IOTC Billfish Working Party 2011

Swordfish SS3 Assessment

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Miguel Herrera

Outline

- SW
  - Assumptions
  - Preliminary Results:
    - Typical fits and Dynamics
    - Interactions among assumptions
  - Stock status

- IO
  - As above

Software

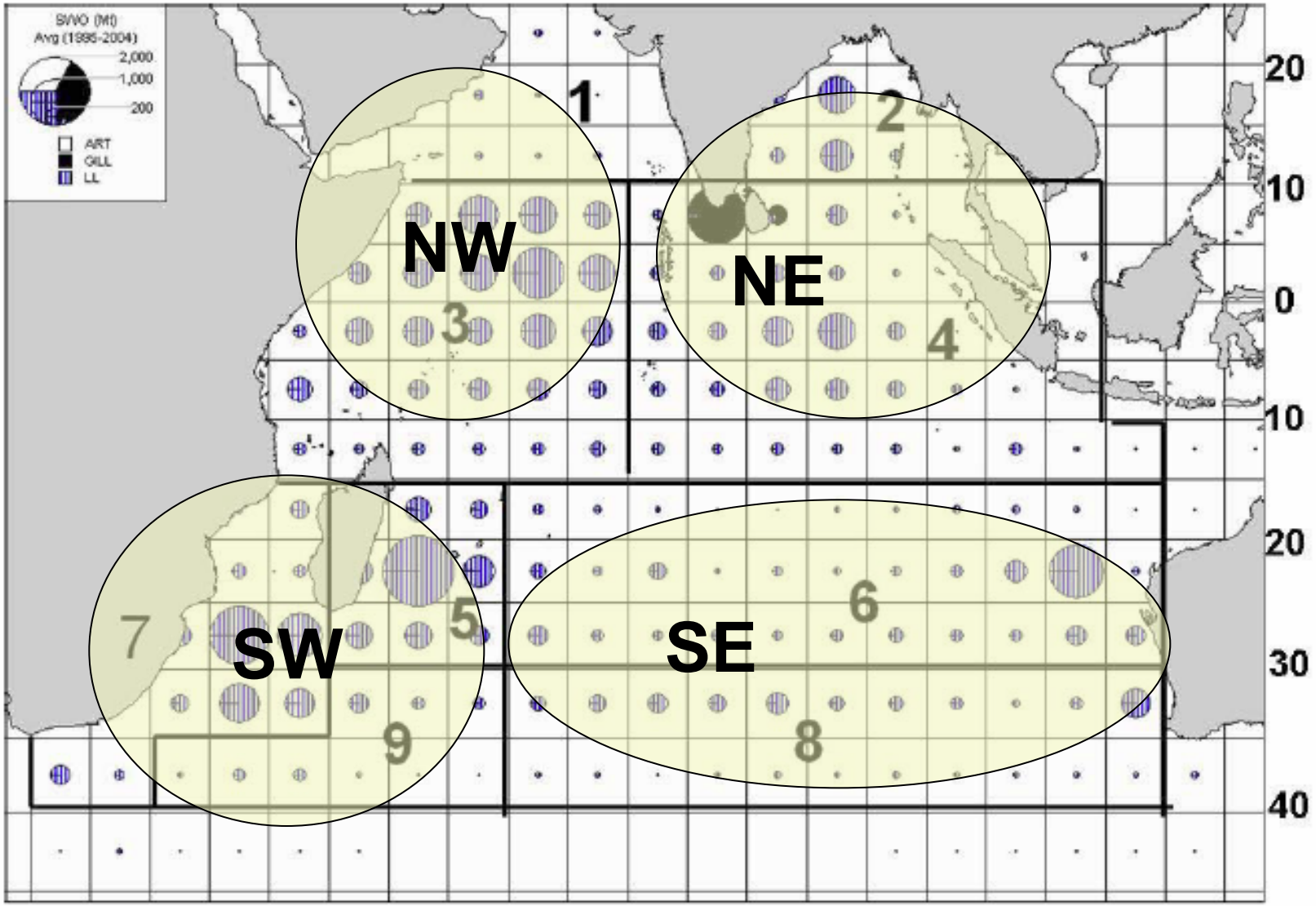
- Stock Synthesis SS3 V3.21d

- Many thanks to Rick Methot and Ian Taylor

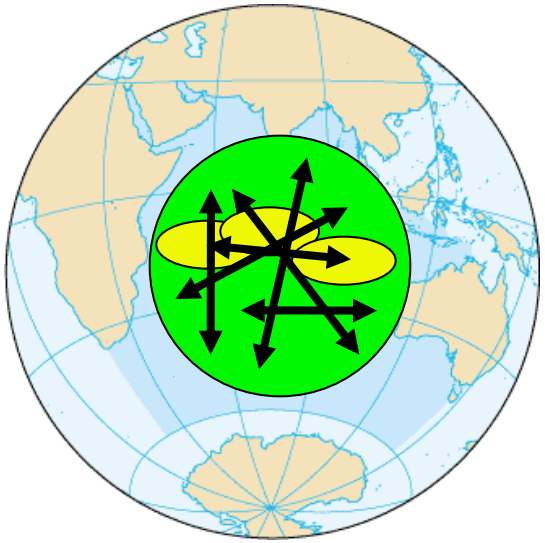
Population dynamics

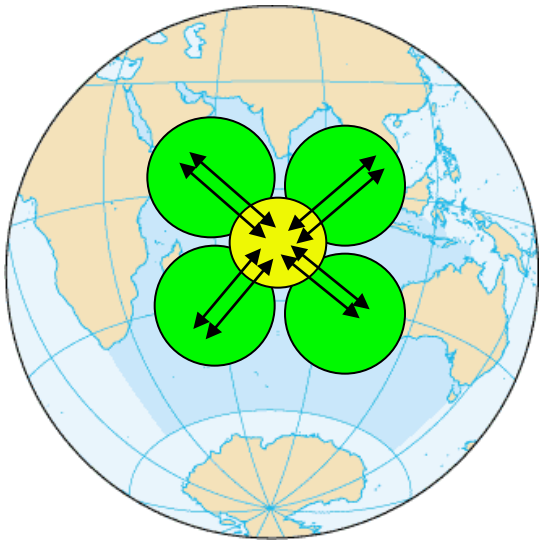
- Sex-structured (size-at-age by sex only)
- Age-structured (0-30+ y)
- Multiple fisheries
- Spatial structure (IO only)
- Annual iteration 1950-2009
- Beverton-Holt Stock recruitment
- Baranov equations (Catch conditioned)

Spatial Structure; CPUE regions



Spatial Structure
IO = Whole Indian Ocean

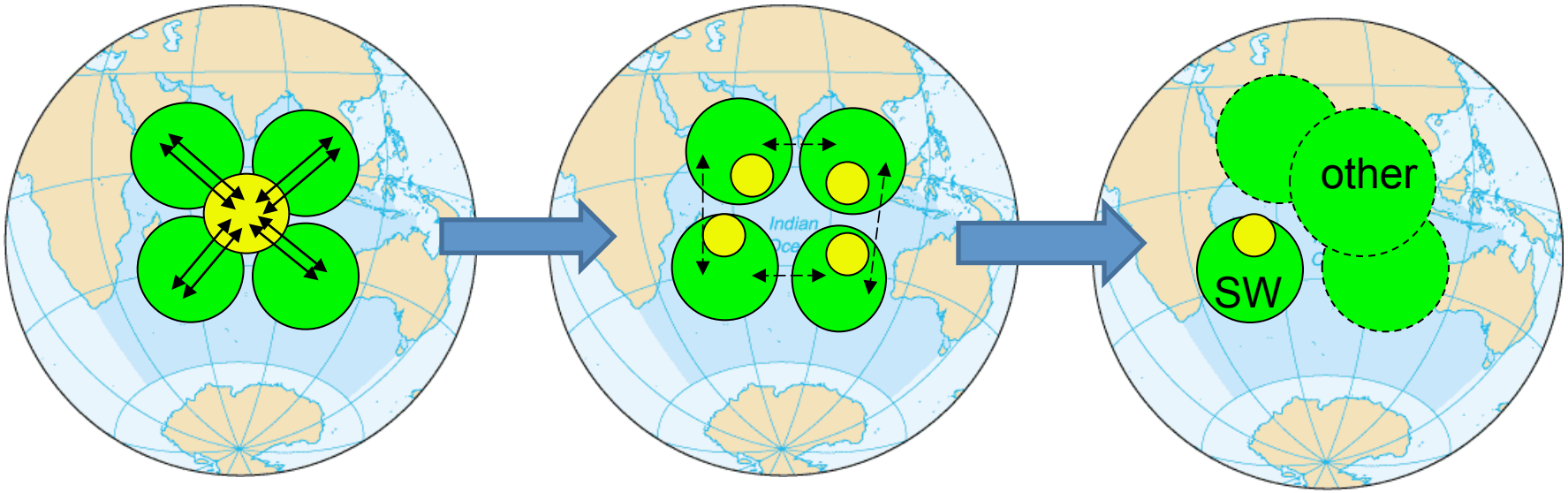




SS3 - IO

Spatial Structure
SW =only southwest region

*"The Commission **requests** that the Scientific Committee provide clear advice outlining alternative management approaches which would provide effective protection of a possible southwest Indian Ocean swordfish stock."* -IOTC 2011



SS3 – IO

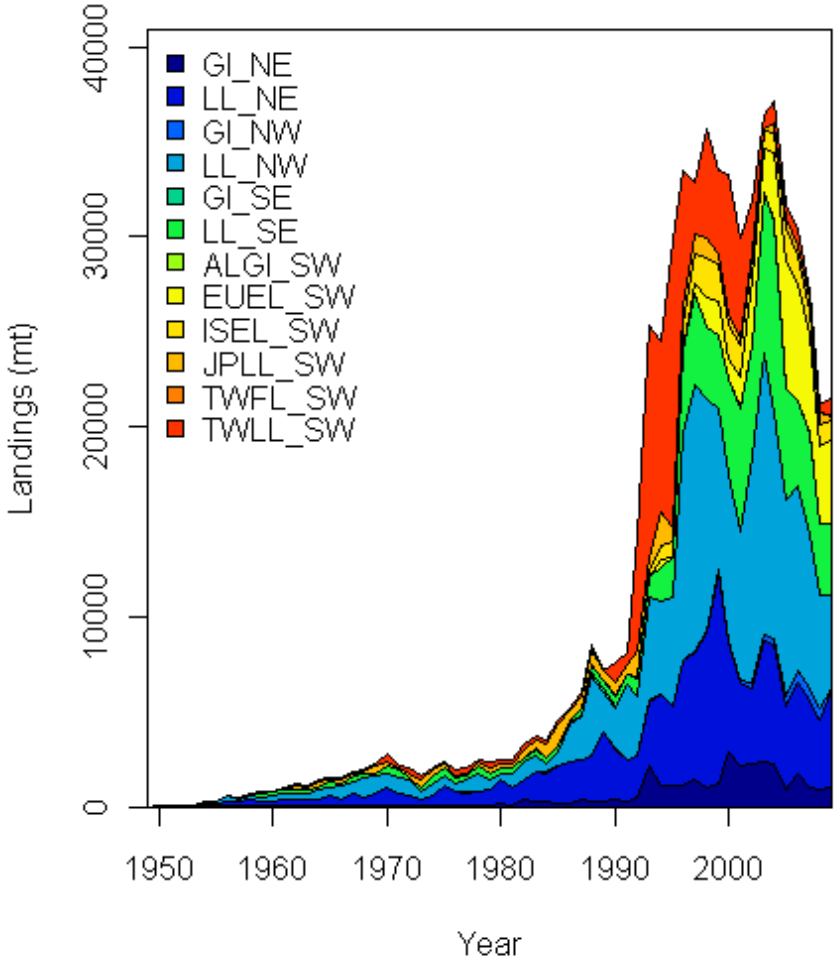
SS3 – SW

Fleet definitions

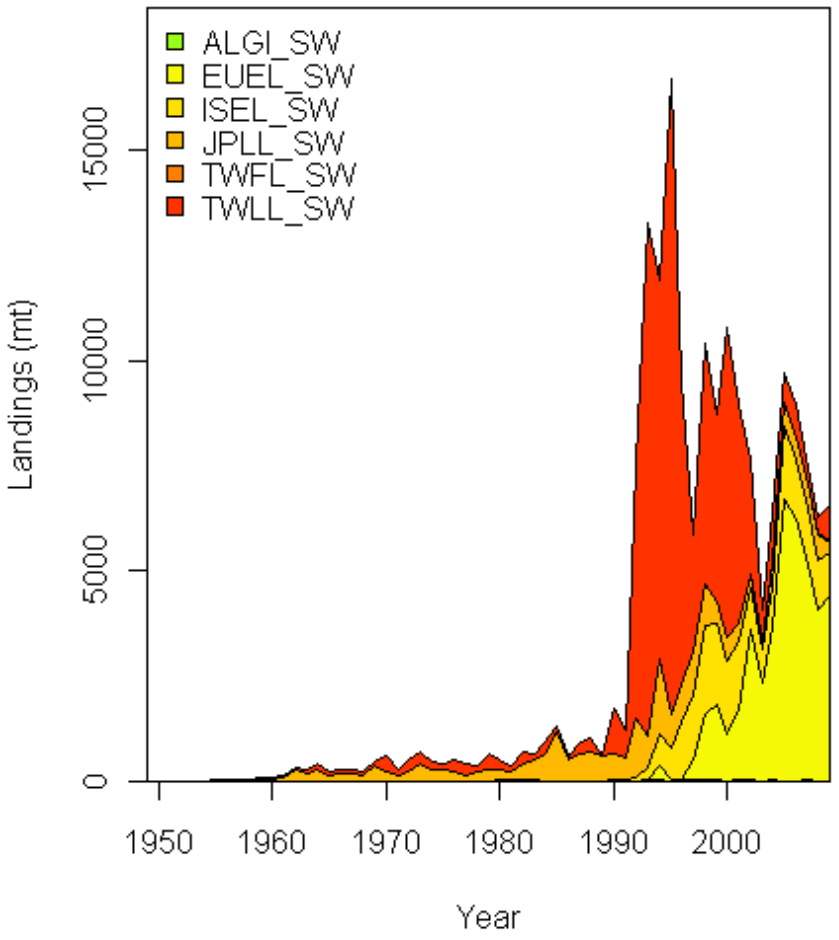
name	number	Area	Description
GI_NE	1	NE	Northeast Gillnet and other non-longline/-handline gears
LL_NE	2	NE	Northeast all longline and handline gears
GI_NW	3	NW	Northwest Gillnet and other non-longline/-handline gears
LL_NW	4	NW	Northwest all longline and handline gears
GI_SE	5	SE	Southeast Gillnet and other non-longline/-handline gears
LL_SE	6	SE	Southeast all longline and handline gears
ALGI_SW	7	SW	Southwest Gillnet and other non-longline/-handline gears
EUEL_SW	8	SW	Southwest European and assimilated longliners (target SWO)
ISEL_SW	9	SW	Southwest semi-industrial longliners (target SWO)
JPLL_SW	10	SW	Southwest Japan and assimilated longliners (target tunas)
TWFL_SW	11	SW	Southwest fresh-tuna longliners (target tunas)
TWLL_SW	12	SW	Southwest Taiwan,China and assimilated longliners and handlines (mixed target)

Catch by Fleet

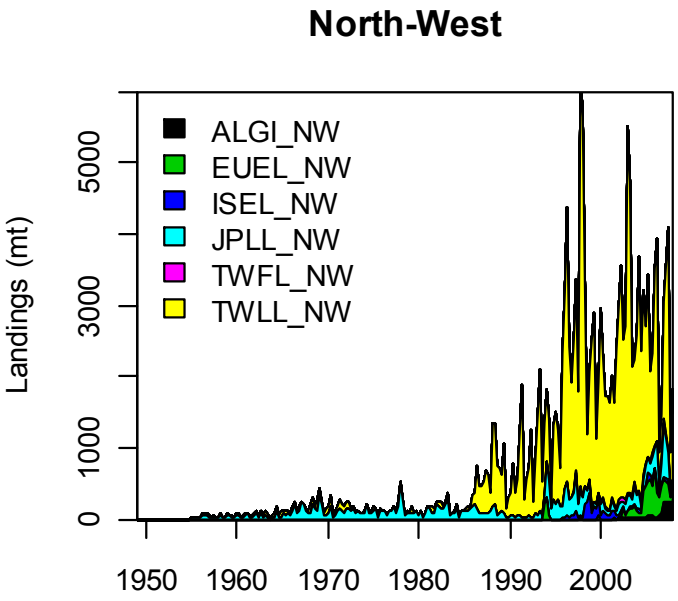
IO

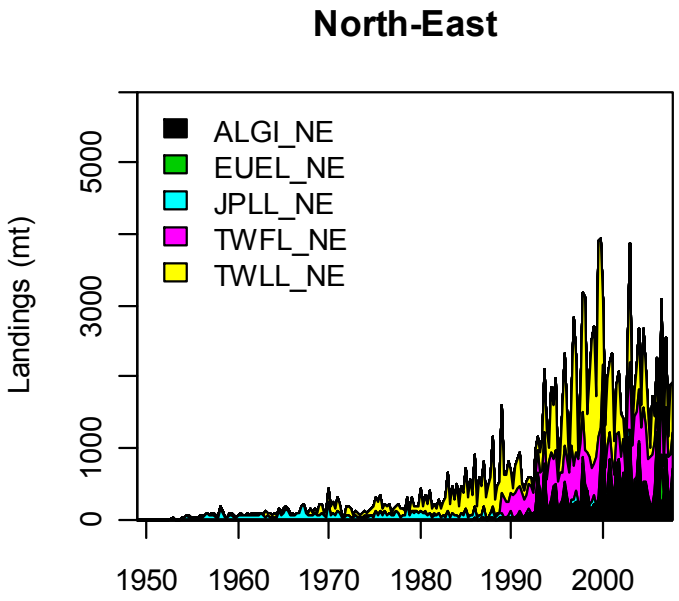


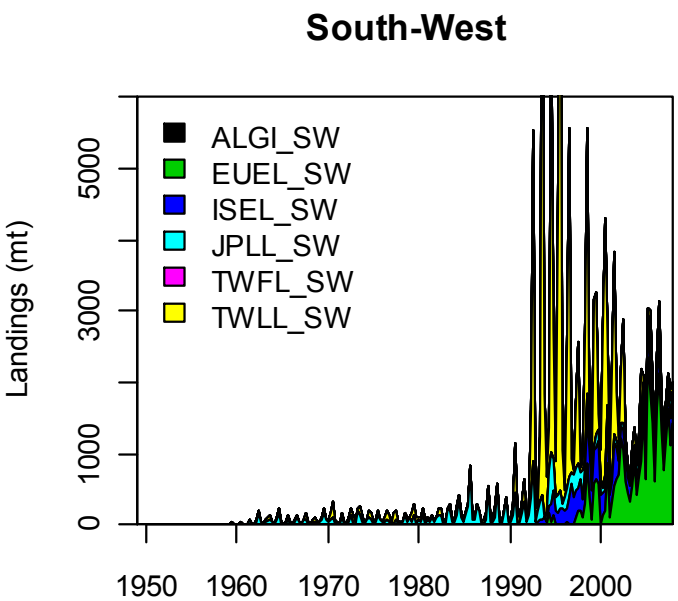
SW

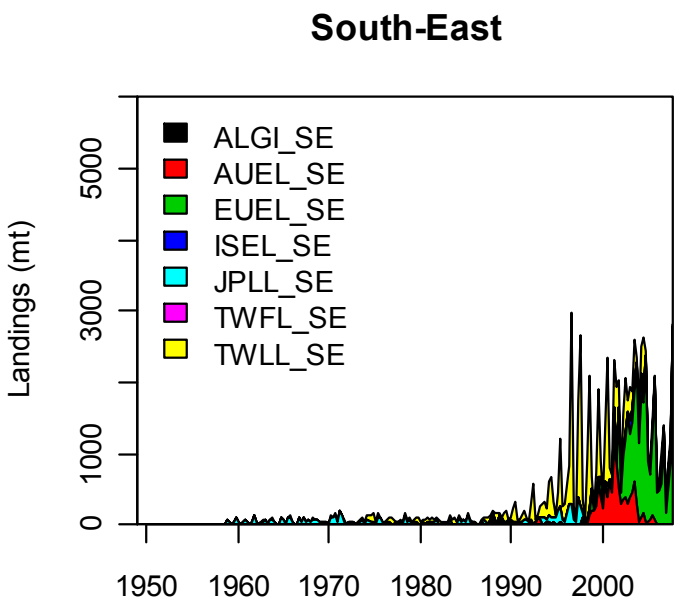


Catch by Region





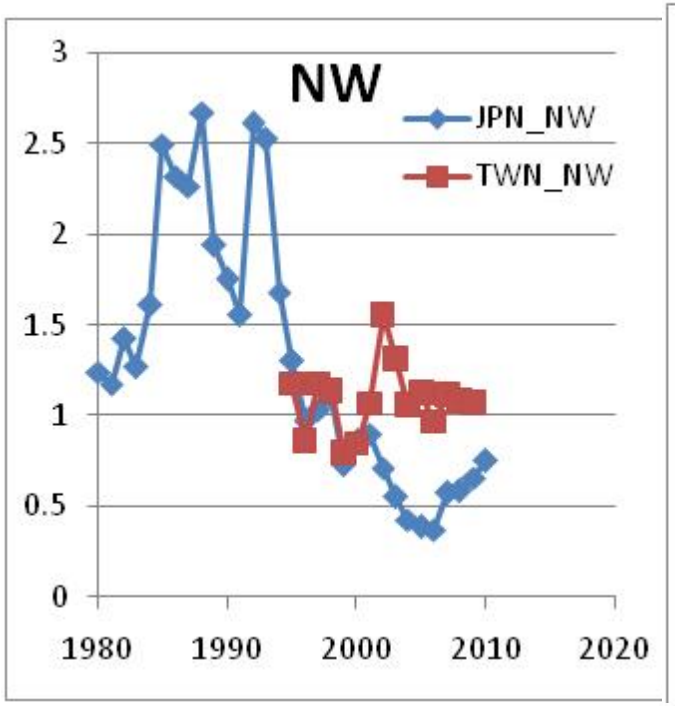


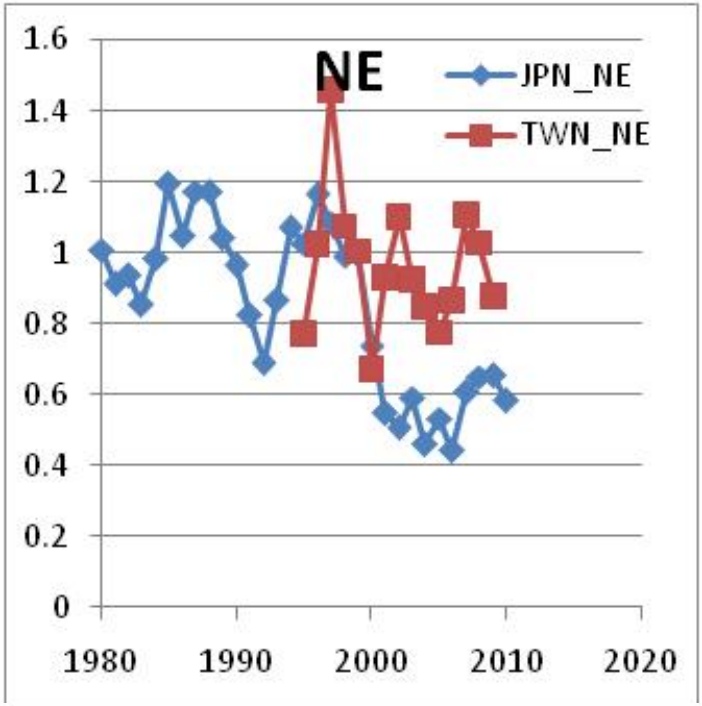


Catch Assumptions

- No discards
- No depredation
- catch in mass extracted without error

CPUE Series


NW
JPN_NW
TWN_NW
3
2.5
2
1.5
1
0.5
0
1980
1990
2000
2010
2020


NE
JPN_NE
TWN_NE
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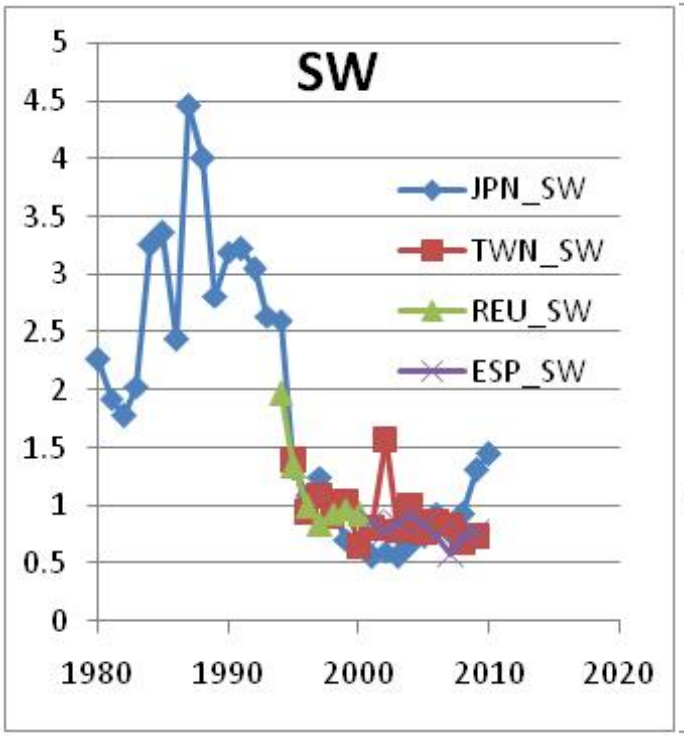
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
2020


SW
JPN_SW
TWN_SW
REU_SW
ESP_SW
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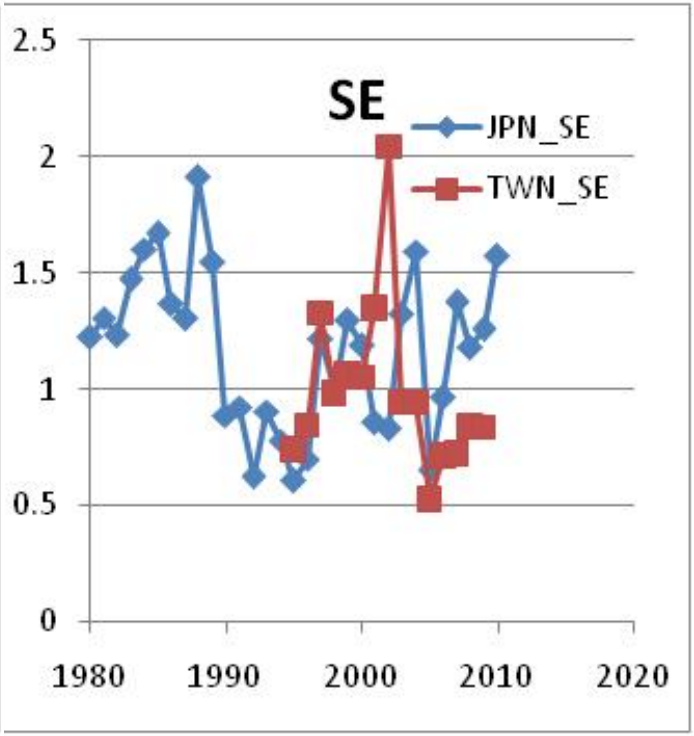
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1980
1990
2000
2010
2020


SE
JPN_SE
TWN_SE
2.5
2
1.5
1
0.5
0
1980
1990
2000
2010
2020

CPUE Assumptions

- lognormal errors;
- CV constant over time

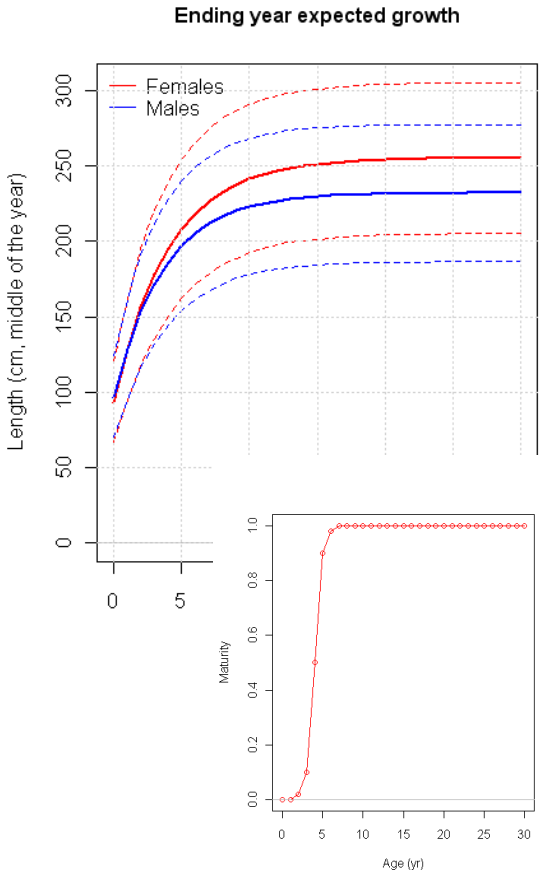
- IO – Q shared among JPN fleets
  - JPN CPUE series weighted by surface area

CPUE Assumption Options

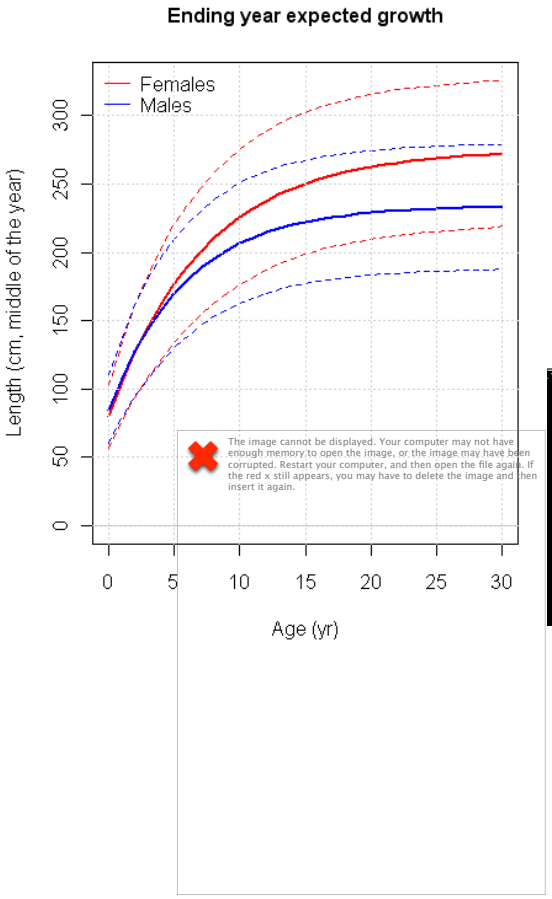
- A1 – all series equal (δ=0.1)
- NT – TWN highly down-weighted
- J1 – only JPN series used
- J2 – JPN δ=0.2, other fleets δ=0.1
  - SW only

Growth / Maturity / Mortality

Hawai'i
M = 0.36



Taiwan-IO
M = 0.25



Australia-IO
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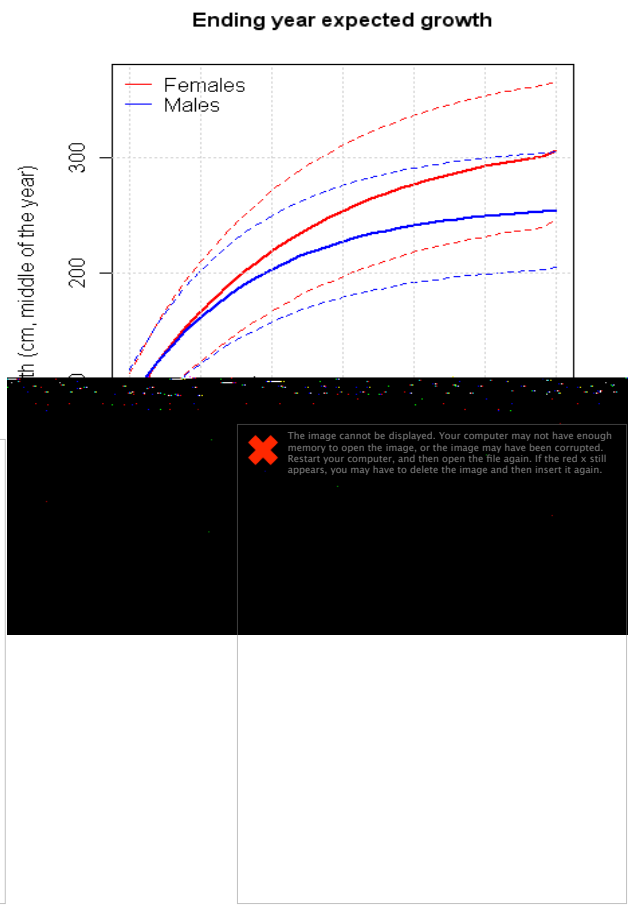
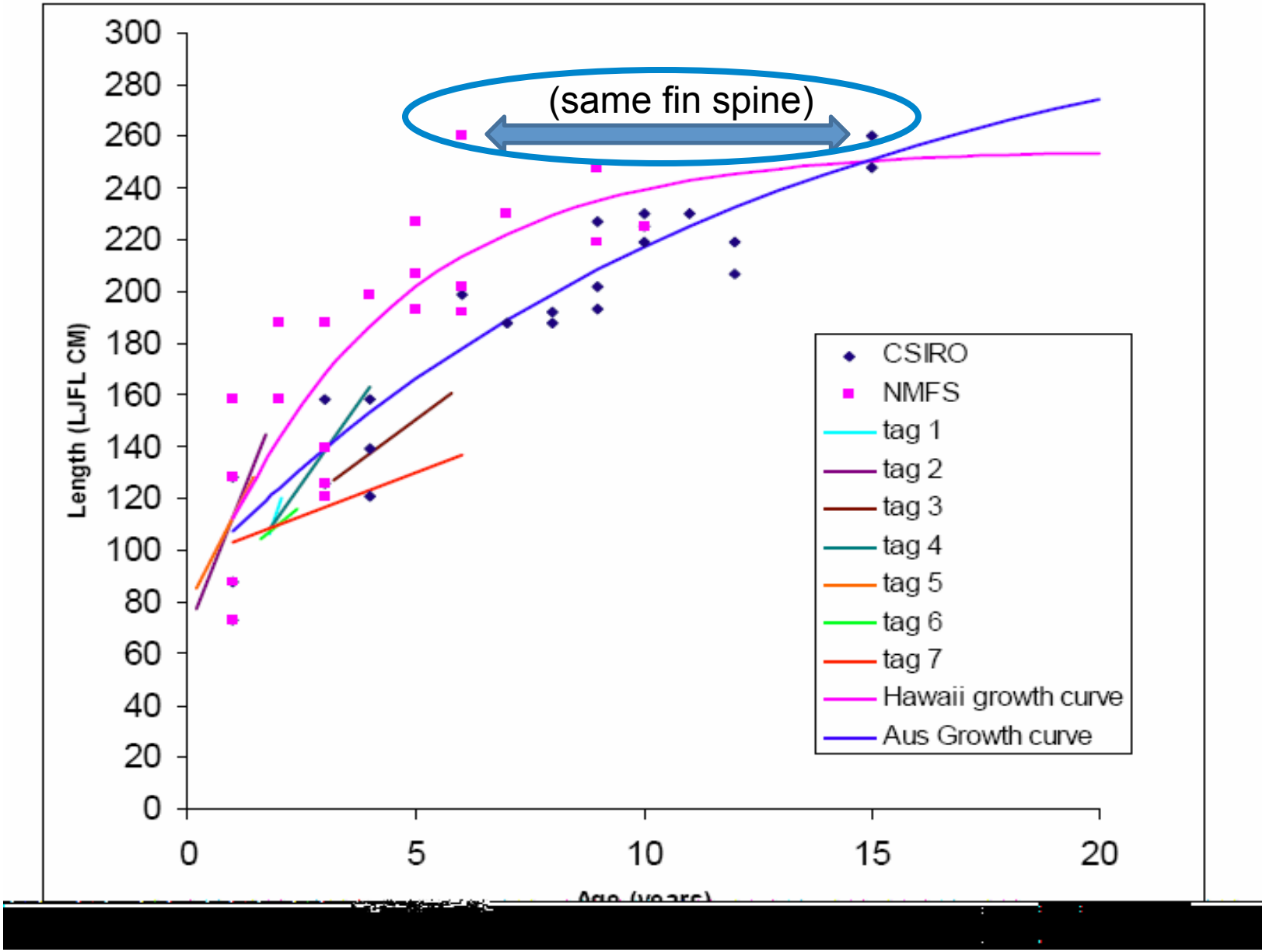


Young et al 2008: Growth Rate Uncertainty

(Comparison of NMFS and CSIRO ageing methods)



Stock Recruitment

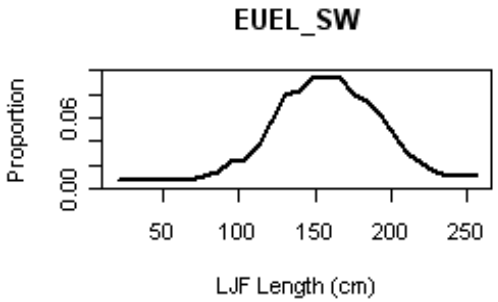
- Beverton-Holt function
- Spawning Biomass = mature females
- Annual lognormal deviates to 2007
- spatial deviates in IO model

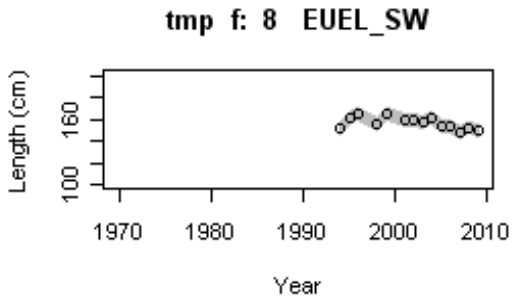
SR Steepness Options

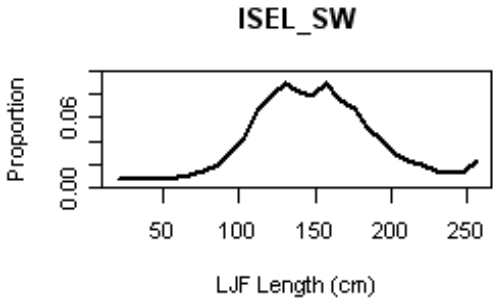
- Fixed at range of levels
- (ISSF 2011)

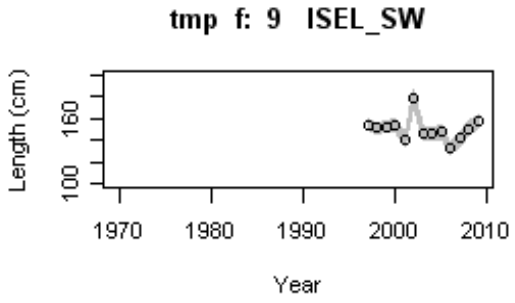
- h=0.55
- h=0.75
- h=0.95

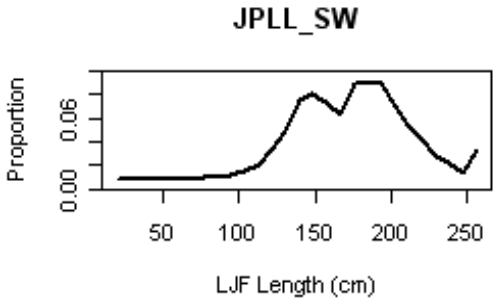
Size data SW &IO

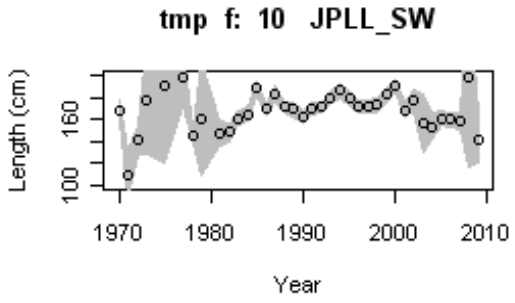


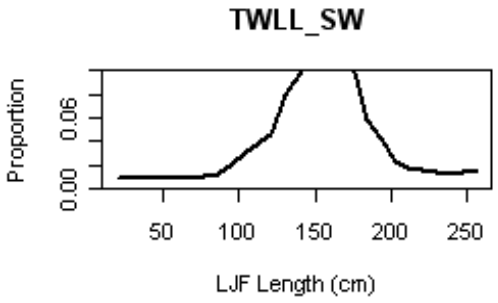


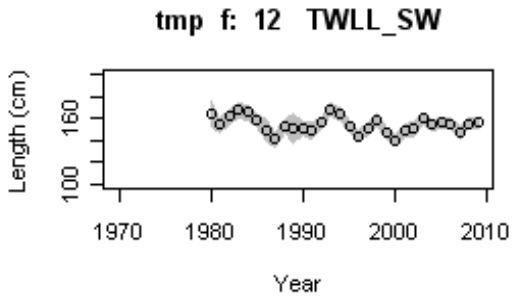






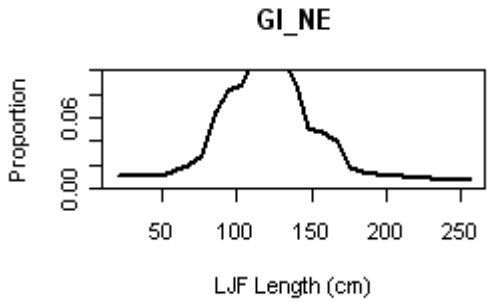


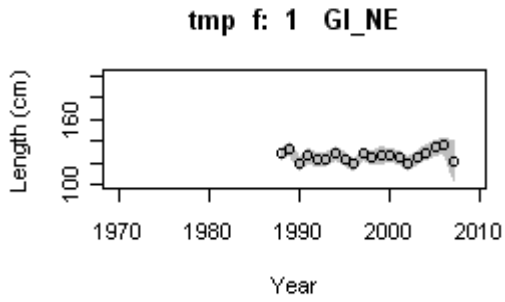


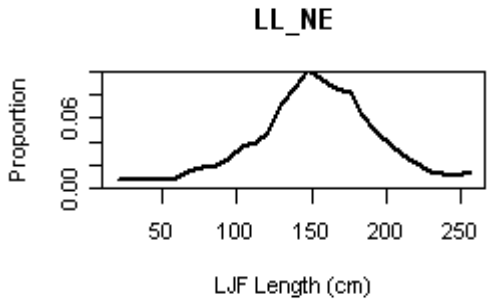


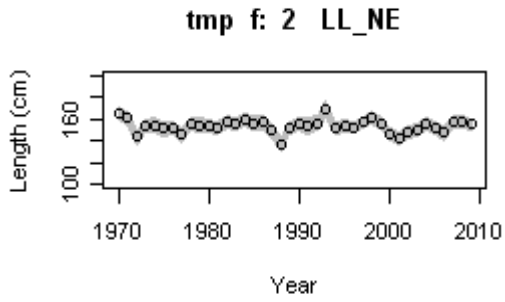
Size data

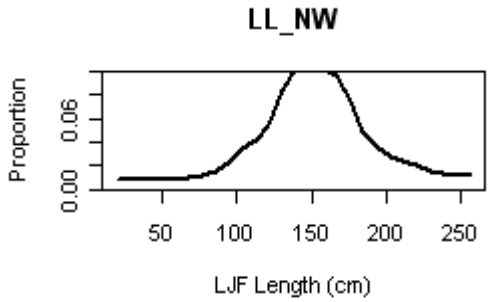
IO only

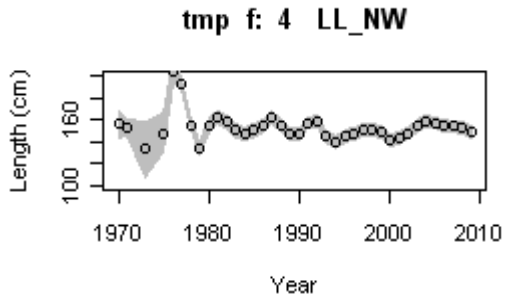


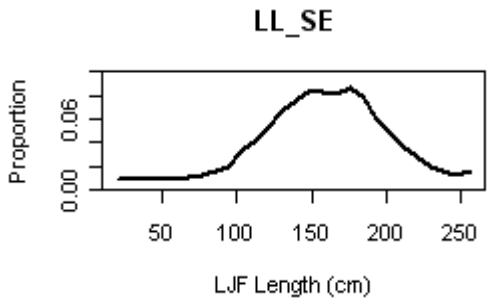


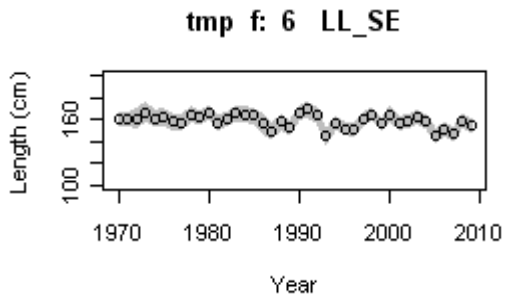












Size Composition Assumptions

- 9cm length bins from <45cm - >252cm
- 1% added to each length bin for robustification
- Multinomial Likelihood

Size Composition Assumptions

- “CL200” – max assumed sample size capped at 200
- “CL020” – downweight by 0.1; max assumed sample size capped at 20
- “CL002” – downweight by 100; max assumed sample size capped at 2

Selectivity

- 2 functions:
  - Longline
  - Other (trivial especially in SW)

- Double-normal (pseudo-length-based)
  - dome or logistic shape can be estimated

Estimated Parameters

- LL selectivity
- IO Gillnet/Other Selectivity
- virgin recruitment
- catchabilities
- annual recruitment deviates (usually)
- IO spatial recruitment deviates

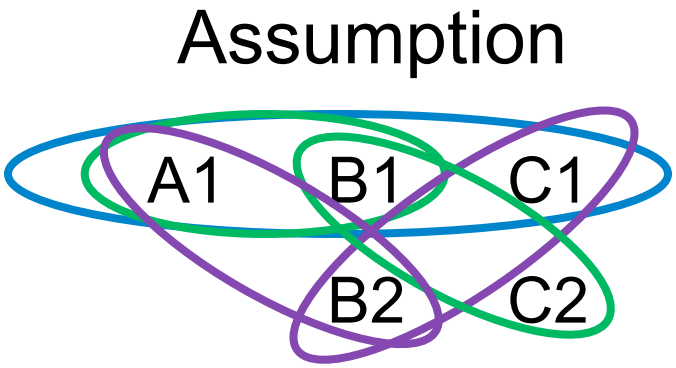
Fixed Parameters

- Growth
- M
- steepness
- SW Gillnet selectivity

Likelihoods and Penalties

- CPUE
- Size Composition
  - 8 fisheries IO
  - 4 fisheries SW
- Priors
  - Very diffuse on all estimated parameters (except recruit deviates)

Model Development Approach 1

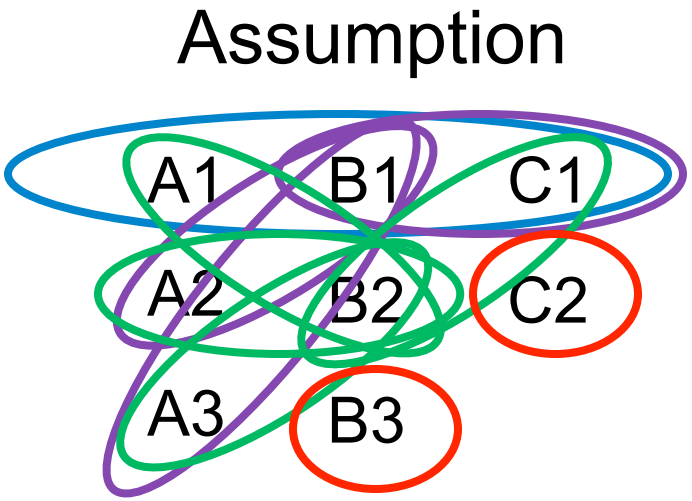


Baseline

Sensitivity 1

Sensitivity 2

Model Development Approach 2



Ref Case =A1B1C1

A2B1C1
A3B1C1
A1B2C1
A2B2C1
A3B2C1
A1B3C1
A2B3C1
A3B3C1

A1B1C2
A2B1C2
A3B1C2
A1B2C2
A2B2C2
A3B2C2
A1B2C2
A2B2C2
A3B2C2

Total models = 3 X 3 X 2 =18

Why do this?

- "The strength of mathematics lies in its ability to reveal the consequences of particular assumptions. Its Achilles heel, however, is that the assumptions might be wrong.“ -Schnute and Richards (2001)

- The purpose of models is not to fit the data, but to sharpen the questions. -Samuel Karlin

Why do this?

- Interactions among assumptions
- What is important and what isn't
- More realistic representation of uncertainty
- Avenues for reducing uncertainty
- …Operating models for MSE

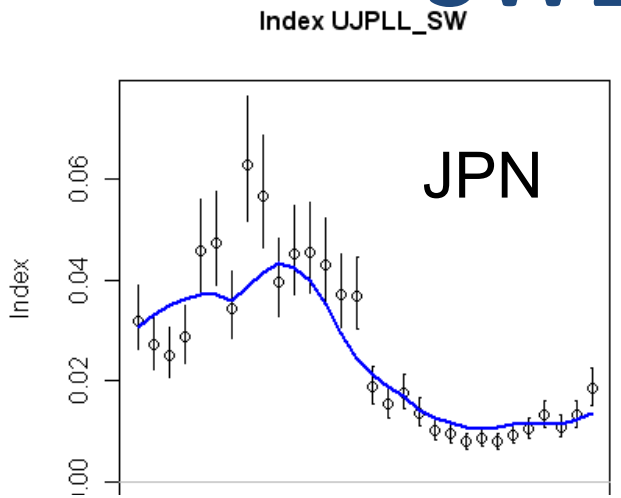
SW Stock Assessment

- Central Reference Case
- Summarizing 324 models
- Model averaging

Reference case SW1

- h=0.75
- growth/M/Maturity = Taiwan
- CPUE series = all equal; sigma=0.1
- Catch-at-length sample size max = 200
- Recruitment variability; sigma=0.4

SW1 CPUE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JPN
Index
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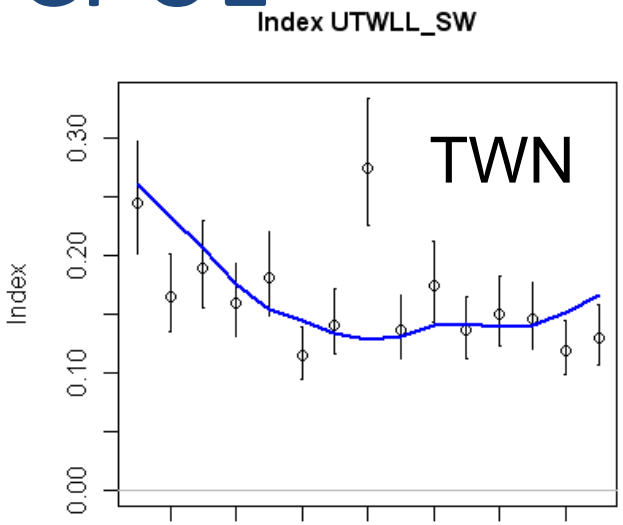
0.04
0.06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TWN
Index
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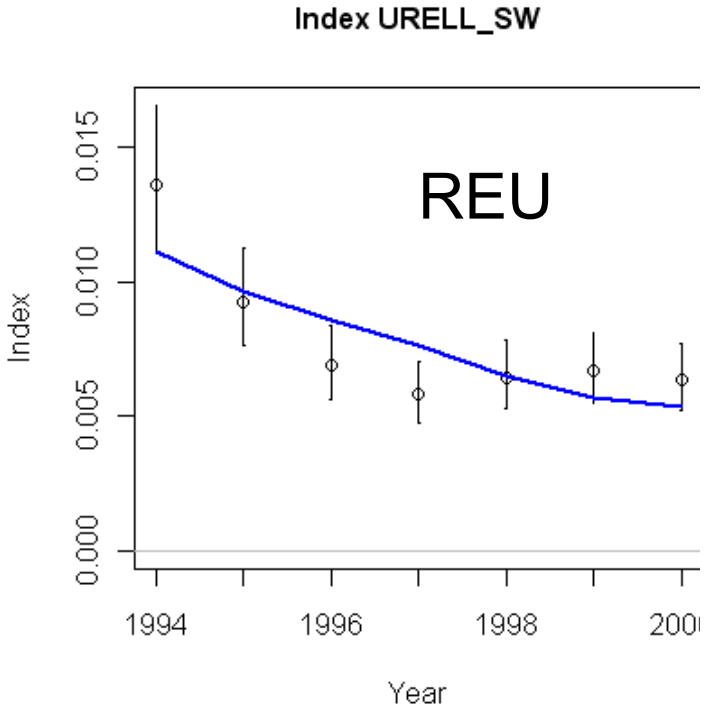
0.30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REU
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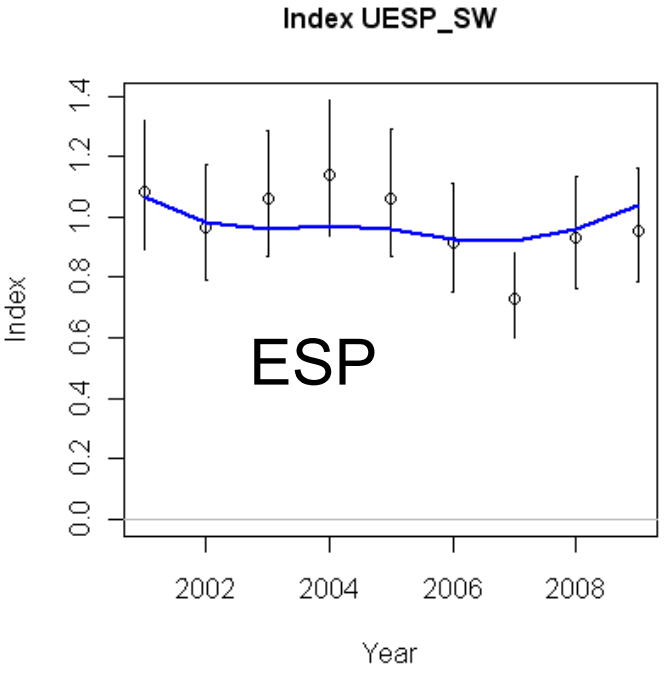
1994
1996
1998
Year


Index UESP_SW
ESP
Index
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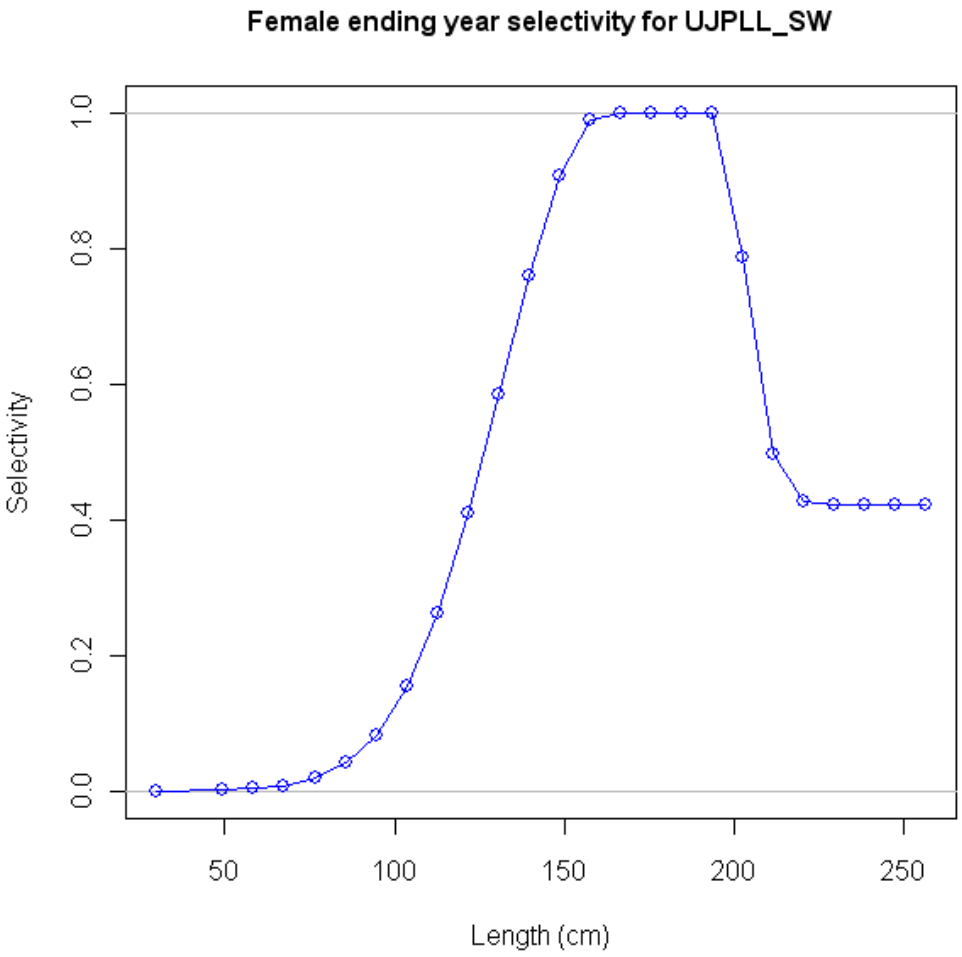
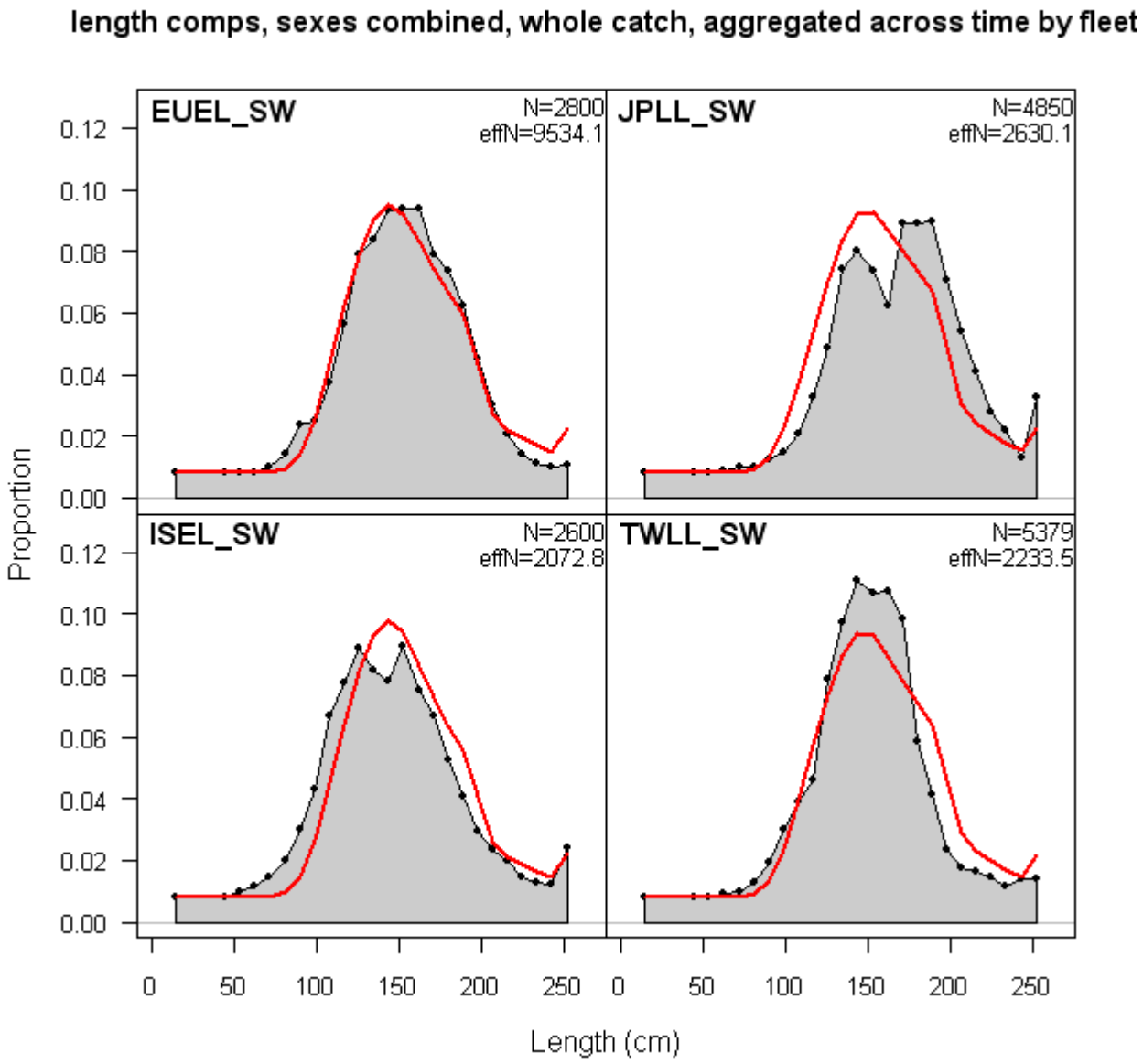
0.6
0.8
1.0
1.2
1.4
2002
2004
2006
2008
Year

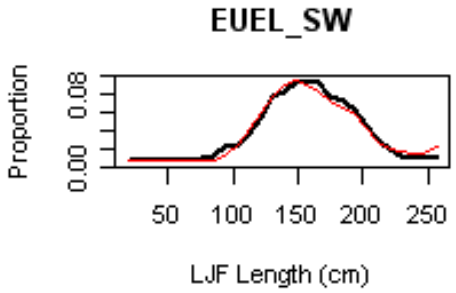
SW1 LL selectivity estimate

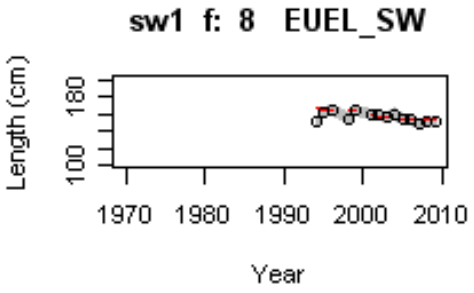


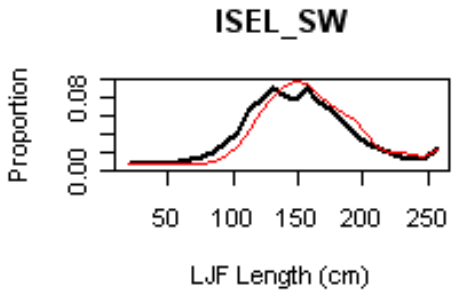
SW1 Size Composition

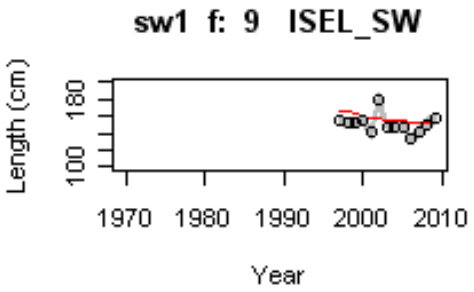


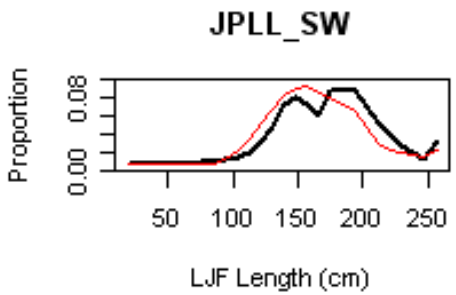
SW1 Size Composition

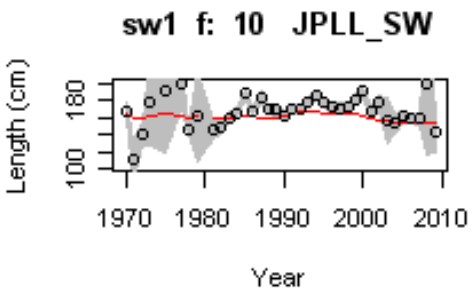


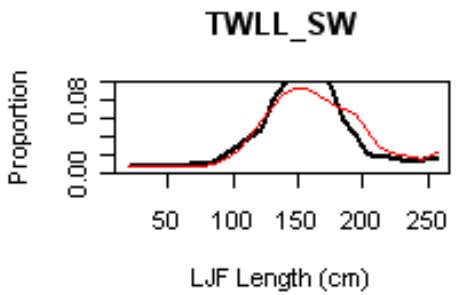


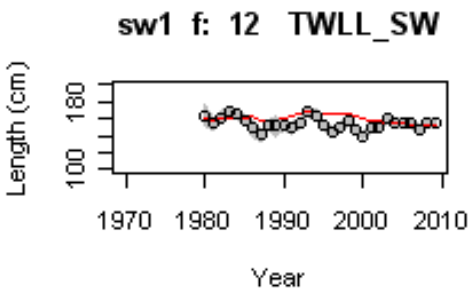




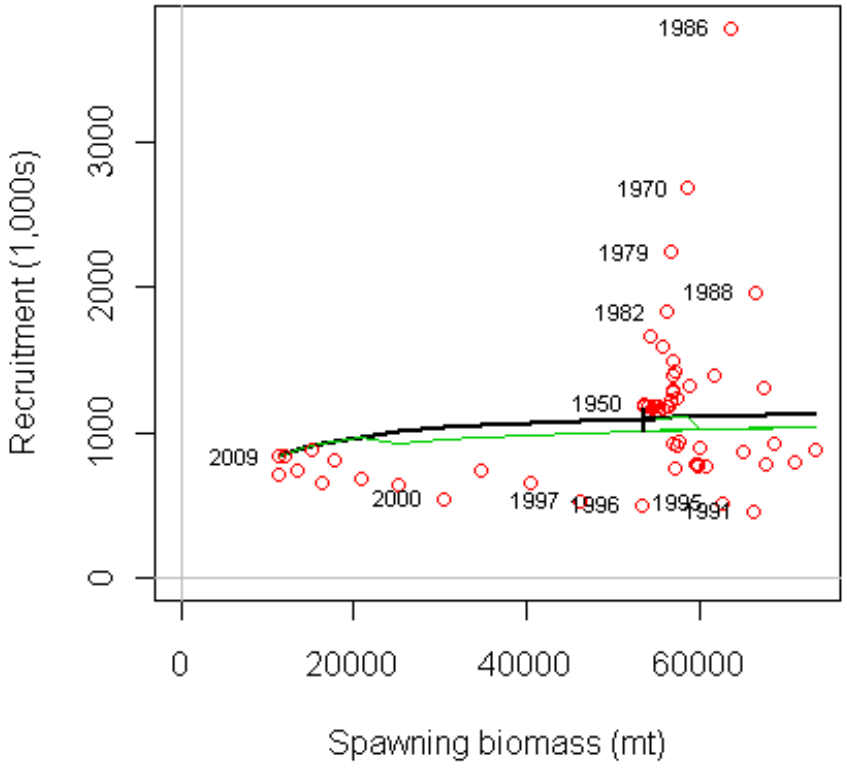


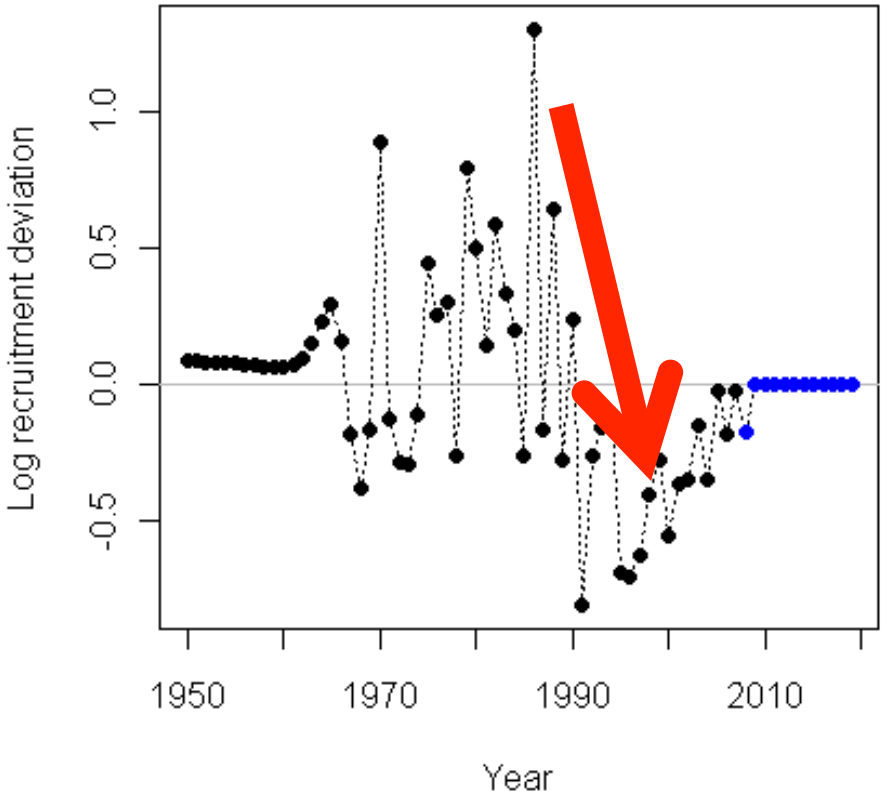




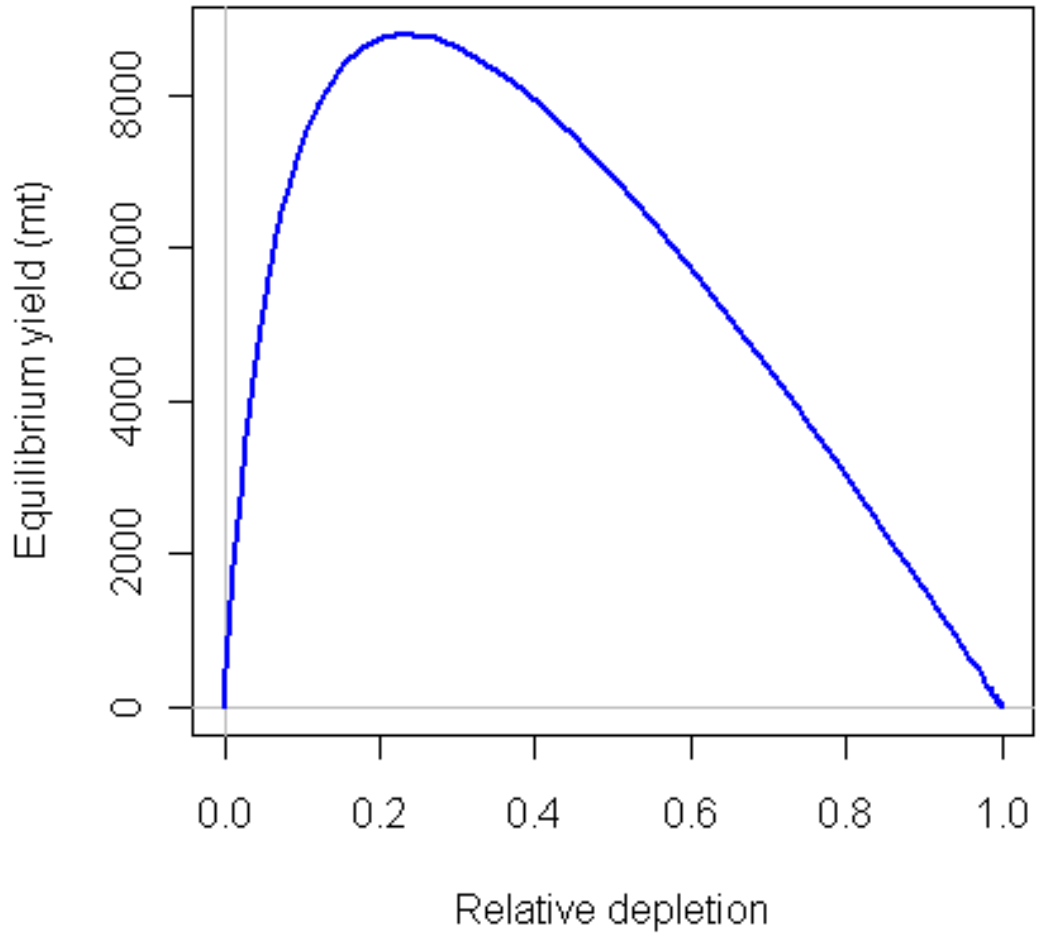


SW1 Recruitment



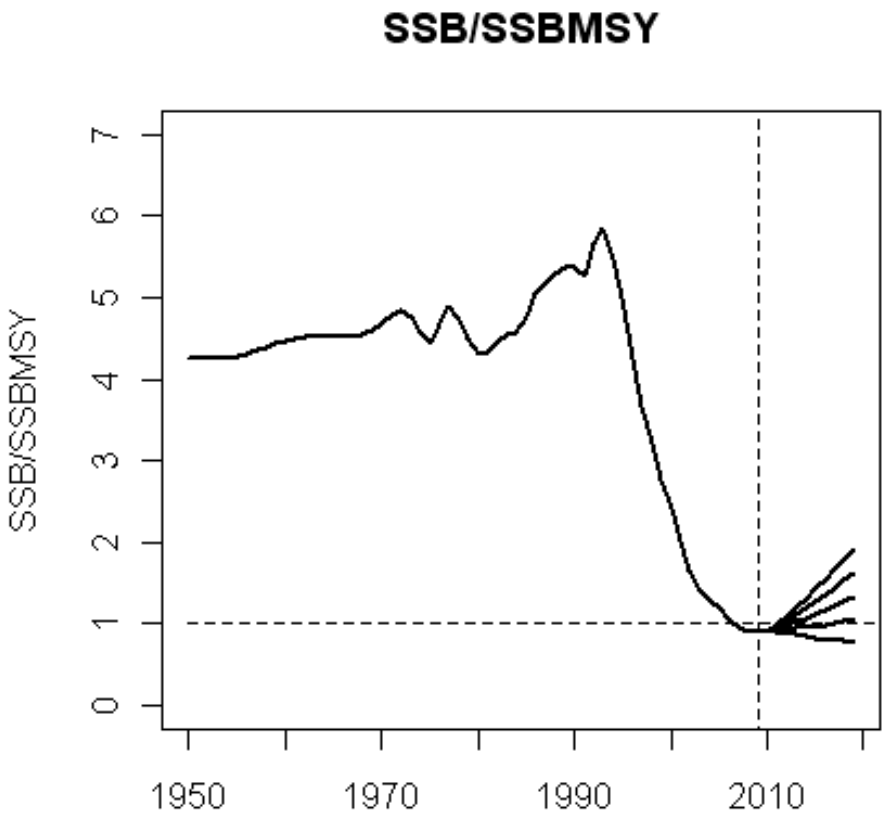


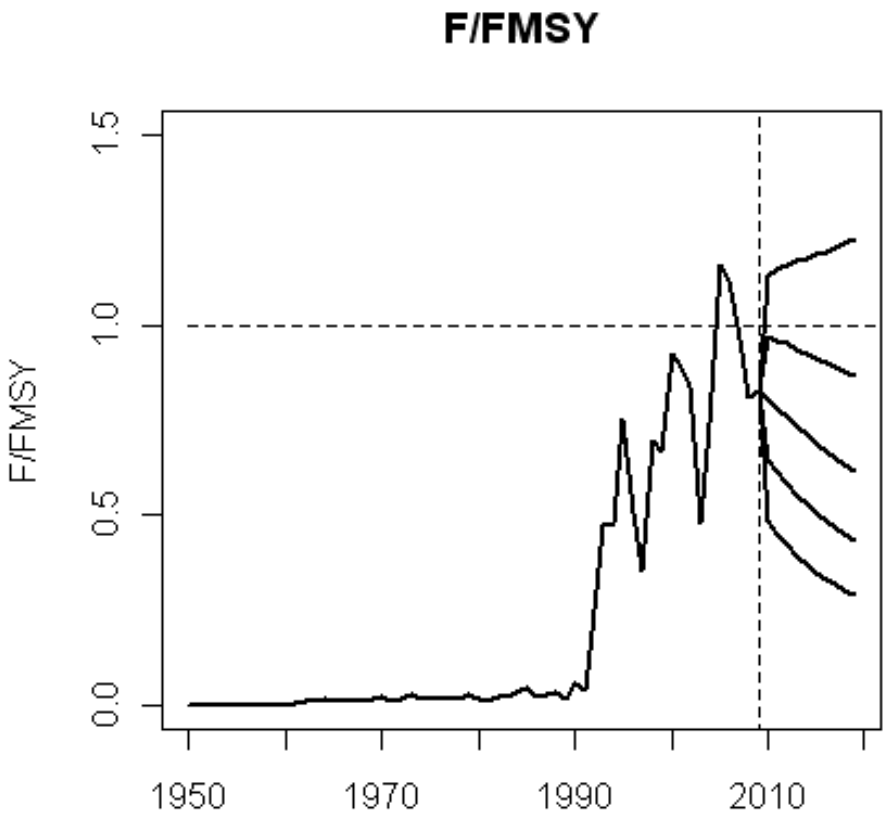
SW1 Production Curve



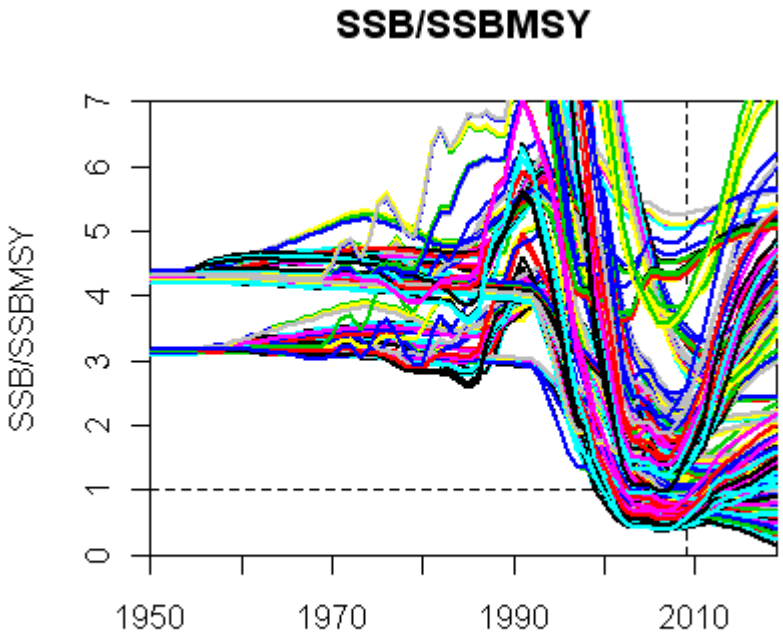
SW1 Stock Status

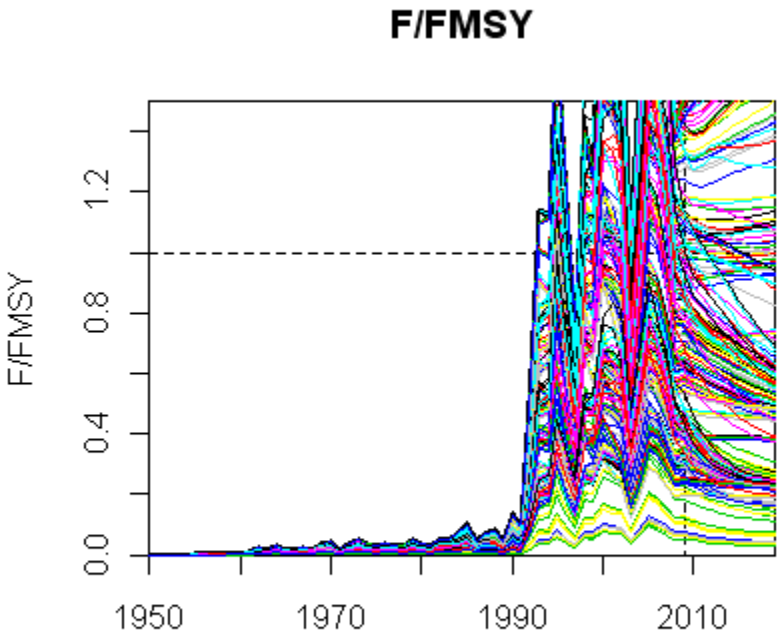
(projections at 60%, 80%, 100%, 120% and 140% of current)





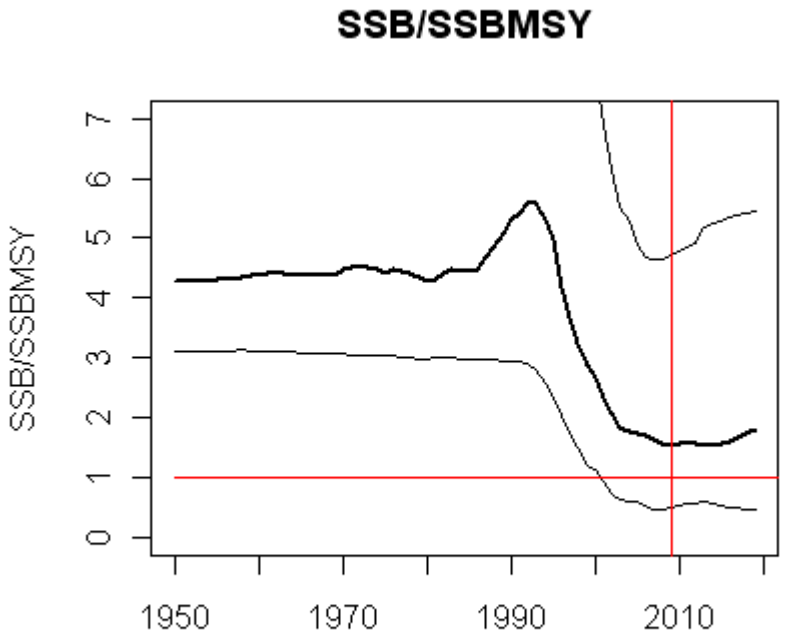
What to do with 324 models?

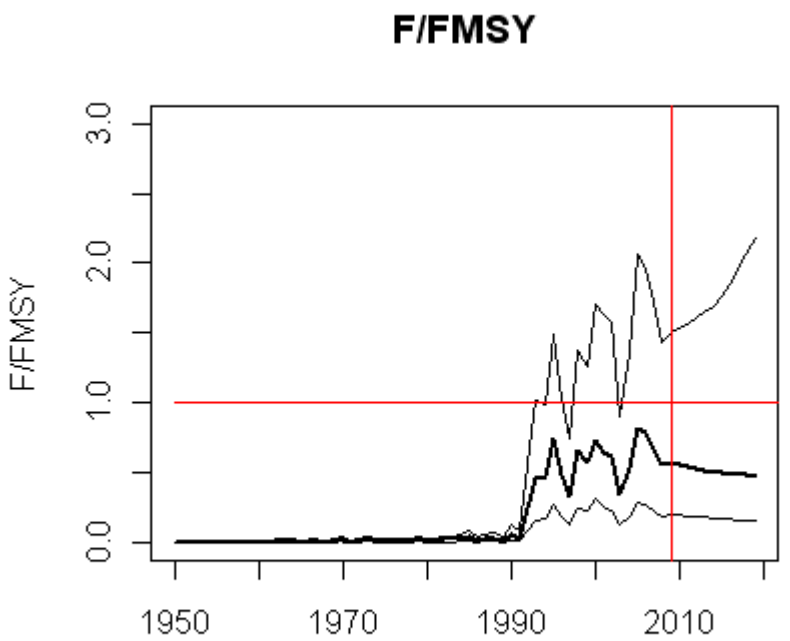




SW Stock Status Results

- All Models weighted equal
- (5^{th}, 50^{th}, 95^{th} percentiles)





Model Plausibility

- Priors
  - Represent uncertainty
- Likelihoods
  - Not comparable across all models
  - Some things hard to estimate
- “Posteriors”
  - Proposed scheme

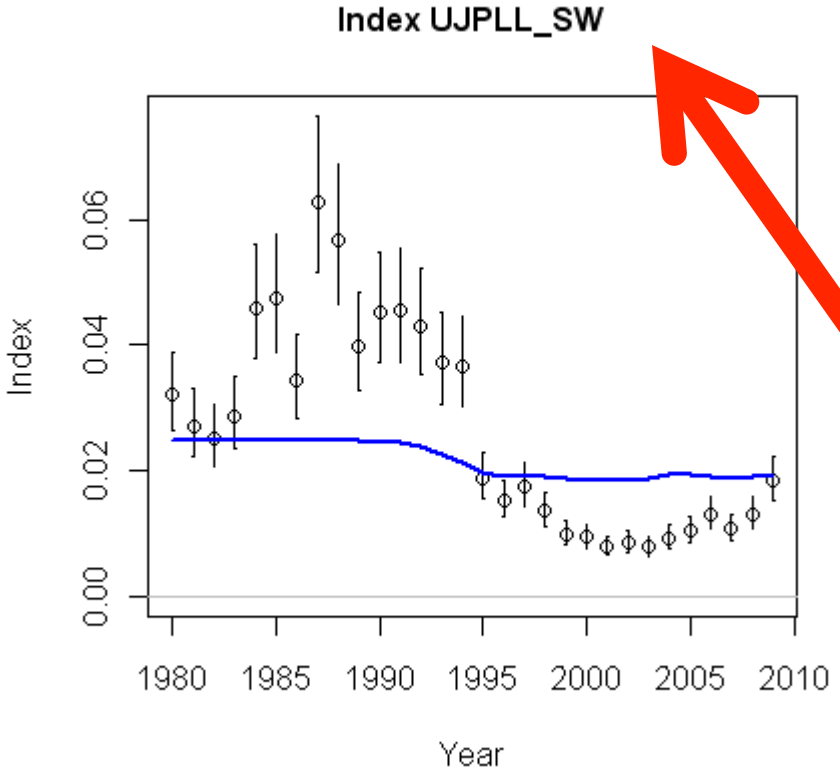
Aggregate Diagnostics

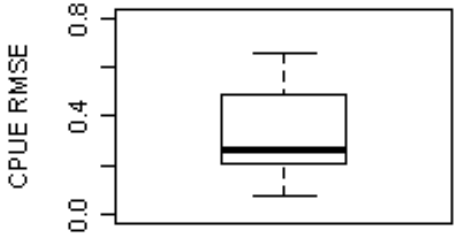
- CPUE
  - RMSE

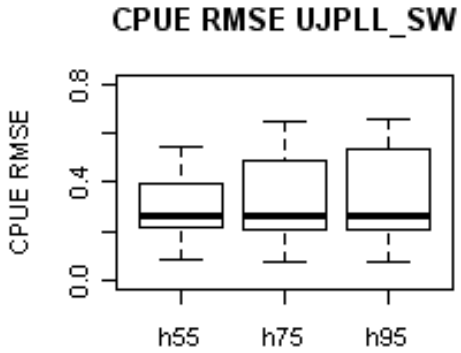
- ESS = Effective Sample Size
  - quality of distribution fit
  - independent of assumed sample size

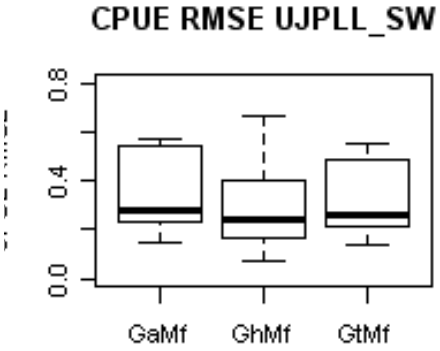
JPN CPUE FIT

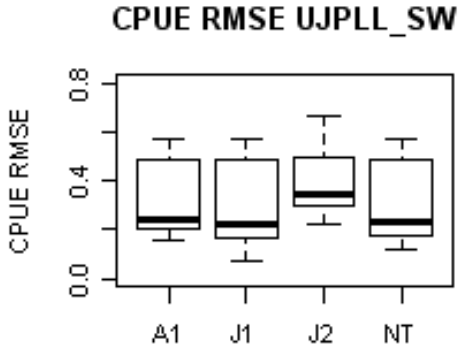
Deterministic Recruitment

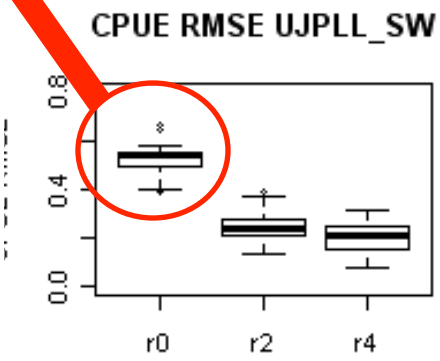


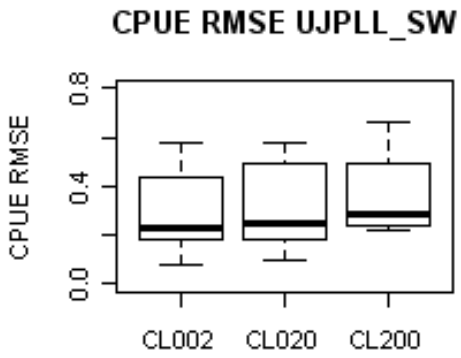






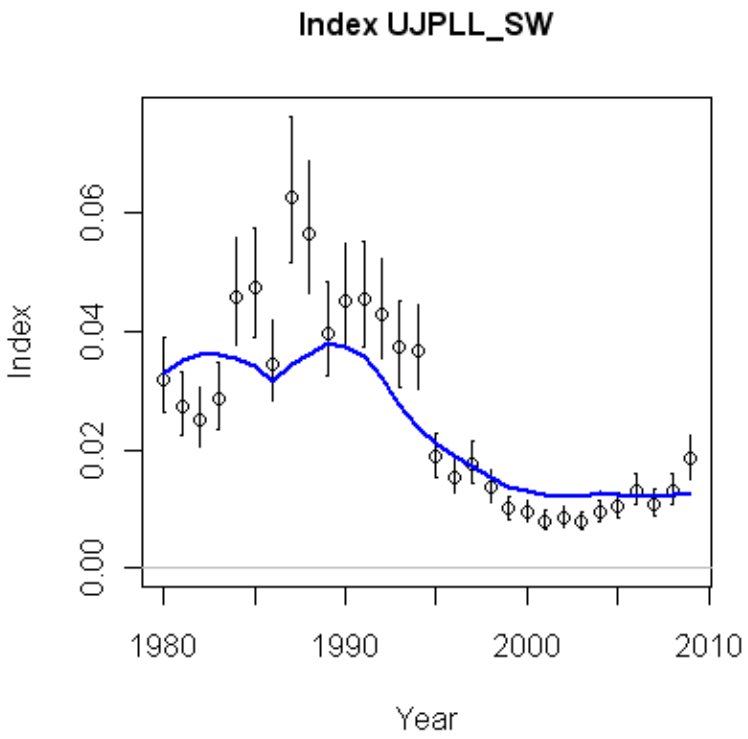


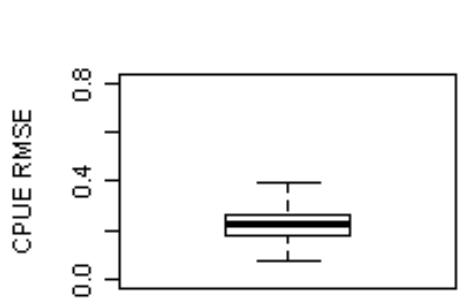


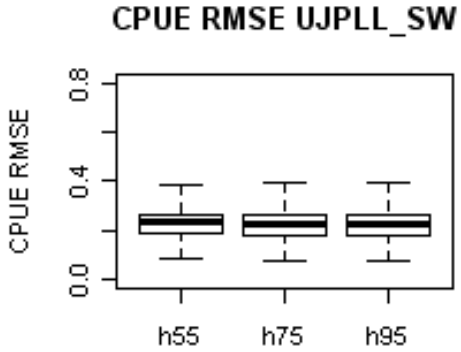


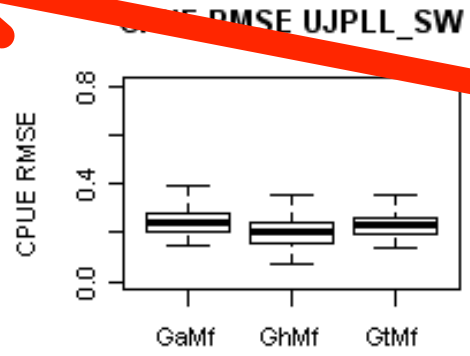
JPN CPUE FIT

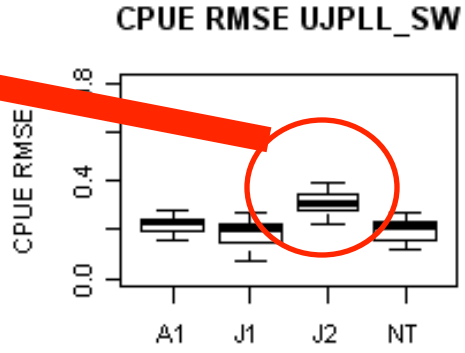
Down-weight JPN CPUE

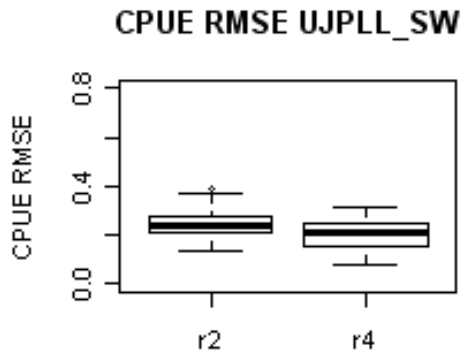


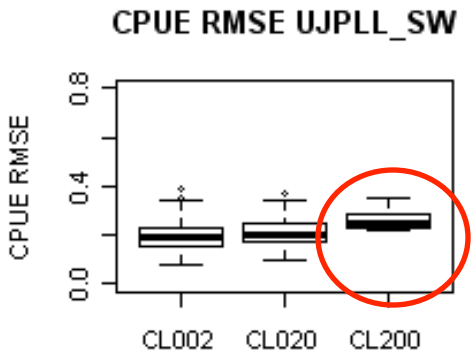






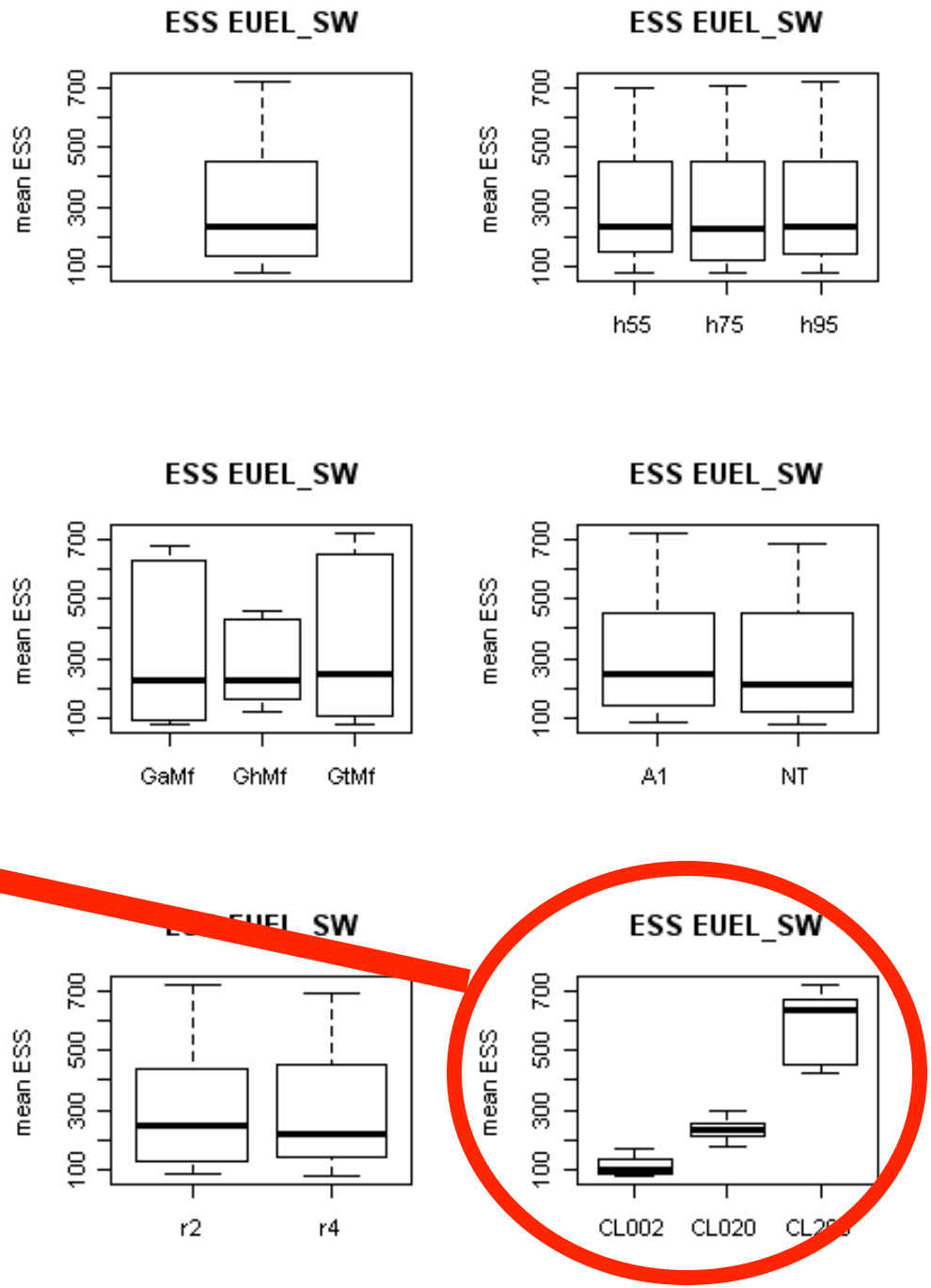






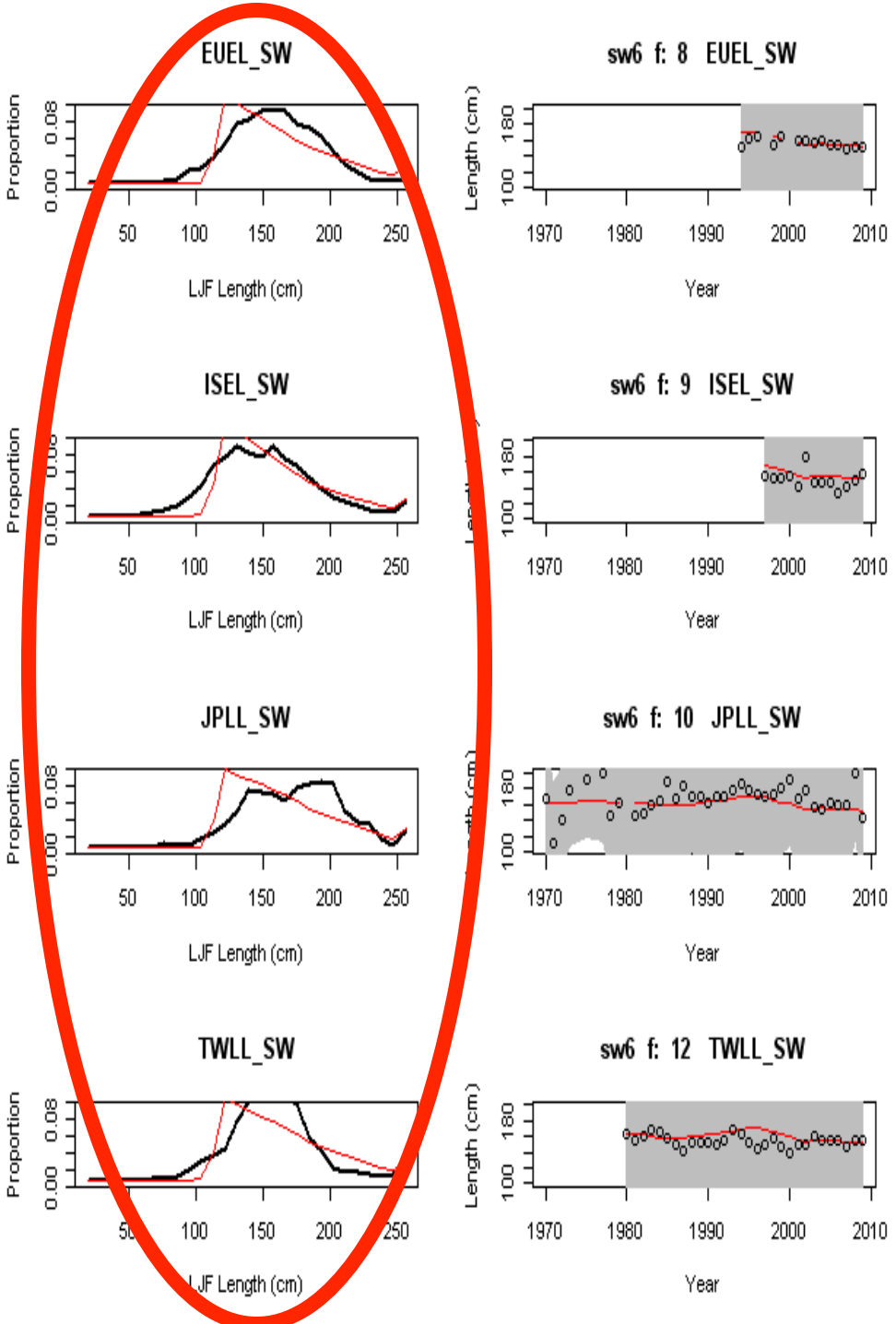
Size Composition Fit

Assumed Sample Size



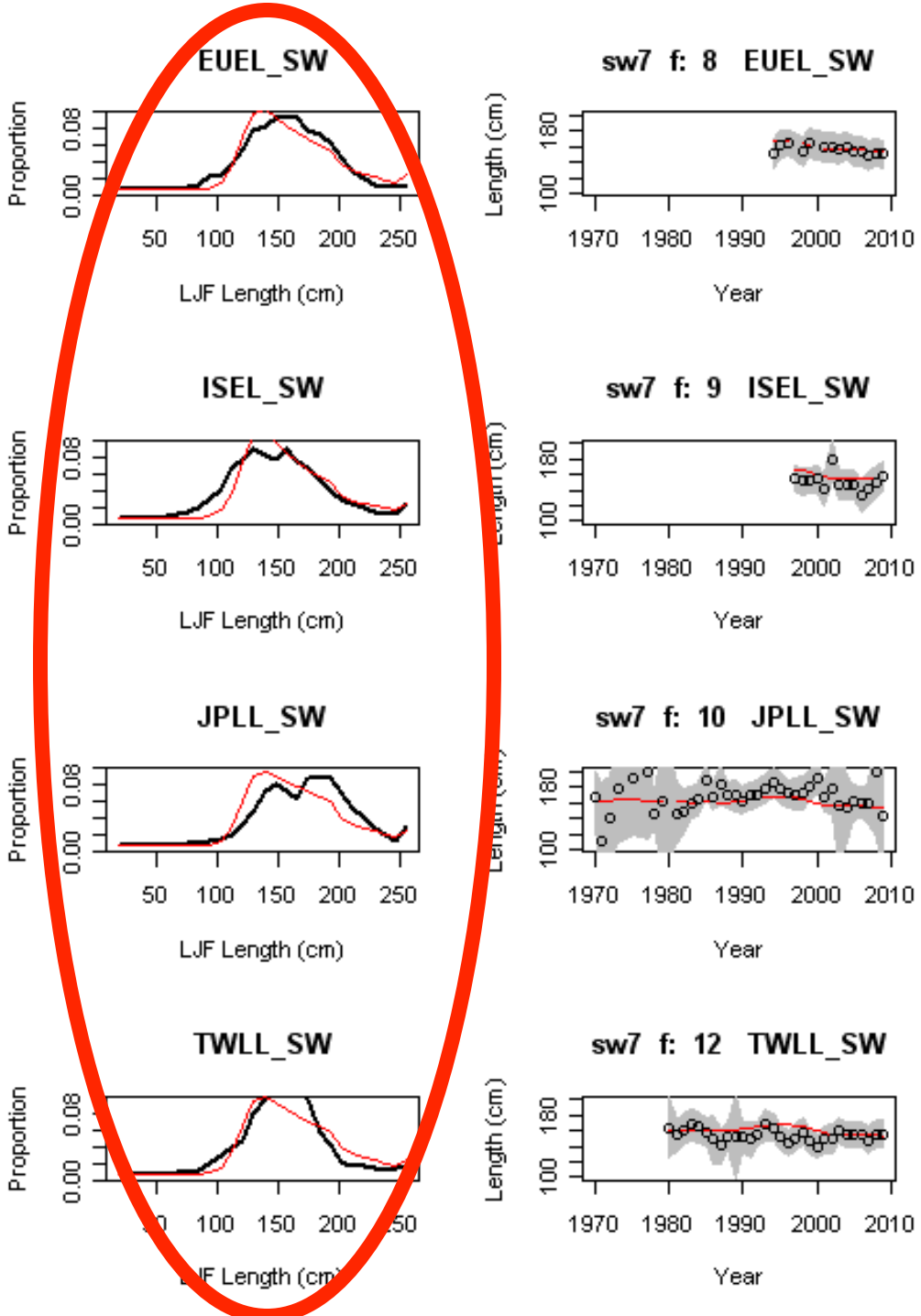
Size Composition Fit

- CL002



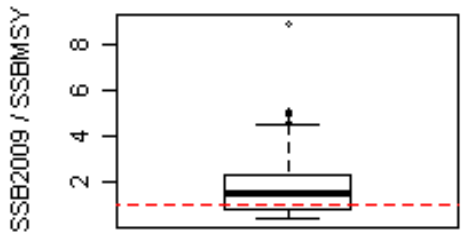
Size Composition Fit

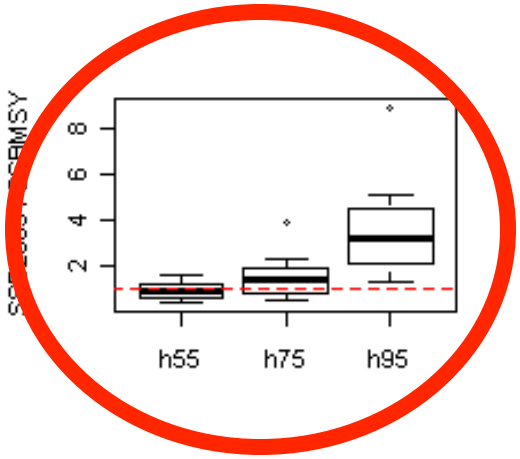
- CL020

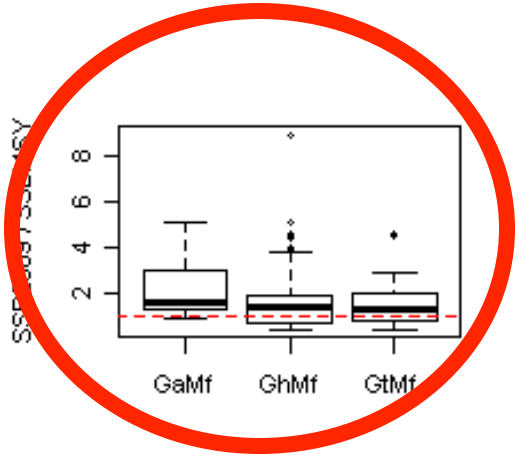


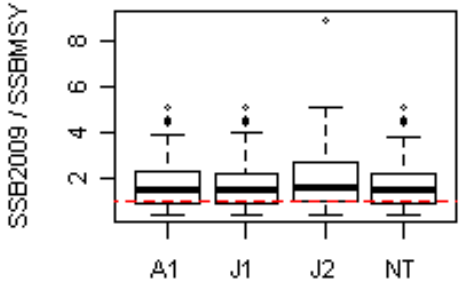
What matters for Management?

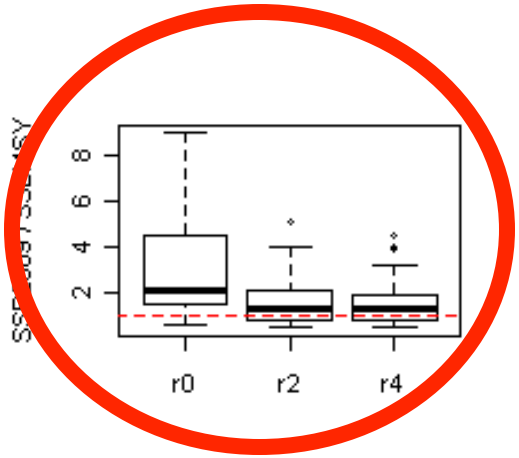
B/BMSY

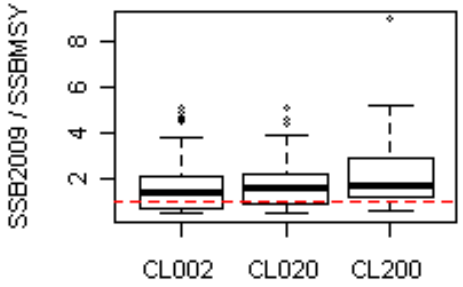






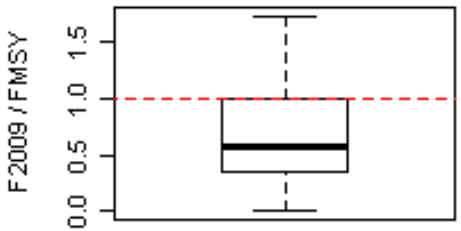


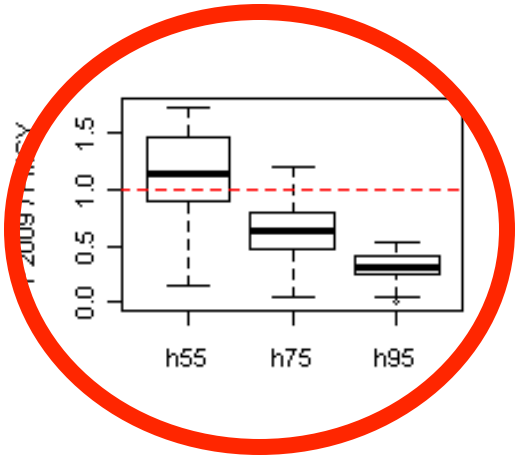


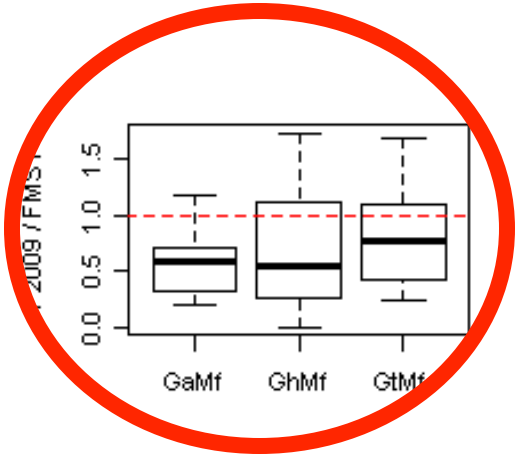


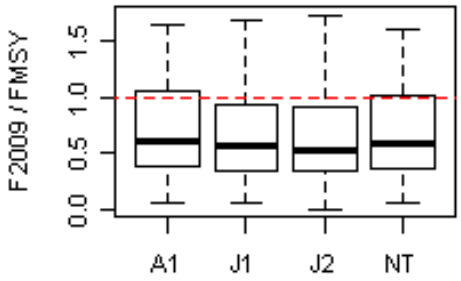
What matters for Management?

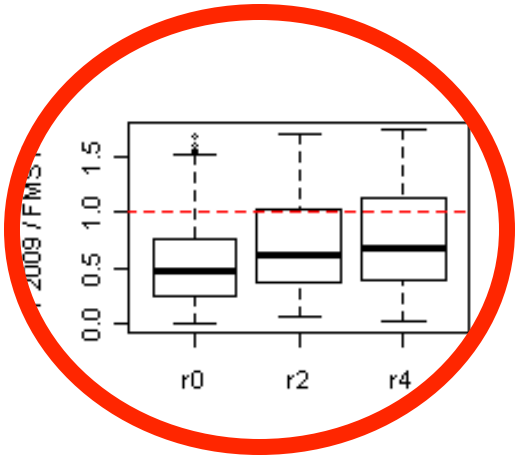
F/FMSY

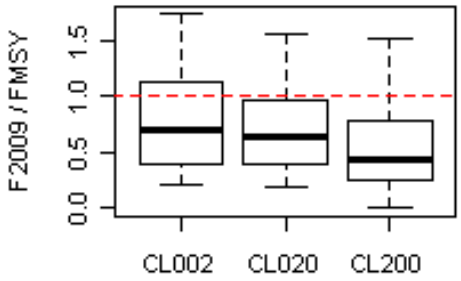






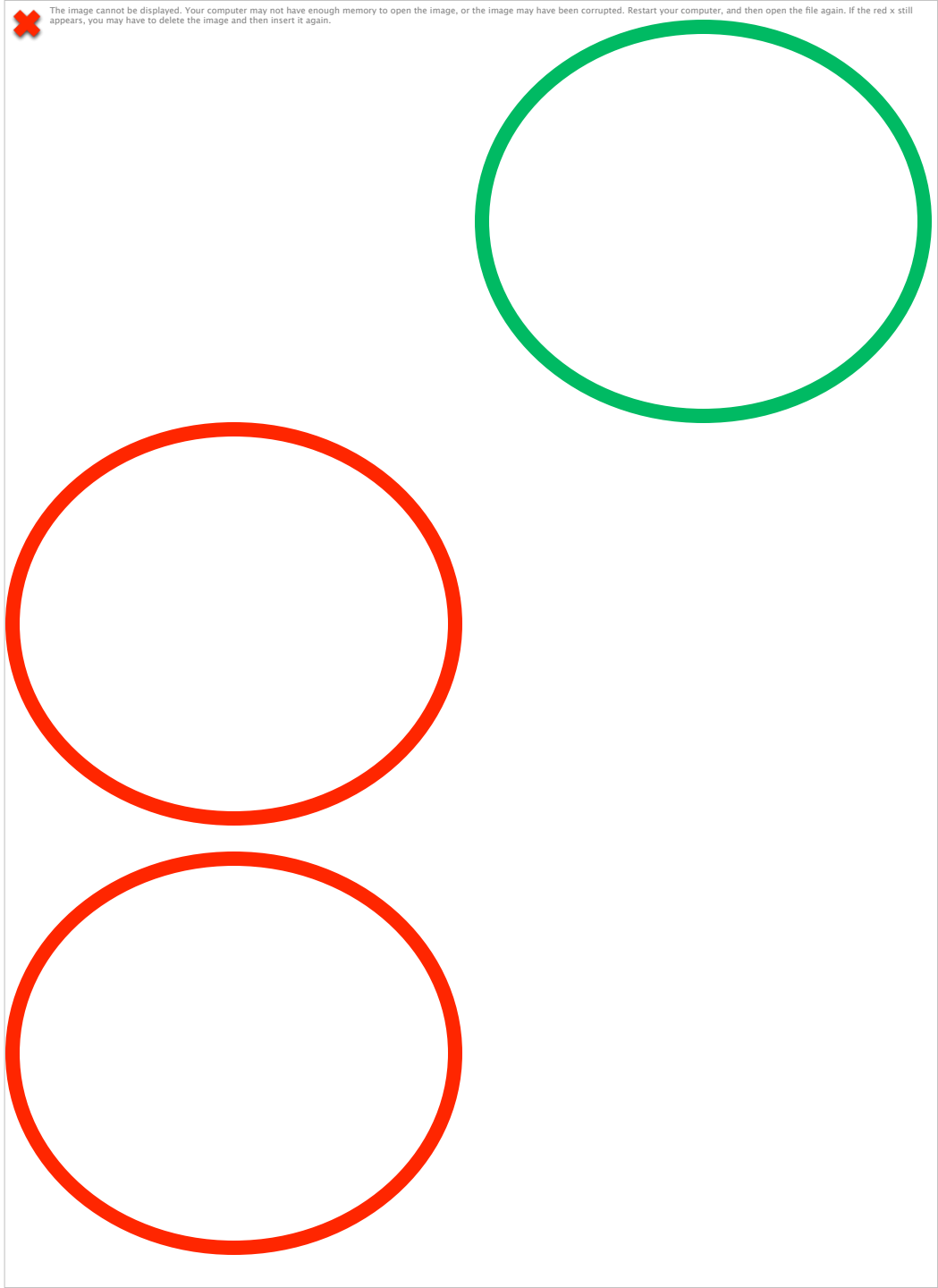






What matters for Management?

B/B0



Plausibility of assumptions

Assumption	Option	Proposed Option Weight
LL Catchability	•A1; All equal •NT ; omit TWN •J1; only use JPN, •J2; dnwt JPN	0.25 0.25 0 0.5
Recruitment σ=sd(log(dev))	R4; σ=0.4 R2; σ=0.2 R0; σ=0	0.3 0.7 0
Catch-at-Length input N	CL200; max(N)=200 CL20; max(0.1N)=20 CL2; max(0.01N)=2	0.2 0.6 0.2

Plausibility of assumptions

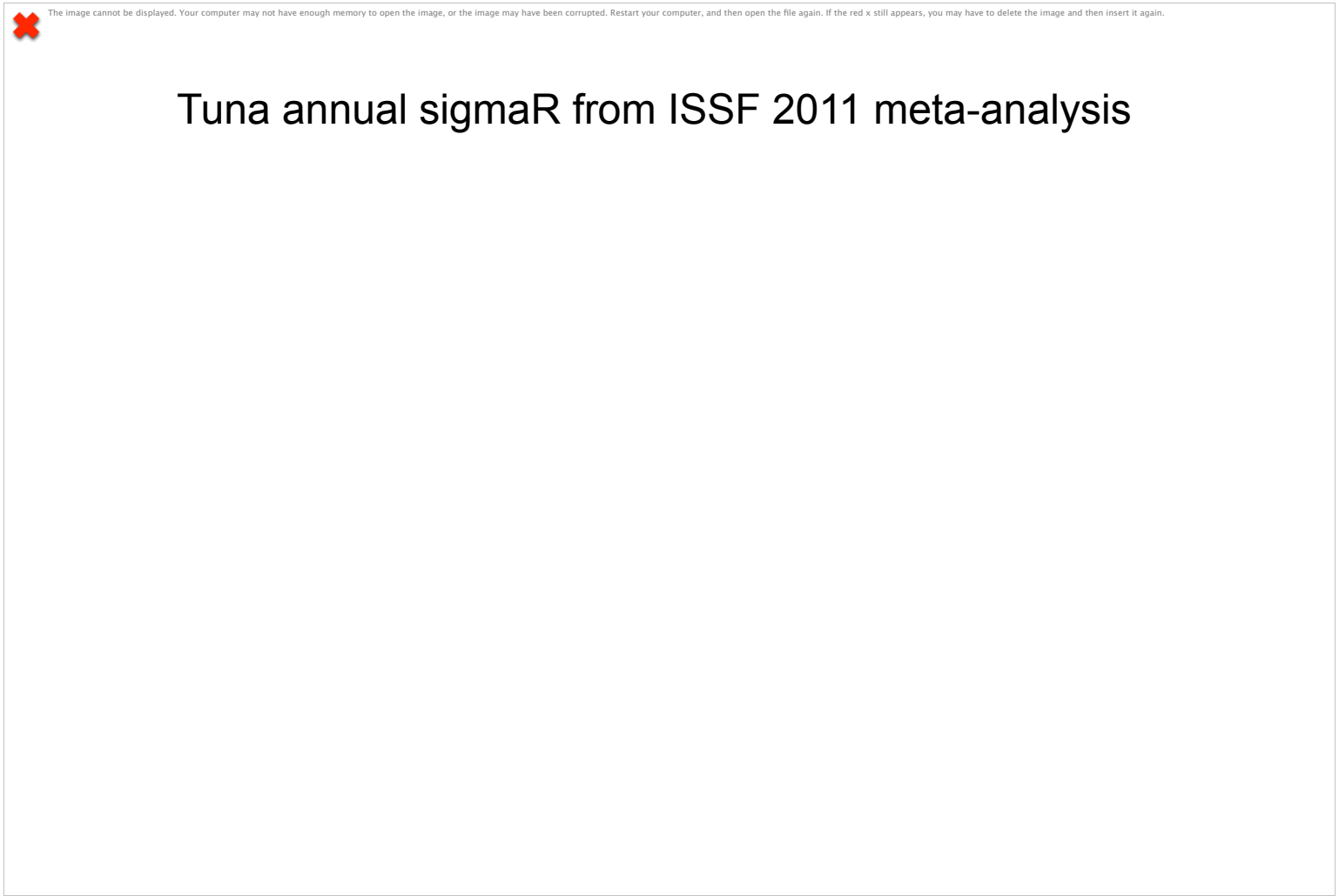
Assumption	Option	weight
Beverton-Holt Steepness	h = 0.55 h = 0.75 h = 0.95	0.1 0.6 0.3
Growth, Natural Mortality and Maturity	GaMf AUS GtMf TWN GhMf Hawai'I	0.4 0.4 0.2

R0 Weighting Justification

- Recruitment variability
  - R0 unrealistic, but
    - Do we believe data informative about rec?

R0 Weighting Justification

- Recruitment variability – R0 unrealistic



Growth Weighting Justification

- Hawai'ian curve is an outlier, generated from another ocean, but
  - unvalidated age estimation seems to be the main problem

Steepness Weighting Justification

- highly fecund
- rapid rebuilding observed in several populations

Steepness Weighting Justification

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ISSF Tuna Steepness meta-analysis

What do the data say about steepness and Growth?

- For a subset of models comparable on basis of Likelihood in principle…

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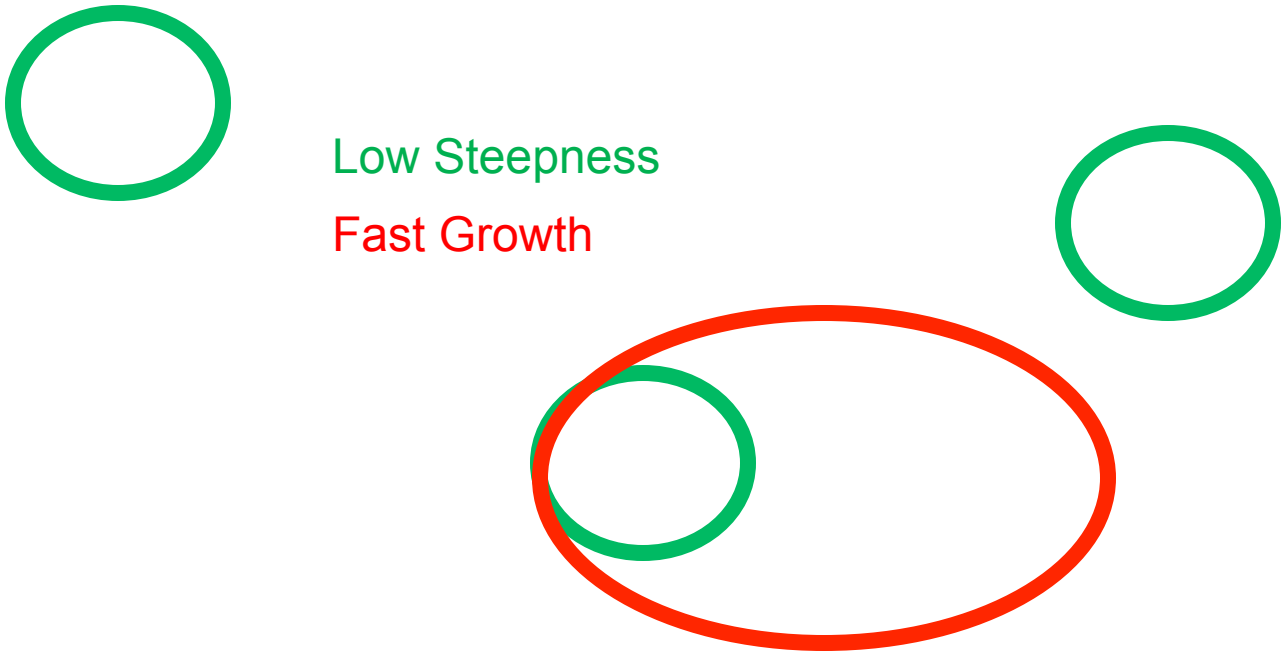
- A1, r4, CL20



What do the data say about steepness and Growth?

- For a subset of models comparable on basis of Likelihood in principle…

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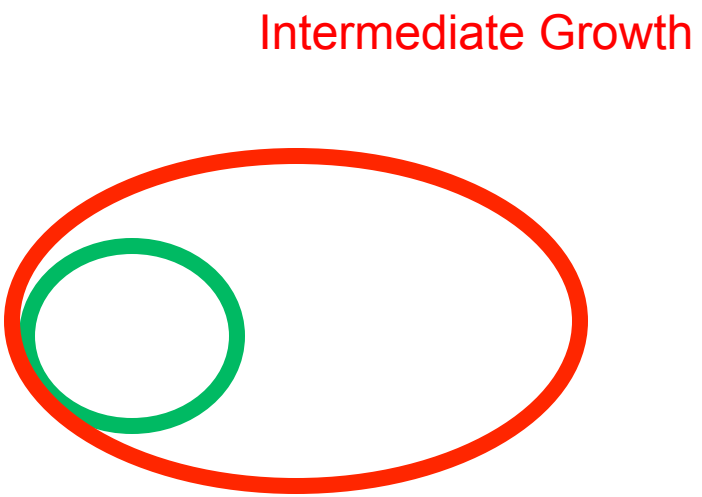
- A1, r2, CL200



What do the data say about steepness and Growth?

- Likelihoods sensitive to other assumptions

SW Stock Status Results

- Proposed Weighting Scheme

SW Stock Status Results

- Proposed Weighting Scheme

Conclusions 1

- SS3 flexible enough to explore options, and convergence reliable (Thanks Rick Methot)
- All CPUE series seem to be very consistent
- Anomalous recruitment essential to fit the steep JPN decline in the 1990s
- Not much confidence in the size data from TWN and JPN

- 324 model results

Conclusions 2

- Stock status (MSY-related) most sensitive to steepness and growth/M/maturity assumptions.
  - Do not have much confidence in the model ability to estimate these values
- Depletion estimates more robust to steepness than BMSY estimates

SW Stock Status Results

(DK weighting scheme) 50% (5% - 95%)

Management Quantity	SW Indian Ocean	Aggregate IO
Most recent catch estimate	~6	
Mean catch over last 5 years		
MSY (1000 t)	9.4 (6.5 – 13.5)	
Current Data Period	2009	
F(Current)/F(MSY)	0.64 (0.27 – 1.27)	
B(Current)/B(MSY)		
SB(Current)/SB(MSY)	1.44 (0.61 – 3.87)	
B(Current)/B(0)		
SB(Current)/SB(0)	0.29 (0.15 – 0.43)	
B(Current)/B(Current, F=0)		
SB(Current)/SB(Current, F=0)		

SW - Kobe 2 Strategy Matrix

	Constant Catch Level (relative to 2009)				
Probability (proportion of weighted model MPDs)	**60%**	**80%**	**100%**	**120%**	**140%**
B(2012) <B(MSY)	0.14	0.18	0.23	0.28	0.29
F(2012) >F(MSY)	<0.01	0.05	0.08	0.17	0.32
B(2019) <B(MSY)	0.14	0.18	0.23	0.30	0.32
F(2019) >F(MSY)	<0.01	0.05	0.08	0.17	0.39

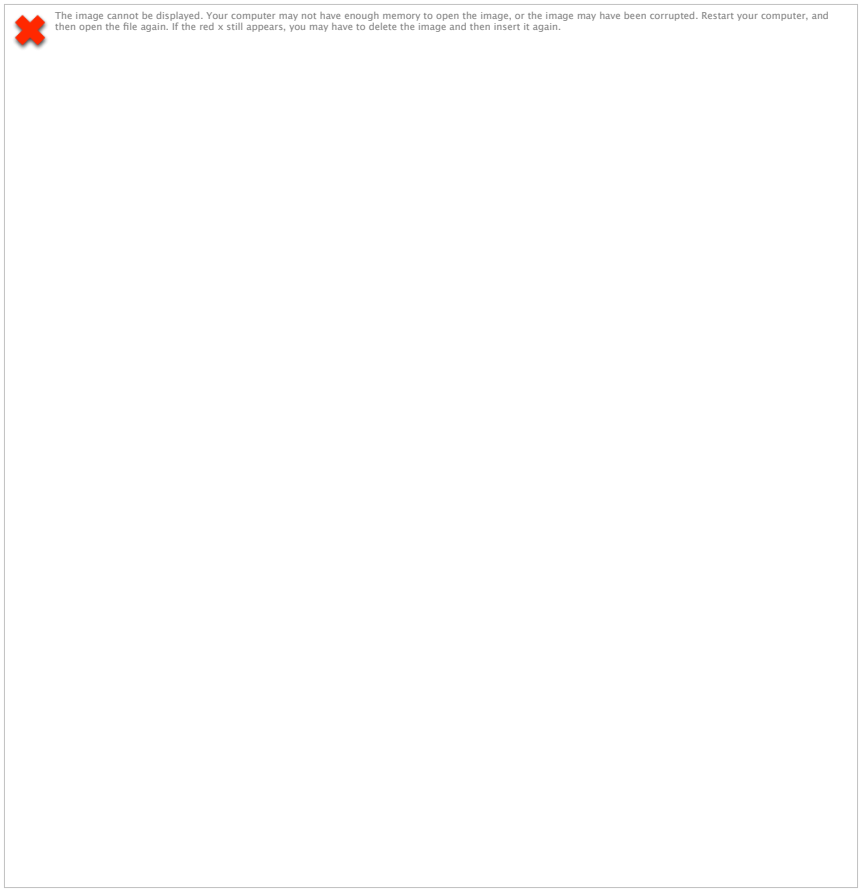
Extreme Models…

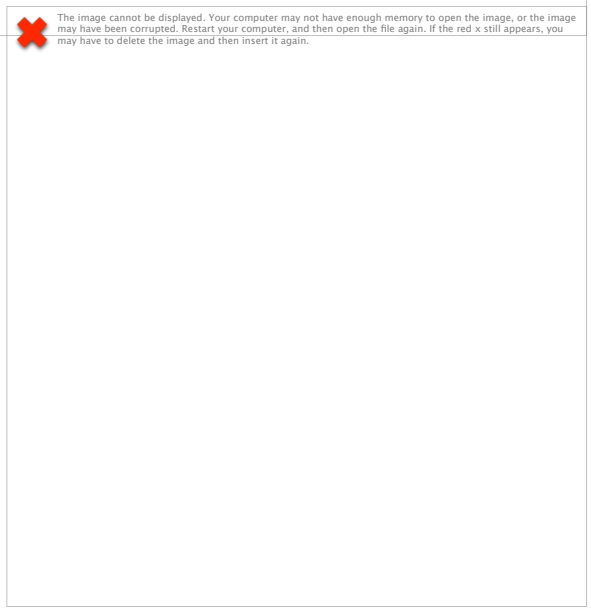
- Highest MSY ~ 100000 t…

Extreme Models…CPUE

Extreme Models… catch-at-length

Most Extreme Model…Stock and Recruitment





Most Extreme

- Do we need to weed the extremes out?

- MSY = 100 Kt = 99.72 percentile
- MSY = 13.5 Kt = 95th percentile

- Outliers probably not important

Aggregate IO Stock Assessment

- Differences from SW
- Example model
- 324 model results
- Weighted average

IO Differences from SW

- 4 areas vs 1
  - 4 non-mixing populations with shared spawning stock
  - Spatial recruitment deviates estimated
- 12 fisheries vs 6
- 10 CPUE series vs 4
  - Q shared for JPN fisheries
  - different CPUE assumption options
- 8 size composition series

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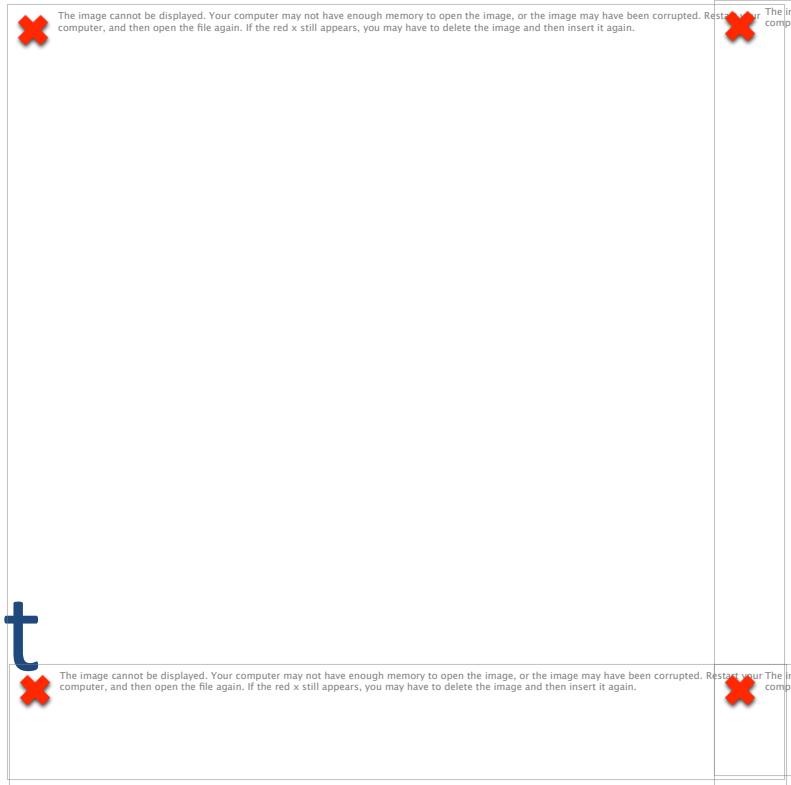
CPUE Assumption Options

- A1 – all series equal (δ=0.1)
- NT – TWN highly down-weighted
- J1 – only JPN series used

Reference case IO1

- h=0.75
- growth/M/Maturity = Taiwan
- CPUE: sigma=0.1; except TWN = 3.1
- Catch-at-length sample size max = 20
- Recruitment variability; sigma=0.2

JPN
CPUE fit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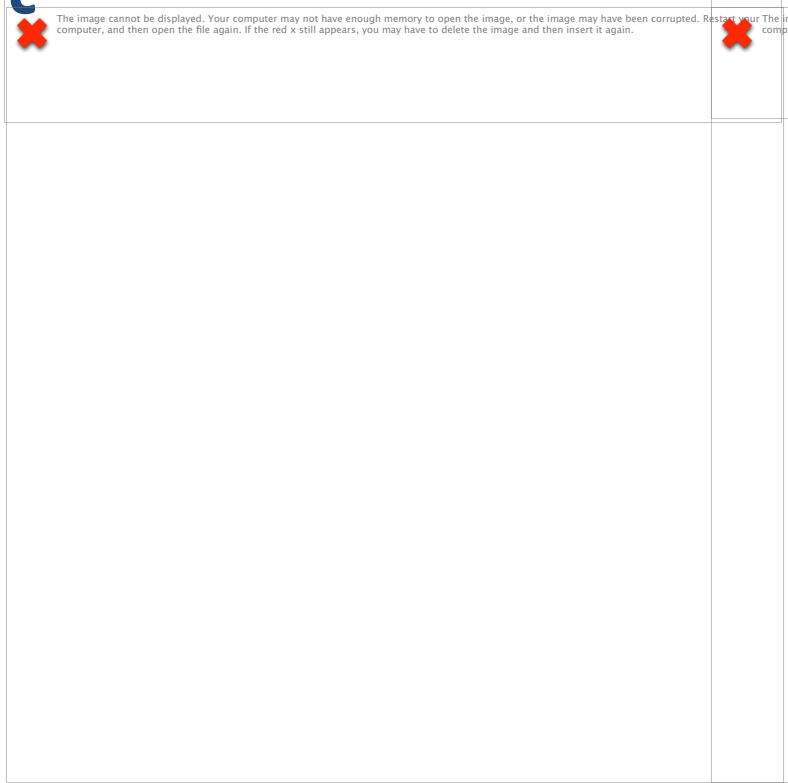
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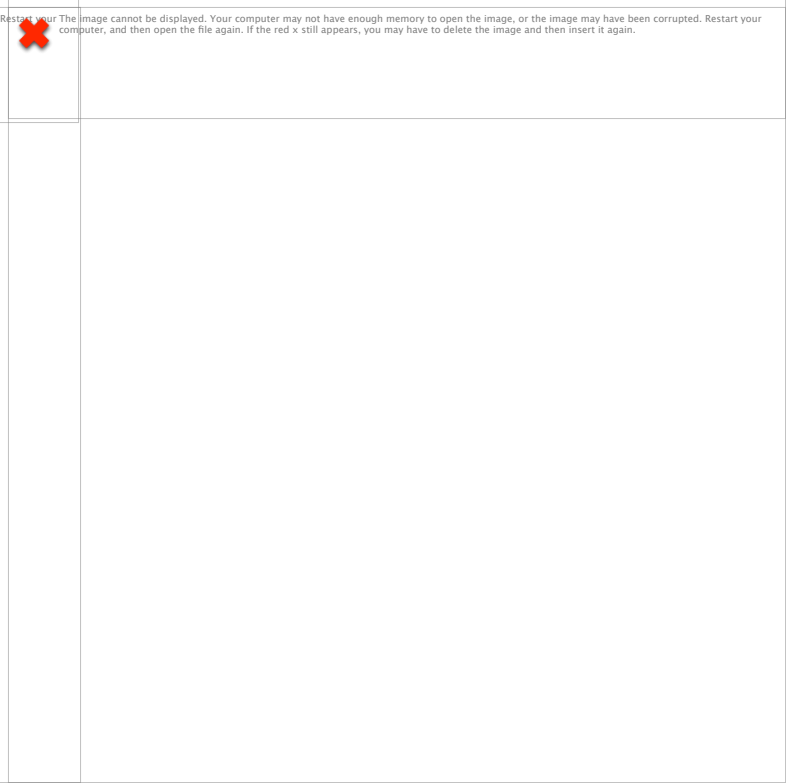
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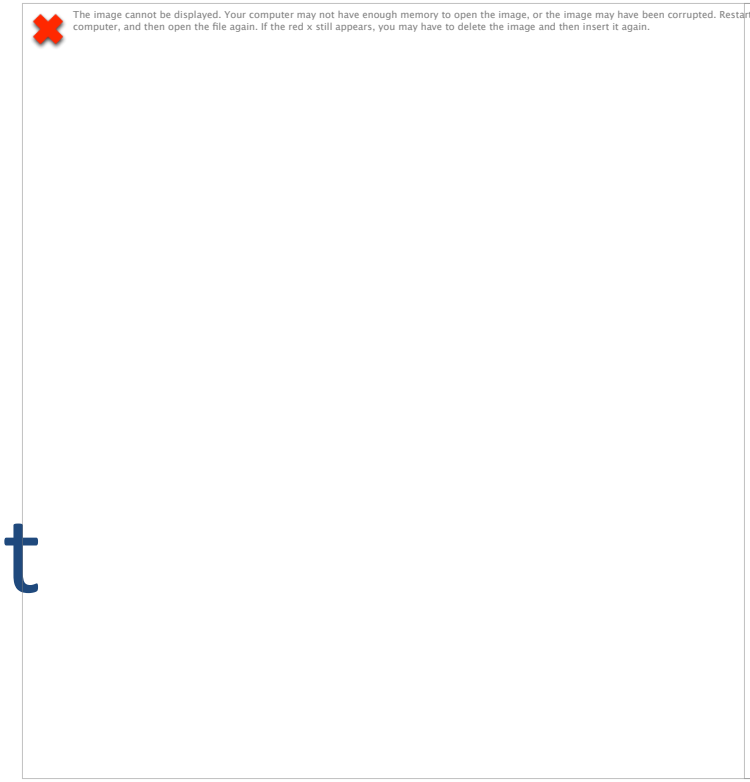
TWN CPUE fit

(highly downweighted)

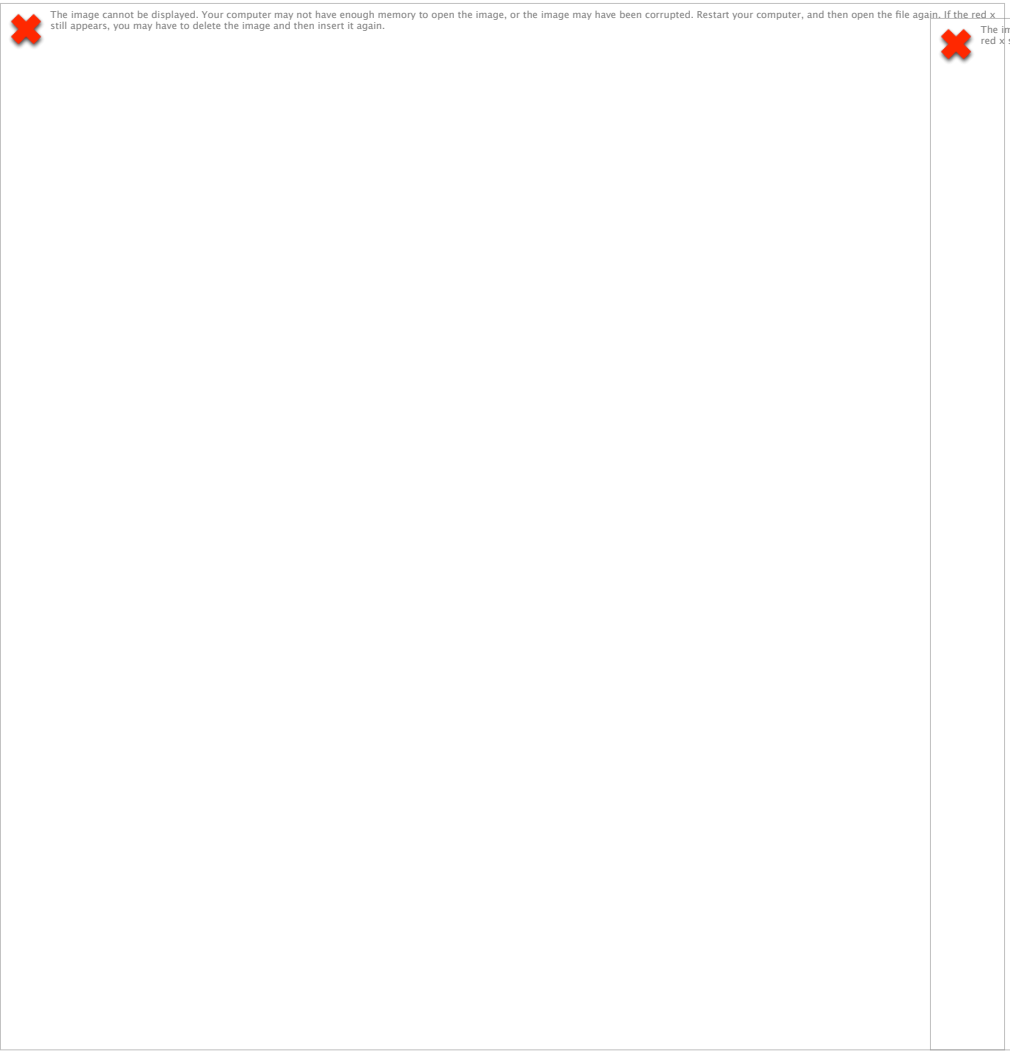
REU

ESP

CPUE fit



Selectivity



Size

Composition

fit

Size
Composition
fit

Aggregate Recruitment Series

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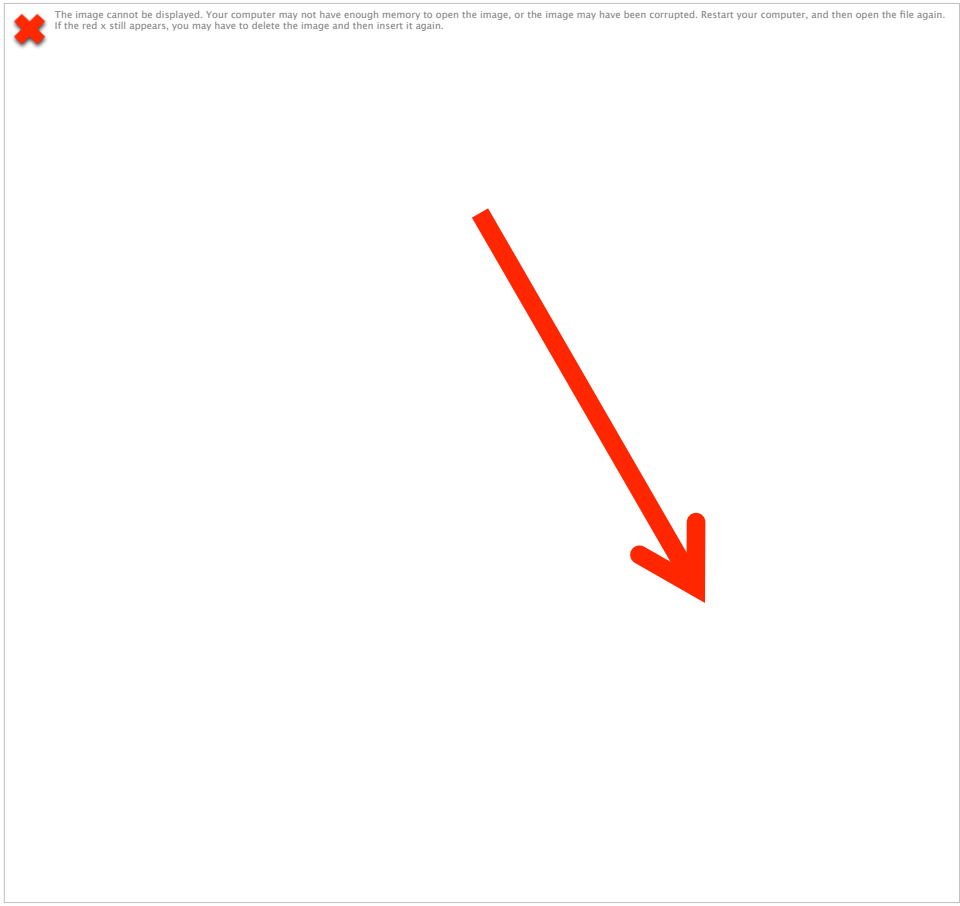

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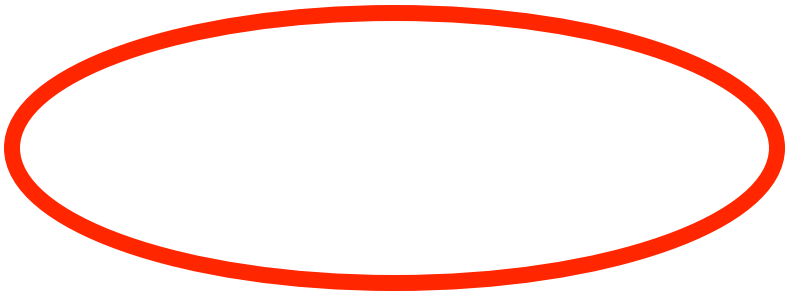

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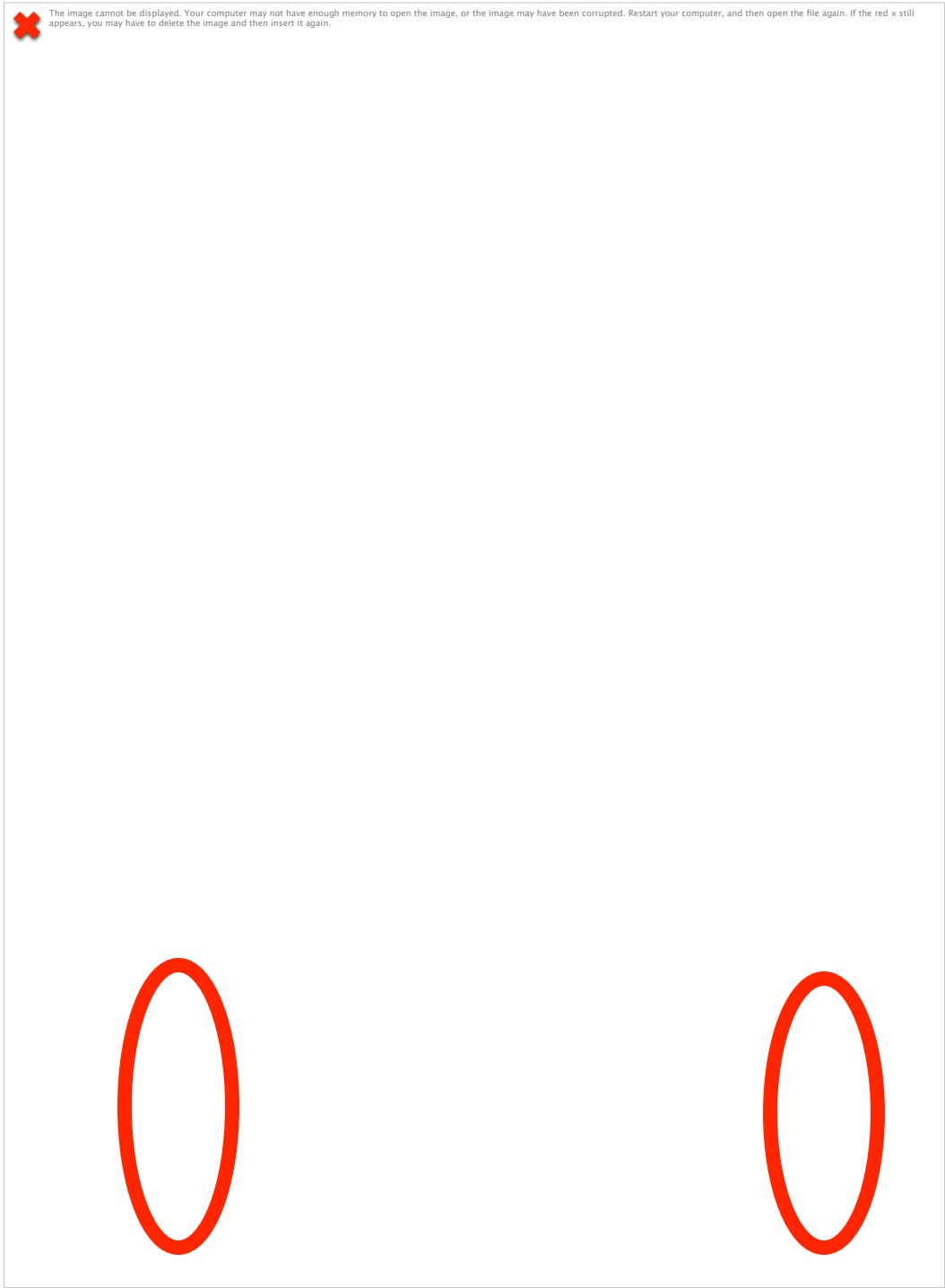
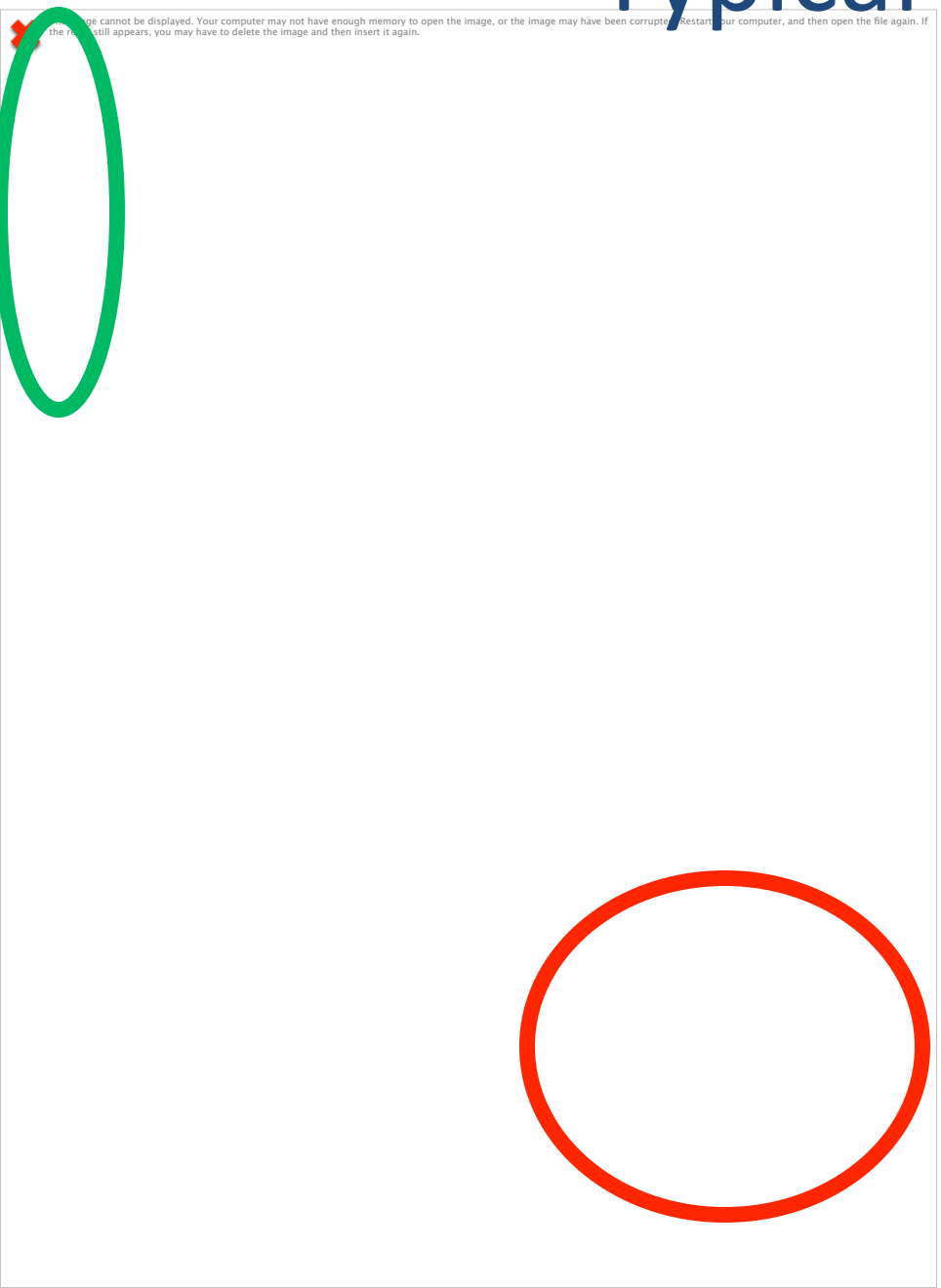
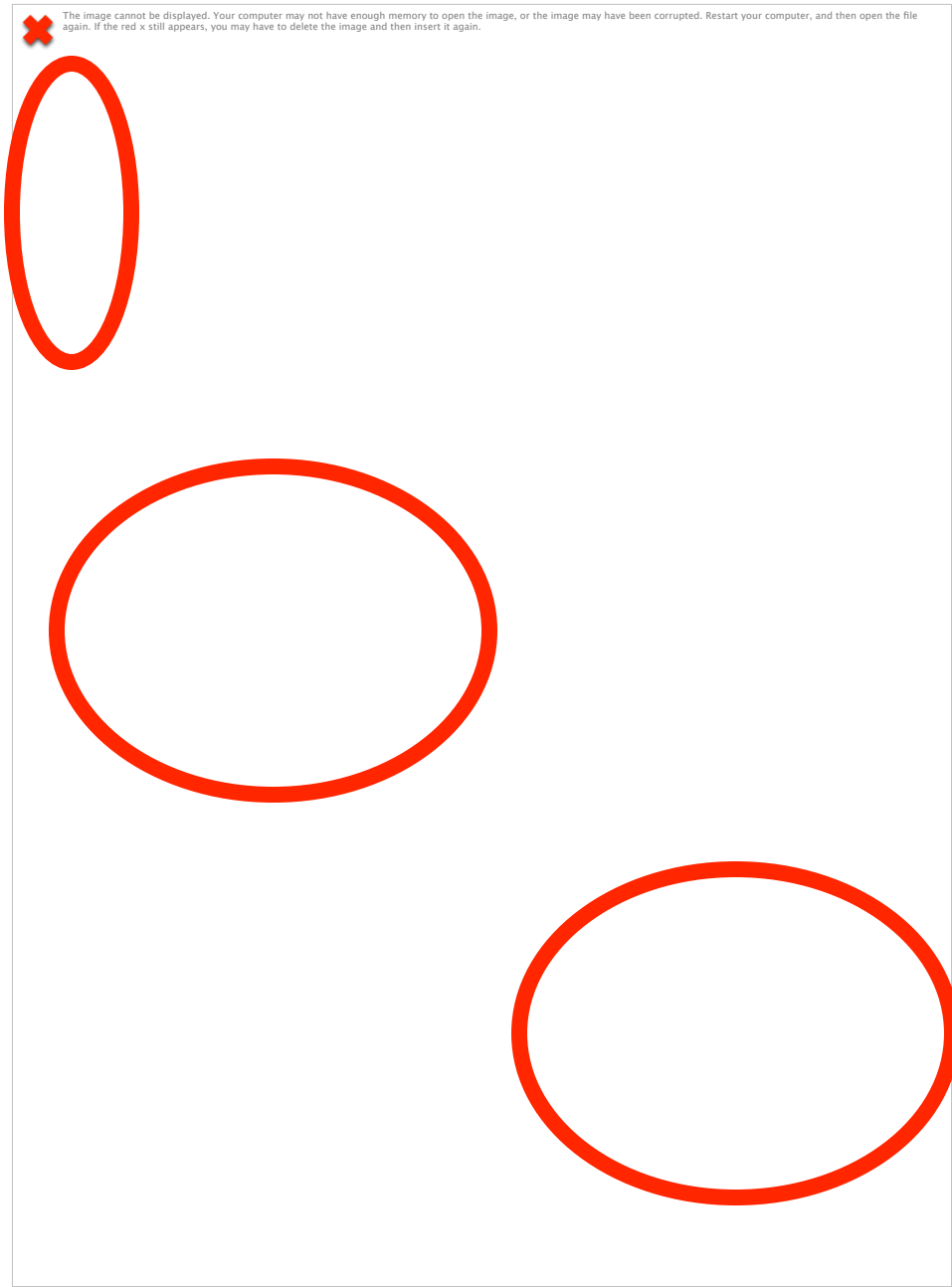
- All CPUE
- RMSE

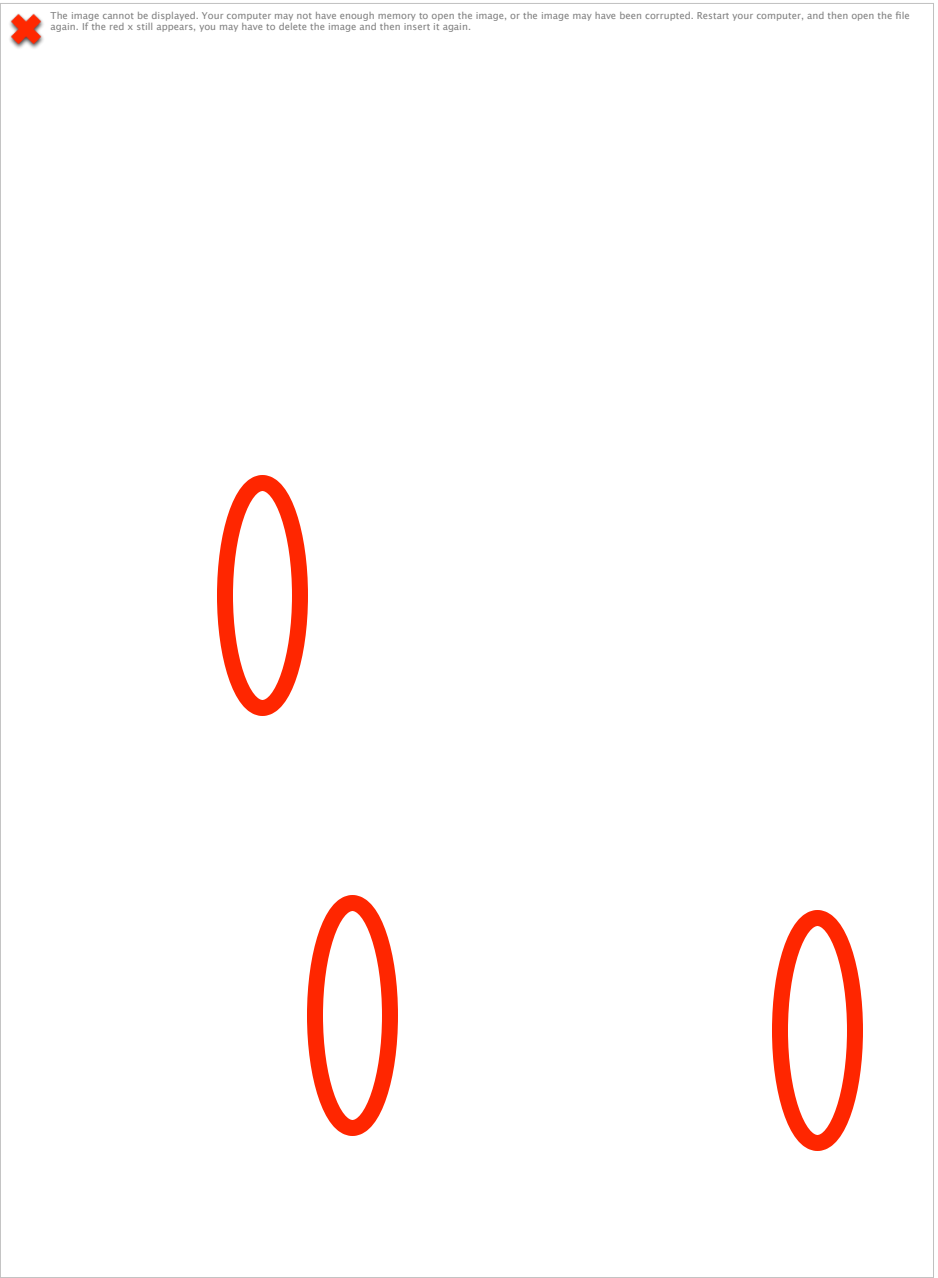


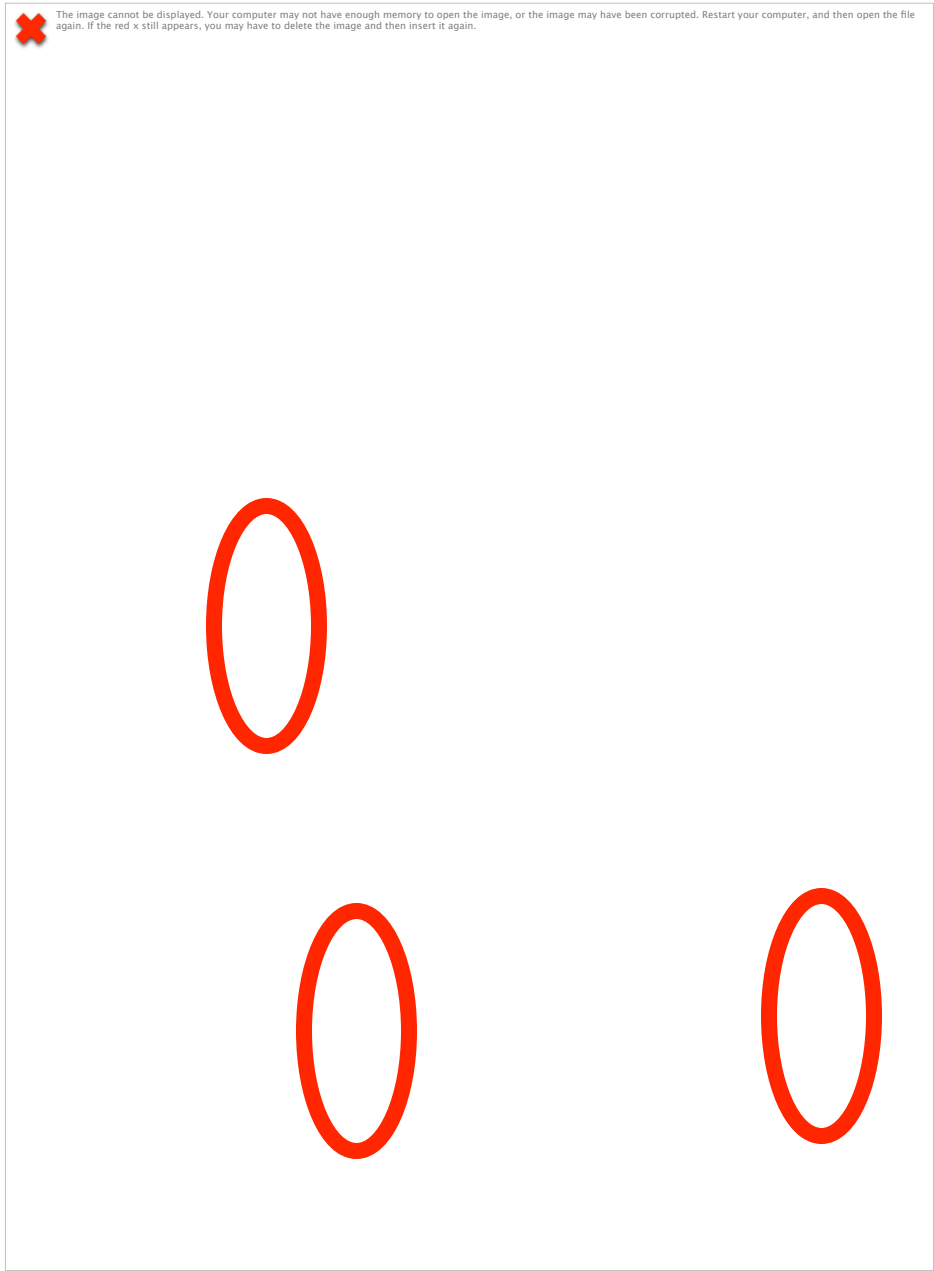
Typical Size fits



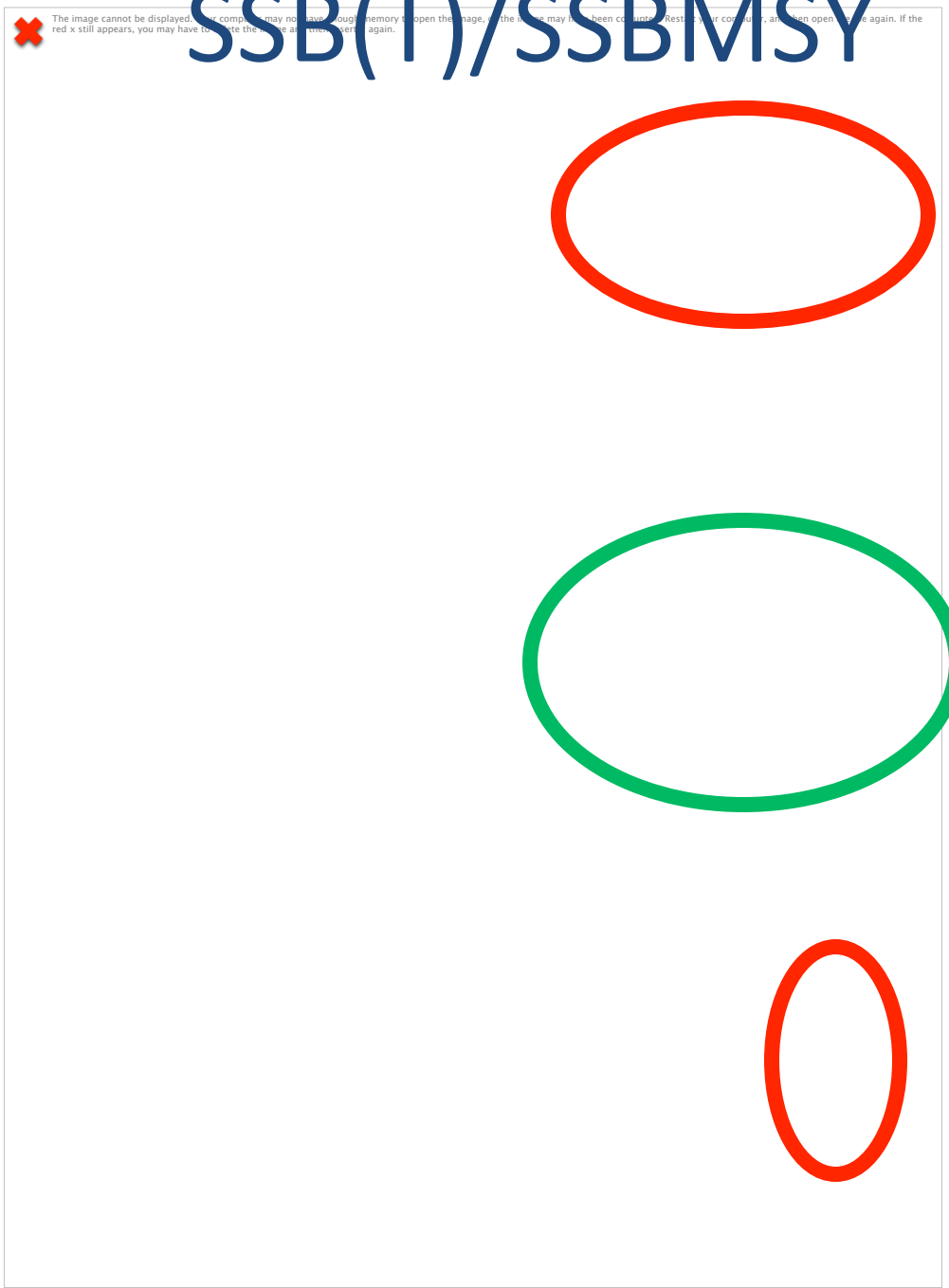


MSY blowouts...





SSB(T)/SSBMSY



F(T)/FMSY

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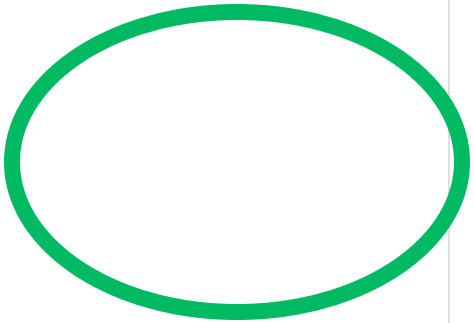
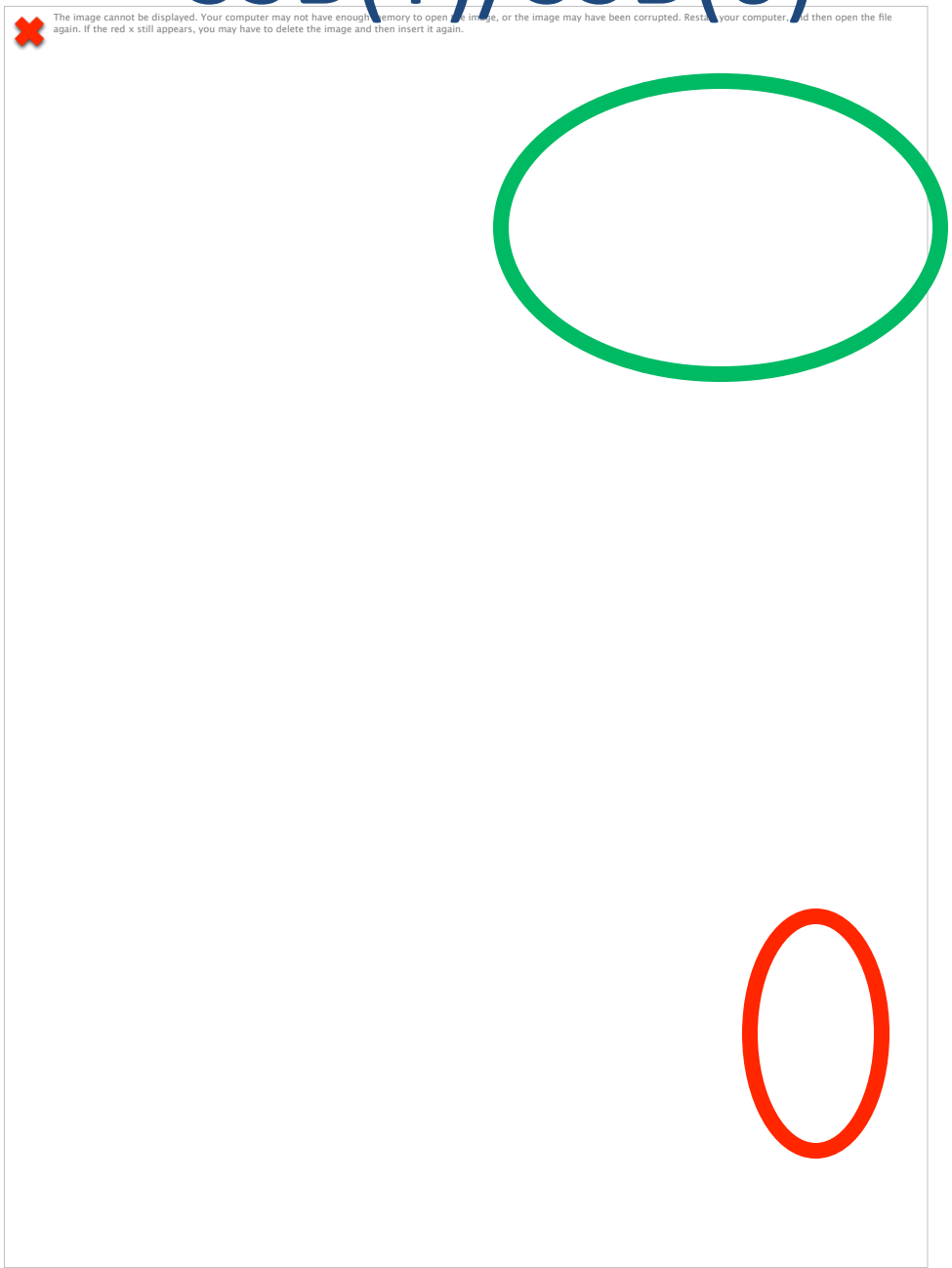


SSB(T)/SSB(0)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Plausibility of assumptions

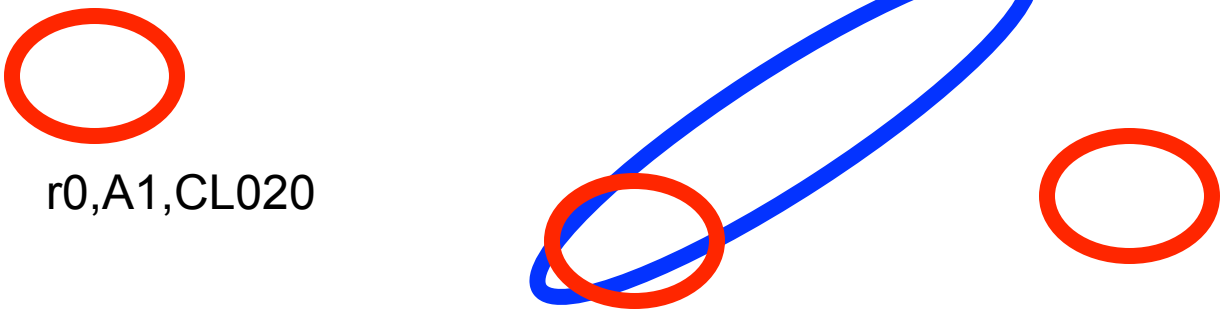
Assumption	Option	Proposed Option Weight
LL Catchability	•A1; All equal •NT ; omit TWN •J1; only use JPN	0.5 0.5 0
Recruitment σ=sd(log(dev))	R4; σ=0.4 R2; σ=0.2 R0; σ=0	0 (SW 0.3) 0.7 0.3 (SW 0)
Catch-at-Length input N	CL200; max(N)=200 CL20; max(0.1N)=20 CL2; max(0.01N)=2	0 (SW 0.2) 0.8 (SW 0.6) 0.2

Plausibility of assumptions

Assumption	Option	weight
Beverton-Holt Steepness	h = 0.55 h = 0.75 h = 0.95	0.1 0.6 0.3
Growth, Natural Mortality and Maturity	GaMf AUS GtMf TWN GhMf Hawai'I	0.4 0.4 0.2

Growth and h likelihoods?

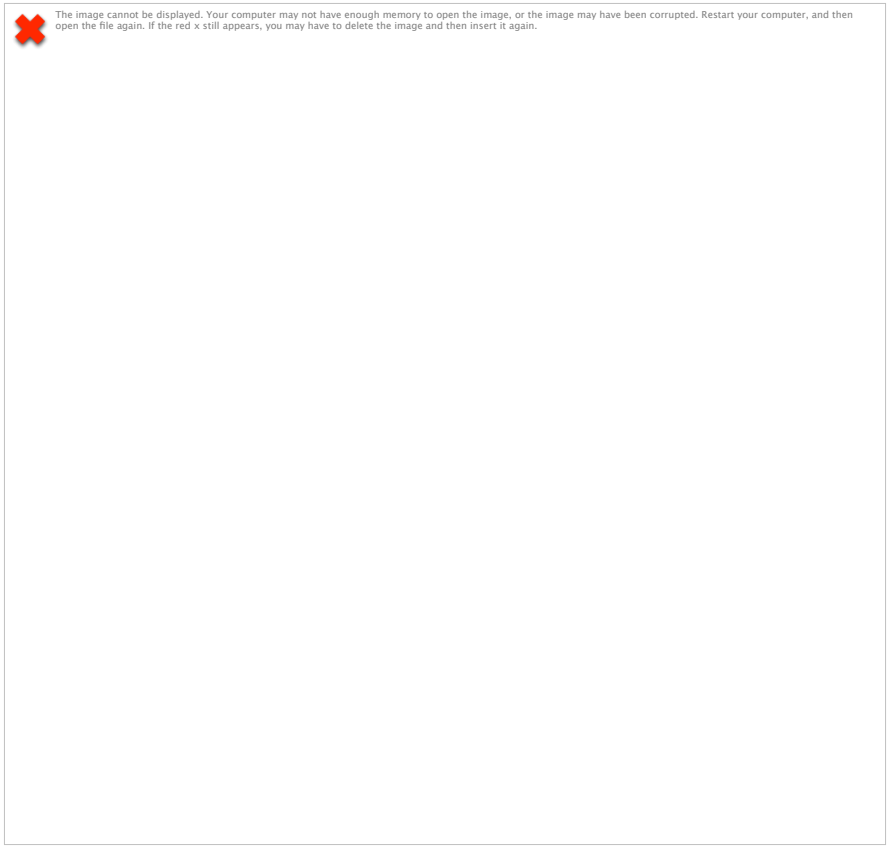
r2,NT,CL020



r0,A1,CL020

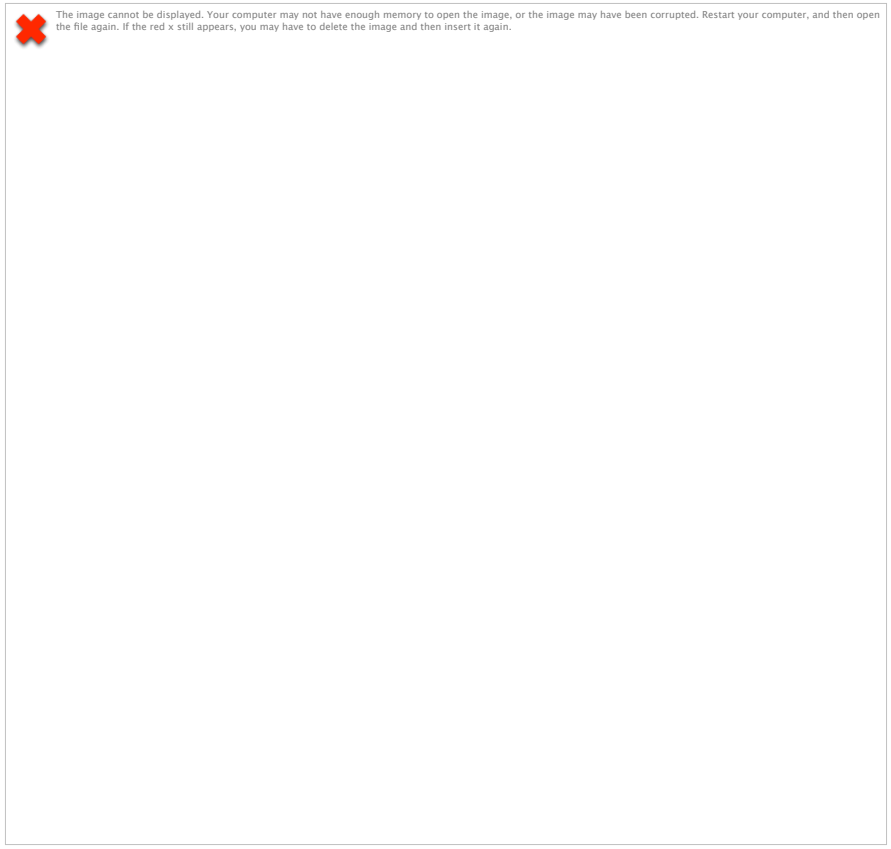
IO Stock Status Results

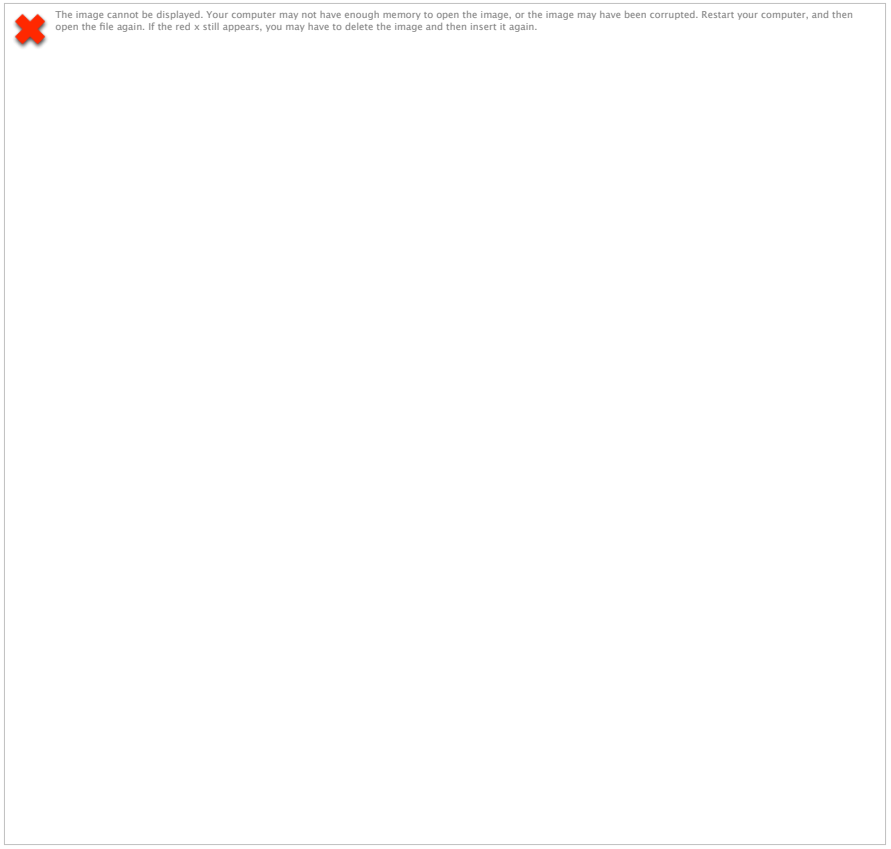
- weighted distribution (50%, 5-95%)



IO Stock Status Results

- Proposed Weighting Scheme





Conclusions 1

- Model can fit most CPUE series
  - TWN NW poor
- Size composition fit marginal
  - except EU and IS fleets are good
- Too much recruitment freedom (and/or too much weight to size composition data) results in fitting to noise
  - needs restriction due to spatial devs

Conclusions 2

- Stock status sensitive to steepness and Growth/M/maturity
  - likelihood-based comparisons not consistent
  - low steepness preferred presumably due to apparent rec anomalies
- Area specific abundance estimates questionable, aggregate better?
- Time to retire this spatial structure?

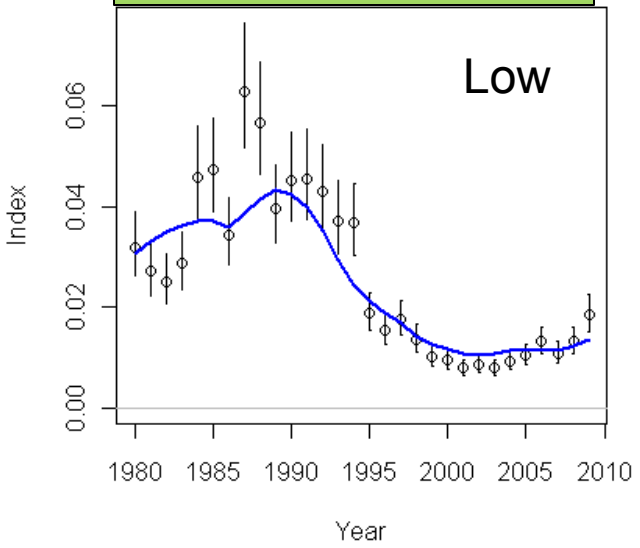
Low

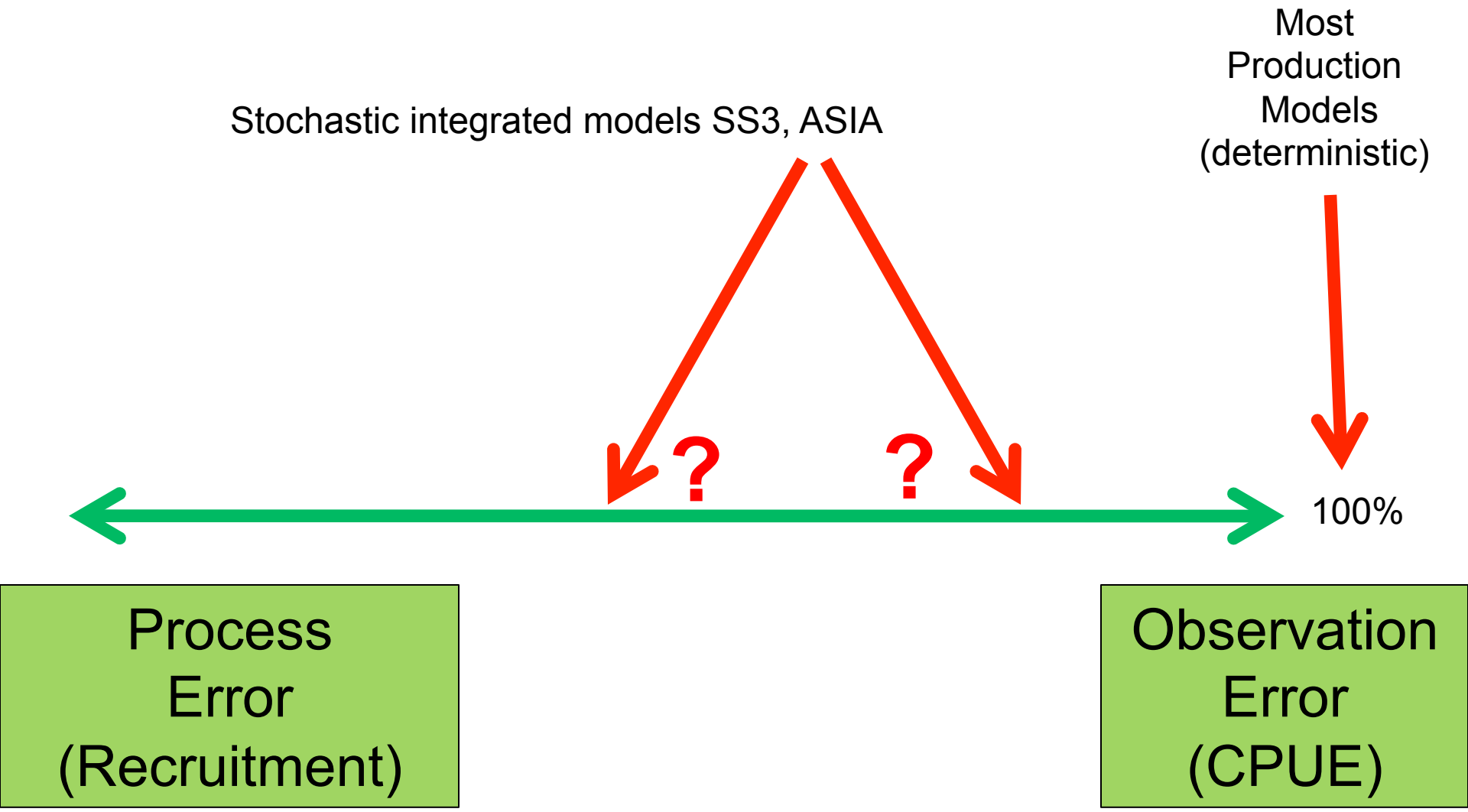
High

Process Error (Recruitment)

Observation Error (CPUE)

High




Most
Production
Models
(deterministic)
Stochastic integrated models SS3, ASIA
?
?
100%
Process
Error
(Recruitment)
Observation
Error
(CPUE)

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