S11

Incorporation of the effect of climate change into management strategy evaluation: illustration with chub mackerel (*Scomber japonicus*) in Korean waters

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Sea surface temperature of Korea EEZ

Source: 해양조사연보 제66권, NIFS of Korea

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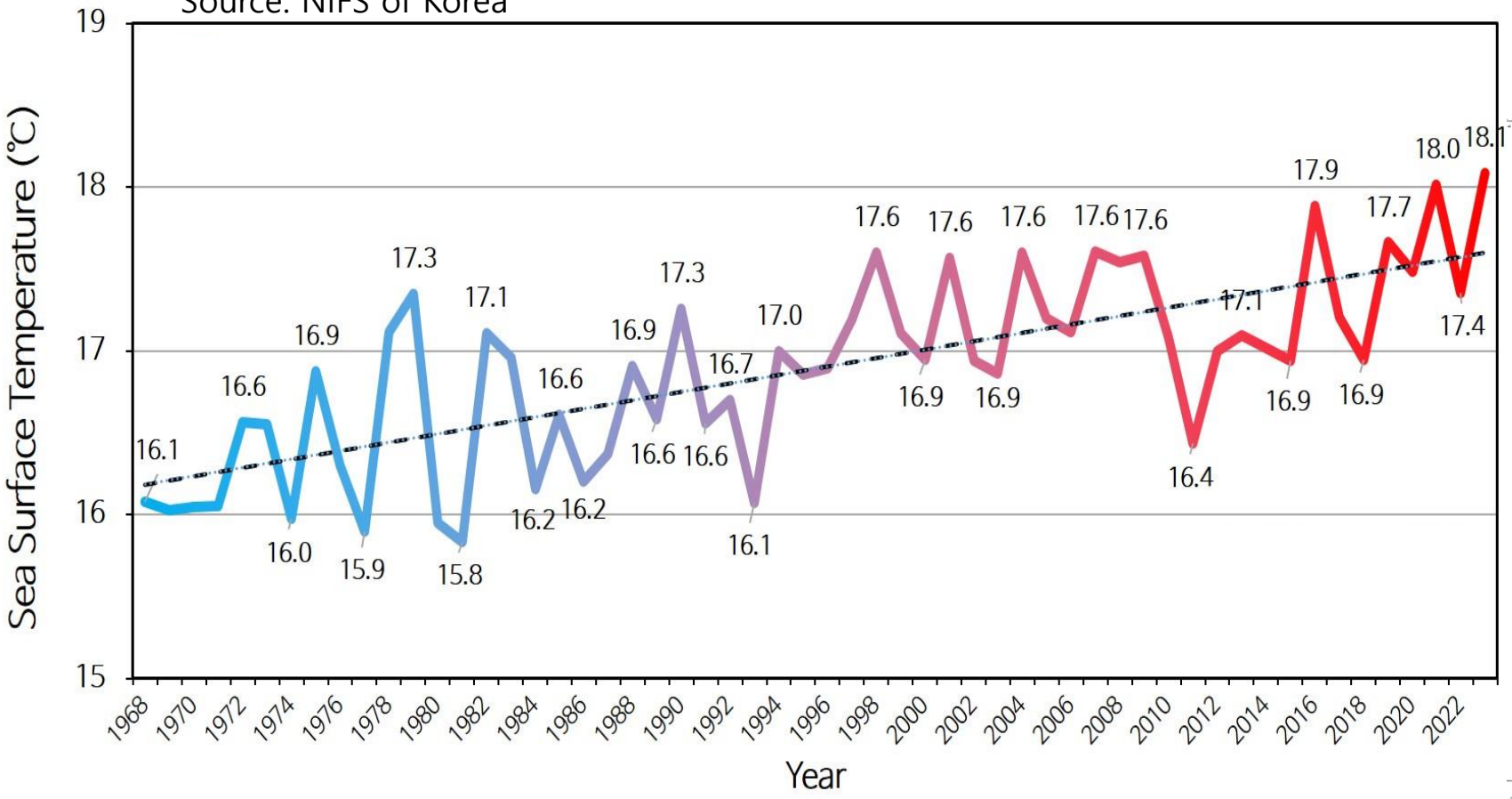
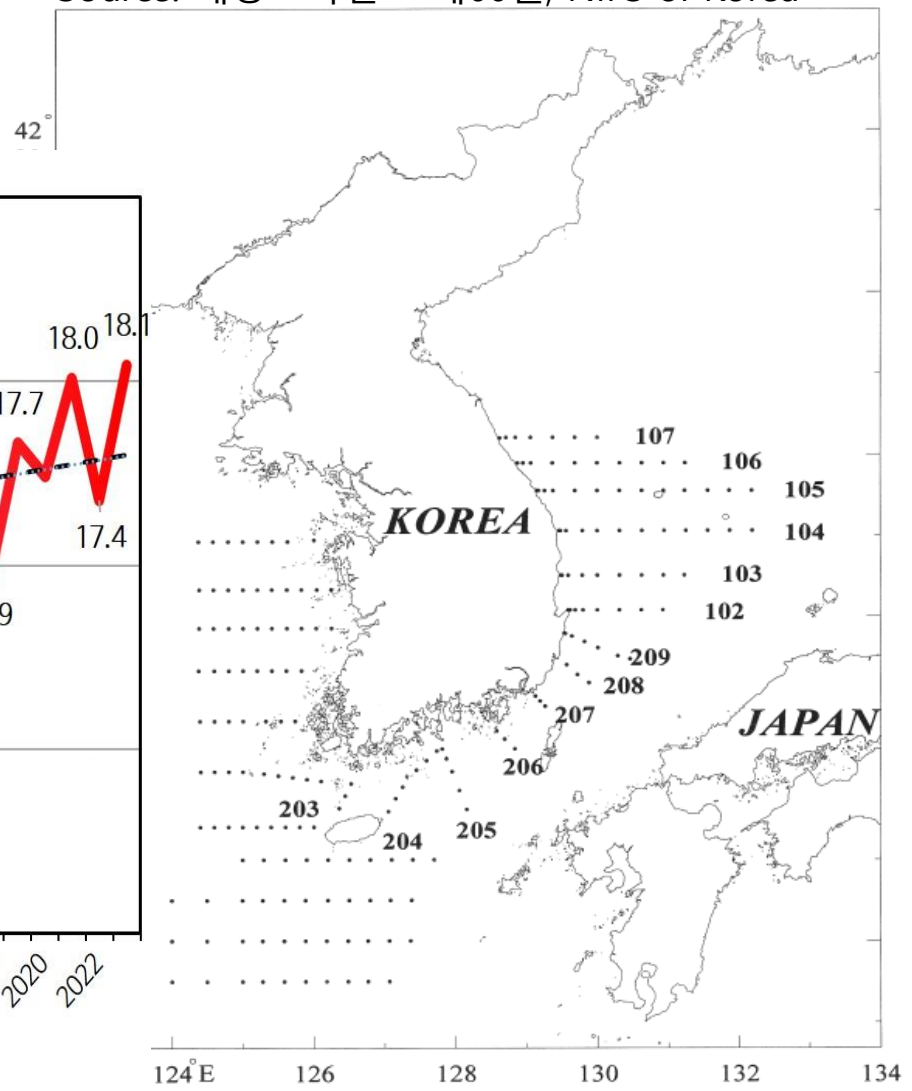




Temperature Size Rule (TSR)

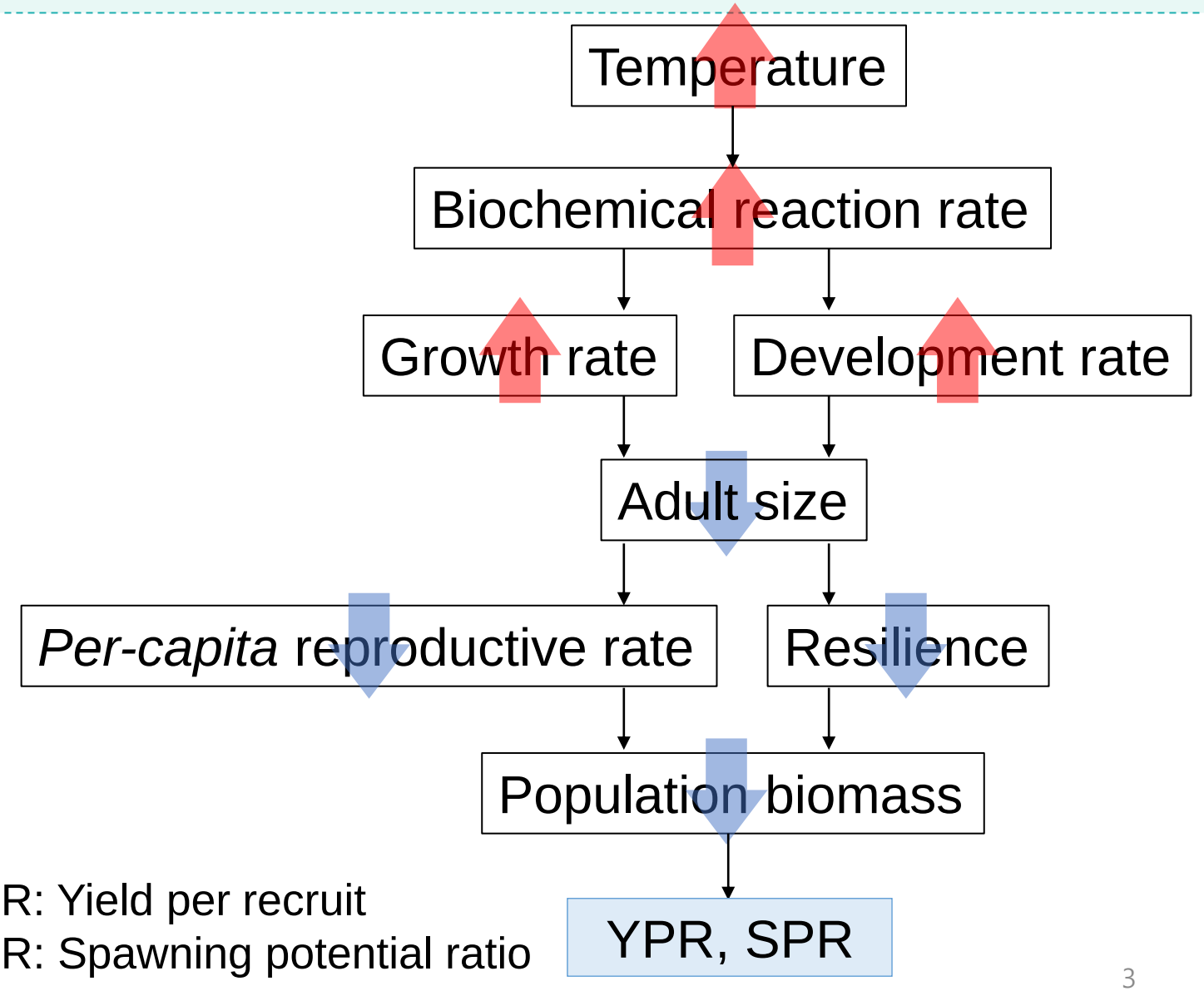
TSR

(Temperature Size Rule)

Ectotherms

Temperature ⇑

Mature body size ⇓



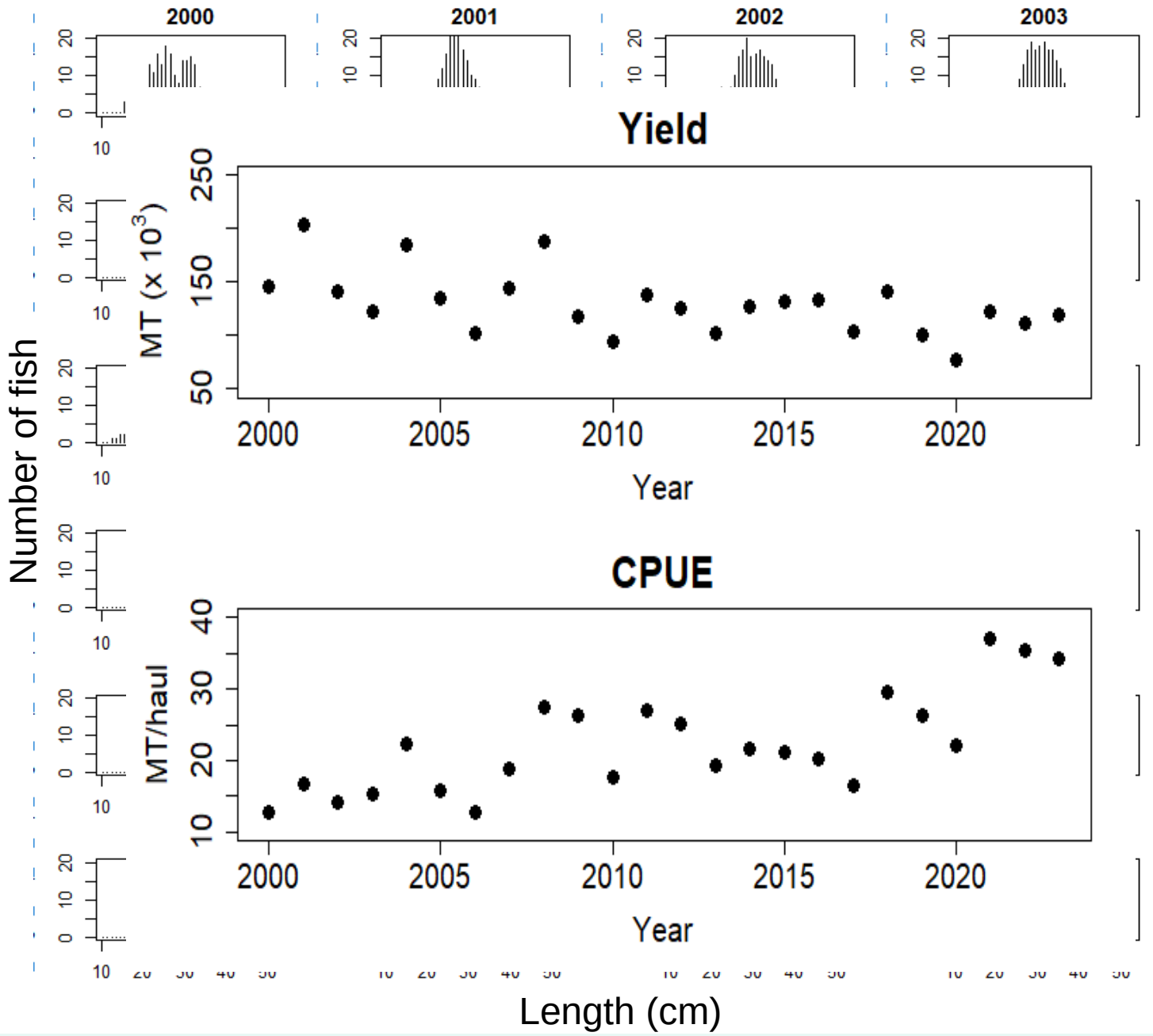
YPR: Yield per recruit
SPR: Spawning potential ratio

A length-based assessment

A stock assessment

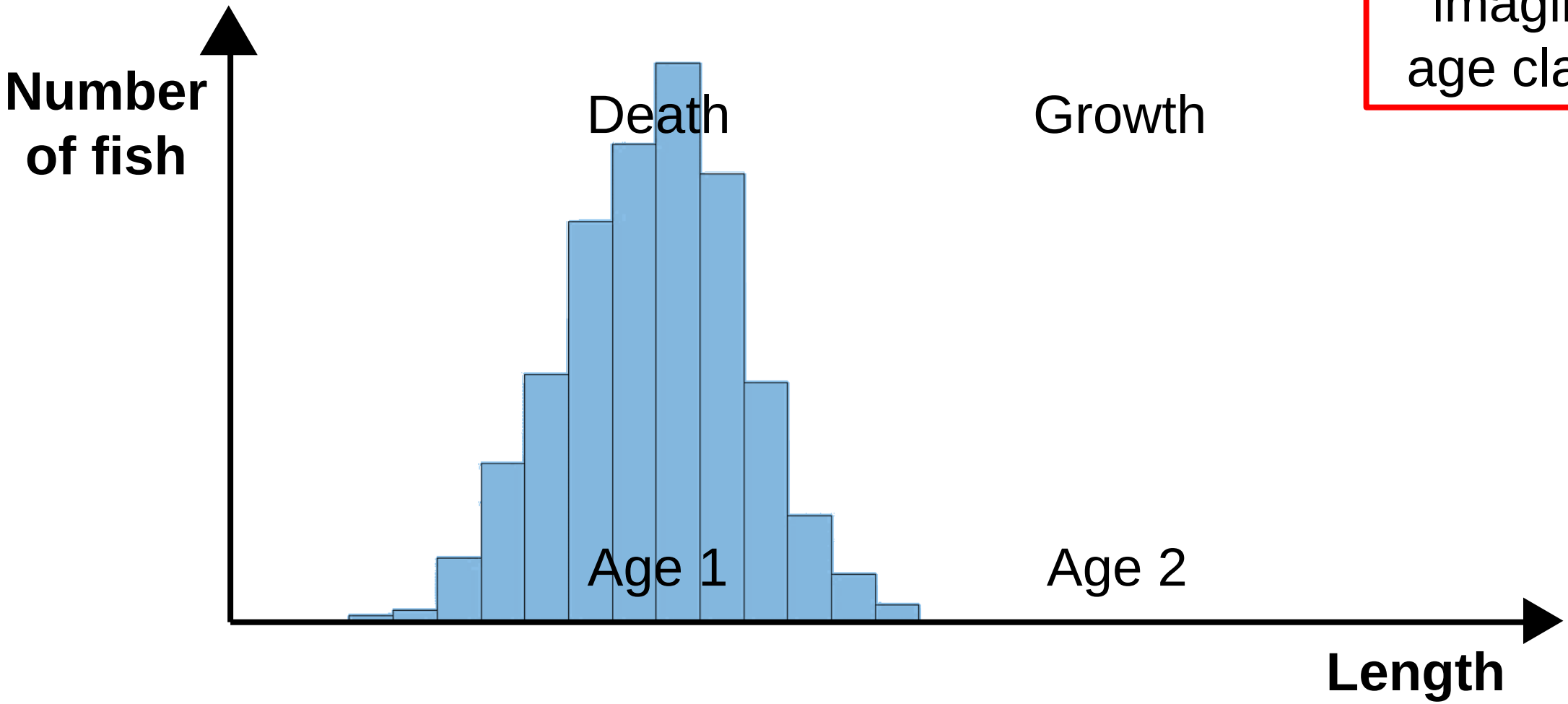
DATA

- Age composition
- Length composition
- Yield
- Catch Per Unit Effort (CPUE) …

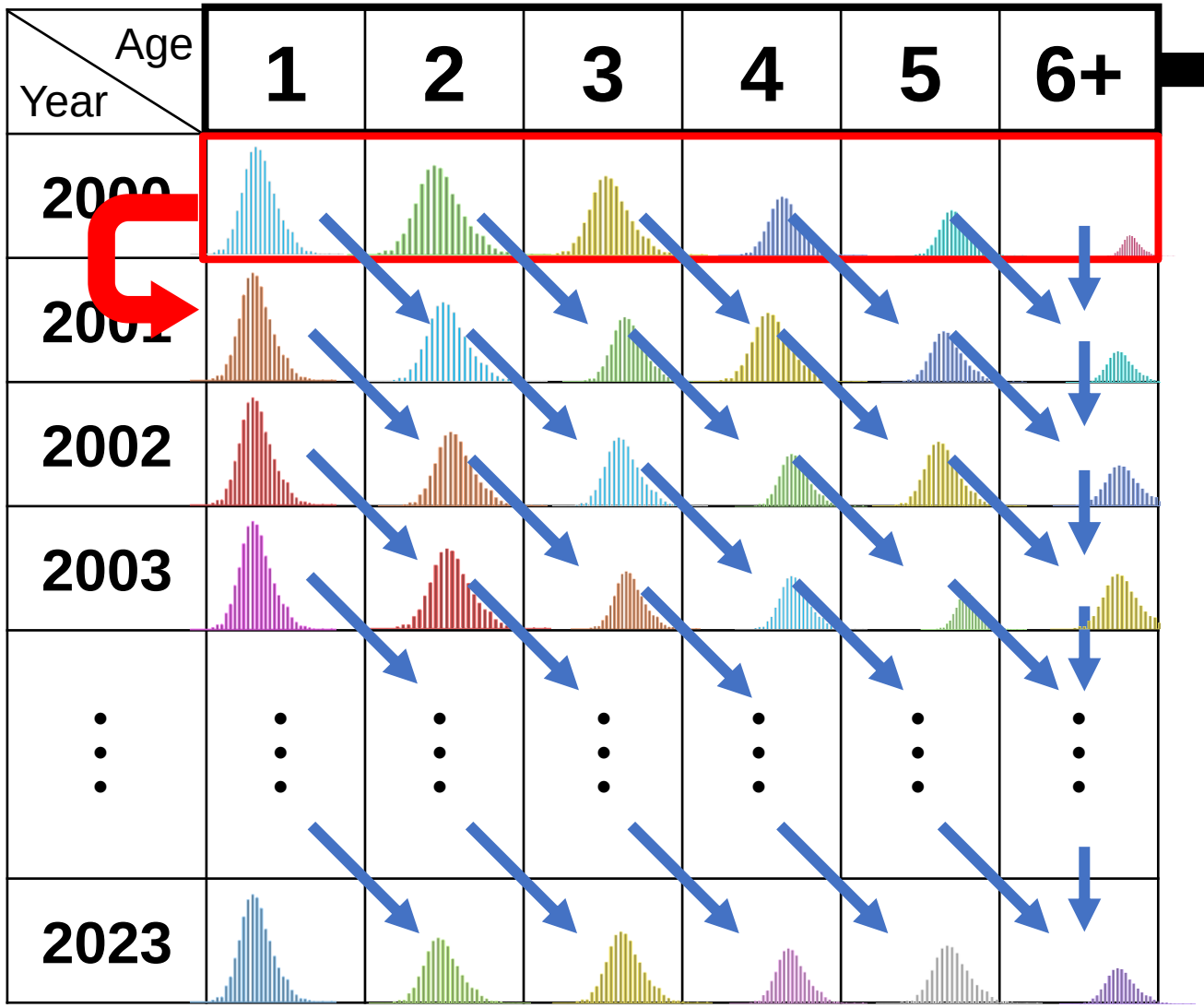


A length-based assessment

Considering imaginary age classes



A length-based assessment



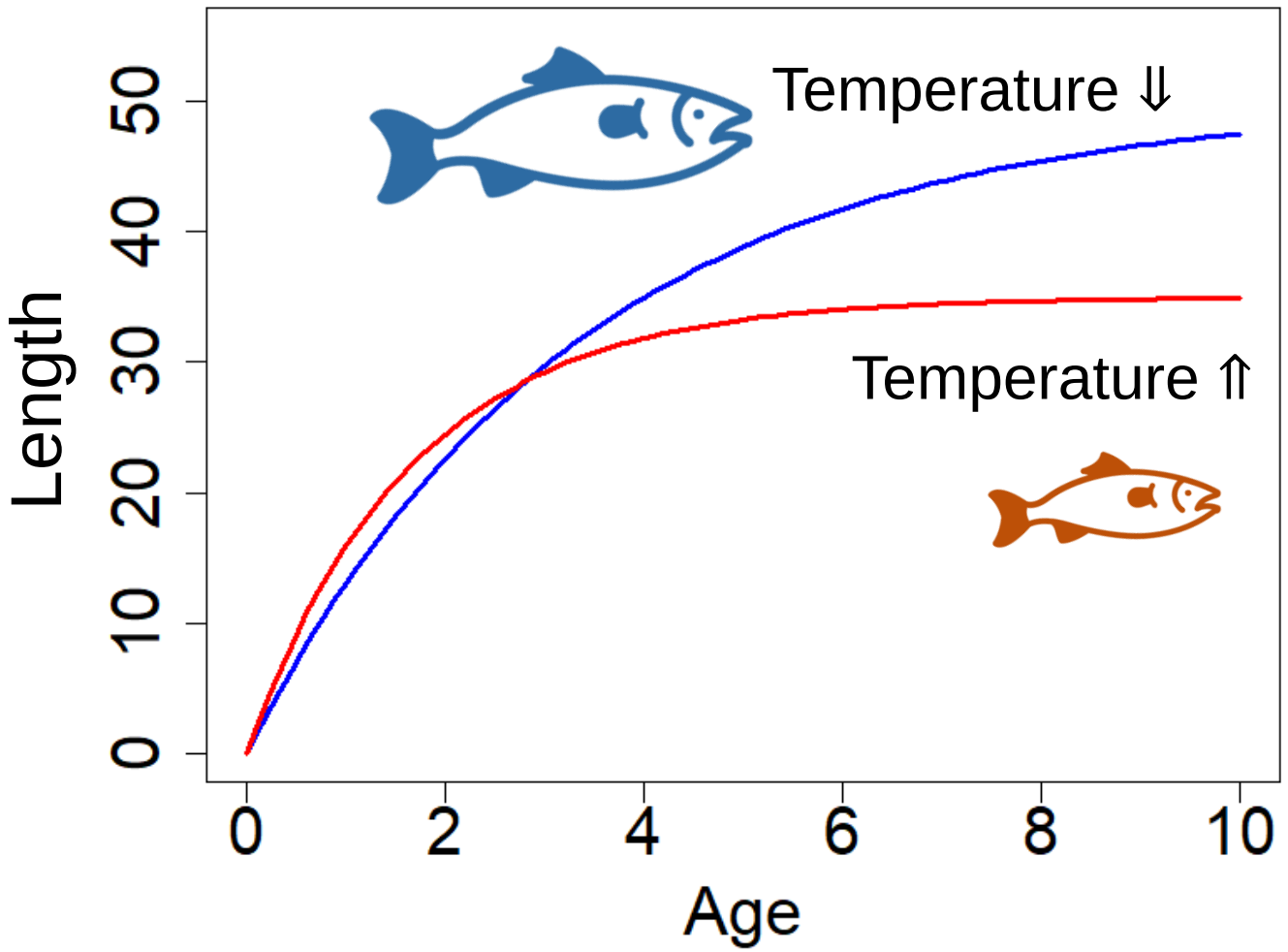
Imaginary age classes

Calculate length frequency of population

: Death and growth

Calculate parameters,
Biomass,
YPR,
SPR

Maturation



Water temperature ⇑
→ Larger juvenile size
→ Smaller size at maturity

In TSR studies,
growth is often the only factor considered.

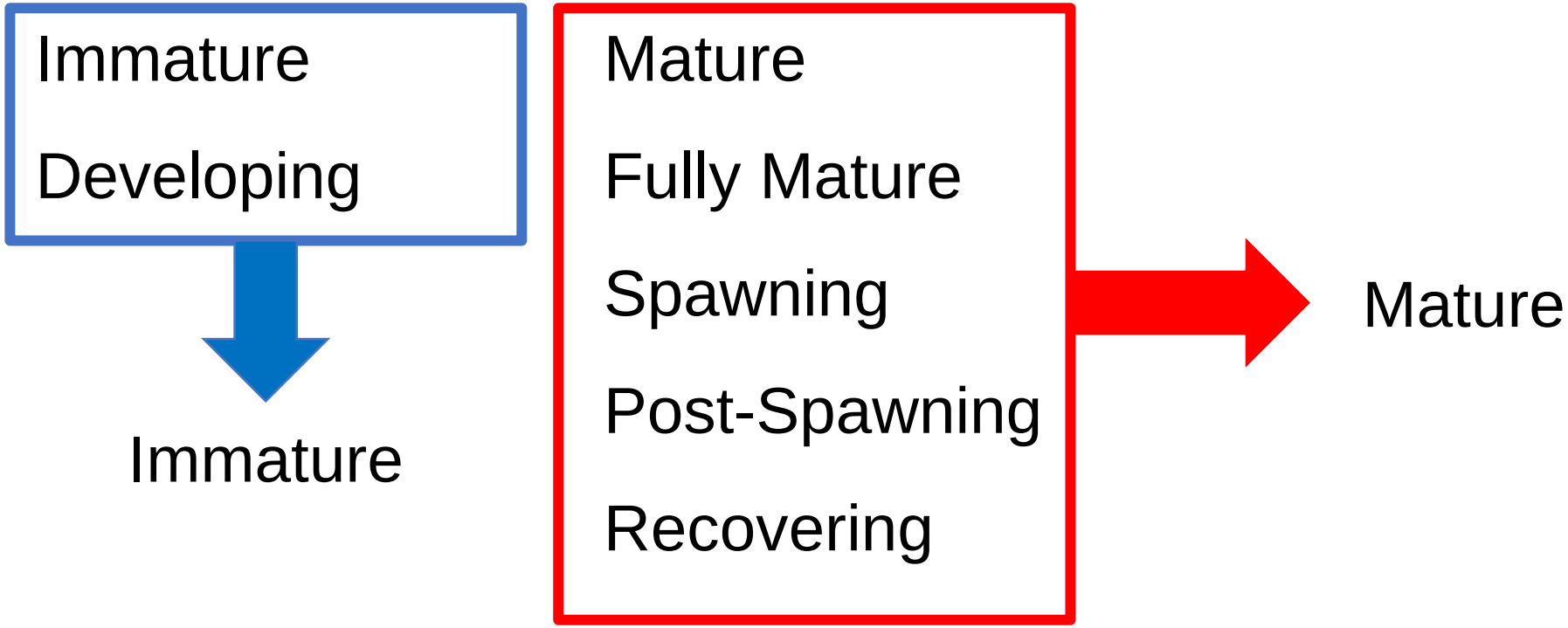
We considered both growth and maturation.

Maturation

Data on reproductive maturation of the chub mackerel

- From 2005 – 2023
- Maturation information was reported as an ordinal scale

e.g.,



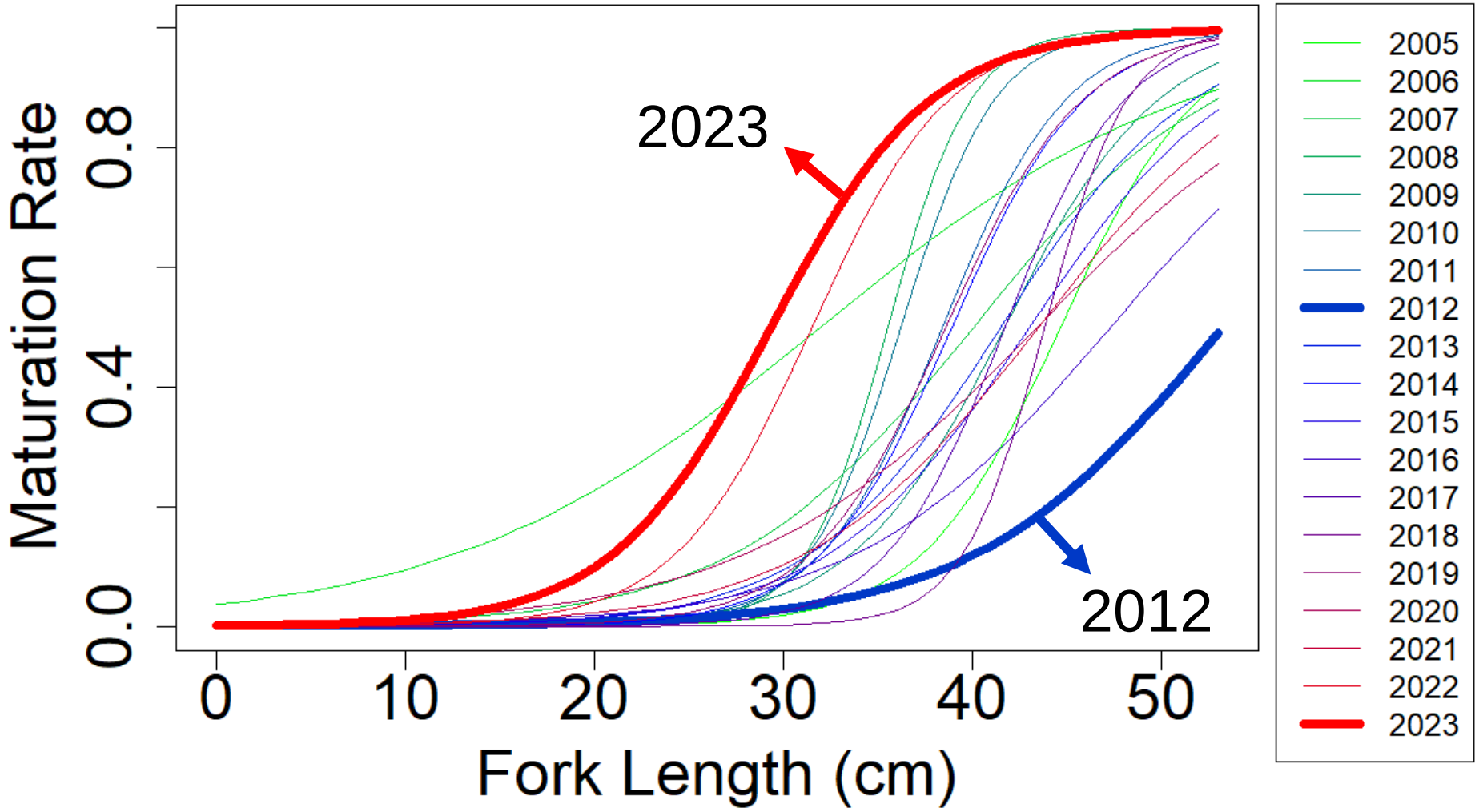
Maturation

Part of the data example on maturation (n = 15,450)

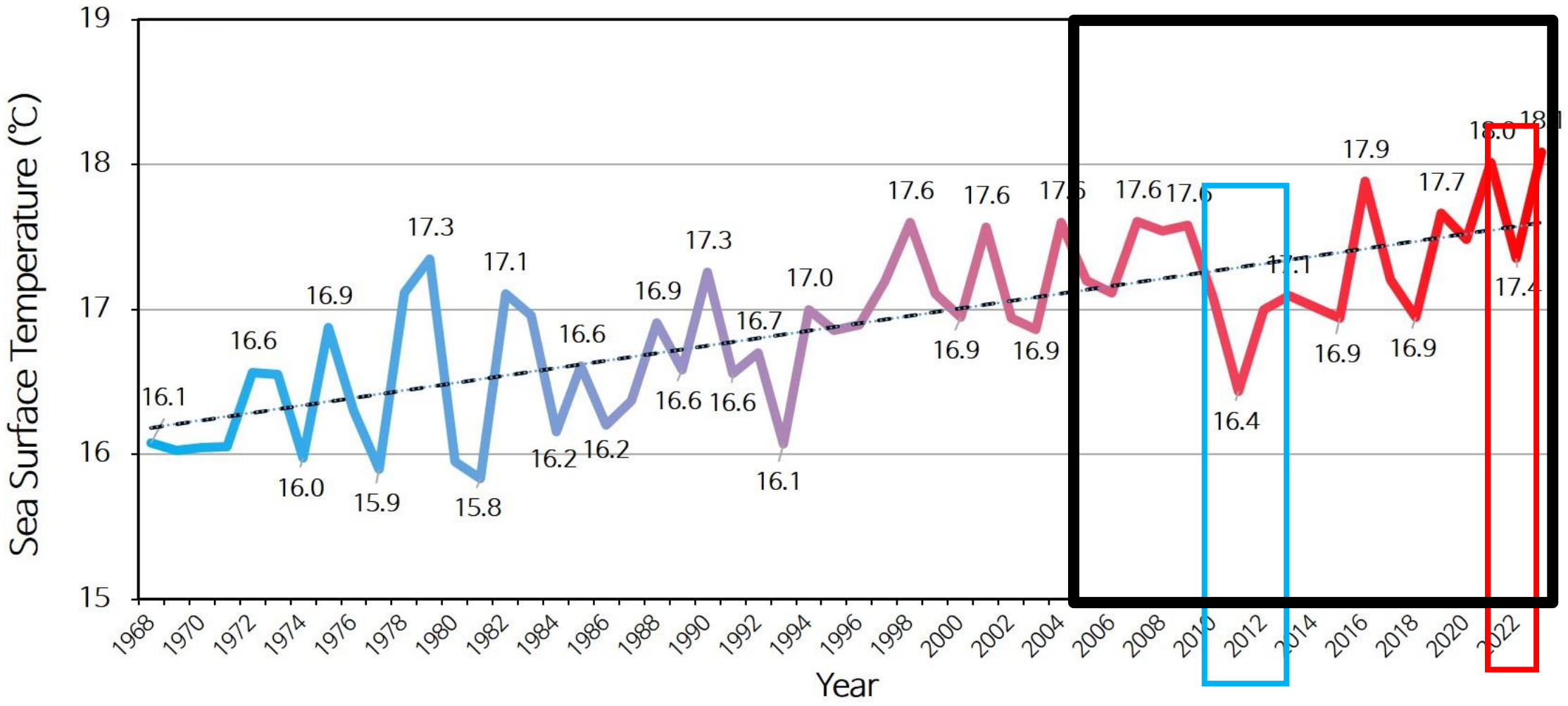
Year	T.L(cm)	F.L(cm)	B.W(g)	Mat.	G.W(g)
2005	35.4	32.5	567.2	Immature	8.75
2005	36.5	33.7	542.1	Immature	4.97
2005	31.2	28.8	295.5	Immature	2.38
2005	32.7	30.2	474.2	Immature	7.53
2005	41.6	38.3	908.3	Immature	20.14
2005	31.9	28.9	614.2	Immature	3.73
2005	37.3	35.3	428.0	Immature	4.41
2005	33.1	31.2	493.6	Immature	0.92
2005	34.5	32.3	489.4	Immature	6.07
2005	38.3	34.8	425.7	Immature	11.63

Maturation

Logistic regression of maturation against fork length by year



Maturation


Sea Surface Temperature (℃)
Year
19
18
17
16
15
16.1
16.6
16.0
16.9
15.9
17.3
15.8
17.1
16.2
16.6
16.2
16.9
17.3
16.6
16.7
16.1
17.0
17.6
16.9
17.6
16.9
17.6
17.6
16.4
17.1
16.9
17.9
16.9
17.7
16.9
18.0
17.4
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022

Management strategy evaluation

Stock assessment

Making reference points of management

Focus on the **present time**

Climate change effect

Stock assessment

Fishery management

Scientific

Practical

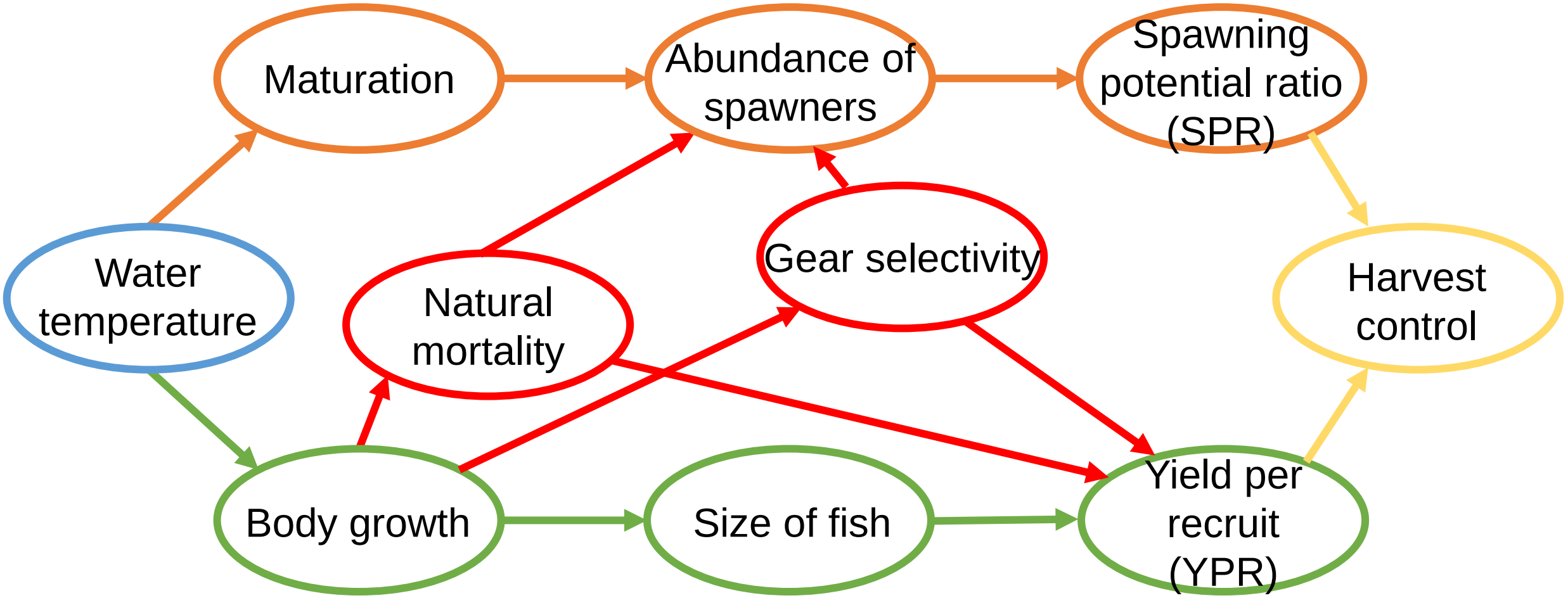
Management Strategy Evaluation (MSE)

Example: Key Model Values

Notation	Description
R_0	Unexploited abundance of recruits
q	Catchability in the relationship between annual biomass and CPUE
K	A von Bertalanffy parameter
$N_{t,a}$	Annual abundance at age a in year 2000 - 2023

➡ Generate data up to 2050

Management strategy evaluation



Scenario examples

Change	Value	S1	S2
Natural mortality	L_∞	Constant	Decrease
Growth	Mean size at recruit	Constant	Increase
Spawning stock biomass	Maturation rate at length	Constant	Mature at smaller length
Fishing mortality	Selectivity at length	Constant	Catch more at same length

TSR

Harvest control rule

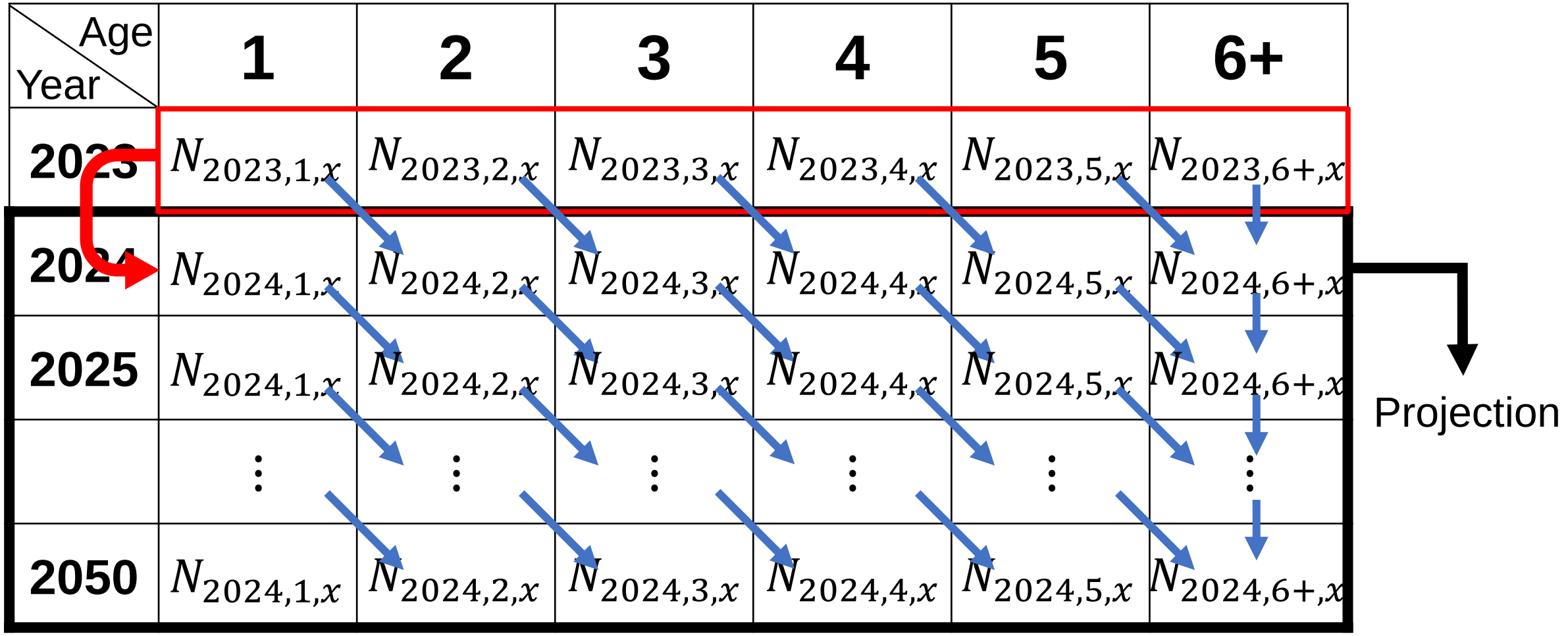
Example: Harvest control rule (HCR)

$$\begin{cases} \dfrac{SSB}{SSB_{40\%}} > 1 \Rightarrow & F_{ABC} \le F_{40\%} \\ 0.5 < \dfrac{SSB}{SSB_{40\%}} \le 1 \Rightarrow & F_{ABC} \le F_{40\%} \times \left(\dfrac{SSB}{SSB_{40\%}} - 0.05 \right) / (1 - 0.05) \\ \dfrac{SSB}{SSB_{40\%}} \le 0.5 \Rightarrow & F_{ABC} = 0 \end{cases}$$

SSB: spawning stock biomass
$SSB_{40\%}$: SSB at $F_{40\%}$ $(target)$
$F_{40\%}$: fishing mortality at 40% of SPR (SSB/SSB_0) (SSB_0: unexploited SSB)

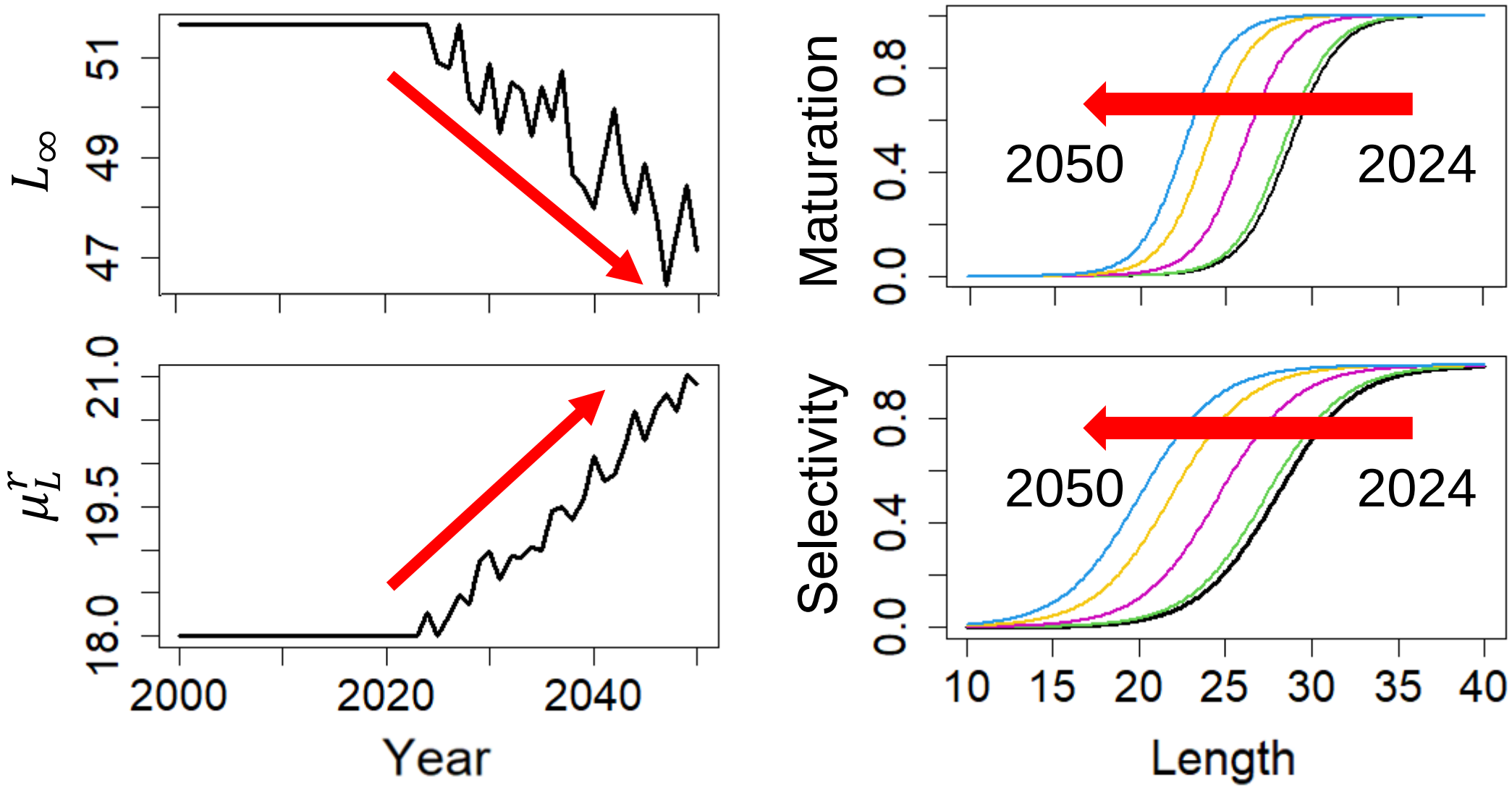
⇒ **Adjust the fishing intensity based on the level of SSB**

Harvest control rule

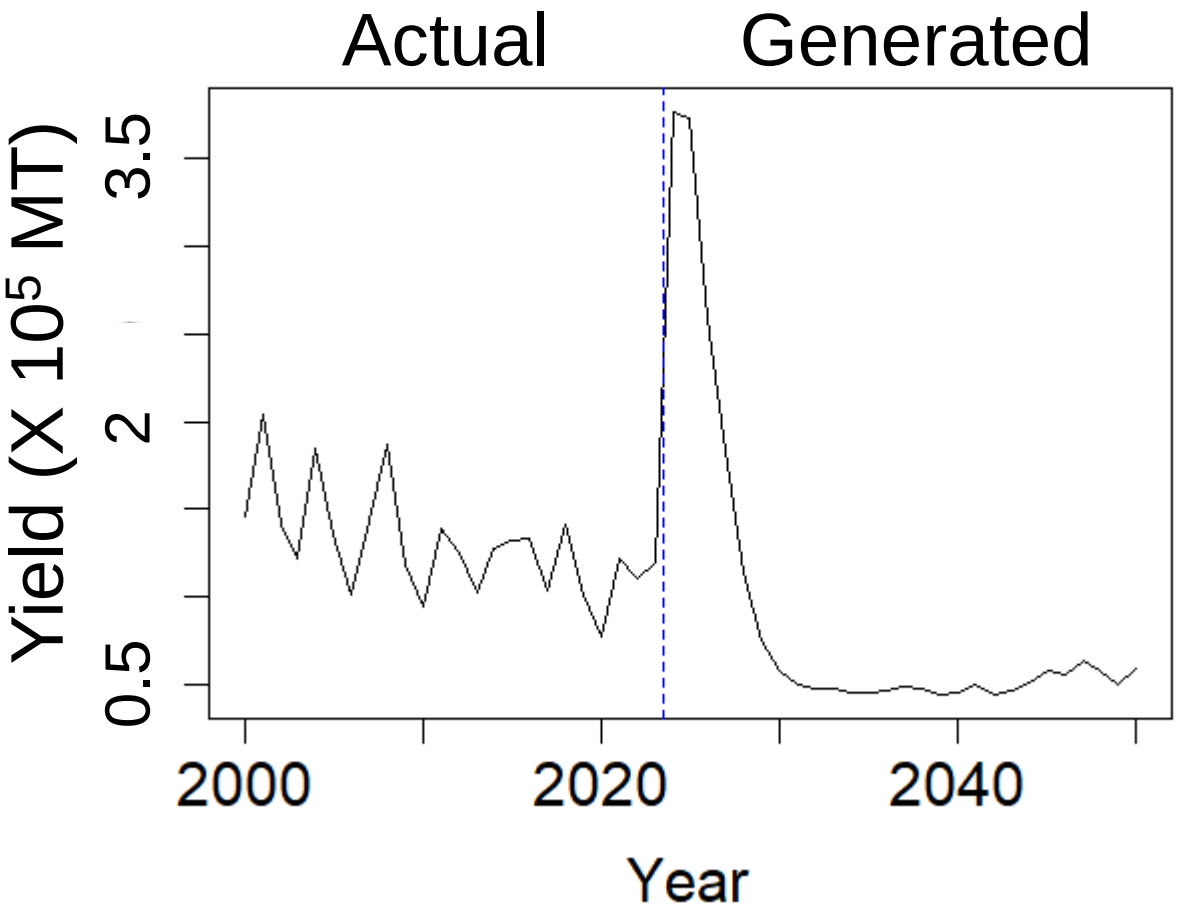


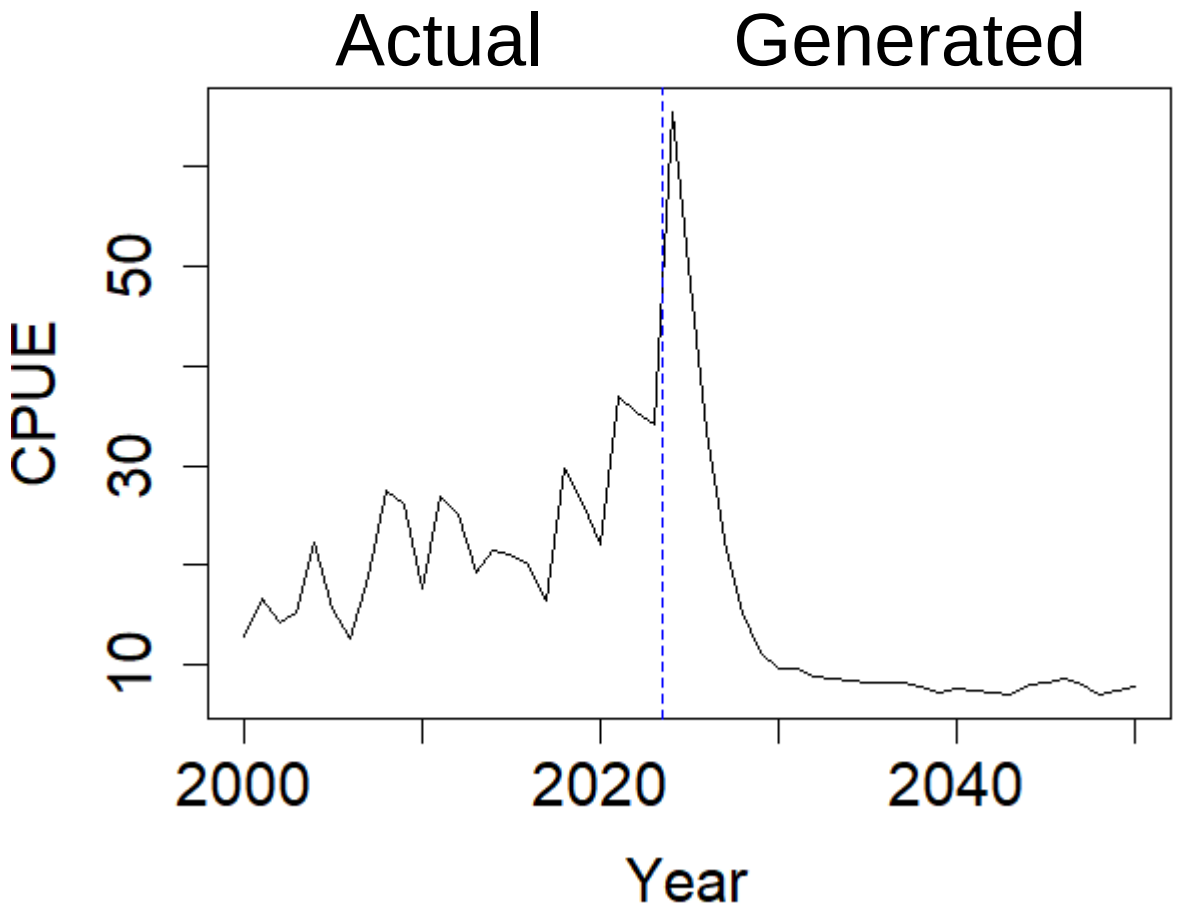
Applying the HCR under the TSR effect scenarios using results from the 2000 - 2023 data

Scenario example

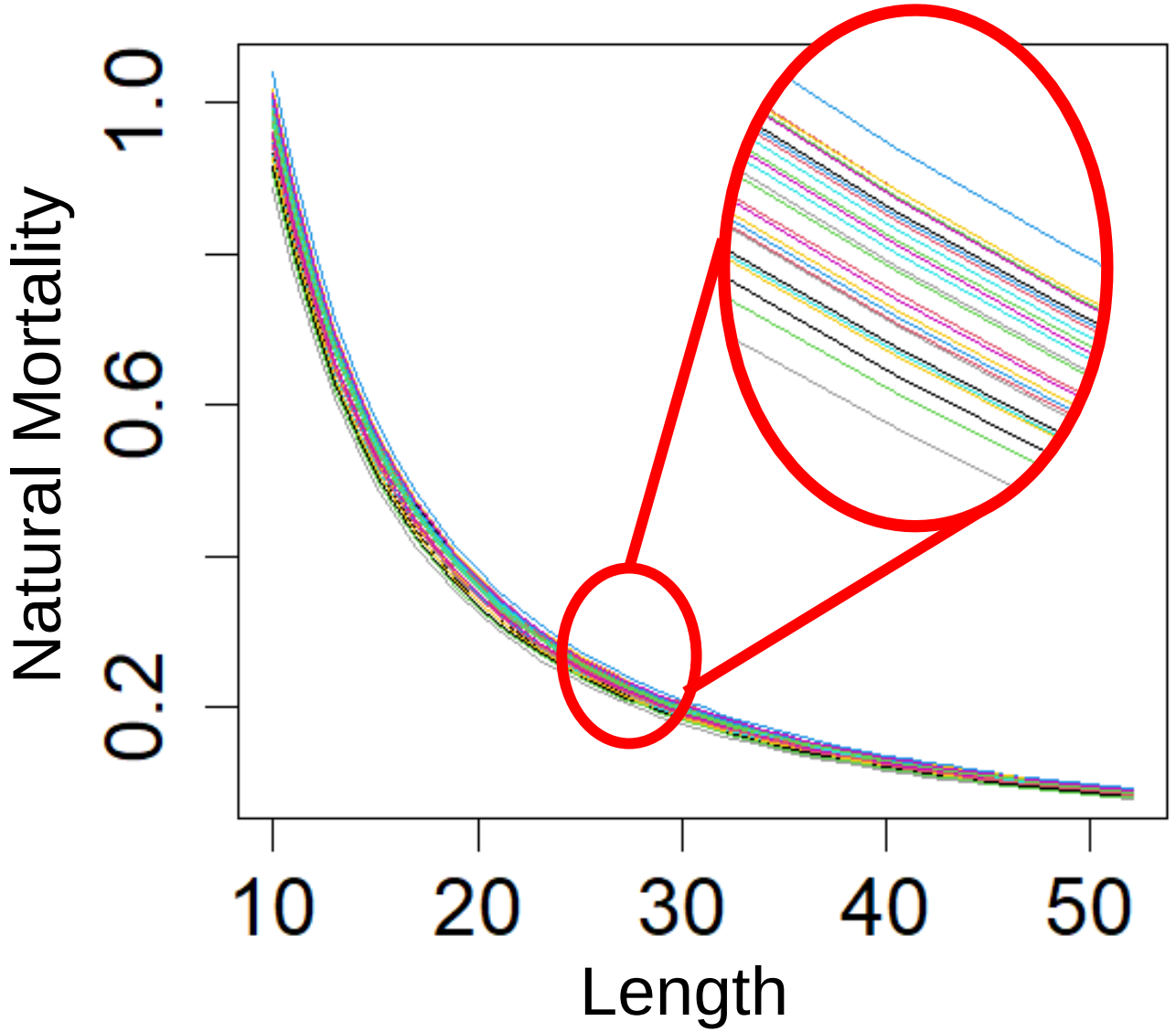


Scenario example



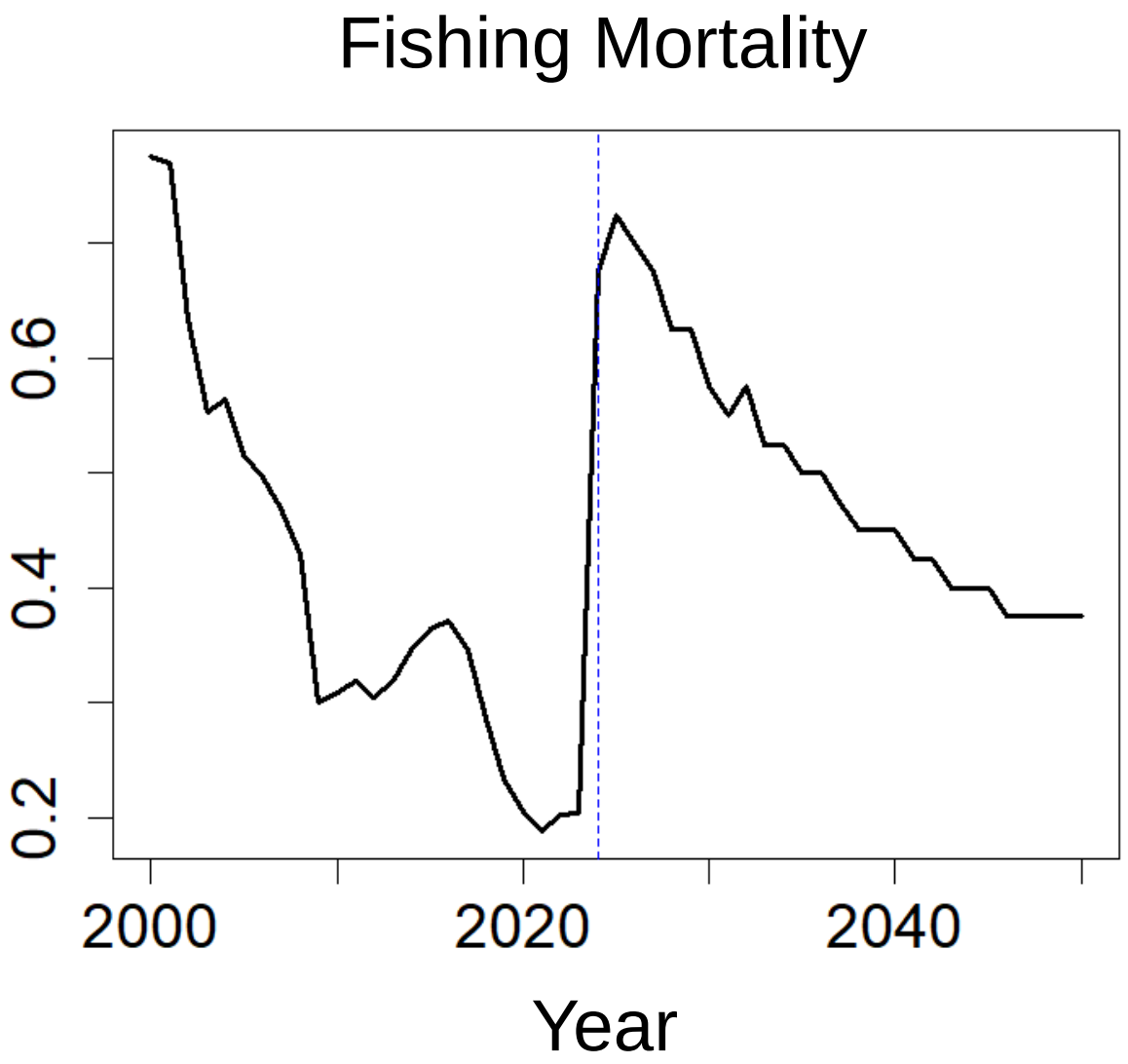


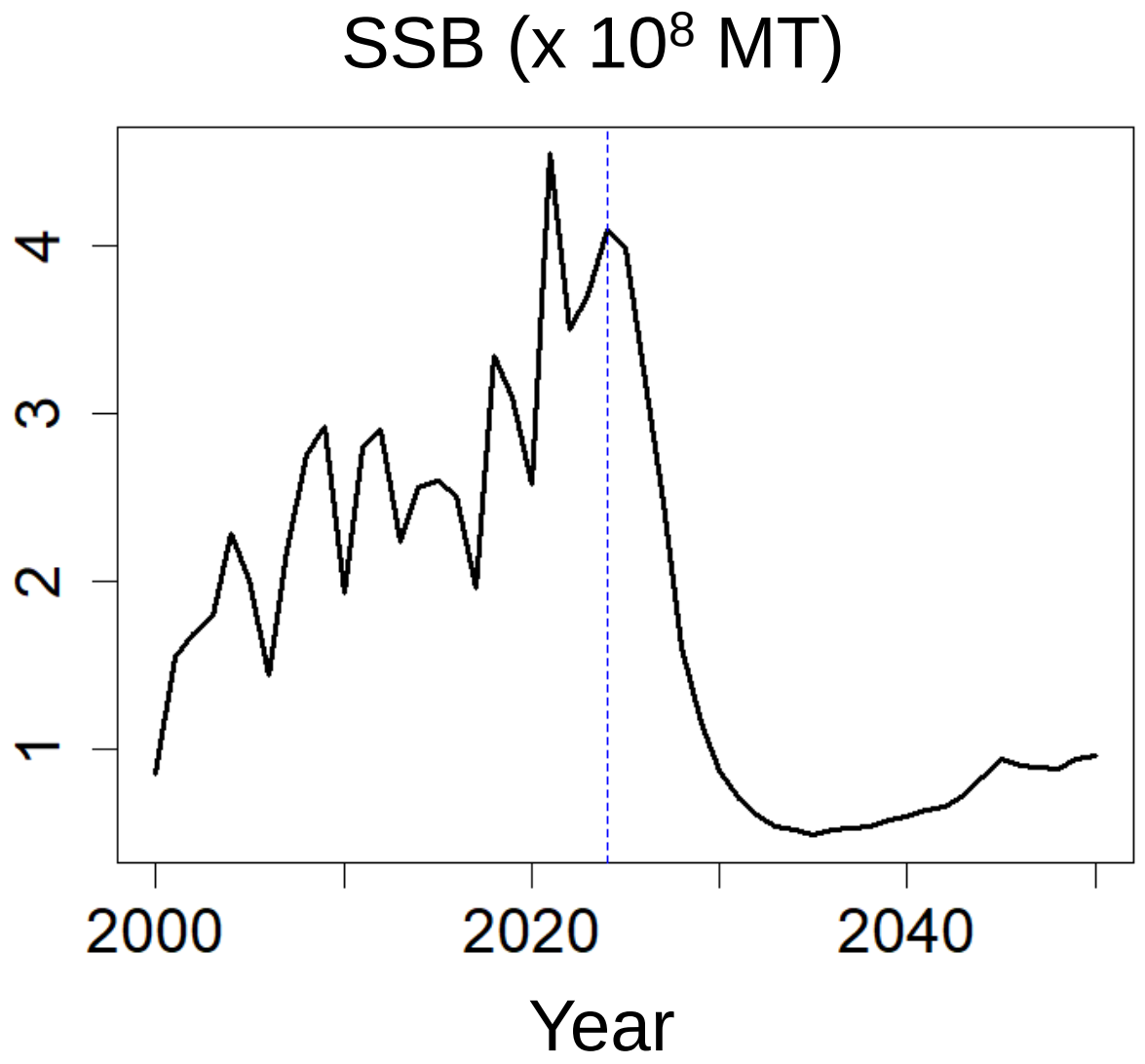
Scenario example



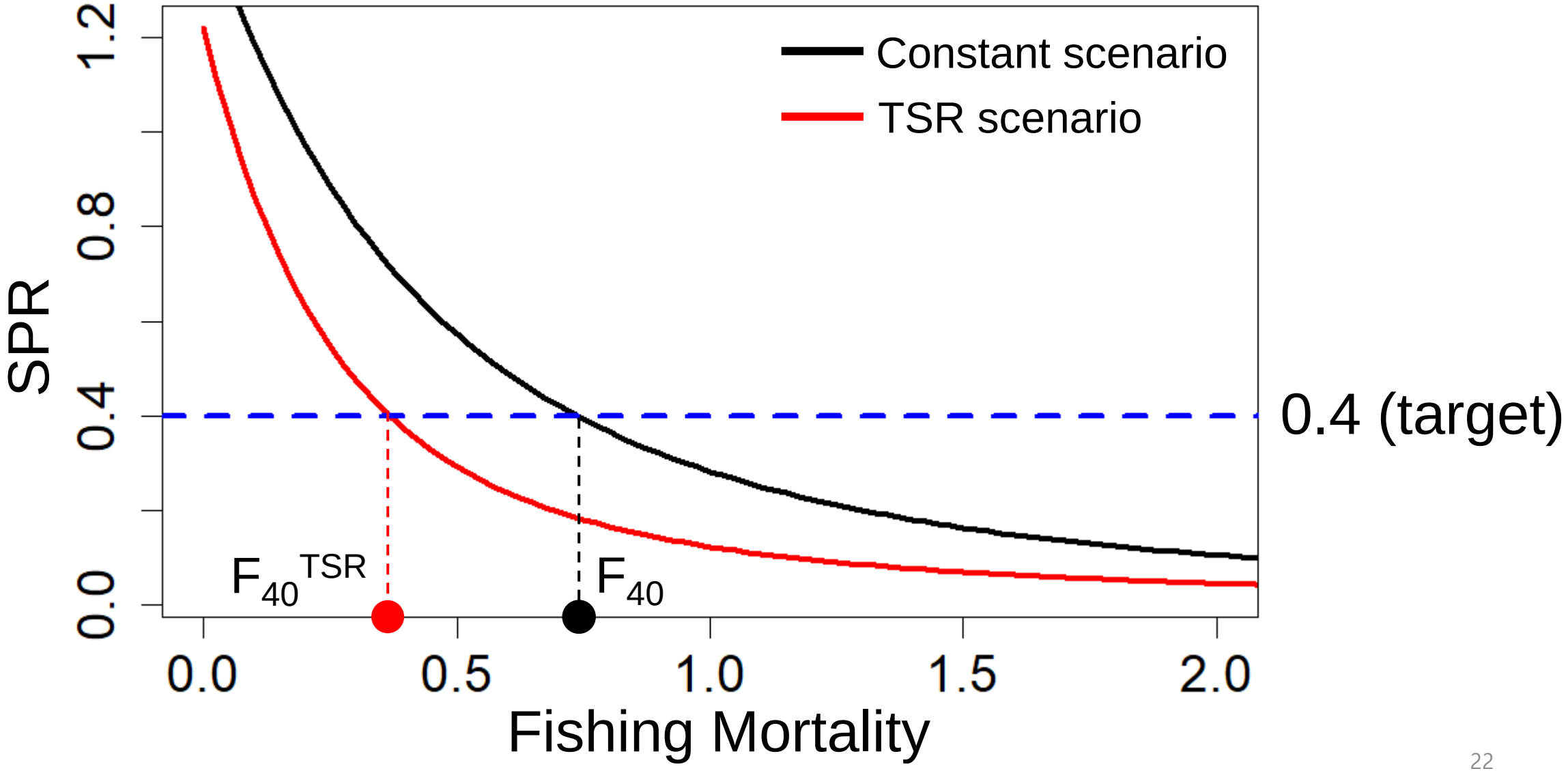
$$M = \left(\frac{L}{L_\infty}\right)^{-1.5} \cdot K$$

Scenario example



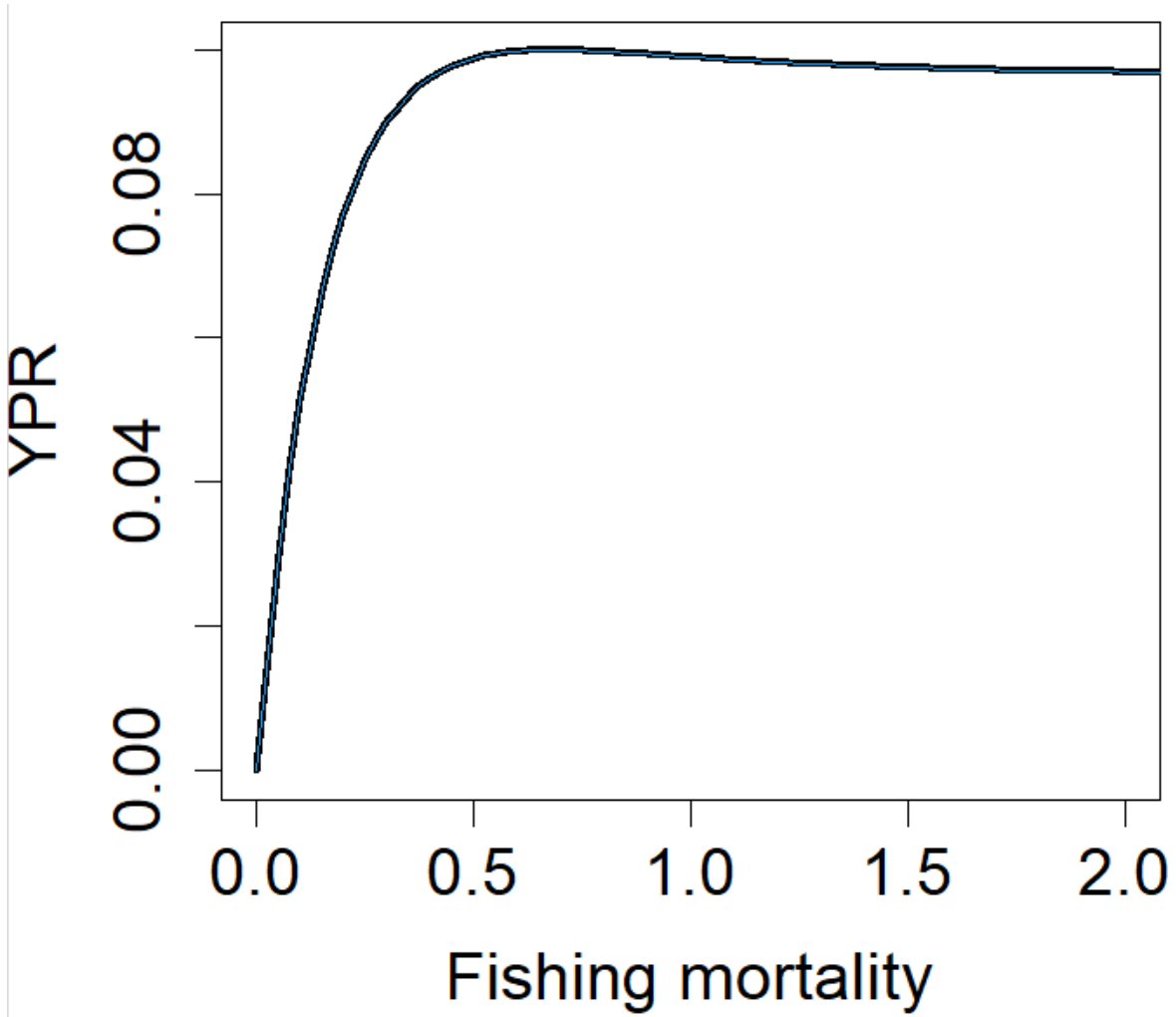


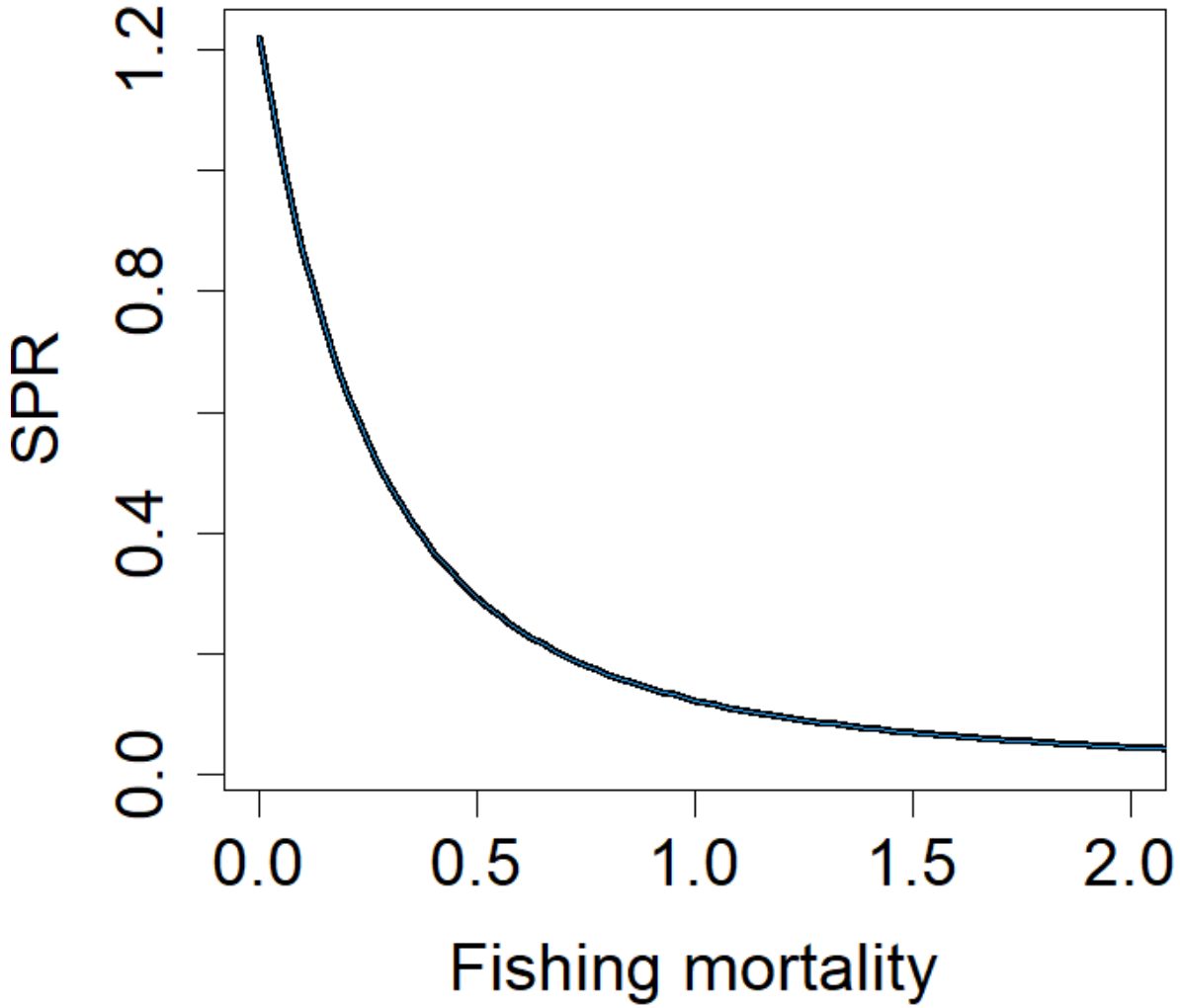
Scenario example



Scenario example

Results of 300 simulations





Scenario example

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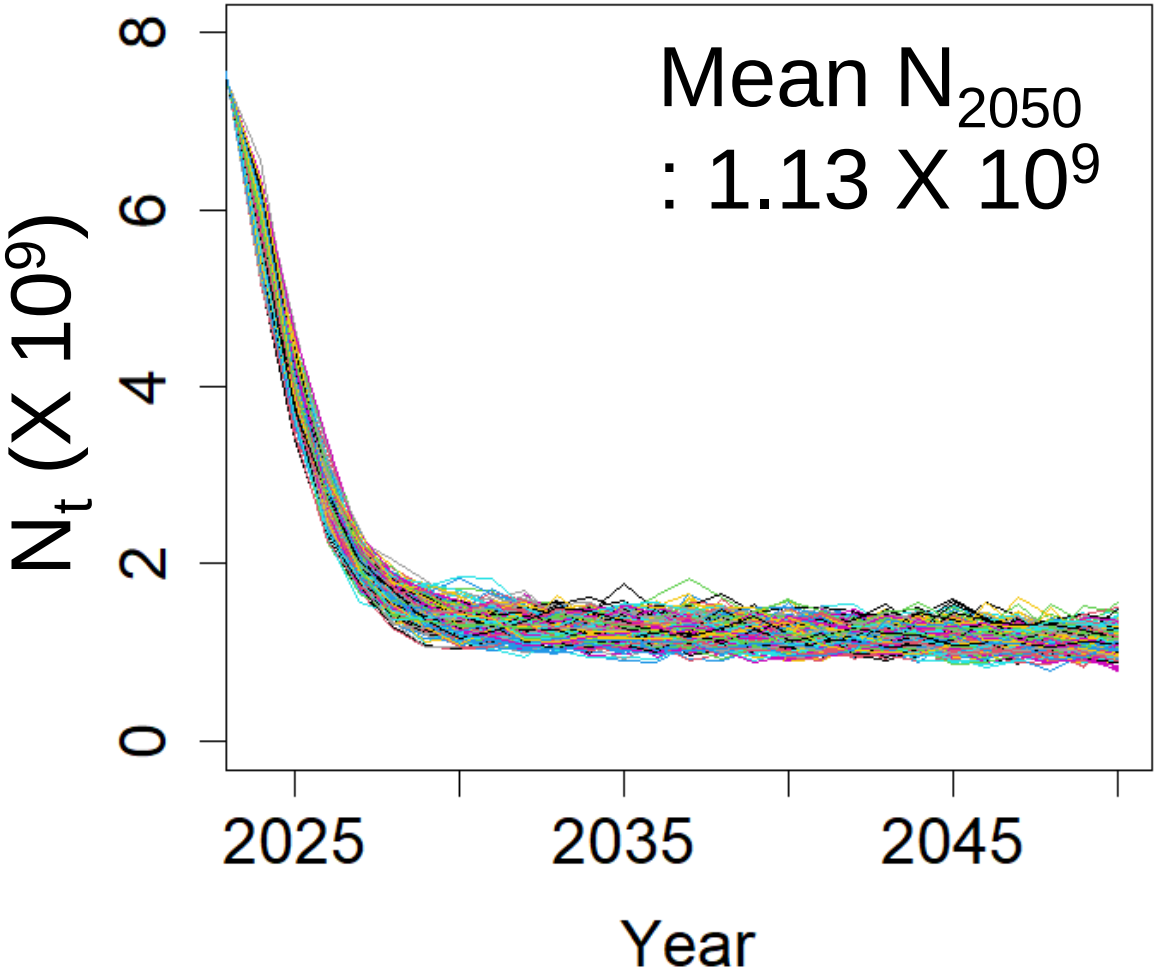
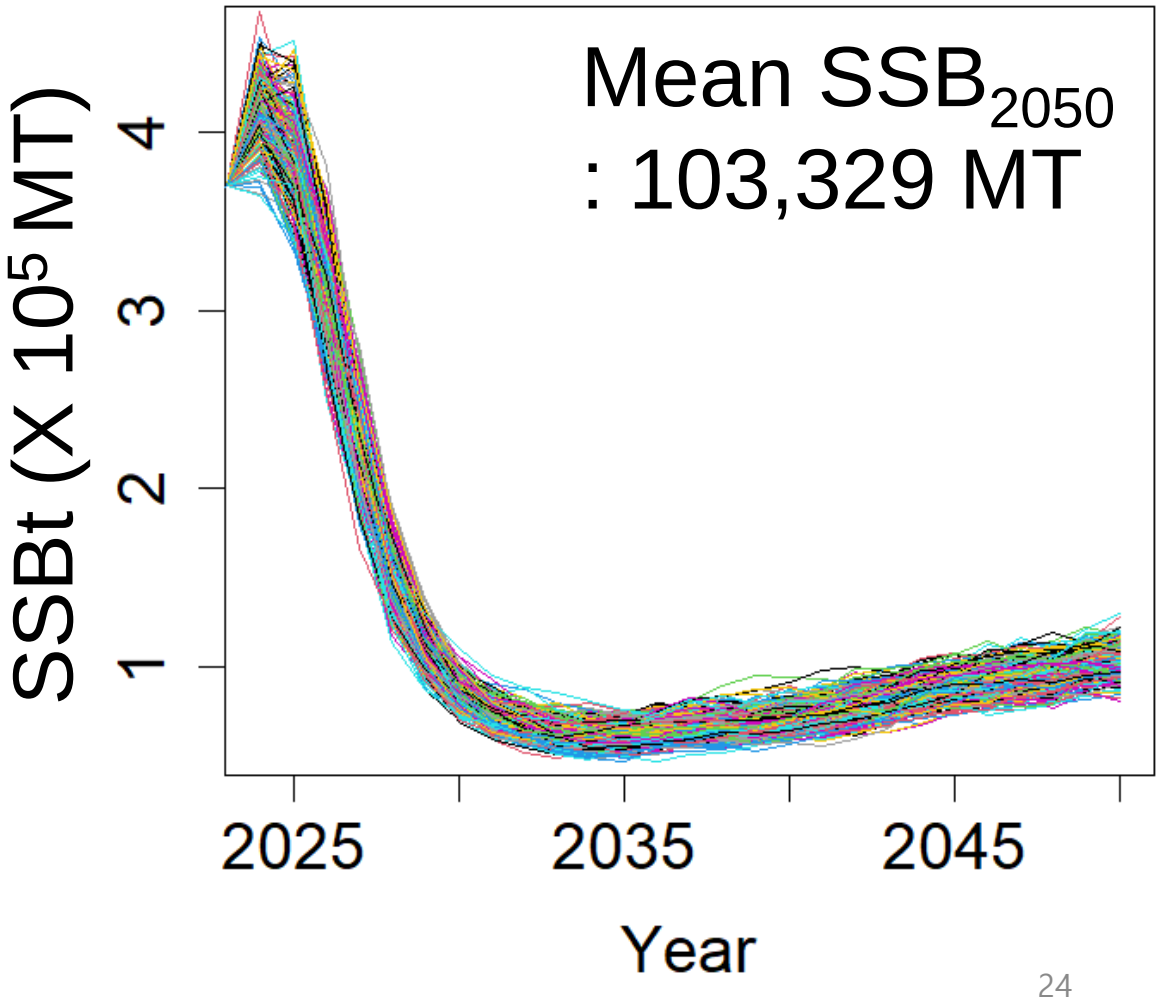
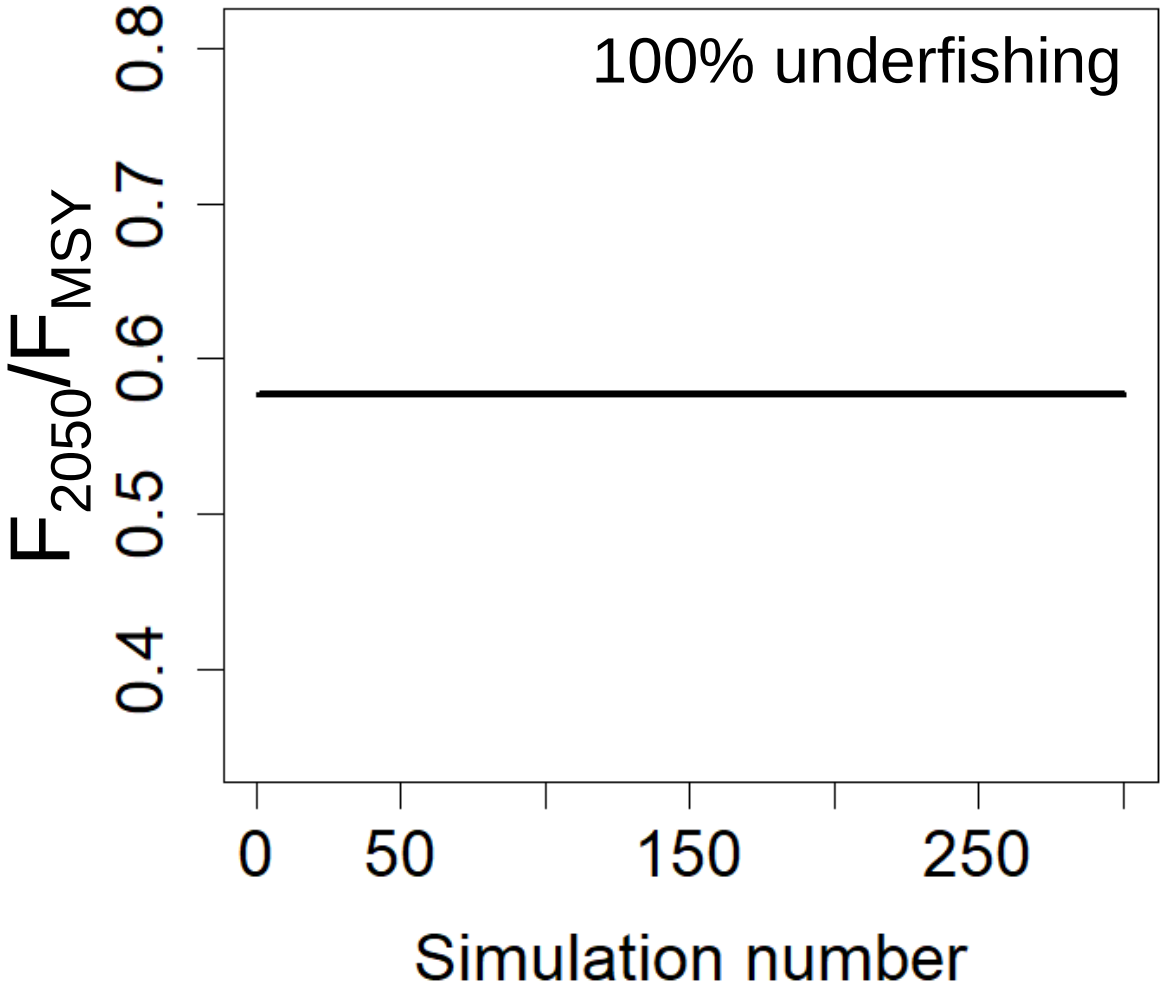
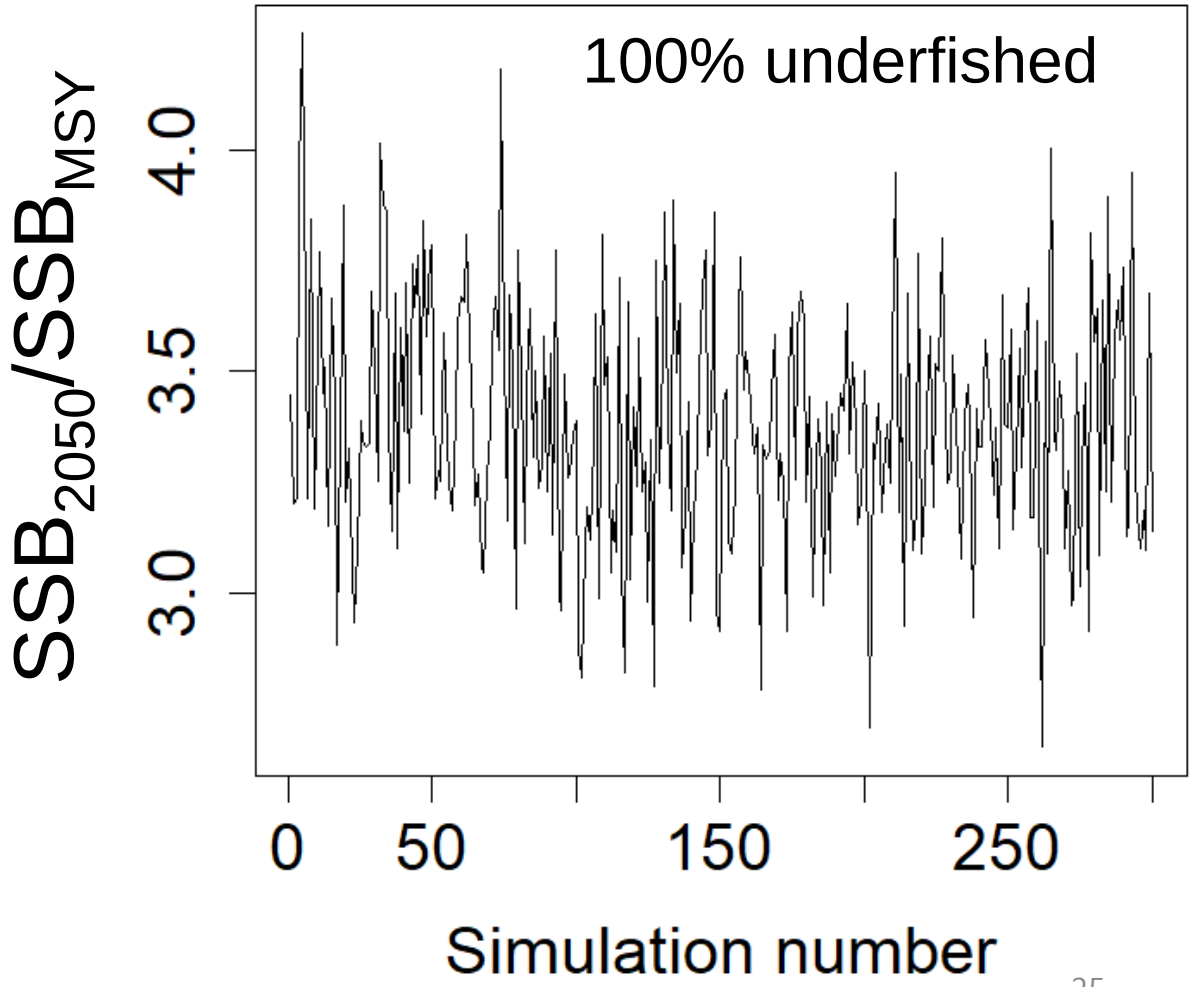




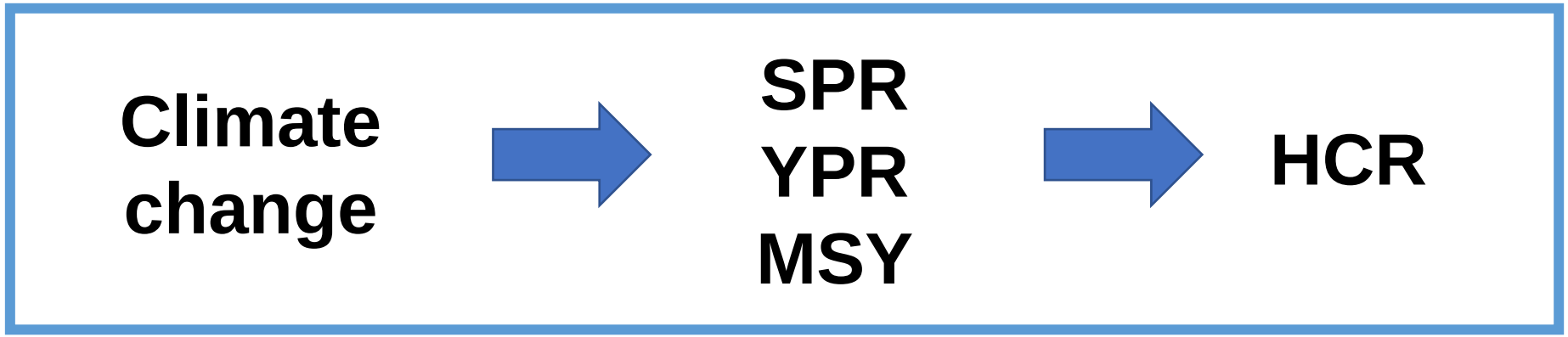
Scenario example

Results of 300 simulations





Summary



- It becomes essential to adapt fisheries management approaches to account for the impacts of climate change, ensuring sustainable practices that are responsive to future environmental shifts

- This adaptation is crucial for maintaining the health of marine ecosystems and supporting long-term fisheries productivity

Acknowledgements

- Data support: National Institute of Fisheries Science
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