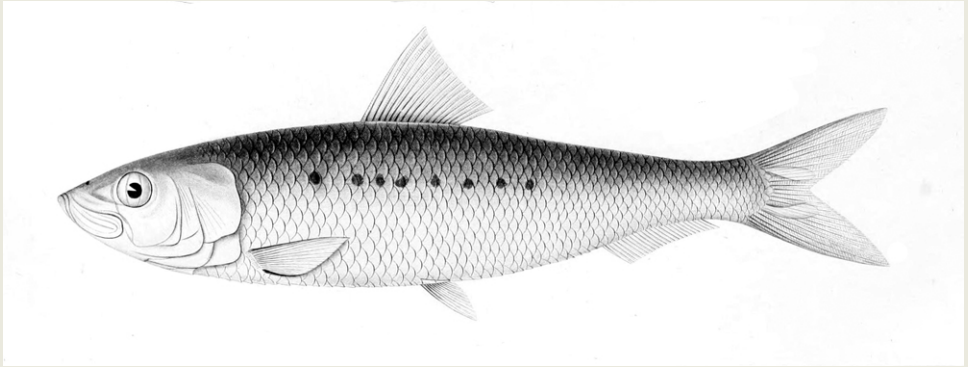
REVISED ANALYSES RELATED TO EVALUATING PARAMETER VALUE CHOICES FOR PACIFIC SARDINE



Felipe Hurtado-Ferro and André E. Punt

School of Aquatic and Fishery Sciences, University of Washington

SUMMARY

- Context
- Environmental index
- Recalculated relationship and new harvest control rule
- Simulation testing of the harvest control rule
- Sensitivities

CONTEXT

Pacific Sardine: Management Process (Amendment 8 & 13)

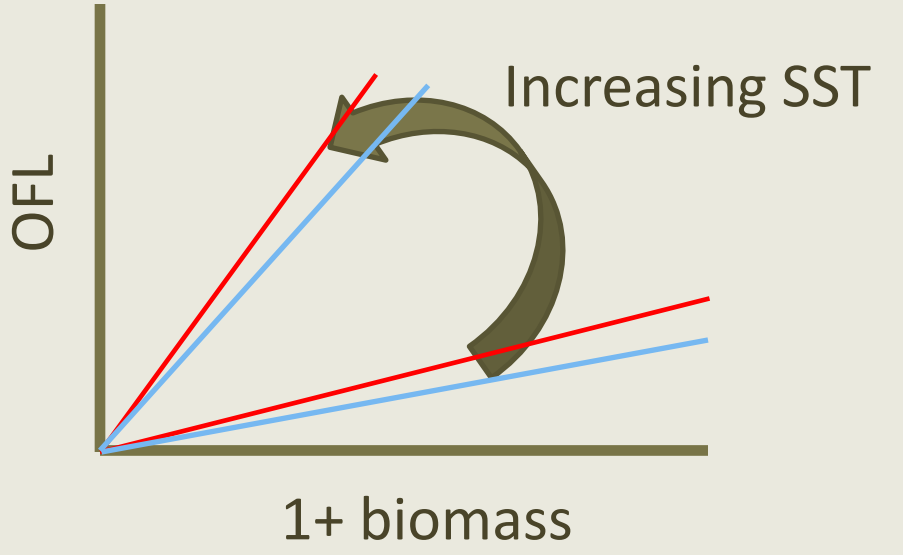
Overfishing Level (OFL)

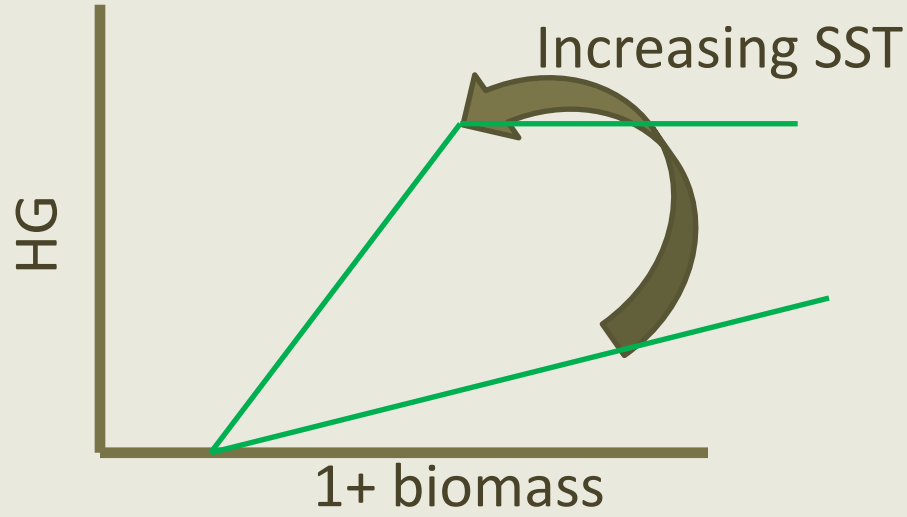
↓ *P**

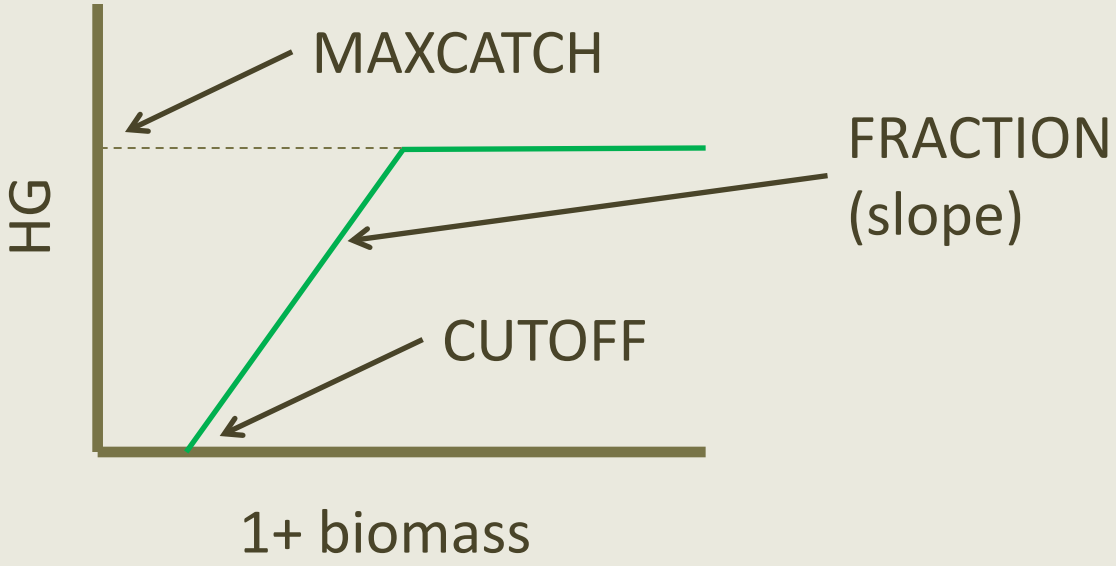
Acceptable Biological Catch (ABC)

↓

Harvest Guideline (HG)







ISSUE:

- Value for MAXCATCH?
- Value for CUTOFF?
- Relationship between FRACTION and an environmental variable?
- What environmental variable to use?

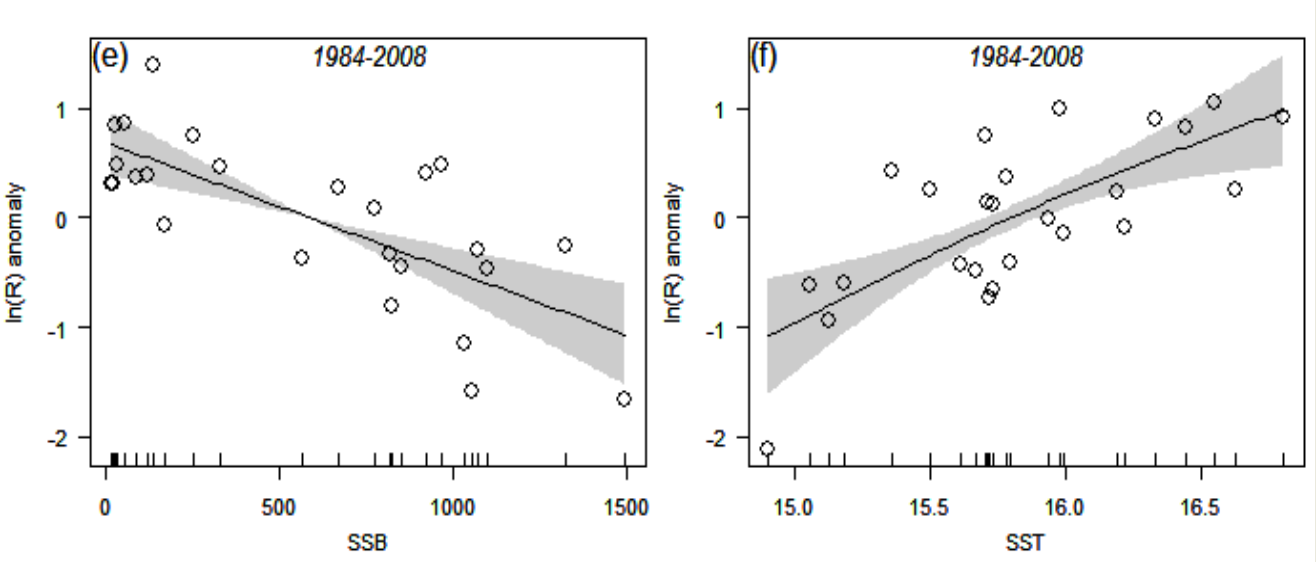
Background

- In Amendment 8 to the CPS FMP, FRACTION is a function of 3-year average sea surface temperature (SST) at Scripps Pier (SIO) (bounded by 5 and 15%).
- McClatchie et al. (2010)* reanalysed the data on which the SST-recruitment relationship was based and found the relationship was no longer significant.

*McClatchie, S., Goericke, R., Auad, G., and Hill, K. 2010. *Canadian Journal of Fisheries and Aquatic Sciences* **67**: 1782–1790.

ENVIRONMENTAL INDEX

Recruitment is related to both environment and spawning biomass



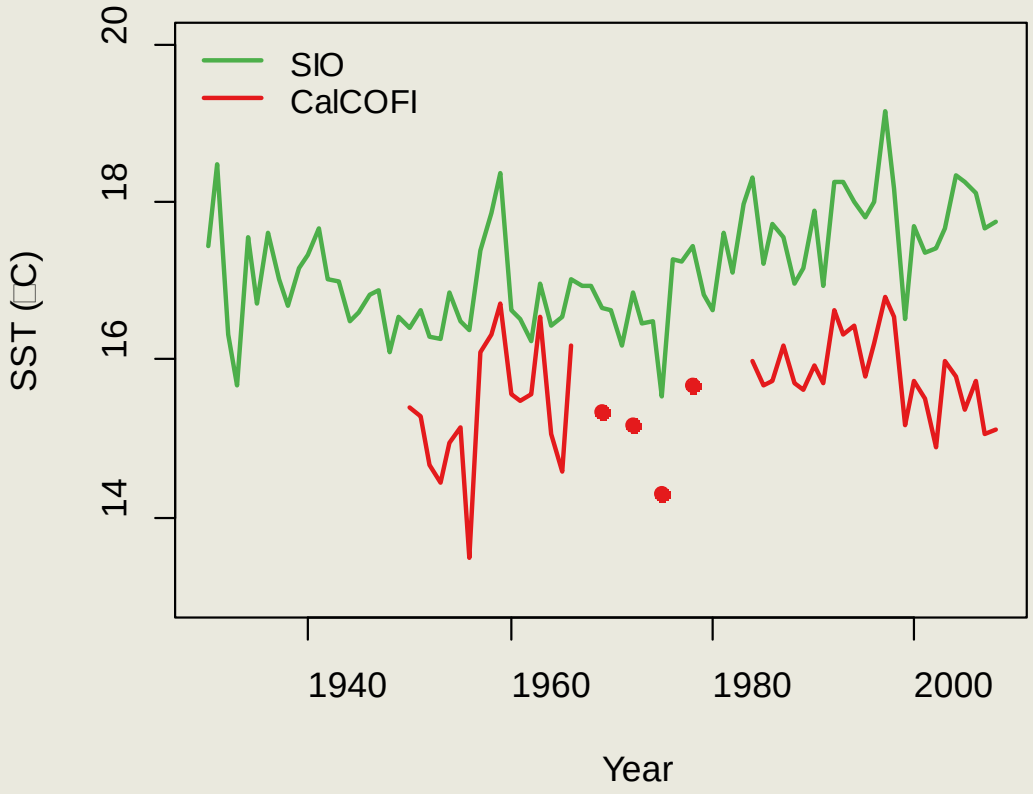
The relation between several environmental indices and recruitment was evaluated.

CalCOFI SST provides a better fit than SIO or ERSST to the stock-recruitment data for 1984-2008

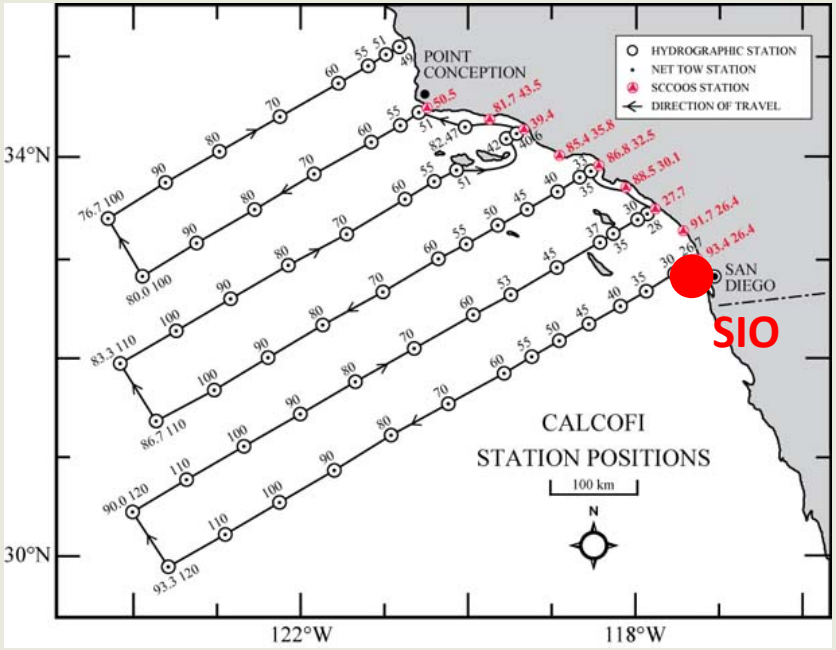
Series	AIC	R^2
SST_CC_ann	44.49	0.76
SIO_SST_ann	56.81	0.61
ERSST_ann	55.3	0.63

From PFMC 2013, Table App.E.6

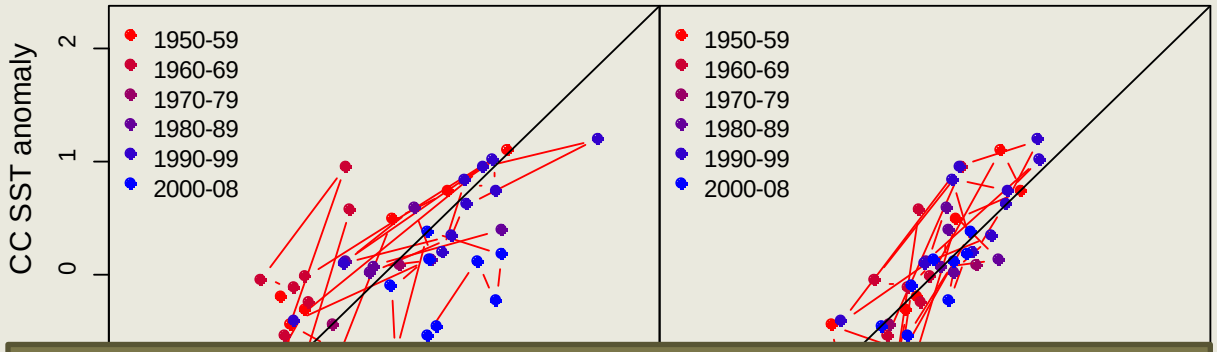
SIO is the index being used in the current harvest control rule. CalCOFI is the index that better explains recruitment



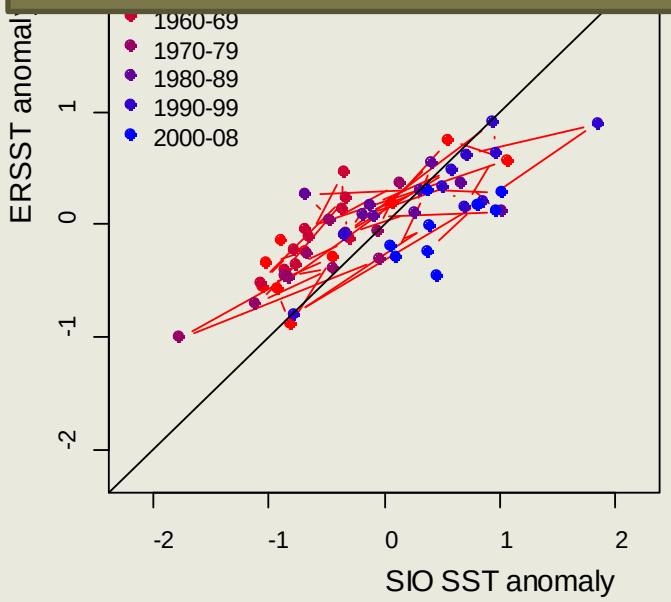
SIO and CalCOFI indices have different scales, and are representative of different geographical areas.

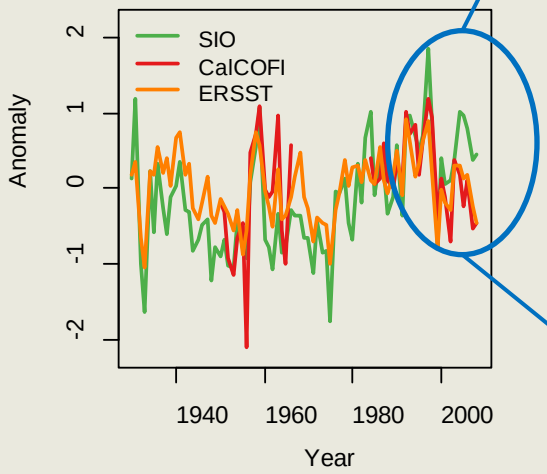


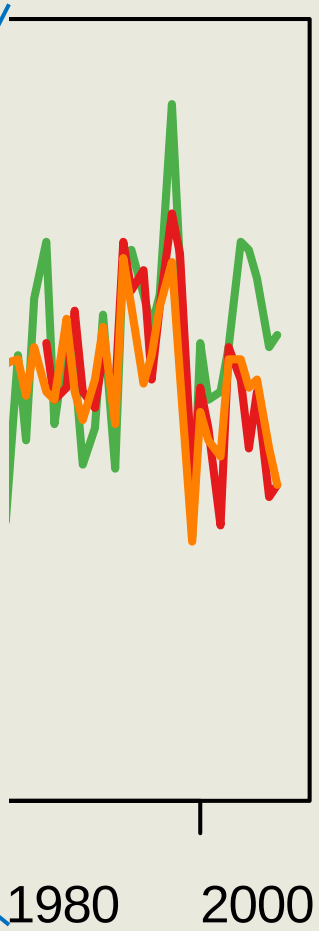
Comparing sea surface temperature time series



SIO is diverging from other environmental indices in the area, remaining warm as others become increasingly colder

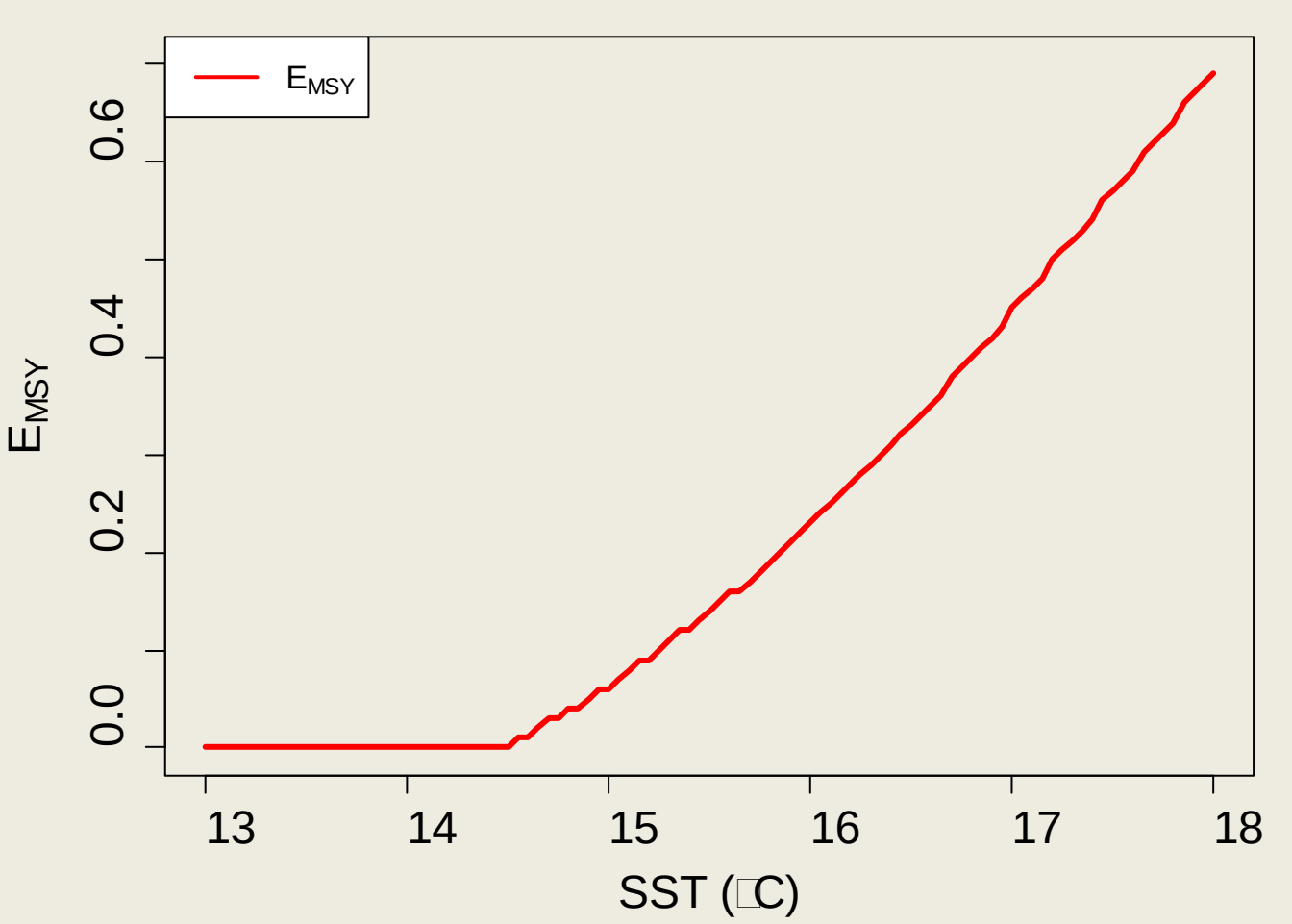




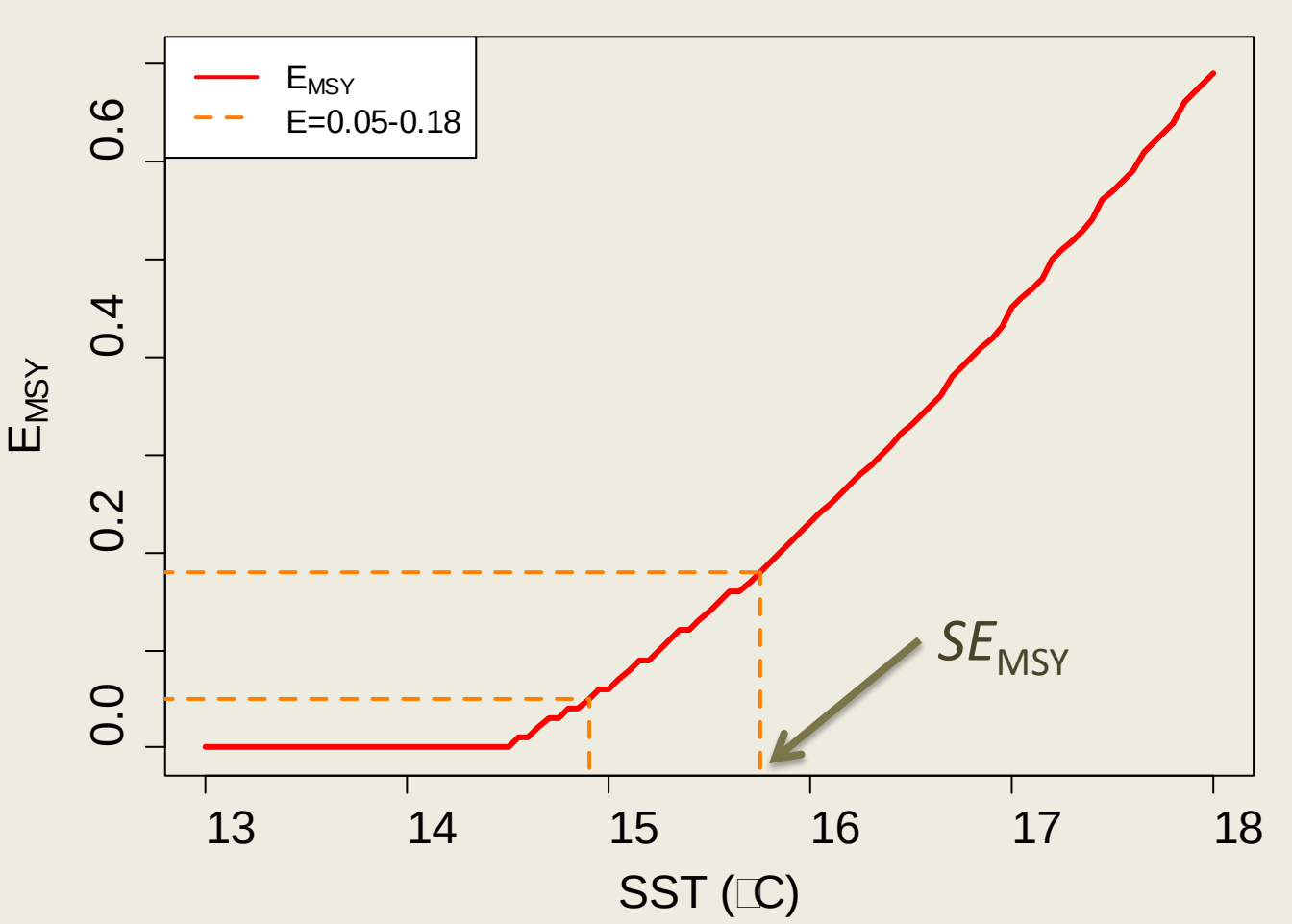


RECALCULATED RELATIONSHIP BETWEEN ENVIRONMENT AND E_{MSY}

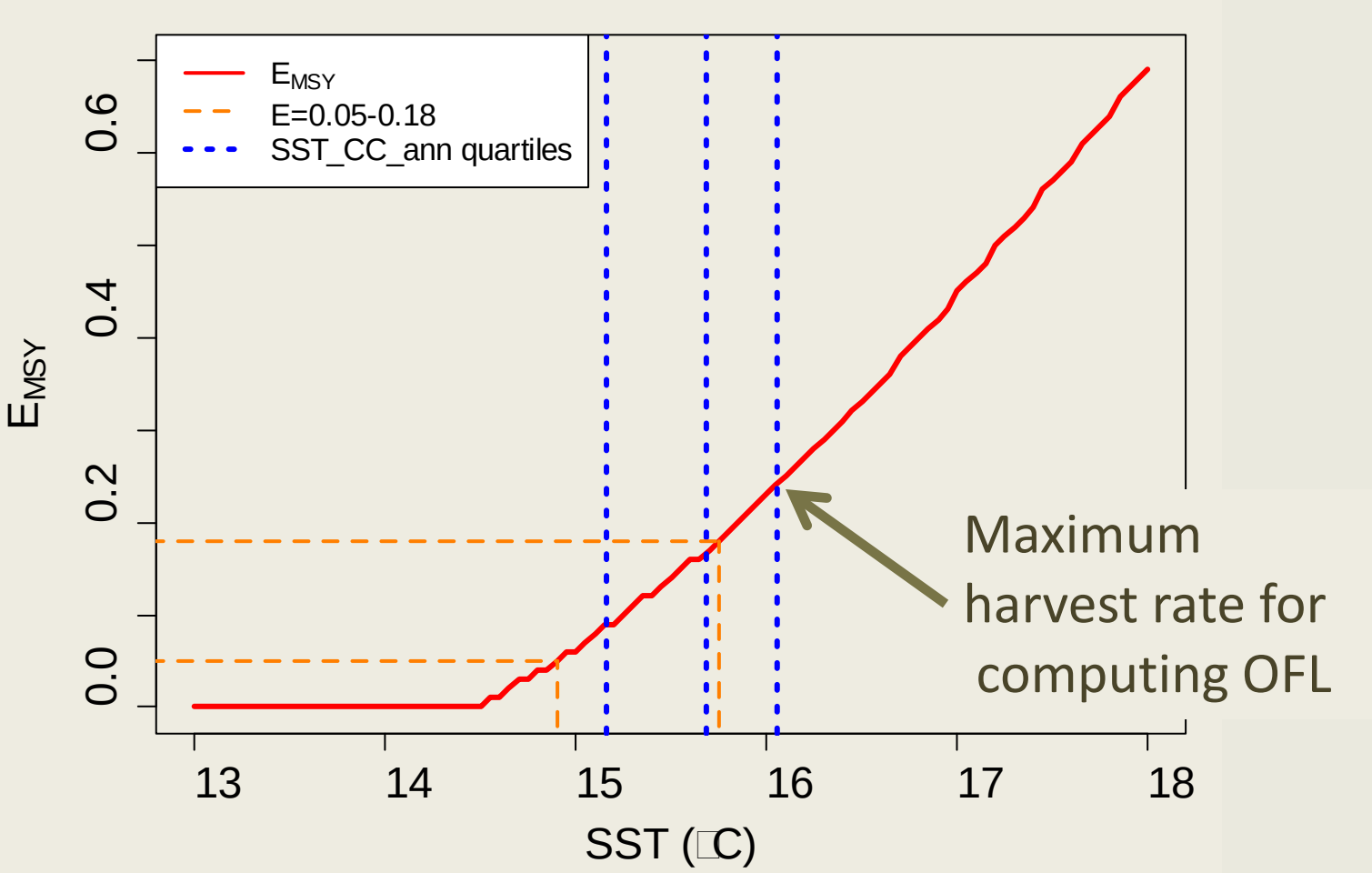
Calibrating the “CalCOFI” HG control rule



Calibrating the “CalCOFI” HG control rule



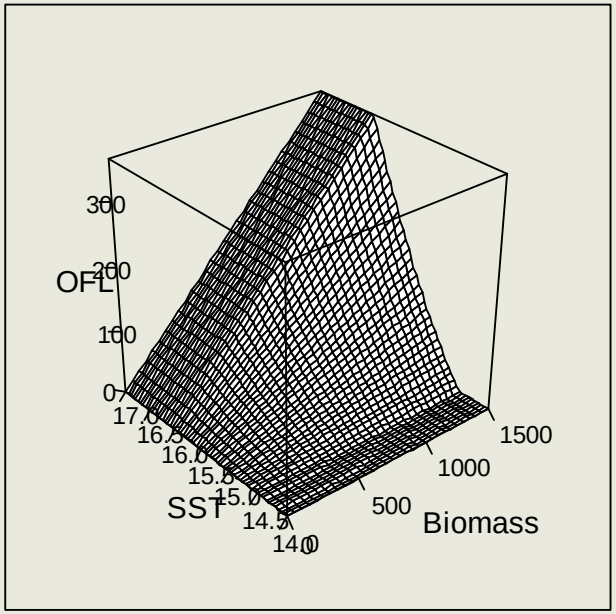
Calibrating the “CalCOFI” HG control rule



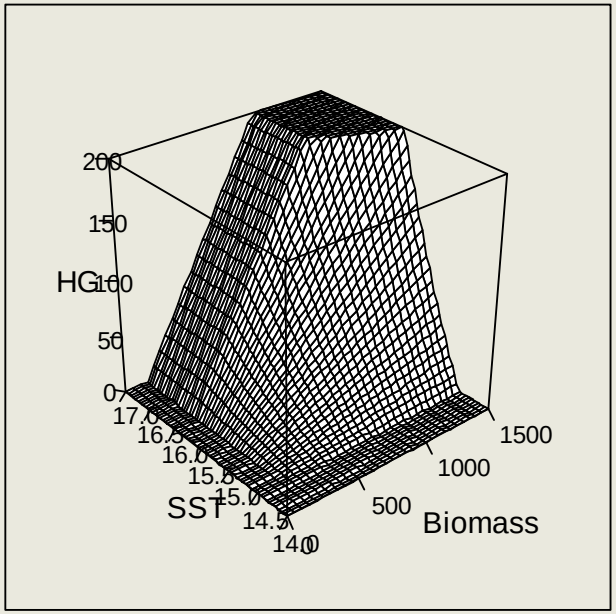
CalCOFI-based harvest control rule

The harvest control rule depends on both the 1+ biomass and the CalCOFI SST

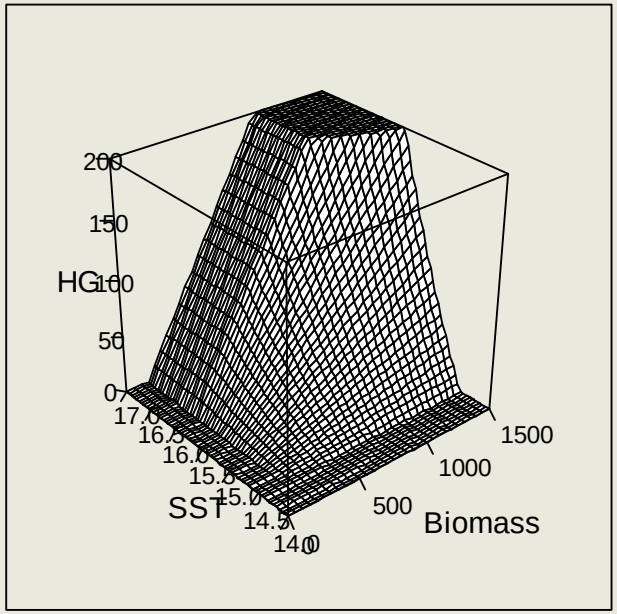
OFL control rule



HG control rule

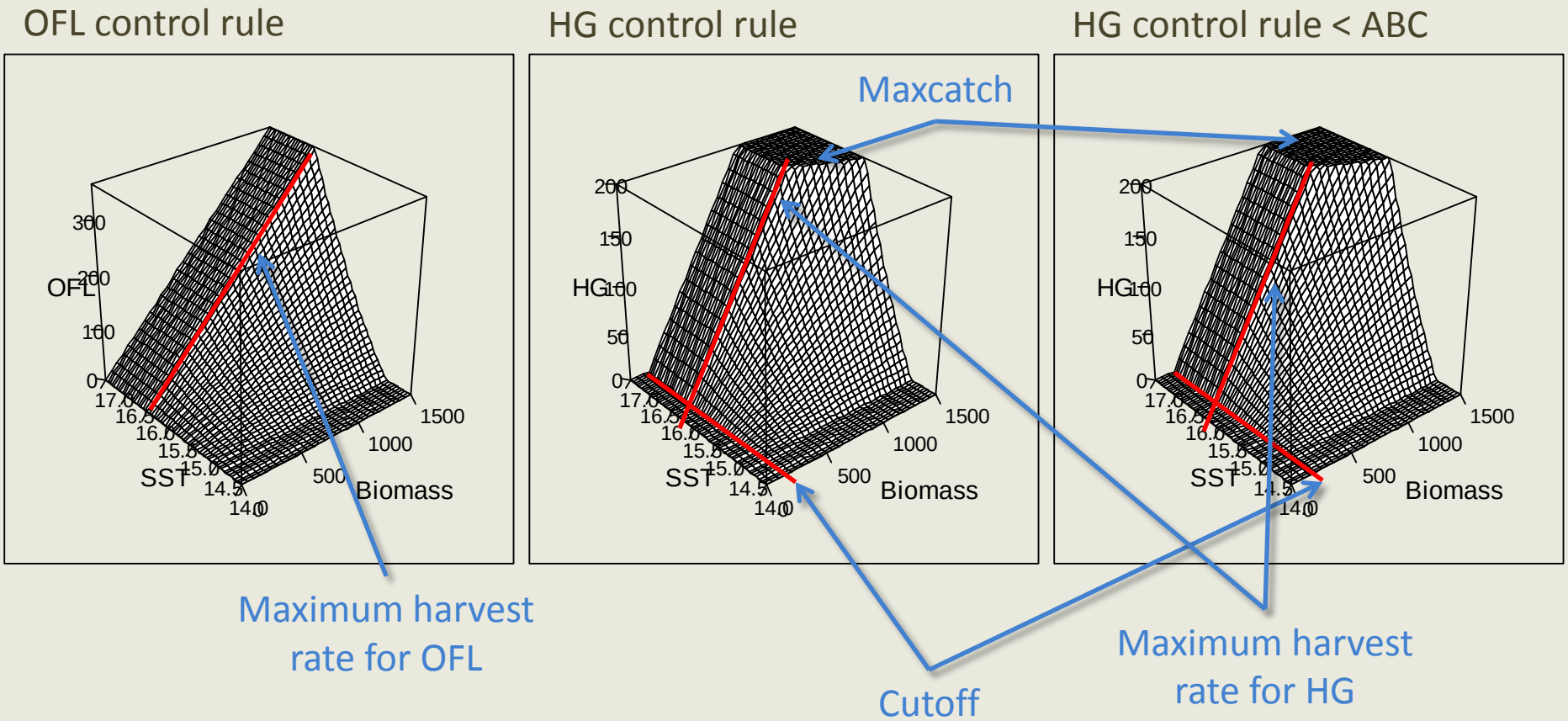


HG control rule < ABC



CalCOFI-based harvest control rule

The harvest control rule depends on both the 1+ biomass and the CalCOFI SST



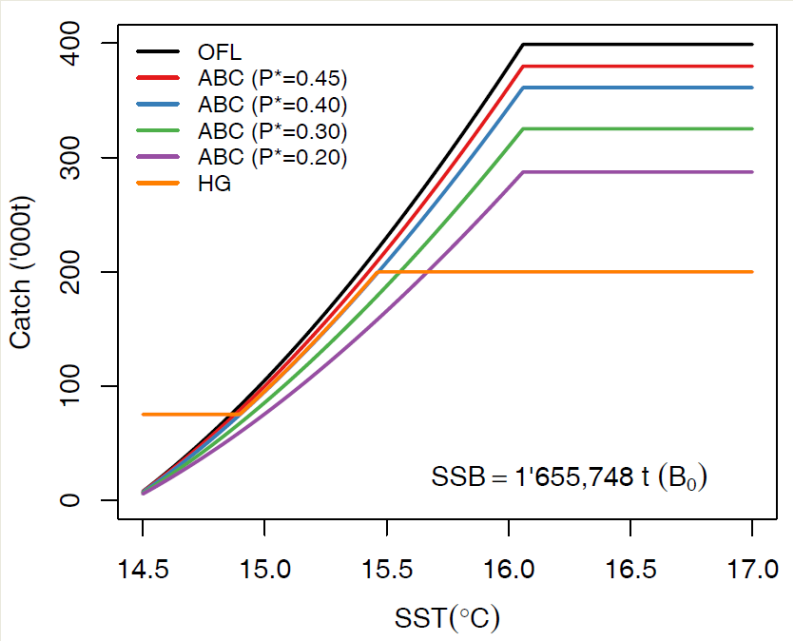
Comparison of the current HCR using CalCOFI as temperature index, revised

Mgmt. Year	Biomass (July)	SIO	
		SST	HG
2000	1581346	18.08	186791
2001	1182465	17.75	134737
2002	1057599	17.24	118442
2003	999871	17.31	110908
2004	1090587	17.46	122747
2005	1193515	17.6	136179
2006	1061391	18.03	118937
2007	1319072	18.11	152564
2008	832706	18.12	89093
2009	662886	17.83	66932
2010	702024	17.84	72039
2011	537173	17.9	50526
2012	988385	17.64	109409
2013	659539	17.35	66495

SIMULATION TESTING OF THE HARVEST CONTROL RULE

Harvest Control Rule variants

- Different choices for FRACTION, CUTOFF and MAXCAT
- FRACTION :
  - can be a constant (e.g. E_{MSY}) or
  - can be related to the environmental variable (e.g. 5% at 14.89^{0}C and E_{MSY} at 15.47^{0}C)
- Note: results are provided for illustrative “harvest policy variants”.

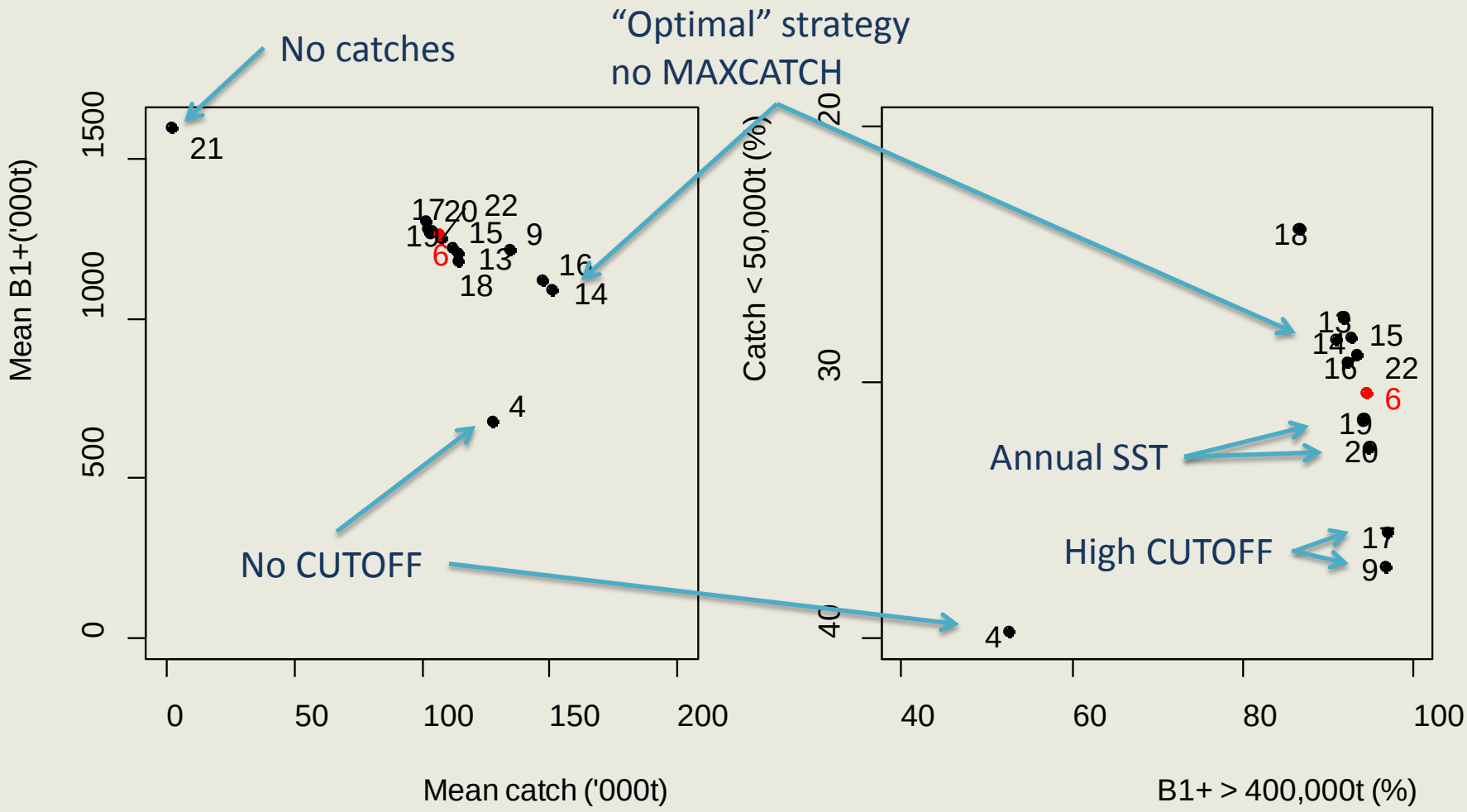


Quantifying trade-offs between different HCR variants: Biomass vs. catch

The performance measures are selected to quantify performance relative to [some] management goals.

- Average catch (total)
- Average population size (1+ biomass)
- Probability [total] catch is less than some threshold (e.g. 50,000t)
- Probability 1+ biomass is below a threshold.

Quantifying trade-offs between different HCR variants: Biomass vs. catch



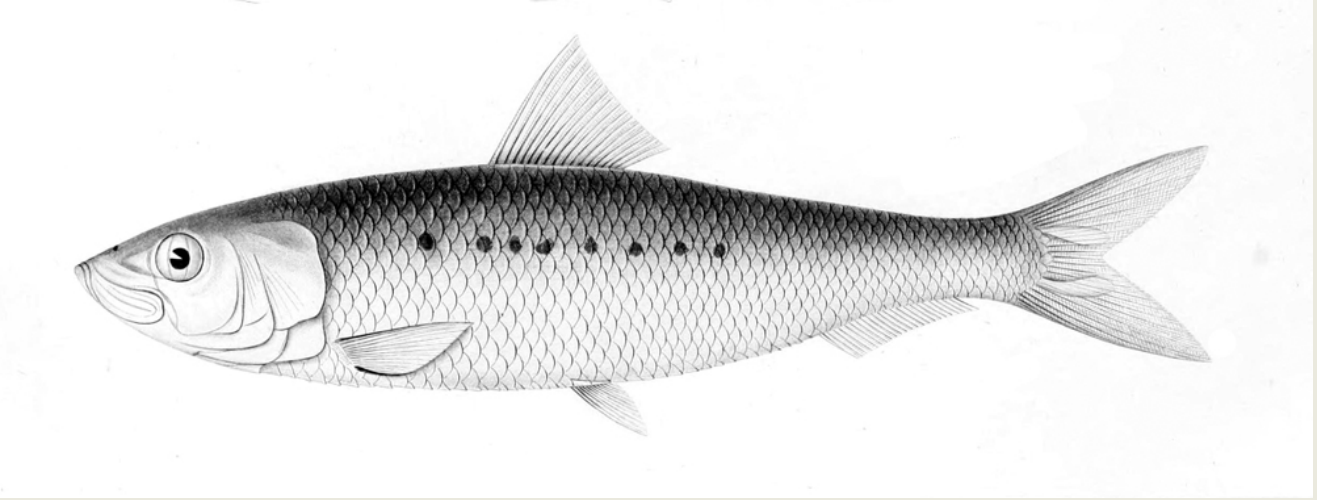
CONCLUSIONS

- There is a trade-off between catch and biomass: maintaining higher biomass levels imply having lower catches.
- Higher cutoffs have higher probability of low catches. However, including a cutoff results in higher mean catches and higher mean biomass than not doing it.
- With the exception of variant 4, all variants explored produce mean biomass at or above ~70% of unfished biomass.
- Using an annual index increases catch variance.

SENSITIVITIES

Sensitivity analyses allow to evaluate the HCR under alternative assumptions

- Lower environmental variability leads to higher, more stable catches.
- Results are not sensitive to changes in selectivity, growth, natural mortality or to hyper-stability in biomass estimates.
- Results are very sensitive to Mexico and Canada not following the US control rule.
- Results are robust to the use of alternative environmental indices (e.g. ERSST or SIO).



Questions?

Technical assistance: Kerry Griffin, Joshua Lindsay, Kevin Hill, Richard Parrish

HCR variants evaluated for the base case

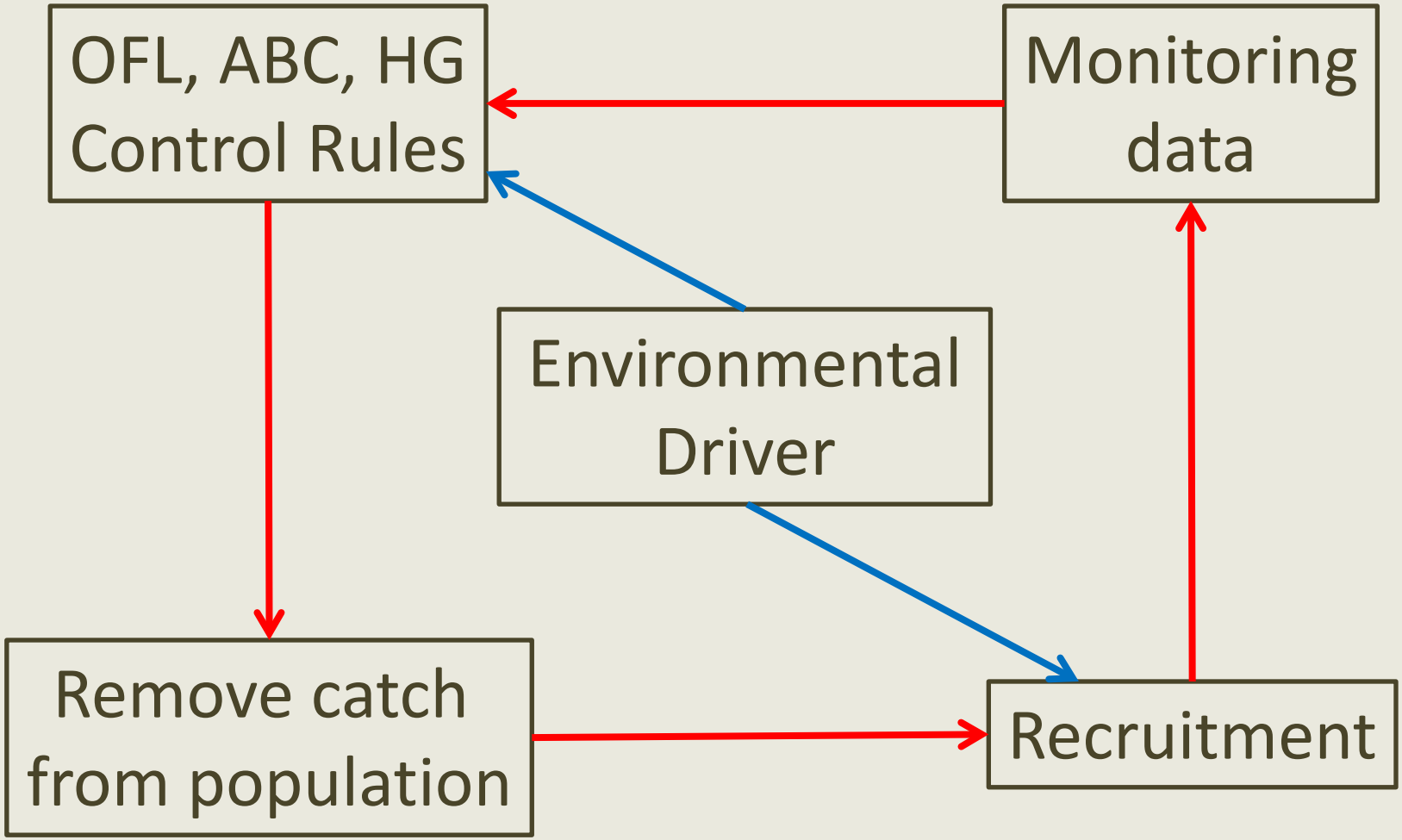
Variants from Hurtado-Ferro and Punt (2013)					
Variant	**M (4)**	**HG (J) (6)**	**HG Variant-3 (9)**	**Alt-3 (13)**	**Alt-4 (14)**
FRACTION (%)	DE_{MSY}	5-15	5- SE_{MSY}	11- SE_{MSY}	SE_{MSY}
CUTOFF	0	150	$0.20B_0$	50	50
MAXCAT		200		200	-
Additional analyses					
Variant	**New-1 (15)**	**New-2 (16)**	**New-3 (17)**	**New-4 (18)**	**New-5 (19)**
FRACTION (%)	SE_{MSY}	SE_{MSY}	5- SE_{MSY}	15*	15**
CUTOFF	150	150	$0.20B_0$	150	150
MAXCAT	200	-	200	200	200
Additional analyses					
Variant	**New-6 (20)**	**New-7 (21)**	**New-8 (22)**		
FRACTION (%)	5-15**	0	15		
CUTOFF	150	-	150		
MAXCAT	200	-	200		

* OFL/ABC = 0.18

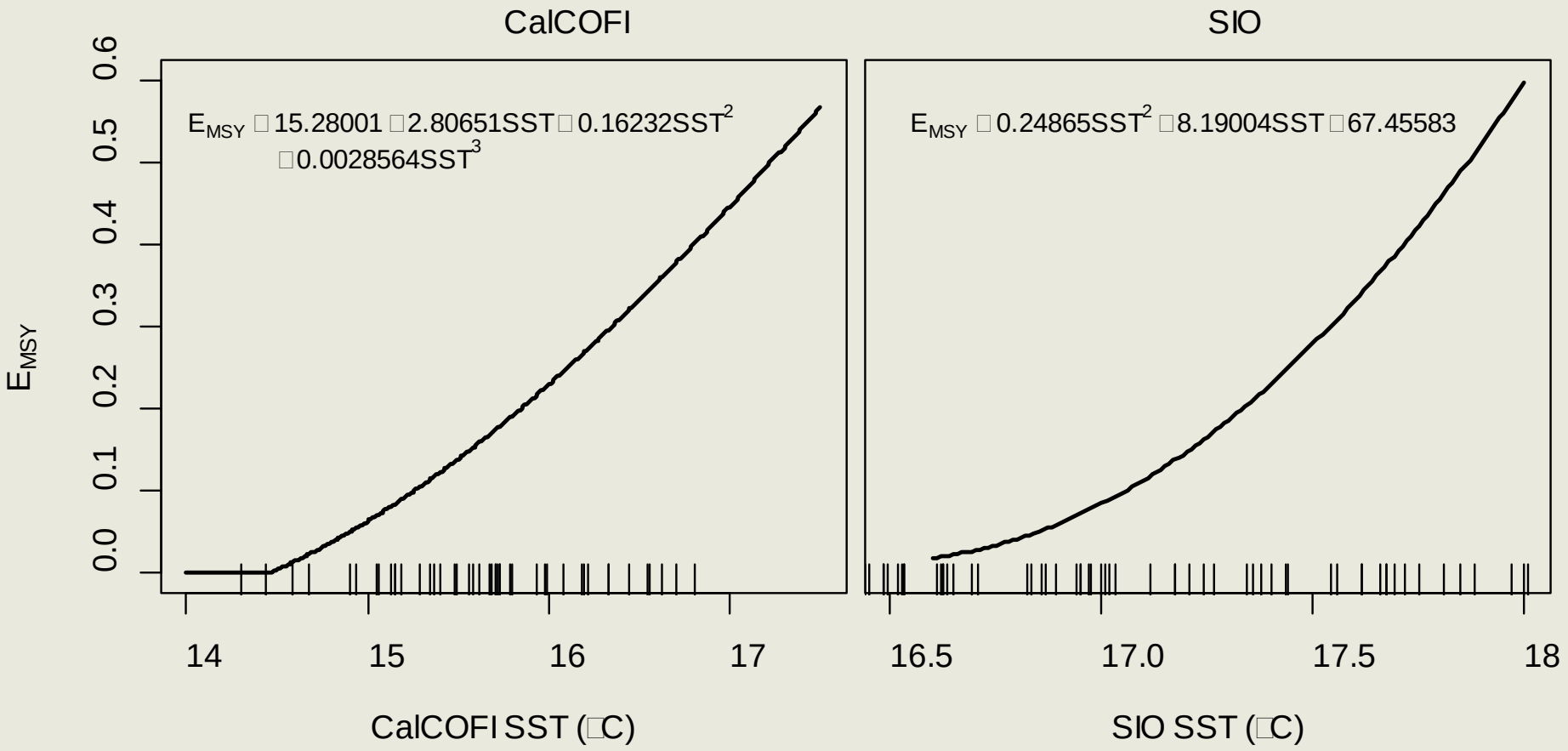
** OFL/ABC based on E_{MSY} (0-0.26), linked to CC_SST_ann

$SE_{MSY} = 0.18$

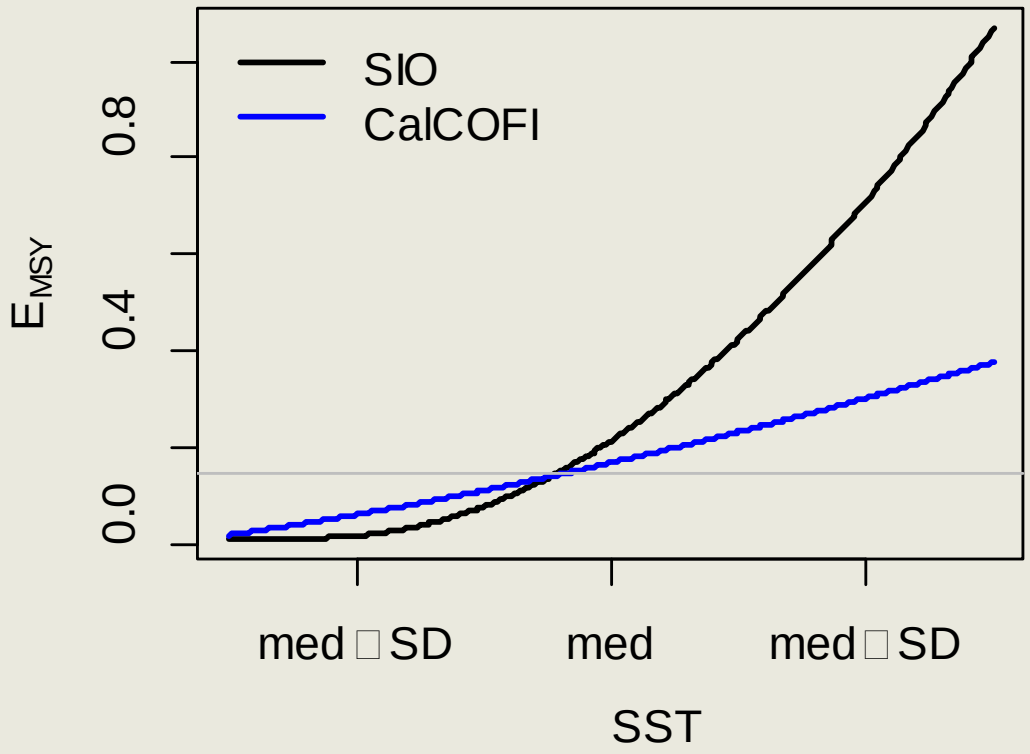
Risk Assessment Framework



Polynomial approximations to revised and current relationship between E_{MSY} and SST

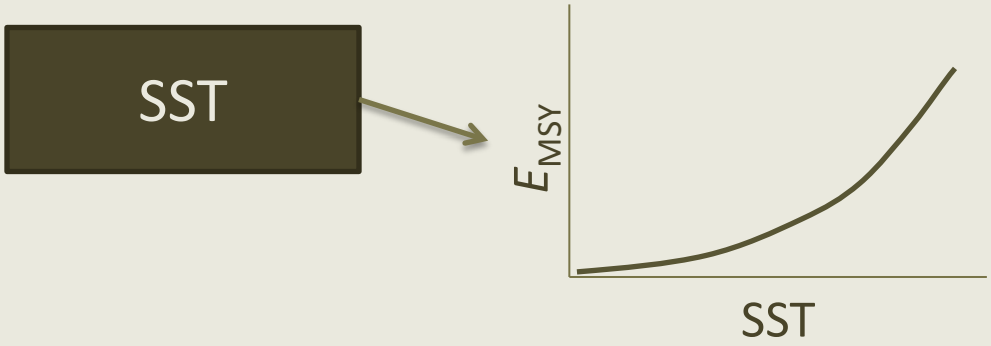


Comparing the relationships between SST and E_{MSY}



Since the relationship between the different indices and EMSY has different scales, to compare them it is necessary to standardize them based on the median of each time series.

The HG is set following this basic process



Calculate OFL
OFL=Biomass*Fraction*Distribution

Calculate ABC
ABC=OFL*P*

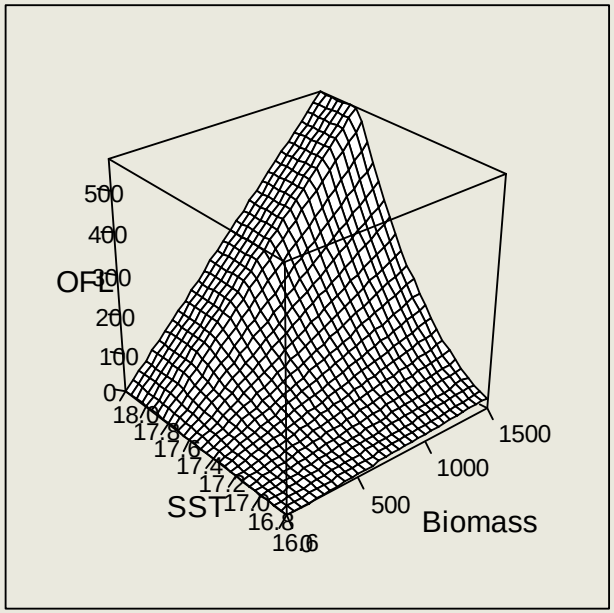
Calculate HG
HG=(Biomass-Cutoff)*
Fraction*Distribution

Select the minimum from these two quantities

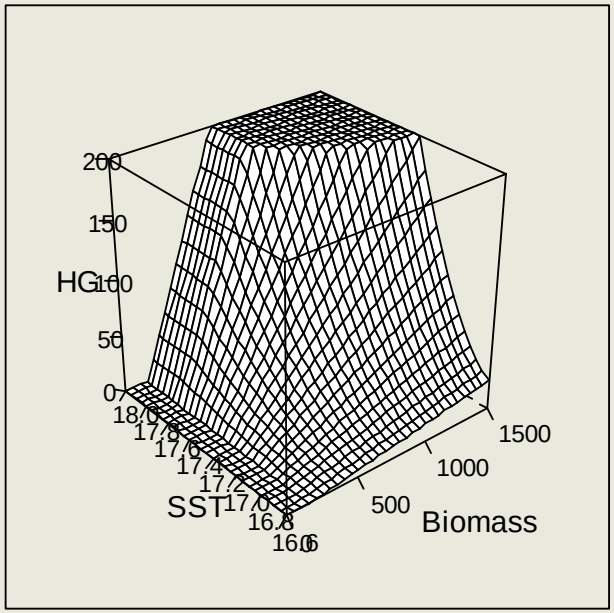
Final HG

Current (SIO) harvest control rule

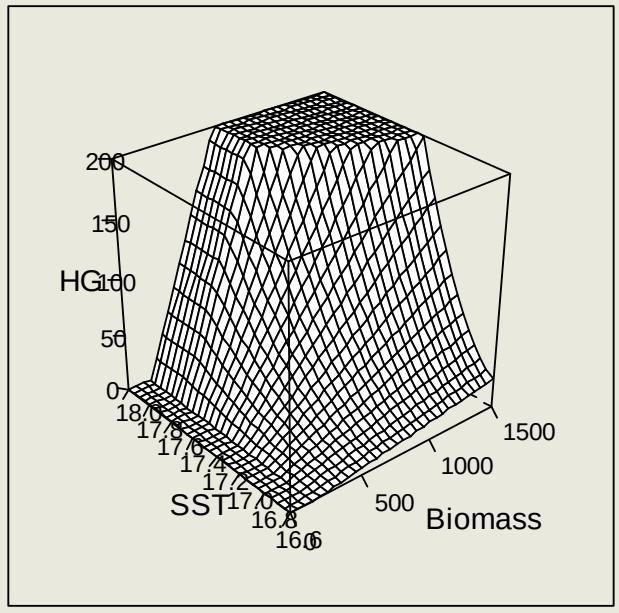
OFL control rule



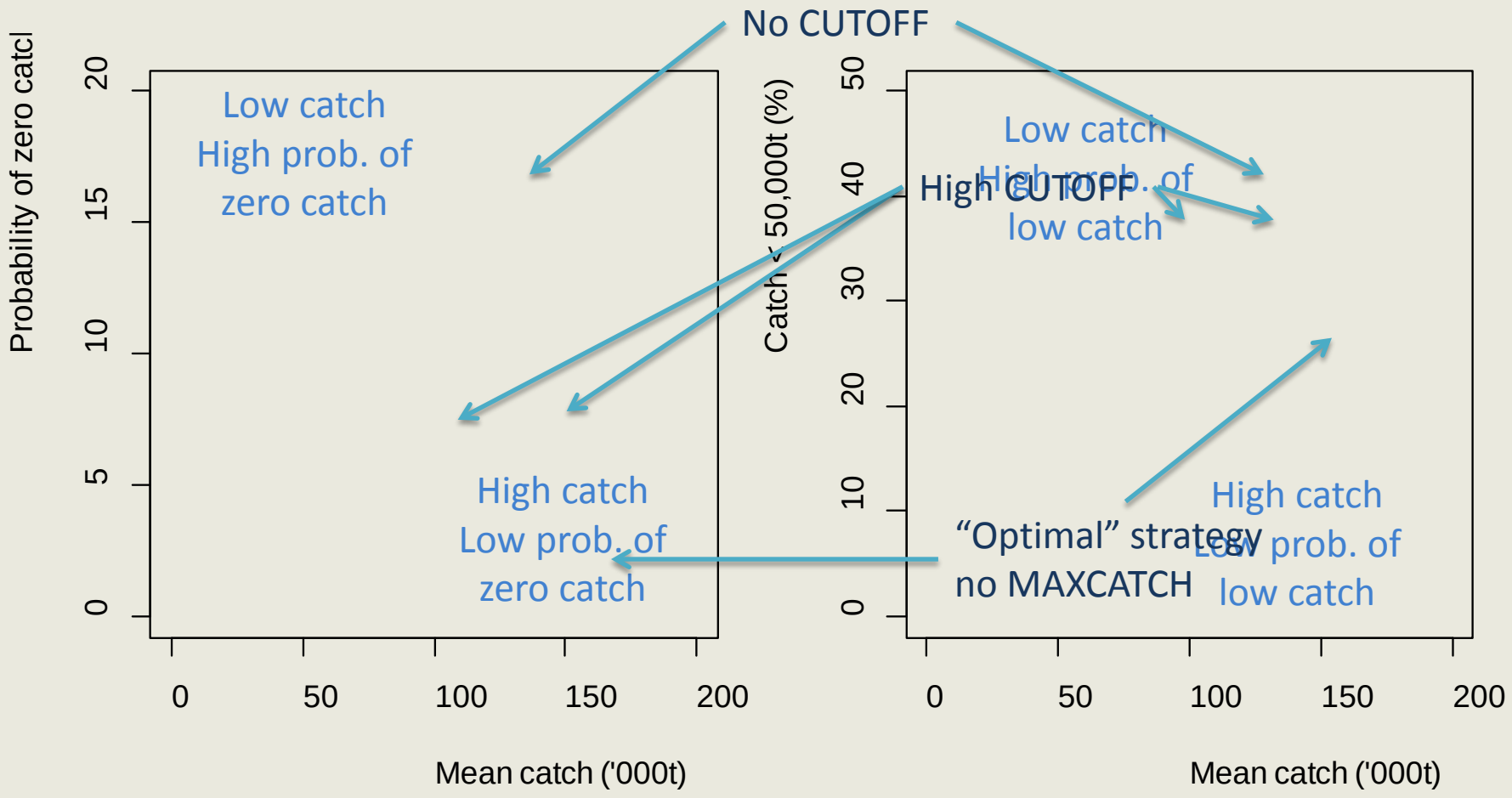
HG control rule



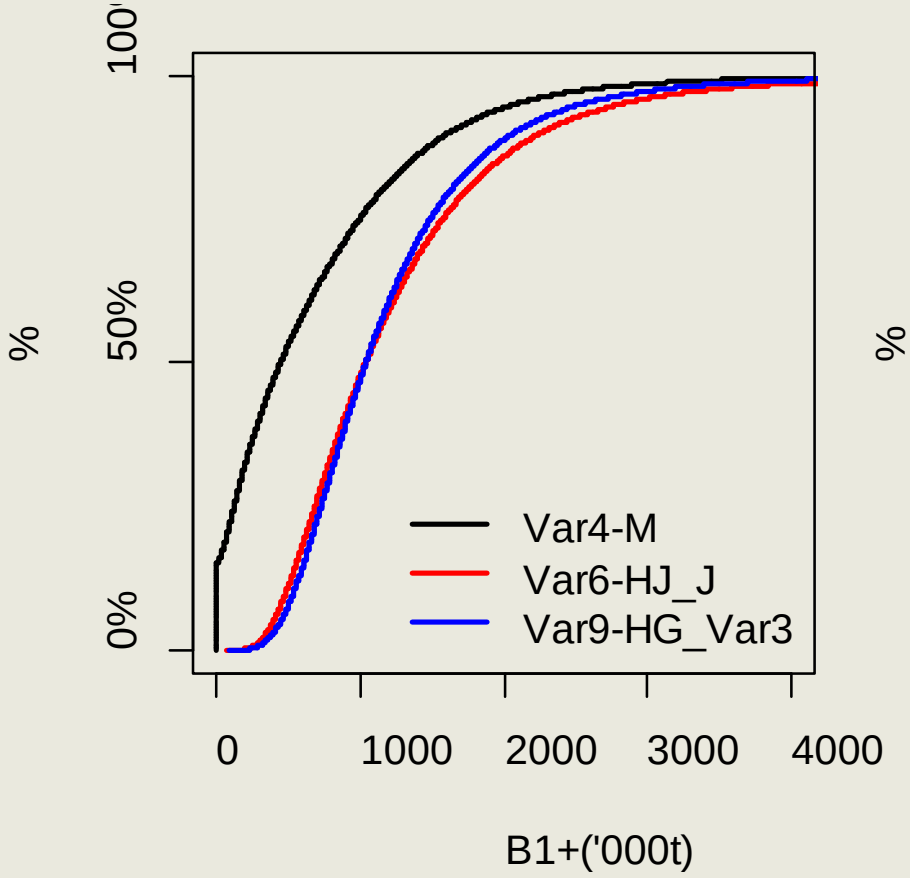
HG control rule < ABC

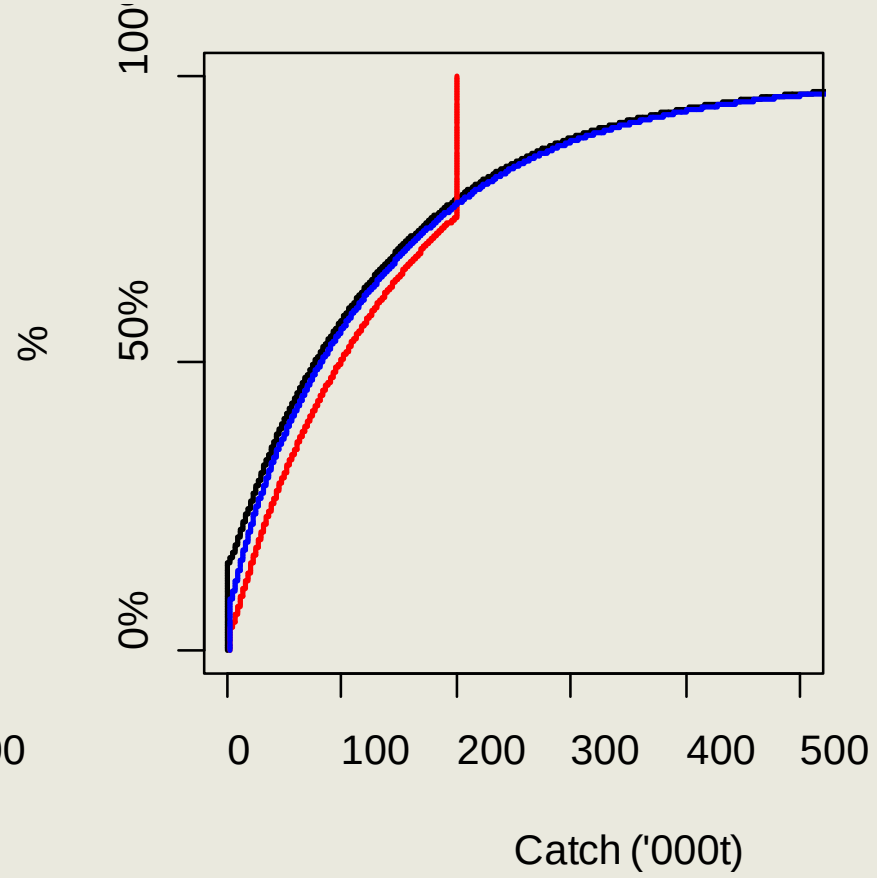


Quantifying trade-offs between different HCR variants: Mean catch vs. catch variability

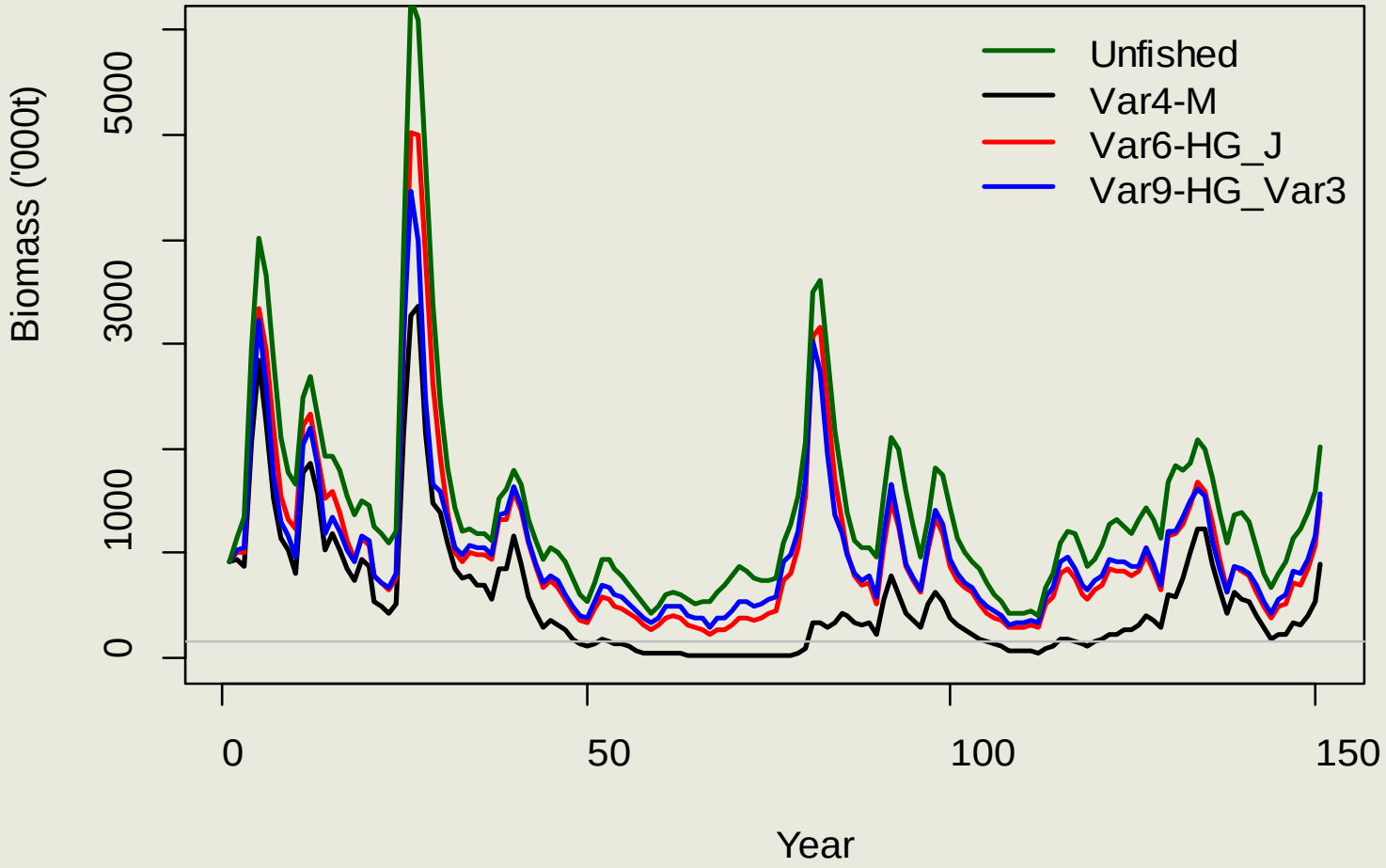


Cumulative distributions for biomass and catch for three HCR variants

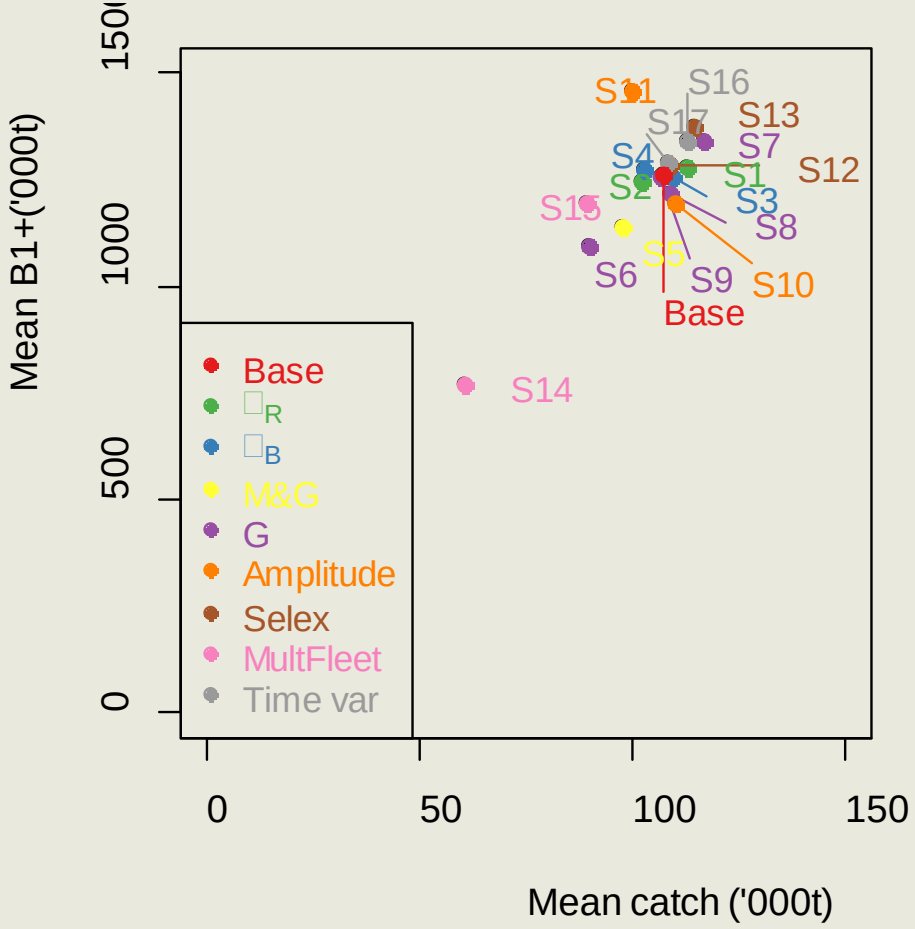


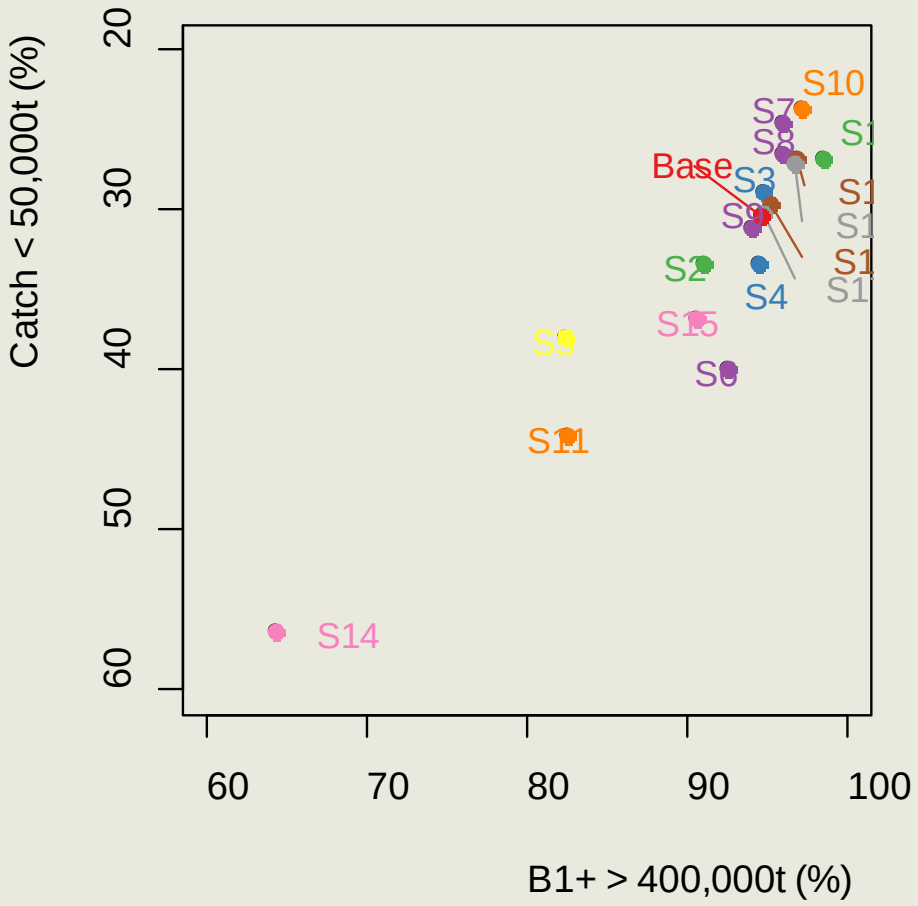


Example 150-year time-trajectory for three HCR variants

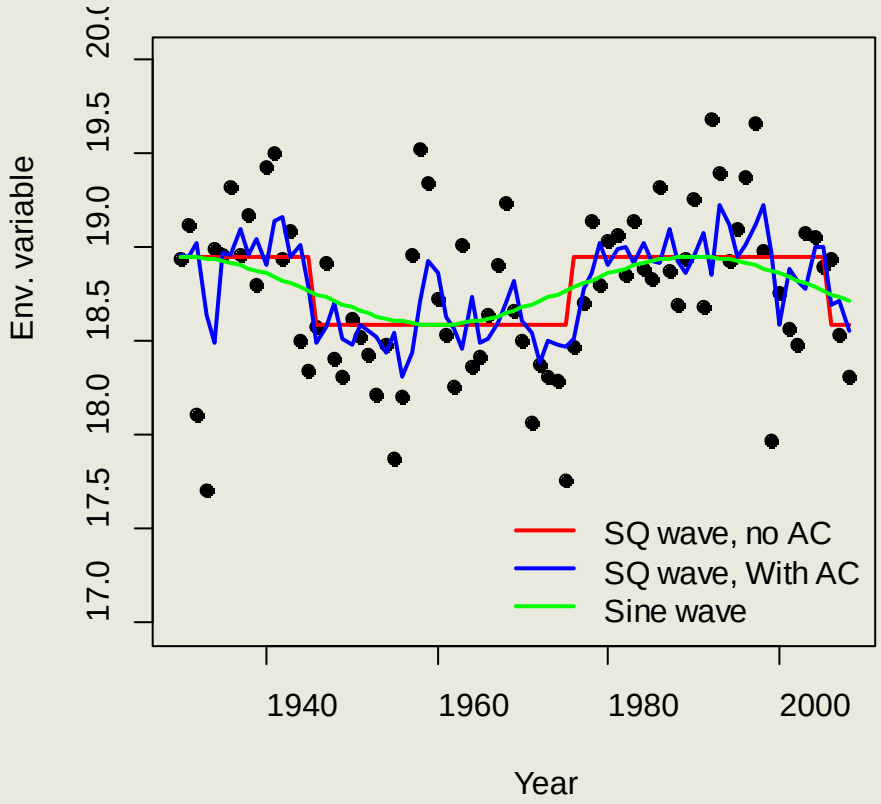


Trade-off plots for sensitivity analyses



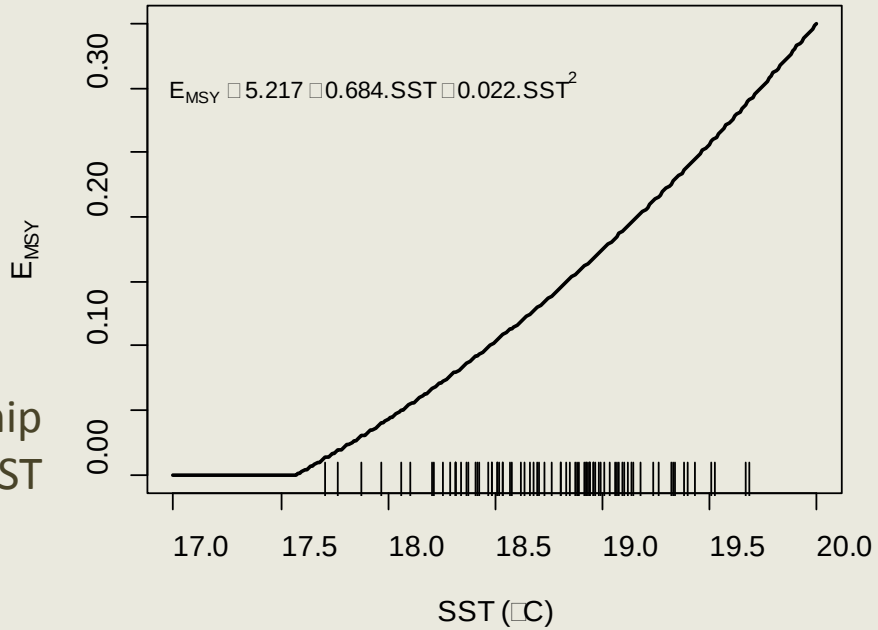


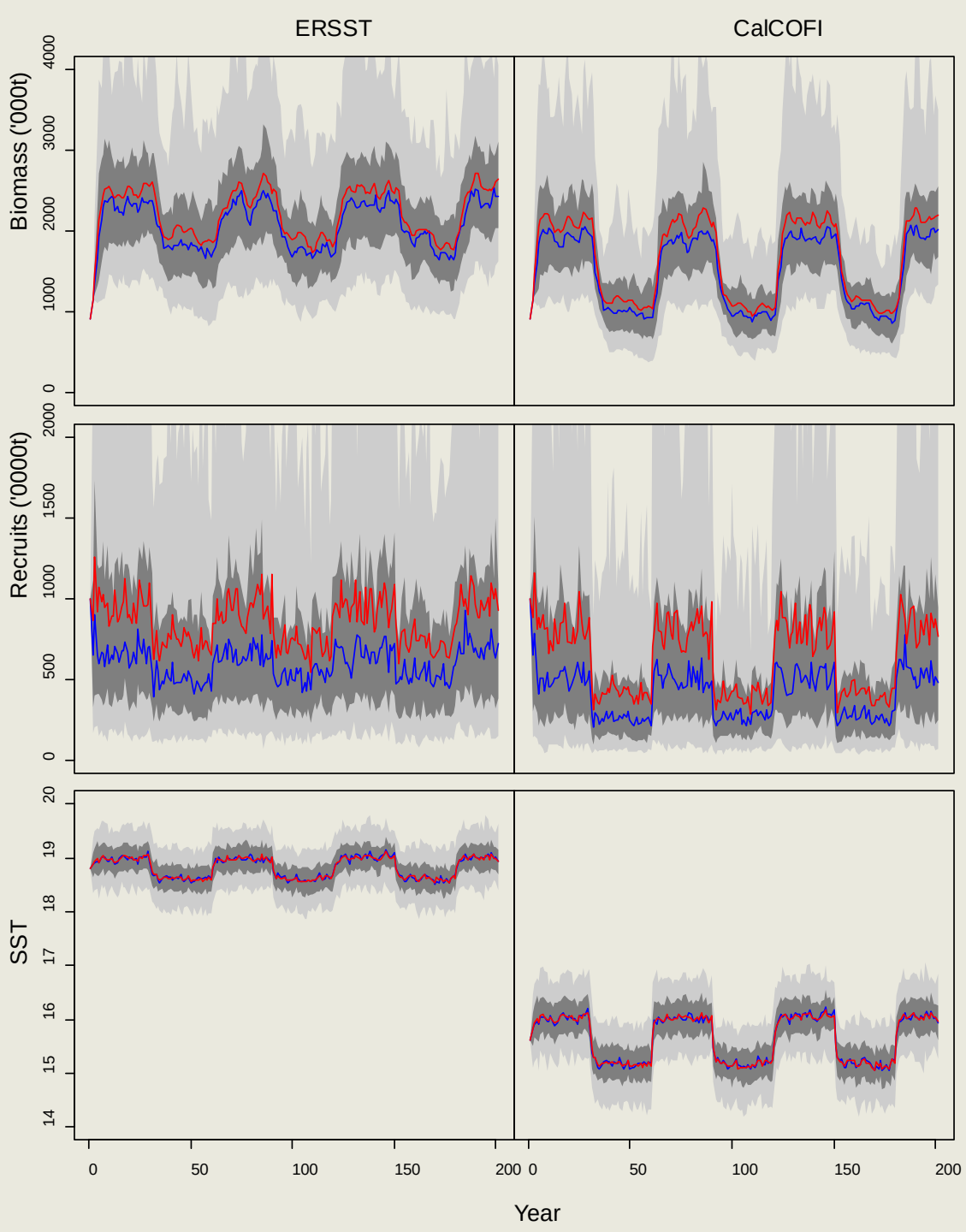
For this request, the analysis was repeated using ERSST as the driver of recruitment



Fit the environmental variable to the ERSTT time series

Recalculate the relationship between E_{MSY} and ERSST





This is a comparison of model runs using ERSST (left) and CalCOFI (right) as the environmental driver of recruitment, and no catches

Remember that CalCOFI provides a better fit than SIO or ERSST to log(RPS) data

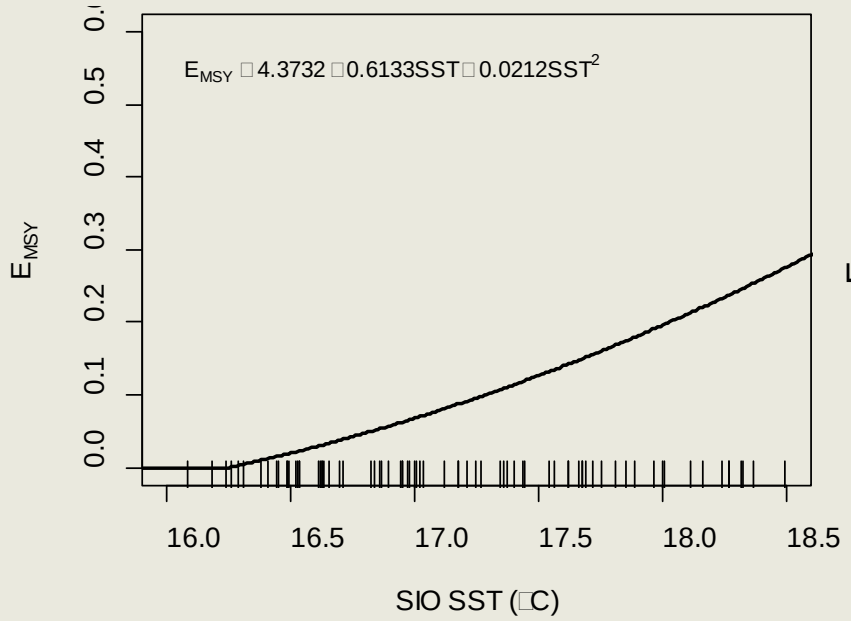
Series	AIC	R^2
SST_CC_ann	44.49	0.76
SIO_SST_ann	56.81	0.61
ERSST_ann	55.3	0.63

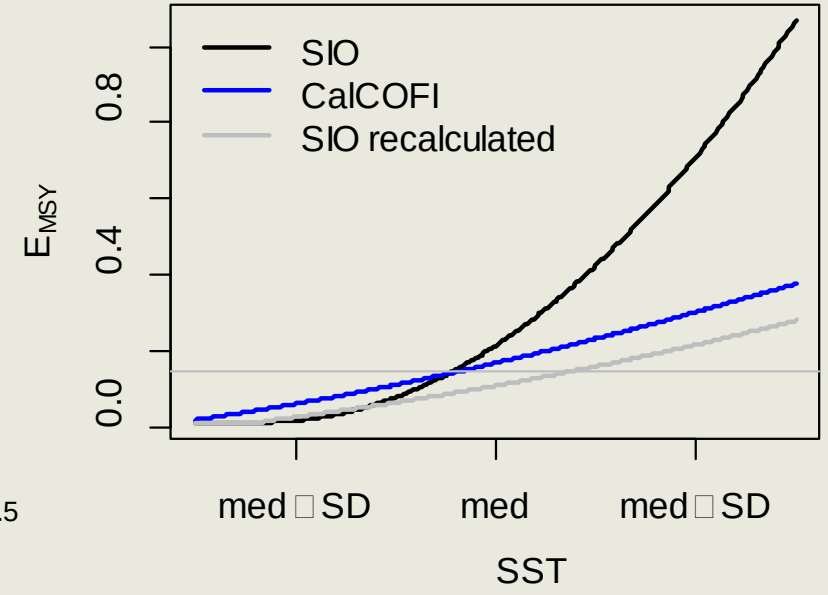
From PFMC 2013, Table App.E.6

Comparison of the current HCR using ERSST as temperature index

Mgmt. Year	Biomass (July)	SIO		ERSST ann			ERSST 3-year average		
		SST	HG	ann SST	HG	Difference	3-y SST	HG	Difference
2000	1581346	18.08	186791	17.96	62264	-124527	18.87	179224	-7566
2001	1182465	17.75	134737	18.76	114844	-19893	18.57	91337	-43399
2002	1057599	17.24	118442	18.57	80636	-37806	18.43	66319	-52123
2003	999871	17.31	110908	18.49	67125	-43784	18.61	78843	-32066
2004	1090587	17.46	122747	19.08	122747	0	18.71	99086	-23661
2005	1193515	17.6	136179	19.06	136179	0	18.87	131001	-5178
2006	1061391	18.03	118937	18.89	116732	-2205	19.01	118937	0
2007	1319072	18.11	152564	18.94	152564	0	18.97	152564	0
2008	832706	18.12	89093	18.54	57766	-31327	18.79	78462	-10631
2009	662886	17.83	66932	18.32	30881	-36051	18.6	47004	-19927
2010	702024	17.84	72039	-	-	-	-	-	-
2011	537173	17.9	50526	-	-	-	-	-	-
2012	988385	17.64	109409	-	-	-	-	-	-
2013	659539	17.35	66495	-	-	-	-	-	-

Standardized comparison of the relationship between EMSY and SST





Comparison of the current HCR using SIO as temperature index

Mgmt year	Biomass (July)	SIO - current			SIO - recalculated relationship		
		SST	Fraction	HG	Fraction	HG	Difference
2000	1581346	18.08	0.15	186791	0.15	186791	0
2001	1182465	17.75	0.15	134737	0.15	134737	0
2002	1057599	17.24	0.15	118442	0.09	74955	-43487
2003	999871	17.31	0.15	110908	0.1	76481	-34428
2004	1090587	17.46	0.15	122747	0.12	99833	-22914
2005	1193515	17.6	0.15	136179	0.14	127299	-8880
2006	1061391	18.03	0.15	118937	0.15	118937	0
2007	1319072	18.11	0.15	152564	0.15	152564	0
2008	832706	18.12	0.15	89093	0.15	89093	0
2009	662886	17.83	0.15	66932	0.15	66932	0
2010	702024	17.84	0.15	72039	0.15	72039	0
2011	537173	17.9	0.15	50526	0.15	50526	0
2012	988385	17.64	0.15	109409	0.15	106344	-3065
2013	659539	17.35	0.15	66495	-	-	-