Harvest strategies and testing

Campbell Davies

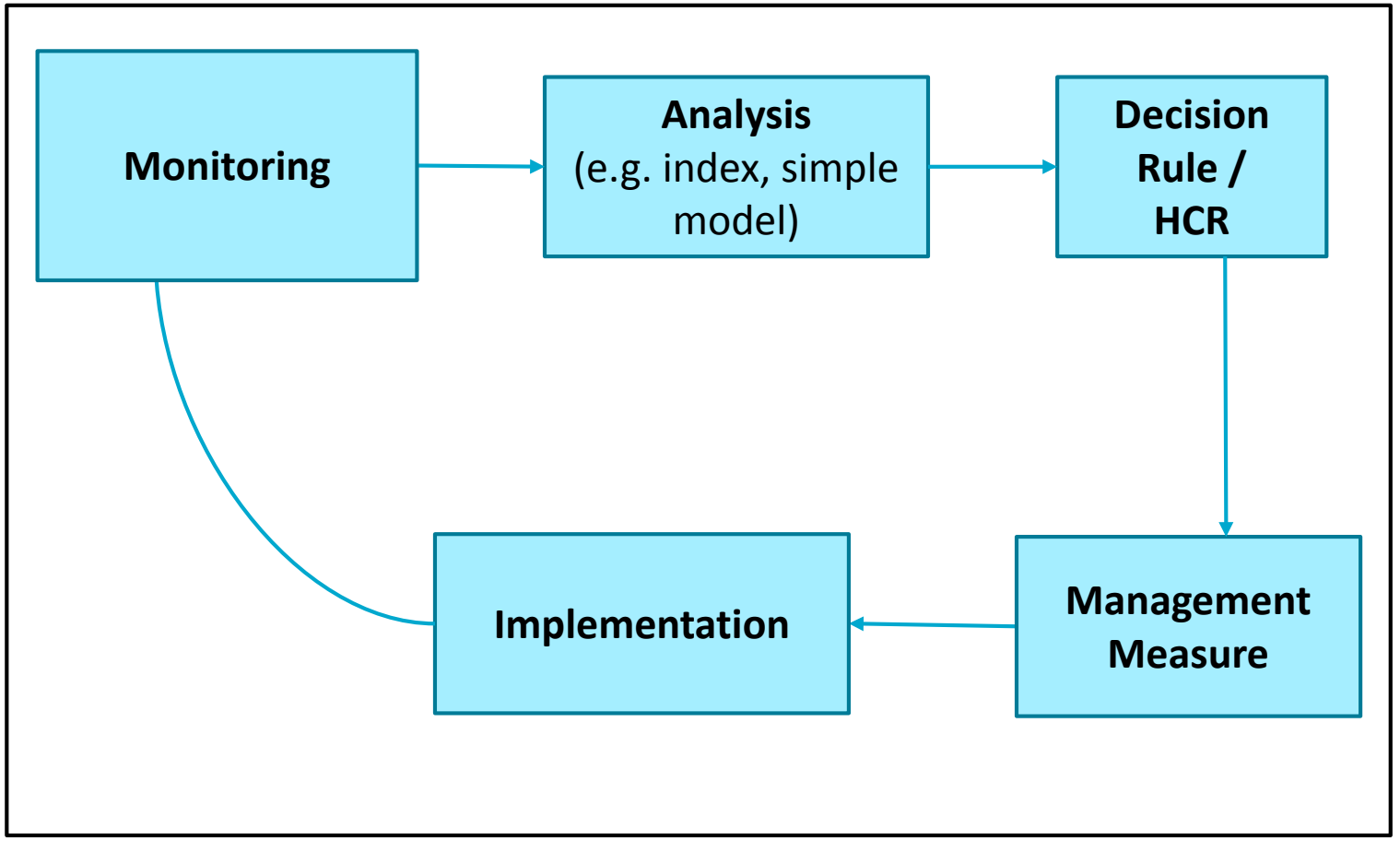
ISSF WS, Kaohsiung, Taiwan, 16 December 2016

What is a harvest strategy?

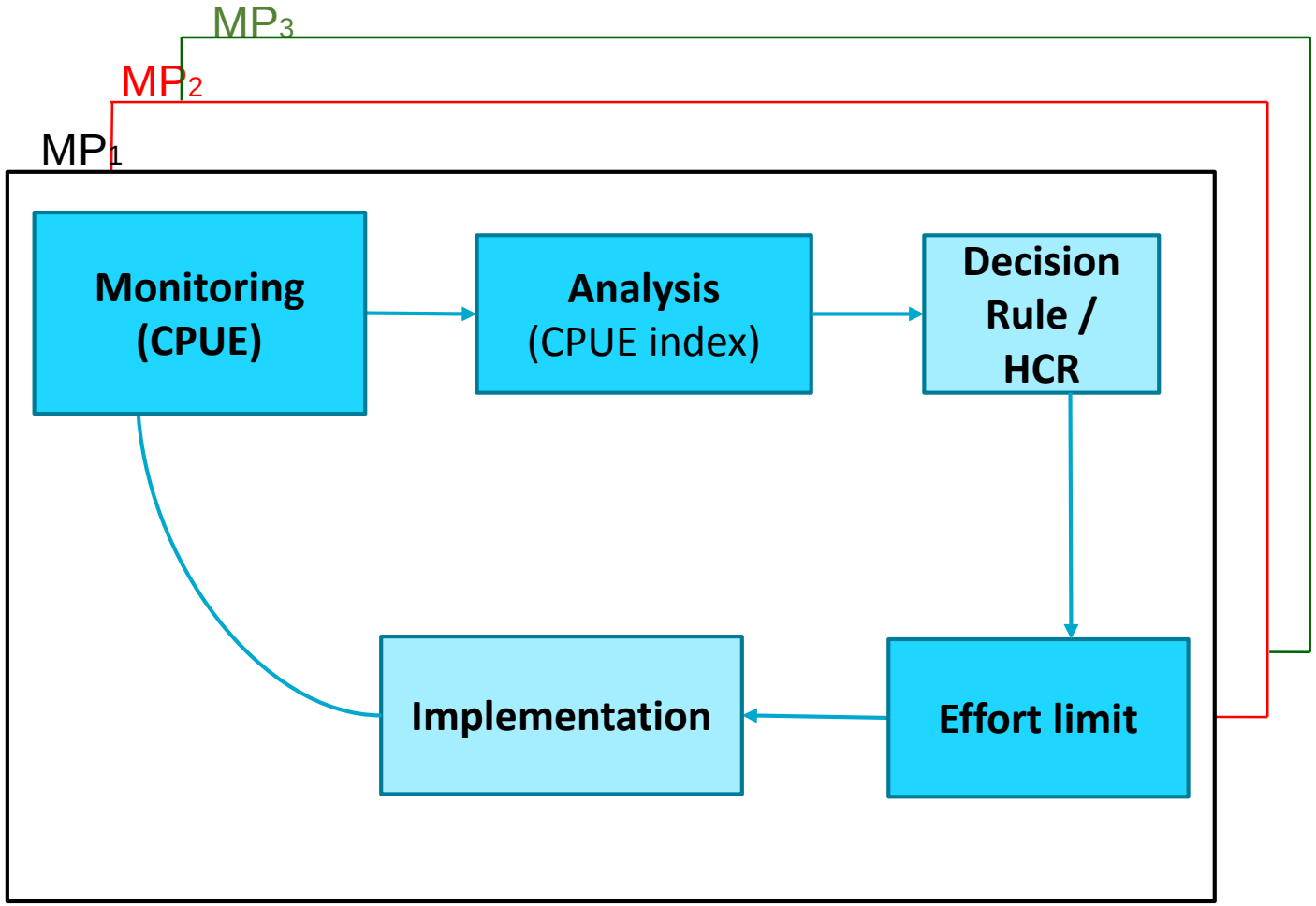
An agreed basis for ***monitoring*** and ***assessing*** a fishery **AND**;
adjusting the level of fishing;
using a specified ***management measure***,
BASED ON the ***harvest control rule***
to meet specific ***objectives***

When all components are specified and tested using MSE, as in CCSBT, it is referred to as a ***Management Procedure*** *(see glossary)*

Components of a harvest strategy



Different components = different strategy



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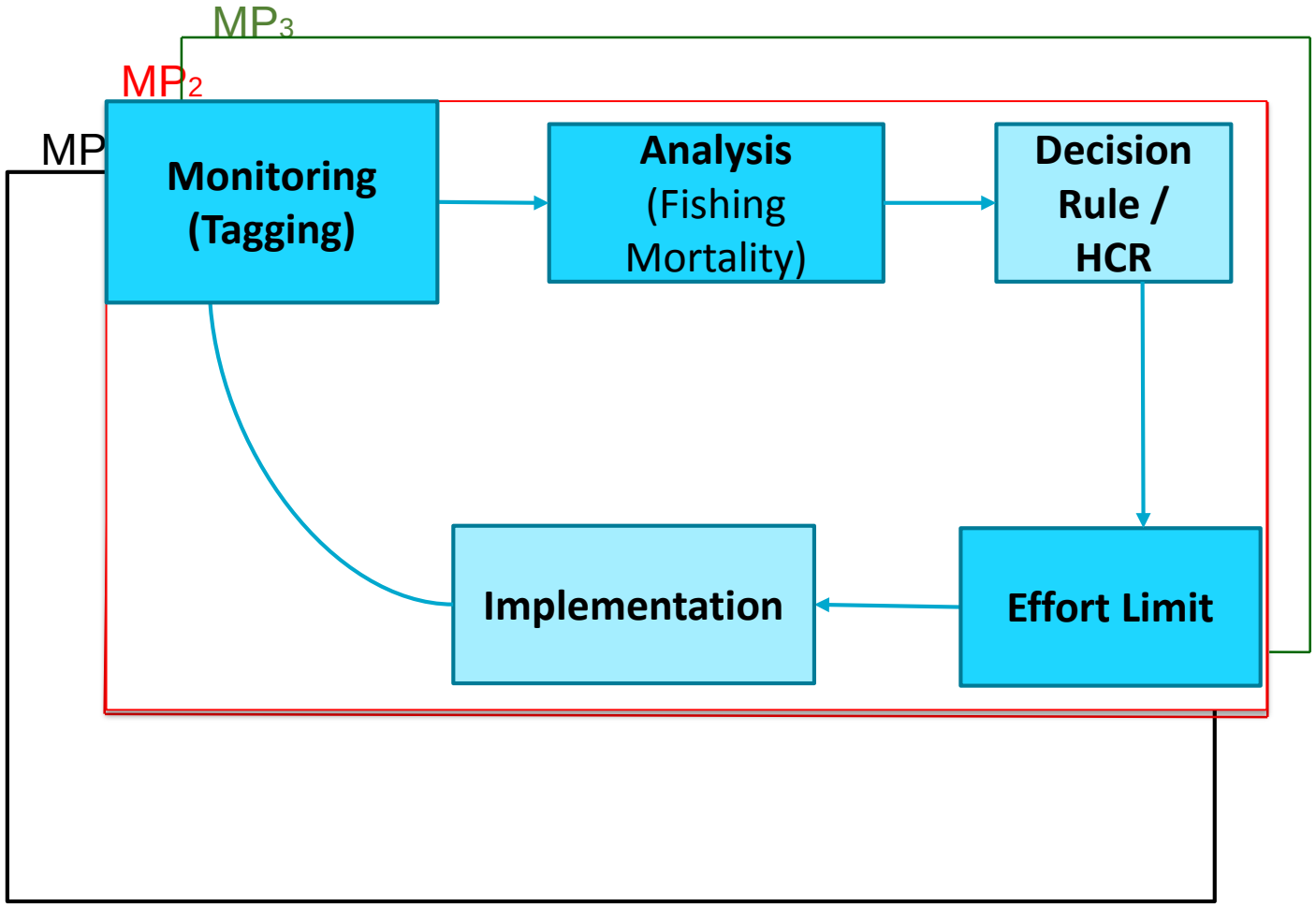

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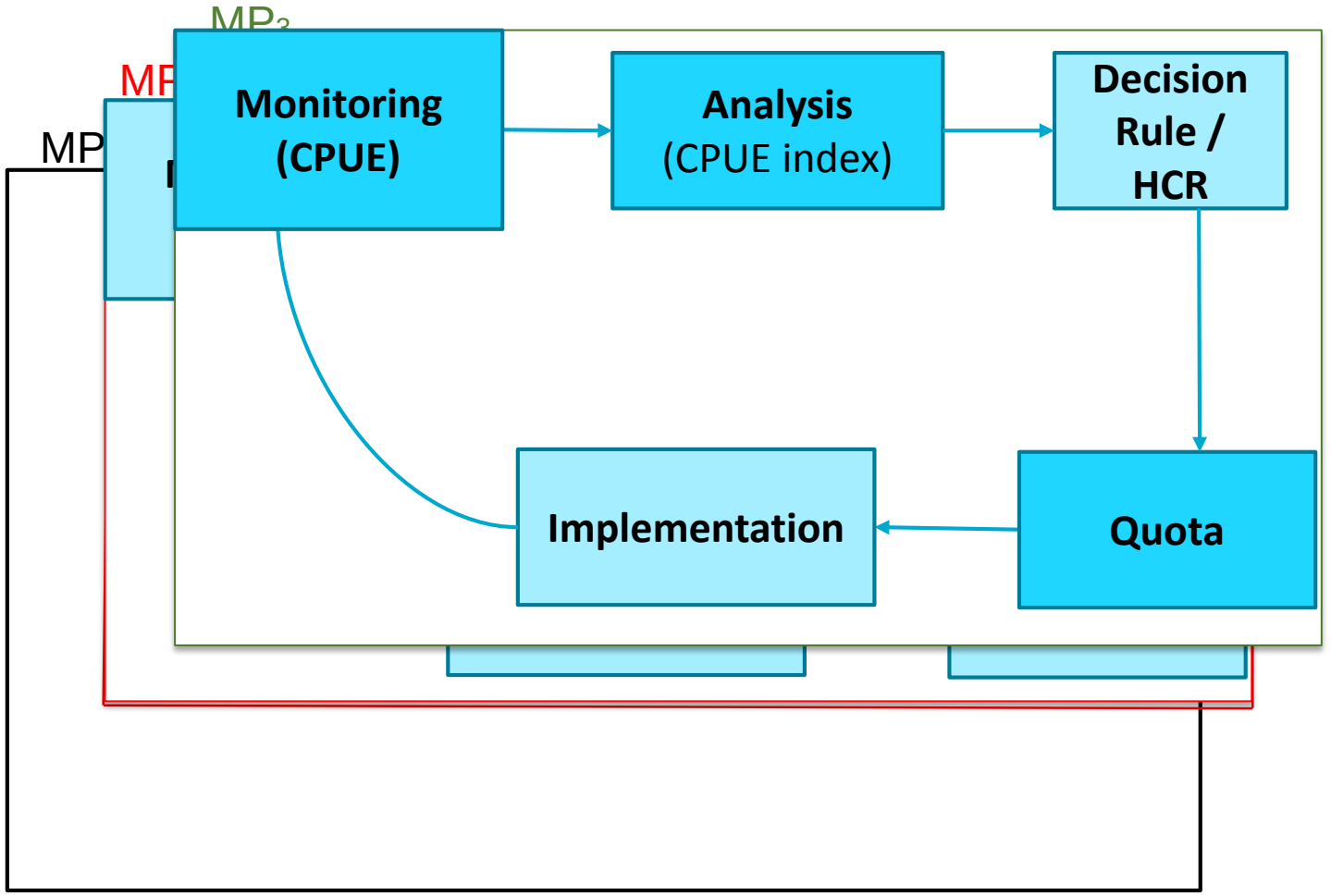
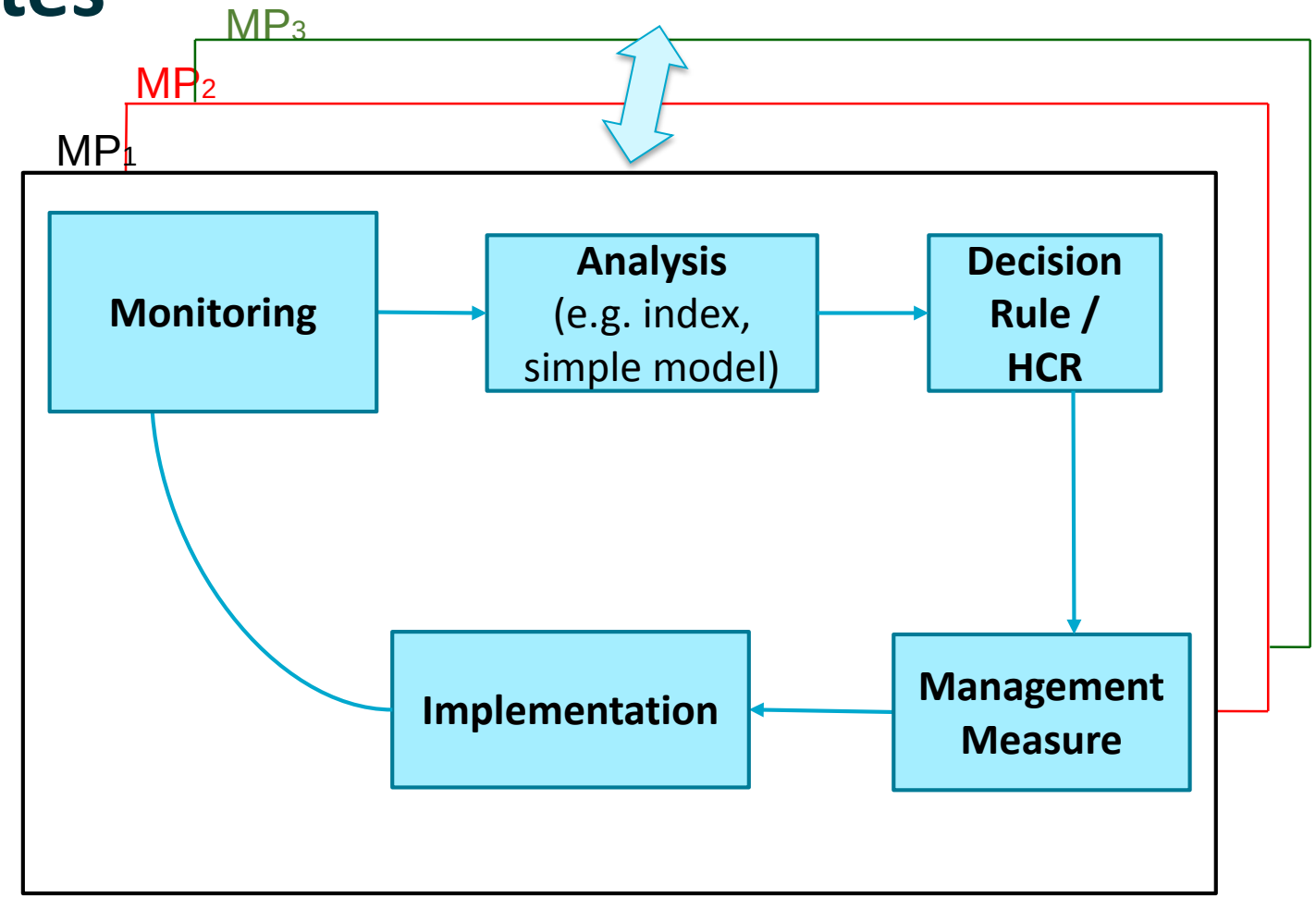


Focus on relative performance of feasible candidates



Performance measures for harvest strategies

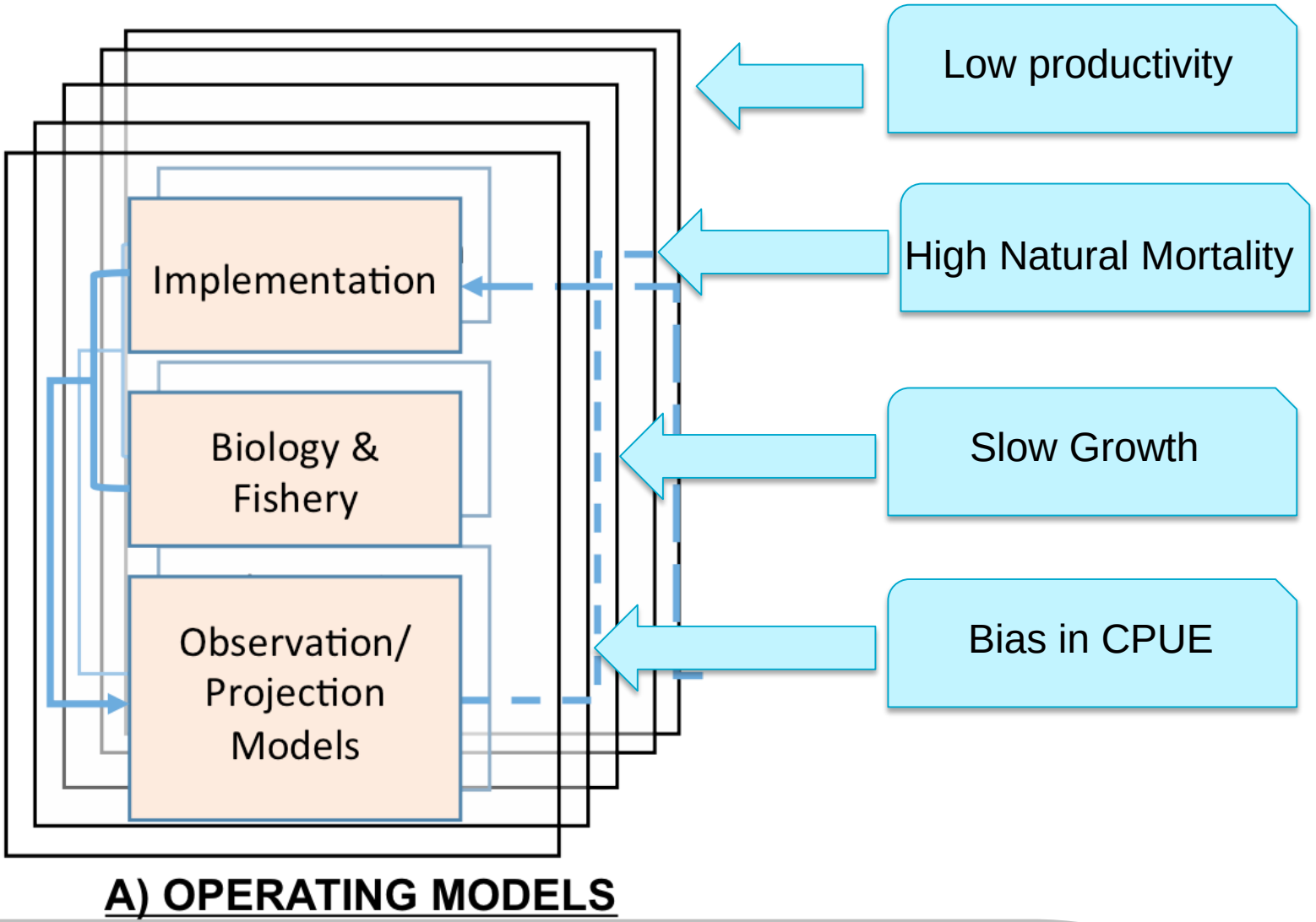
Generally, three major categories:

- Catch (total return, jobs, food provision)
- CPUE (efficiency/profit)
- Stock (management contingency/conservation risk)

Generic Management Decision Table

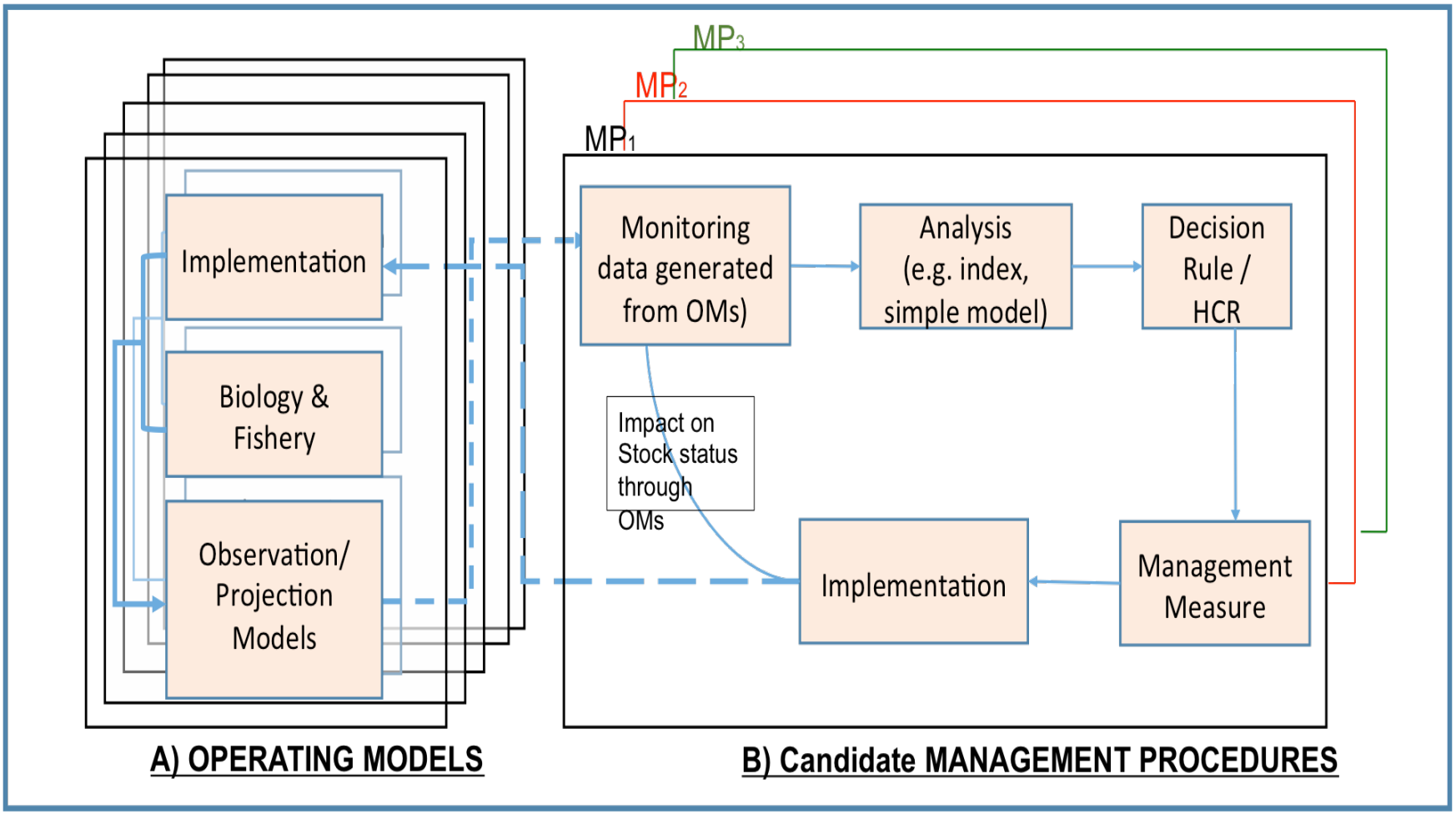
Performance Measure	Management Options		
	1 ✖	2	3 ✖
Biomass	X% ✖	X%	X%
Catch	X%	X%	X% ✖
CPUE	X% ✖	X%	X%

Operating Models – “the test bed”



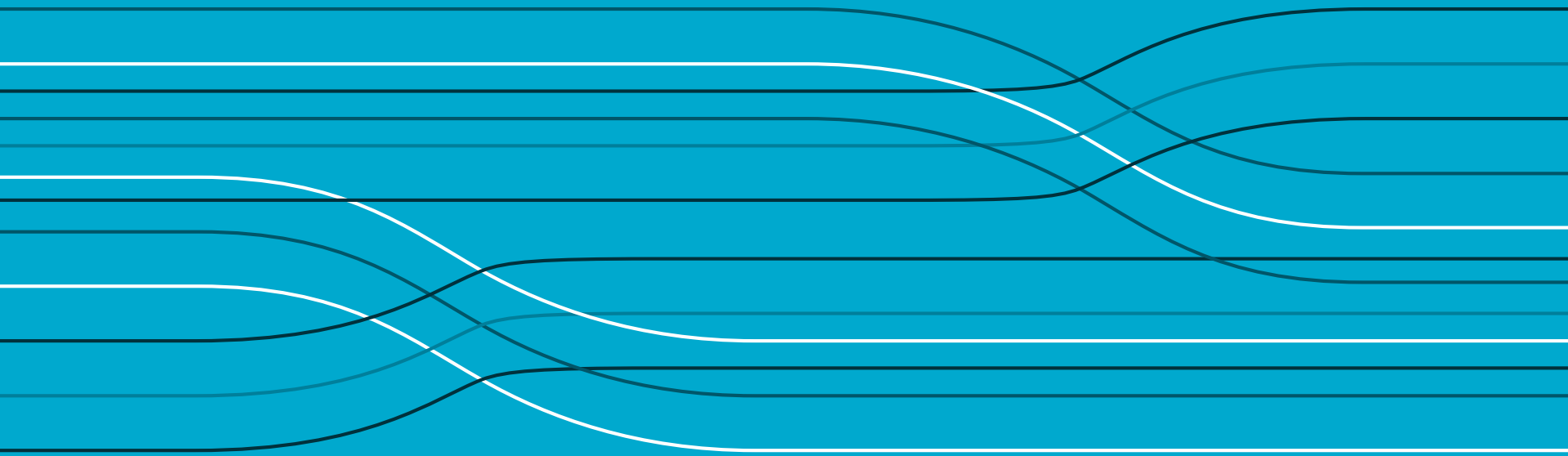
Management Strategy Evaluation

Testing & Selection Harvest Strategies



Steps in the MSE process

1. **Design OM** based on what you know (and don't know) about the system and data
2. **Detailed analysis** of available data to **understand** sources of bias and observation **uncertainty**
3. Identify **plausible management measures** for fishery
4. Design different **plausible Harvest Strategies**
5. Do initial MSE → to **identify candidate Harvest Strategies**
6. **Iterative dialogue** with stakeholders and managers to select and refine **most appropriate HS based on performance**.

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Testing and selection of Management Procedure in CCSBT

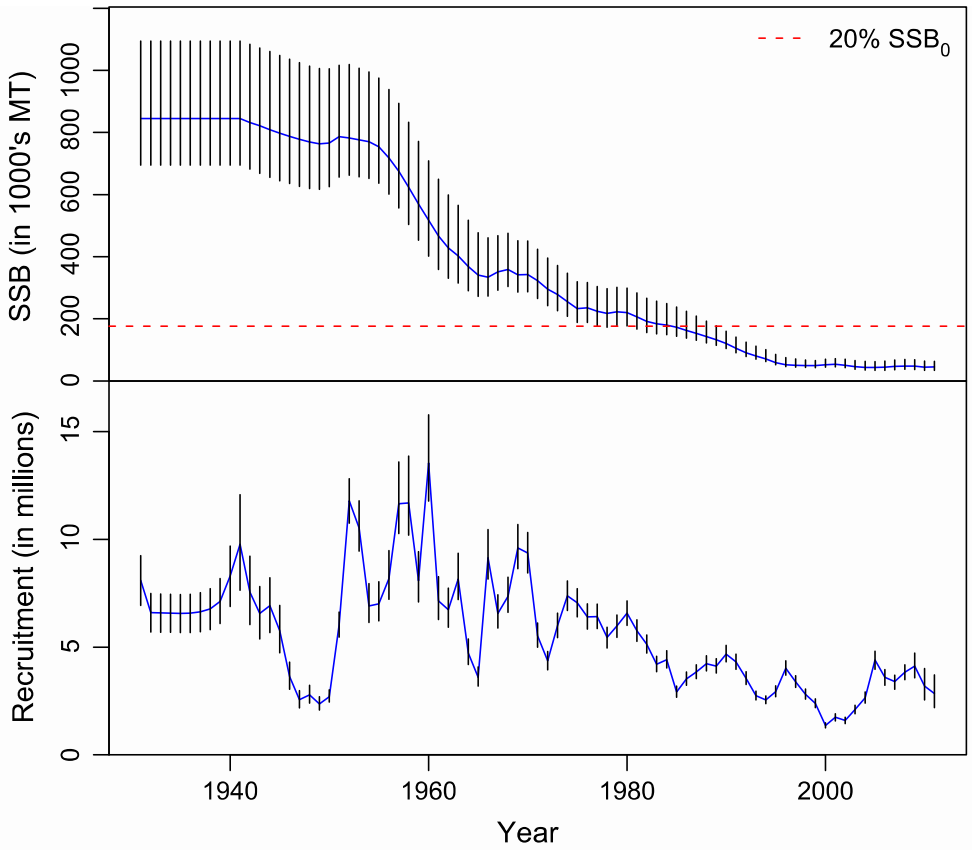
FISH and FISHERIES

A scientific alternative to moratoria for rebuilding depleted international tuna stocks

Richard M Hillary[1], Ann L Preece[1], Campbell R Davies[1], Hiroyuki Kurota[2,3], Osamu Sakai[3], Tomoyuki Itoh[3], Ana M Parma[4], Doug S Butterworth[5], James Ianelli[6] & Trevor A Branch[7]

See recent CCSBT Scientific Committee and OMMP Technical Meeting papers

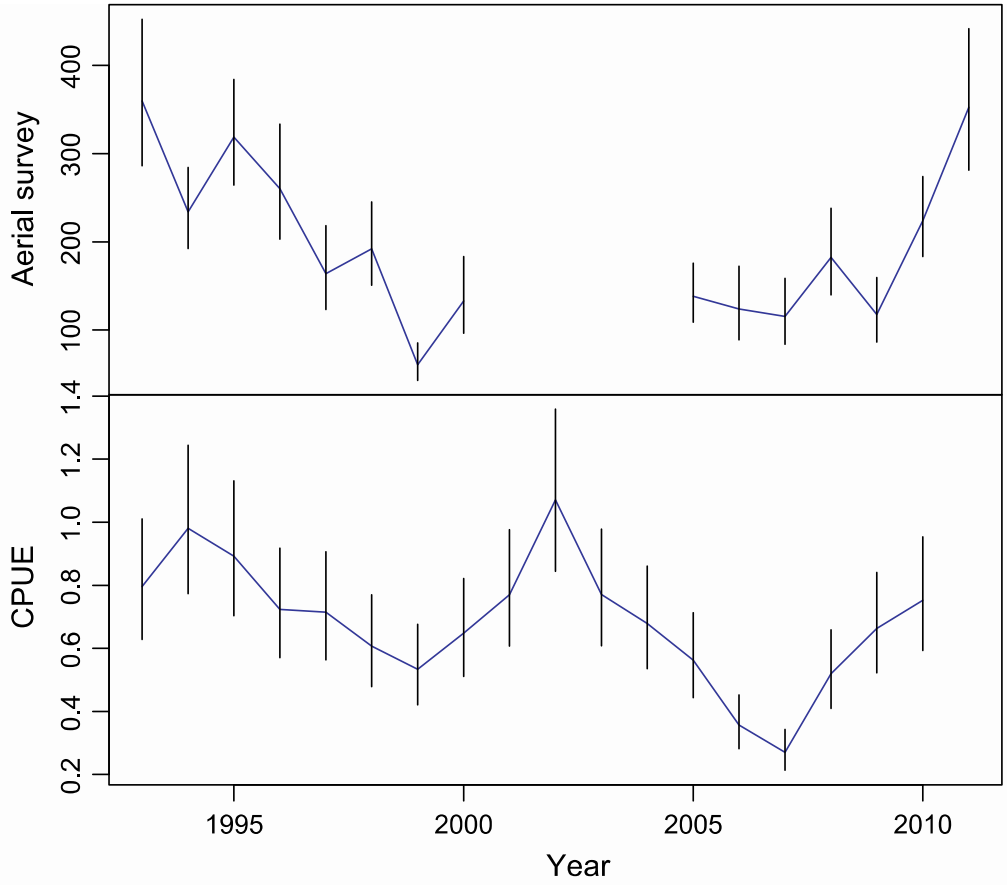
SBT stock status – At adoption



Monitoring Series for MP

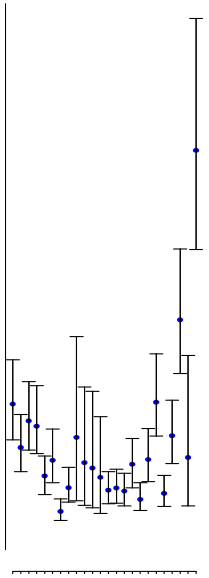
Aerial Survey
(2-4 yr olds)

LL CPUE
(4+ sub-adults)



Analysis

- Biomass Random Effects model
- Aerial Survey = Index of “recruits”
- LL CPUE = index of “sub-adults”
- Simple model estimates trend in “Adult Biomass” resulting from trends in “recruits” and “sub-adults”.



Harvest Control Rule/Decision Rule

- A trend-based effect whereby catch is increased or decreased based on the **positive or negative trend in the log-scale adult** biomass.
- **A target-based effect** whereby catch is increased or decreased based on whether the **adult biomass** is above or below a **threshold level**.
- A **precautionary juvenile biomass term** whereby catch will be **strongly decreased** for levels **of juvenile biomass below a threshold level** set using historical estimates and permitted to increase weakly when above it.

Management Measure

- Global Total Allowable Catch
- National Allocations for members and Cooperating Non-Members
- Catch documentation Scheme
- 10% observer coverage
- Market monitoring

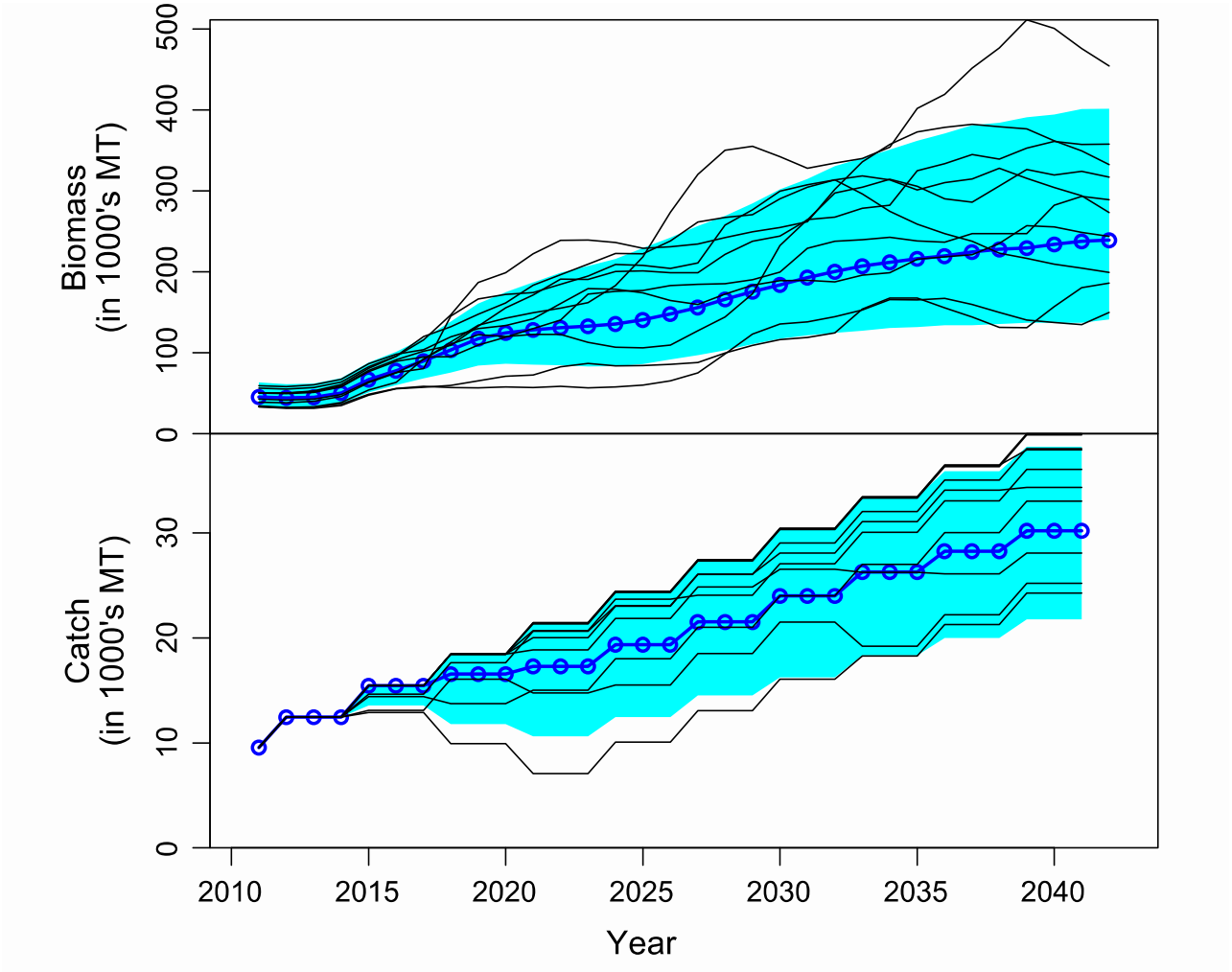
Performance Measures

Case, max. TAC change	$P(SSB_{2022} > 0.2SSB_0)$	$P(SSB_{2035} > 0.2SSB_0)$	$E(SSB_{2022}/SSB_{2011})$	$E(C_{2012–2022})$	$P(C\uparrow\downarrow)$
Reference, 3000	0.19	0.7	2.76	15 200	0.49
Reference, 5000	0.14	0.7	2.65	15 600	0.71
Pessimistic scenarios					
lowR, 3000	0.06	0.66	2.32	13 200	0.83
Upq, 3000	0.08	0.45	2.58	15 300	0.50
STwin, 3000	0.01	0.34	2.39	12 872	0.81
Omega75, 3000	0.06	0.48	2.74	13 304	0.74

Likely Rebuilding Performance

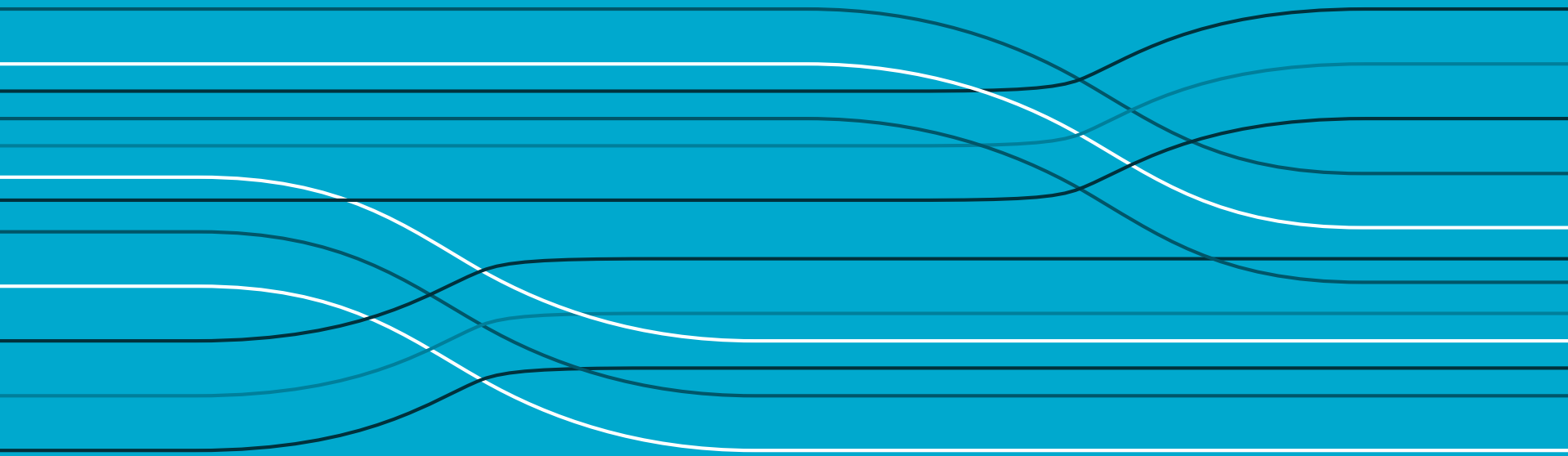
Biomass

Catch



Implementation

- MP run to set global TAC every 3 years (2011, 2013*, 2016, 2019)
- Operating Models used to test MP, “reconditioned with updated data every 3 years, for regular “stock assessment”
- Aerial Survey not run in 2015 due to lack of funding (missing data)
- MP testing assumes all catches reported accurately
- No allowance for unreported catches
- Initiating development of new MP using:
  - new recruitment monitoring method (gene-tagging)
  - Possibly close-kin data
  - allowing for unaccounted mortality

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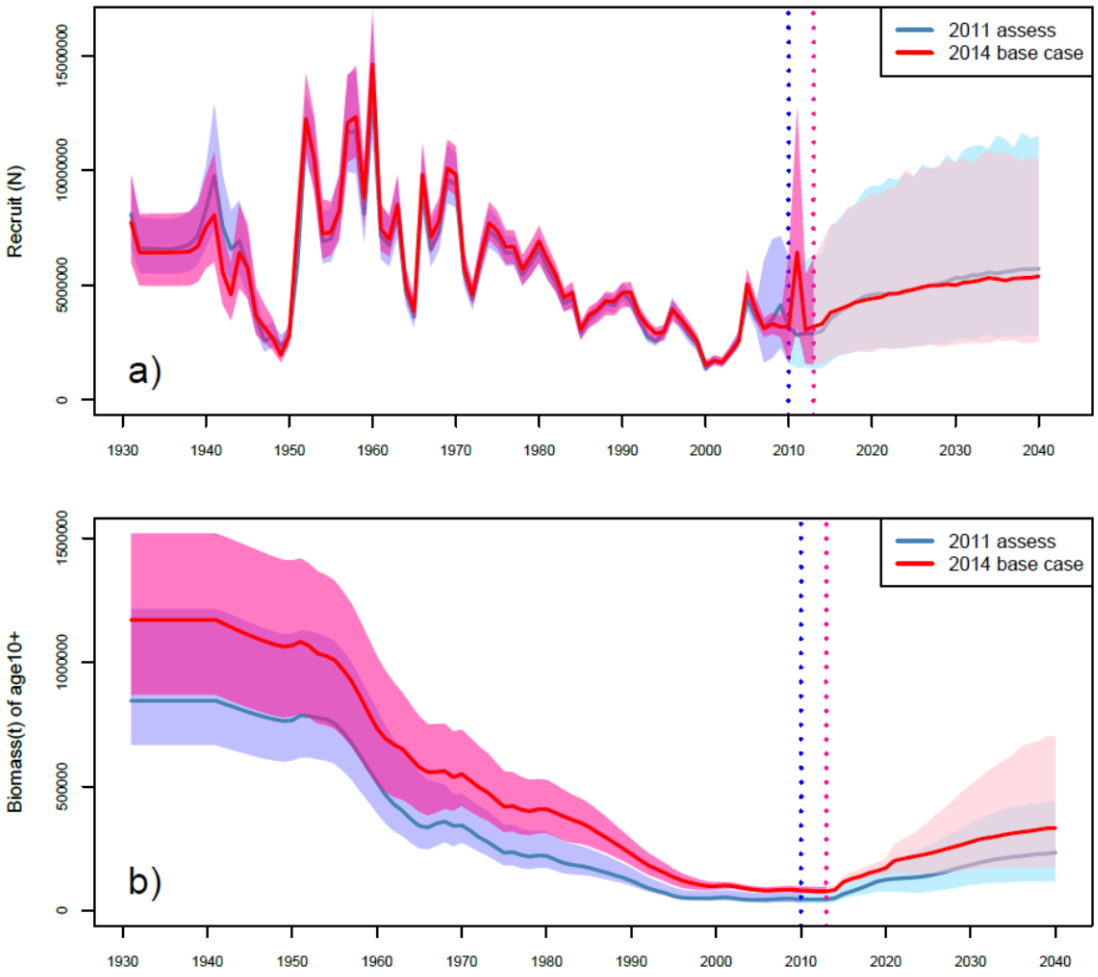
CCSBT Reference set of Operating Models - 2014

Table 1. The default grid structure specified at the 18th ESC.

	Levels	Cumulate Number	Values	Prior	Simulation weight
Steepness	5	5	0.55, 0.64, 0.73, 0.82, 0.90	Uniform	Prior
M_1	4	20	0.35, 0.40, 0.45, 0.50	Uniform	Likelihood
M_{10}	4	80	0.050, 0.075, 0.100, 0.125	Uniform	Likelihood
Omega	1	80	1	NA	NA
CPUE series	2	160	w0.5, w0.8	Uniform	Prior
q-age-range	2	320	4-18, 8-12	0.67, 0.33	Prior
Sample size	1	320	Sqrt	NA	NA

Stock status - 2014



MSY

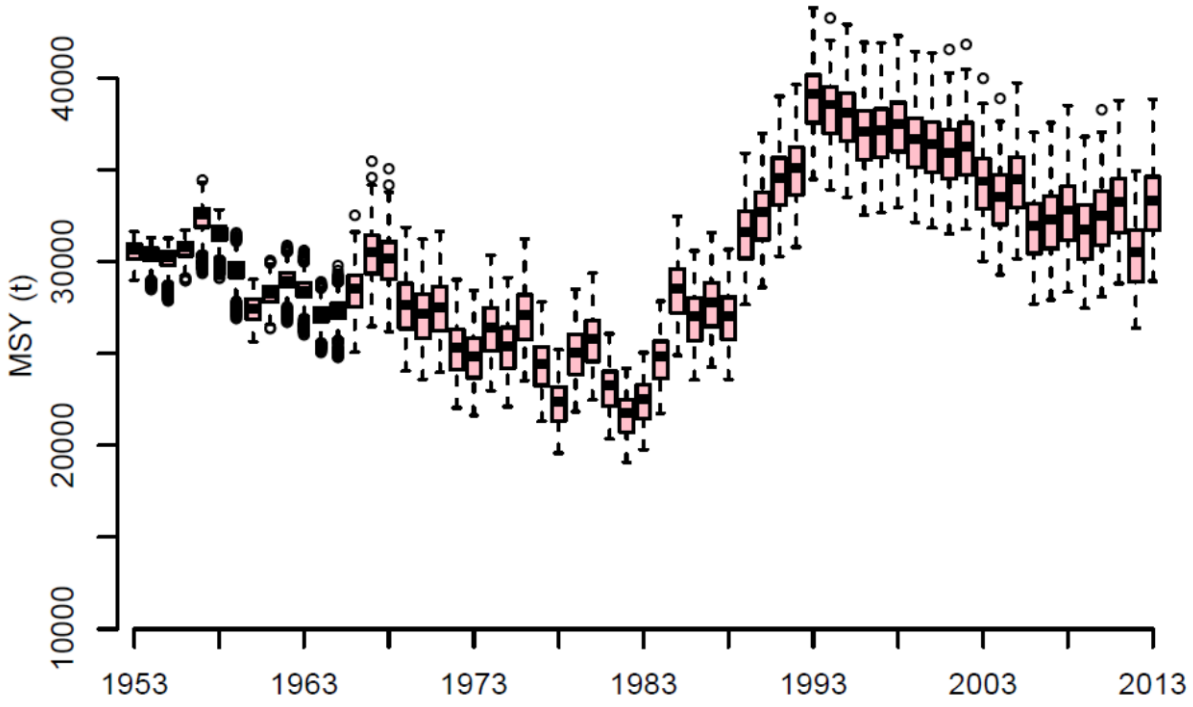


Fig. 2. Estimated MSY based on annual age-specific mean weight and selectivity as estimated using the base case

F_{MSY}

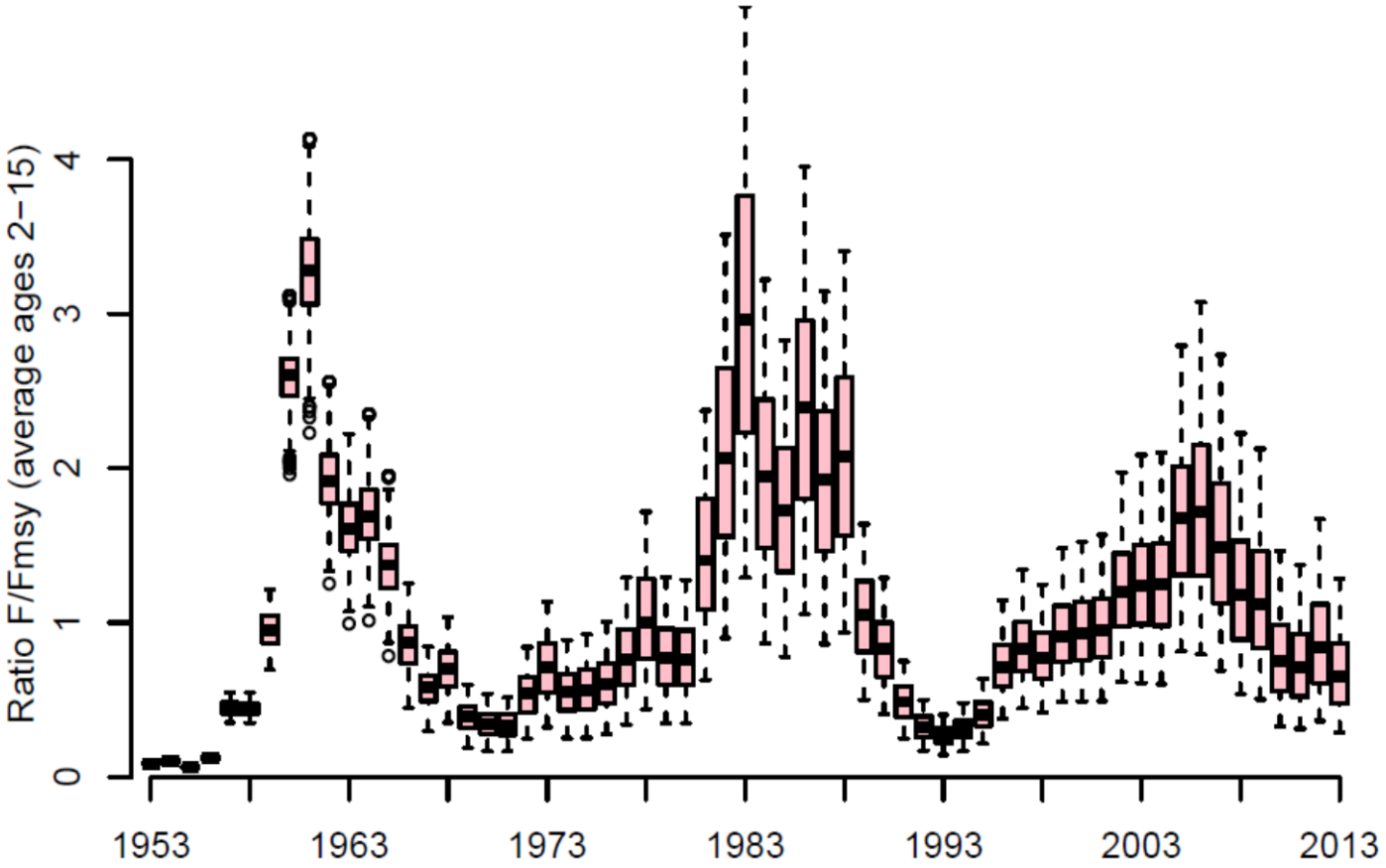


Fig. 3. Boxplot of the fishing mortality over the Fmsy (for ages 2-15) as estimated using the base case of the OM

Kobe plot for Reference Set of models

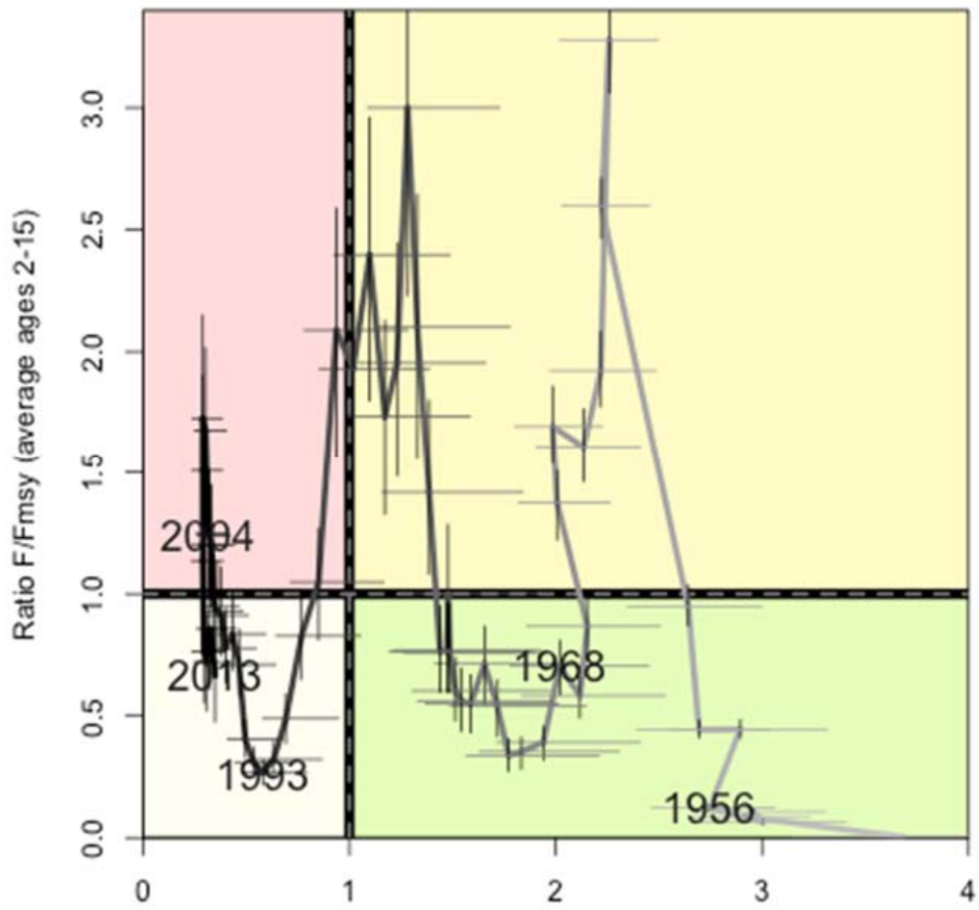
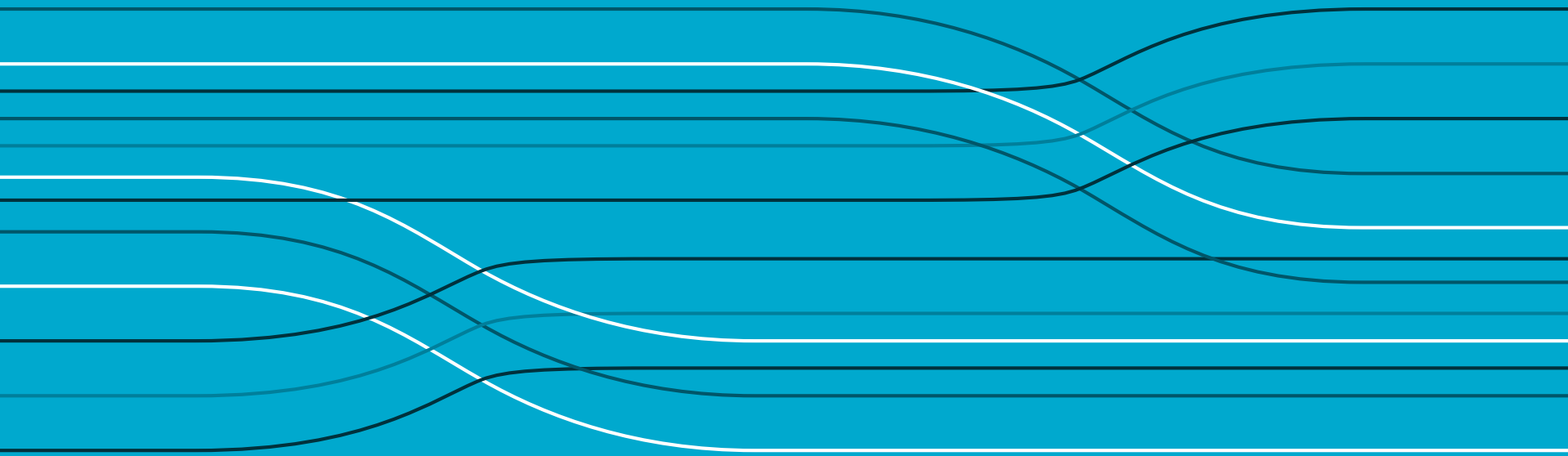


Figure 5a. Time trajectory from 1952 to 2013 of median fishing mortality over the F_{msy} (for ages 2-15) versus spawning biomass (B) over B_{msy}. The fishing mortality rates are based on biomass-weighted values and the relative fishery catch composition and mean SBT body weights in each year. Vertical and horizontal lines represent 25th-75th percentiles from the operating model grid.

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Empirical - Billfish

ICES Journal of Marine Science (2011), 68(5), 947–960. doi:10.1093/icesjms/fsr029

A simple cost-effective and scale-less empirical approach to harvest strategies

Jeremy D. Prince[1]*, Natalie A. Dowling[2], Campbell R. Davies[3], Robert A. Campbell[2], and Dale S. Kolody[2]‡

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[3]*CSIRO Aspendale Laboratories, Station Street, Aspendale, Victoria 3195, Australia*

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Prince, J. D., Dowling, N. A., Davies, C. R., Campbell, R. A., and Kolody, D. S. 2011. A simple cost-effective and scale-less empirical approach to harvest strategies. – ICES Journal of Marine Science, 68: 947–960.

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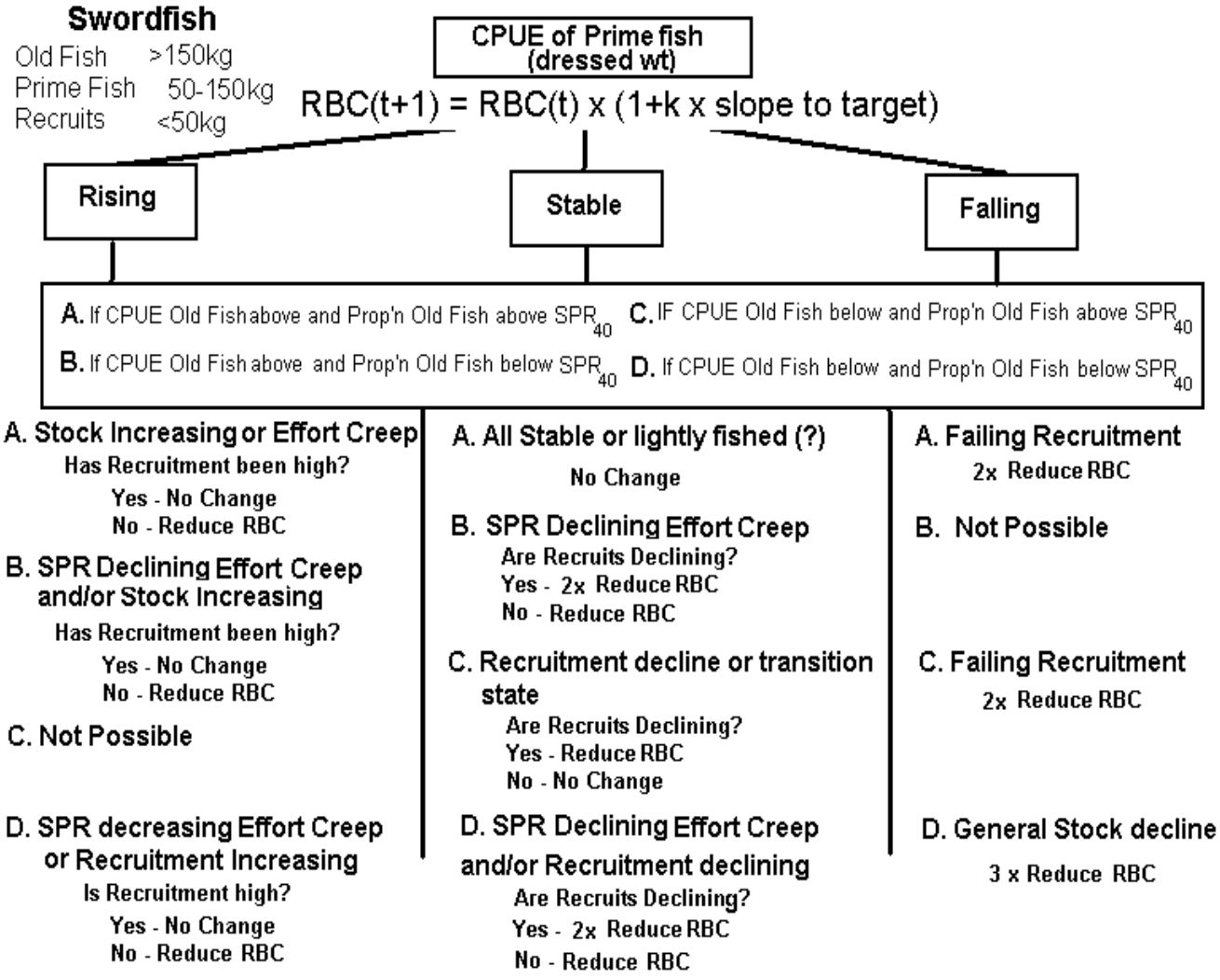
Empirical - Billfish



Empirical - Billfish

- Obtain overall CPUE from logbook information
- Size data from samples of catch from existing port monitoring
- Apply size sample proportions to CPUE to obtain size-based CPUEs

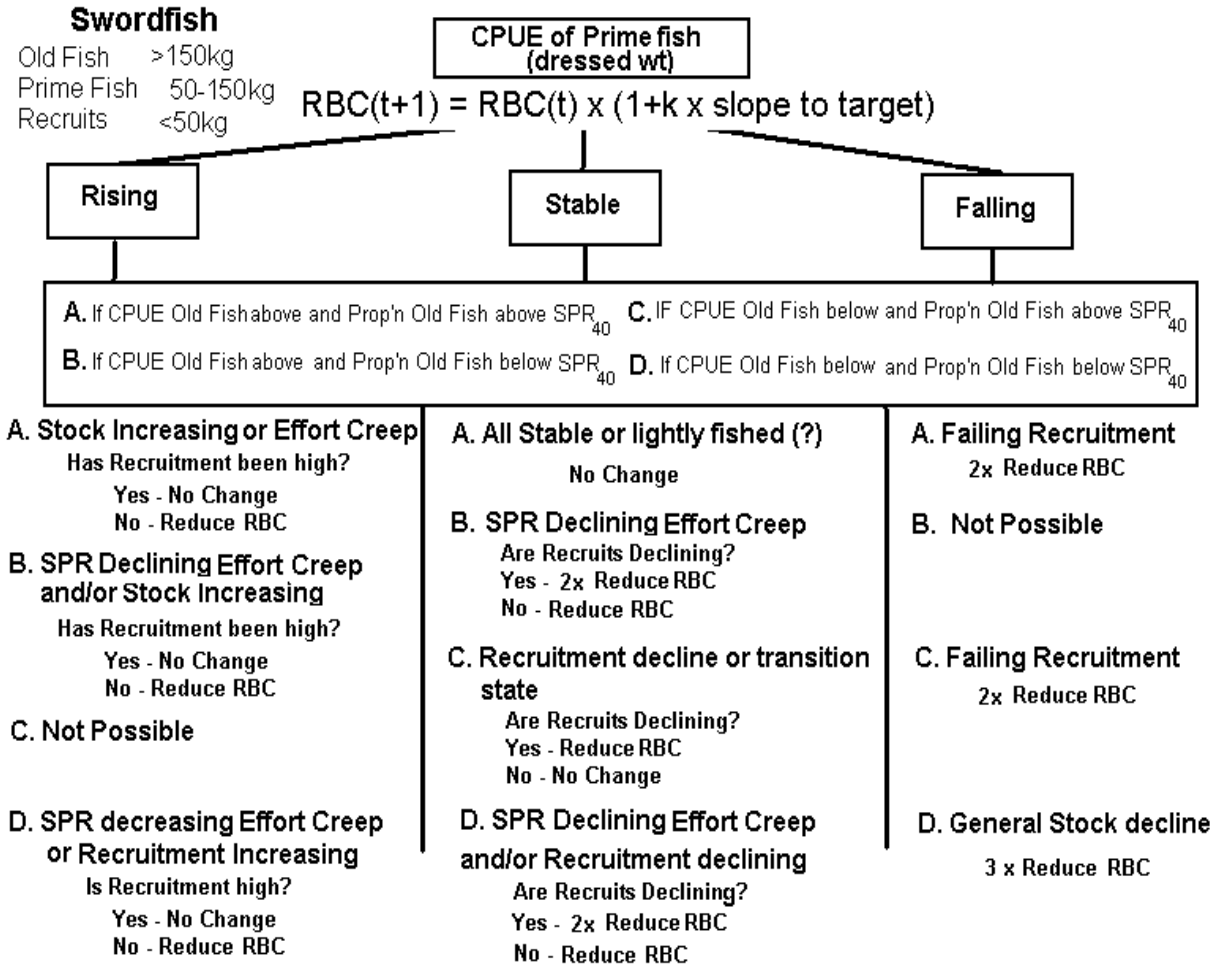
Decision tree (slope to target dec. rule sits on top)

"Recruits" = small fish recruiting to the fishery

(i.e. will move into "prime" category in next 1-3 years)

For SWO:

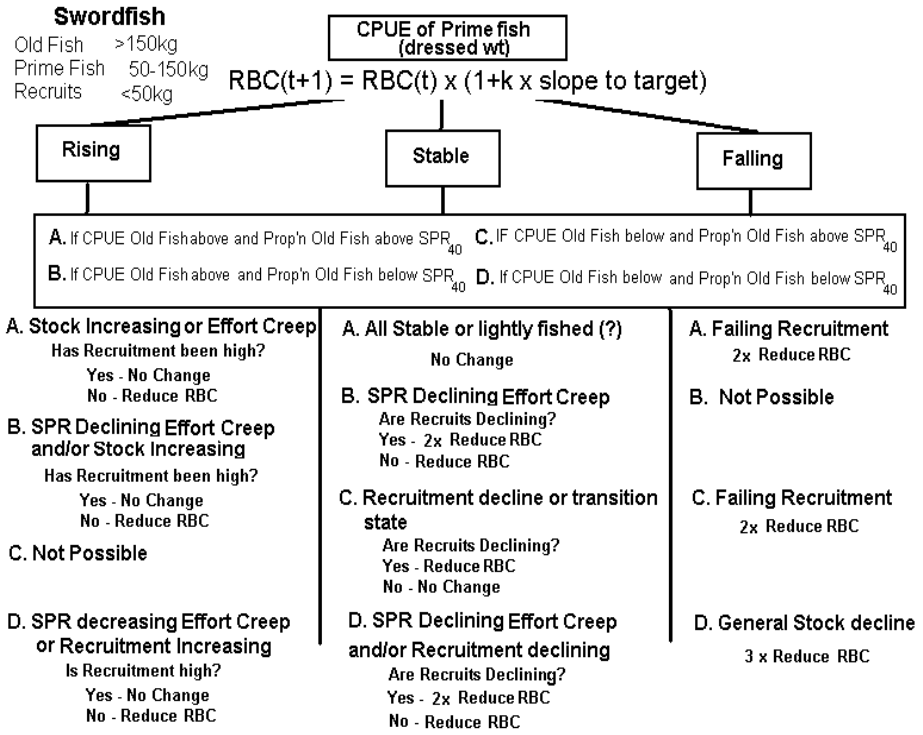
- **"Recruits": <50kg**
- **"Prime": 50-150kg**
- **"Old": >150kg**



Empirical - Billfish

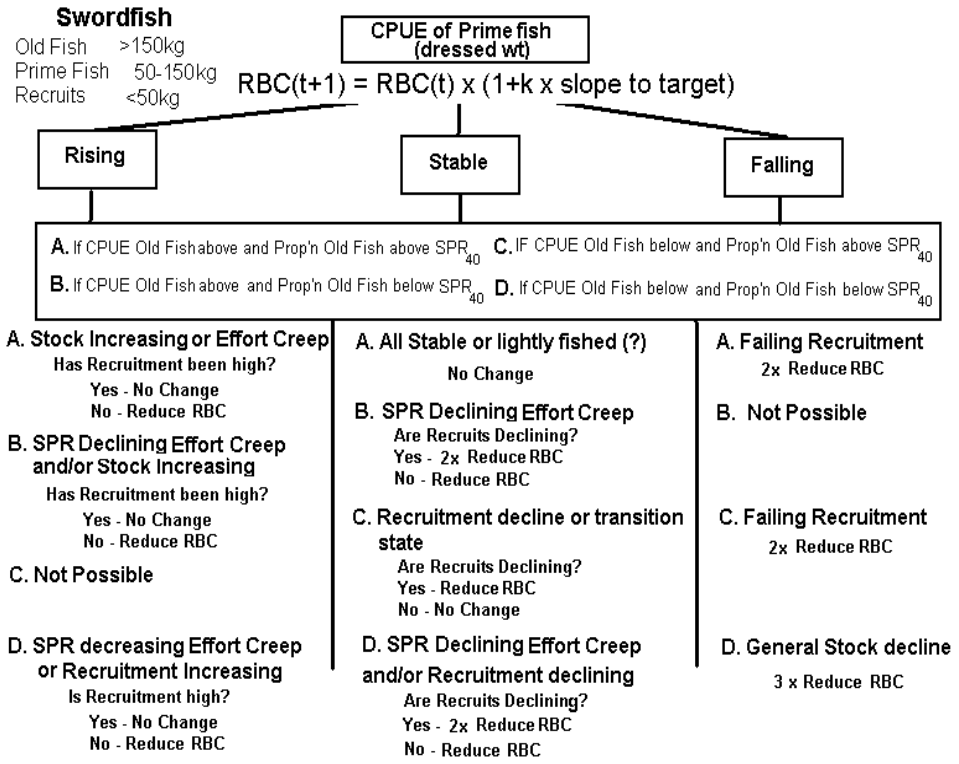
- Using the biology and theory:
- calculate
  - spawner-potenital-per-recruit
  - for UNFISHED STOCK

    = SPR_0



Empirical - Billfish

- Find fishing mortality F
- that will drive stock to 40% SPR_0
  - $SPR_{40} = 0.4\ SPR_0$
- Gives
- TARGET REFERENCE POINT
- (i.e. where we'd like to be)



Empirical - Billfish

- **Obtain indicator values**

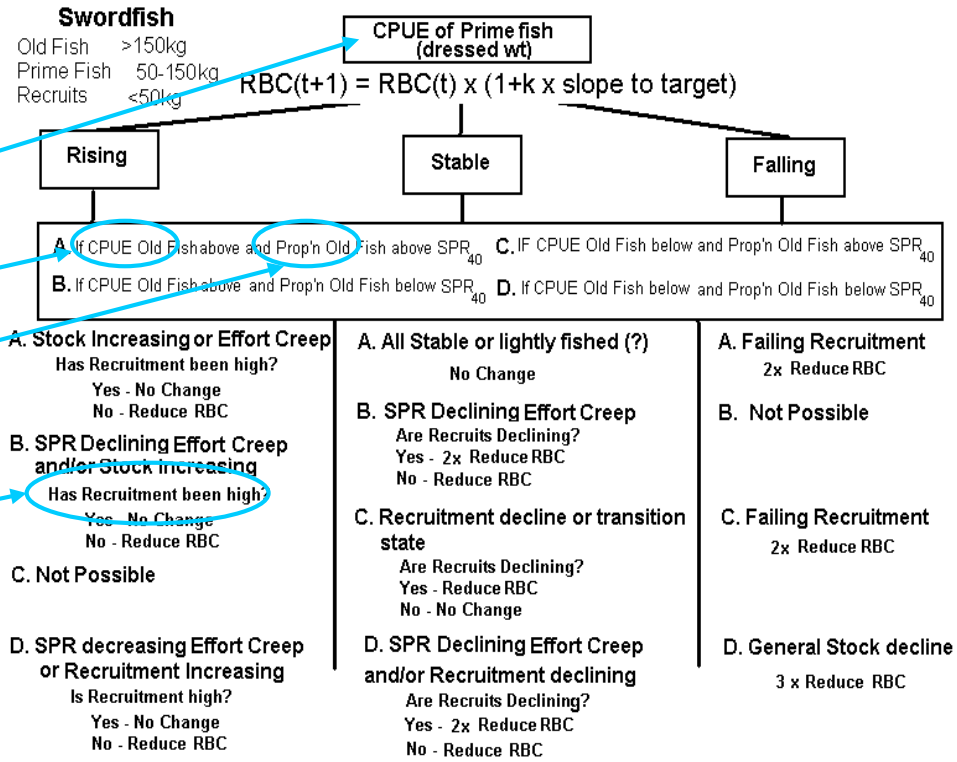
CPUEprime

CPUEold

PropOld

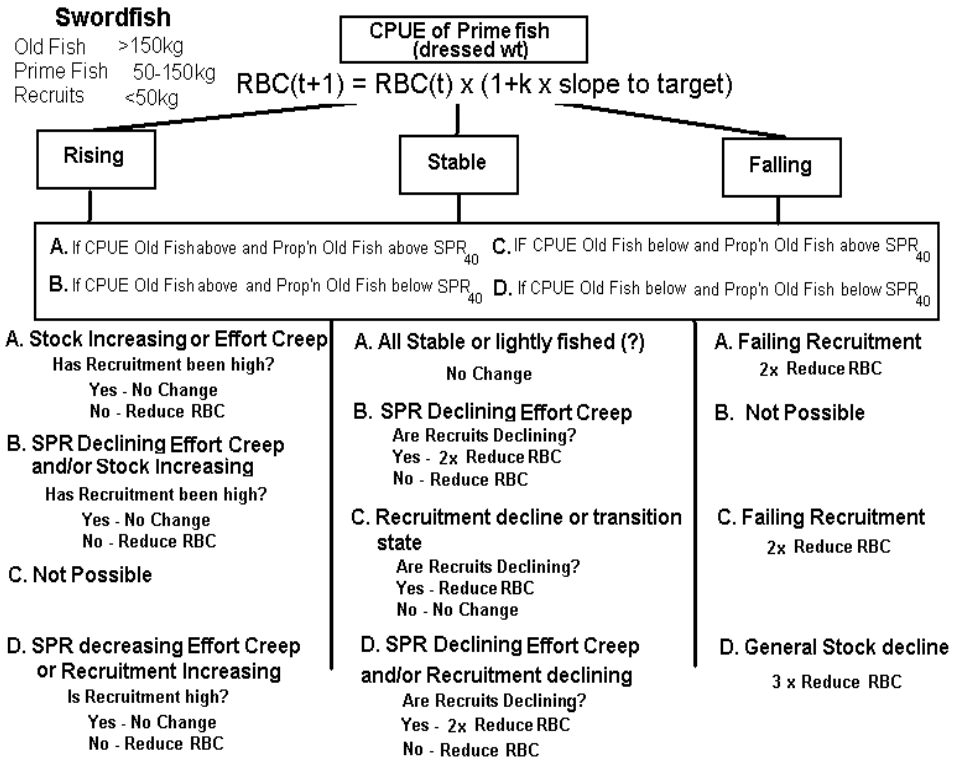
CPUErecruits

corresponding to SPR_{40} fishing mortal



Empirical - Billfish

- These values are our reference levels within the decision tree
- Compare values of indicators from sampled catches against the reference levels to make decisions
- “tuning” decision rule to keep at/above TRP & avoid LRP



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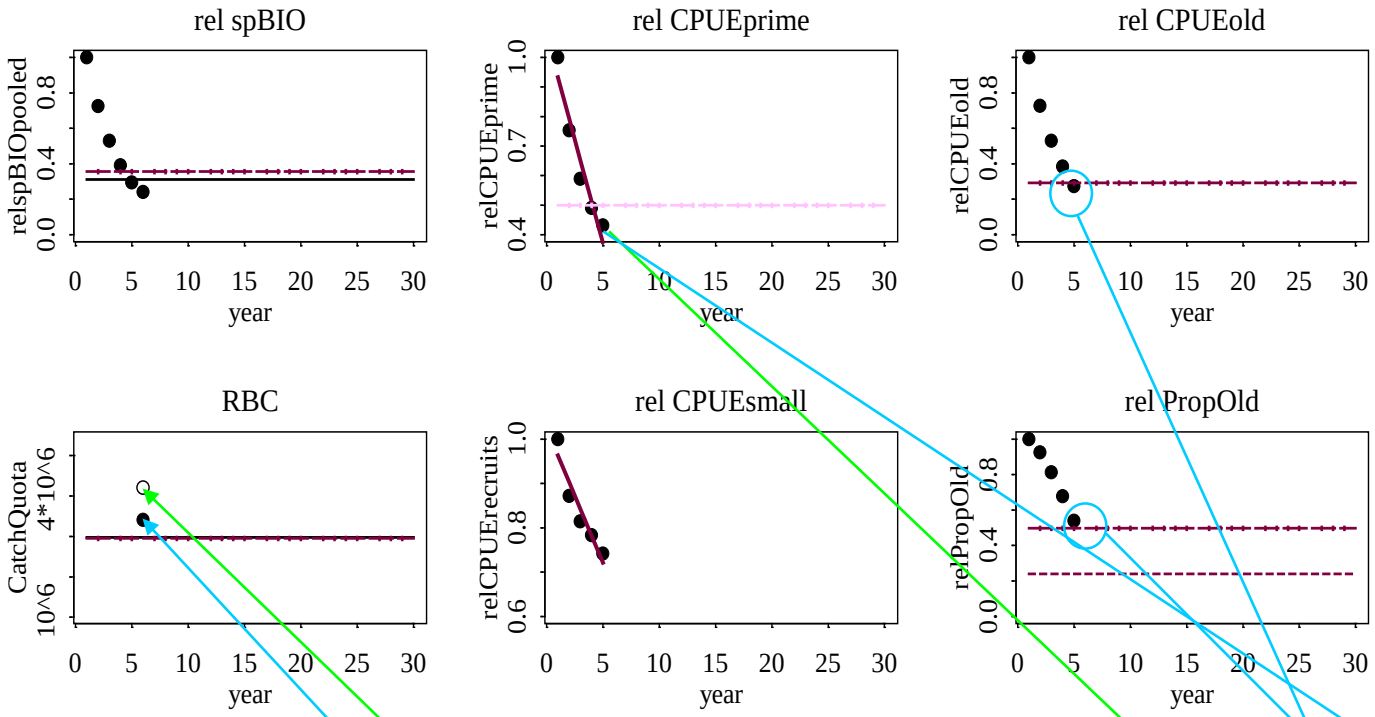
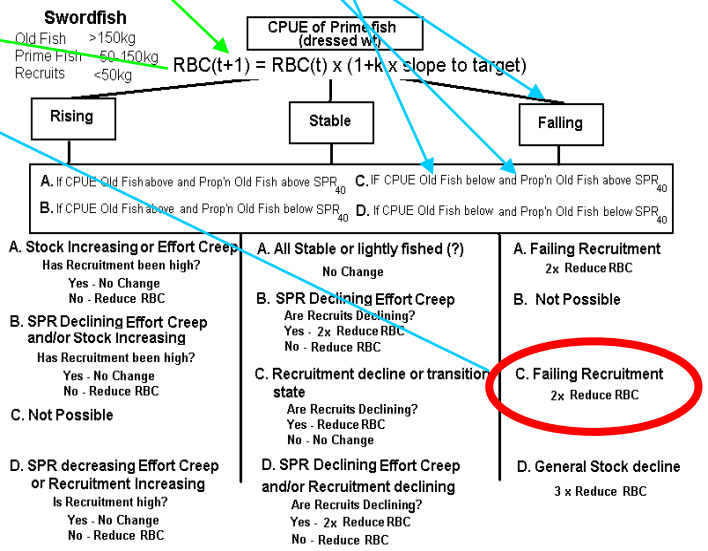


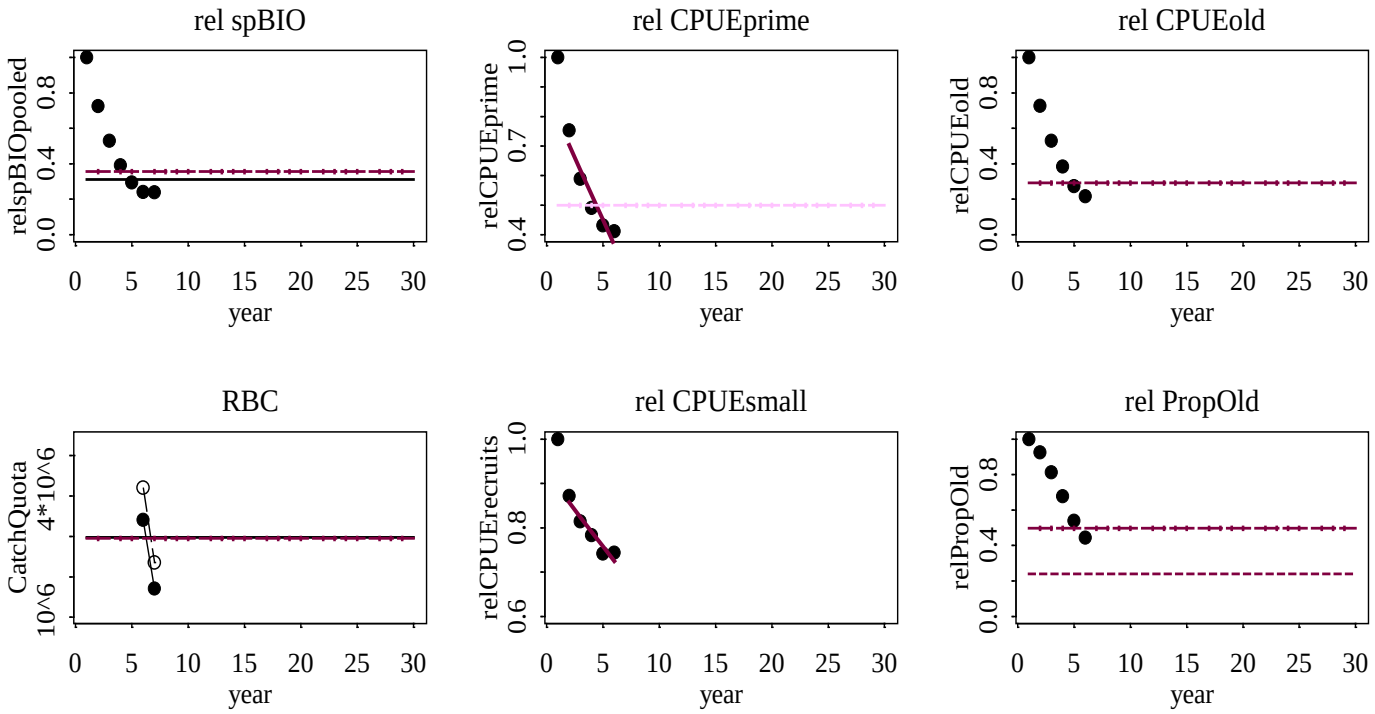
Initial RBC (simple dec. rule)

Modified RBC (decision tree)



- level at MSY
- level at SPR_{40} (decision tree target)
- level at SPR_{20} (decision tree limit)
- 50% $CPUEprime_0$ (simple decision rule target)
- linear trend (showing slope) over last 5 years

Year = 7



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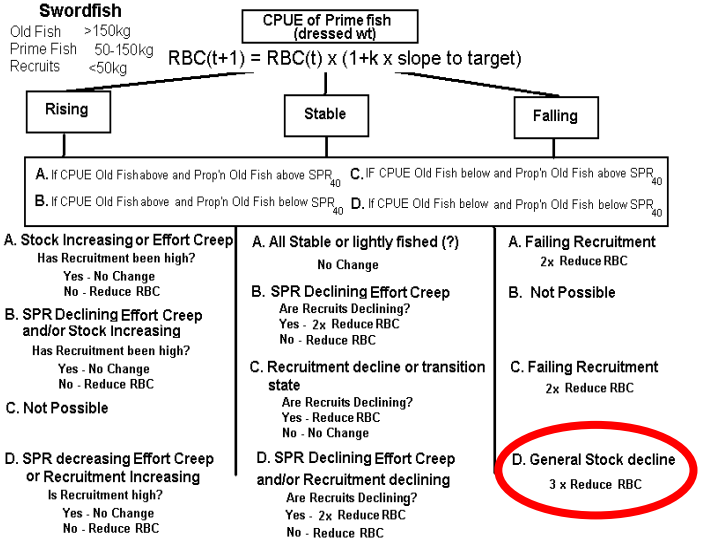

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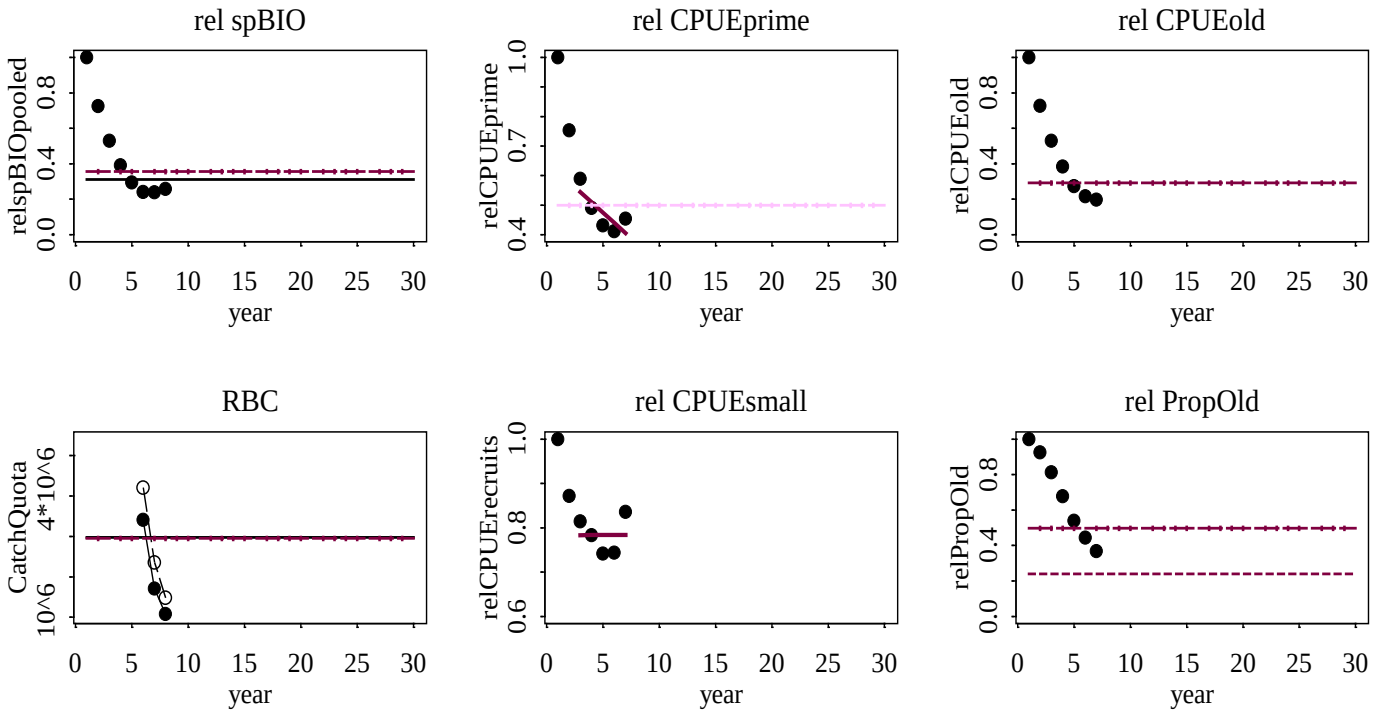

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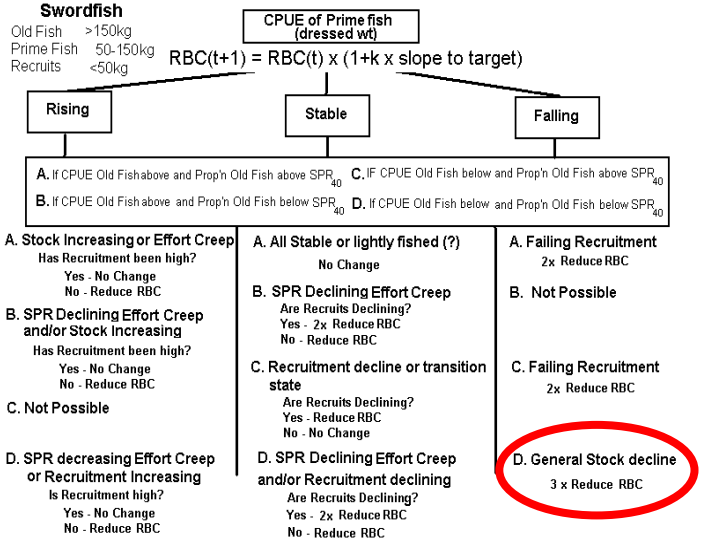

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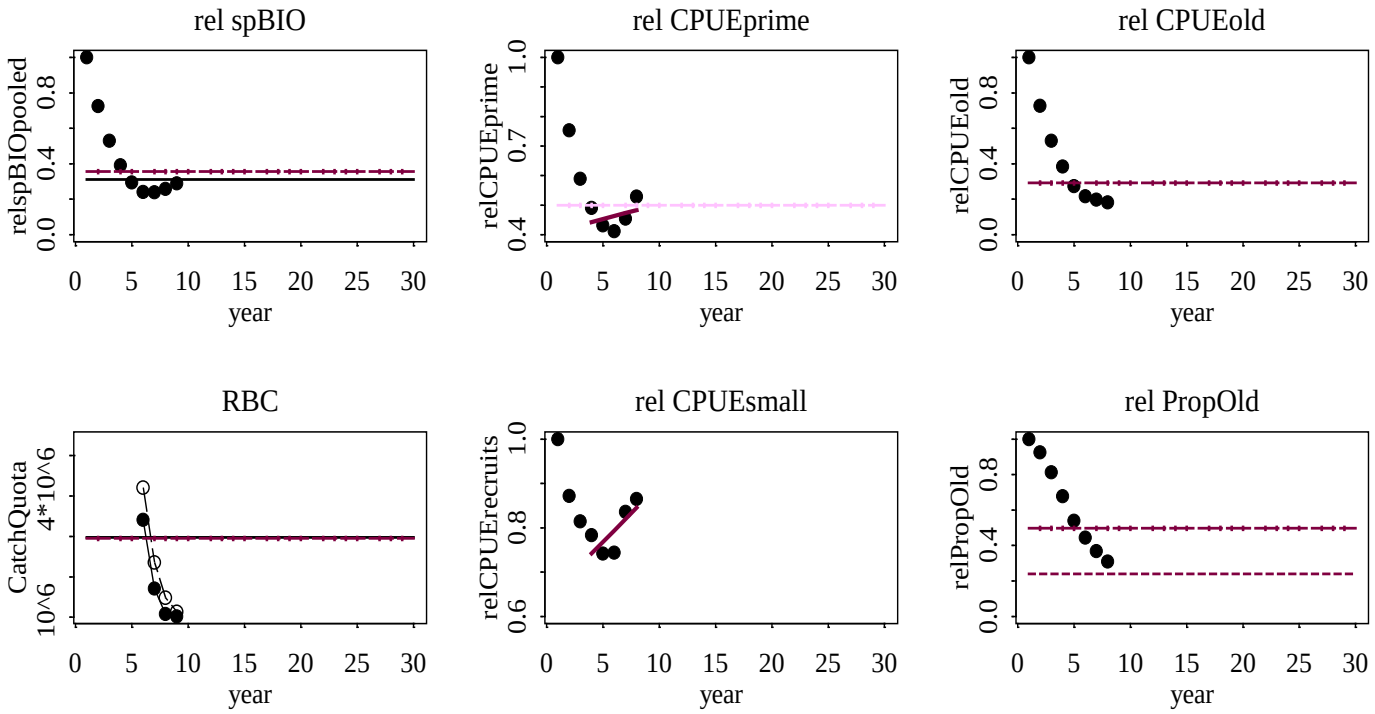

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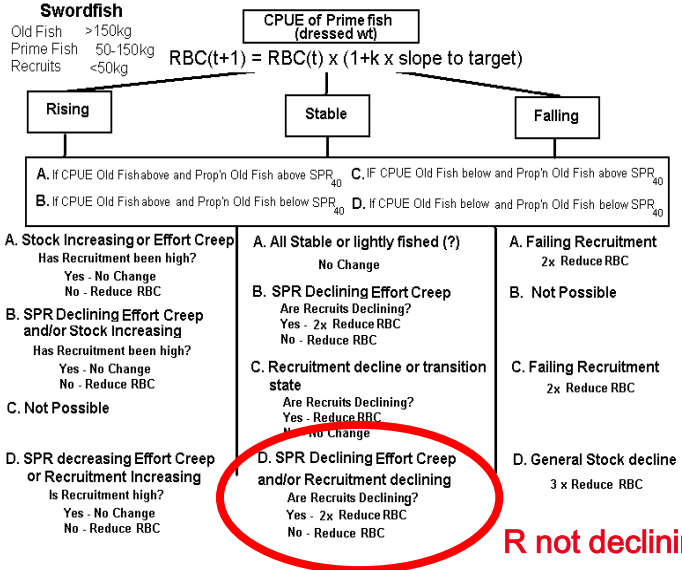

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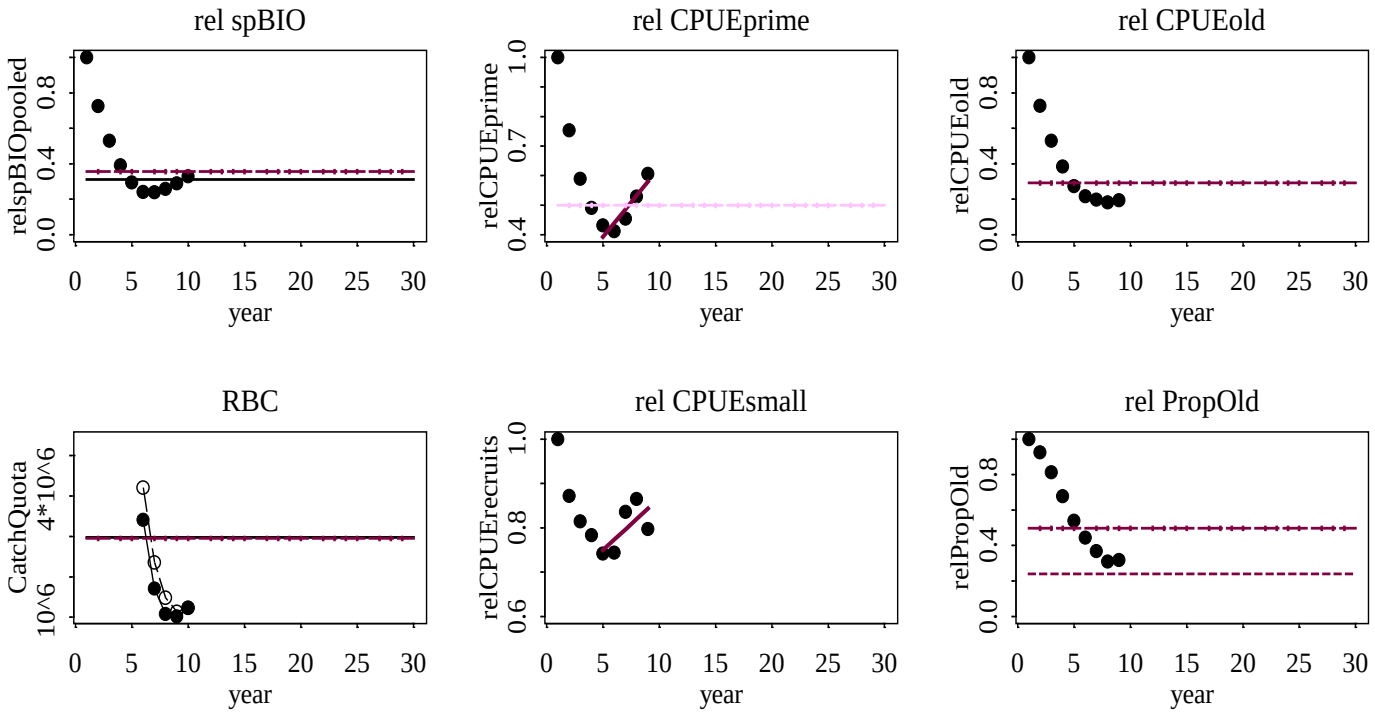

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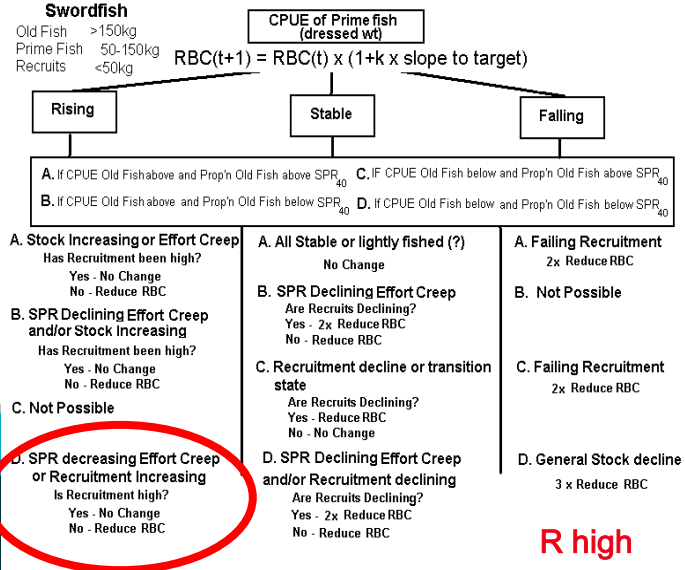

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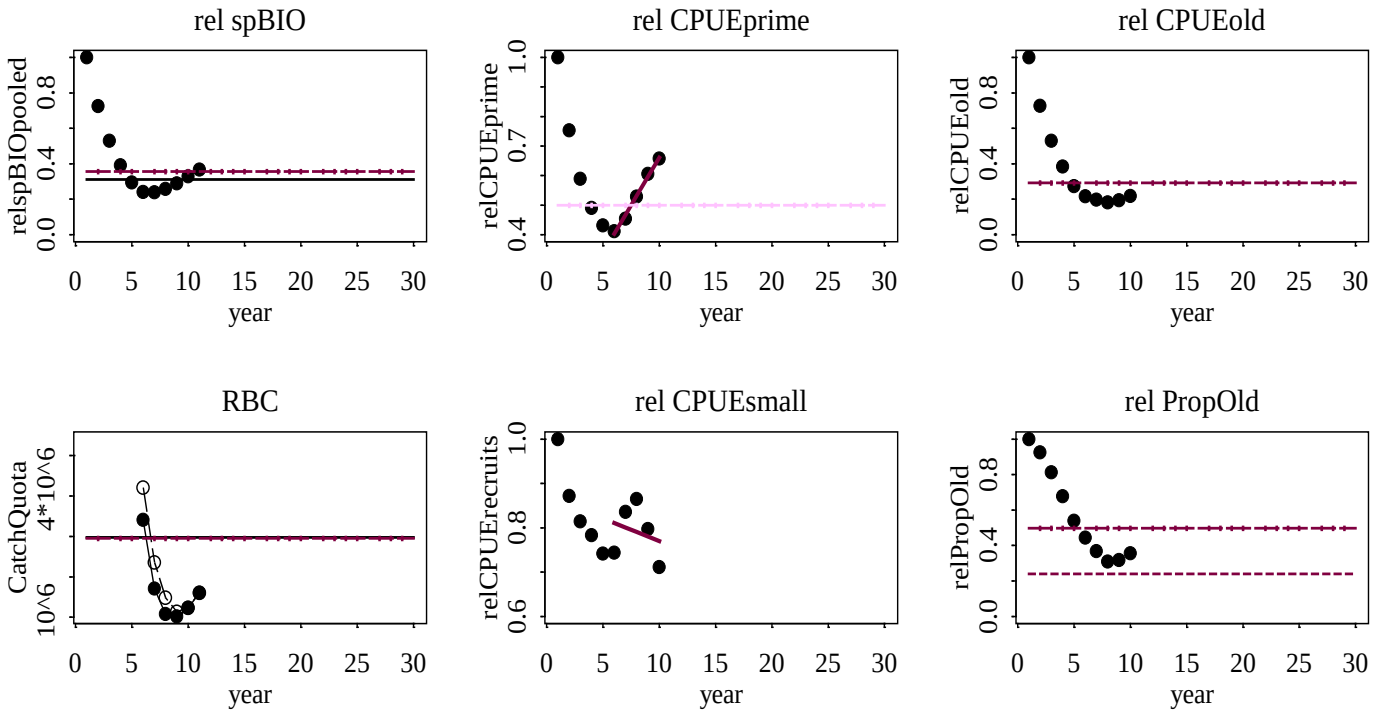

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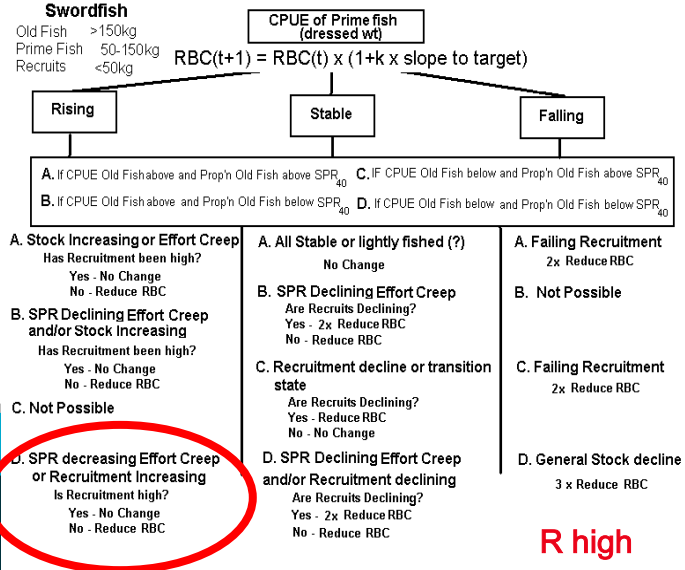

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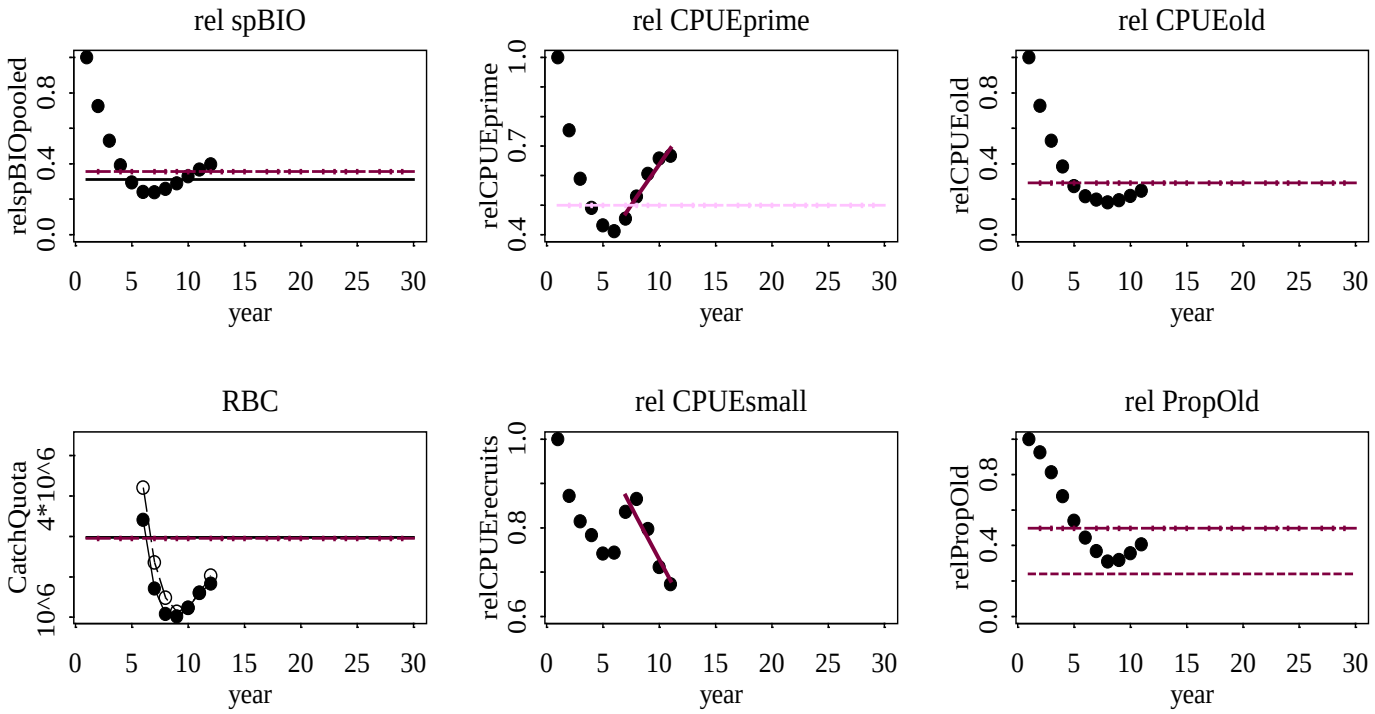

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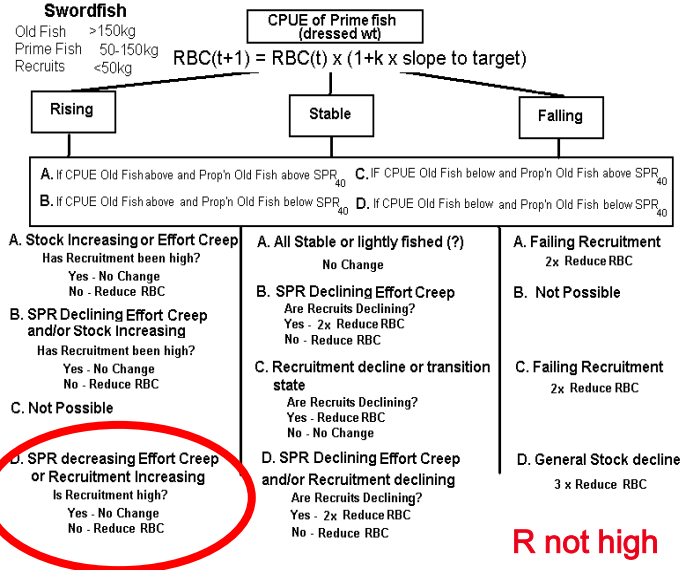

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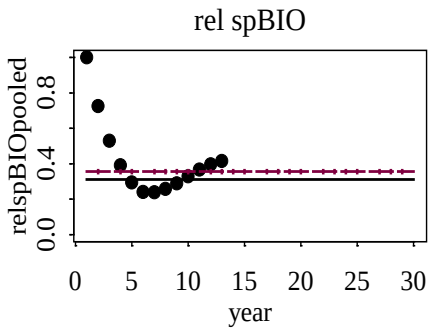
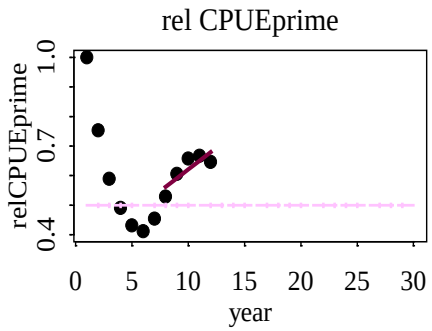
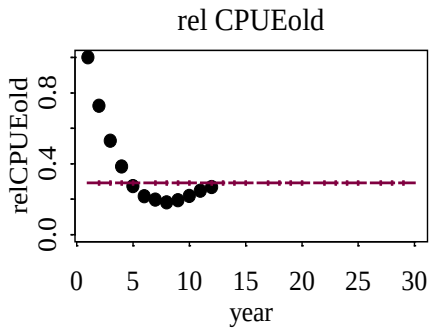
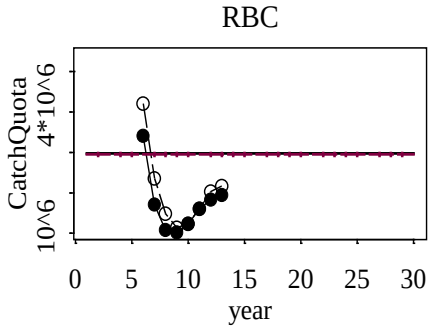
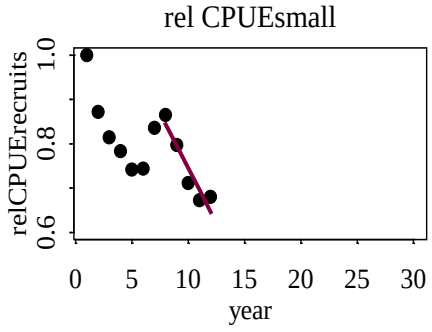
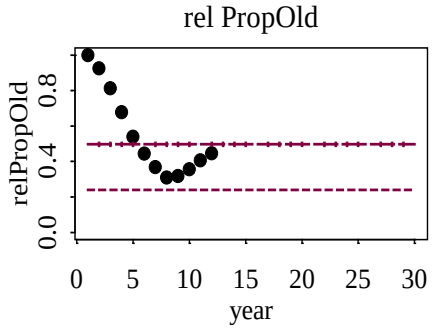












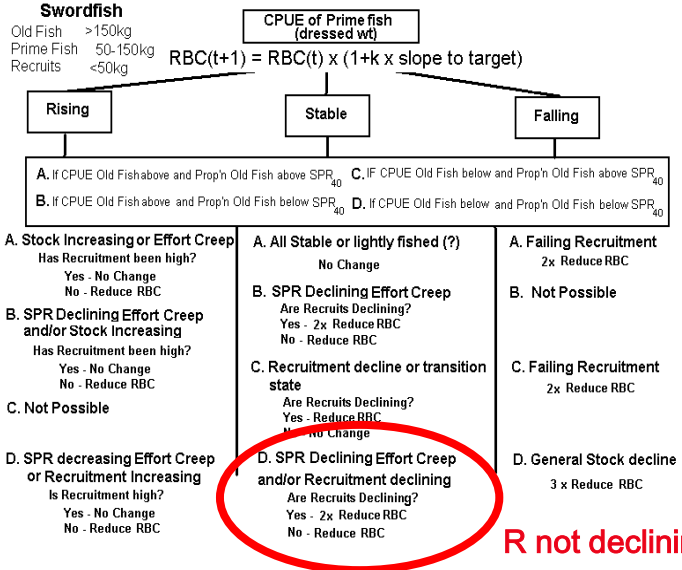
level at MSY

level at SPR_{40} (decision tree target)

level at SPR_{20} (decision tree limit)

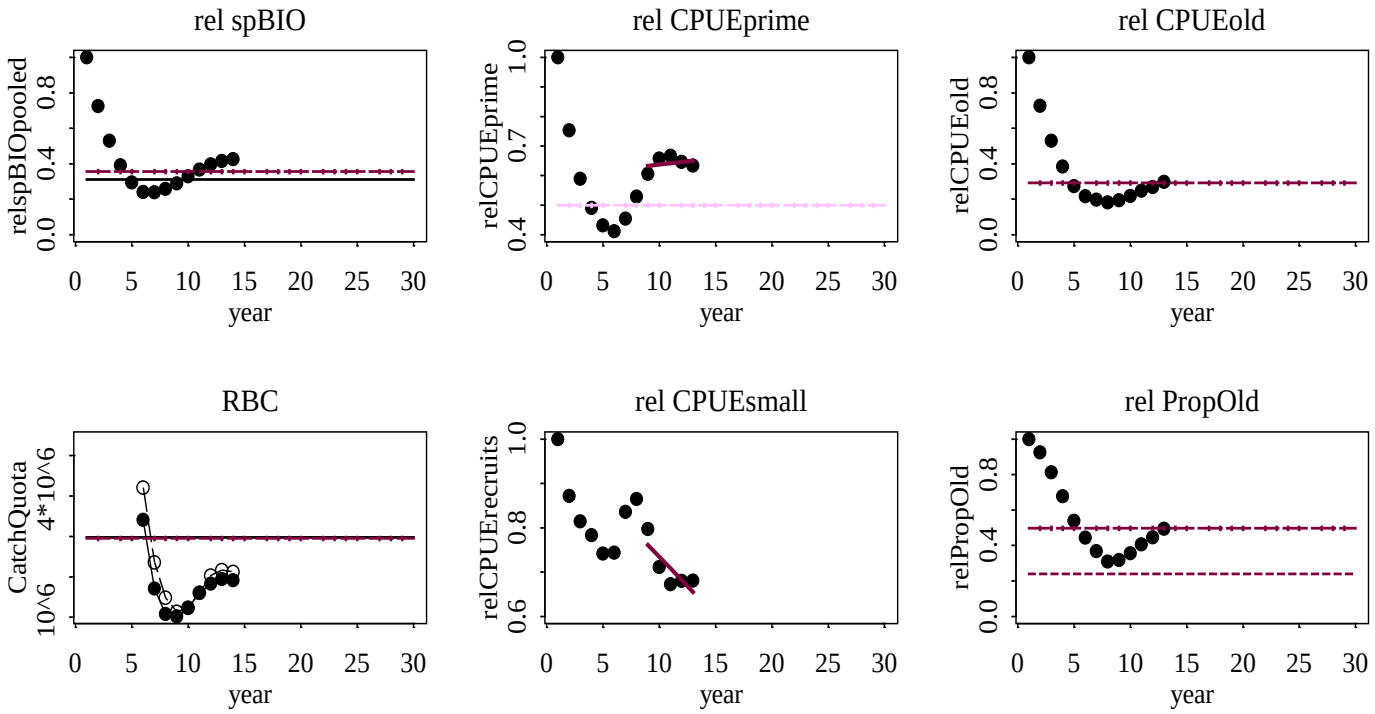
50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



R not declining

Year = 14



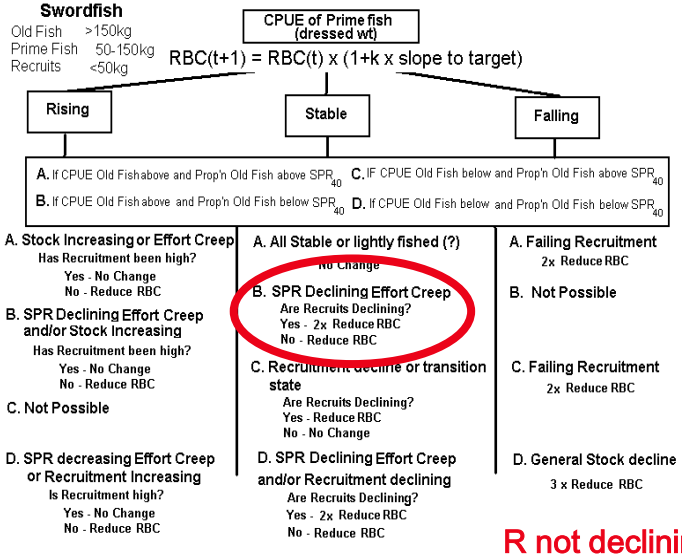
level at MSY

level at SPR_{40} (decision tree target)

level at SPR_{20} (decision tree limit)

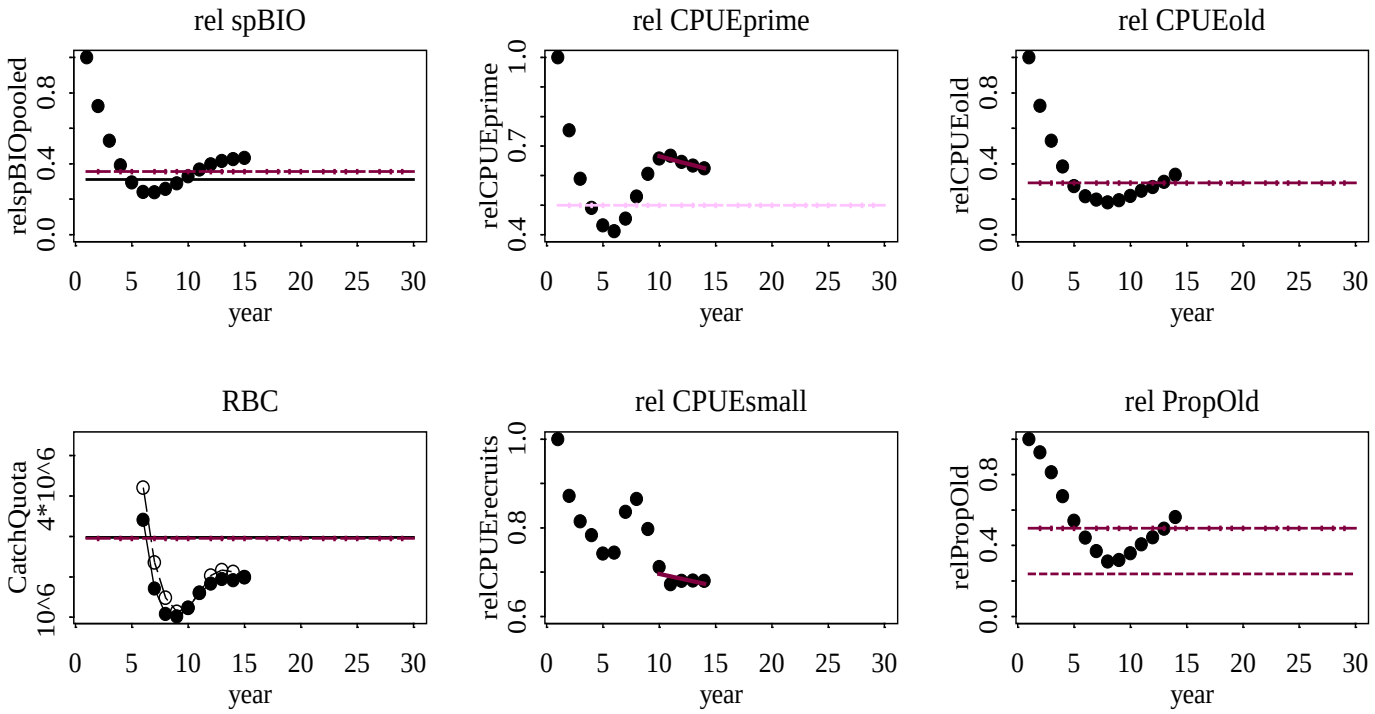
50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



R not declining

Year = 15



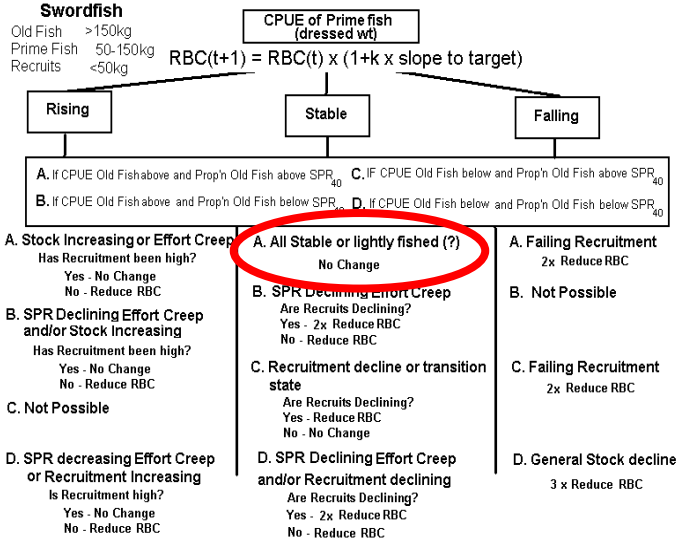
level at MSY

level at SPR_{40} (decision tree target)

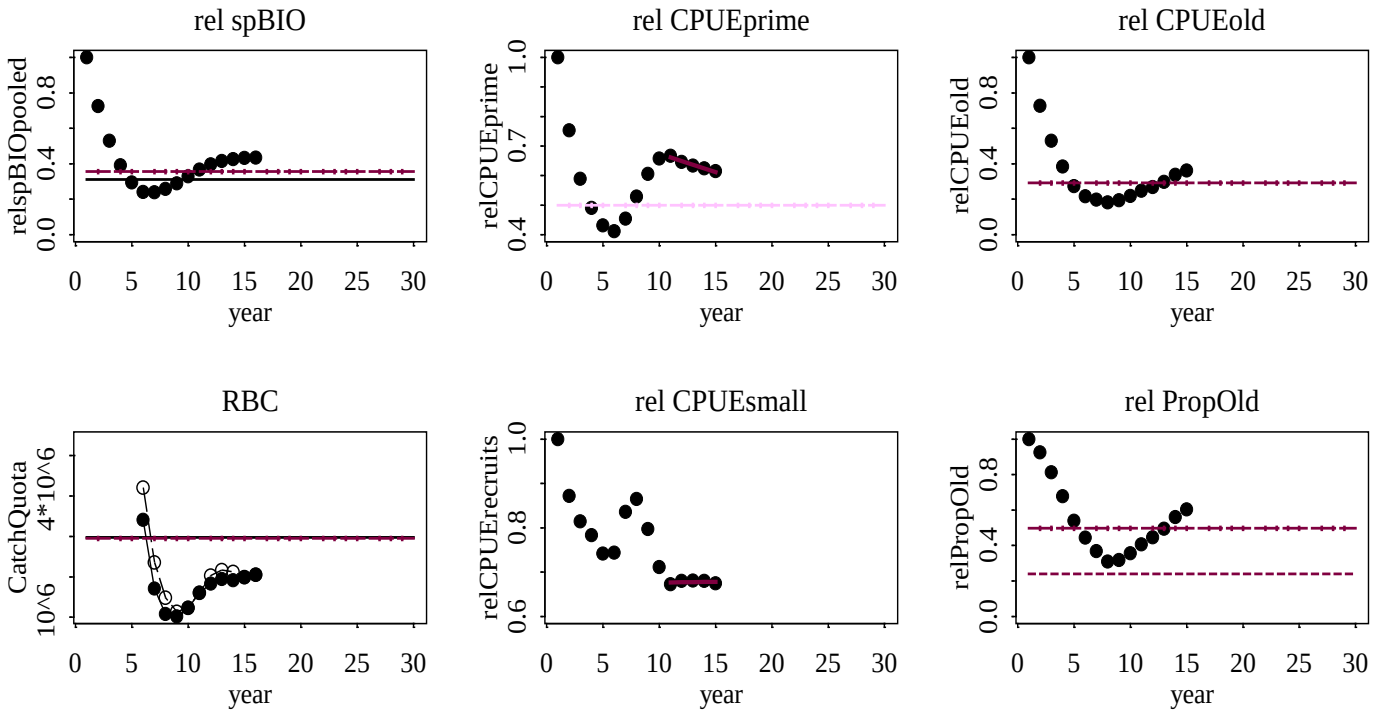
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 16



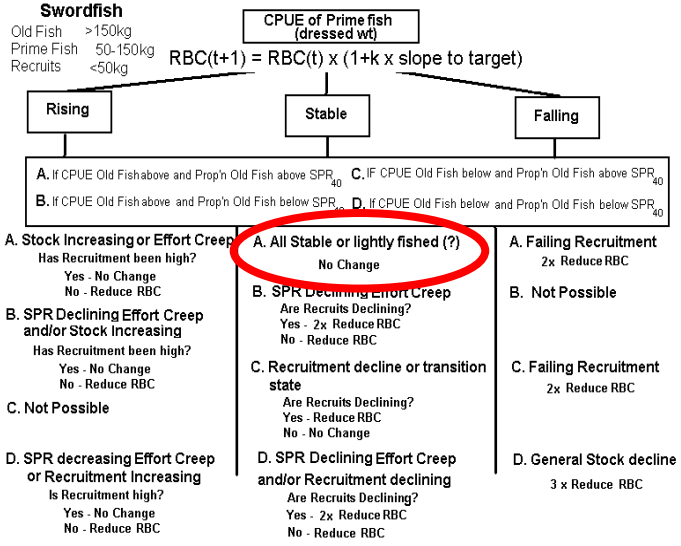
level at MSY

level at SPR_{40} (decision tree target)

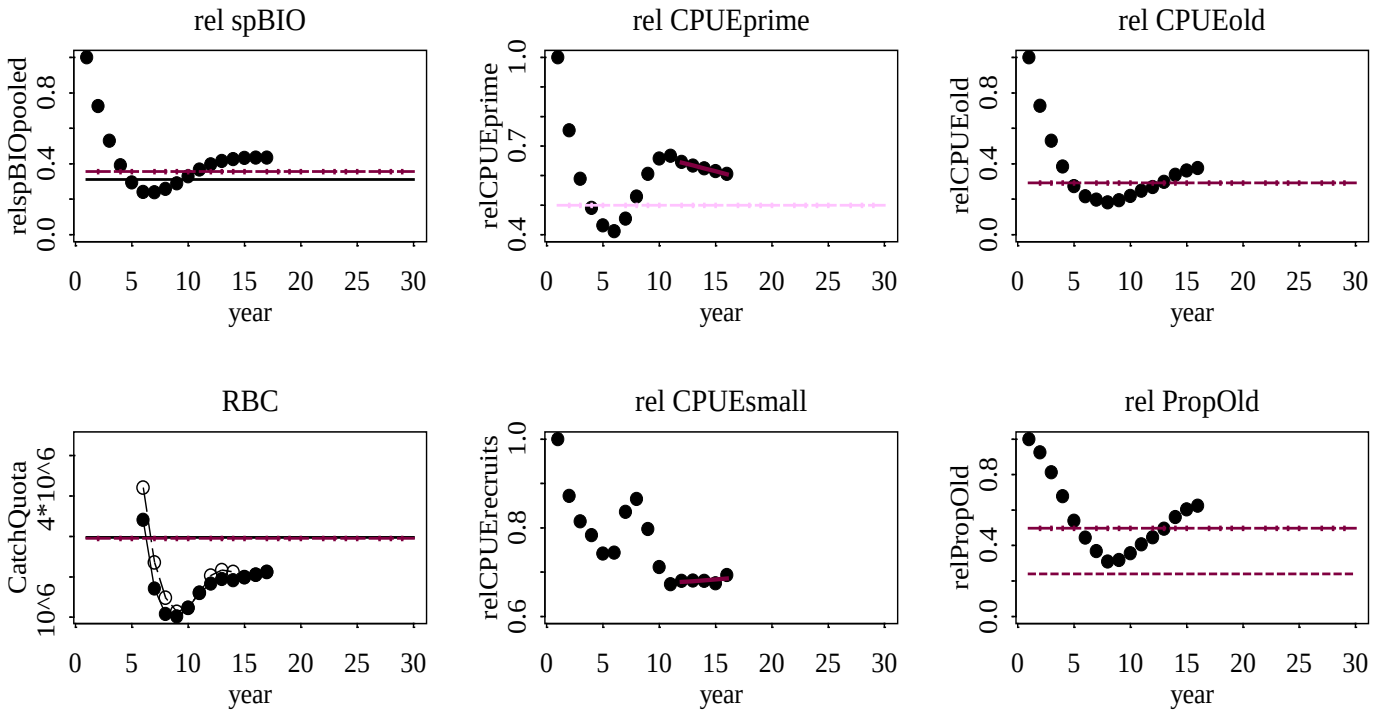
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 17



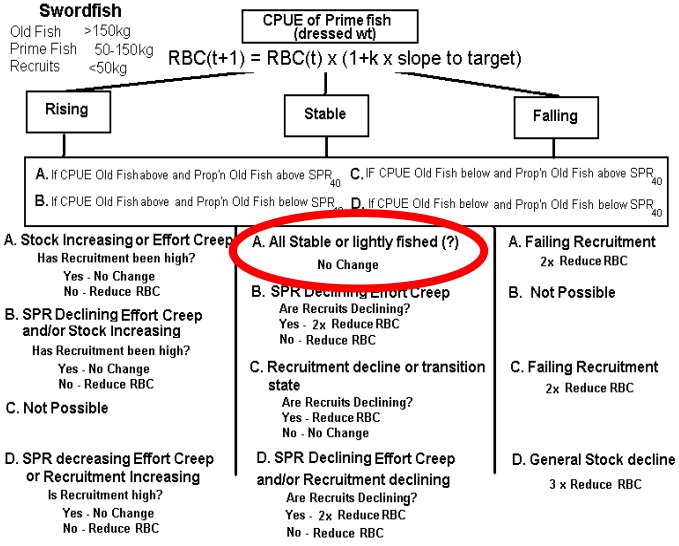
level at MSY

level at SPR_{40} (decision tree target)

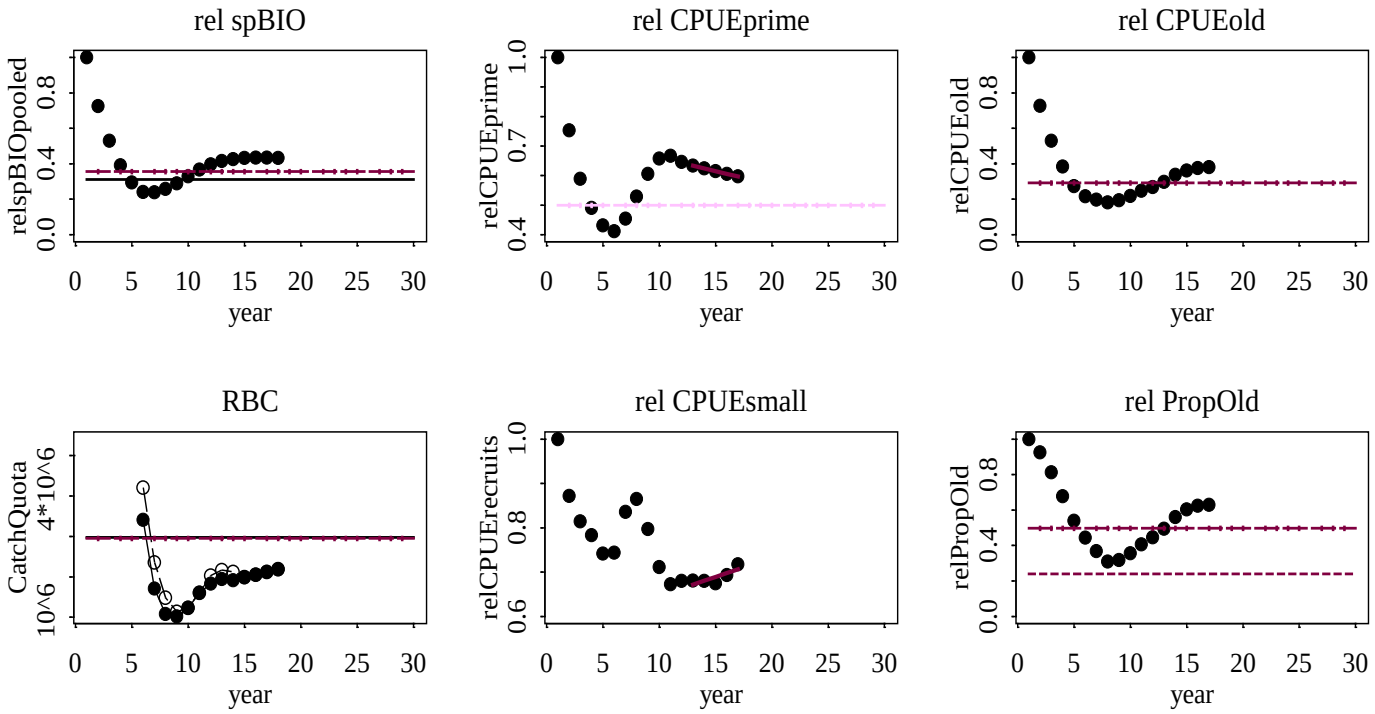
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 18



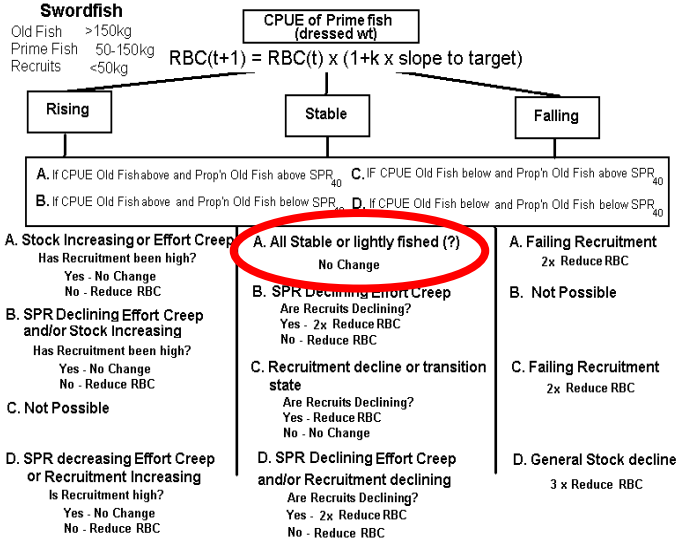
level at MSY

level at SPR_{40} (decision tree target)

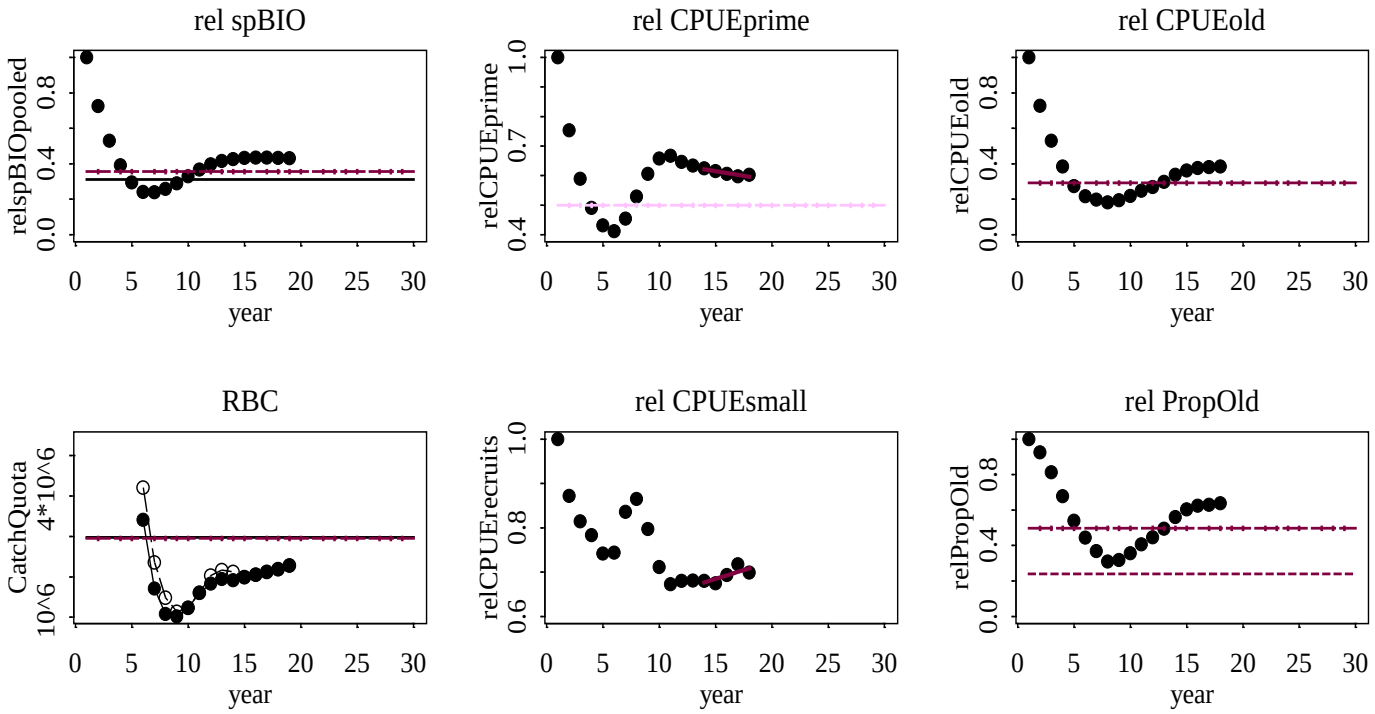
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 19



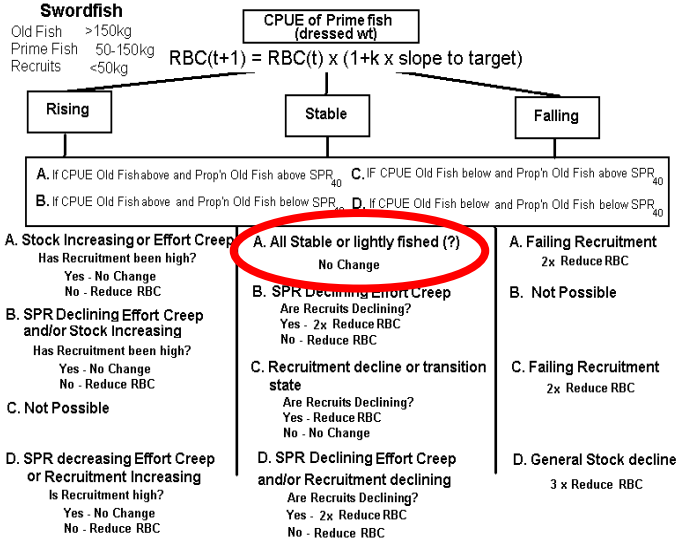
level at MSY

level at SPR_{40} (decision tree target)

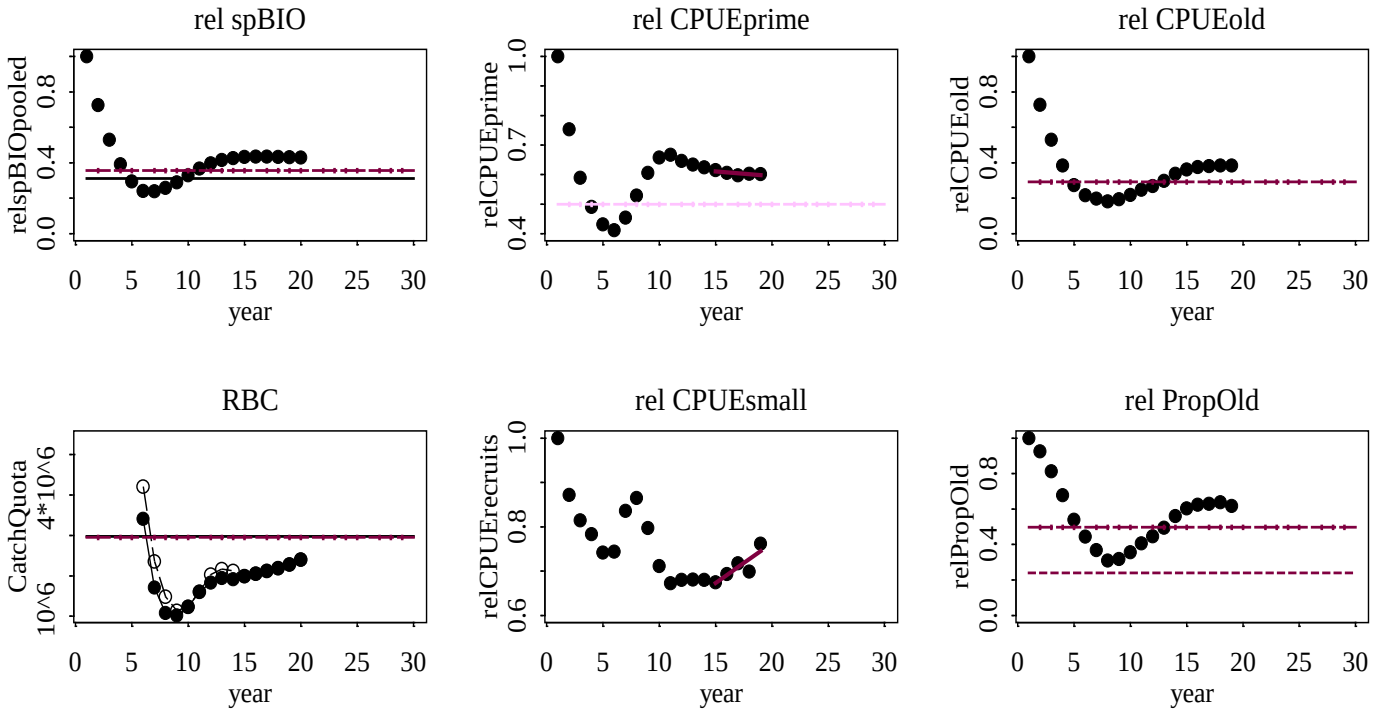
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 20



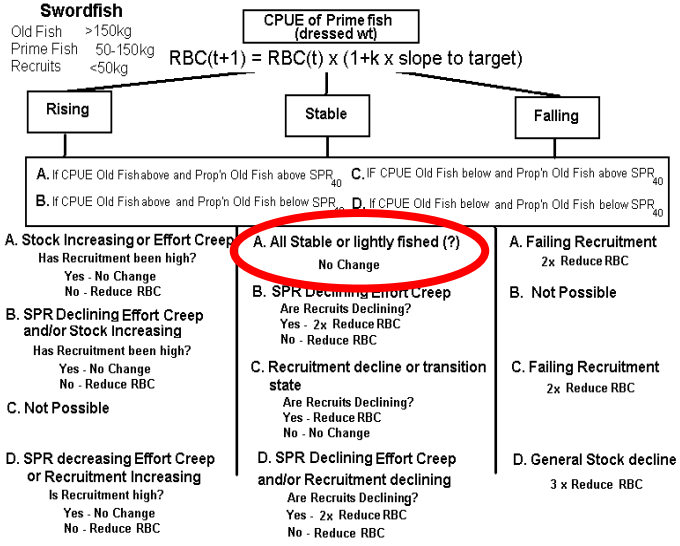
level at MSY

level at SPR_{40} (decision tree target)

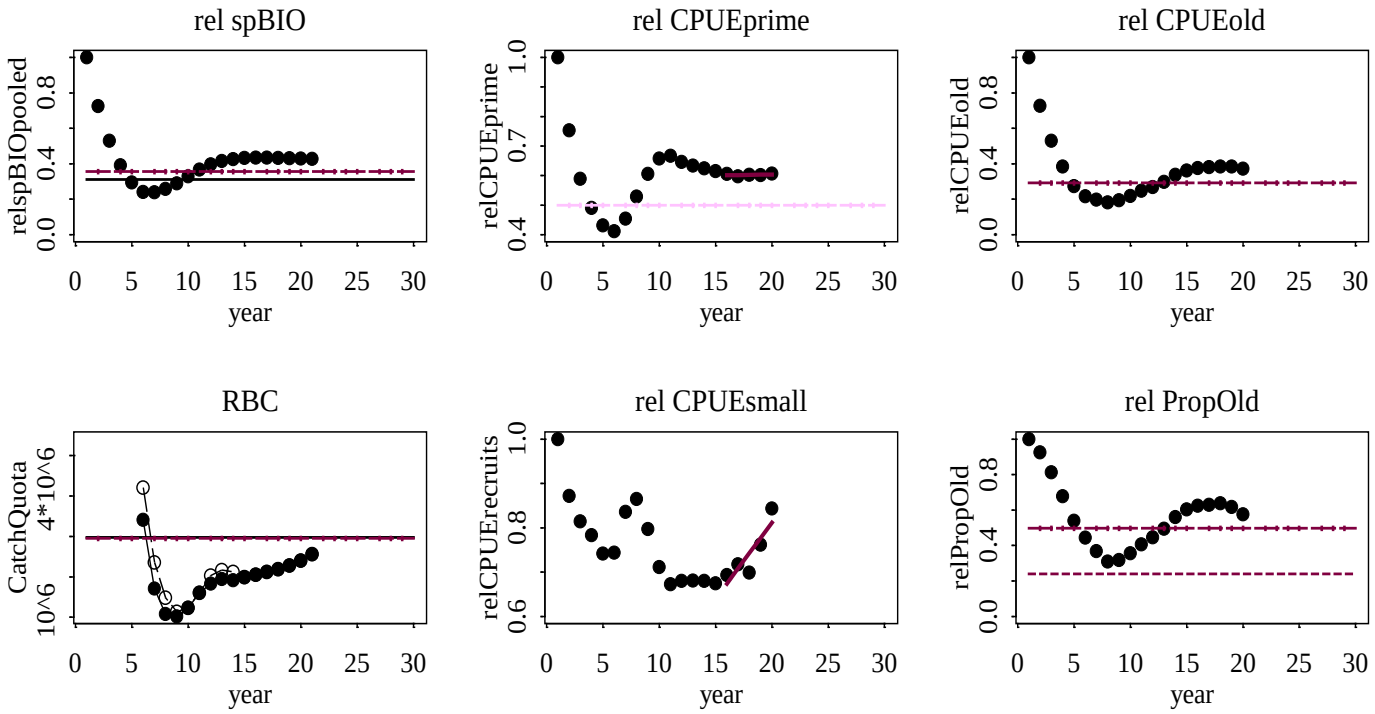
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 21



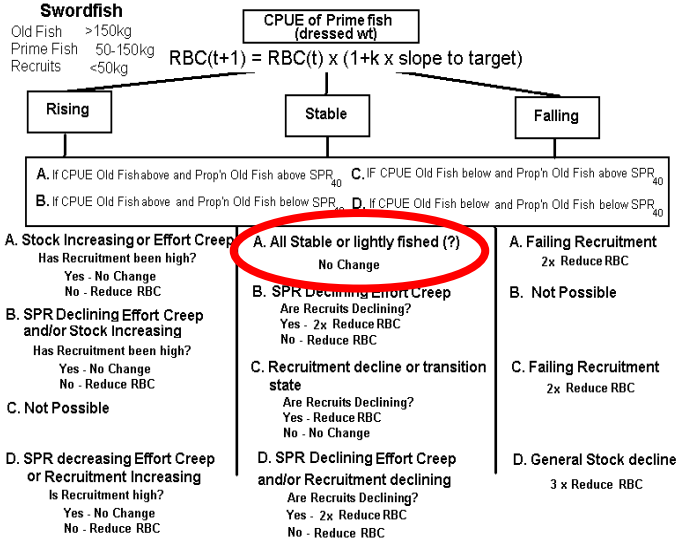
level at MSY

level at SPR_{40} (decision tree target)

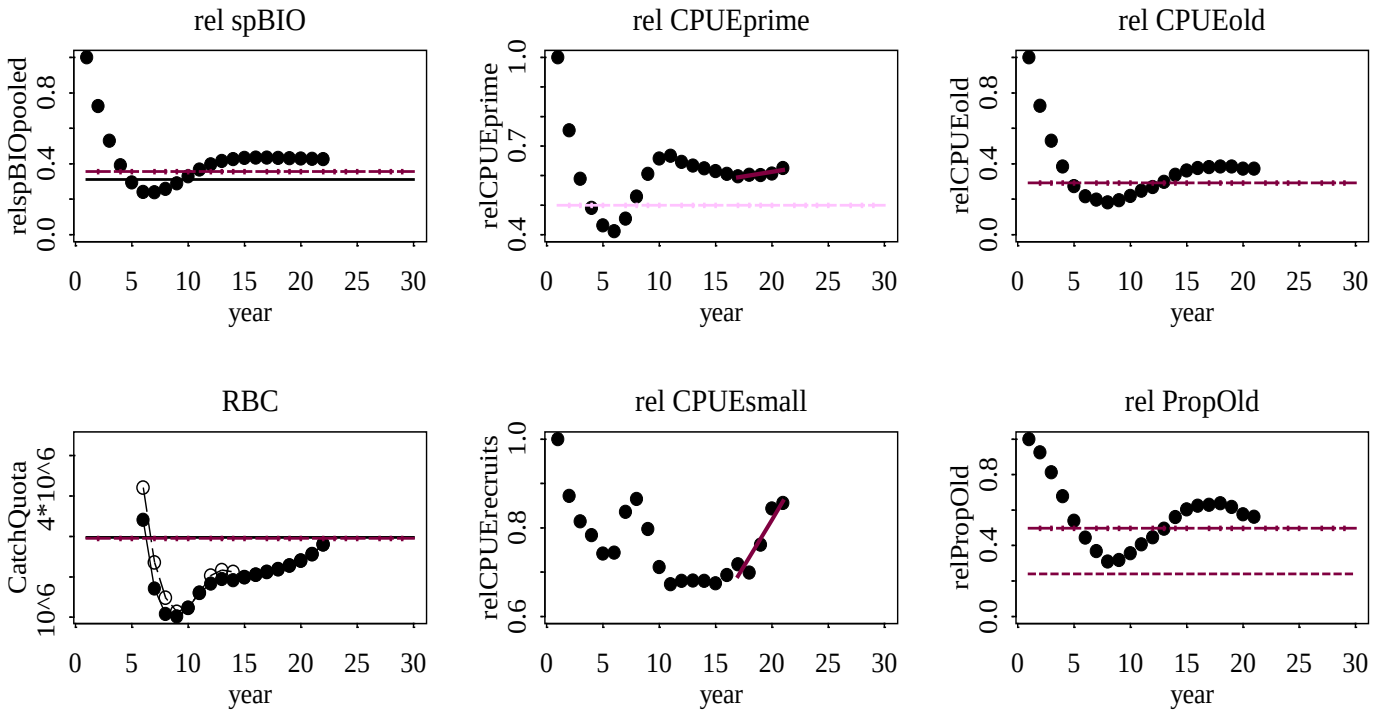
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

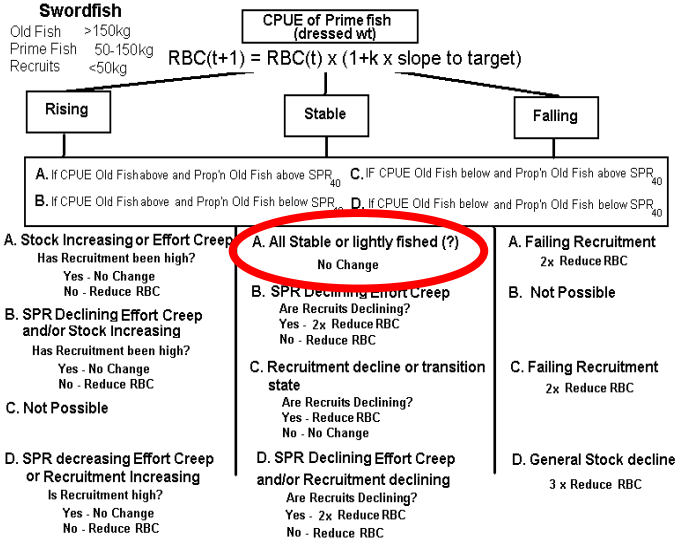
linear trend (showing slope) over last 5 years



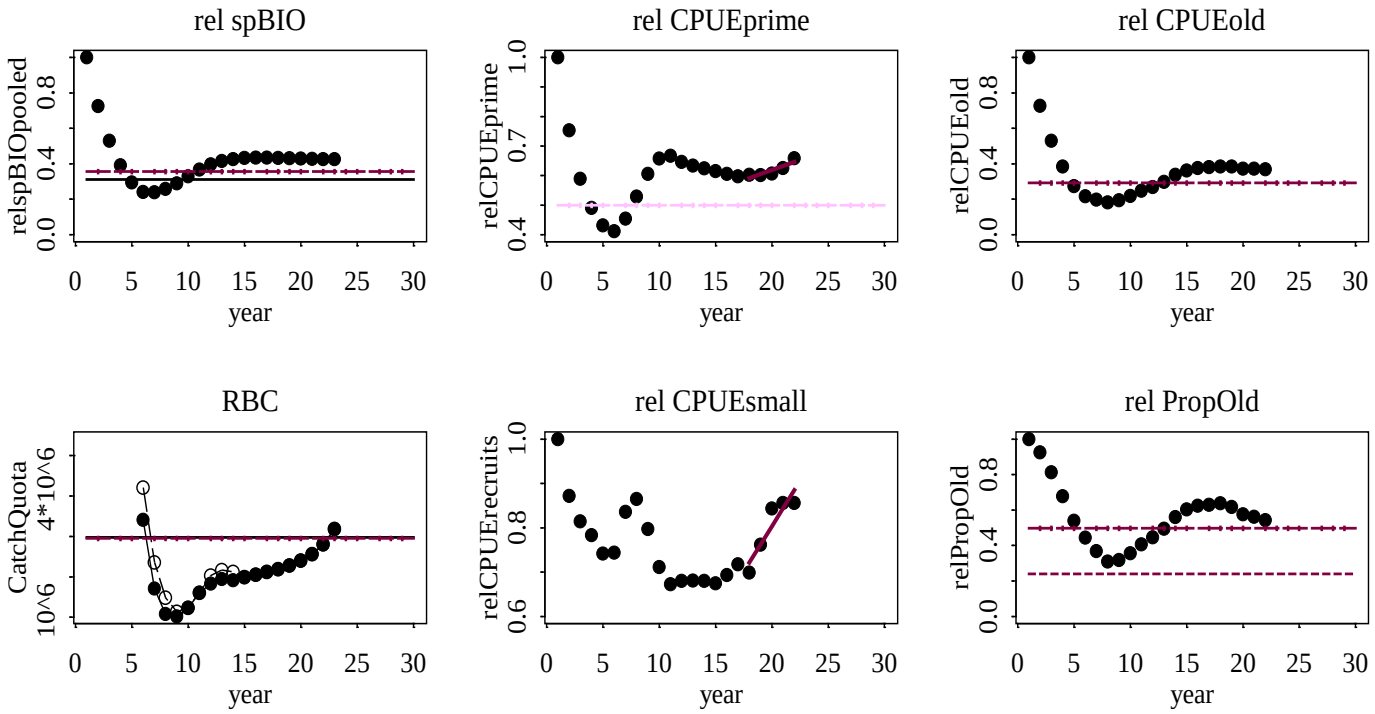
Year = 22



- level at MSY
- level at SPR_{40} (decision tree target)
- level at SPR_{20} (decision tree limit)
- 50% *CPUEprime*$_0$ (simple decision rule target)
- linear trend (showing slope) over last 5 years



Year = 23



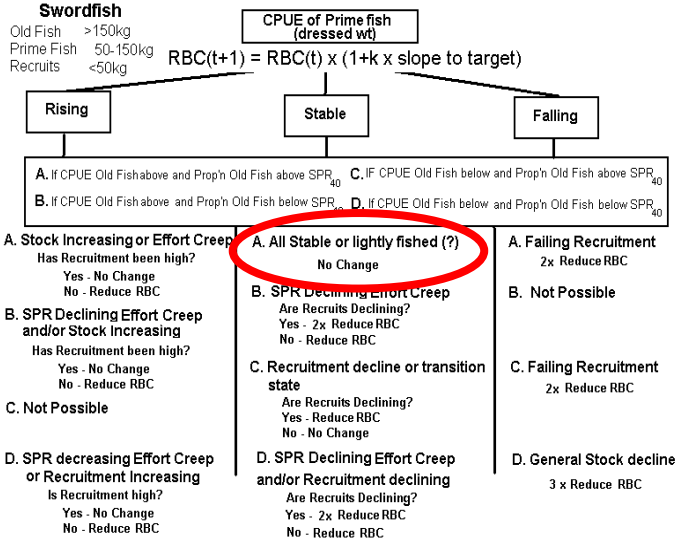
level at MSY

level at SPR_{40} (decision tree target)

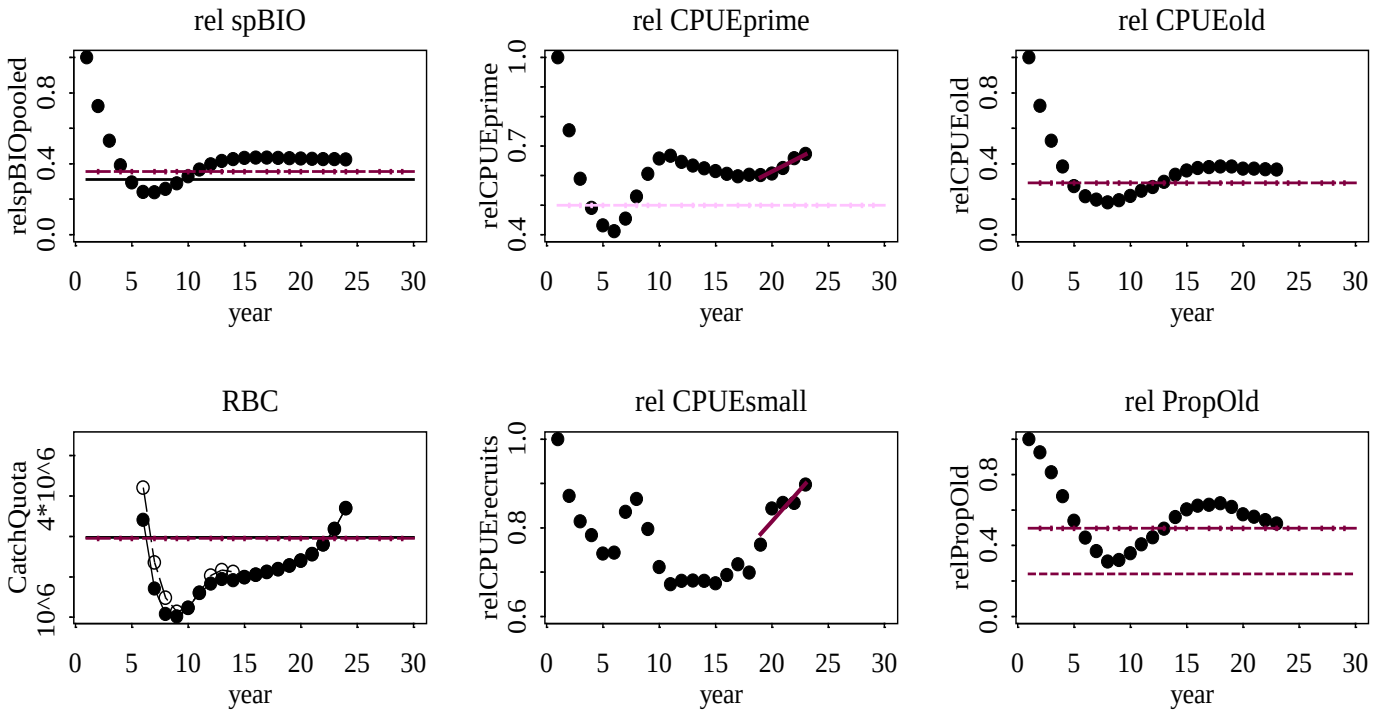
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 24



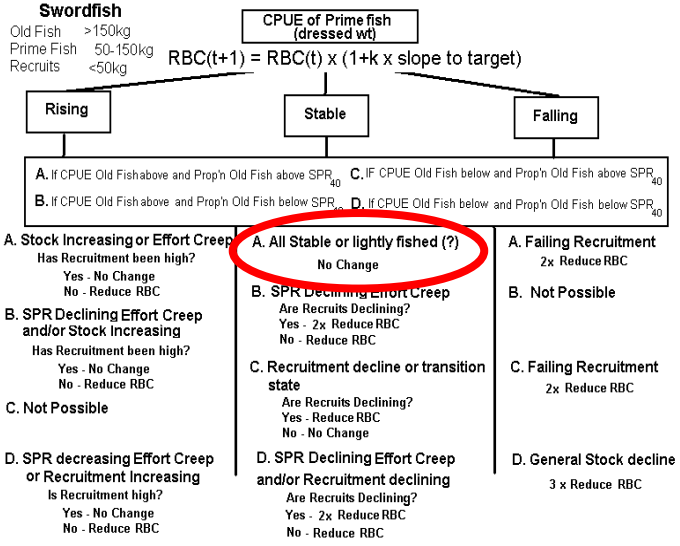
level at MSY

level at SPR_{40} (decision tree target)

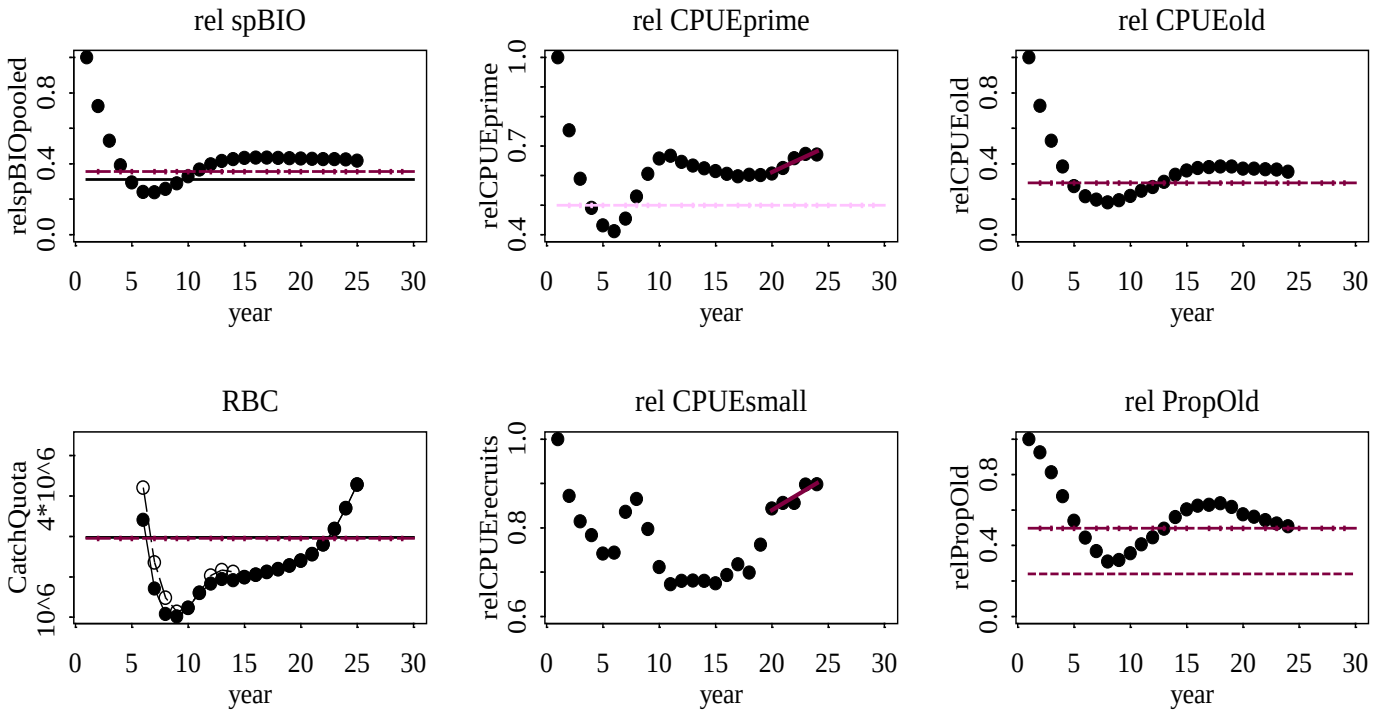
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 25



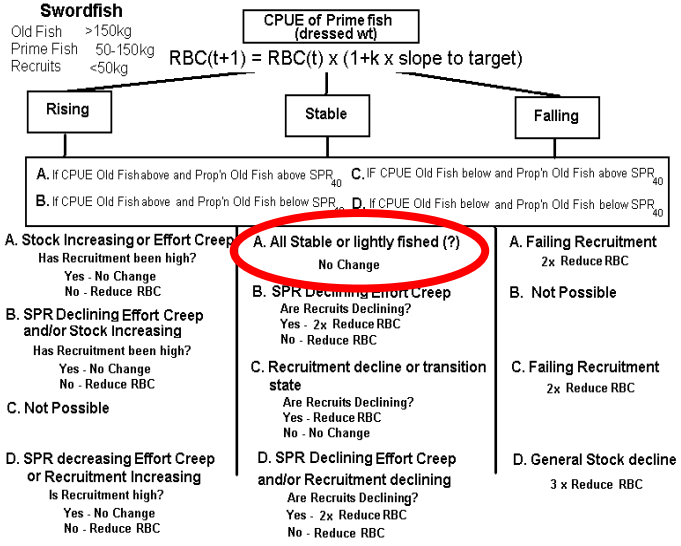
level at MSY

level at SPR_{40} (decision tree target)

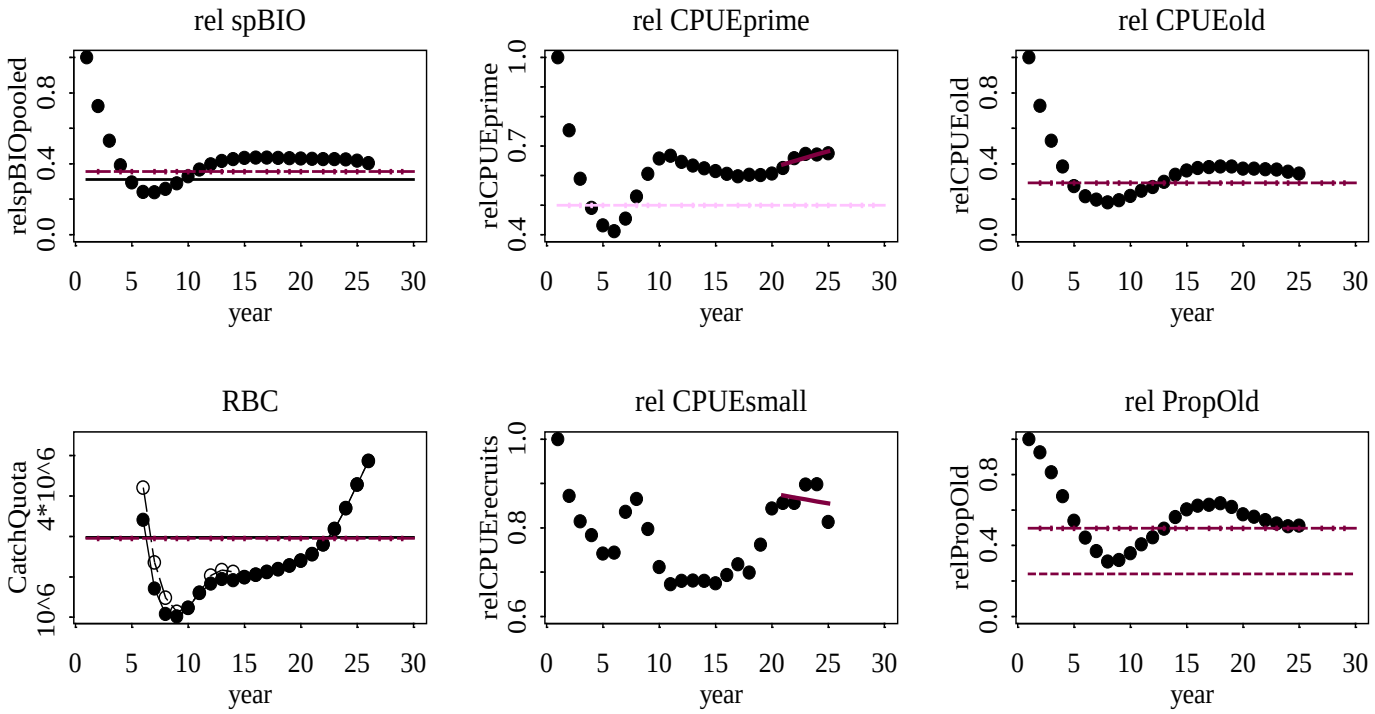
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 26



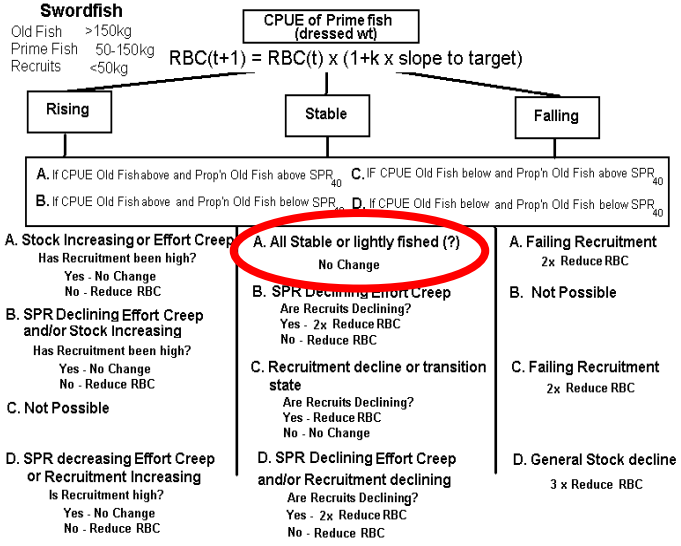
level at MSY

level at SPR_{40} (decision tree target)

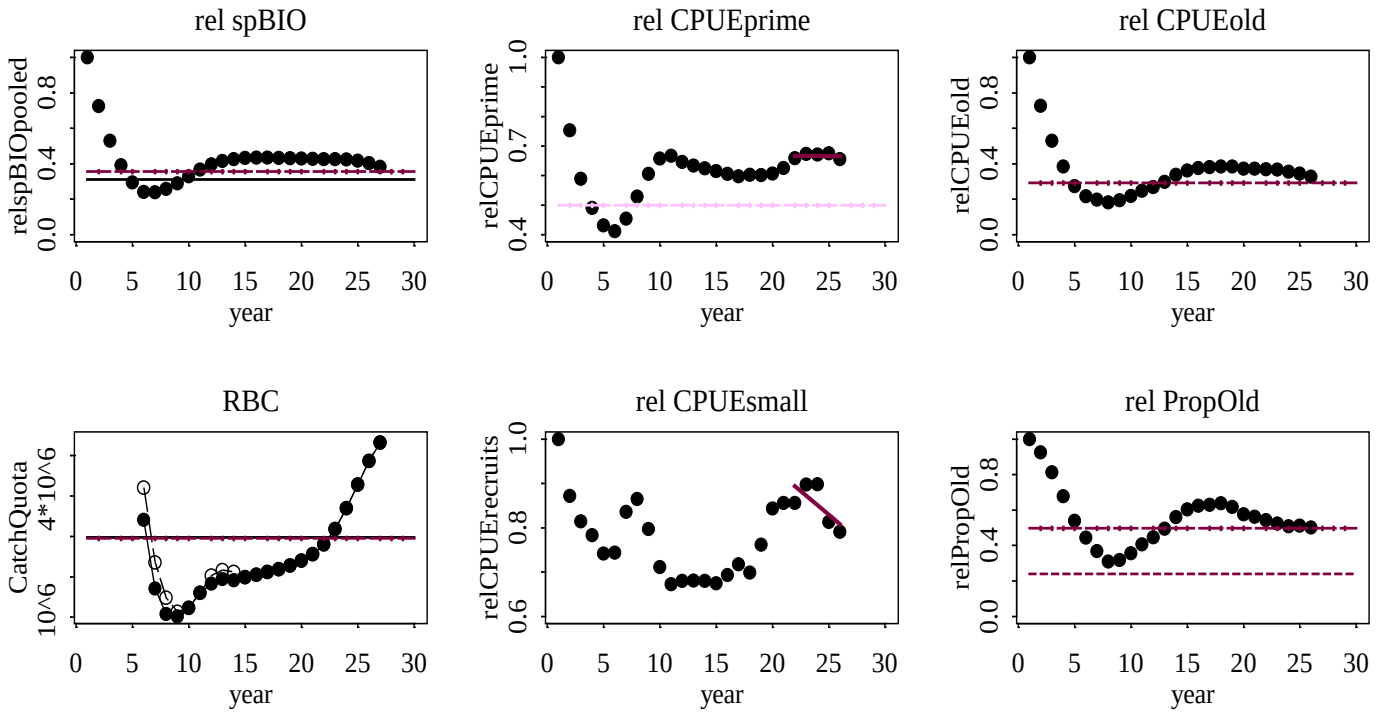
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 27



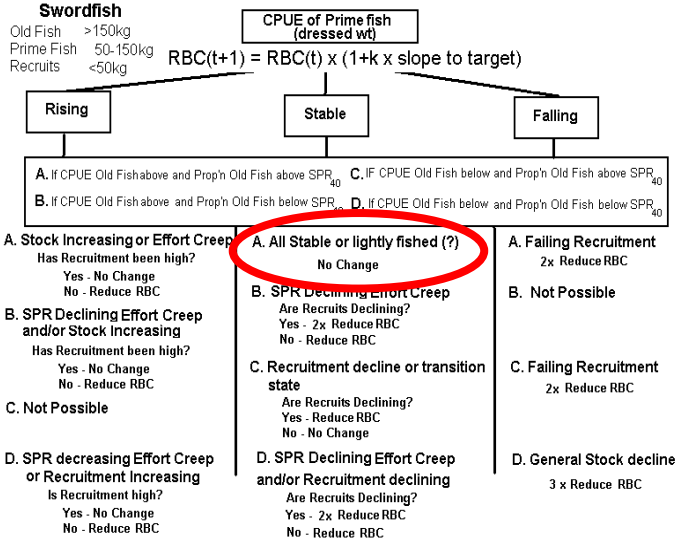
level at MSY

level at SPR_{40} (decision tree target)

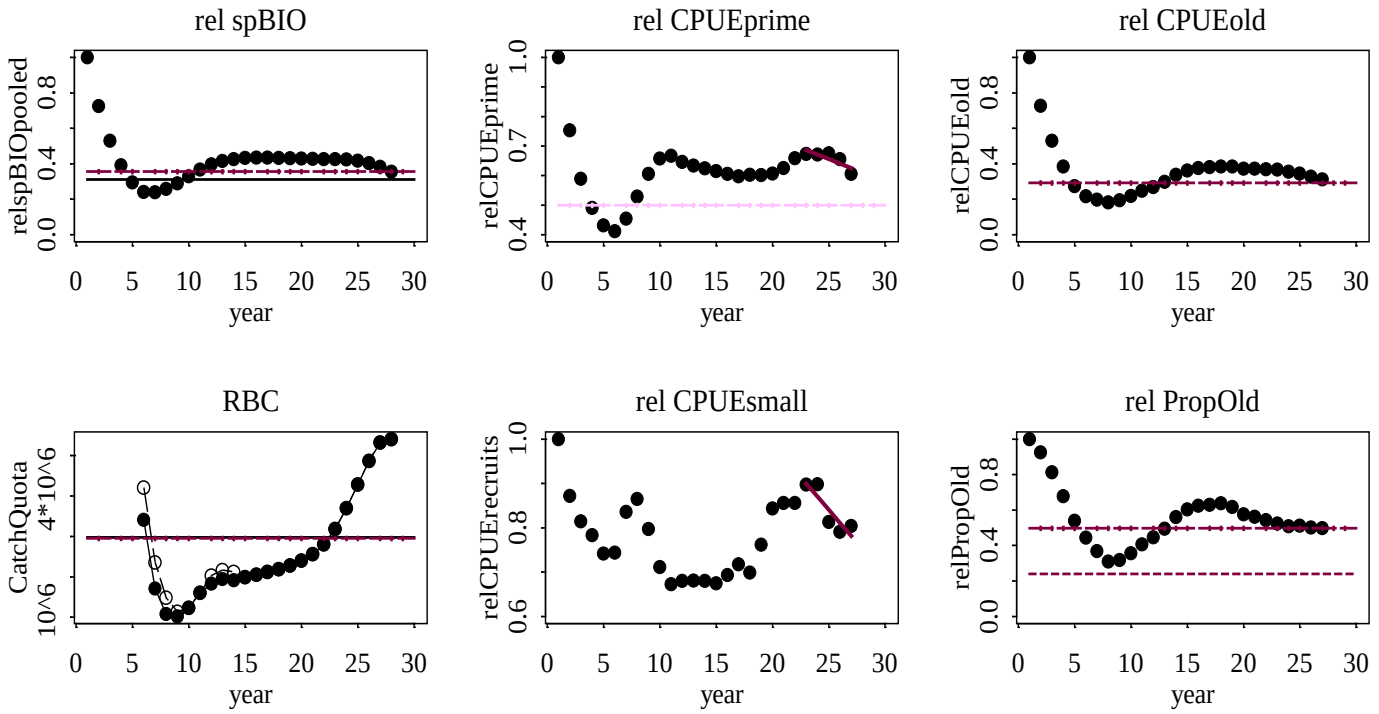
level at SPR_{20} (decision tree limit)

50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 28



level at MSY

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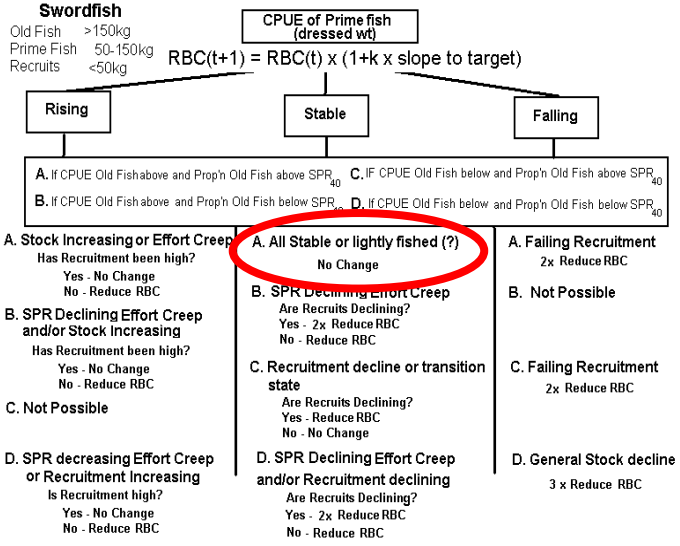
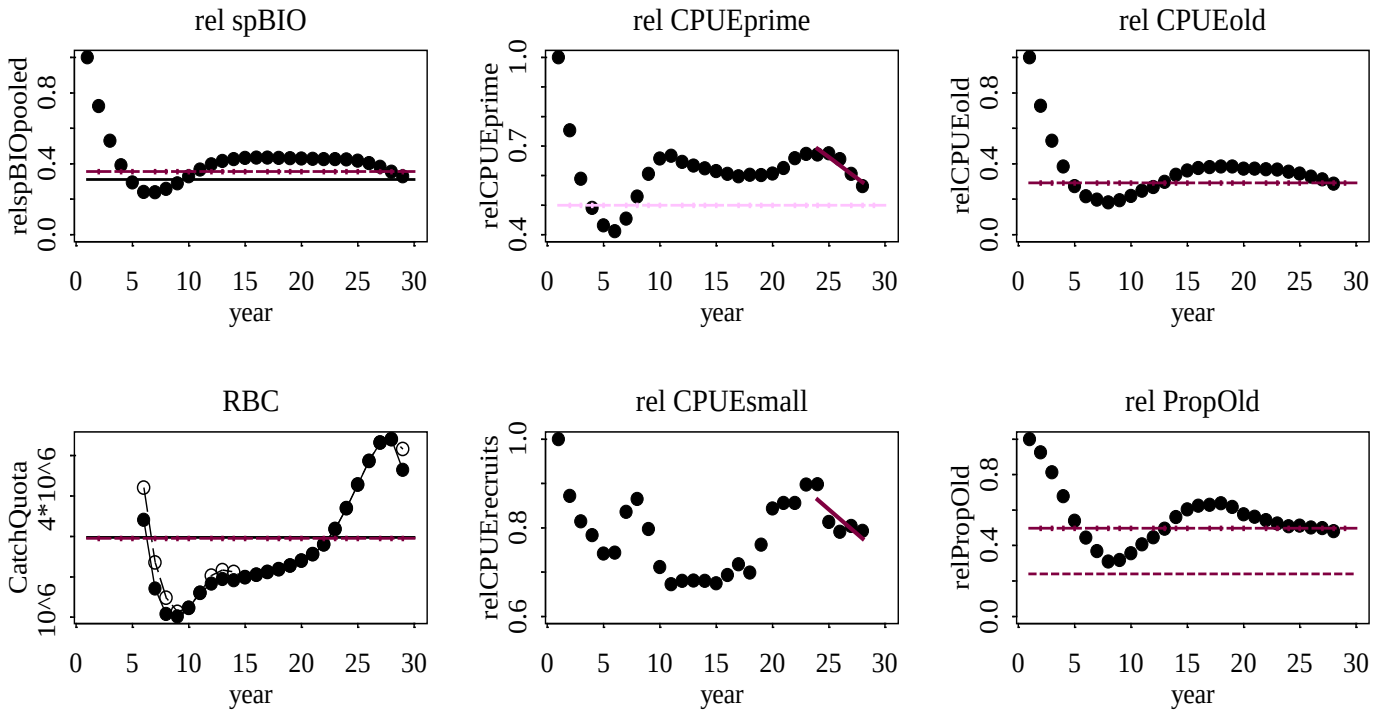
50% *CPUEprime*$_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 29



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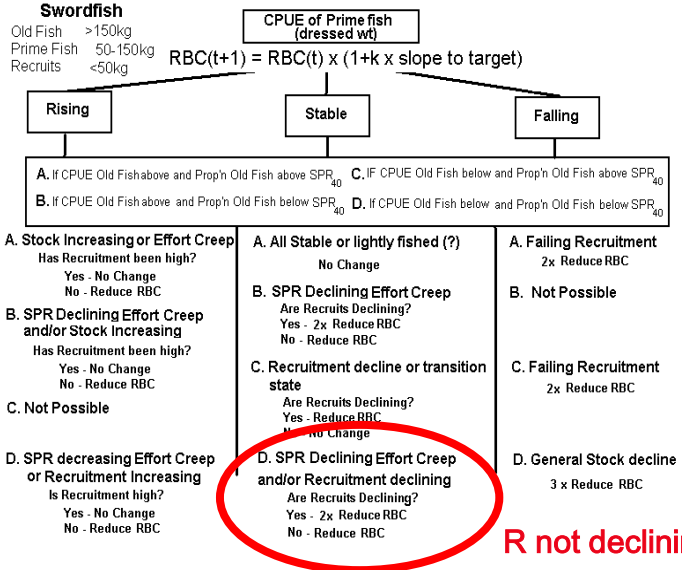
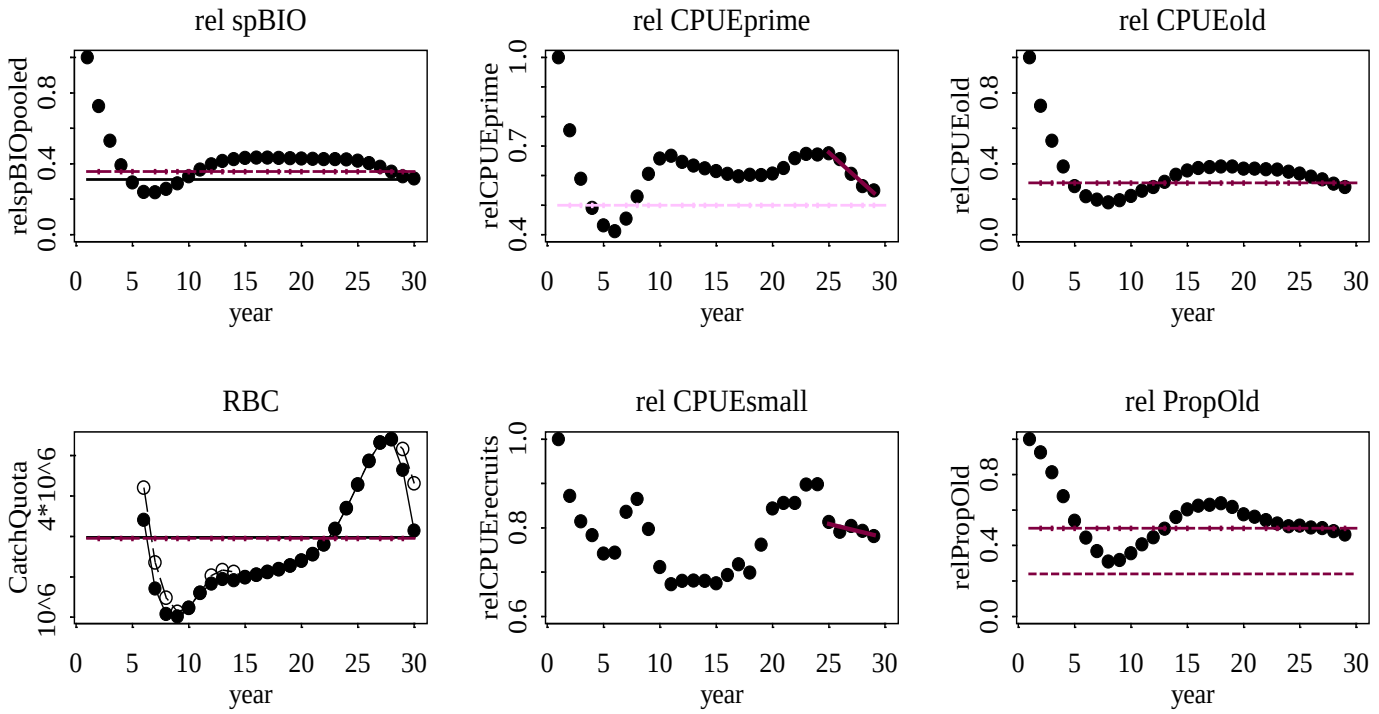
linear trend (showing slope) over last 5 years



R not declining

Year = 30



level at MSY

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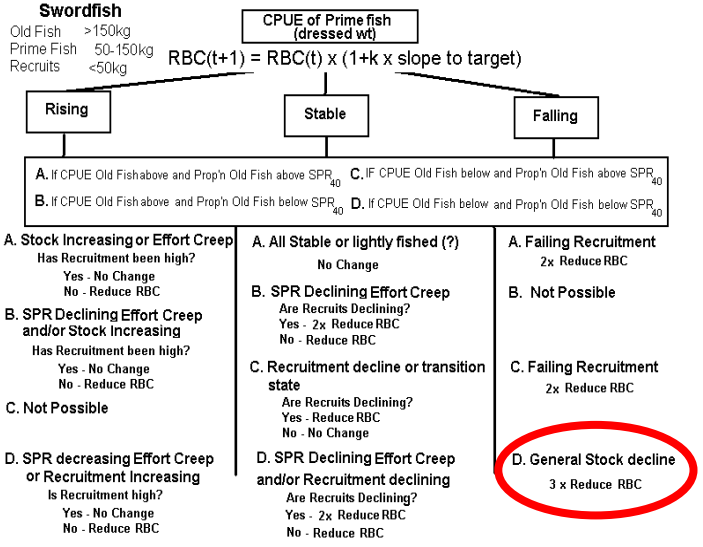
50% *CPUEprime*$_0$ (simple decision rule target)

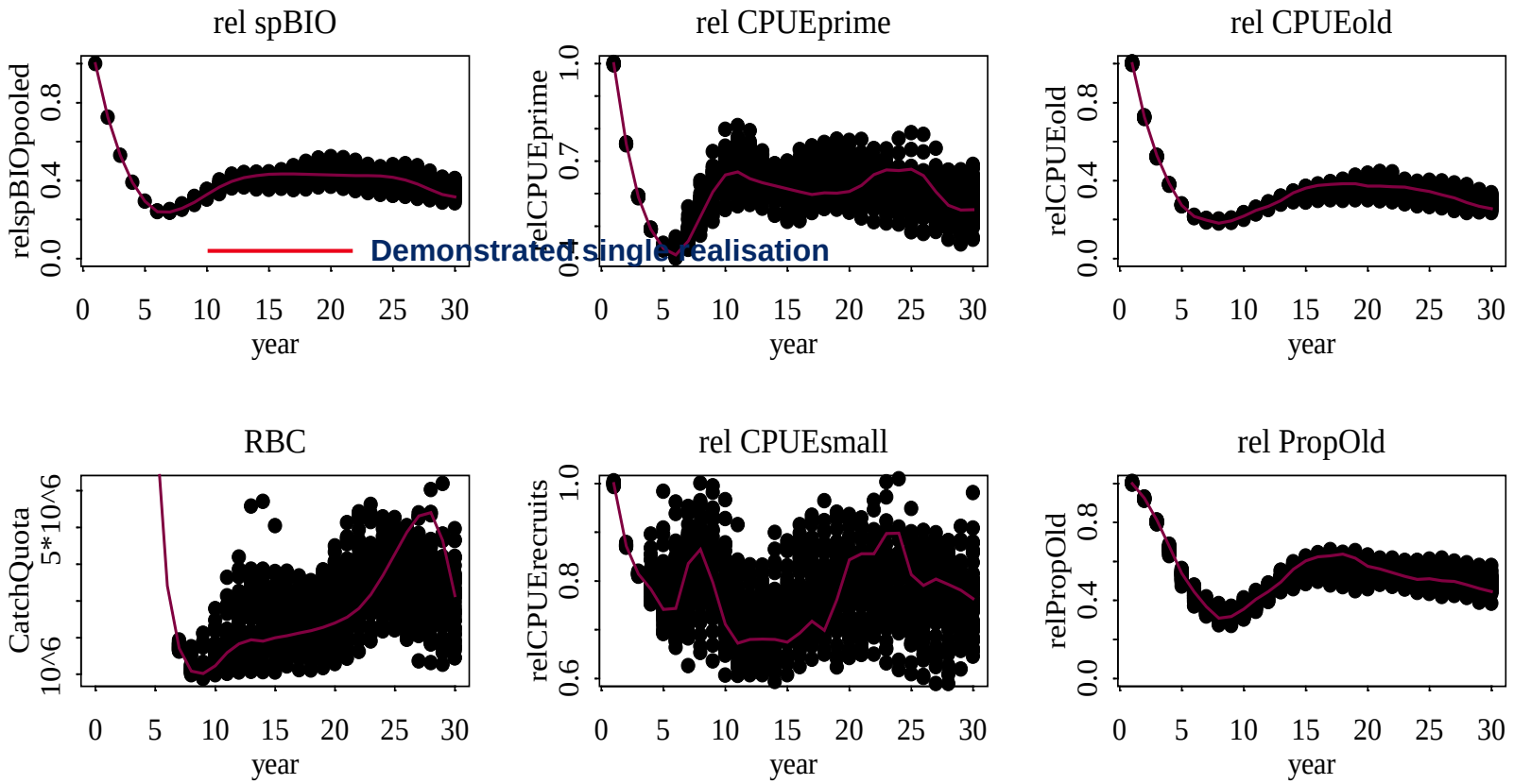
linear trend (showing slope) over last 5 years



Sources of uncertainty

- Recruitment variation (annual)
- Observation uncertainty
- Environmental variation (e.g. oceanographic influence on availability)
- Bias in CPUE
- Uncertainty in other population dynamics

Introducing natural variation



- Random uncertainty –annual recruitment variation