

Letting the “data” speak for themselves

The use of stock-recruit relationships to determine a biomass threshold above which management should aim to keep a resource



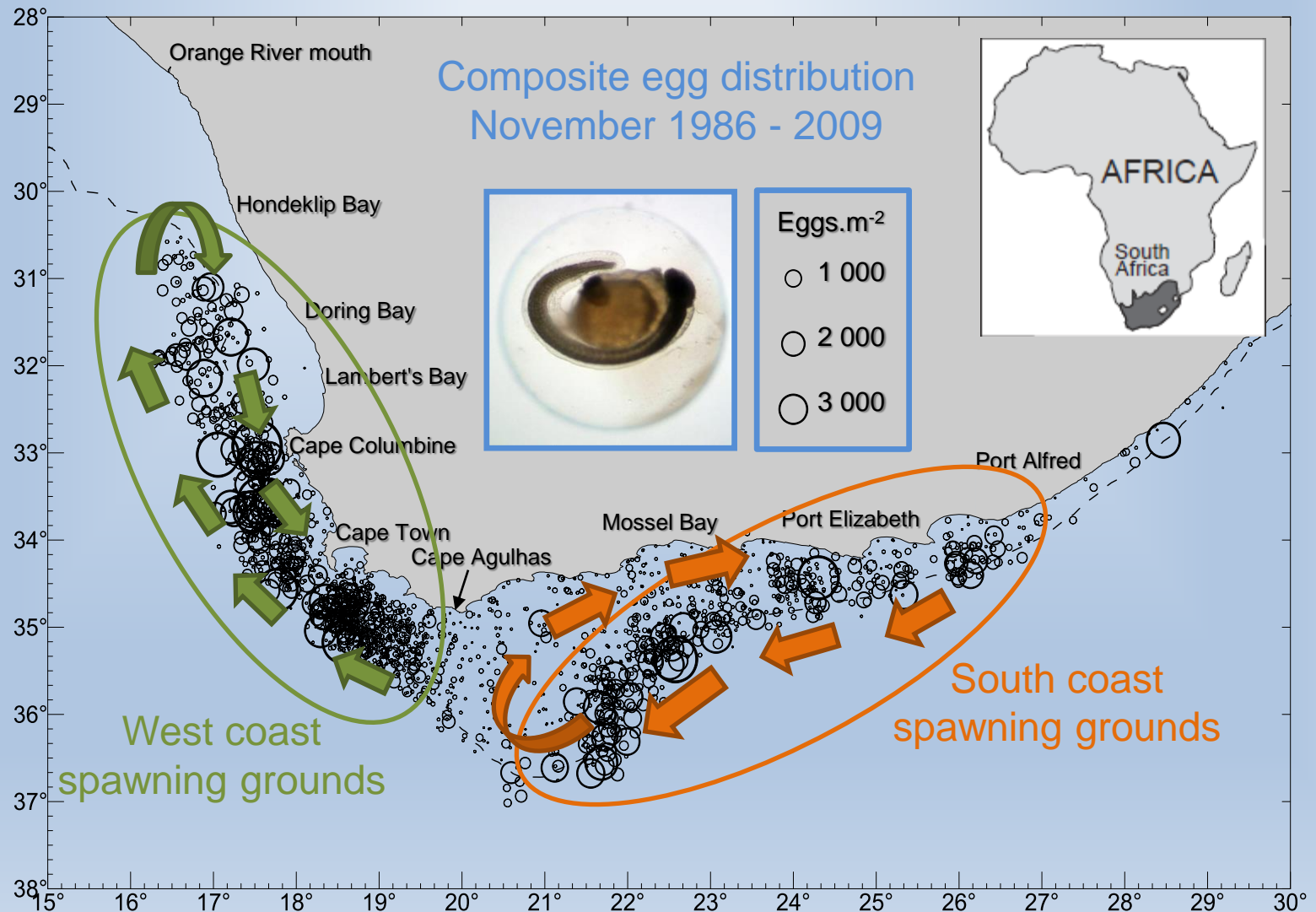
CAPAM Workshop
Miami, USA
2nd November 2017

Carryn de Moor & Doug Butterworth

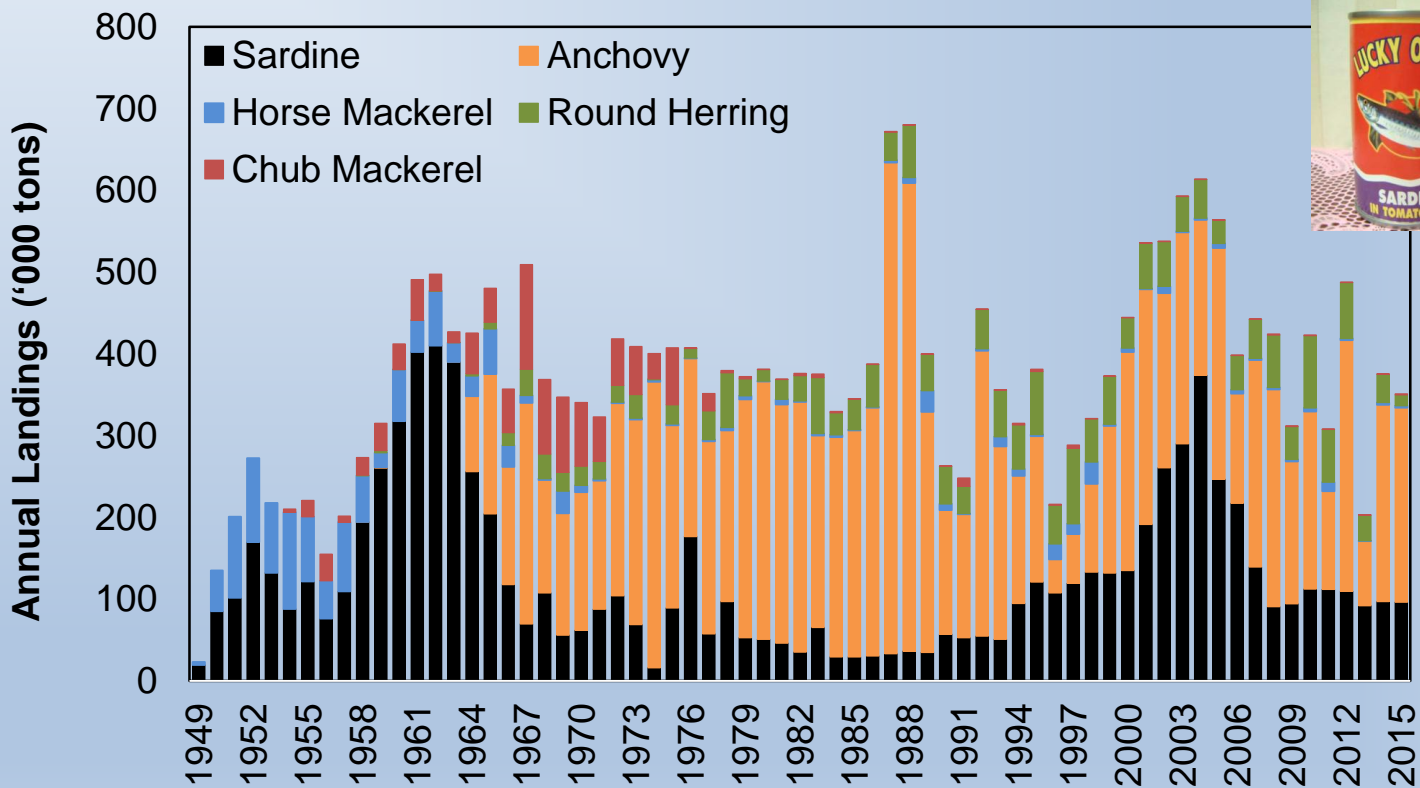


Marine Resource Assessment and Management Group (MARAM)
Department of Mathematics and Applied Mathematics
University of Cape Town

SA Sardine Distribution



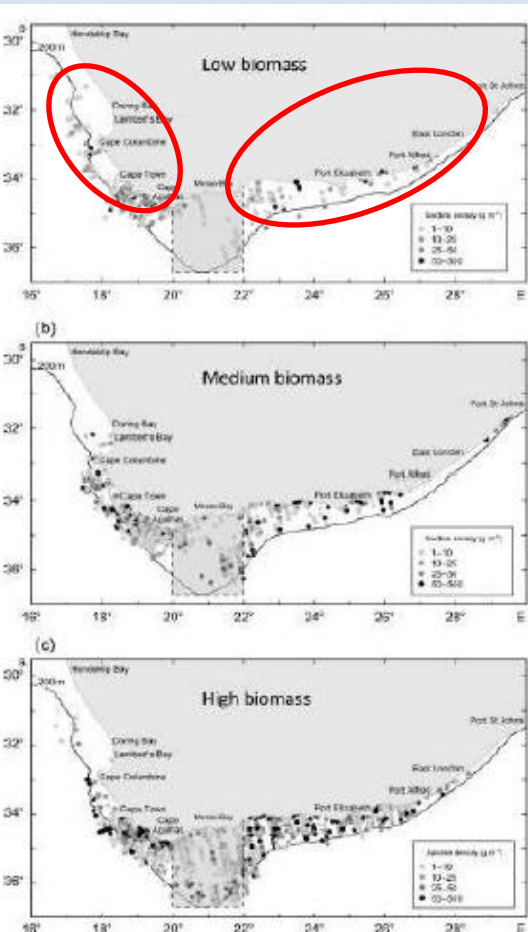
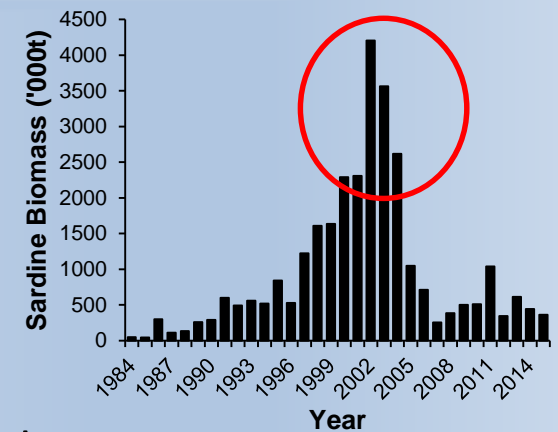
History of Fishery



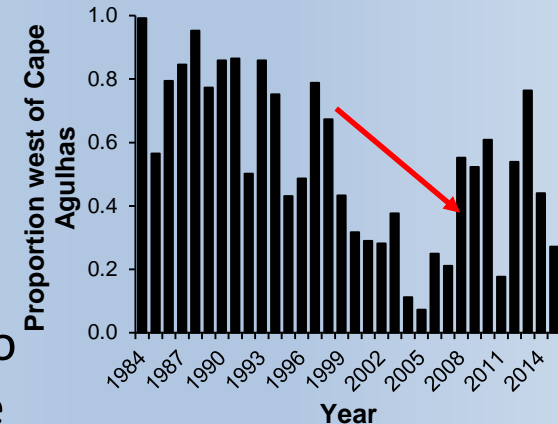
Sardine have also been commercially harvested off the south coast since the 1990s

Background

- Historically, SA sardine assessed and managed as a single homogeneous fishery management unit under the assumption that the resource consists of a single biological population

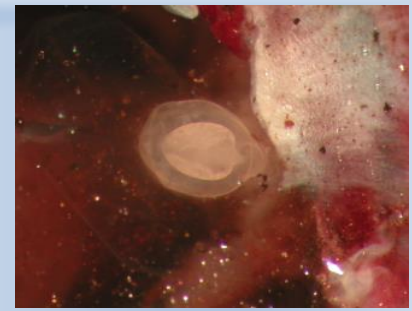


- A boom in abundance and an almost simultaneous eastward shift at the turn of the century prompted renewed research into the stock structure of SA sardine
- Raised the possibility of two distinct and separate spawning aggregations
- Observed that the sardine distribution was concentrated in two widely separated areas at low and medium (but not high) biomass levels





Parasite Bio-tagging

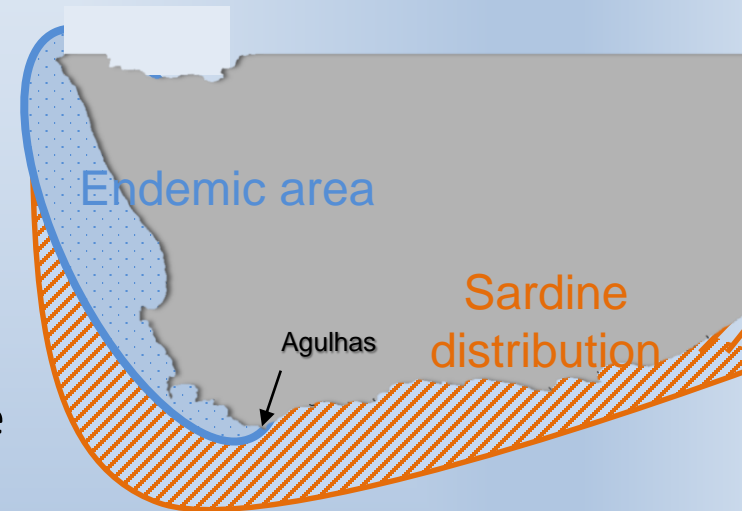


- For SA sardine, the digenean “tetracotyle” type metacercariae found in sardine eyes showed greatest bio-tag potential
- 1st intermediate host endemic to west coast
- No fish-to-fish transmission

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

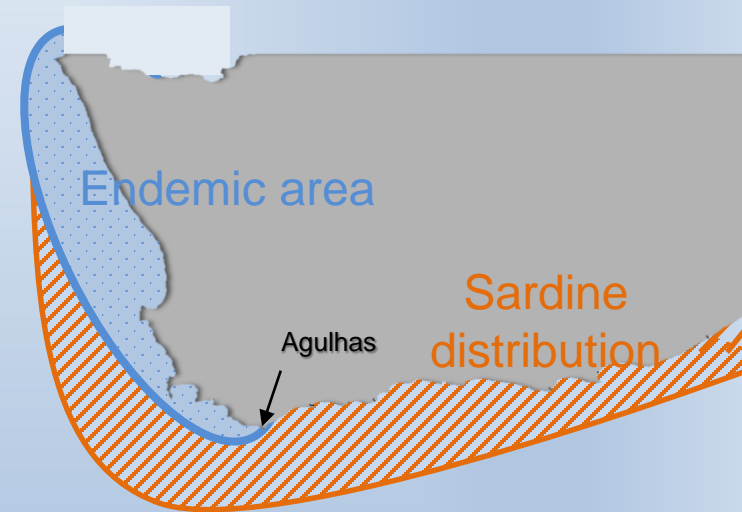
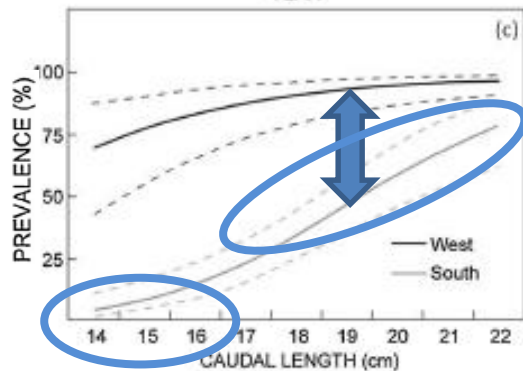
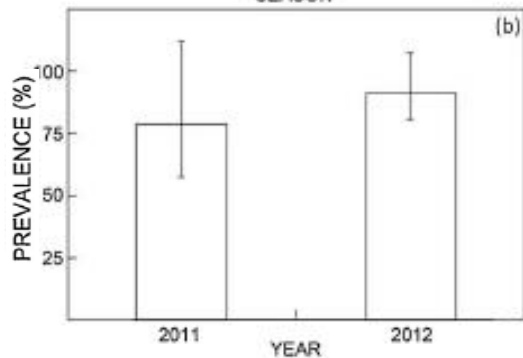
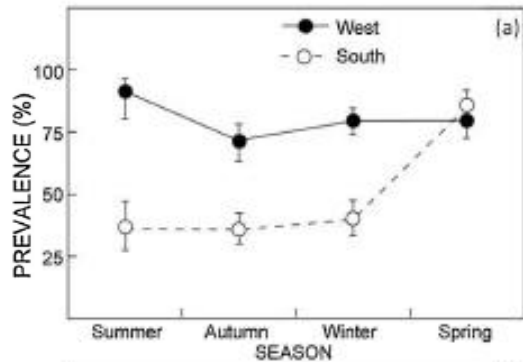
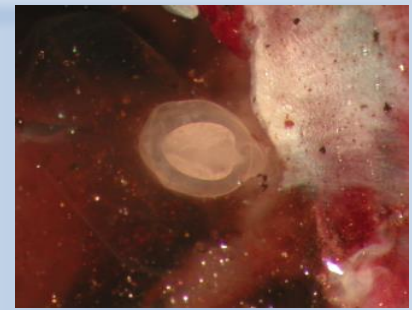
- Differences in the prevalence, mean infection intensity and mean abundance of the parasite

➡ Sardine are NOT homogeneously distributed





Parasite Bio-tagging

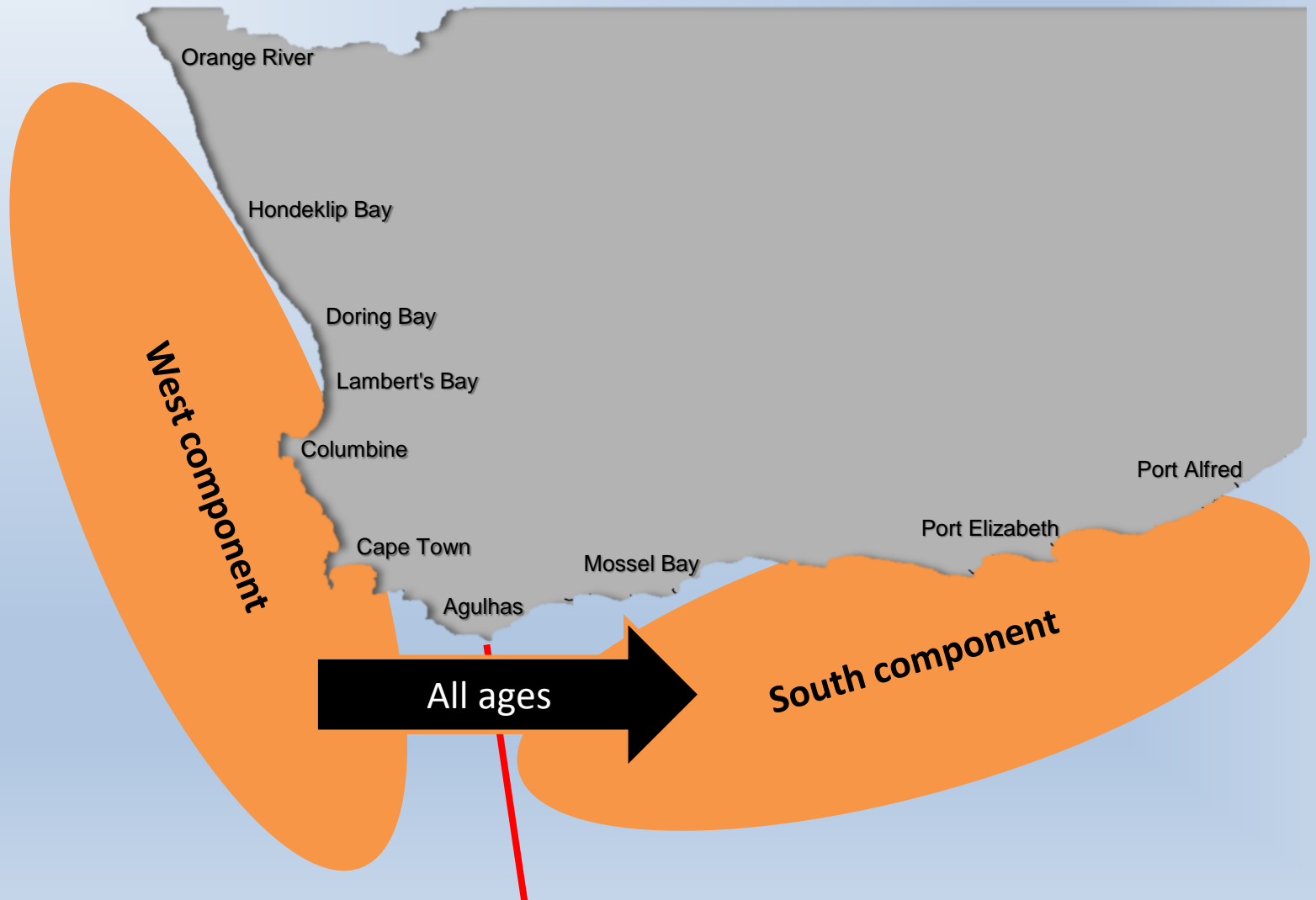


- Parasite prevalence on west coast higher than on south coast
- Parasite prevalence increases with length on both west and south coasts



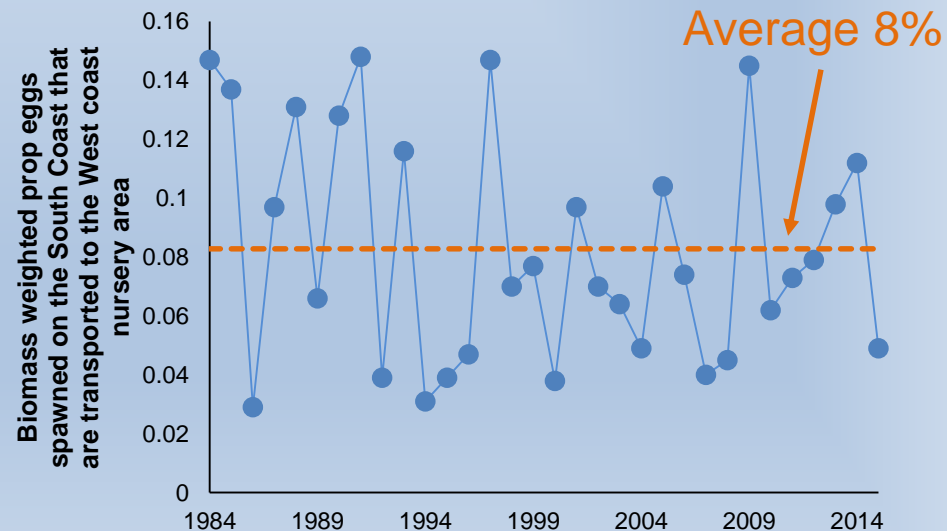
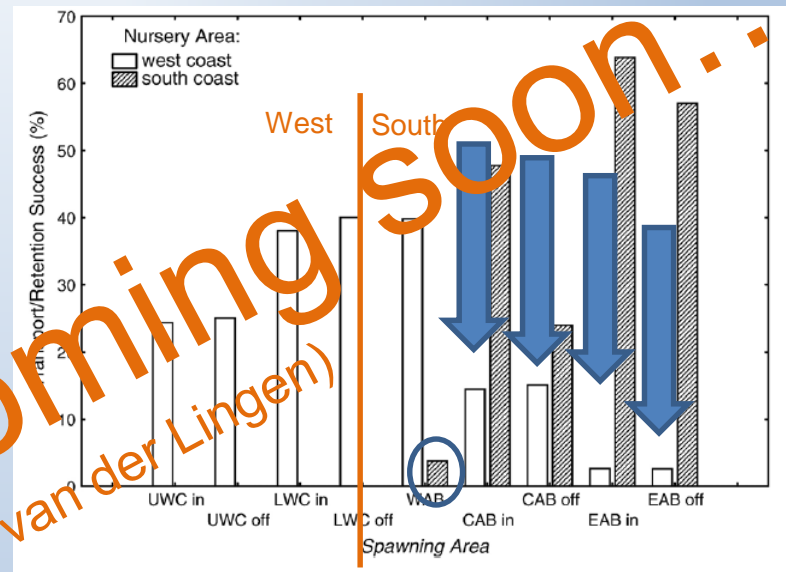
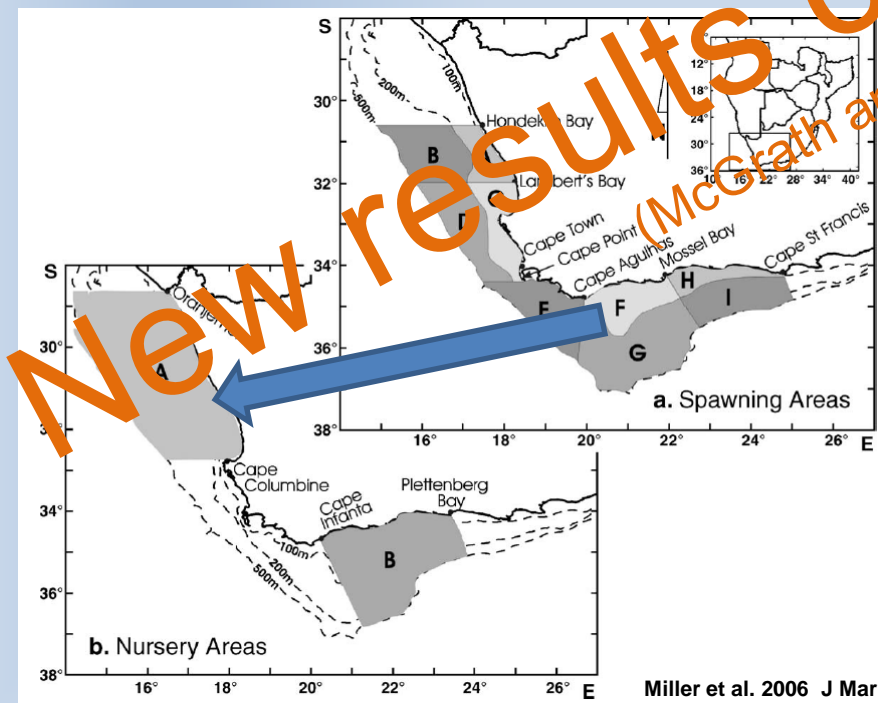
Sardine must move at older ages

Two-Mixing Component Hypothesis

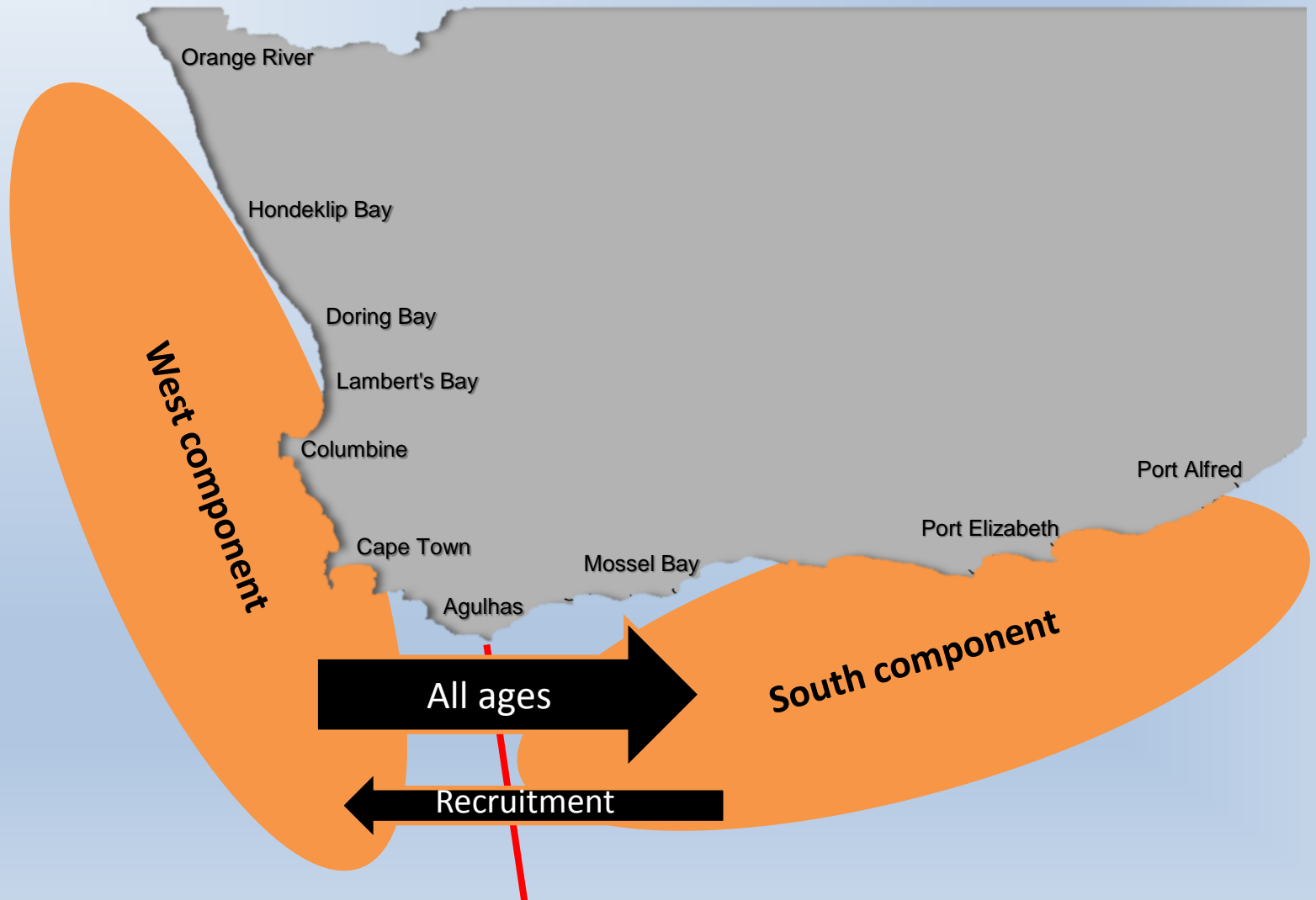


IBM + hydrodynamic model

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



Two-Mixing Component Hypothesis



Assessment Details

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Assessing the South African sardine resource: two stocks rather than one?

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- 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

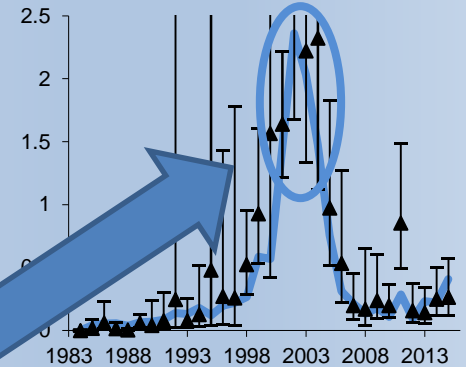
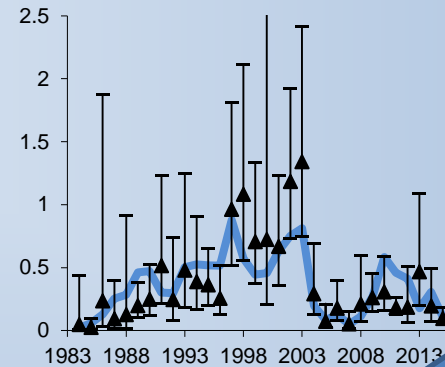
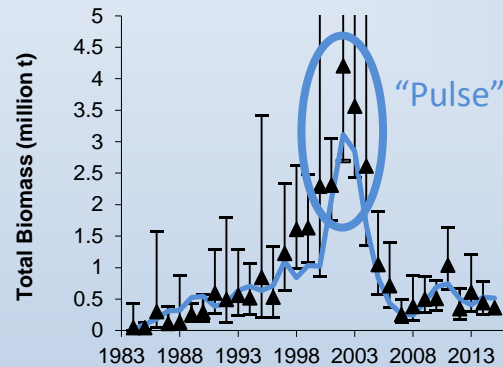
Model Fit to Survey Abundance Indices

Single Stock

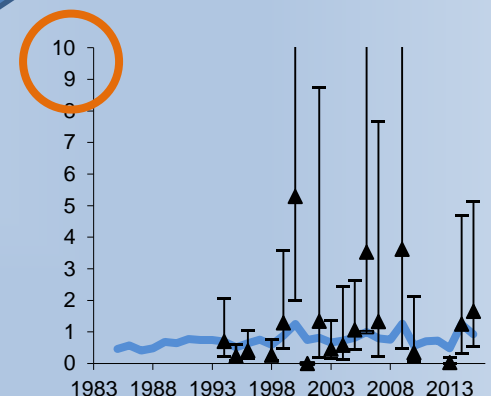
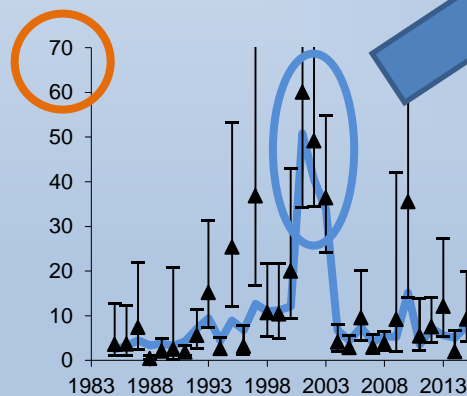
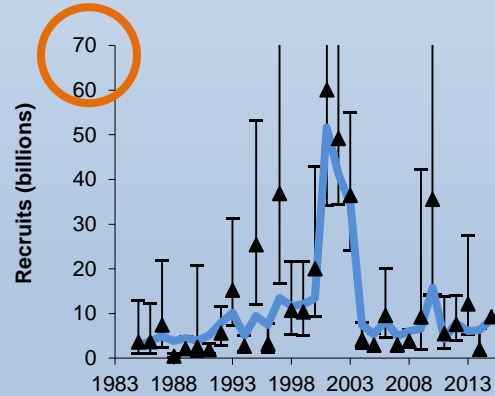
West Component

South Component

November
biomass survey



May
recruit survey

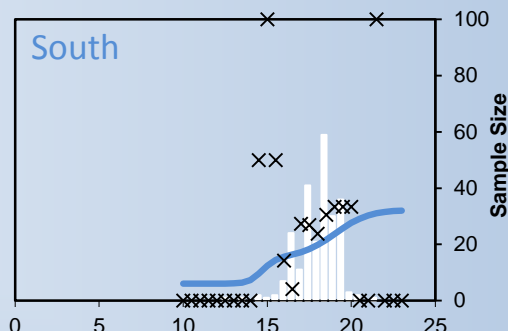
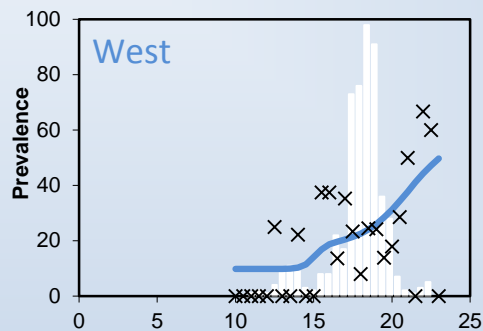


Single Stock Hypothesis

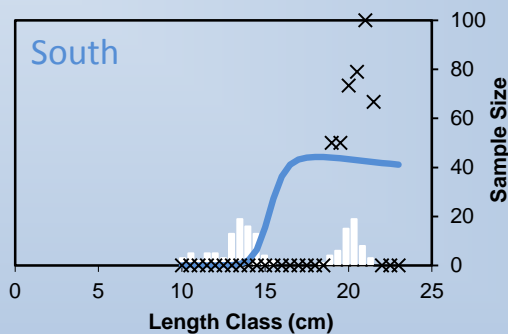
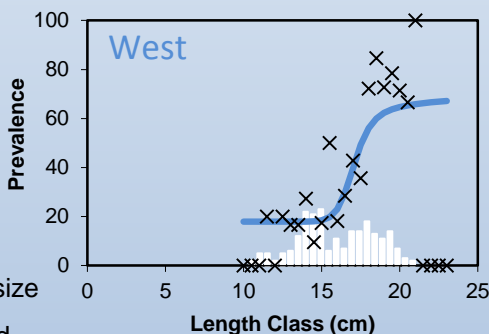
Two Component Hypothesis

Parasite Prevalence Data ('08-15)

2011



2014



Sample size

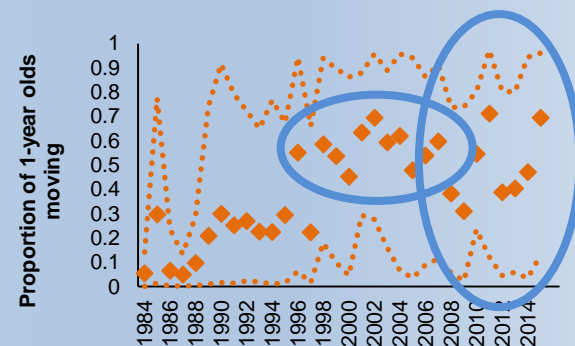
x Observed

— Predicted

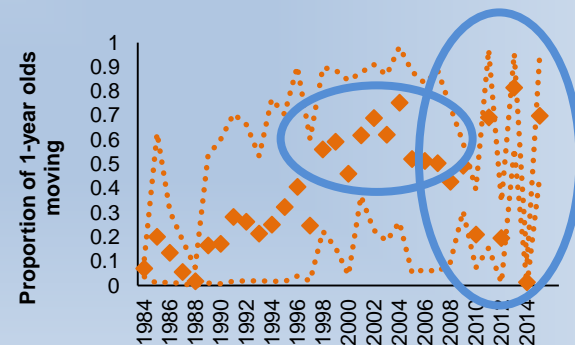
Length Class (cm)

Length Class (cm)

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



ARTICLE

The quantitative use of parasite data in multistock modelling of South African sardine (*Sardinops sagax*)¹

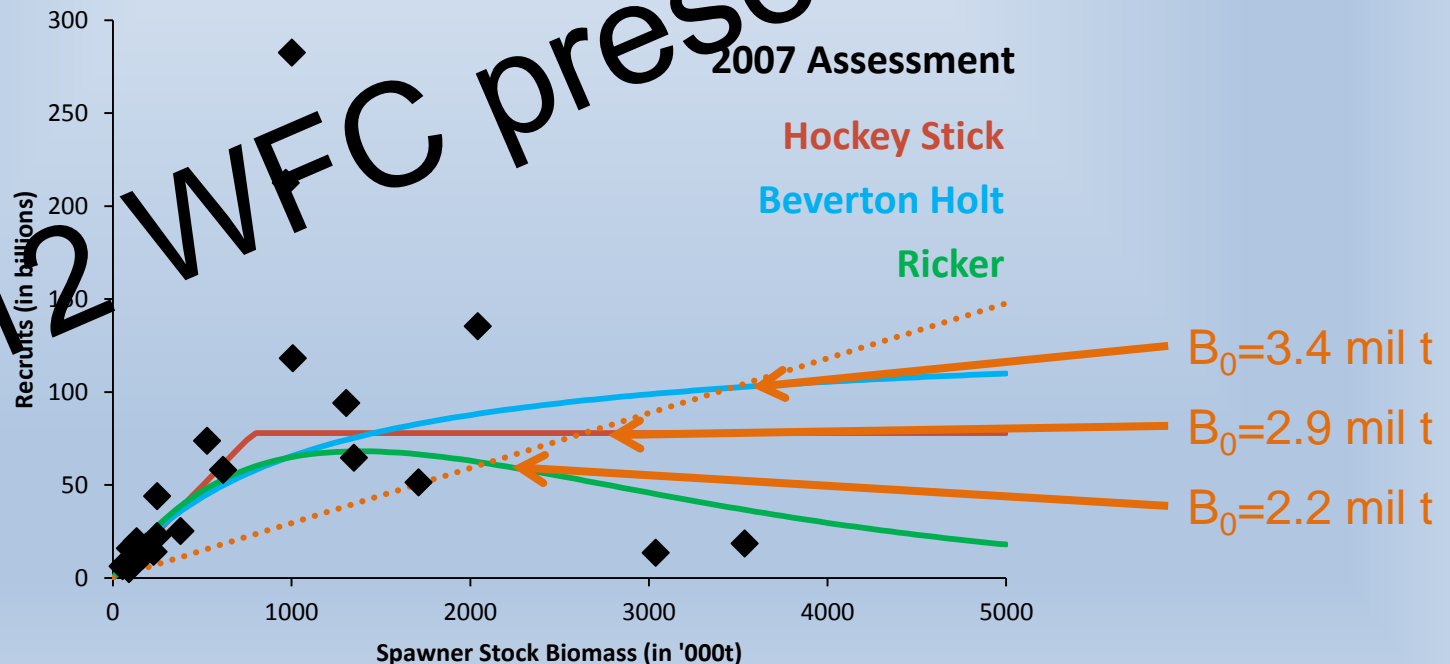
Carryn L. de Moor, Douglas S. Butterworth, and Carl D. van der Lingen

Anti-Steepness?!

- MSY based reference points...

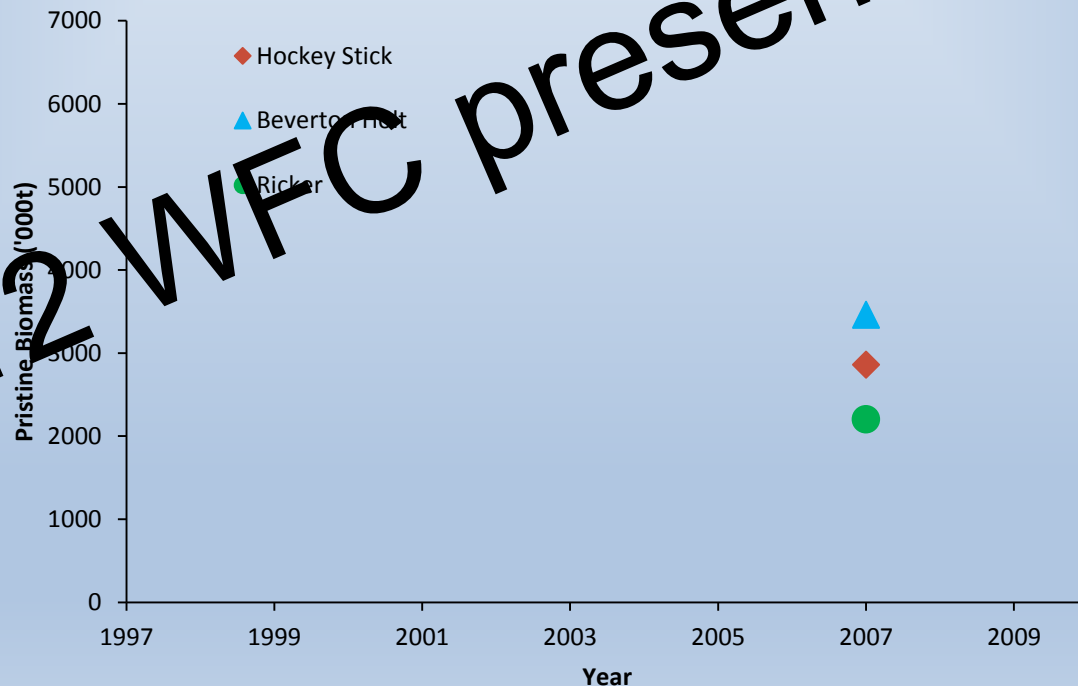
What is Pristine Biomass (B_0)?

- B_0 can differ considerably for alternative stock recruit relationships, all fit data near equally well



What is Pristine Biomass (B_0)?

- B_0 estimates can also change over time



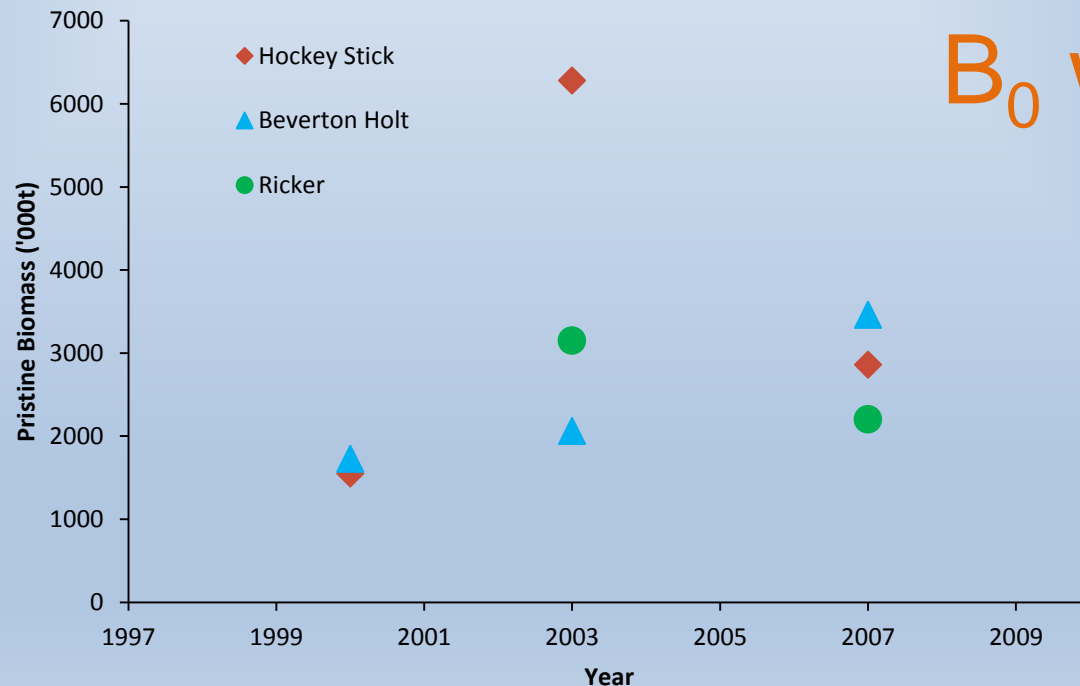
South
African
Sardine

What is Pristine Biomass (B_0)?

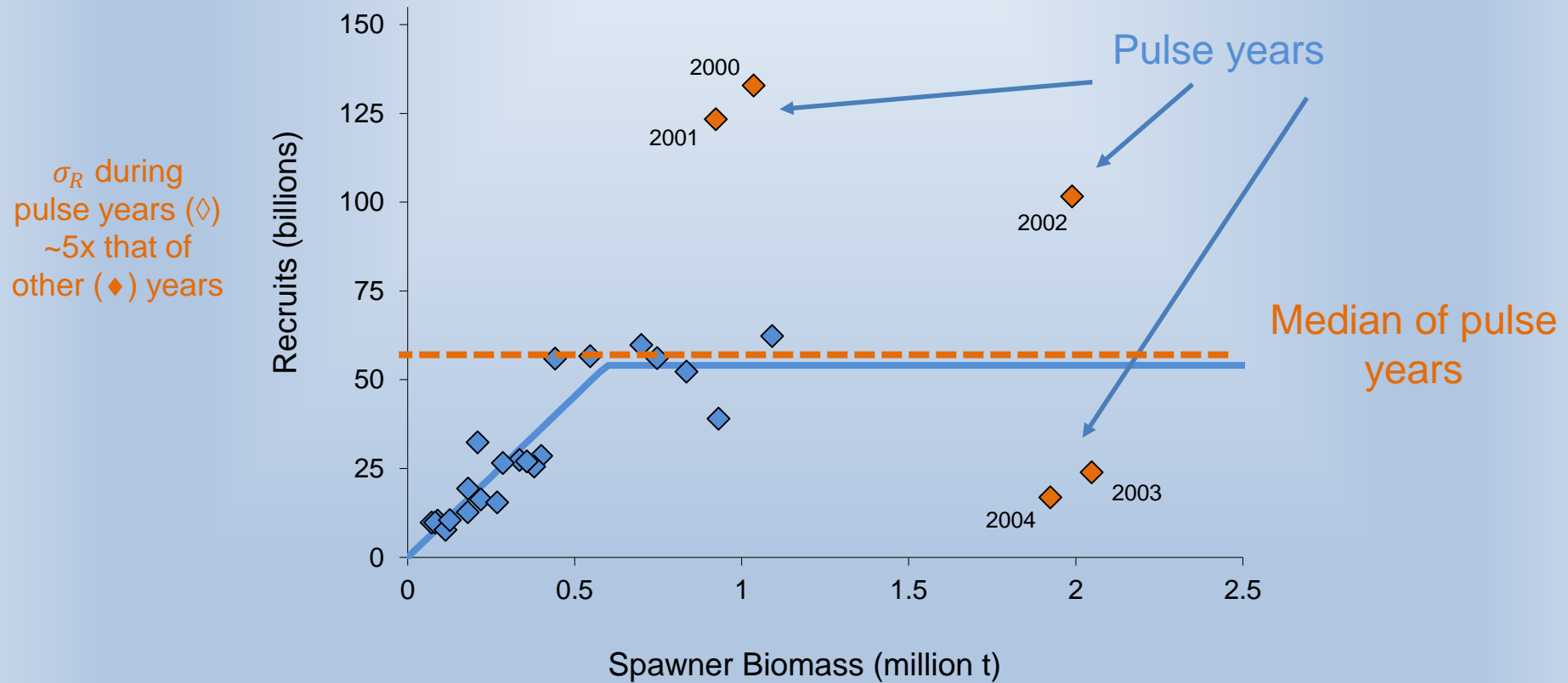
- B_0 estimates can also change over time

We don't know
 B_0 well!

South
African
Sardine

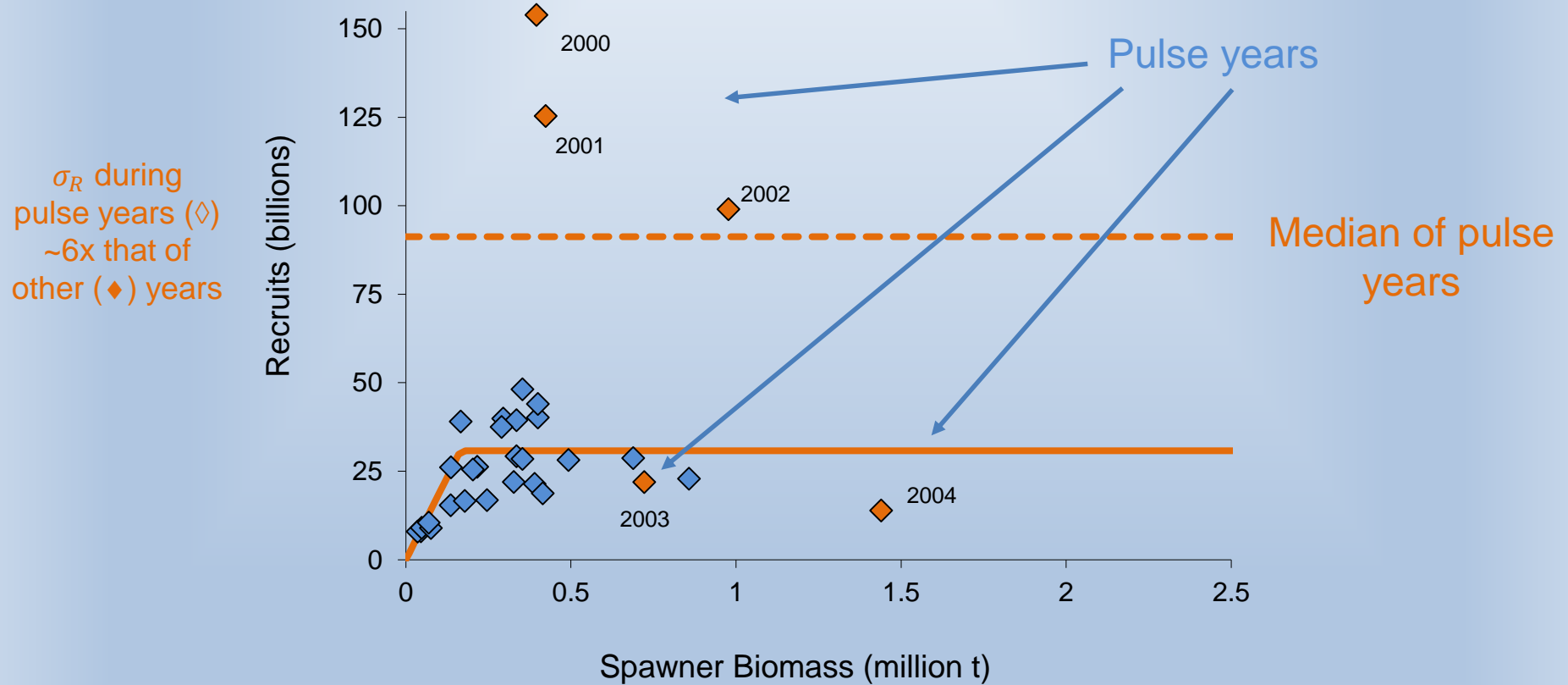


Previous Operating Model



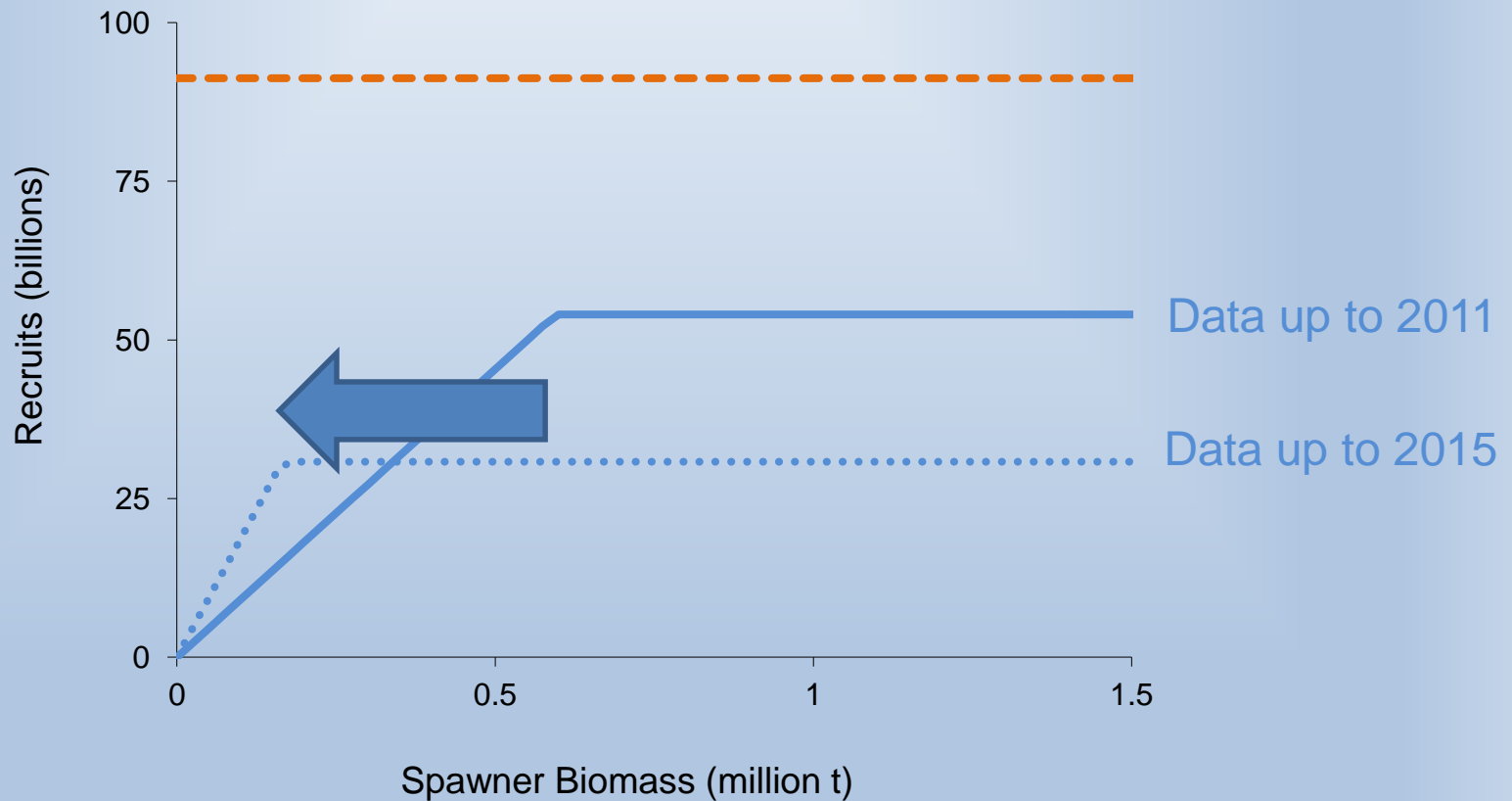
Single Stock Hypothesis

Updated Operating Model



Single Stock Hypothesis

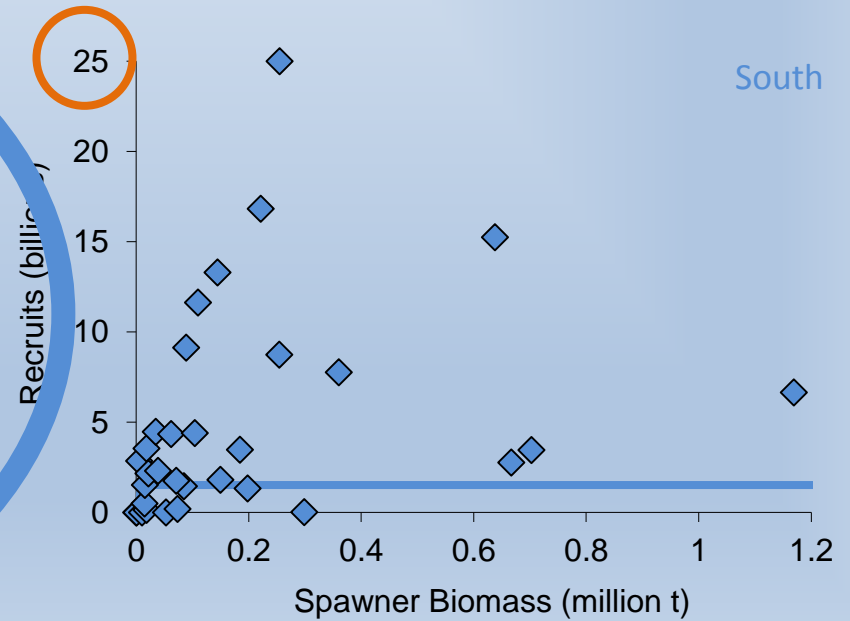
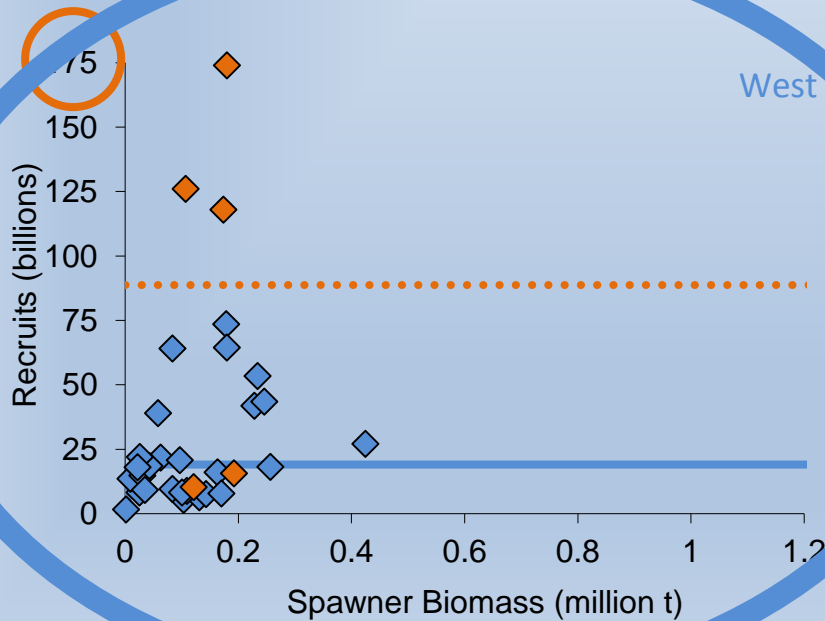
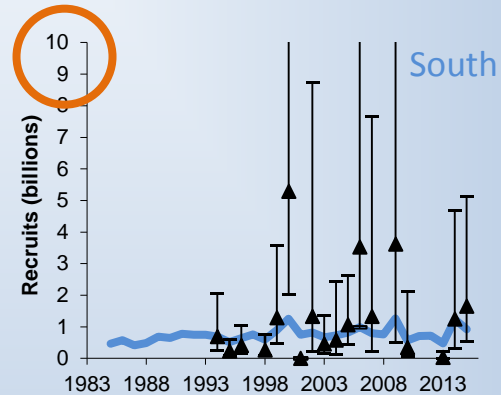
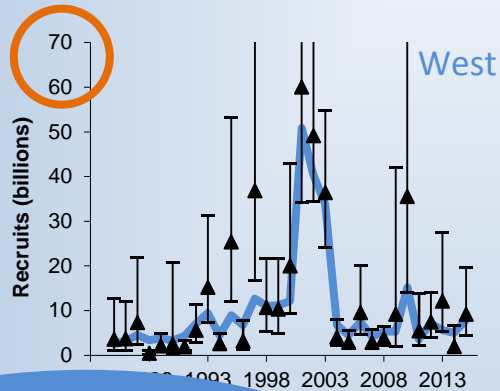
Updated Operating Model



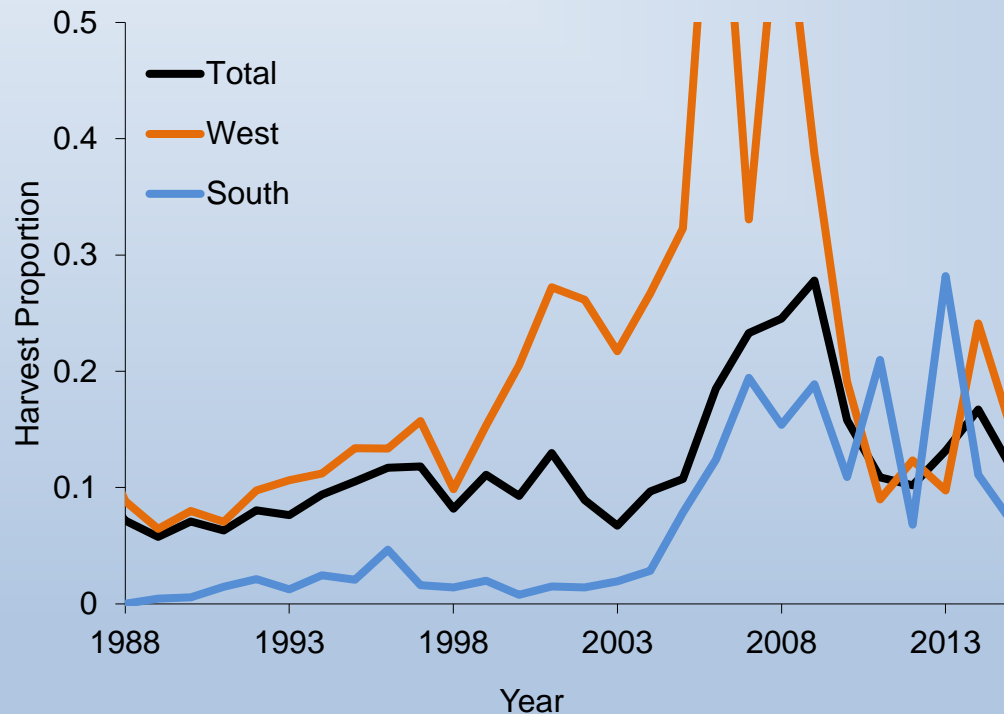
Single Stock Hypothesis

Two Component Operating Model

May
recruit survey



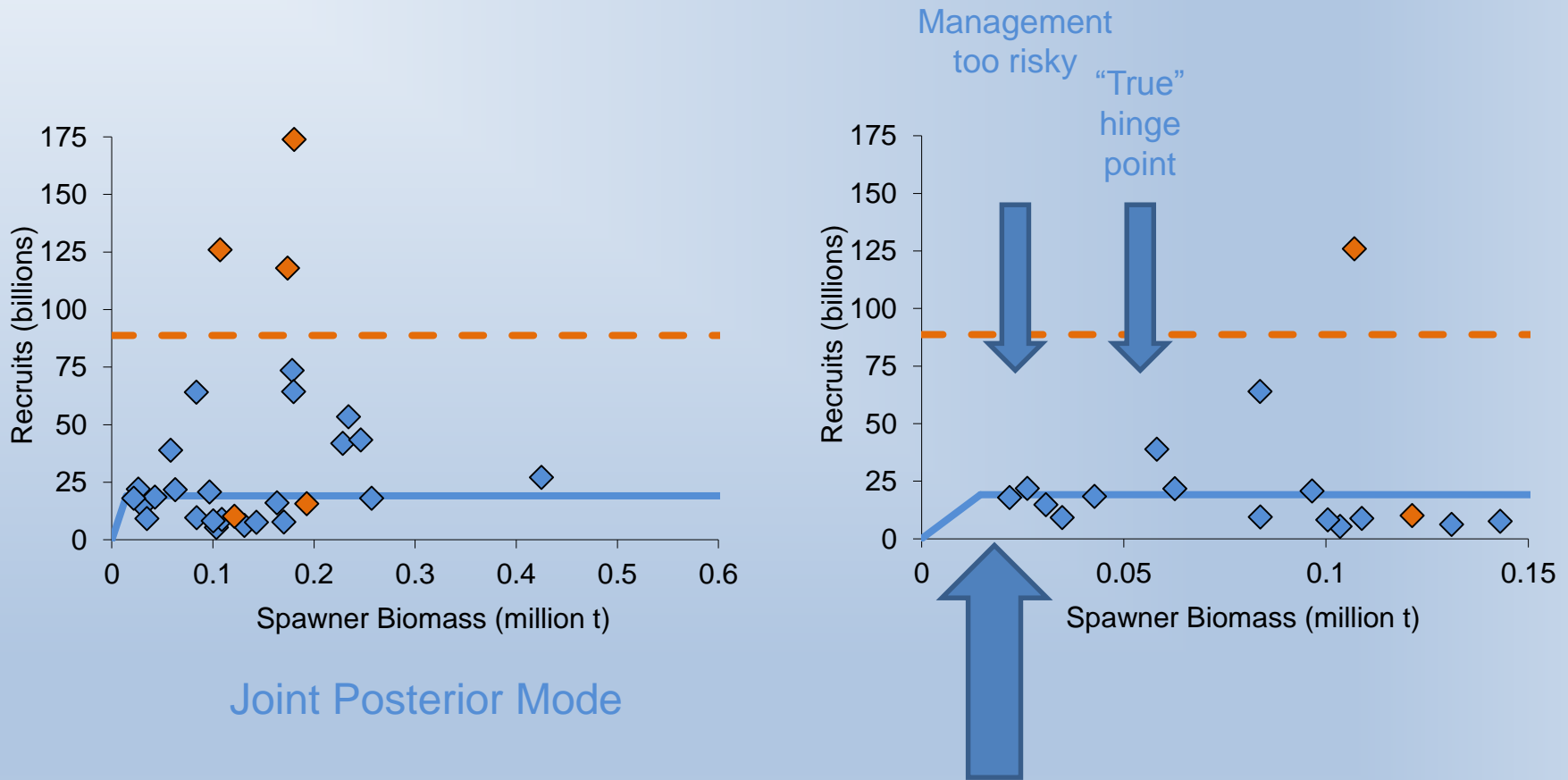
Focussing on the West Component



Harvest proportion on west component much higher

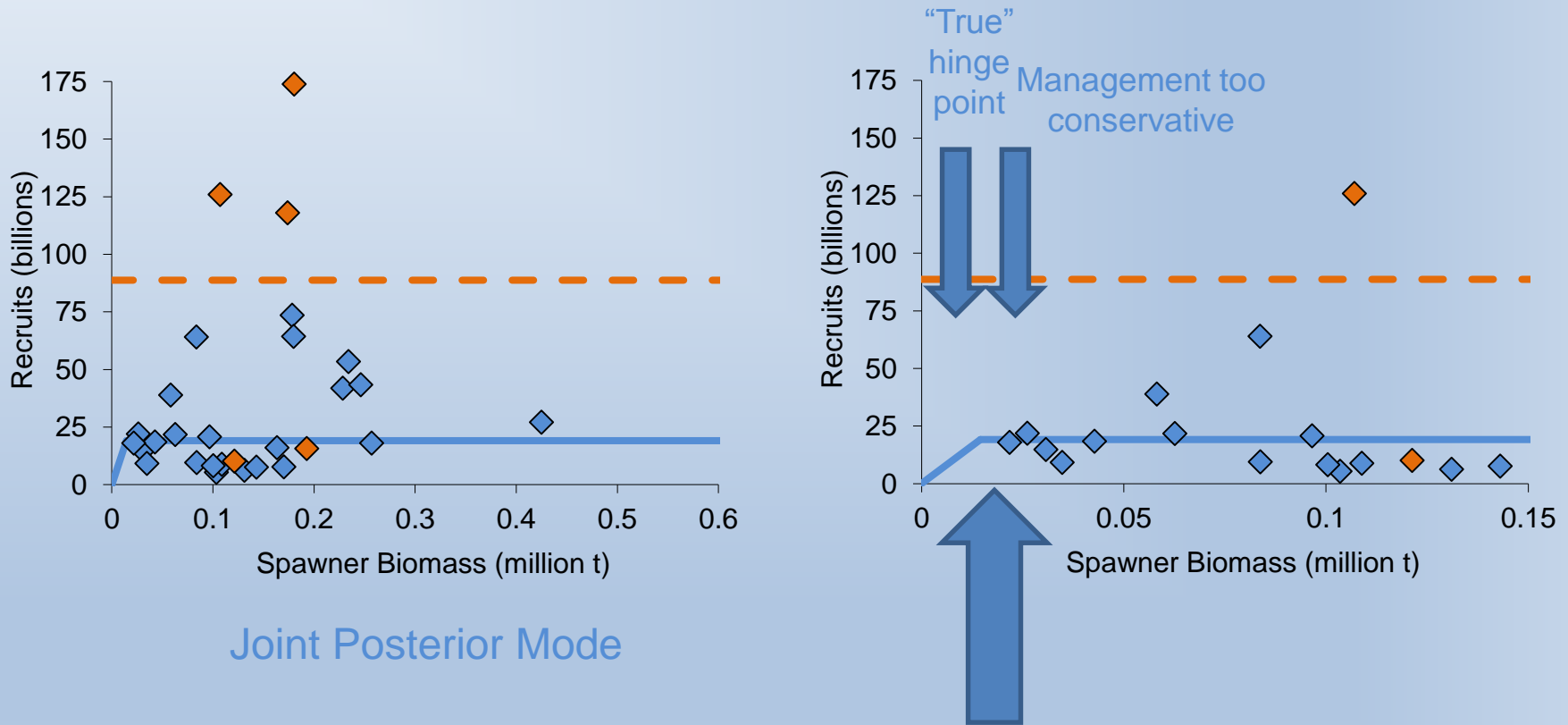
Of concern given poor recruitment to west component in recent decade if this is a “feeder” to both coasts

How Reliably is the Hockey Stick Hinge Point Estimated?



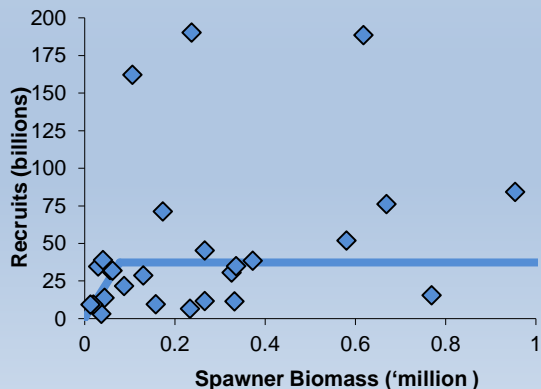
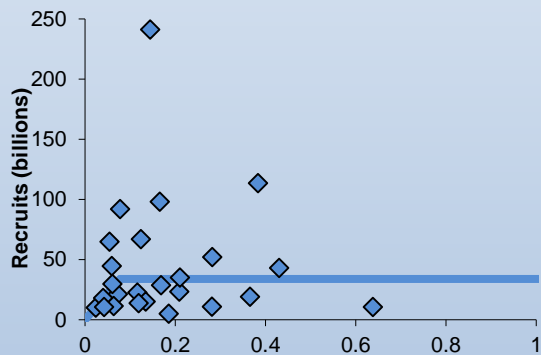
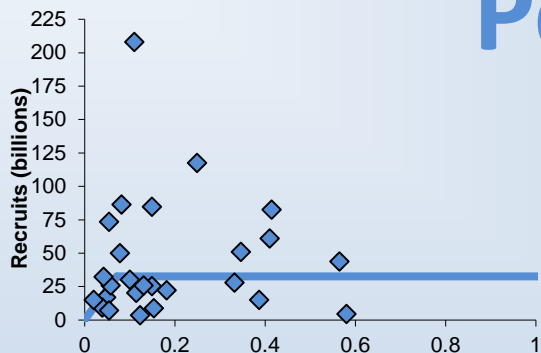
Is this hinge point precisely estimated?
Can we base management decisions on it?

How Reliably is the Hockey Stick Hinge Point Estimated?

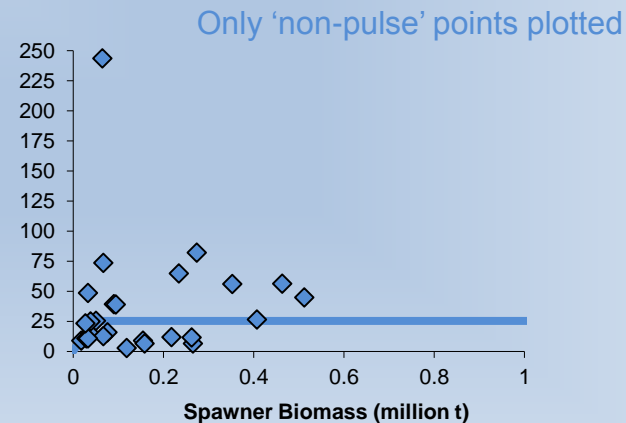
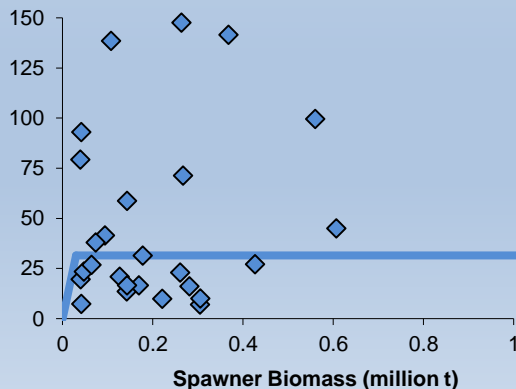
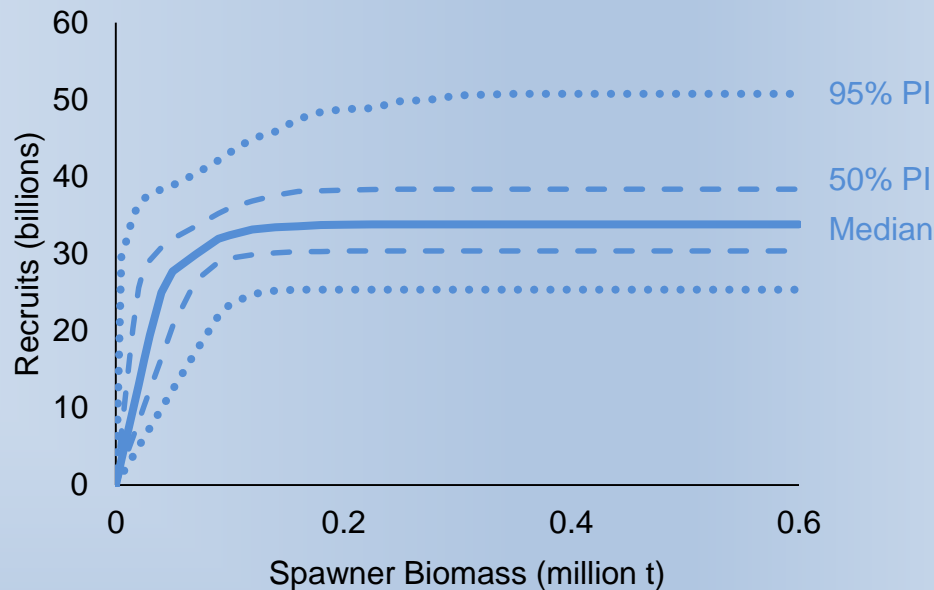


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How Reliably is the Hockey Stick Hinge Point Estimated?

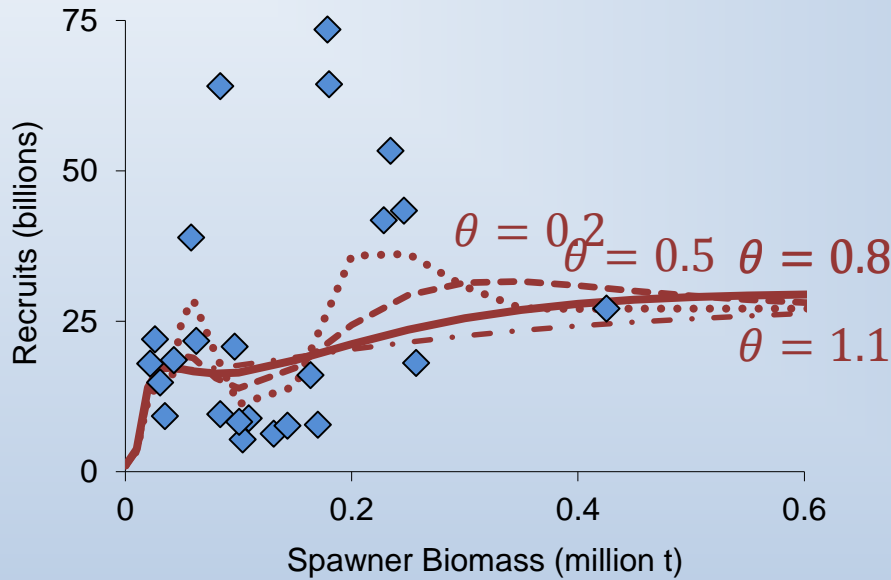


Individual Posterior Realisations



Let The Data Speak For Themselves!

Use of a Smoother



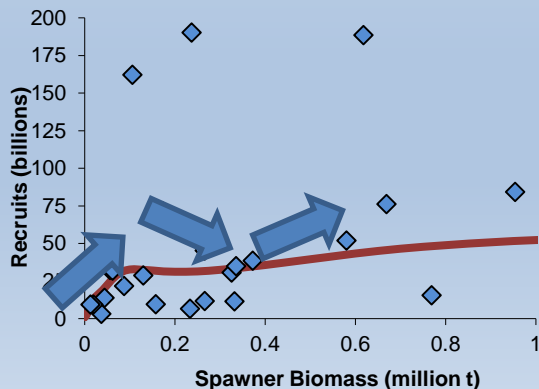
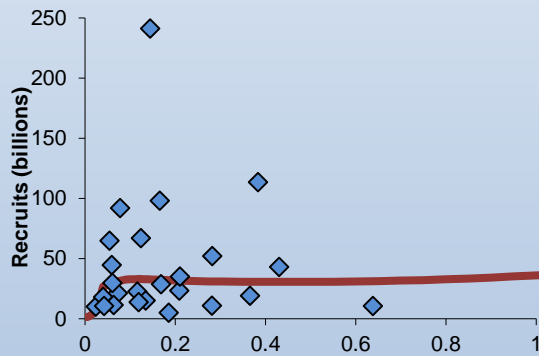
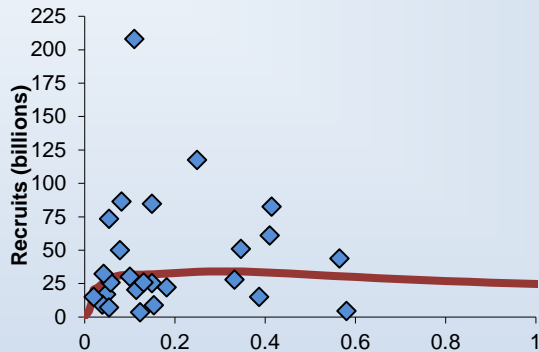
Gaussian kernel smoother
+
straight line from origin to lowest B_{sp}

Joint Posterior Mode

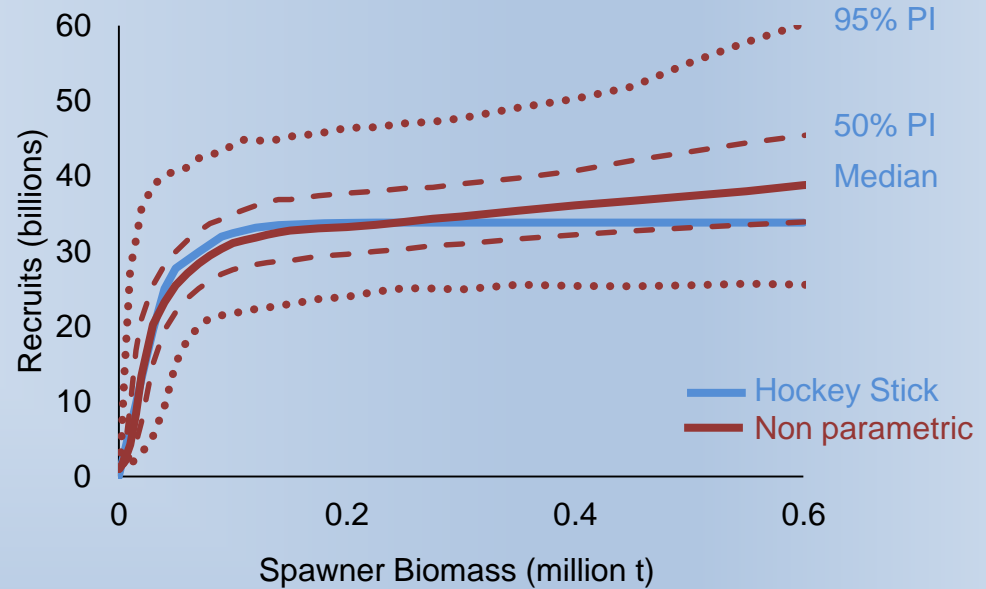
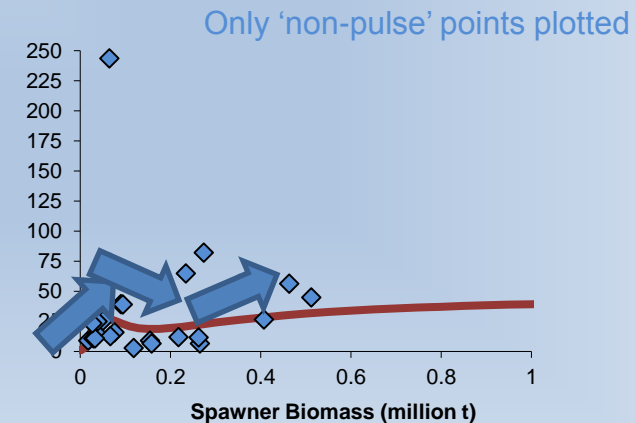
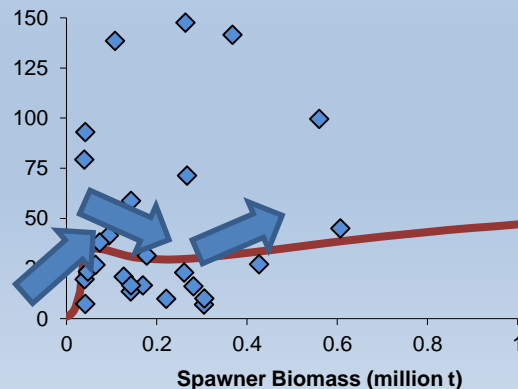
$$N_{SSB,j} = \exp \left[\frac{\sum_{y=1986}^{2014} \ln(N_{j,y}) \times \exp \left\{ \frac{-[\ln(SSB_{j,y}) - \ln(SSB)]^2}{\theta^2} \right\}}{\sum_{y=1986}^{2014} \exp \left\{ \frac{-[\ln(SSB_{j,y}) - \ln(SSB)]^2}{\theta^2} \right\}} \right]$$

Let The Data Speak For Themselves!

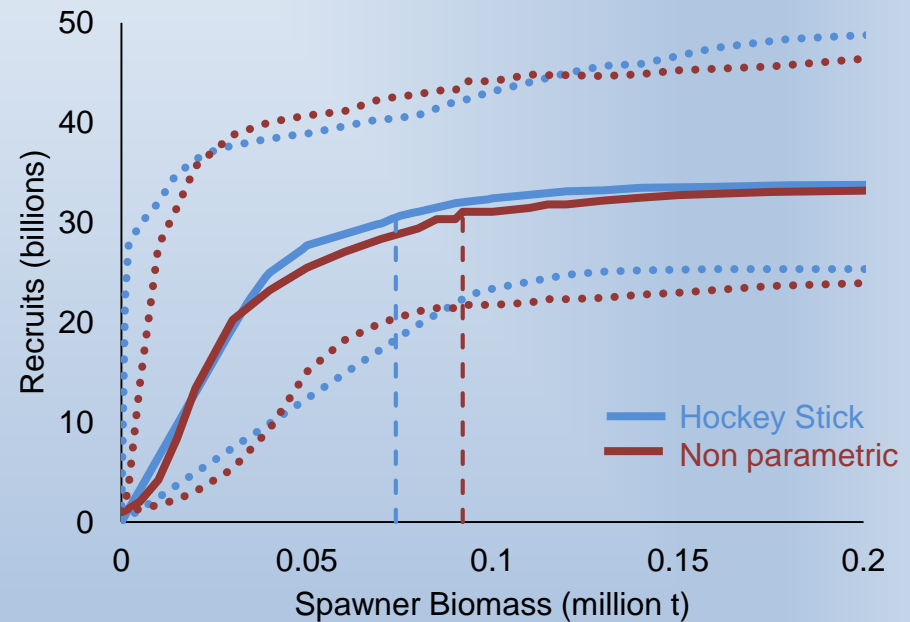
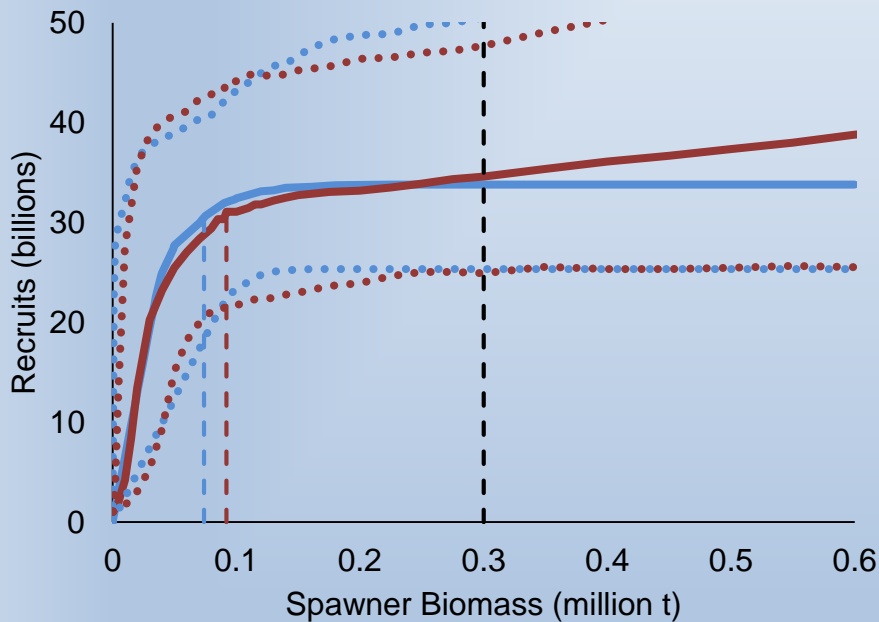
Use of a Smoother



Individual Posterior Realisations



How Reliably is the Hockey Stick Hinge Point Estimated?



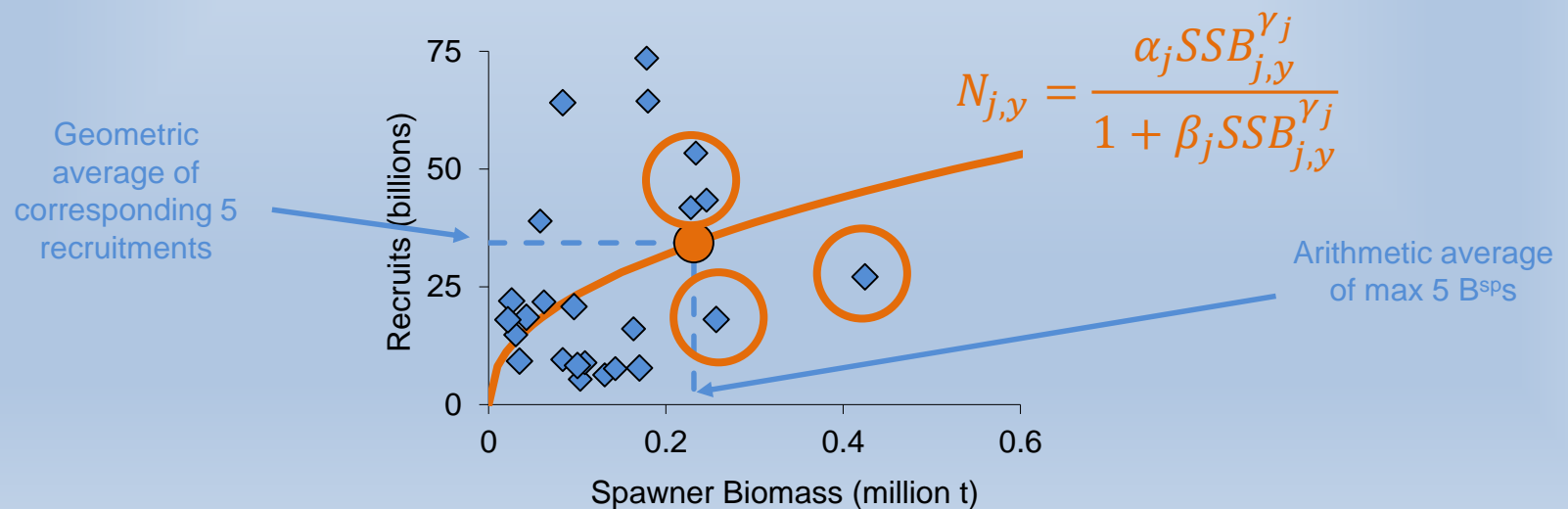
B^{sp} at which $R = 0.9 \times R_{B^{sp}=0.3}$:

~74 000t for Hockey Stick

~92 000t for non Parametric Smoother

Alternatives?

- Other alternatives
 - Quadratic Hockey Stick (Barrowman and Myers 2000)
 - Shape Constrained Additive Models (Pya and Wood 2015)
 - ‘Generalised’ parametric



Summary

Letting the “data” speak for themselves...

Did we succeed?

Was it worth it?

Yes!

We've confirmed the hinge point is reliably estimated and can be used for key management-related decisions

and

No!

Non parametric relationship not used in Operating Model
Returned to original Hockey Stick relationship!

Letting the “data” speak for themselves

The use of stock-recruit relationships to determine a biomass threshold above which management should aim to keep a resource



Thank you for your attention



With thanks to National Research Foundation for financial assistance