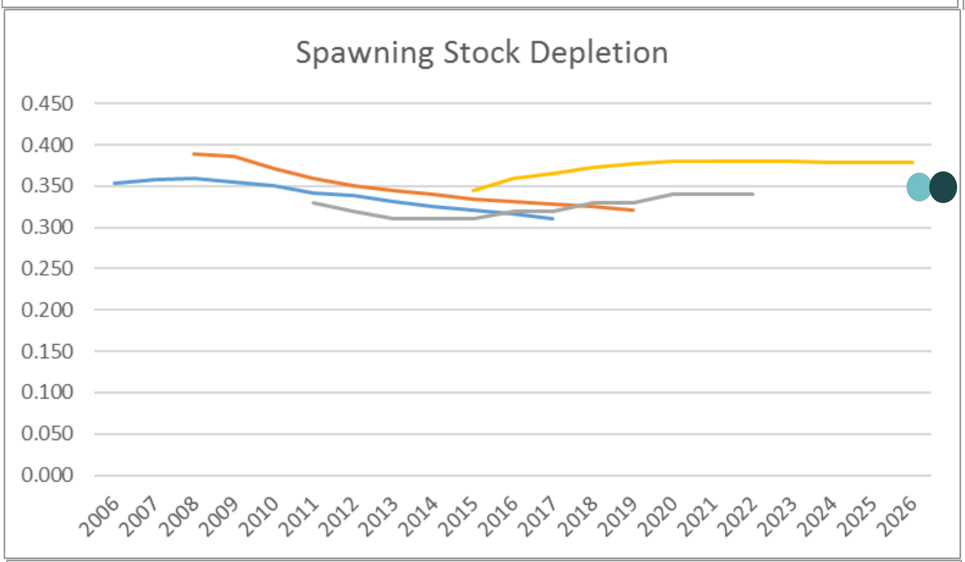
Ratio of biomass 2015-2024 to Unfished spawning biomass	43.1%	3.2%	34.6%	3.5%	36.0%	2.4%
Ratio of biomass 2051-2060 to Unfished spawning biomass	73.1%	17.2%	34.9%	7.5%	34.5%	8.5%

Past and Projected Management Advice







2005 Assessment

2007 Assessment

2011 Assessment

2015 Assessment

2015-2024 40-10 Mean Projected Value, IPCC

2051-2060 40-10 Mean Projected Value, IPCC

Catch 40% Unfished spawning biomass (mt)

Future Directions

Maintain monitoring programs

Engage with industry and managers to solicit feedback on alternative control rules and performance metrics

Collaborate with NE Pacific sablefish scientists

- Straddling stock data and assessment issues

Consider community adaptation strategies

Investigate the utility and skill of short term seasonal to annual forecasting using regional environmental indices at spatio-temporal scales relevant to the sablefish life history.

Research technical aspects of recruitment hindcasting and bias correction.