An overview of the key issues to be discussed relating to the South African sardine two-mixing-stock hypothesis

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Outline

• Fishery and Data
• Stock Structure Hypotheses
• Sardine Two Stock Assessment Model Fits
• Considering the Parasite Data
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Small Pelagic Fishery: primarily sardine and anchovy, also round herring, chub mackerel and juvenile horse mackerel
Data

• Two annual hydro-acoustic surveys
  - November total biomass; split at Cape Agulhas
  - May recruitment; split at Cape Infanta
Hydro-acoustic Surveys

Provided by Janet Coetzee
Hydro-acoustic Surveys

Total Area

West Coast

South Coast
Distributional Shift

Provided by Janet Coetzee
Data

• Two annual hydro-acoustic surveys
  - November total biomass; split at Cape Agulhas
  - May recruitment; split at Cape Infanta
• Limited ageing information – excluded from current assessment
• Proportion at length data
  - Commercial catches (quarterly)
  - November survey
• Parasite prevalence at length data *NEW*
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Stock Structure Hypotheses

• Single sardine stock
  - used historically
  - previous & current OMPs were developed using a single stock operating model

• Two sardine stocks ("west" and "south") split at Cape Agulhas
  - a two stock model has been under development since 2009
  - a two mixing stock hypothesis produced an acceptable fit to the data in time for OMP-14 development, but future projections were heavily dependent on assumption of future stock mixing

• Current OMP includes some spatial management advice (i.e. based qualitatively not quantitatively on two stock hypothesis)
Key Model Structure/Assumptions

- Operating model conditioned over Nov 1983 – Nov 2014
- Quarterly time steps
- Catch-at-age taken in a pulse each quarter
- Maturity ogive that is time-dependent (4 time-periods) *NEW*
- Time-invariant juvenile and adult M
- Hockey stick S/R relationship
- Estimate commercial selectivity-at-length (parametric form used which was informed by initial work with a non-parametric curve)
- Survey trawl selectivity-at-length logistic for small lengths
- Survey biomass is associated with 0+ biomass *NEW*
- Weight-at-length relationship, adjusted annually based on average survey weight *NEW*
Key Model Structure/Assumptions

• Two sardine stocks: key assumptions
  - mixing: “west” stock recruits move to “south” stock (estimated annually - no assumed relationship)
  - mixing: no “south” recruits move to “west” stock
  - mixing: no adult movement
  - 0+ biomass west/east of Cape Agulhas is from the “west” / “south” stock
  - recruitment west/east of Cape Infanta is from to the “west” / “south” stock
  - same $M_{juv}$ and $M_{adult}$ for both stocks
  - allowance for difference in May survey bias east/west of Cape Infanta (proportion of recruits surveyed east of Cape Infanta $\leq$ that surveyed west of Cape Agulhas (winter spawning))
  - allowance for difference in weights and growth by stock
  - $S/R$ curve parameters estimated separately for each stock
Key Model Structure/Assumptions

• Two sardine stocks: key assumptions
  - mixing: “west” stock recruits move to “south” stock (estimated annually - no assumed relationship)
  - mixing: no “south” recruits move to “west” stock
  - mixing: no adult movement a lower proportion of 2+ sardine move
  - 0+ biomass west/east of Cape Agulhas is from the “west” / “south” stock
  - recruitment west/east of Cape Infanta is from to the “west” / “south” stock
  - same $M_{juv}$ and $M_{adult}$ for both stocks
  - allowance for difference in May survey bias east/west of Cape Infanta (proportion of recruits surveyed east of Cape Infanta ≤ that surveyed west of Cape Agulhas (winter spawning))
  - allowance for difference in weights and growth by stock
  - S/R curve parameters estimated separately for each stock
  - age- and time-invariant annual infection of “west” stock sardine
Outline

• Fishery and Data
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• Sardine Two Stock Assessment Model Fits – INITIAL RESULTS
• Considering the Parasite Data
## Four Alternative Initial Assumptions

<table>
<thead>
<tr>
<th>Model</th>
<th>Annual Proportion of West Stock Infected</th>
<th>Age-1 fish move</th>
<th>Age 2-5+ fish move</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>20%</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>b)</td>
<td>40%</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>c)</td>
<td>20%</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>d)</td>
<td>40%</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Model Fits – Nov Biomass

[Graph showing biomass trends over years in West and South regions, with lines for different age classes and error bars indicating variability.]
Model Fits – May Recruitment

- Note difference in y-axis
- No south coast survey estimates for early part of time series
Model Fits – Stock Recruitment

- Note difference in y-axis; but west stock maximum recruitment lower than previous model
- West stock $\sigma_R$ larger than previous model

- Similar plots for alternative models
Increase in “south” stock biomass primarily a result of movement from “west” stock rather than “south” stock productivity

Proportion of 2+ sardine moving is ~25% of age-1 sardine
Increase in “south” stock biomass primarily a result of movement from “west” stock rather than “south” stock productivity

Proportion of 2+ sardine moving is ~25% of age-1 sardine
Model Fits – Survey Prop at Length

Average predicted is much closer to average observed than previous model.

South coast winter spawning?
Model Fits – Commercial Prop at Length

West

Length Class (cm)

South

Length Class (cm)

Commercial Selectivity

length (cm)

West

Commercial Selectivity

length (cm)

South
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Comparison of Model Predicted Parasite Prevalence With Observations

West: 2010

South: 2010

West: 2011

South: 2011
Comparison of Model Predicted Parasite Prevalence With Observations

West: 2012

South: 2012

West: 2013

South: 2013
Comparison of Model Predicted Parasite Prevalence With Observations

West: 2014

South: 2014
Some Discussion Points

Comment on the ongoing development of the two mixing stock hypothesis, and the use of parasite data as a ‘biological tag’:

• The revised model structure
• Fitting the model to parasite prevalence data (and/or parasite intensity data)
• Assuming a time- and age-invariant infection rate
• Estimating annual age-1 movement proportions, with ages 2+ a time-invariant proportion of those estimates
• Modelling two south stock co-horts (1 Nov, 1 May) to account for winter spawning
• The chosen stock-recruitment relationship
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Thank you for your attention