Using GLM and VAST to Estimate CPUE Indices from Fishery Dependent Data: Aleutian Islands Golden King Crab

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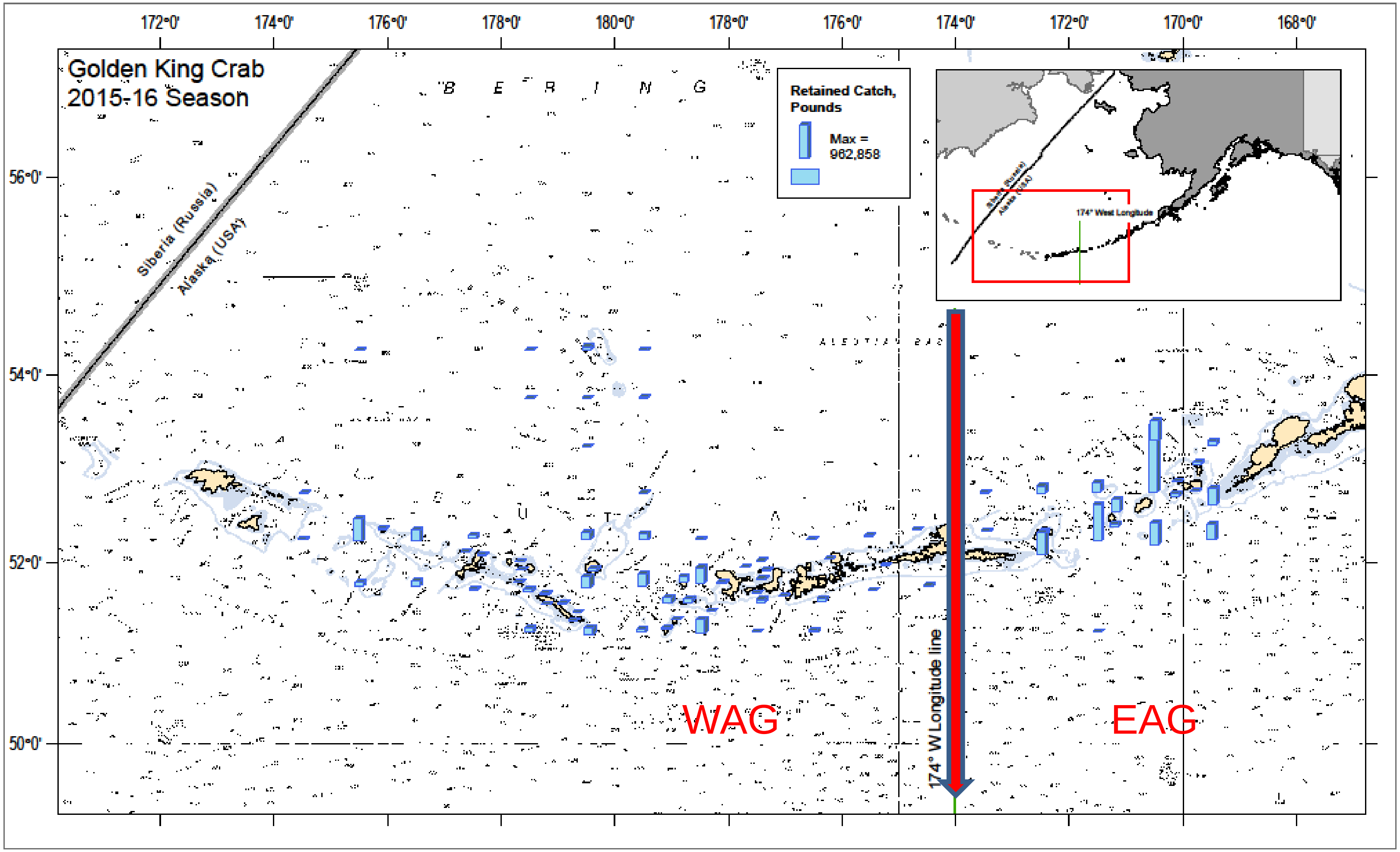
Introduction and Objectives

- Fishery dependent (preferential sampling) data are used for assessment of Aleutian Islands golden king crab (*Lithodes aequispinus*) in the east (EAG) and the west (WAG) of the 174E Long.
- Observer sample CPUE plays an important role in the assessment.
- To obtain a more fishery-independent abundance index, ADF&G has completed the first three years (2015–2017) of an agency/industry cooperative survey in the EAG. Data are yet to be analyzed.
- The area of fishery and the number of vessels have dropped over the years and drastic reduction occurred since crab rationalization in 2005.
- We use the GLM and the spatio-temporal delta generalized linear mixed model to determine sets of CPUE indices for the two regions based on the fishery-dependent observer data and compare the two types of estimates.
- We also use the two sets of CPUE indices in the length-based integrated assessment model to estimate mature male biomass time series and compare the trends.

Aleutian Islands golden king crab stocks in the two management regions (EAG and WAG). Fishery catches are recorded by ADFG statistical area. We used the ADFG statistical area as a factorial variable in the GLM



GLM based CPUE standardization

Observer CPUE index:

null model:

- $\ln(CPUE_i) = Year_{y_i}$

Full model for stepwise selection by GLM with negative binomial error model :

- $\ln(CPUE_I) = Year_{y_i} + ns(Soak_{si}, df) + Month_{m_i} + Area_{ai} + Vessel_{vi} + Captain_{ci} + Gear_{gi} + ns(Depth_{di}, df) + ns(VesSoak_{vsi}, df)$

Fish ticket CPUE index:

null model:

- $\ln(CPUE_i) = Year_{y_i}$

Full model for stepwise selection by GLM with lognormal error model:

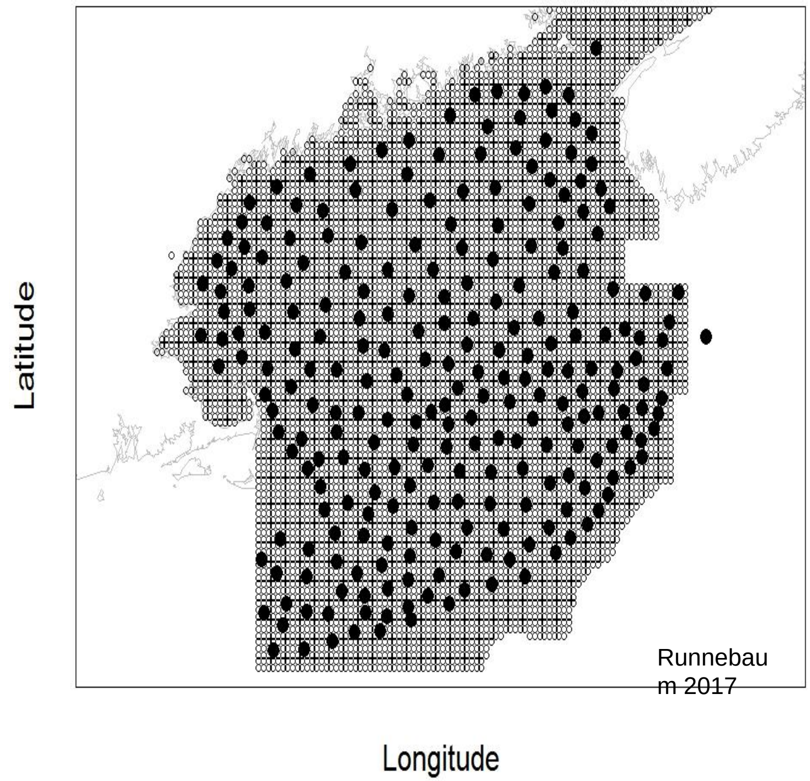
- $\ln(CPUE_I) = Year_{y_i} + Month_{m_i} + Area_{ai} + Vessel_{vi} + Captain_{ci}$

Predictor variable selection based on $R^2 \geq 0.01$

VAST based CPUE Standardization: Delta-GLMM (Thorson et al. 2015)

$$p_i = \text{logit}^{-1}\left(d^{(p)}_{T_{(i)}} + r^{(p)}_{V(i)} + \omega^{(p)}_{J_{(i)}} + \varepsilon^{(p)}_{J_{(i)},T_{(i)}}\right)$$

$$\lambda_i = w_i \exp\left(d^{(\lambda)}_{T_{(i)}} + r^{(\lambda)}_{V(i)} + \omega^{(\lambda)}_{J_{(i)}} + \varepsilon^{(\lambda)}_{J_{(i)},T_{(i)}}\right)$$



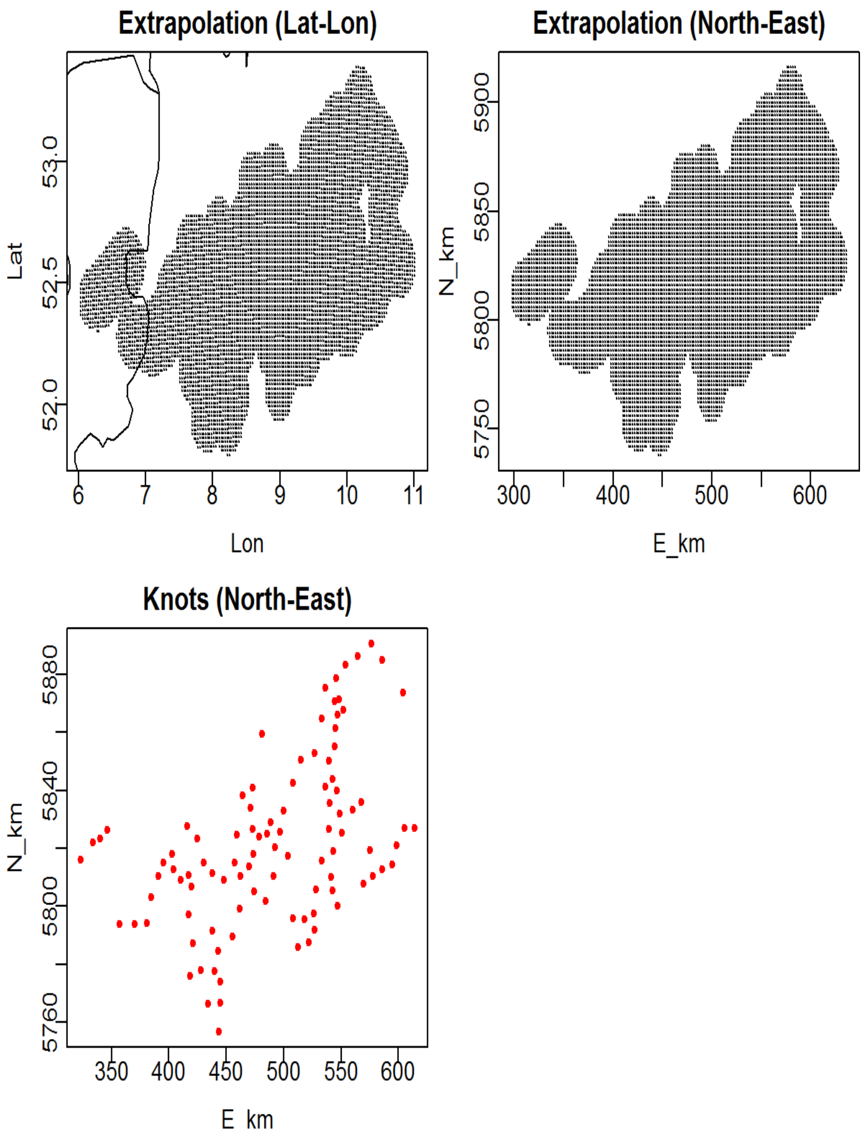
Runnebaum 2017

Our choice on spatial resolution for VAST: "Mesh" with 100 knots, 15km grid size

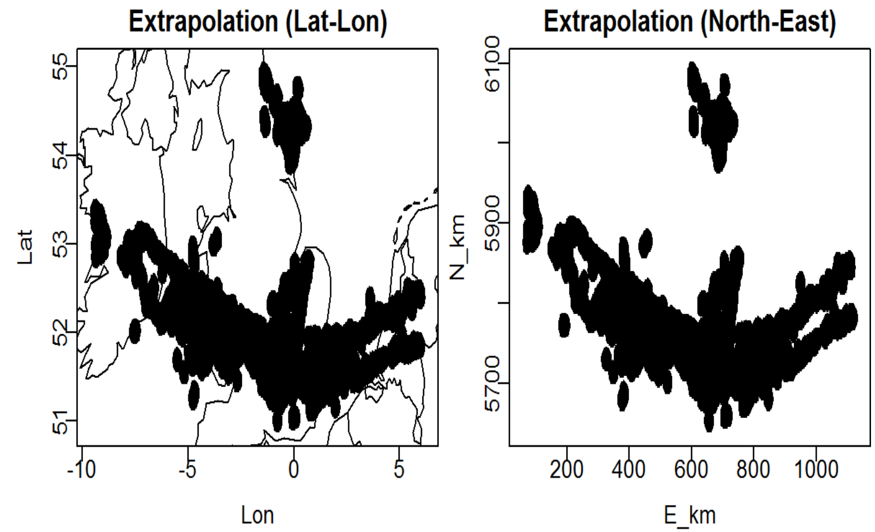
Concept of ‘Area Fished’

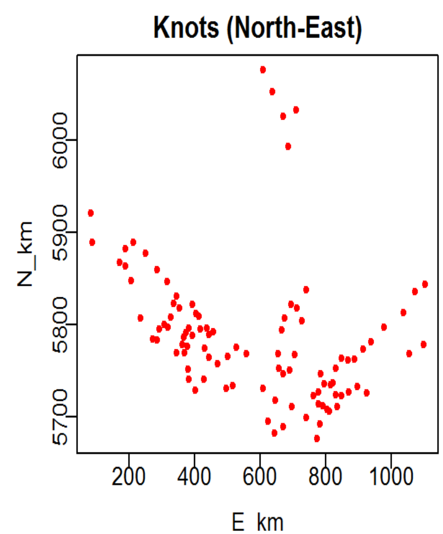
- VAST models have typically used area swept from trawl survey data.
- It is possible to use a different concept of area fished (Runnebaum et al. 2017)
- For GKC currently using either area of the pot or the soak time

East



West

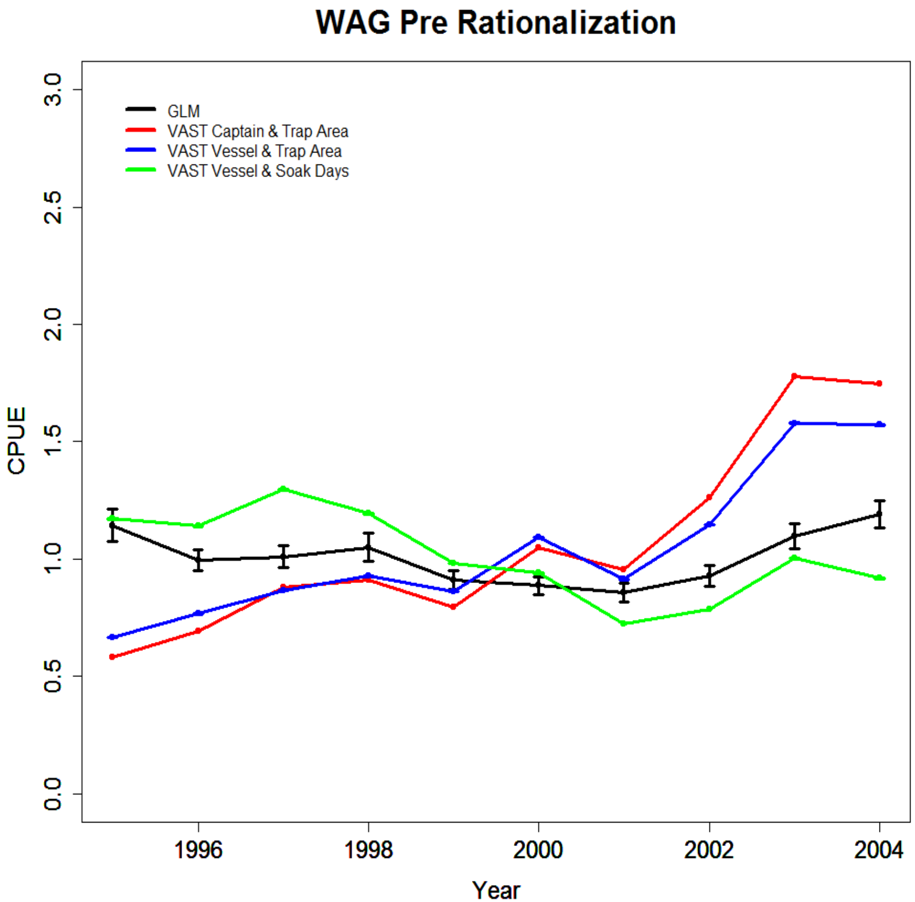


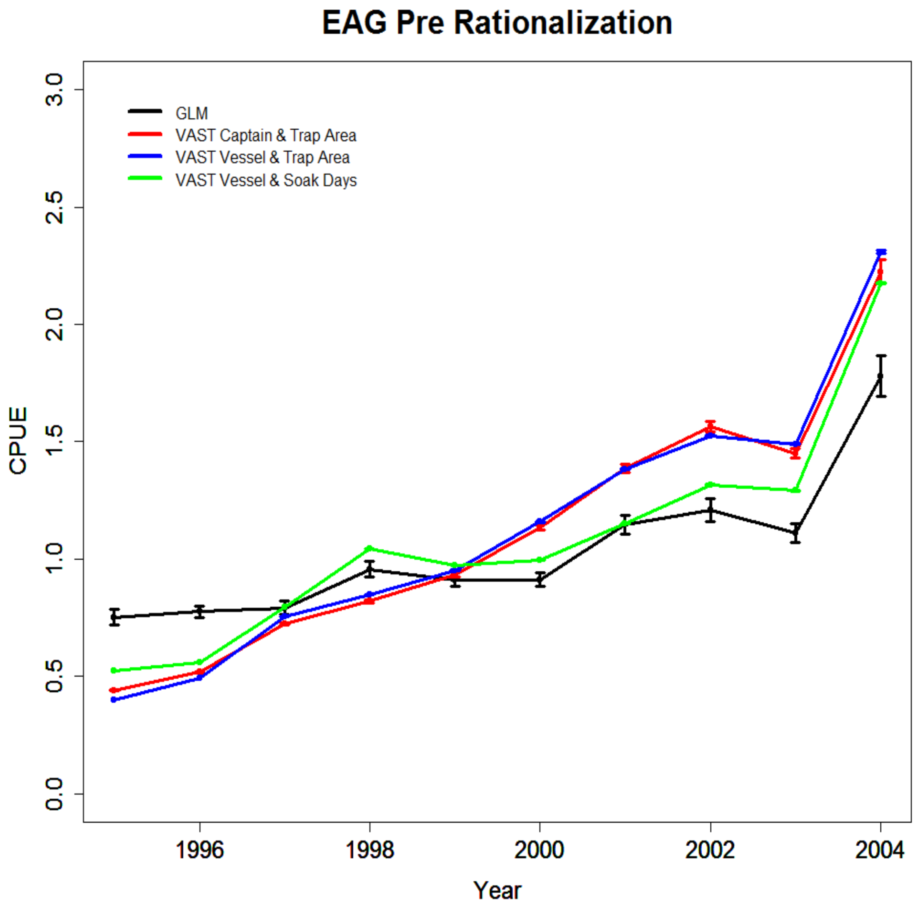


Need to determine how to project a grid for the east and west that is more consistent between the two and taking into consideration the dateline.

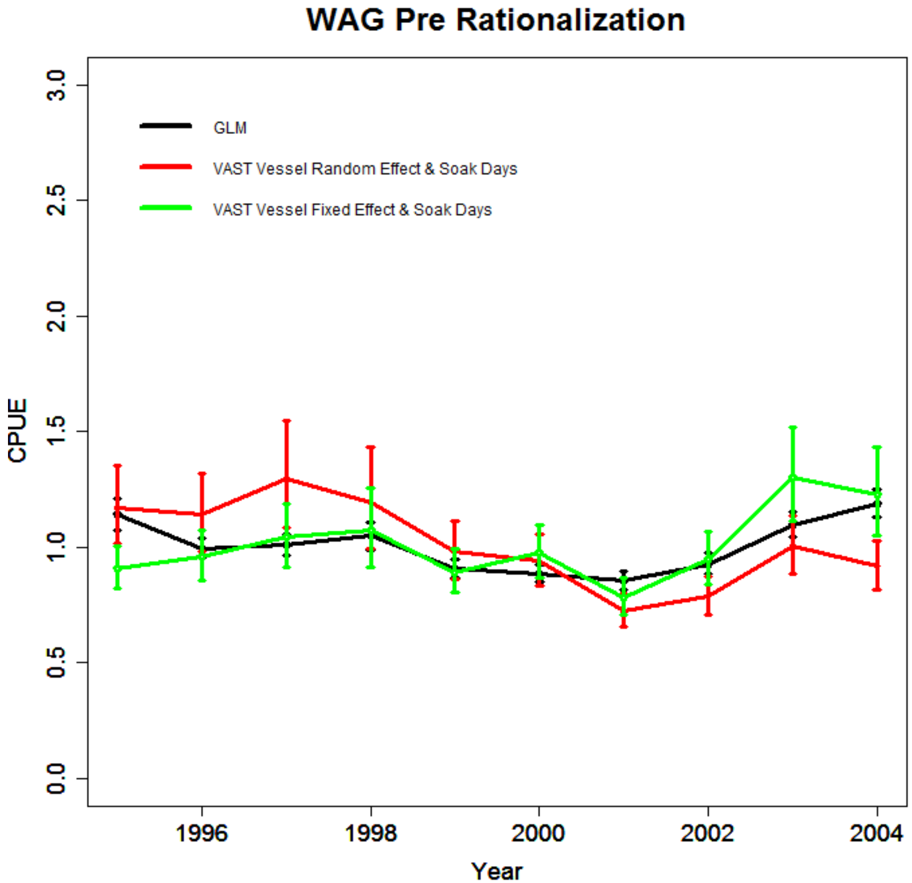
How much does the grid projection impact abundance estimates?

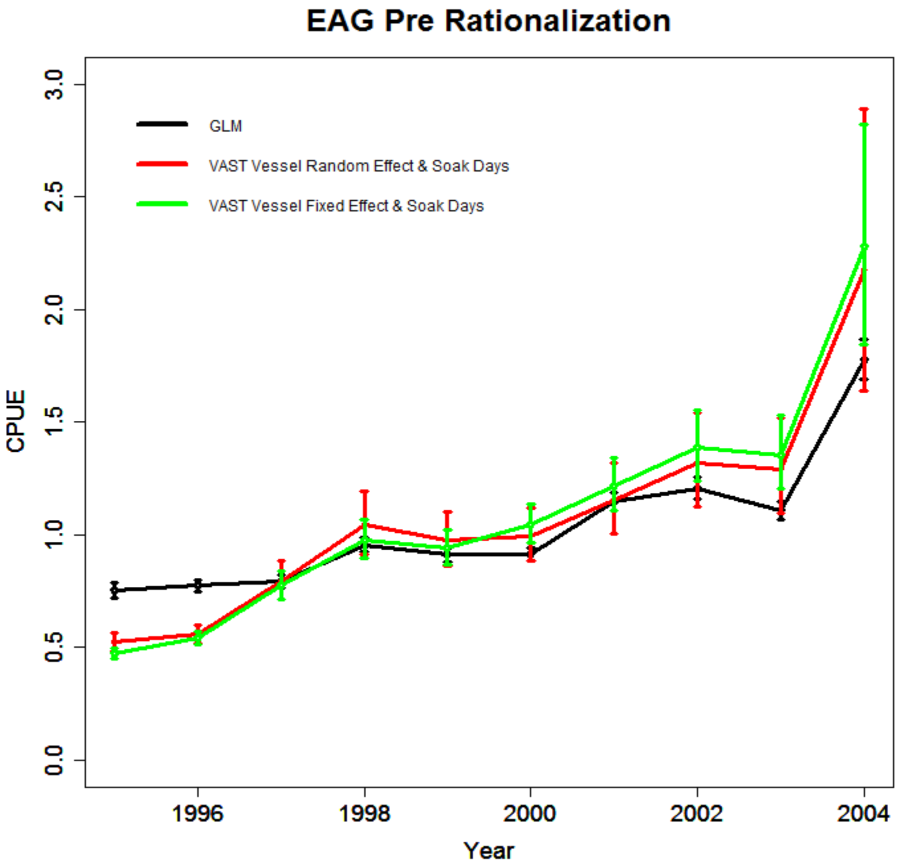
Comparison of GLM and VAST CPUE. In the VAST, Captain or Vessel was considered random effect with either crab pot (trap) area or Soak time used for abundance index estimation





Comparison of CPUE indices between GLM and VAST. In the VAST, vessel was treated two different ways : random effect and fixed effect with Soak time used for abundance index estimation.

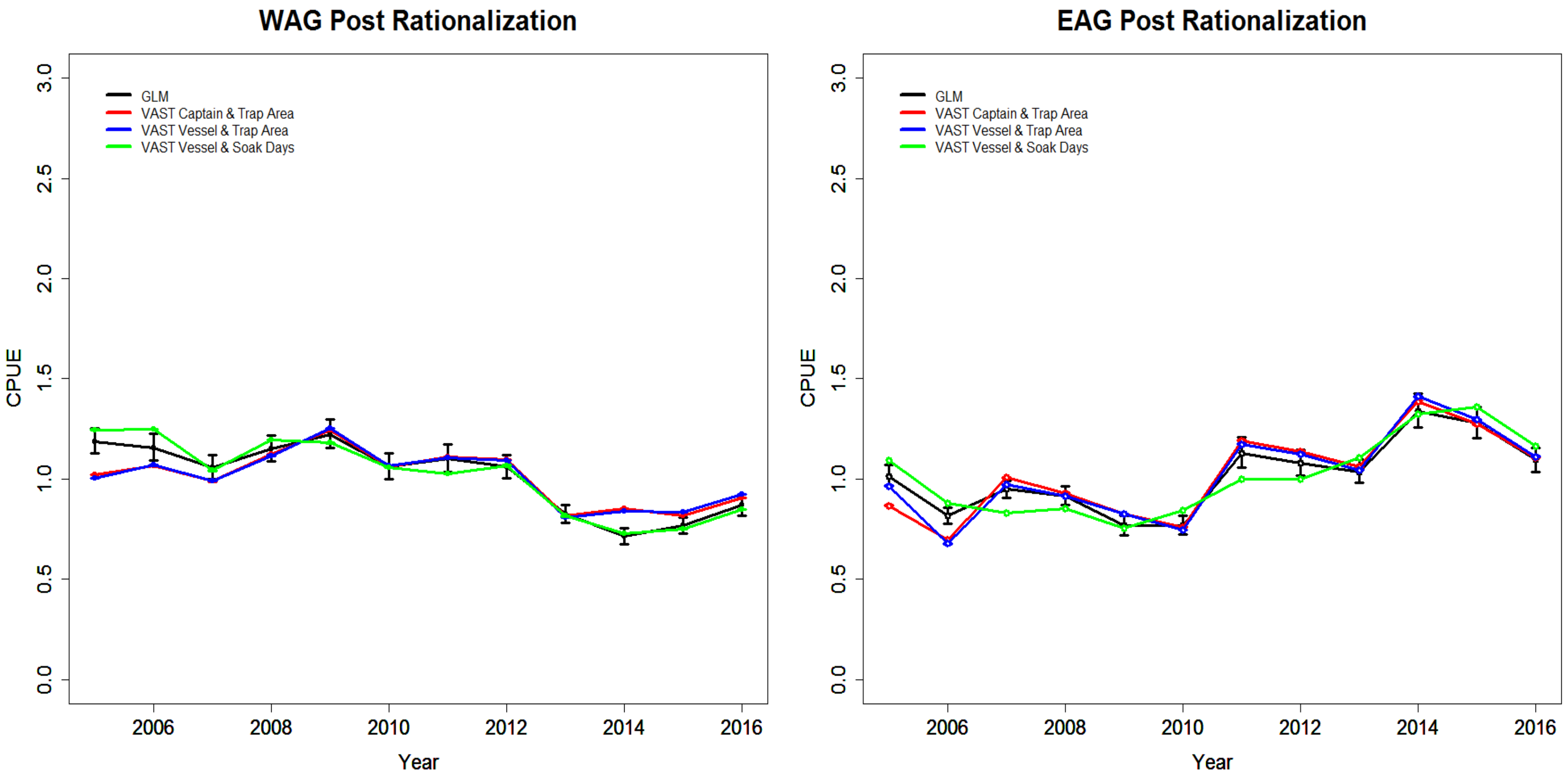




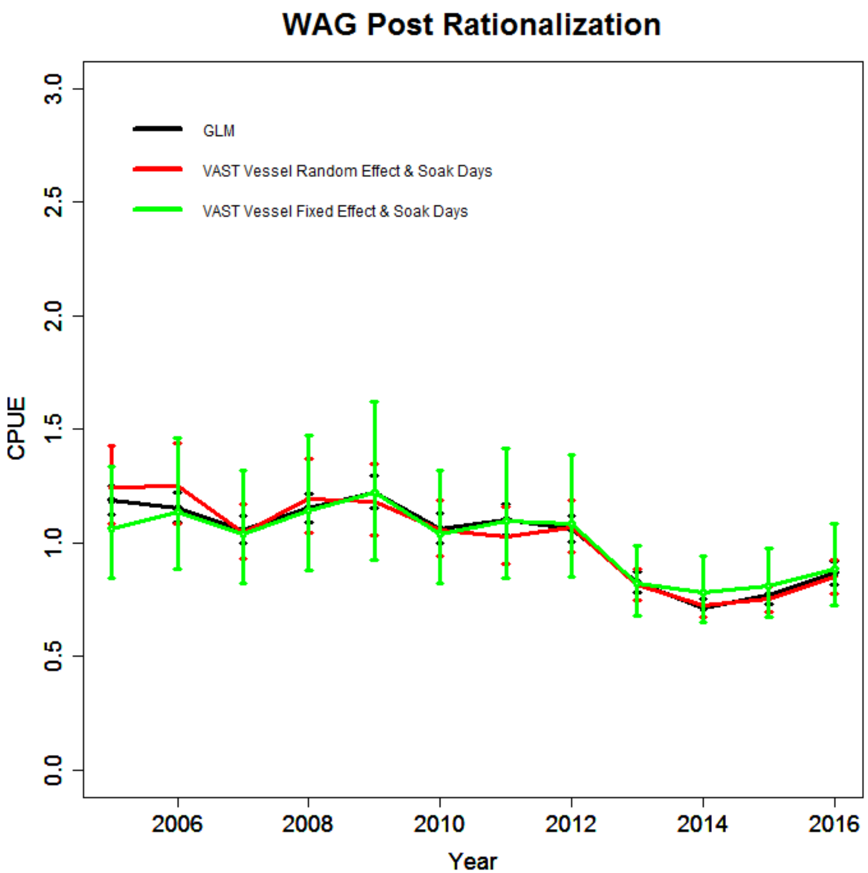
GLM: Ln(CPUE) = Year + Captain + Gear + ns(Soak, df=10) + Area, NB (θ = 1.0)

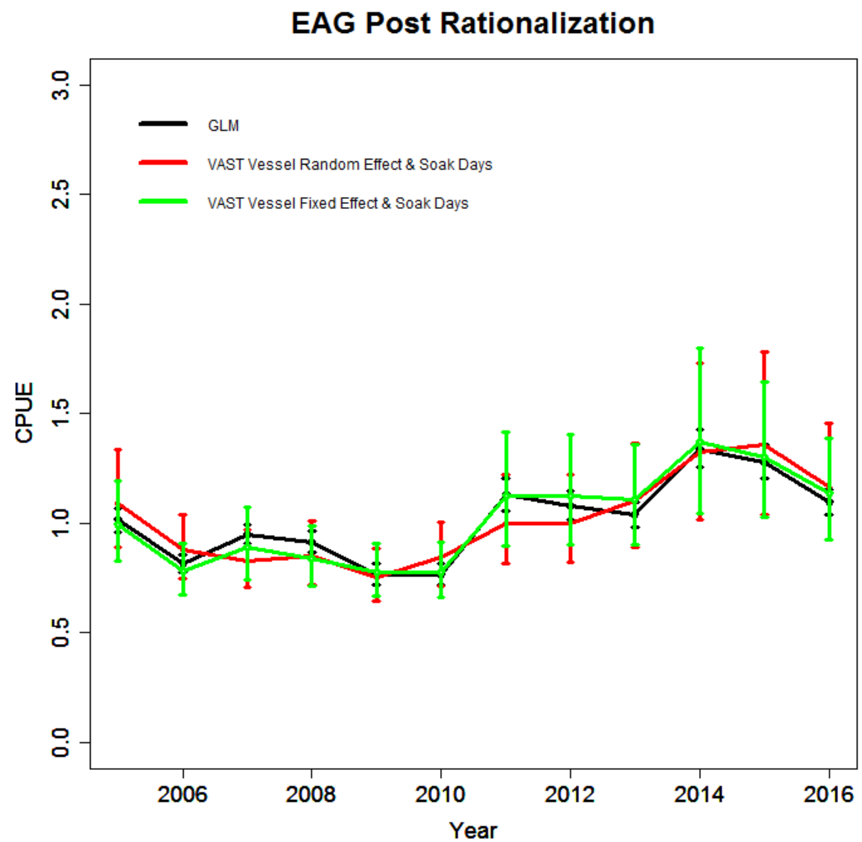
GLM: Ln(CPUE) = Year + Gear + Captain + Area + ns(Soak, df=4), NB (θ = 1.37)

Comparison of GLM and VAST CPUE. In the VAST, Captain or Vessel was considered random effect with either crab pot (trap) area or Soak time used for abundance index estimation



Comparison of CPUE indices between GLM and VAST. In the VAST, Vessel was treated two different ways : random effect and fixed effect with Soak time used for abundance index estimation.

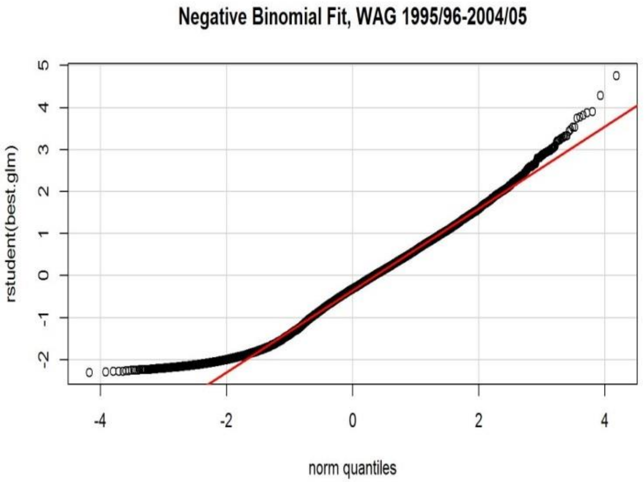


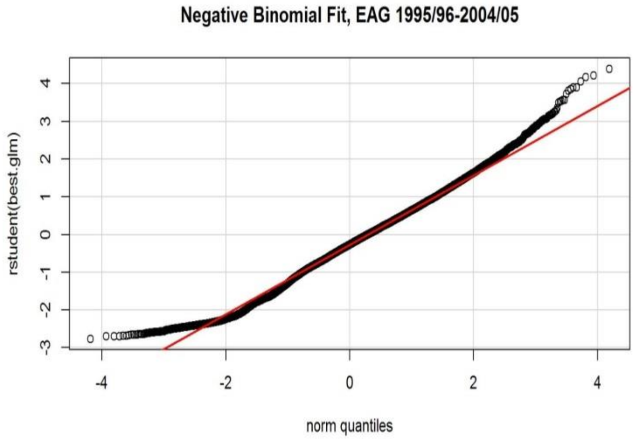


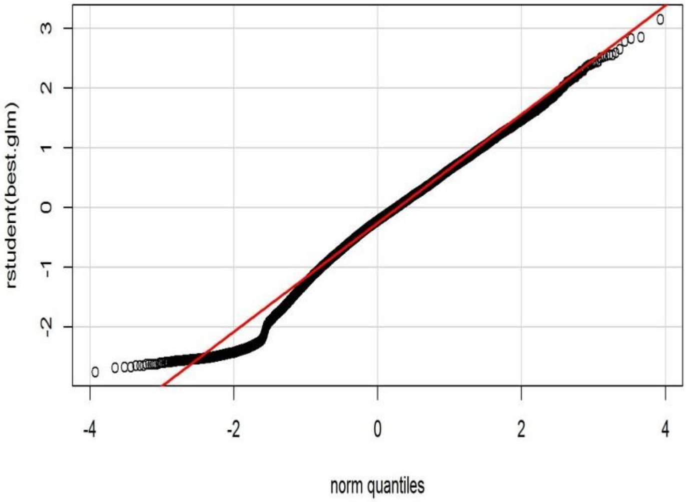
GLM: Ln(CPUE) = Year + Area + Gear + ns(Soak, df=5), NB (θ = 1.17)

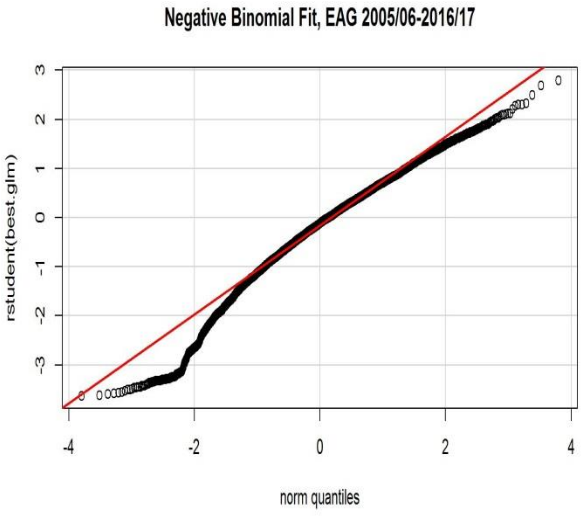
GLM: Ln(CPUE) = Year + Captain + Gear + ns(Soak, df=11), NB (θ = 2.3)

GLM diagnostic: Studentized residuals



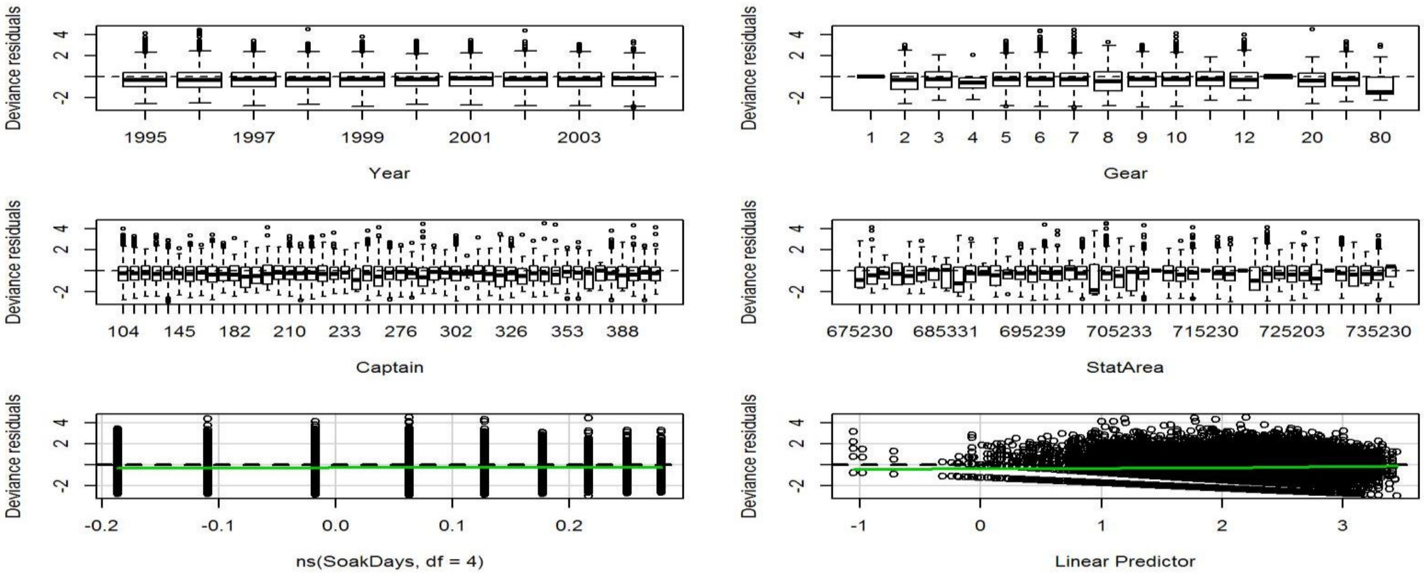




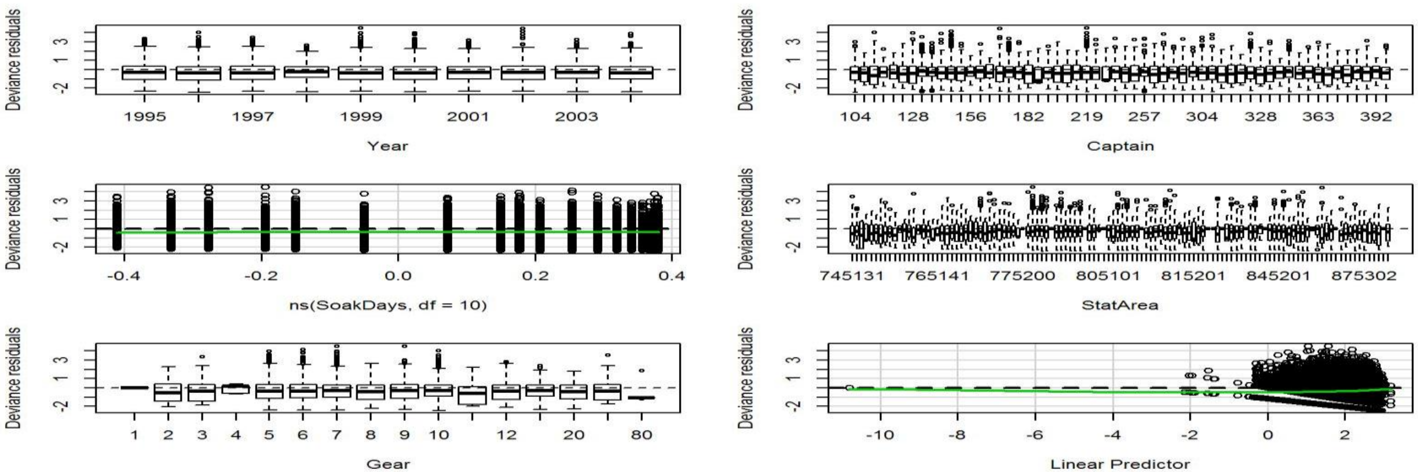


GLM diagnostic continued.

EAG pre-rationalization



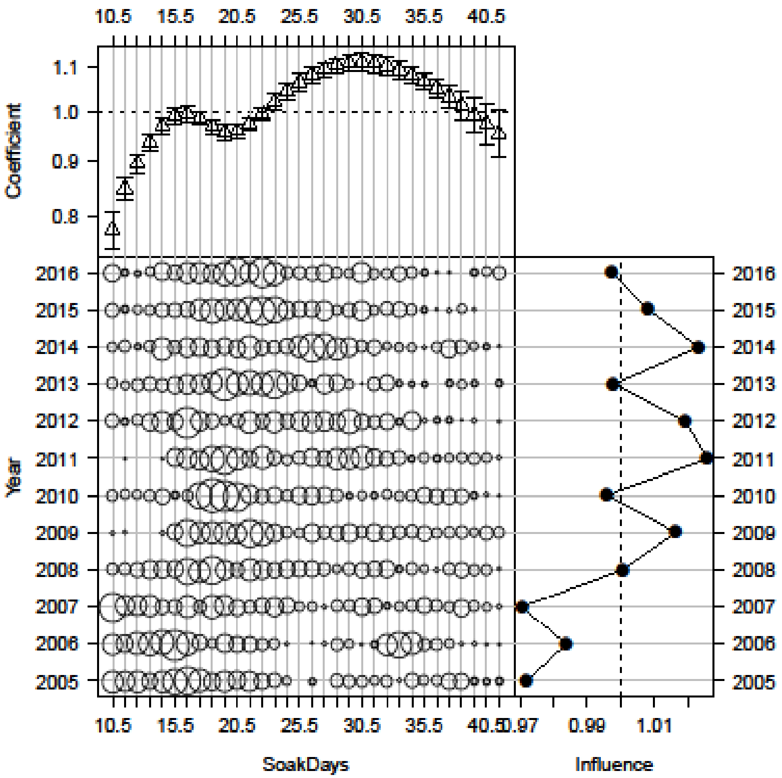
WAG pre-rationalization



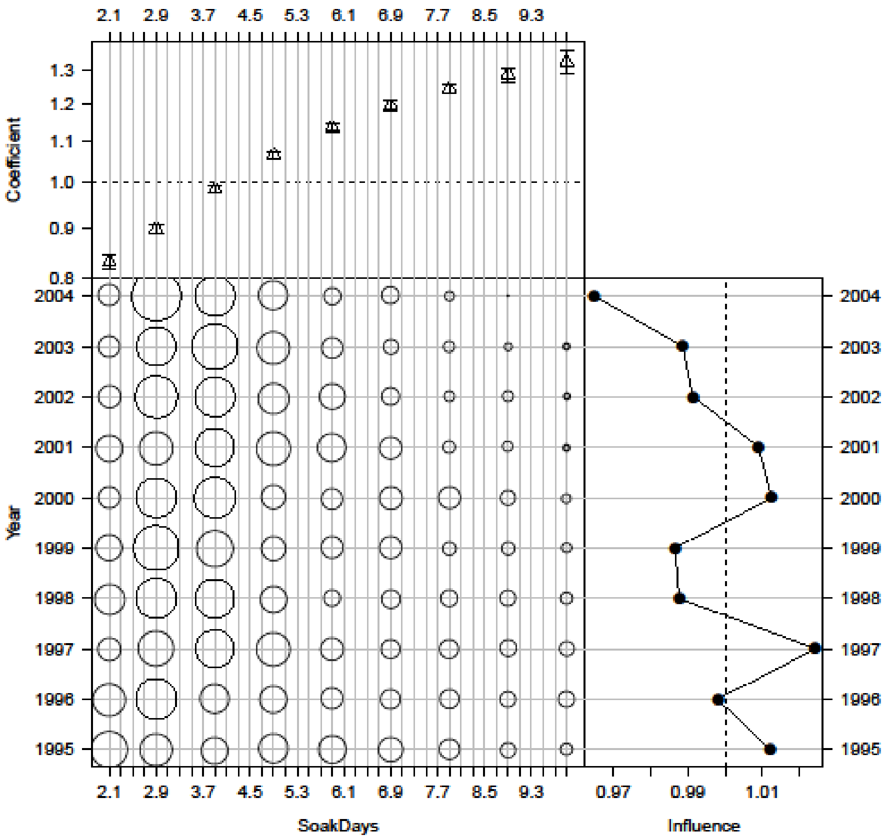
e.g., Soak time influence plot

(Bentley, N., T.H. Kendrick, P.J. Starr, and P.A. Breen. 2012. Influence plots and metrics: tools for better understanding fisheries catch-per-unit-effort standardizations. ICES Journal of Marine Science 69:84-88.)

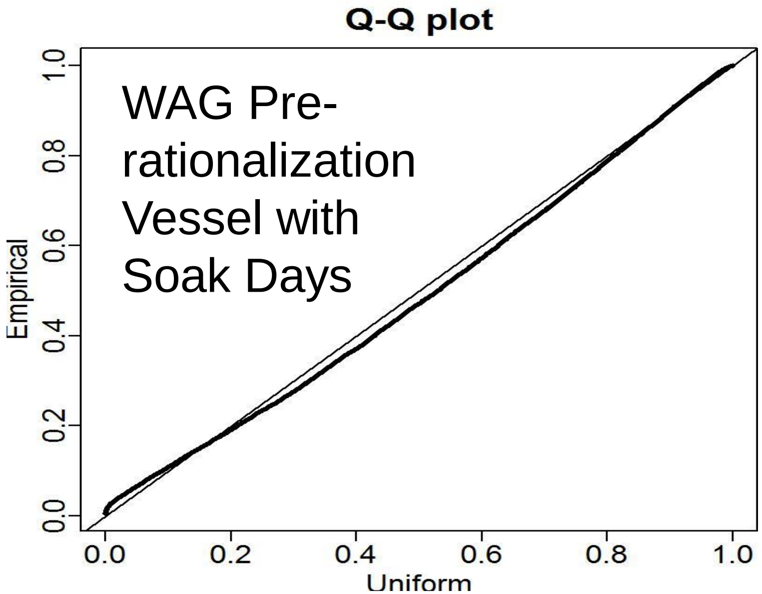
WAG pre-rationalization

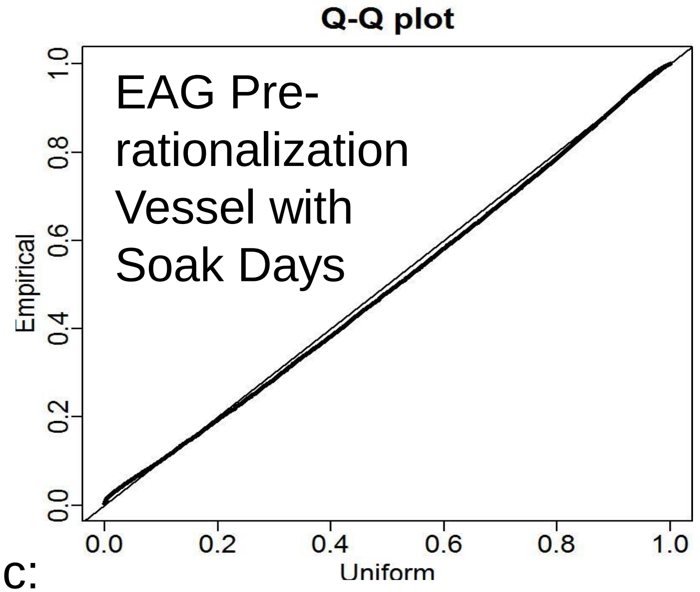


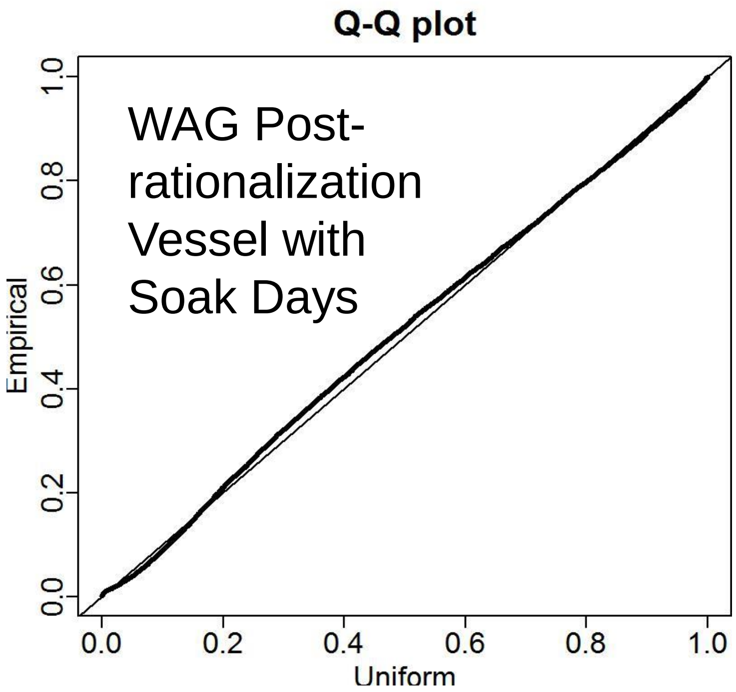
EAG pre-rationalization

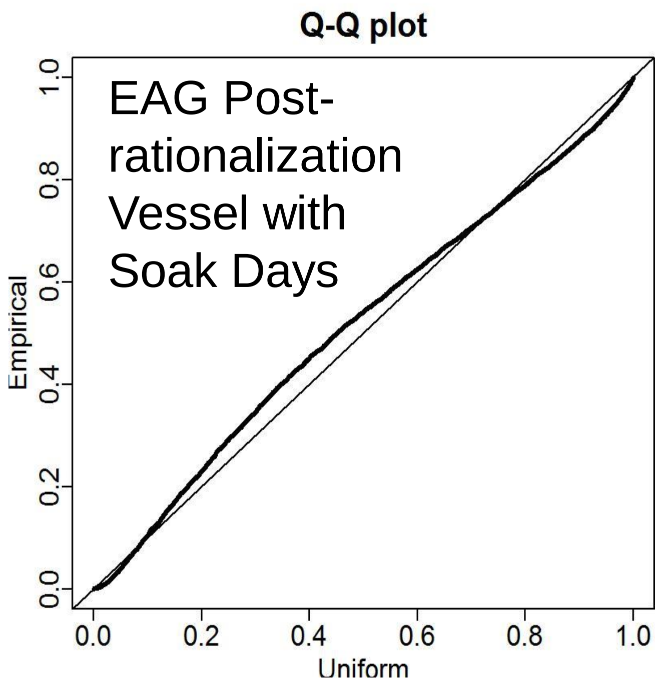


VAST diagnostic: Q-Q plot

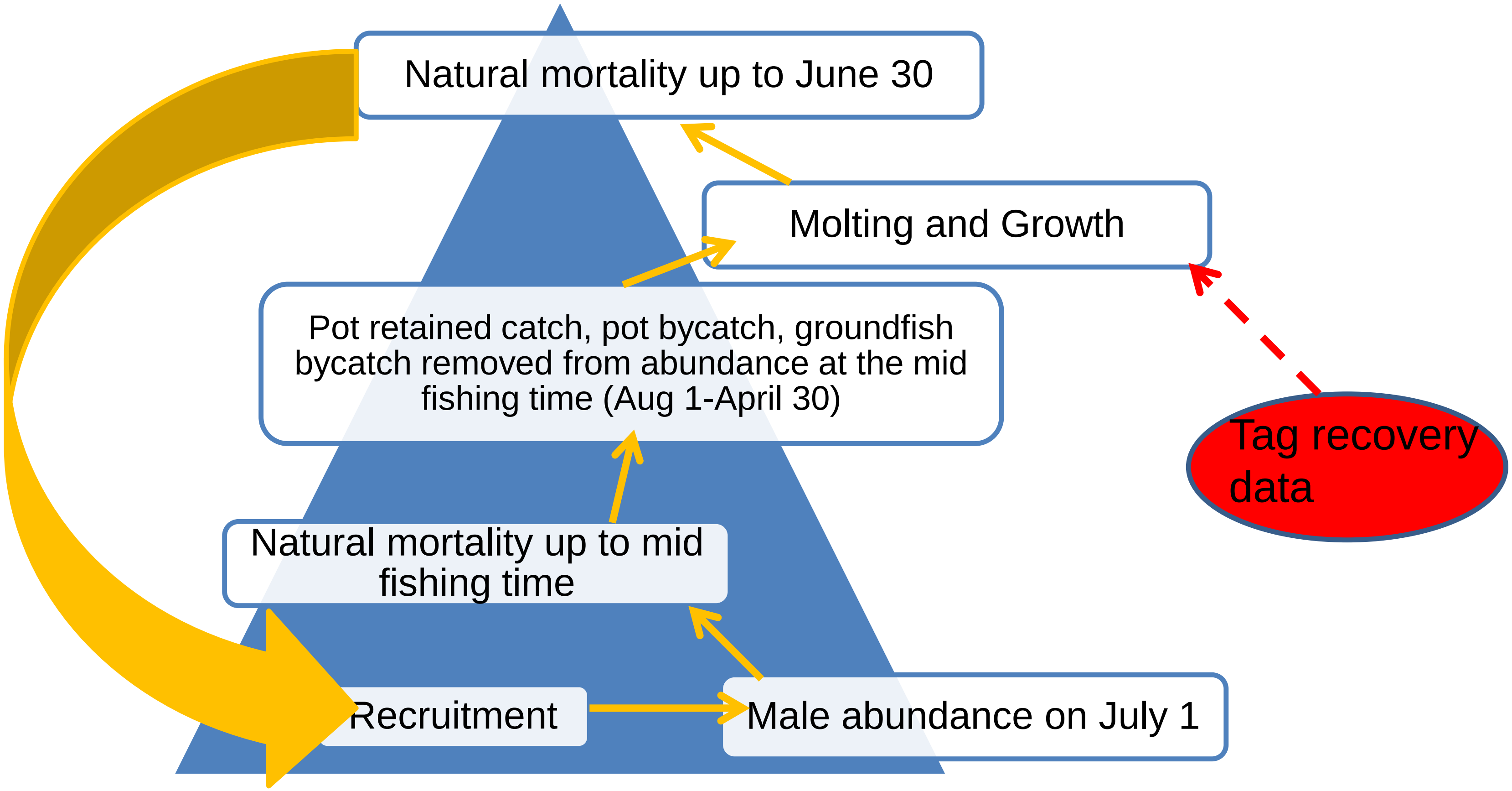








Conceptual length based model

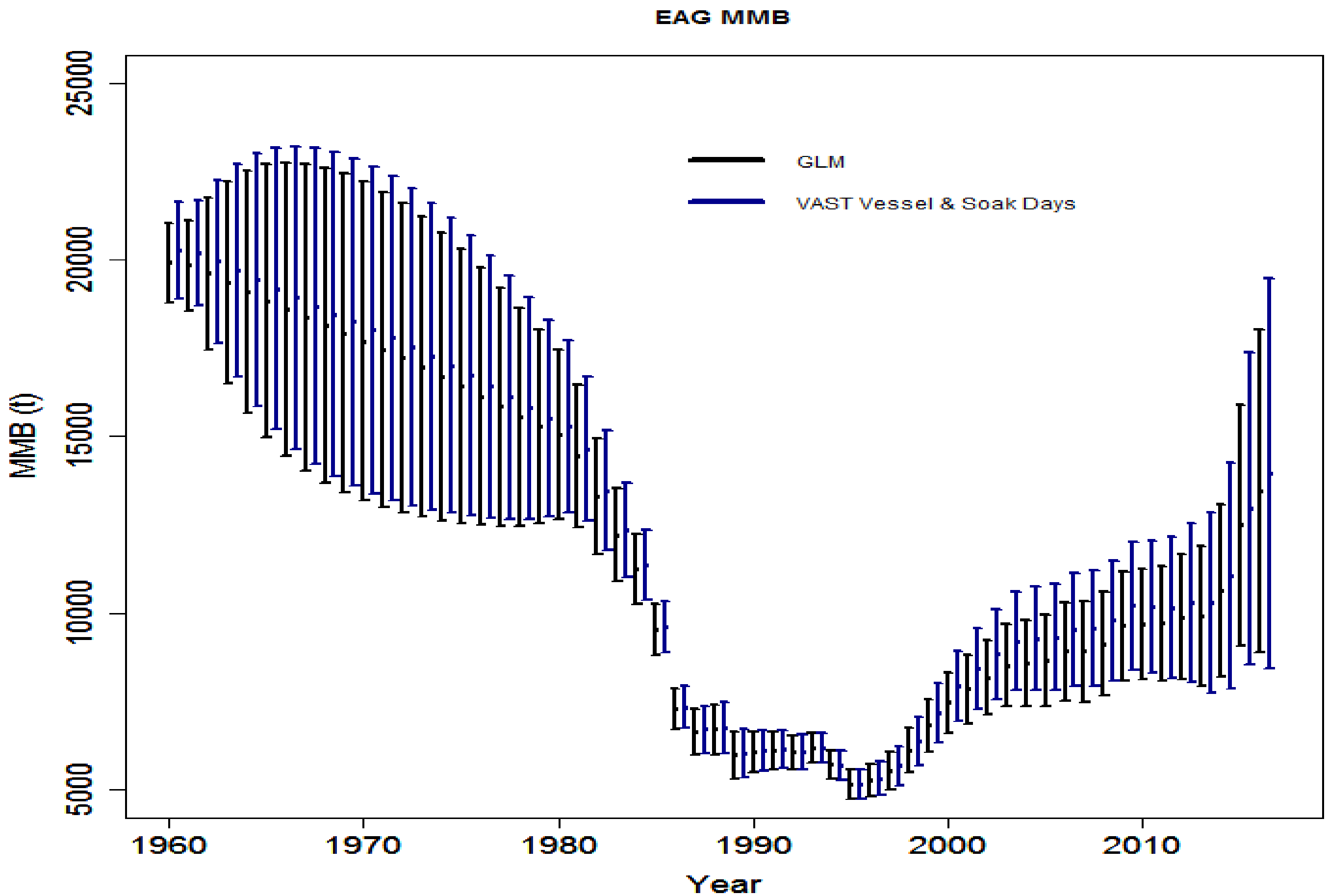


CPUE Likelihood component for GLM or VAST index

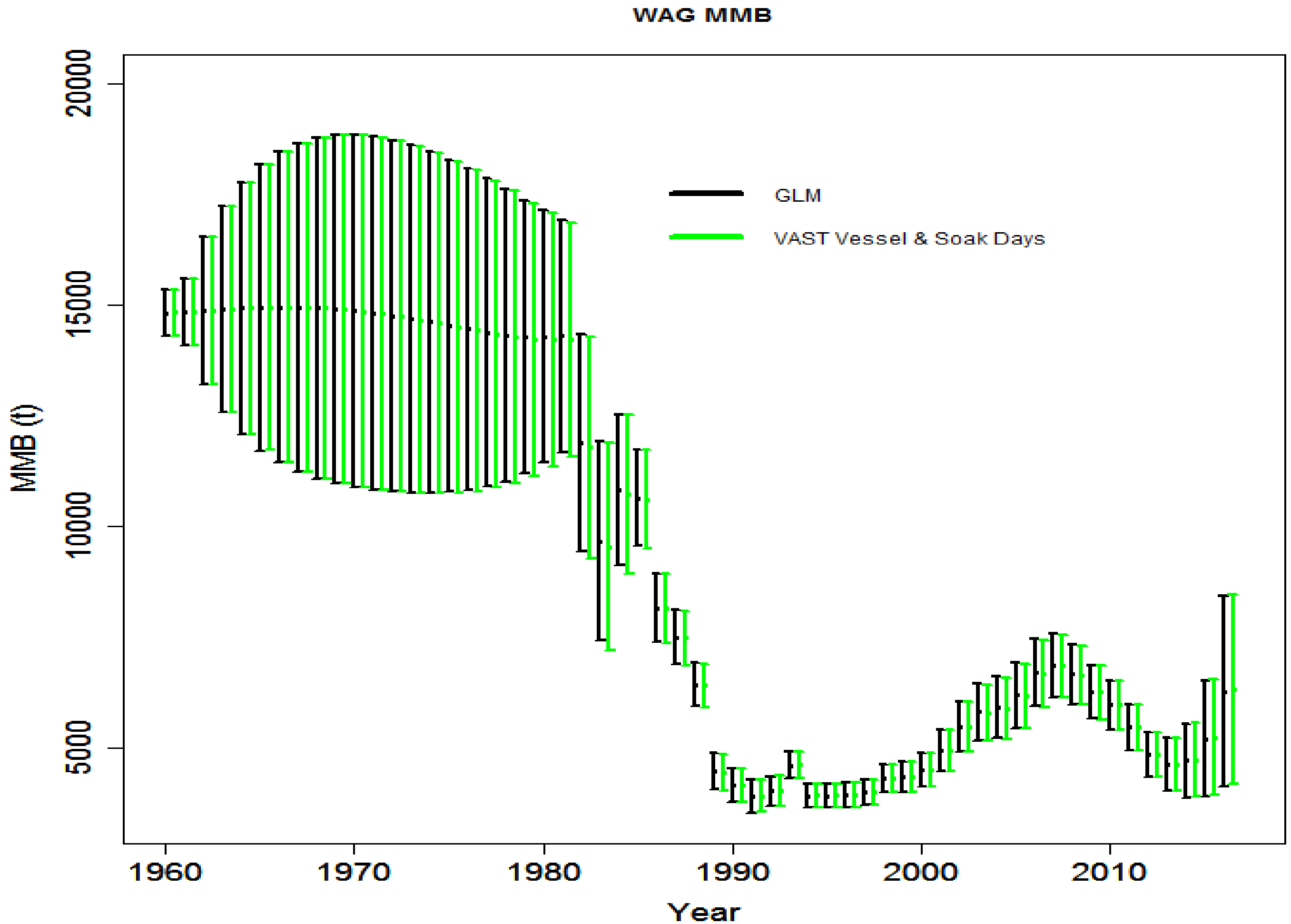
- $$LL_r^{CPUE} = \lambda_{rCPUE}\left\{0.5\sum_t \ln\left[2\pi\left(\sigma_{r,t}^2 + \sigma_e^2\right)\right] + \sum_t \frac{\left(ln(CPUE_t^r + c) - \ln(\widehat{CPUE}_t^r + c)\right)^2}{2\left(\sigma_{r,t}^2 + \sigma_e^2\right)}\right\}$$

$$\widehat{CPUE}_t^r = q_k \sum_j S_j^T\, S_j^r \left(N_{t,j} - 0.5\left[\widehat{C_{t,j}} + \widehat{D_{t,j}} + \widehat{Tr_{t,j}}\right]\right)e^{-y_t M}$$

Comparison of MMB trends between GLM and VAST CPUE input for the EAG. In the VAST, Vessel was treated as random effect.



Comparison of MMB trends between GLM and VAST CPUE input for the WAG. In the VAST, Vessel was treated as random effect.



Conclusions and Questions

- The trends in CPUE indices between GLM and VAST are similar.
- The trends in MMB are also similar.
- We recognize the problem of using fishery dependent data in VAST.
- We also recognize the difficulty of differentiating between random and fixed effect variables, for example Vessel, in the VAST.

Other questions:

- How to evaluate the concept of "area swept" for pot fisheries within the spatio-temporal model.
- How to incorporate a model selection procedure to select the appropriate covariates for capturing differences in fishing effect.
- How to account for a decrease in vessel number and fishing area since post rationalization.
- How to correct for potential bias due to the use of fisheries-dependent data.

Thank you

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