MRIP Time-Series Calibration

Presentation Outline

I. Background
II. FES Calibration
III. APAIS Calibration
IV. Effects on Time Series

I. **Background**

II. Effort Calibration

III. Catch Rate Calibration

IV. Effects on Time Series

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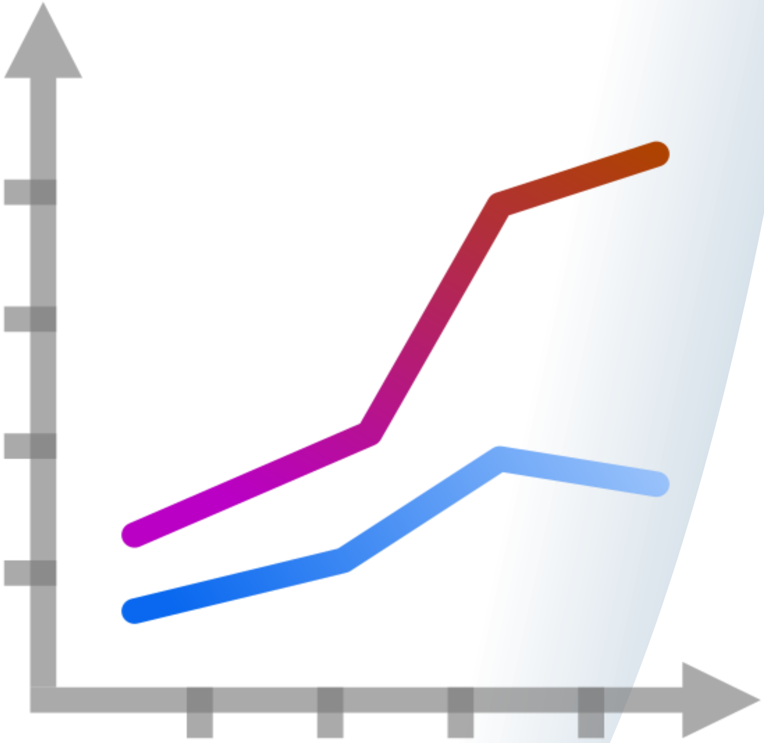
Background

- Why Calibrate?
  - Maintain consistency of historical time series
- Ideal approach involves:
  - Benchmarking: where old and new survey methods conducted side-by-side
  - Fit a model to relate both sets of estimates



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Background

CHTS ⟷ FES

- 3-year benchmarking period (2015-2017)
- Model fit to relate both sets of estimates

- Sequential sample weight adjustments
  - Funding constraints prevented extensive benchmarking
  - Too many estimates (800+ species) to develop calibrations for each

MRFSS Intercept Survey ⟷ APAIS

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Background

- Calibration methods developed with expert statistical consultants
- Peer Review Workshops held for each:
  - FES: CALIBRATION MODEL PEER REVIEW
    JUNE 27-29, 2017 SILVER SPRING, MD
  - APAIS: **Access Point Angler Intercept Survey Calibration Workshop**
    March 20-22, 2018 Silver Spring, MD
- Reviewers identified through Center of Independent Experts (CIE), Regional Council SSC's and Atlantic States Marine Fisheries Commission
- Review panels endorsed methods for both calibrations

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Benchmarking results

- FES estimates are several times larger than the CHTS estimates

FES provides much greater coverage of household population due to transition away from landline telephone service

FES may have improved recall since it is a self-administered survey (De Leeuw, 2005; Dillman et al., 2009)

FES questionnaire is much shorter, resulting in lower reporting burden on respondents, less missing data, minimal imputation

Mail vs telephone survey mode effects (de Leeu and Desiree 1992, Dillman et al. 1996)

FES has higher response rates (~35% compared to <10% for CHTS from 2015-2017)

Effort Model Overview

- Uses Fay-Herriot small area estimation
  - Well-established procedure originally developed to produce model-based estimates for small areas with small populations in the USA

1979

Estimates of Income for Small Places: An Application of James-Stein Procedures to Census Data

ROBERT E. FAY III and ROGER A. HERRIOT

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Effort Model Overview (cont)

- Fay Herriot estimation: a linear mixed modeling approach

Fixed Effects:
- used to estimate one true effect of one or more independent variables on a dependent variable
- Connects estimates to auxiliary variables
- Very common in basic statistical analyses

+

Random Effects:
- used to estimate the mean of a potential range of effects on a dependent variable
- Captures variation in estimates not explained by auxiliary variables
- Common in more complex statistical analyses

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Effort Model Overview (cont)

Method effects caused by differences in survey coverage, non-response, measurement error (systematic or random)

A factor in ALL surveys whenever a sample is used to estimate population characteristics – well understood and can be easily estimated

$$\text{Estimated Effort} = \underbrace{\text{True Effort} + \text{Nonsampling Error}}_{\text{Cannot disentangle true effort from nonsampling error}} + \text{Sampling Error}$$

Shared Effects

Estimated Effort = **True Effort** + Nonsampling Error + Sampling Error

Trend

- Changes in fishing effort from year to year
- Modeled using state-specific population sizes from U.S. Census Bureau

Shared Effects

$$\text{Estimated Effort} = \textbf{True Effort} + \text{Nonsampling Error} + \text{Sampling Error}$$

Trend

- Changes in fishing effort from year to year
- Modeled using state-specific population sizes from U.S. Census Bureau

Seasonal

- Changes in fishing effort from season to season
- Modeled using indicators for the six two-month waves in each state

Shared Effects

Estimated Effort = **True Effort** + Nonsampling Error + Sampling Error

Trend

- Changes in fishing effort from year to year
- Modeled using state-specific population sizes from U.S. Census Bureau

Seasonal

- Changes in fishing effort from season to season
- Modeled using indicators for the six two-month waves in each state

Irregular

- Encompasses any other effect distinct from trend and seasonal effects
- Modeled as a random variable with a normal distribution, a mean of zero, and unknown variance to be estimated

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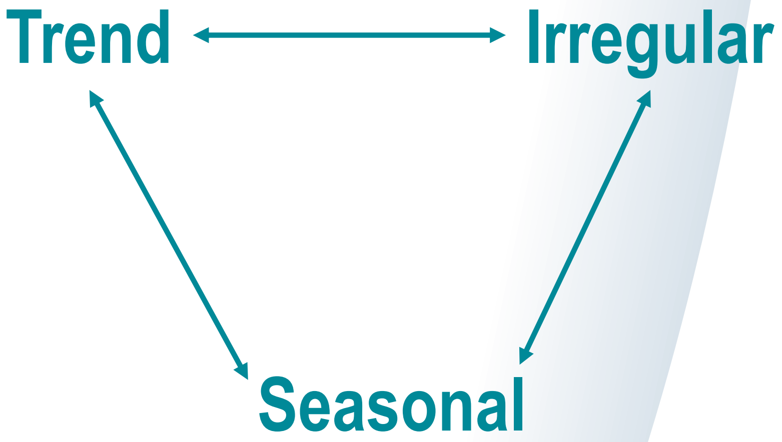
Shared Effects (cont)

Estimated Effort = **True Effort** + Nonsampling Error + Sampling Error

- Effects may interact
  - e.g. seasonal patterns vary by trend (year-to-year variation in fishing activity)



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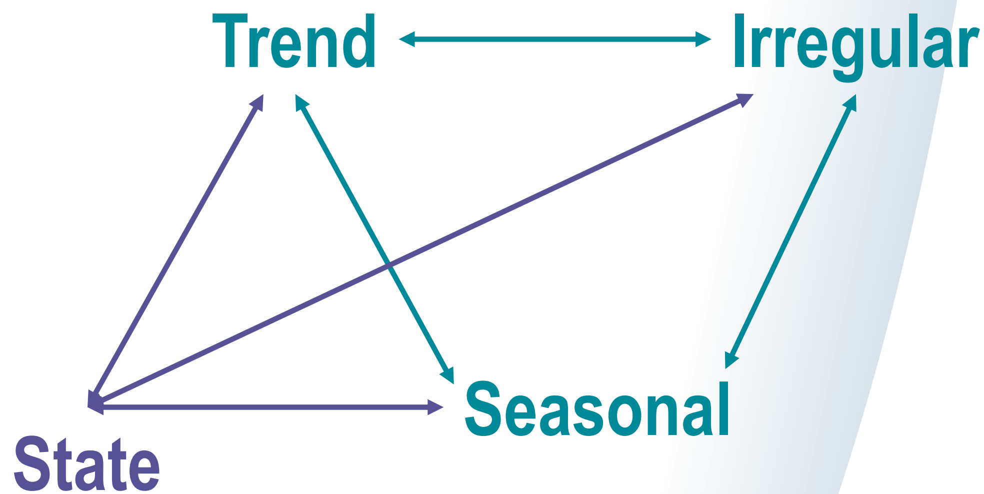
Shared Effects (cont)

Estimated Effort = **True Effort** + Nonsampling Error + Sampling Error

- Effects may interact
  - e.g. seasonal patterns vary by trend (year-to-year variation in fishing activity)
- Effects may vary by state

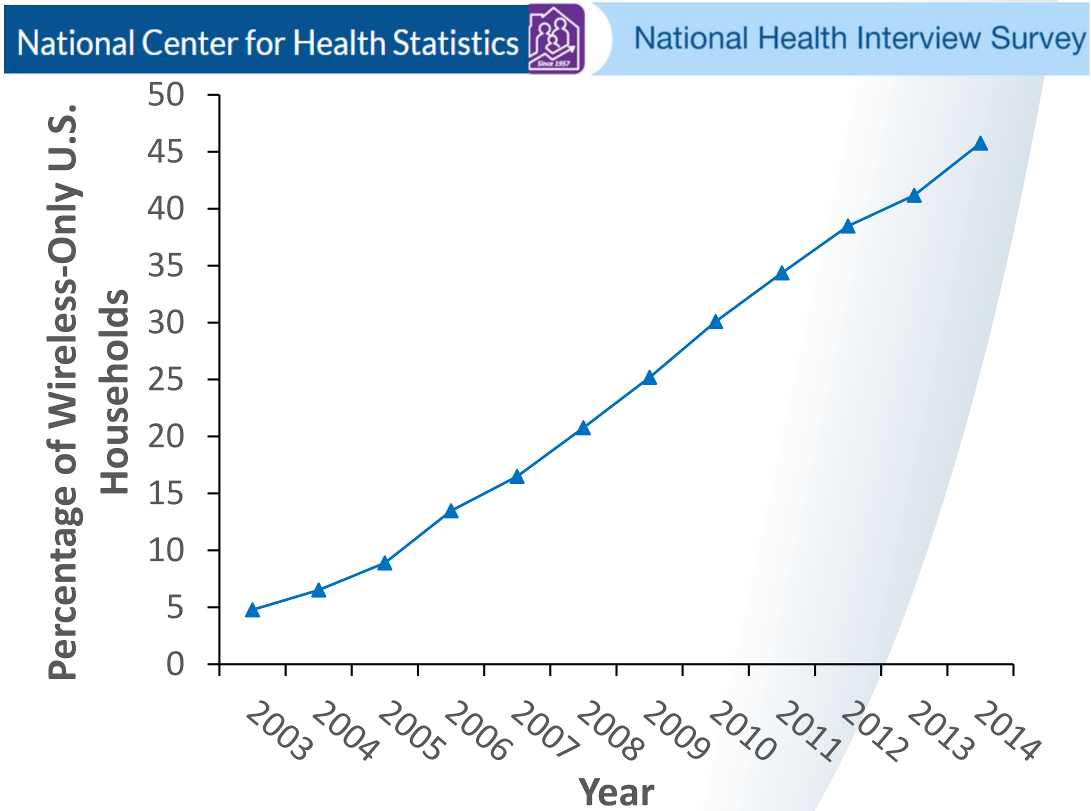


Additional set of individual state indicator terms to account for state variation

Unshared Effects

Estimated Effort = True Effort + **Nonsampling Error** + Sampling Error

- **Non-sampling error:** primary measurable covariate that changed over the course of the CHTS was the trend in wireless-only households (had estimates from 2007-2014
  - Fit simple model to expand wireless-only trend across 1981-2017)
    - Indicated that wireless effect was approximately zero pre-2000

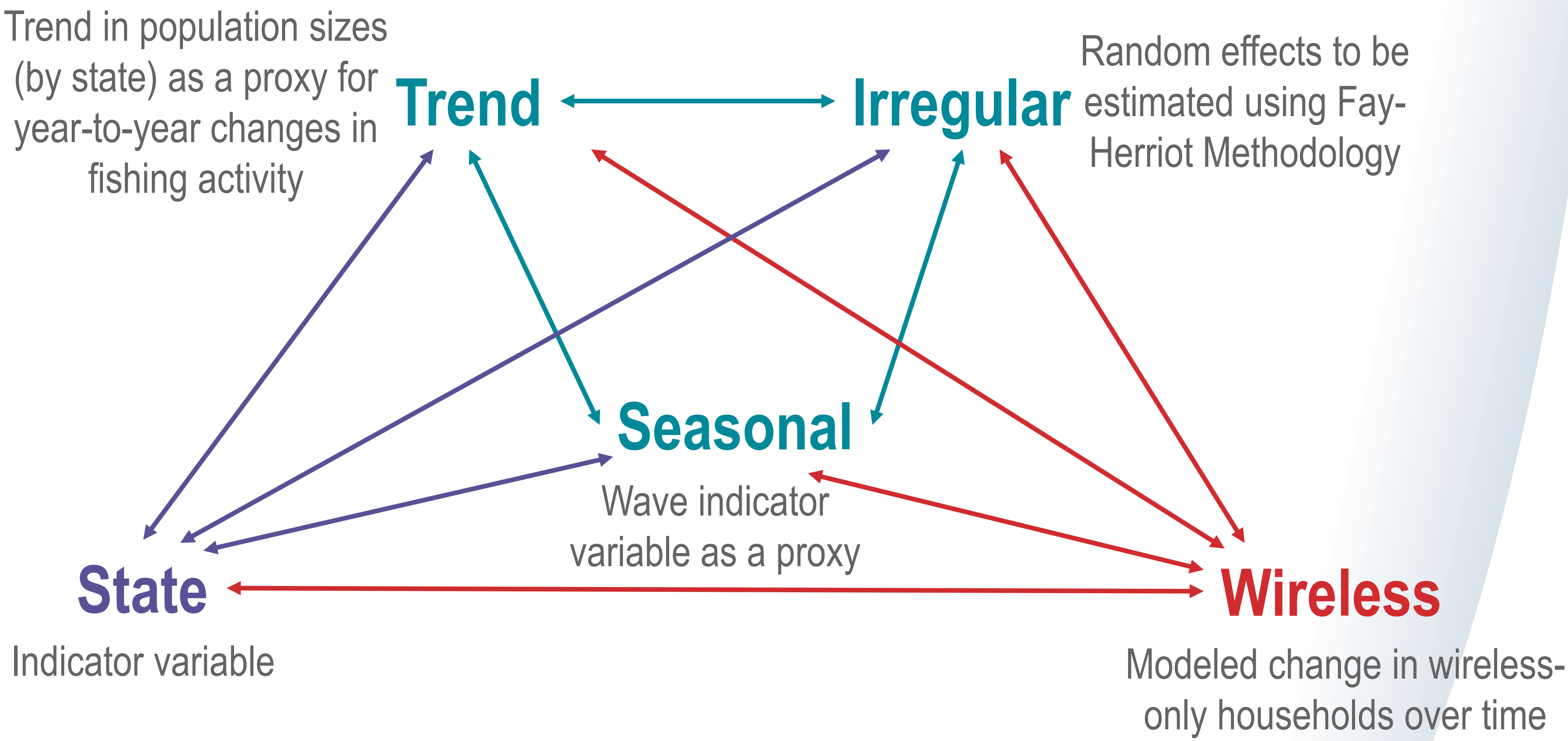


Unshared Effects

Estimated Effort = True Effort + Nonsampling Error + **Sampling Error**

- **Sampling error:** estimated for each survey using the variances of FES fishing effort estimates and CHTS fishing effort estimates – assumed independent from one another

Putting All Together



As with the other effects, the wireless-only effect's interactions with state, season and trend population are also taken into account in the model

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CHTS Calibration (post 2017 estimates)

$$\underbrace{\hat{Y}_d^T}_{\text{Estimated Effort}} = \overbrace{\theta_d^T}^{\text{True Effort + CHTS Nonsampling Error}} + \underbrace{e_d^T}_{\text{CHTS Sampling Error}}$$

$$\theta_d^T = x'_d \beta_d + v_d$$

Multi-dimensional term encompassing all <u>fixed effects relevant to CHTS</u> (trend, seasonal, state and wireless) and their interactions

Set of random regression coefficients, estimated using standard statistical methods

Irregular term (random effect) assumed to be distributed with mean of zero and a variance estimated using standard statistical methods

Separate model fit for each fishing mode (shore and private boat)

FES Calibration (pre 2015 estimates)

True Effort + FES Nonsampling Error

Estimated Effort

$$\hat{Y}_d^T = \theta_d^T + e_d^T$$

FES Sampling Error

$$\theta_d^T = x'_d \beta_d + v_d$$

Multi-dimensional term encompassing all fixed effects relevant to FES (trend, seasonal, and state only - **NO WIRELESS**) and their interactions

Set of random regression coefficients, estimated using standard statistical methods

Irregular term (random effect) assumed to be distributed with mean of zero and a variance estimated using standard statistical methods

Separate model fit for each fishing mode (shore and private boat)

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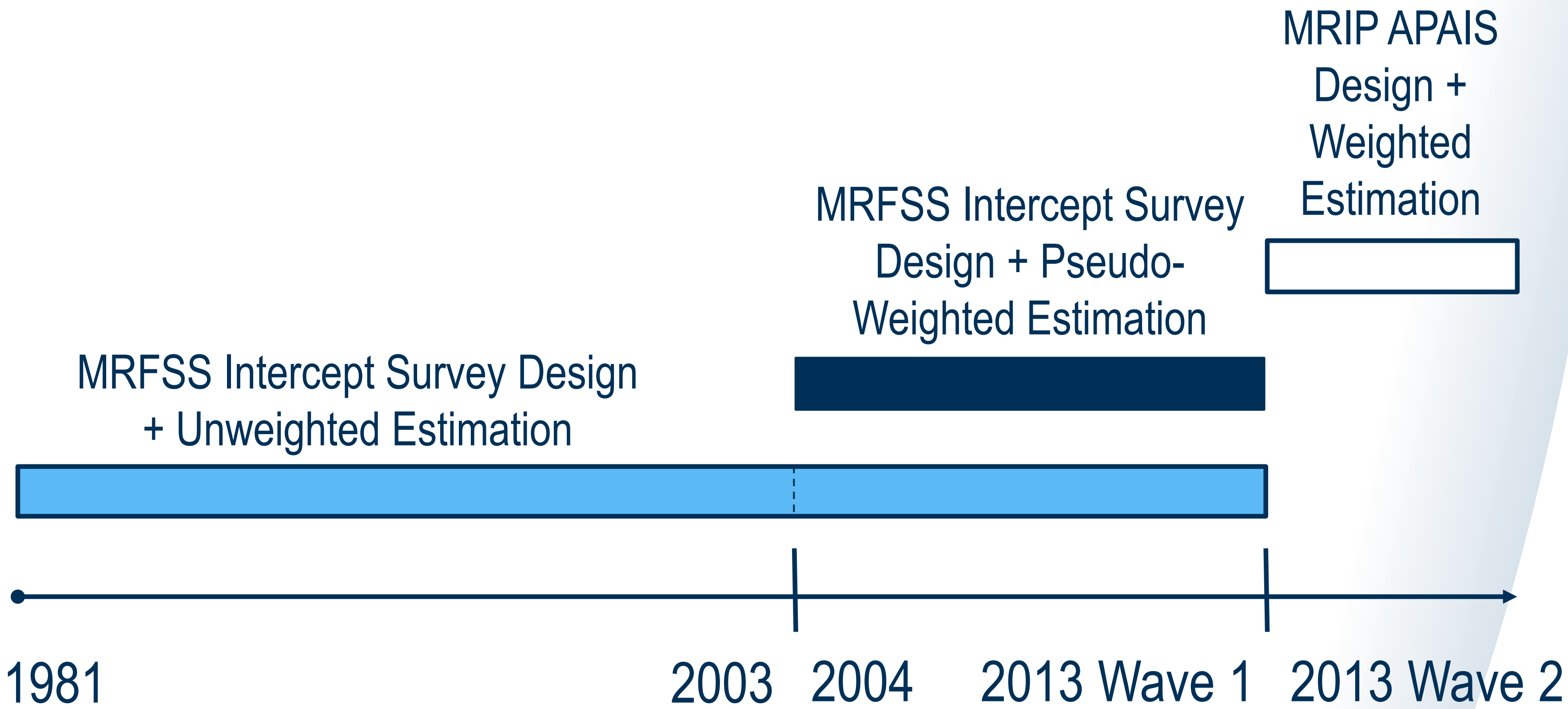
Catch Rate Estimation Methods Timeline

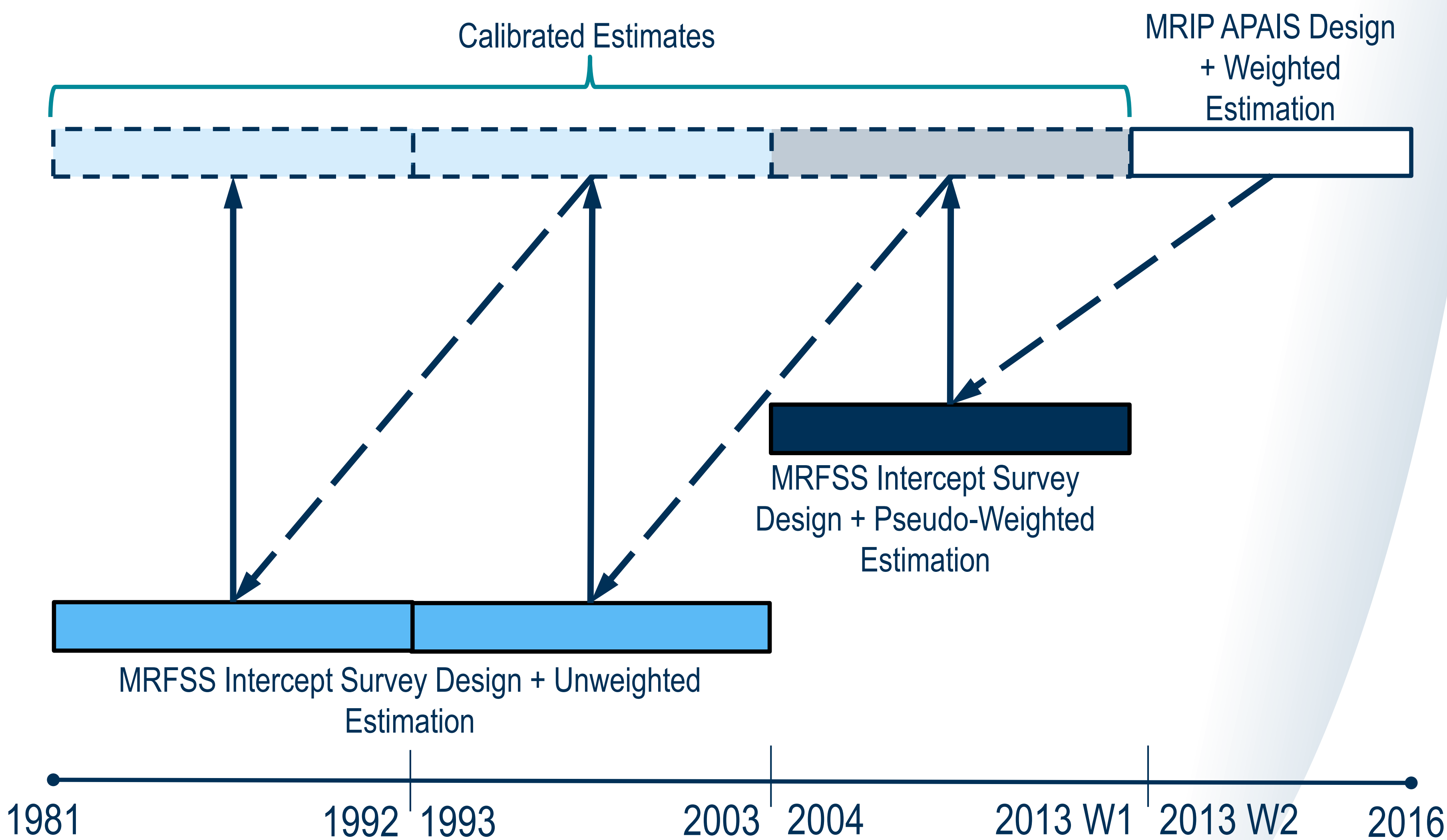


General Catch Rate Calibration Approach

- Raking ratio adjustment - widely used survey calibration approach (Deming and Stephan 1940)
  - Consists of sequential adjustments to sample weights, based on known population characteristics, until weights converge (i.e. stop changing)

Final adjusted weight = iterated weight

Raking Ratio (Sample Weight) Adjustment Method



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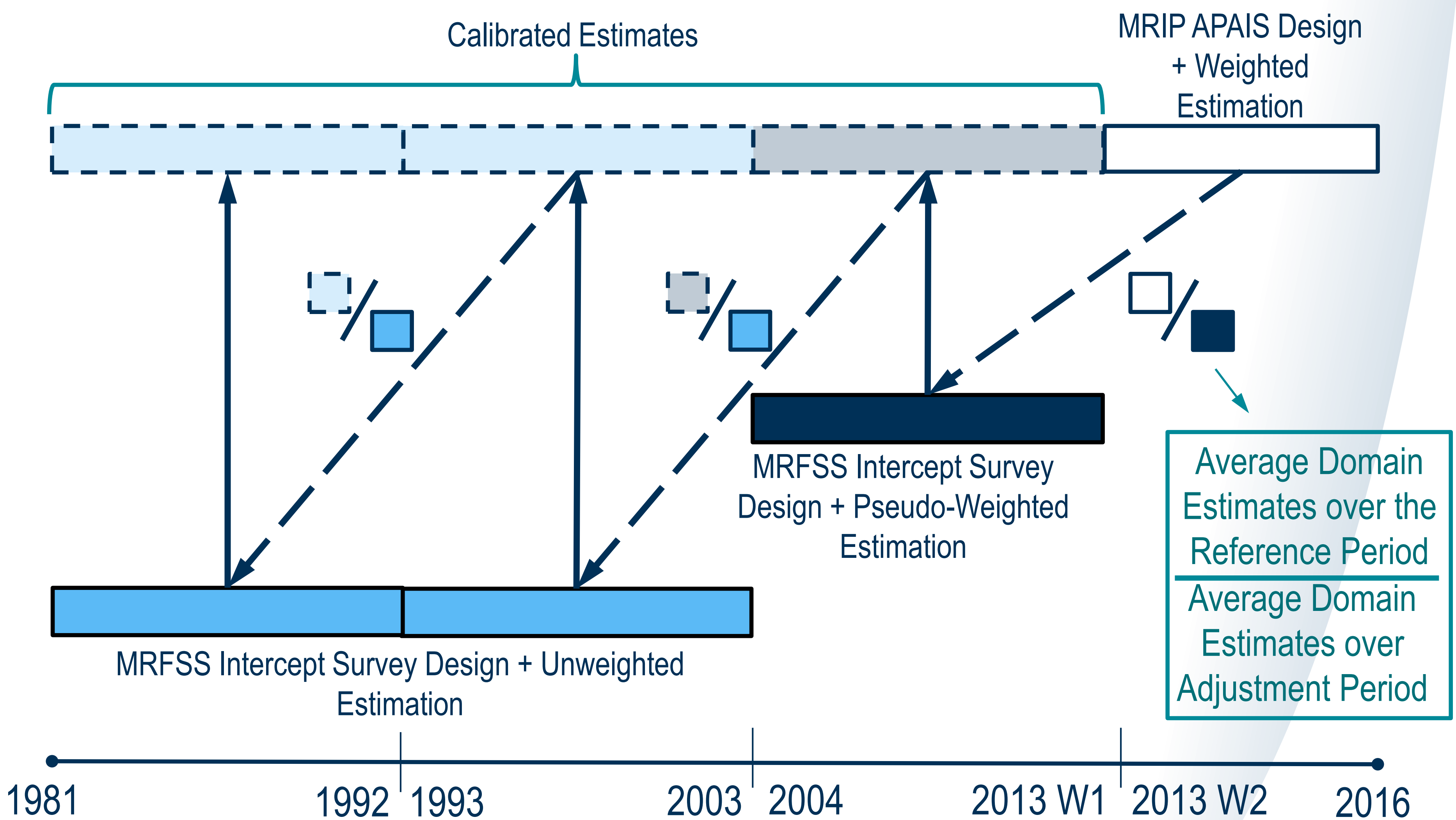
Raking Ratio (Sample Weight) Adjustment Method



Raking Ratio (Sample Weight) Adjustment Method

- 4 coarse domains selected for 2004-2013 calibration
  - **Area Fished**, State, Wave, and Fishing Mode
  - **Household Status** (i.e. Coastal or Non-Coastal), State, Wave and Fishing Mode
  - **For-hire frame status** (i.e. vessels on the for-hire sample frame or not), State, Wave, and Fishing Mode
  - **Sub-State Region**, State, Wave, and Fishing Mode

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Raking Ratio (Sample Weight) Adjustment Method

- 2 additional domains selected for 1981-2003 calibration to control for unobserved design effects
  - **Kind of Day**, State, Wave, and Fishing Mode
  - **Site Activity Class**, State Wave and Fishing Mode

Raking Ratio (Sample Weight) Adjustment Method

Starting calculation for raking algorithm:

Average of the domain estimates of intercepted angler trips from reference period

Initial sample weight of angler trip *j*

$$w_j^* = \frac{\hat{N}_{D,new}}{\hat{N}_{D,old}} w_j$$

Adjusted sample weight of angler trip *j*

Average of the domain estimates of intercepted angler trips from adjustment period

Measures taken to reduce risk of over-adjustment when real changes in fishery could have occurred

- Linear regression of totals over time – slopes of each time series tested for significant differences from zero (97.5% confidence level)
- If significant trend detected, raking applied over shorter time increments (e.g. ~3 year instead of ~10 year)

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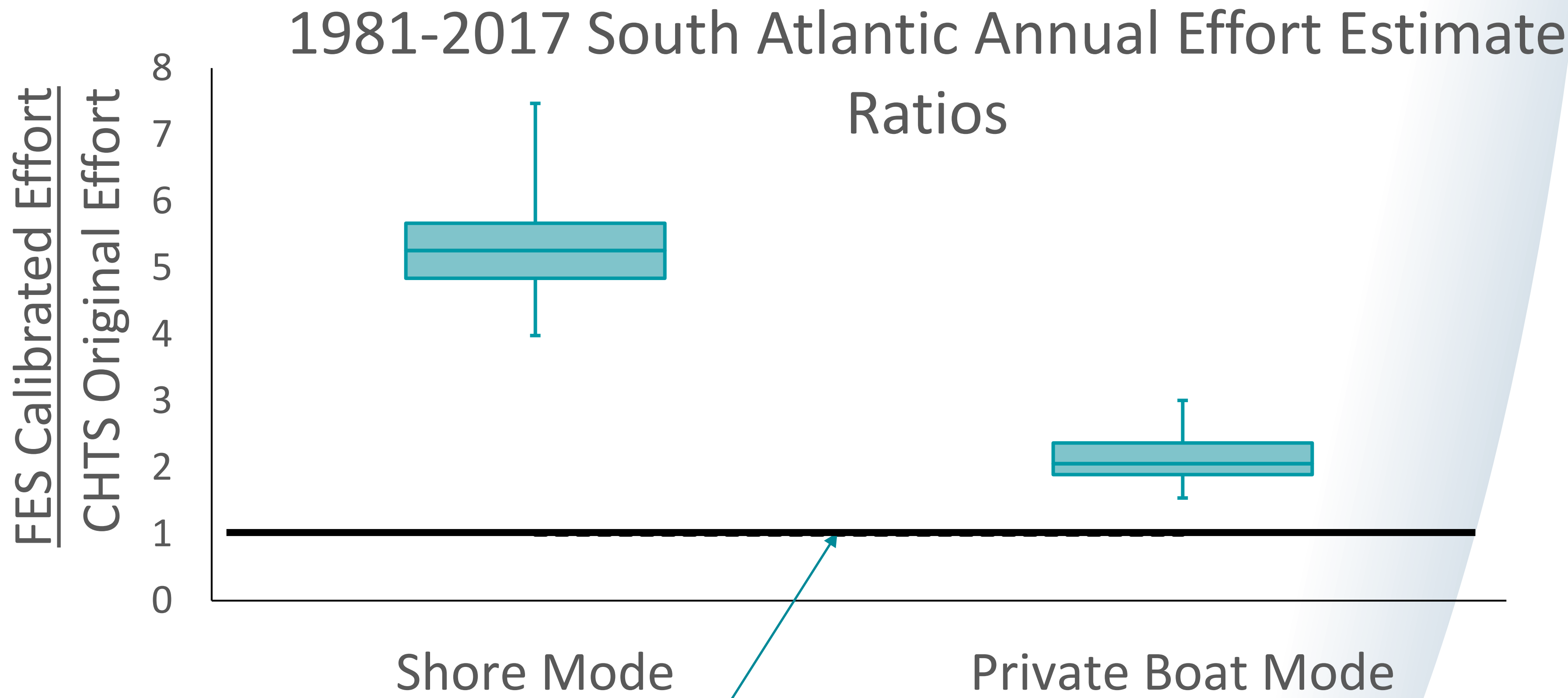
Effects on Time Series – FES Calibration



1:1
(what time series ratio would be if calibration had no effect on historical estimates)

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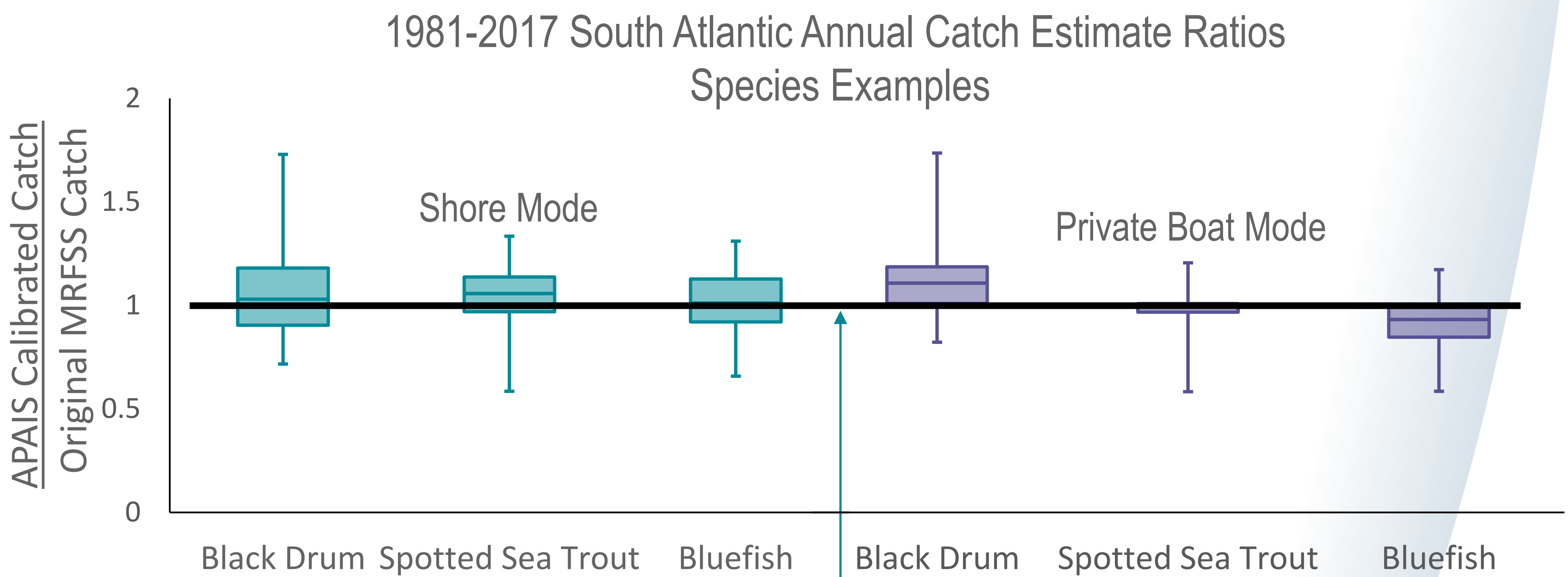
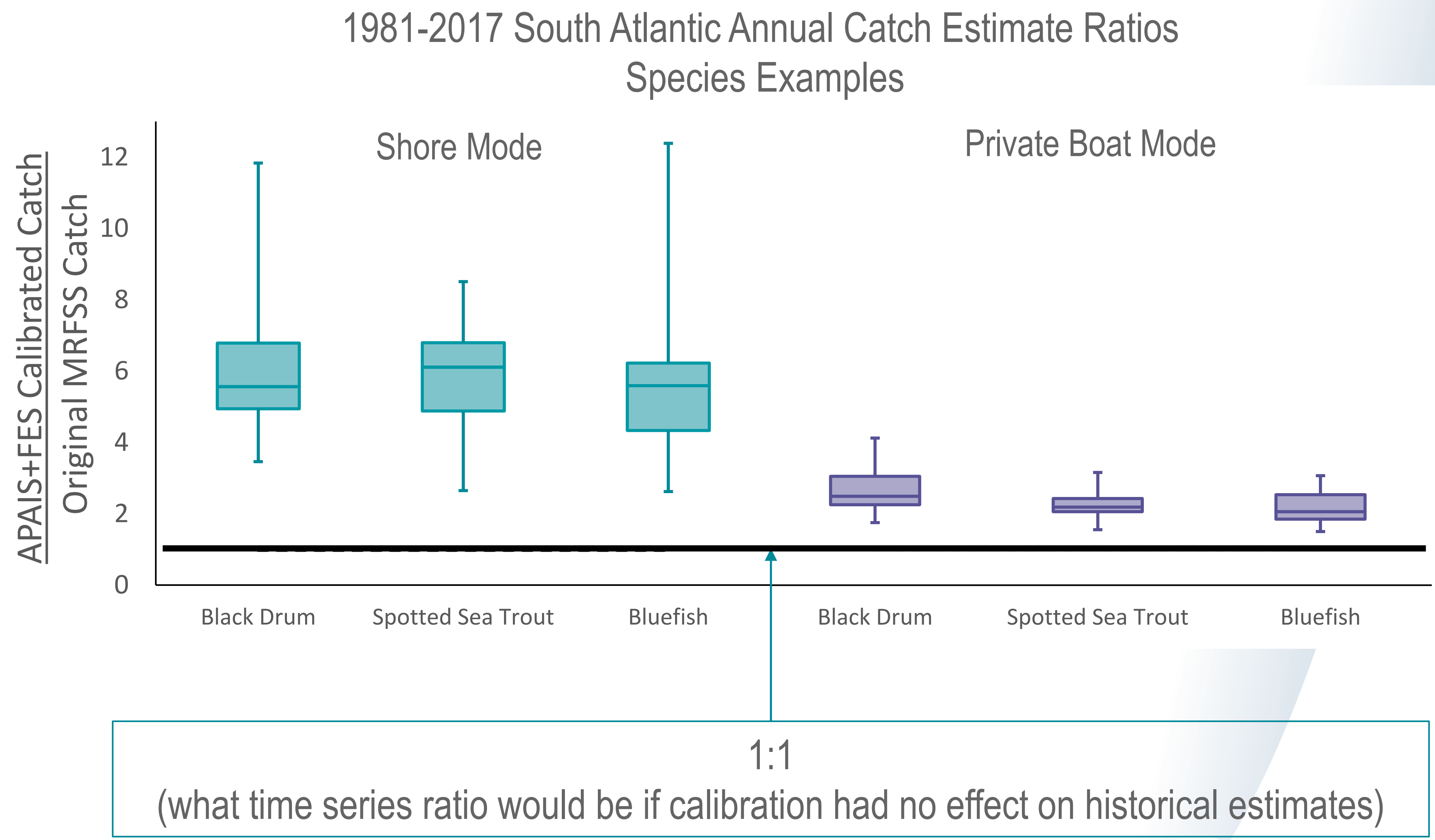
Effects on Time Series – APAIS Calibration



1:1
(what time series ratio would be if calibration had no effect on historical estimates)

Effects on Time Series – APAIS+FES Calibration



Questions?