Introduction to South African sardine: Assessment and Management

International Stock Assessment Workshop
Cape Town
27th November 2017

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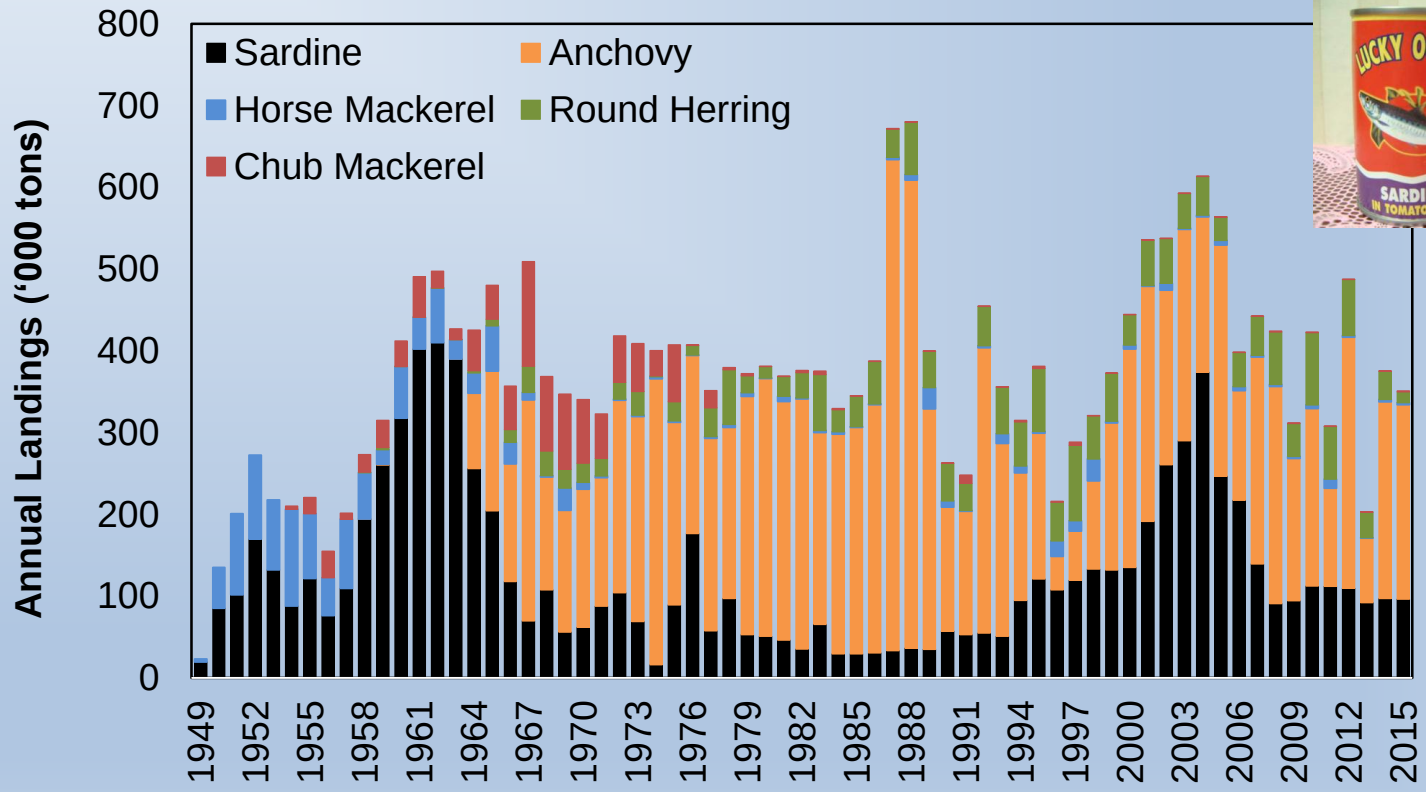
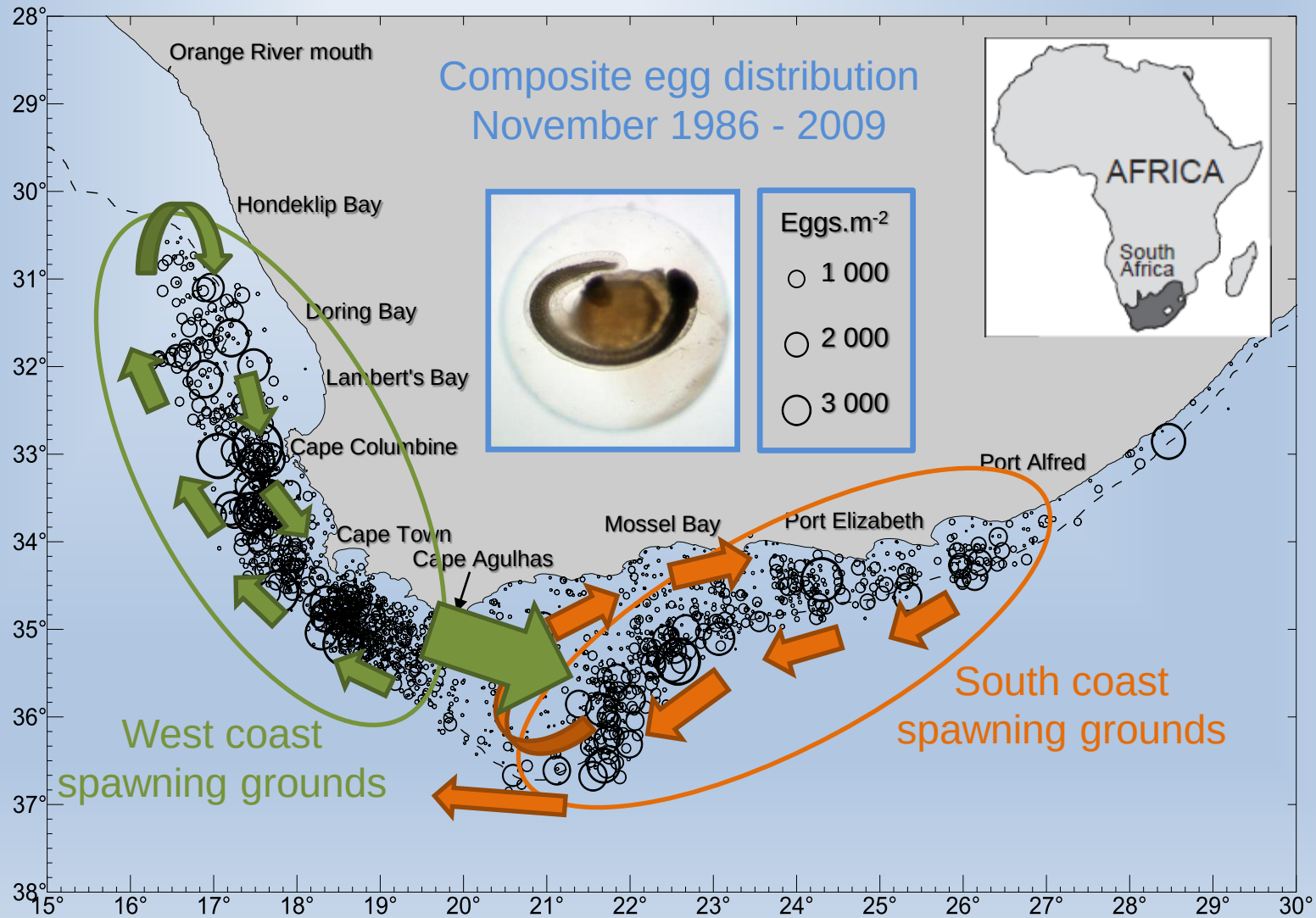
History of Fishery

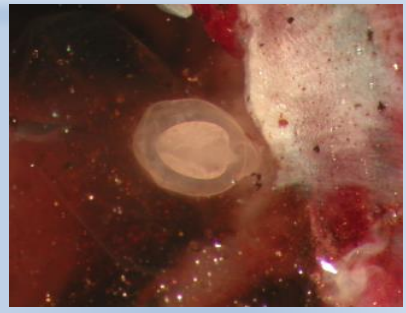


Sardine have also been commercially harvested off the south coast since the 1990s

South African Sardine Distribution and Stock Structure



Parasite Bio-tagging

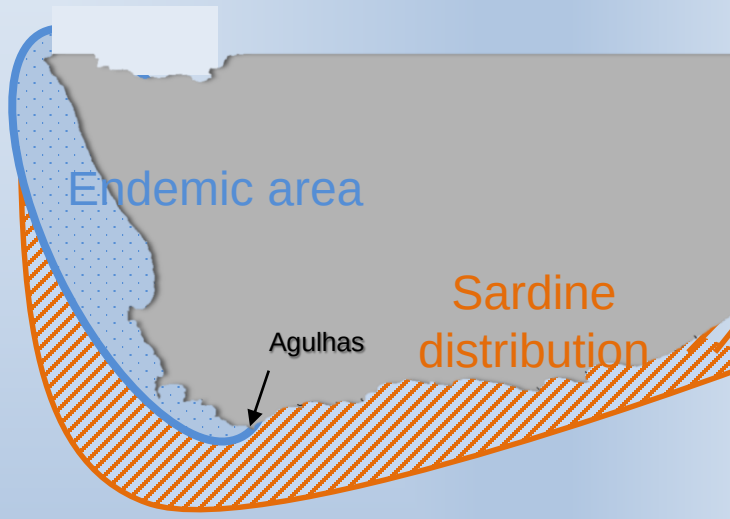


- For SA sardine, the digenean “tetracotyle” type metacercariae found in sardine eyes showed greatest bio-tag potential
- 1st intermediate host endemic to west coast
- No fish-to-fish transmission

→ South coast sardine infected with parasite must have previously been on west coast

- Differences in the prevalence, mean infection intensity and mean abundance of the parasite

→ Sardine are NOT homogeneously distributed



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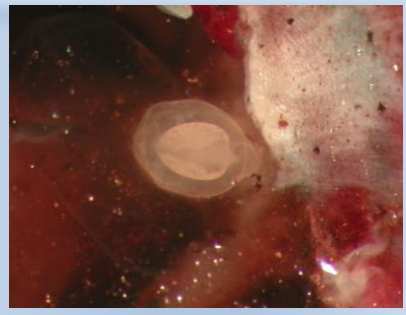
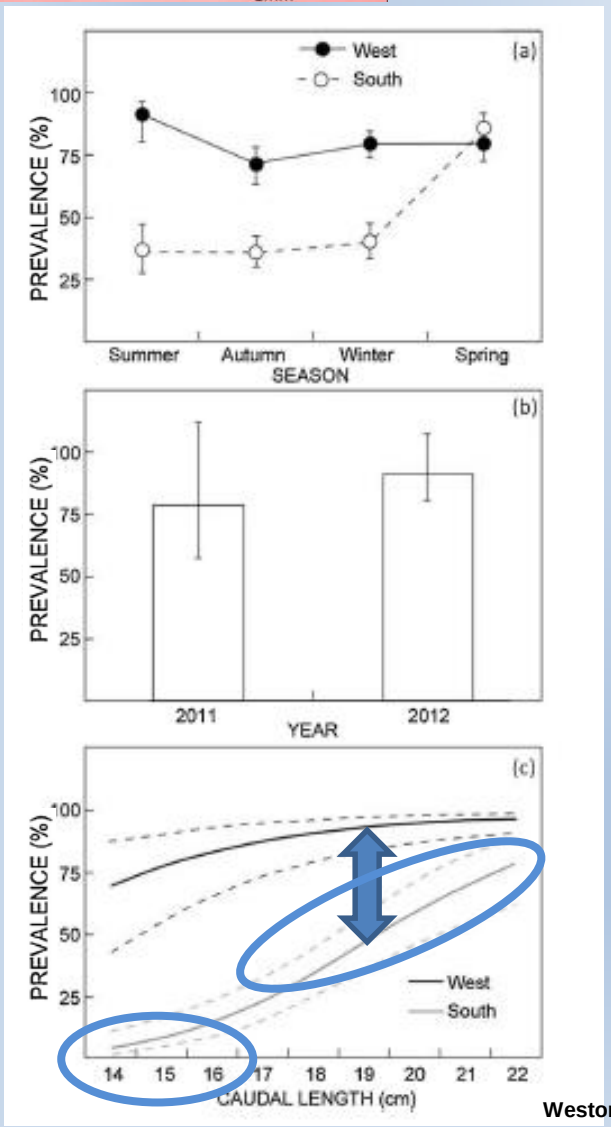
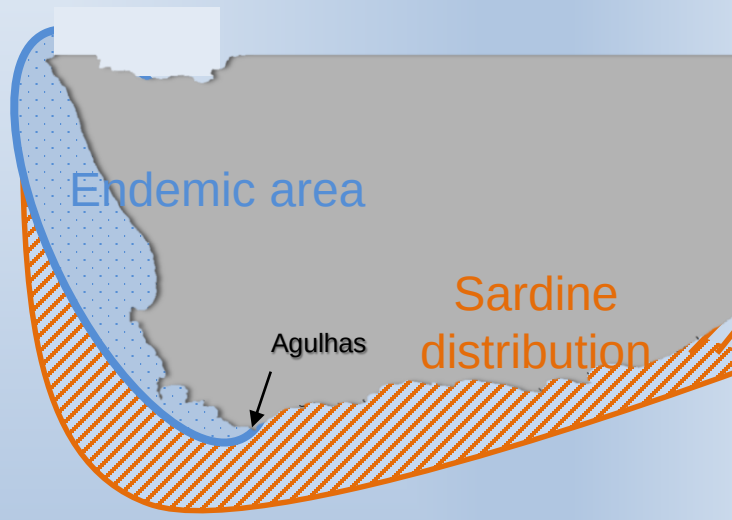






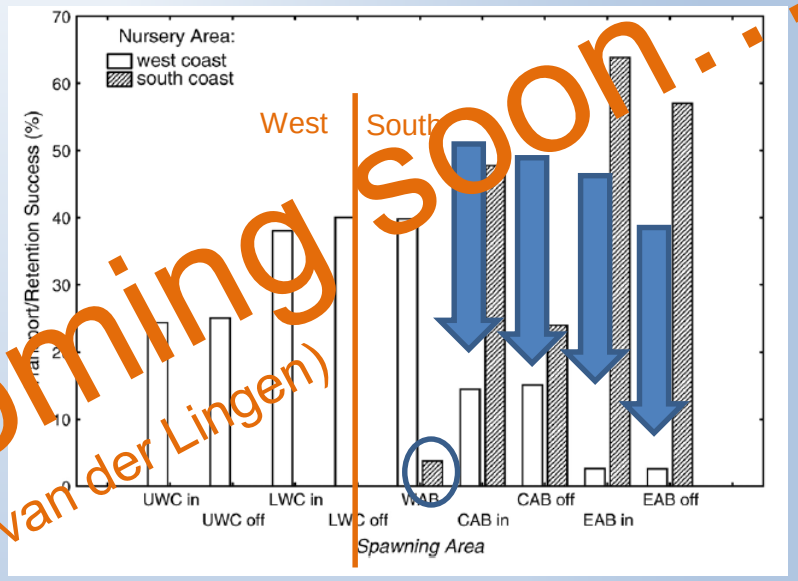
- Parasite prevalence on west coast higher than on south coast
- Parasite prevalence increases with length on both west and south coasts

→ Sardine must move at older ages

Weston et al. 2015 Fisheries Research 164

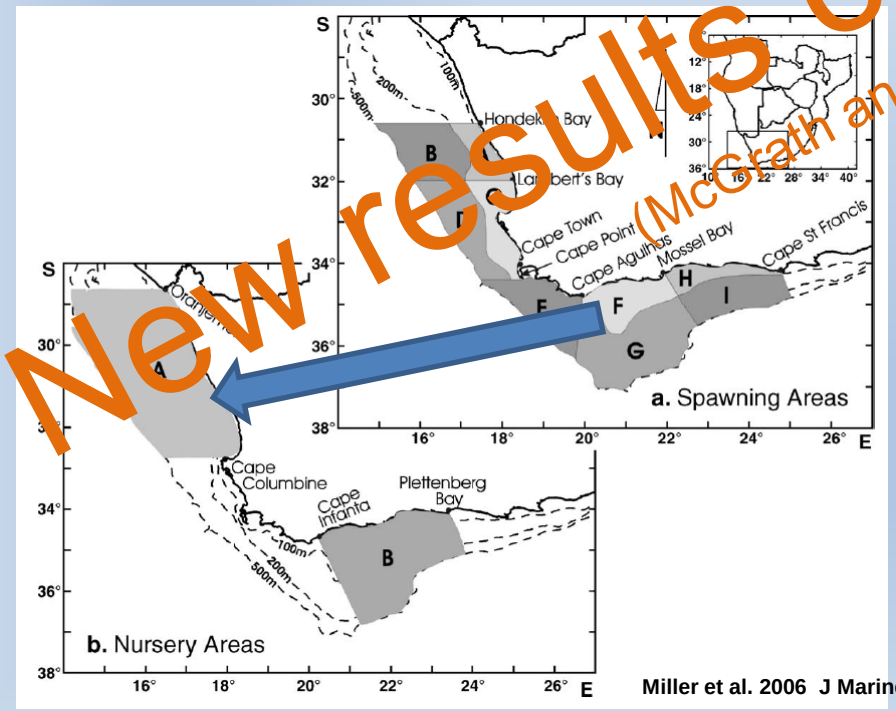
IBM + hydrodynamic model

Eggs/larvae from south coast successfully reach west coast nursery areas

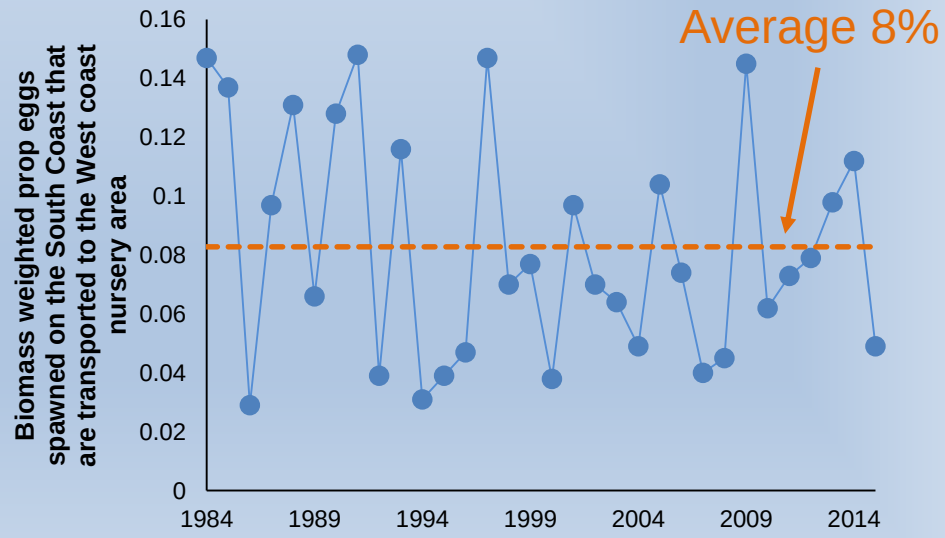


New results coming soon...

(McGrath and van der Lingen)



Miller et al. 2006 J Marine Systems 61

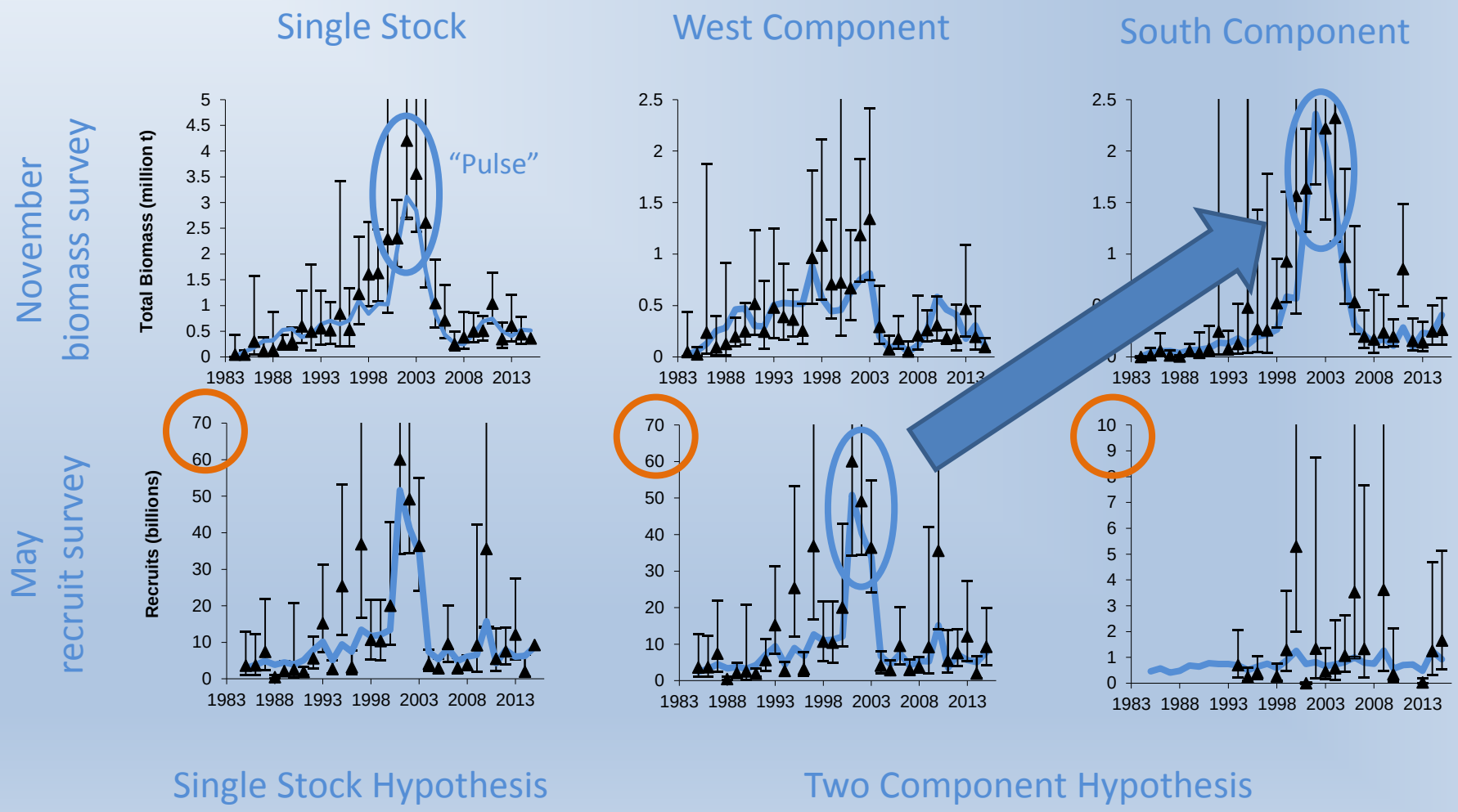


Coetzee 2016 FISHERIES/2016/AUG/SWG-PEL/37

Assessment Details

- Age-structured production method framework, incorporating key elements of Statistical catch-at-age and Integrated Analysis methods
- Fit to survey estimates of recruitment and total abundance, catch data and length frequencies
- Estimate time-invariant growth curve with variability about length-at-age
- Bayesian analysis, with integration implemented numerically using ADMB

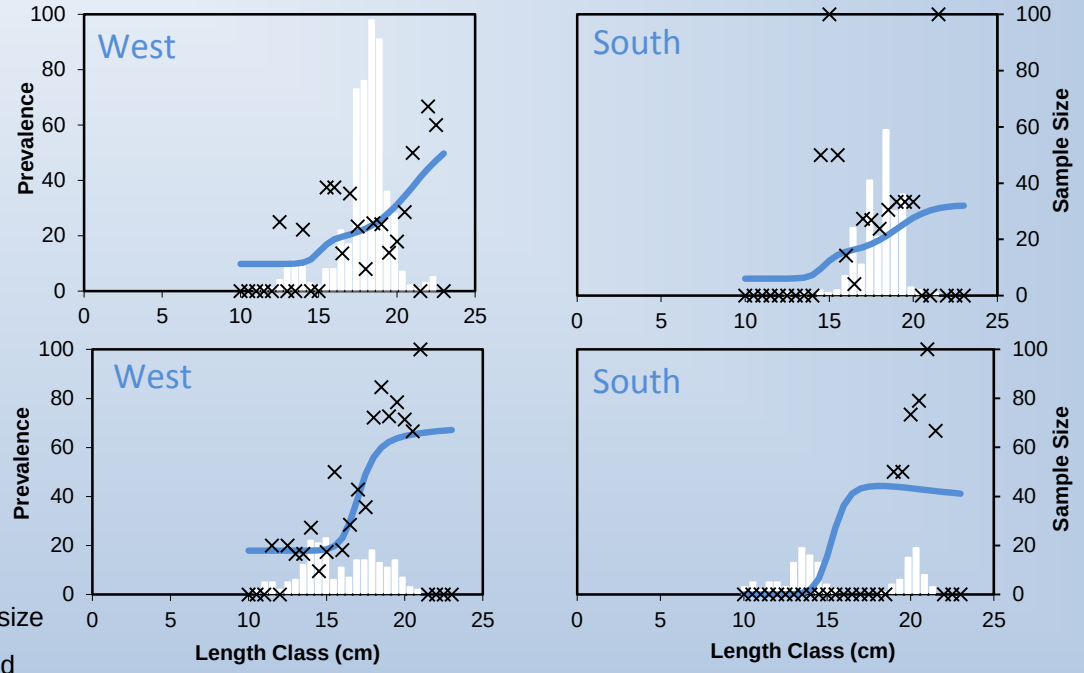
Model Fit to Survey Abundance Indices



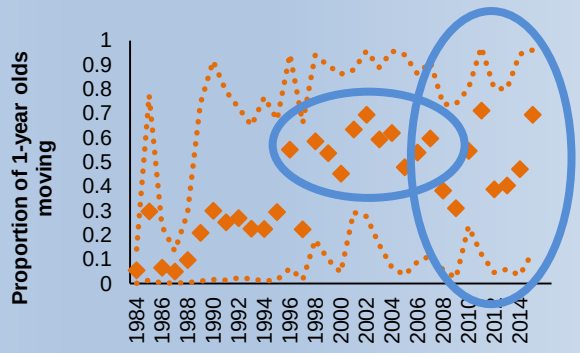
Parasite Prevalence Data ('08-15)

2011

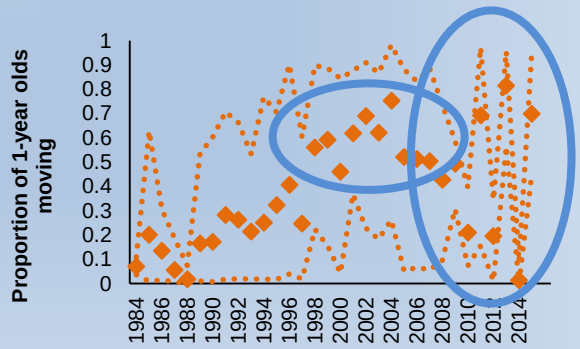
2014



Movement of west recruits to south had a greater impact on the south biomass than years of above-average south recruitment



Excluding parasite data



Including parasite data

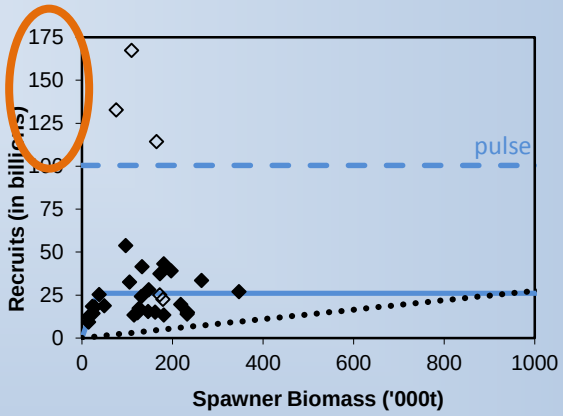
On average, the movement parameters are more precisely estimated once parasite data are included in the model

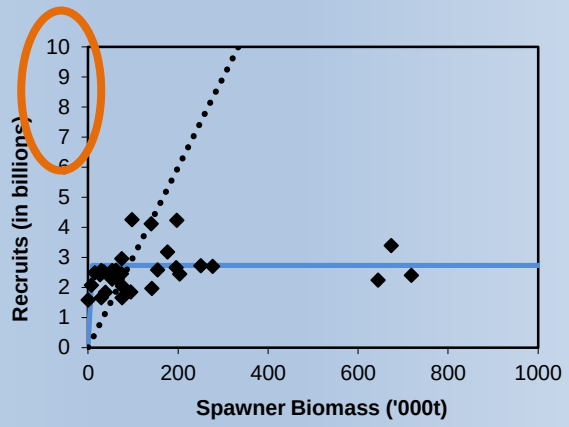
Stock Recruitment Relationships

Different curves estimated for each component

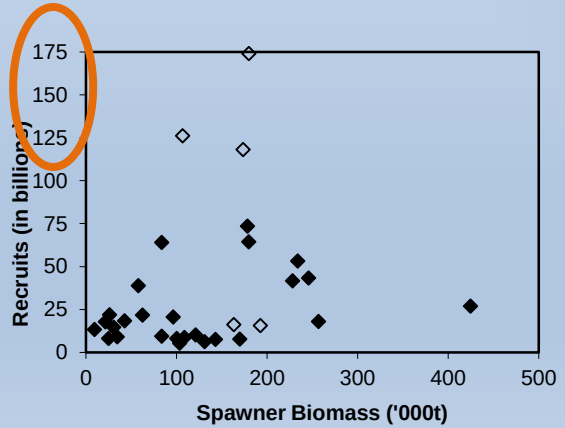
West component

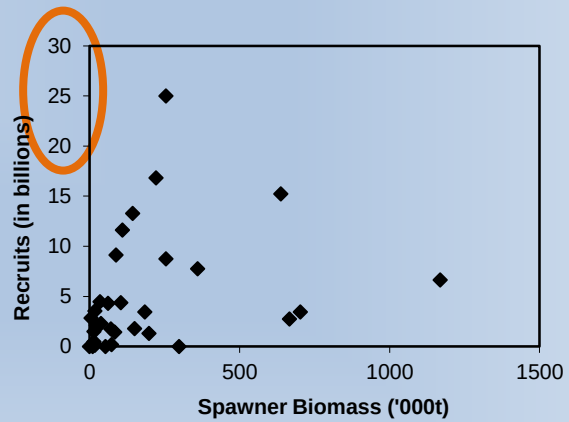
South component





No stock-recruitment relationship





West component is substantially more productive than the south component

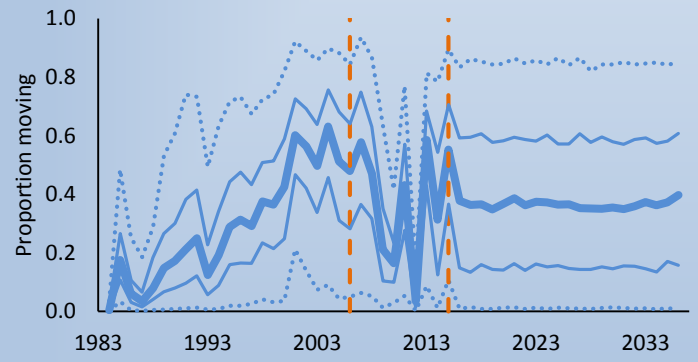
Key Question 1

- Have we an adequate reference set of operating models for sardine? How do we best report performance statistics for this set?
- Primary doc #6
- Two mixing component hypothesis
- West to south movement
- South contribution to west recruitment

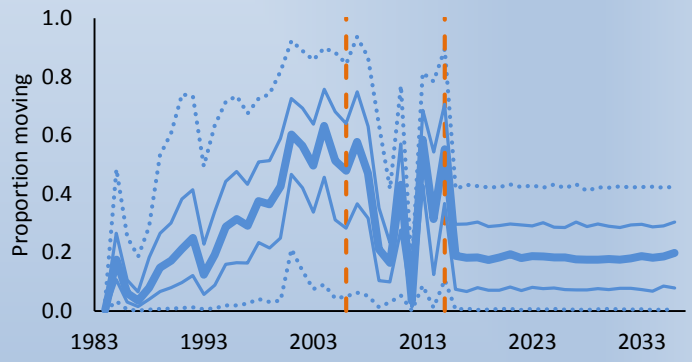
Key Question 1

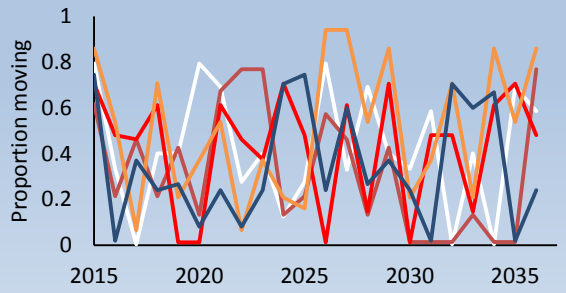
- Proportion of 1-year olds that annually move from the west to the south component
- (Proportion of 2+ that move is linked to this)

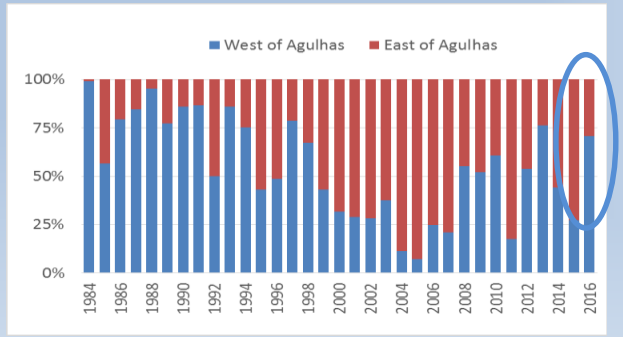
MoveR



0.5MoveR







Key Question 1

- Proportion of south component B^{sp} that forms part of west component effective B^{sp}:

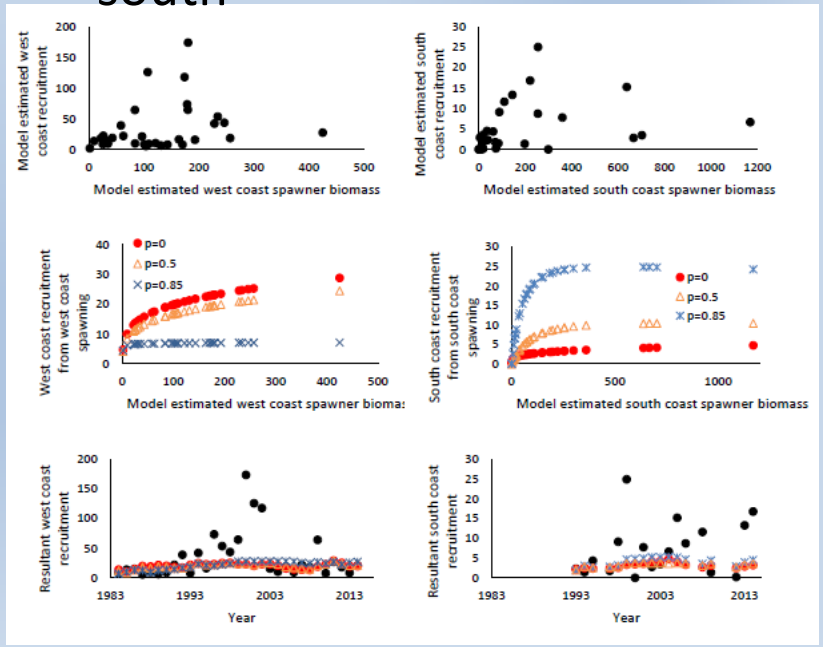
$$R_{west} = f(B^{sp}_{west} + p\ B^{sp}_{south})$$

$$R_{south} = f((1-p)\ B^{sp}_{south})$$

$p = 0\%, 8\%, 20\%, 60\%$

Hydrodynamic model + variability

Fits to SR 'data'



Key Question 1

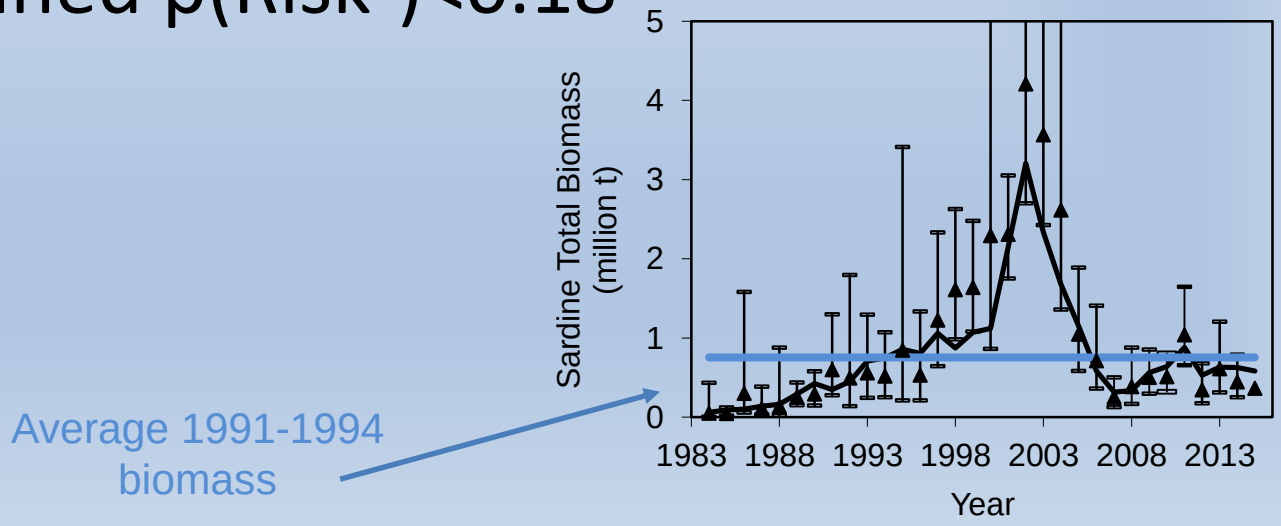
- 2016 recommendations -> don't weight

	$p = 0.0$	$p = 0.08$	$p = 0.2$	$p = 0.6$		MoveR	0.5MoveR
Option 1	0.05	0.50	0.35	0.10		0.75	0.25
Option 2	0.01	0.29	0.40	0.30		0.75	0.25
Option 3	0.01	0.04	0.30	0.65		0.30	0.70
Option 4	0.05	0.55	0.30	0.10		0.80	0.20
Option 5	0.20	0.50	0.20	0.10		0.80	0.20
Average	0.064	0.376	0.310	0.250		0.68	0.32
Median	0.050	0.500	0.300	0.100		0.75	0.25
Renormalised Median	0.053	0.526	0.316	0.105		0.75	0.25

- Major model/data changes considered during next OMP cycle

Key Question 2

- How do we best choose risk thresholds in terms of biomass levels for sardine and anchovy?
- Primary doc #2
- Sardine: previously used avg 91-94 total biomass
- OMP-14 tuned p(Risk^{S})<0.18

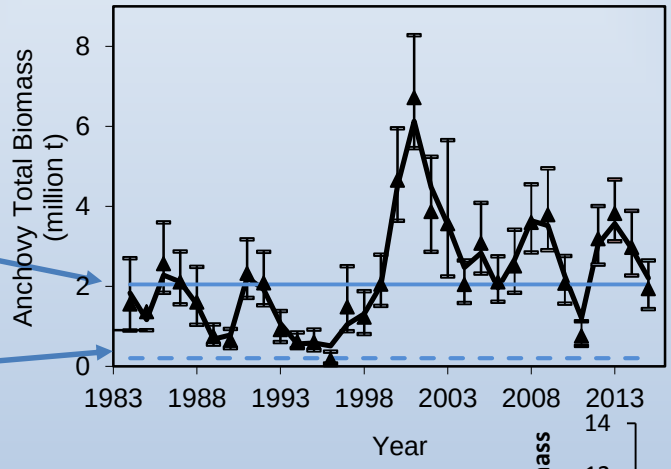


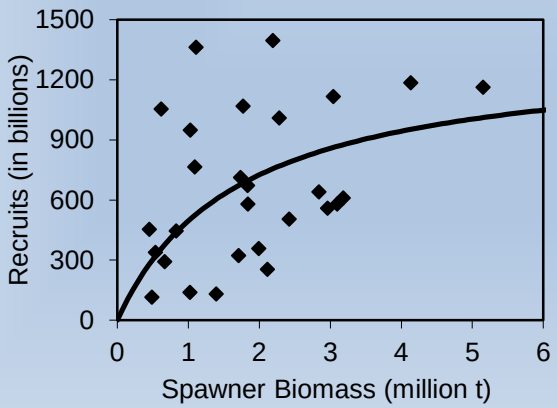
Key Question 2

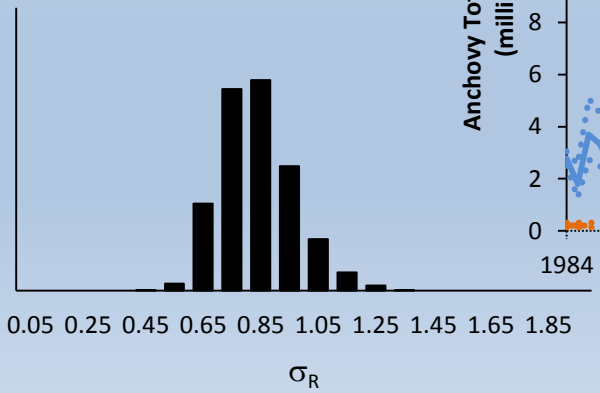
- Anchovy – previously used 10% of avg 84-99 total biomass

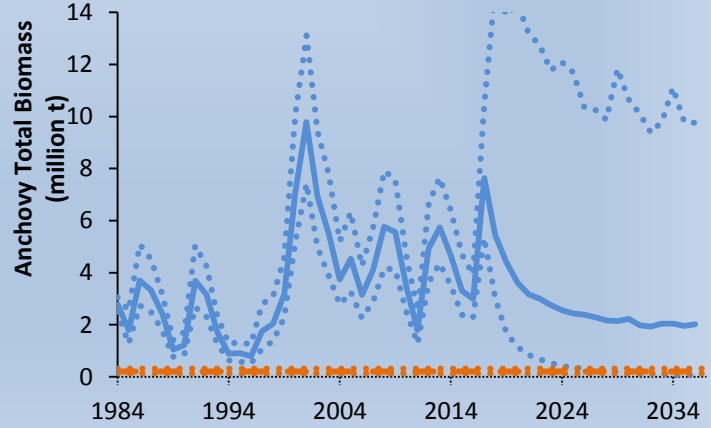
Average 1991-1994 biomass

10% of average 1991-1994 biomass



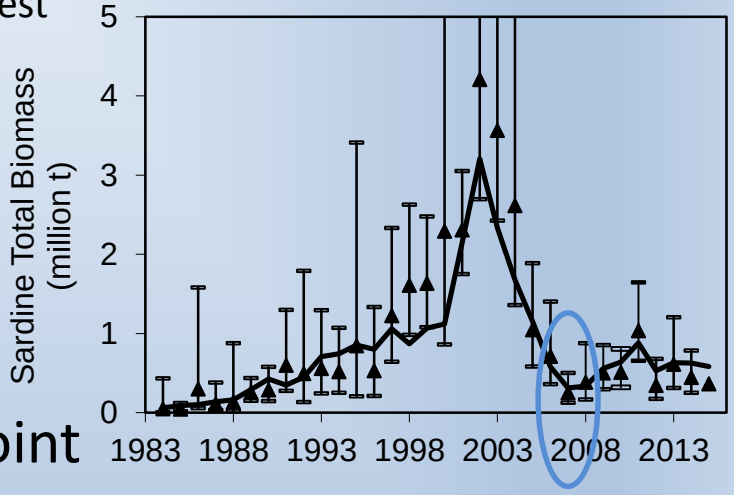






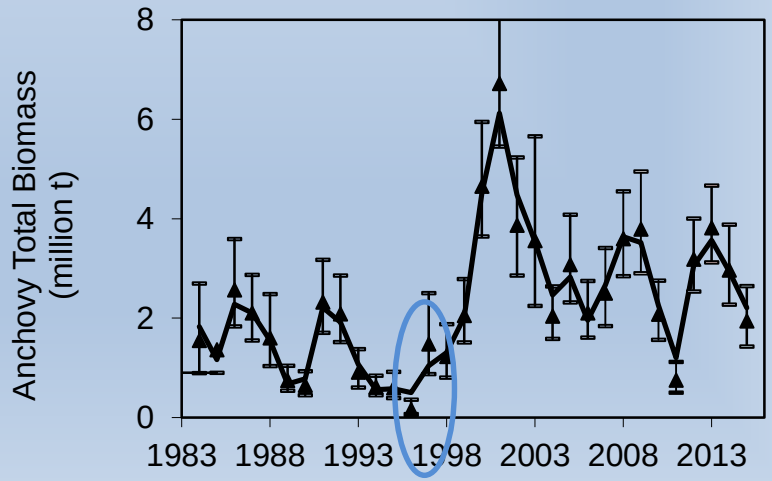
Key Question 2

- $Risk^{S}_{2007}$: lowest historical median B_{west}

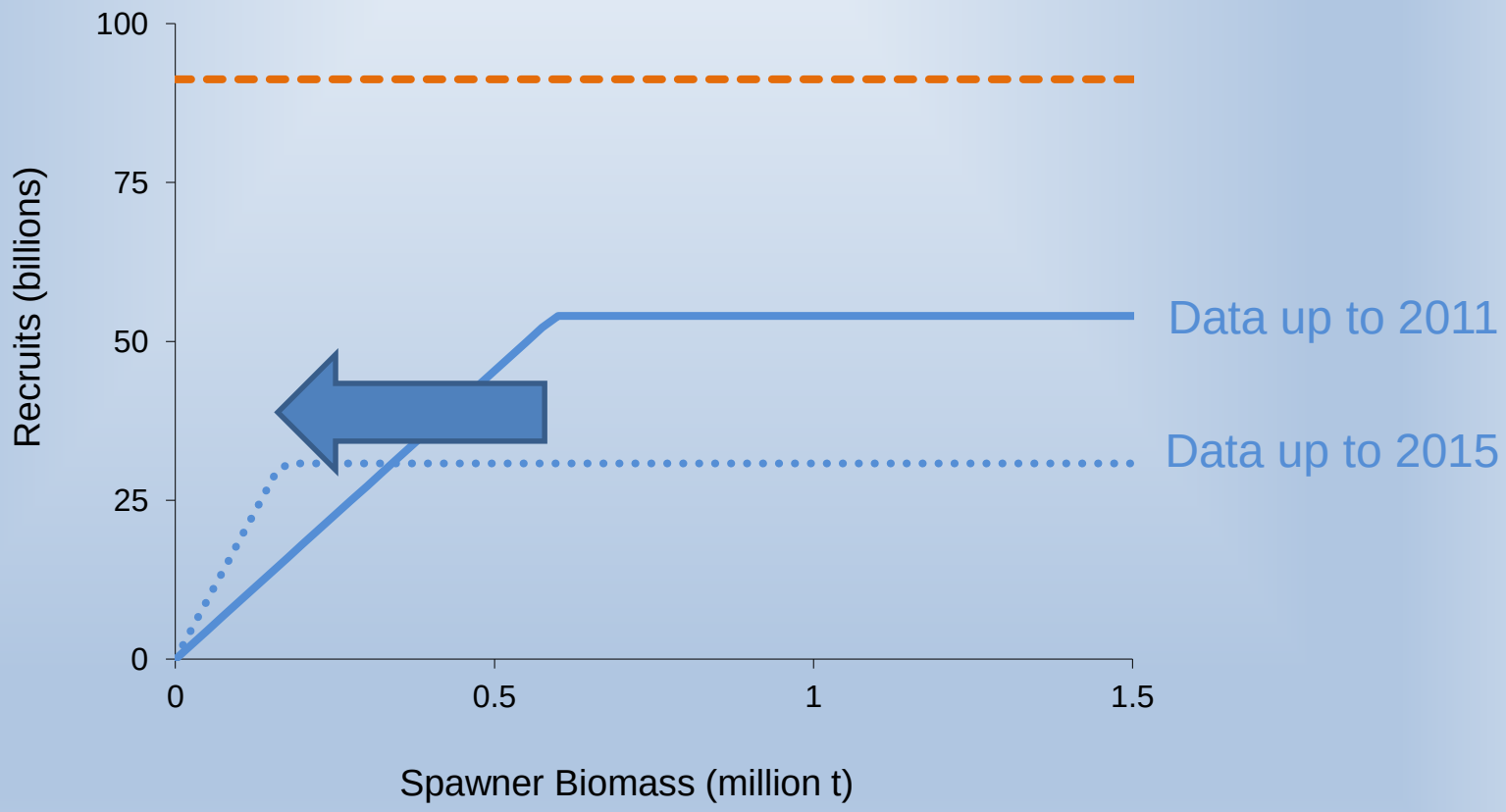


- $Risk^{S}_{70}$: 70 000t B^{sp}
- $Risk^{S}_{100}$: 100 000t B^{sp}
- $Risk^{S}_{hinge}$: B^{sp} at Hockey-stick hinge point

- $Risk^{A}_{1996}$: lowest historical median -> 25% of this level due to wide future PIs

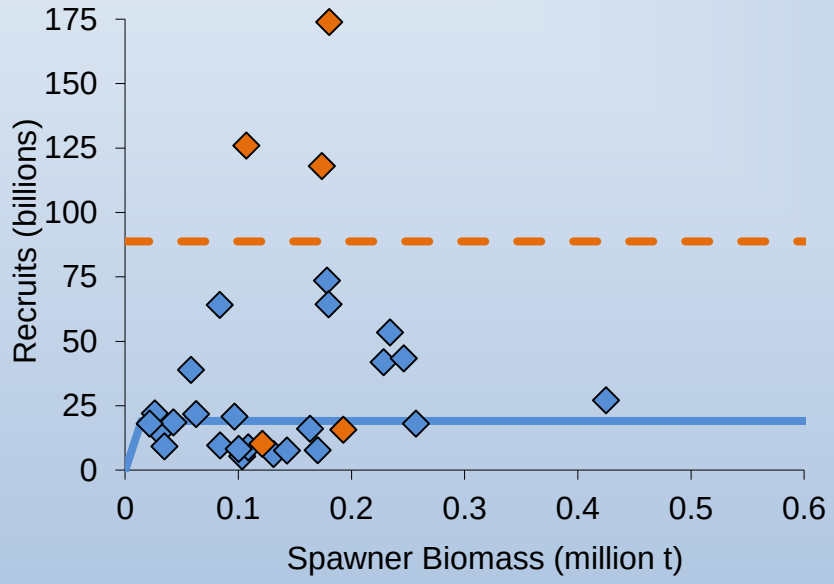


Updated Operating Model

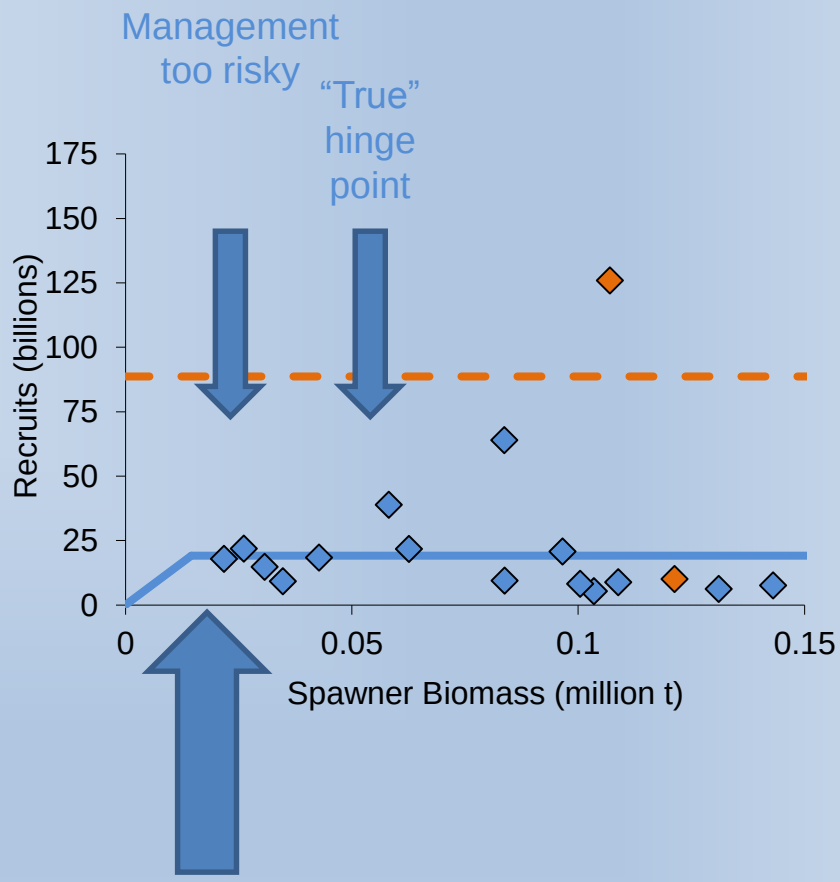


Single Stock Hypothesis

How Reliably is the Hockey Stick Hinge Point Estimated?



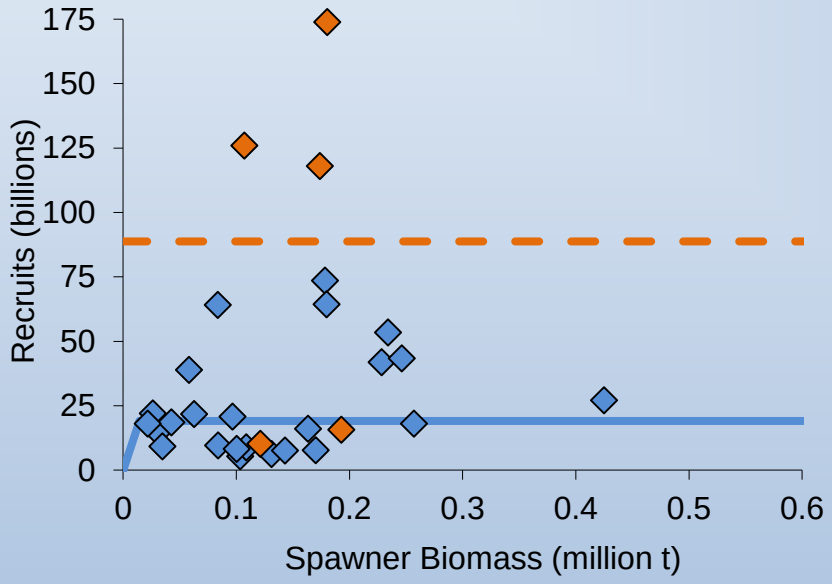
Joint Posterior Mode



Is this hinge point precisely estimated?

Can we base management decisions on it?

How Reliably is the Hockey Stick Hinge Point Estimated?



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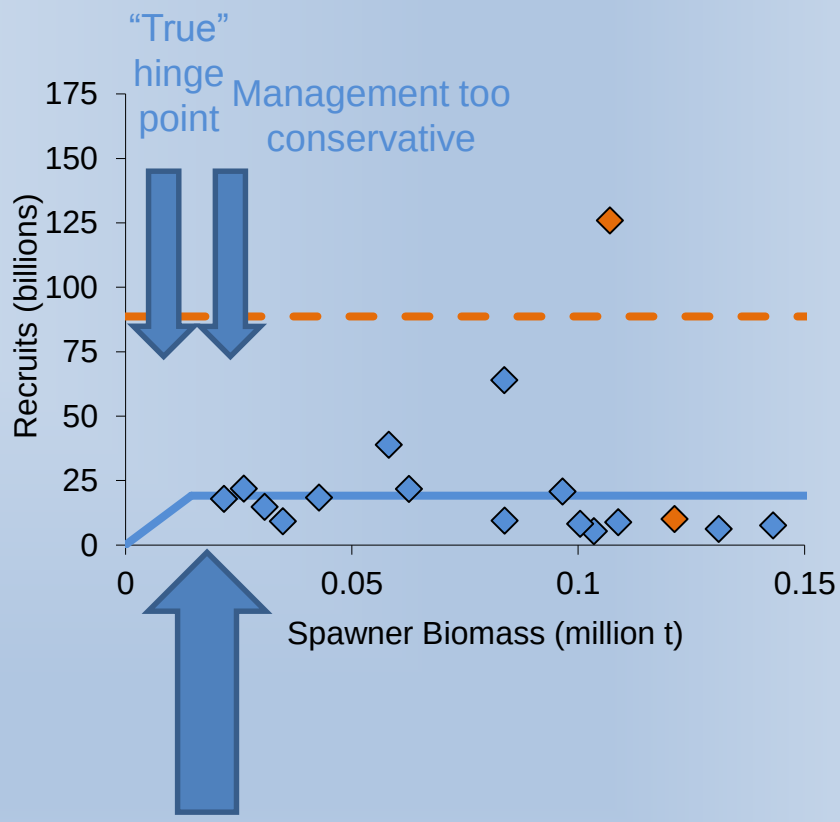

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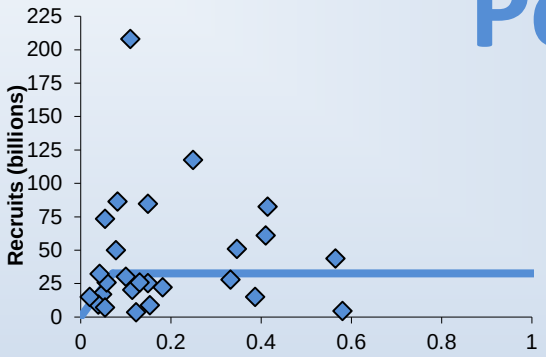
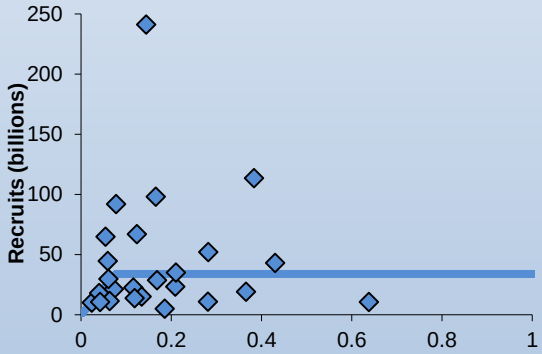
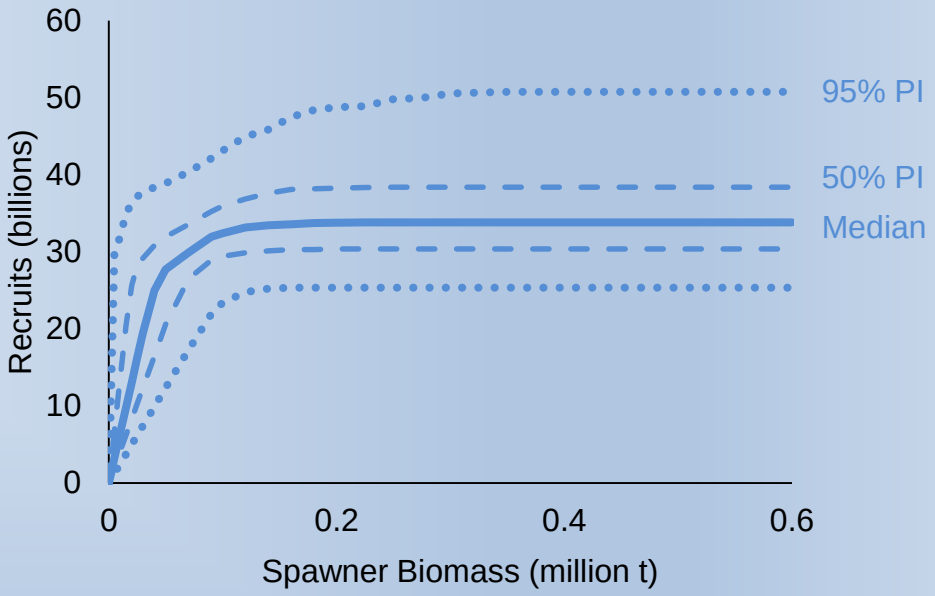
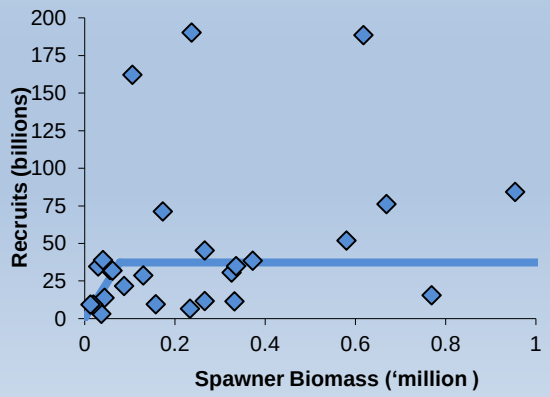


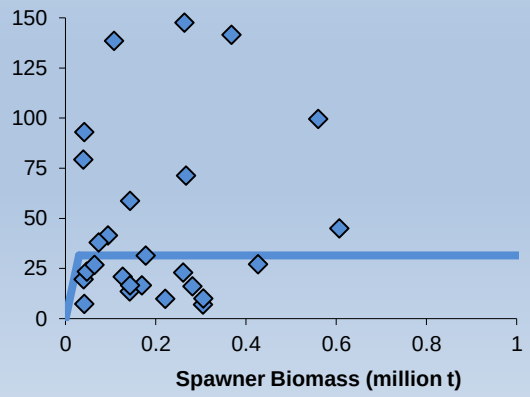


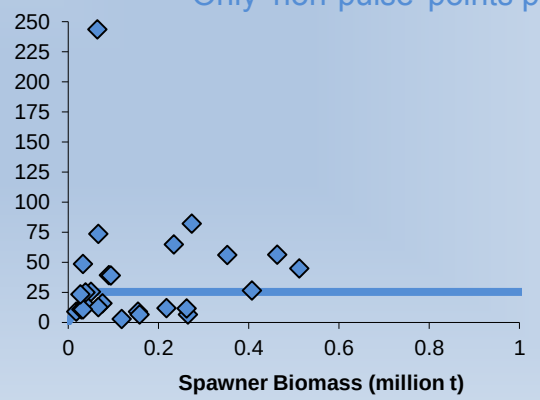


Individual Posterior Realisations

Only 'non-pulse' points plotted

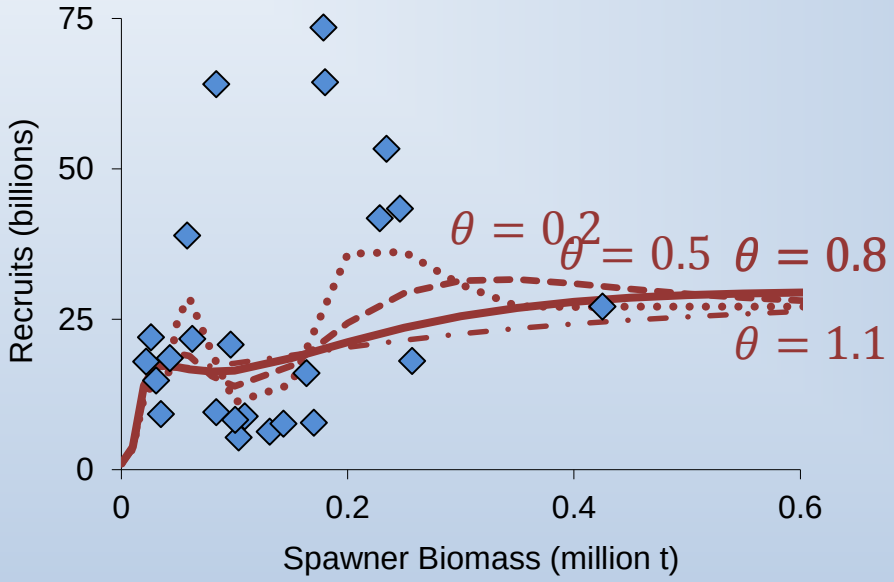






Let The Data Speak For Themselves!

Use of a Smoother



Gaussian kernel smoother
+
straight line from origin to lowest B_{sp}

Lower θ - matches data points more closely
Considering risk - shape of curve at lower spawner biomass levels.

Joint Posterior Mode

$$N(SSB_j) = exp\left[\frac{\sum_{y=1986}^{2014} ln(N_{j,y}) \times exp\left\{\frac{-[ln(SSB_{j,y}) - ln(SSB_j)]^2}{\theta^2}\right\}}{\sum_{y=1986}^{2014} exp\left\{\frac{-[ln(SSB_{j,y}) - ln(SSB_j)]^2}{\theta^2}\right\}}\right]$$

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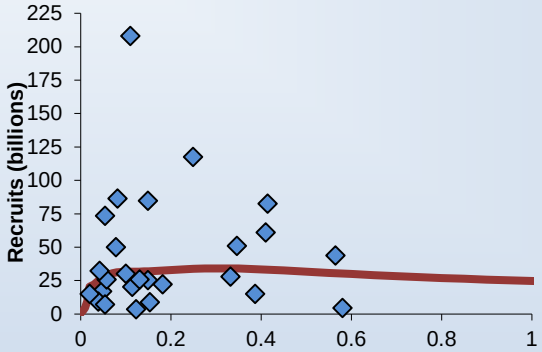

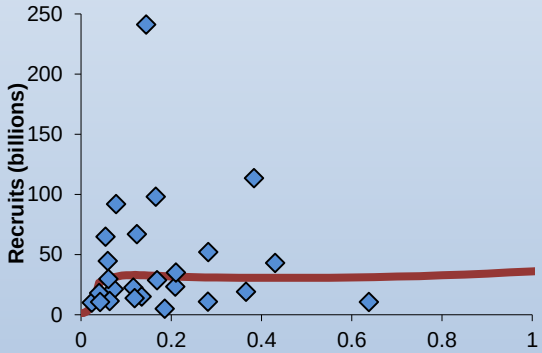

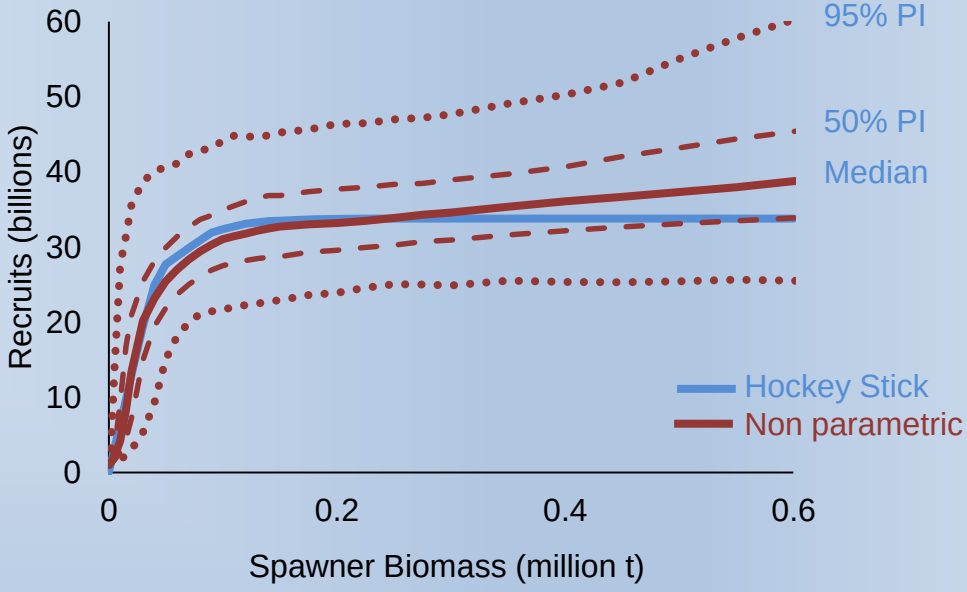

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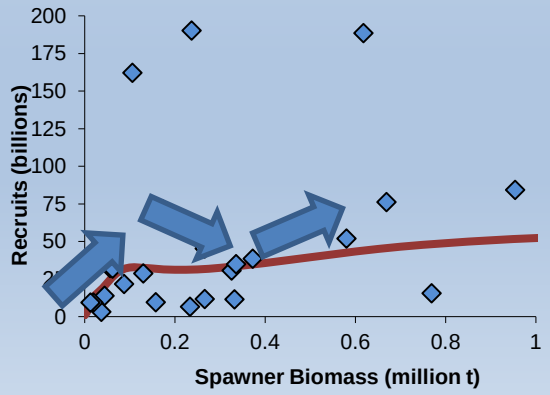
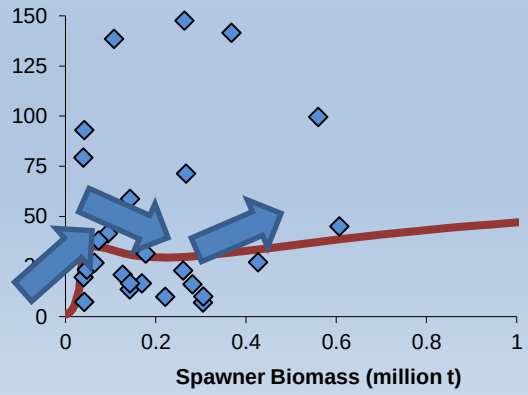
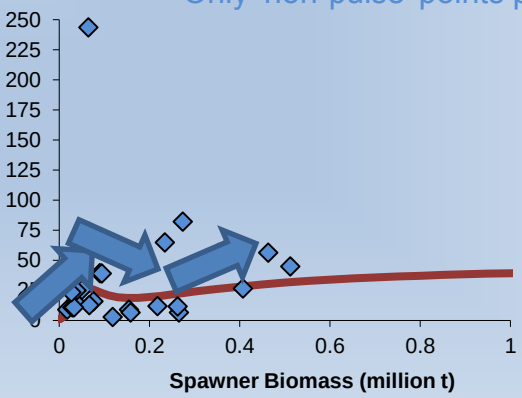
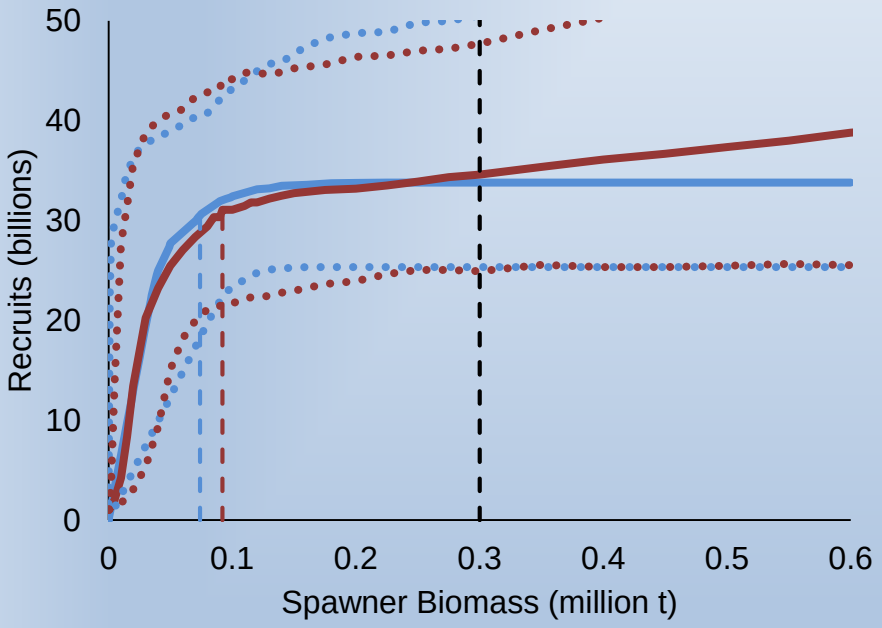
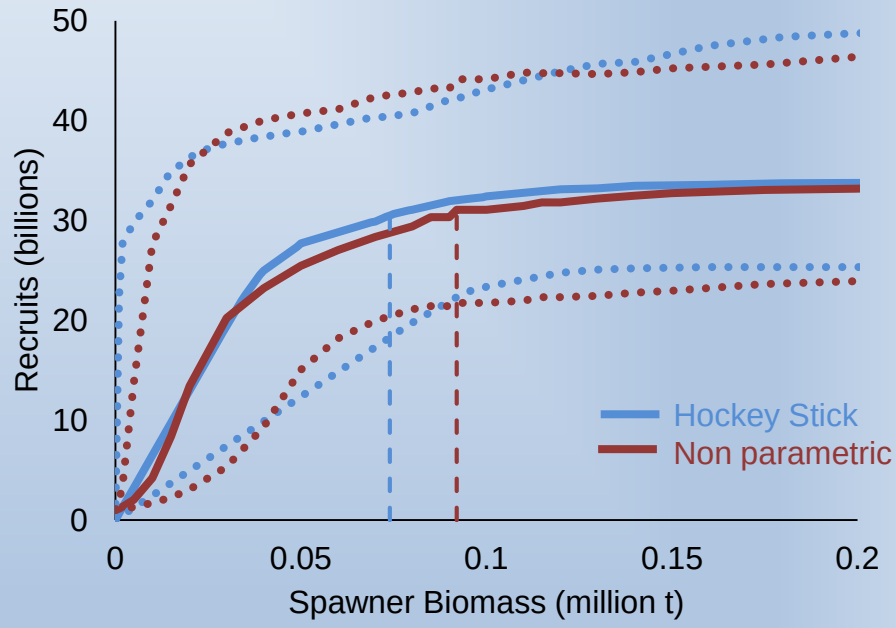






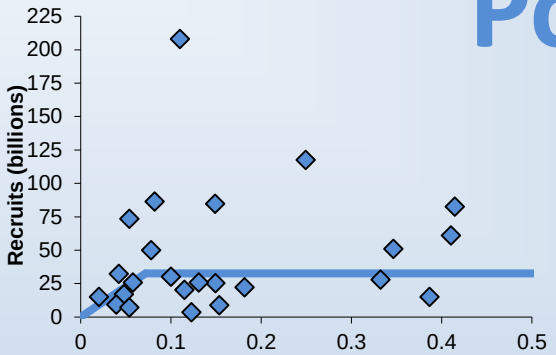
How Reliably is the Hockey Stick Hinge Point Estimated?

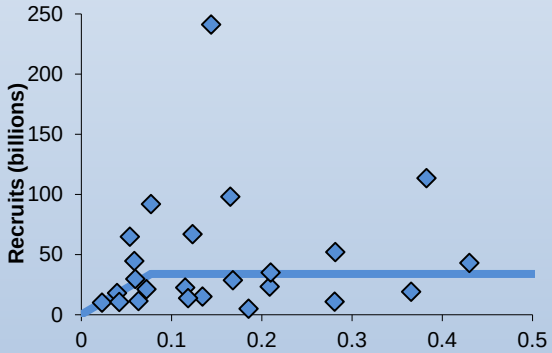


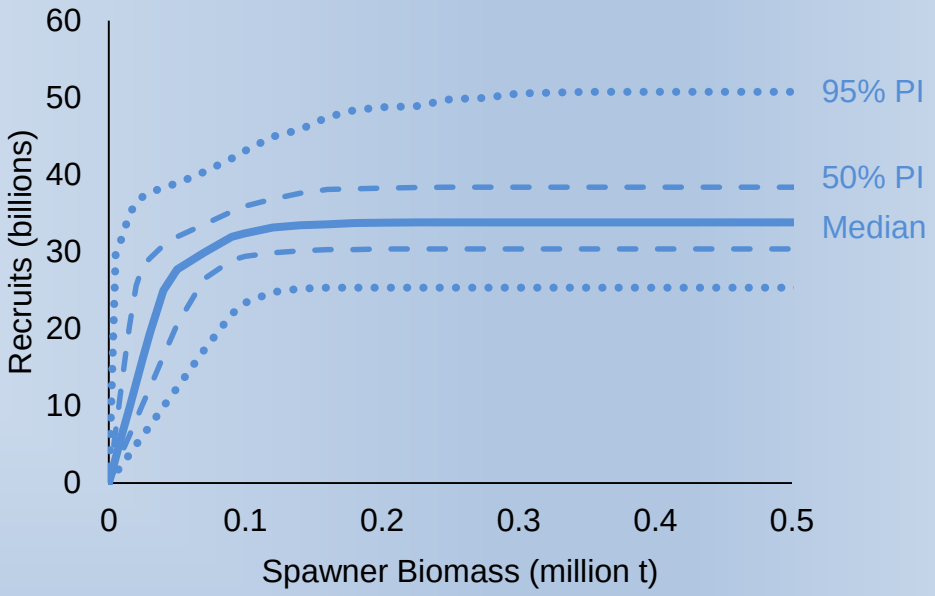


B^{sp} at which $R = 0.9 \times R_{Bsp=0.3}$: ~74 000t for Hockey Stick
~92 000t for non Parametric Smoother

How Reliably is the Hockey Stick Hinge Point Estimated?

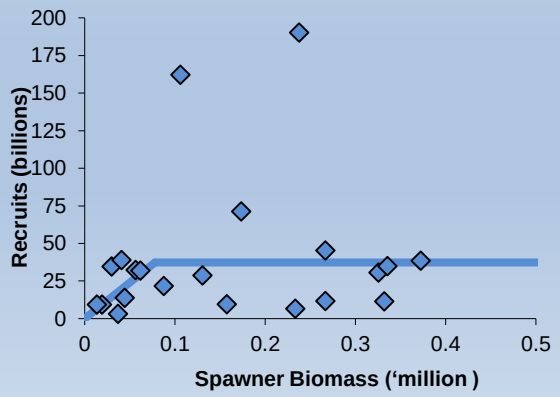


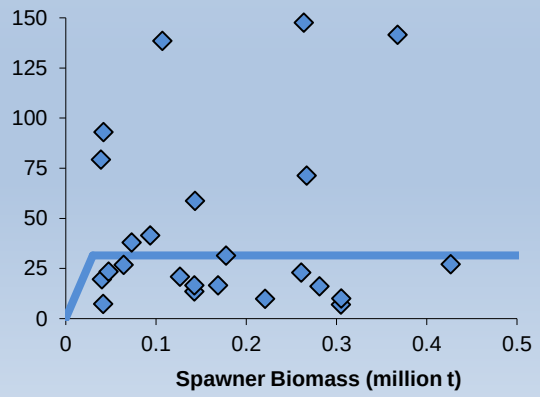


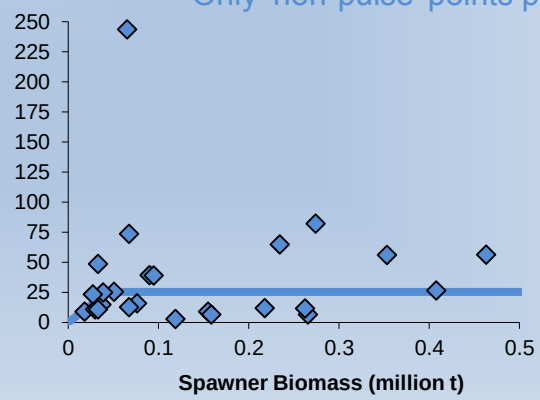


$Risk^S_{70}$, $Risk^S_{100}$, $Risk^S_{hinge}$

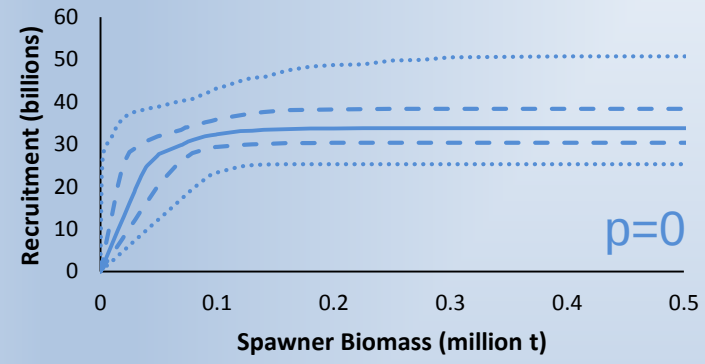
Only 'non-pulse' points plotted

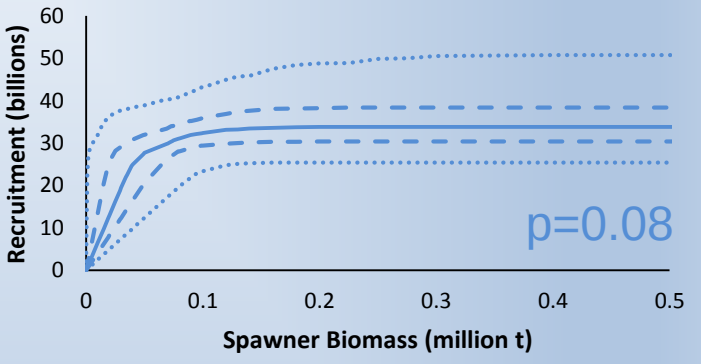




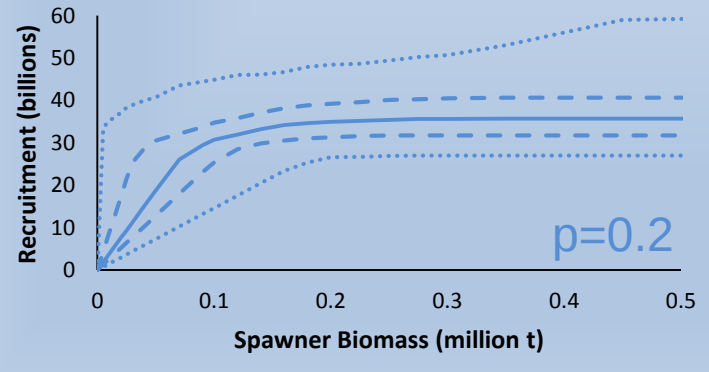


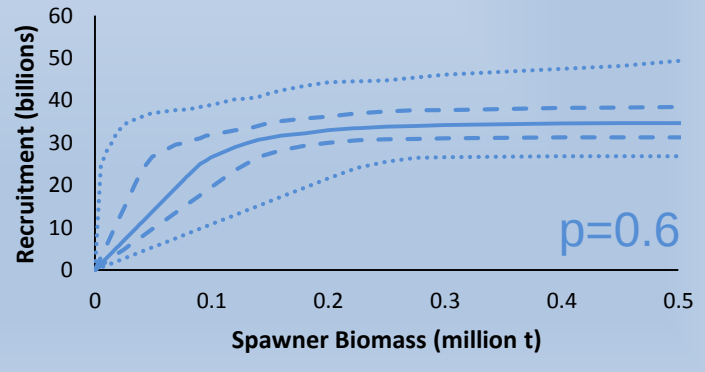
Key Question 2



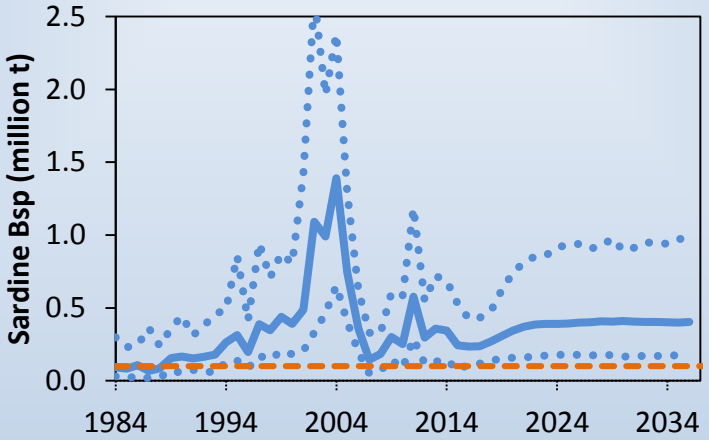


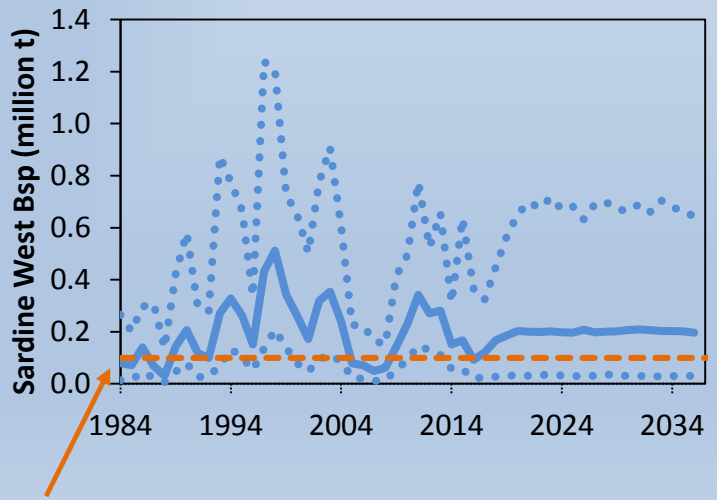
$Risk^{S}_{70}$, $Risk^{S}_{100}$, $Risk^{S}_{hinge}$

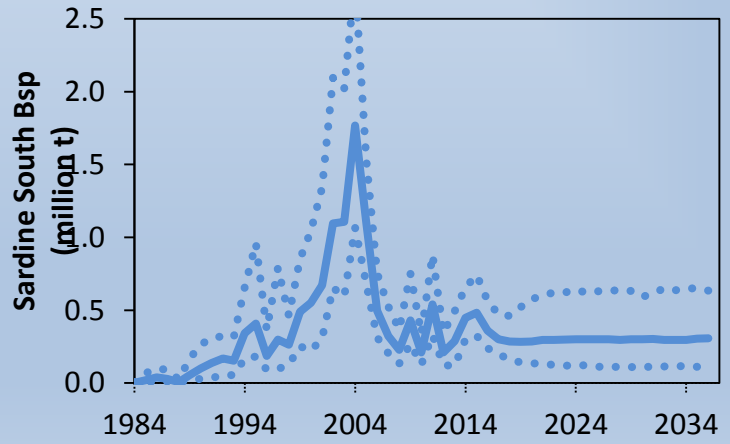




Key Question 2







$Risk^{S}_{100}$ =100 000t

Key Question 2

- Don’t currently consider a risk threshold for south component
- Some risk threshold can be more easily translated to single stock than others

Key Question 3

- How do we best select the acceptable probability of dropping below a risk threshold?
- Primary doc #3
- “risk level” = probability of dropping below a pre-defined risk threshold

Key Question 3

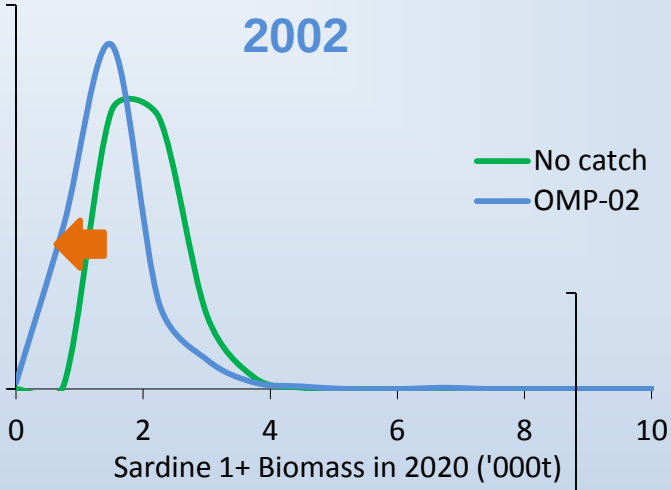
- Previous OMPs:

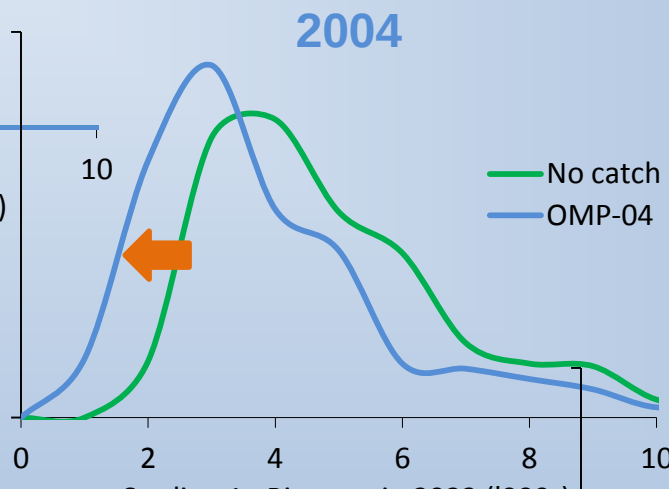
$risk_S$ = the probability that simulated total sardine 1+ biomass falls below the average total sardine 1+ biomass between Nov 91-94 at least once during the projection period of 20 years

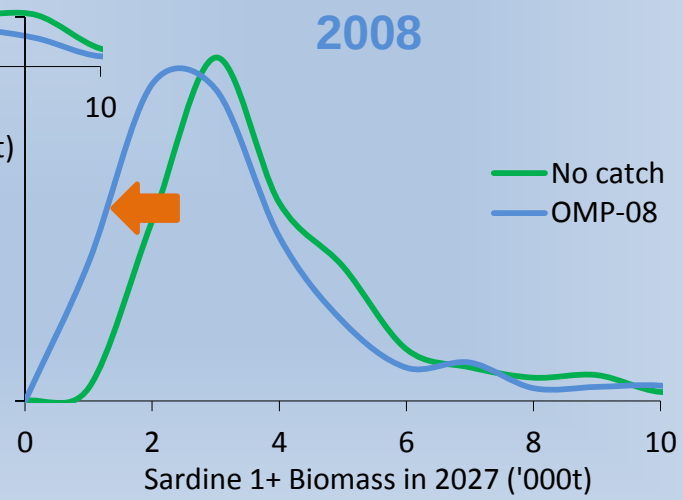
- $risk_S$<0.10 (OMP-04)
- $risk_S$<0.18 (OMP-08)
- $risk_S$<0.21 (OMP-14)

Not pre-defined
Changes in OMs
- increase/decrease in M or σ_R
- Increase/decrease in resilience of resource to reduction to a low level

Risk Level: SA sardine



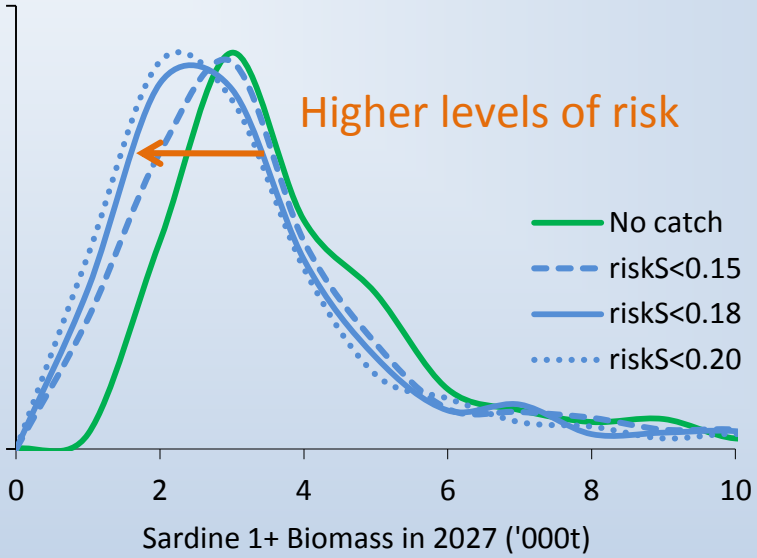




Consider lower percentiles of $B_{OMP}/B_{F=0}$

Maintain a similar level of downward shift under proposed new MP

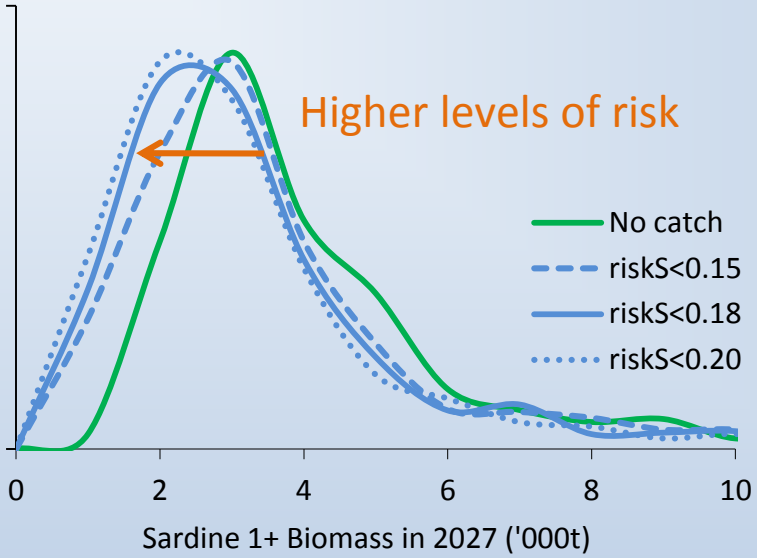
Risk Level: SA sardine



$risk_S$ – the probability that adult sardine biomass falls below the average adult sardine biomass over Nov 91-94 at least once during the projection period of 20 years

	$B_{OMP-04}/B_{F=0}$	Options for $B_{OMP-08}/B_{F=0}$		
		$risk_S$<0.15	$risk_S$<0.18	$risk_S$<0.20
10%ile	0.59			
20%ile	0.68			
30%ile	0.69			
40%ile	0.71			
median	0.72			

Risk Level: SA sardine



$risk_S$ – the probability that adult sardine biomass falls below the average adult sardine biomass over Nov 91-94 at least once during the projection period of 20 years

Aim:

Match ratios at 20%ile

Similar ratios at other lower %iles

Green – less

Black – same

Red – more

	$B_{OMP-04}/B_{F=0}$	Options for $B_{OMP-08}/B_{F=0}$		
		$risk_S$<0.15	$risk_S$<0.18	$risk_S$<0.20
10%ile	0.59	**0.60**	**0.49**	**0.45**
20%ile	0.68	**0.76**	**0.68**	**0.62**
30%ile	0.69	**0.80**	**0.72**	**0.68**
40%ile	0.71	**0.80**	**0.73**	**0.68**
median	0.72	**0.80**	**0.72**	**0.68**

Key Question 3

- i) probability of being below the risk threshold at least once during the projection period
  - High given biomass currently relatively low?
  - Doesn't taken probability of recovery into account
- ii) the probability of being below the risk threshold during the projection period
  - Average risk over the projection period
- iii) the probability of being below the risk threshold at the end of the projection period
  - Considers risk once transient influence of starting point has dissipated
  - Together with i) and ii) could inform on some probability of recovery

Key Question 4

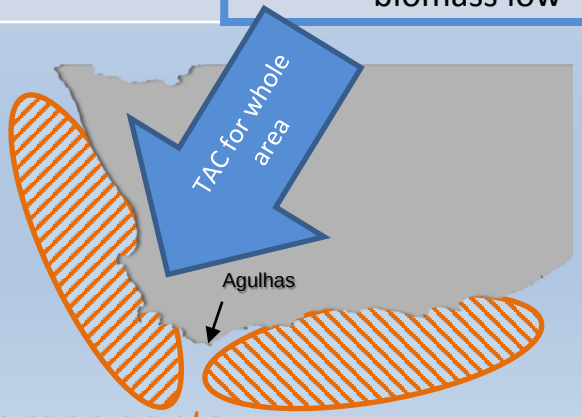
- Can one dispense with risk and simply consider catch over the medium-to-long term as sufficient to incorporate any negative consequences of undue depletion of the population? (This because future catches should be reduced if the stock is depleted such that future recruitment drops.)
- Primary doc #9

Key Question 5

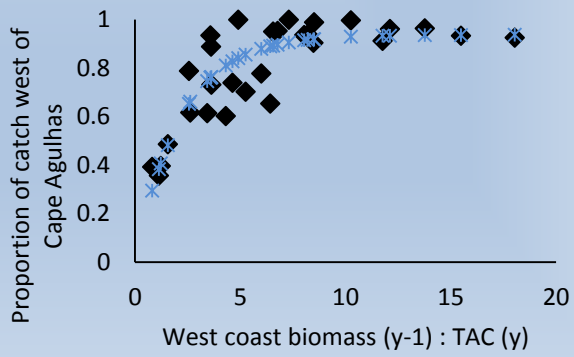
- What would be the best way to simulation test the impact of a single area directed sardine TAC in a situation of two spatially distinct sardine population components?
- Primary doc #4

Key Question 5

		The type of sardine TAC arising from the candidate MS	
		Single area TAC	Two area TAC
The underlying sardine stock OM	Single sardine stock	All catch taken from single stock	Add TACs, and subsequent catch taken from single stock
	Two mixing sardine components	Greater proportion of TAC caught from west component when TAC/WC biomass low	West/south TAC taken from west/south component



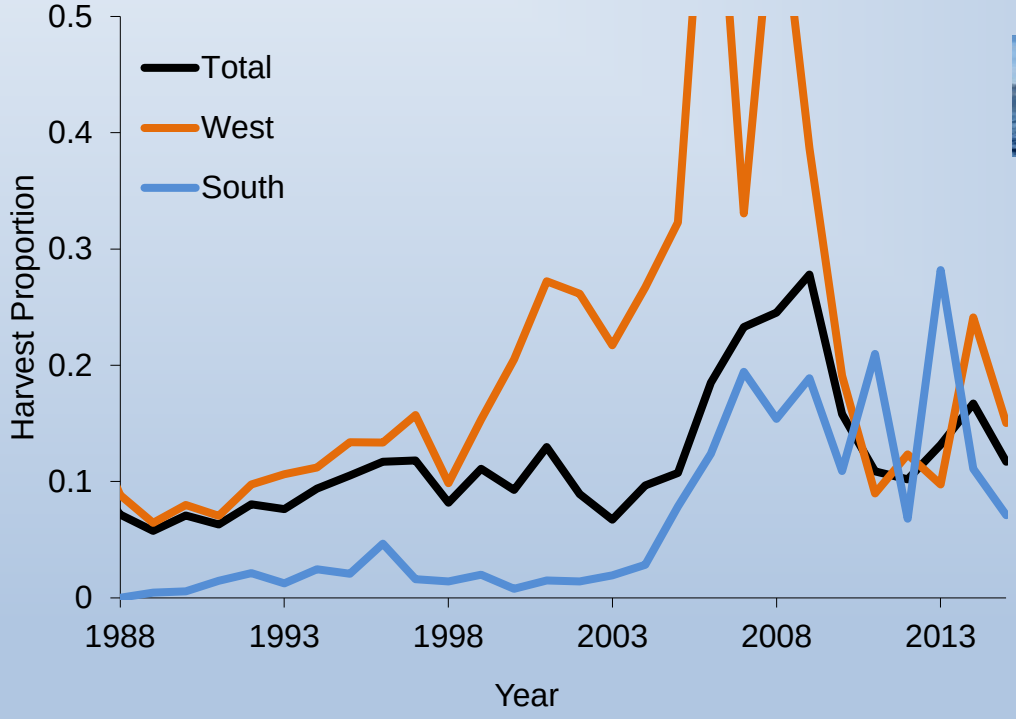
Two sardine components



Key Question 6

- The 2016 panel recommended OMP variants that include spatial management be considered. Is spatial management of the sardine TAC necessary? If we consider explicit spatial management to be necessary during "concerning periods" only, how do we best determine the "flags" for switching such spatial management on and off?
- Primary doc #7

Focussing on the West Component



Harvest proportion on west component much higher

Of concern given poor recruitment to west component in recent decade if this is a “feeder” to both coasts

Key Question 6

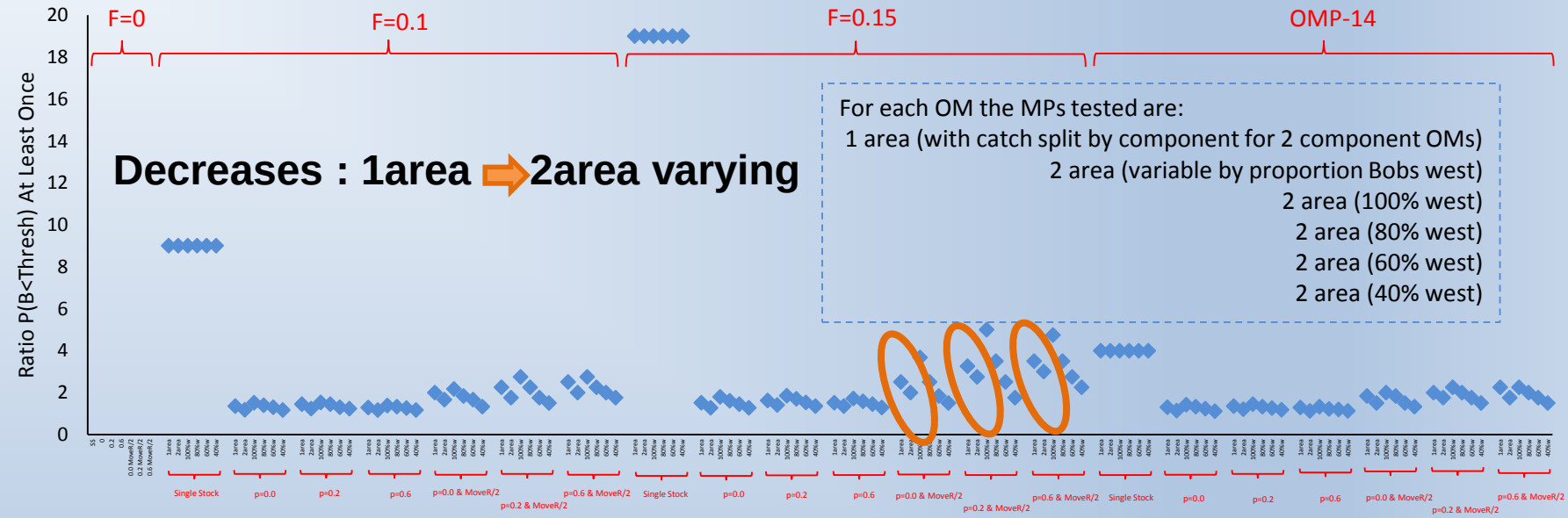
- Single area management

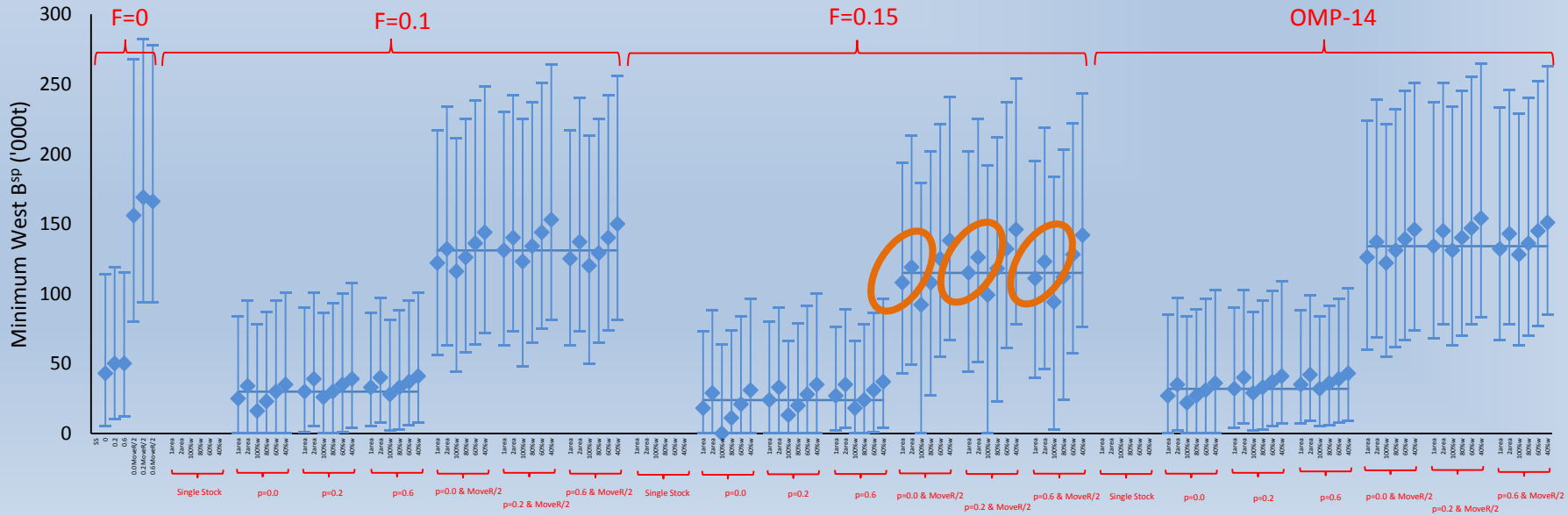
- "implicit" spatial management if we assume "fishing as in the past" (key question #5)

- Two area management

- Fixed proportion of TAC west/east of Cape Agulhas each year
- Variable proportion of TAC west/east of Cape Agulhas each year (e.g. based on survey proportions west/east of Cape Agulhas)
- "Gentleman's Agreement"
- Only required during 'concerning' periods?
- 'concerning' defined as i) a low west coast survey estimate of biomass or ii) high proportions of catch on west coast in preceding years

From FISHERIES/2017/OCT/SWG-PEL/24





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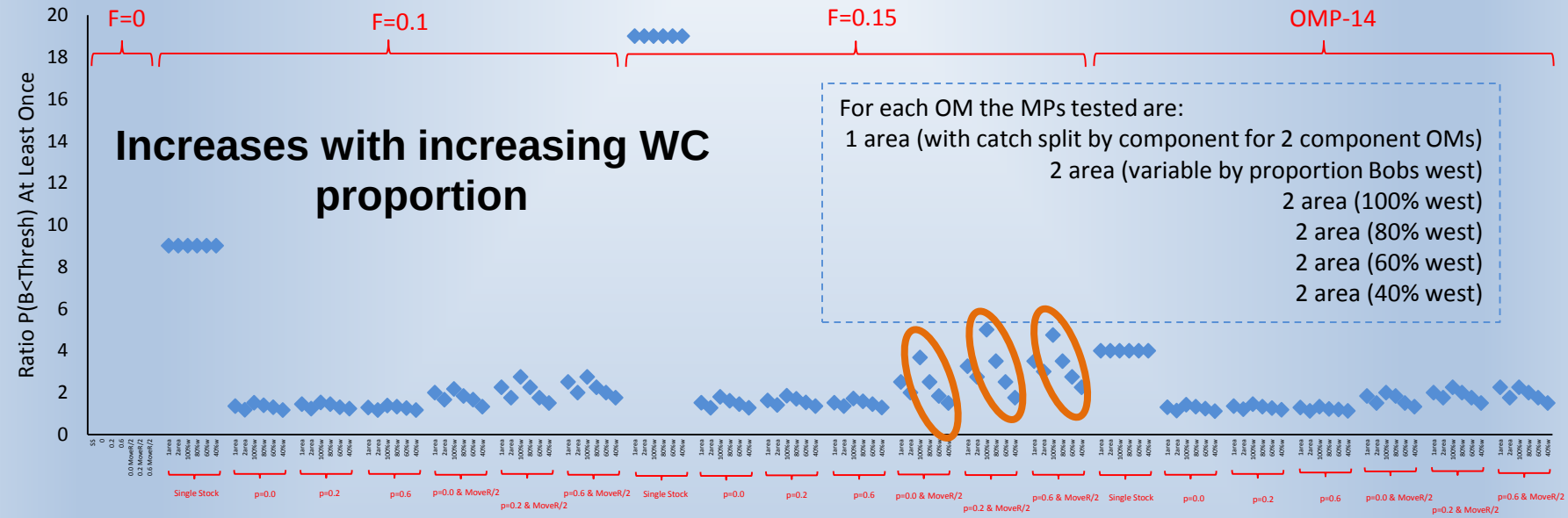
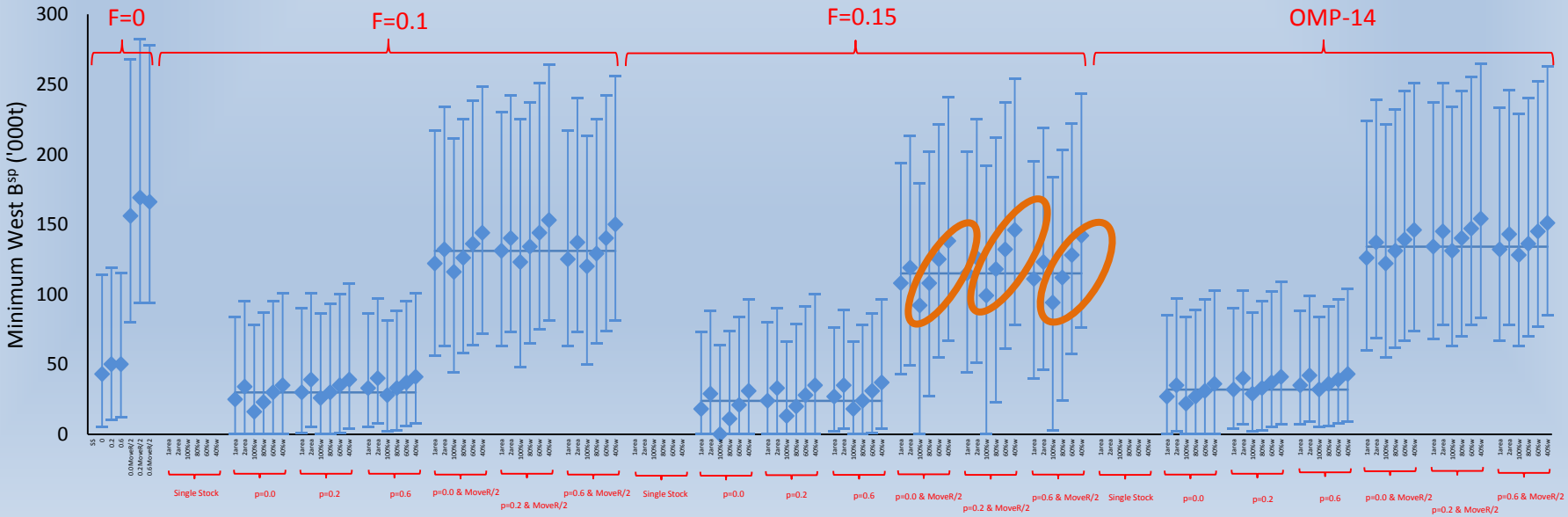
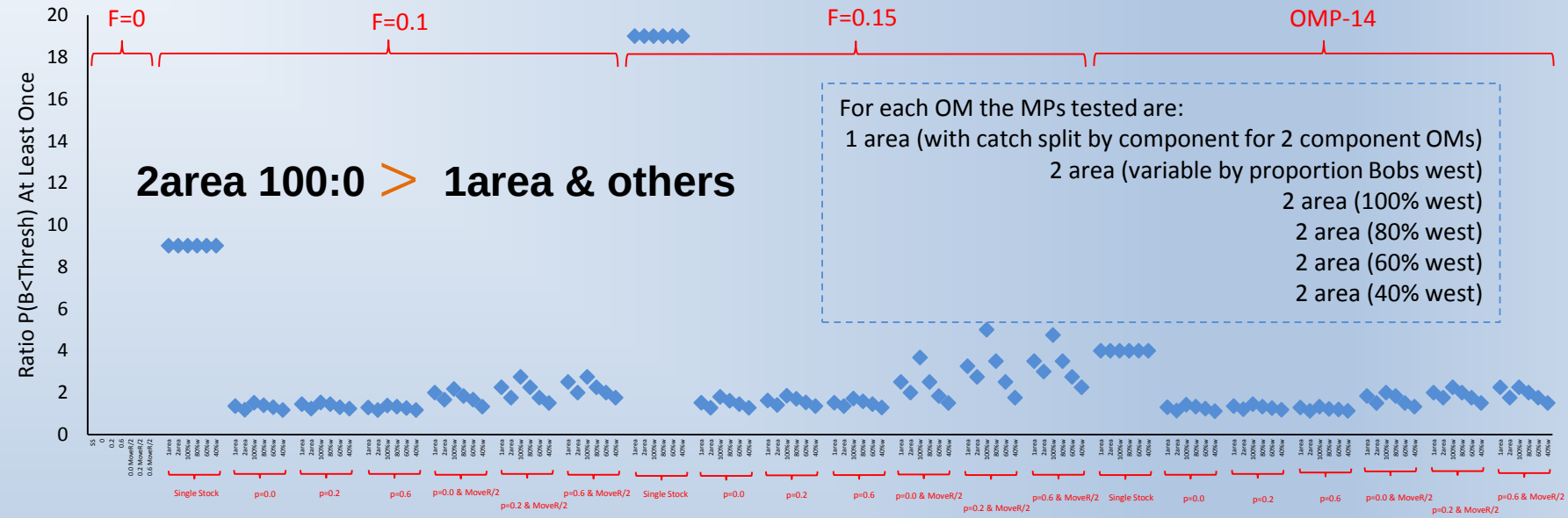
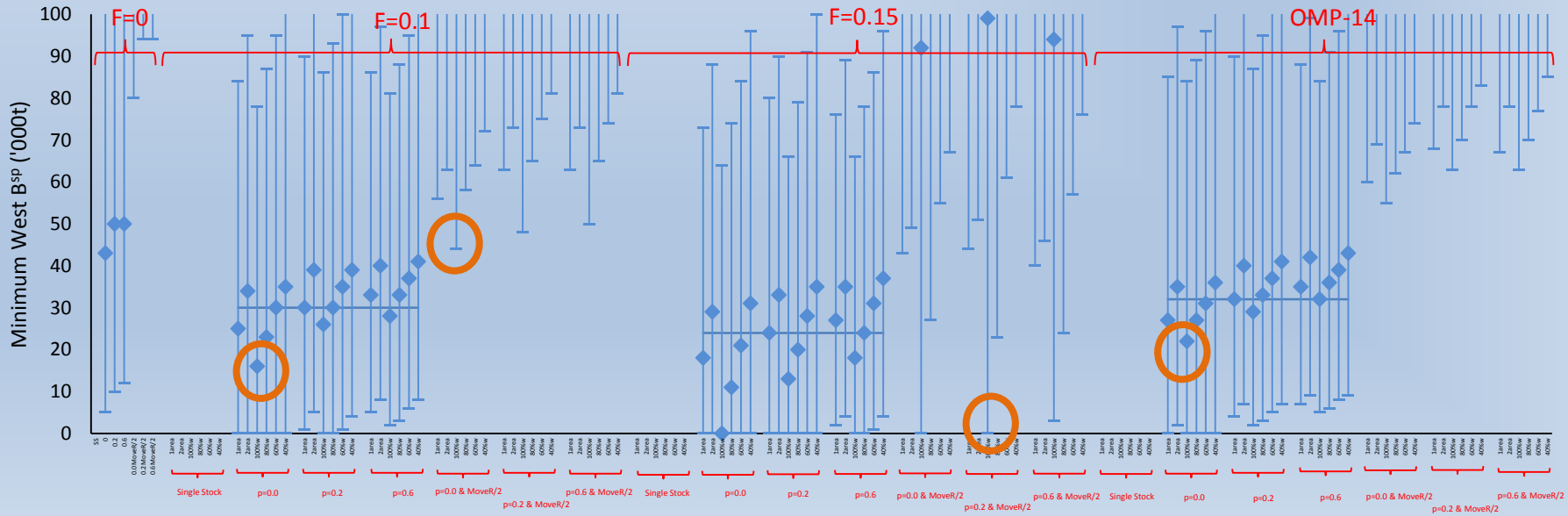




From FISHERIES/2017/OCT/SWG-PEL/24





Key Question 6

		$p(B_{west,y} < Risk^{S}_{2007})$	$p(B^{sp}_{west,y} < Risk^{S}_{hinge})$			Average weight	Average weight	Median weight	Median weight
MoveR	$p = 0.0$	0.12	0.15			0.064	0.044	0.053	0.040
	$p = 0.08$	0.10	0.22			0.376	0.256	0.526	0.395
	$p = 0.2$	0.07	0.23			0.310	0.211	0.316	0.237
	$p = 0.6$	0.06	0.31			0.250	0.17	0.105	0.079
0.5MoveR	$p = 0.0$	0.01	0.01			0.064	0.02	0.053	0.013
	$p = 0.08$	0.00	0.01			0.376	0.12	0.526	0.131
	$p = 0.2$	0.00	0.03			0.310	0.099	0.316	0.079
	$p = 0.6$	0.00	0.06			0.250	0.08	0.105	0.026
Avg MoveR		0.08	0.24			No future directed sardine catch			
Avg 0.5MoveR		0.00	0.03						
Avg		0.06	0.17						
Median MoveR		0.09	0.23						
Median 0.5MoveR		0.00	0.02						
Median		0.07	0.18						

Key Question 6

		$p(B_{west,y} < Risk^{S}_{2007})$	$p(B^{sp}_{west,y} < Risk^{S}_{hinge})$	Median C_{west}	Median AAV_{tot}	Average weight	Average weight	Median weight	Median weight
MoveR	$p = 0.0$	0.21	0.25	77	13.9	0.064	0.044	0.053	0.040
	$p = 0.08$	0.18	0.33	78	13.2	0.376	0.256	0.526	0.395
	$p = 0.2$	0.13	0.33	81	11.2	0.310	0.211	0.316	0.237
	$p = 0.6$	0.10	0.41	82	10.3	0.250	0.17	0.105	0.079
0.5MoveR	$p = 0.0$	0.01	0.01	86	9.0	0.064	0.02	0.053	0.013
	$p = 0.08$	0.01	0.03	86	8.9	0.376	0.12	0.526	0.131
	$p = 0.2$	0.01	0.05	87	8.7	0.310	0.099	0.316	0.079
	$p = 0.6$	0.01	0.11	87	8.9	0.250	0.08	0.105	0.026
Avg MoveR		0.15	0.34	80	11.9				
Avg 0.5MoveR		0.01	0.05	87	8.8				
Avg		0.10	0.25	82	10.9				
Median MoveR		0.16	0.33	79	12.3				
Median 0.5MoveR		0.01	0.04	86	8.8				
Median		0.12	0.26	81	11.4				

Future catches according to OMP-14 with single area management

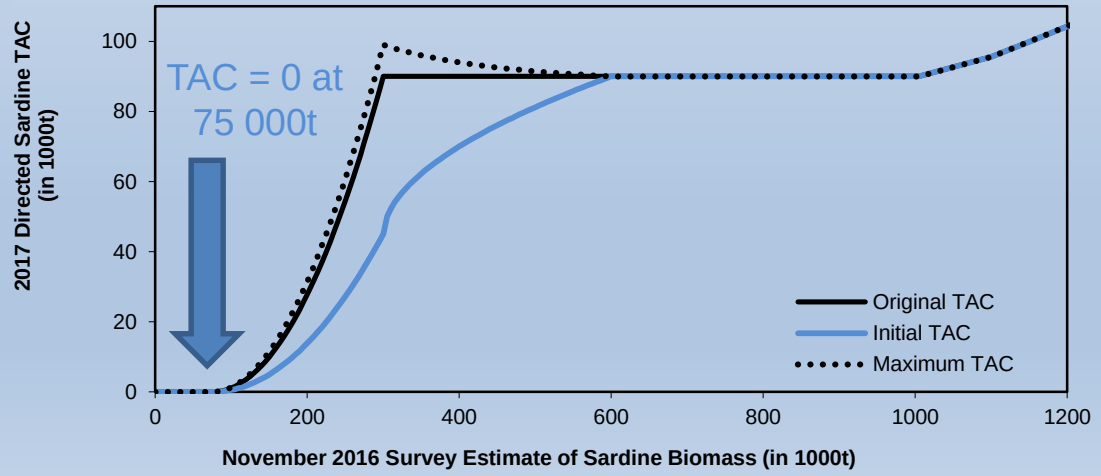
Key Question 6

		$p(B_{west,y} < Risk^{S}_{2007})$	$p(B^{sp}_{west,y} < Risk^{S}_{70})$	$p(B^{sp}_{west,y} < Risk^{S}_{100})$	$p(B^{sp}_{west,y} < Risk^{S}_{hinge})$	$p(B_{west,y} < Risk^{S}_{2007})$	$p(B^{sp}_{west,y} < Risk^{S}_{70})$	$p(B^{sp}_{west,y} < Risk^{S}_{100})$	$p(B^{sp}_{west,y} < Risk^{S}_{hinge})$
		At lease once				All years			
p=0.2 and MoveR	F=0	0.32	0.69	0.89	0.68	0.07	0.14	0.23	0.23
	Single Area	0.44	0.86	0.96	0.76	0.13	0.25	0.37	0.33
	100:0	0.46	0.87	0.96	0.77	0.14	0.26	0.38	0.34
	70:30	0.44	0.85	0.96	0.76	0.13	0.24	0.36	0.33
	40:60	0.42	0.84	0.96	0.74	0.12	0.22	0.34	0.31
	Variable (GA)	0.41	0.84	0.96	0.75	0.11	0.21	0.34	0.31

Choice of risk thresholds and risk levels
(key questions 2 and 3)

Key Question 7

- How might one best specify the November survey estimate of abundance below which the directed sardine fishery should be closed?
- Primary doc #5



Key Question 7

- Remain part of the HCR
- No need for a step function from TAC>0 to TAC=0; indications are industry will catch even a very small TAC
- Ecosystem considerations (escapement threshold?)

Introduction to South African sardine: Assessment and Management

Thank you for your attention

MARAM