Developing a Harvest Strategy for the Torres Strait tropical rock lobster (TRL) fishery

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March 2016

CSIRO Oceans and Atmosphere

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Australian Fisheries Management Authority

Australia's National Harvest Strategy Guidelines

Harvest Strategy: "a framework that specifies the pre-determined management actions in a fishery necessary to achieve the agreed ecological, economic and/or social management objectives."

A key principle is that fishery managers, fishers and key stakeholders utilise pre-agreed (and preferably pre-tested) rules as to how to adjust management recommendations given updates of data and/or model outputs

http://www.agriculture.gov.au/fisheries/domestic/harvest_strategy_policy

What is a Harvest Strategy?

A harvest strategy sets out the management actions necessary to achieve defined biological and economic objectives in a given fishery.

The Harvest strategy must contain:

- a process for monitoring and conducting assessments of the biological and economic conditions of the fishery; and
- rules that control the intensity of fishing activity according to the biological and economic conditions of the fishery.

Australia's National Harvest Strategy Guidelines recommend the strategy be:

- ✓ consistent with the legislative objectives, including the principles of Ecological Sustainable Development:
- ✓ pragmatic and easy to understand;
- ✓ cost-effective;
- ✓ transparent and inclusive;
- ✓ unambiguous;
- ✓ precautionary; and
- ✓ adaptive

Harvest Strategy Aims

The aim of a harvest strategy is to maintain commercial fish stocks at environmentally sustainable levels and to maximise the economic returns to the Australian community.

The harvest strategy should give the fishing industry a more reliable operating environment.

http://www.afma.gov.au/sustainability-environment/harvest-strategies/

The Harvest Strategy must address the TRL Fishery Management Plan Objectives

To maintain the spawning stock at levels that meet or exceed the level producing maximum sustainable yield.

To protect the traditional way of life and livelihood of Traditional Inhabitants, particularly in relation to their traditional fishing for TRL.

To provide for the optimal utilisation, co-operative management with Queensland and PNG and for catch sharing to occur with PNG.

To monitor interactions between the prawn and lobster fisheries.

To maintain appropriate controls on fishing gear allowed in the fishery so as to minimise impacts on the environment.

To promote economic development in the TS area with an emphasis on providing the framework for commercial opportunities for Traditional Inhabitants and to ensure that the opportunities available to all stakeholders are socially and culturally appropriate for the TS and the wider Queensland and Australian community.

To optimise the value of the fishery.

http://pzja.gov.au/the-fisheries/torres-strait-tropical-rock-lobster-fishery/#.VvIZ7TEYc1o

Harvest Strategy Components

(1) Indicators (data from the fishery; Docket books & Logbooks)

(2) Monitoring (agreed protocols to get data; Population surveys, Size/age monitoring)

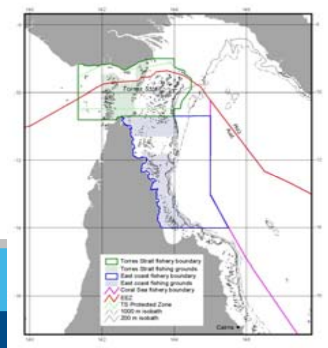
(3) Reference points (targets and limits; Stock biomass, Fishing mortality)

(4) Method of assessment (Stock assessment, Catch per Unit of Effort (CPUE) standardisation)

(5) Decision rules (agreed rules for setting catch levels; called Harvest Control Rules)

TRL Harvest Strategy Timeline

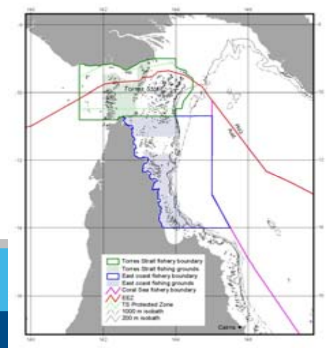
March	July	Aug/Sept	Oct	Nov	End Nov	Season opening - Dec
Update catch, catch at age, survey and TIB & TVH CPUE information	Apply updated stock assessment model to assess stock status	Preliminary catch recommendation	Bilateral catch sharing meeting	Conduct Preseason survey and analyse data	Rerun assessment OR apply empirical HCR	Final TAC



Revised TRL Harvest Strategy Timeline under Quota Management

March	July	Aug/Sept	Oct	Nov	End Nov	Season opening - Dec
Update catch, catch at age, survey and TIB & TVH CPUE information	Stock assessment model every 3 yrs?		Bilateral catch sharing meeting – move ??	Conduct Preseason survey and analyse data	~~Rerun assessment OR~~ apply empirical HCR	Final TAC



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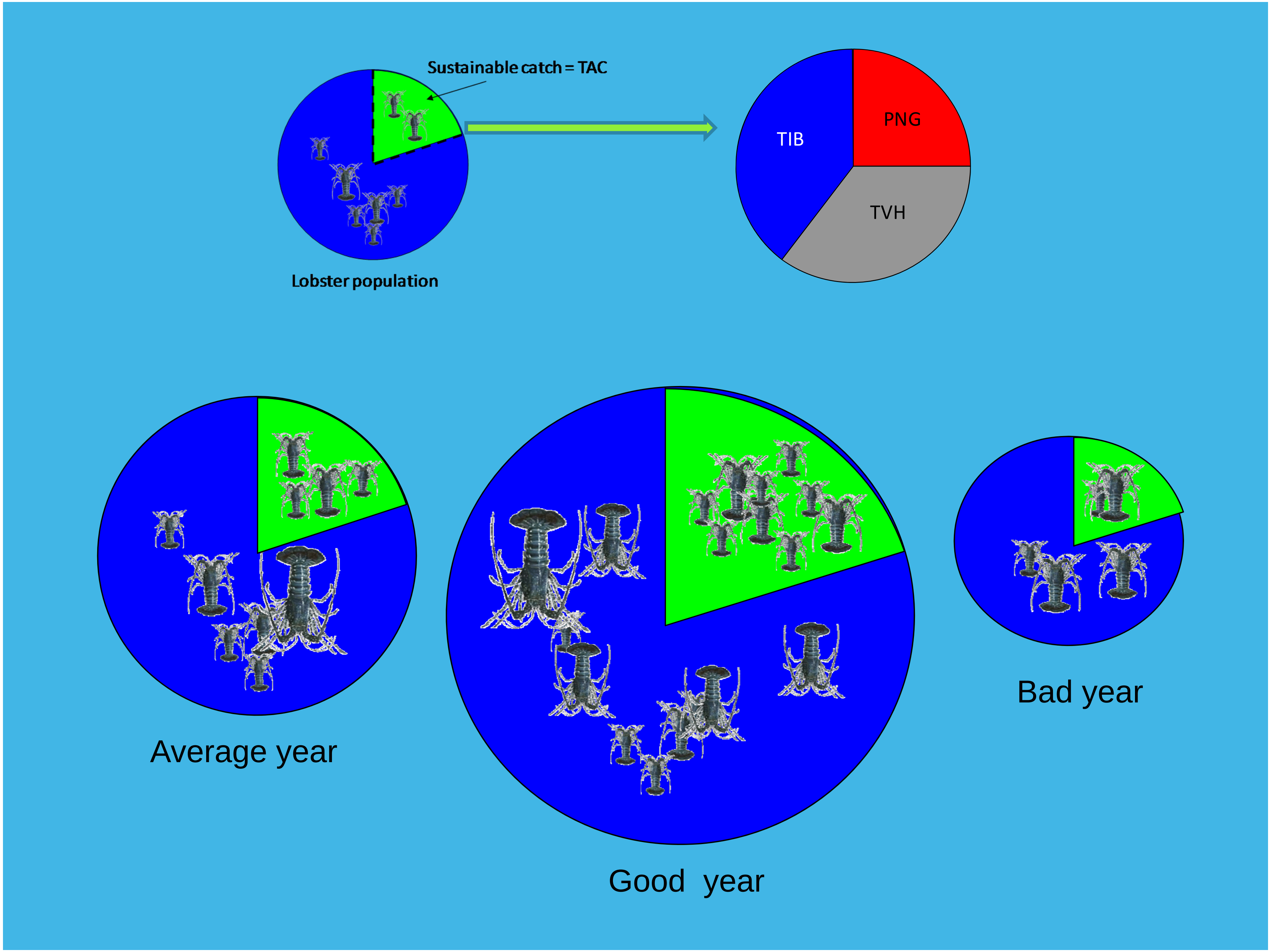
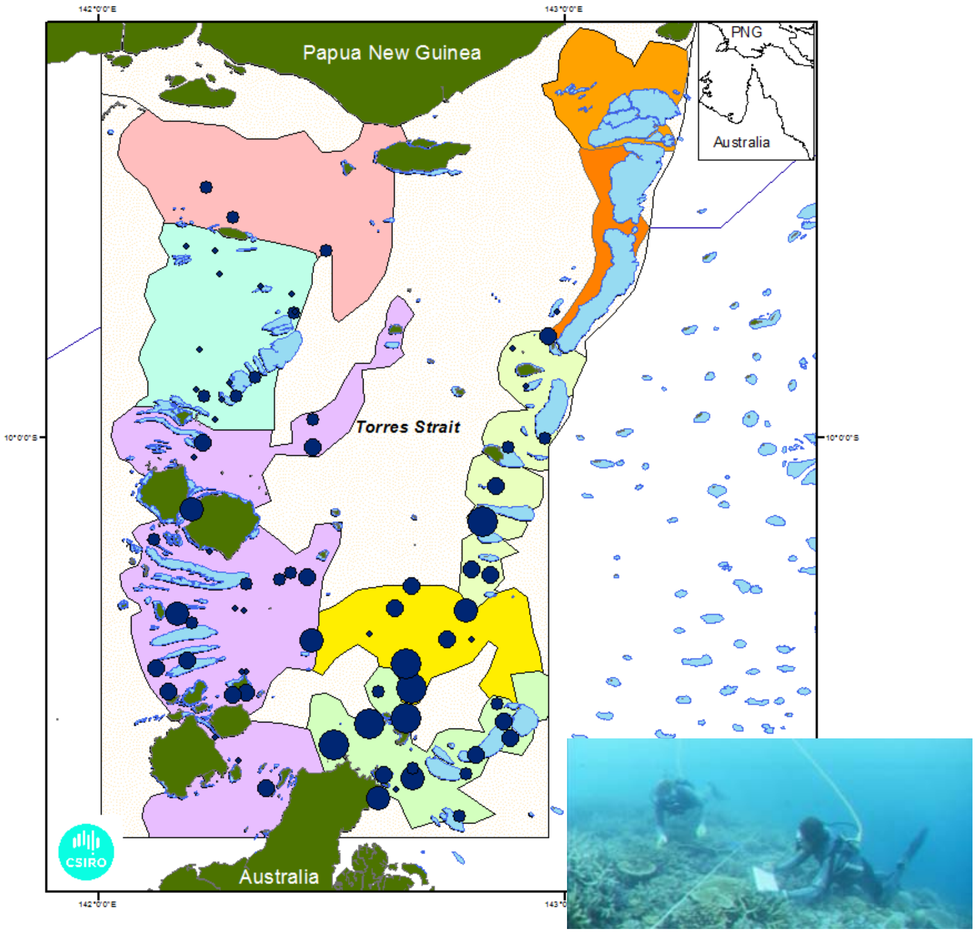


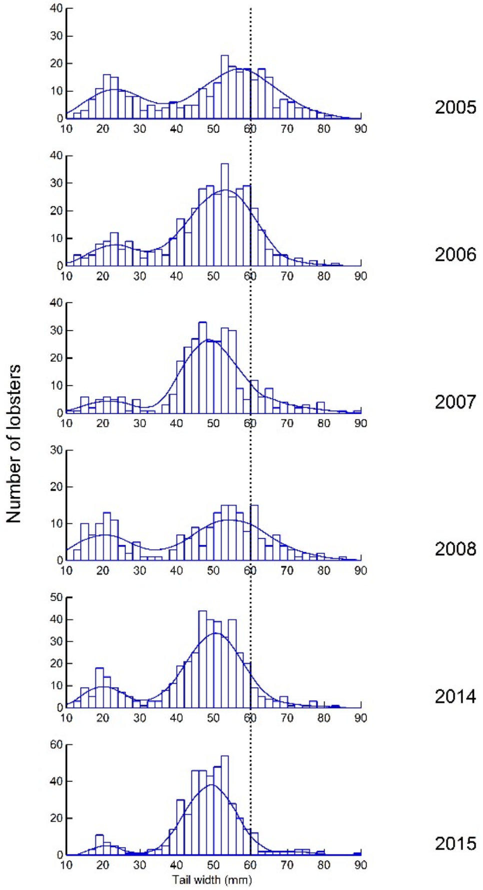
Sustainable catch = TAC
Lobster population
TIB
PNG
TVH
Average year
Good year
Bad year

(1) Harvest Strategy Indicators (Fishery data)

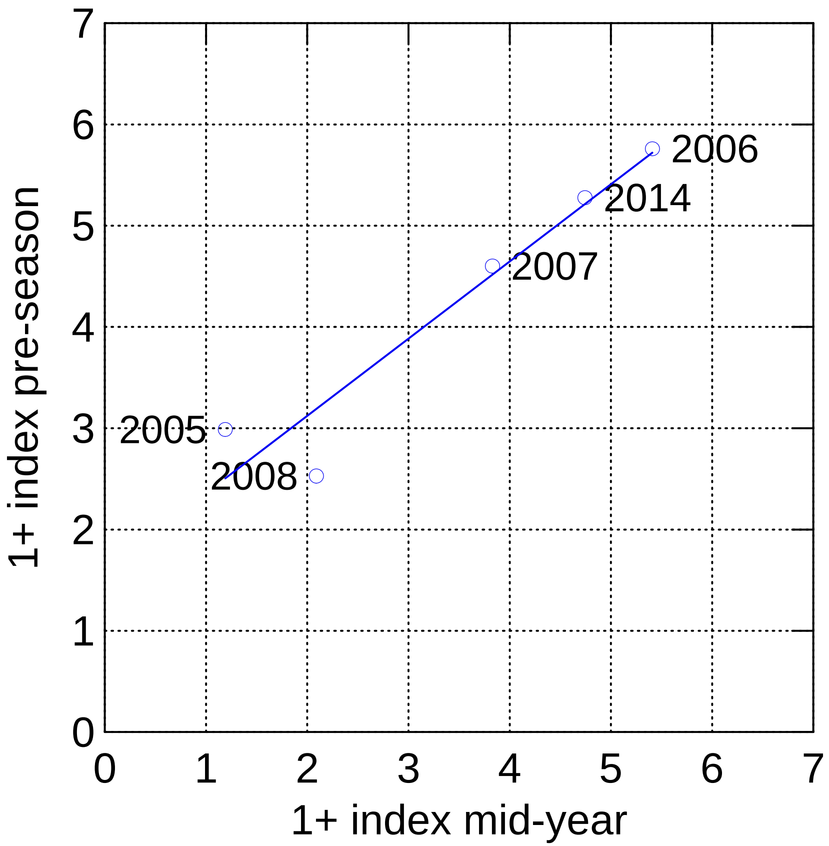
Year	Catch	TiB	TVH	PNG
2004	898	235	481	182
2005	1131	358	545	228
2006	430	152	135	142
2007	770	274	269	228
2008	538	217	100	221
2009	388	136	91	161
2010	766	191	283	293
2011	869	201	503	165
2012	713	169	370	174
2013	611	141	362	108
2014	682	148	273	261
2015	490	151	151	187

(2) Harvest Strategy Monitoring (Population surveys, Size/age monitoring)





(2) Harvest Strategy Monitoring (Population surveys, pre-season versus mid-year)

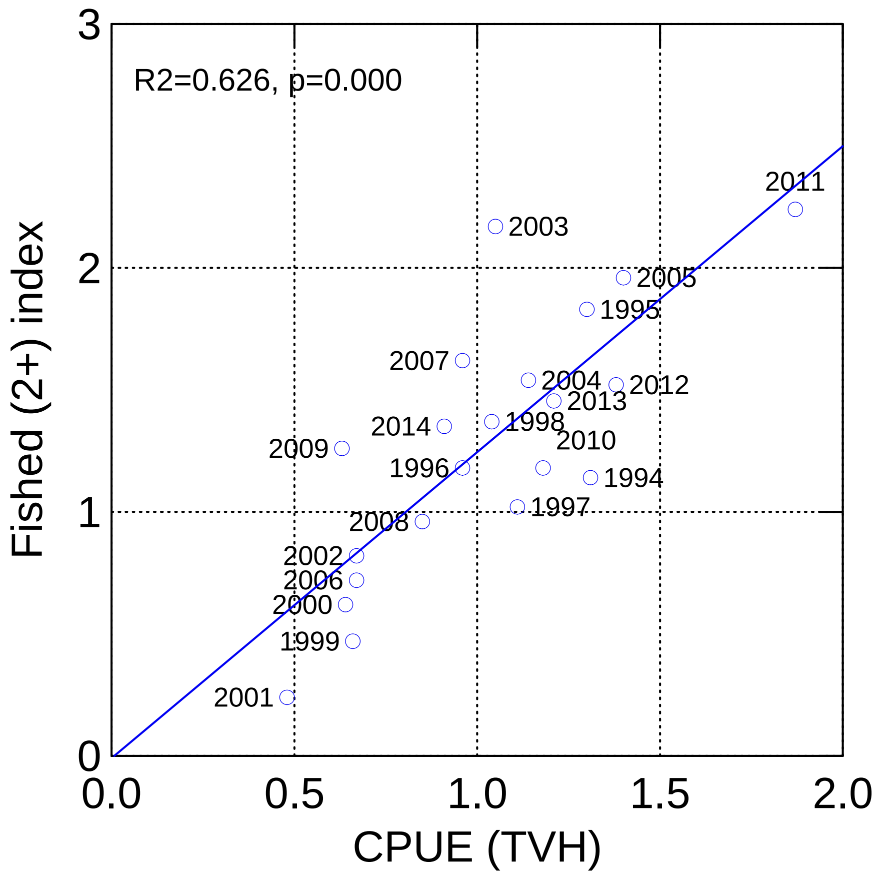


For the 5 years both mid-year and pre-season surveys were conducted the recruit (1+) indices were highly correlated (R^2=0.97)

This was anticipated given that the surveys were conducted only four months apart (June and November)

This relationship is important as mid-year surveys are phased out under future management

(2) Harvest Strategy Monitoring (Population surveys, CPUE data to replace mid-year 2+)

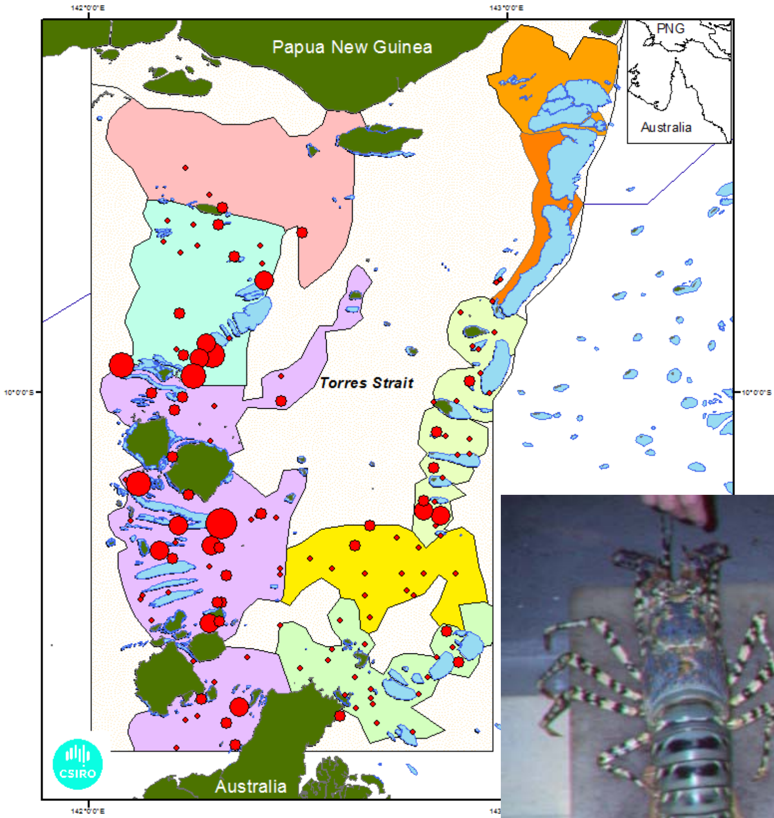


The relationship between mid-year survey 2+ and TVH CPUE (1994-2014) is also highly significant (p=0.000)

This provides confidence that for future stock assessments the CPUE data will be a reliable alternative for 2+ abundance and subsequently breeding stock abundance

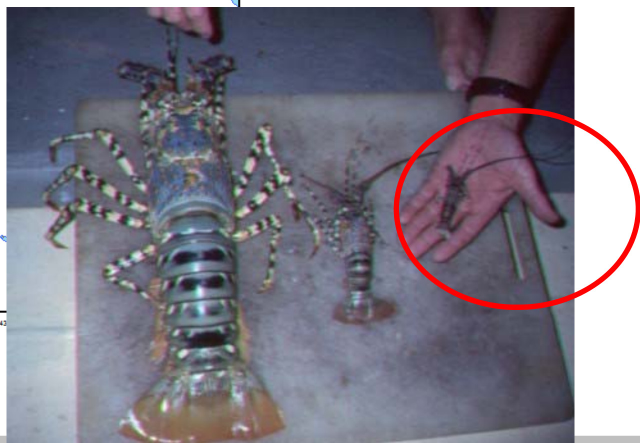
This assumes fisher behaviour will not markedly change

(2) Harvest Strategy Monitoring (Population surveys, 0+ indices from pre-season surveys)

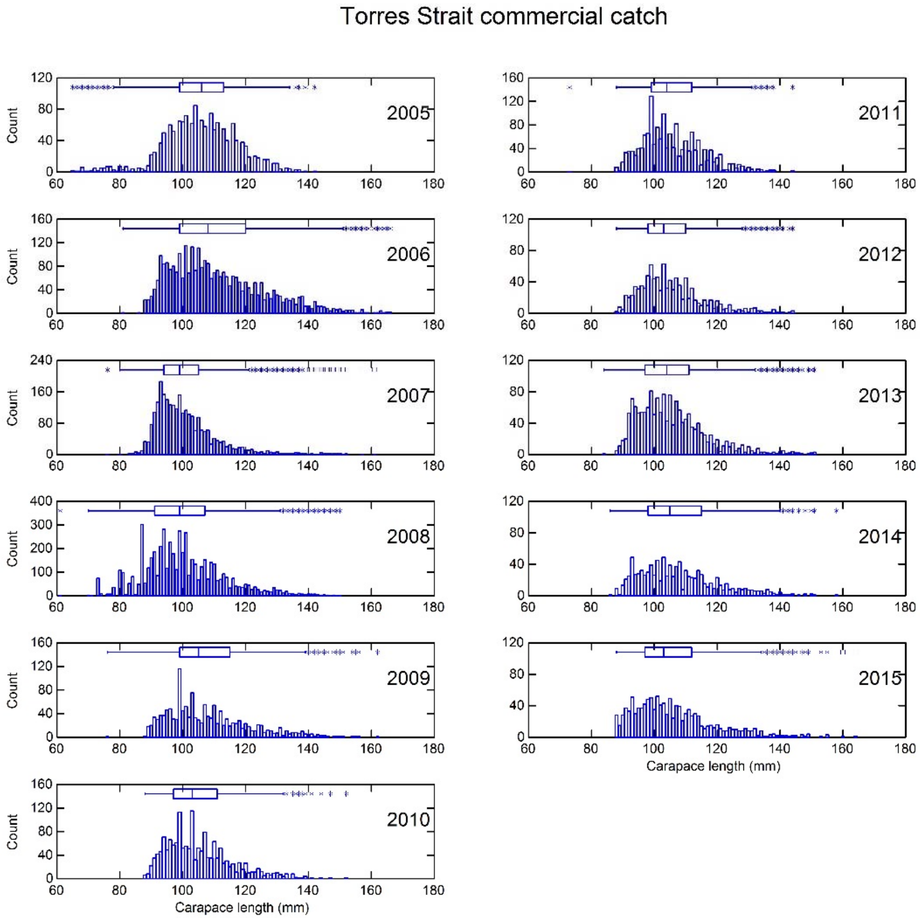


Pre-season surveys also provide indices of recently-settled (0+) lobster abundance

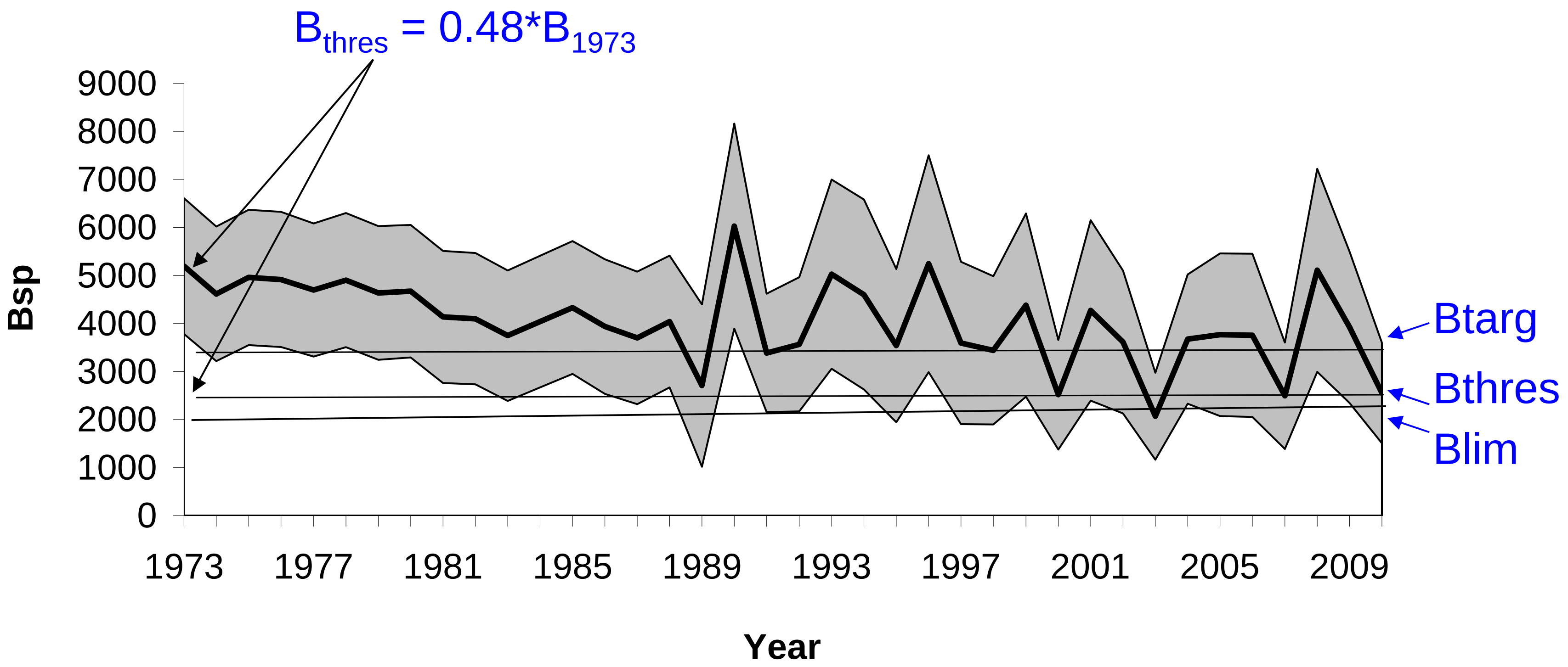
These indices may allow early forecasts of recruit and stock abundance as per puerulus collection programs for southern and WA rock lobsters



(2) Harvest Strategy Monitoring (Size/age monitoring)

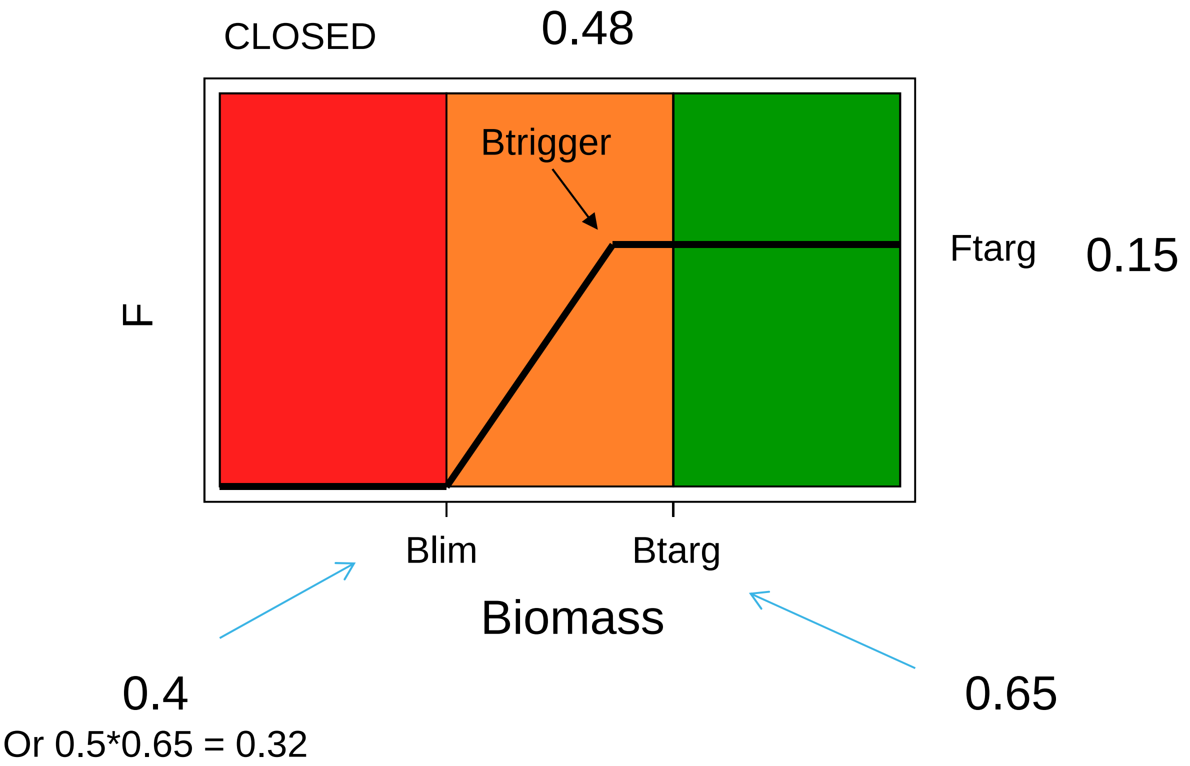


(3) Harvest Strategy Reference points (targets and limits)



Spawning Biomass trajectory with Hessian-based 90% Confidence Interval

Interim Harvest Control Rule for TS lobster



(3) Harvest Strategy Reference points (targets and limits)

B_{lim} (0.2$S_{0;}$ 0.5Bmsy) =0.4Bsp(0)

B_{targ} – Biomass level corresponding to F_{targ} =0.65Bsp(0)

F_{targ} – model dependent =0.15

$B_{threshold}$ /$B_{trigger}$ - Biomass level below which more stringent rules for calculating TAC are applied =0.48Bsp(0)

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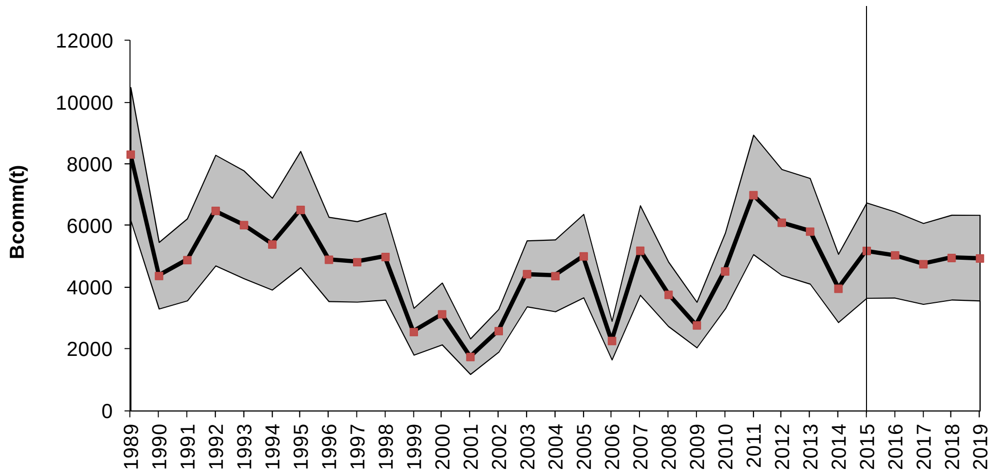
(4) Harvest Strategy Assessment Method (Stock assessment & CPUE standardisation)

Age Structured Production Model (ASPMs) / Statistical Catch-at-Age Analysis (SCAA); widely used approach

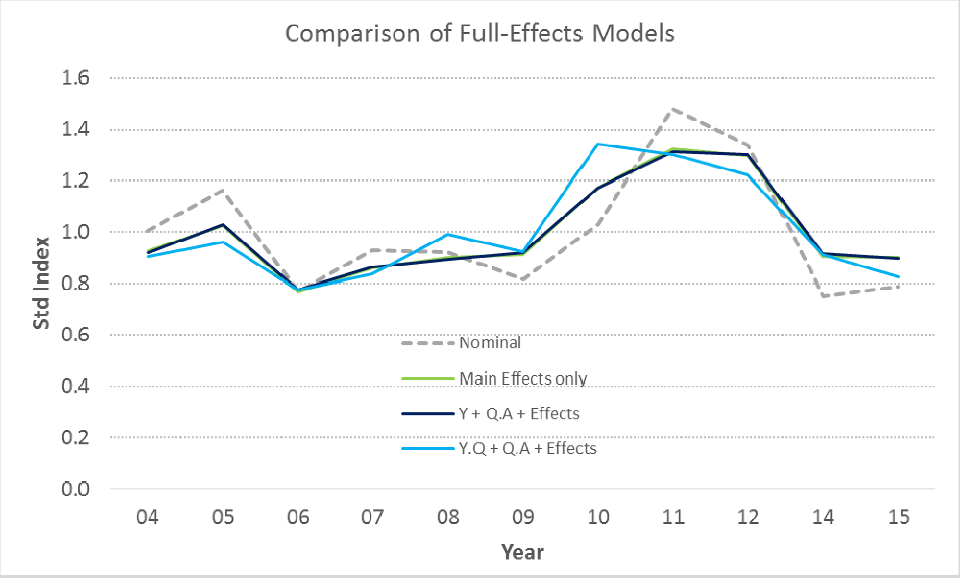
Outputs a recommended biological catch (with Confidence Interval)

Integrates all available survey & catch data (Mid-year survey data 1989-2014, Catch statistics, Length frequency data, Pre-season survey data (2005-2008, 2014, 2015), CPUE data (TiB & TVH), Historic information

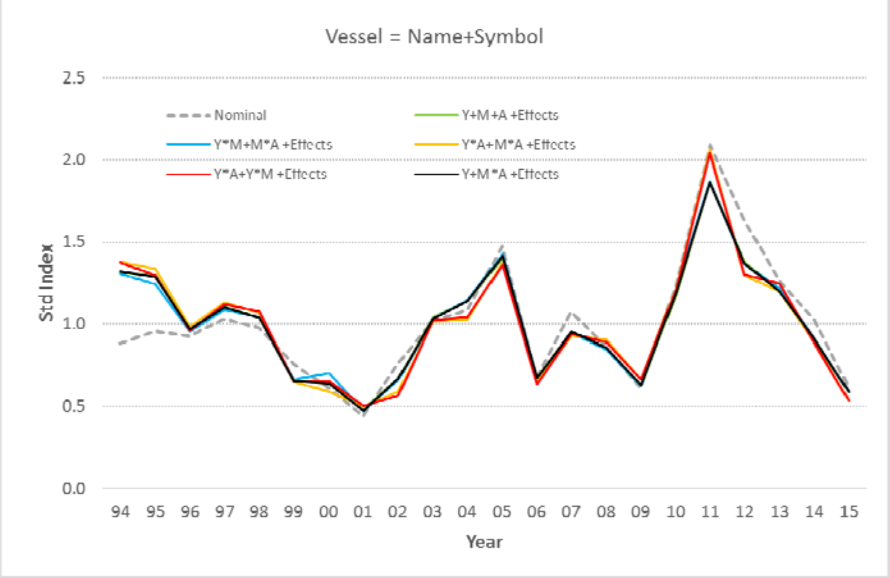


(4) Harvest Strategy Assessment Method (Stock assessment & CPUE standardisation)

TiB Sector



TVH Sector



(5) Harvest Control Rules (HCR)

Traditional Approach

• Model analyses fishery data and assesses current status and productivity of the resource

•"**Best assessment**" provides RBC (Recommended Biological Catch)

• Reference-point HCR informs TAC recommendation and management action

HCR Approach

• A **formula** for recommending the TAC, based on pre-specified data inputs

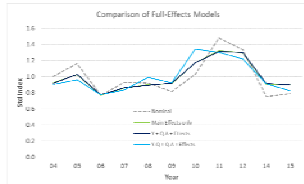
•**Empirical**, uses the data directly e.g recent upward or downward trends in abundance indices used directly as feedback ⇒ TAC changes in the same direction

•Tested by **simulation** to provide appropriate trade-offs, taking into account range of uncertainties

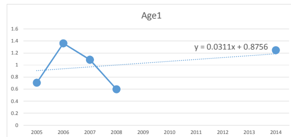
How do we develop an empirical HCR?

1. **Management Objectives** – what are we trying to achieve?

2. **Data inputs** - Decide what data will be used and available in time for input to HCR formula each year: Need Catch, CPUE (TVH), CPUE (TIB) and Preseason survey data (0+, 1+) before end November



3. **Alternative Rules/Formulae = HCR candidates** - Consider some different ways of using trends/updates in some or all of these data to adjust the RBC upwards or downwards



4. **Simulation testing using Operating Model (OM)** – How well do different HCR candidates perform in terms of meeting objectives: quantify using **Performance Statistics** to show trade-offs, risk to resource, average RBC

(RBC = Recommended Biological catch)

How do we develop an empirical HCR cont?

5. **Stakeholder feedback** – key performance measures, preferred trade-offs, tuning to achieve objectives, action needed to avoid penalties (eg if insufficient data) or want a bonus (eg do more surveys, increase precision and accuracy of data inputs)

6. **Final HCR or set of candidate HCRs** – Additional tuning to optimise performance, and test robustness using a range of tests

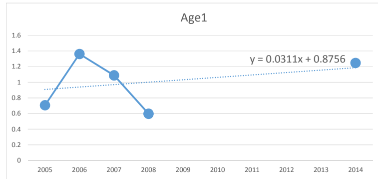
$$TAC_y = \lambda \cdot \left(1 + s_y^{surv}\right) \cdot \bar{C}_{05\_08}$$

7. **Agreement re HCR formula to apply** – Use formula to recommend TAC once Preseason survey data available (unless there are exceptional circumstances)

8. **Stock assessment every 3 years** – Comprehensive check on resource – is recalibration of HCR needed?

Simple example…

All data collected, checked and analysed
Preseason 1+ numbers are 10% greater than previous average



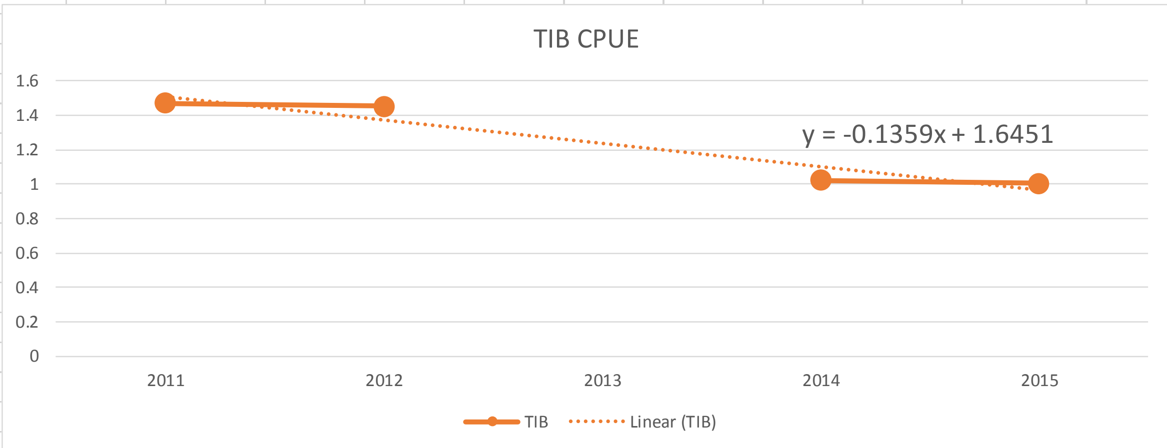
HCR: TAC = (1+p) * Average Catch
TAC = (1+0.1) * 680 = 748 t

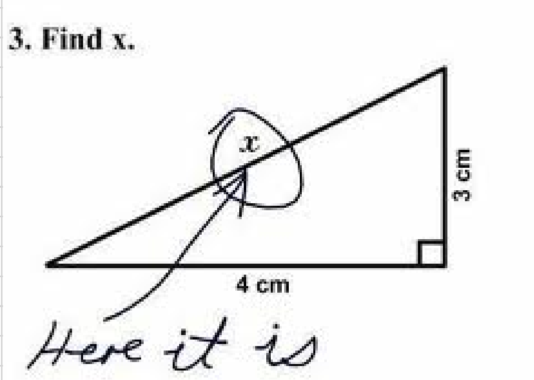
Using this rule, we pre-tested that average catches and catch rates would be reasonably high, inter-annual variability acceptable and low risk of depletion of lobster population

After 3 years, we conduct a stock assessment as a double -check, e.g. if the resource has dropped below the target level, adjust the HCR so that it ensures some rebuilding over the next 3 years

Anyone can do the maths and use the final formula!

EXCEL SPREADSHEET CALCULATIONS											
			wts	0.15	0.15					0.6	0.1
	TVH		TIB	slopeTVH	slopeTIB		Age1		Age0	slope_pre1	slope_pre0
2005	1.468256	2005	1.150579			2005	0.706113	2005	1.716919		
2006	0.701436	2006	0.86629			2006	1.361401	2006	0.541224		
2007	0.990124	2007	0.96345			2007	1.087655	2007	0.813392		
2008	0.888407	2008	0.997269			2008	0.597608	2008	0.926754		
2009	0.652056	2009	1.028565	-0.1445	-0.0113	2009		2009			
2010	1.233647	2010	1.311098	0.0726	0.0955	2010		2010			
2011	1.931844	2011	1.468828	-0.0113	0.1325	2011		2011			
2012	1.425147	2012	1.453196	0.2353	0.1352	2012		2012			
2013	1.243556	2013		0.1375	0.1432	2013		2013			
2014	0.951777	2014	1.022412	-0.1252	-0.0837	2014	1.247222	2014	1.061155	0.0311	-0.0136
2015	0.615251	2015	1.004475	0.3107	-0.1359	2015	1.589523	2015	0.940556	0.0433	0.0356

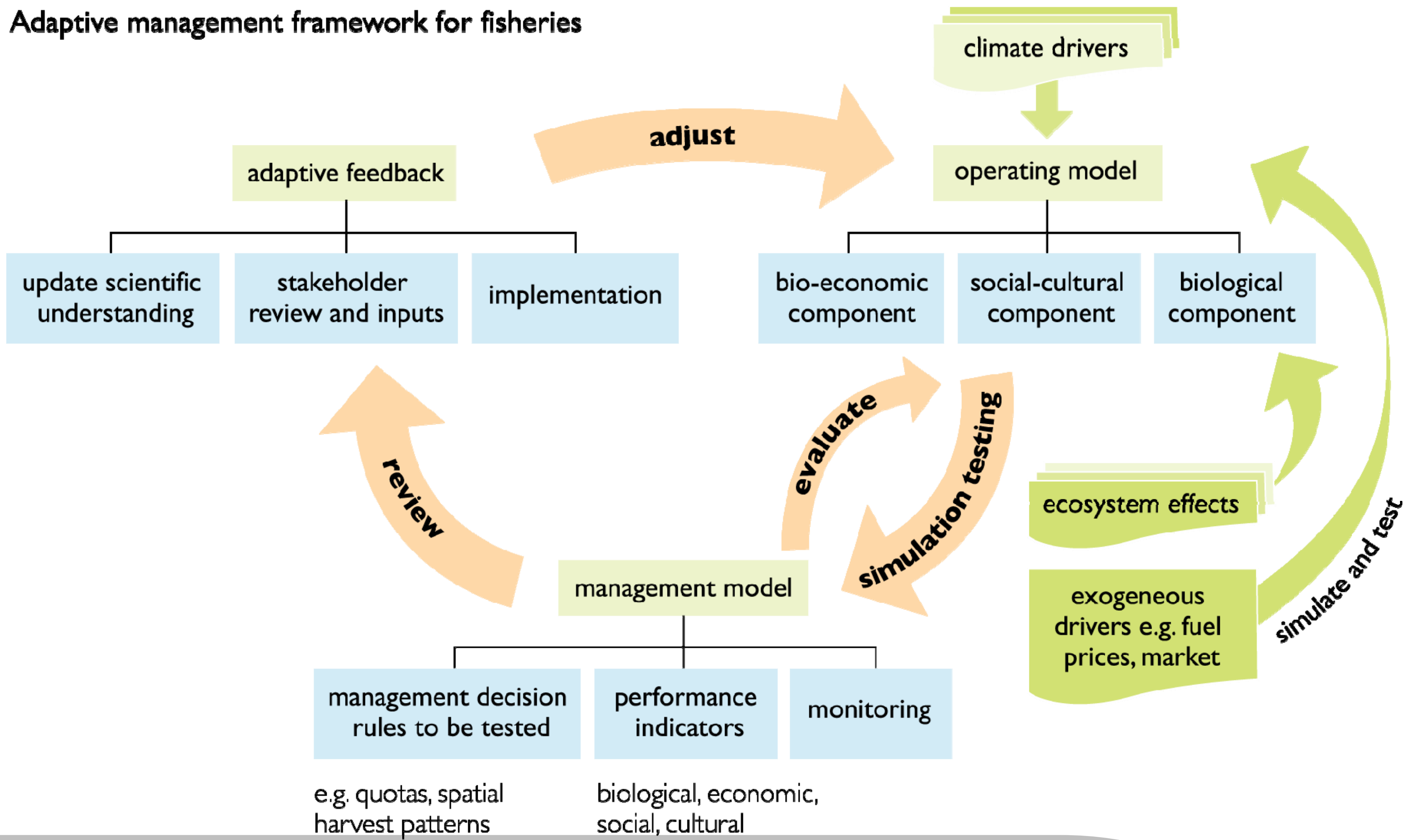




Ocular Trauma - by Wade Clarke ©2005

MSE approach

MSE = Management Strategy Evaluation



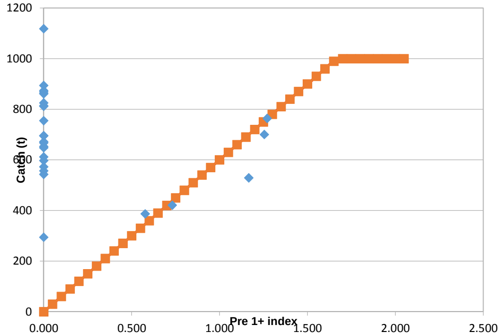
Harvest Control Rule - Data

The HCR is applied after the pre-season survey (November) to set TAC for the following year

HCR data includes:
Pre-season survey indices (0+ & 1+)
Total catches (or alternatively use TAC if data not available)
CPUE TIB indices
CPUE TVH indices

Could also include other survey data (eg midyear survey/industry surveys/size structure data)

HCR Alternative Candidates



1. Constant Catch (e.g. 400t/yr)

$$TAC_y = \bar{C}$$

2. Simple slope

$$TAC_y = \mu \cdot \left(\lambda^{pre1} \cdot I_y^{pre1} \Big/ I^{pre1} + (1-\lambda^{pre1}) \cdot I_y^{pre0} \Big/ I^{pre0} \right)$$

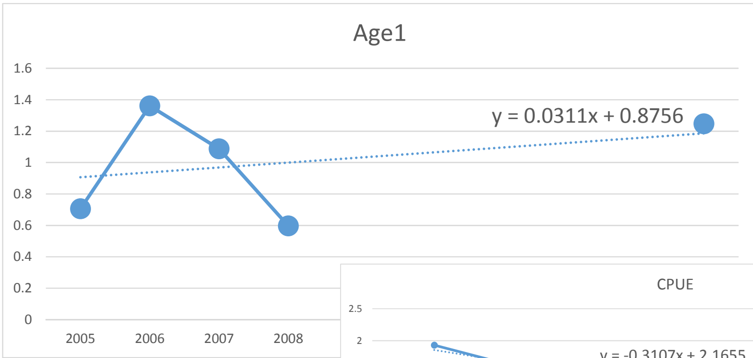
3. Regression slope

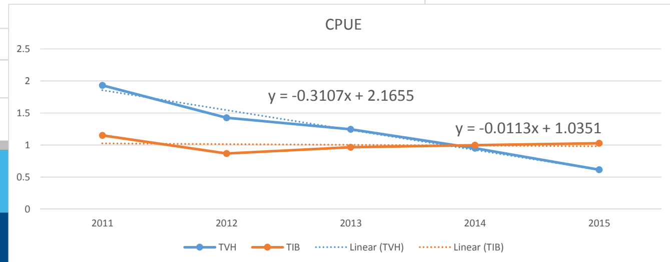
$$TAC_y = \lambda \cdot \left(1 + s_y^{surv}\right) \cdot \bar{C}_{y-4,y} + (1-\lambda) \cdot \left(1 + s_y^{CPUE}\right) \cdot \bar{C}_{y-4,y}$$

4. Log regression slope

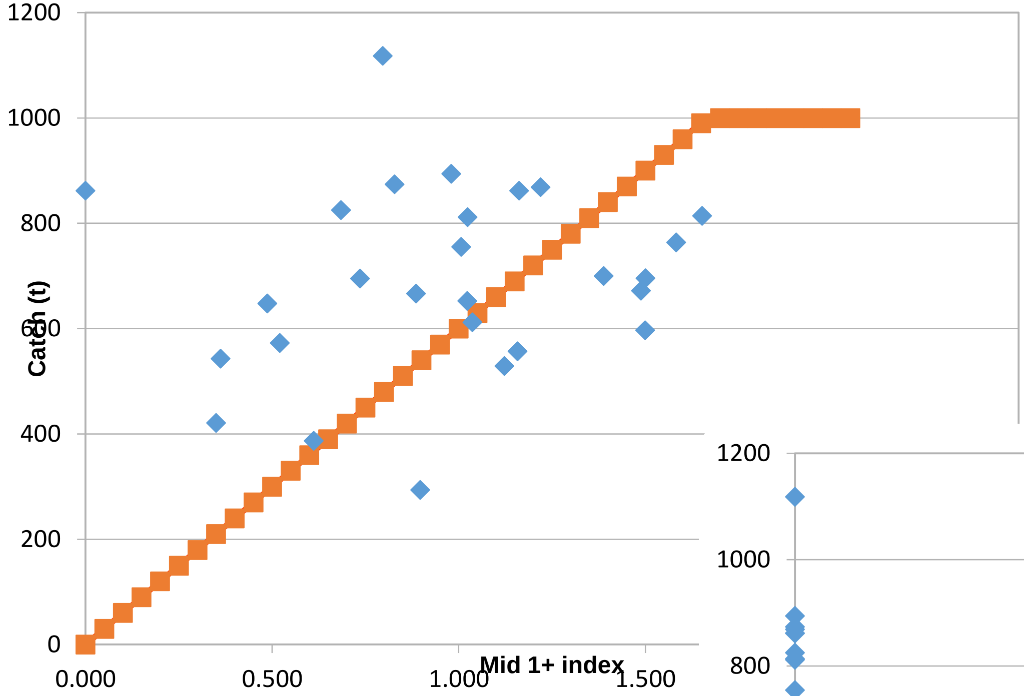
5. Add constraints (limit on upper and lower levels/changes)

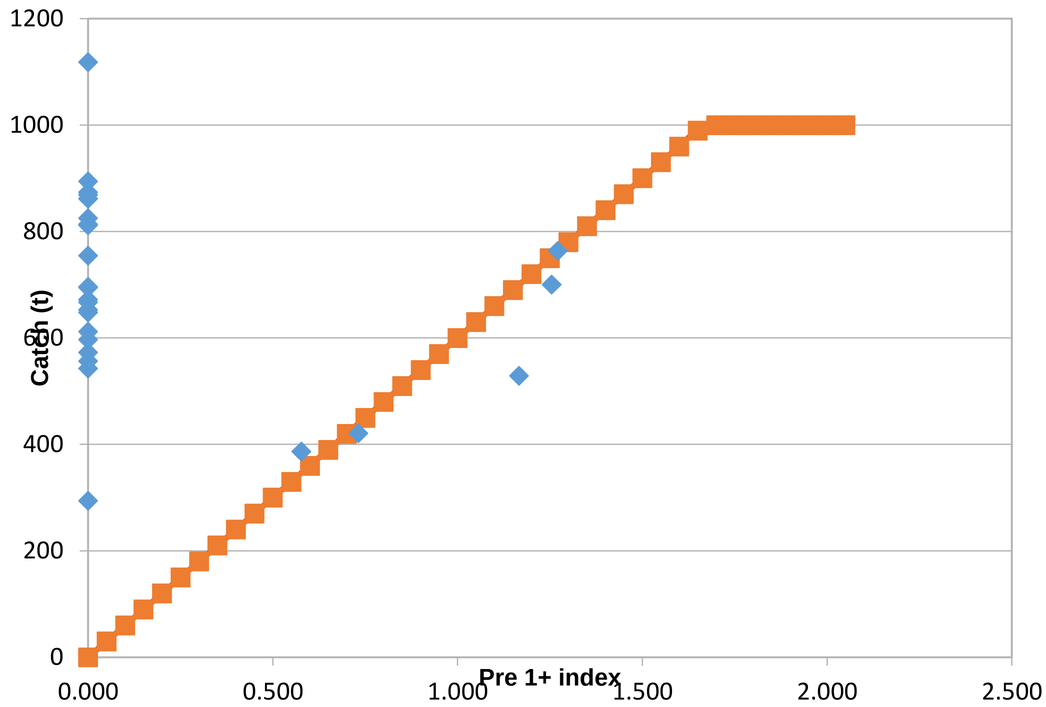
6. Add empirical reference points





SIMPLE SLOPE RULE





Rule	Slope	600
	Max	1000

HCR Regression slope

$$TAC_y = \lambda \cdot \left(1 + s_y^{surv}\right) \cdot \bar{C}_{y-4,y} + (1-\lambda) \cdot \left(1 + s_y^{CPUE}\right) \cdot \bar{C}_{y-4,y}$$

TACy is the total TAC recommended for year *y*,

$C_{y-4,y}$ is the average achieved catch during the past 5 years, i.e. from year y-4 to year y,

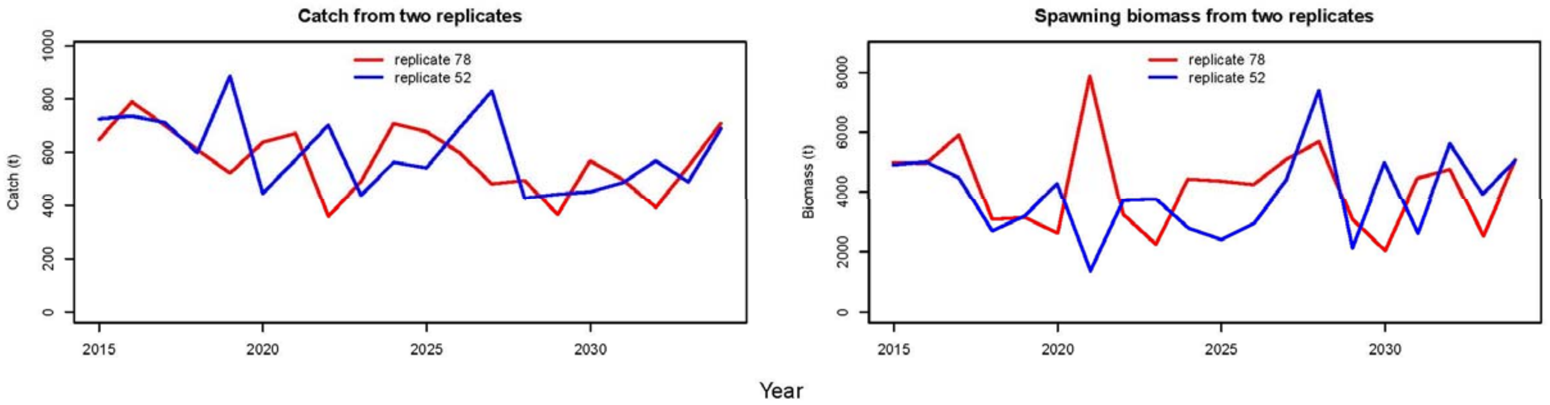
λ is a tuning parameter that assigns weight to the pre-season trend compared with the CPUE trends, preliminary value is 0.7,

S^{surv} is a measure of the past trend in the preseason survey abundance index as available to use for calculations for year *y*, and including the original 4 survey years, and

S^{CPUE} is the average of the recent past trend in both the TVH and TIB CPUE abundance index as available to use for calculations for year *y*.

Operating Model

- Stock assessment model
- Explore uncertainties re model specification and fit to data
- Generate "future" survey and CPUE data, with observation error added
- Use same random numbers to test every candidate HCR



Generate 100 replicates = plausible future trajectories

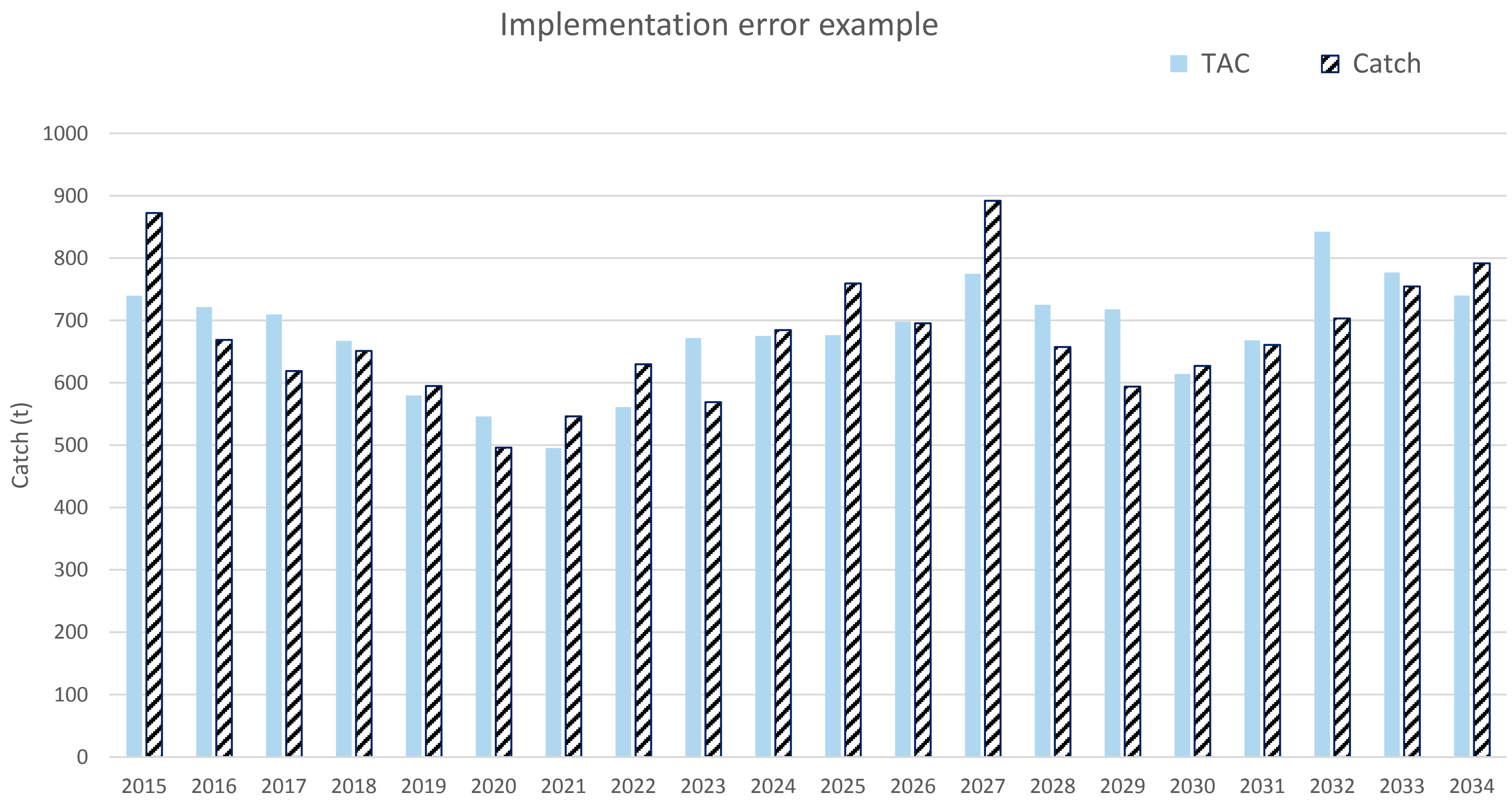
Quantifying Uncertainty

Several types of Uncertainty:

- **Process uncertainty** (e.g. recruitment variability, stock-recruit relationship, natural mortality)
- **Observation uncertainty** (e.g. surveys, measured by CVs* for abundance estimates).
- **Model uncertainty** (do alternative models fit the data adequately?)
- **Estimation uncertainty** – given a model and some data, how well do the data determine the parameters (and predictions) of the model
- **Implementation uncertainty** – given a management decision, how well is it enforced or implemented?

CV = Coefficient of Variation = Std Deviation/Mean

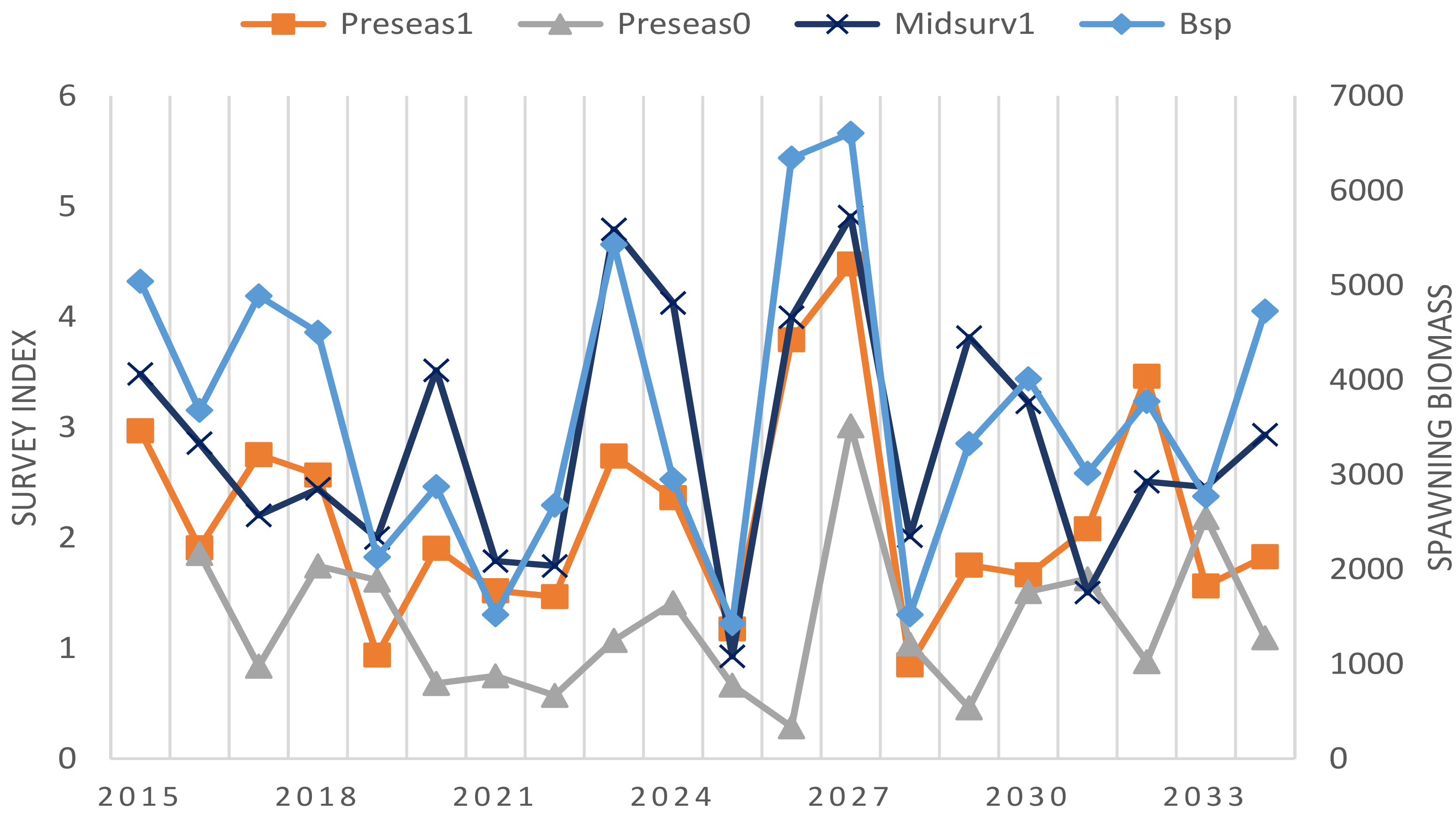
Implementation uncertainty



Random example from single realisation

Observation Uncertainty

1 realisation



Evaluating a candidate HCR

- Project the biomass forward under the catch prescribed by the candidate HCR
- At the end of a 20 year period, assess the simulated performance using **Performance Statistics**

Simulated projections:

- Multiple independent replicate projections (100) to account for at least some stochastic effects:
  - Observation errors (e.g. noise in CPUE and survey abundance indices)
  - Process errors (e.g. variation in recruitment about the value expected from the stock-recruit relationship)
  - Levels of variation for these errors set to values estimated to have applied in the past.

Performance Statistics

Resource status-related

- $B^{sp}_{2034} / B^{sp}_{2015}$ the expected median spawning biomass at the end of the projection period, relative to the current 2015 level.
- $B^{sp}_{2034} / B^{sp}_{1973}$ the expected median spawning biomass at the end of the projection period, relative to the starting (1973) level (used as a proxy for K).
- Risk of depletion: percentage of all individual runs that ended below (a) 20% and (b) 40% of K.

Tuned to target level; avoid Blim

How much risk is okay?

Utilisation-related

- Average catch: $\overline{C} = \frac{1}{20}\sum C_y$ over 2015 to 2034.
- Catch variability $\frac{1}{20}\sum C_y / \overline{C}$
- Implementation error – difference between TAC and actual catch over the projection period

Average / target level

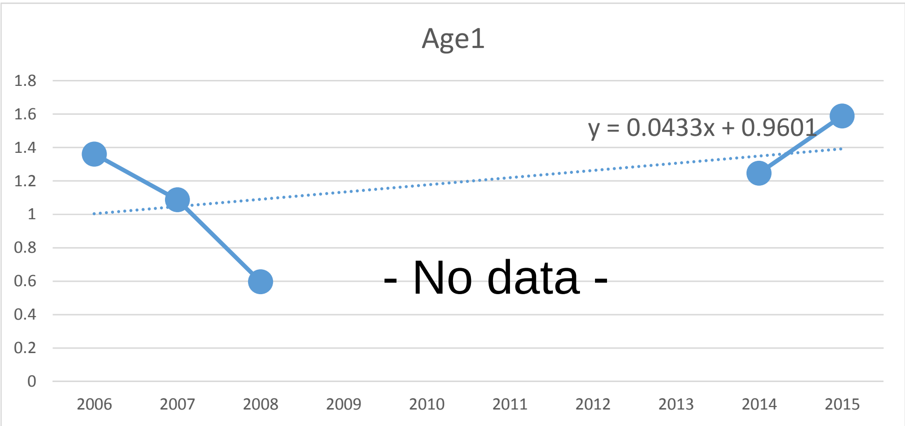
How variable?

Other examples also provided for stakeholder input and consideration

HCR regression slope example using both preseason survey indices and CPUE indices

Weights relative to reliability and relevance of different indices

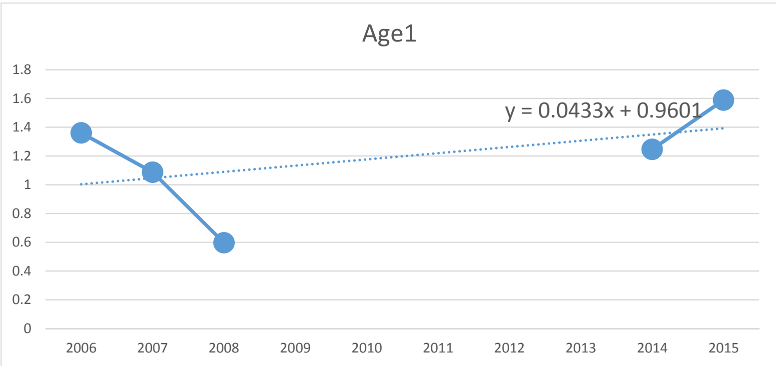
$$TAC_y = 0.6 \cdot \left(1 + s_y^{presurv,1}\right) \cdot \bar{C}_{y-4,y} + 0.1 \cdot \left(1 + s_y^{presurv,0}\right) \cdot \bar{C}_{y-4,y}$$
$$+ 0.15 \cdot \left(1 + s_y^{CPUE,TVH}\right) \cdot \bar{C}_{y-4,y} + 0.15 \cdot \left(1 + s_y^{CPUE,TIB}\right) \cdot \bar{C}_{y-4,y}$$

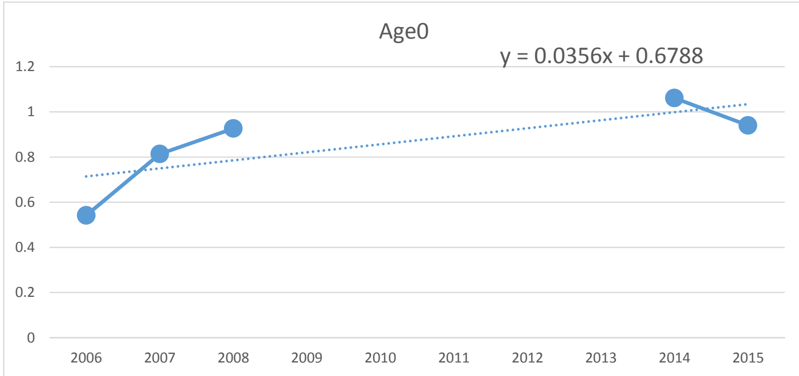


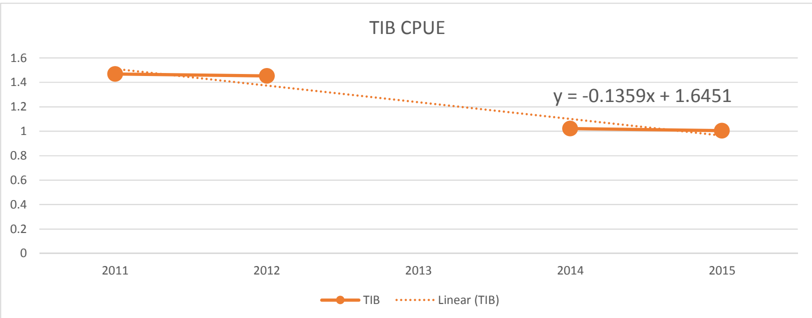
HCR regression slope example using both preseason survey indices and CPUE indices

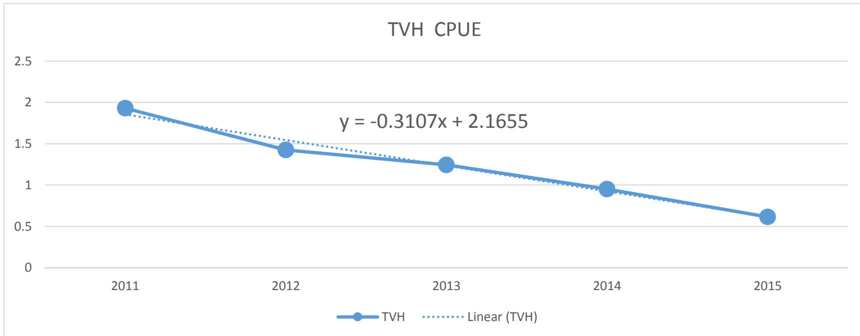
$$TAC_y = 0.6 \cdot \left(1 + s_y^{presurv,1}\right) \cdot \bar{C}_{y-4,y} + 0.1 \cdot \left(1 + s_y^{presurv,0}\right) \cdot \bar{C}_{y-4,y} + 0.15 \cdot \left(1 + s_y^{CPUE,TVH}\right) \cdot \bar{C}_{y-4,y} + 0.15 \cdot \left(1 + s_y^{CPUE,TIB}\right) \cdot \bar{C}_{y-4,y}$$

TAC (2016) = 756 t







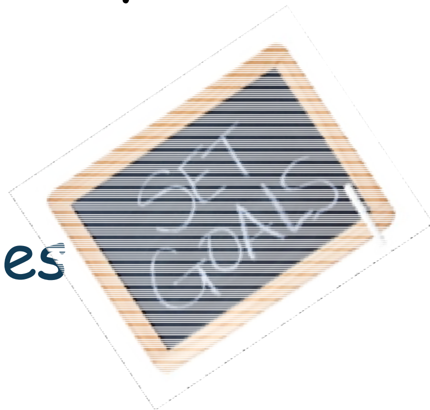


Comparing Performance Statistics

- Key variables
- Biomass
- Catch and AAV (Annual average variability)
- Risk

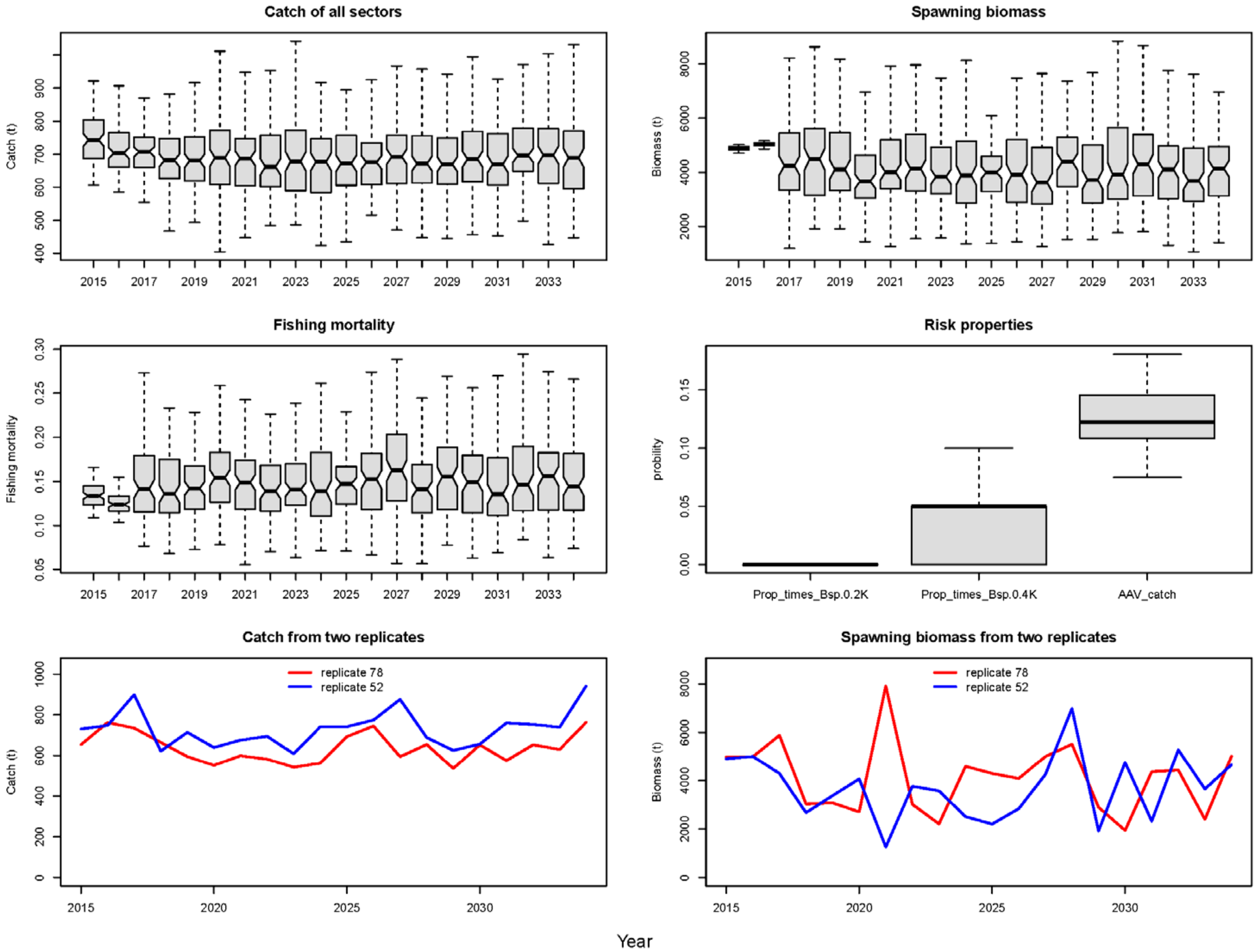
Results:

- Medians of 100 stochastic replicates
- 90th and 10th percentiles
- Range of values
- Average and trend over years

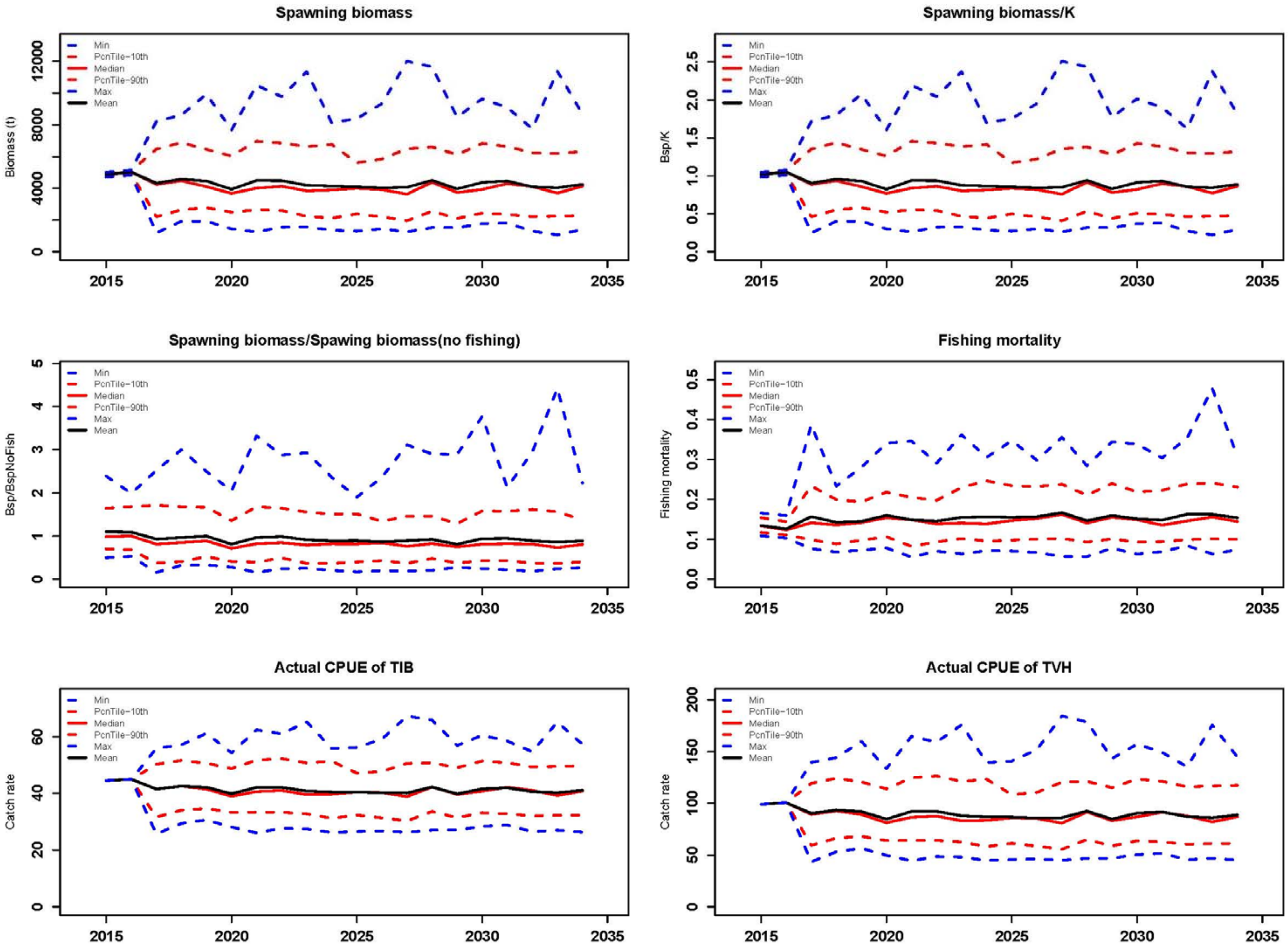


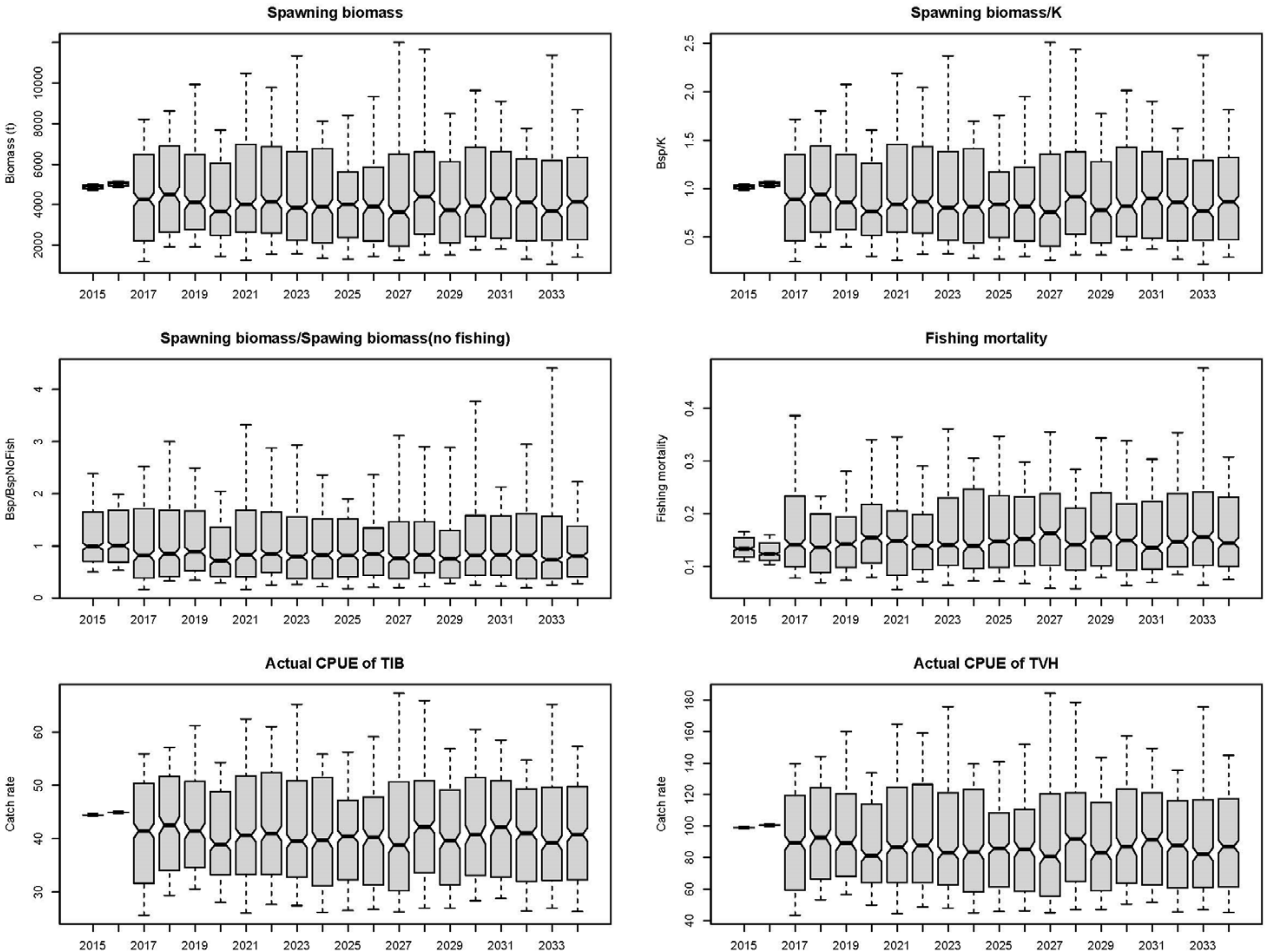
Robustness tests – your inputs needed

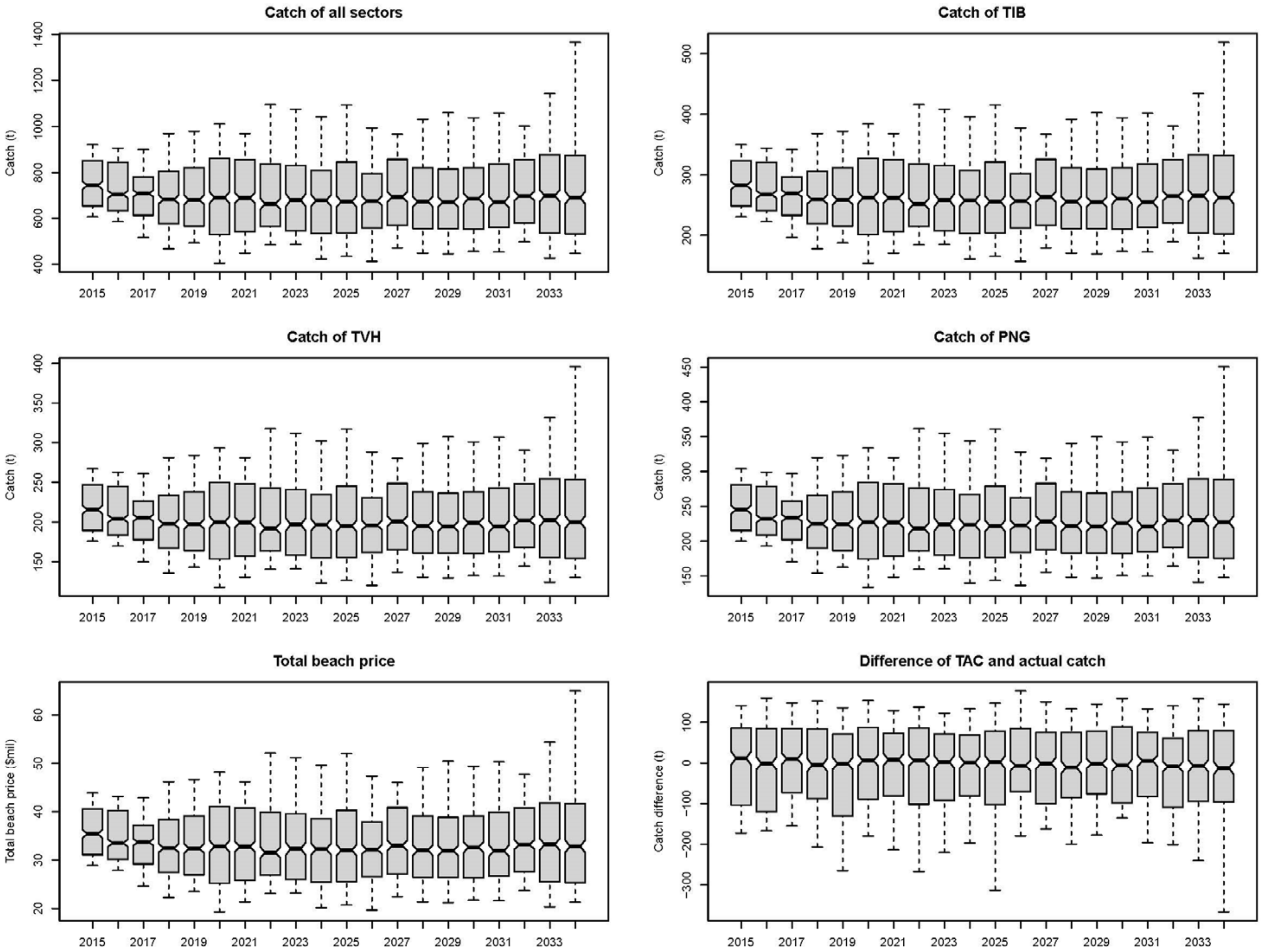
Results
Regression slope example; log of slopes; all indices (pre1+, pre0+, CPUE_TVH, CPUE_TIB) with default weightings (0.6, 0.1, 0.15,0.15); implementation error 5%

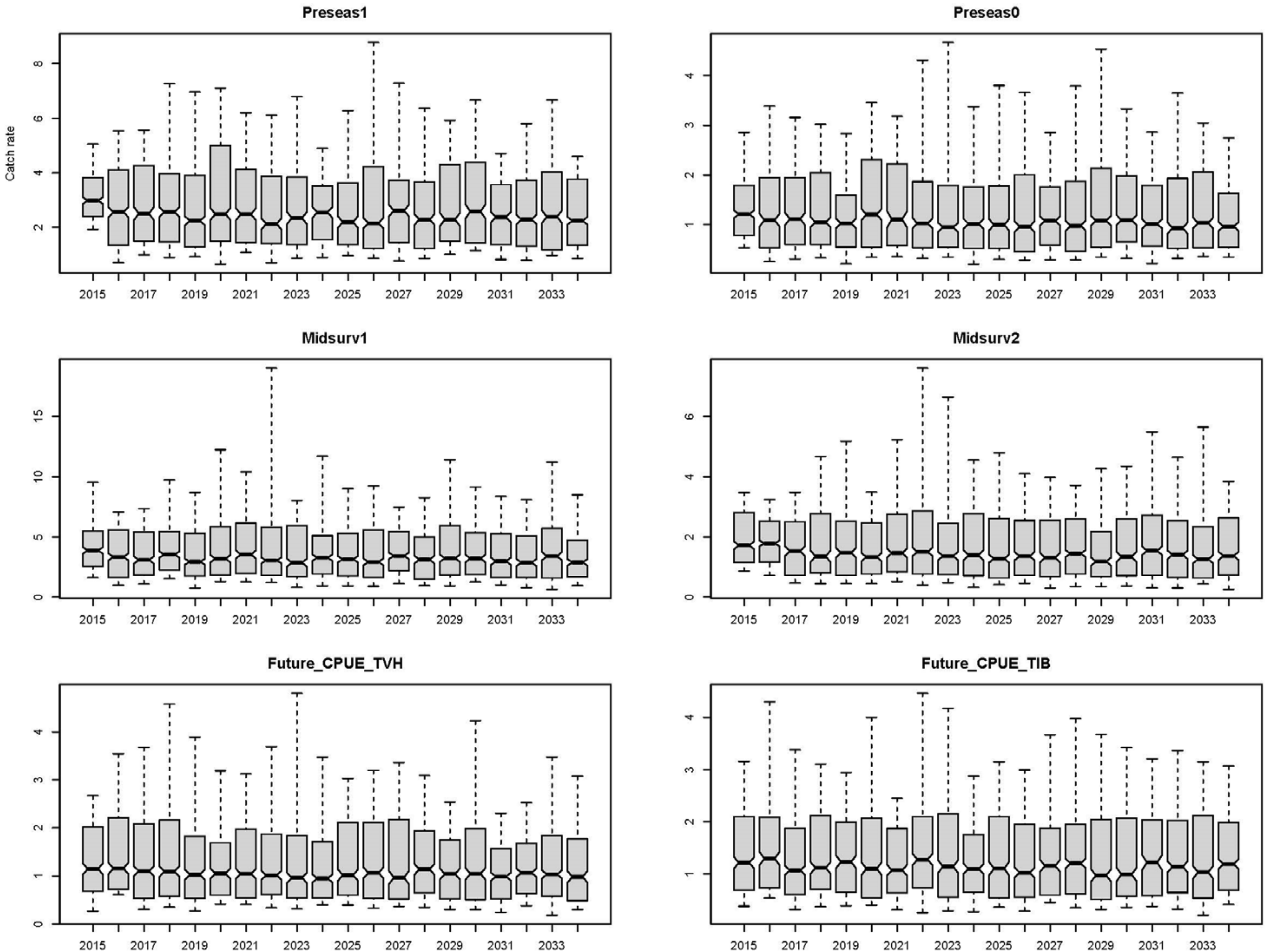


Catch of all sectors
Catch (t)
400
500
600
700
800
900
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Spawning biomass
Biomass (t)
2000
4000
6000
8000
Fishing mortality
Fishing mortality
0.05
0.10
0.15
0.20
0.25
0.30
Risk properties
probility
0.00
0.05
0.10
0.15
Prop_times_Bsp.0.2K
Prop_times_Bsp.0.4K
AAV_catch
Catch from two replicates
replicate 78
replicate 52
Catch (t)
0
200
400
600
800
1000
2015
2020
2025
2030
Spawning biomass from two replicates
replicate 78
replicate 52
Biomass (t)
0
2000
4000
6000
8000
Year

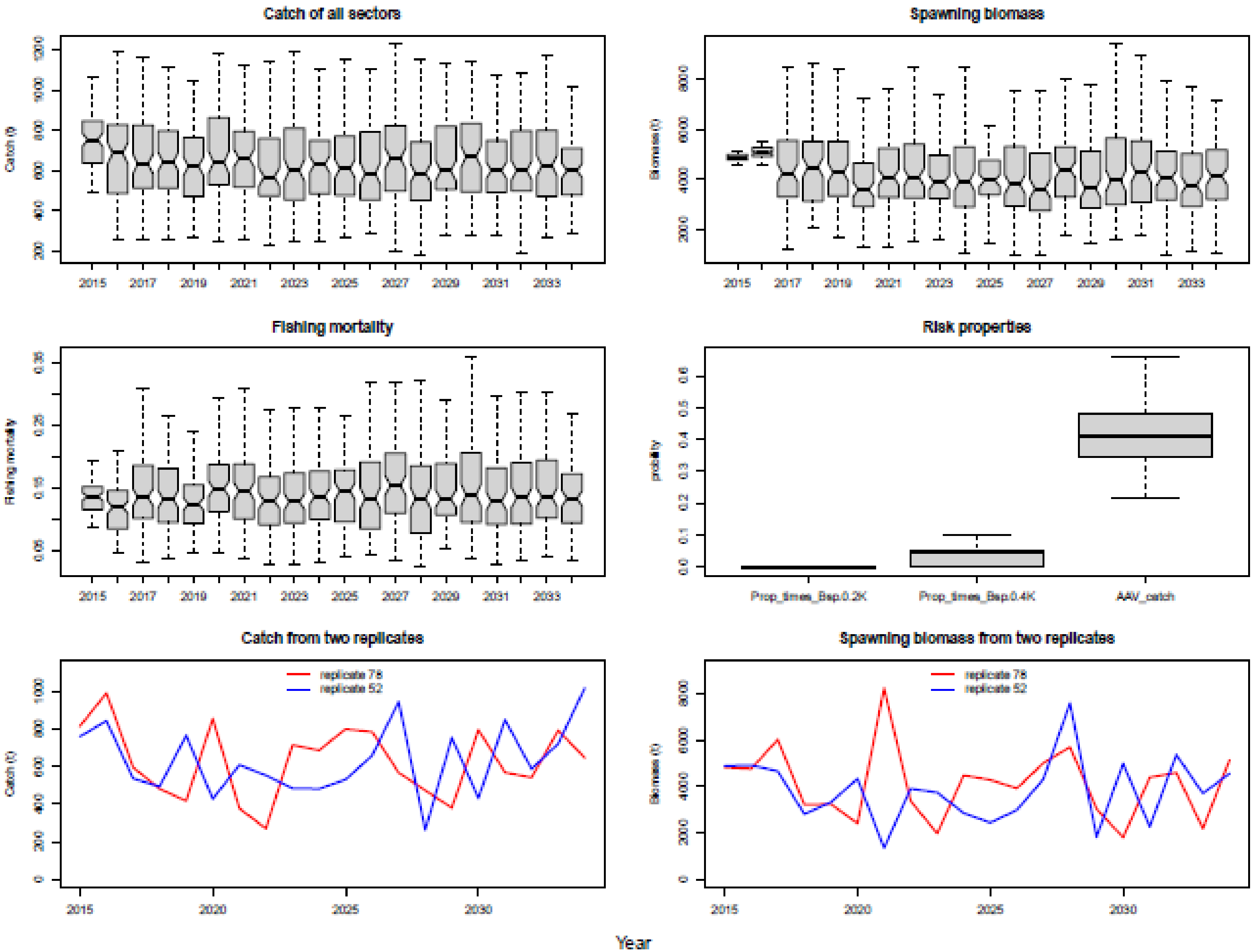

Spawning biomass
Biomass (t)
Spawning biomass/K
Bsp/K
Spawning biomass/Spawing biomass(no fishing)
Bsp/BspNoFish
Fishing mortality
Fishing mortality
Actual CPUE of TIB
Catch rate
Actual CPUE of TVH
Catch rate
Min
PcnTile-10th
Median
PcnTile-90th
Max
Mean
2015
2020
2025
2030
2035

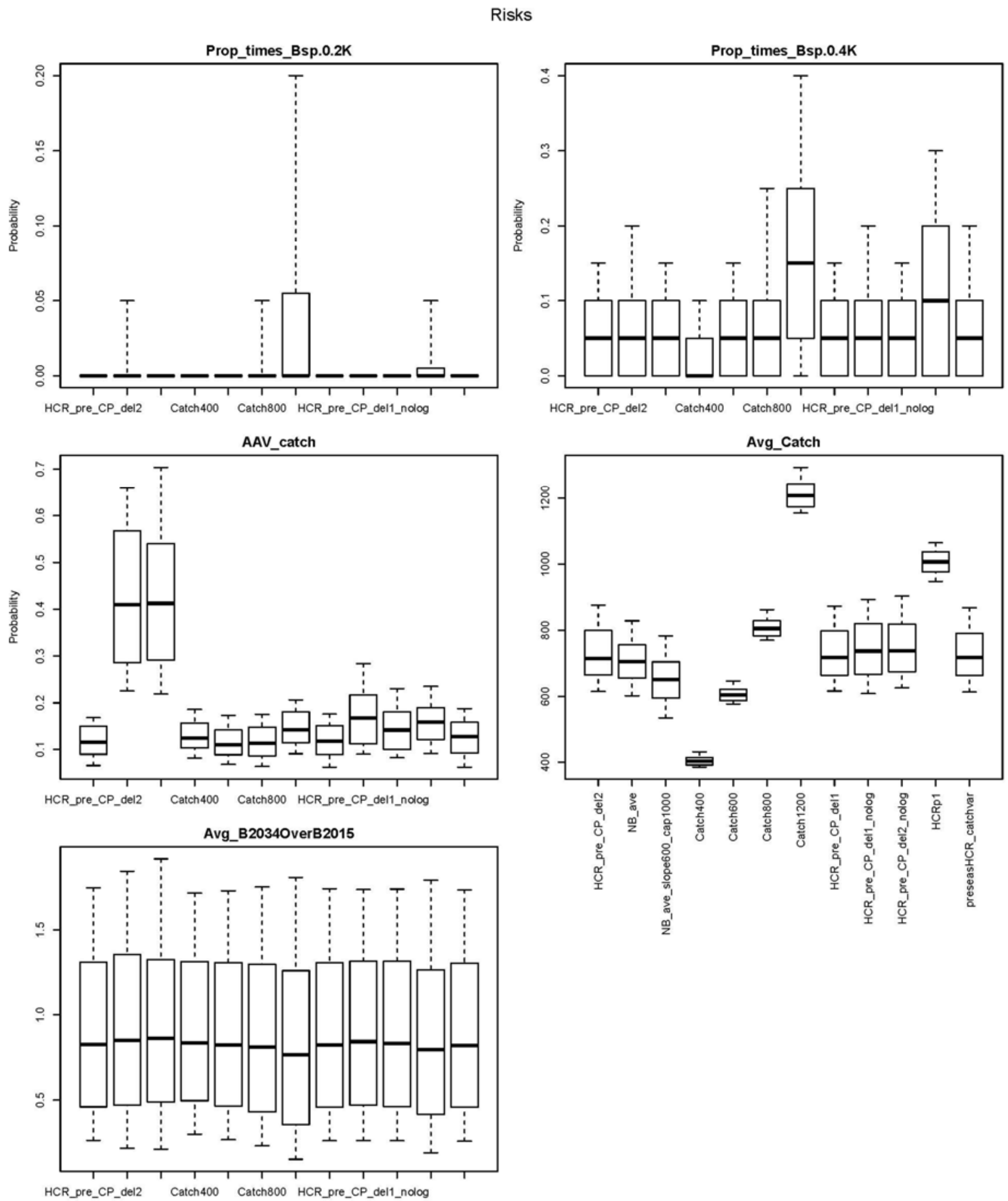

Spawning biomass
Biomass (t)
Spawning biomass/K
Bsp/K
Spawning biomass/Spawing biomass(no fishing)
Bsp/BspNoFish
Fishing mortality
Fishing mortality
Actual CPUE of TIB
Catch rate
Actual CPUE of TVH
Catch rate
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033

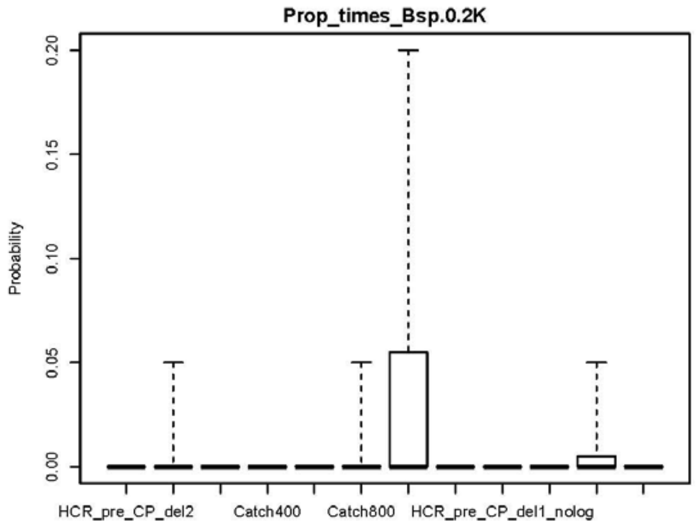

Catch of all sectors
Catch (t)
400
600
800
1000
1200
1400
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Catch of TIB
Catch (t)
200
300
400
500
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Catch of TVH
Catch (t)
150
200
250
300
350
400
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Catch of PNG
Catch (t)
150
200
250
300
350
400
450
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Total beach price
Total beach price ($mil)
20
30
40
50
60
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Difference of TAC and actual catch
Catch difference (t)
-300
-200
-100
0
100
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033

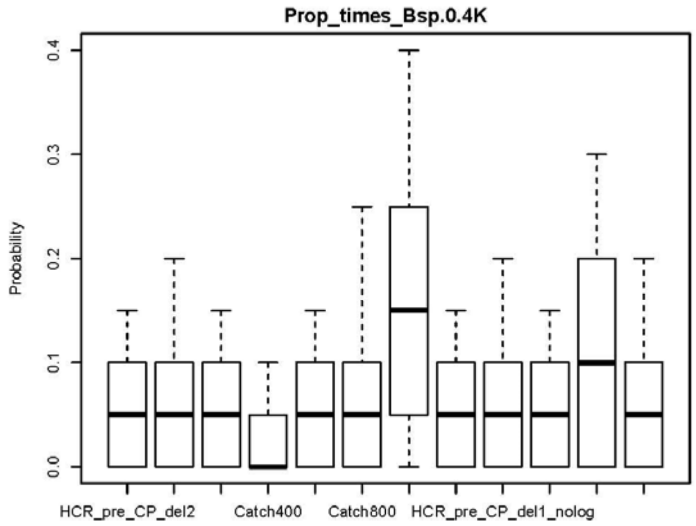

Preseas1
Preseas0
Midsurv1
Midsurv2
Future_CPUE_TVH
Future_CPUE_TIB
Catch rate
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033

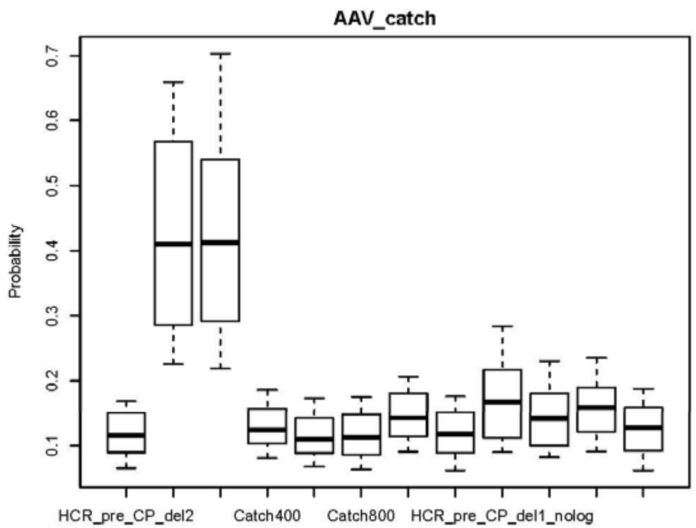
Results
Simple slope example; pre1+ index; slope parameter 600; max catch 1000; implementation error 5%

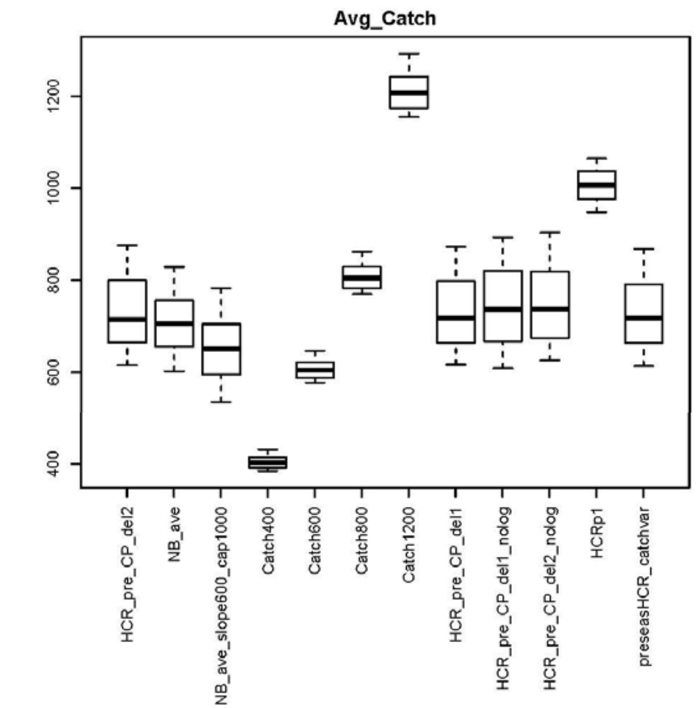

Catch of all sectors
Spawning biomass
Fishing mortality
Risk properties
Prop_times_Bsp.0.2K
Prop_times_Bsp.0.4K
AAV_catch
Catch from two replicates
Spawning biomass from two replicates
replicate 78
replicate 52
Year

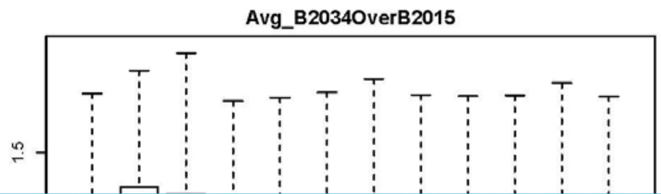

Risks
Prop_times_Bsp.0.2K
Prop_times_Bsp.0.4K
AAV_catch
Avg_Catch
Avg_B2034OverB2015
Probability
HCR_pre_CP_del2
Catch400
Catch800
HCR_pre_CP_del1_nolog
NB_ave
NB_ave_slope600_cap1000
Catch600
Catch1200
HCR_pre_CP_del1
HCR_pre_CP_del2_nolog
HCRp1
preseasHCR_catchvar


Prop_times_Bsp.0.2K
Probability
0.00
0.05
0.10
0.15
0.20
HCR_pre_CP_del2
Catch400
Catch800
HCR_pre_CP_del1_nolog

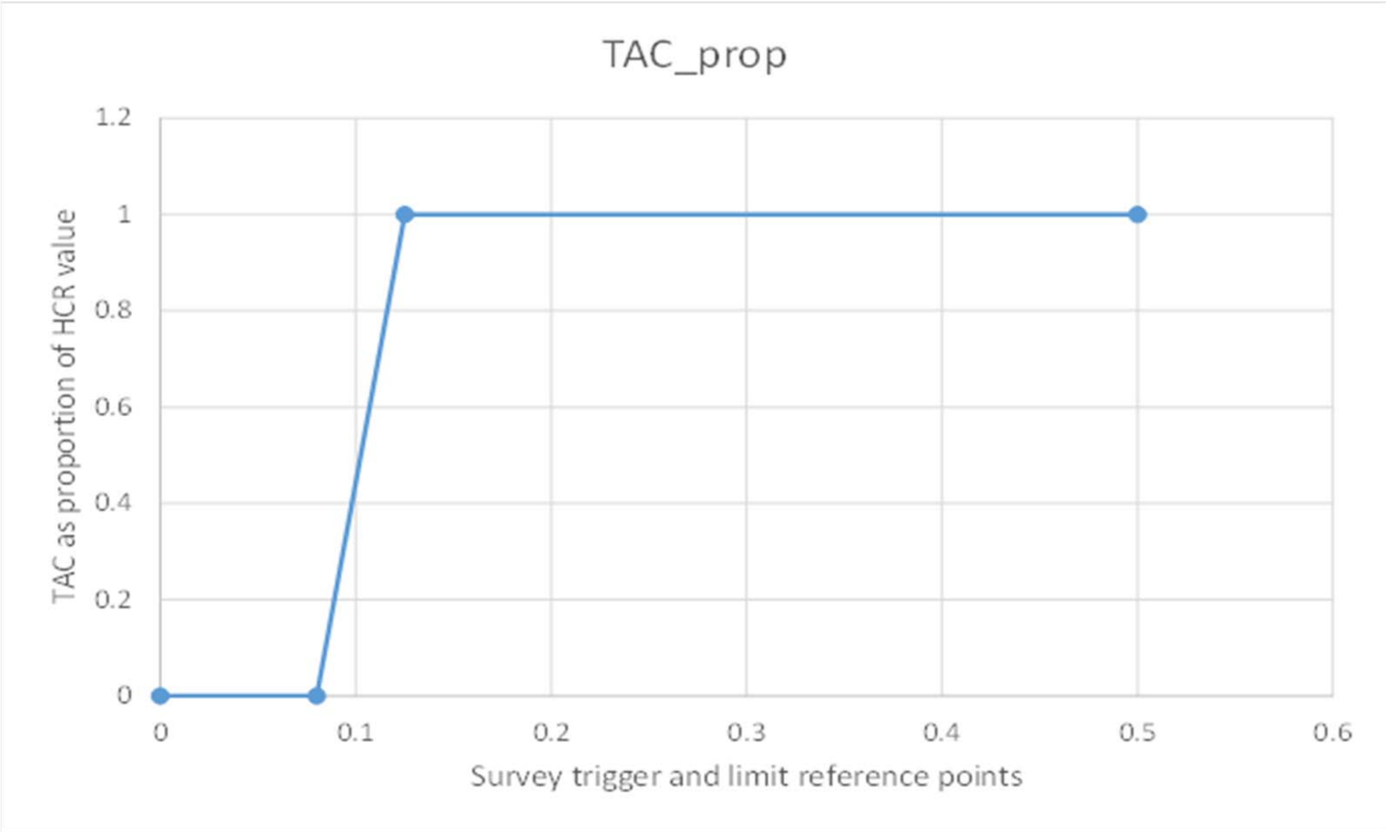

Prop_times_Bsp.0.4K
Probability
0.0
0.1
0.2
0.3
0.4
HCR_pre_CP_del2
Catch400
Catch800
HCR_pre_CP_del1_nolog

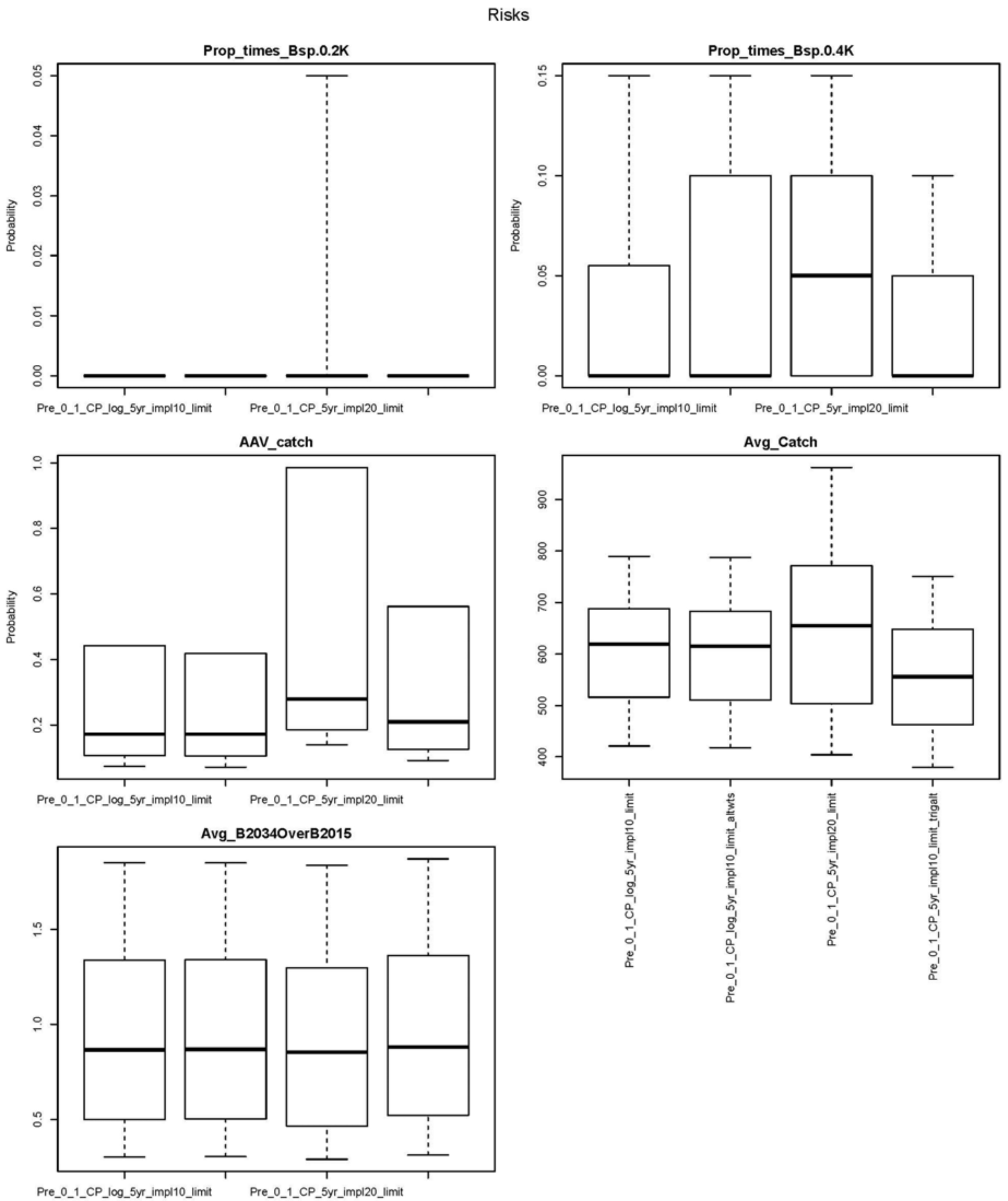

AAV_catch
Probability
0.1
0.2
0.3
0.4
0.5
0.6
0.7
HCR_pre_CP_del2
Catch400
Catch800
HCR_pre_CP_del1_nolog


Avg_Catch
400
600
800
1000
1200
HCR_pre_CP_del2
NB_ave
NB_ave_slope600_cap1000
Catch400
Catch600
Catch800
Catch1200
HCR_pre_CP_del1
HCR_pre_CP_del1_nolog
HCR_pre_CP_del2_nolog
HCRp1
preseasHCR_catchvar


Avg_B2034OverB2015
1.5

Adding survey trigger and limit reference points




Risks
Prop_times_Bsp.0.2K
Probability
Pre_0_1_CP_log_5yr_impl10_limit
Pre_0_1_CP_5yr_impl20_limit
Prop_times_Bsp.0.4K
AAV_catch
Avg_Catch
Pre_0_1_CP_log_5yr_impl10_limit_altwts
Pre_0_1_CP_5yr_impl10_limit_trigalt
Avg_B2034OverB2015

Sensitivities

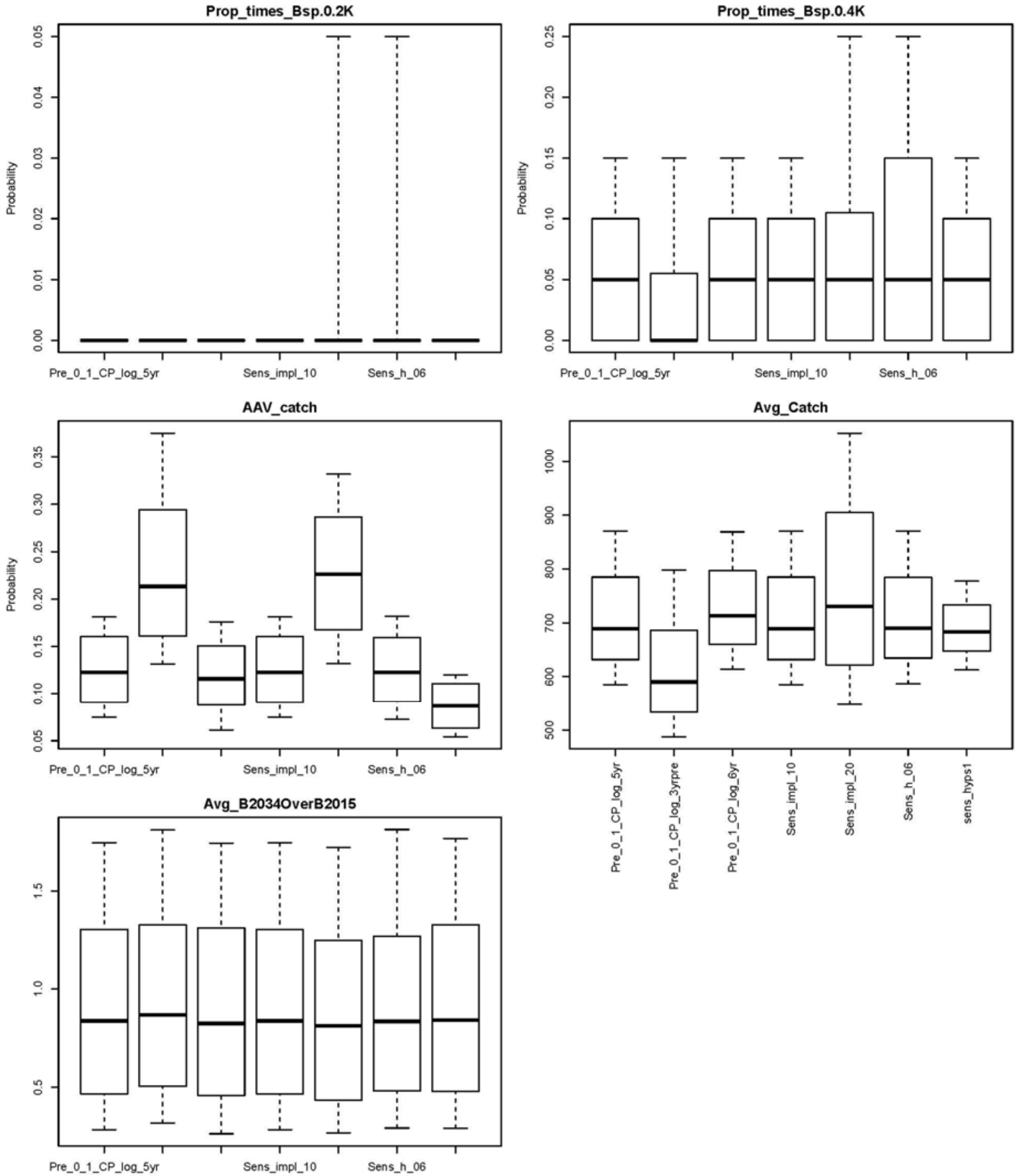
Key sensitivities include :

- Changing the number of years in calculating the slope of the trend in the recent preseason survey data (3yrs. 5yrs, 6yrs);
- increasing the implementation error too much larger values (0.1, 0.2);
- setting the stock recruit steepness parameter to a lower value of *h*=0.6 (and refitting the model); and
- changing the hyperstability parameters to one for both CPUE series (and refitting the model)
- Recent tests: recruitment failures in some years

Summary results:

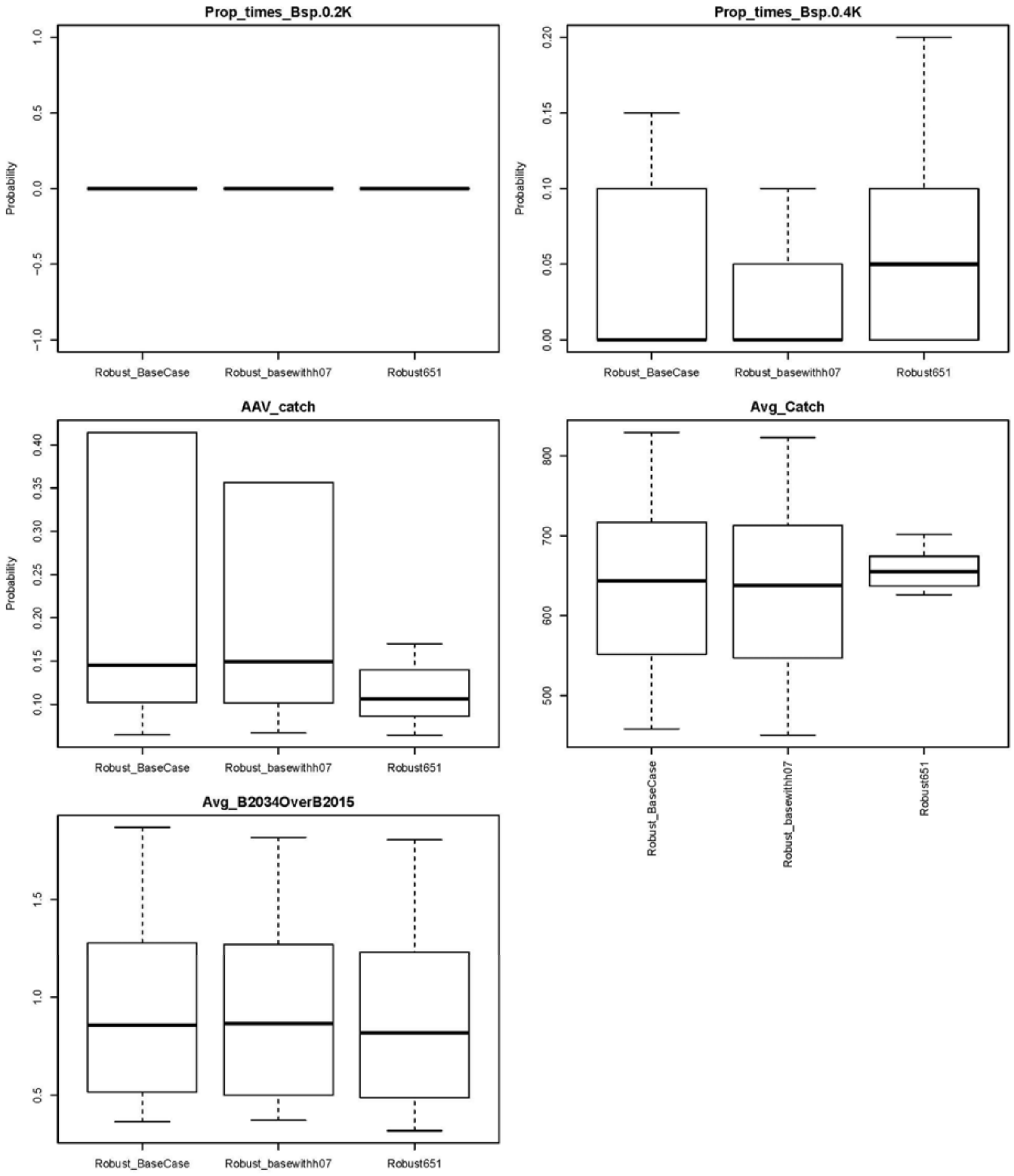
- using fewer preseason survey points in the regression leads to poor outcomes in terms of average catch and AAV.
- If implementation error is large, the performance of the basic HCRs deteriorates in terms of both catch statistics and risk to the resource.
- The risk of depletion of spawning stock biomass is highest under the low steepness scenario.

Risks



Prop_times_Bsp.0.2K
Probability
0.00
0.01
0.02
0.03
0.04
0.05
Pre_0_1_CP_log_5yr
Sens_impl_10
Sens_h_06
Prop_times_Bsp.0.4K
Probability
0.00
0.05
0.10
0.15
0.20
0.25
Pre_0_1_CP_log_5yr
Sens_impl_10
Sens_h_06
AAV_catch
Probability
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Pre_0_1_CP_log_5yr
Sens_impl_10
Sens_h_06
Avg_Catch
500
600
700
800
900
1000
Pre_0_1_CP_log_5yr
Pre_0_1_CP_log_3yrpre
Pre_0_1_CP_log_6yr
Sens_impl_10
Sens_impl_20
Sens_h_06
sens_hyps1
Avg_B2034OverB2015
0.5
1.0
1.5
Pre_0_1_CP_log_5yr
Sens_impl_10
Sens_h_06

Risk under same catch using constant vs adaptive feedback strategy



Harvest Strategy for TRL: variability and exceptional circumstances

Short-lived species (e.g. TRL) have stocks comprised of only one year class and the stock abundance may vary fourfold on an annual basis depending on the recruitment success in a particular year.

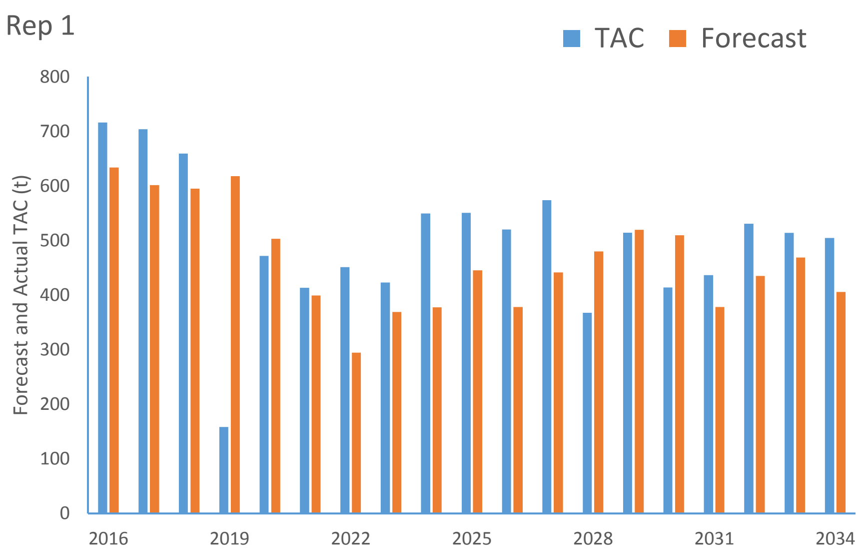
Hence, the TAC will vary significantly on an annual basis reflecting stock abundance.

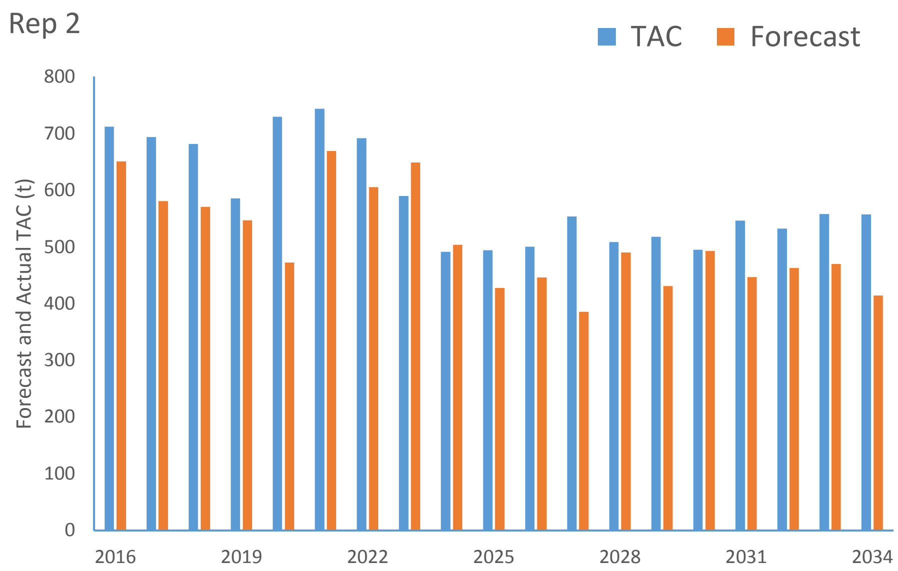
The harvest strategy may include exceptional circumstances clauses to account for events such as environmental impacts to allow for stocks to recover rapidly.

Forecast TAC : Empirical rule based on preseason survey 0+

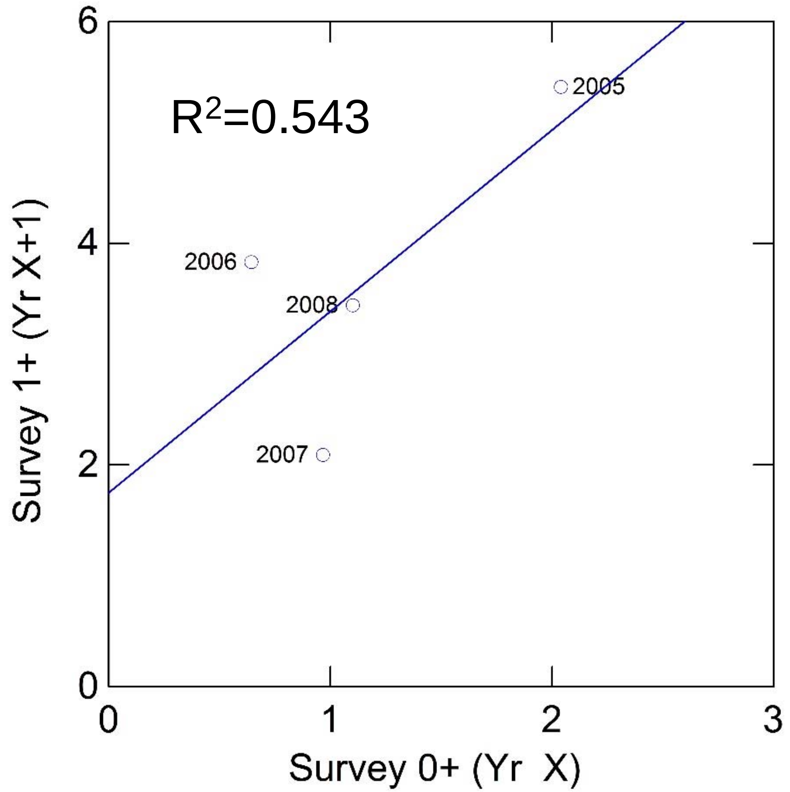
Forecast(Year) = c * (1+slope0) * Catch_ave

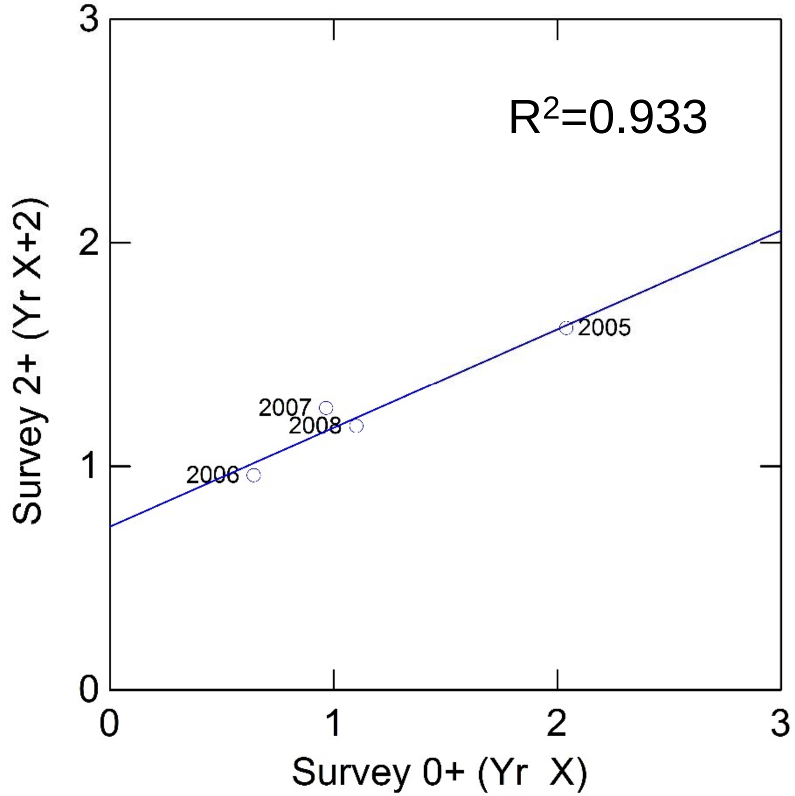
- *c*= tuning parameter (0.85) to adjust so that forecast mostly < actual TAC
- Slope0 = same slope estimate as used in HCR
- Catch_ave = average of previous 5 years' catch





Forecast TAC – based on 0+





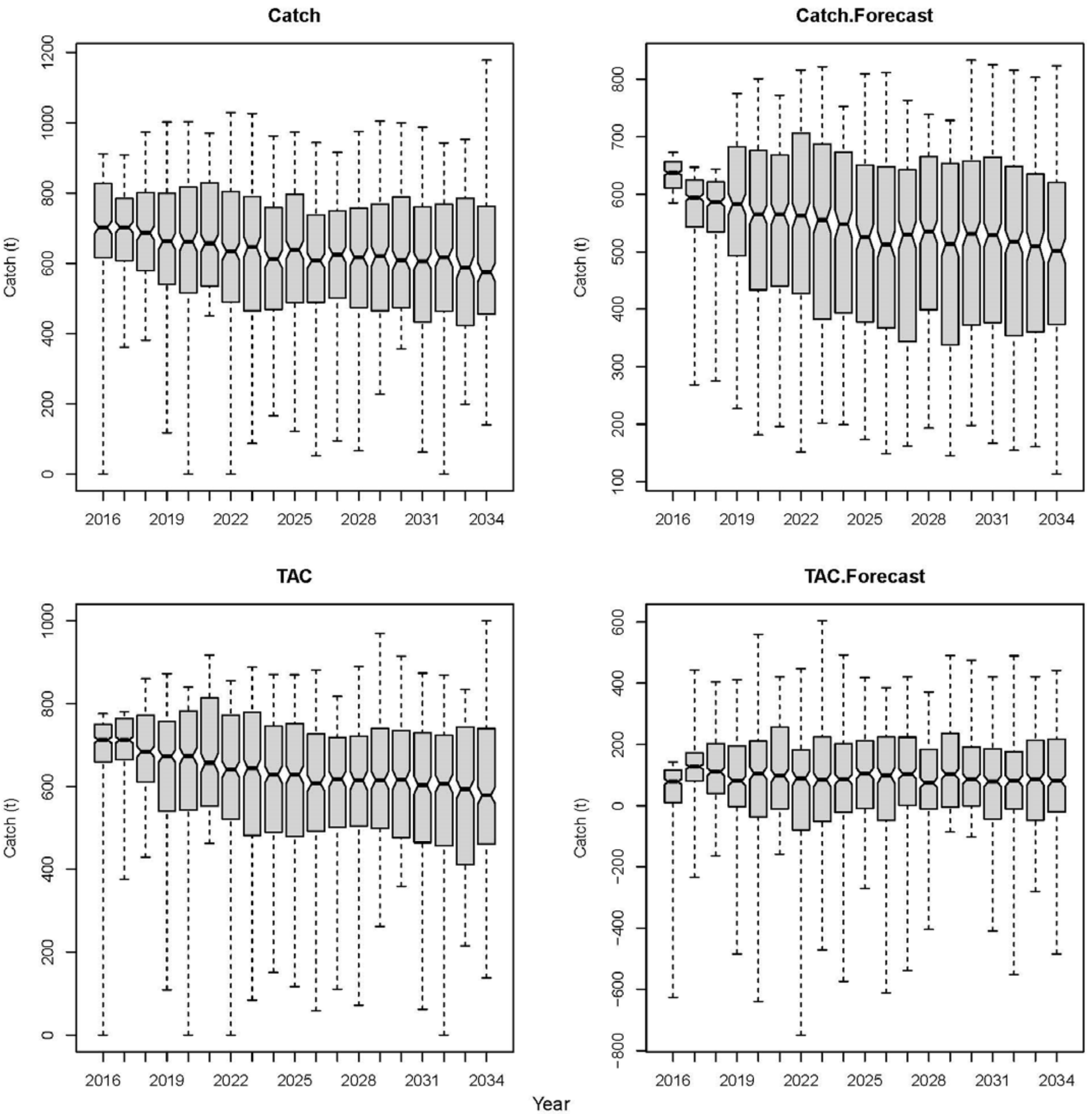
Forecast TAC

	Catch	Forecast	TAC	TAC-Forecast
median	616.7	536.4	614.2	83.8
stdev	145.4	101.6	130.7	113.3
min	0.0	193.6	0.0	-741.5
max	1028.1	820.5	910.9	350.2

With survey limit ref pt

	Catch	Forecast	TAC	TAC-Forecast
median	616.74	532.981	614.2035	88.08825
stdev	145.4113	123.9306	130.7415	128.4741
min	0	96.8245	0	-741.45
max	1028.05	820.463	910.877	593.856

- Can tune so higher probability < final TAC
- Can improve predictive ability by improving precision of survey, particularly 0+ survey sampling (e.g. industry supplemented)
- Initial testing but needs further work if add limit reference point to make more comparable to HCR with limit and trigger reference points


Catch
Catch.Forecast
TAC
TAC.Forecast
Catch (t)
Year
2016
2019
2022
2025
2028
2031
2034

Auto-pilot approach?

- The HCR is an auto-pilot, but the pilot stays on the plane to check for unanticipated events (by conducting regular assessment updates)
- HCR reviews can be brought forward if appreciable changes in scientific perceptions about the resource occur
- Key criteria for such action are:
  - Indications that resource has moved outside the range for which the HCR was tested
  - Evidence to support this must be compelling, so that such action is not taken lightly

Butterworth (2007) Why a Management Procedure Approach

Potential revised harvest strategy

- Annual fishery data analyses (catch, CPUE, size structure)
- Annual survey data analyses (preseason 0+, 1+; any additional survey data)
- Annual implementation of empirical HCR to recommend TAC, also taking into account empirical proxies for resource status (survey reference points) + recommend Forecast TAC
- If exceptional circumstances – trigger action eg stock assessment, analyse size structure and environmental information
- Every 3 years – full stock assessment to more reliably assess stock status – if deviations from target level, recalibrate HCR

Summary

- Compare and select between candidate HCRs that perform satisfactorily
- Challenge and compare performance with robustness tests

•Can tune candidate HCRs to have the same average catch, and then compare risk and other performance measures OR can tune to have the same risk and compare what the average catch will be under each

- Stakeholders select between candidate HCRs based on clear criteria
- Useful to focus on few key performance statistics

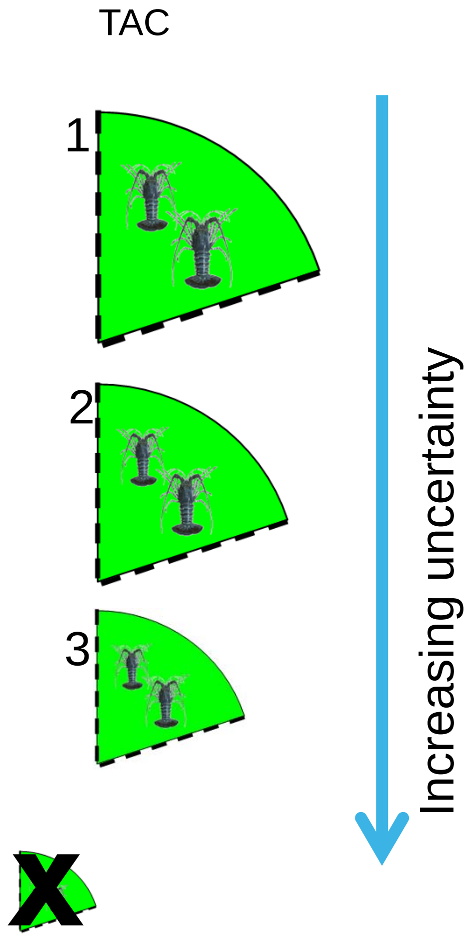
Greatest advantages are probably:

- **A sound basis for setting TACs without compromising resource status**
- **Properly addressing concerns about scientific uncertainty through simulation testing to ensure that feedback secures reasonably robust performance across a range of plausible alternative resource dynamics**

Alternatives for TAC setting

Empirical (data-based) HCR : alternatives depending on data availability and quality:

1. Bonus tier – Midyear and Preseason survey, reliable timely provision of catch data, TIB and TVH CPUE data
2. Top tier - Preseason survey, reliable timely provision of catch data, TIB and TVH CPUE data
3. Middle tier – Preseason survey + catch data
4. Low tier – No surveys, CPUE data 4 
5. Penalty tier – No surveys, no CPUE data 5



(3) Final Agreed (by TRLRAG) Harvest Strategy Reference points (targets and limits)

B_{targ} =0.65Bsp(0)

Bsp(0) is assumed to be the model-estimate of spawning biomass in 1973 (start of the fishery)

Btarg has been chosen by TRLRAG as a proxy for BMEY

B_{lim} (0.5Btarg) =0.32Bsp(0)

If LRP is triggered 2 years out of the most recent 3 year period, then the fishery is closed

F_{targ} – estimated by model to keep stock around B_{targ} =0.15

$B_{threshold}$ /$B_{trigger}$ - Biomass level below which more stringent rules for calculating TAC are applied =0.48Bsp(0)

Thank you

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Darren Dennis, Trevor Hutton

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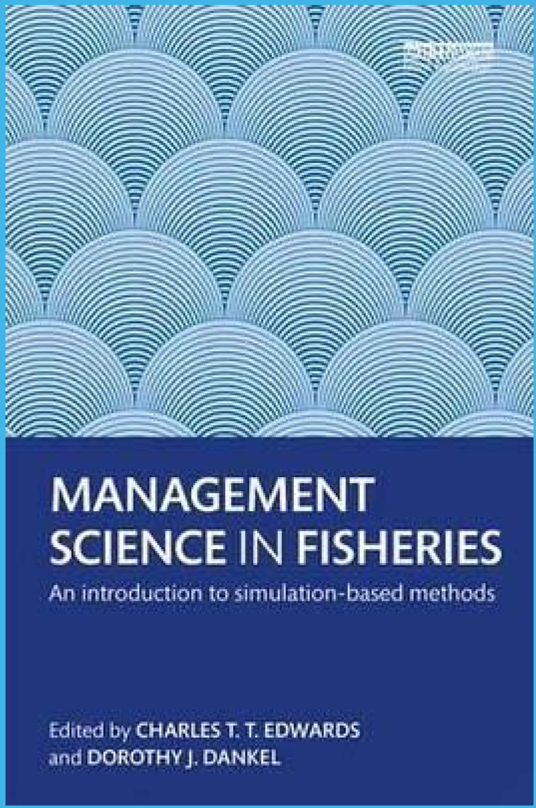
www.csiro.au



Book on MSE just published!