2020 Groundfish Assessment Program: Model-based Indices (VAST) Summary

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AFSC-RACE

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Objective

Provide Stock Assessment authors with design-based and model-based estimates of abundance indices

The Vector Autoregressive Spatio-Temporal (VAST) model was selected based on contemporary research as well as available staff expertise (Thorson, 2019)

Questions for the Plan Team

- Does the Plan Team want indices extrapolated to deep stations (>700m) in the GOA?
- What other products should be developed based on these fits (e.g., for use in the ESR and ESP)?
  - center of gravity (distribution shift)
  - effective area occupied (range expansion)
  - cold pool response (spatially varying responses to cold pool)
- Does the Plan Team recommend including a spatially varying response to cold-pool extent for those indices using NBS and EBS data?
- How should untrawlable habitat in the GOA be addressed in VAST?
- Are there specific research questions the Plan Team would prioritize to support stock assessments?

Benefits and drawbacks of VAST

Benefit (ranked large to small)
Combine multiple data streams (i.e., to avoid bias arising from differences in area-sampled)
Disciplined approach to spatially unbalanced data (propagates variance without “ignoring” missing data)
Account for portion of variance associated with randomized sample location
Improve “statistical efficiency” (decrease standard errors) for limited data
Improved communication and intuition by visualizing survey products on a map
Single approach that works for many uses; improved efficiency for methods review

Drawback	Response to drawback
Potential to introduce bias	• Simulation suggests bias in trend is small/nonexistent • Simulation suggests bias in scale is small
Results are model-based (so affected by user decisions)	Pre-define terms of reference (TOR)
Complicated to use and explain	Simplified user-interface in progress
Many decisions to make	Decision guidance available

Papers testing spatio-temporal model performance (particularly VAST)

Shelton et al. 2014 CJFAS

- Case study demonstration of improved precision relative to design-based

Thorson et al. 2015 ICES JMS

- Simulation testing for estimating indices of abundance

Thorson et al. 2017 CJFAS

- Simulation testing for fishery-dependent standardization

Cao et al. 2017 CJFAS

- Case study comparison of design and spatio-temporal index in Gulf of Maine northern shrimp assessment

Thorson and Haltuch 2018 CJFAS

- Simulation testing for estimating age/length composition data

Grüss et al. 2019 Fish. Res.

- Blinded experiment with independently made operating model

Johnson et al. 2019 Fish. Res.

- Simulation experiment comparing model performance for VAST when missing covariates

Brodie et al. 2020 Ecography

- Biologically motivated operating model, comparing VAST, random forest, and GAMs

Maunder et al. 2020 Fish. Res.

- Discussion of importance for spatio-temporal standardization of fishery-dependent CPUE

O'Leary et al. In press Fisheries Oceanography

- Case-study comparison of design-based and spatio-temporal standardization for EBS pollock

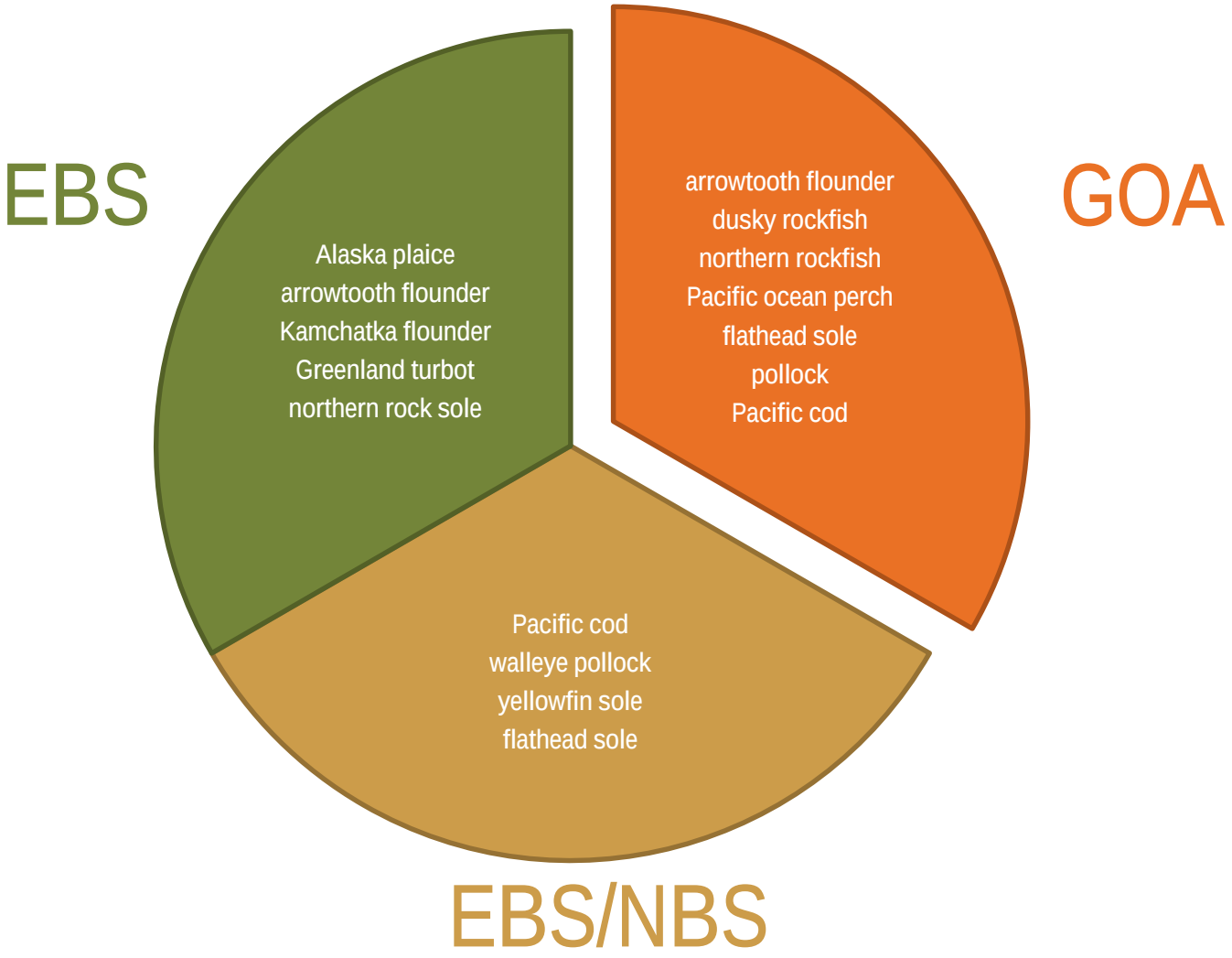
Thorson et al. In press Fish. Res.

- Simulation and case study showing that gamma distribution (and Tweedie model) match scale of design-based estimator on average

WKUSER ICES Workshop Report (http://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=36905)

- Several participants are working on papers comparing design-based and VAST estimates in a simulation framework for GOA and EBS

2020 VAST Species



Standard Settings

- 2 linear predictors in a Poisson-link delta model with gamma distributed positive catch rates
- Catch density extrapolated over a 4 nmi^2 grid (3.7 km X 3.7 km)
- 500 knots distributed in proportion to the extrapolation grid, using fine-scale bilinear interpolation
- No temporal smoothing
- Each linear predictor included spatial and spatio-temporal terms
- Retransformation bias was corrected using the epsilon bias-correction feature
- GOA extrapolation grid was limited to <700m, however all data were used in the model

Non-standard VAST Settings

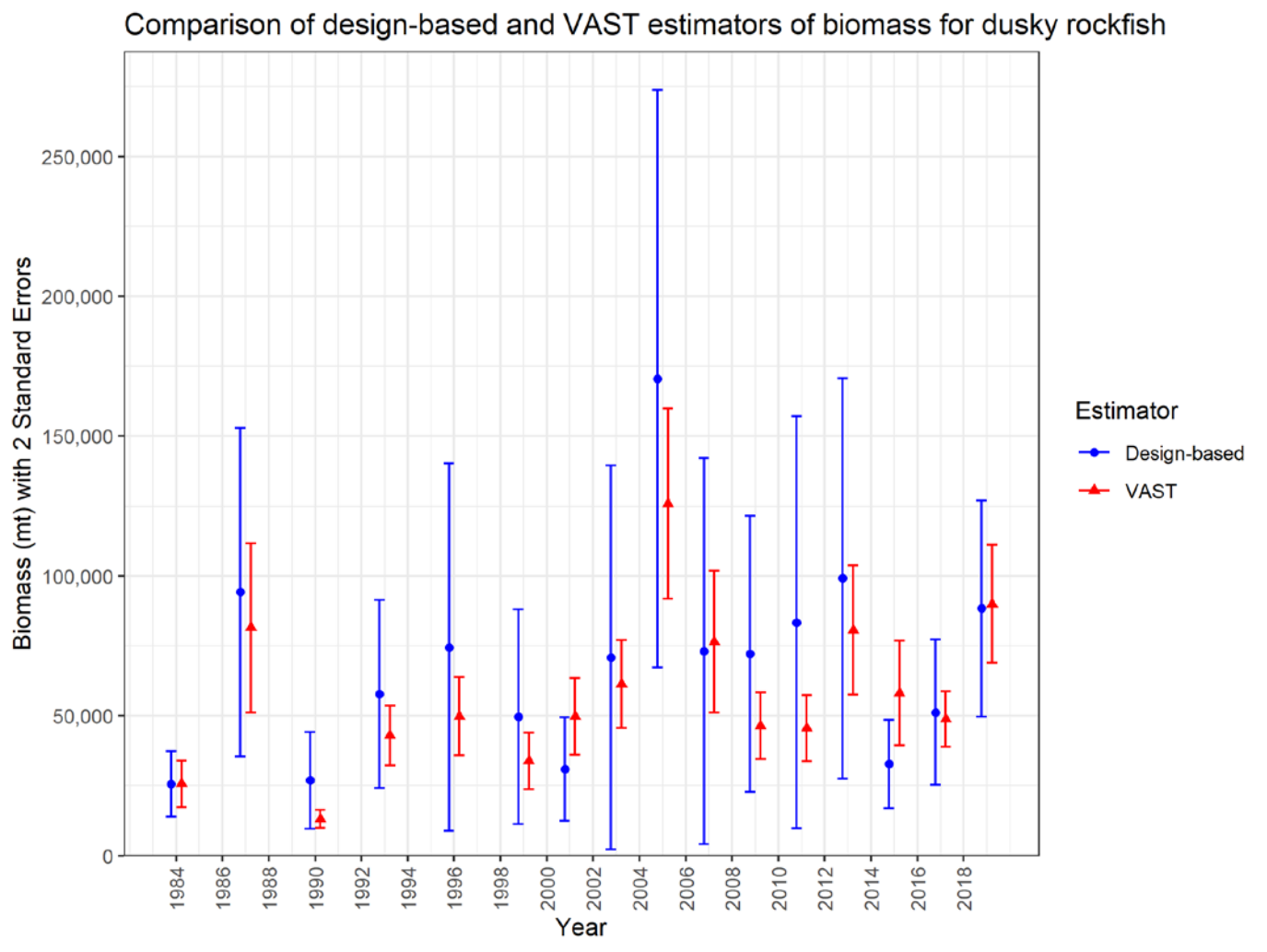
- GOA dusky and northern rockfish:
  - an additional run using the lognormal distribution for positive catches was done for comparison
- GOA pollock had a supplementary run using only data west of 140° W longitude
- Bering Sea pollock, cod, flathead sole and yellowfin sole:
  - combined data from NBS and EBS used for estimation
  - “knots” reduced to 250
  - temporal autocorrelation was enabled for the spatio-temporal term
  - included a spatially varying response to cold pool extent as a covariate
- EBS/NBS Pacific cod uses a Poisson-link delta model and gamma distributed positive catch rates, but fixes encounter probability for 100% encounters
- Age composition was estimated with VAST for EBS/NBS pollock and Pacific cod

GOA Results

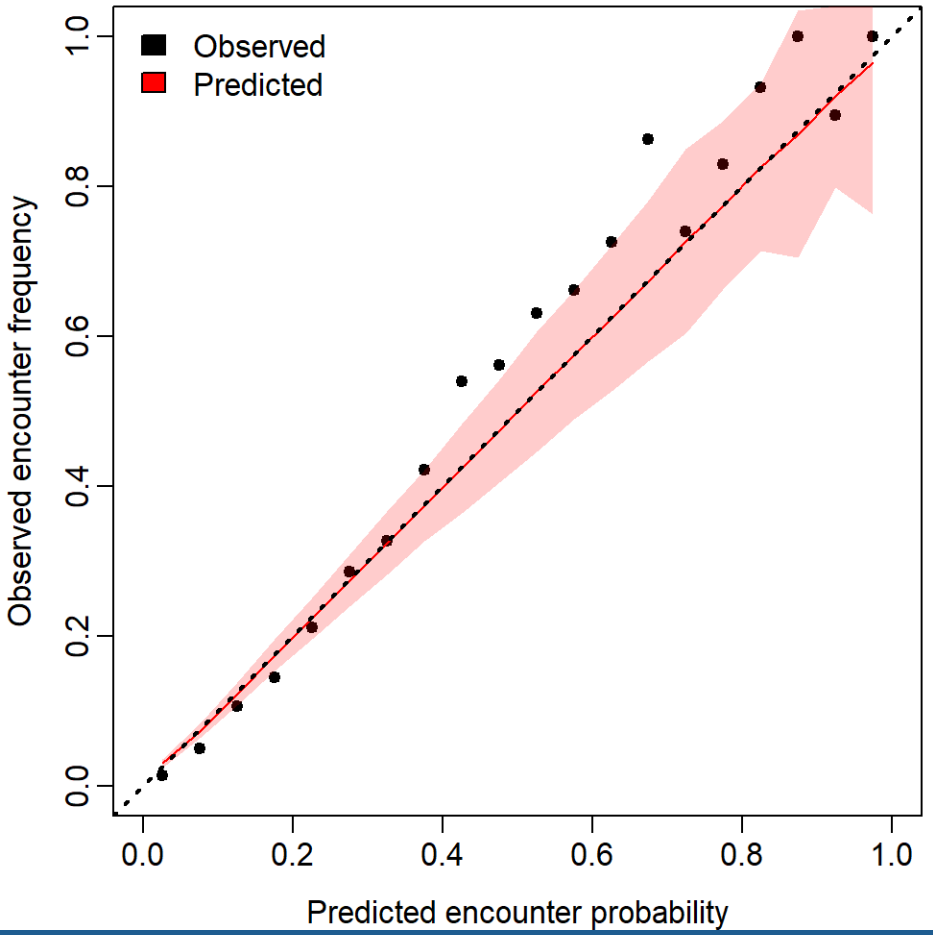
Only dusky rockfish and northern rockfish VAST estimates will be included in the 2020 Stock Assessment.

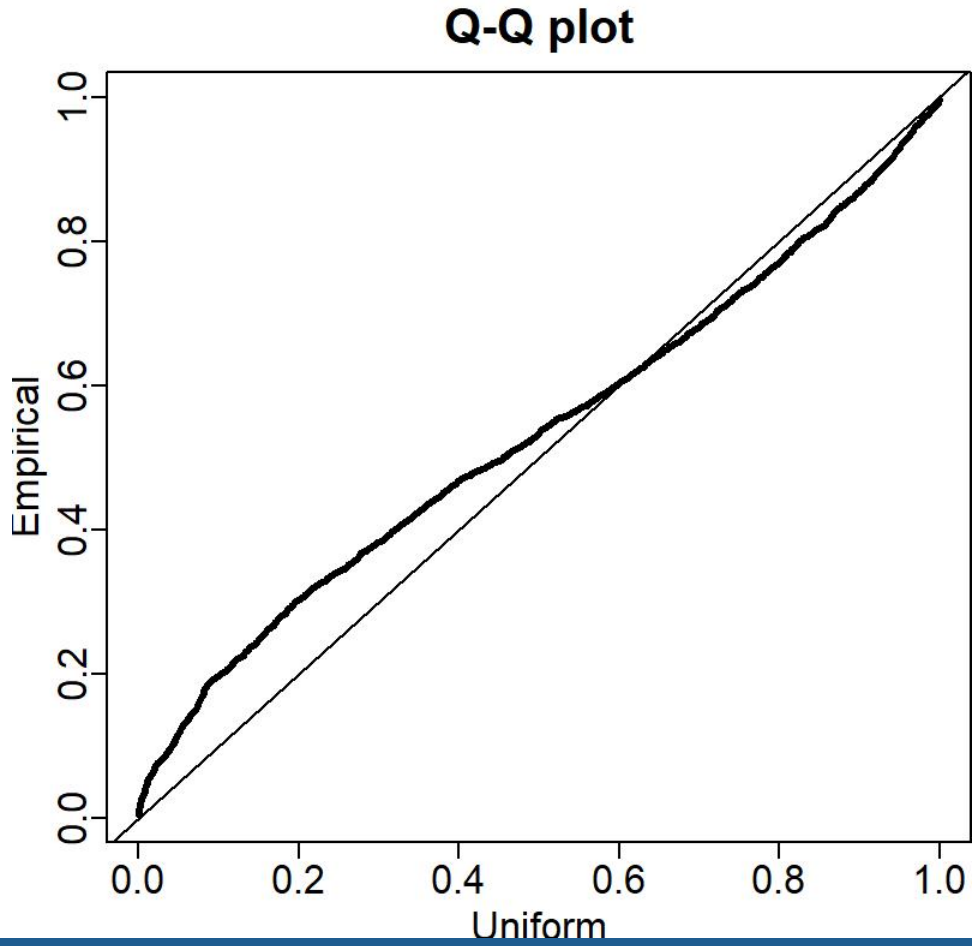
GOA – Dusky Rockfish Index

Prior to 1993, species were mixed and these results include dusky and dark rockfishes

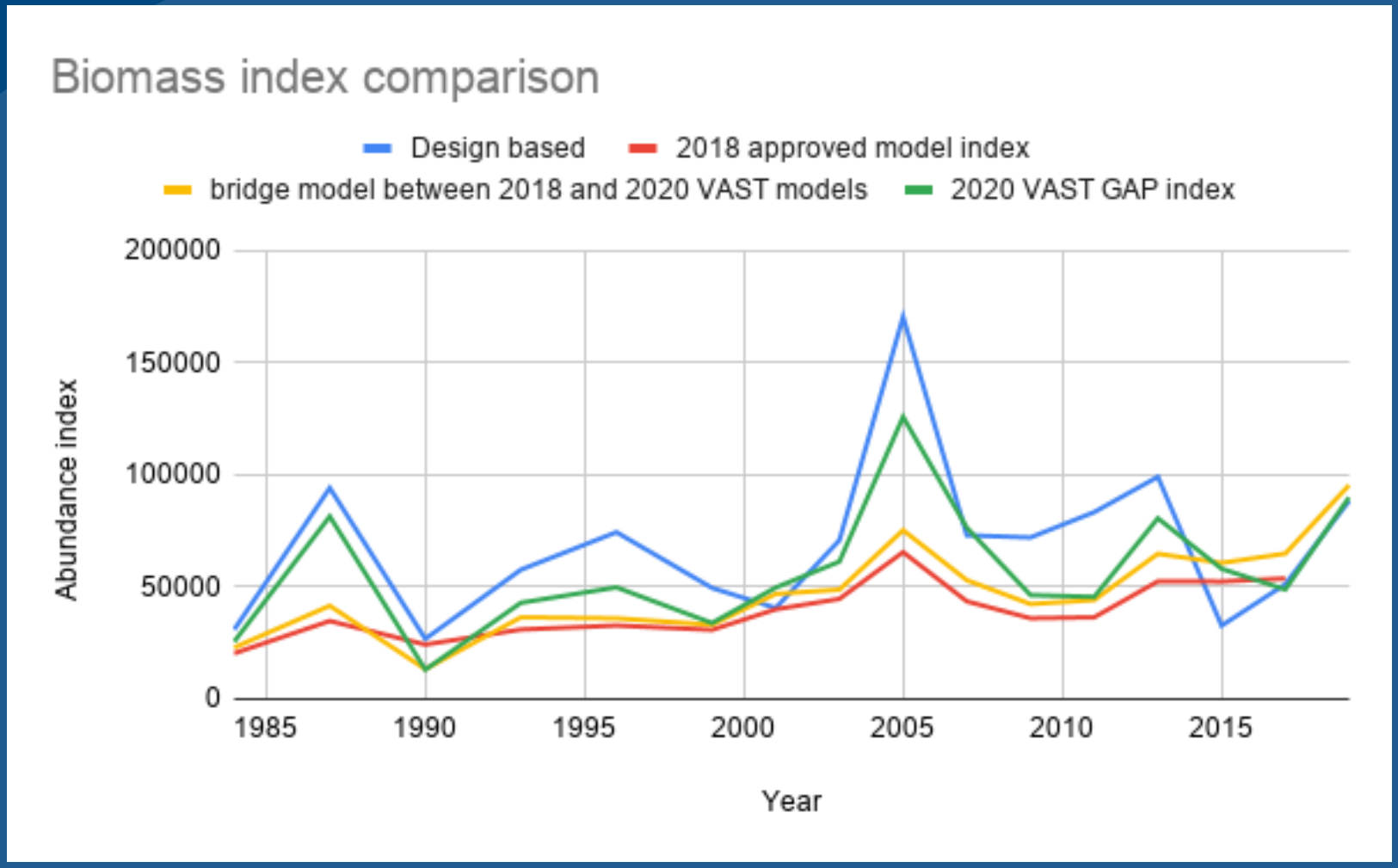


GOA – Dusky Rockfish Diagnostics

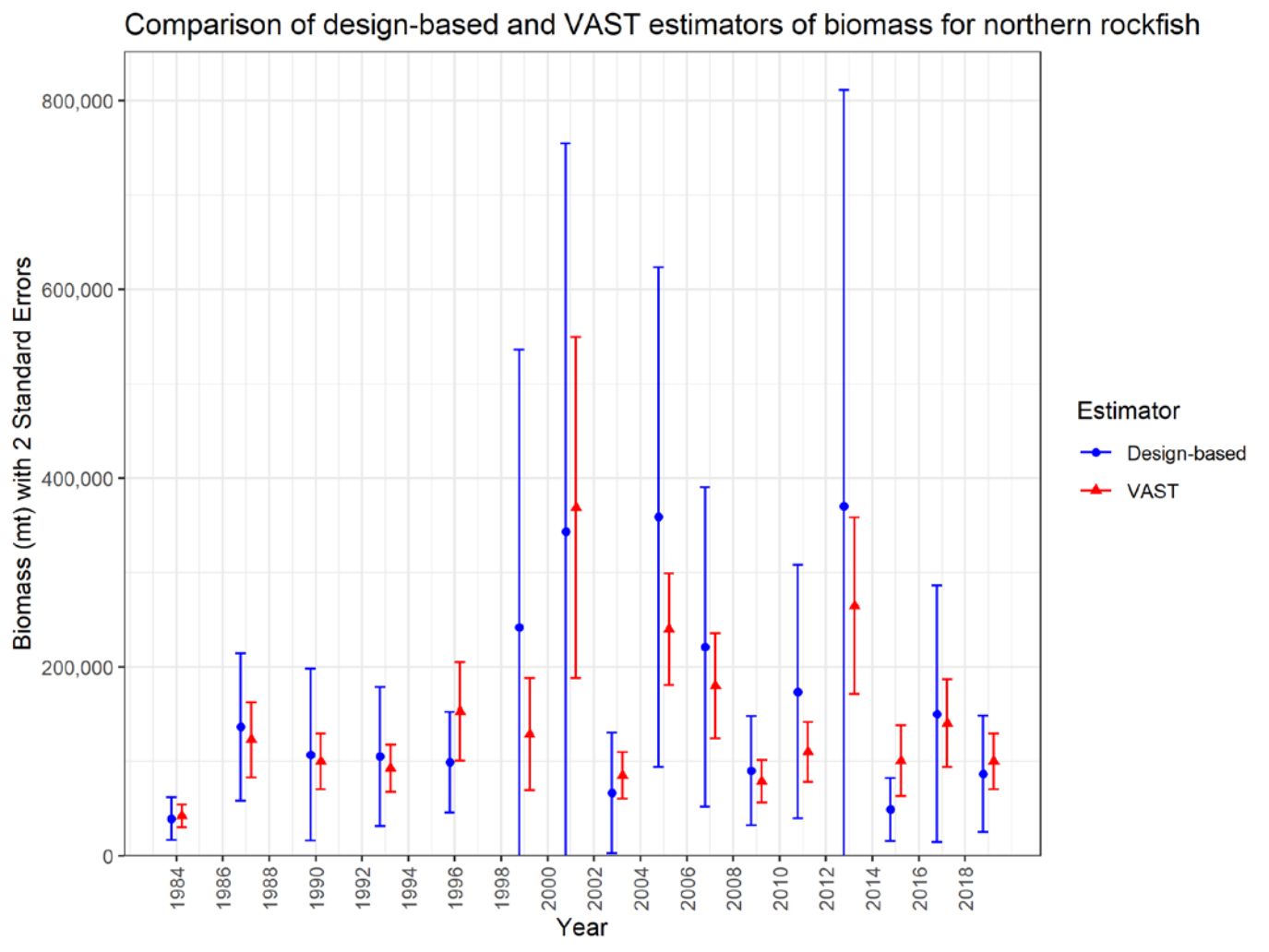




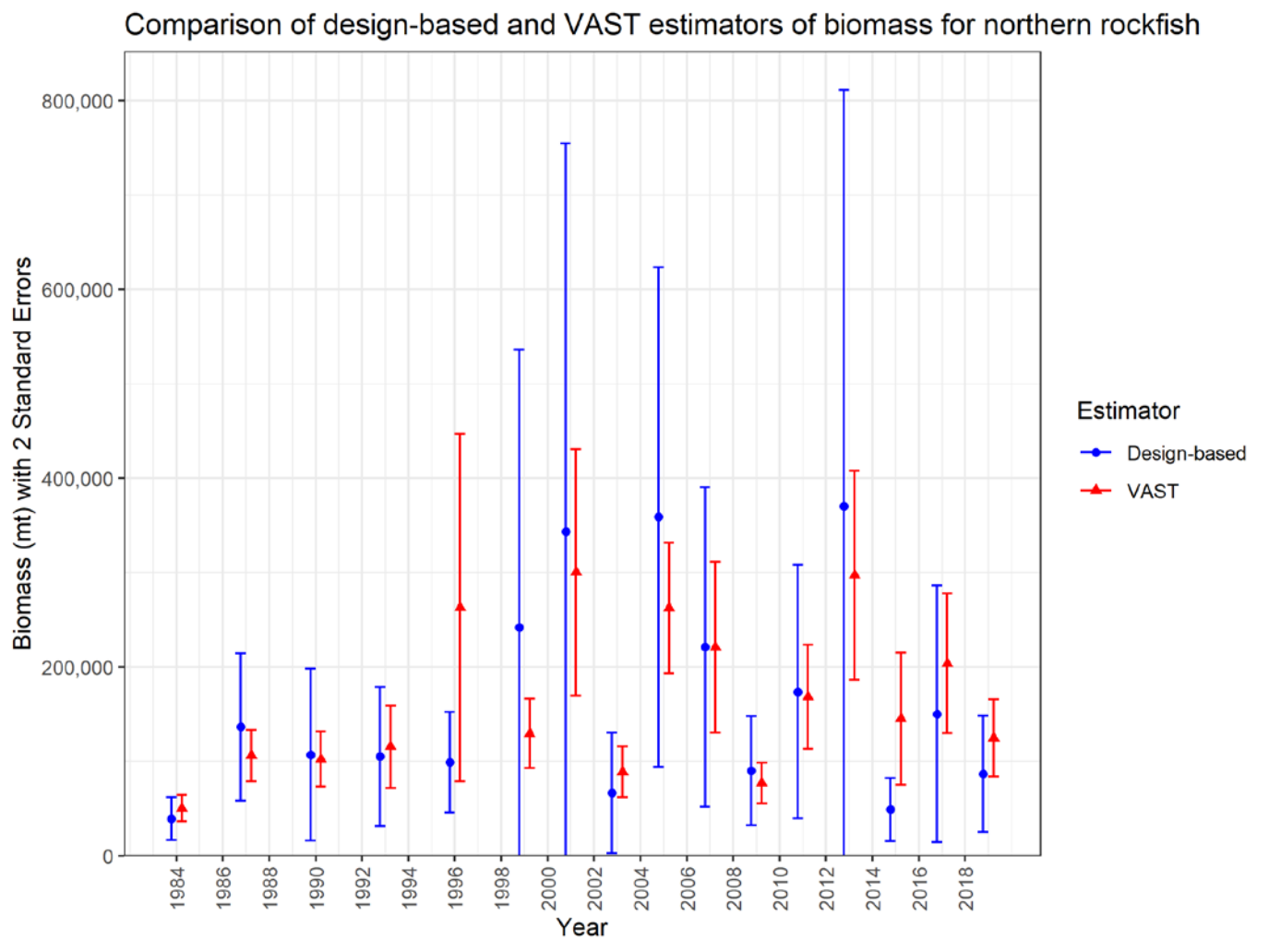
GOA Dusky Rockfish – MESA



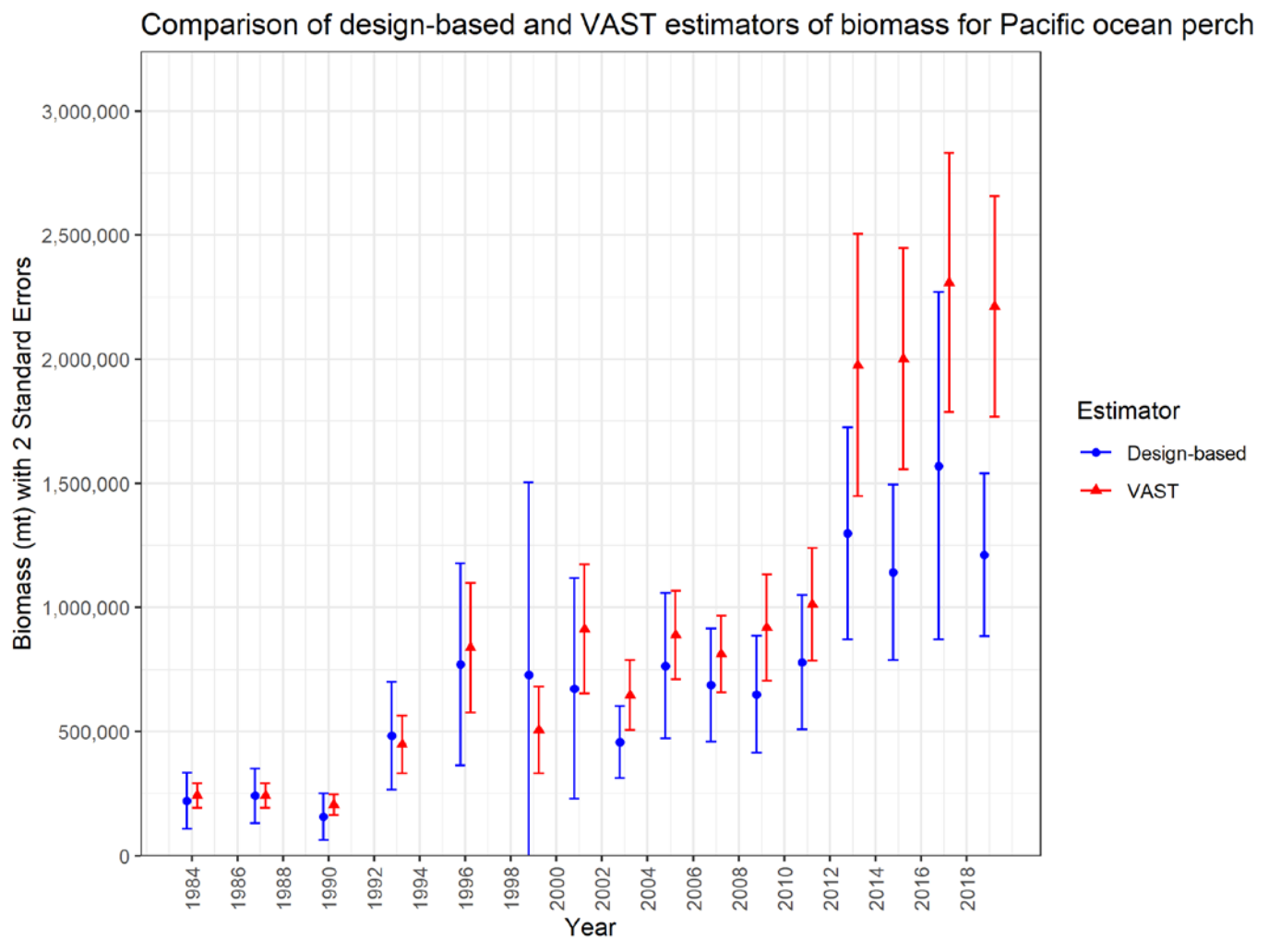
GOA – Northern Rockfish Index



GOA – Northern Rockfish Index Includes Strata > 700m

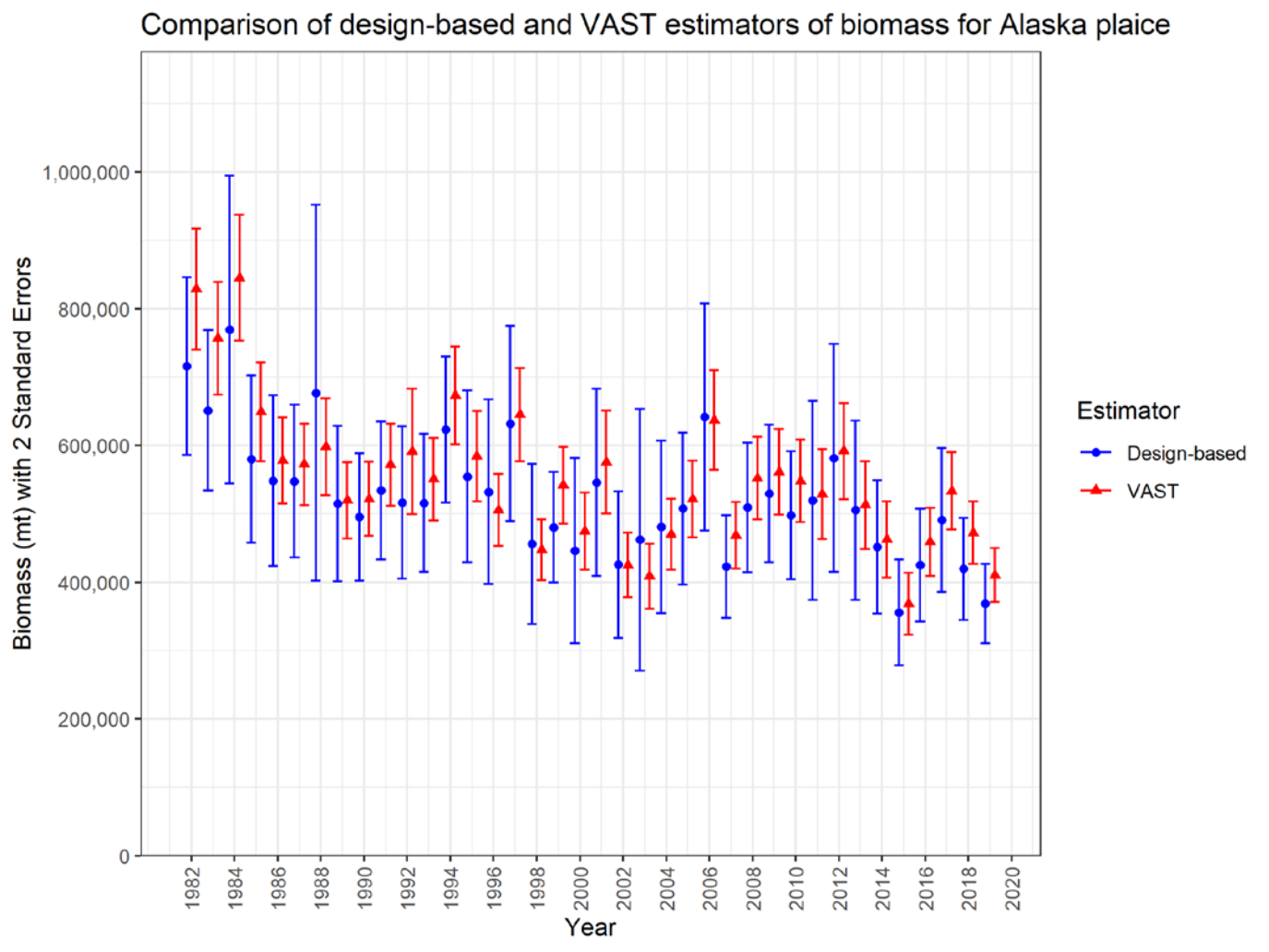


GOA – Pacific Ocean Perch Index

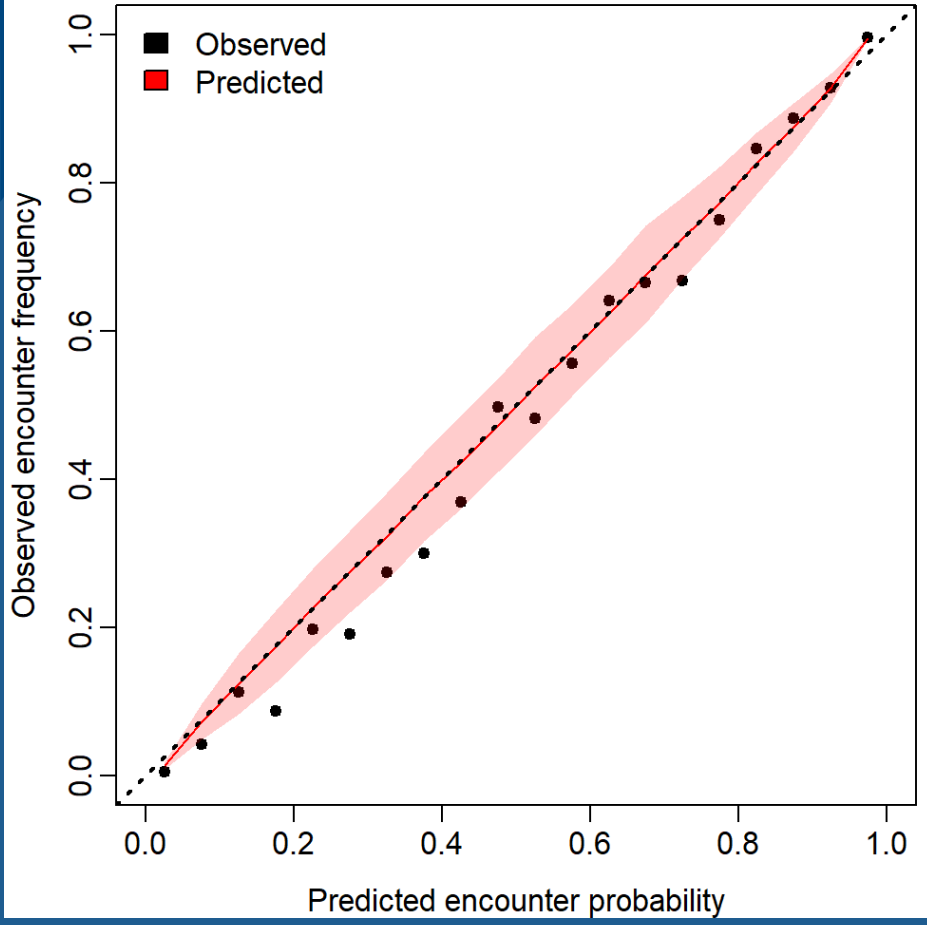


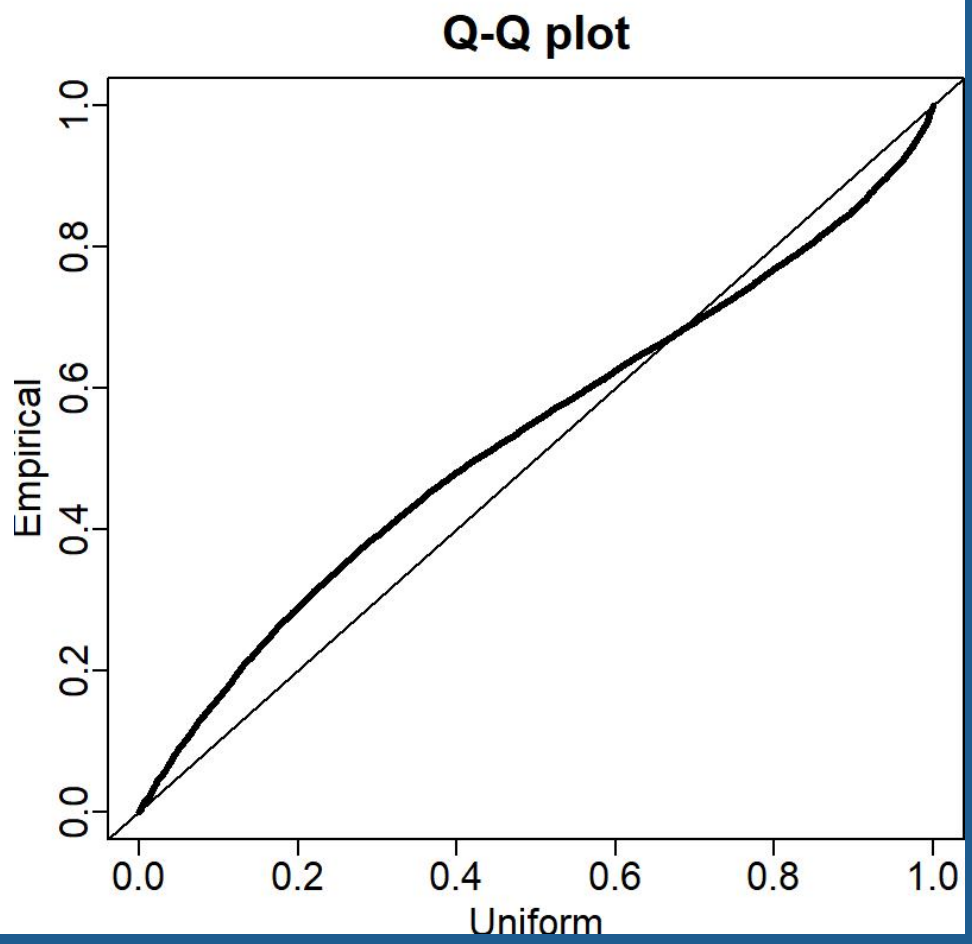
EBS Results

EBS – Alaska Plaice Index

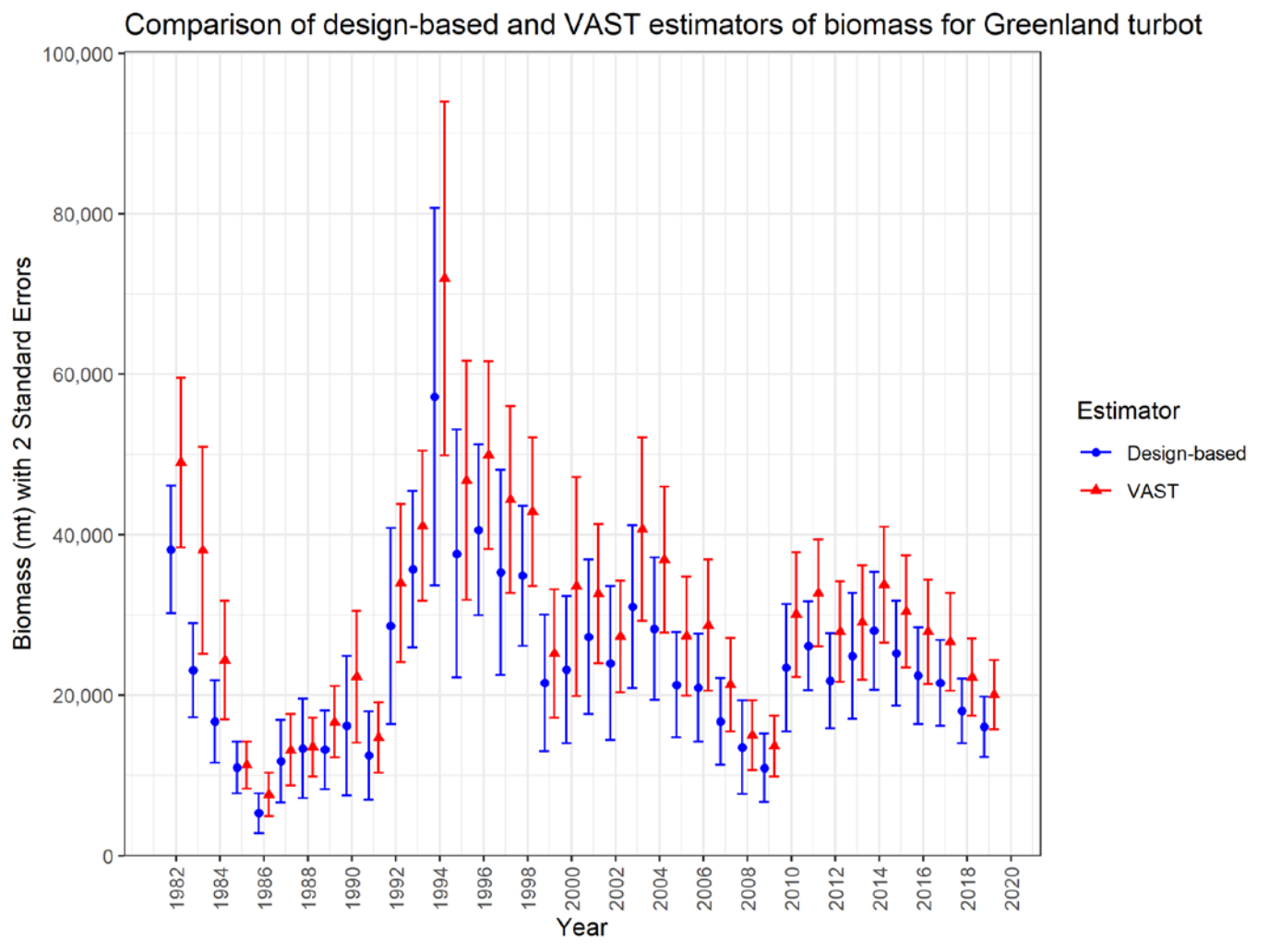


EBS – Alaska Plaice Diagnostics





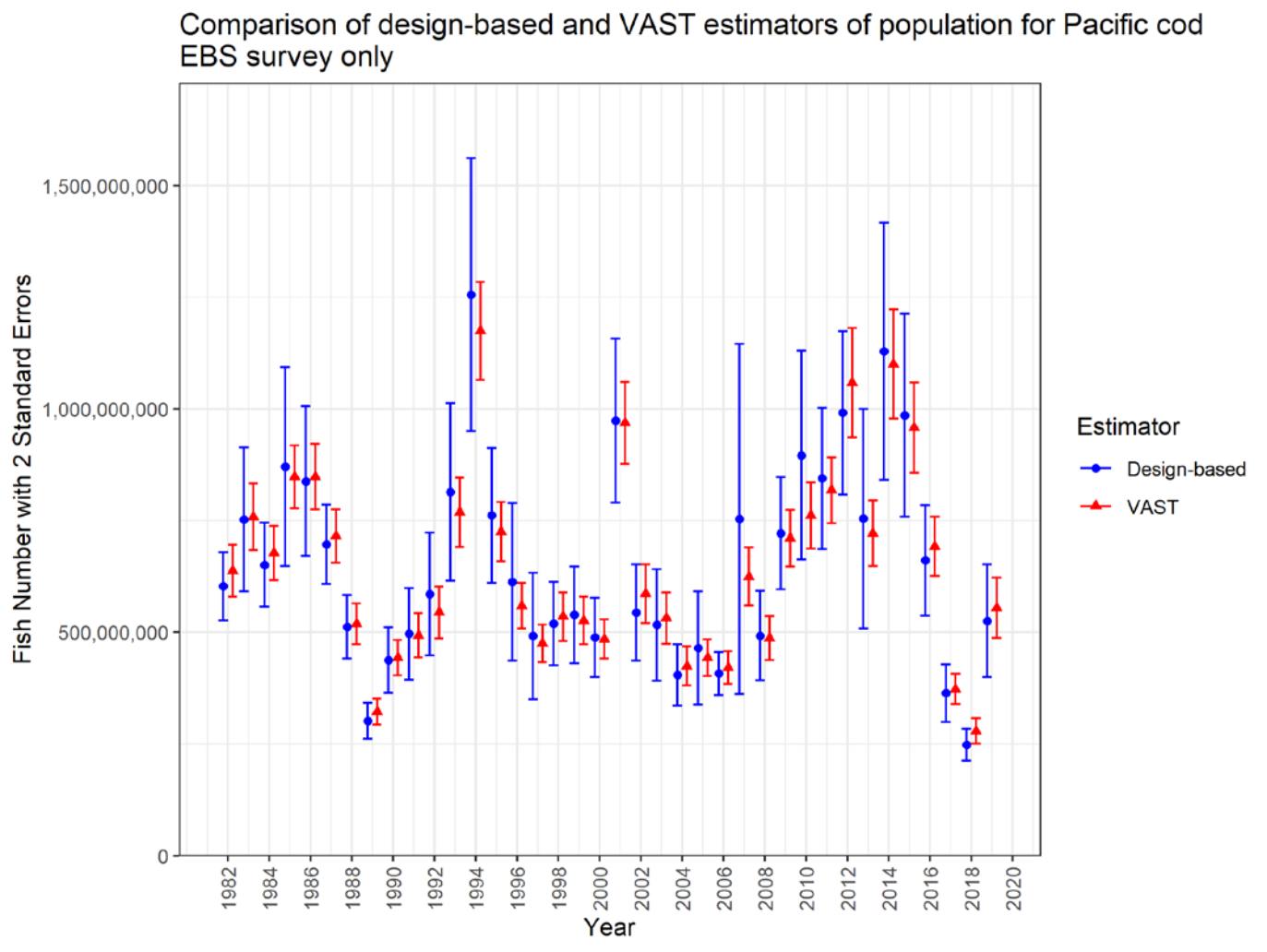
EBS – Greenland Turbot Index



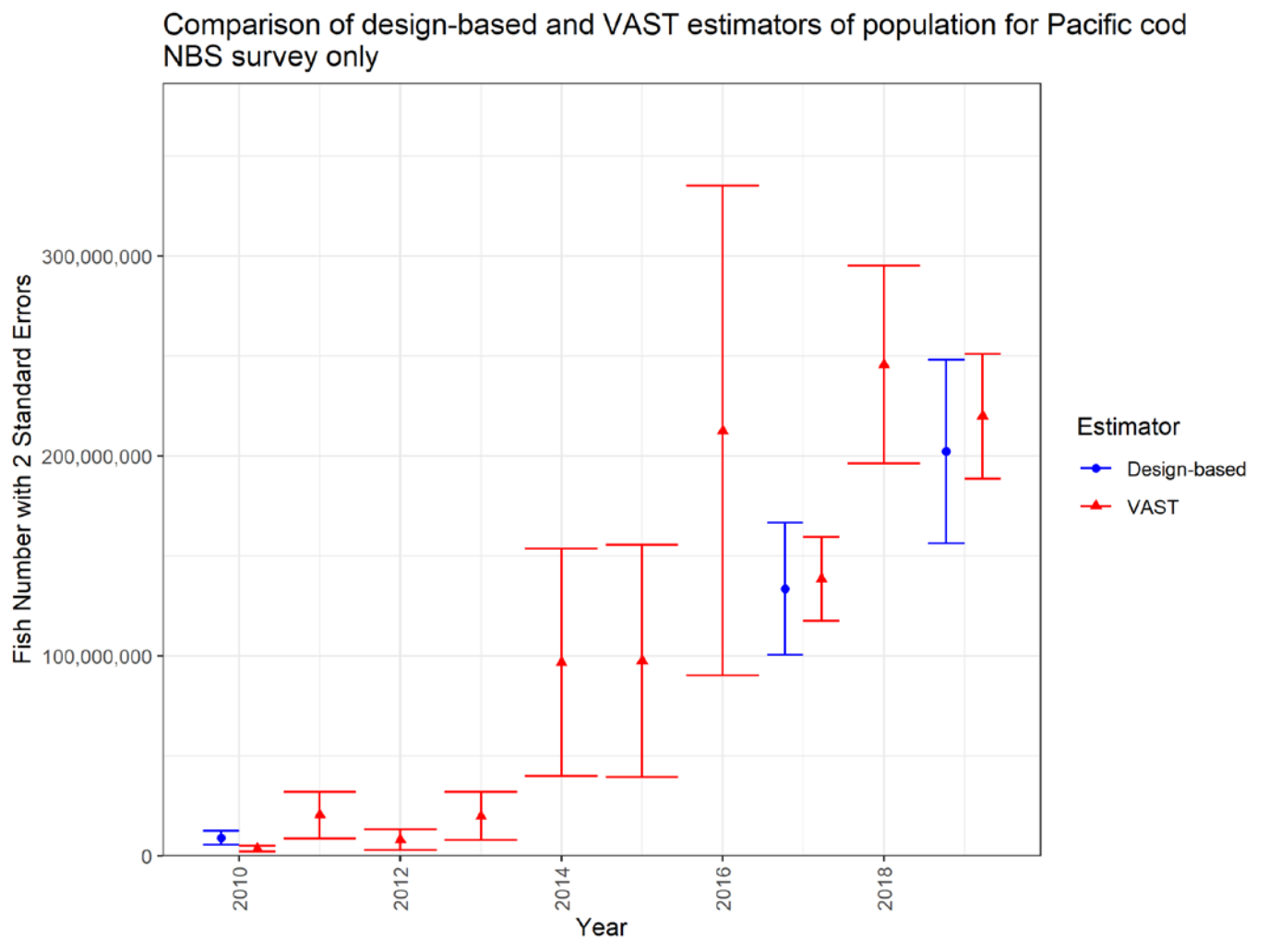
EBS/NBS Results

EBS only – Pacific Cod Index

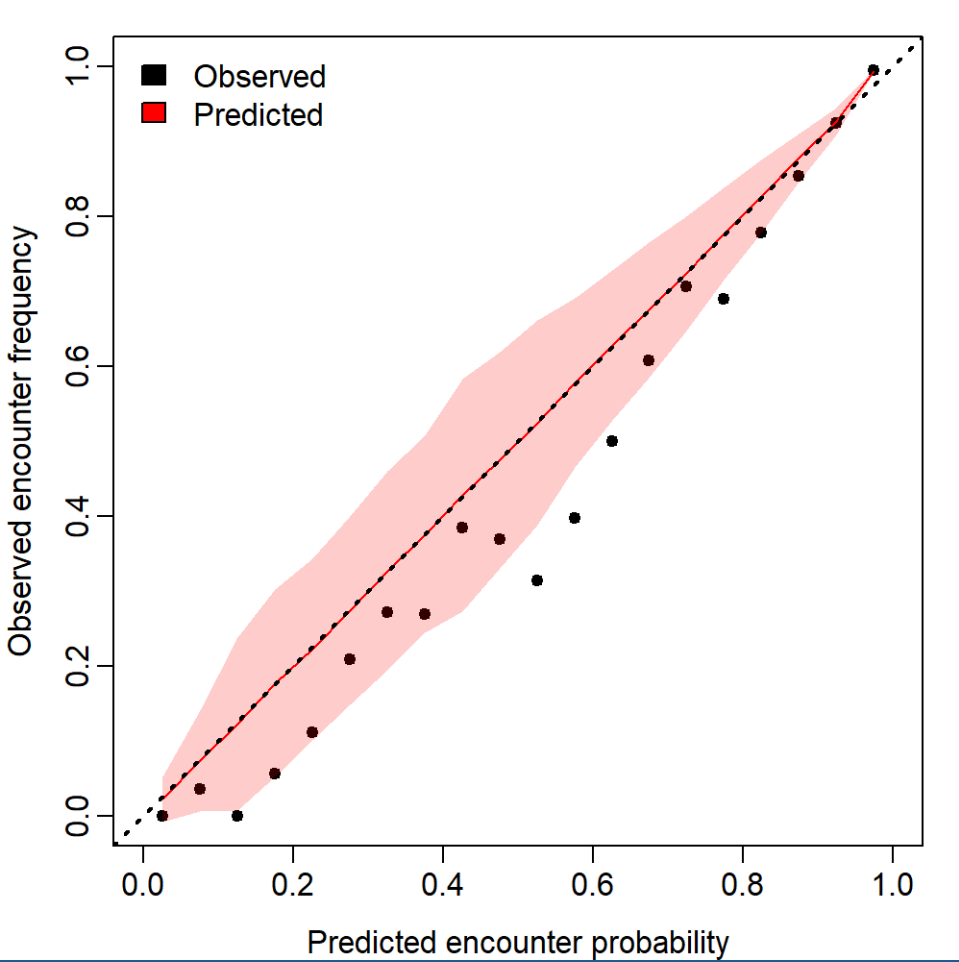
Pacific cod are estimated using fish numbers instead of weight.

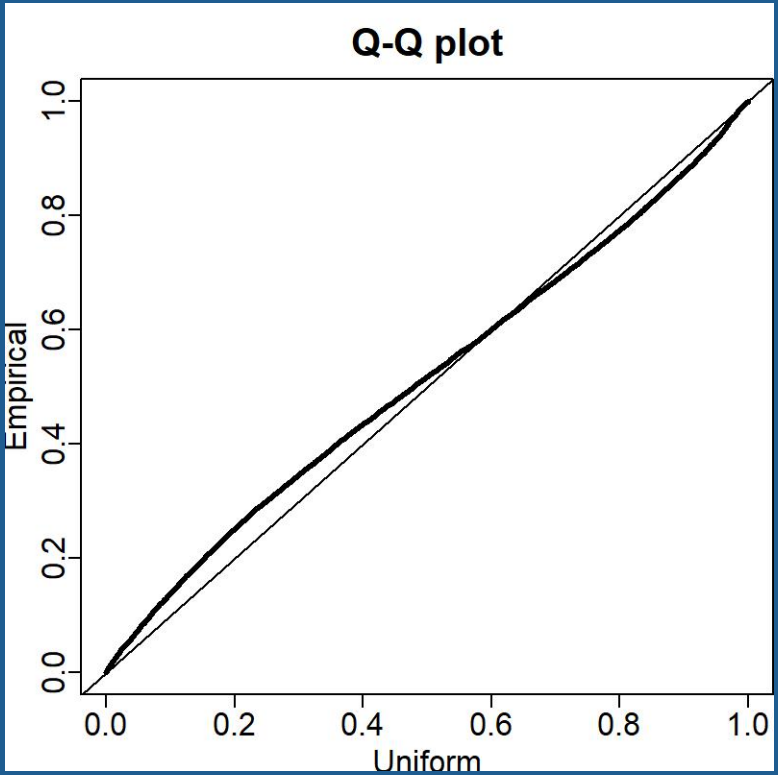


NBS Only – Pacific Cod Index

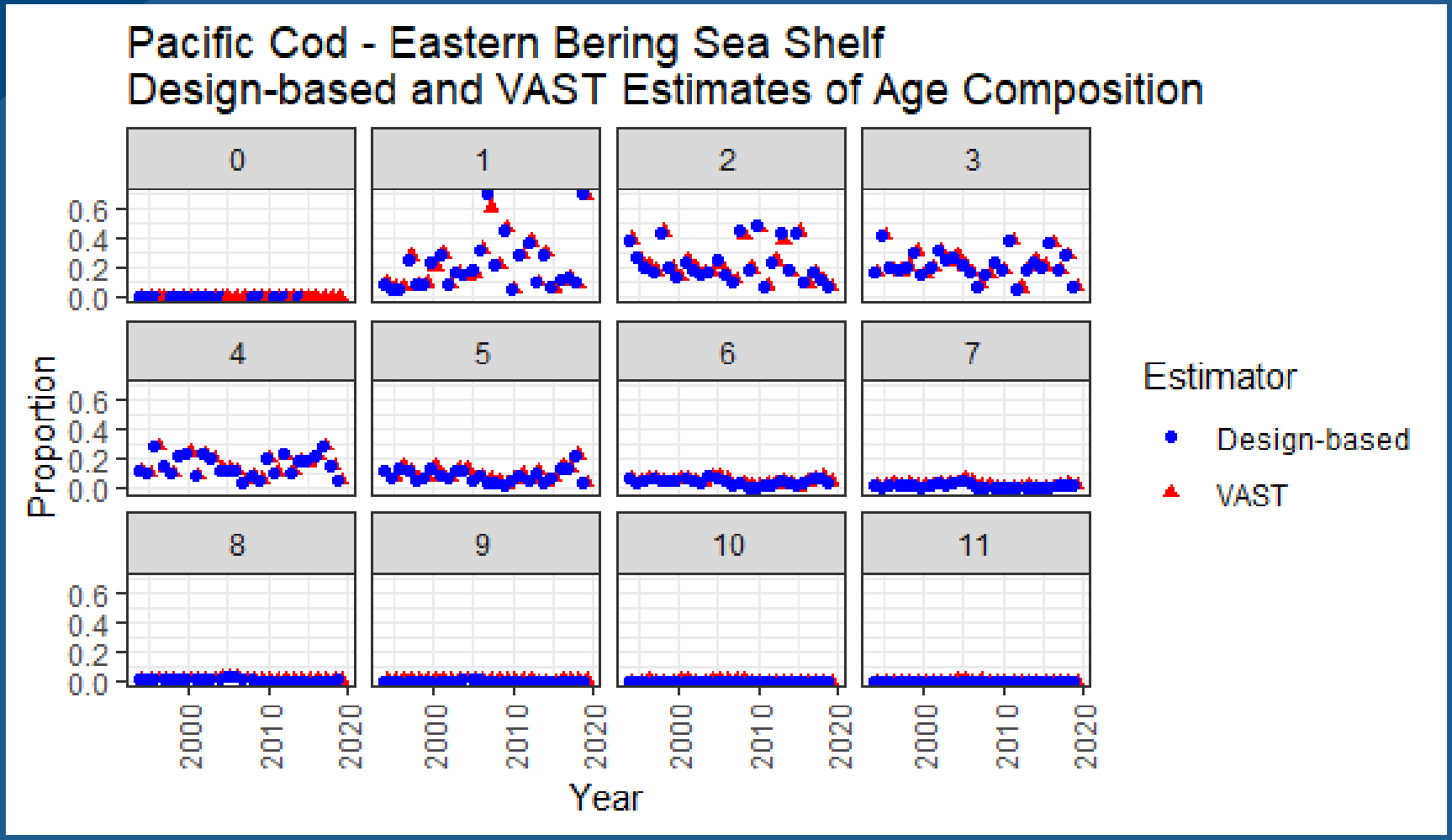


EBS/NBS – Pacific Cod Diagnostics



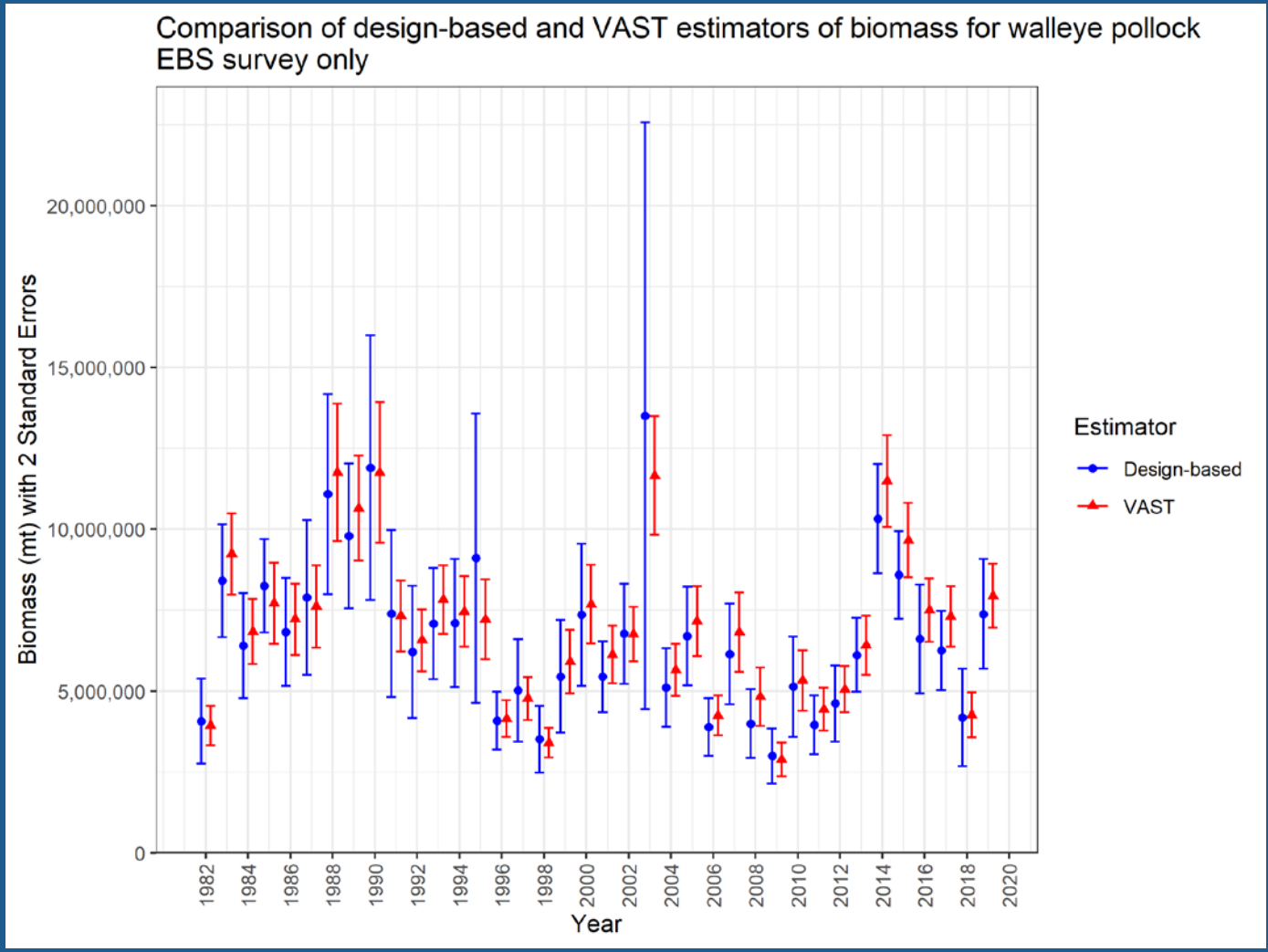


EBS/NBS – Pacific Cod Age Composition

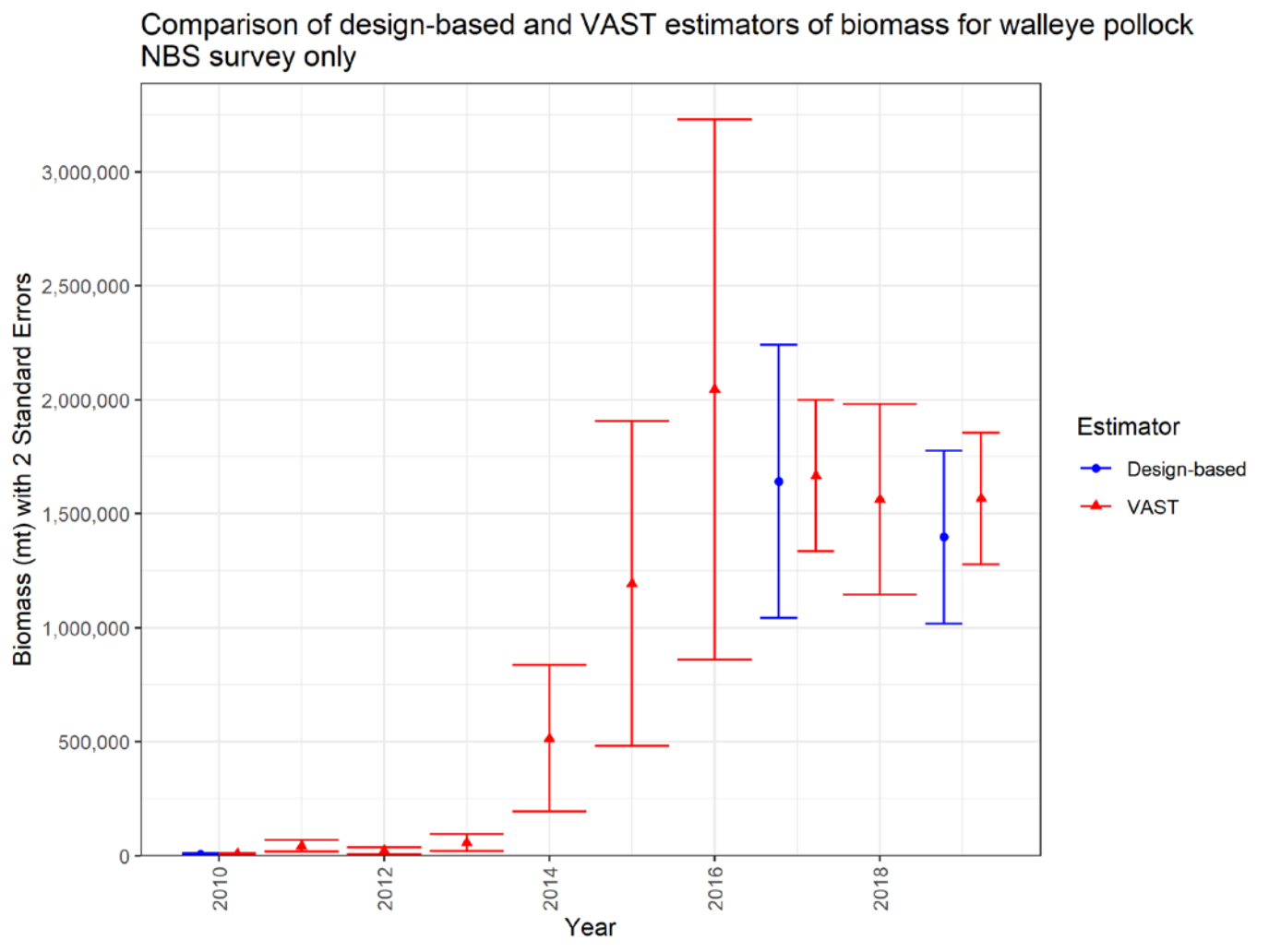


EBS only – Walleye Pollock Index

Pollock CPUE estimates were corrected for density-dependence.



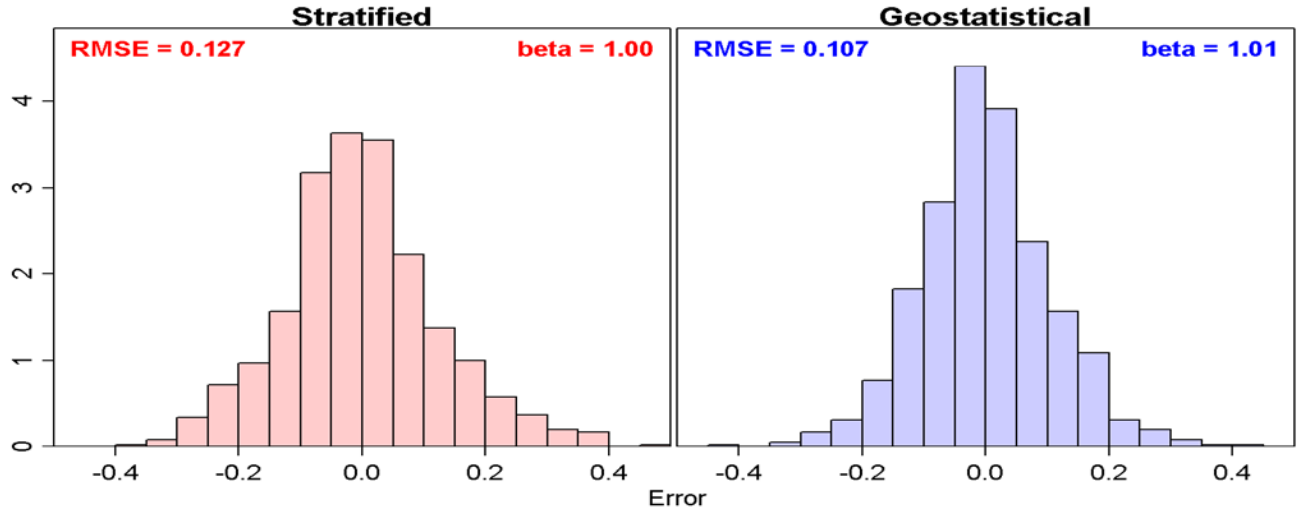
NBS only – Walleye Pollock Index



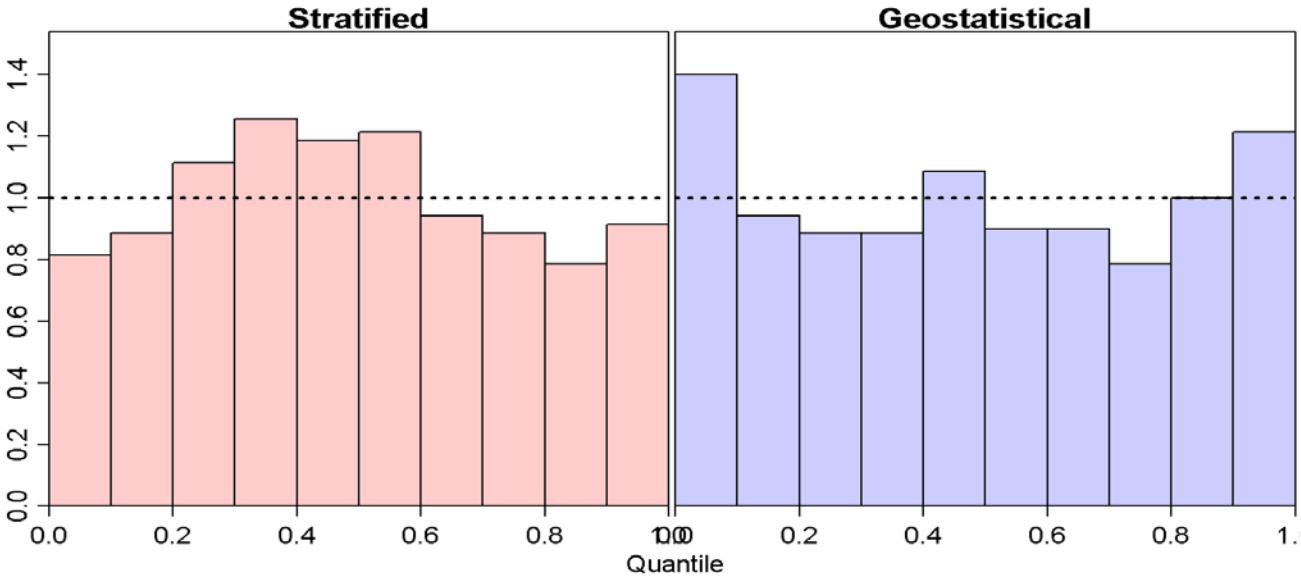
References

- ICES. 2020. ICES Workshop on unavoidable survey effort reduction (WKUSER). ICES Scientific Reports. 2:72. 92pp. http://doi.org/10.17895/ices.pub.7453
- Thorson, J. T. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. *Fisheries Research* (210), pp. 143-161.

Supplemental Slides



Neither model has badly calibrated intervals



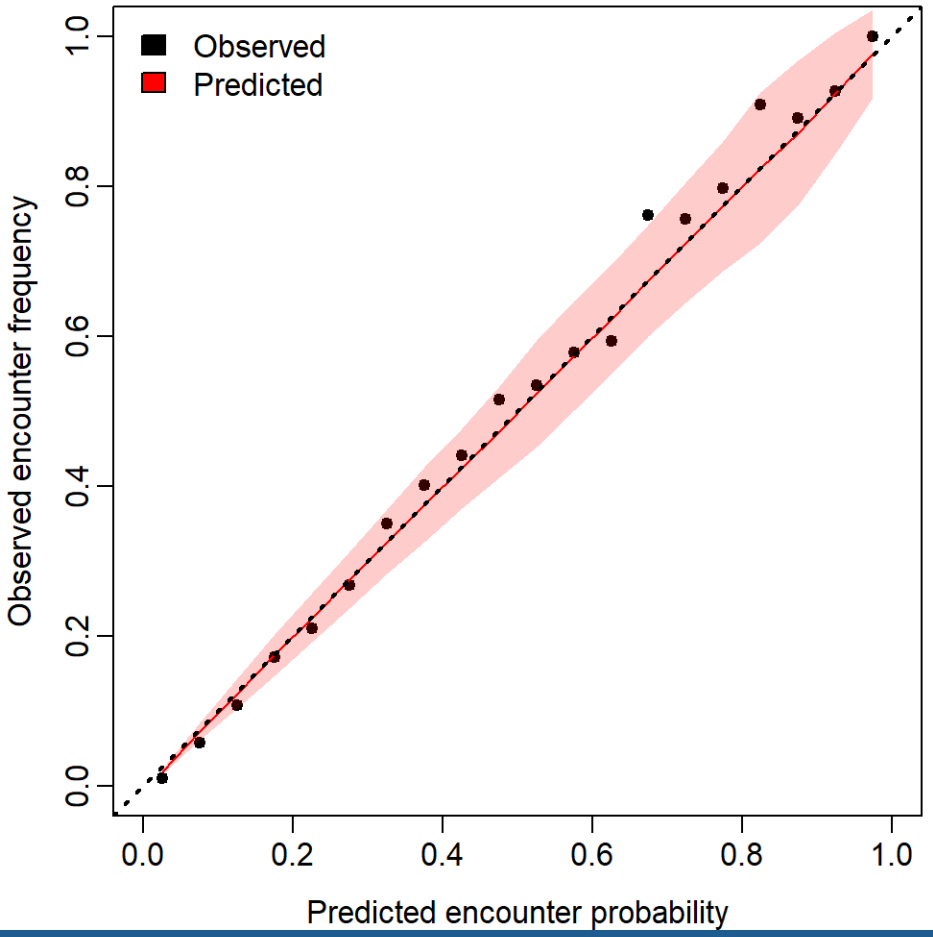
Thorson et al. 2015 ICES JMS

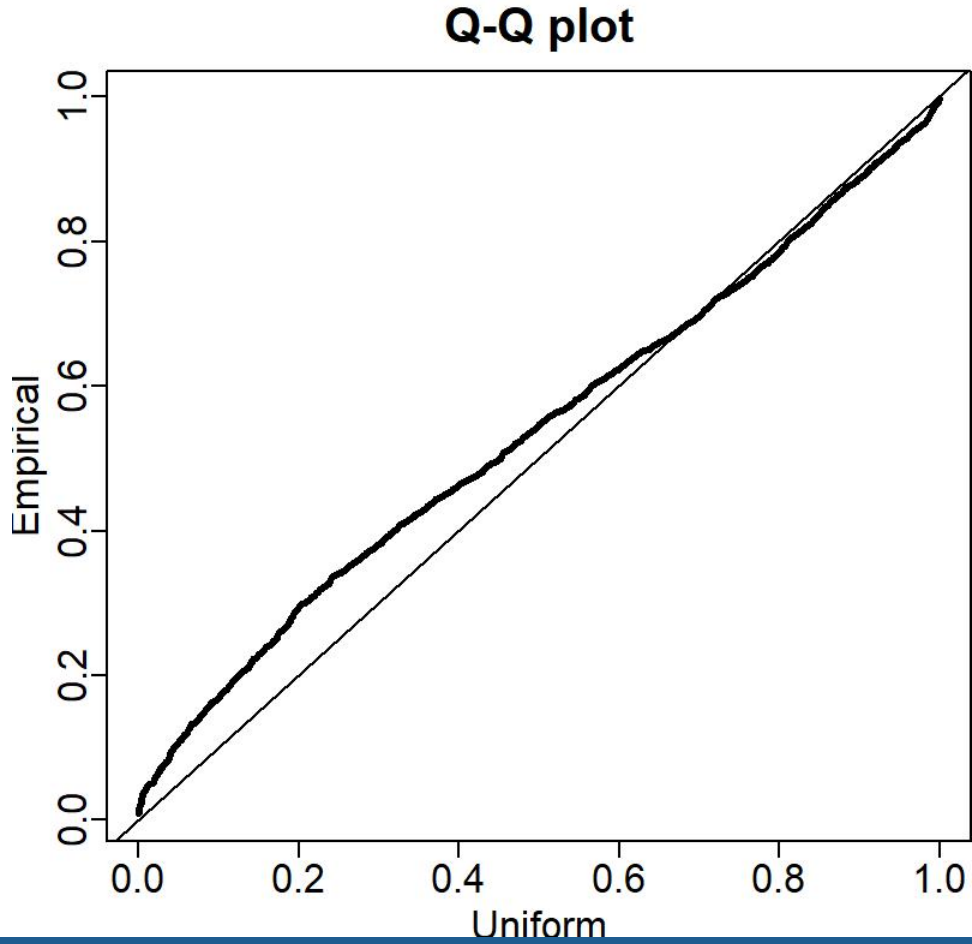
Software Versions

- INLA - 18.07.12
- TMB - 1.7.15
- TMBhelper - 1.2.0
- FishStatsUtils - 2.5.0
- VAST - 3.3.0
- cpp - VAST_v8_5_0
- sumfish - >= 3.1.22

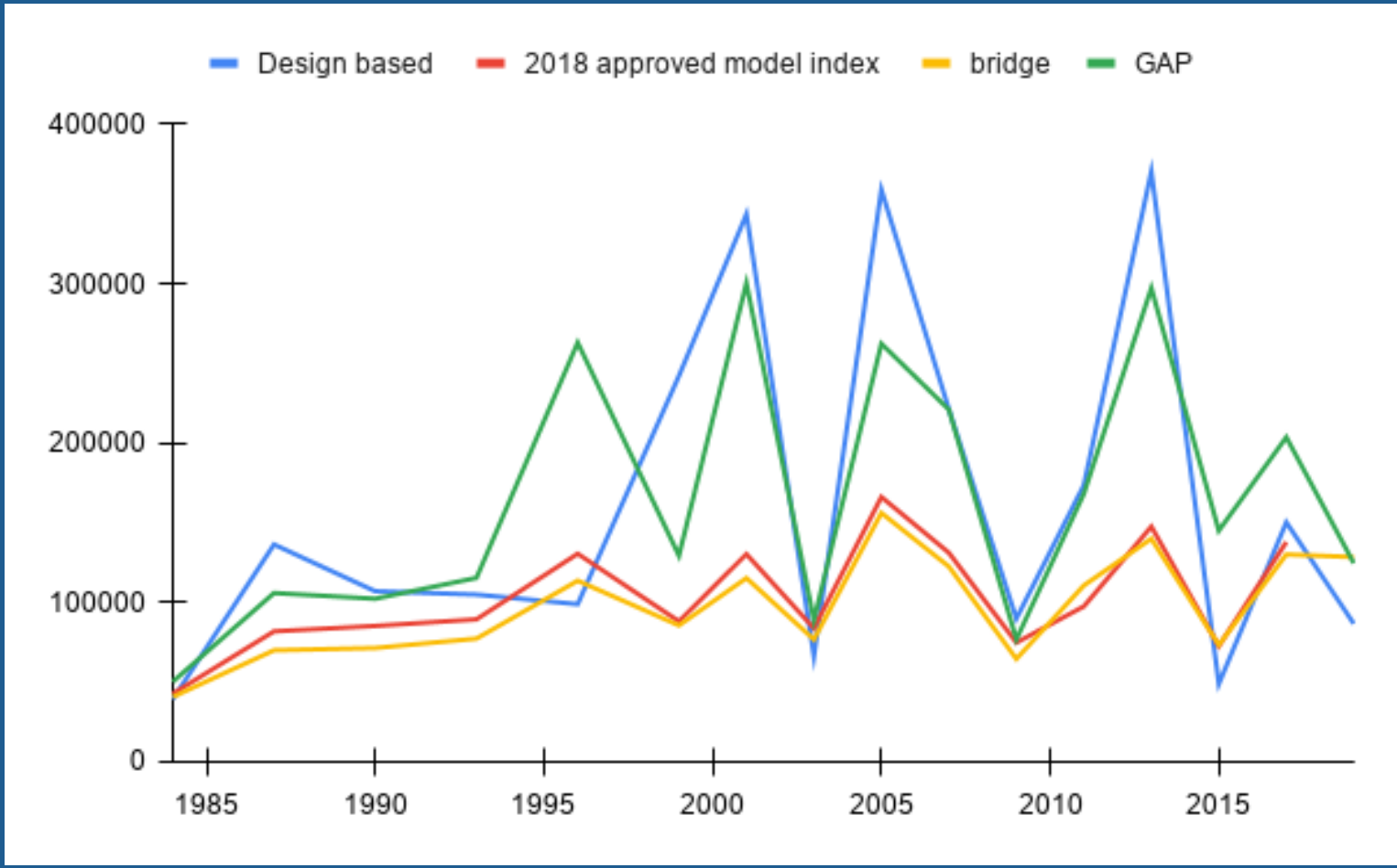
GOA Results - Supplemental

GOA – Northern Rockfish Diagnostics

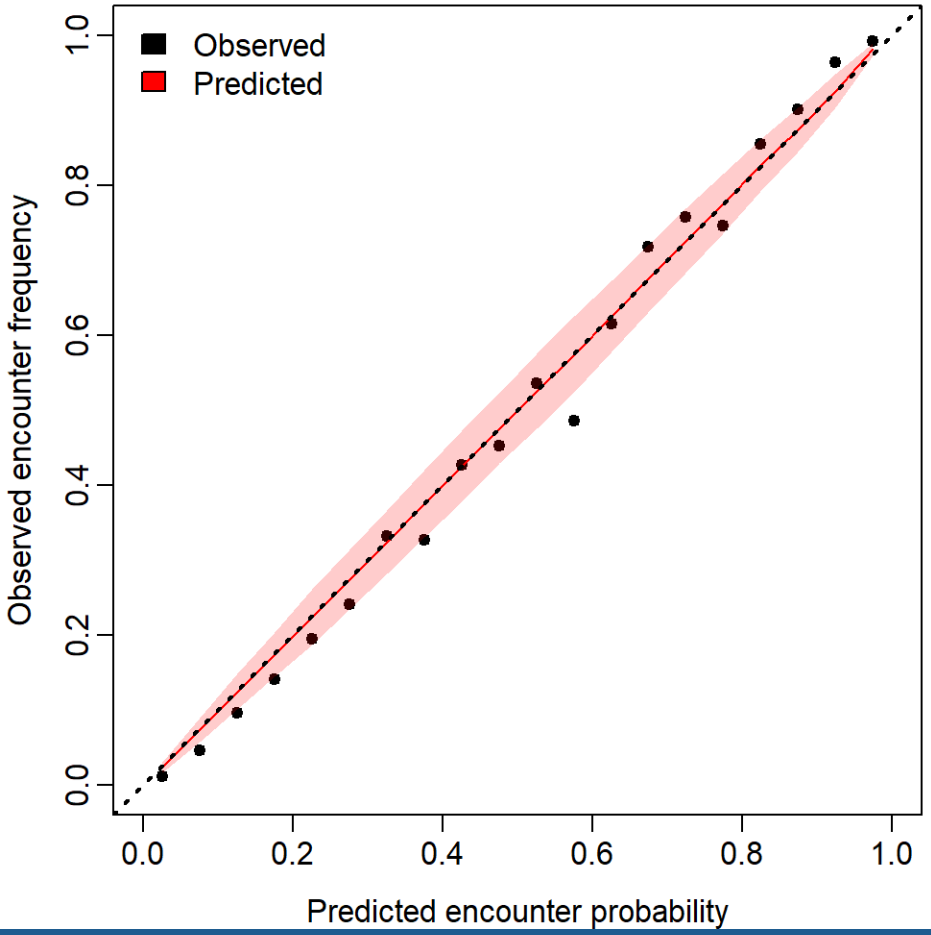


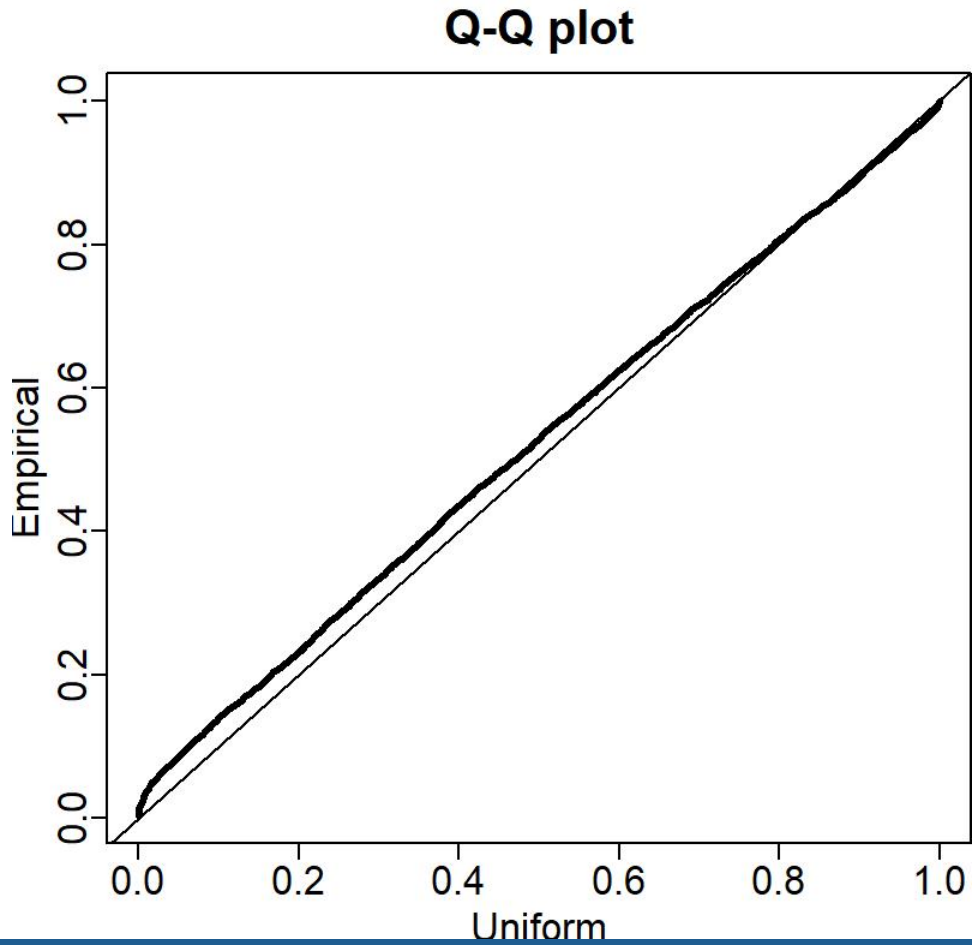


GOA northern rockfish - MESA (preliminary run includes strata >700m)

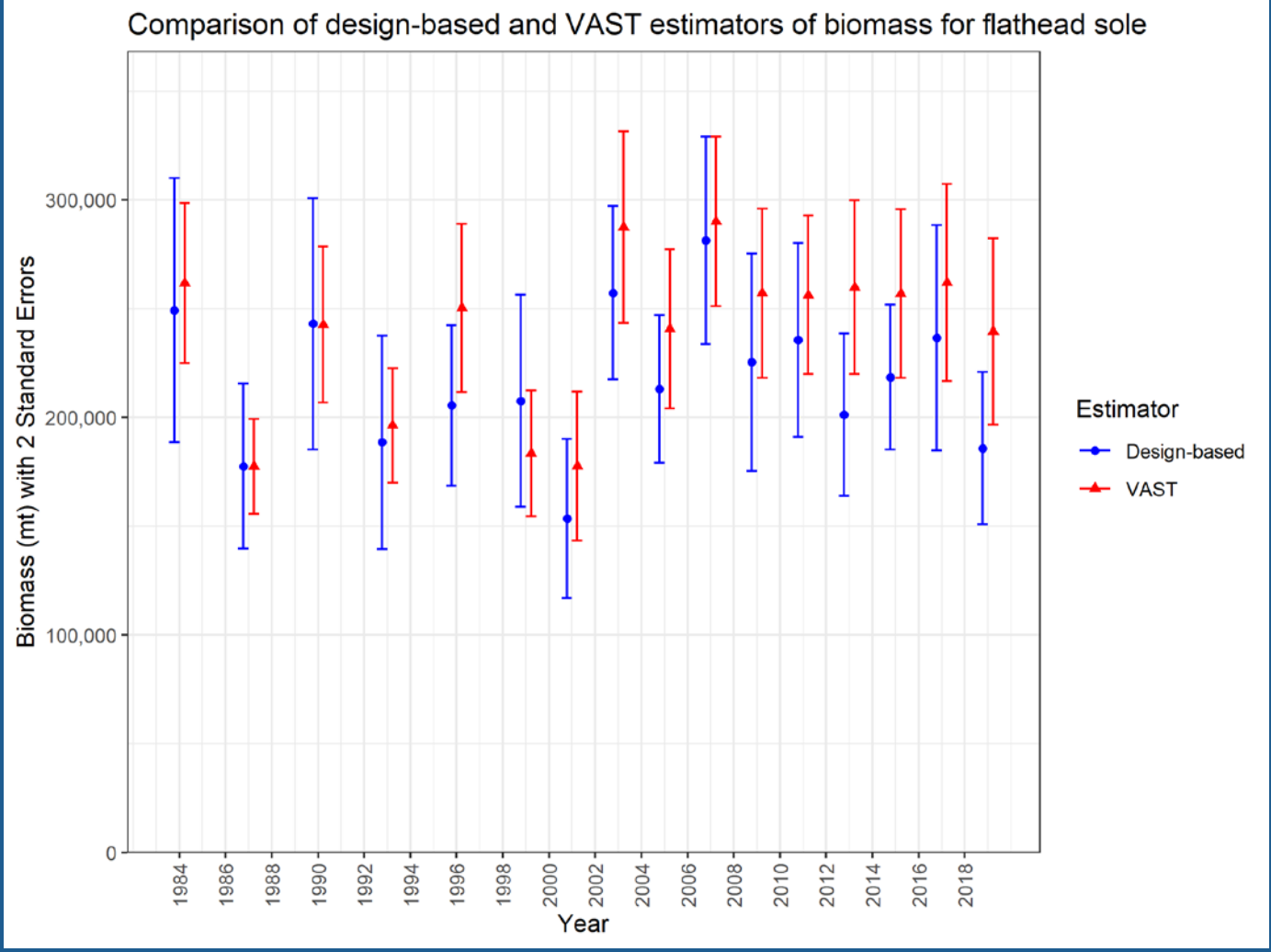


GOA – Pacific Ocean Perch Diagnostics

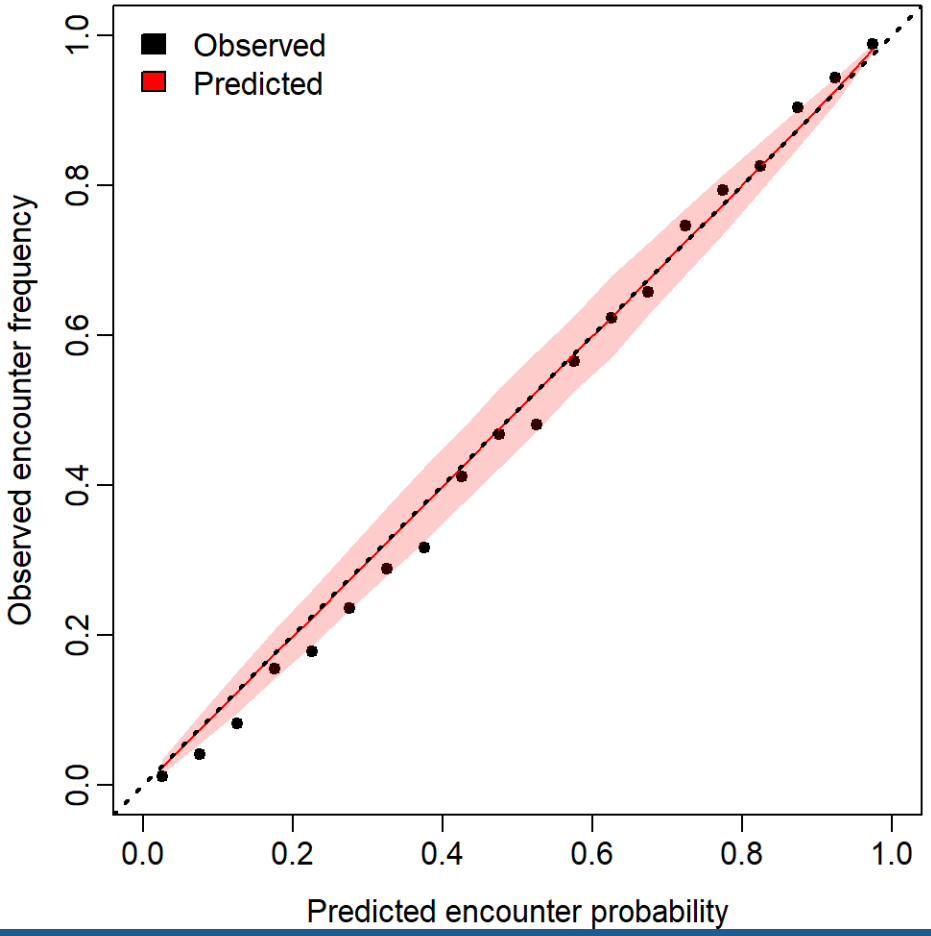


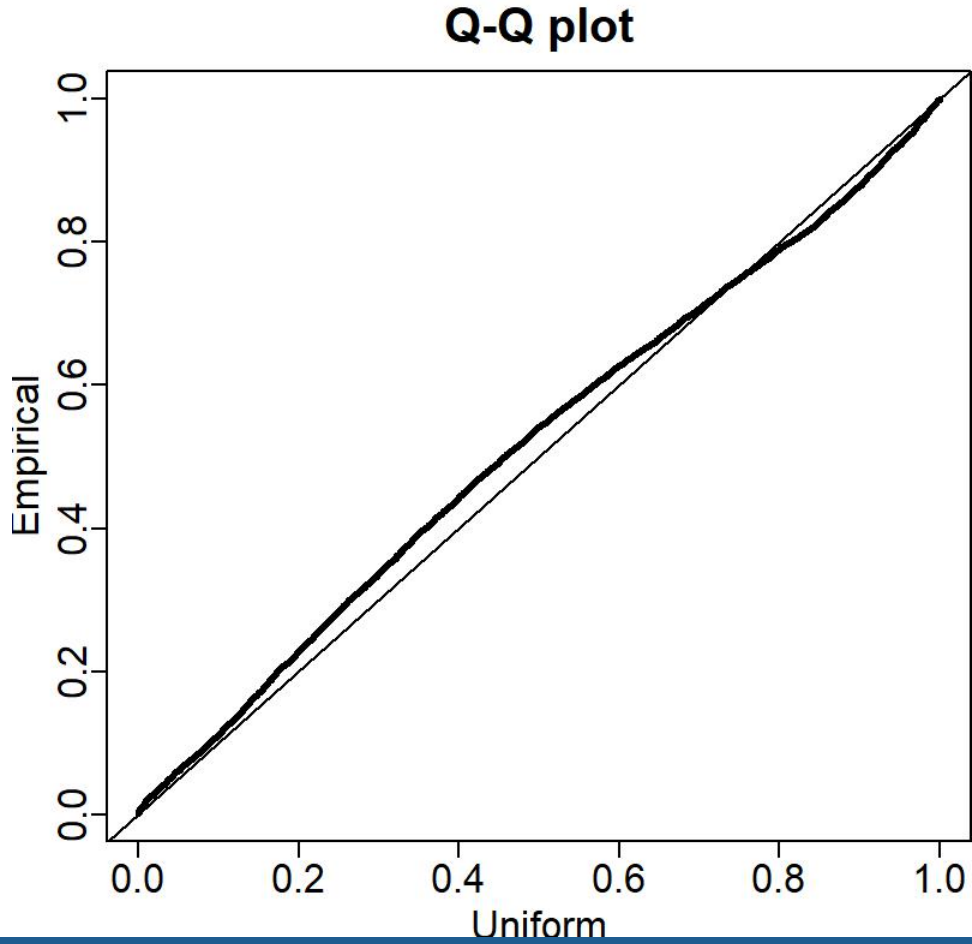


GOA – Flathead Sole Index

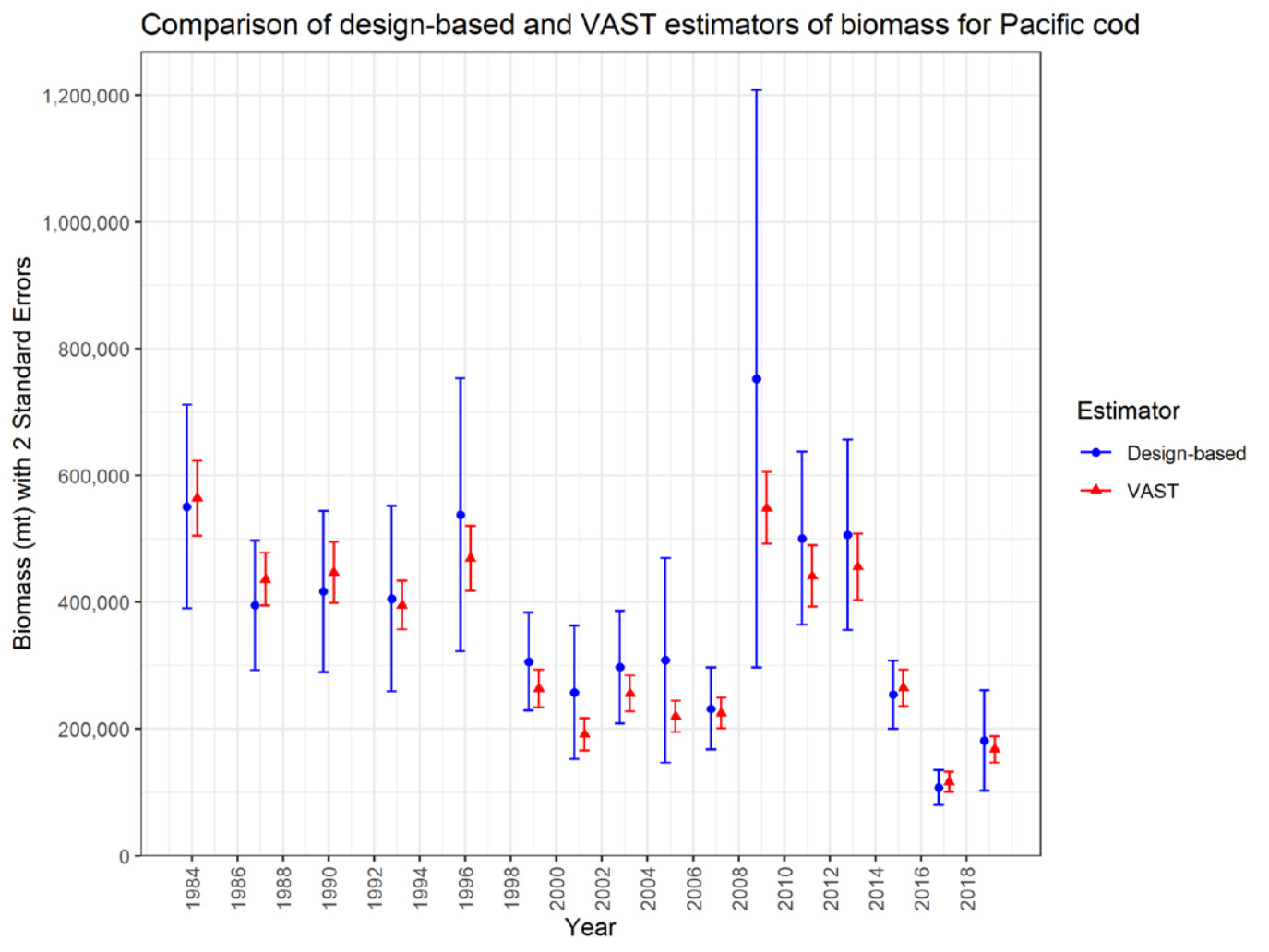


GOA – Flathead Sole Diagnostics

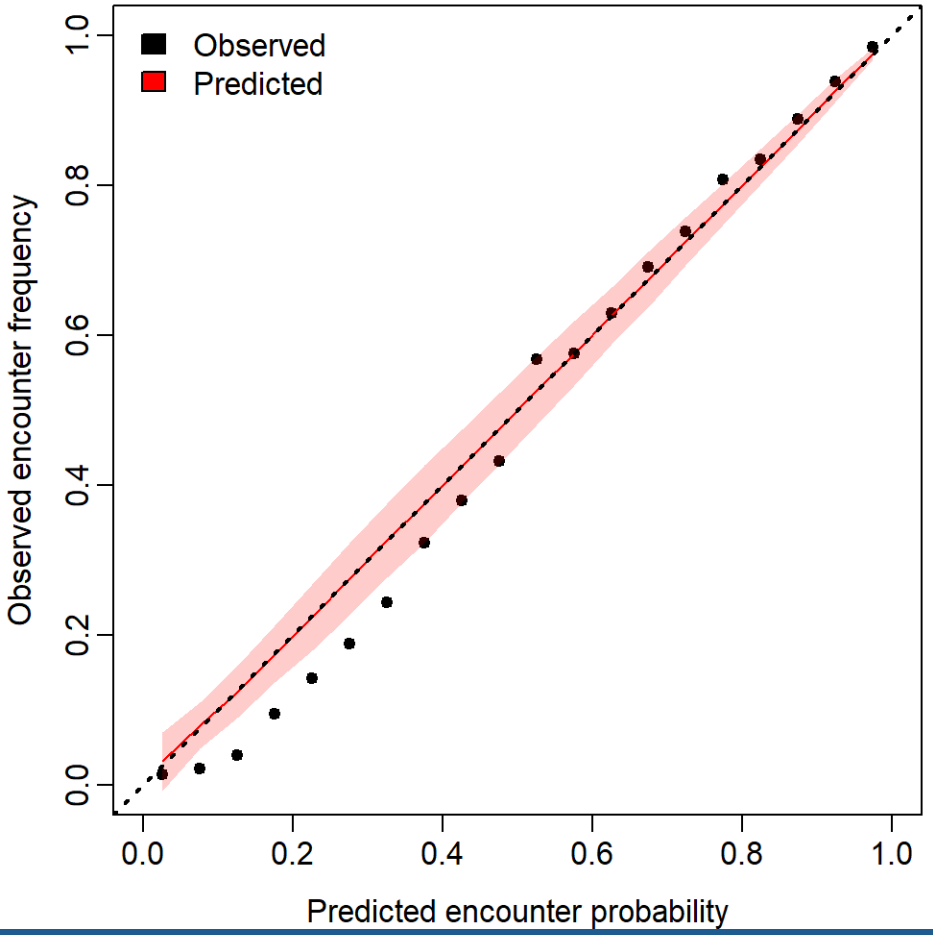


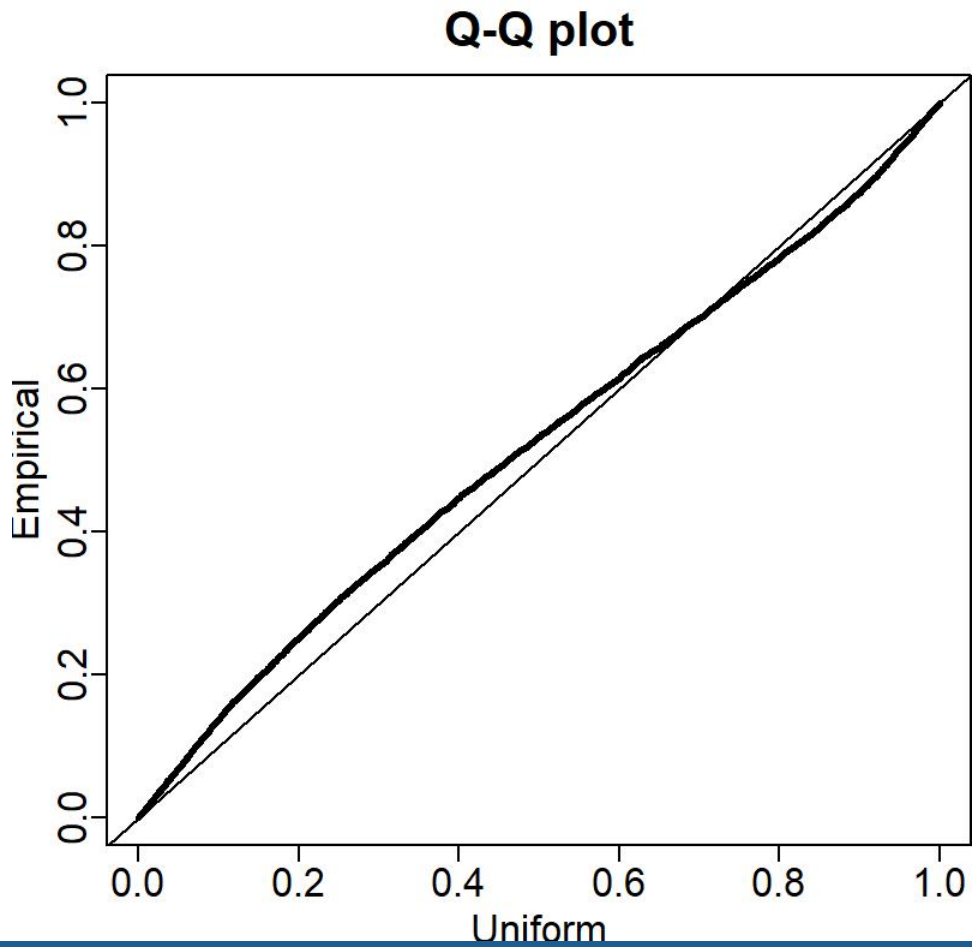


GOA – Pacific Cod Index

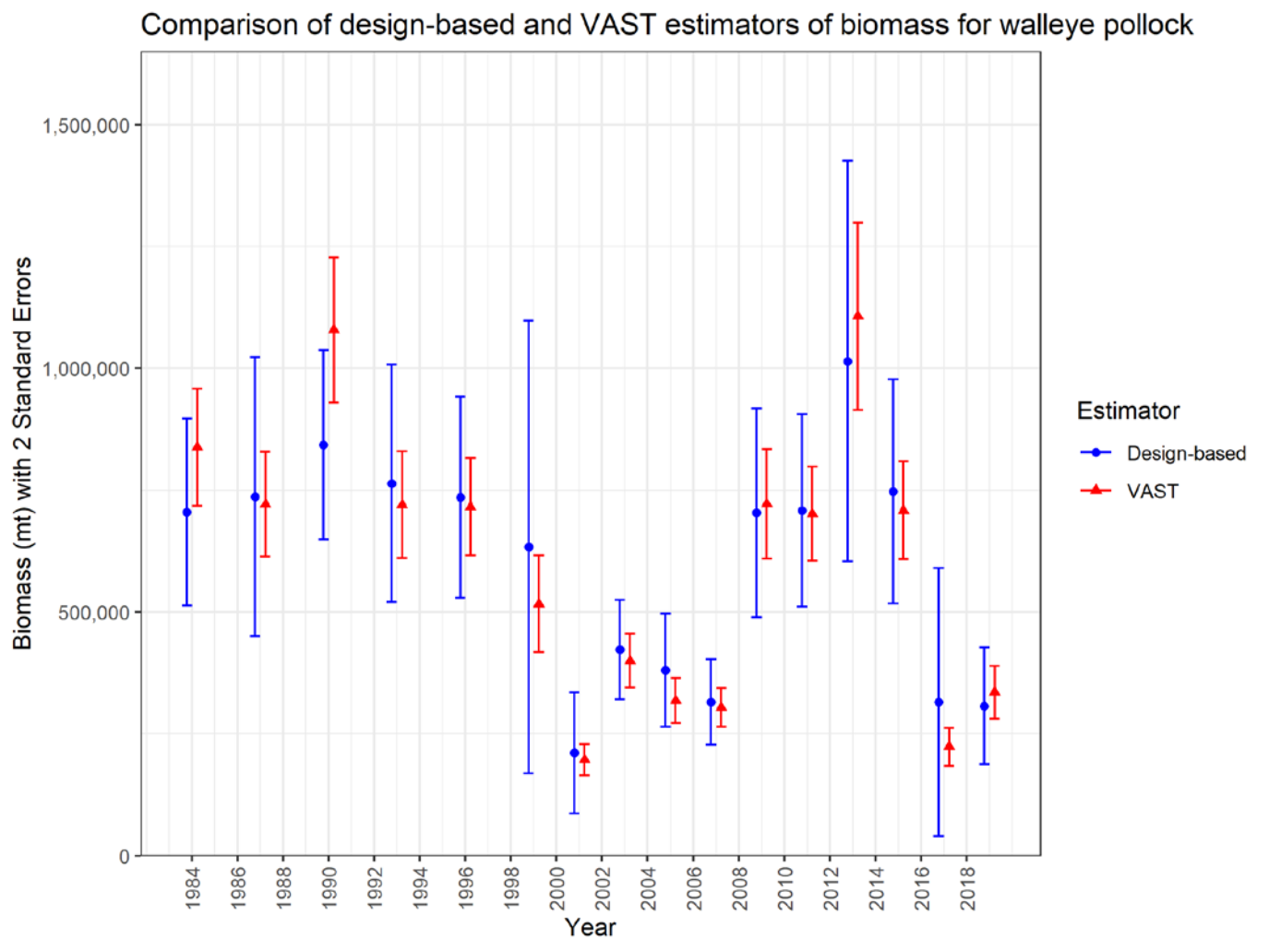


GOA – Pacific Cod Diagnostics

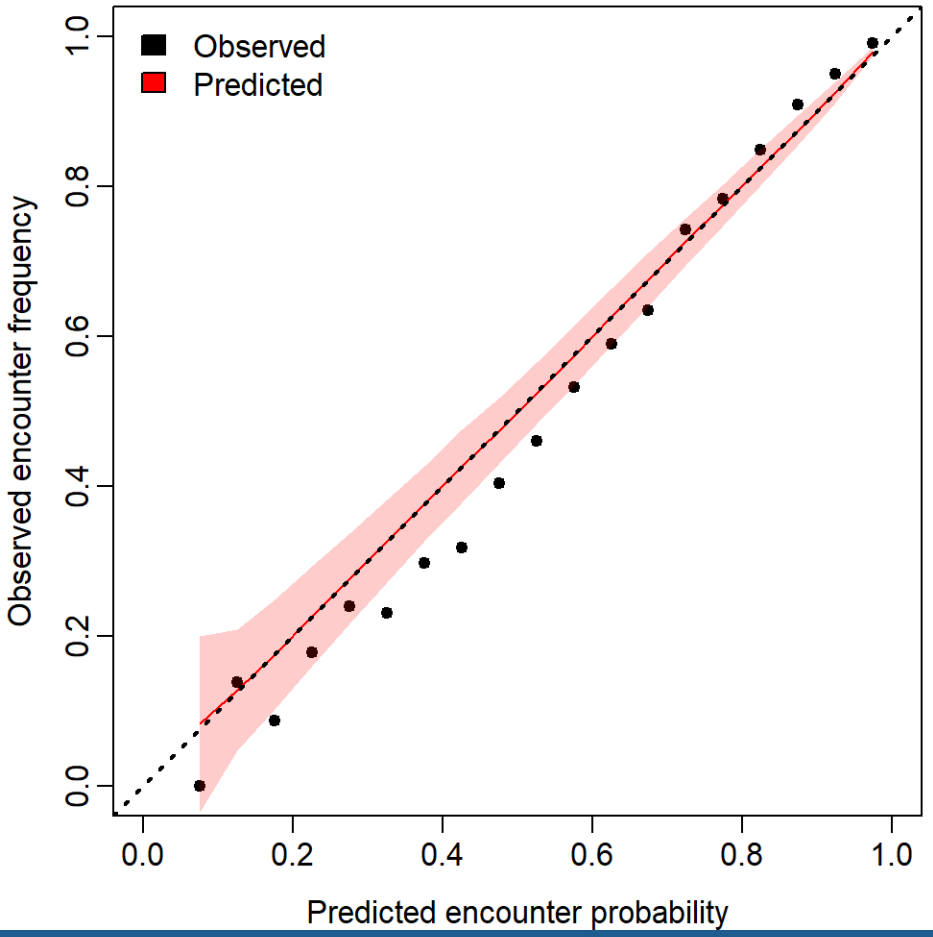


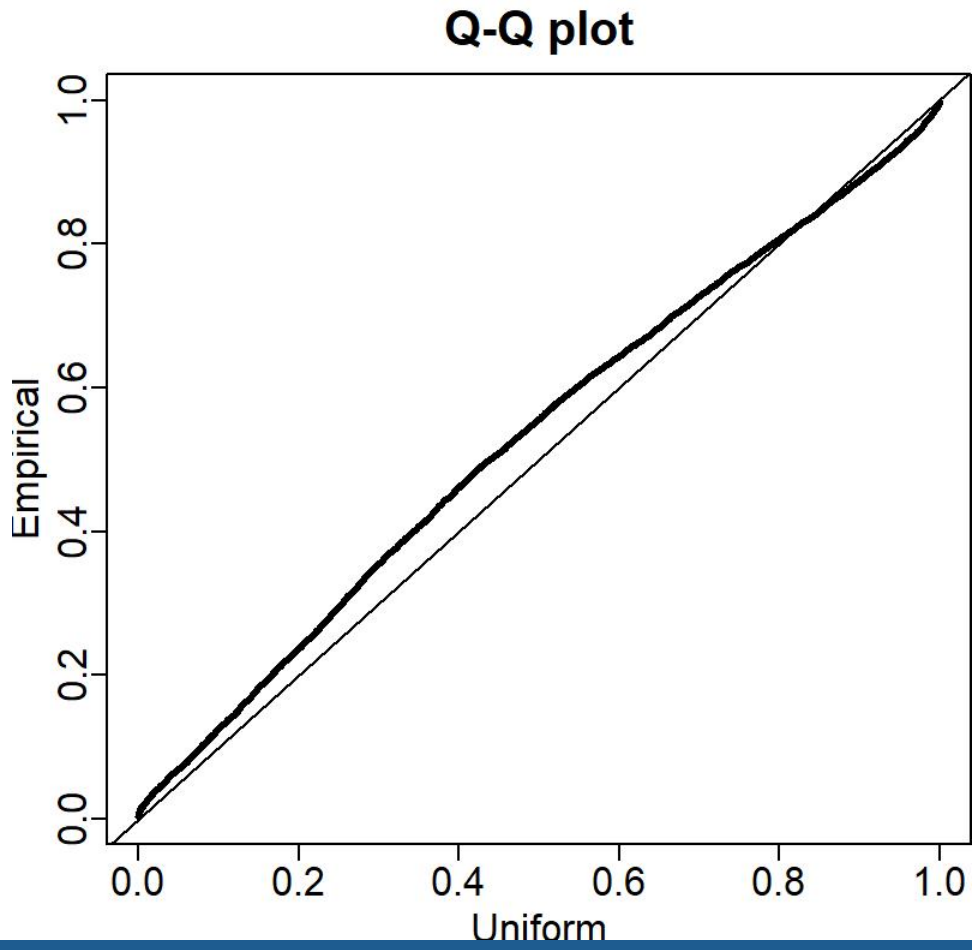


GOA – Walleye Pollock Index

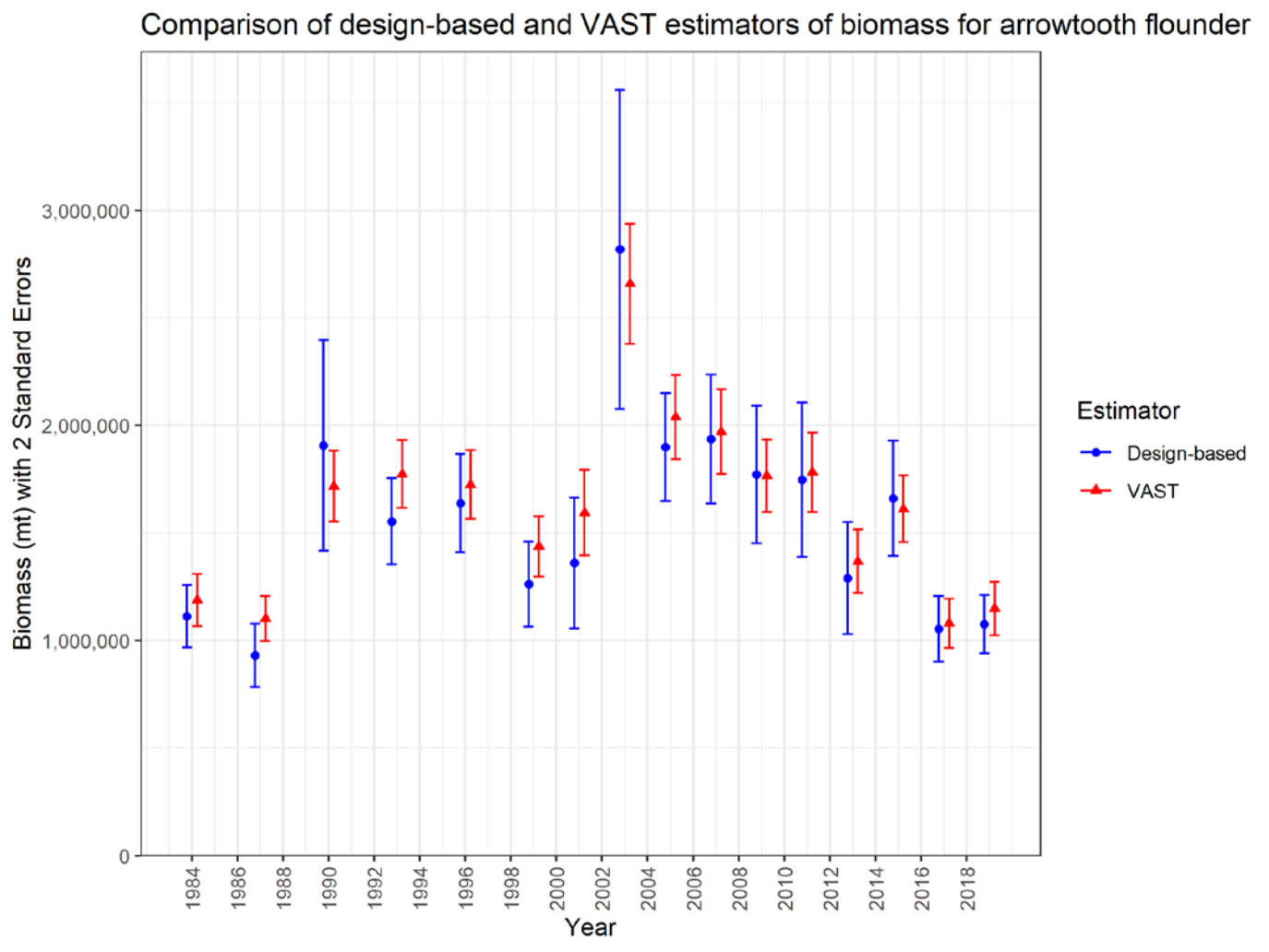


GOA – Walleye Pollock Diagnostics

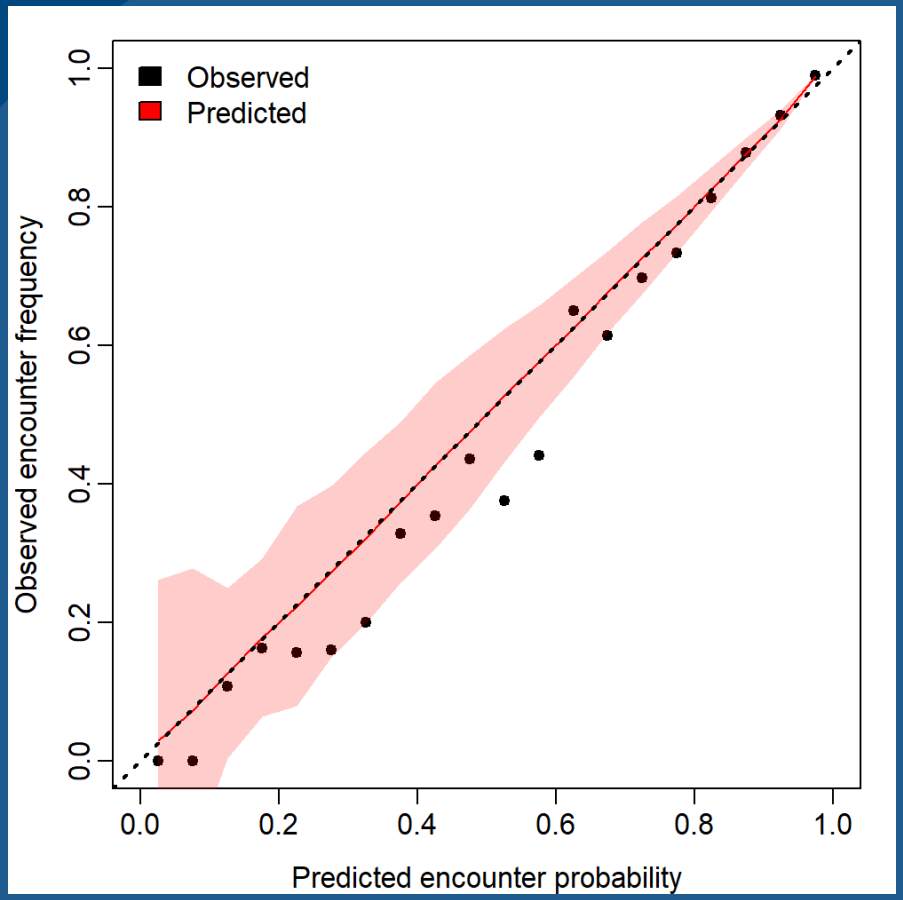


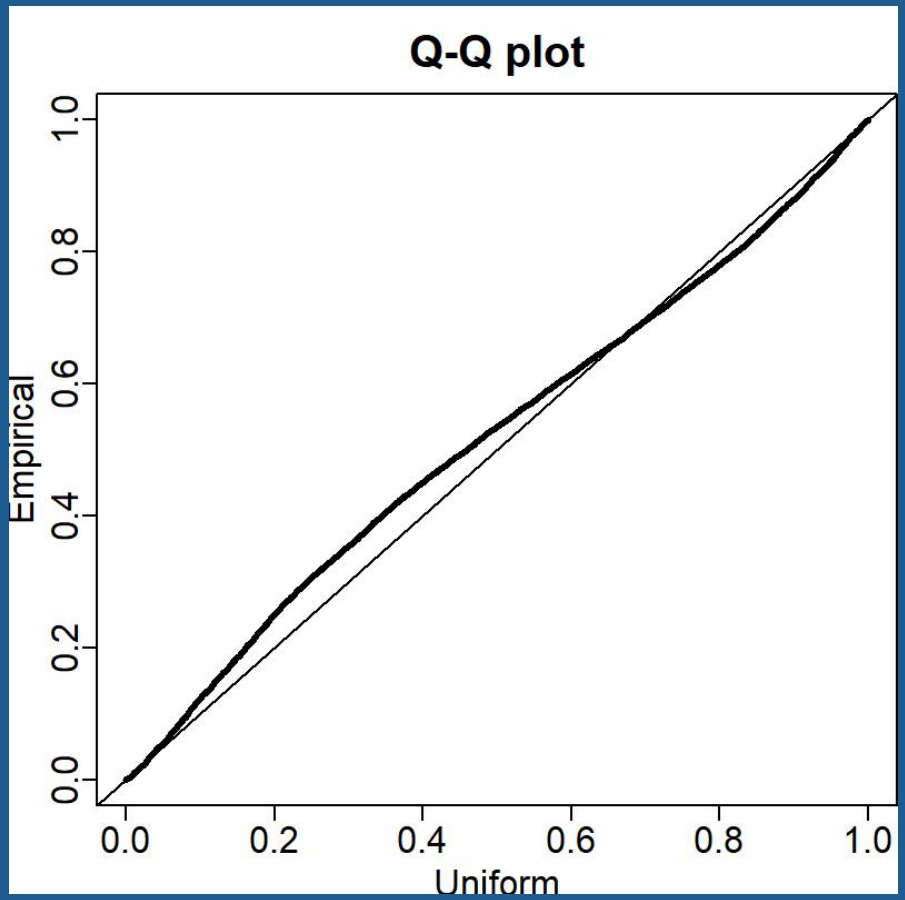


GOA – Arrowtooth Flounder Index



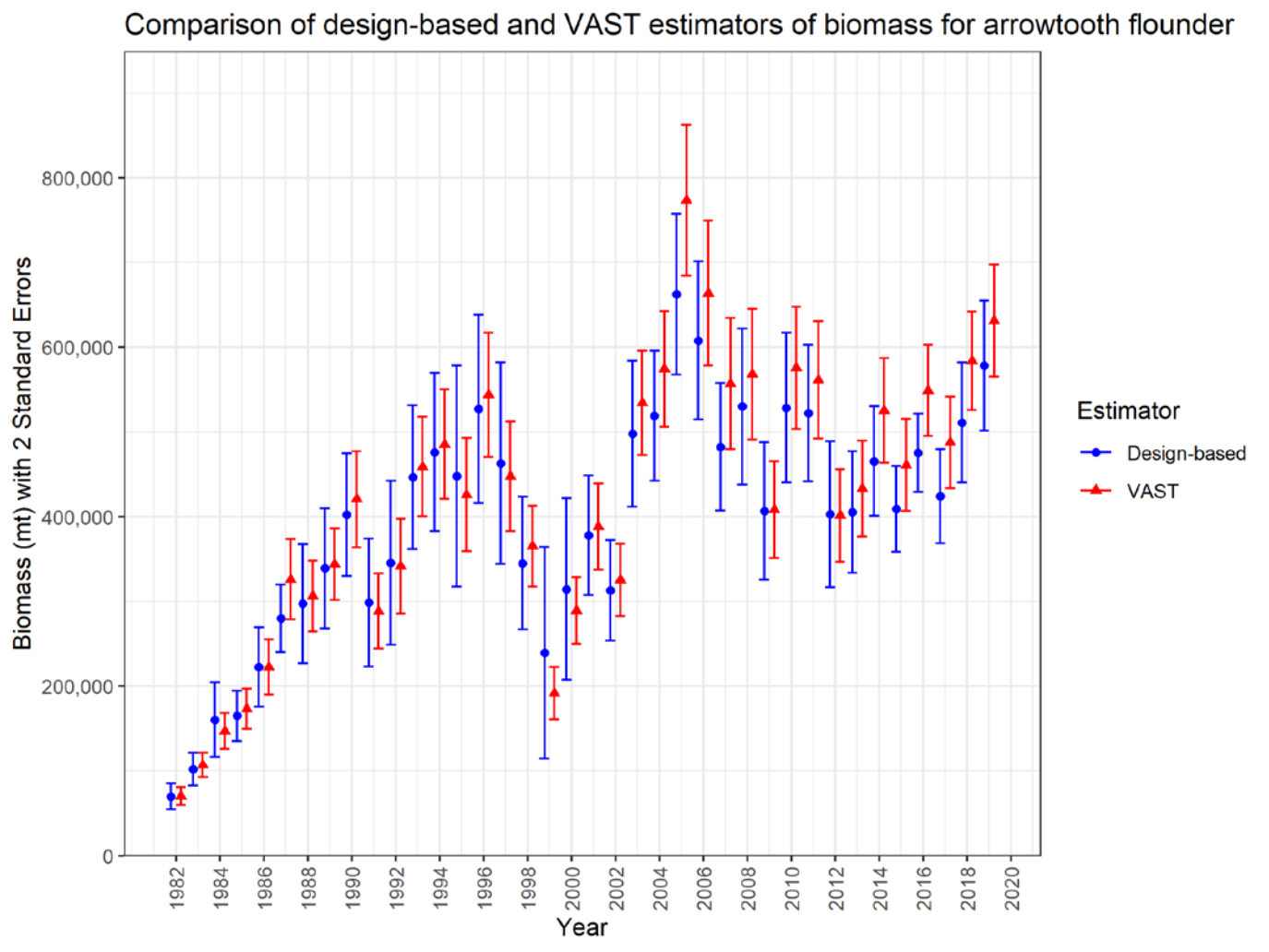
GOA – Arrowtooth Flounder Diagnostics



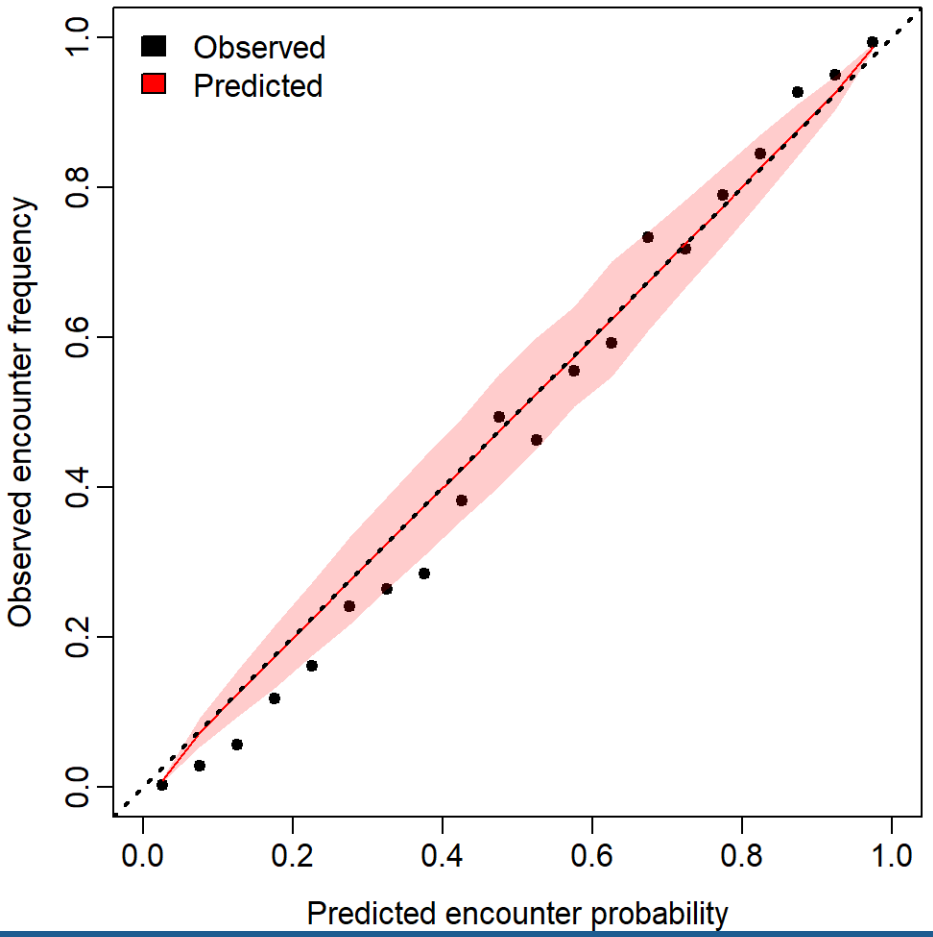


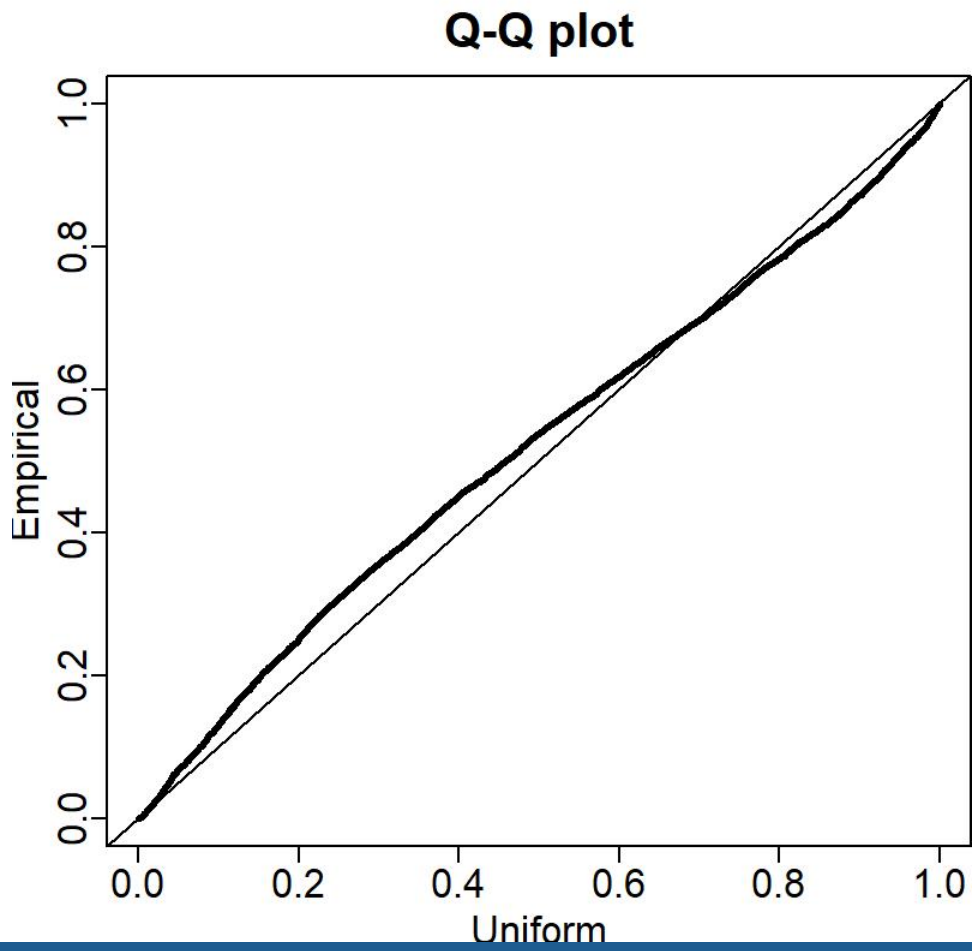
EBS Results - Supplemental

EBS – Arrowtooth Flounder Index

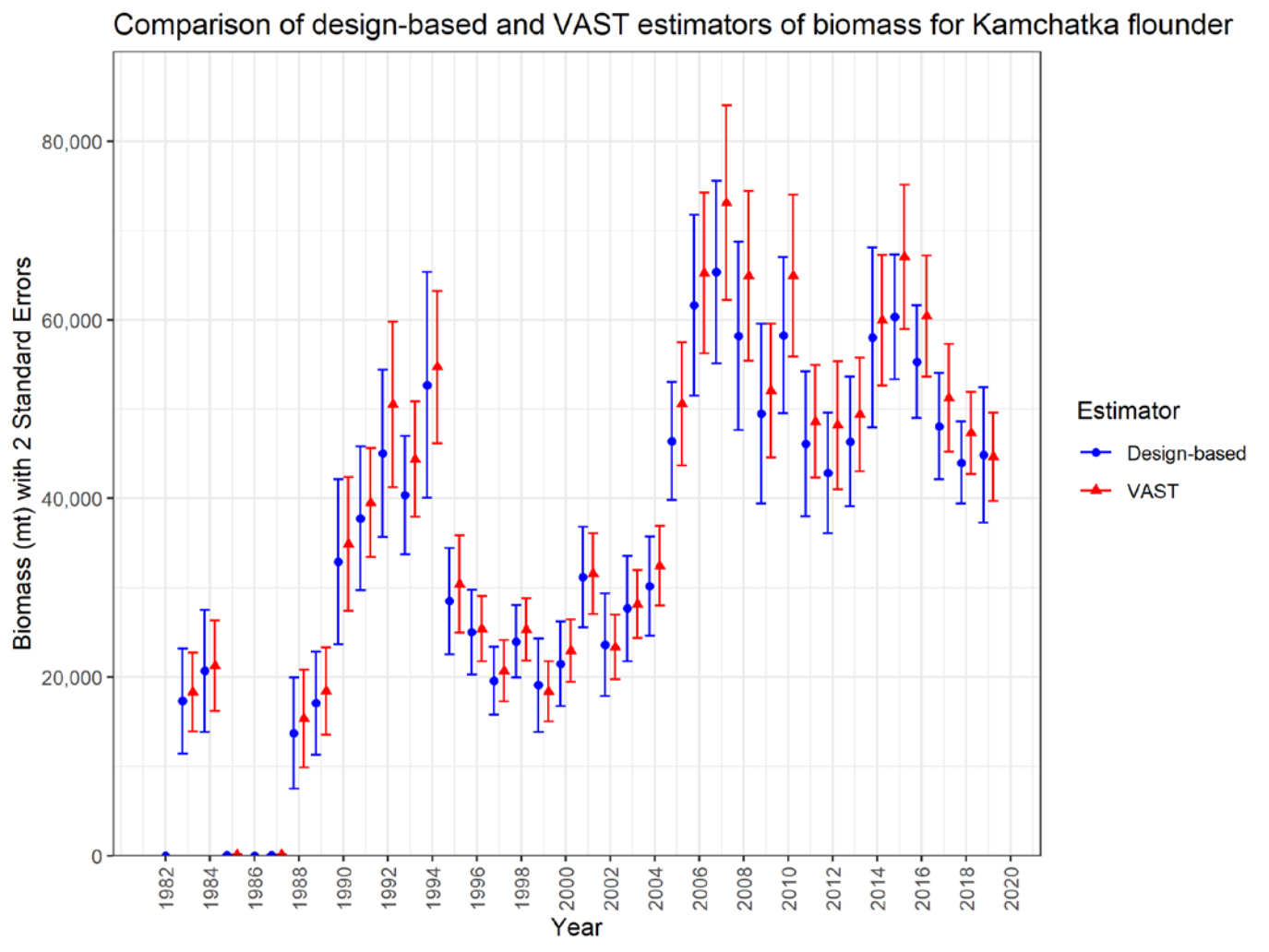


EBS – Arrowtooth Flounder Diagnostics

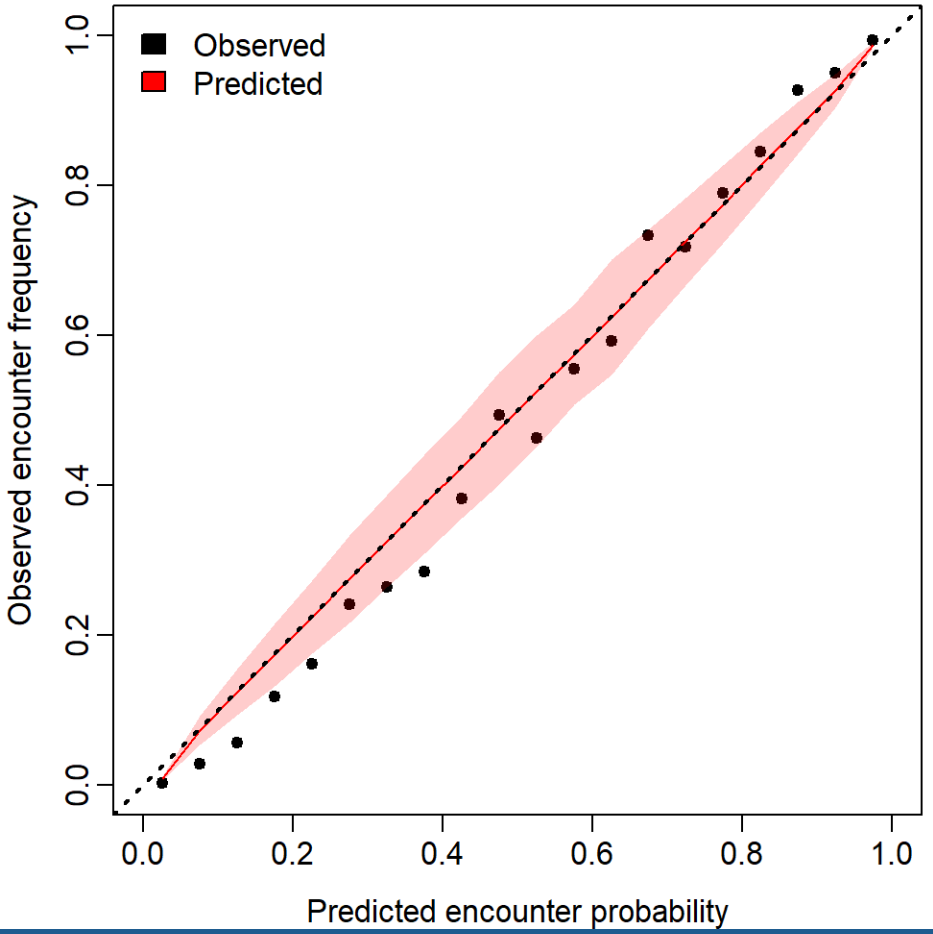


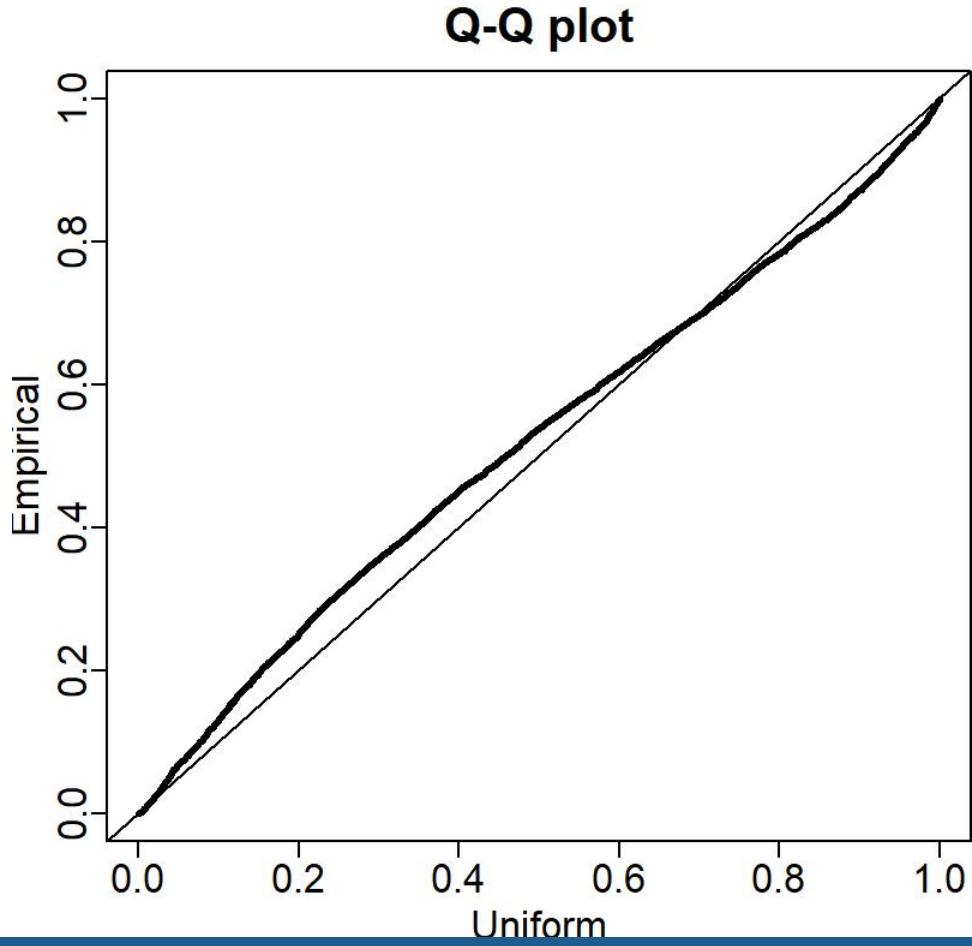


EBS – Kamchatka Flounder Index



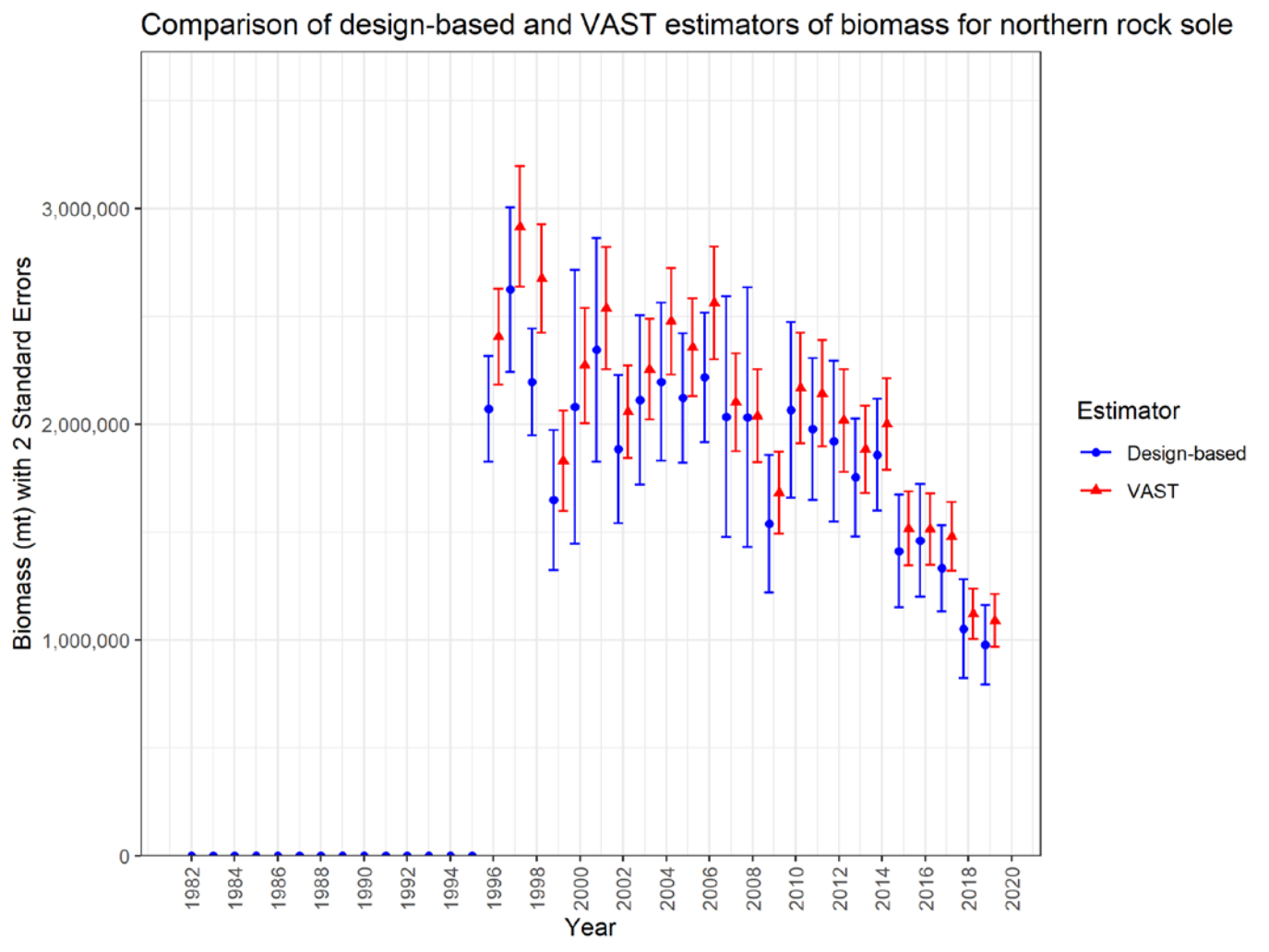
EBS – Kamchatka Flounder Diagnostics



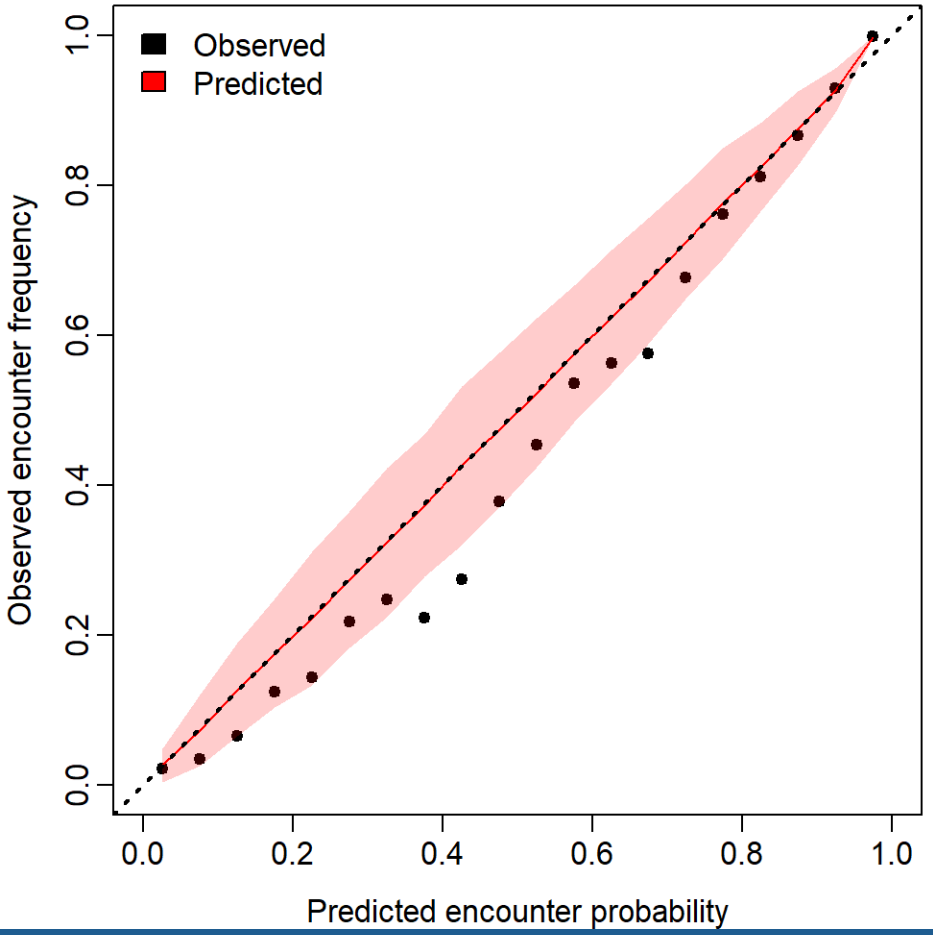


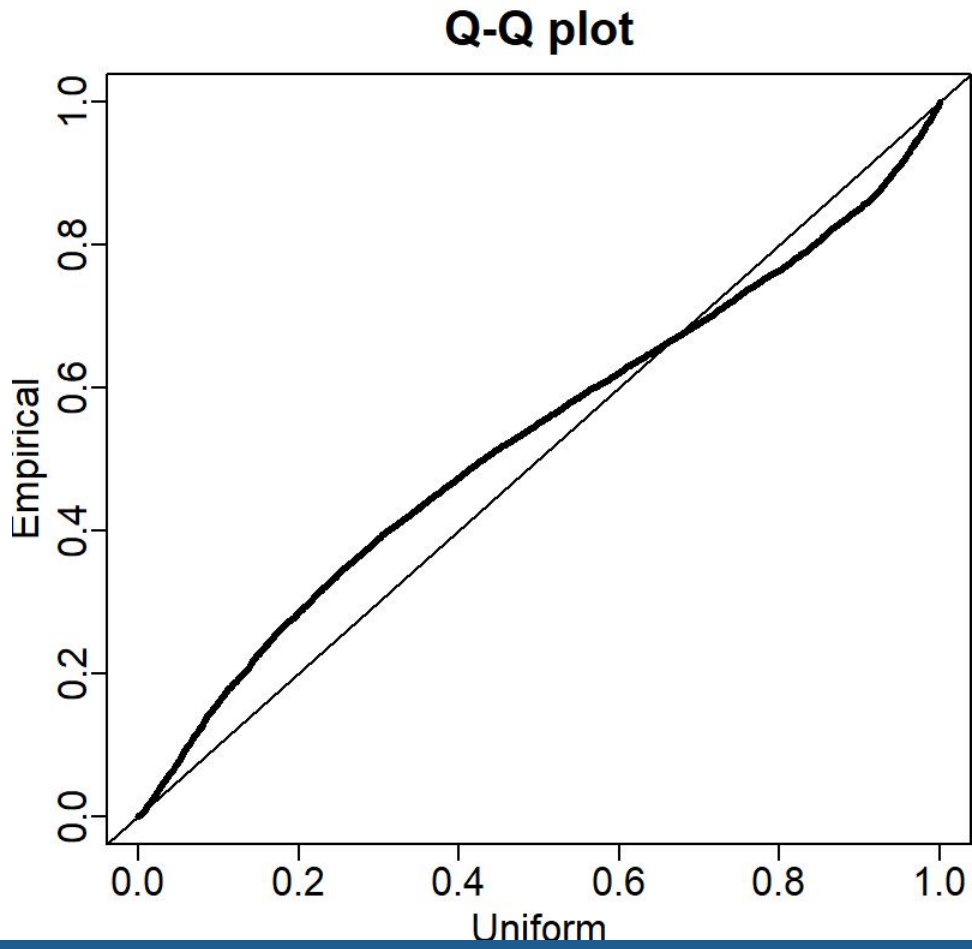
EBS – Northern Rock Sole Index

Prior to 1996 rock sole species ID was not well worked out

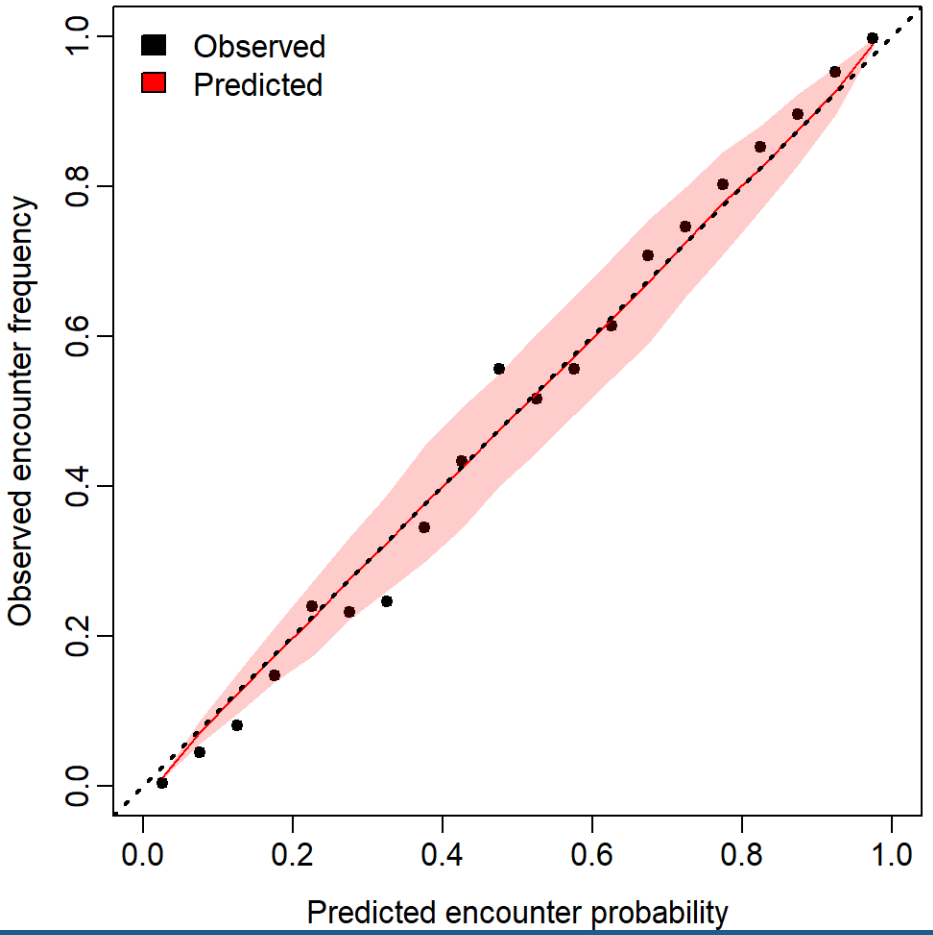


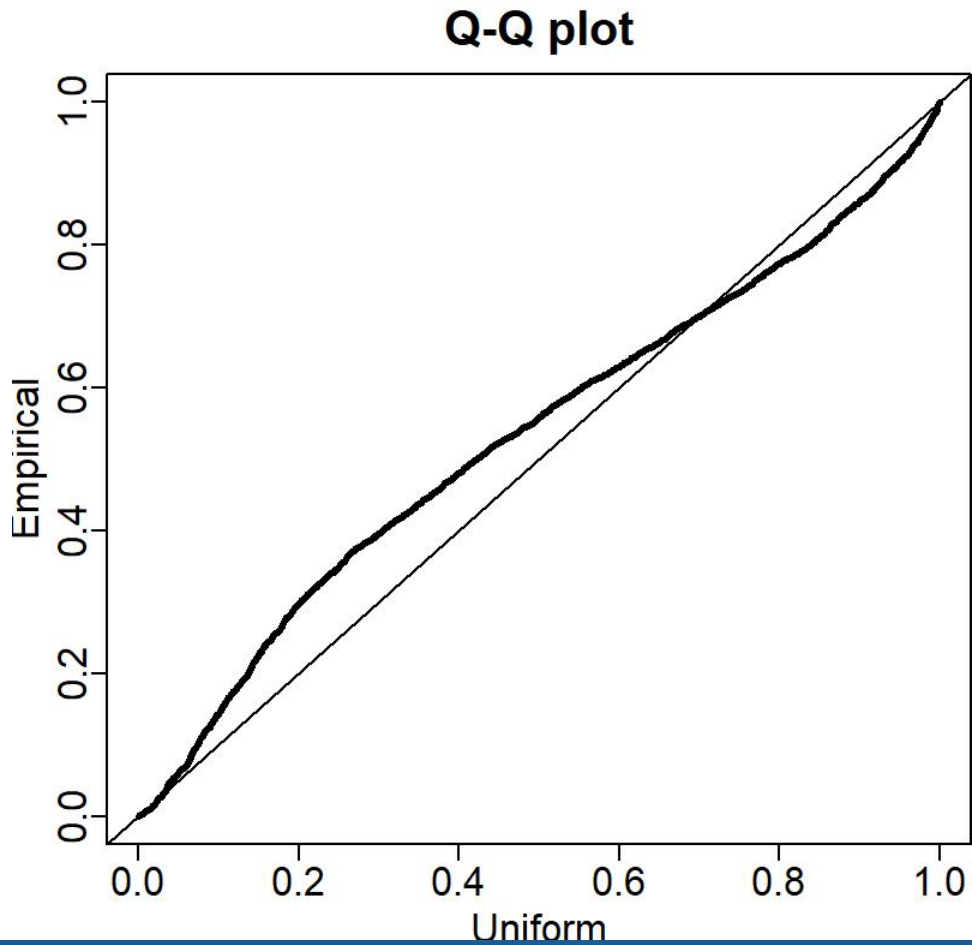
EBS – Northern Rock Sole Diagnostics





EBS – Greenland Turbot Diagnostics

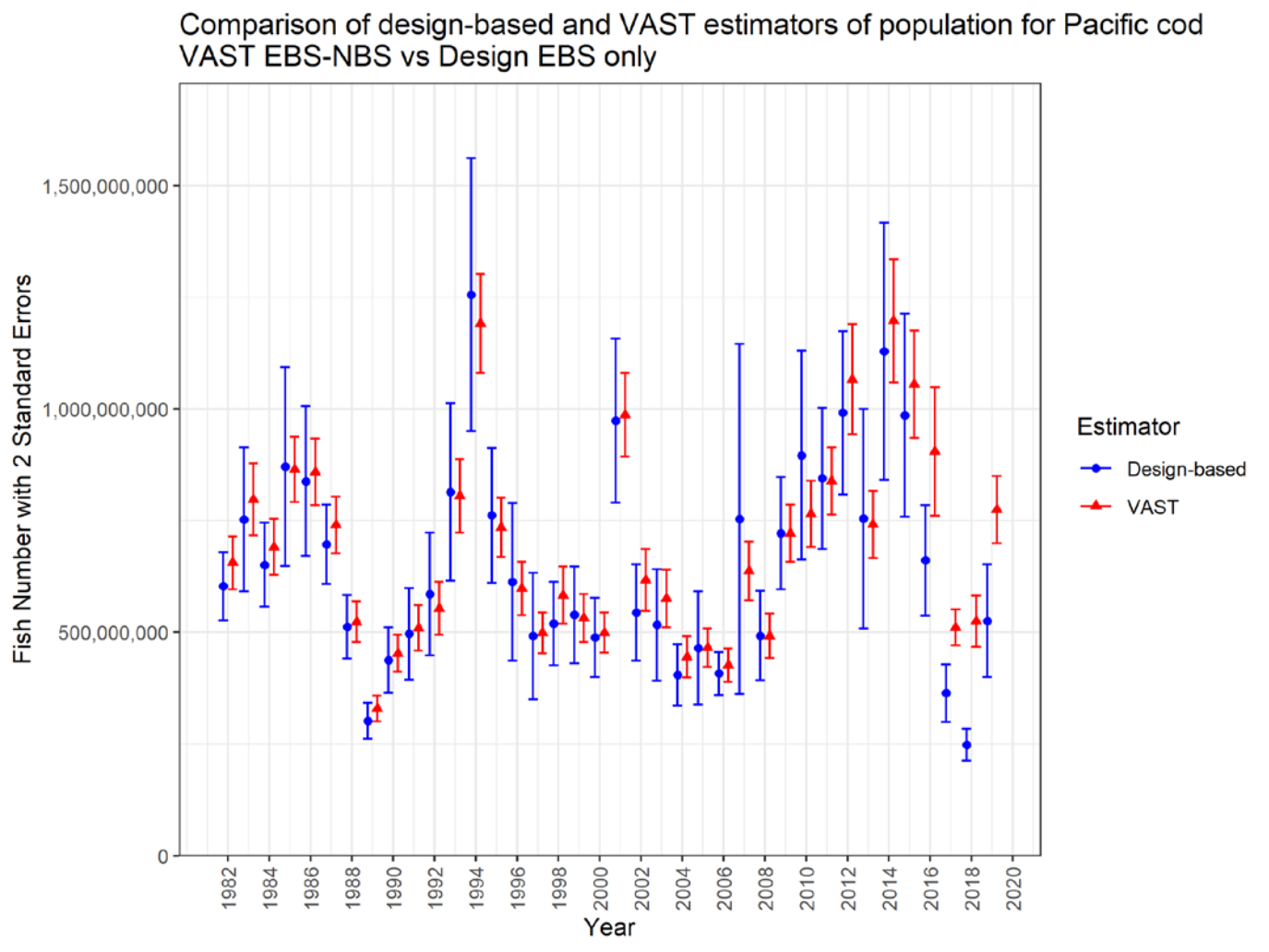




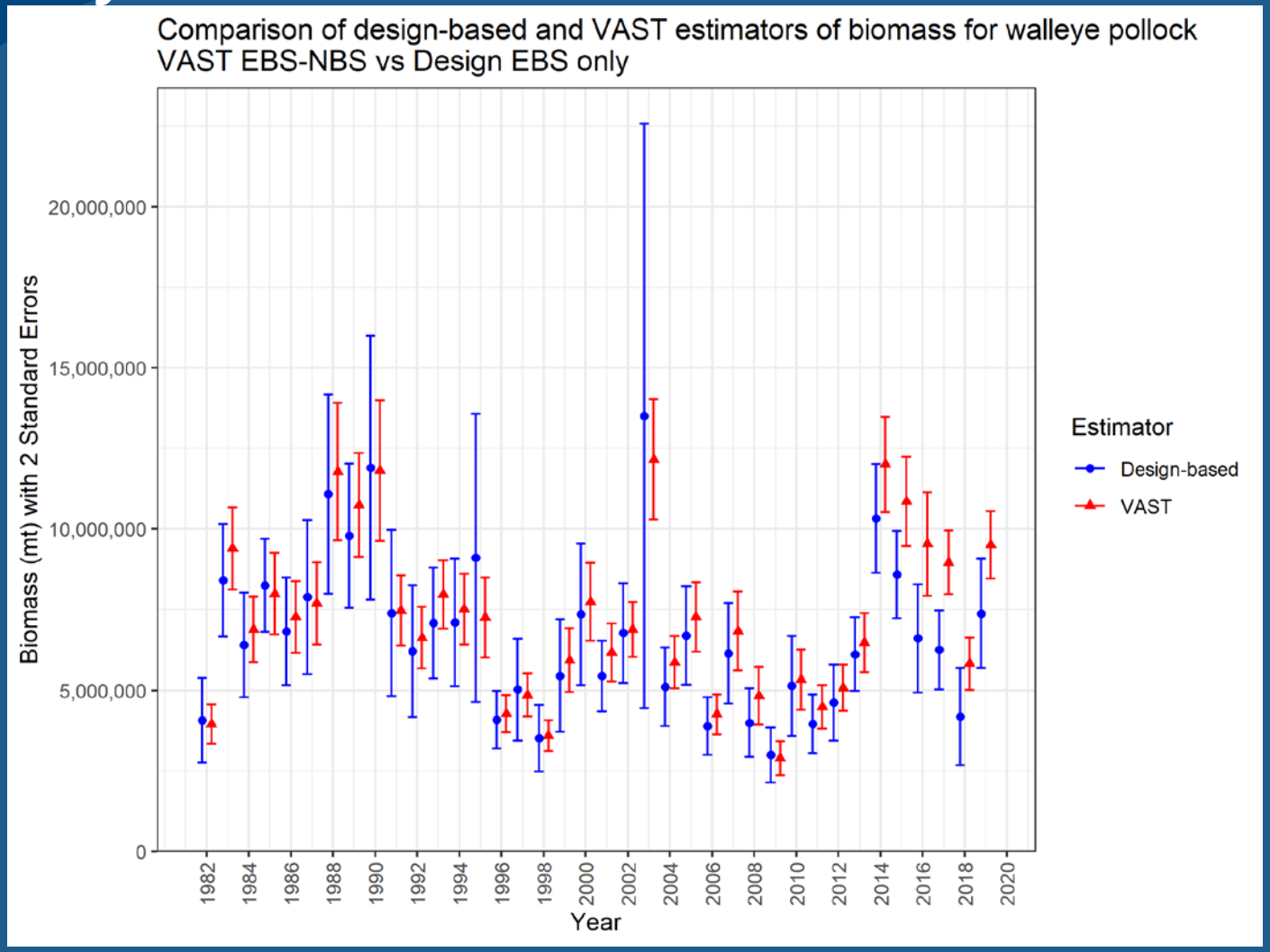
EBS/NBS Results - Supplemental

EBS/NBS – Pacific Cod Index

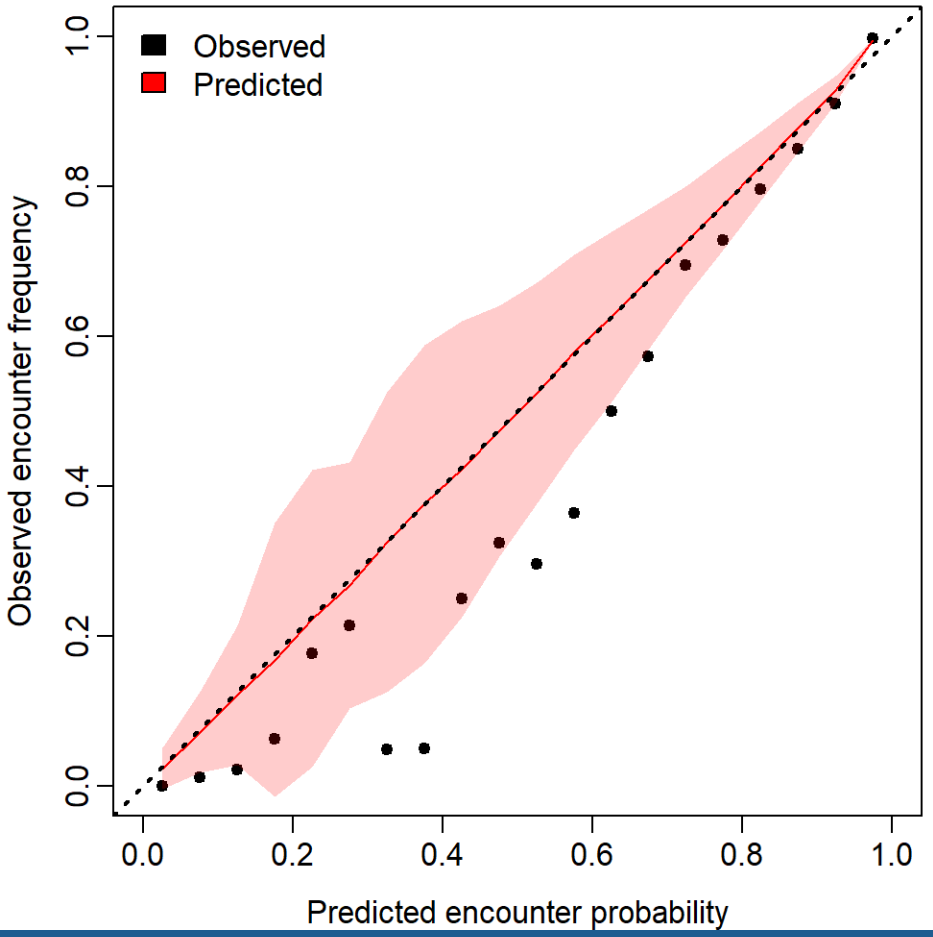
This figure shows VAST estimates for EBS/NBS combined compared to design-based estimates for the EBS only.

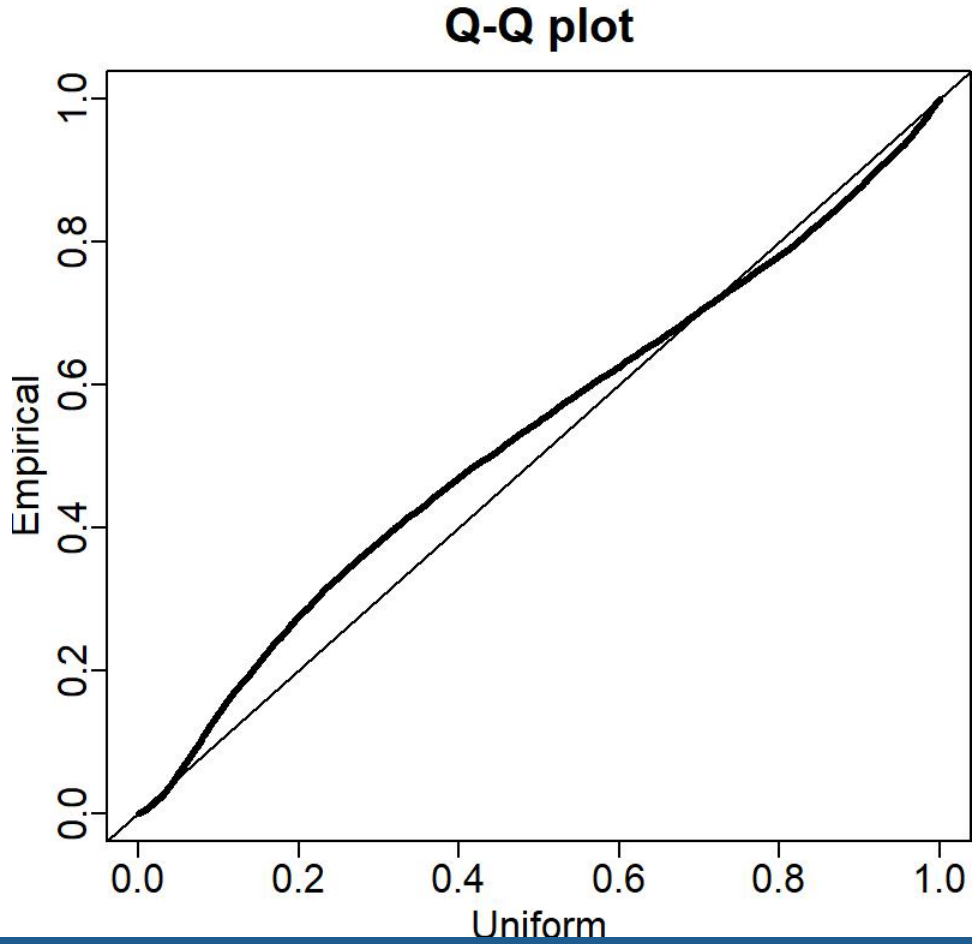


Pollock VAST EBS/NBS vs Design EBS only

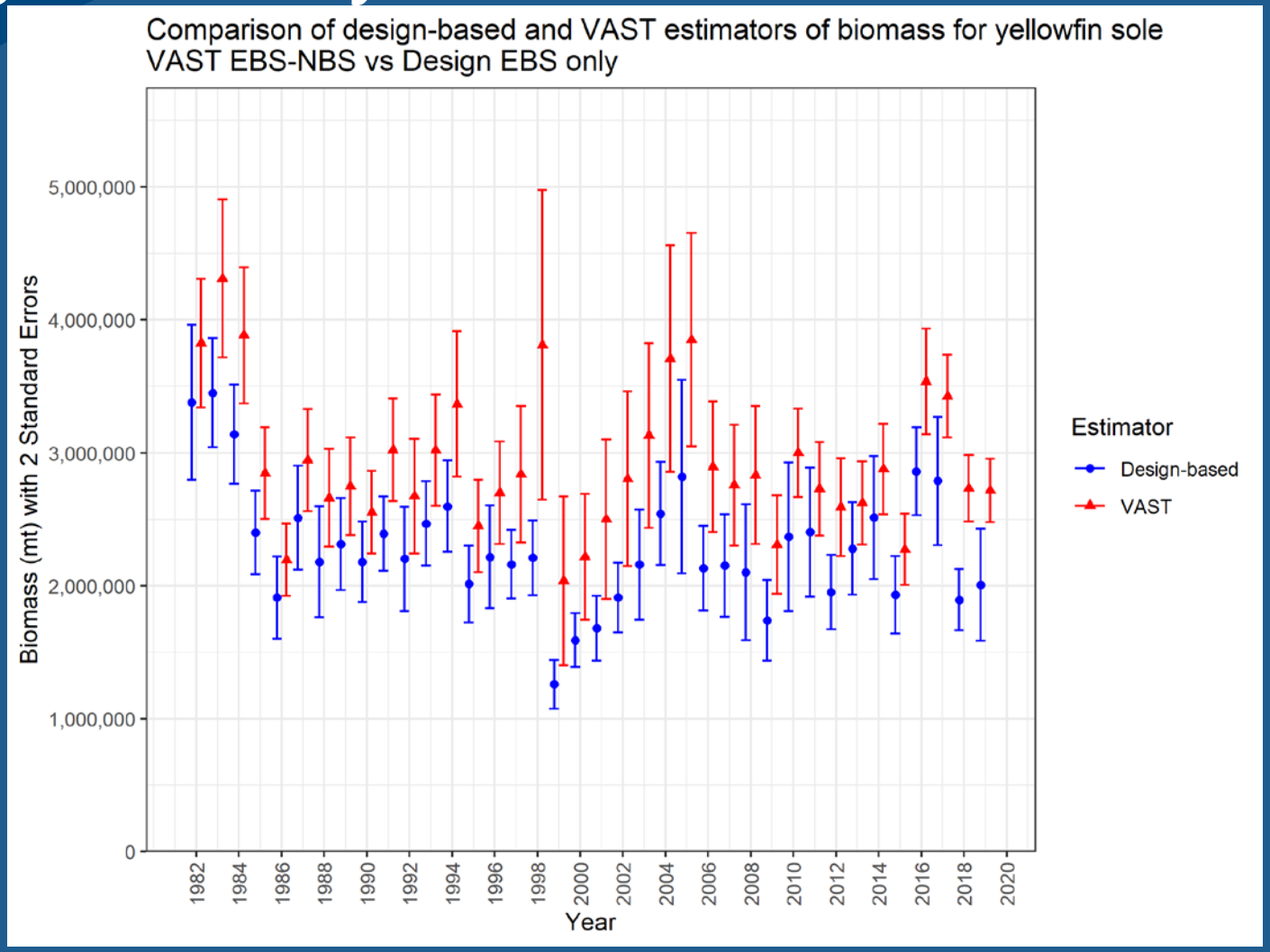


EBS/NBS– Pollock Diagnostics

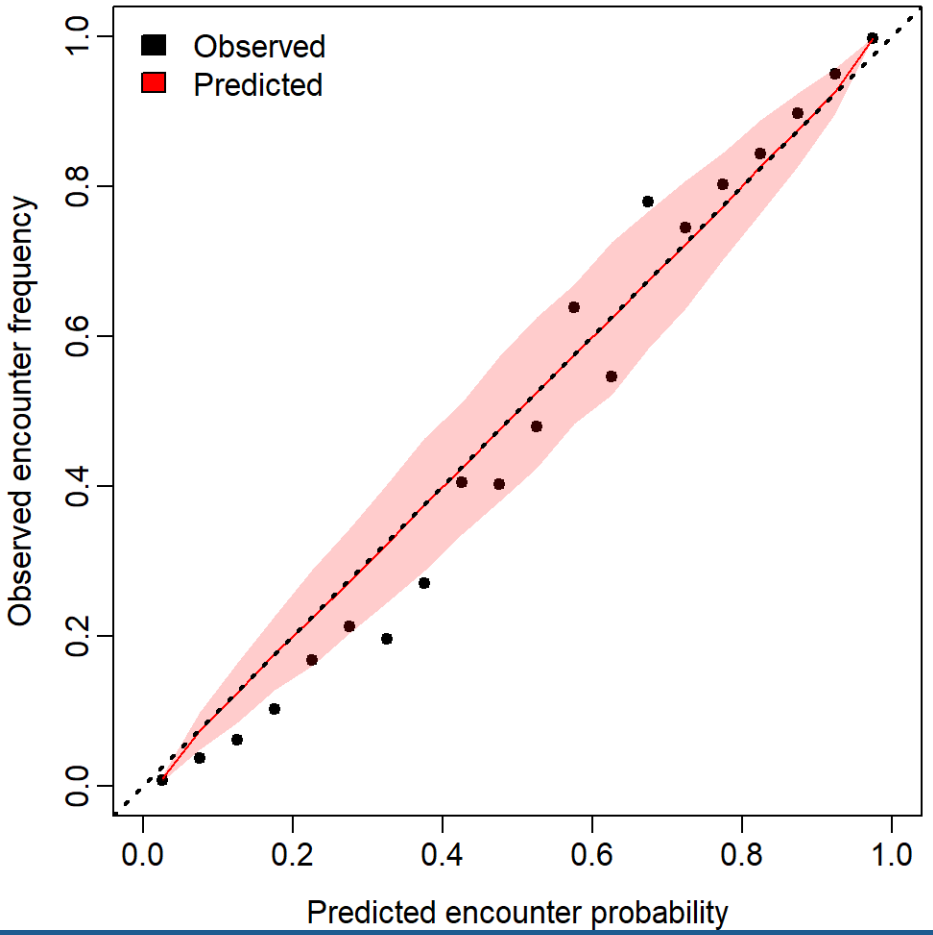


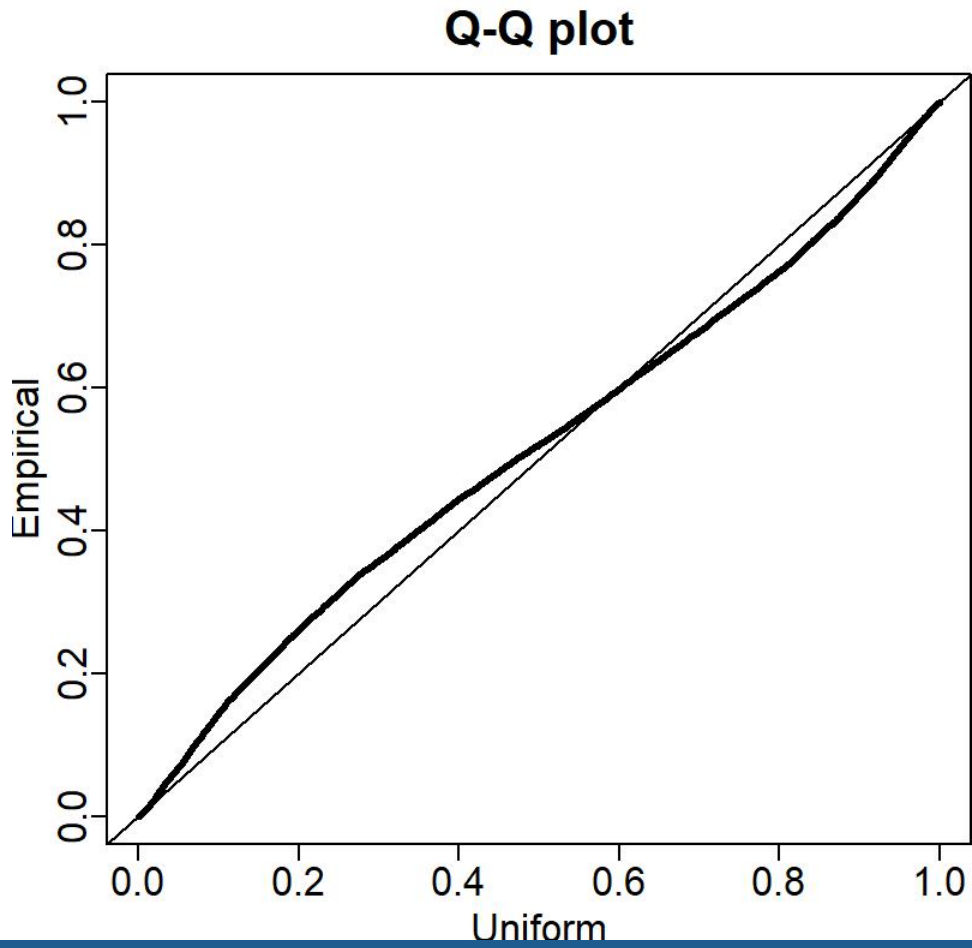


Yellowfin Sole VAST EBS/NBS vs Design EBS only

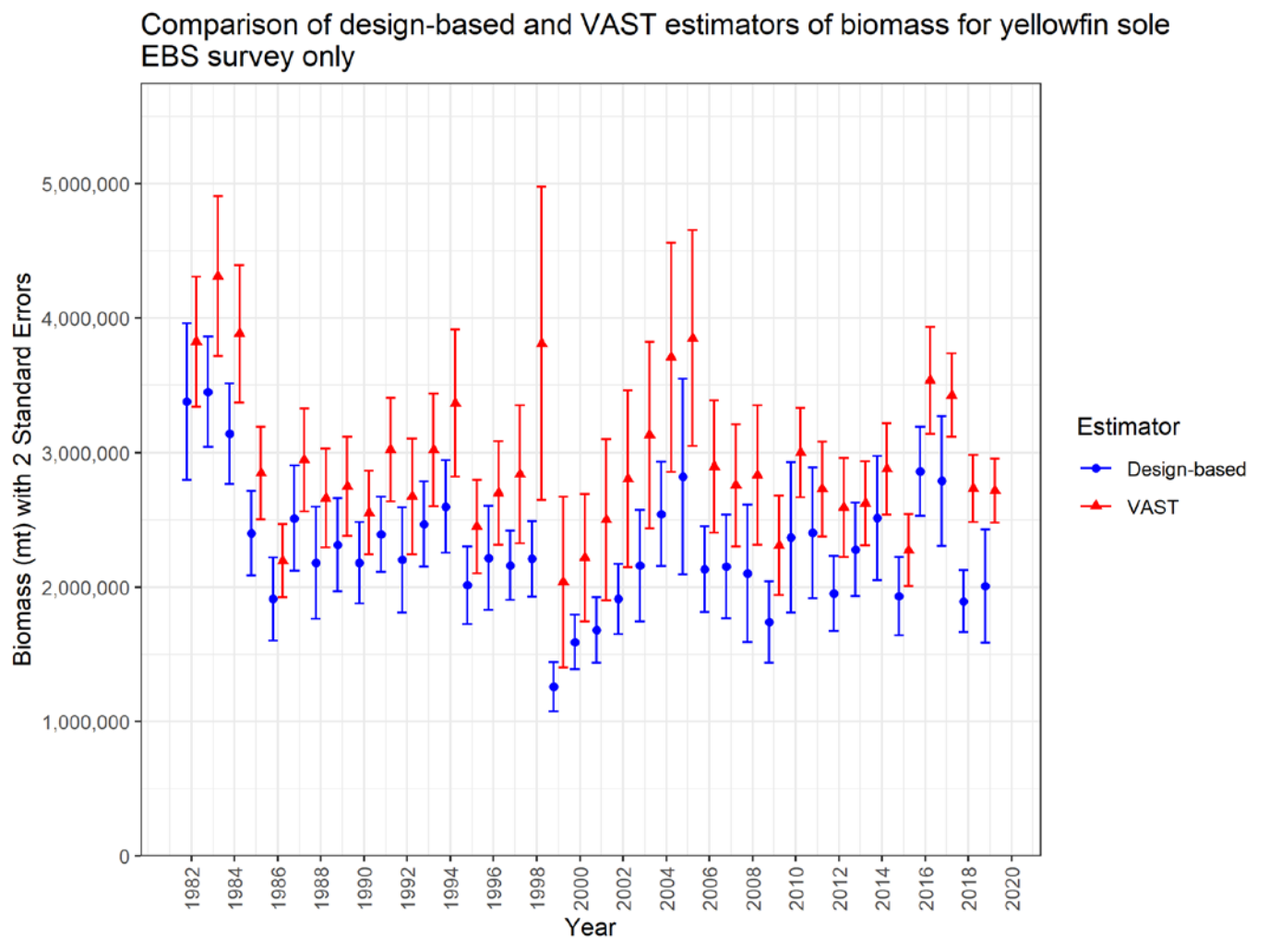


EBS/NBS– Yellowfin Sole Diagnostics

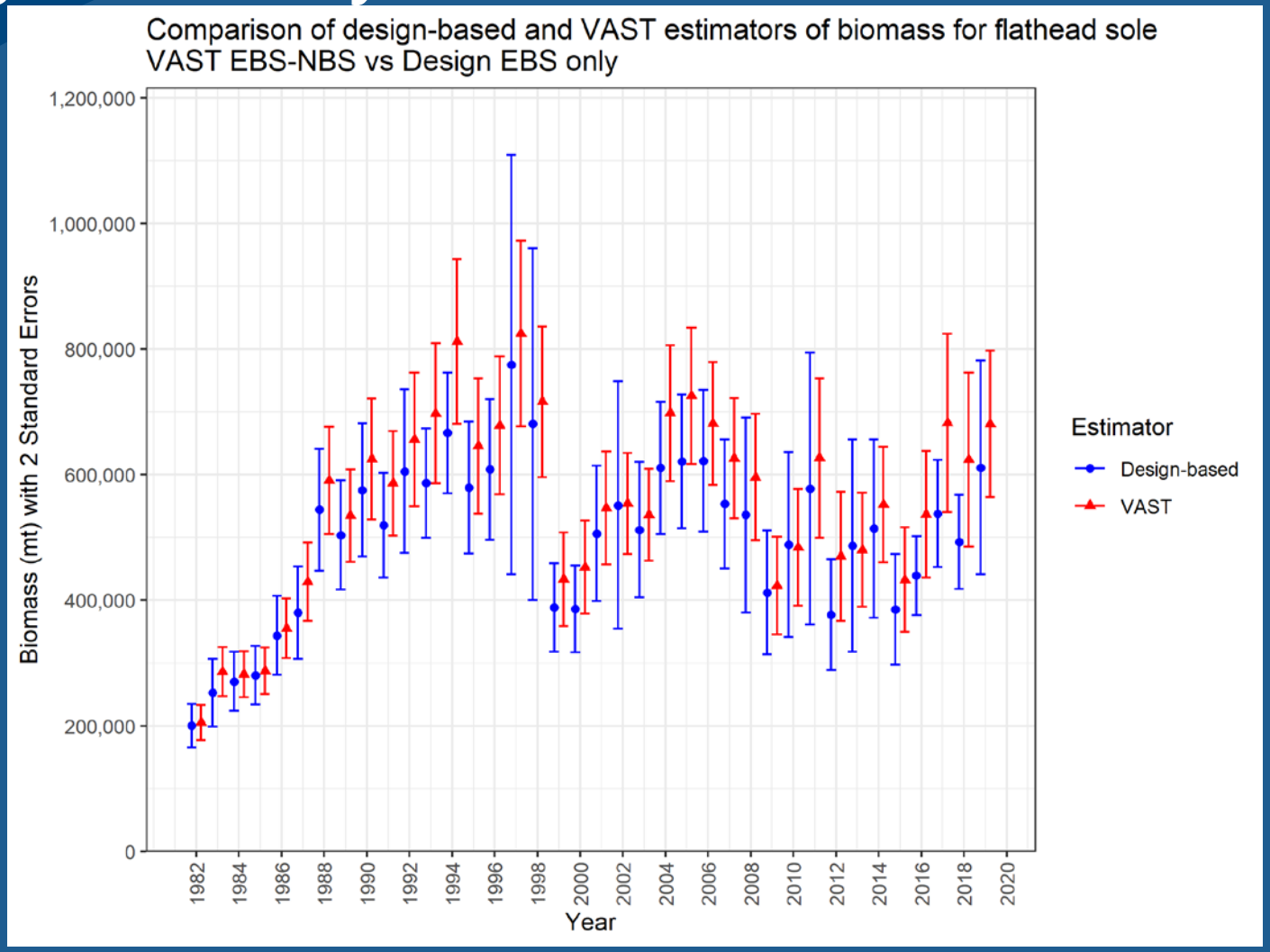




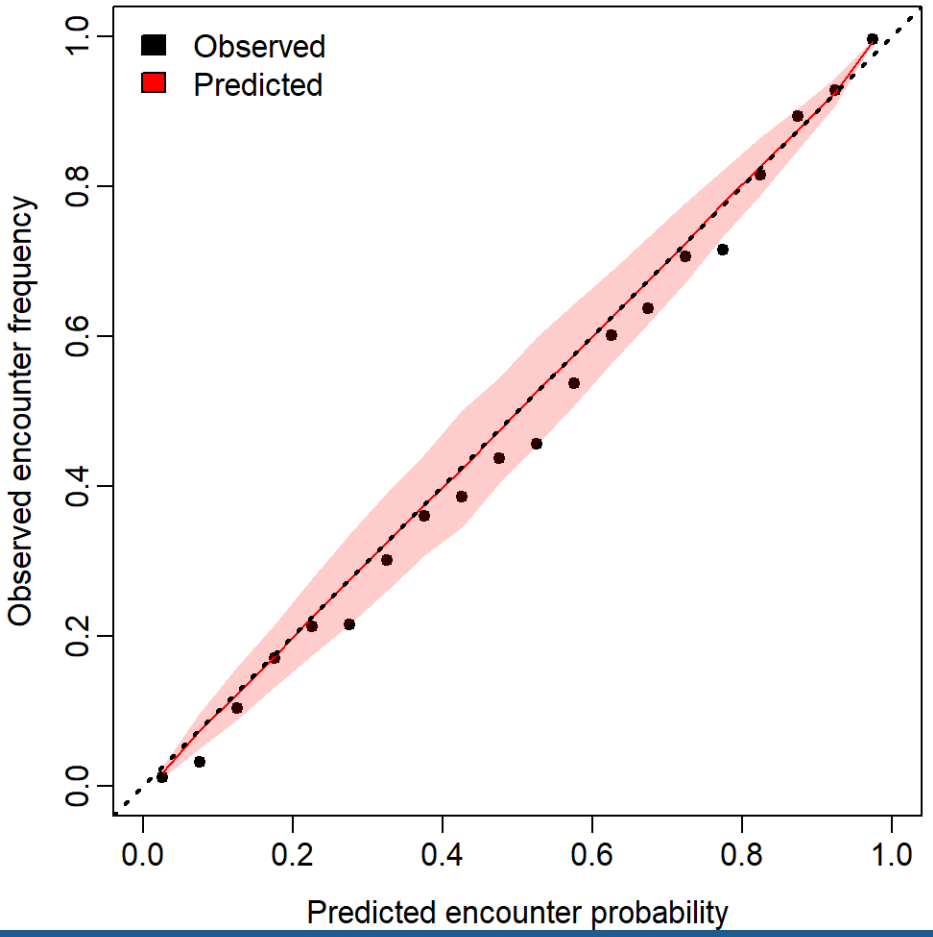
EBS Only – Yellowfin Sole Index

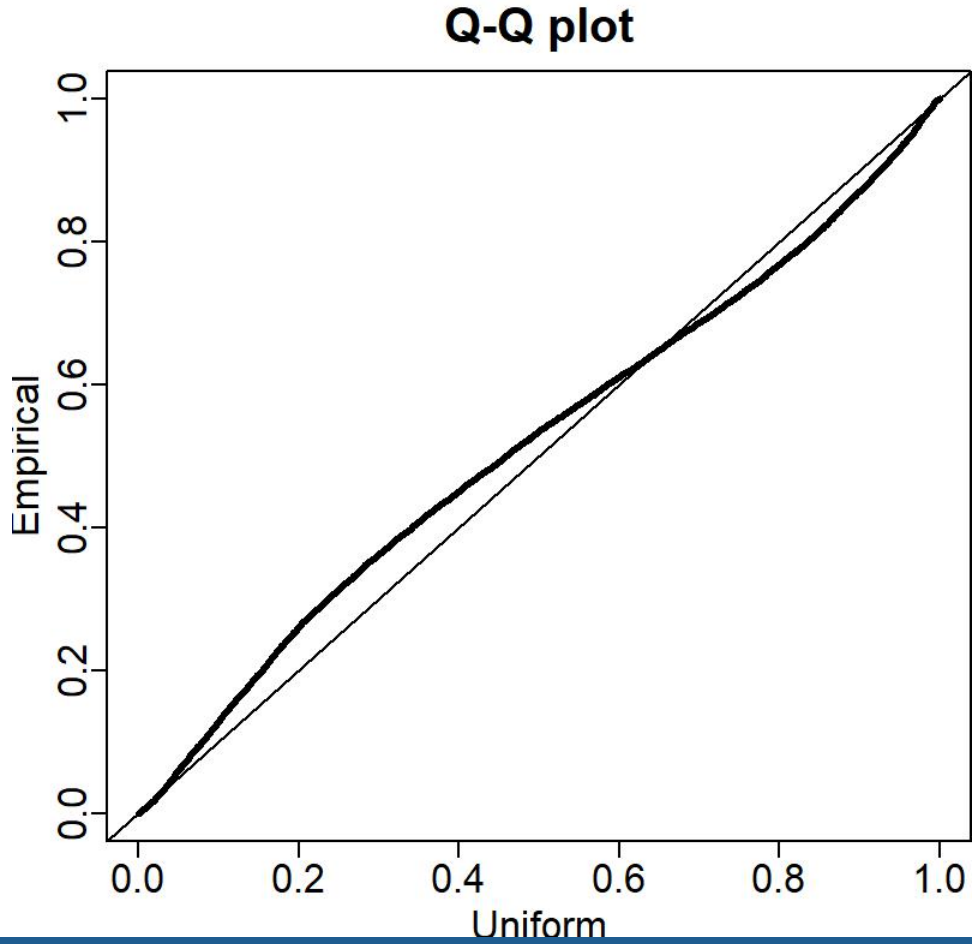


Flathead Sole VAST EBS/NBS vs Design EBS only

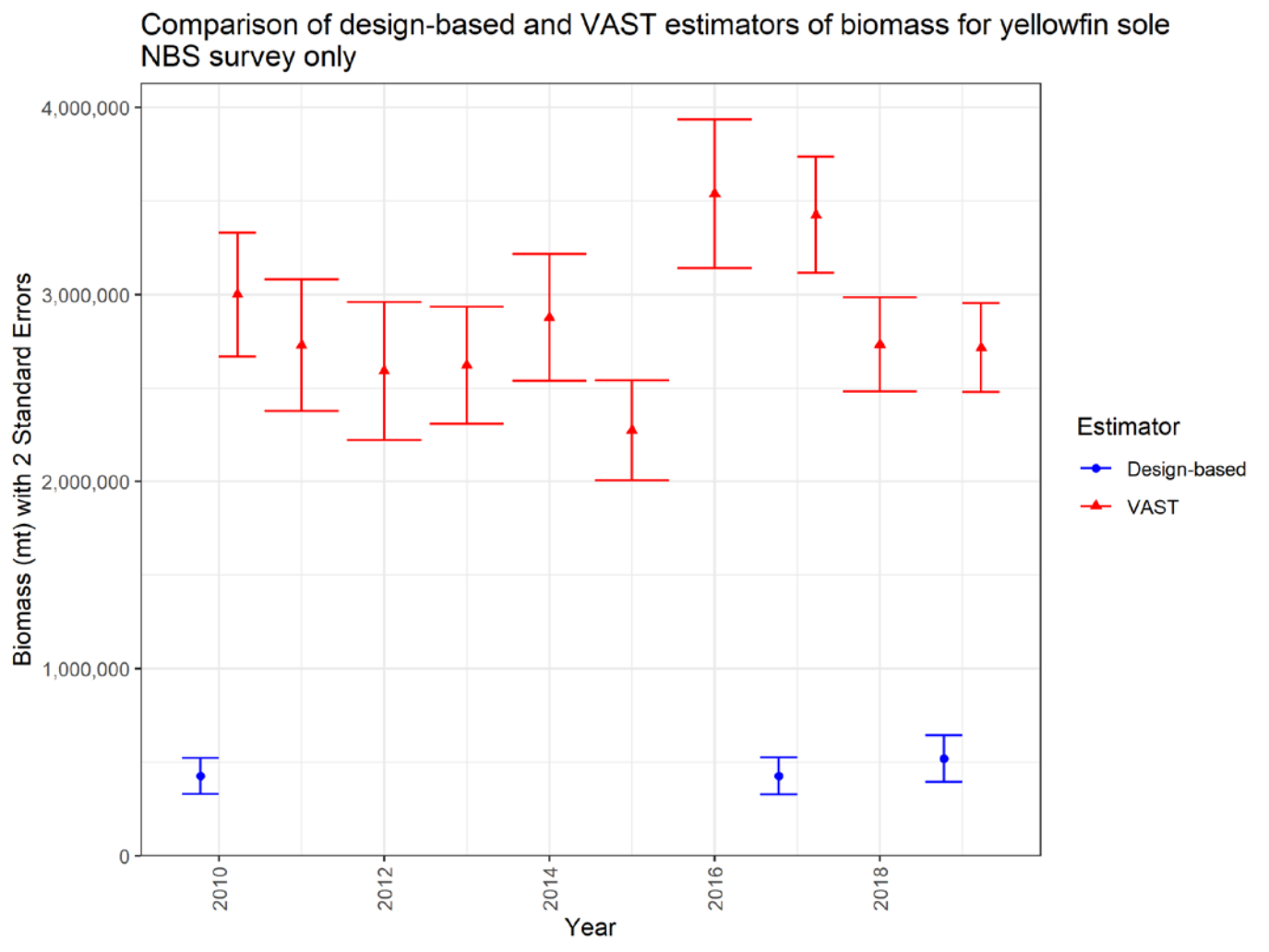


EBS/NBS– Flathead Sole Diagnostics

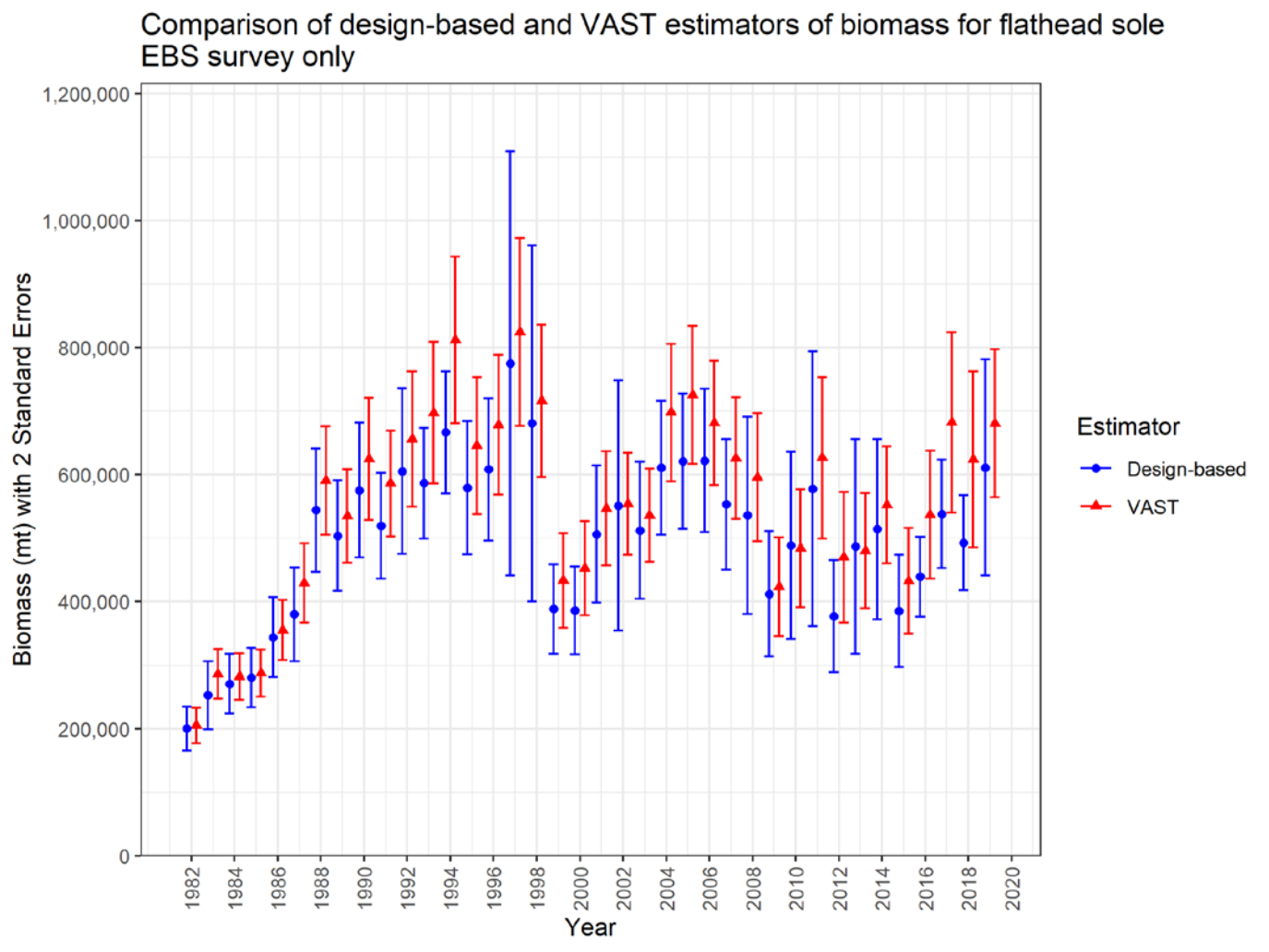




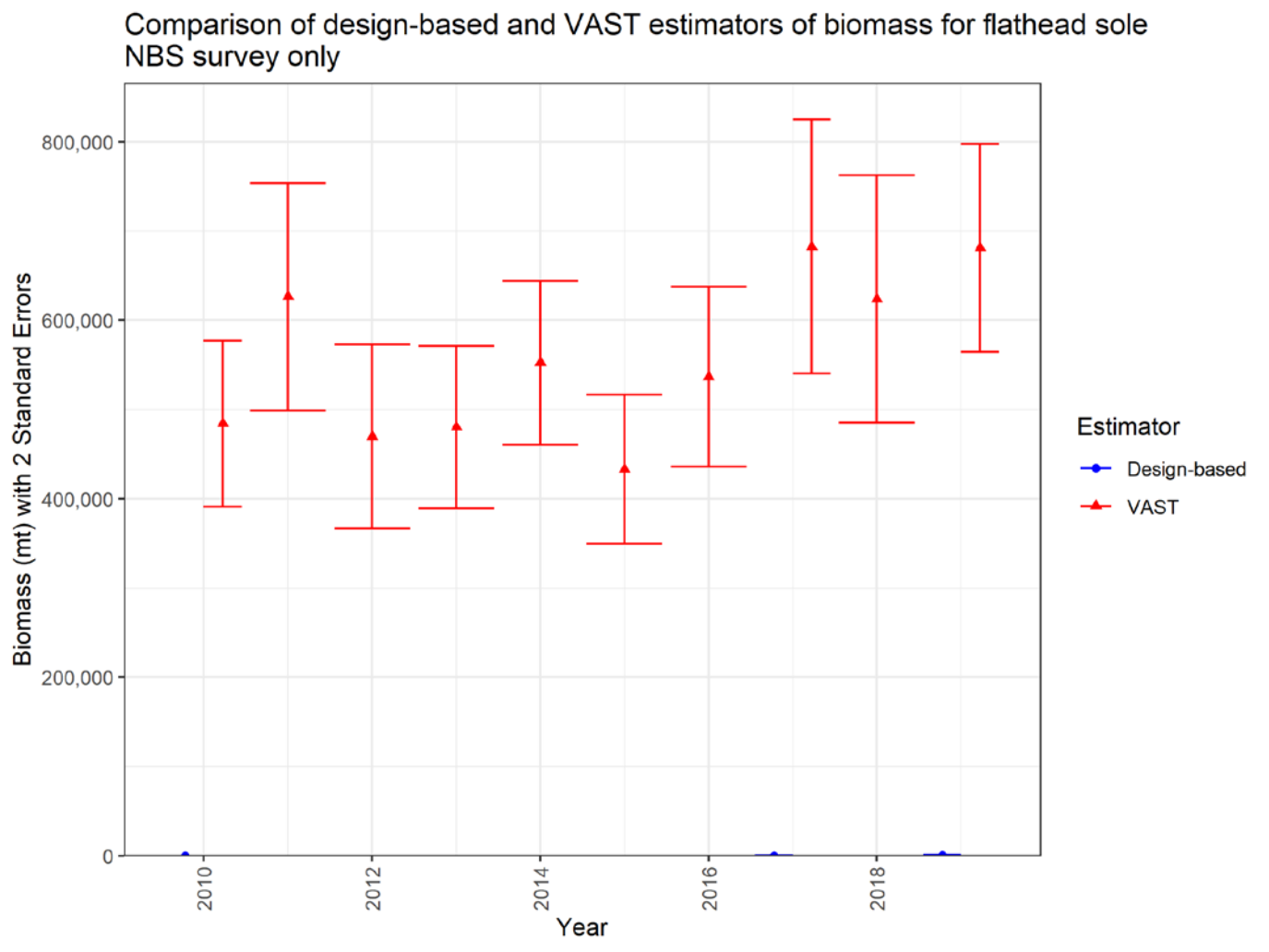
NBS only – Yellowfin Sole Index



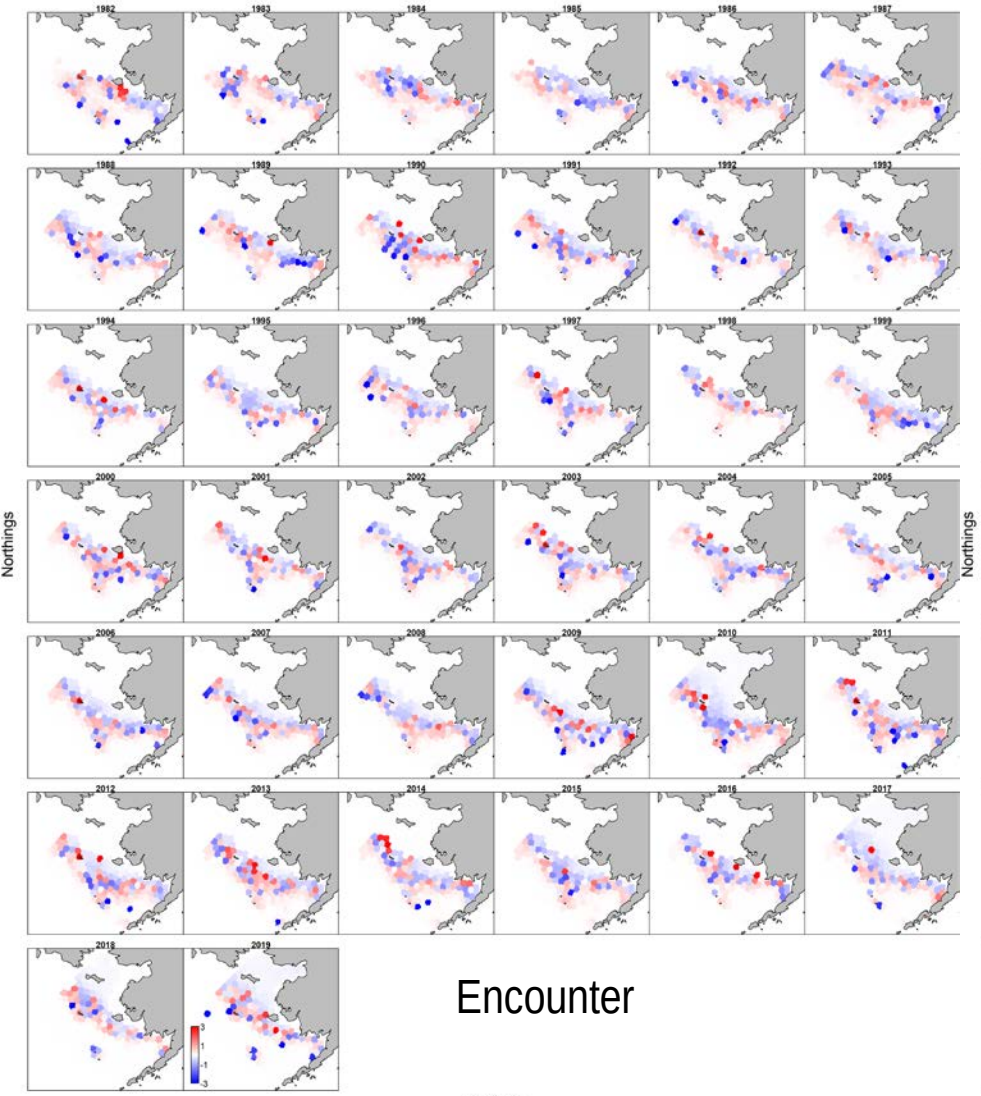
EBS Only – Flathead Sole Index



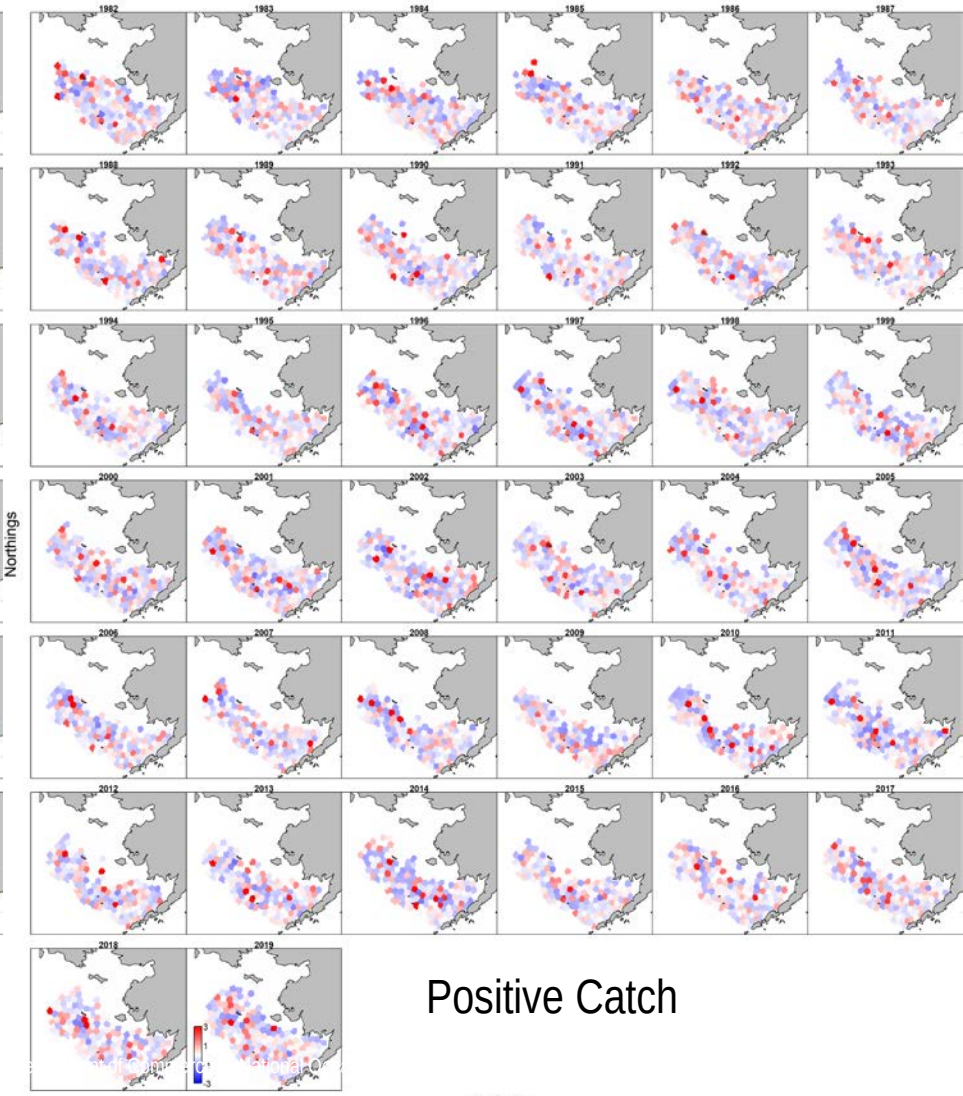
NBS only – Flathead Sole Index



EBS/NBS– Flathead Pearson Residuals



Encounter



Positive Catch