Consequences of environmentally driven uncertainty in productivity for management of North Pacific Albacore tuna

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With thanks to Barbara Muhling, Steve Teo, and Gerard DiNardo, and the ISC ALBWG

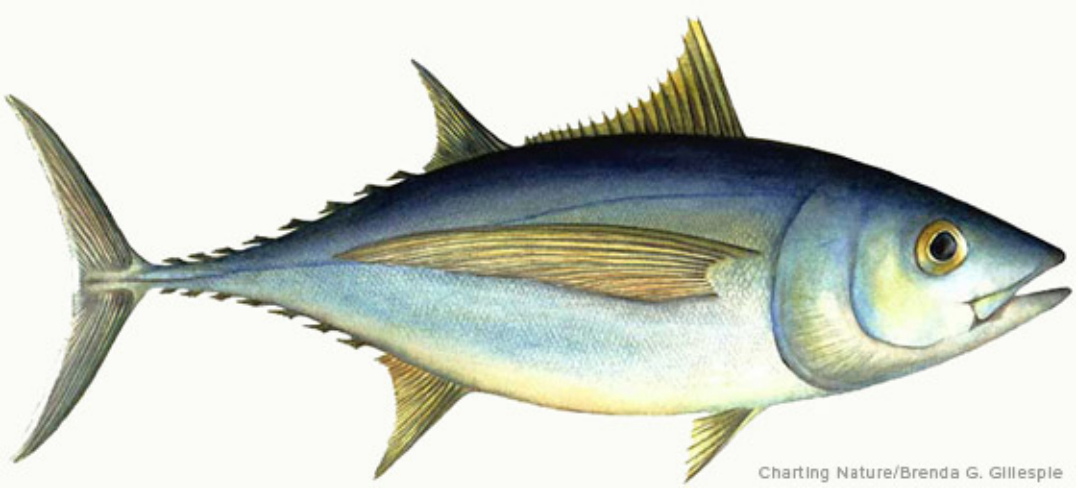
Outline

1. North Pacific Albacore MSE framework
2. Albacore life history
3. Albacore growth and climate
4. Future work

Management Strategy Evaluation (MSE)

"Use of simulation to evaluate the trade-offs achieved by alternative management strategies and to assess the consequences of uncertainty in achieving management goals"

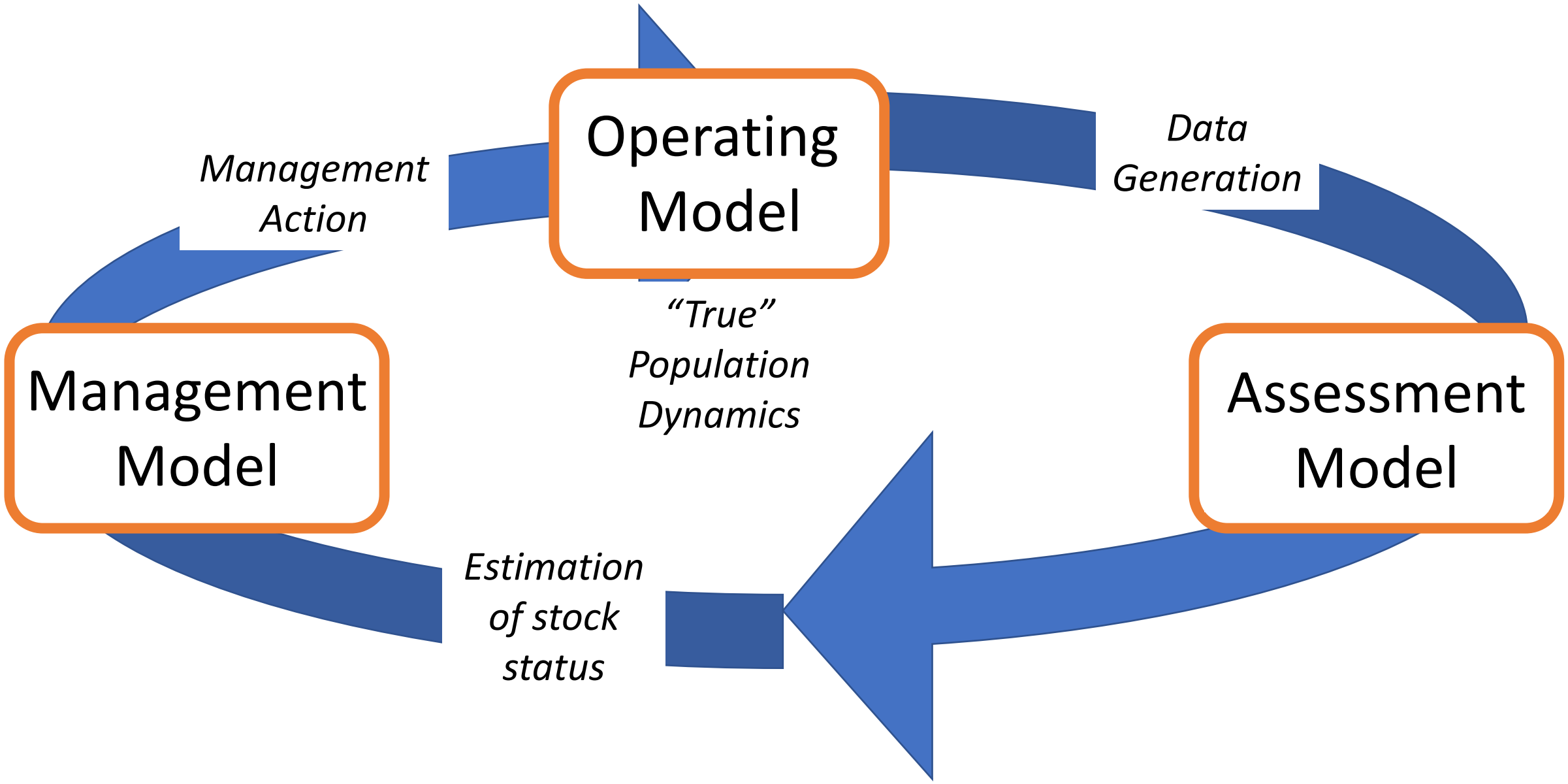
Punt et al. 2016, Fish and Fisheries



North Pacific Albacore MSE

- Examine performance of candidate alternative management strategies and target reference points for North Pacific albacore given uncertainty
- International effort involving the Albacore Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)

Albacore MSE Framework



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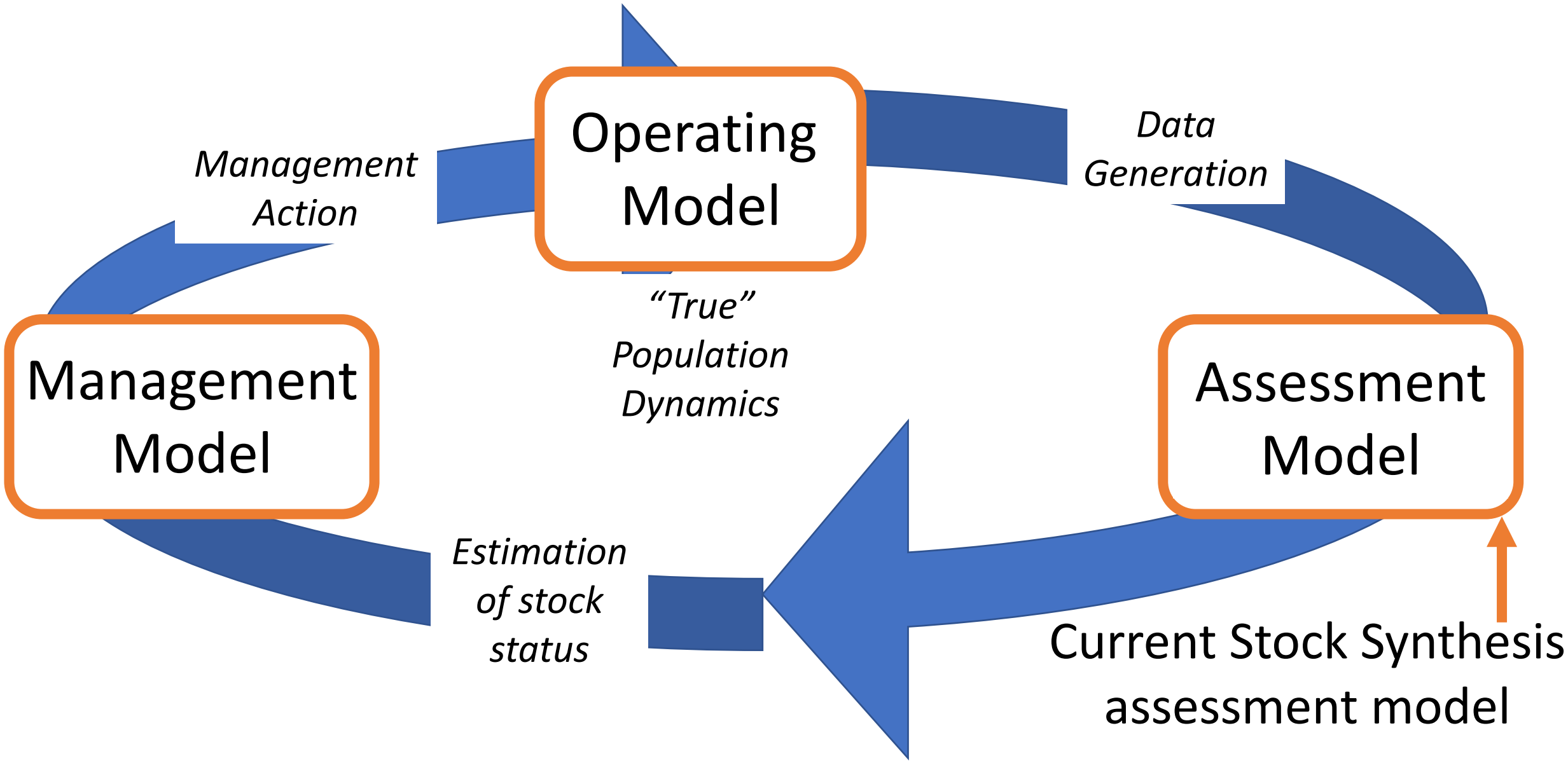
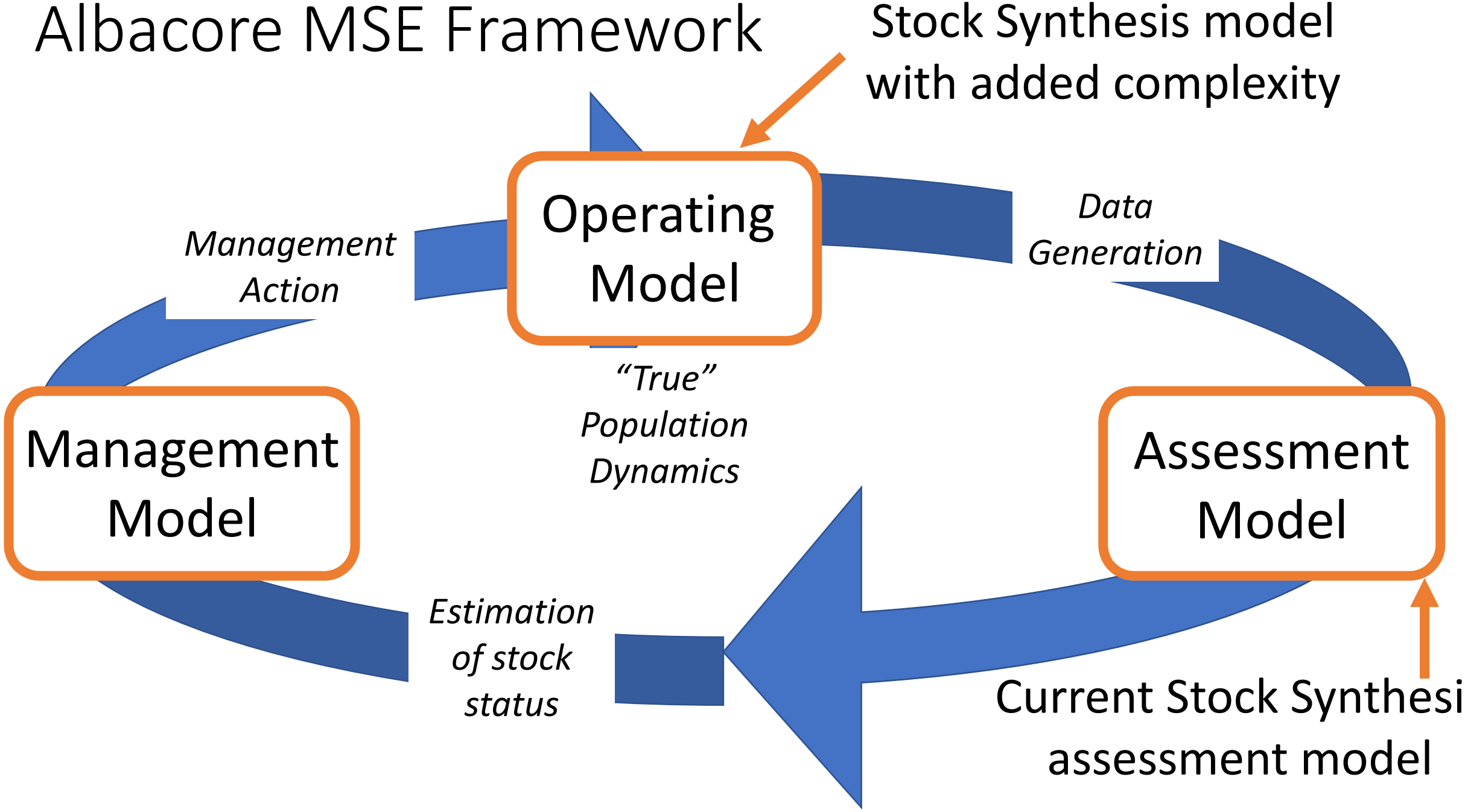


Albacore MSE Framework



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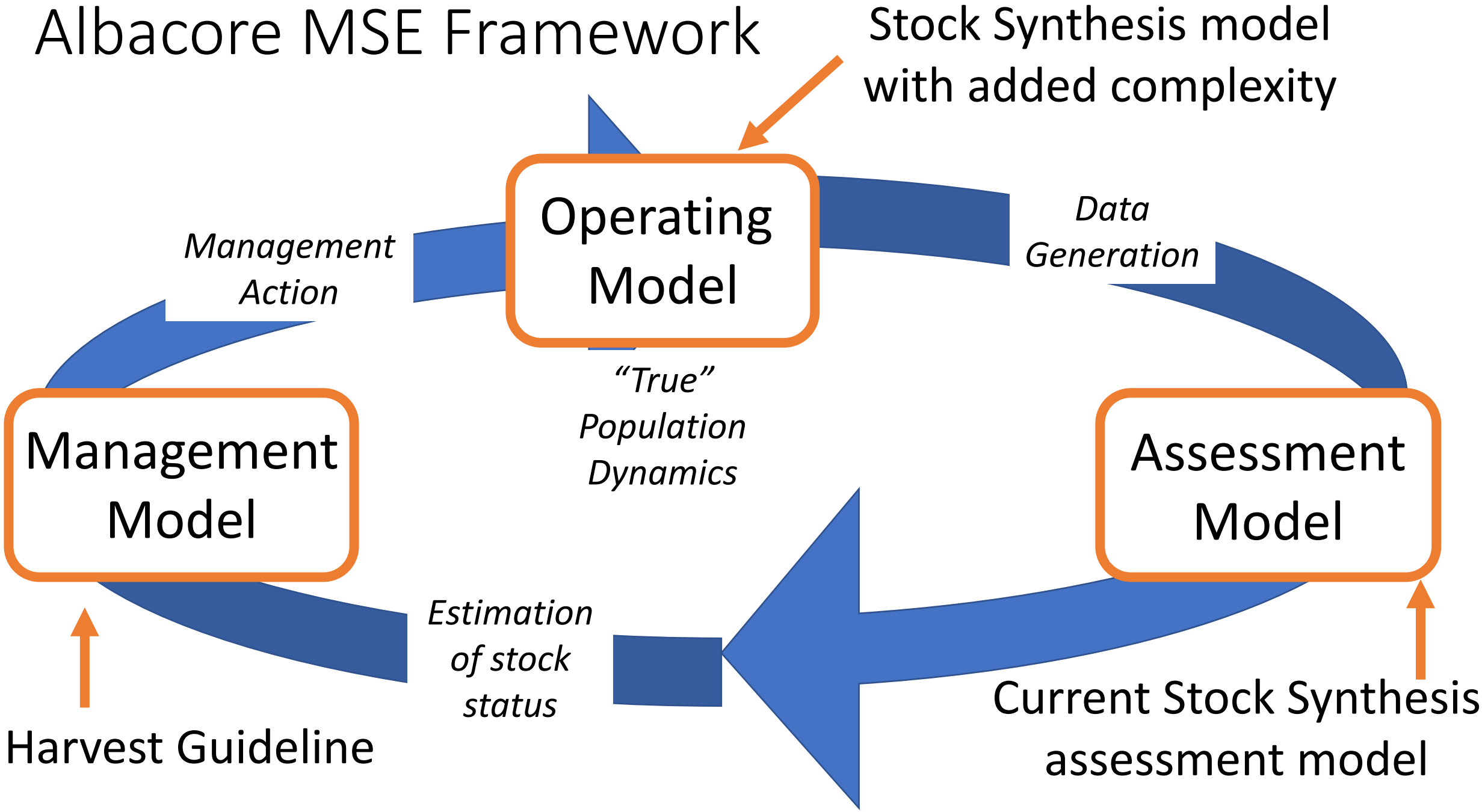
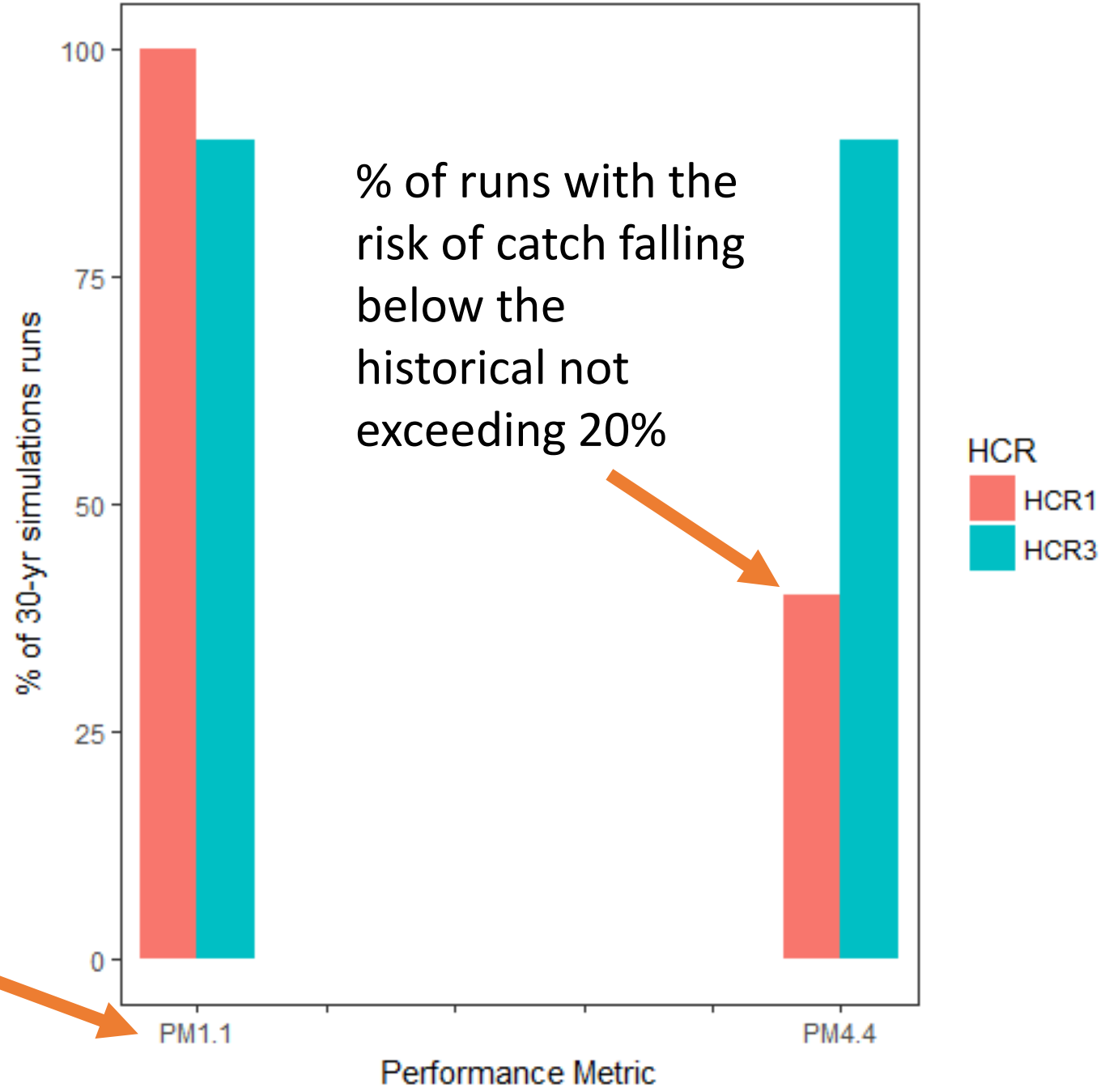
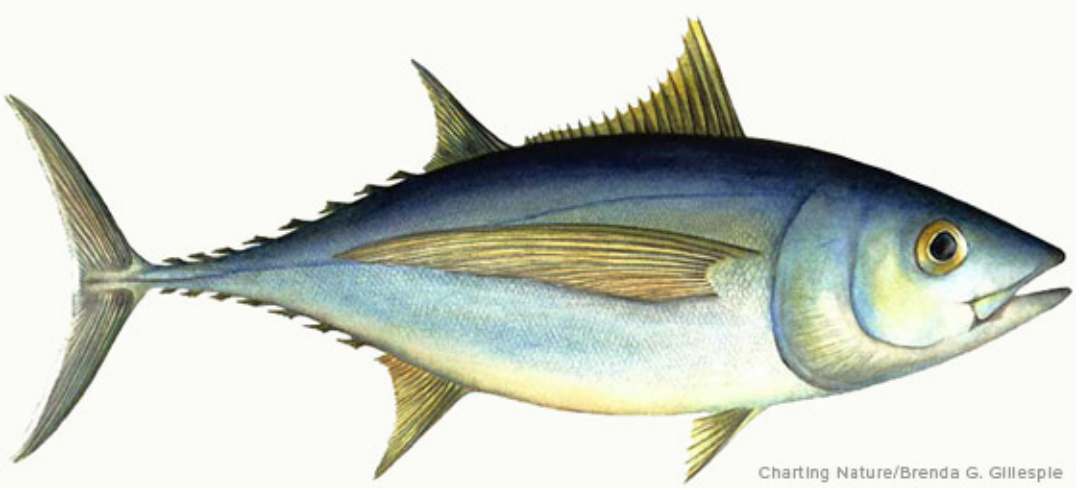


Assess performance metrics under different harvest guidelines

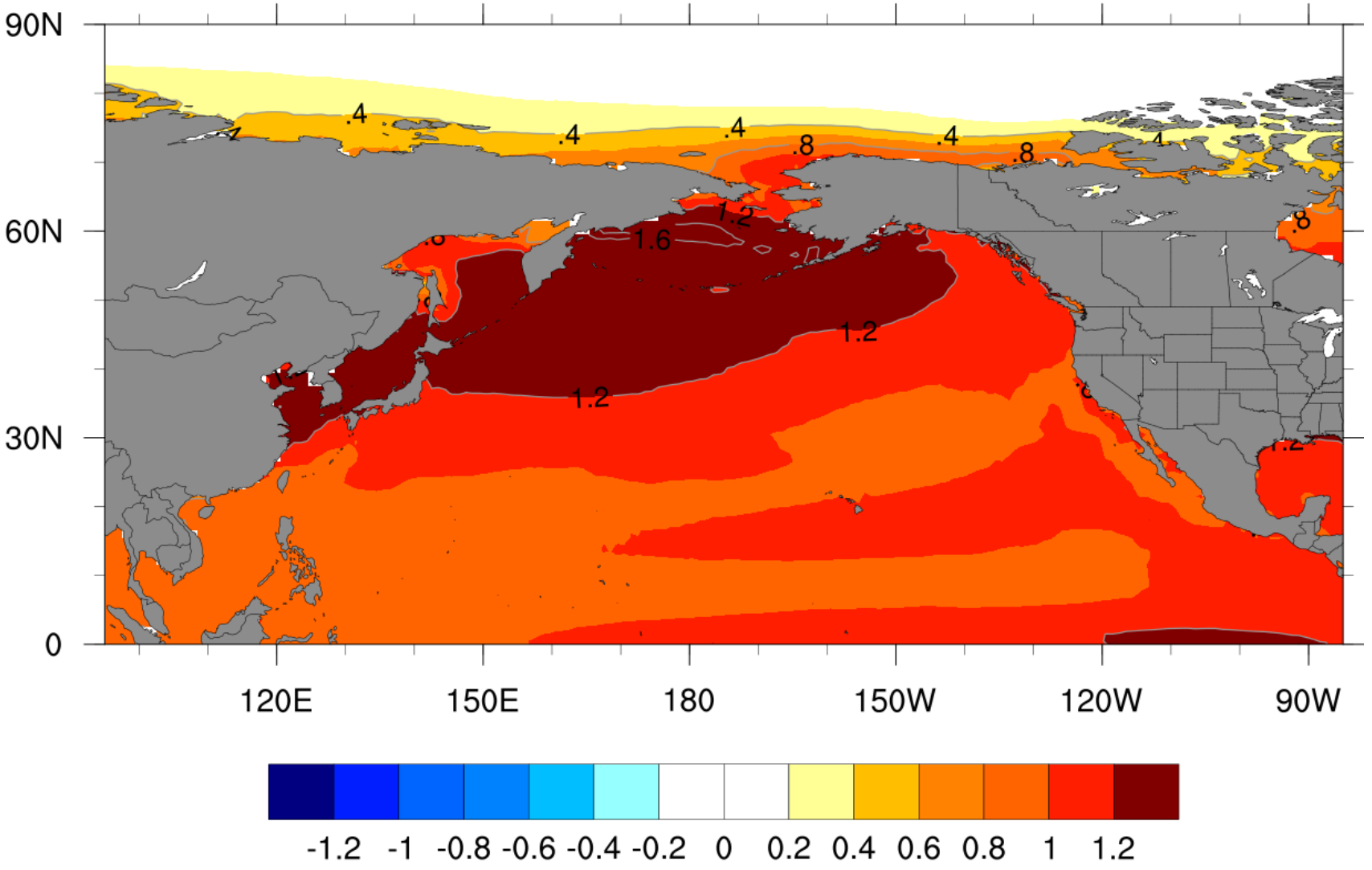




North Pacific Albacore MSE

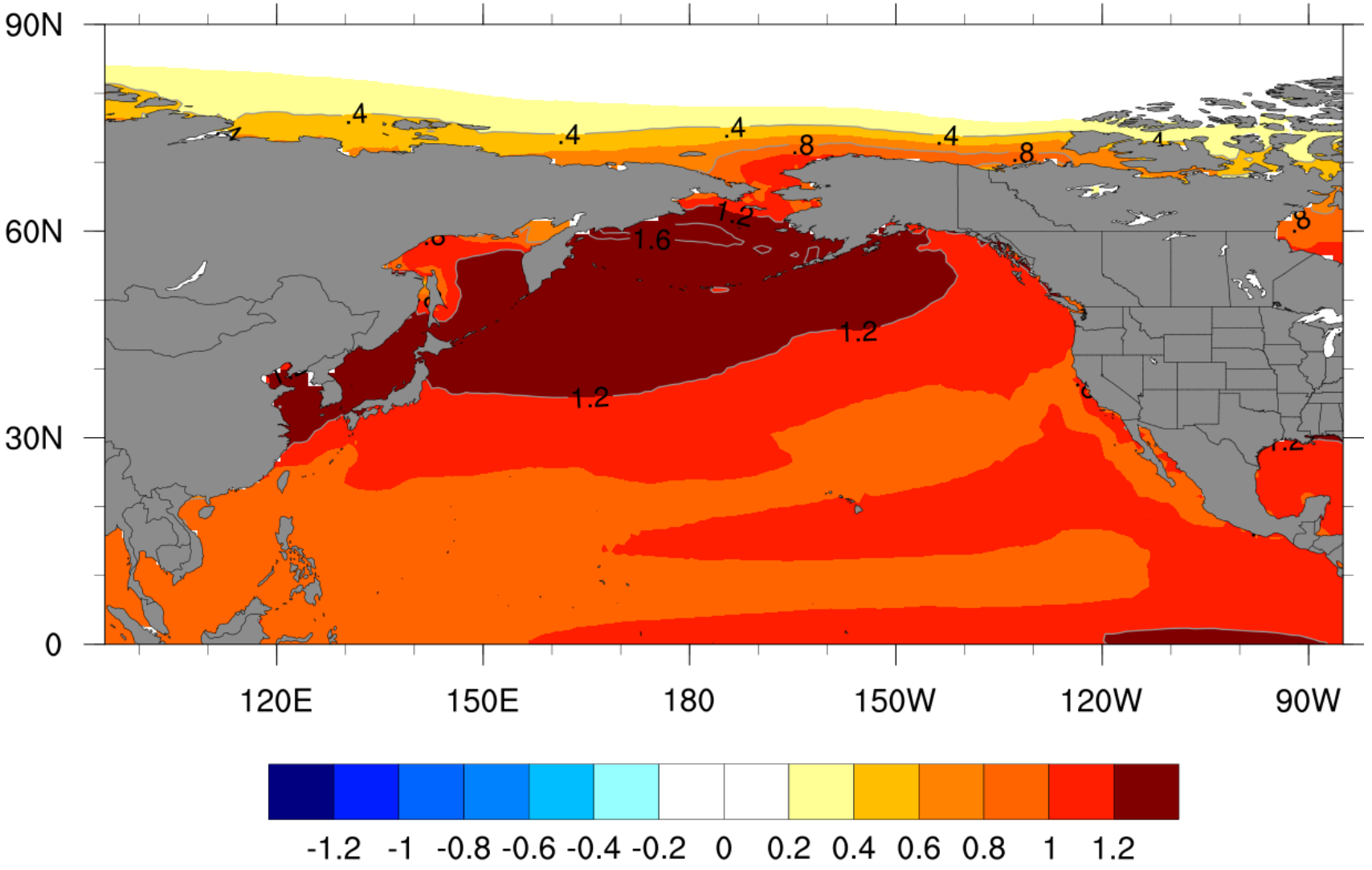
- Examine performance of candidate alternative management strategies and target reference points for North Pacific albacore given uncertainty
- Assess consequences of environmentally driven uncertainty in productivity (growth and recruitment) in achieving Albacore management goals
- Assess robustness of candidate management strategies in a changing climate

Projected Changes in North Pacific SST over the next 50 years



2006-2055 CMIP5 ensemble mean under RCP 8.5 – 1955-2005 historical average

Will albacore harvest strategies be robust to projected environmental change?



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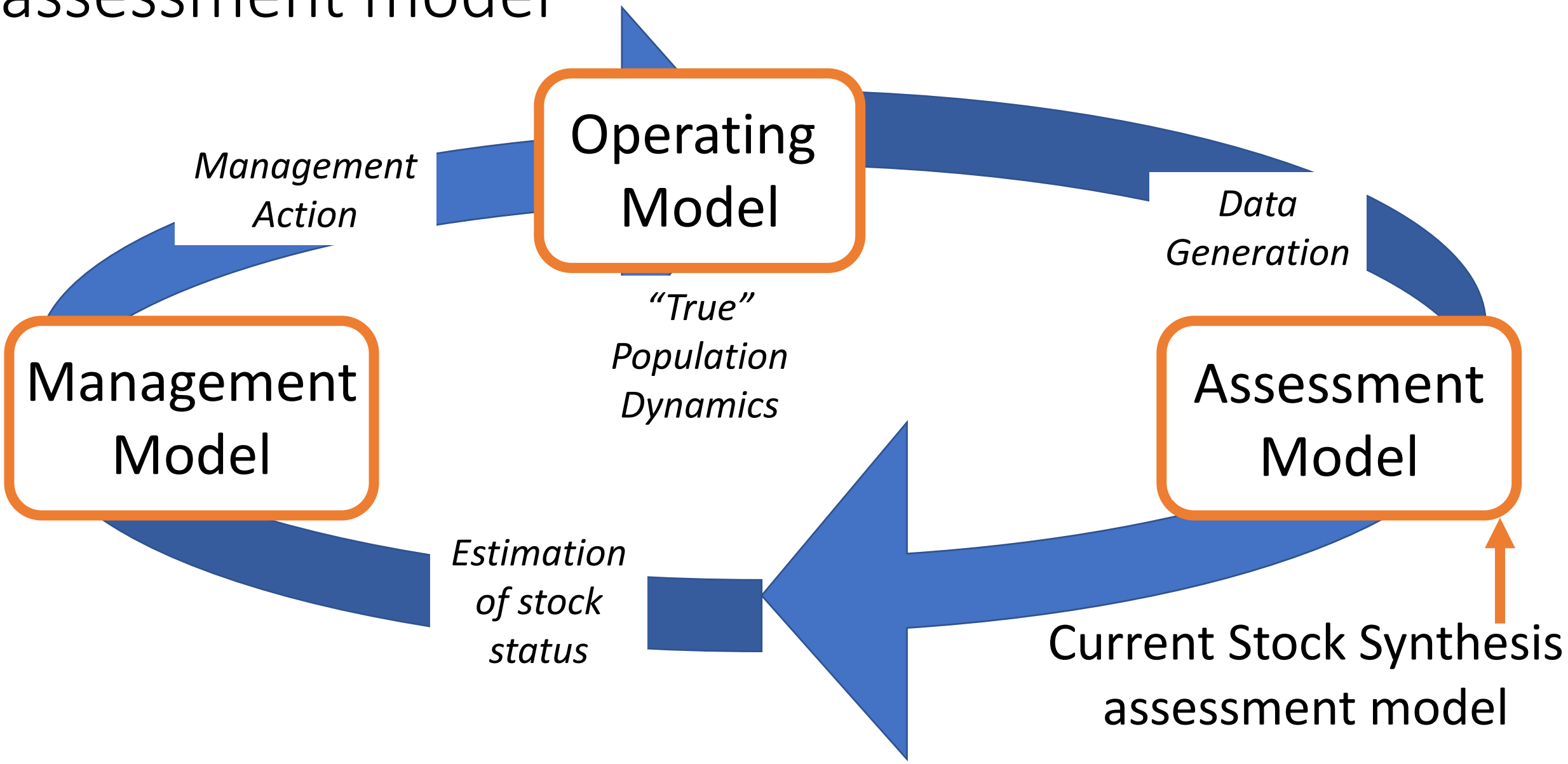
No environment in current assessment model



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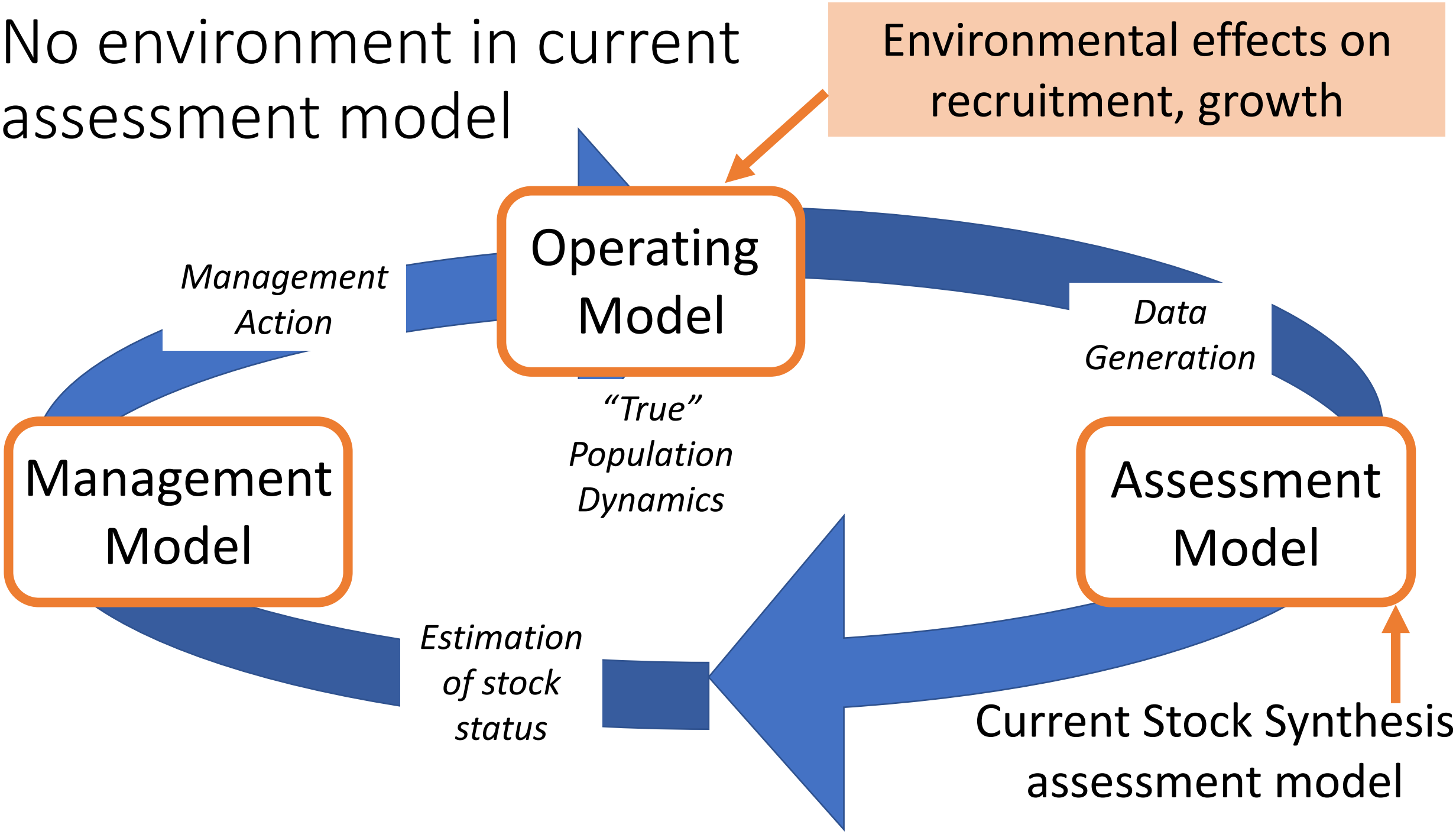
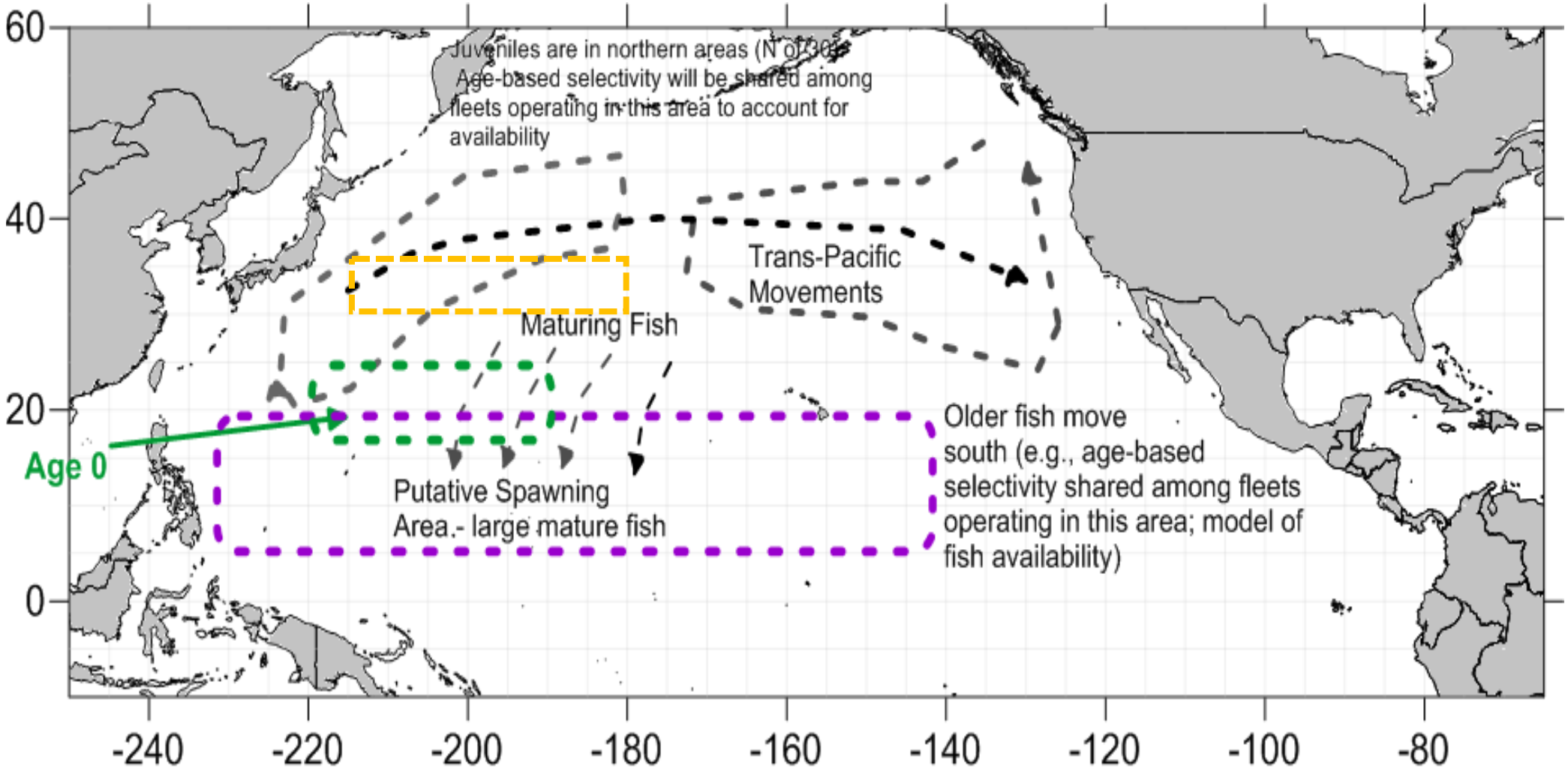
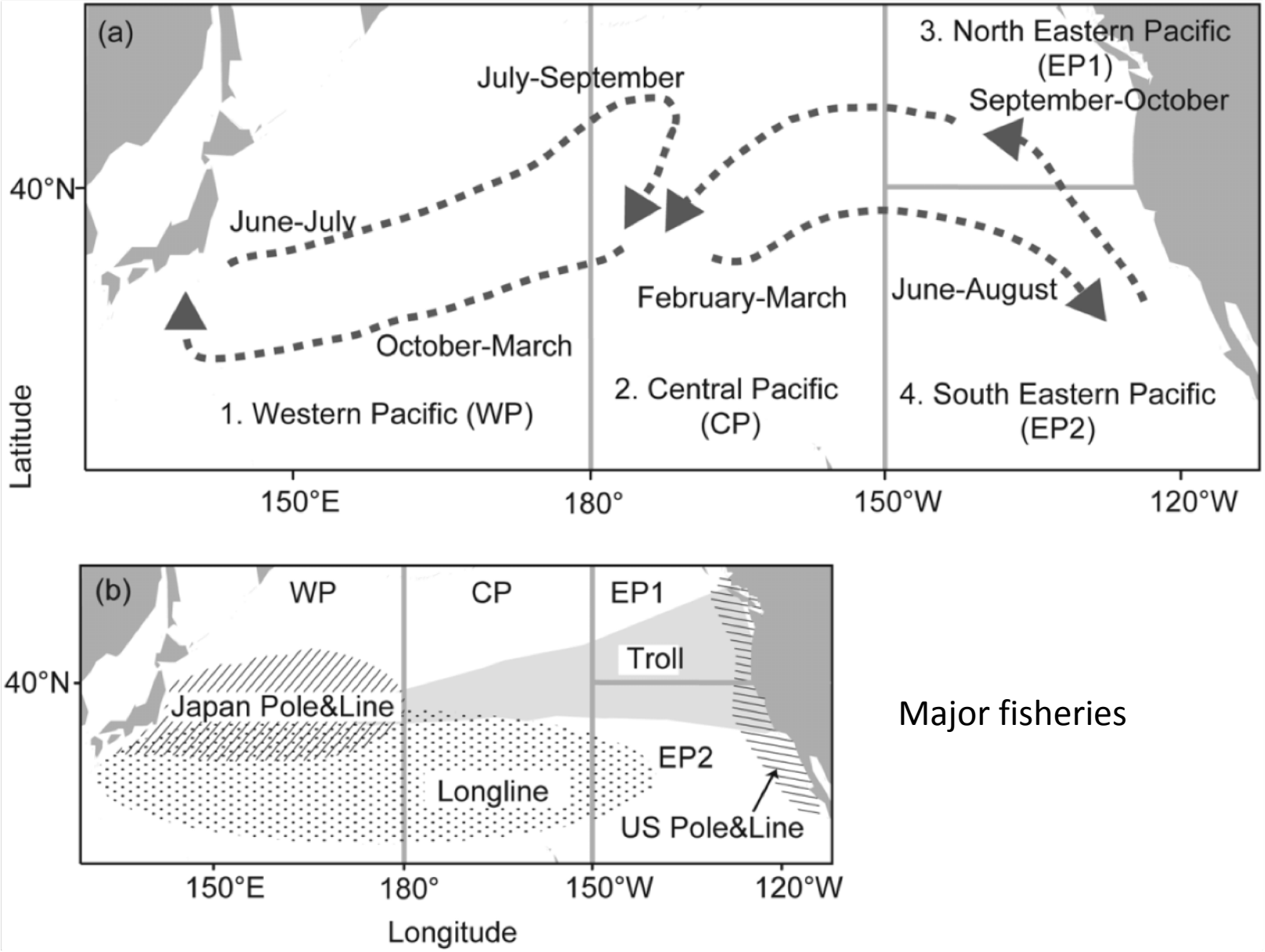


Albacore tuna life history



ISC 2016, ALBWG Meeting Report

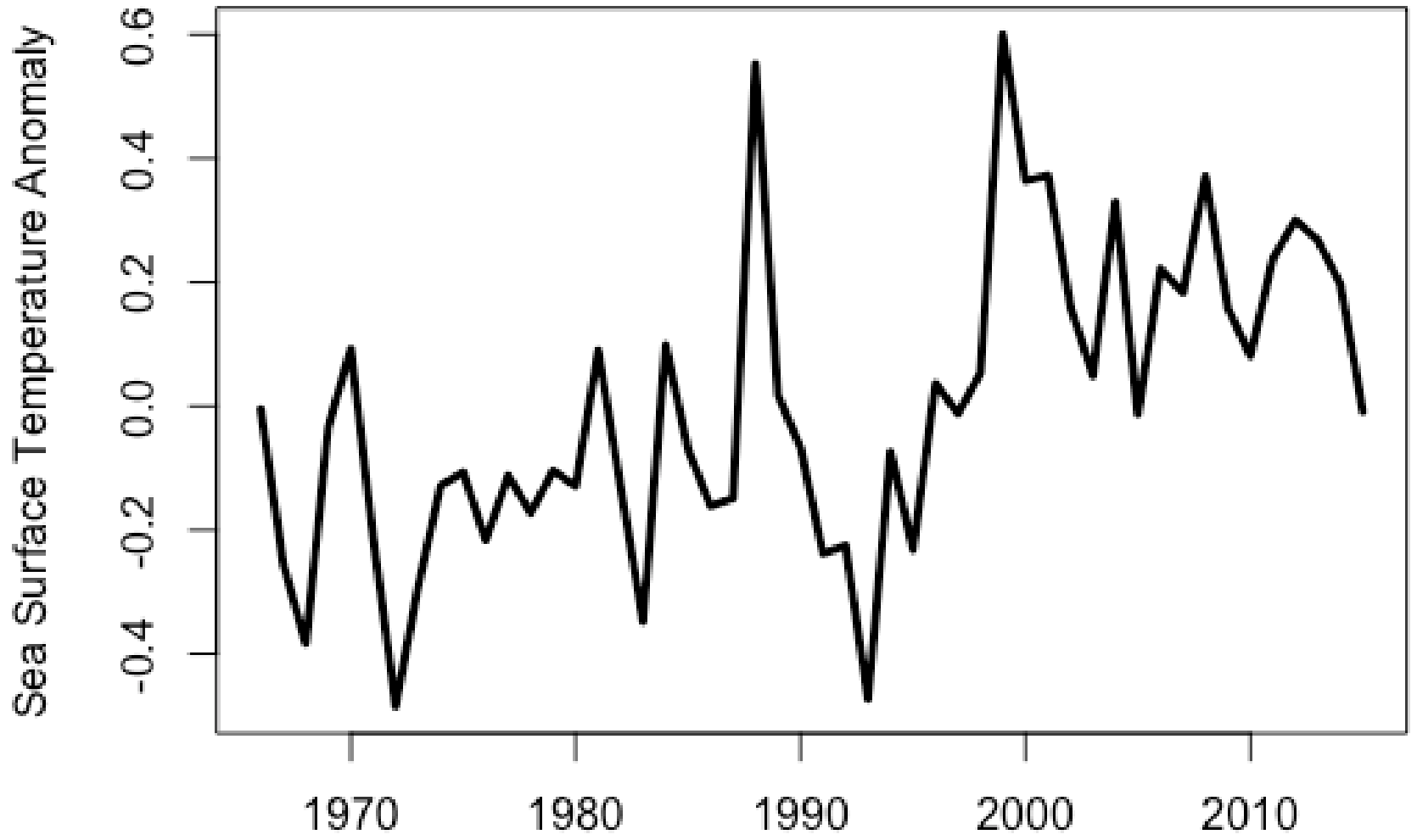
Albacore tuna life history



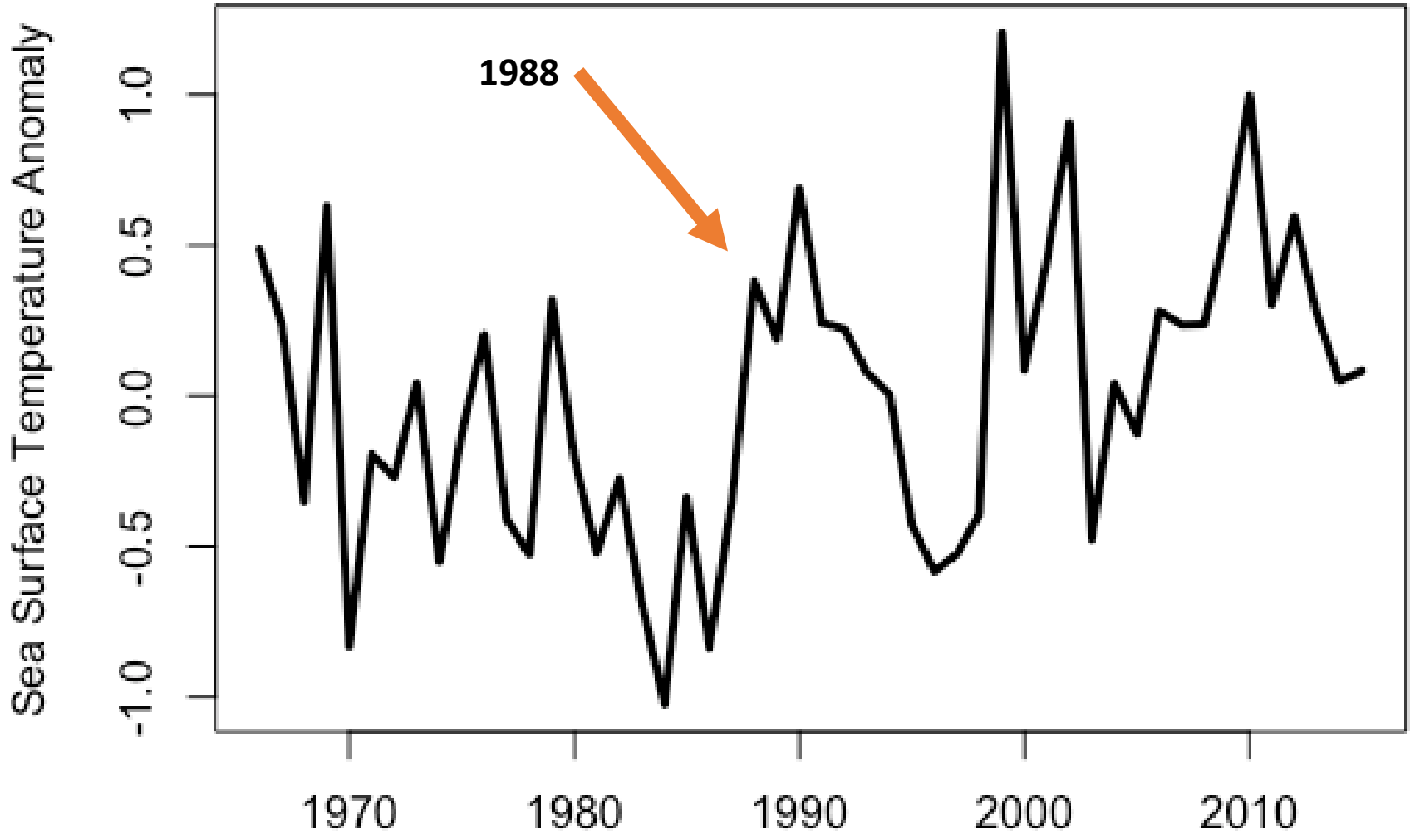
Major fisheries

Ichinokawa et al. 2008, Canadian Journal of Fisheries and Aquatic Sciences

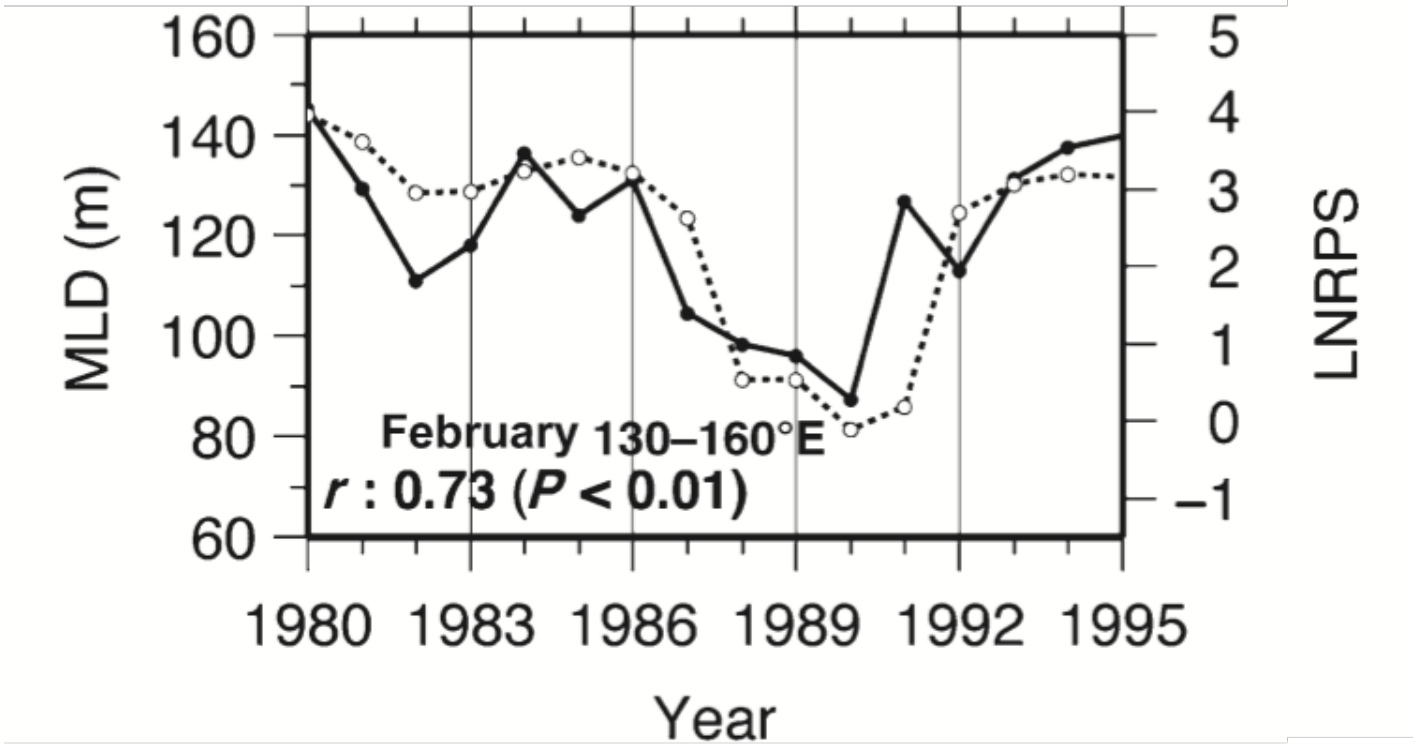
March SST in spawning region – 1966-2015



March SST in Kuroshio Extension and Southern Recirculation Area (KESA)– 1966-2015



Winter SST ↑ Mixed Layer Depth ↓ April Chlorophyll ↓ Sardine Survival



Nishikawa et al. 2008 and 2011, Fisheries Oceanography

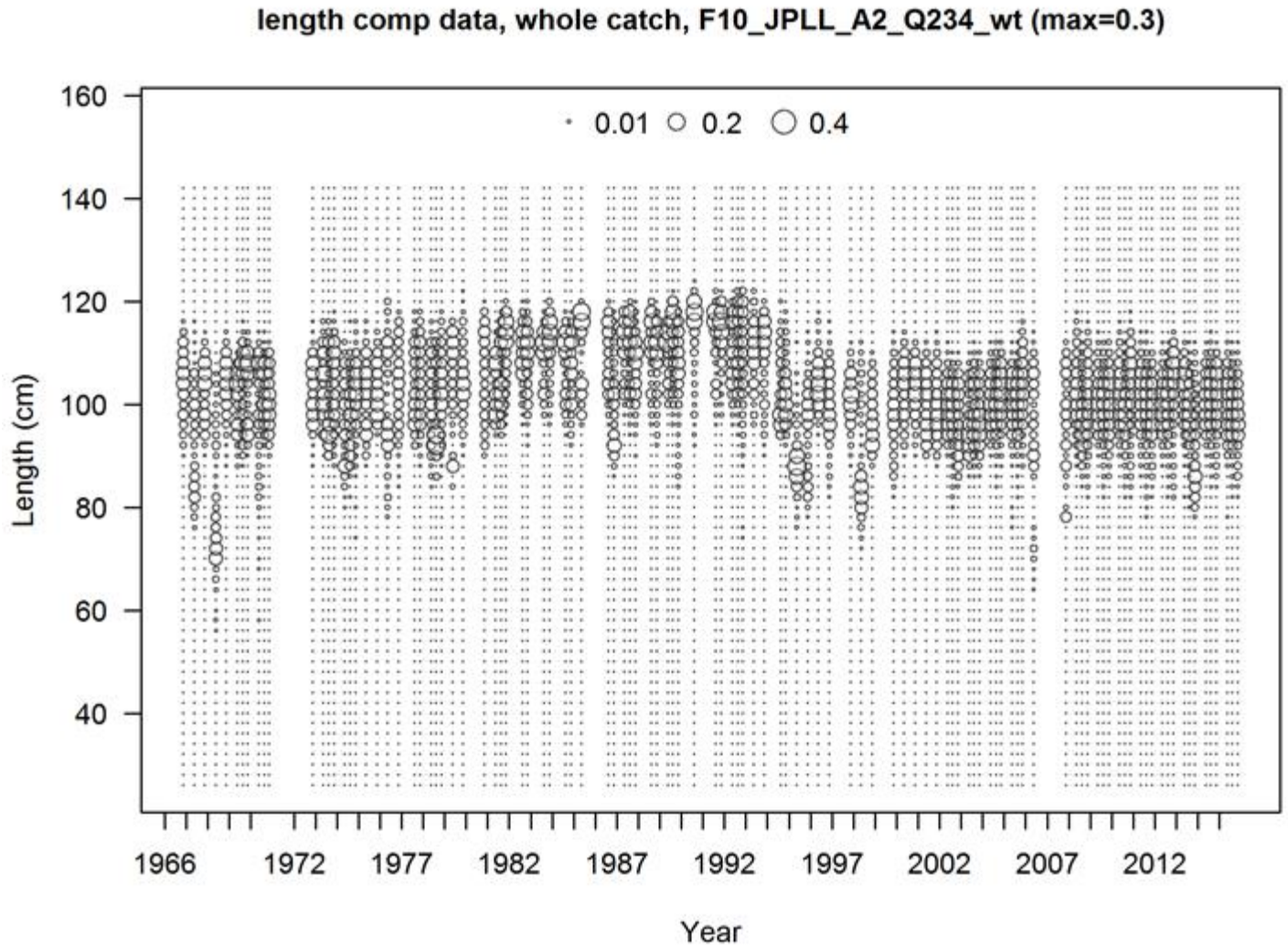
What were the effects on albacore of historical environmental change?

RECRUITMENT

- Barbara Muhling presentation at 12:05
- Similar approach used for albacore tuna
- SST, chlorophyll may be important drivers, stay tuned!

What were the effects on albacore of historical environmental change?

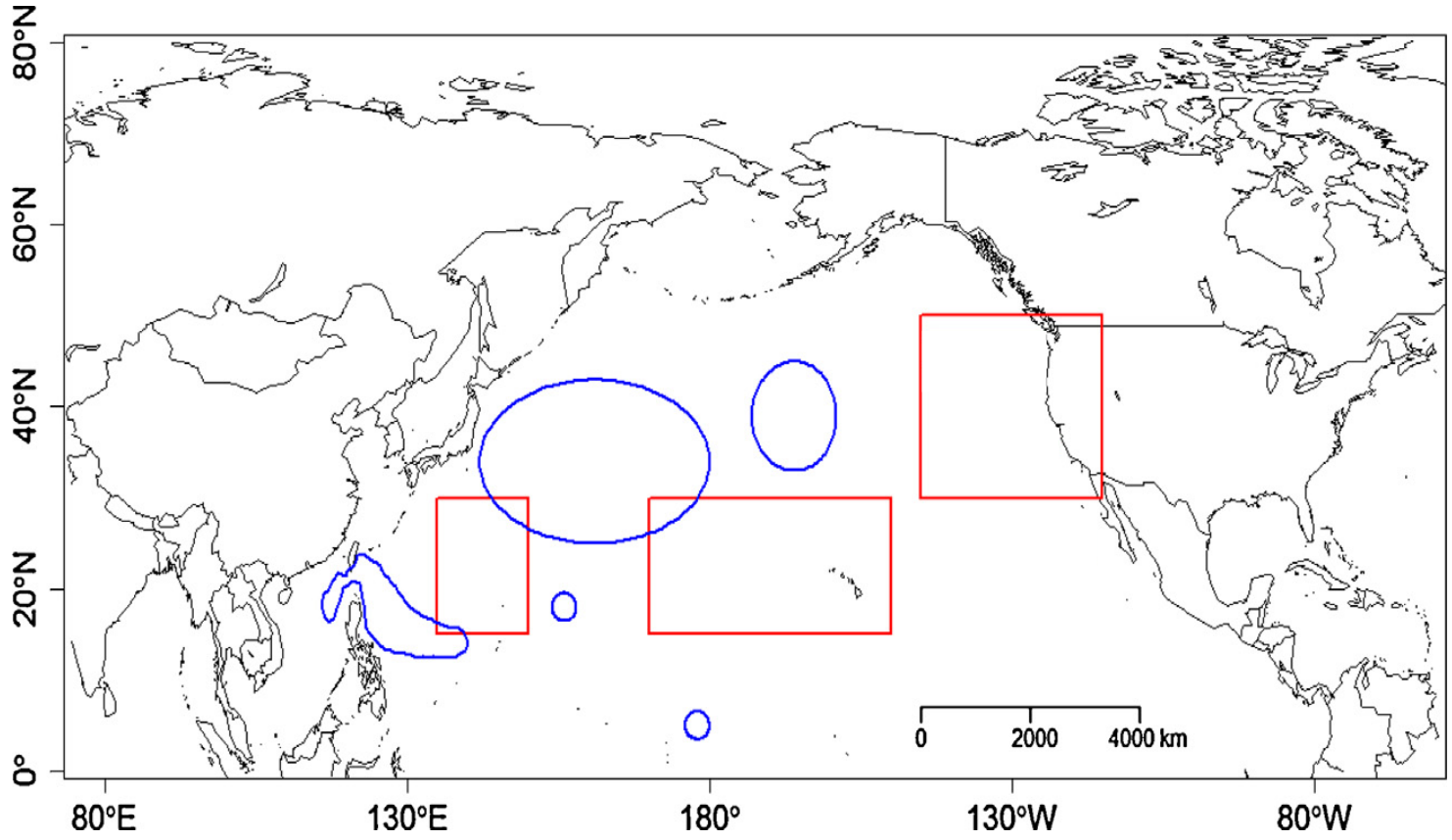
GROWTH



- Smaller fish post 1992
- Pre-1992 length composition data poorly fit by assessment model
- Current assessment model starts in 1993

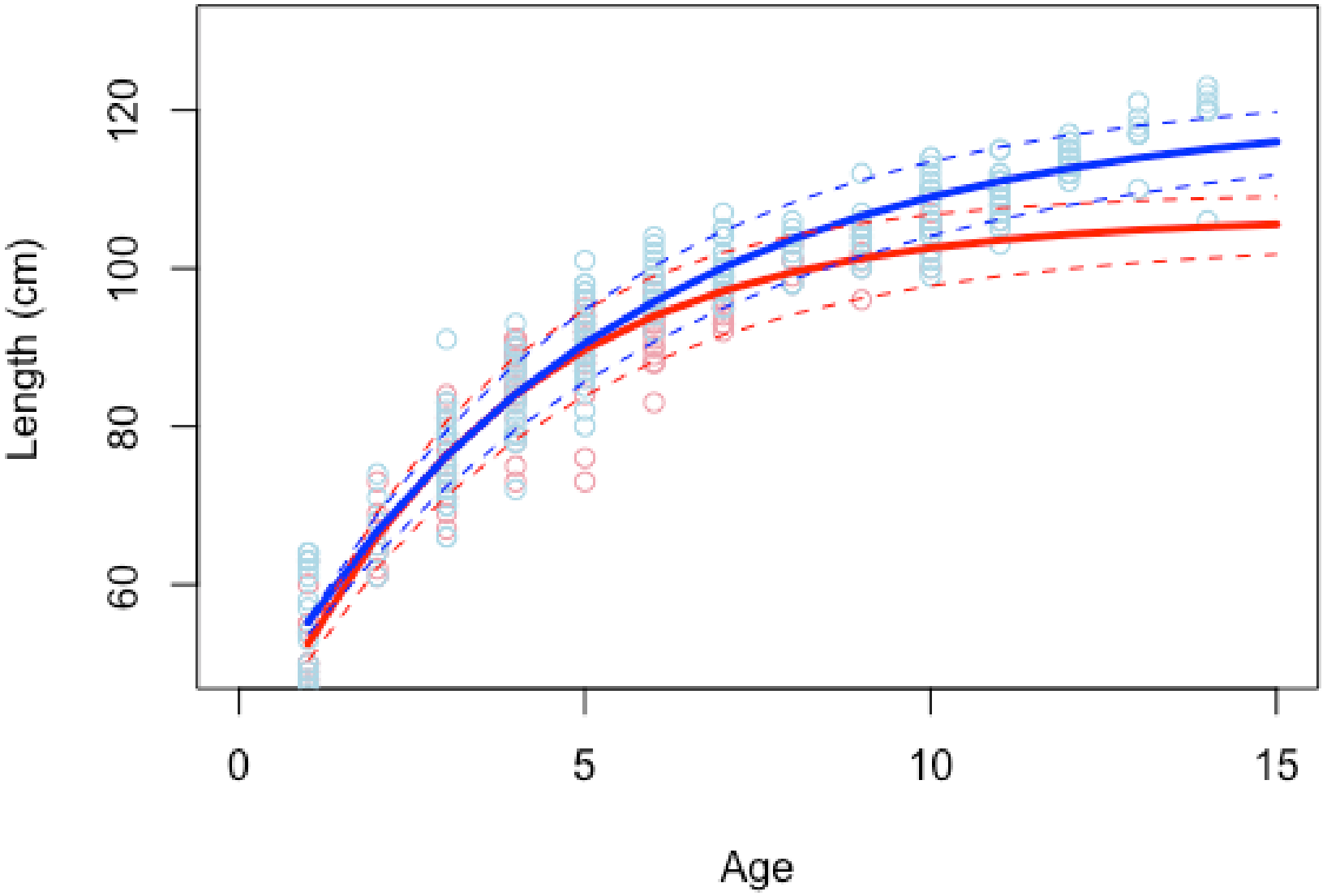
Current Growth Model

- Growth parameters don't vary through time
- Growth modelled by a von Bertalanffy growth function (VBGF)
- Growth parameters estimated externally to the assessment
- Length and age (estimated from otoliths) data was from Wells et al. 2013 (red, 1990-2012) and Chen et al. 2012 (blue, 2001-2008



Xu et al. 2015, Fisheries Research

Current Growth Model



male
female

$$L_a = L_{inf}(1-e^{-K(a-ao)})$$

L_a = length at age
L_{inf} = asymptotic fork length
K = growth coefficient
a = age
a_o = age at length 0

Approach

- Used Schnute (1981) reparametrization of VBGF to avoid correlation between parameters K and L_{inf}

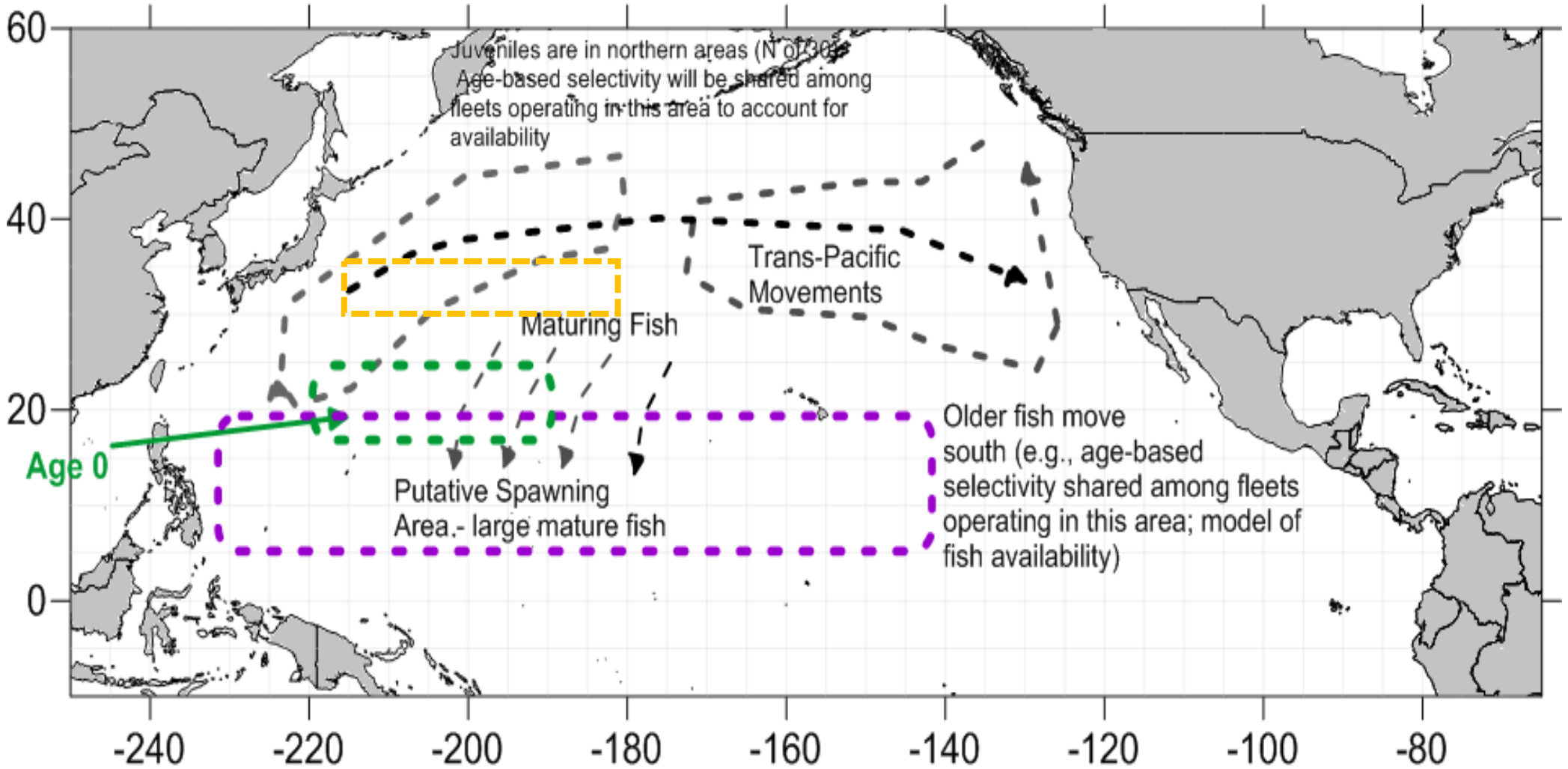
$$L_a = L_1 + (L_2 - L_1)((1-e^{-K(a-a1)})/(1-e^{-K(a2-a1)}))$$

L_1 = length at age a_1
L_2 = length at older age a_2

- Growth function modified to allow temperature dependent growth by allowing the L2 parameter to be a linear function of SST

$$L_2 = a + bSST$$

Size at age differences driven by processes occurring in the first and half year of life (Renck et al. 2014, CalCOFI Report)



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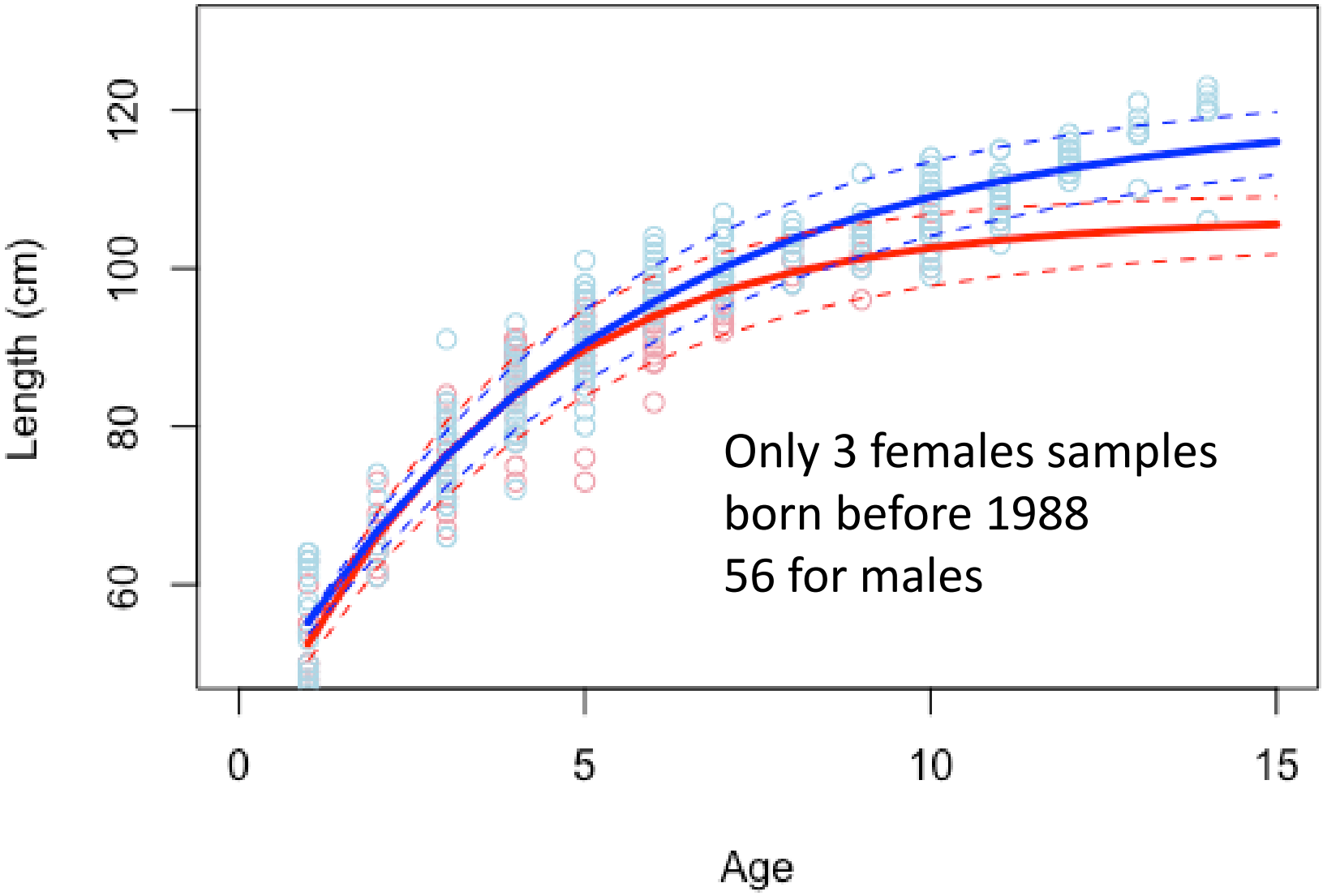
$$L_2 = a + bSST_{yb}$$

SST_{yb} = 2 year moving average of SST at year of birth

- Model fit by non-linear regression in R

Current Growth Model



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Results

- Time varying SST dependent growth model provides a better fit to length at age data than VBGF model

- Delta AIC = 5

But…

- Assume, for each age, that the length observations are a random sample
- Fisheries are selective
- Some members of the population are more likely to be fished because of gear and fish behavior (spatiotemporal distribution)
- If gear selective for larger sizes, younger ages may have bias in size distribution
- If albacore spatiotemporal distribution is dependent on size, the size of fish caught for each age will be dependent on where/when the fishers decided to fish

Future Work

- Estimate time varying growth within stock assessment model as random deviations
- Make use of length composition data and account for age and size-based selectivity
- Link estimated growth deviations to SST indices to identify temperature dependence of growth function
- Run MSE framework forced by SST projections from GCMs
- Assess robustness of candidate management strategies to future changes in growth

Thank you!

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