Assessing a tool for crab modeling to inform management

Shortcut Management Strategy Evaluation (**MSE**) **Methods** for Applied Fisheries Management in **Alaska**

May 14, 2026

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May CPT

Agenda

01	The Question
02	Model Framework and Methods
03	Computing Comparison
04	Model Results
05	What have we learned / Recommendations from the CPT

THE QUESTION

Can we use **Shortcut Management Strategy Evaluation (MSE)** methods to **inform** fisheries management **decisions** for **North Pacific crab stocks** at the **state** and **federal** levels?

THE QUESTION

Overfishing Level (OFL)

UNCERTAINTY BUFFER (20%)

Allowable Biological Catch (ABC)

Harvest Control Rule (HCR)

TOTAL ALLOWABLE CATCH (TAC)

Aims to achieve MSY

THE QUESTION

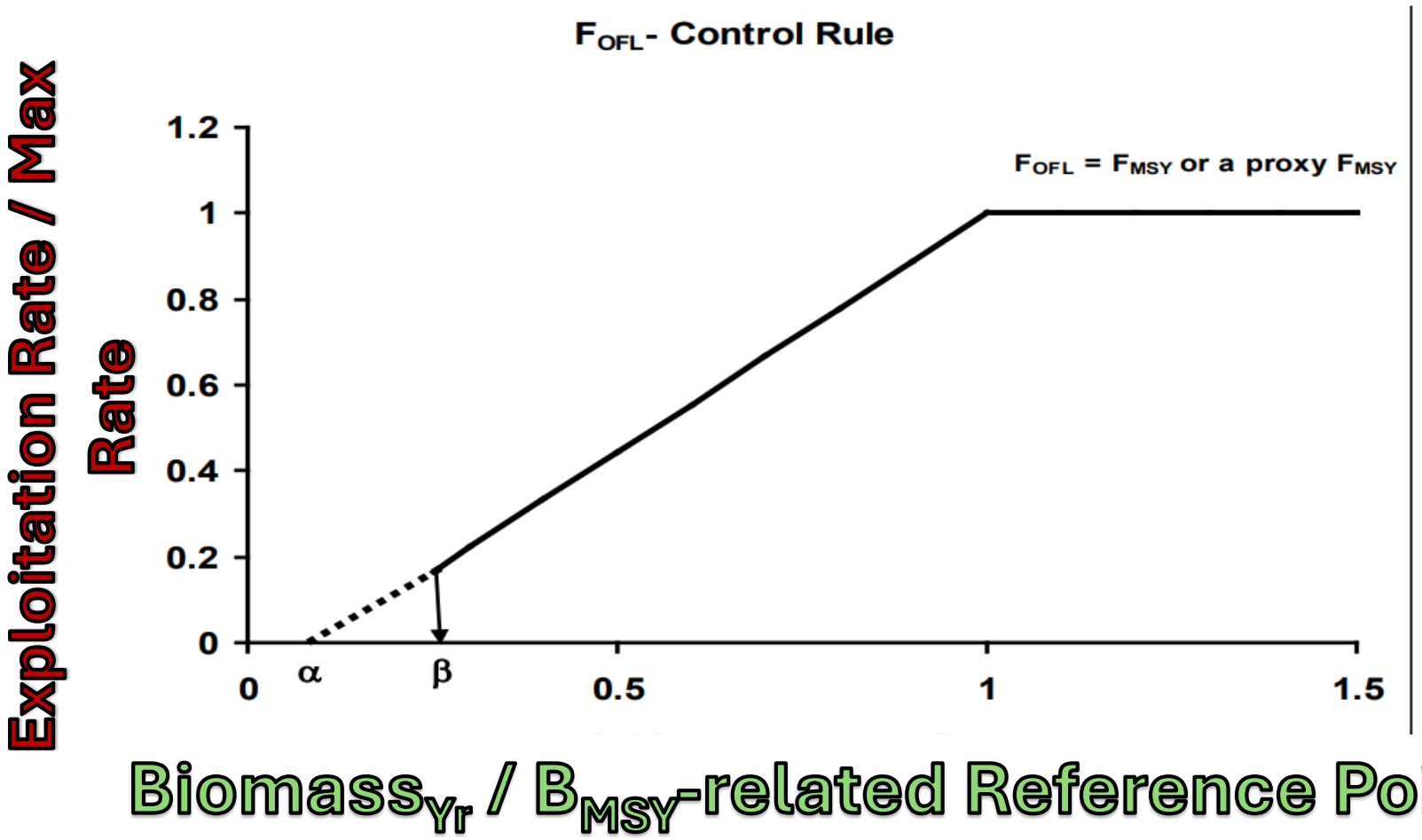
Federal HCR

State HCR

Model Framework and Methods

Federal HCR

OFL Control Rule for **Tiers** 1 through 4



Tier 3:

- $F_{35\%} \equiv F_{MSY}$
- $B_{35\%} \equiv B_{MSY}$

Tier 4:

- $\gamma M \equiv F_{MSY}$
- $\bar{B} \equiv B_{MSY}$

Model Framework and Methods

State HCRs

HCR Selection

Policy	Descript	Ramp v fixed expl	Lowest Non-0 expl	Max expl	Max TAC
HCR2_1	Male Only	Ramp	0.05	0.1	0.5 ELM
HCR2_4	Male Only	Ramp	0.05	0.225	0.5 ELM
HCR3	TAC = $ABC_{127mm+males}$	Ramp (Fmsy)	NA	NA	NA
HCR4_1	Female “Dimmer”	Ramp	0.05	0.2	0.5 ELM
HCR4_2	Female “Dimmer”	Ramp	0.1	0.225	0.5 ELM
HCR6_3	ELM 30%	Fixed	NA	NA	0.3 ELM
HCR6_5	ELM 40%	Fixed	NA	NA	0.5 ELM

Model Framework and Methods

State HCRs

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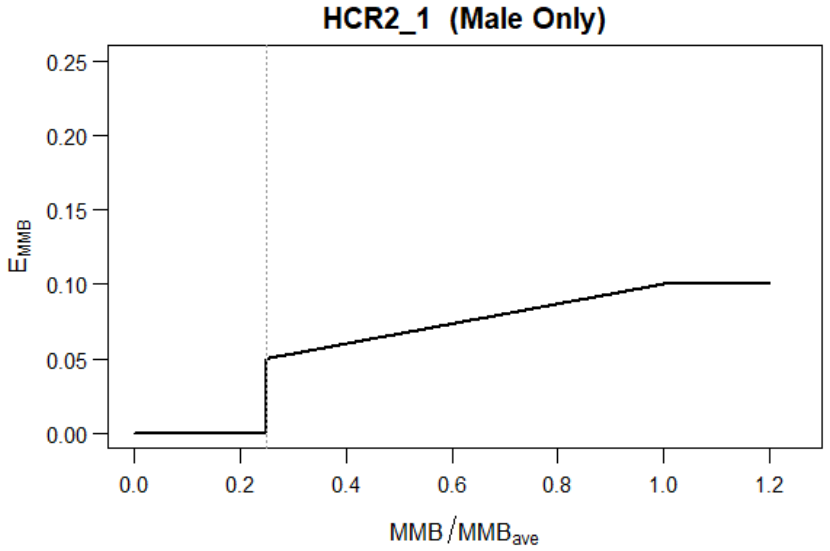
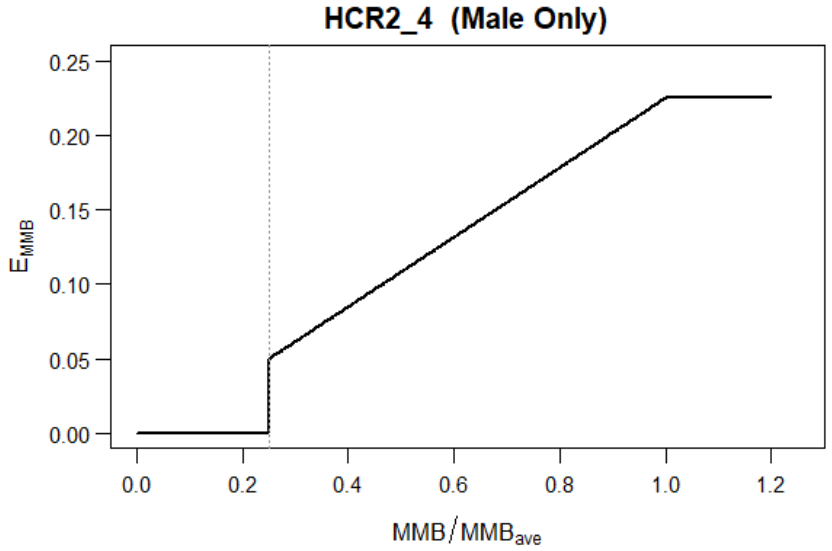
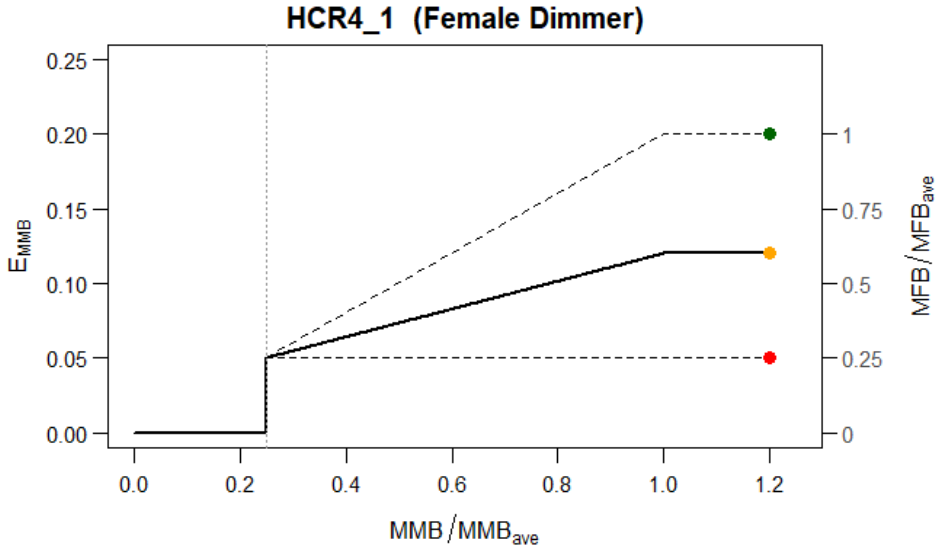
HCR6_5	ELM 40%	Fixed	NA	NA	0.5 ELM

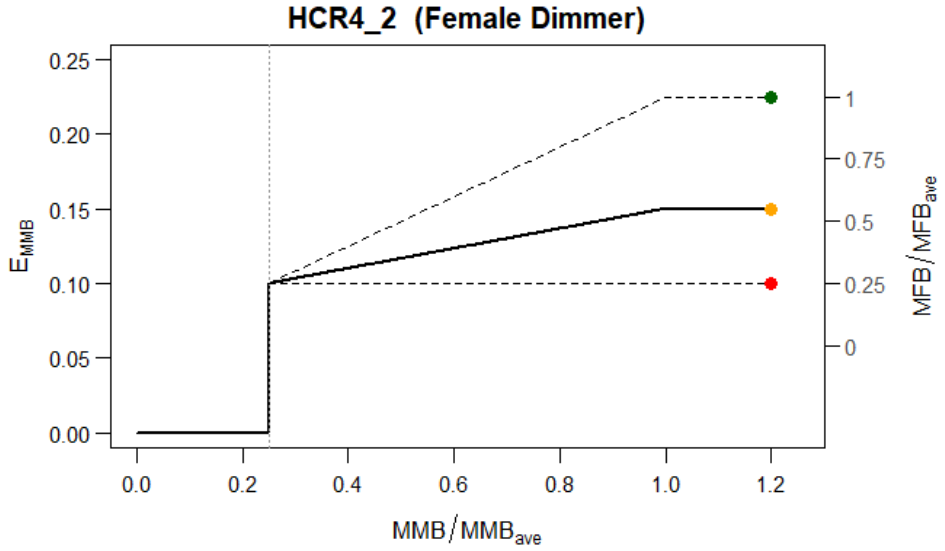
Model Framework and Methods

State HCRs



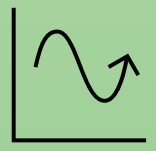




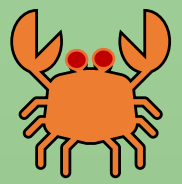


All capped at 50% ELMB

Model Framework and Methods



- Fits total **catch** for year



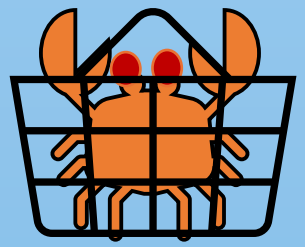
- **Projects** population forward one year

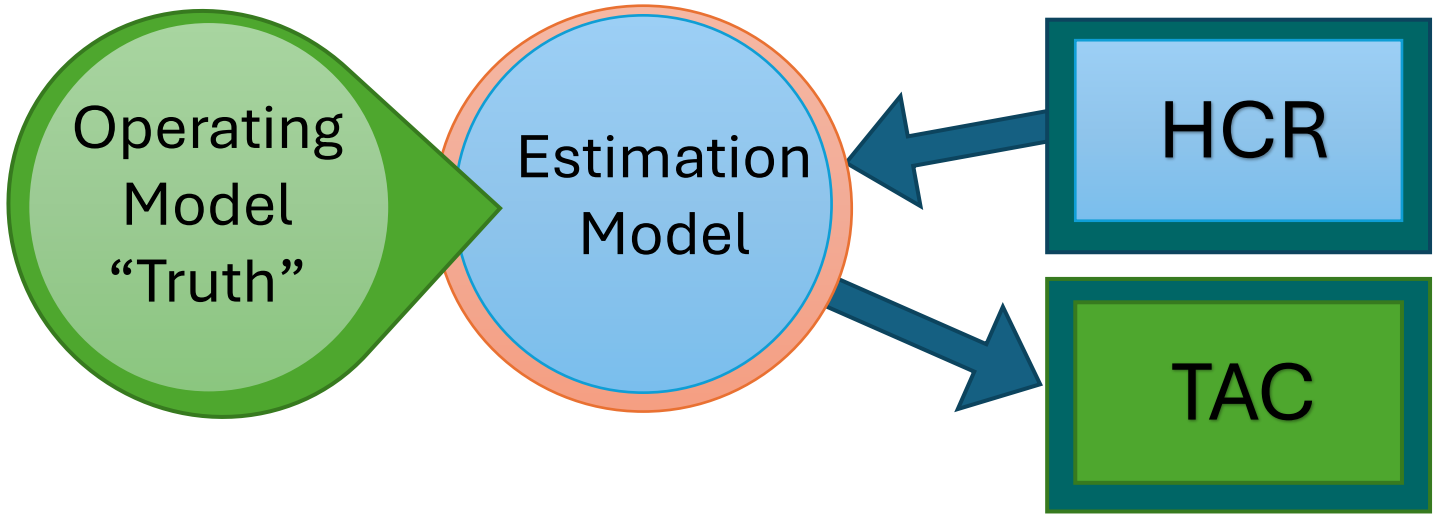
- Creates fishery and survey **data files**

Operating Model "Truth"

Model Framework and Methods

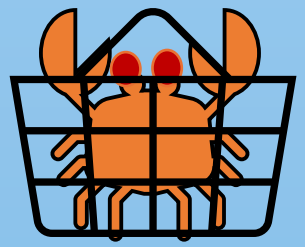
OFL/ABC



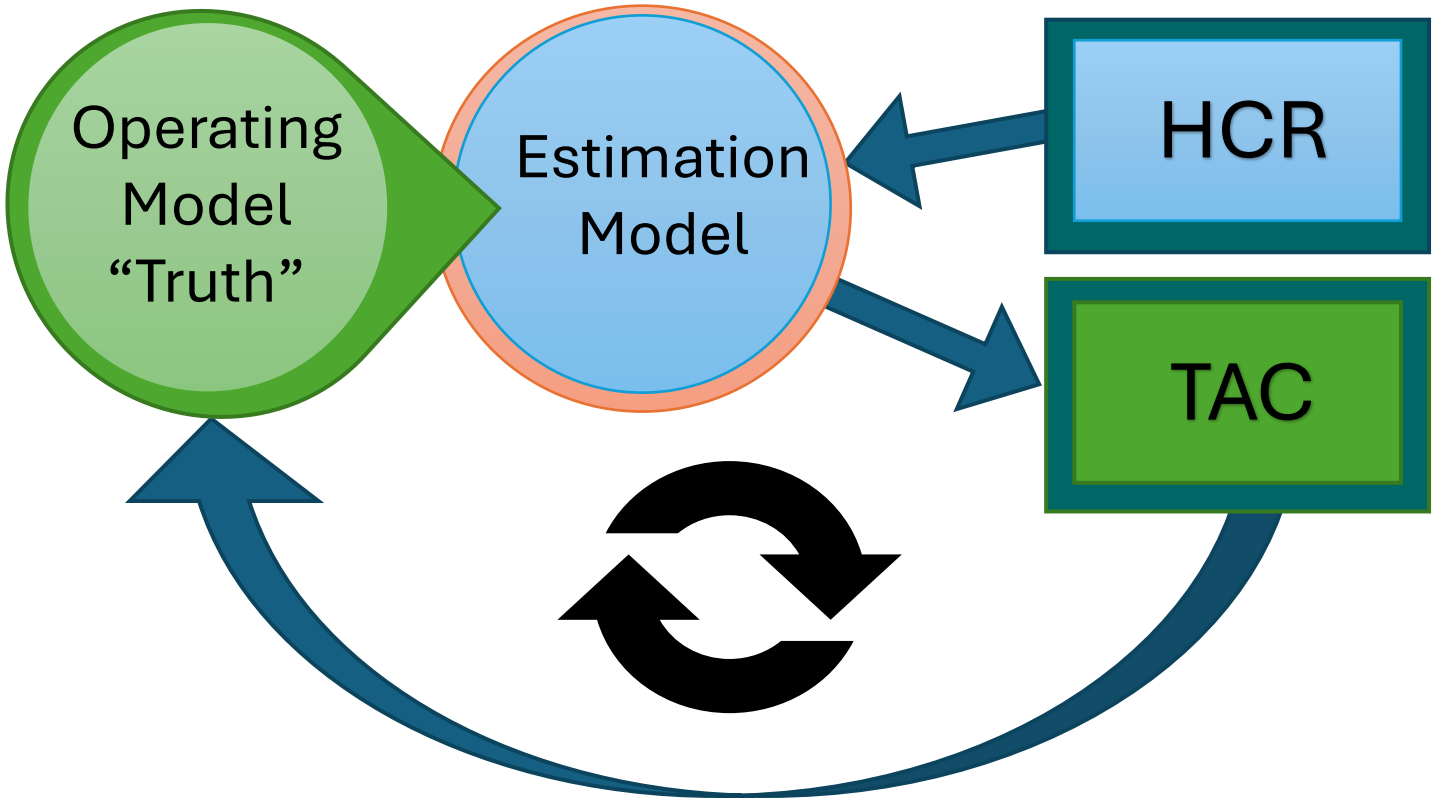


Model Framework and Methods

OFL/ABC



TAC →Operating model



Closed-loop simulation

Model Framework and Methods

THE QUESTION

1x Operating Model (TCSAM02 2018)

2x Federal HCR Tiers (Tier 3 & Tier 4)

2x Estimation Method (Full & Shortcut)

7x State HCRs

Model Framework and Methods

THE QUESTION

1x Operating Model (TCSAM02 2018)

2x Federal HCR Tiers (Tier 3 & Tier 4)

Cannot use shortcut methods with Tier 3 !

2x Estimation Method (Full & Shortcut)

7x State HCRs

Model Framework and Methods

Estimation Methods

Complex Estimation (TCSAM02)

- Stage/size-based population dynamics model
- Fits to:
  - Survey data
    - Abundance by sex, maturity state, shell condition-specific size-composition
  - Landed catches and discards
- Estimates growth/maturity
- Recruitment randomly selected
  - pool of estimates (1974- 2017)

Simple Estimation

- No modeled quantities
- Survey Biomass + error
  - Projected to the time of fishing

Model Framework and Methods

Three Frameworks

OM: TCSAM02

- **EM:**
  - Tier 3 Fed HCR
  - Full Estimation

OM: TCSAM02

- **EM:**
  - Tier 4 Fed HCR
  - Full Estimation

OM: TCSAM02

- **EM:**
  - Tier 4 Fed HCR
  - Shortcut Estimation

Model Framework and Methods

Three Frameworks

OM: TCSAM02

- **EM:**
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OM: TCSAM02

- **EM:**
  - Tier 4 Fed HCR
  - Full Estimation

OM: TCSAM02

- **EM:**
  - Tier 4 Fed HCR
  - Shortcut Estimation

Tier 3: $F_{MSY} = F_{35\%}$; $B_{MSY} = B_{35\%}$

Tier 4: $F_{MSY} = \gamma M$; $\gamma = 1$; $B_{MSY} = \overline{B}$

Model Framework and Methods

Intermediary/Shortcut Assumptions for Federal HCR Tier 4

- **OM**
  - B_{MSY} *Proxy* = **mean estimated** survey biomass from 1974 – 2017
    - *q* estimated
  - *M* = Model **estimated *M*** (by sex and maturity → no difference in shell condition partition)

- **Full EM**
  - B_{MSY} *Proxy* = **mean estimated** survey biomass from 1974 – MxYr
    - Matches the period of recruitment draws
    - Changes Annually
    - *q* estimated
  - *M* = Model **estimated *M*** (male only, by maturity)

- **Shortcut EM**
  - B_{MSY} *Proxy* = **mean raw** survey biomass from **1975 – MxYr**
    - *q* = 1
    - Changes Annually
  - *M* = Estimates hard-coded to the values for the OM (mature and immature)

Model Framework and Methods

Modeled v Raw inputs

- Modeled aveMMB
  - From modeled spawning biomass
    - Survey selectivity and q, catches removed, projected forward to spawning
    - Ex/ ~51.3836 kt
- Shortcut aveMMB
  - Raw survey data
  - SpawnB = $SurveyB_y$ – $Catch_y$ * exp(-dtM * M)
    - Ex/ ~36.72 kt

~30% difference

Model Framework and Methods

Run Structure

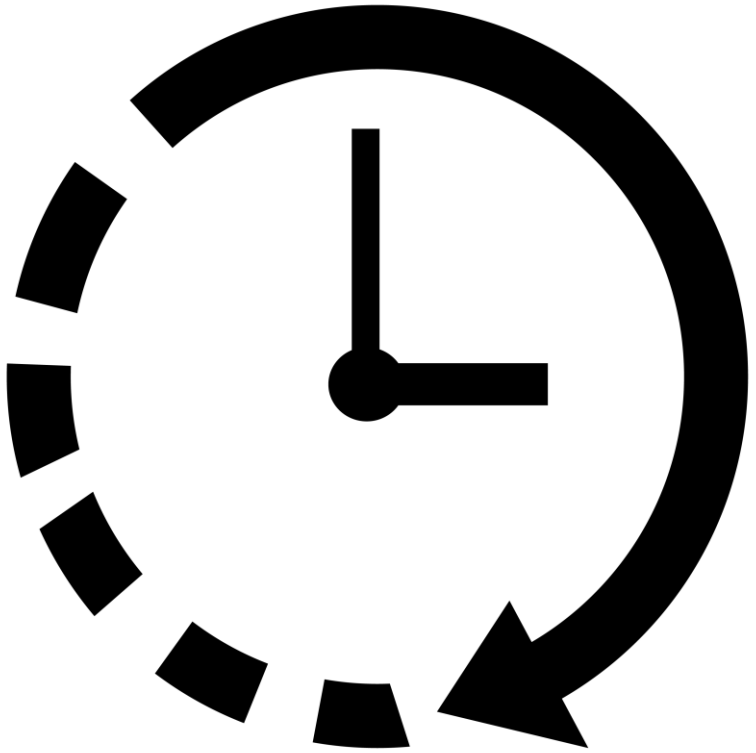
100-Year Projections

100 Replicates

Relative Differences for **7state HCRs**

21 Model Runs (14 Full EM + 7 Short EM)

Computing Comparison



Computing Comparison

Space Requirements

~572GB per model run

21runs → ~12TB

Regardless of the estimation method

(repeating data files and folder structure)

Computing Comparison

Run Times

Complex Estimation

- 2.3 min/simyear
  → 10,000 simyears/HCR

~385 hours (16 days)

Shortcut Estimation

Computing Comparison

Run Times

Complex Estimation

- 2.3 min/simyear
  →10,000 simyears/HCR
  ~385 hours (16 days)

- 7 HCRs
  ~2,695 hours
  (112 days)

Shortcut Estimation

Computing Comparison

Run Times

Complex Estimation

- 2.3 min/simyear
  →10,000 simyears/HCR
  ~385 hours (16 days)

- 7 HCRs
  ~2,695 hours (112 days)

Shortcut Estimation

- 0.1 min/simyear (5.3 sec)
  →10,000simyears/HCR
  ~15 hours (0.6 days)

- 7 HCRs
  ~102 hours (4.3 days)

Computing Comparison

Run Times

Complex Estimation

- 2.3 min/simyear
  →10,000 simyears/HCR

  ~385 hours (16 days)

- 7 HCRs

  ~2,695 hours (112 days)

Shortcut Estimation

- 0.1 min/simyear (5.3 sec)
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  ~15 hours (0.6 days)

- 7 HCRs

  ~102 hours (4.3 days)

Ran in parallel on local machine (4 x 25 replicates) x 2HCR at a time

Computing Comparison

Run Times

Complex Estimation

- 2.3 min/simyear
  →10,000 simyears/HCR

~4 days in parallel

- 7 HCRs (2 at a time)

~16 days

Shortcut Estimation

- 0.1 min/simyear (5.3 sec)
  →10,000simyears/HCR

~4 hours in parallel

- 7 HCRs (2 at a time)

~16 hours

Ran in parallel on local machine (4 x 25 replicates) x 2HCR at a time

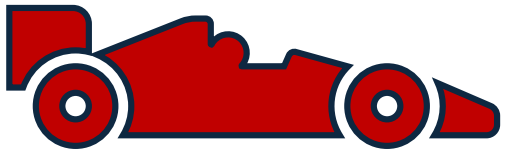
Computing Comparison

Shortcut Estimation

Pros

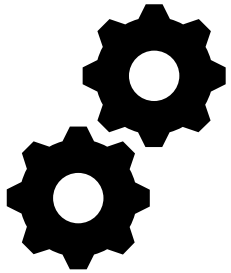
- Fast run time

(probably faster development time if it's not a PhD student doing the dev…)



Cons

- Doesn't reflect the federal assessment process
- No change in storage space requirements



Results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NOAA
U.S. DEPARTMENT OF COMMERCE


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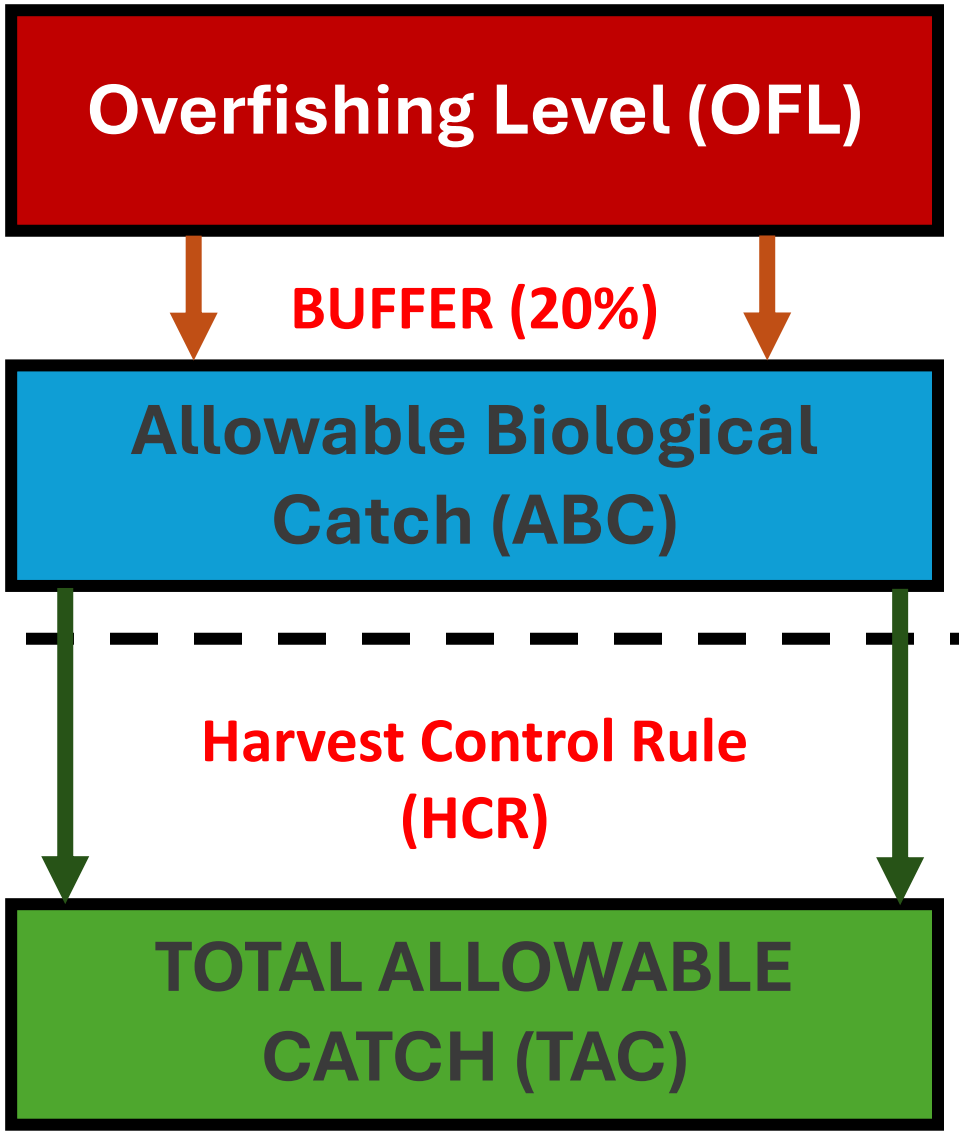
Overfishing Level (OFL)
BUFFER (20%)
Allowable Biological Catch (ABC)
Harvest Control Rule (HCR)
TOTAL ALLOWABLE CATCH (TAC)

Results


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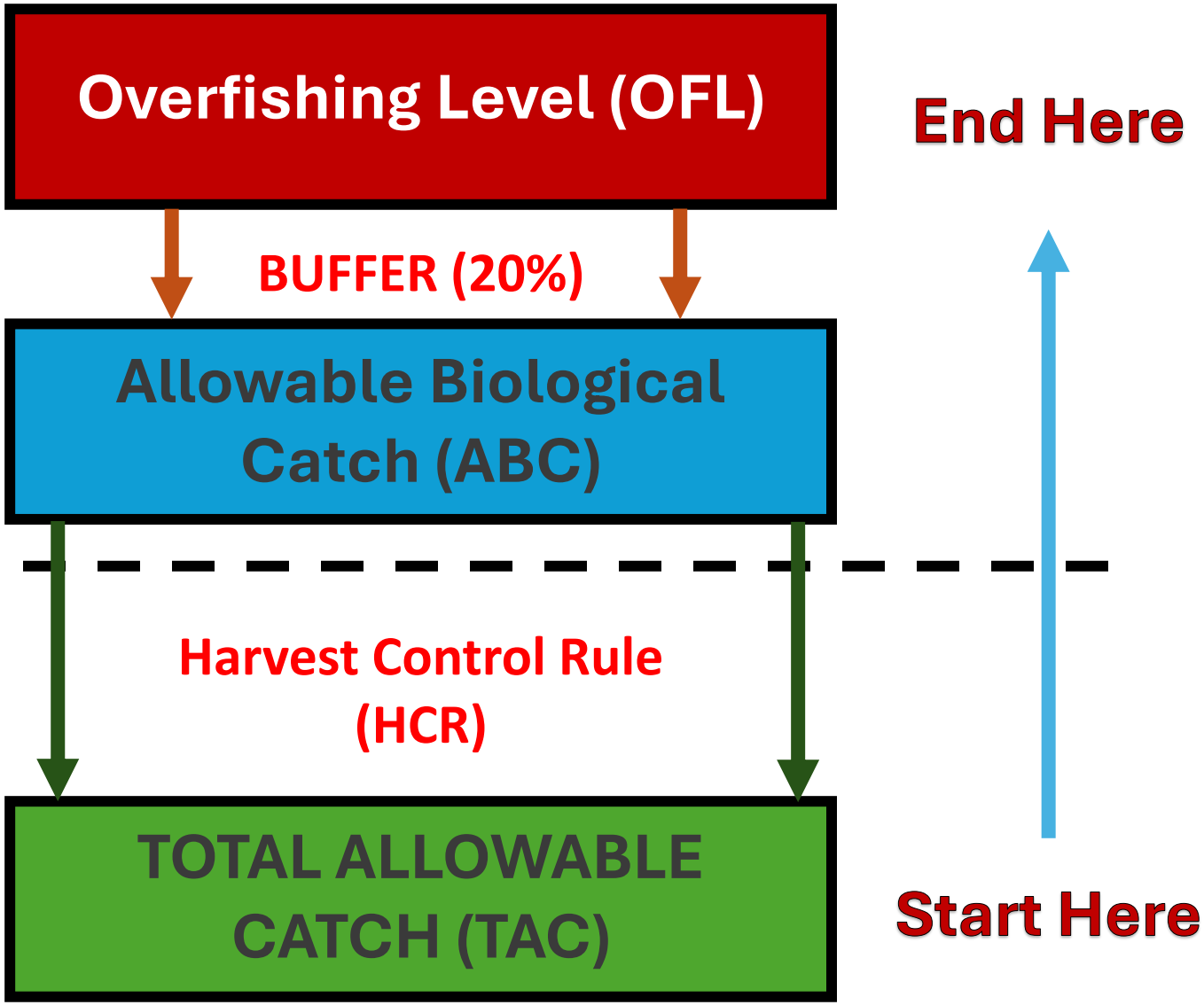
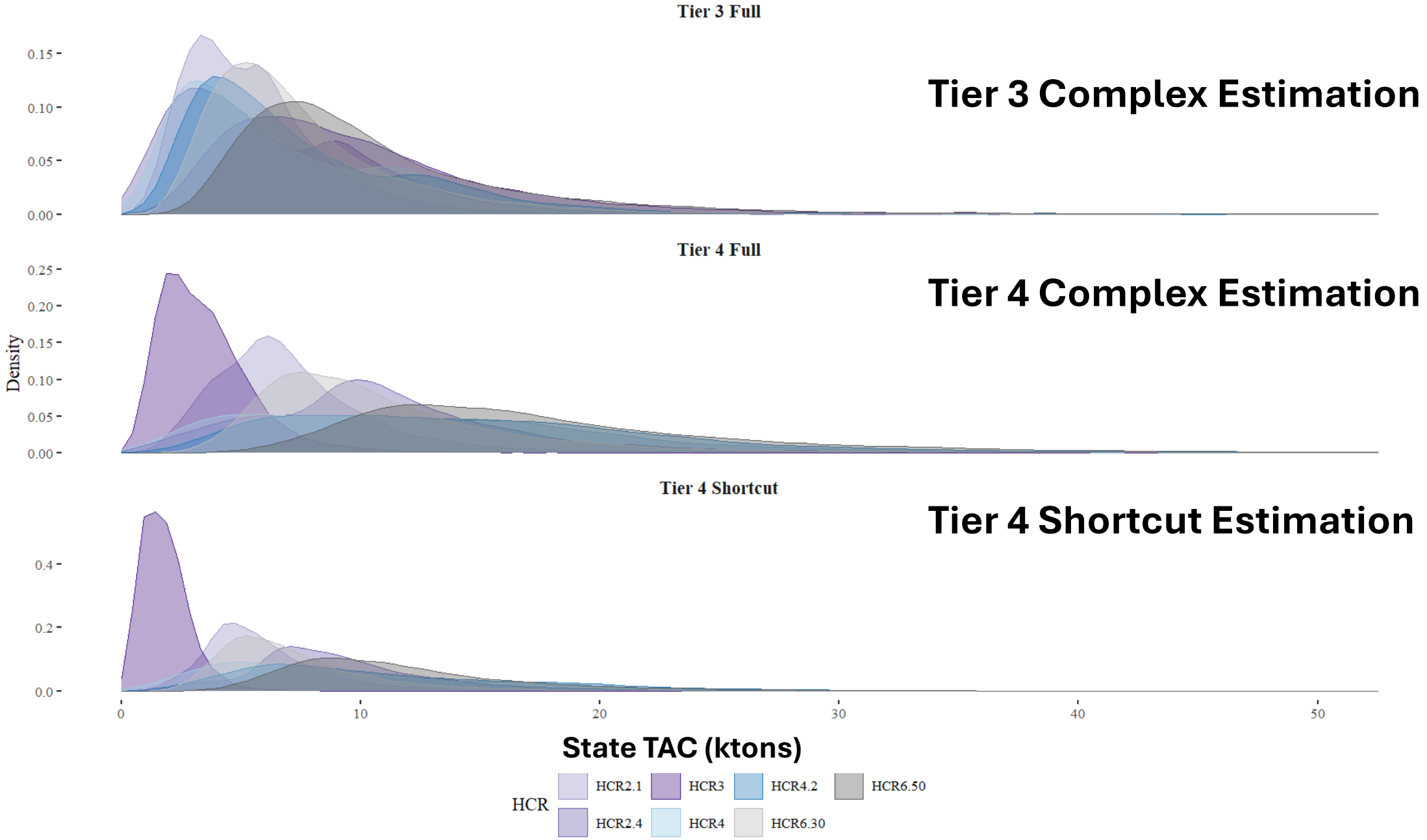

Overfishing Level (OFL)
End Here
BUFFER (20%)
Allowable Biological Catch (ABC)
Harvest Control Rule (HCR)
TOTAL ALLOWABLE CATCH (TAC)
Start Here

Results

Notes

- First 10 years (2019-2028) excluded to avoid initial conditions
- Some axes are bounded
  - Some high variability and outliers → zoomed in

Results – State TAC (uncapped; all)

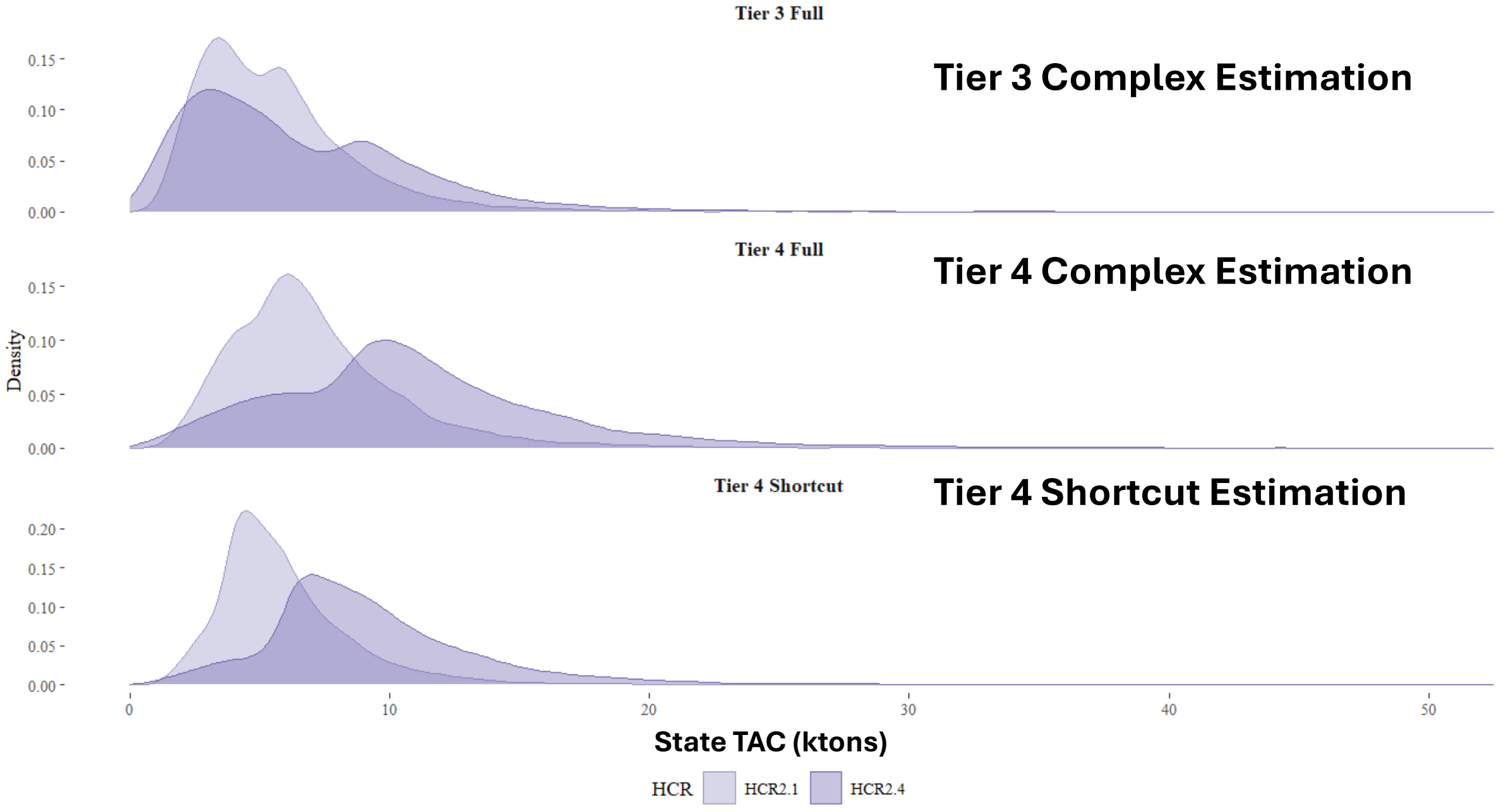


Tier 3 Complex Estimation

Tier 4 Complex Estimation

Tier 4 Shortcut Estimation

Results – State TAC (male only)

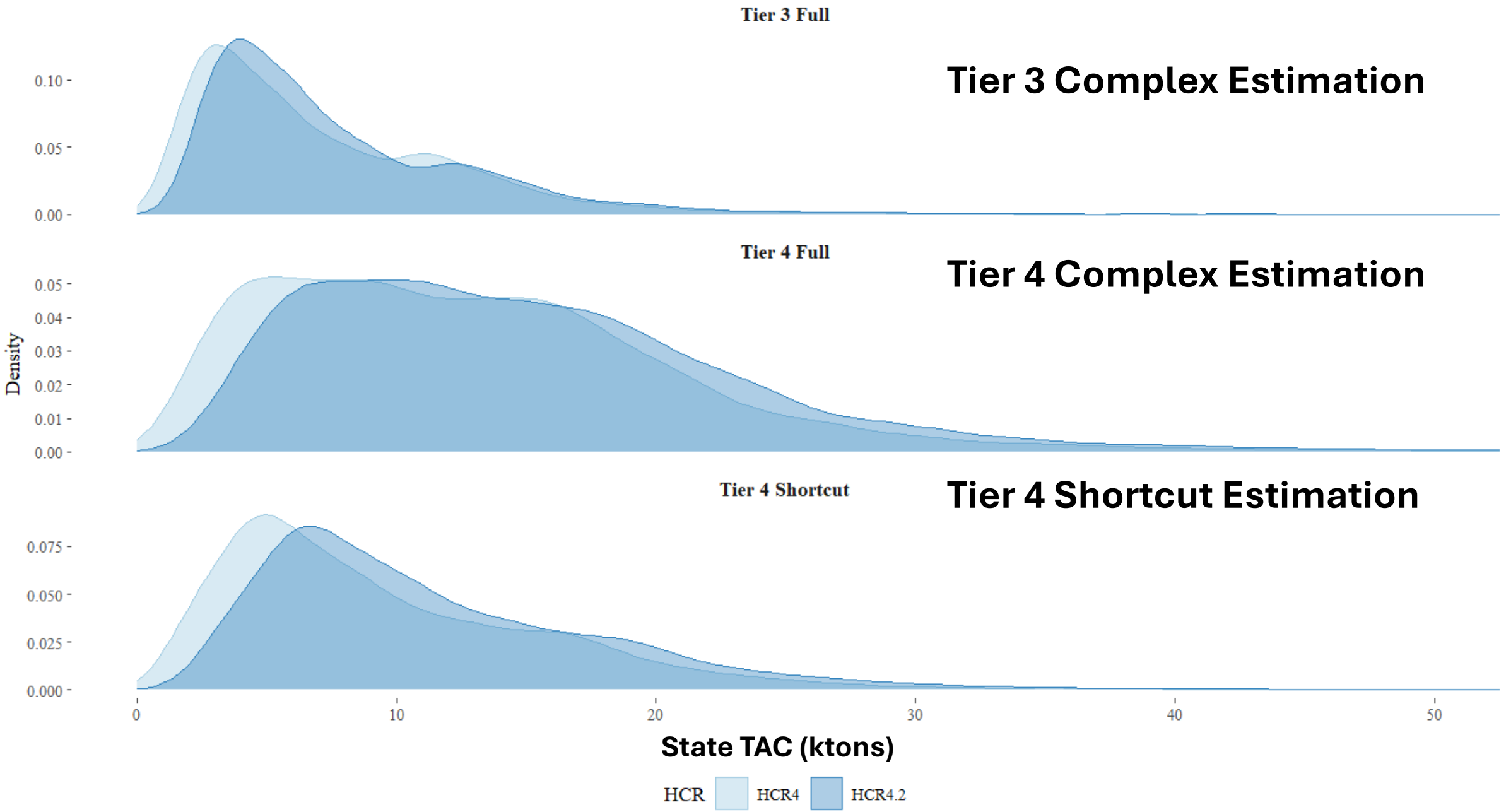


Tier 3 Complex Estimation

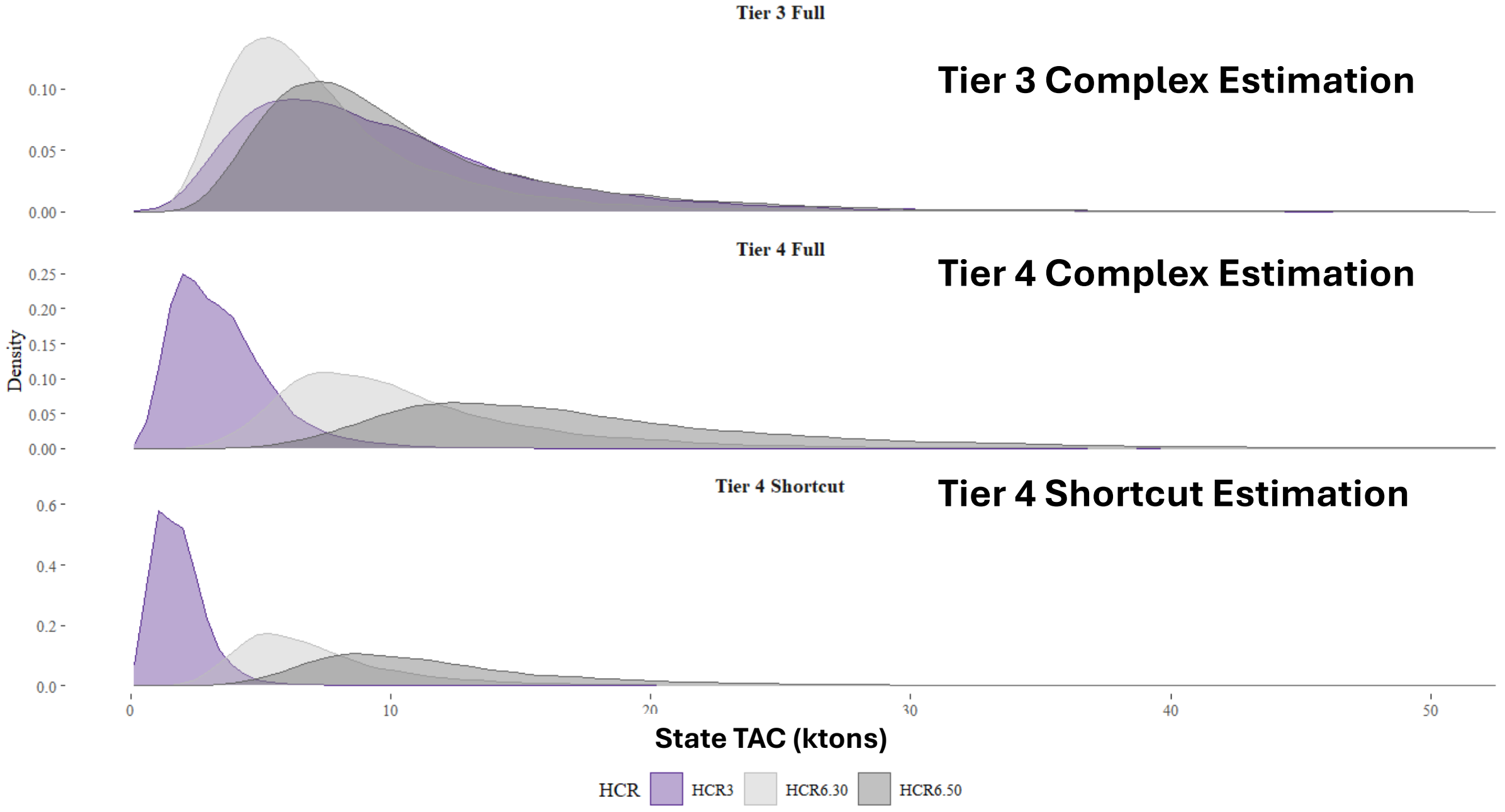
Tier 4 Complex Estimation

Tier 4 Shortcut Estimation

Results – State TAC (female dimmer)



Results – State TAC (catch scalers)

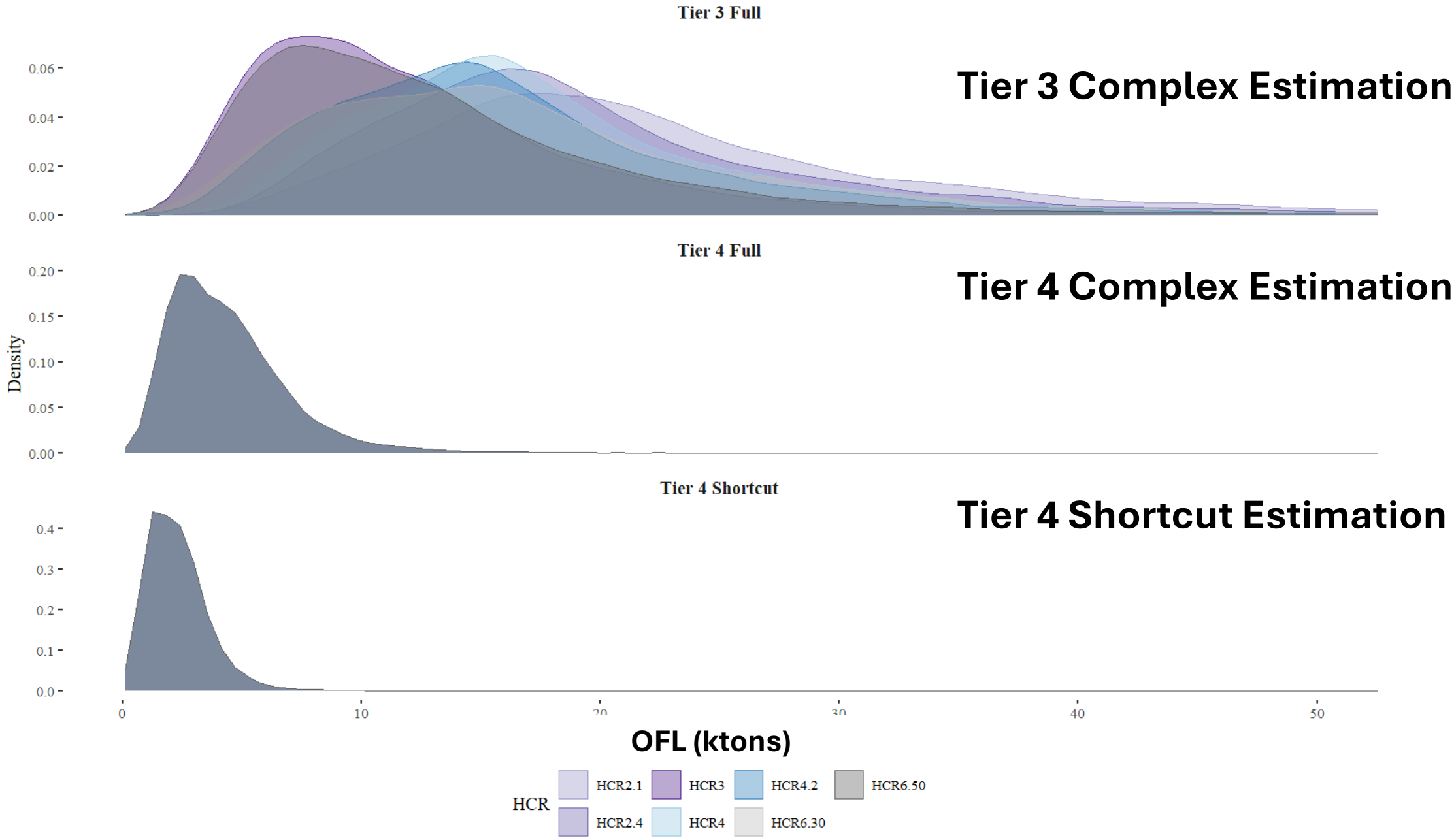


Tier 3 Complex Estimation

Tier 4 Complex Estimation

Tier 4 Shortcut Estimation

Results – OFL (all)

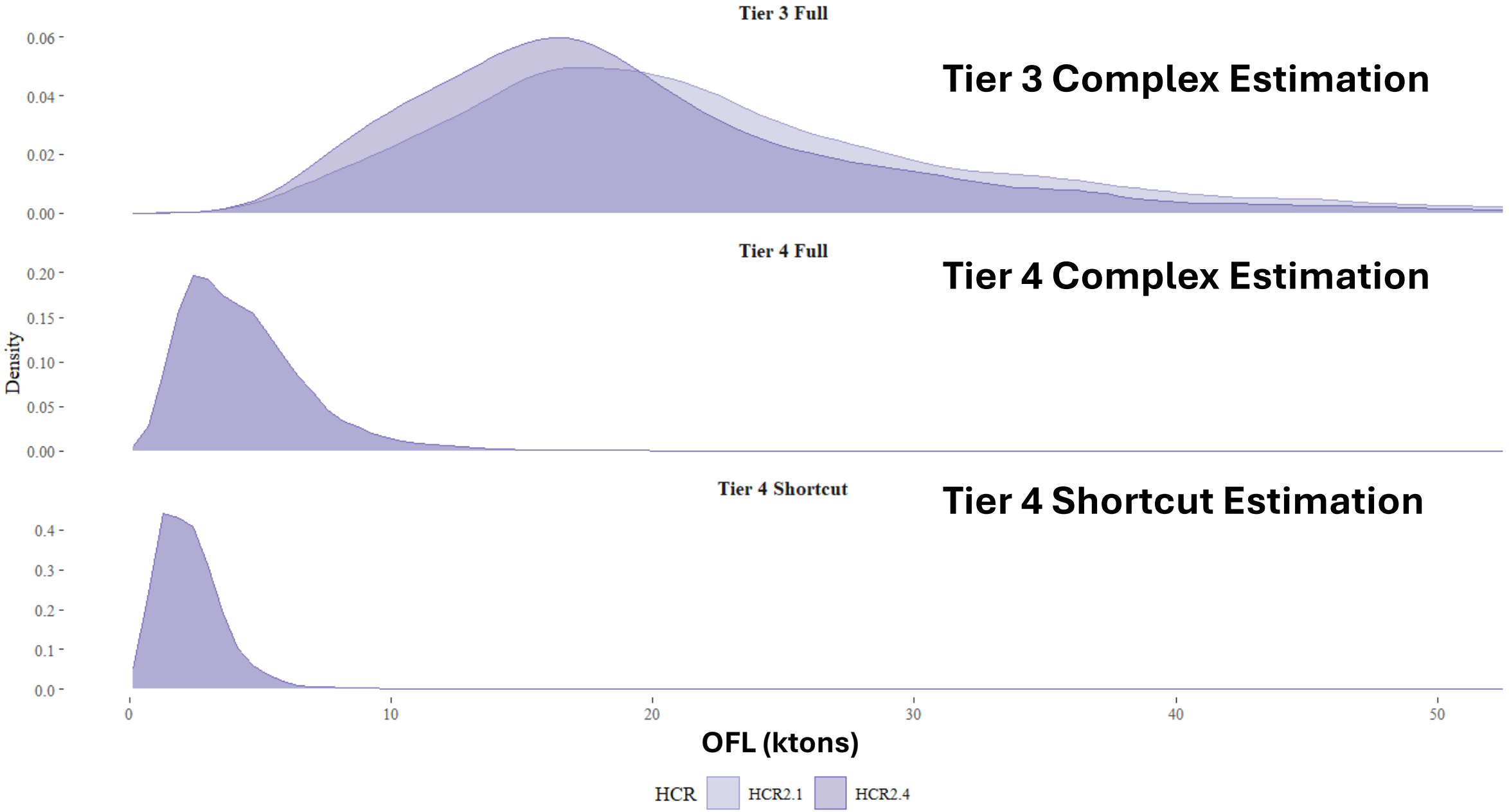


Tier 3 Complex Estimation

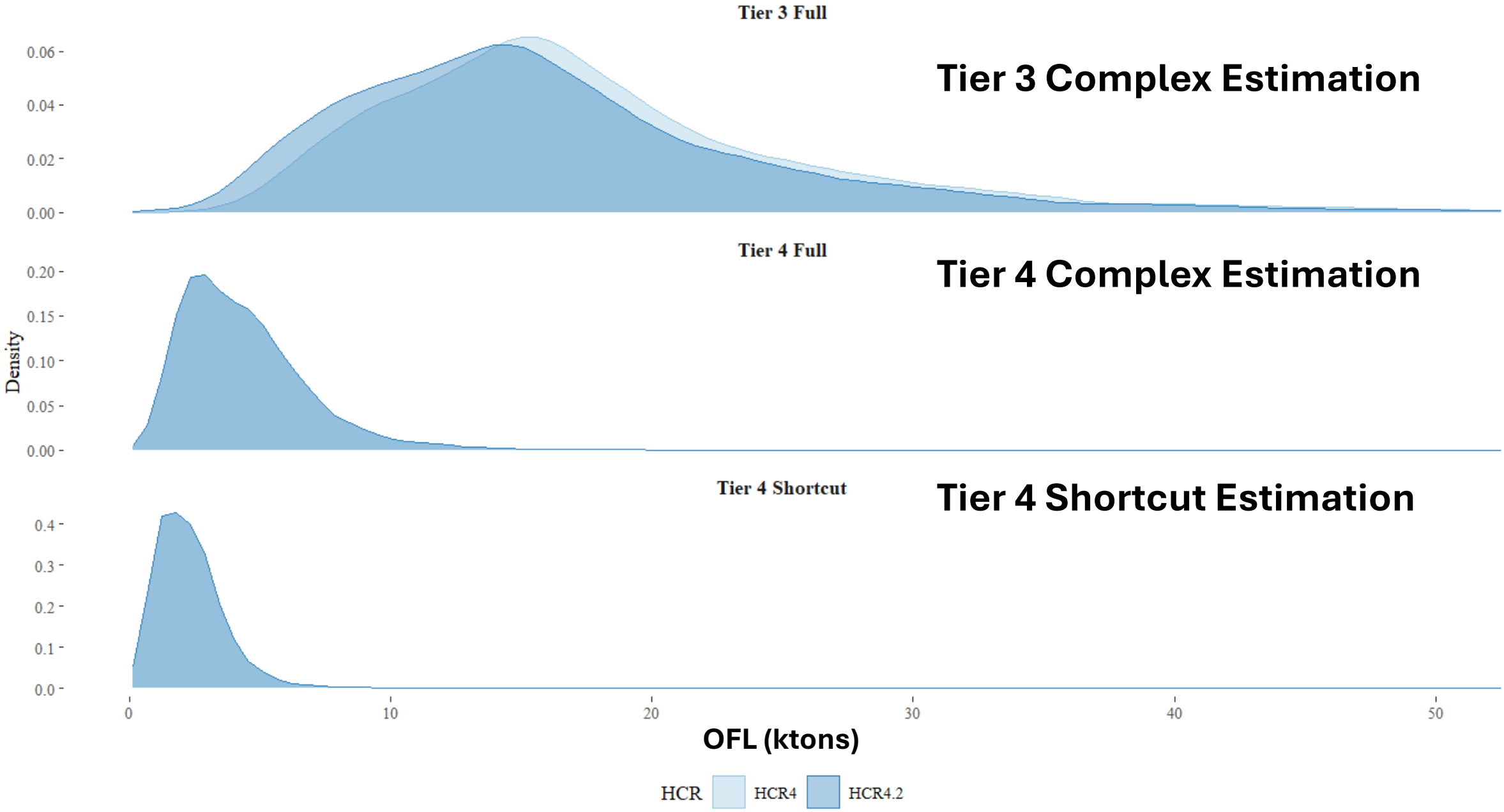
Tier 4 Complex Estimation

Tier 4 Shortcut Estimation

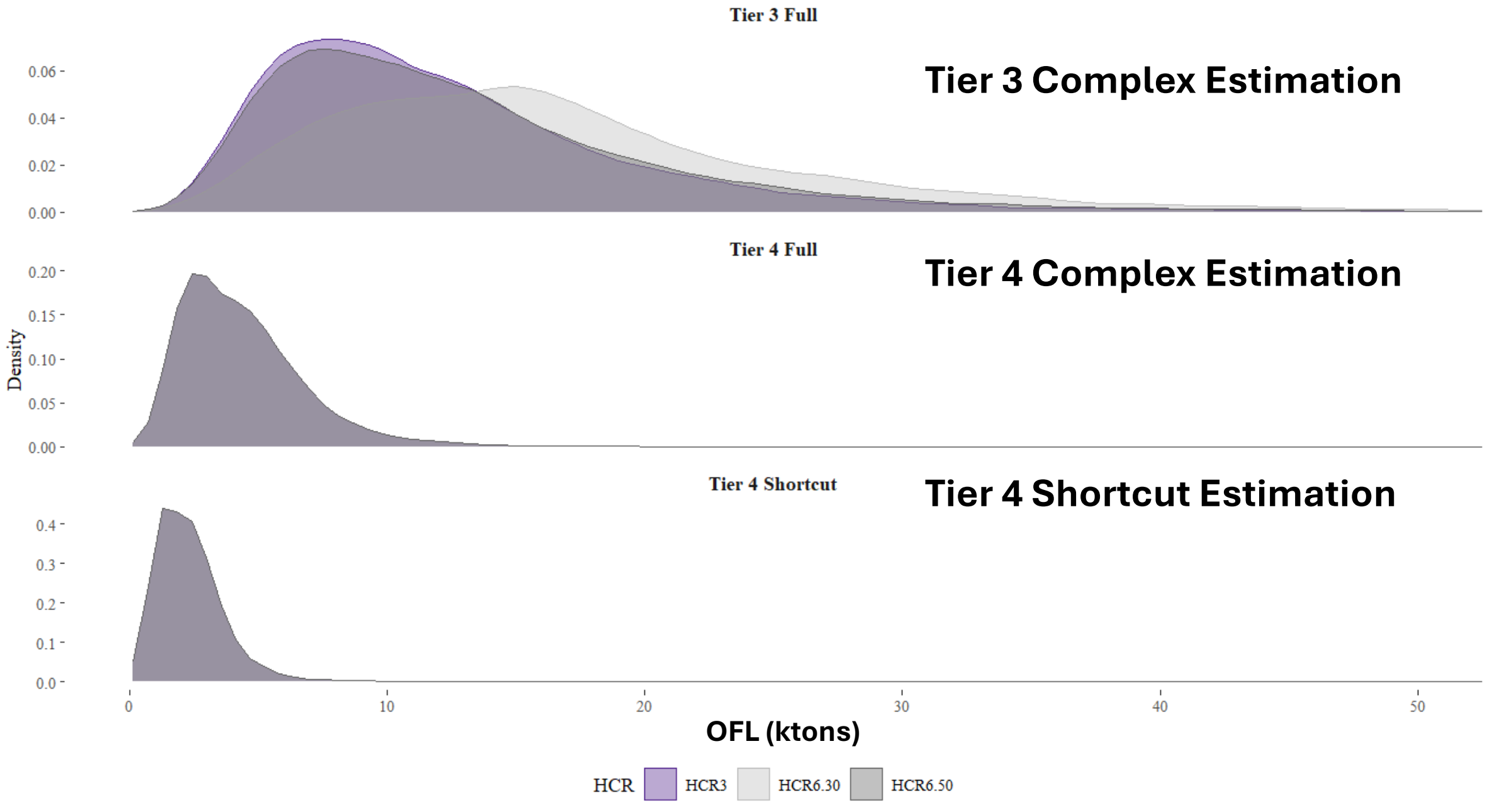
Results – OFL (male only)



Results – OFL (female dimmers)



Results – OFL (catch scalers)

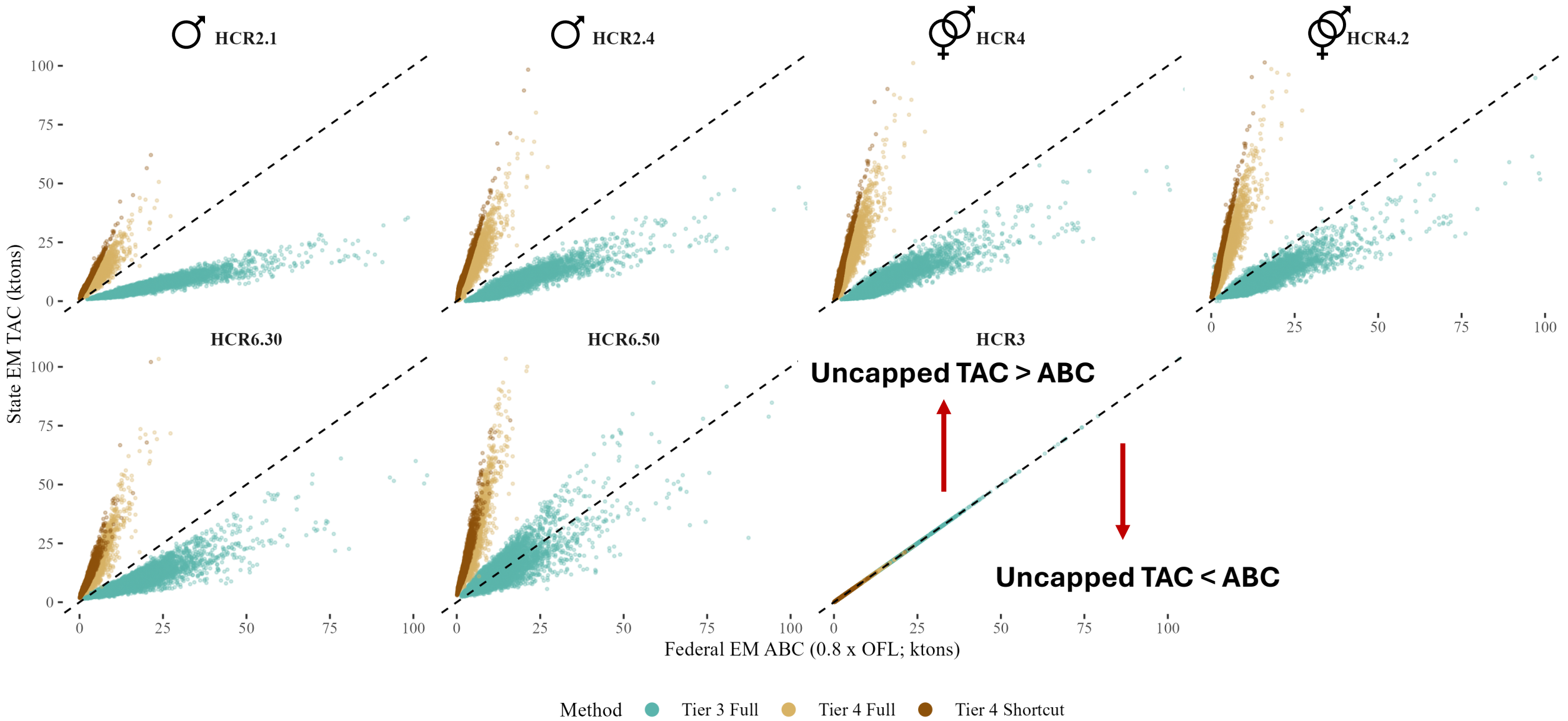


Tier 3 Complex Estimation

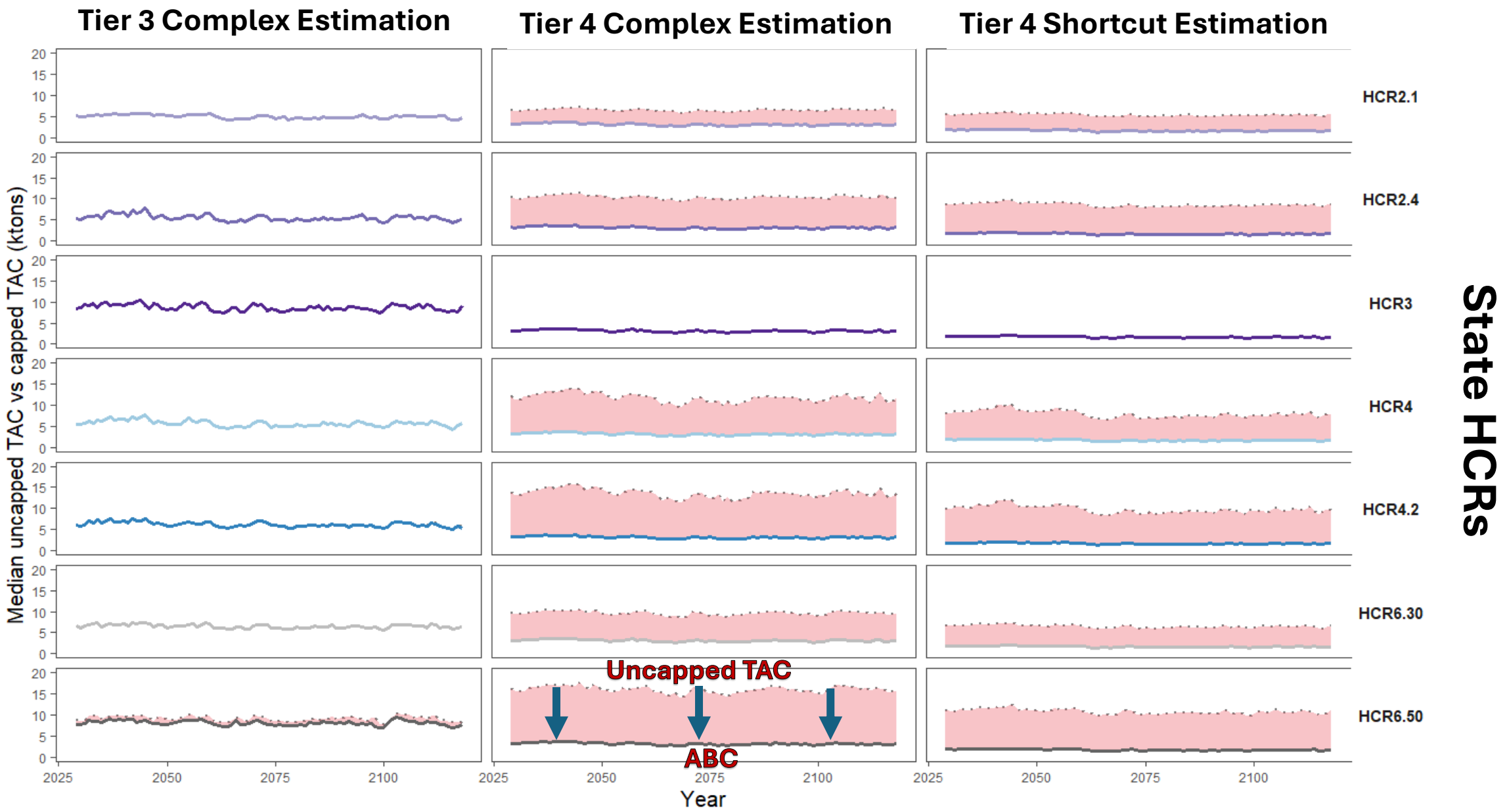
Tier 4 Complex Estimation

Tier 4 Shortcut Estimation

Results – TAC uncapped



Results – Uncapped v Capped TAC



What have we learned?

THE QUESTION

Can we use **Shortcut Management Strategy Evaluation (MSE)** methods to **inform** fisheries management **decisions** for **North Pacific crab stocks** at the **state** and **federal** levels?

What have we learned?

Status of the stock

- Demand for **HCR Evaluation for crab stocks**
  - **Snow crab MSE**
  - **BBRKC MSE?**
  - **Maturity assumptions? What size crab should be targeted?**
- **Shortcut Method**
  - Results **Hours/Days** instead of **Weeks/Months**
- Good for a first cut comparison
  - **Prioritize** HCRs or stock-related questions that should be fully evaluated

What have we learned?

State-level

HCR Comparison

Shortcut Estimation

What have we learned?

Federal-level

Federal Tier System

At Tier 4, state management is constrained, regardless of the HCR or the estimation method

What have we learned?

Federal-level

Federal Tier System

The state HCR feedback into the OM did not reflect the uncapped TACs

Recommendations from the CPT?

Sensitivity/ Stress Testing

- **Remove Federal Caps**
  - Scale Catches as it relates to Tier 4 OFL Calculations
    - **TAC = OFL_{Tier4}*{1.5, 0.75, 0.5, 0.25, 0 }**
    - At what point is the model going to **buckle**?

Recommendations from the CPT?

Sensitivity/ Stress Testing

- A scalar, ***γ***, is multiplied by ***M*** to estimate the F_{OFL}
- ***γ*** is intended to **allow adjustments** in the overfishing definitions to account for differences in biomass measures
- A default value of ***γ* is set at 1.0**, with the understanding that the **SSC may recommend a different value**

Tier 4

B, M, $B_{msy^{prox}}$	4	a. $\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = \gamma M$
		b. $\beta < \frac{B}{B_{msy^{prox}}} \leq 1$	$F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{msy^{prox}}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$†

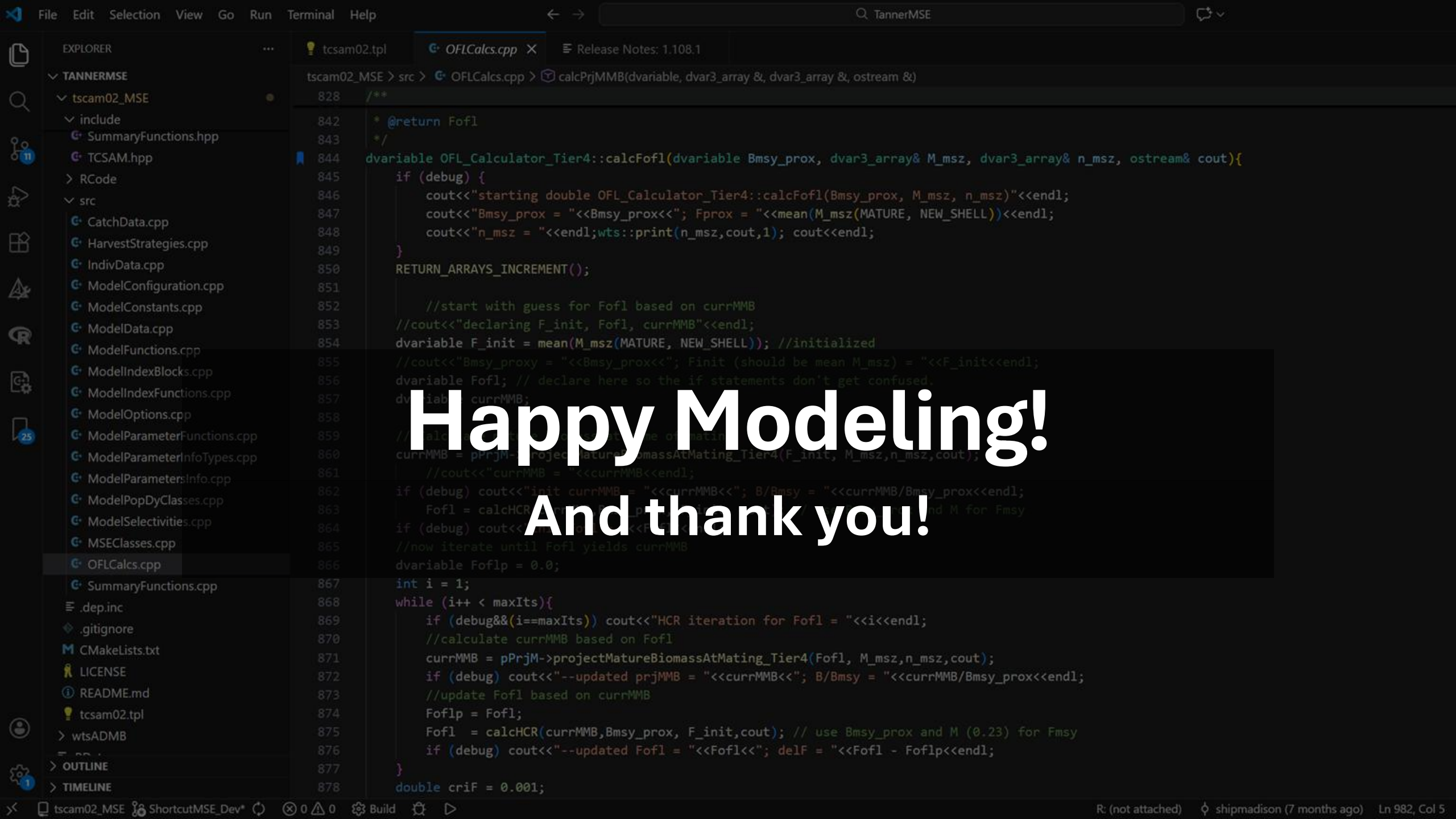
Recommendations from the CPT?

Sensitivity/ Stress Testing

Worth playing with γ assumptions?

Tier 4

B, M, $B_{msy^{prox}}$	4	a. $\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = \gamma M$
		b. $\beta < \frac{B}{B_{msy^{prox}}} \leq 1$	$F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{msy^{prox}}} \leq \beta$	*Directed fishery F = 0* $F_{OFL} \leq F_{MSY}^{\dagger}$


Happy Modeling!
And thank you!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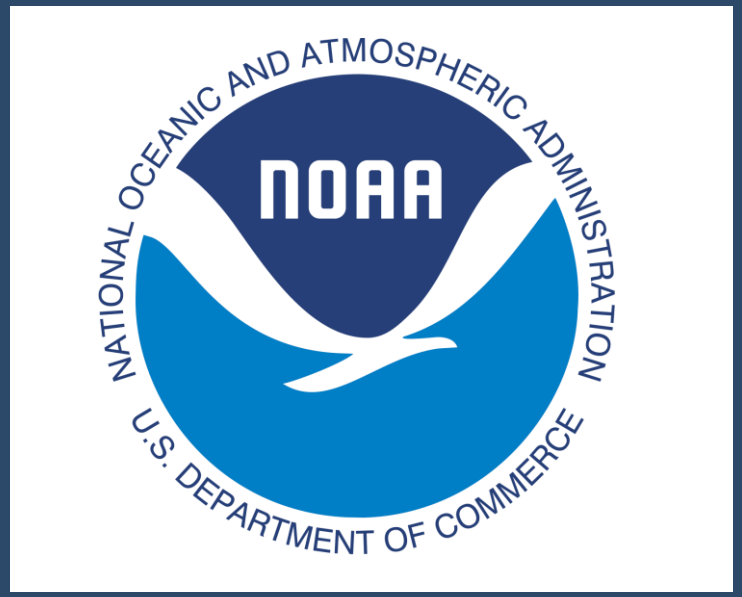
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NRC


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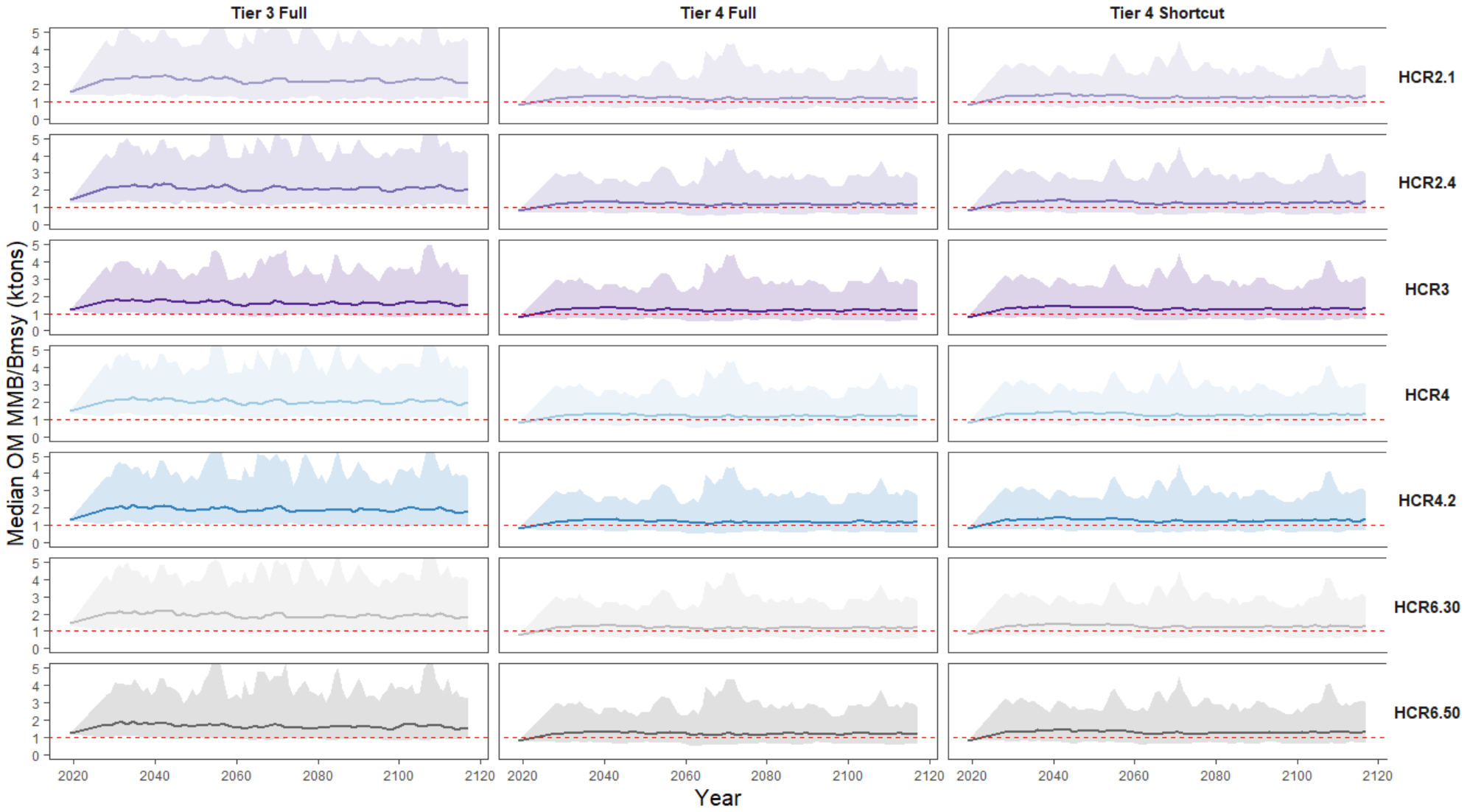
Concluding Thoughts

OM MMB/B_{MSY}



Note: Bmsy is calculated differently for Tier 3 and Tier 4; shaded area shows 95% confidence interval
First 10 years (2018-2027) excluded to avoid initial condition effects

Code changes

- Added Tier 4 components
  - Model Option added for Tier level
  - PopProjector::projectMatureBiomassAtMating_Tier4
  - OFL_Calculator_Tier4::OFL_Calculator_Tier4
  - OFL_Calculator_Tier4::calcHCR
  - OFL_Calculator_Tier4::calcFofl
  - OFL_Calculator_Tier4::calcOFL
  - OFL_Calculator_Tier4::calcPrjMMB
  - OFL_Calculator_Tier4::calcOFLResults
- Added calcOFL_Shortcut function to tpl
  - calcProxyBmsy function also added
- Updated calcTAC, repTAC, and repTAC_capped
  - Shortcut switch to alternate between raw data inputs and modeled inputs (spawning stock biomass, exploitable legal males)
  - Helper functions to reduce redundancies