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APPLICABILITY OF HISTORICALLY BASED LIMIT REFERENCE POINTS TO NORTH PACIFIC TUNA STOCKS

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Applicability of historically-based limit reference points to North Pacific tuna stocks

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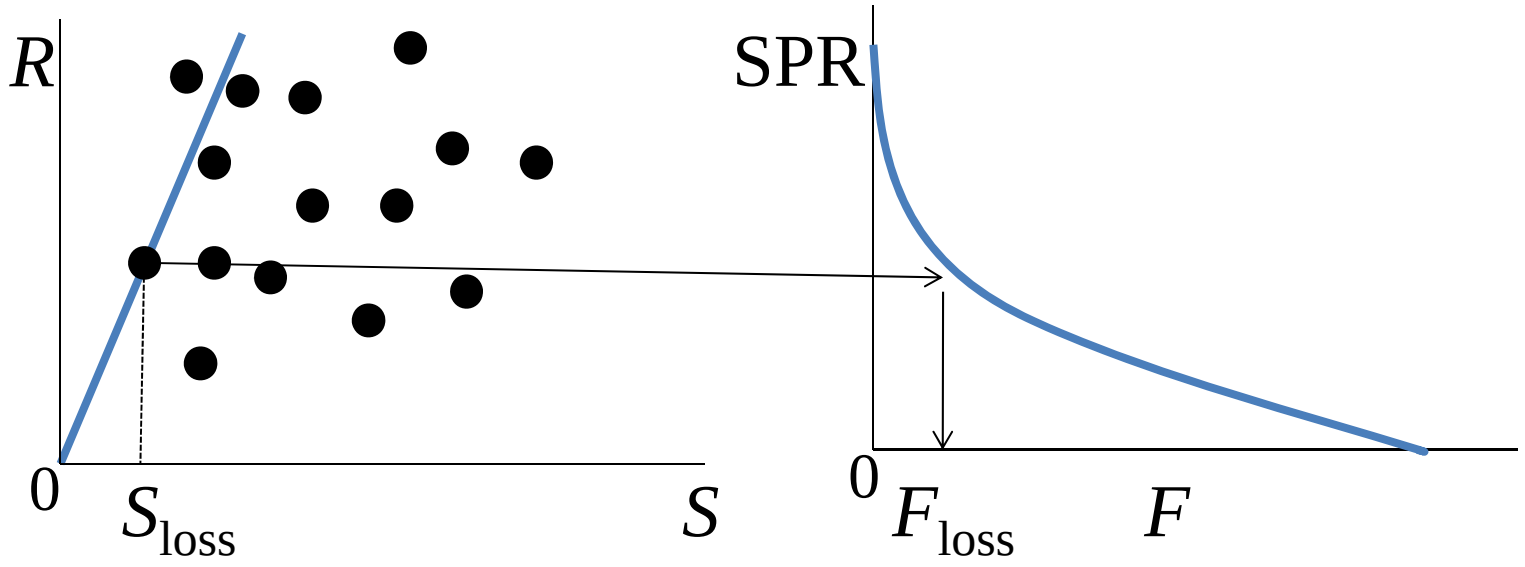
What is an historically-based LRPs?

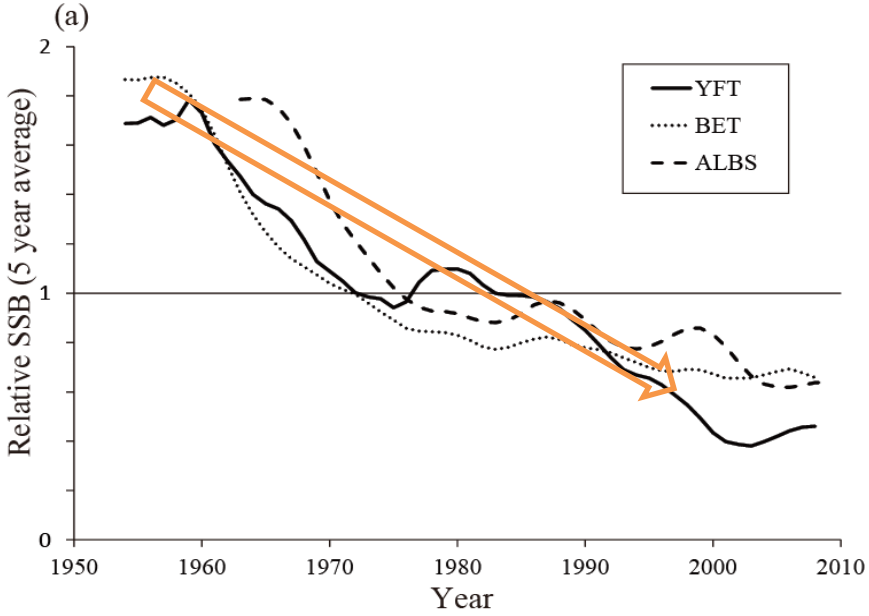
F_{loss}(Cook 1998): the rate of fishing mortality that produces a SPR associated with the historically lowest spawning stock size (S_{loss})



Concept: If F_{loss} is maintained, S can be maintained at S_{loss} on average

What are the different characteristics?

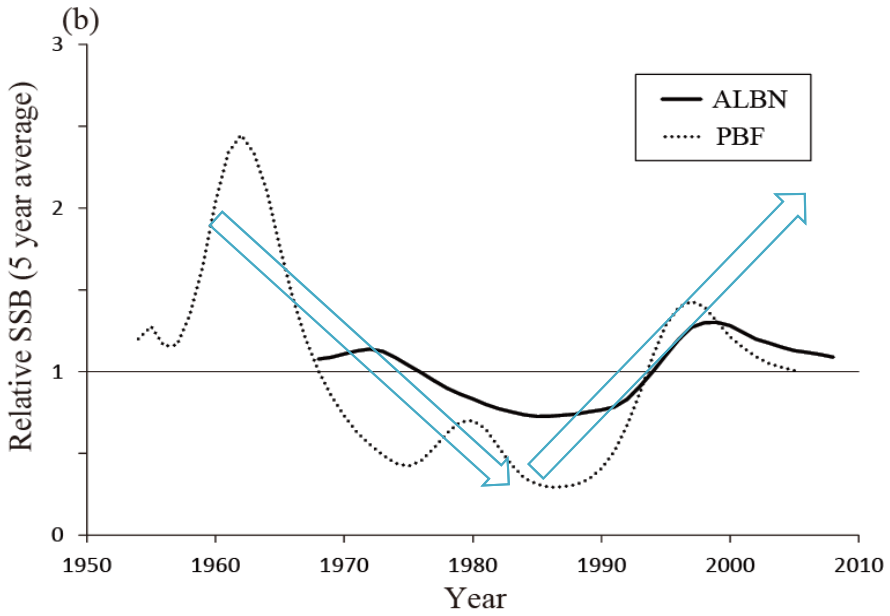
Tropical tunas (southern stocks)



"One-way trip"

Short-term history

Temperate tunas (northern stocks)



"V-turn around"

Long-term history

Objectives

(1) To propose alternative historically-based limit reference points (LRPs) such as F_{loss} for northern stocks;

(2) To compare the performance of historically-based and MSY-based LRPs (F_{loss} and F_{MSY}) using numerical simulations for northern and southern stocks; and

(3) To discuss the applicability and advantages of historically-based LRPs for particular northern stocks.

Methods (1)

- We used a basic simulation model to evaluate the differential performance of two LRPs defined in terms of fishing mortality (F) for southern and northern stocks.
- This model contrasts the historically-based LRP F_{loss} with the MSY-based LRP, F_{MSY}

F_{loss} versus F_{MSY}

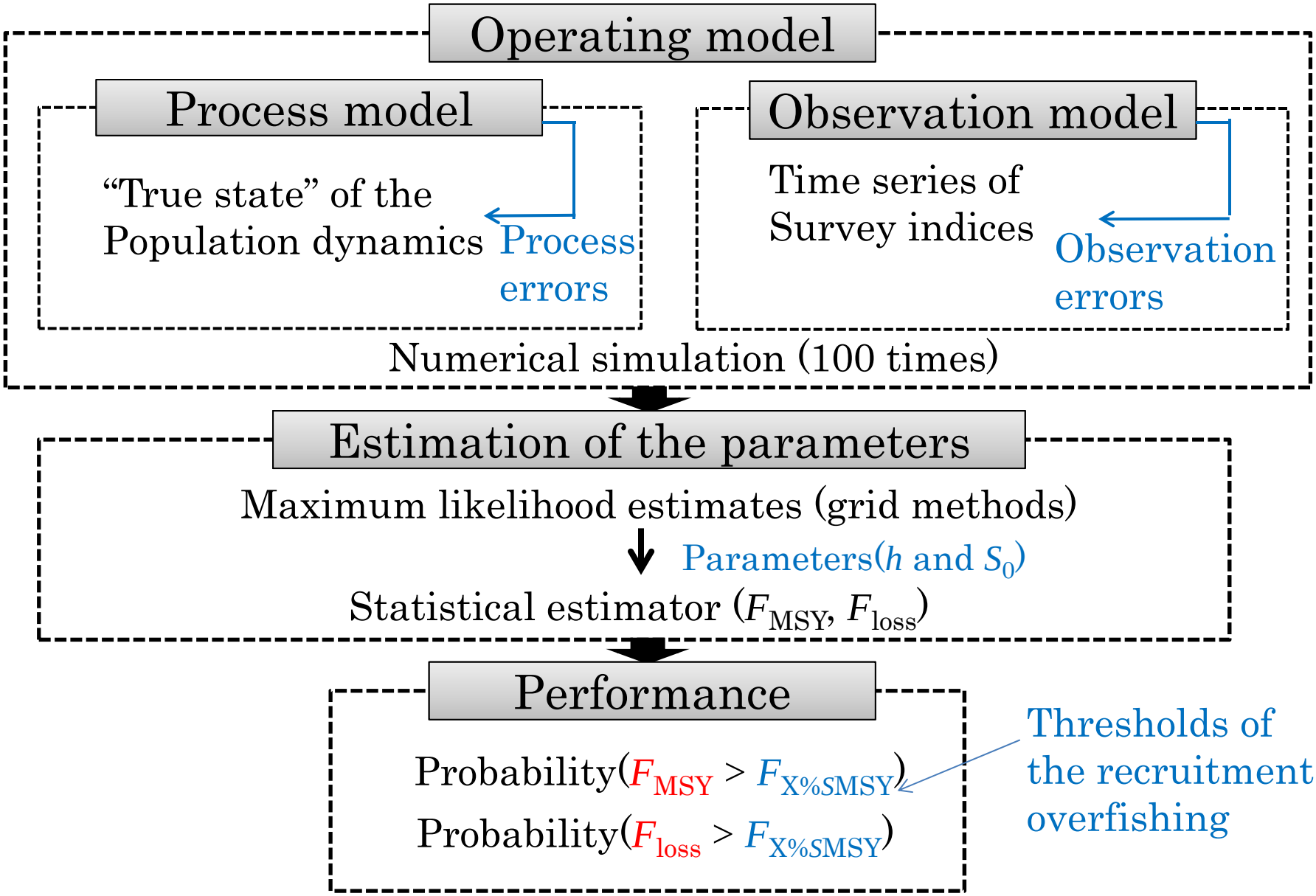
Methods (2)

- To create a set of indicators for the risk of recruitment overfishing, we computed F for various fractions of S_{MSY} (i.e. 100%, 50%, 20% and 10%, and S=0), each of which represents varying degrees of depletion of stock biomass.

> $F_{\%SMSY}$ is the F value corresponding to a fraction of the S_{MSY}

- We evaluated the probability that either candidate LRP would exceed the value of F at the various depletion levels (= risk of recruitment overfishing).

Simulation Procedures



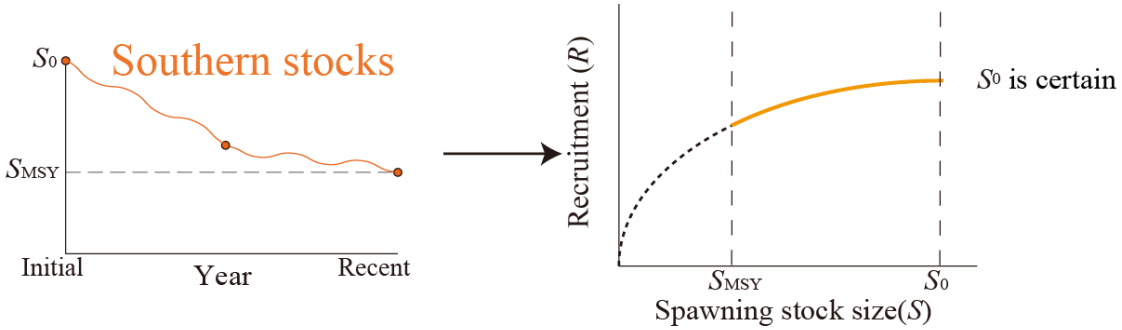
Results - Base Case

Thresholds	Southern stocks				Northern stocks (PBF)				Northern stocks (ALB-N)			
	Small variance		Large variance		Small variance		Large variance		Small variance		Large variance	
	F_{MSY}	F_{loss}	F_{MSY}	F_{loss}	F_{MSY}	F_{loss}	F_{MSY}	F_{loss}	F_{MSY}	F_{loss}	F_{MSY}	F_{loss}
***h* = 0.3**												
Pr (> F_{Smsy})	0.48	0.49	0.4	0.23	0.74	0.94	0.65	0.47	0.72	0.5	0.54	0.19
Pr (> $F_{50\%Smsy}$)	0.29	0.25	0.29	0.17	0.43	0.72	0.52	0.39	0.54	0.25	0.42	0.12
Pr (> $F_{20\%Smsy}$)	0.19	0.18	0.24	0.15	0.22	0.49	0.48	0.33	0.43	0.21	0.4	0.11
Pr (> $F_{10\%Smsy}$)	0.19	0.13	0.23	0.11	0.15	0.43	0.46	0.33	0.4	0.14	0.38	0.1
Pr (> $F_{S=0}$)	0.13	0.11	0.21	0.09	0.11	0.39	0.41	0.31	0.38	0.12	0.36	0.08
***h* = 0.6**												
Pr (> F_{Smsy})	0.24	0.21	0.07	0.02	0.13	0.47	0.33	0.11	0.47	0.05	0.3	0.03
Pr (> $F_{50\%Smsy}$)	0.06	0.02	0.05	0.01	0.01	0.13	0.29	0.05	0.2	0	0.25	0.02
Pr (> $F_{20\%Smsy}$)	0	0.01	0.05	0	0	0.05	0.29	0.04	0.11	0	0.24	0.01
Pr (> $F_{10\%Smsy}$)	0	0.01	0.05	0	0	0.01	0.29	0.02	0.11	0	0.24	0.01
Pr (> $F_{S=0}$)	0	0	0.04	0	0	0.01	0.29	0	0.09	0	0.23	0
***h* = 0.9**												
Pr (> F_{Smsy})	0.07	0.02	0.03	0	0.11	0.03	0.45	0	0.38	0	0.33	0.01
Pr (> $F_{50\%Smsy}$)	0	0	0.03	0	0.11	0.01	0.45	0	0.33	0	0.33	0
Pr (> $F_{20\%Smsy}$)	0	0	0.03	0	0.11	0	0.45	0	0.33	0	0.33	0
Pr (> $F_{10\%Smsy}$)	0	0	0.03	0	0.11	0	0.45	0	0.33	0	0.33	0
Pr (> $F_{S=0}$)	0	0	0.03	0	0.11	0	0.45	0	0.33	0	0.33	0

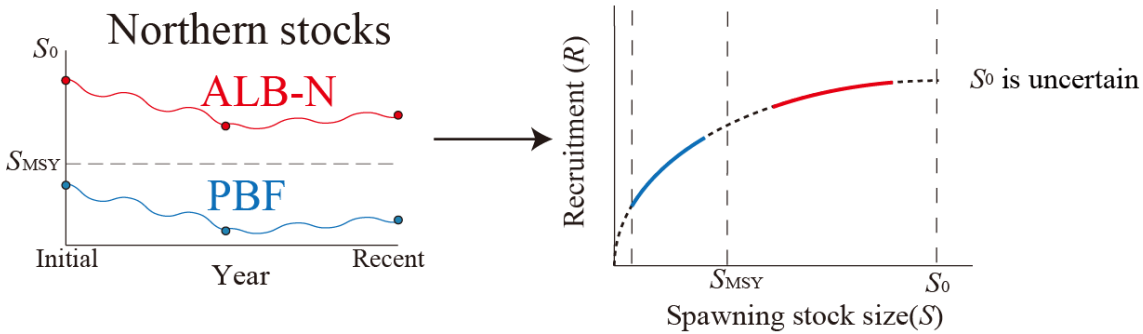
Results - Summary

- For southern stocks, the performance of both F_{loss} and F_{MSY} is good when recruitment compensation is high (i.e. when "steepness" in the stock recruitment relationship is high)
- For northern stocks, the performance of F_{loss} is better than F_{MSY} if the steepness is high and the process error is large.

Discussion-Data Contrast



No history of the stock being below S_{MSY}



Historical S have varied only within a narrow range

The observed ranges of S for northern stocks are narrower than those for southern stocks

It is more difficult to estimate steepness accurately for northern stocks

Discussion - F_{MSY} vs F_{loss}

- Large process error
- A lack of data contrast

⇩

Inaccurate estimation of steepness

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Uncertainty in h can lead to large uncertainties in the estimates of F_{MSY}

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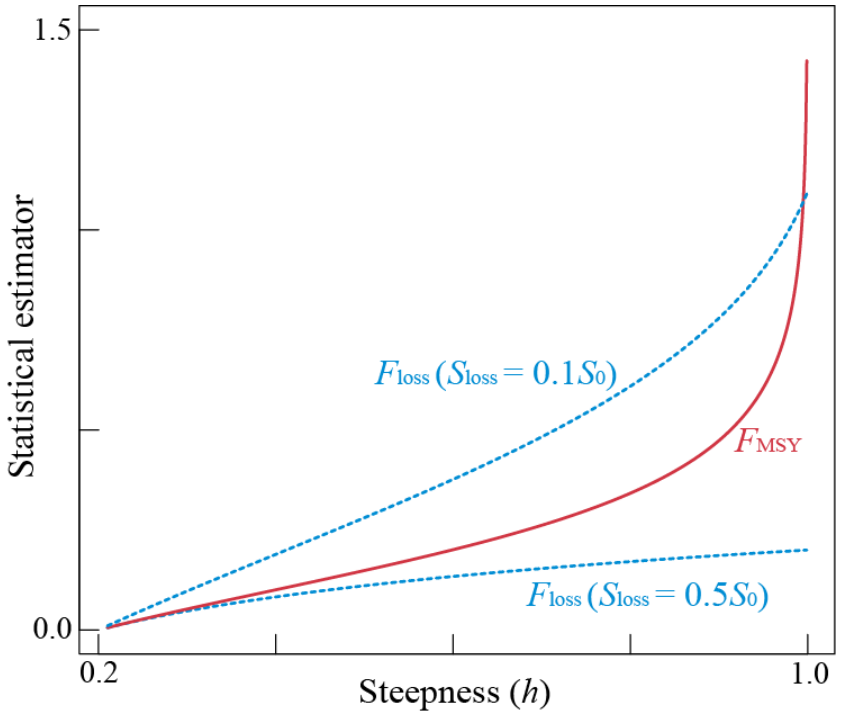
In these simulation, this situation caused F_{MSY} to be overestimated but did not affect F_{loss} as much



Steepness is high

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Estimation of F_{MSY} is very difficult because F_{MSY} can vary a lot with just a small change in steepness

Discussion - MSY-based LRPs

Inaccurate estimation of steepness can lead to overestimation of F_{MSY}, which in turn is associated with a high risk of recruitment overfishing and stock depletion.

In this sense, it is not recommended to apply MSY-based LRPs such as F_{MSY} to northern stocks.

Discussion - Historically-based LRPs

F_{loss} was robust to the overestimation of steepness. This means the F_{loss} can be used to achieve a risk-averse and conservative fisheries management.

In this sense, historically-based LRPs such as F_{loss} would be appropriate for northern stocks such as PBF and ALB-N.

Conclusion

- We suggest that limit reference points based on historical stock sizes are worthy of consideration for temperate tunas in the North Pacific

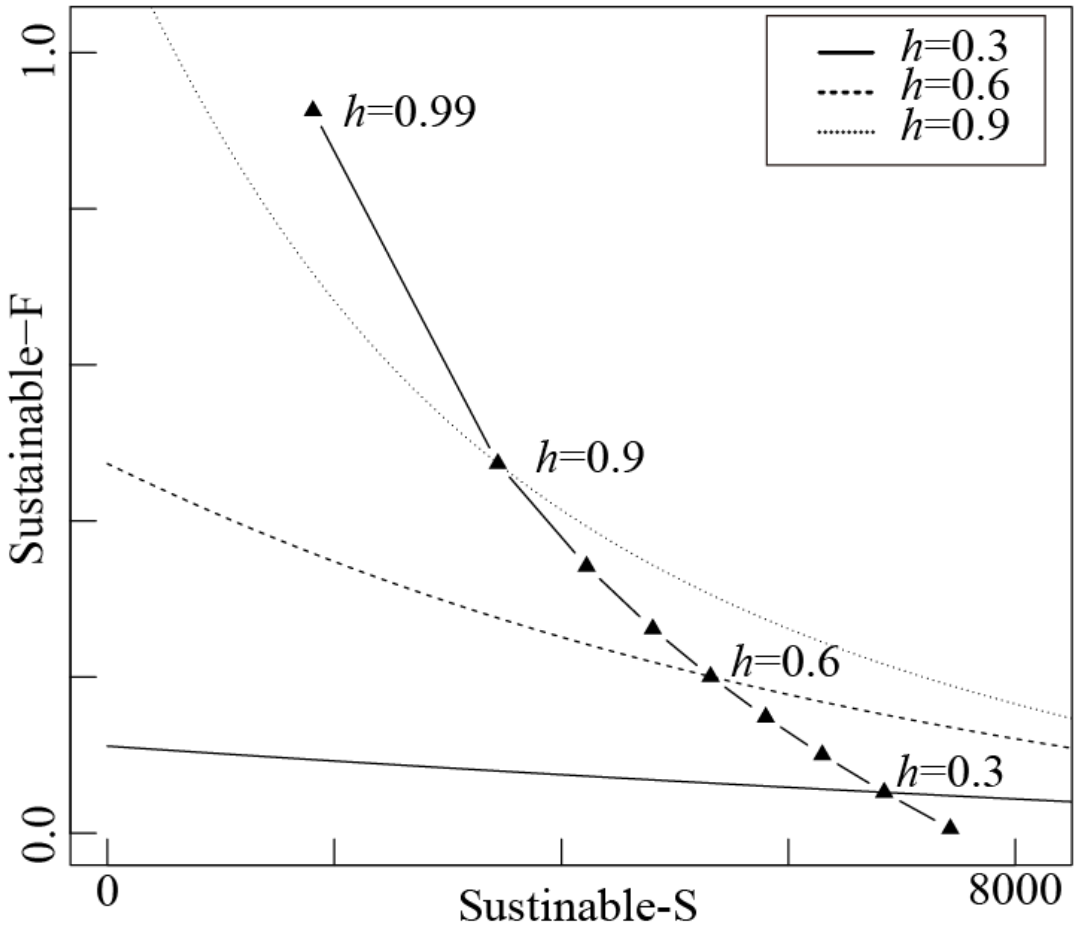
Thank you for your attention

Discussion - Steepness

Tuna stocks	Base Case	Range	Reference
YFT, BET, ALB-S	0.8	0.65-0.95	Harley et al. 2011
PBF	0.999	0.8-1.0	Iwata et al. 2012
ALB-N	0.955	0.7-1.0	Iwata et al. 2011

Discussion - The relationship between S and F in the steady state

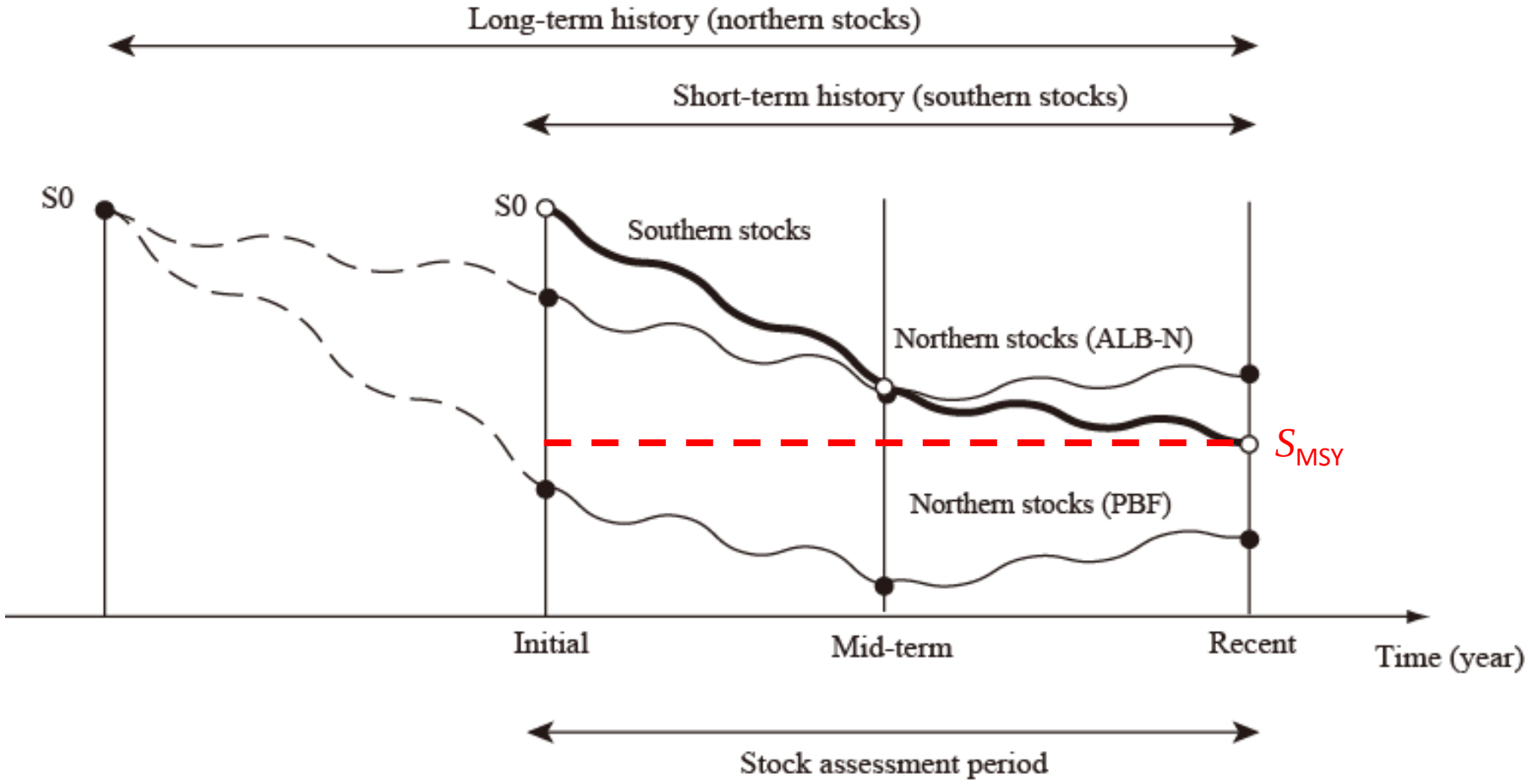
S1

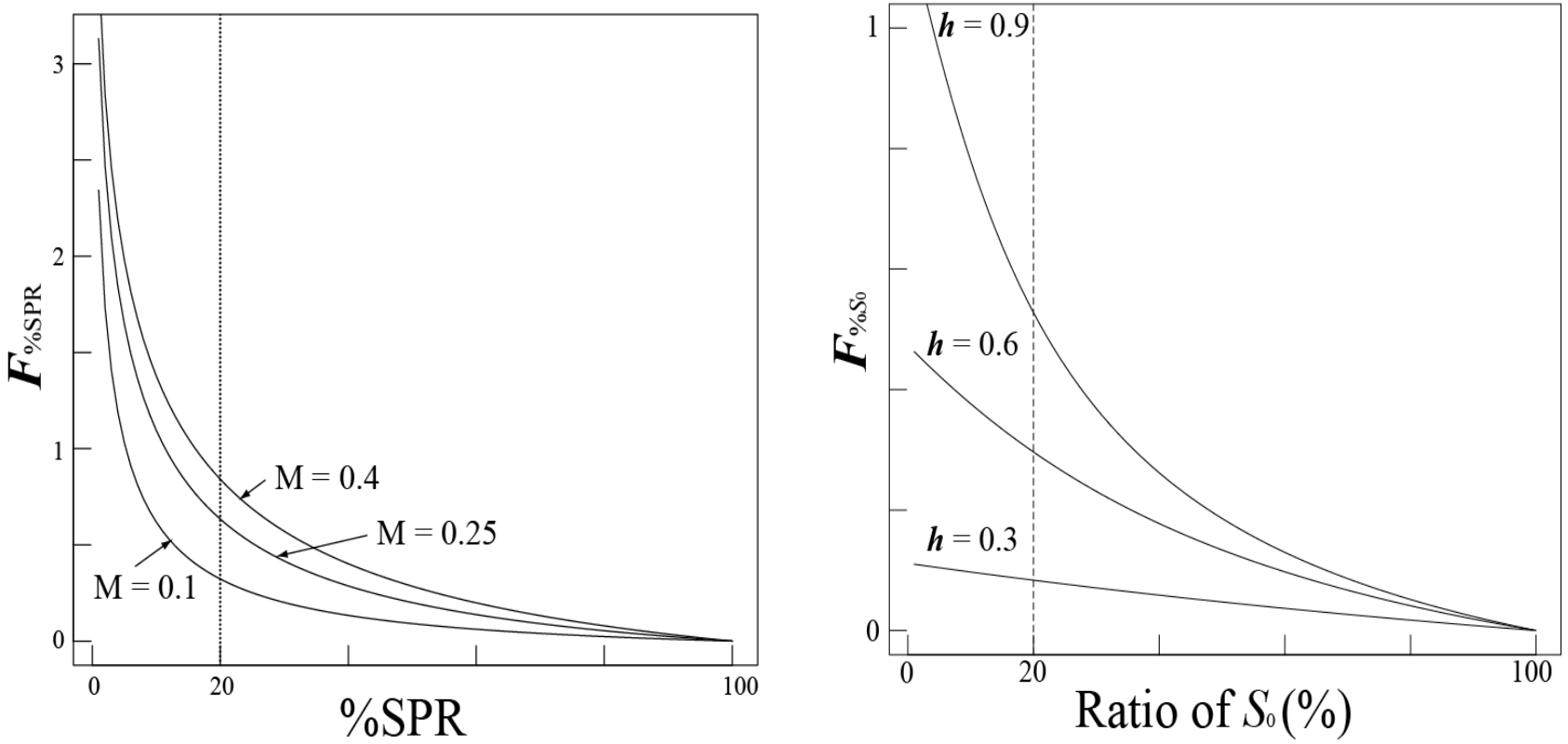


Slide 18

S1 Note that "sustainable" is mis-spelled on the x-axis.
SCC, 11/21/2012

Schematic diagram of historical population dynamics scenarios





The effect of natural mortality and steepness on proxy MSY-based reference points: (a) relationships between %SPR and $F_{\%SPR}$ with different natural mortality coefficients; and (b) relationships between the ratio of S_0 and $F_{\%S0}$ with different values of steepness.