Simple Data Driven Feedback Decision Rules:

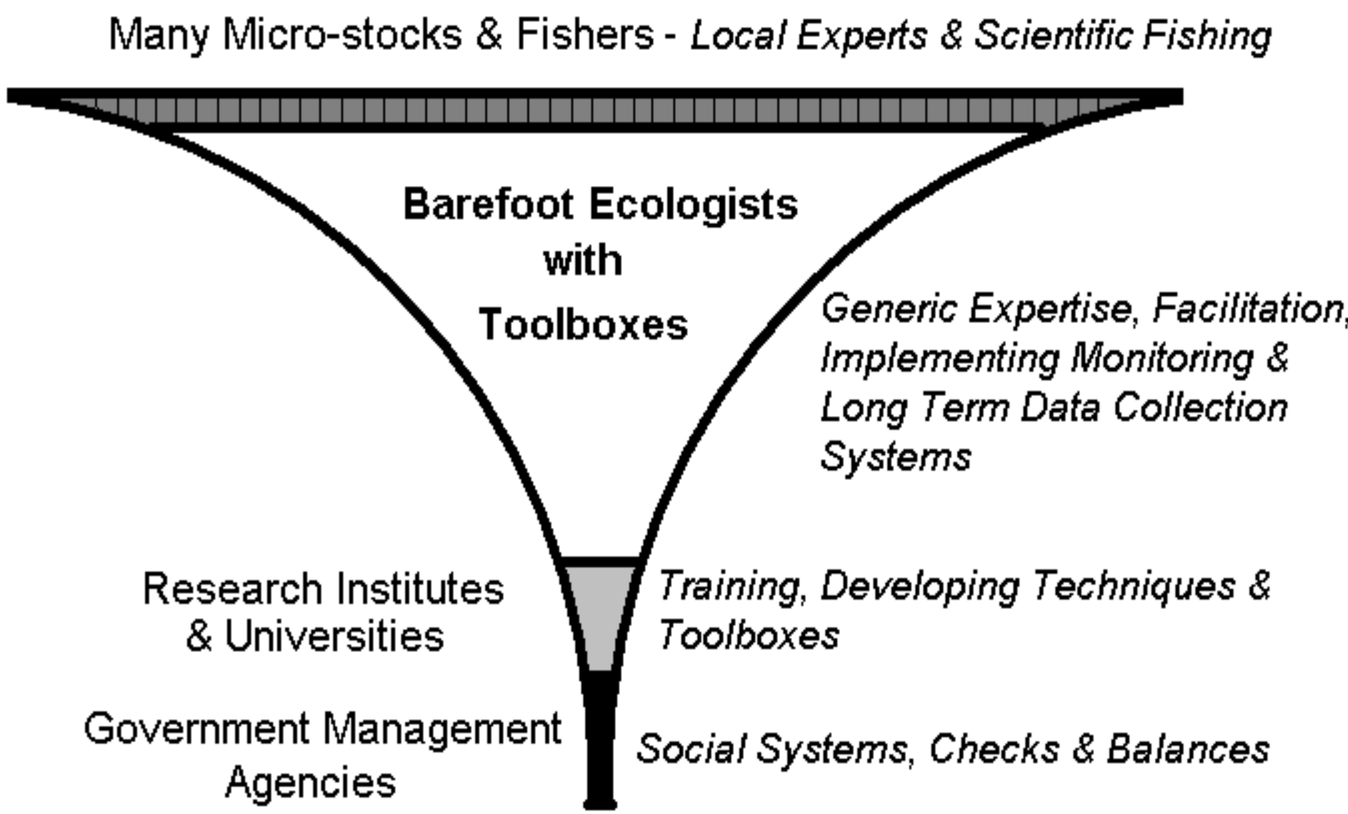
From $1million to $5000 Harvest Strategies

Jeremy Prince

Exploring Tools for Improving Management of Data Poor Stocks Workshop

23-24 February 2011

The Solution ?



Prince, J.D. (2003). The barefoot ecologist goes fishing. *Fish and Fisheries* 4: 359-37

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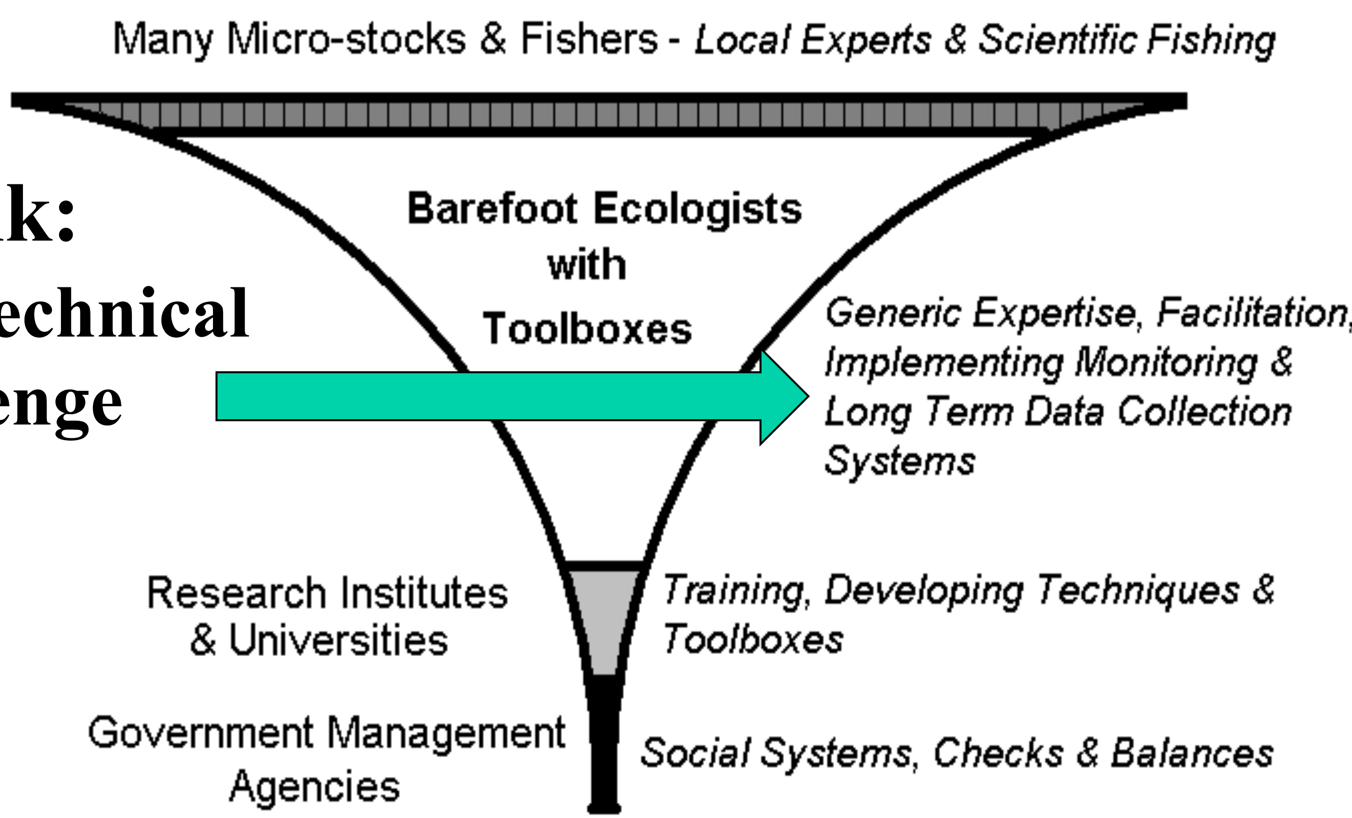


This Talk:

The Technical Challenge

Prince, J.D. (2003). The barefoot ecologist goes fishing. *Fish and Fisheries* 4: 359-37

Outline

Retooling the Mindset

- **Fisheries as Carpets**

From $1 million to $100,000 Harvest Strategies

- **Spawning Potential Ratio (SPR)**
- **Abundance weighted SPR**
- **Empirical SPR Decision Tree**

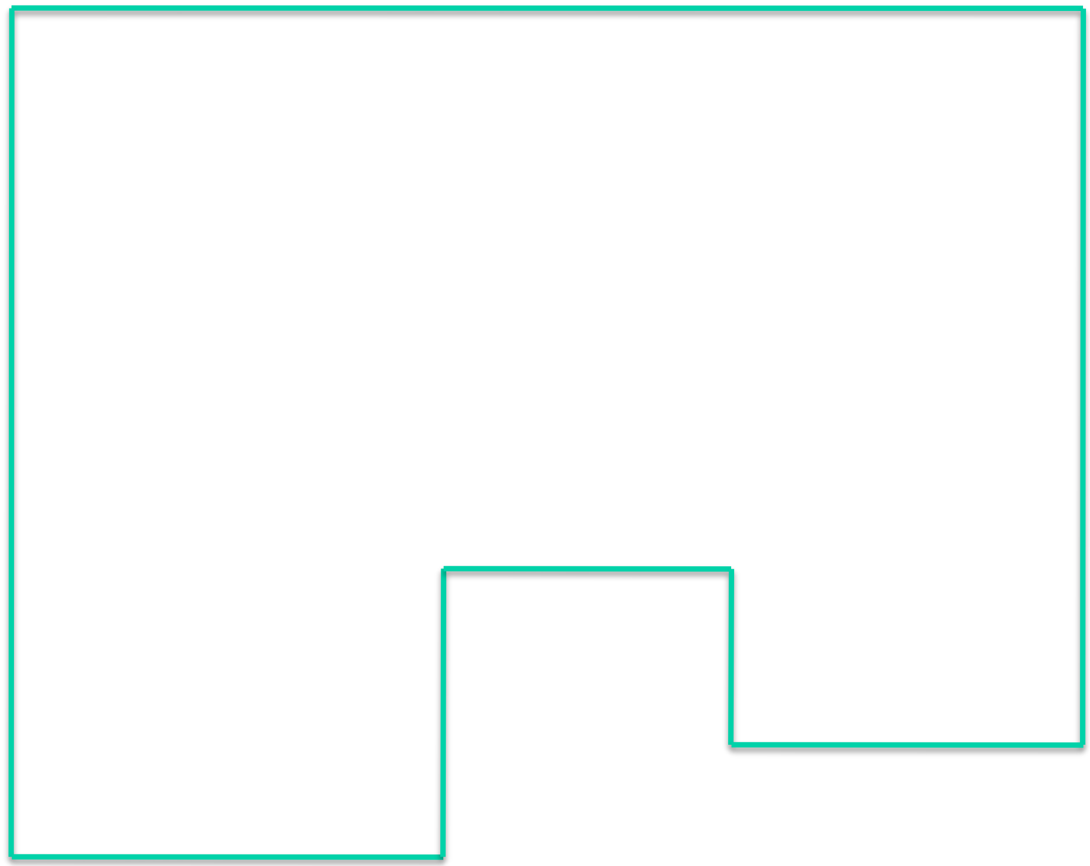
From $100,000 to $5,000 Harvest Strategies

- **Empirically estimating size based SPR reference points**

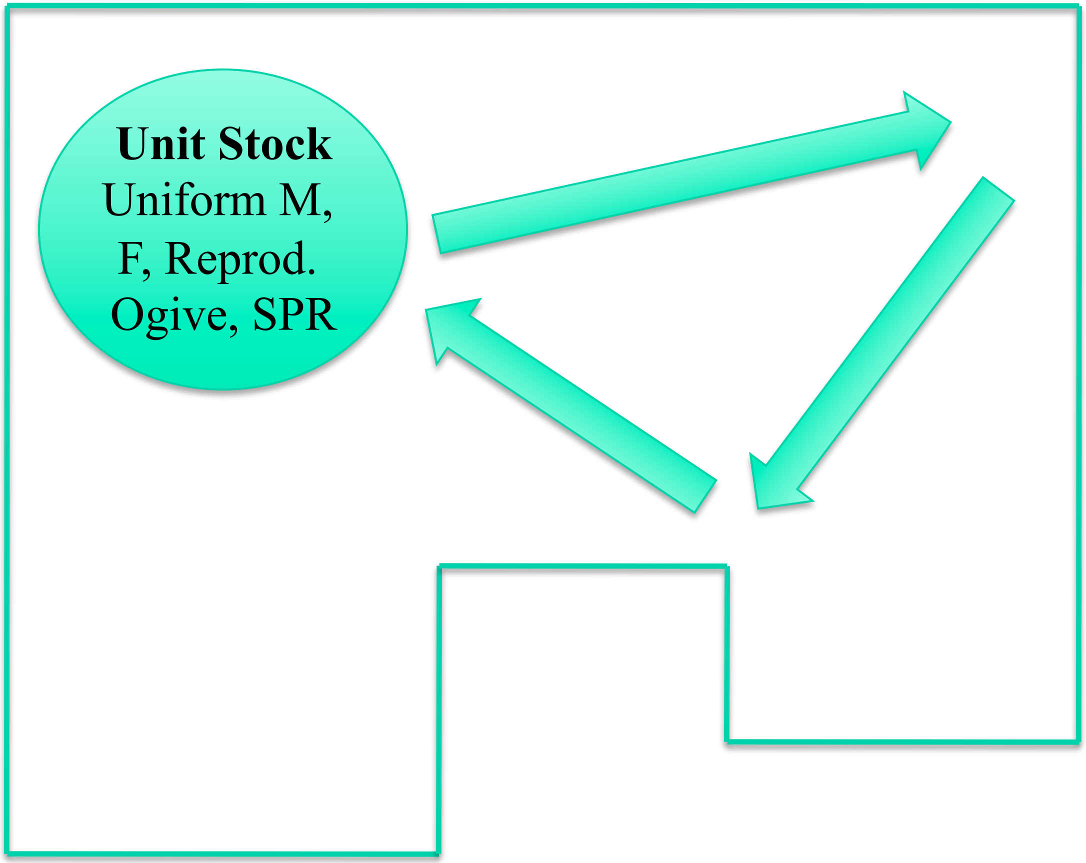
Retooling the Mindset:

Fisheries as Carpets

Area of the Fishery



Unit Stock Model



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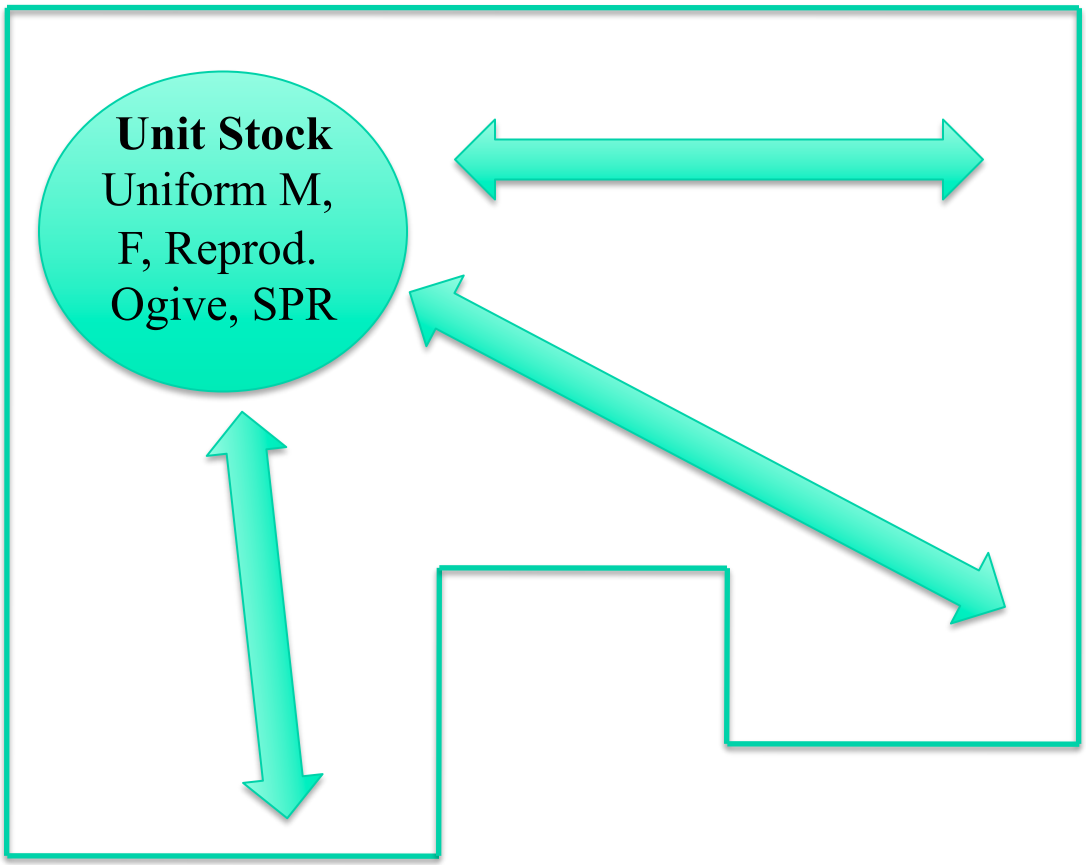
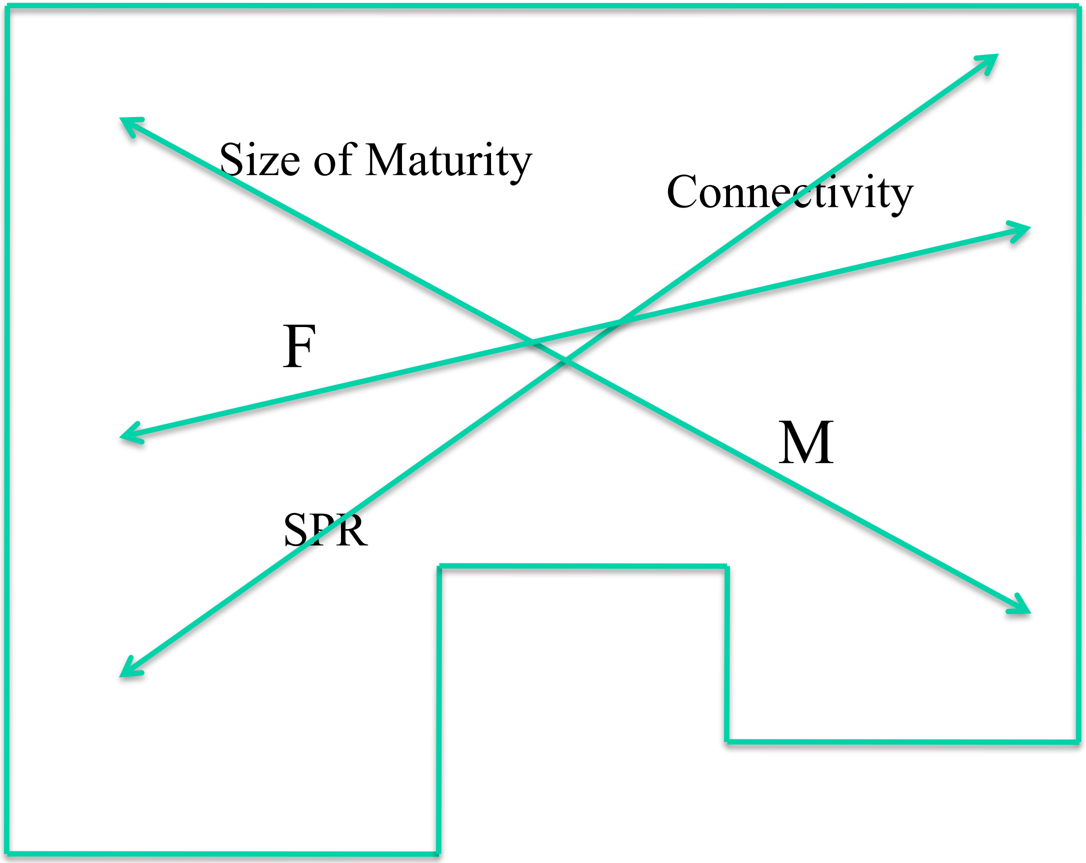


The Resource as a Carpet

Locally Recruiting variable populations within meta-populations



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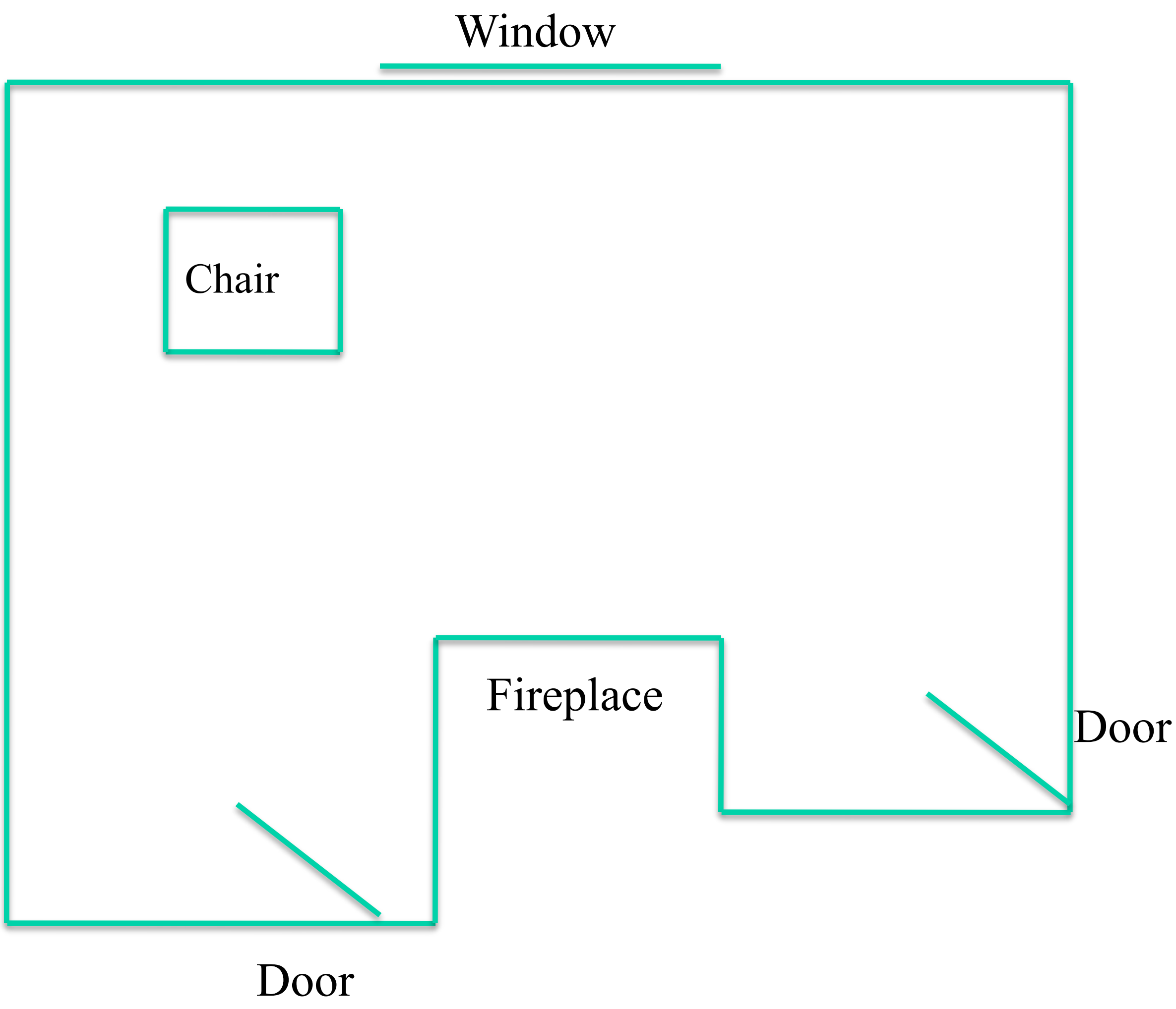

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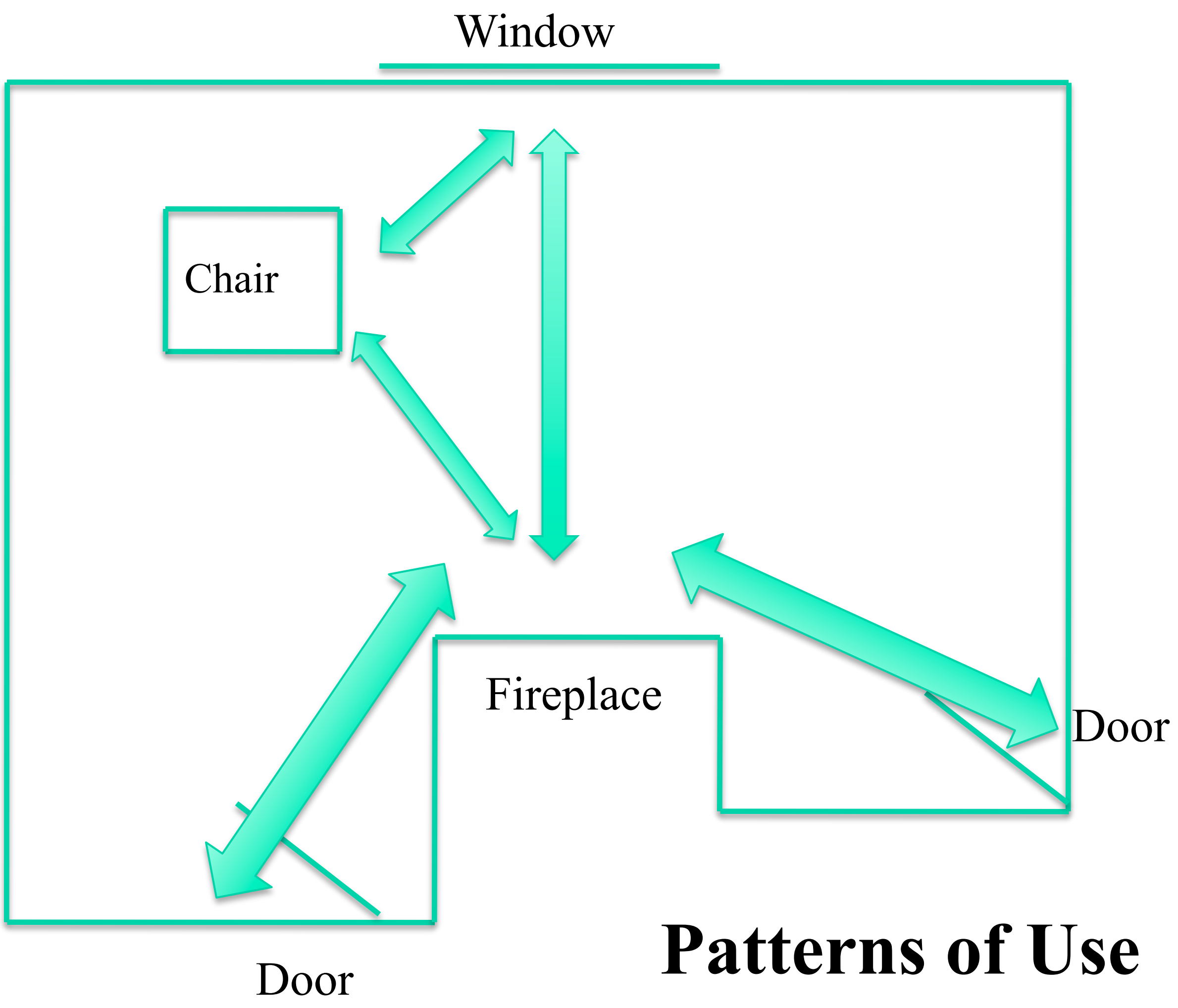
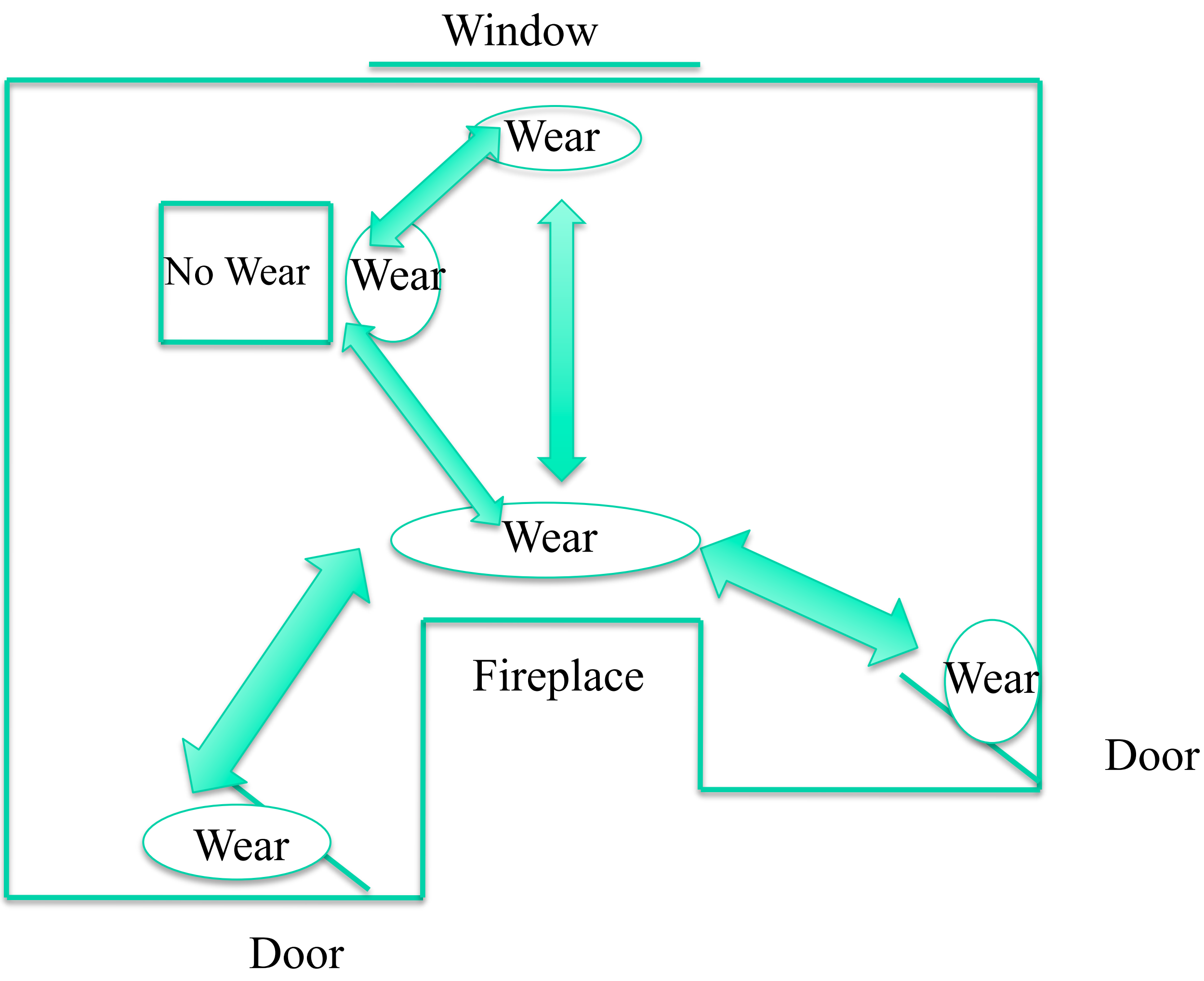


Patterns of Use

The Resource as a Carpet



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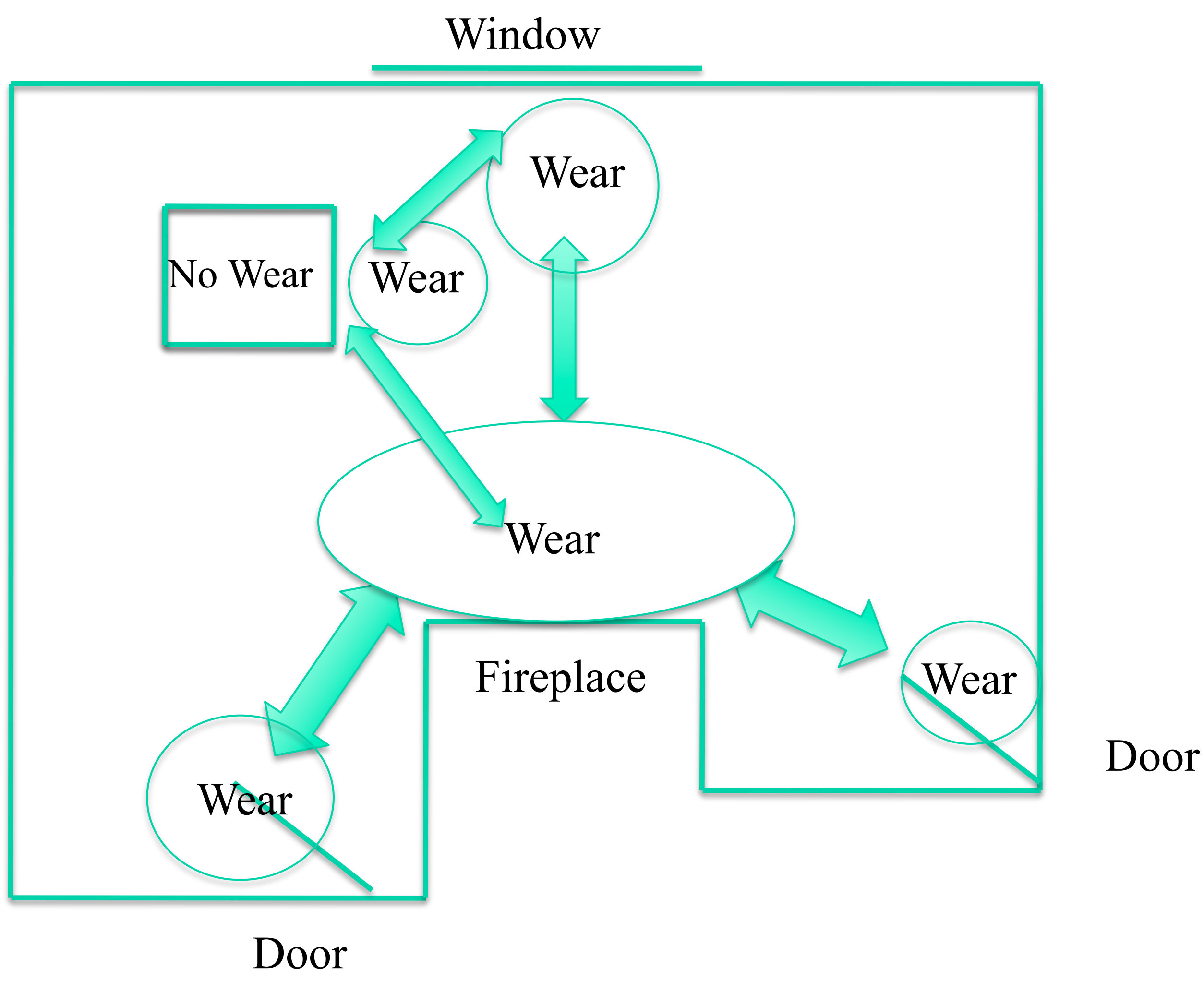

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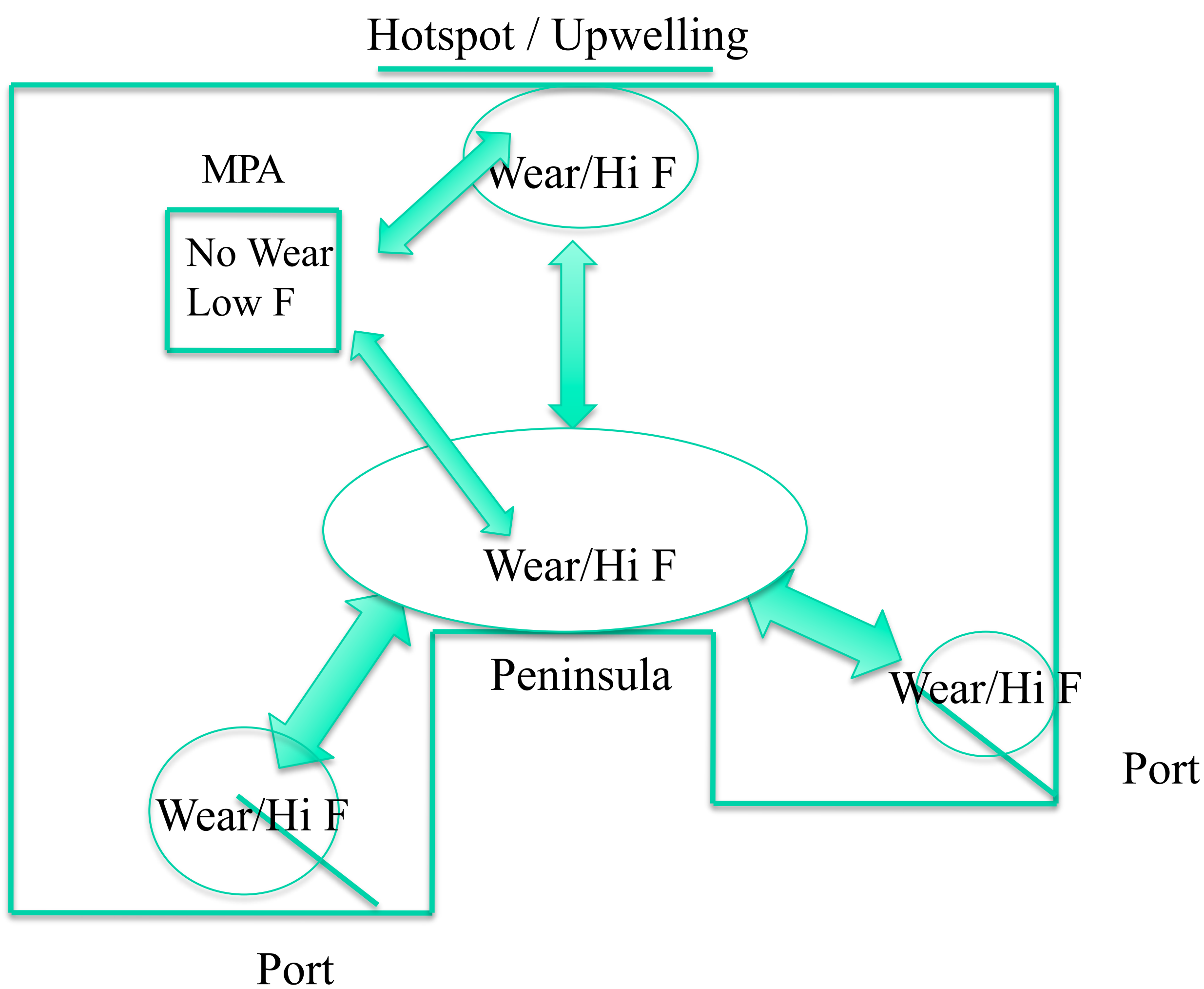
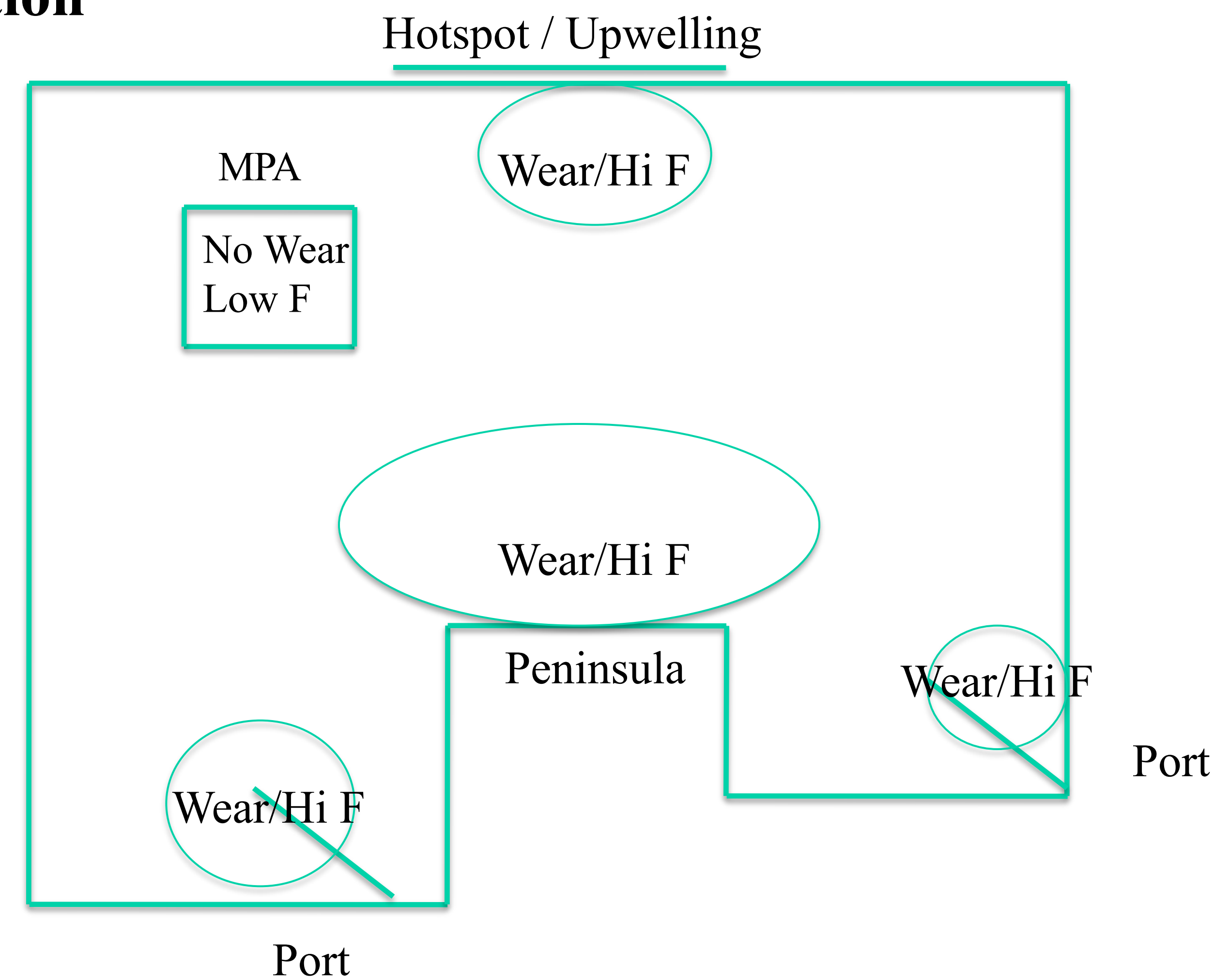


The Resource as a Carpet

Serial Depletion

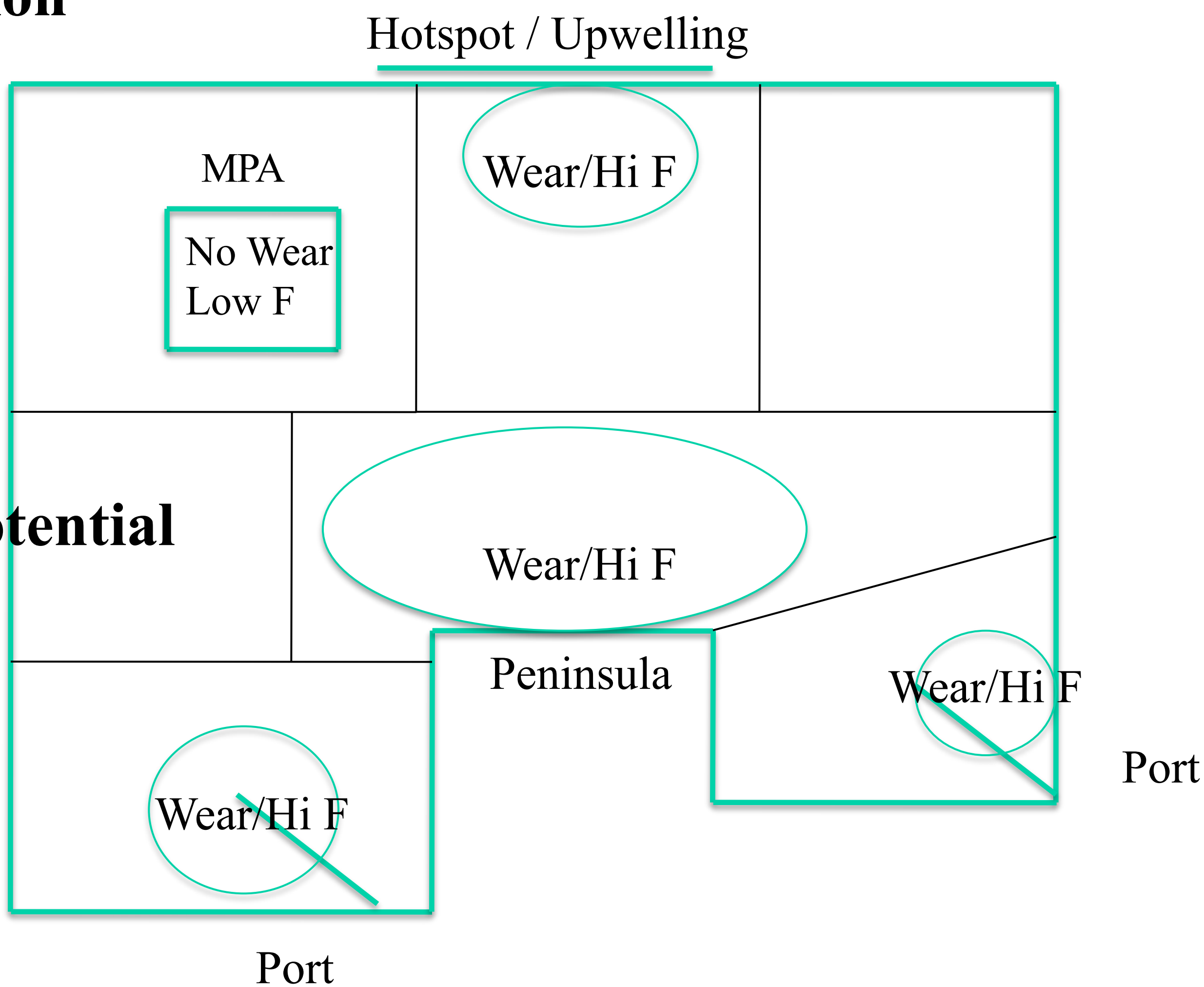


The Resource as a Carpet

Serial Depletion

Local F

Local Sp. Potential



Basic Premises:

- **Lack of sophisticated analysis is not the problem, rather it is the generally the lack of meaningful data with sufficient spatial resolution.**

- **Much of our failure in management and assessment is due to our need and inability to account for complex stock structure (i.e. the 'unit stock' assumption)**

- **Stock structure is too complex & expensive to study universally across all marine resources and so (outside our need for pure research on the topic) not a cost-effective approach to improving assessment and management.**

Technical Solution:

1. Manage all component parts of populations to preserve 'conservative' levels of spawning (SPR) to negate sink / source issues.

2. As a default treat all meta-populations as potential sources.

3. Use simple local harvest strategy to match size and cpue with SPR targets using SPR decision tree to involve local fishing communities in incremental change.

4. Set up local fishing communities to collect spatially explicit size and catch rate data.

Fisheries as Carpets

- **Balancing Local Fishing Pressure**

To maintain:

- **Local Spawning Biomass (SPR) targets**

Spawning Potential Ratio (SPR)

Also known as: Eggs per Recruit, Spawning per Recruit, Proportion Lifetime Egg Production

Definition: **Proportion of unfished spawning allowed by harvest policy (Walters & Martell 2004)**

Fishing Intensity (F) based harvest strategy rather than Biomass (B) based harvest strategy.

Mace and Sissenwine (1993) – Review and meta-analysis of generic SPR reference points for teleosts.

Recognized in International & US Fisheries Law (Restrepo 1998)

Abundance weighted SPR (Mace et. al. 1996)


From $1 million ….
…. to $100,000 Harvest Strategies
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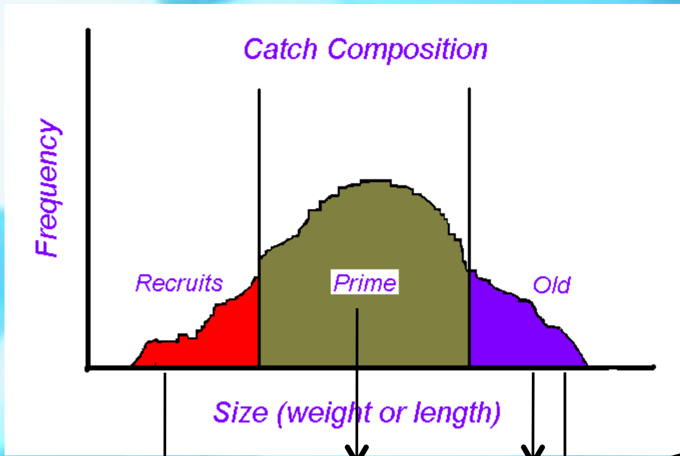
Scale-less Assessment

Conditioned to SPR targets

Applies Cohort Analysis Logic

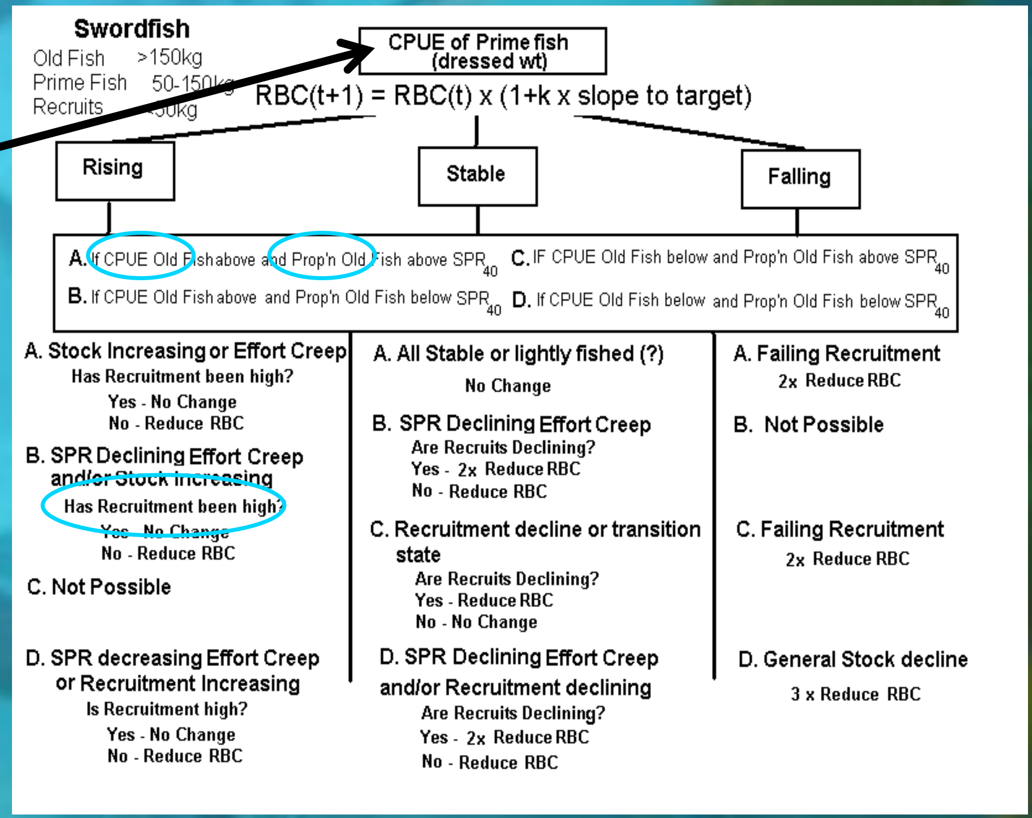


CPUEprime

CPUEold

PropOld

CPUErecruits



Step 1 – Level 1

Evaluates CPUE*prime*

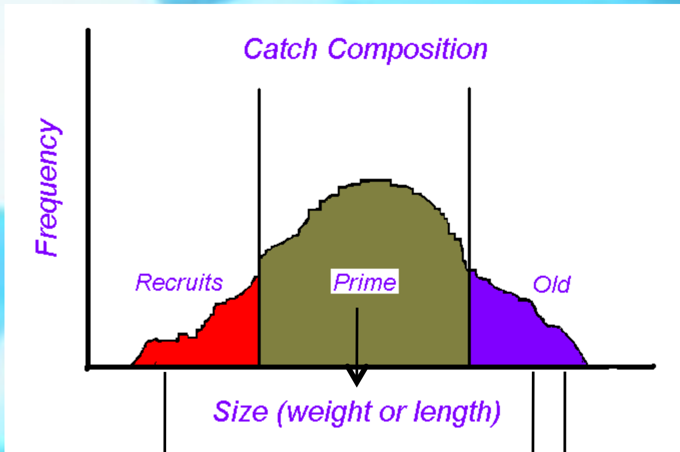
Relative to SPR CPUE target

And Slope to CPUE Target

Provides Initial estimate of Incremental Change

Prince et al. 2011. A simple cost-effective and scale-less empirical approach to harvest Strategies. ICES Journal of Marine Science In Press. May 2011.

Iterative Assessment



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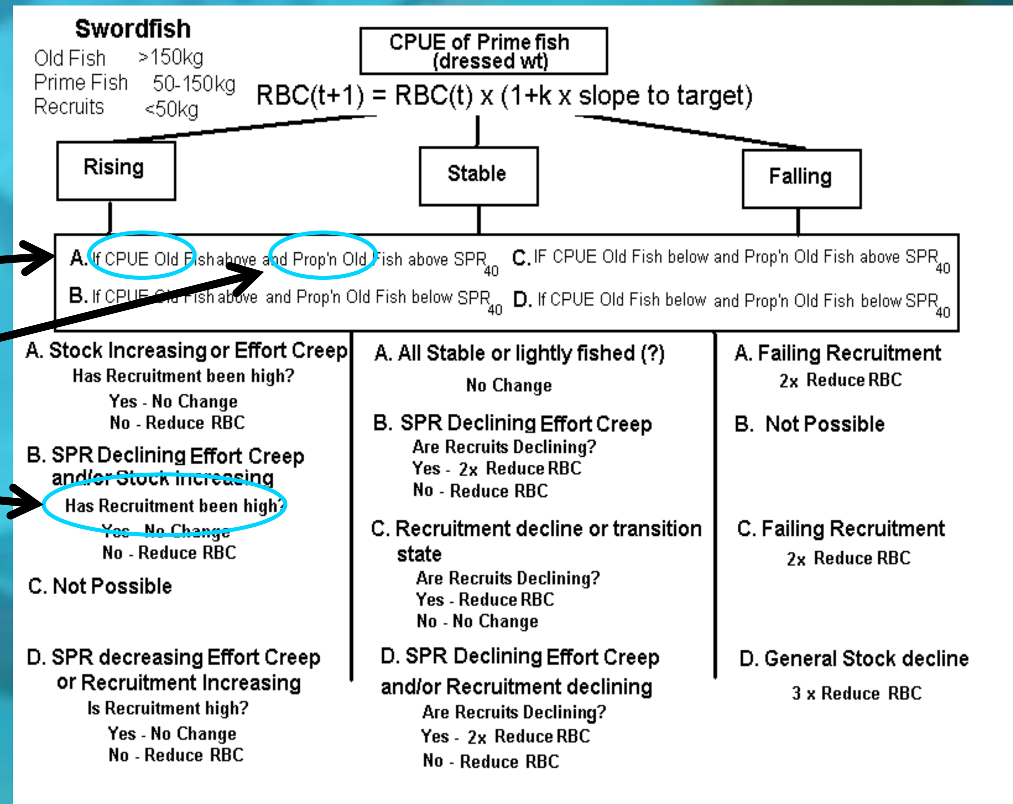

Step 2 – Lower Levels

Evaluate Size Structure

Relative to SPR size target

Modify Initial estimate of

Incremental Change – Iterative Process stabilises size & cpue at SPR targets

Courtesy N. Dowling

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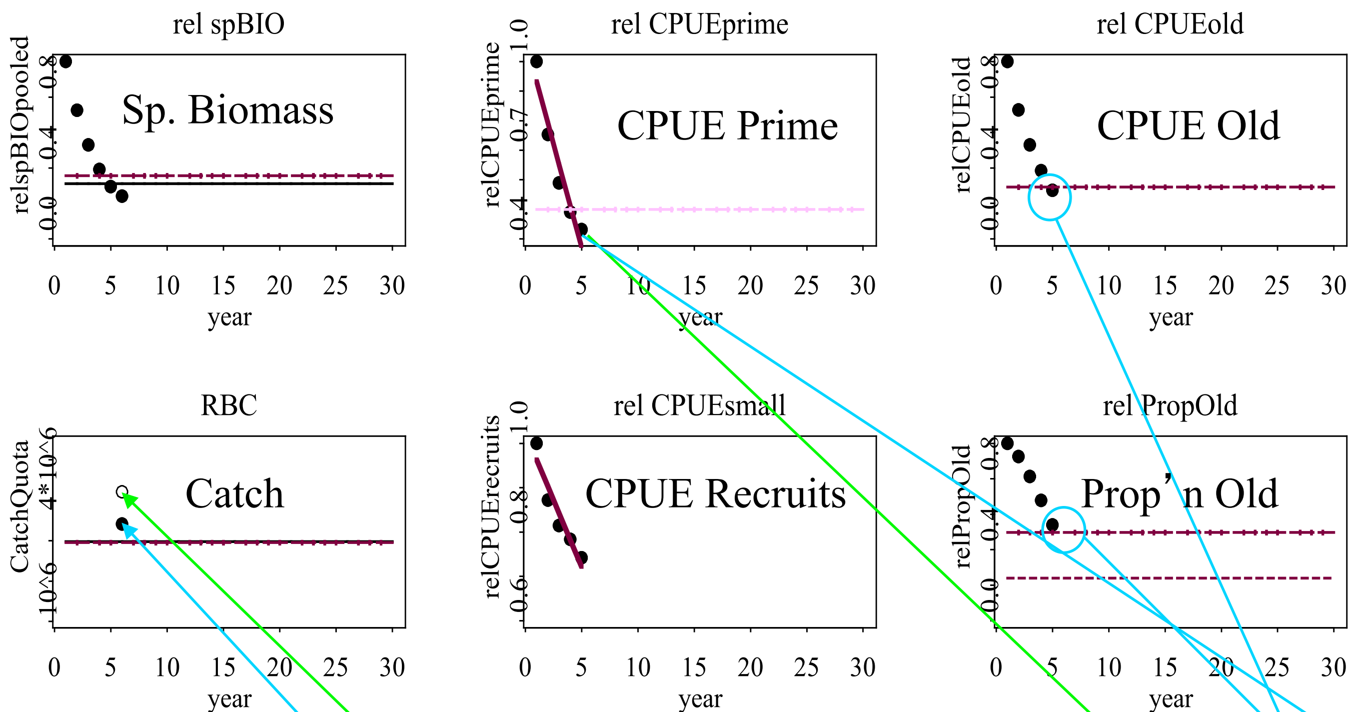
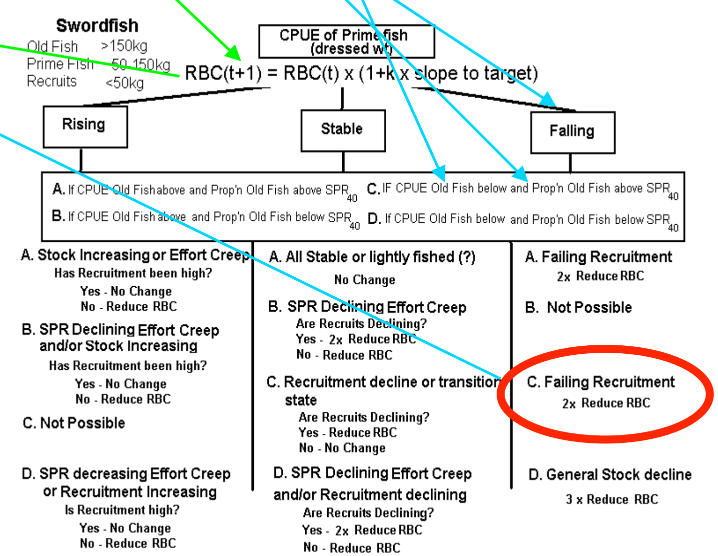


Initial RBC (simple dec. rule)

Modified RBC (decision tree)



level at MSY

level at SPR_{40} (decision tree target)

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50% $CPUEprime_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years

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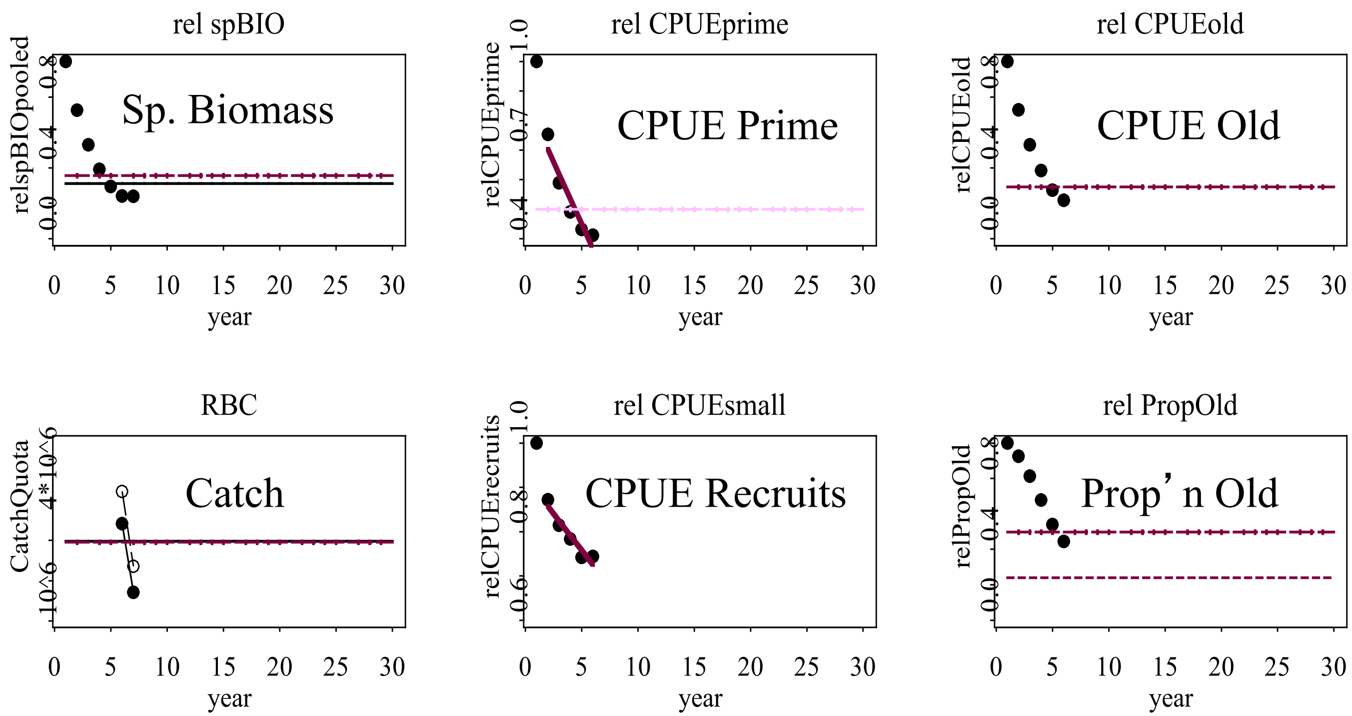

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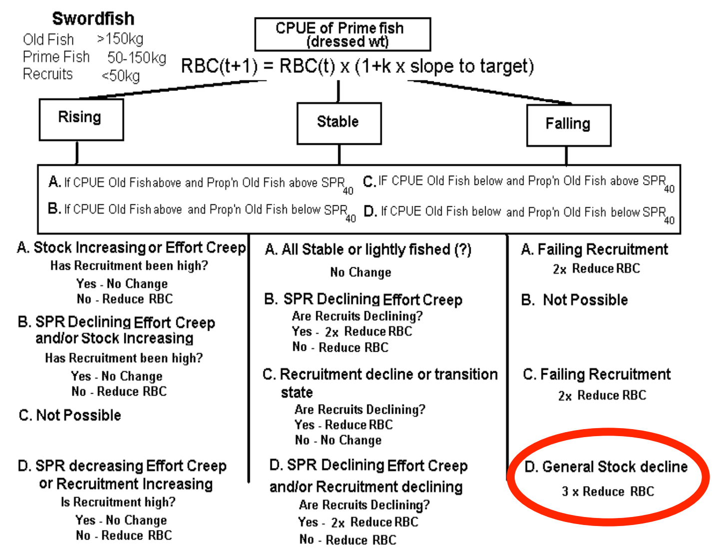

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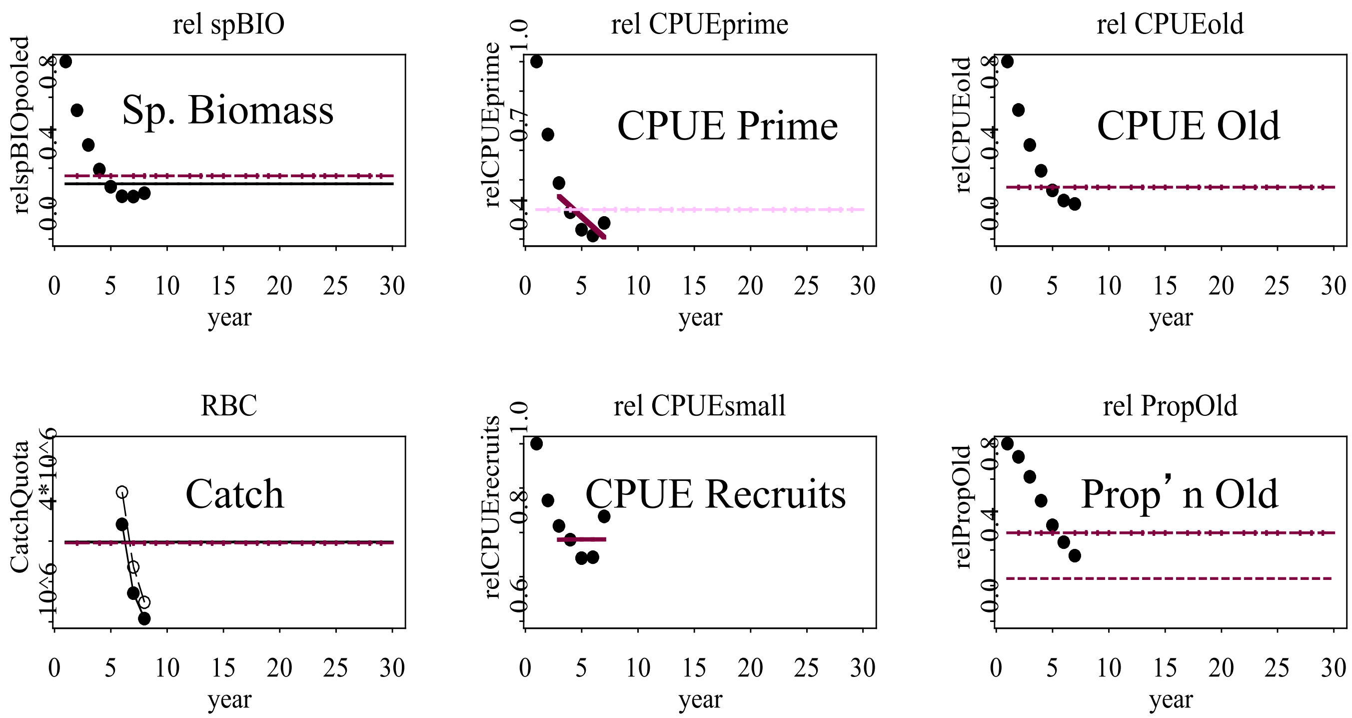

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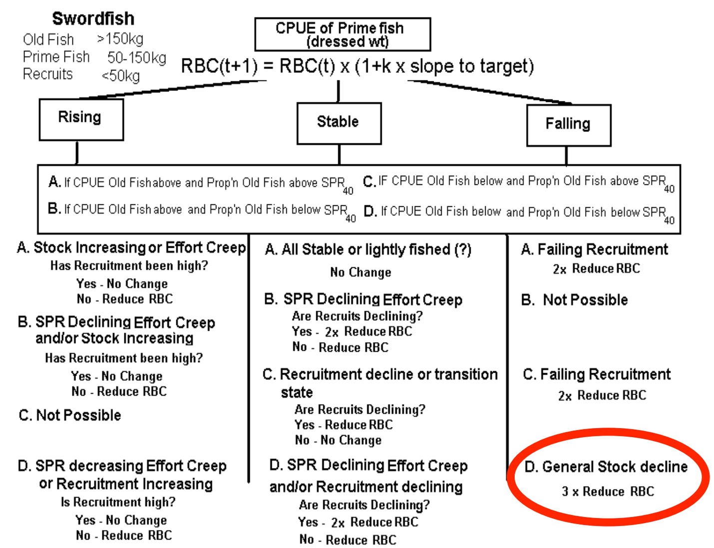

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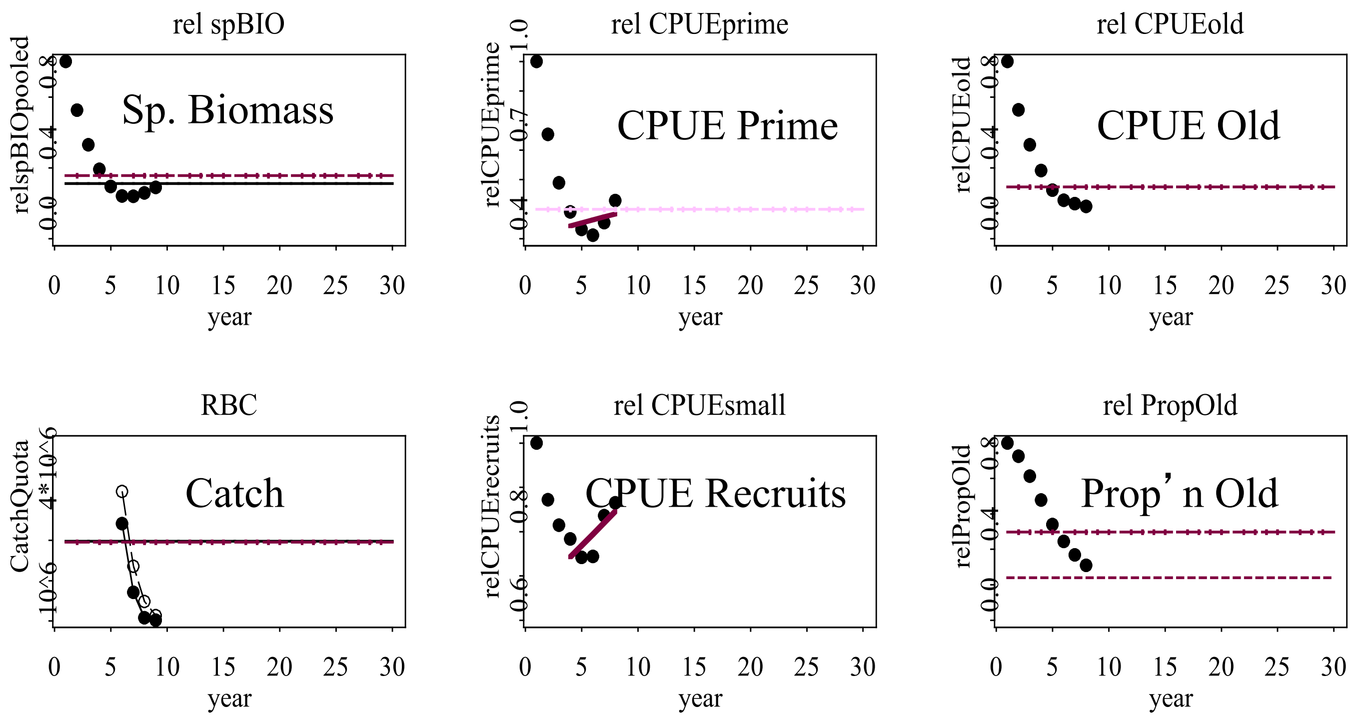

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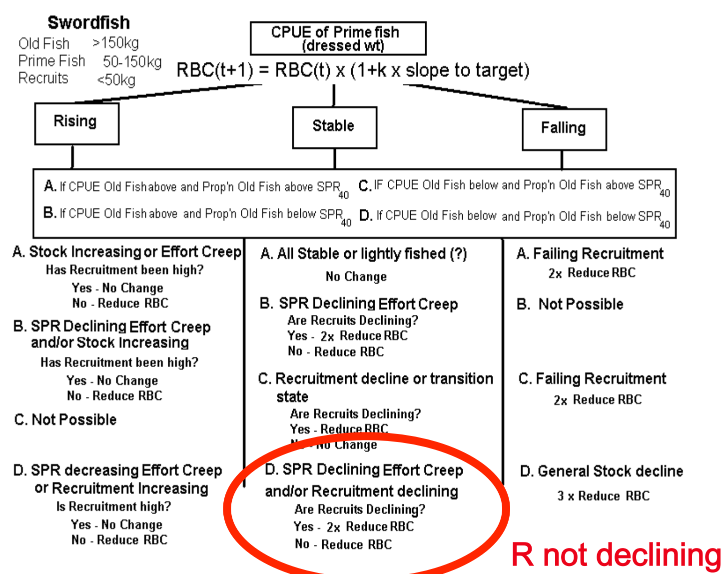

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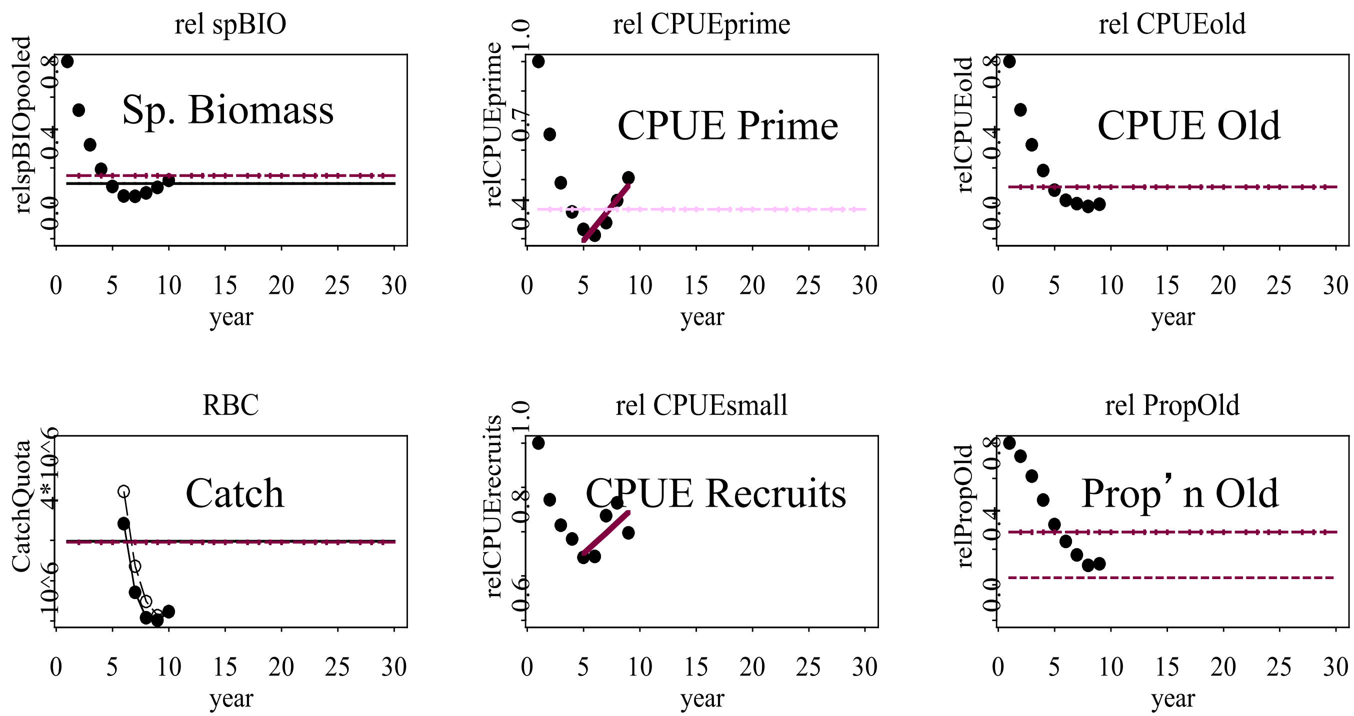

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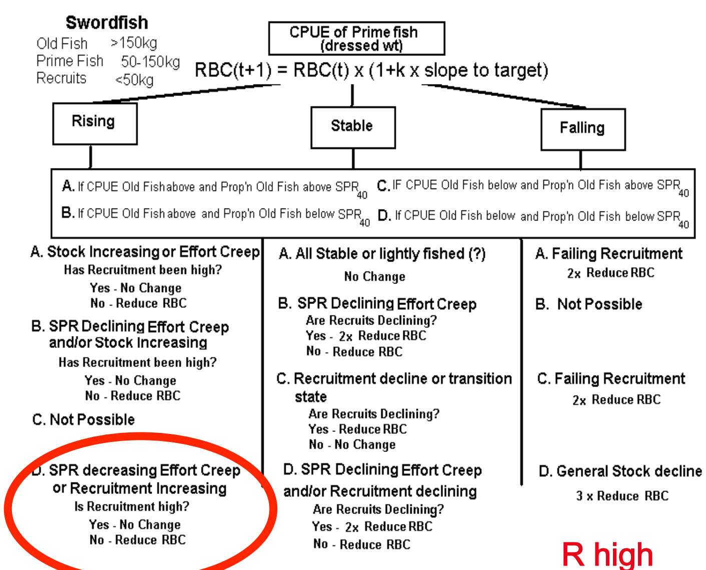

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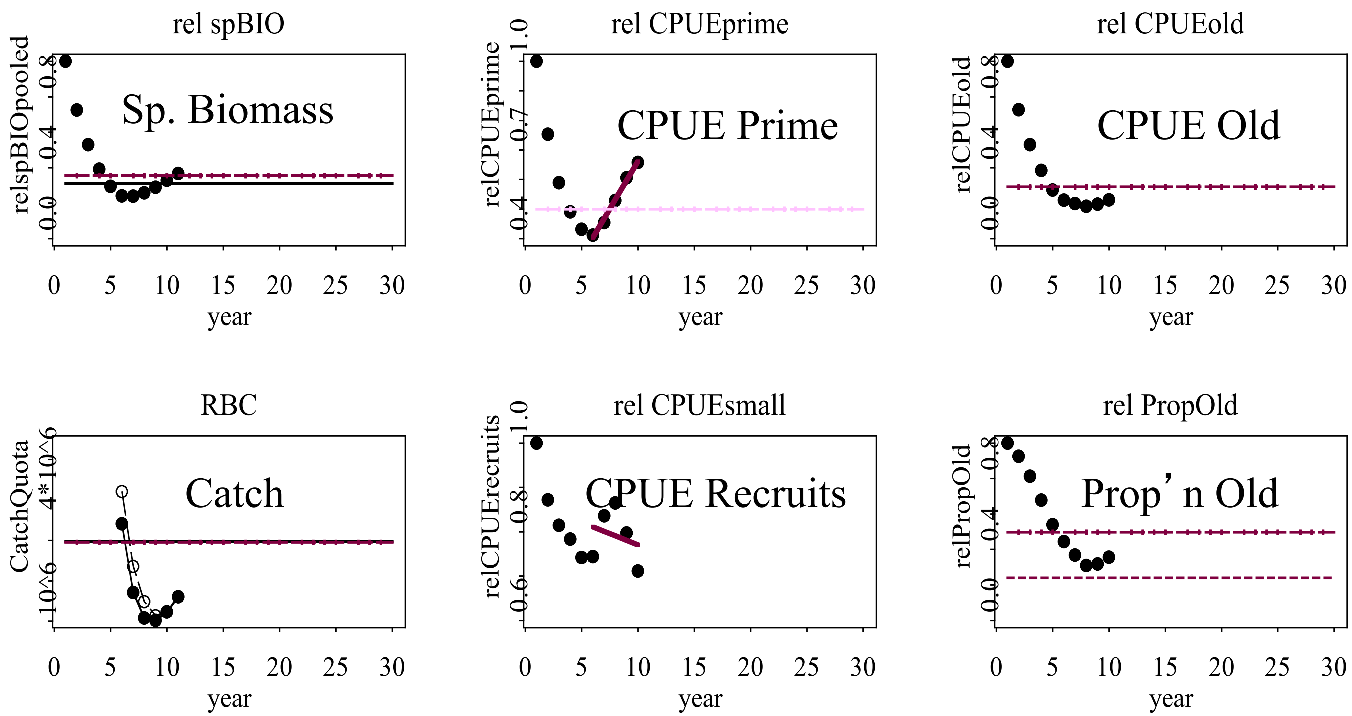

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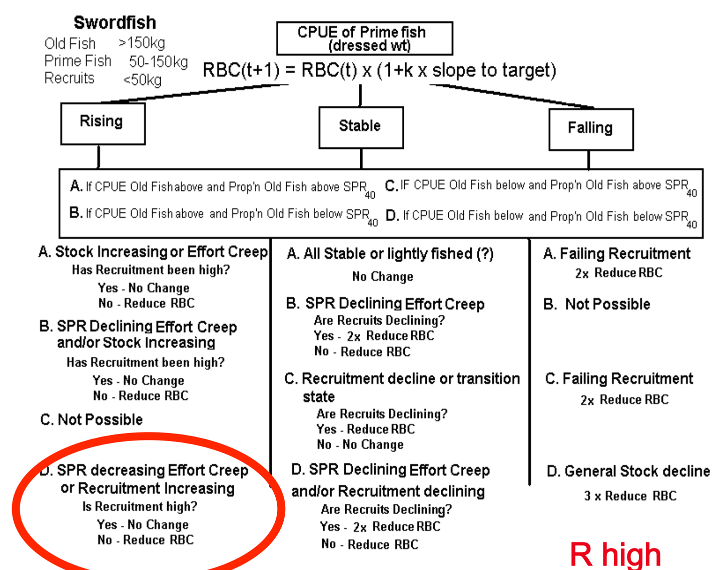

R high

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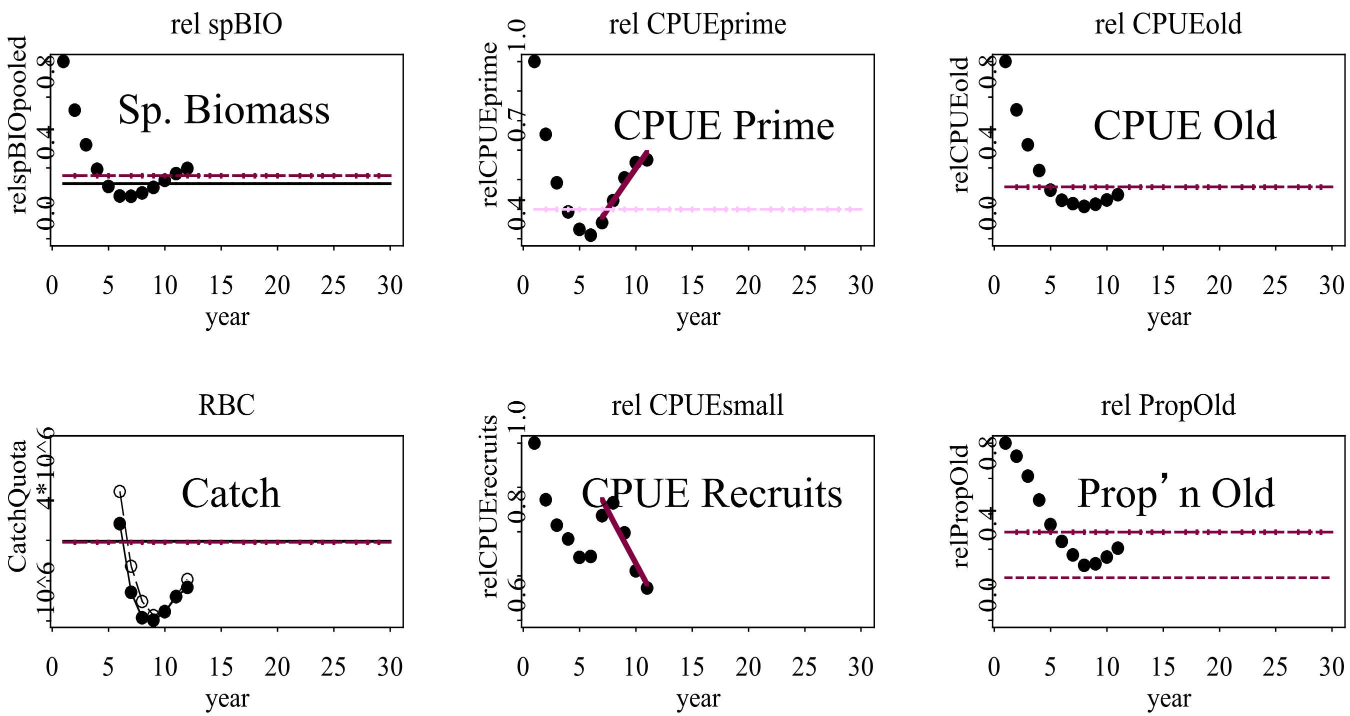

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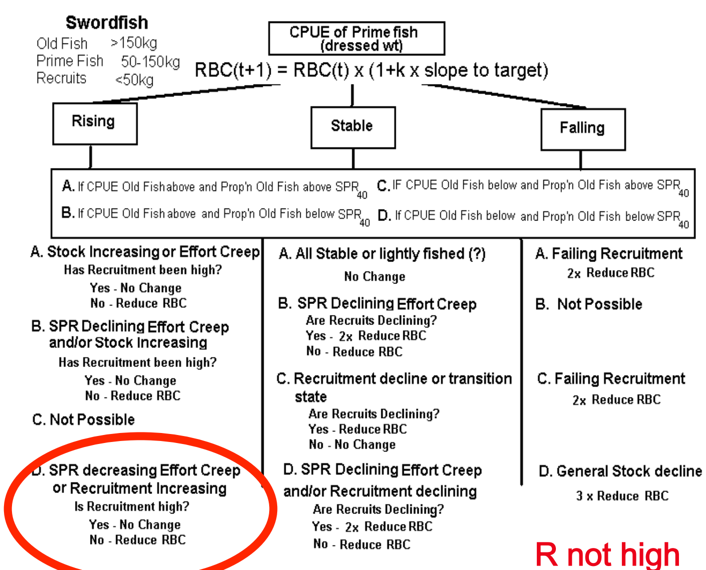

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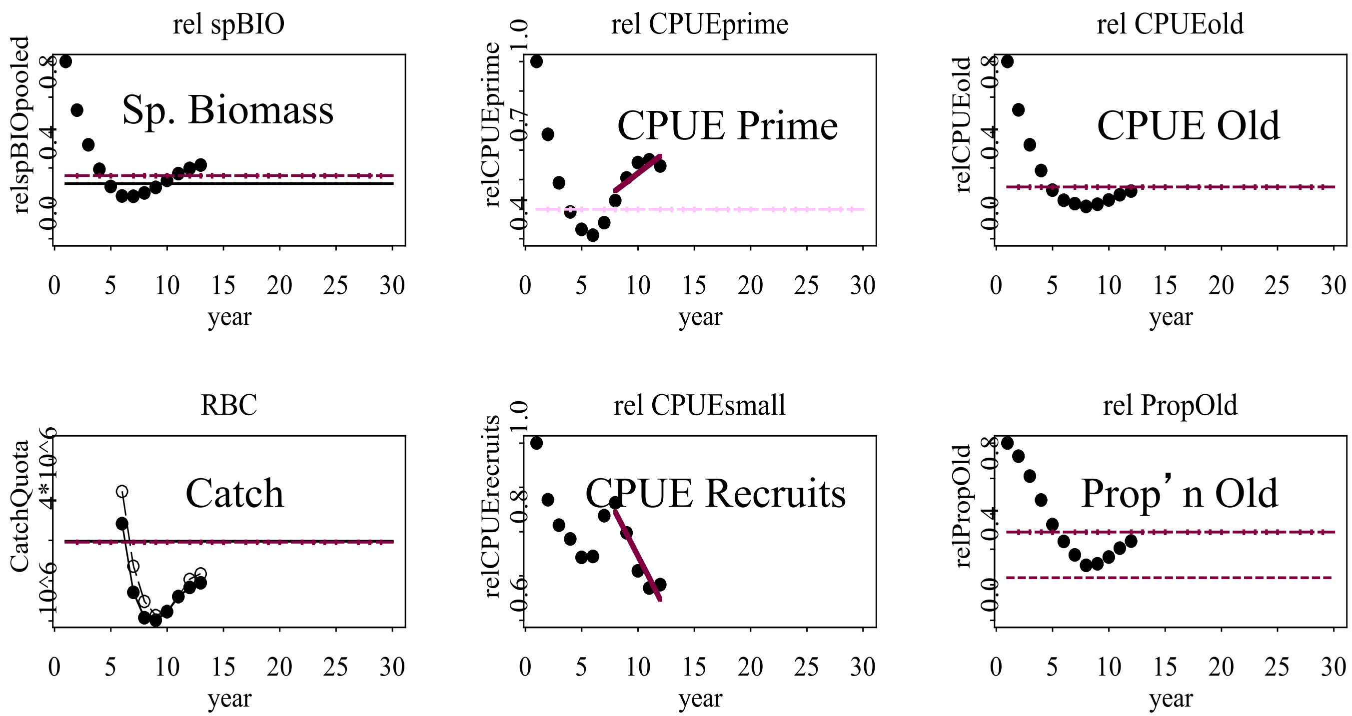

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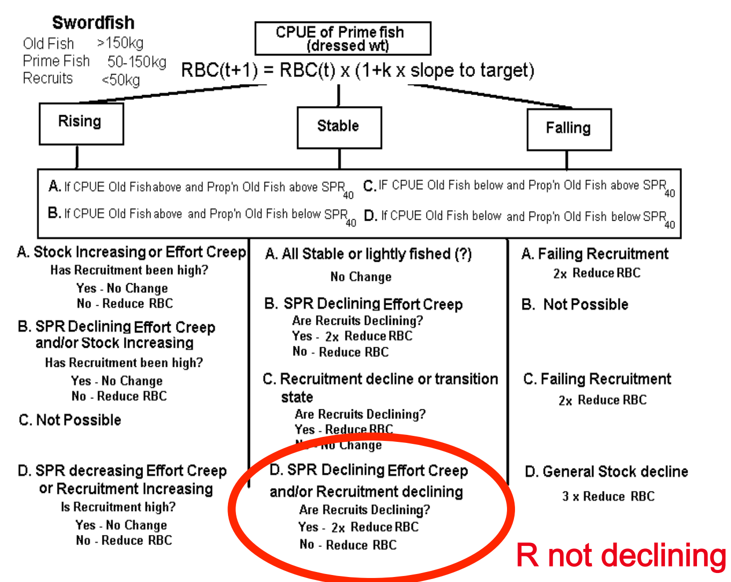

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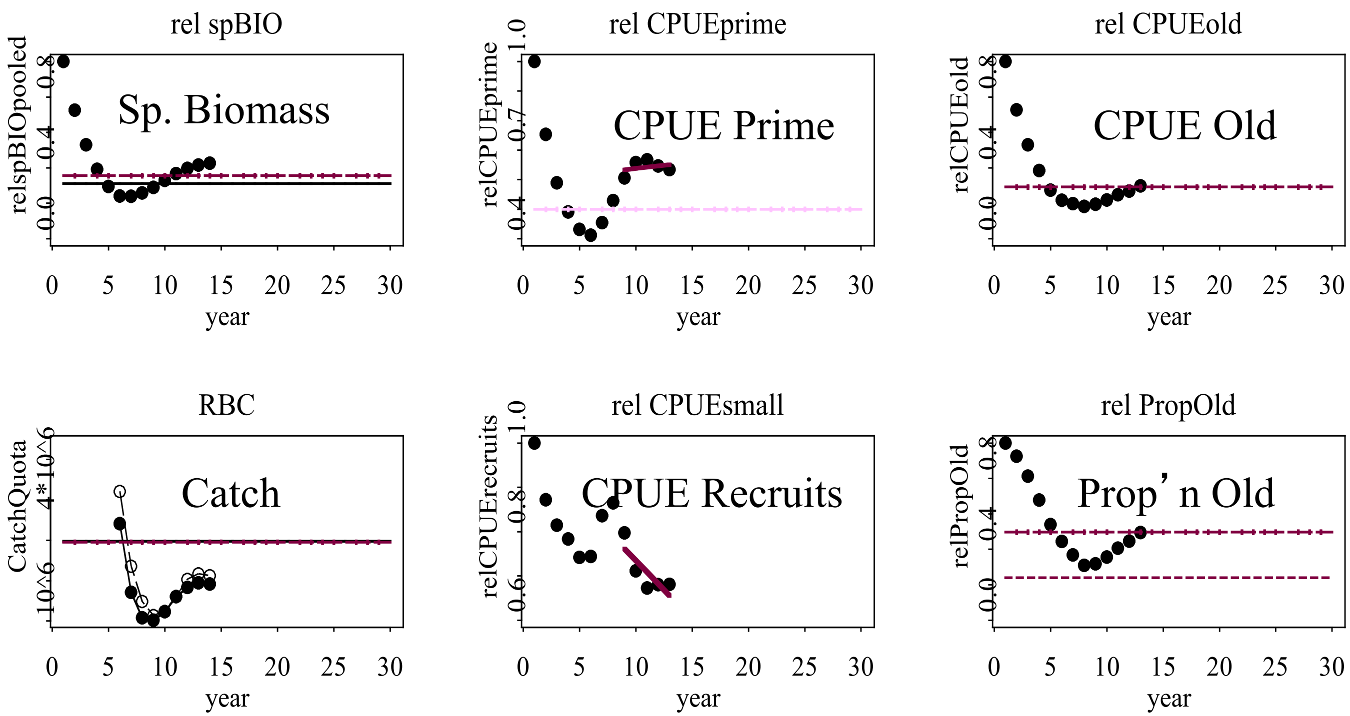

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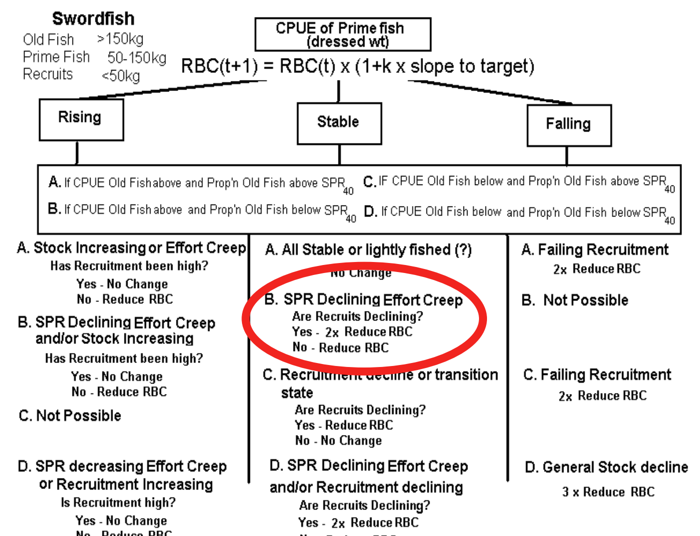

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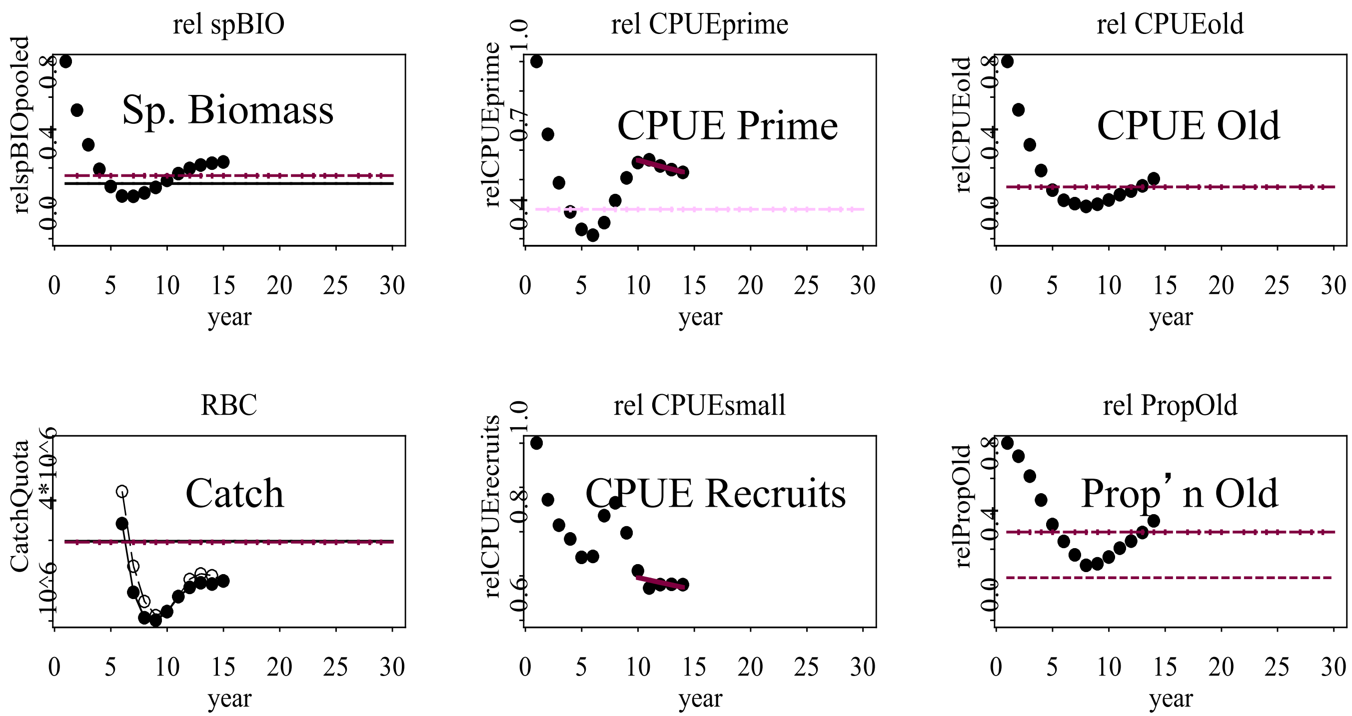

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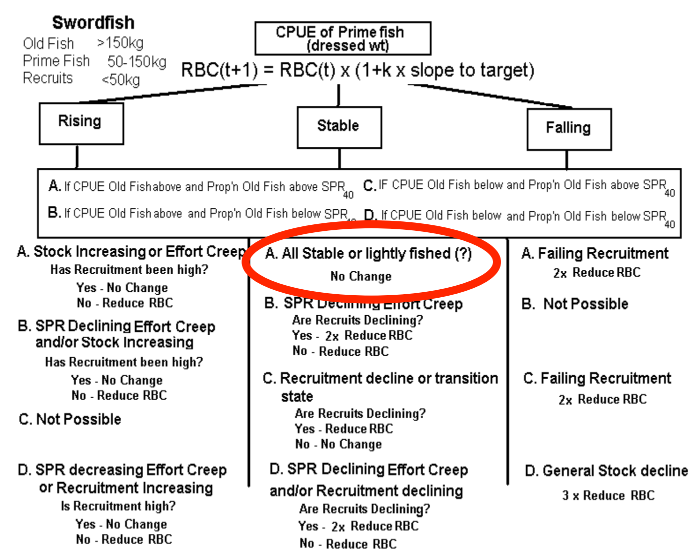

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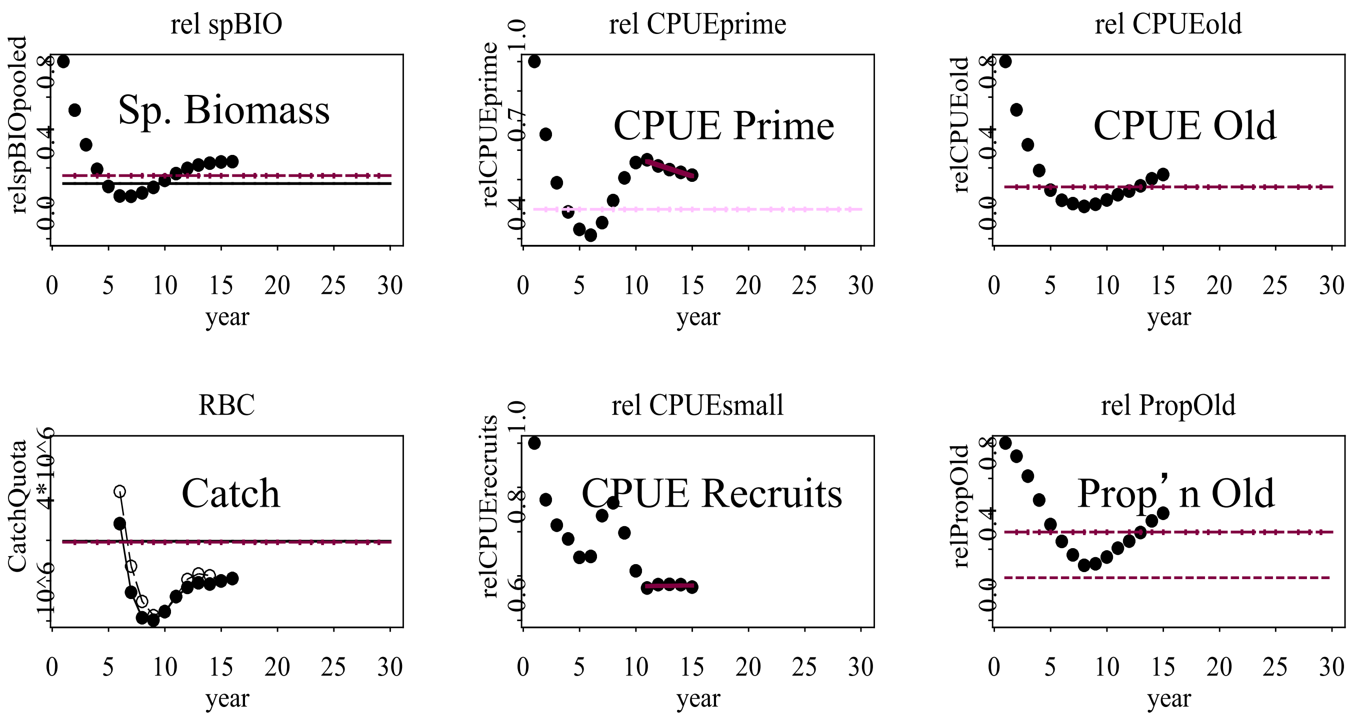

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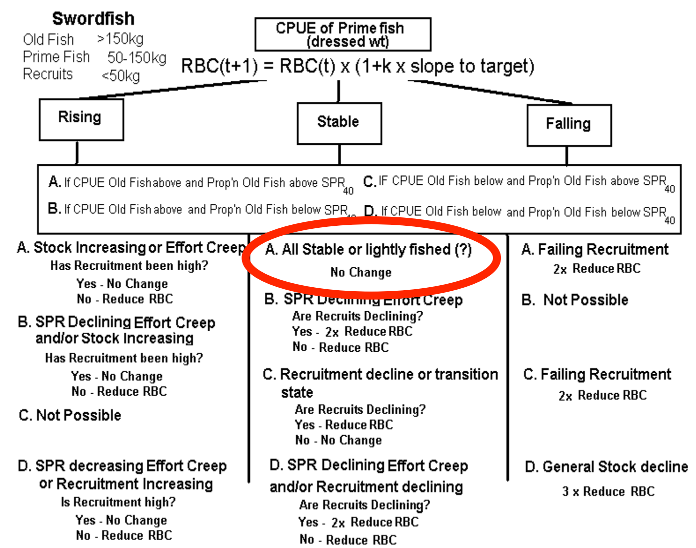

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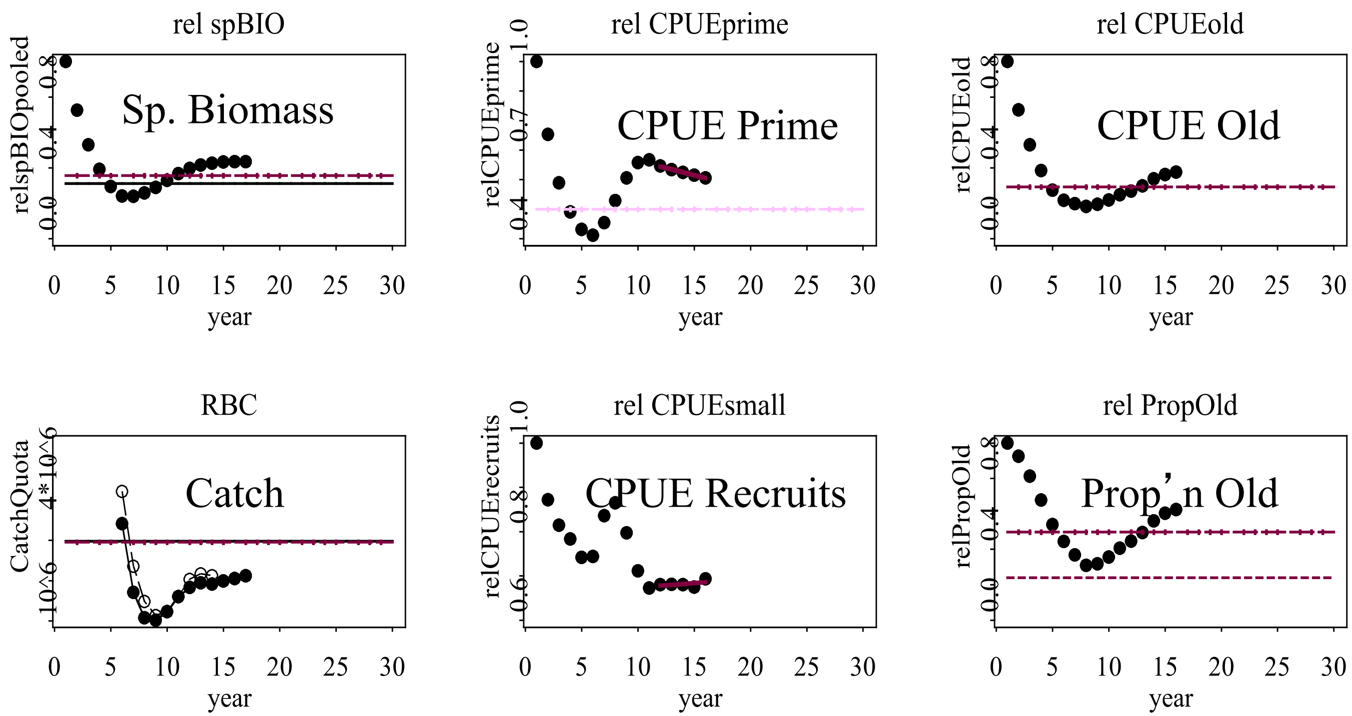

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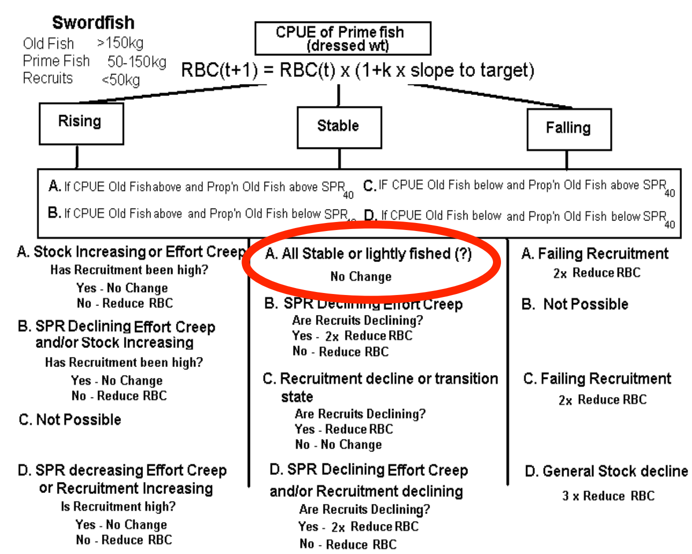

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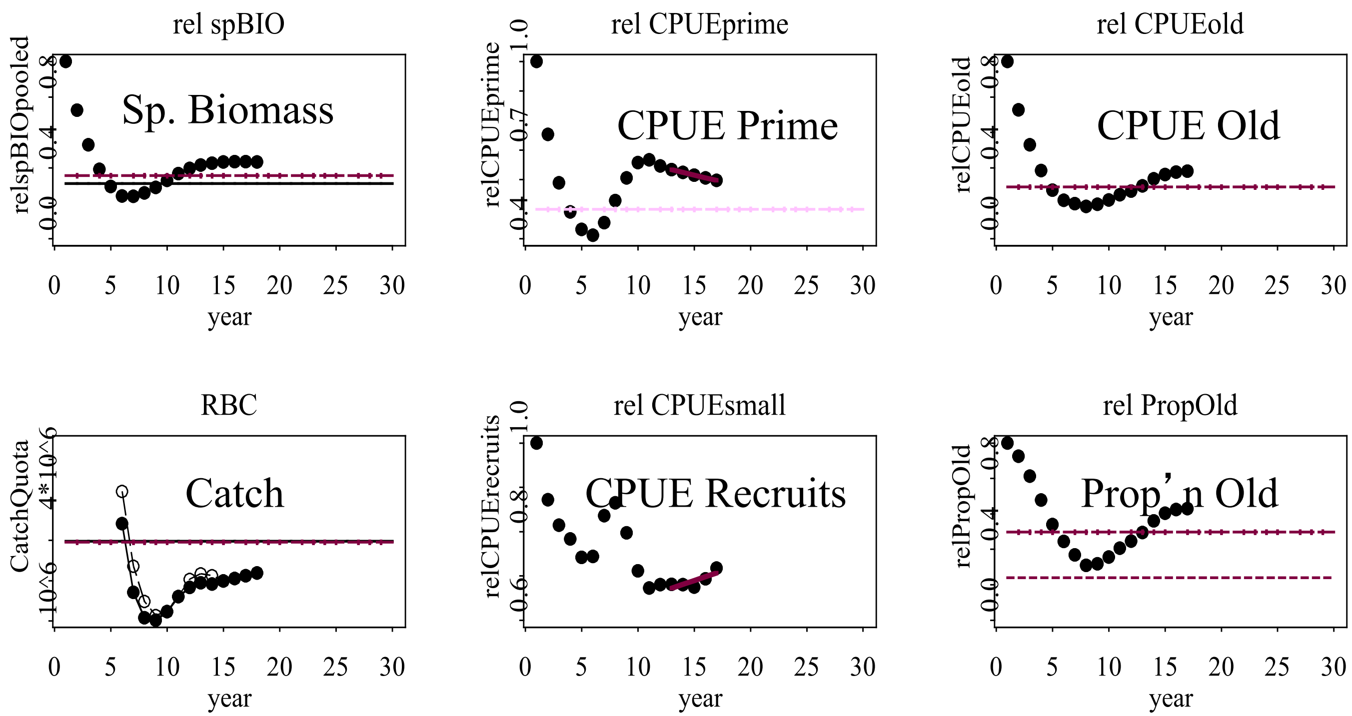

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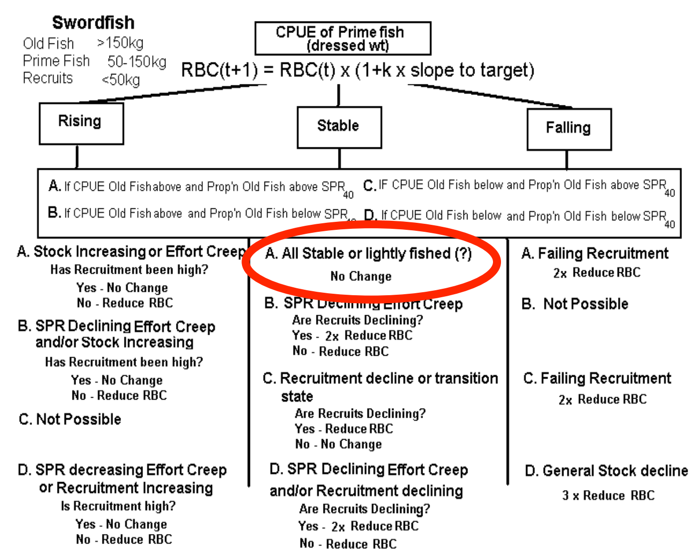

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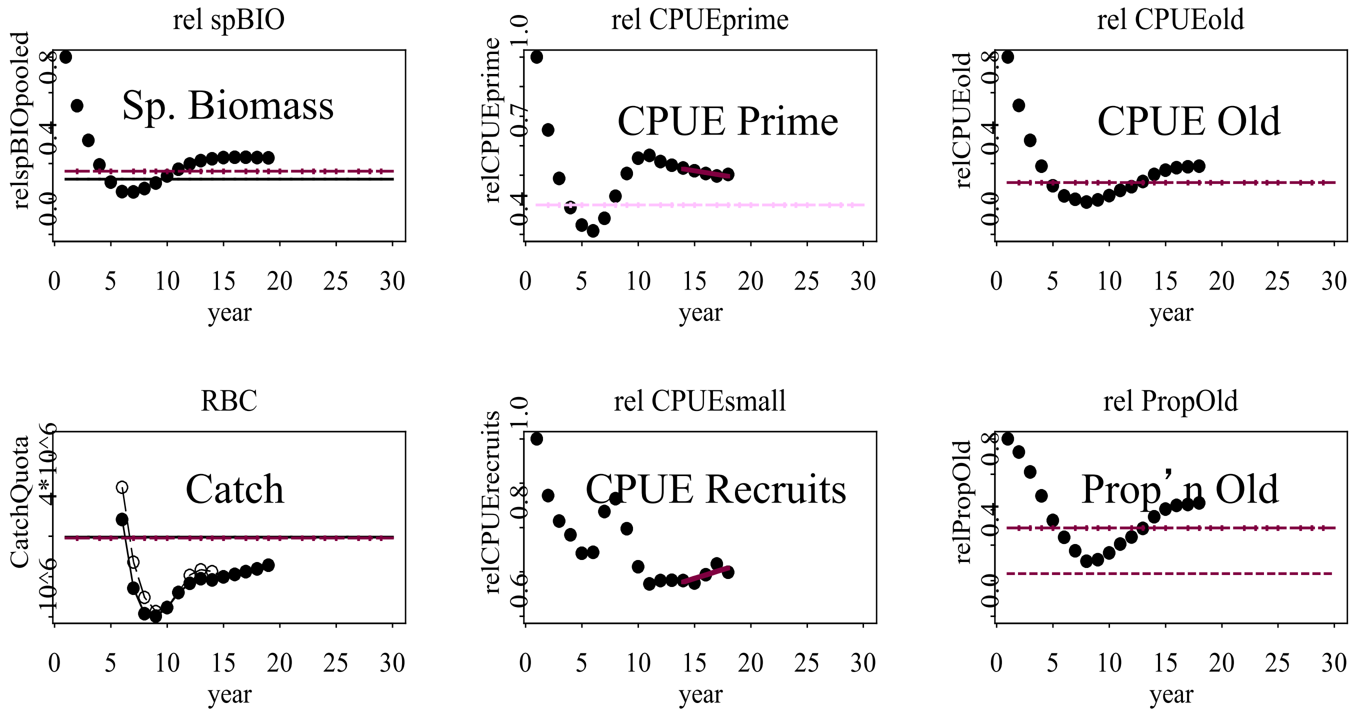

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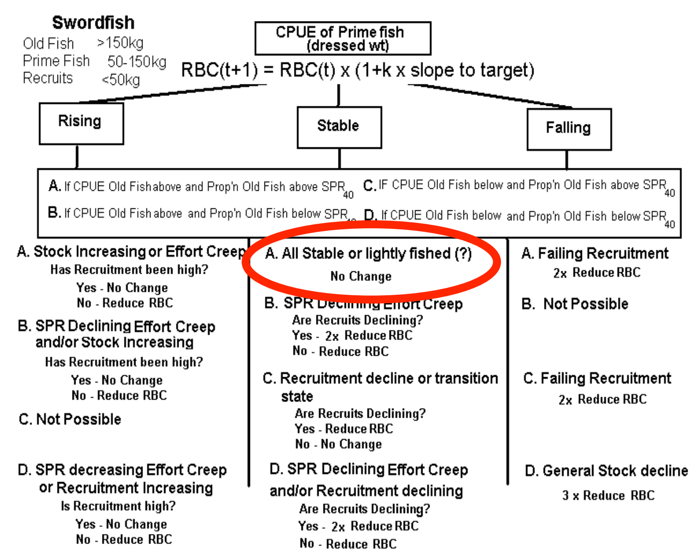

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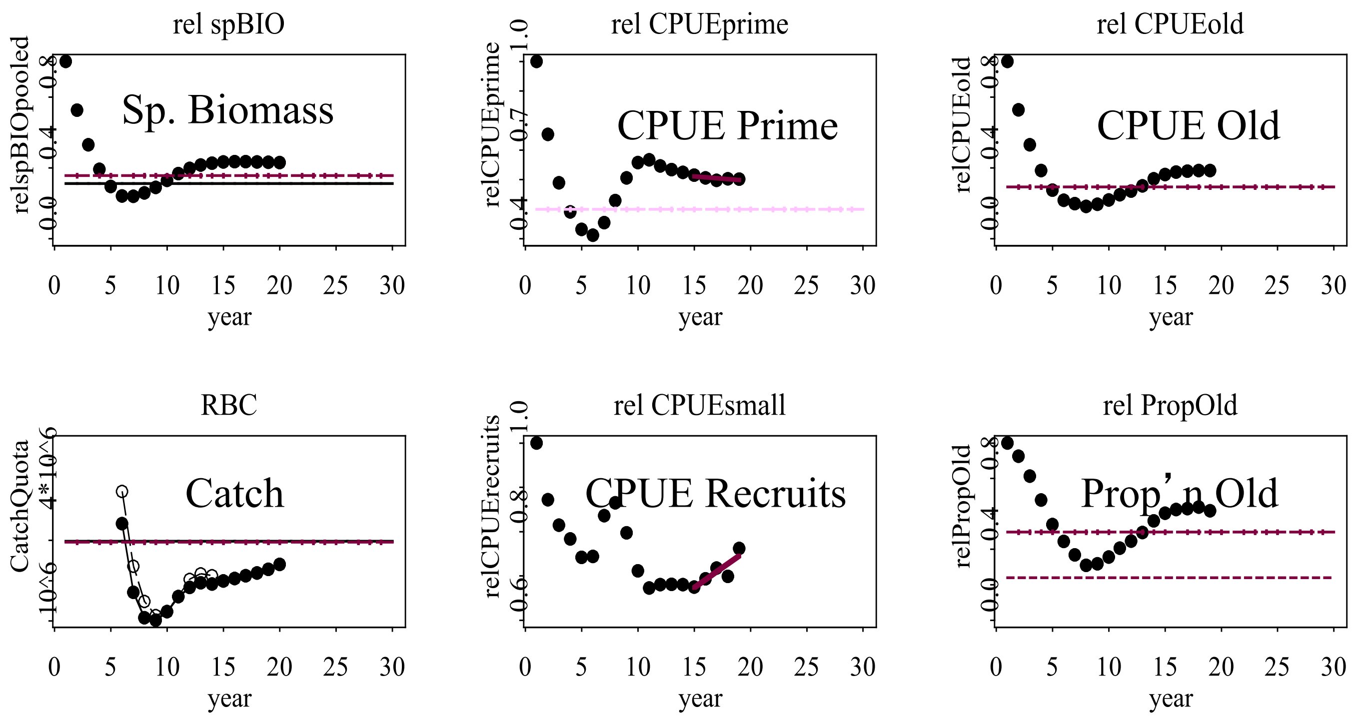

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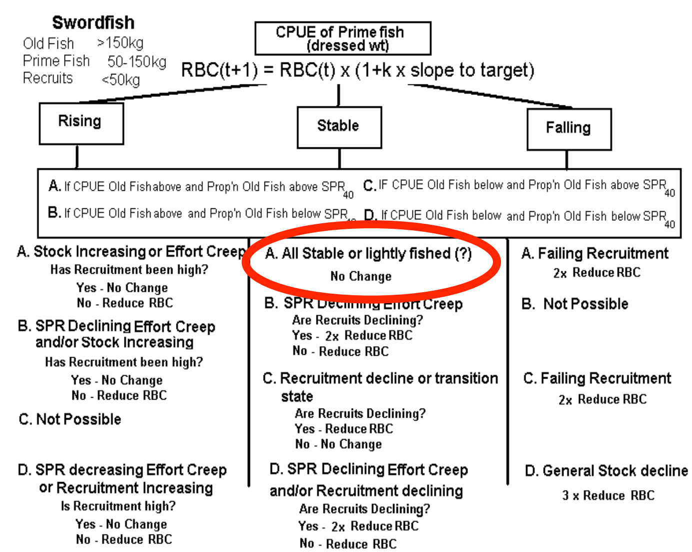

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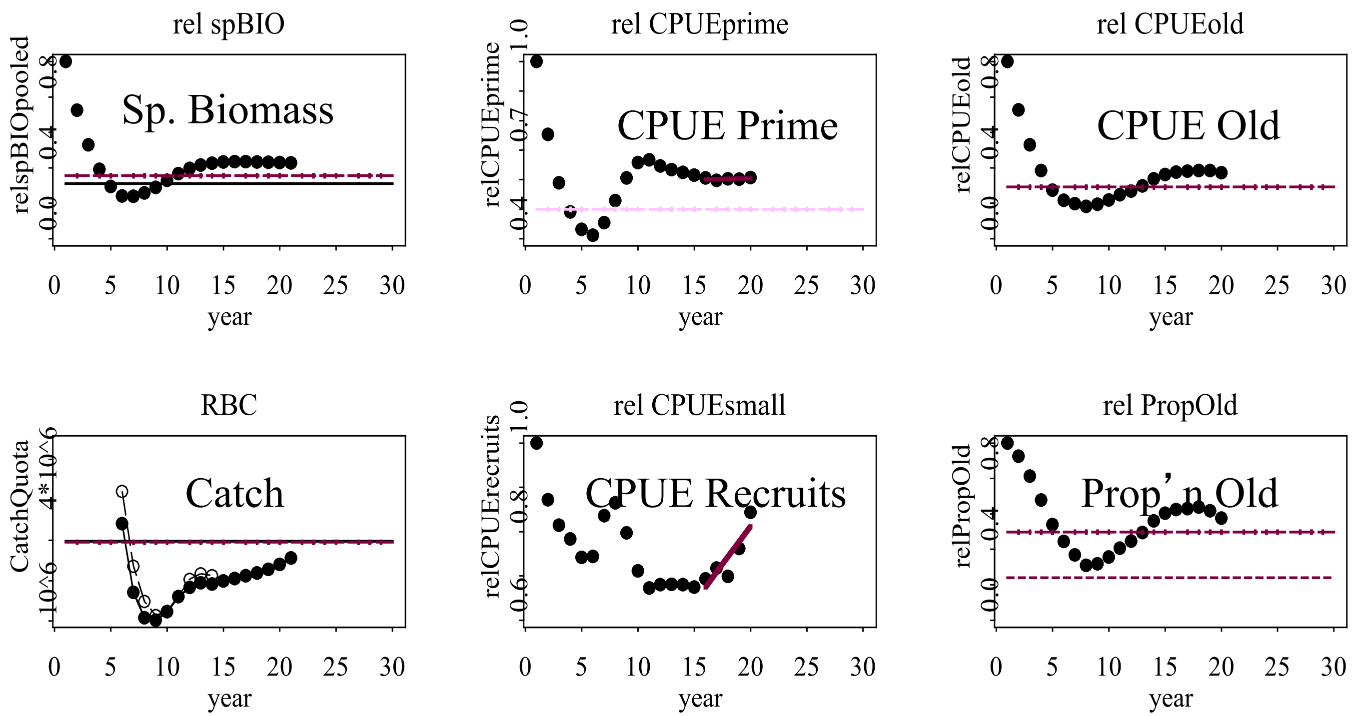

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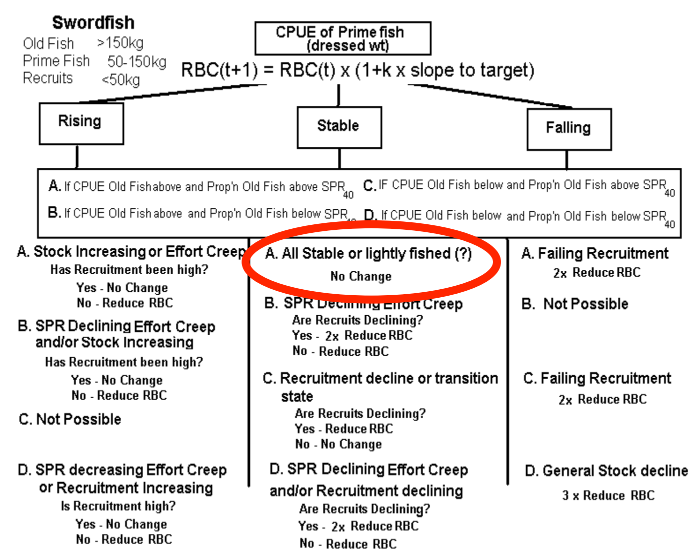

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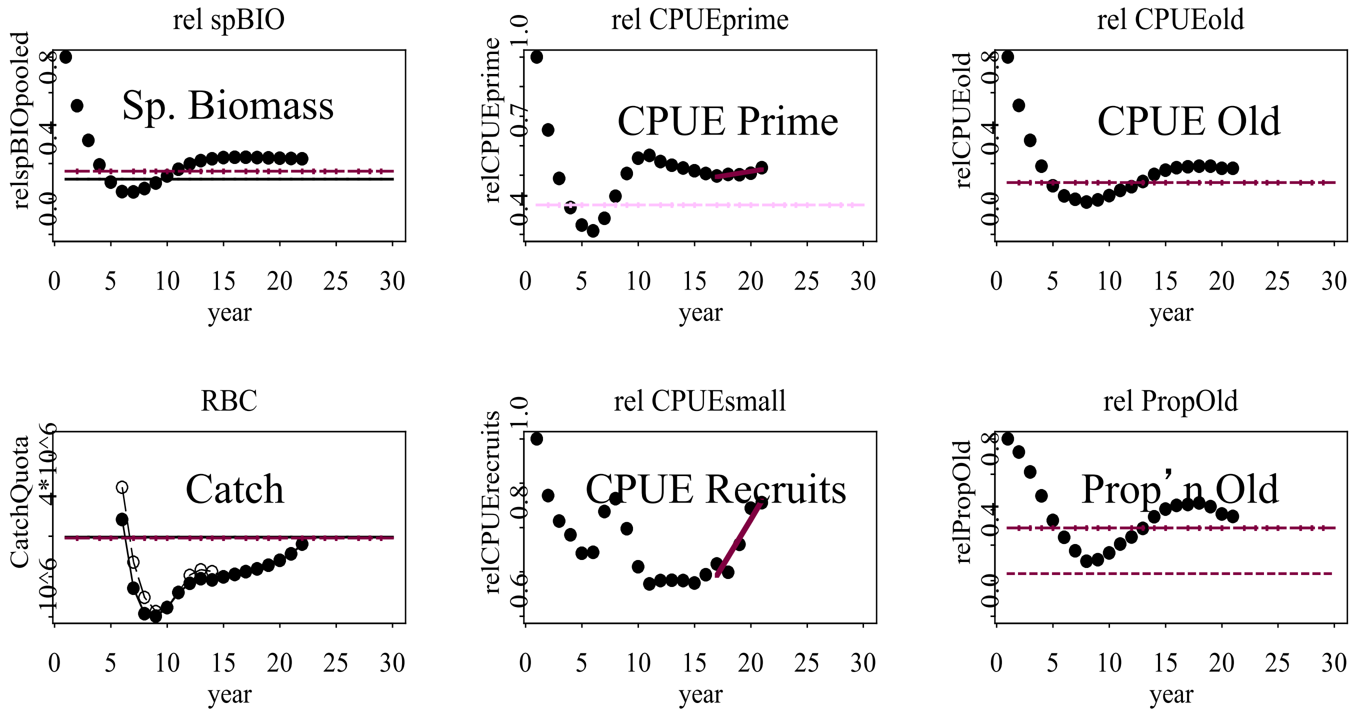

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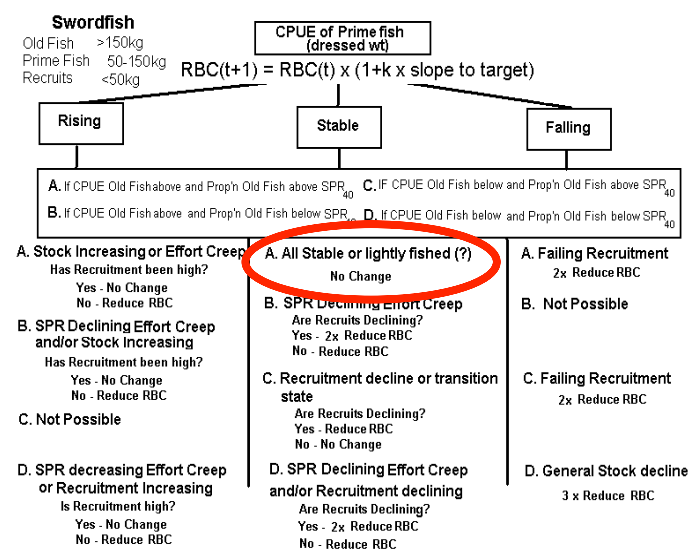

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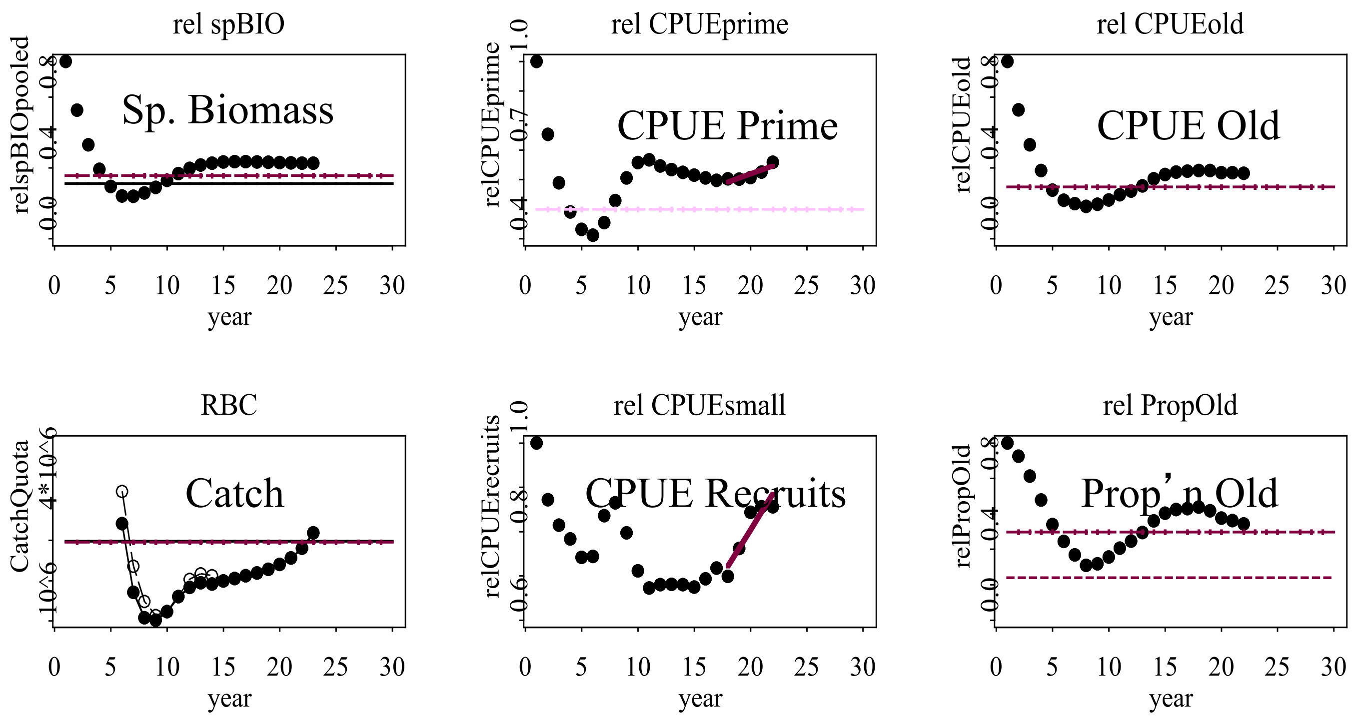

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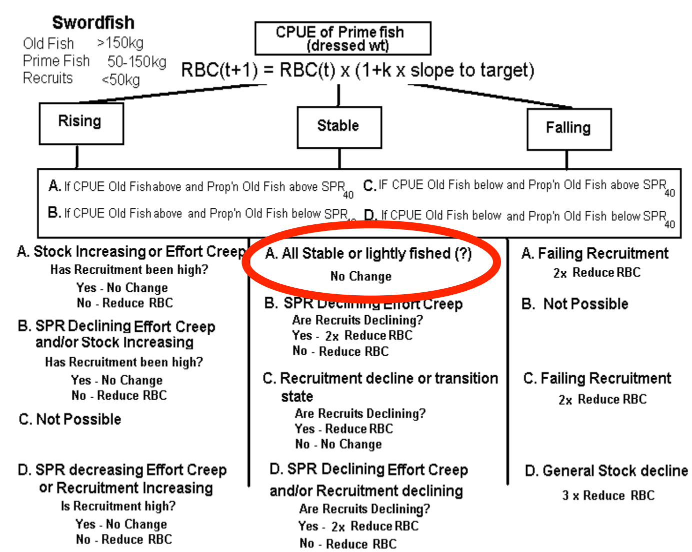

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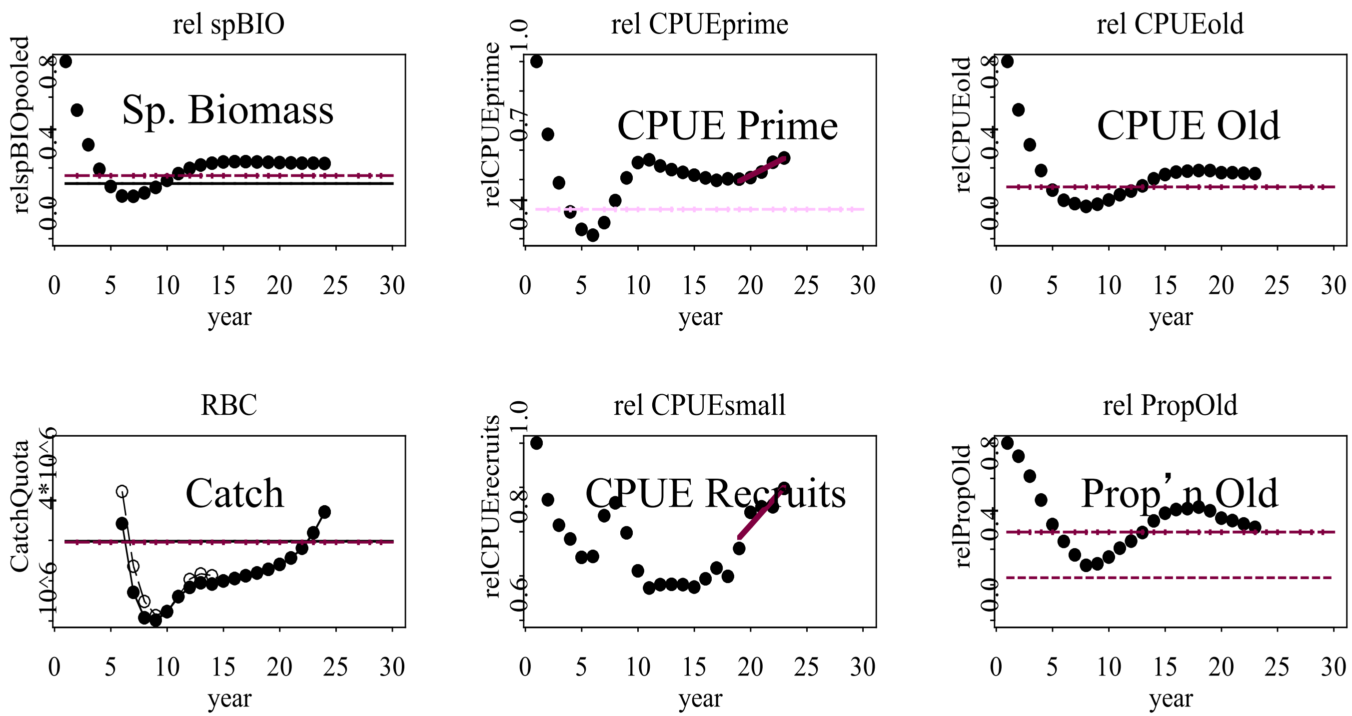

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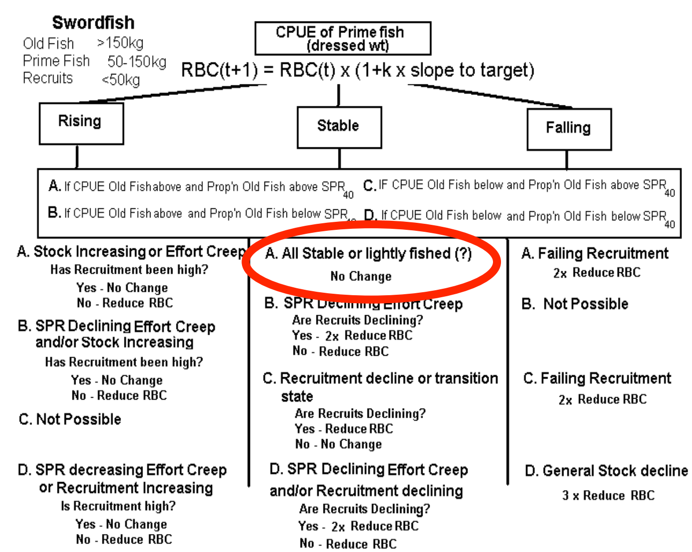

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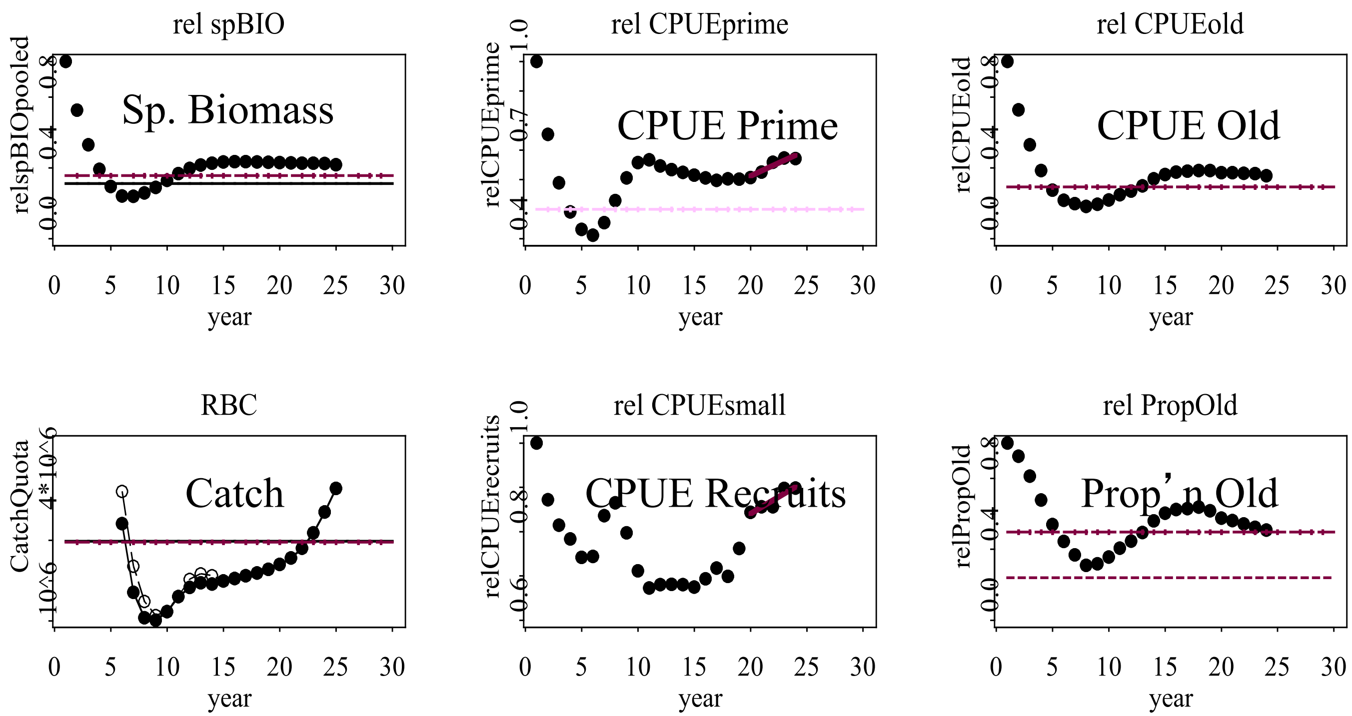

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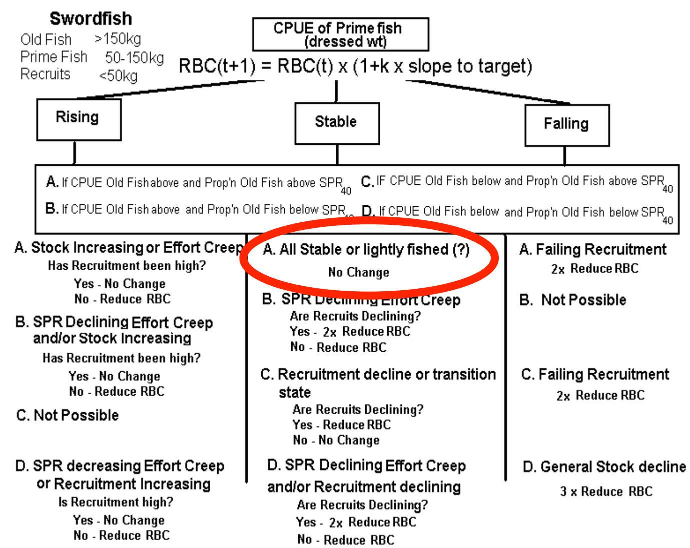
level at SPR_{40} (decision tree target)

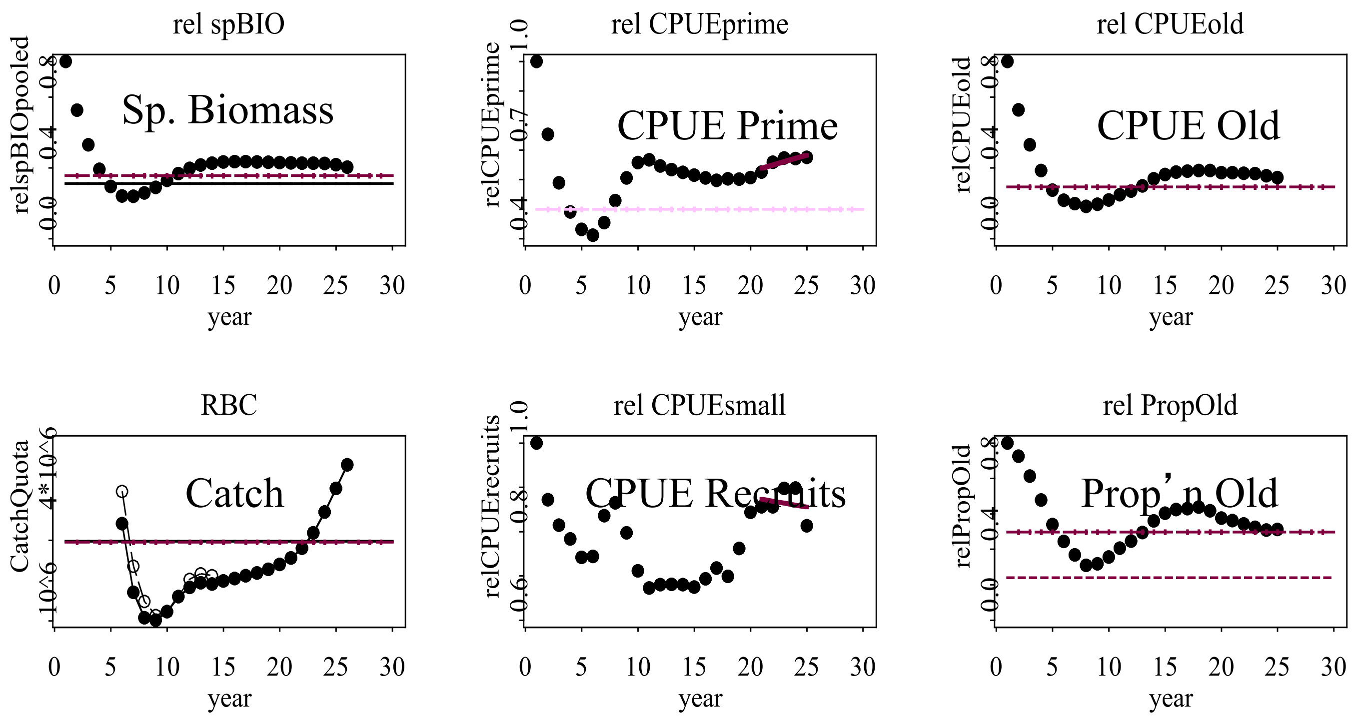
level at SPR_{20} (decision tree limit)

50% $CPUEprime_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 26



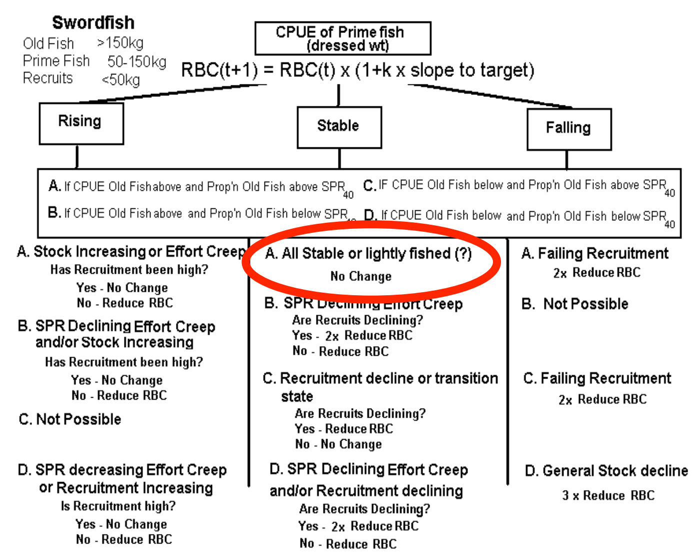
level at MSY

level at SPR_{40} (decision tree target)

level at SPR_{20} (decision tree limit)

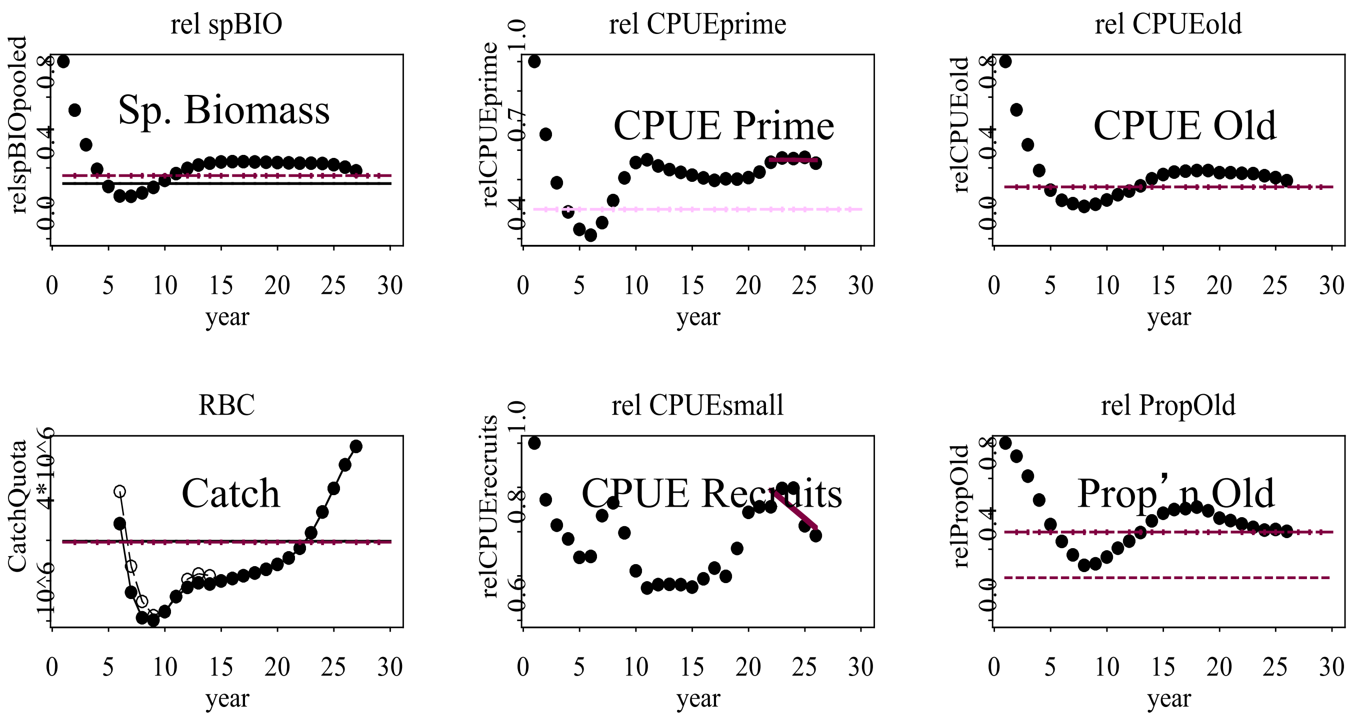
50% $CPUEprime_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



CSIRO

Year = 27



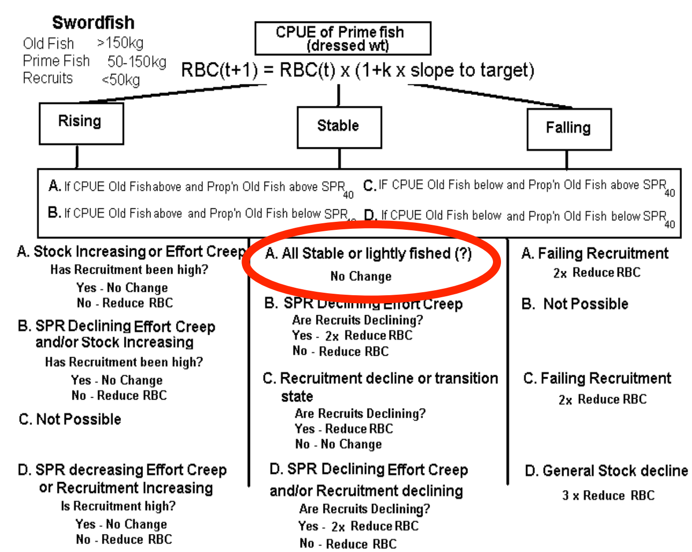
level at MSY

level at SPR_{40} (decision tree target)

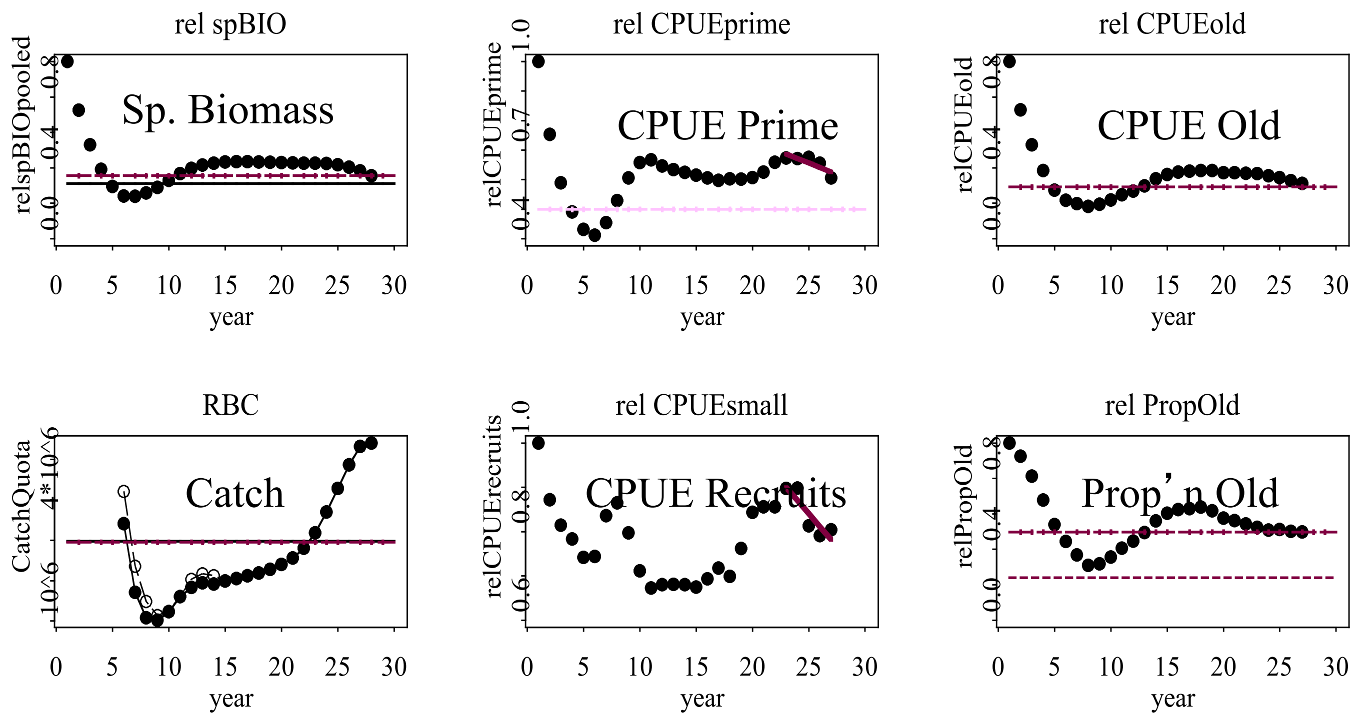
level at SPR_{20} (decision tree limit)

50% $CPUEprime_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 28



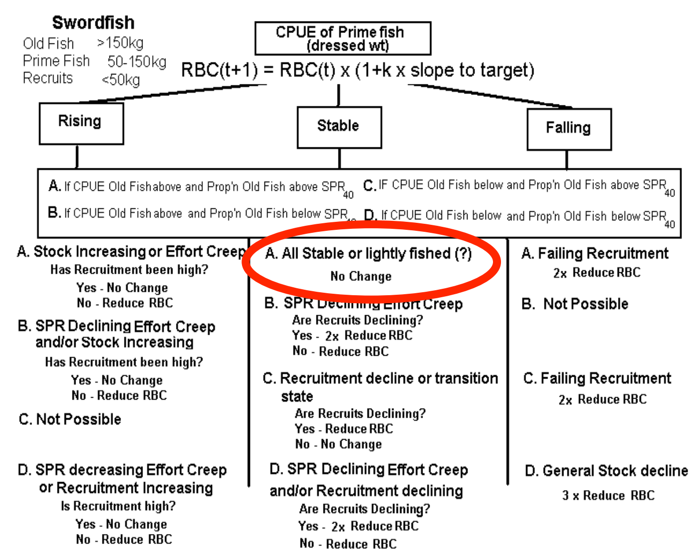
level at MSY

level at SPR_{40} (decision tree target)

level at SPR_{20} (decision tree limit)

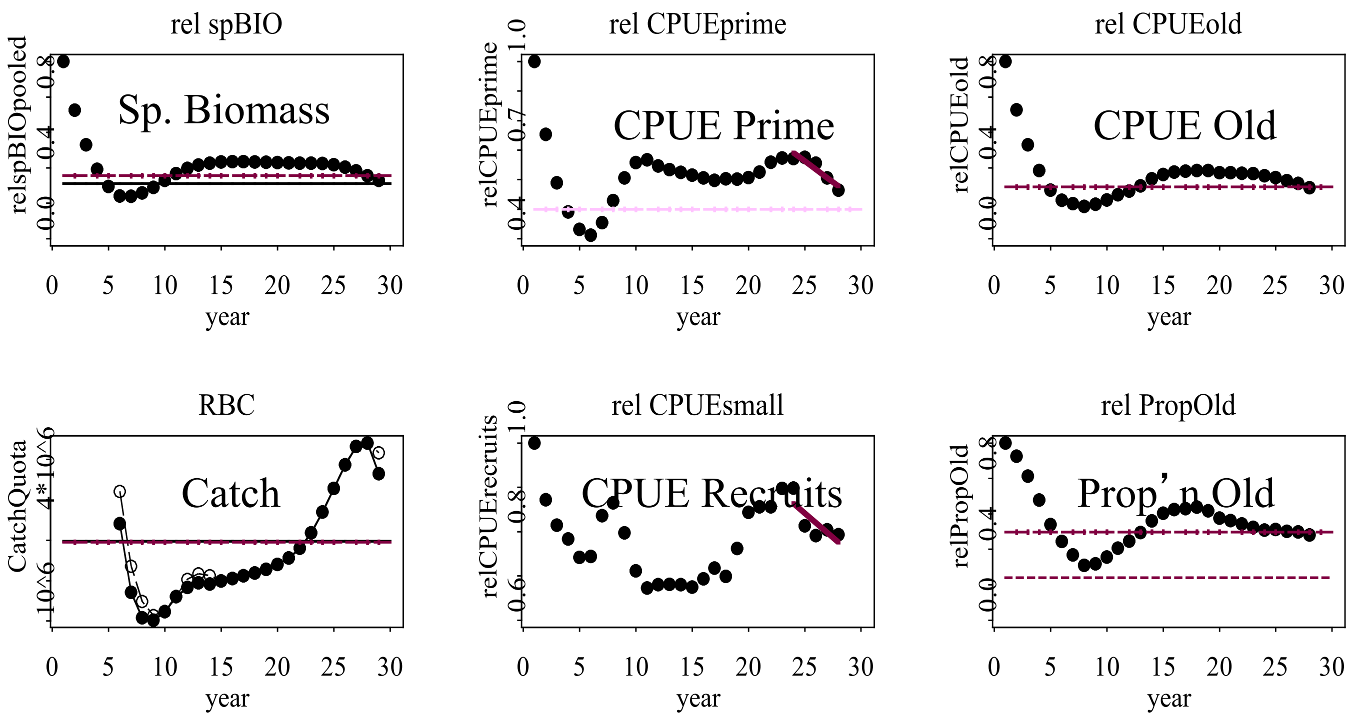
50% *$CPUEprime_0$* (simple decision rule target)

linear trend (showing slope) over last 5 years



CSIRO

Year = 29



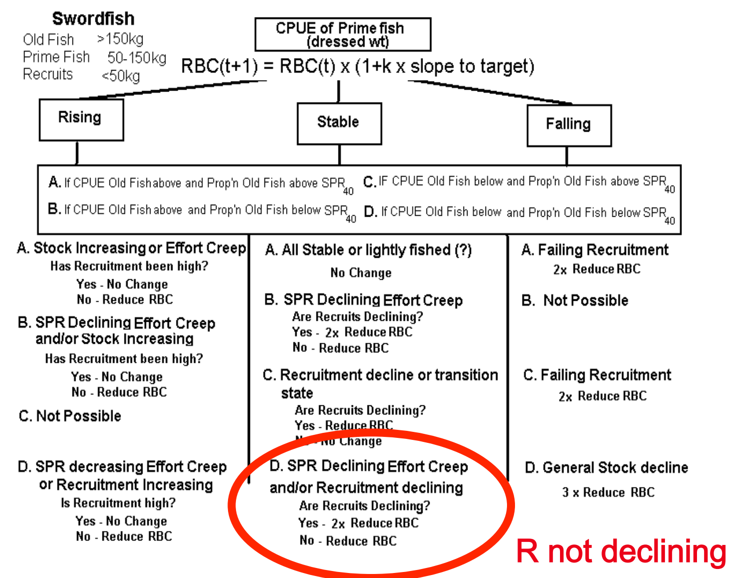
level at MSY

level at SPR_{40} (decision tree target)

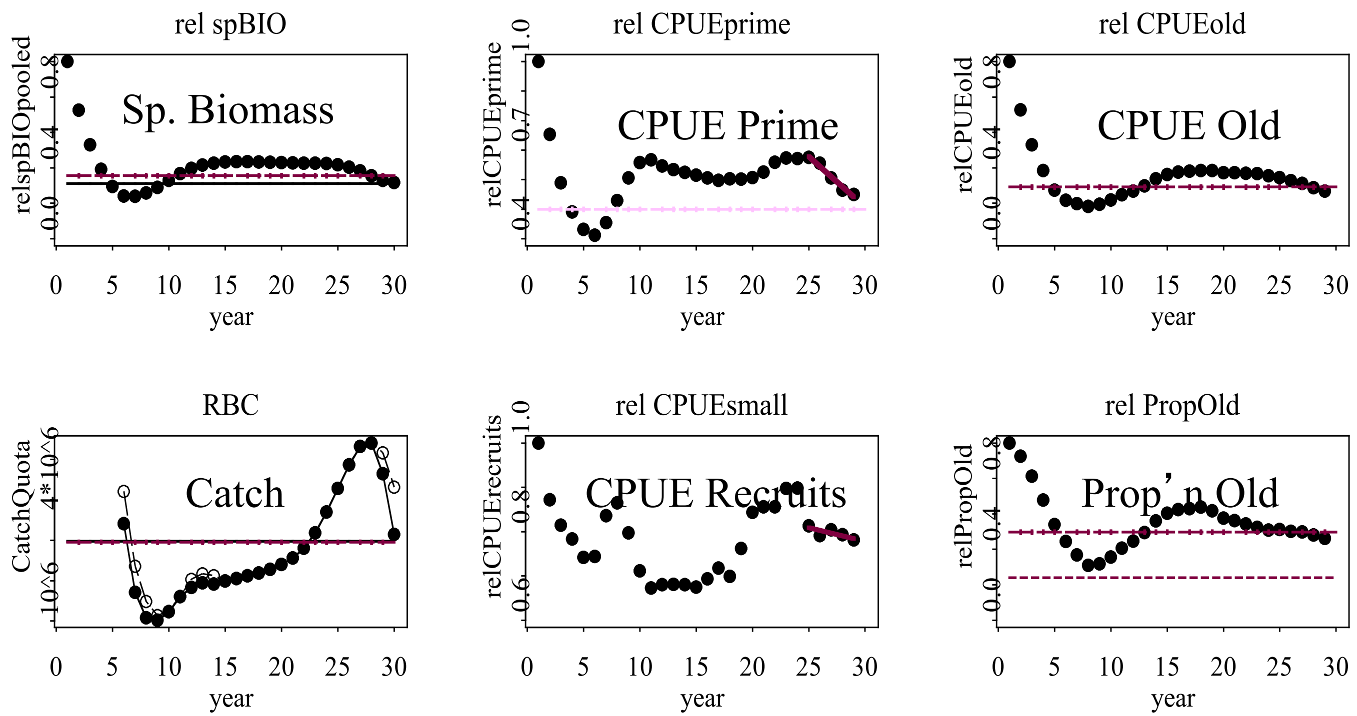
level at SPR_{20} (decision tree limit)

50% $CPUEprime_0$ (simple decision rule target)

linear trend (showing slope) over last 5 years



Year = 30



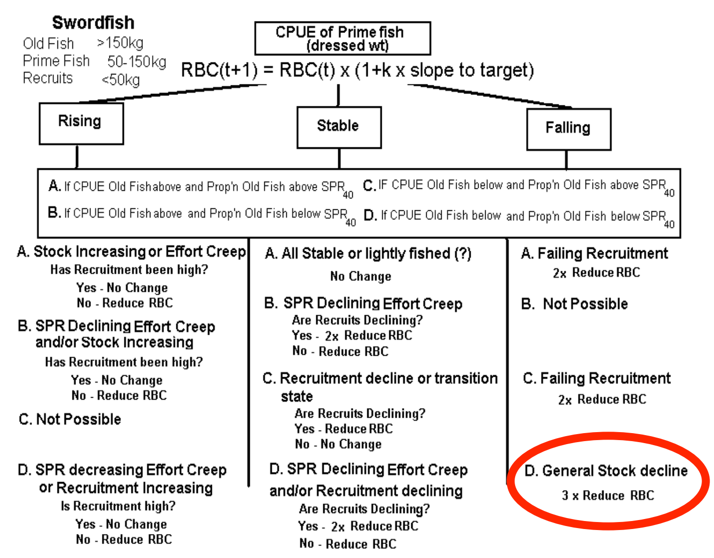
level at MSY

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



From $1 million to $100,000 Harvest Strategies with SPR Decision Trees

- Simple scale-less system for conserving local SPR
- No knowledge or assumptions about spatial structure required
- No biomass estimates
- SPR conditioned decision trees using CPUE & size
- Incremental changes to management to acheive target SPR levels
- Optimal catch level ‘discovered’ when target SPR achieved

But … still requires knowledge of growth, reproduction and mortality rates

.......from $100,000 down to……. $5,000 Harvest Strategies ….

Extending the Principal of Beverton-Holt Life History Invariance to Empirically Estimate Size based SPR Reference Points

Beverton-Holt Life History Invariance

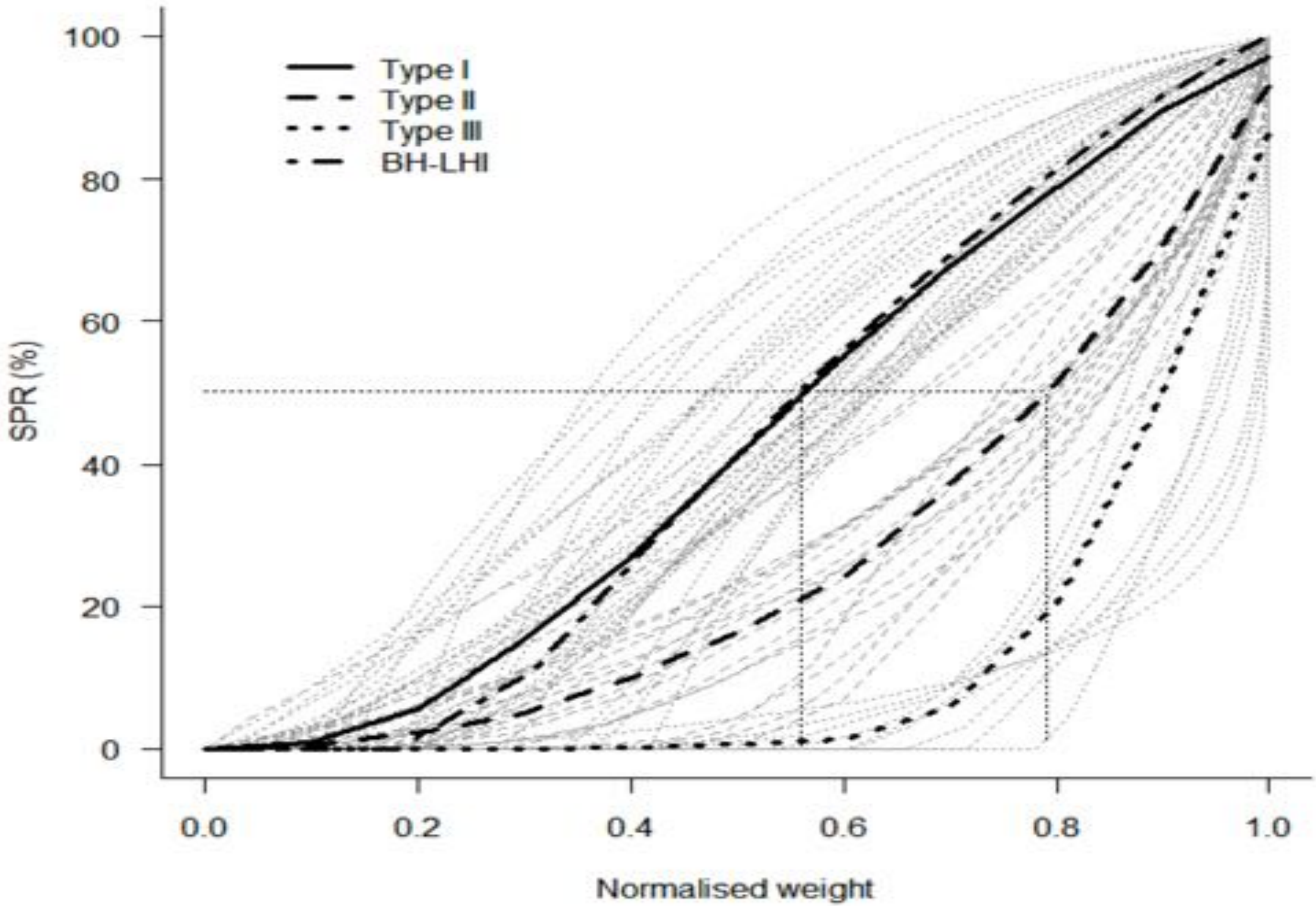
Correlation between life history parameters:

$L_m/L_{inf} = 0.66$, $M/k = 1.5$ and M x $Age_m = 1.65$ (Jensen 1996)

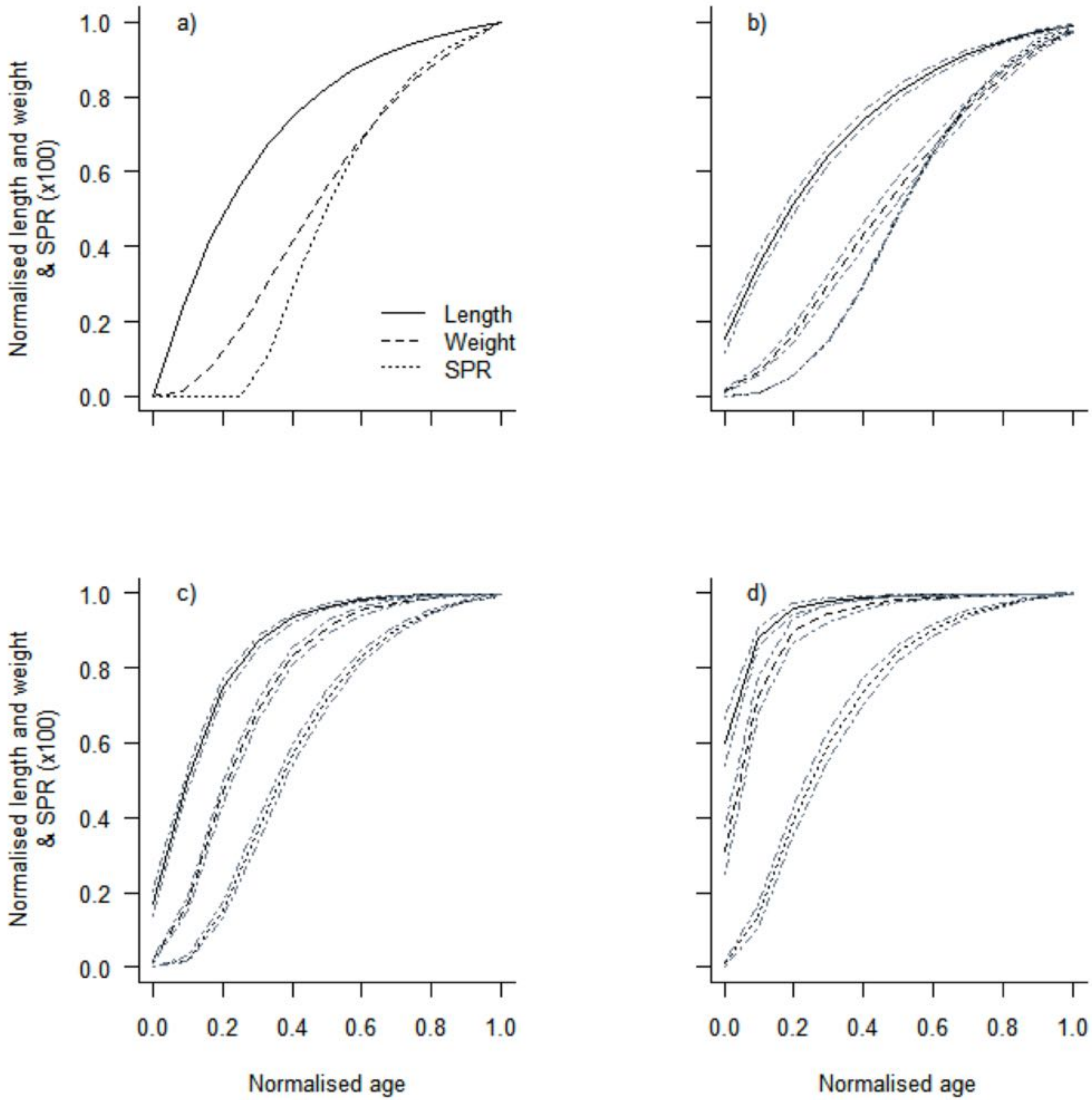
Used extensively to specify stock assessment models.

Meta-Analysis

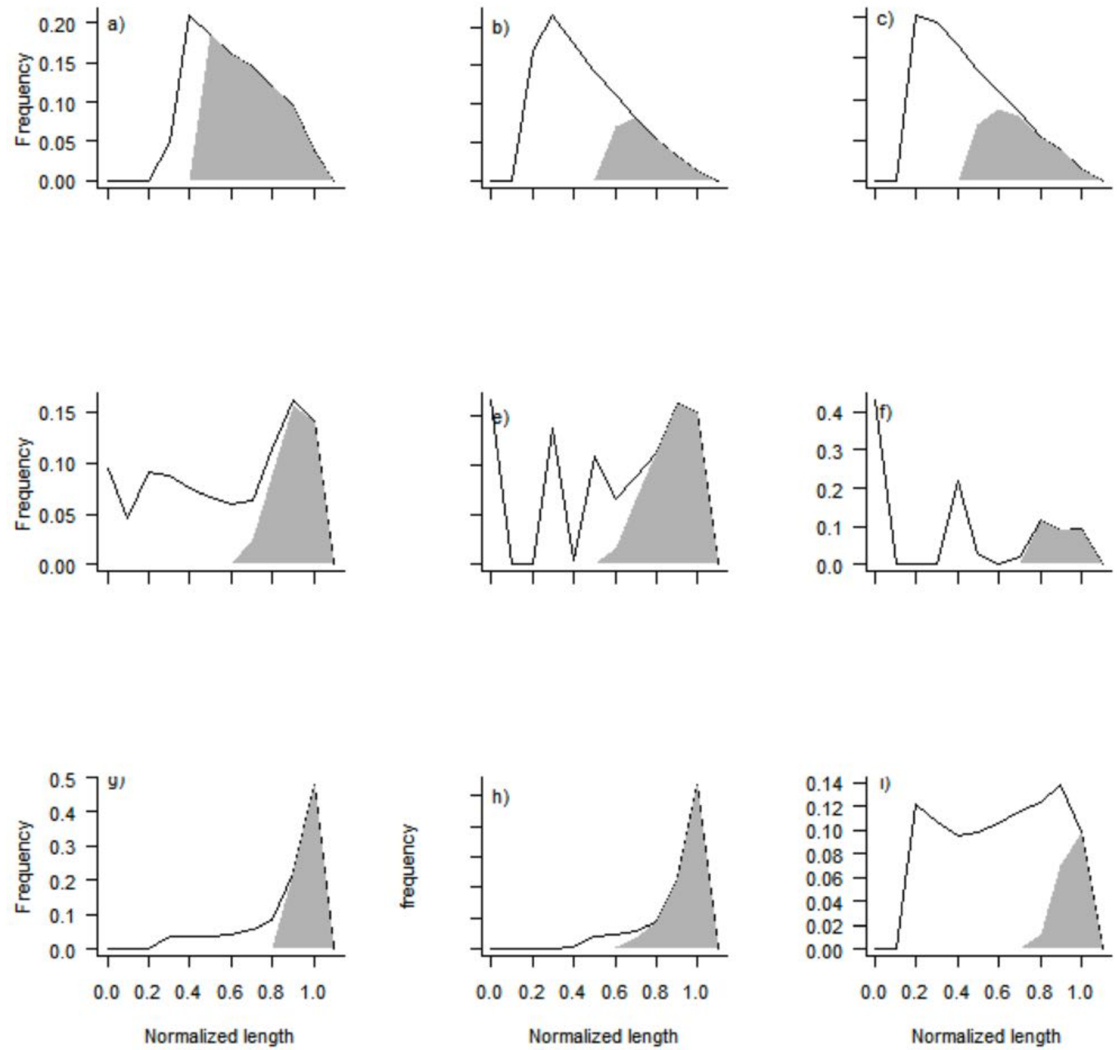
- 63 species for all SPR parameters robustly estimated directly; biological studies of tagging or ageing in unexploited or lightly fished populations, or estimated by integrated stock assessment.
- No use of B-H derived parameters.
- SPR models for each species
- Standardized wt., length, age & SPR estimated assuming 100% when cohort declines to 0.1% of original size



Type I
Type II
Type III
BH-LHI
SPR (%)
Normalised weight
0
20
40
60
80
100
0.0
0.2
0.4
0.6
0.8
1.0



a)
b)
c)
d)
Length
Weight
SPR
Normalised length and weight & SPR (x100)
Normalised age
0.0
0.2
0.4
0.6
0.8
1.0



Indicative length-frequency histograms estimated for unfished populations of 9 species used in this analysis; Type I a) tiger flathead (*Neoplatycephalus richardsoni*), b) sharpnose shark (*Rhizoprionodon taylori),* c) gulf menhaden (*Brevoortia patronus*), Type II d) banana prawn (*Penaeus mergueiensis*), e) kawhai (*Arripis trutta*), f) sandbar shark (*Carcharinus plumbeus*), Type III g) sperm whale (*Physteter macrocephalus*), h) Mexican geoduck (*Panopea globosa*), i) school shark (*Galeorhinus galeus)*. Shading indicates adult component of each length-frequency histogram. These length –frequency histograms were estimated on the basis of the parameters sets used in this meta-analysis.

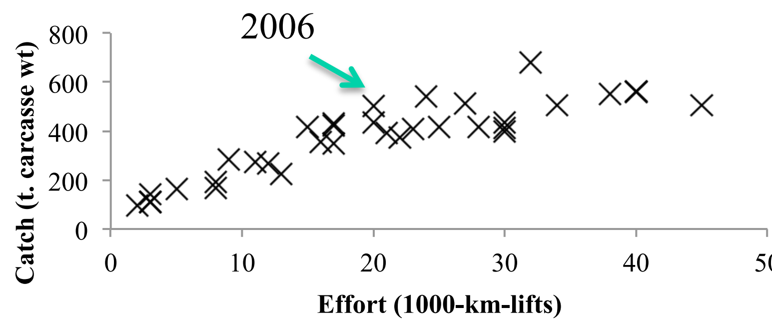
$5000 Harvest Strategies

1Parameterize SPR Decision trees empirically with size composition studies.
2Monitor CPUE & size in the catch.
3Incrementally adjust local catch / effort / size limits / MPAs until local target size & CPUE are achieved.

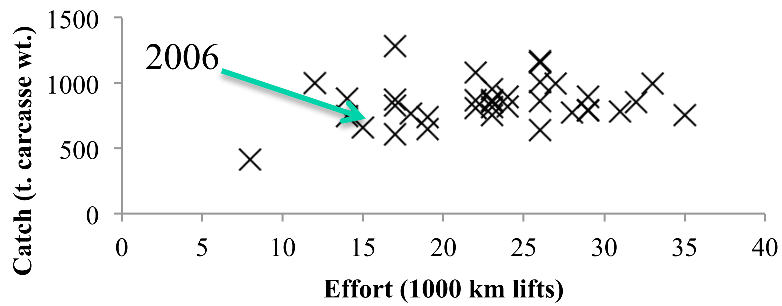
4Replicate, Replicate, Replicate ……


The End

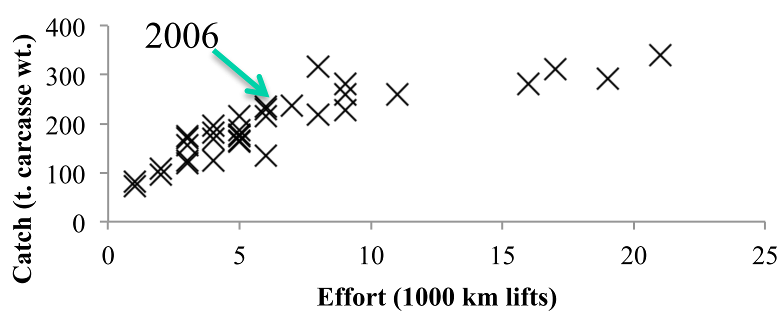
SA - Catch vs Effort

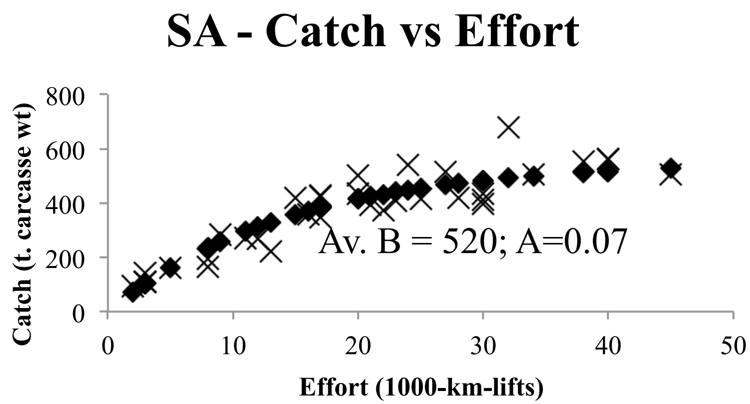


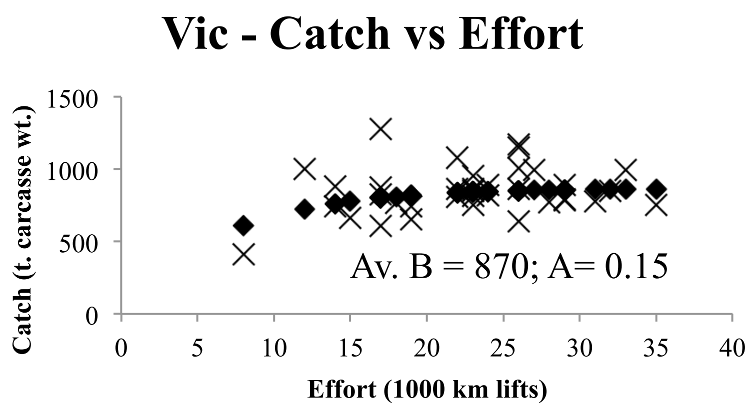
Vic - Catch vs Effort

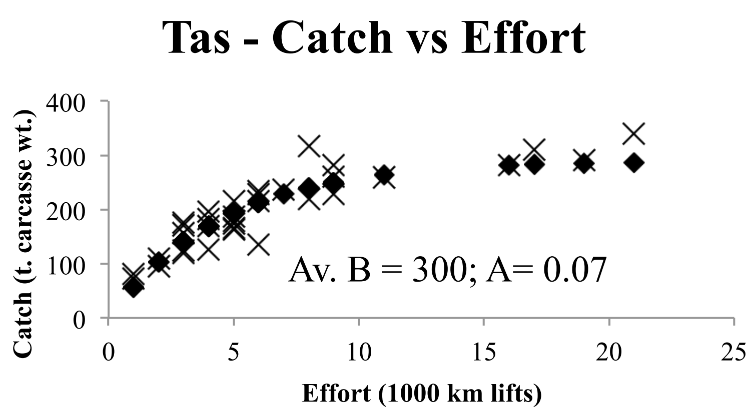


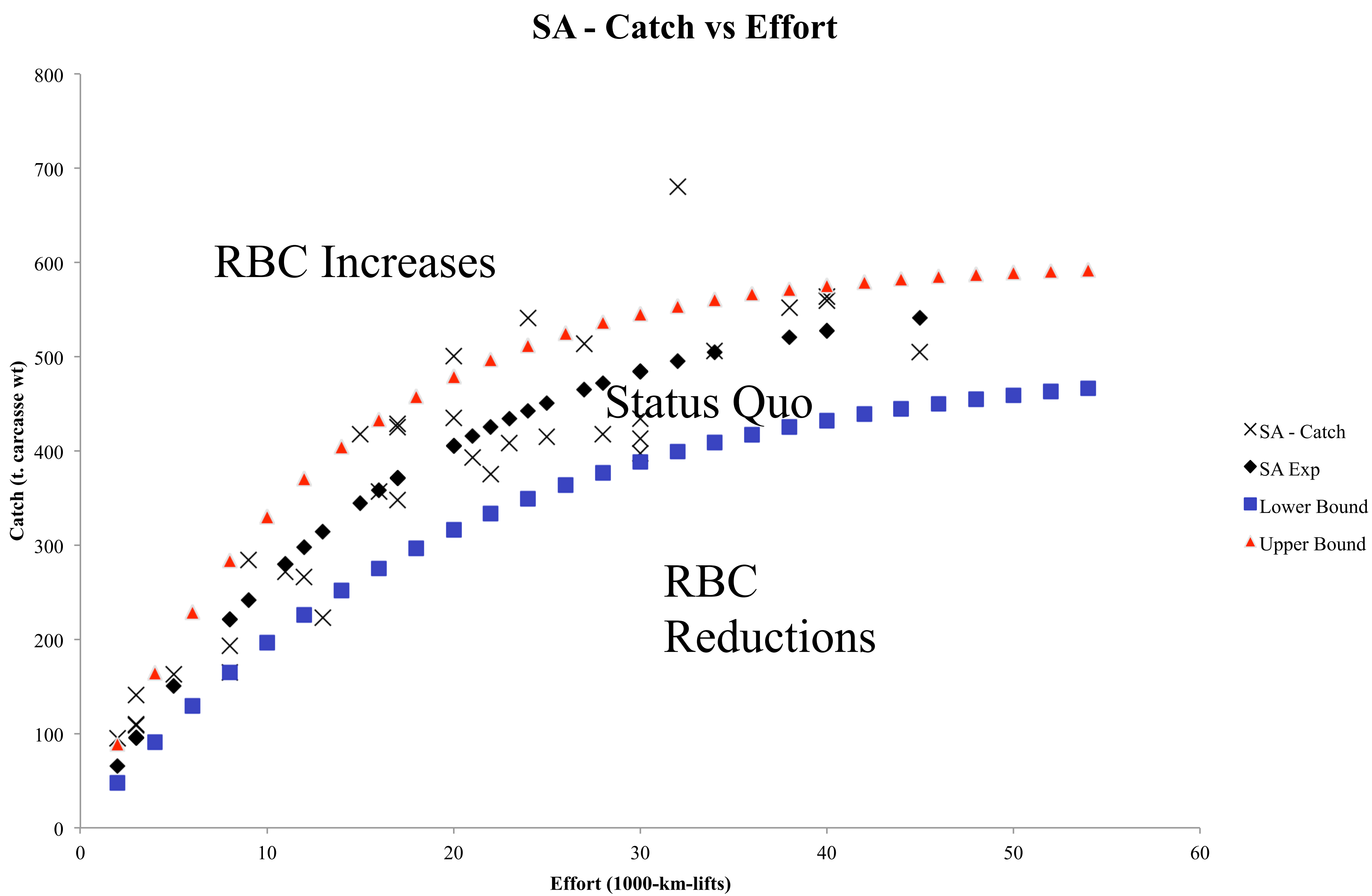
Tas - Catch vs Effort

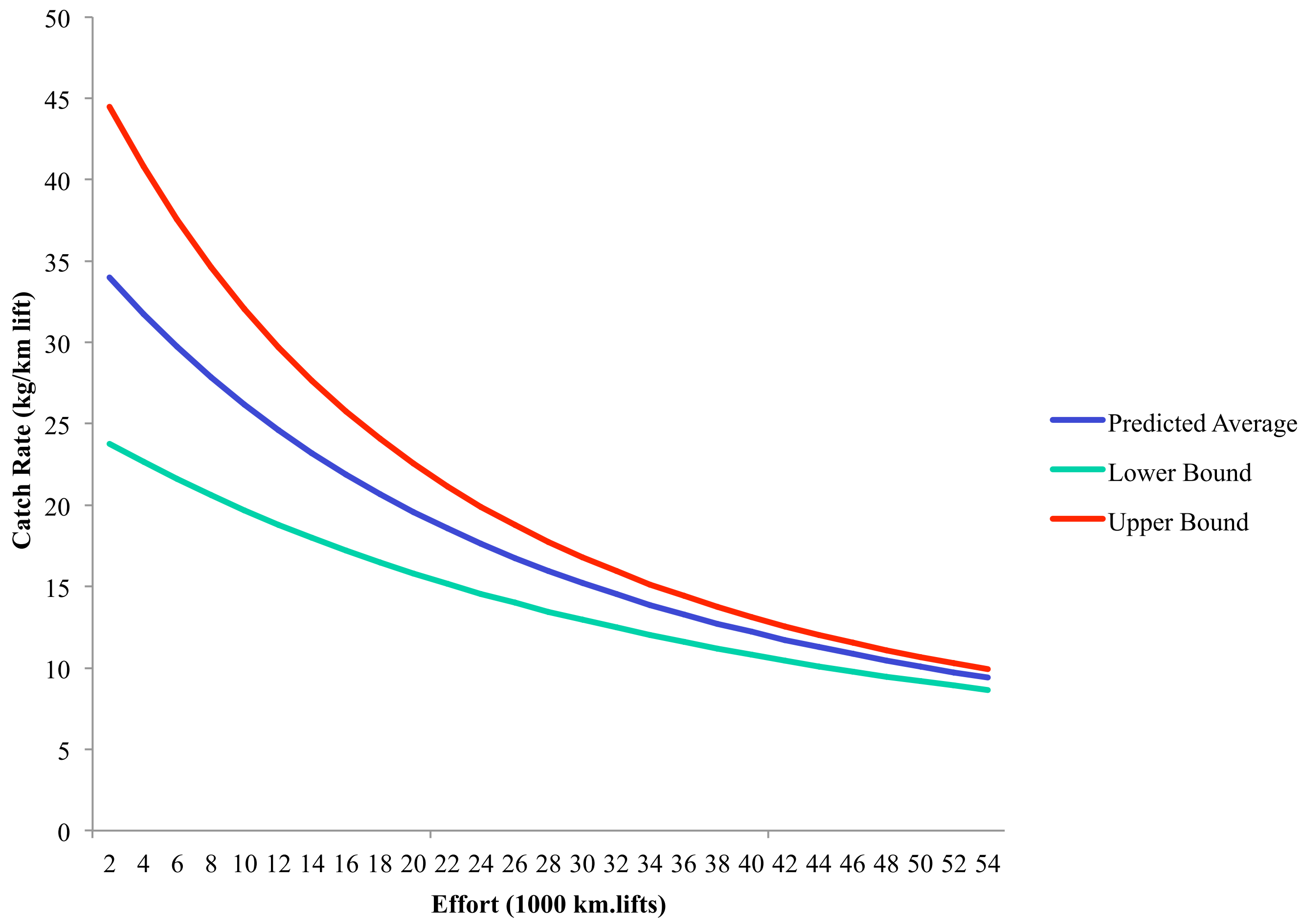


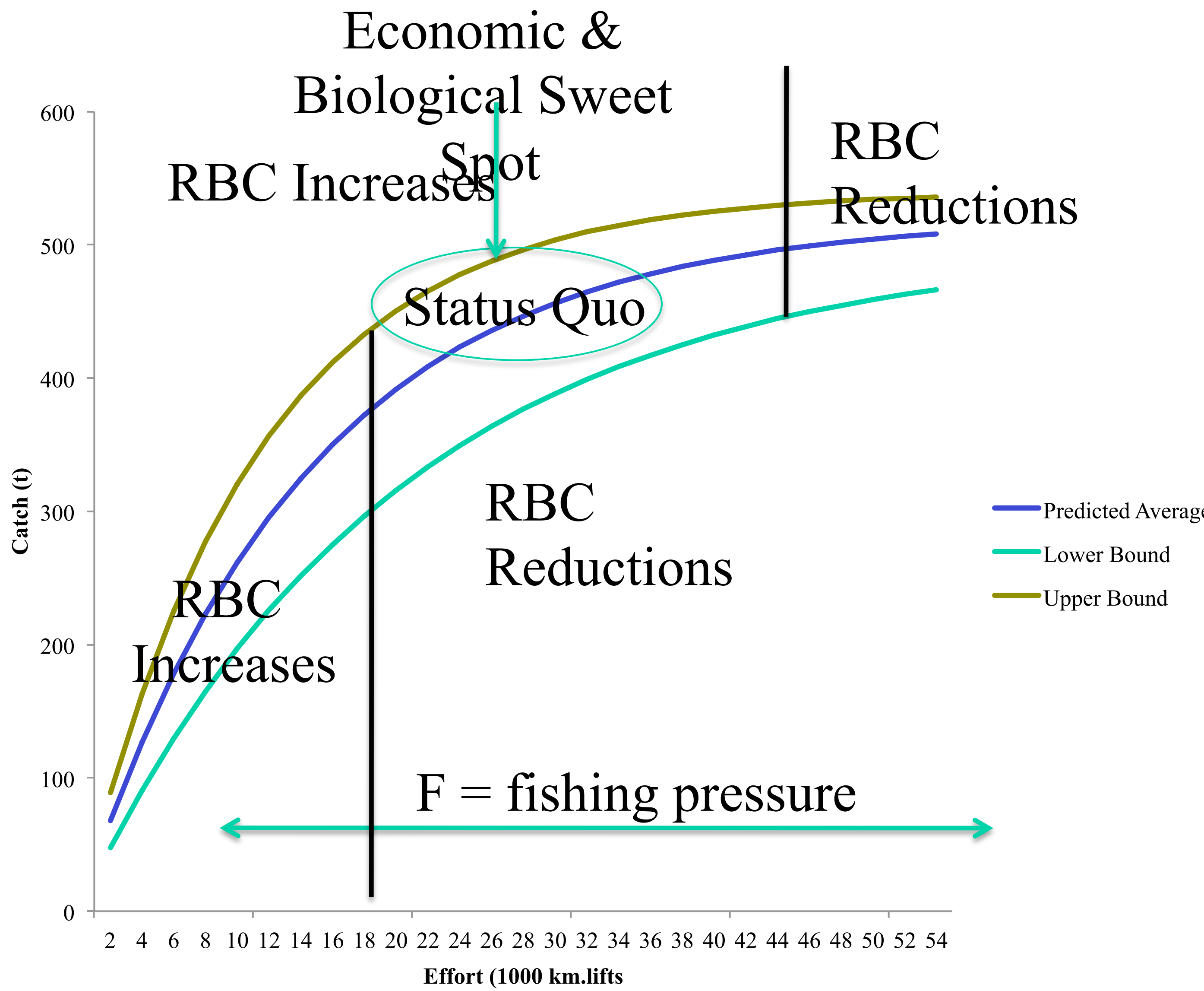

SA - Catch vs Effort
Catch (t. carcasse wt)
800
600
400
200
0
0
10
20
30
40
50
Effort (1000-km-lifts)
Av. B = 520; A=0.07


Vic - Catch vs Effort
Catch (t. carcasse wt.)
1500
1000
500
0
0
5
10
15
20
25
30
35
40
Effort (1000 km lifts)
Av. B = 870; A= 0.15


Tas - Catch vs Effort
Catch (t. carcasse wt.)
400
300
200
100
0
0
5
10
15
20
25
Effort (1000 km lifts)
Av. B = 300; A= 0.07


SA - Catch vs Effort
Catch (t. carcasse wt)
Effort (1000-km-lifts)
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
RBC Increases
Status Quo
RBC
Reductions
SA - Catch
SA Exp
Lower Bound
Upper Bound


Catch Rate (kg/km lift)
50
45
40
35
30
25
20
15
10
5
0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Effort (1000 km.lifts)
Predicted Average
Lower Bound
Upper Bound


Economic &
Biological Sweet
Spot
RBC Increases
RBC
Reductions
Status Quo
RBC
Reductions
RBC
Increases
F = fishing pressure
600
500
400
300
200
100
0
Catch (t)
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Effort (1000 km.lifts
Predicted Average
Lower Bound
Upper Bound