Generic Management Procedures for data-poor fisheries: forecasting with few data

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Fisheries management

Key management questions:

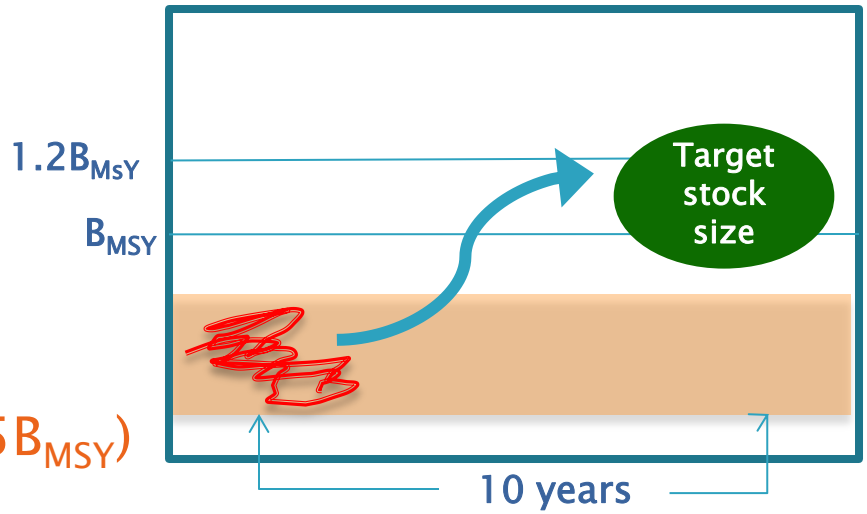
Where are we?

Not sure

Where do we go?

To target: 0.5K ($1.2B_{MSY}$)

Stay above limit: 0.2K ($0.5B_{MSY}$)



How do we get there?

Management Procedures:

simple harvest control rules that have been simulation tested to show robustness to uncertainty.

The problem

Stock status unknown:

Some knowledge of current depletion interval [?< B/K<?]

Few data:

Some knowledge of life-history parameters: M, growth parameters

A catch time-series

Mean length ("data-limited") or Index of abundance ("data-moderate")

High levels of uncertainty:

Data-poor, poor data and poor assumptions

Simulation test!

The challenge

Account for uncertainty:

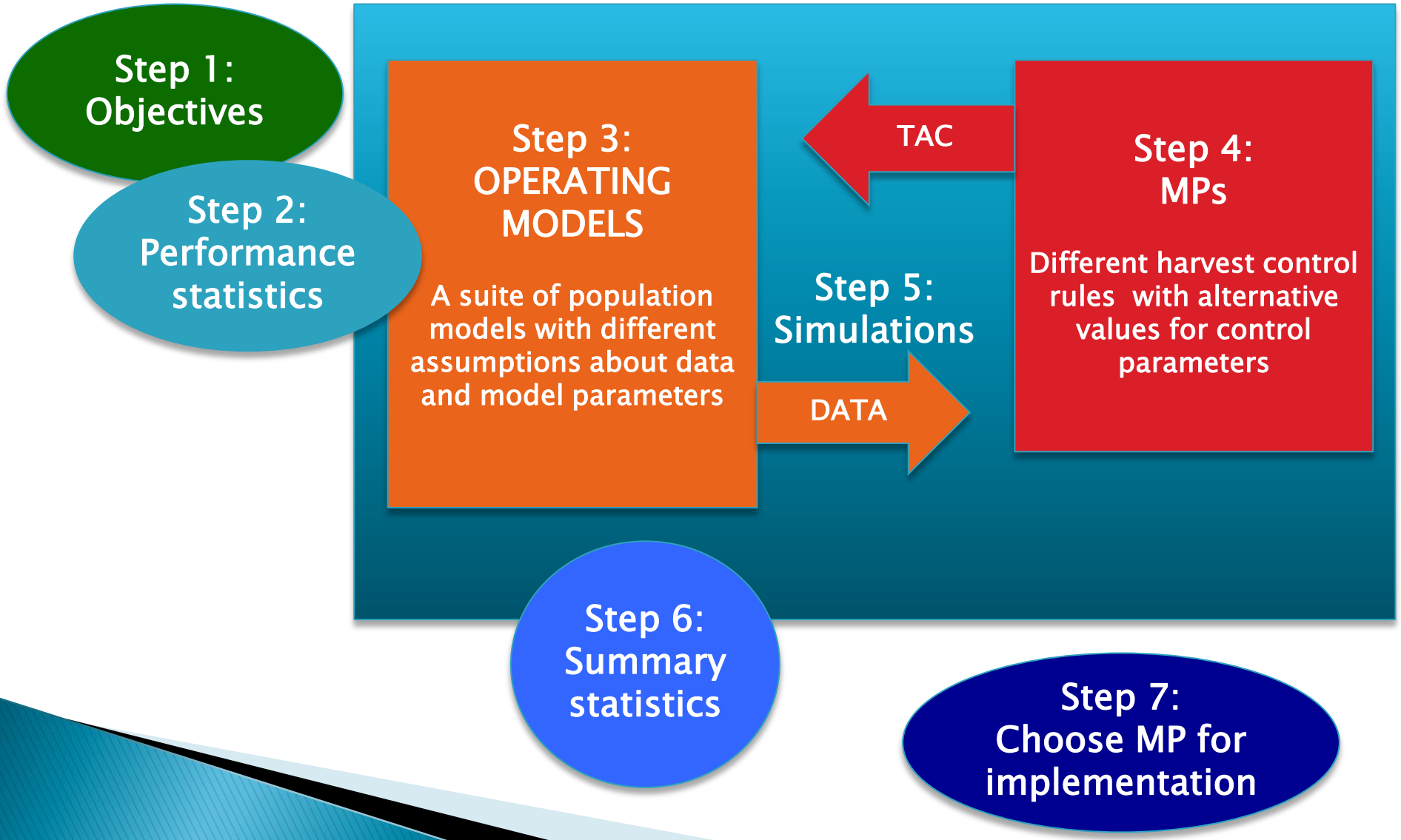
- model uncertainty
- process error
- observation error
- implementation error

Balance management objectives and trade-offs:

- Maximise future catch
- Minimise risk of resource depletion
- Need a harvest control rule with feedback
- Need simple and cheap management solution that works!

Management Procedure Approach

MP approach: 7 steps



Basic approach

Group stocks in depletion/productivity baskets:

Productivity/ Depletion	Low	Medium	High
Severely	M:U[0.05,0.2] B/K:U[0.1,0.3]	M:U[0.2,0.4] B/K:U[0.1,0.3]	M:U[0.4,1] B/K:U[0.1,0.3]
Moderately	M:U[0.05,0.2] B/K:U[0.3,0.5]	M:U[0.2,0.4] B/K:U[0.3,0.5]	M:U[0.4,1] B/K:U[0.3,0.5
Near target	M:U[0.05,0.2] B/K:U[0.5,0.7]	M:U[0.2,0.4] B/K:U[0.5,0.7]	M:U[0.4,1] B/K:U[0.5,0.7]

Set up operating model (Age Structured Production Model):

Bayes-like approach: sample from distributions for key model parameters (no fitting to data!)

Operating model (ASPM)

Model uncertainty: parameter distributions

Depletion:	B/K: U[0.1,0.3]
Natural mortality rate:	M: U[0.2,0.4]
Steepness of S-R:	h: U[0.5,0.9]

Process error:

Logistic selectivity-at-age:	Log-normal CV=0.4
Beverton-Holt stock-recruitment:	Log-normal CV=0.5

Observation error:

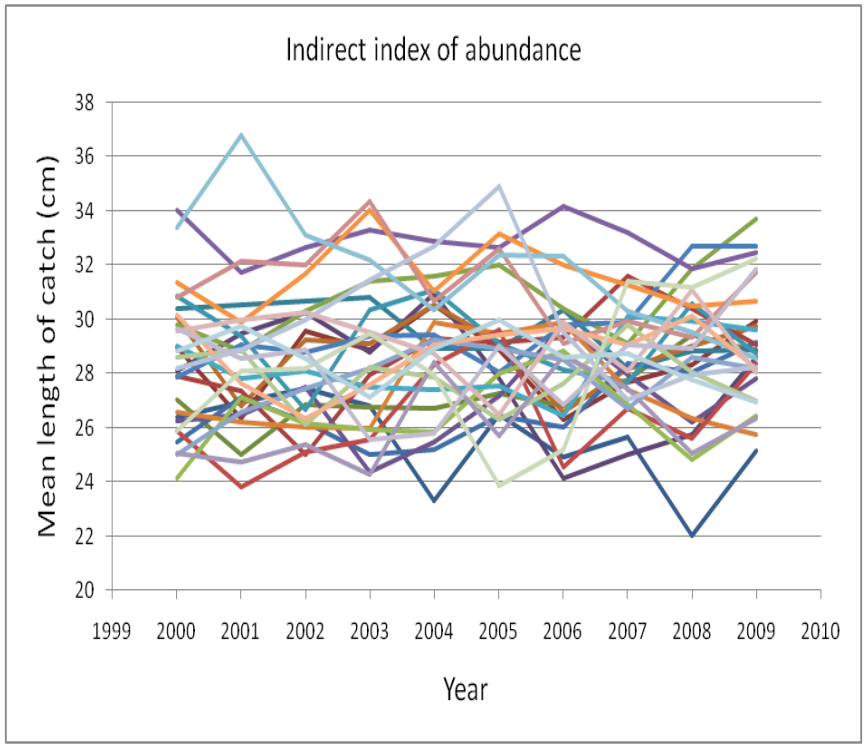
Mean length of catch:	Log-normal CV=0.25
Index of abundance:	Log-normal CV=0.2

Implementation error:

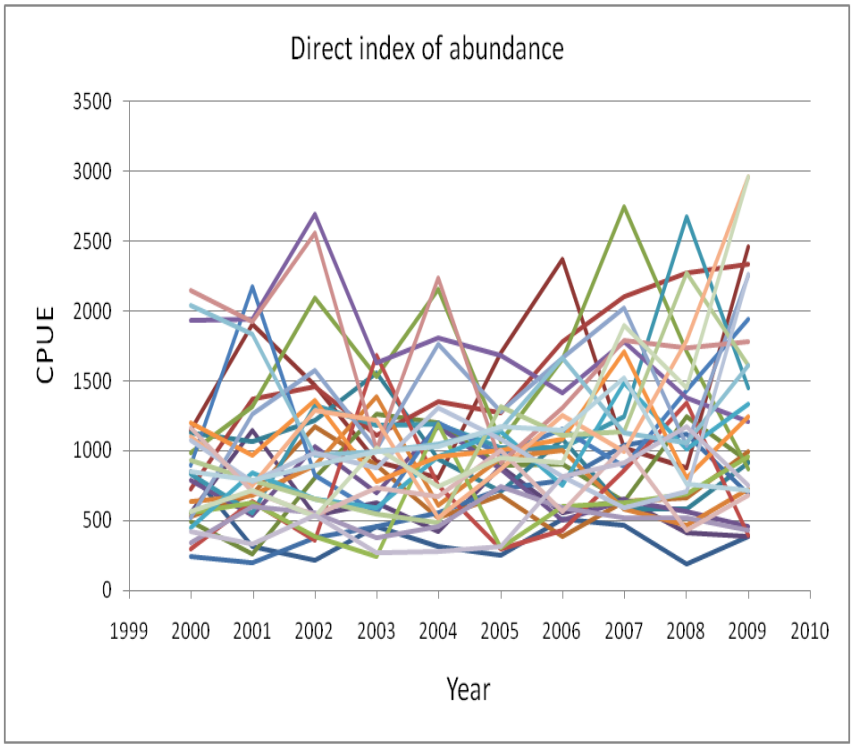
Catch time series:	Log-normal CV=0.2

Generated data:

Mean Length (L)



Index of abundance (I)



Annual historic mean length (left) and CPUE (right) data generated by the operating model (30 from a total of 8000 simulations shown here).

Management Procedures

Constant catch (CC):

$$TAC_{y+1} = TAC^{*} = (1 - x)C^{ave}$$

Step-wise CC (LstepCC):

$$TAC_{y+1} = TAC_{y} \pm \text{step}$$

Length L target (Ltarget):

$$TAC_{y+1} = 0.5TAC^{*}\left[1 + \left(\frac{L_{y}^{recent} - L^{0}}{L^{target} - L^{0}}\right)\right]$$

Index I Slope (Islope):

$$TAC_{y+1} = TAC_{y}(1 + \mathit{ls}_{y})$$

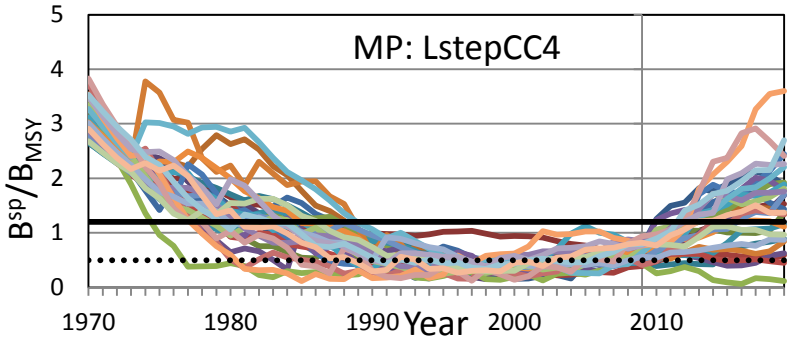
Index I target (Itarget):

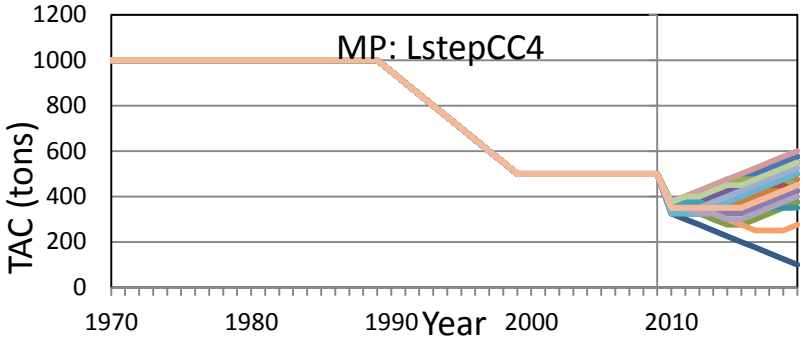
$$TAC_{y+1} = 0.5TAC^{*}\left[1 + \left(\frac{I_{y}^{recent} - I^{0}}{I^{target} - I^{0}}\right)\right]$$

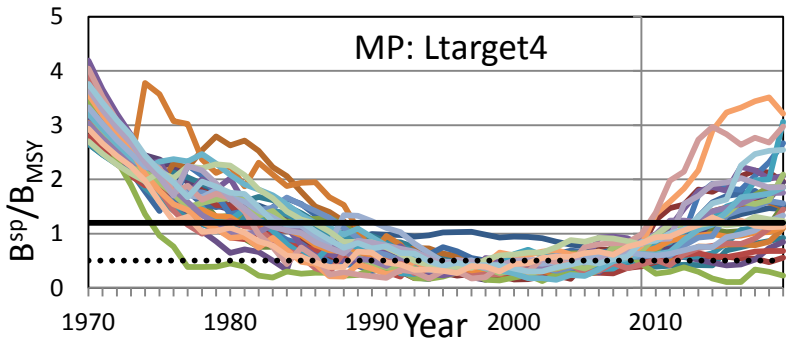
L = mean length of catch

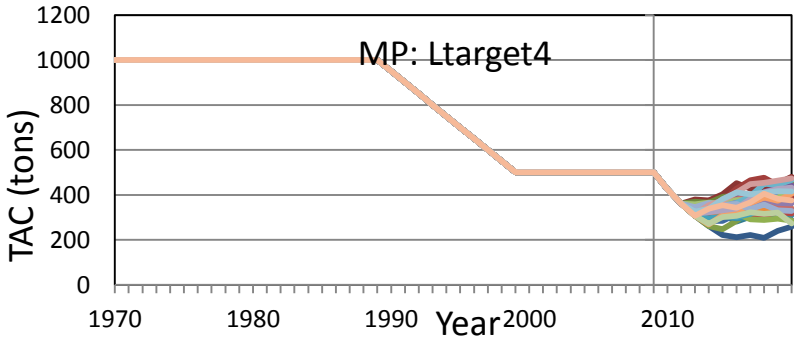
I = index of abundance (CPUE or survey)

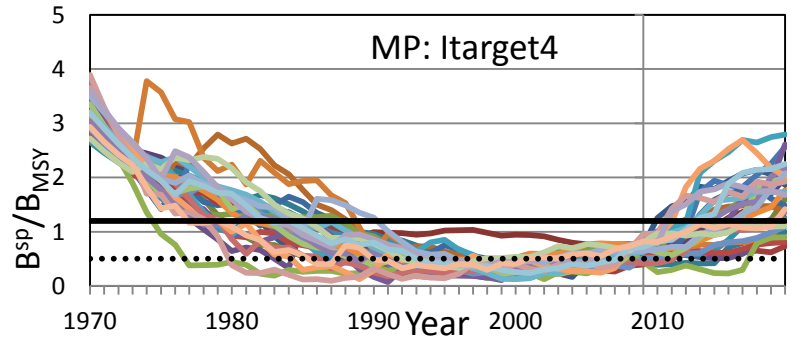
Stochastic projections: No implementation error

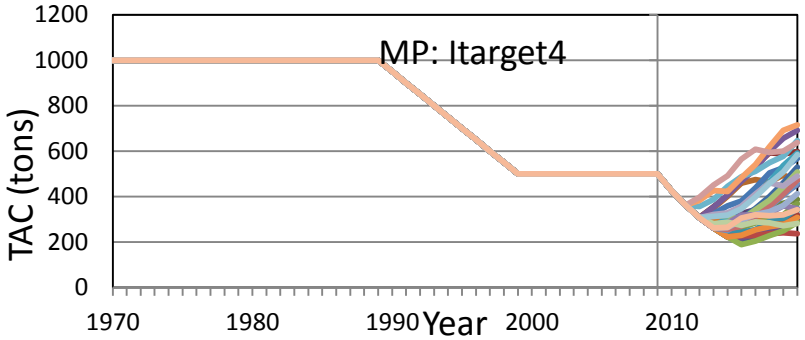










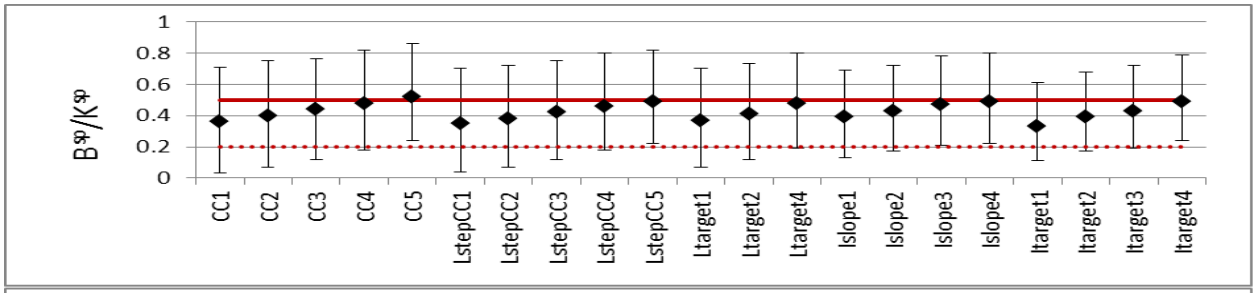


$B^{sp}/B^{sp}(MSY)$

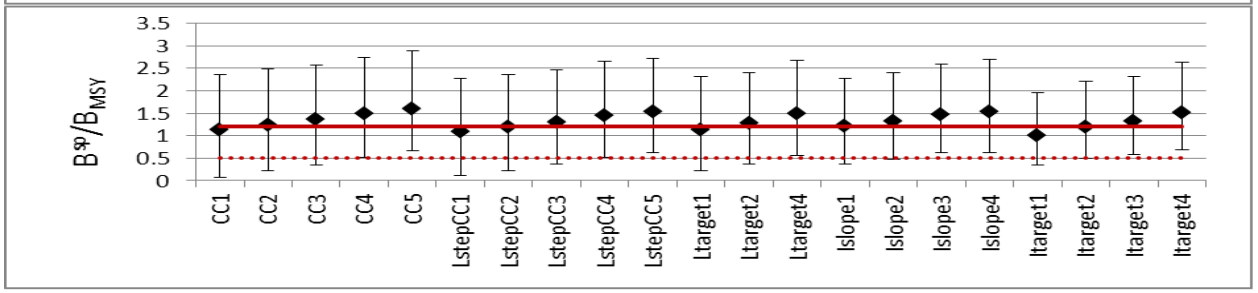
Annual catch (tons)

Summary statistics: all MPs

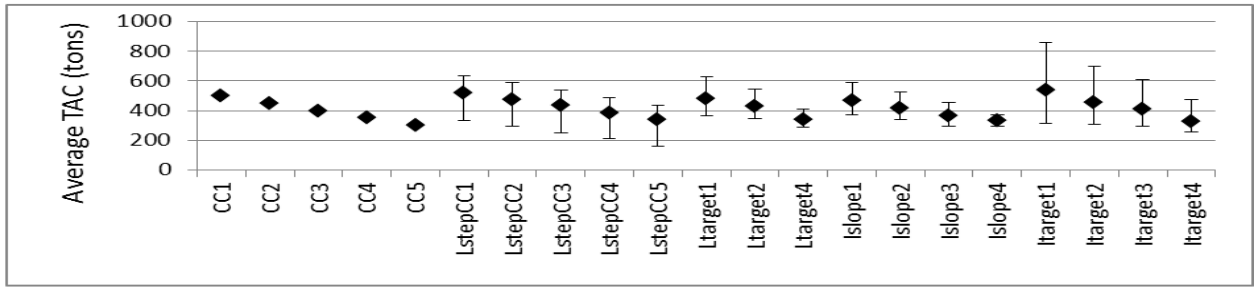
Final B/K



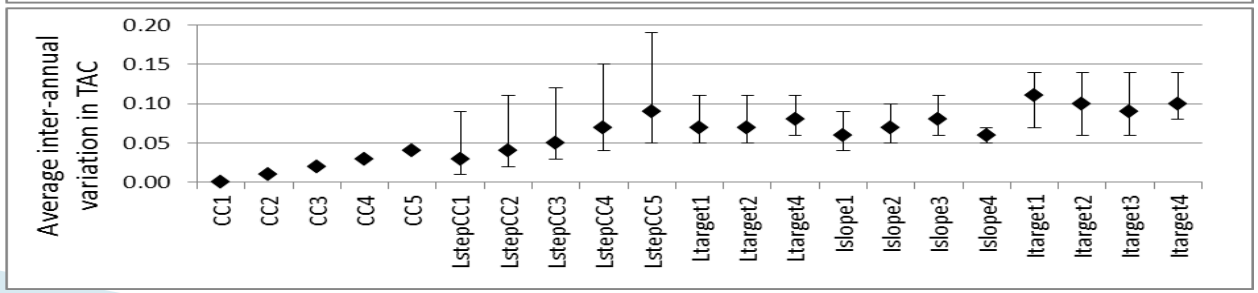
Final B/Bmsy



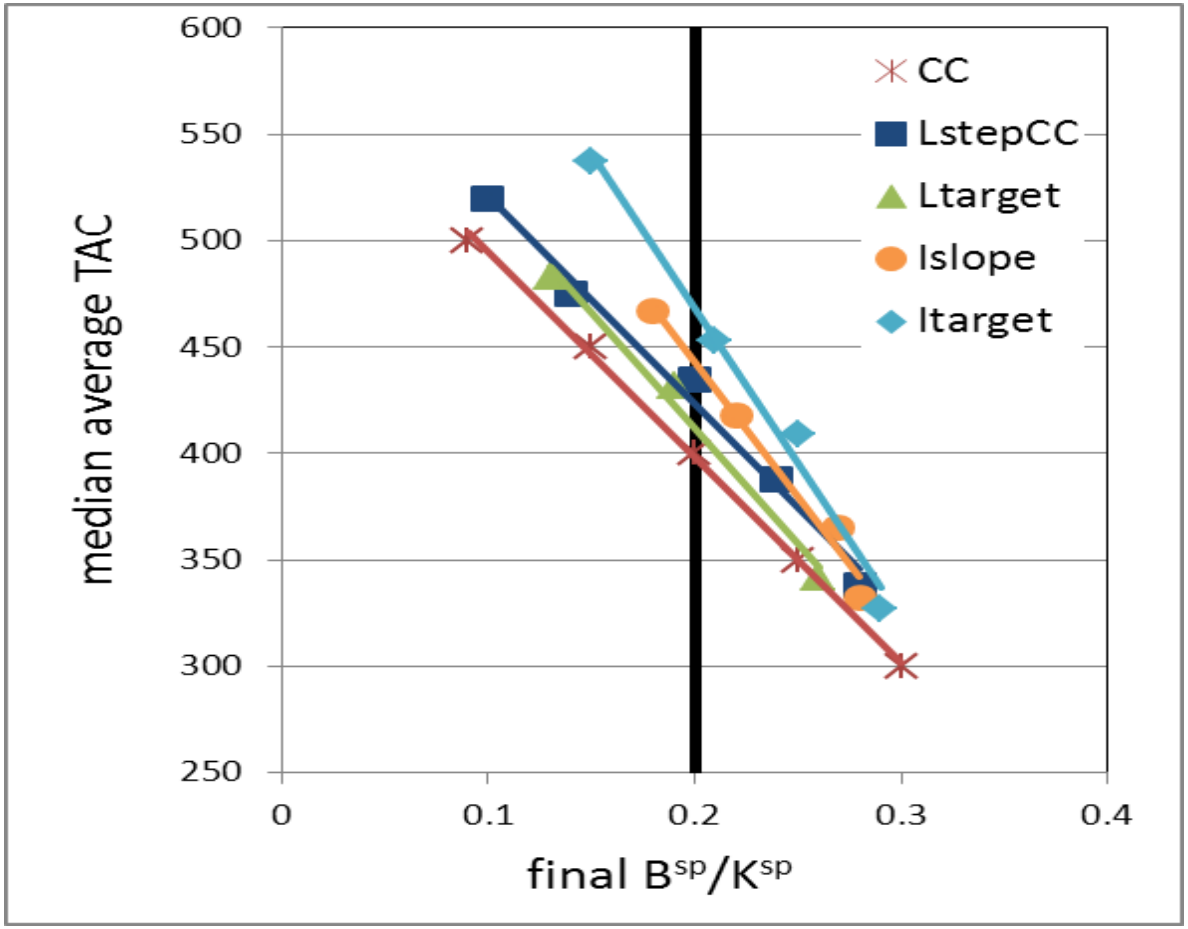
Annual average catch (tons)



Average change in catch

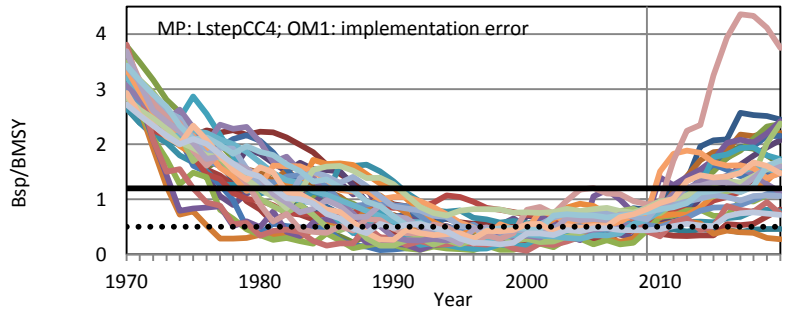


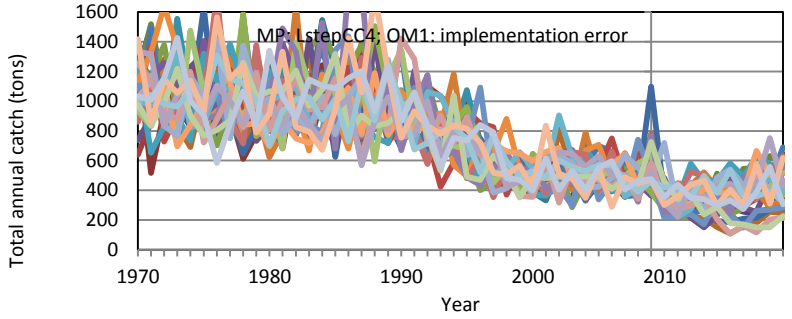
Performance trade-offs: Yield versus risk

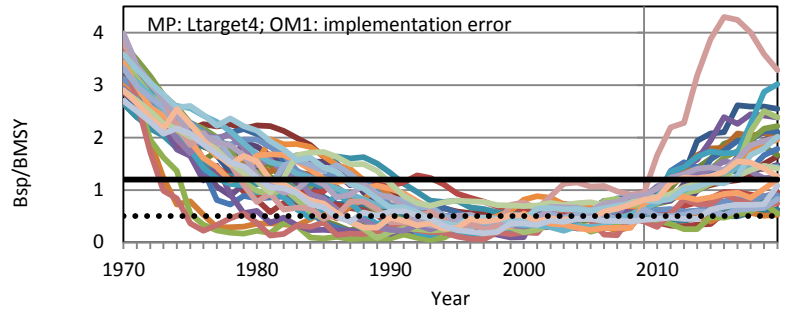


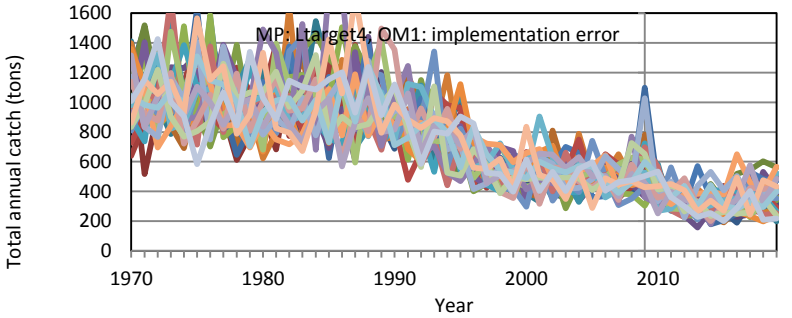
Median average catch plotted against the 10%-ile values for final spawning biomass depletion

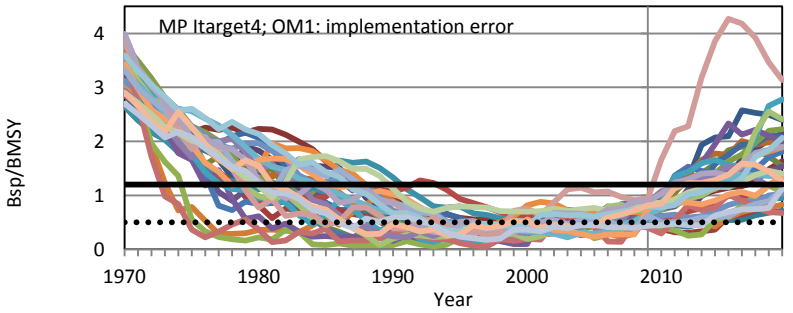
Stochastic projections: with implementation error

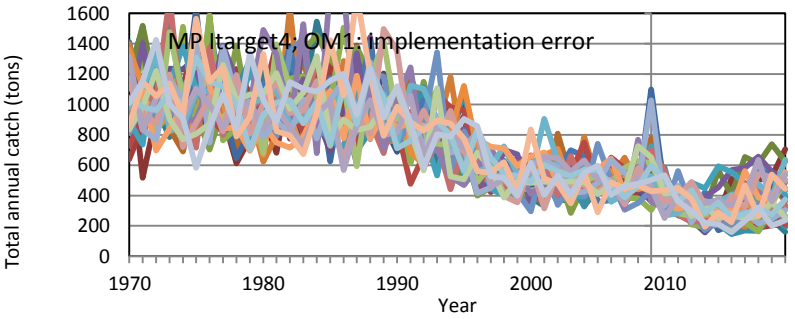












$B^{sp}/B^{sp}(MSY)$

Annual catch (tons)

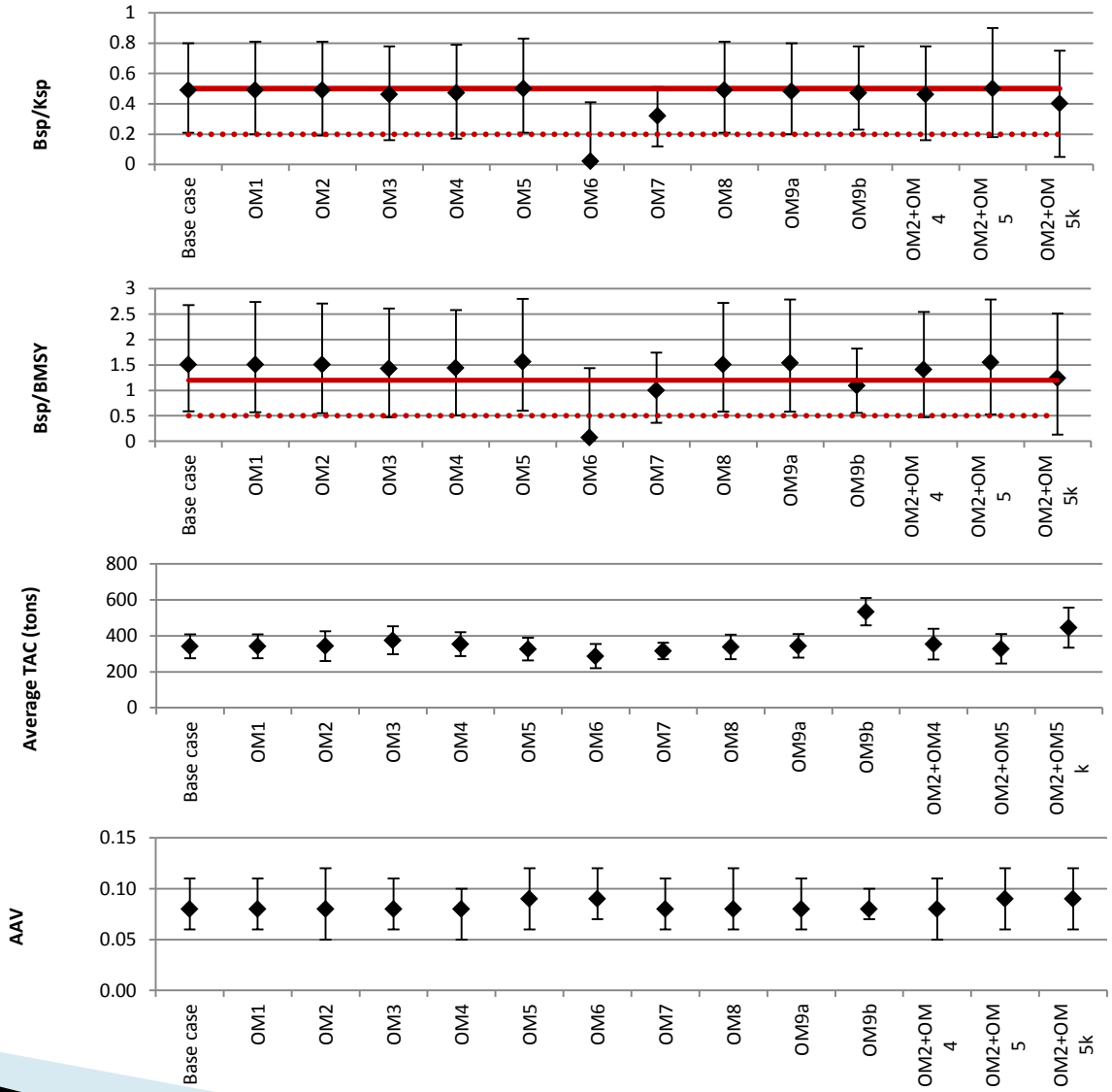
Summary statistics: robustness tests for target HCR based on mean length data (Ltarget4)

Final B/K

Final B/Bmsy

Annual average catch (tons)

Average change in catch



Initial conclusions

- Index-based MPs better than very data-poor MPs based on mean length of catch
- Length-based MPs perform surprisingly well
- Need feed-back control!
- Require some reliable index of abundance: mean length or CPUE/survey
- HCR not robust outside depletion/production range

Future work

- Simulation test more HCRs for different data types
- Generic OMs for each “basket” with different production and depletion levels
- Conduct additional robustness tests (uncertainty about growth parameters)
- Implementation: selection of HCRs for application to “real” stocks/fisheries

Thank you

Research results reported here form part of my doctoral study. I thank Dr Butterworth for his supervision and the National Research Foundation (NRF) of South Africa for the financial assistance towards this research.