Influence of timing and duration of recreational seasonal harvest restrictions on gag effort, harvest, and discards in the Gulf of Mexico

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Gulf gag population declines

- **Gulf of Mexico Gag stock overfished, and overfishing is occurring**
- **Population has declined precipitously in recent years**
- **Action needed to reverse trajectory**
- **Council dramatically reduced the gag recreational quota and moved the season start date from June to September 1st**

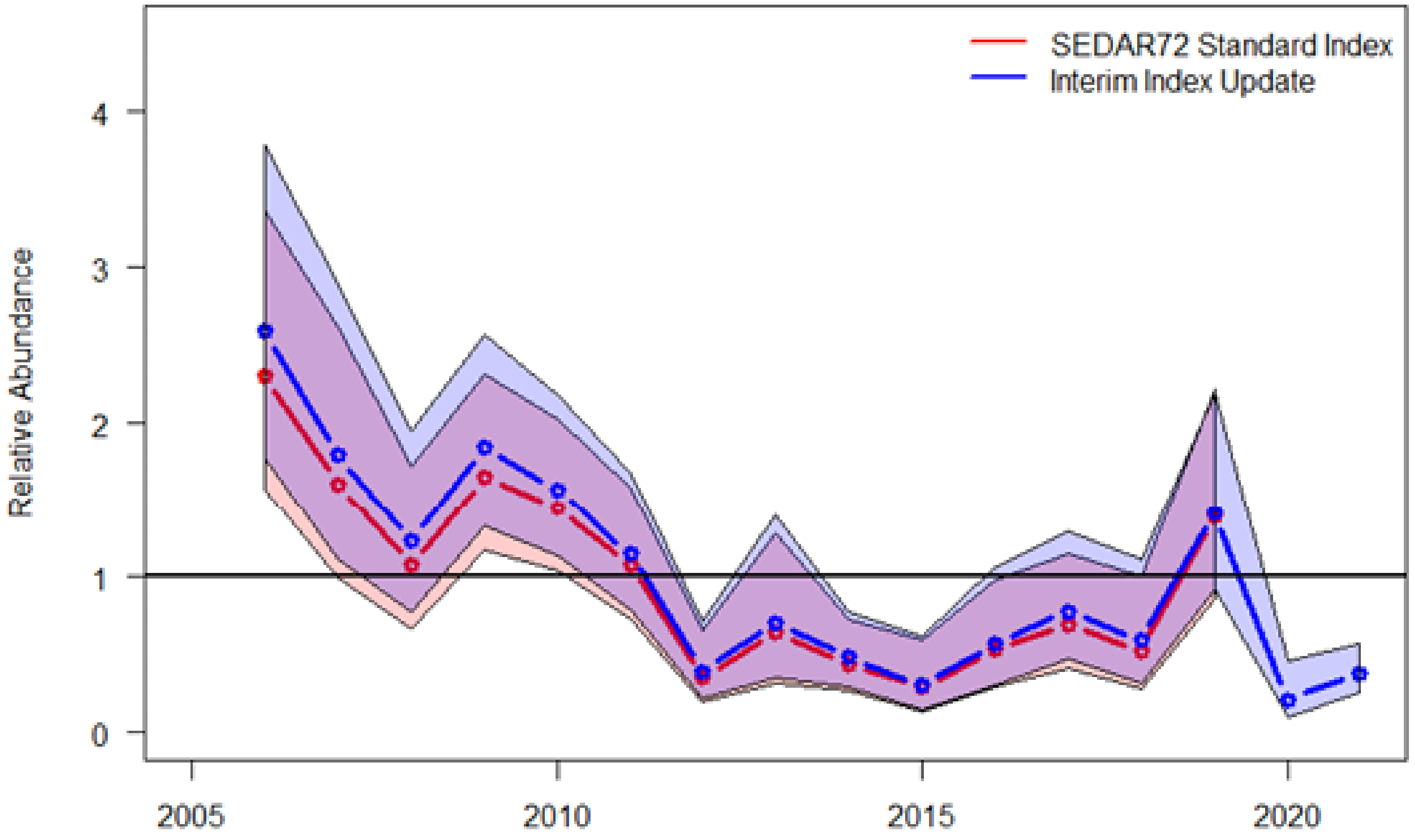
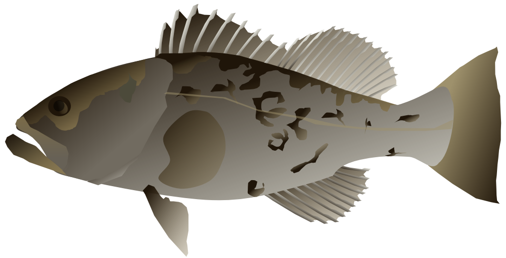


Figure 3. Comparison of Panama City Laboratory Camera Fishery-Independent Survey index of abundance derived for Gag Grouper in the Gulf of Mexico for SEDAR 72 compared to the index updated through 2021 with confidence intervals. All indices have been standardized to a mean of 1.

https://gulfcouncil.org/wp-content/uploads/09b-GagGrouperHealthCheck.pdf

Questions

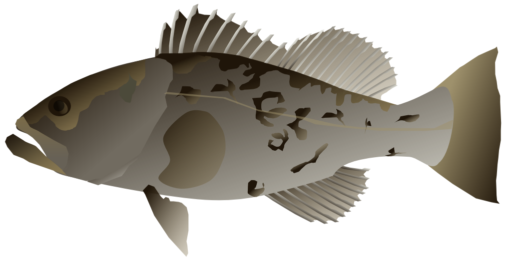


Several lines of thinking and uncertainty behind change in season start date:

- **Cumulative discards will not be notably affected by season start dates, and therefore managers should set seasons based on harvest rate.**

- **Discards may vary annually due to seasonal patterns as well as potential interactions with other major fisheries within the multi-species reef complex.**
  - **For example, catch rates may remain high in June because of red snapper season, and therefore a June season capitalizing on this may reduce dead discards.**

Objectives

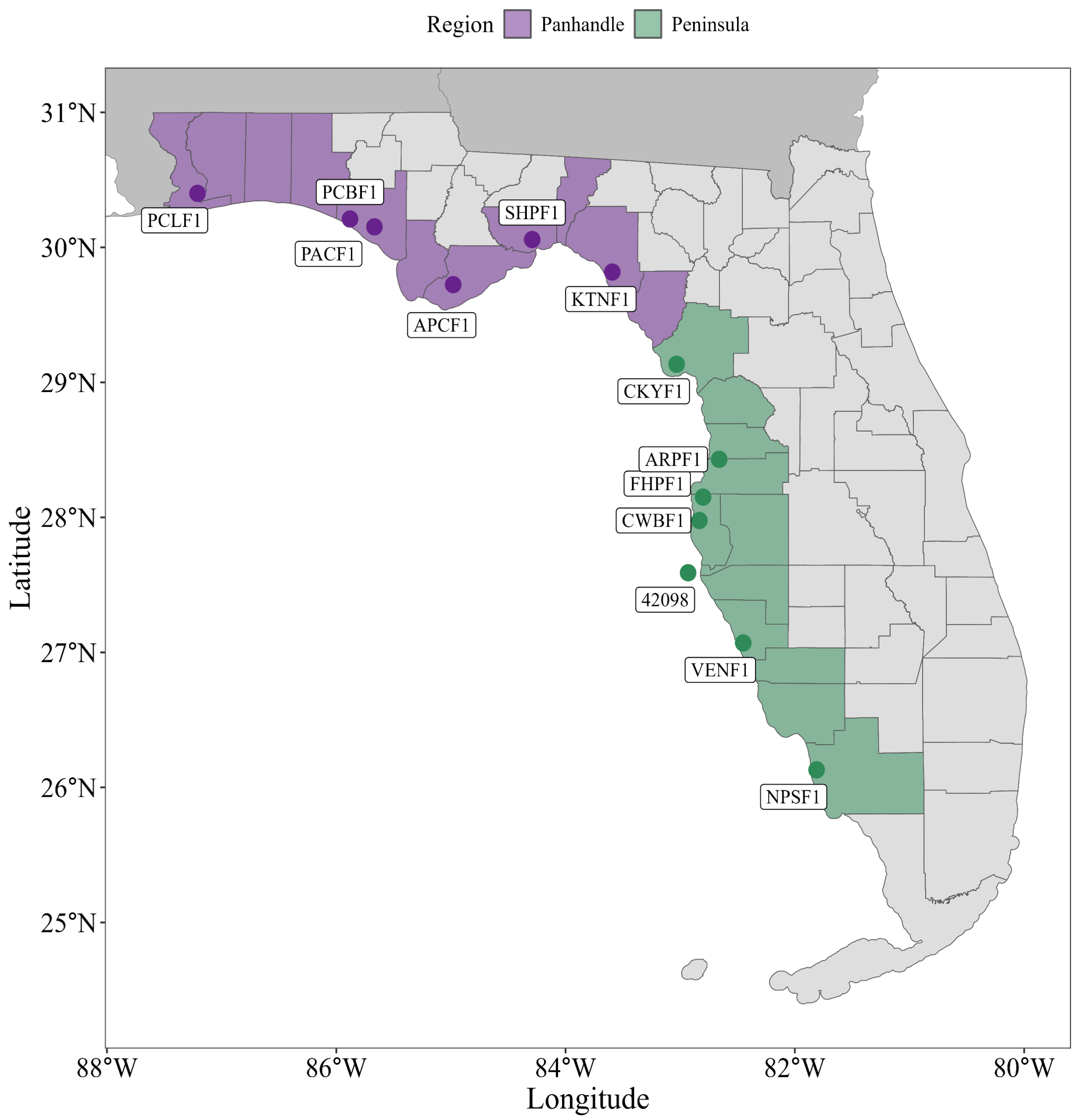


1. Develop multi-model framework to predict recreational effort, gag CPUE, and proportion of gag harvested using MRIP dataset

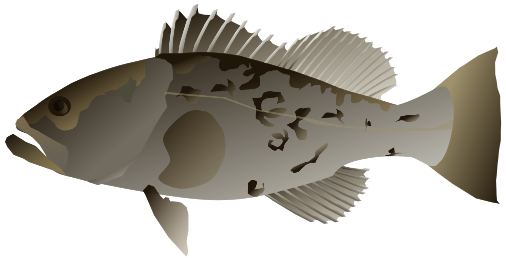
2. Use framework to simulate multiple season start dates and season duration and examine corresponding harvest and dead discard projections

Study region

- Focused on the Gulf of Mexico gag stock
  - Primarily caught along the west coast of Florida
  - Used MRIP substate regions 1 and 2
  - Denoted “Panhandle” and “Peninsula”



Overview



1. Model framework (no equations)
2. Model diagnostics (fit and out-of-sample cross-validation)
3. Simulation methodology
4. Simulation results and inference

Model framework

Model

Predictors

Effort (angler-trips)

Reef effort only

- Region
- Fraction of season open in given month
  - Gag
  - Red snapper
- Season length
  - Gag
  - Red snapper
- Region-specific indices of abundance
  - Gag
  - Red snapper
  - Red grouper
- Seasonal terms
- Economic terms

CPUE

$$\frac{A + B1 + B2}{\text{Angler-trips}}$$

- Region
- Region-specific index of gag abundance
- Juvenile index of abundance
- Fraction of season open in given month
  - Gag
  - Red snapper
- Season length
  - Gag
  - Red snapper
- Seasonal terms
- SST
- Effort

Harvest (proportion)

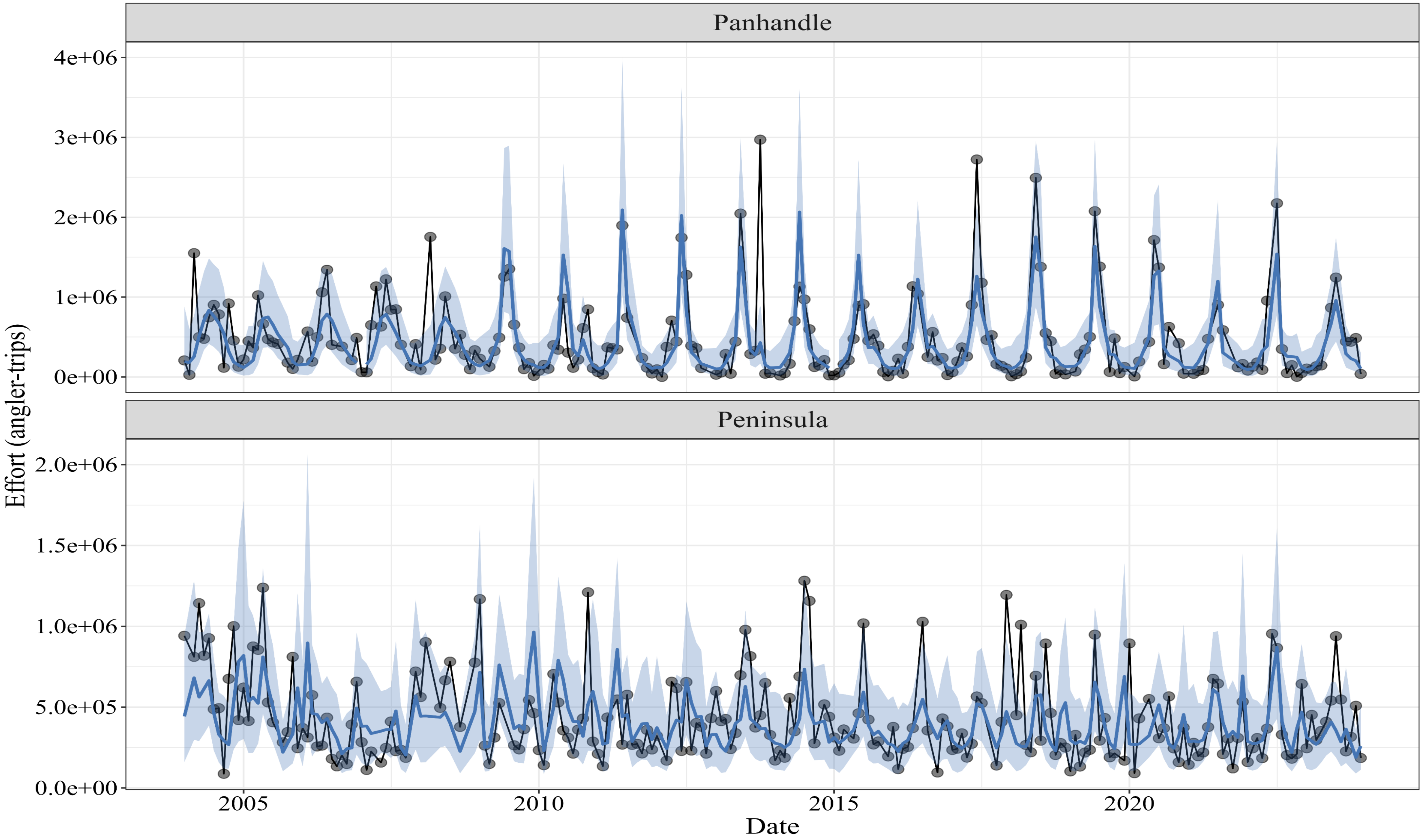
$$\frac{A + B1}{A + B1 + B2}$$

- Region
- Fraction of interval open to harvest for gag
- Region-specific gag CPUE (present)
- Seasonal terms
- Bag limit
- Size limit

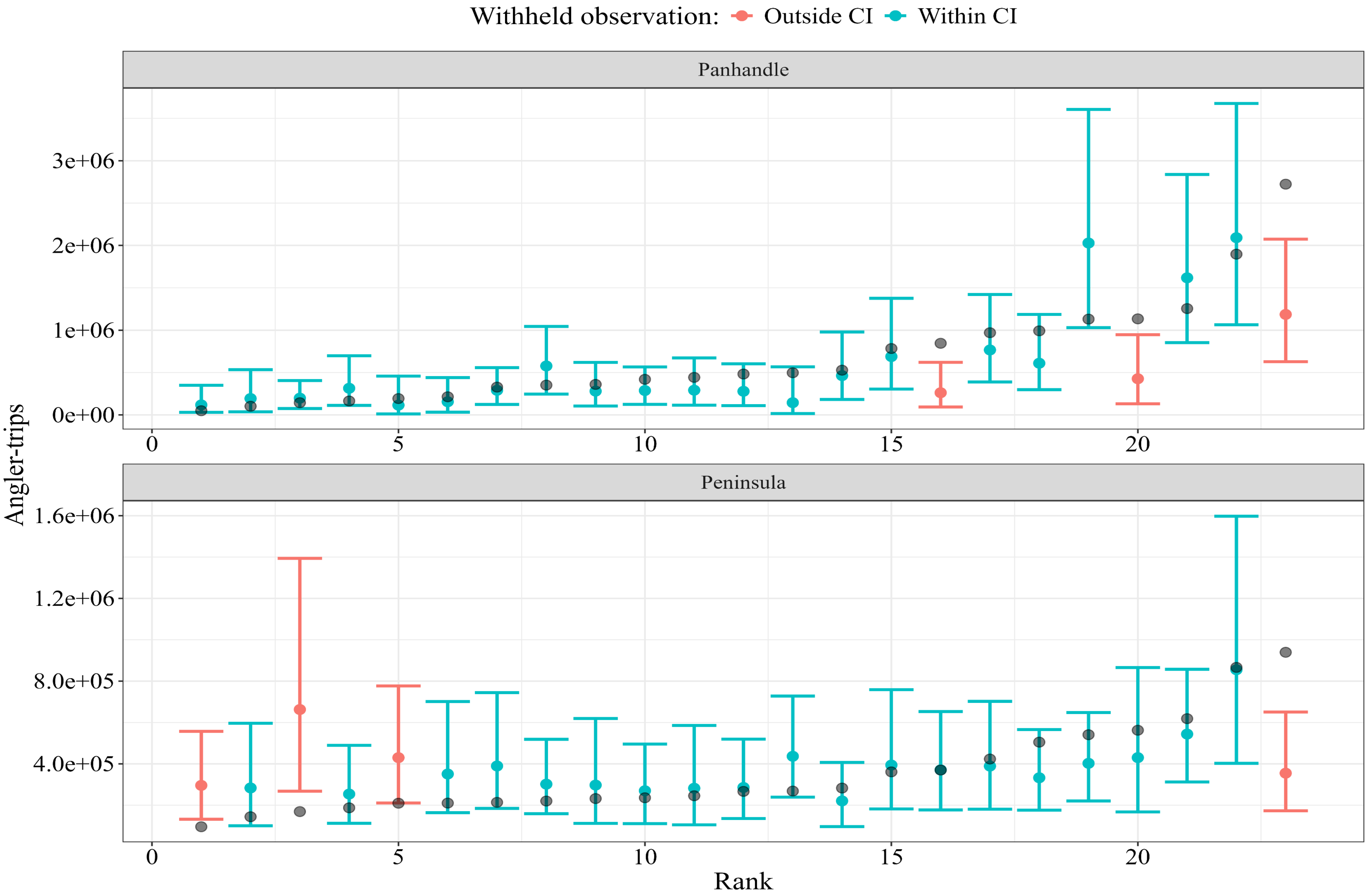
Probability distributions were gamma, hurdle-gamma, and beta for effort, CPUE, and harvest, respectively

Response values weighted using MRIP-FES

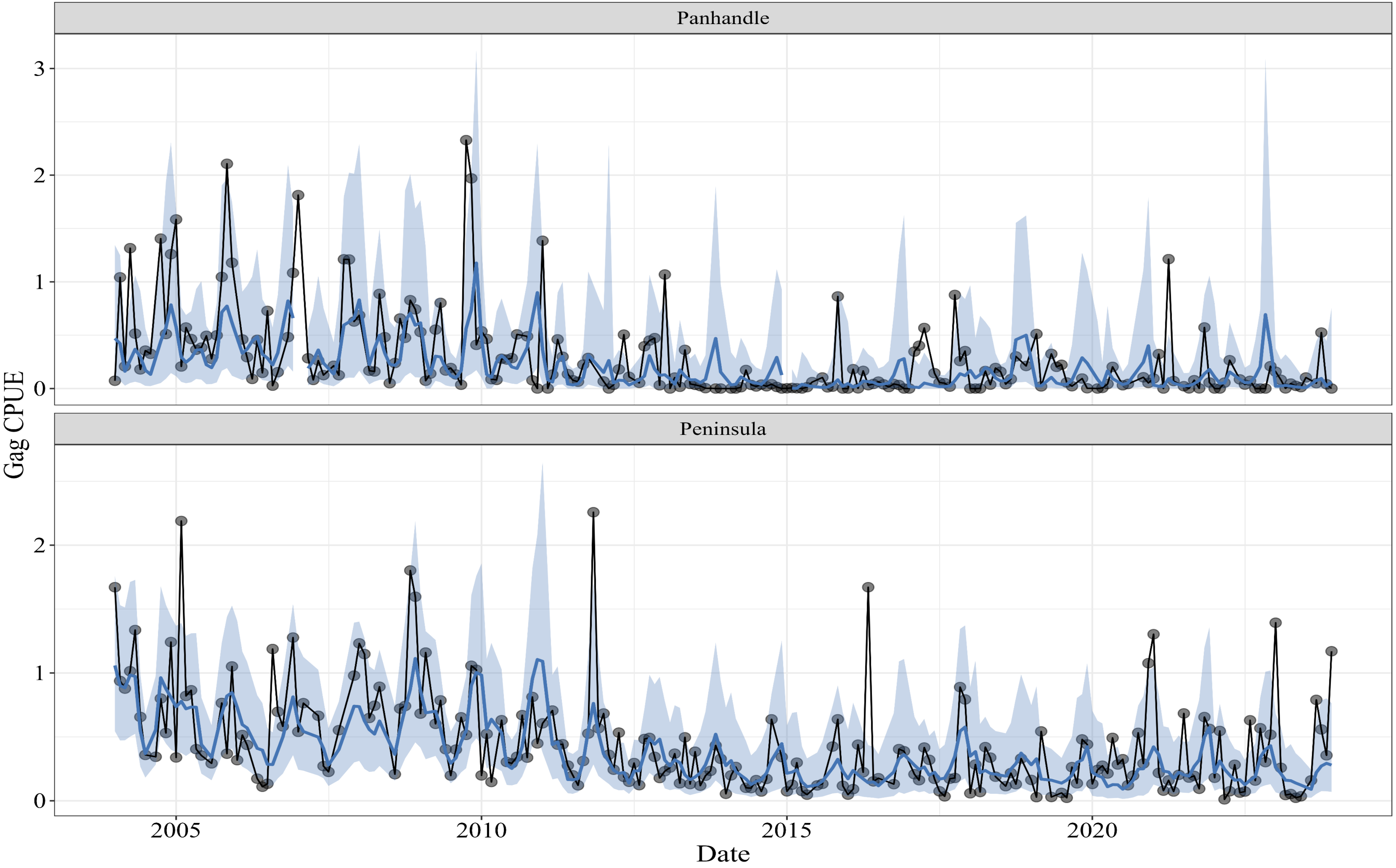
Effort model



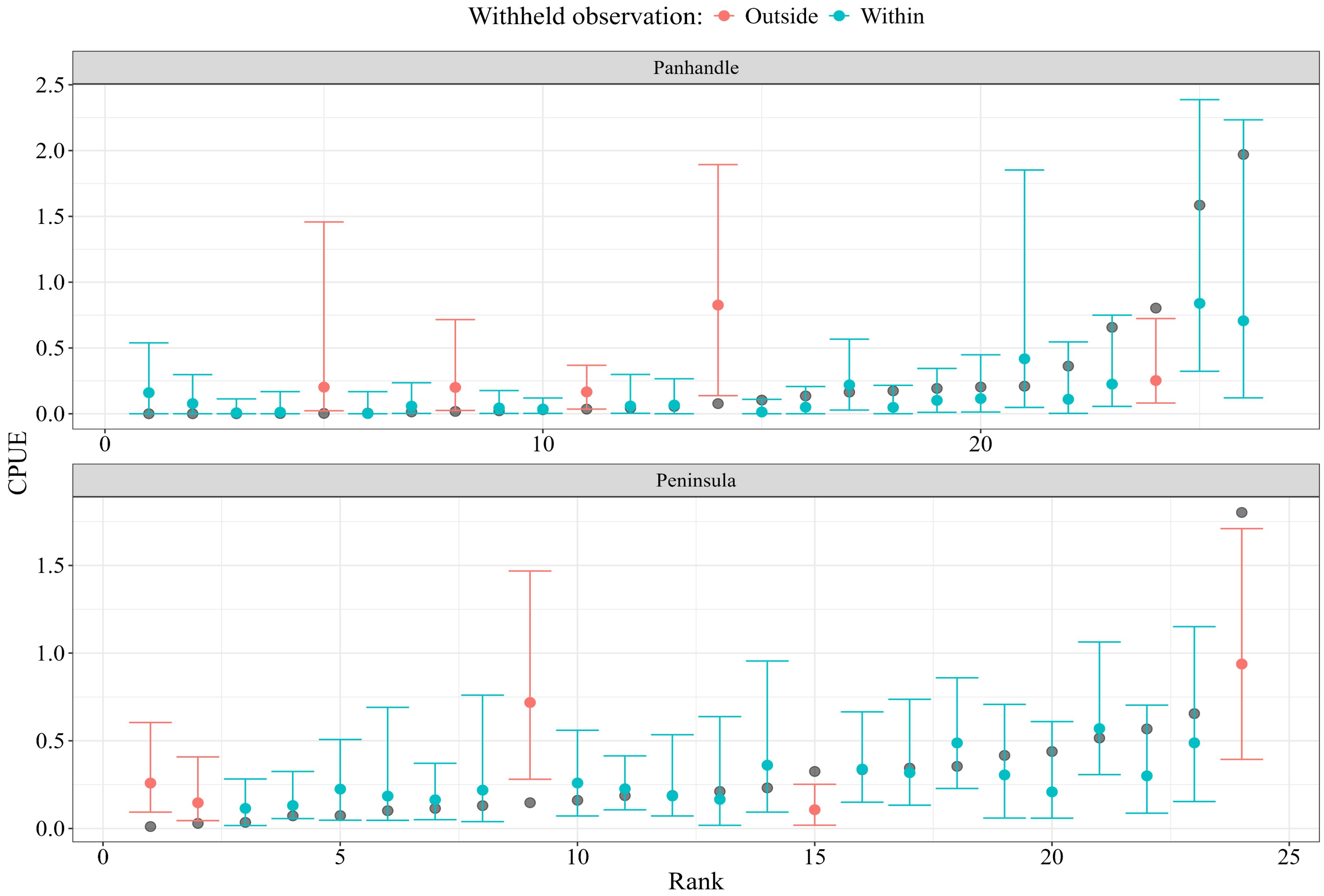
Effort model



Catch model

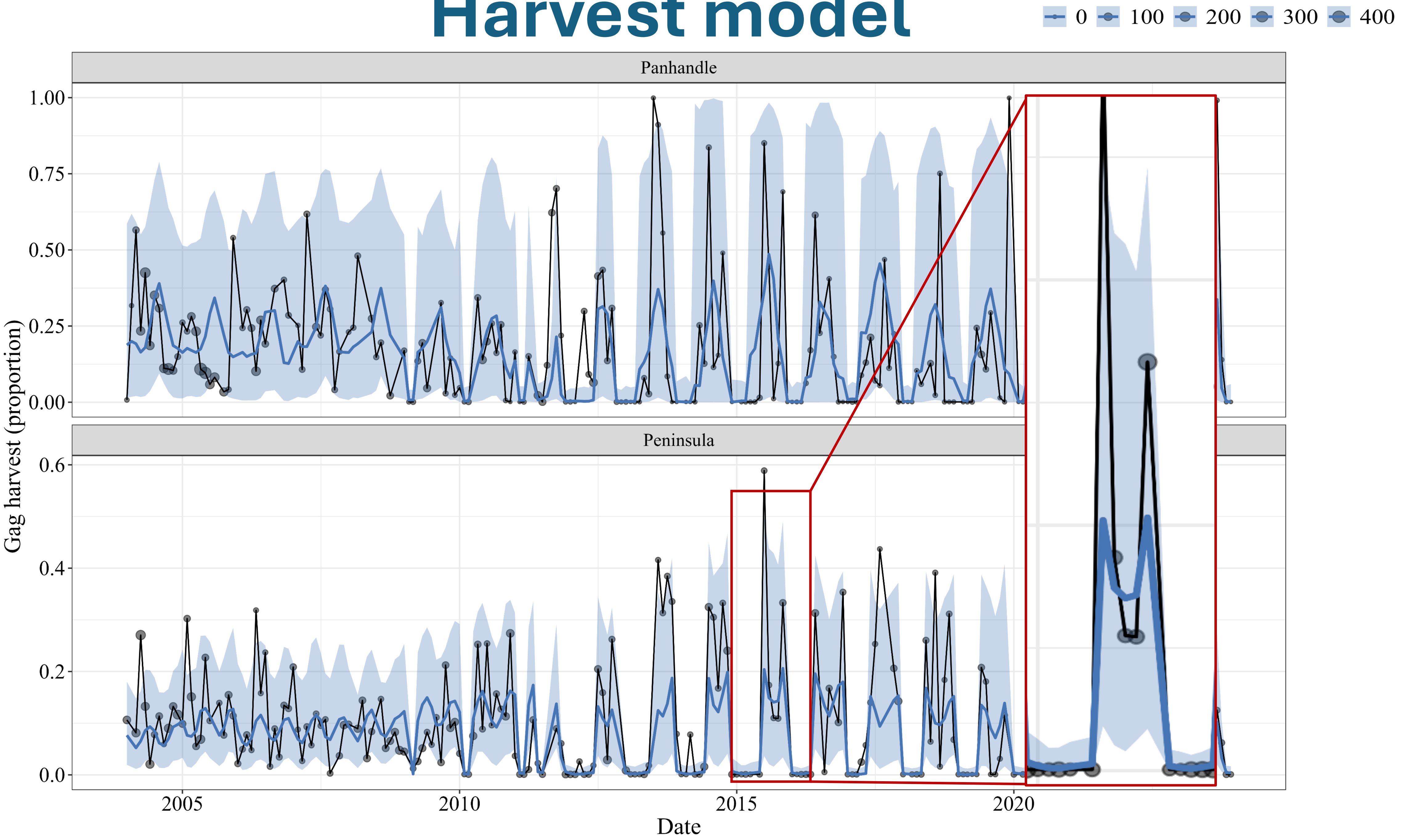


Catch model

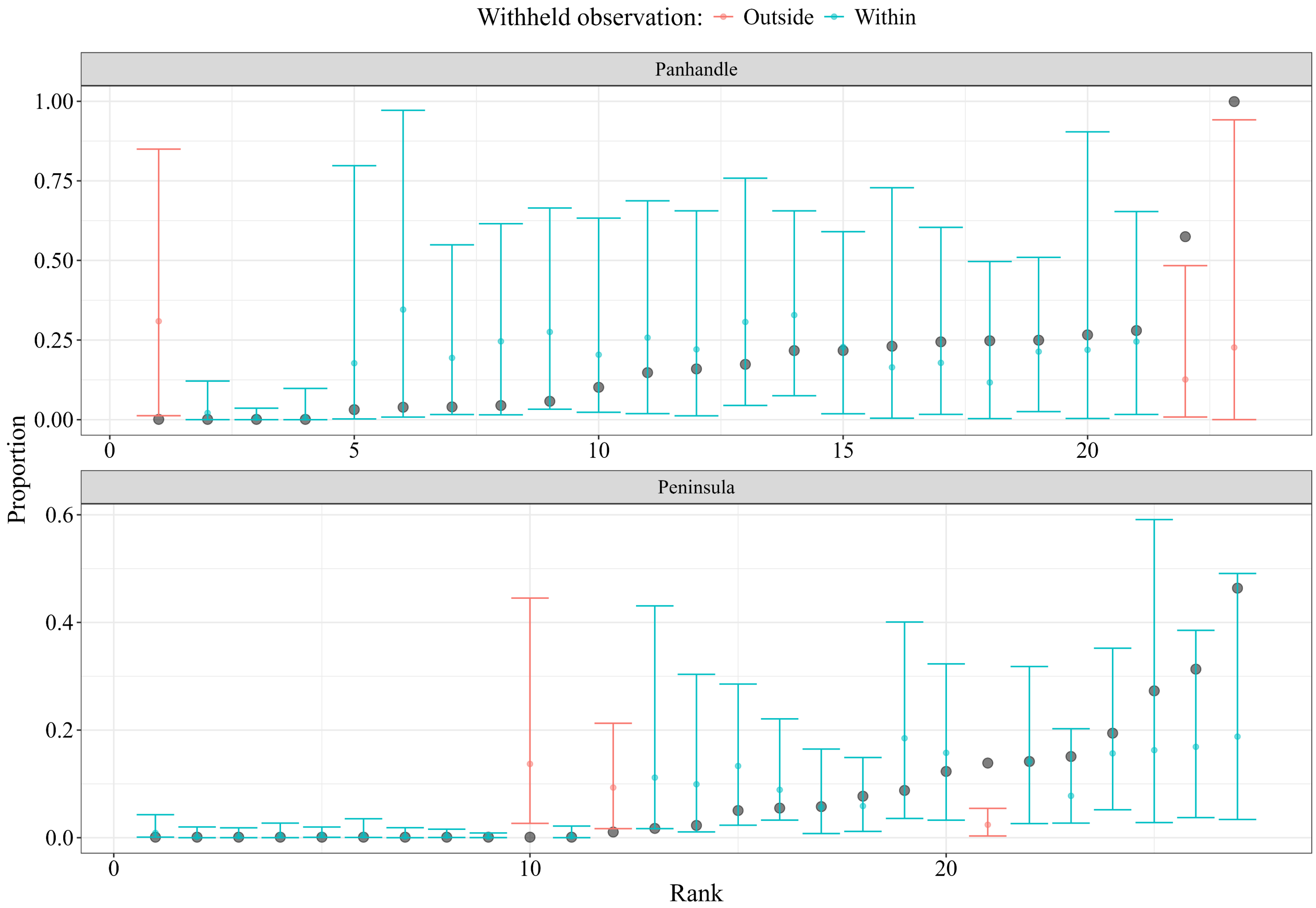


Withheld observation: Outside Within
Panhandle
Peninsula
CPUE
Rank
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25

Harvest model



Harvest model



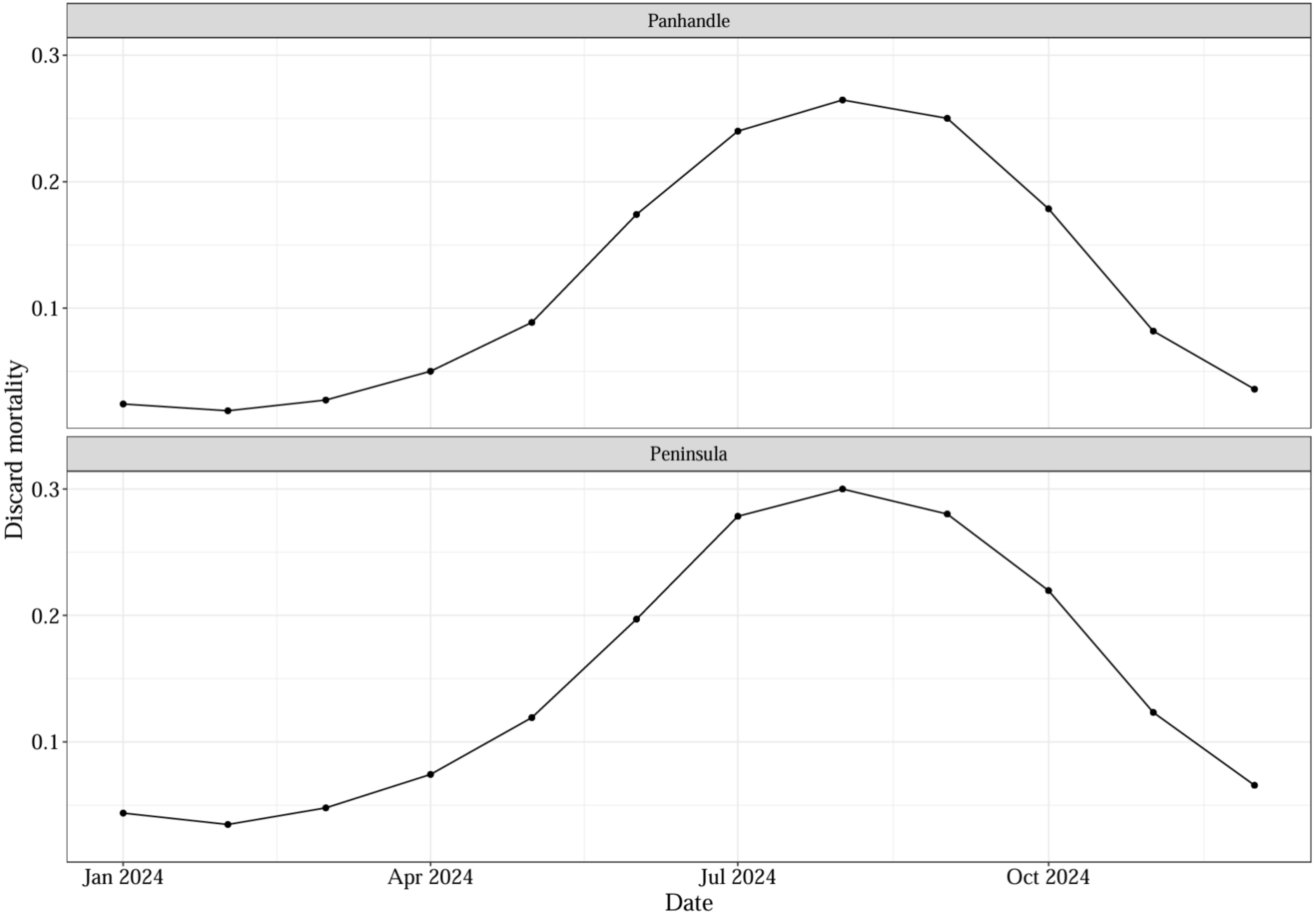
Simulation conditions

Constants

- Indices and CPUE (all species): 2023 values
- Seasonal/weather: monthly average for each region
- Economic variables: 2023 values
- Red snapper season: 2024 (includes reopening dates)
- Discard mortality: function of SST (15% average)

Manipulations

- Season start dates: June, September, November
- Season lengths: one- and two-month



Simulation framework

Effort (angler-trips)

- Region
- Fraction of season open in given interval
  - Gag
  - Red snapper
- Season length
  - Gag
  - Red snapper
- Region-specific indices of abundance
  - Gag
  - Red snapper
  - Red grouper
- Seasonal terms
- Economic terms

CPUE

- Region
- Region-specific index of gag abundance
- Juvenile index of abundance
- Fraction of season open in given interval
  - Gag
  - Red snapper
- Season length
  - Gag
  - Red snapper
- Seasonal terms
- SST
- Effort

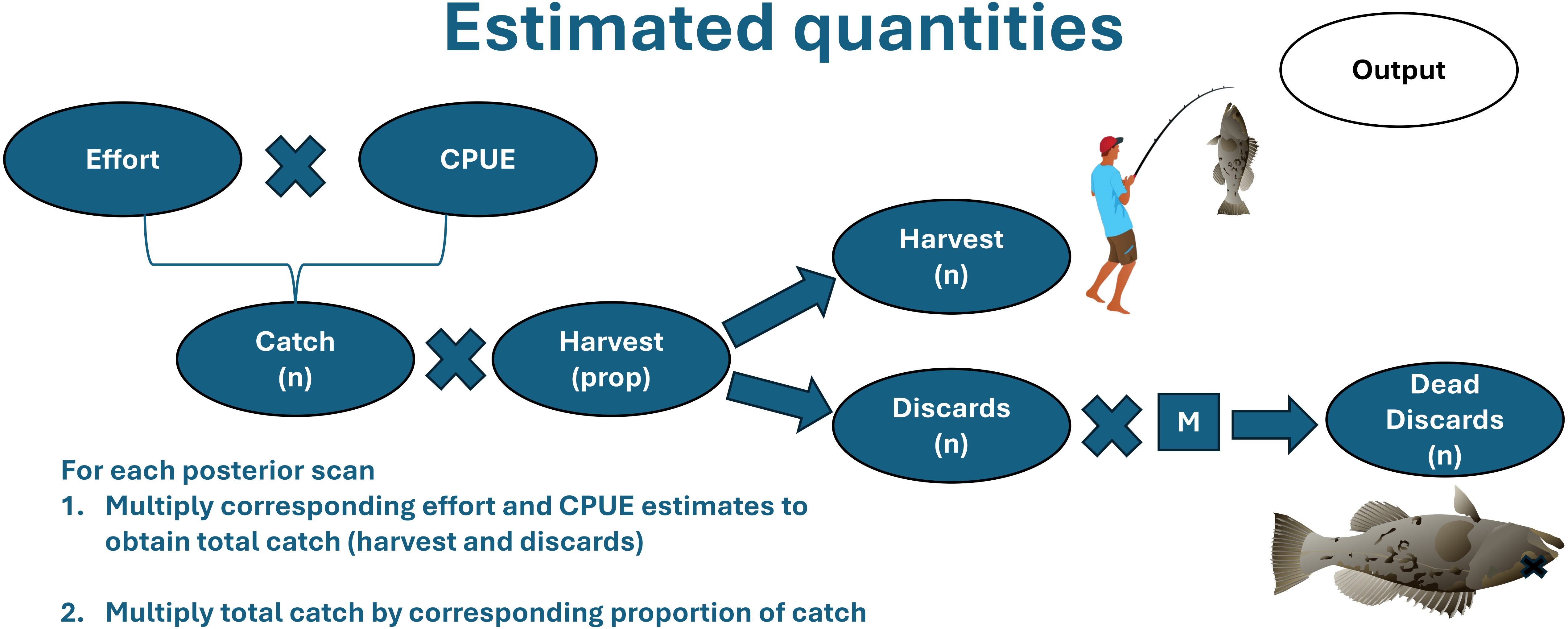
Harvest (proportion)

- Region
- Fraction of interval open to harvest for gag
- Region-specific gag CPUE (present)
- Seasonal terms
- Bag limit
- Size limit

For each of 1000 posterior scans

1. Simulate effort based on conditional design matrix based on fixed simulation conditions
2. Include effort simulation as predictor in CPUE model and simulate CPUE
3. Include CPUE simulation in conditional design matrix for proportional harvest model and simulate proportional harvest

Estimated quantities



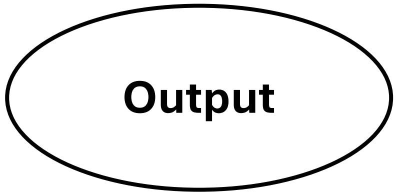
For each posterior scan

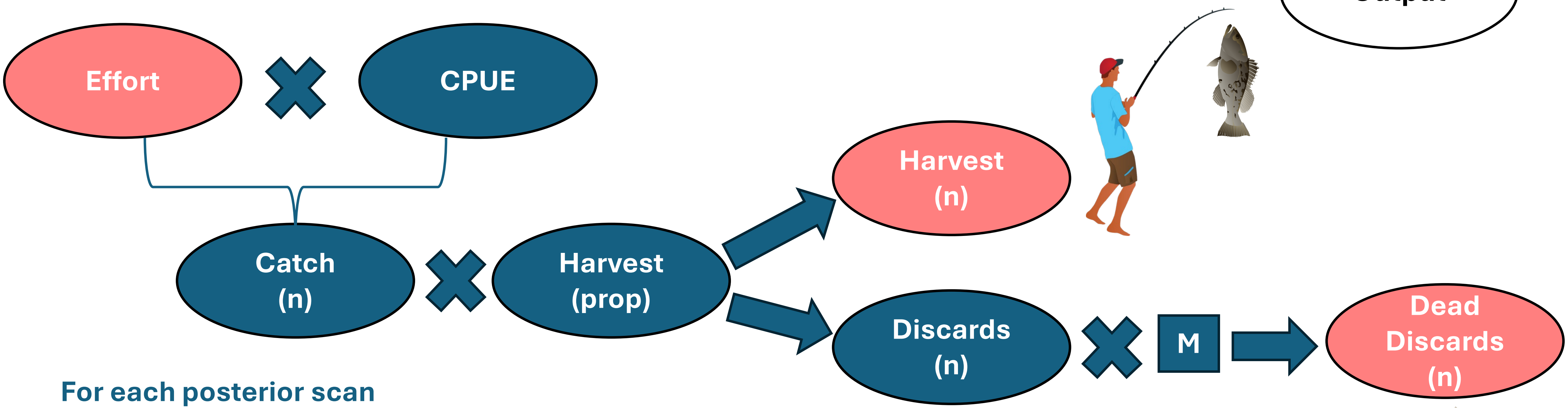
1. Multiply corresponding effort and CPUE estimates to obtain total catch (harvest and discards)

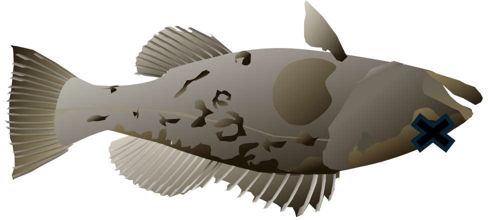
2. Multiply total catch by corresponding proportion of catch harvested to obtain total estimated harvest and discards

3. Multiply discards by seasonal discard mortality estimate to obtain dead discards

Estimated quantities







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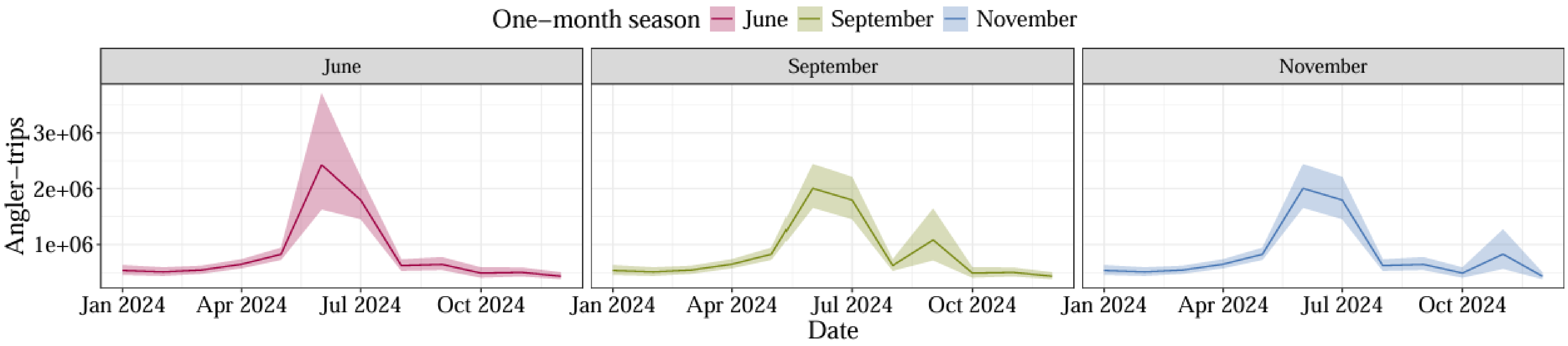


One−month season
June
September
November
June
September
November
Angler−trips
3e+06
2e+06
1e+06
Jan 2024
Apr 2024
Jul 2024
Oct 2024
Date

Cumulative estimates

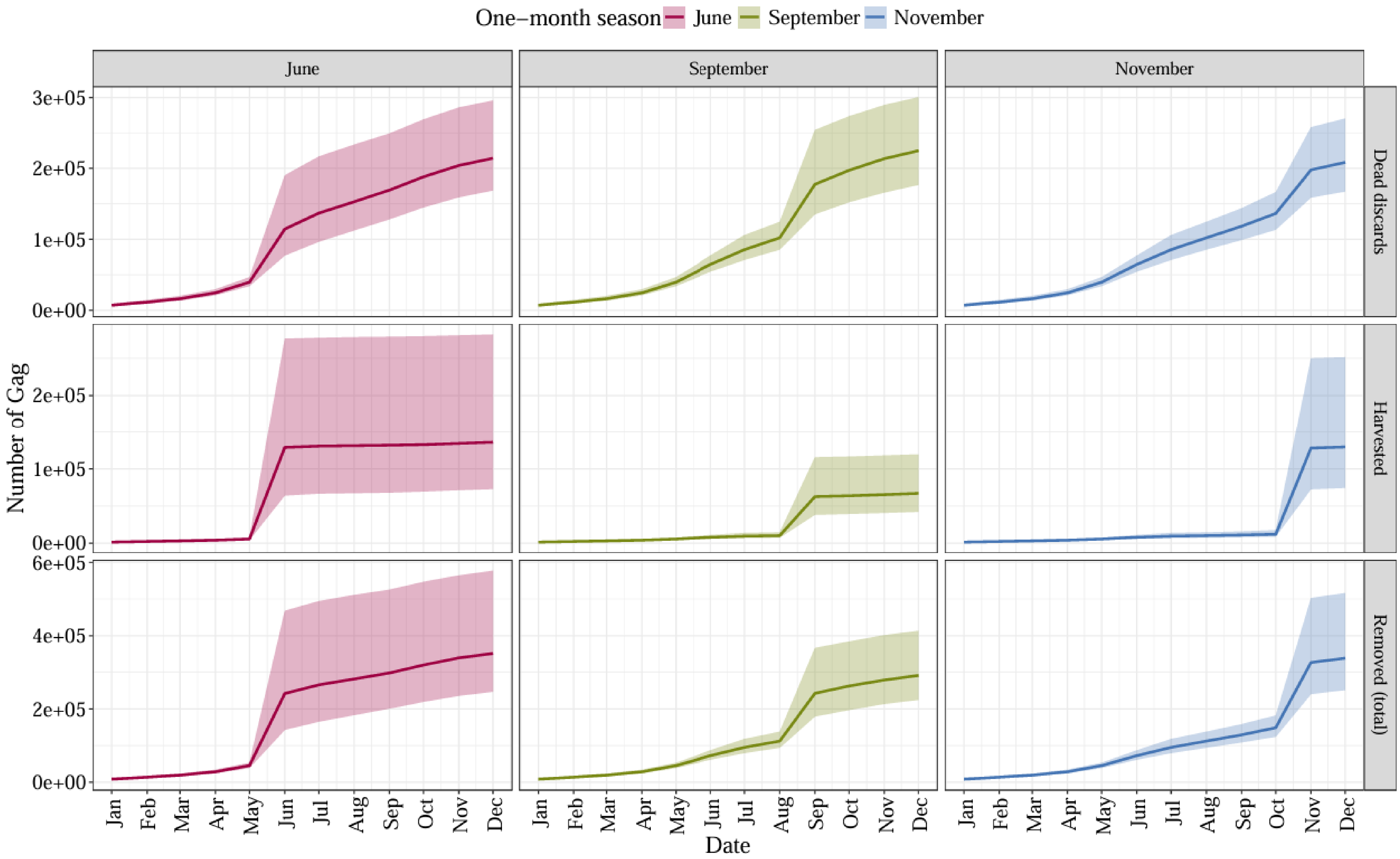
Discards

Month	Panhandle	Peninsula
1	0	300,000
2	100,000	200,000
3	200,000	400,000
4	400,000	600,000
5	600,000	400,000
6	800,000	700,000
7	800,000	700,000
8	600,000	800,000
9	400,000	400,000
10	200,000	200,000
11	100,000	200,000
12	00000	300,000

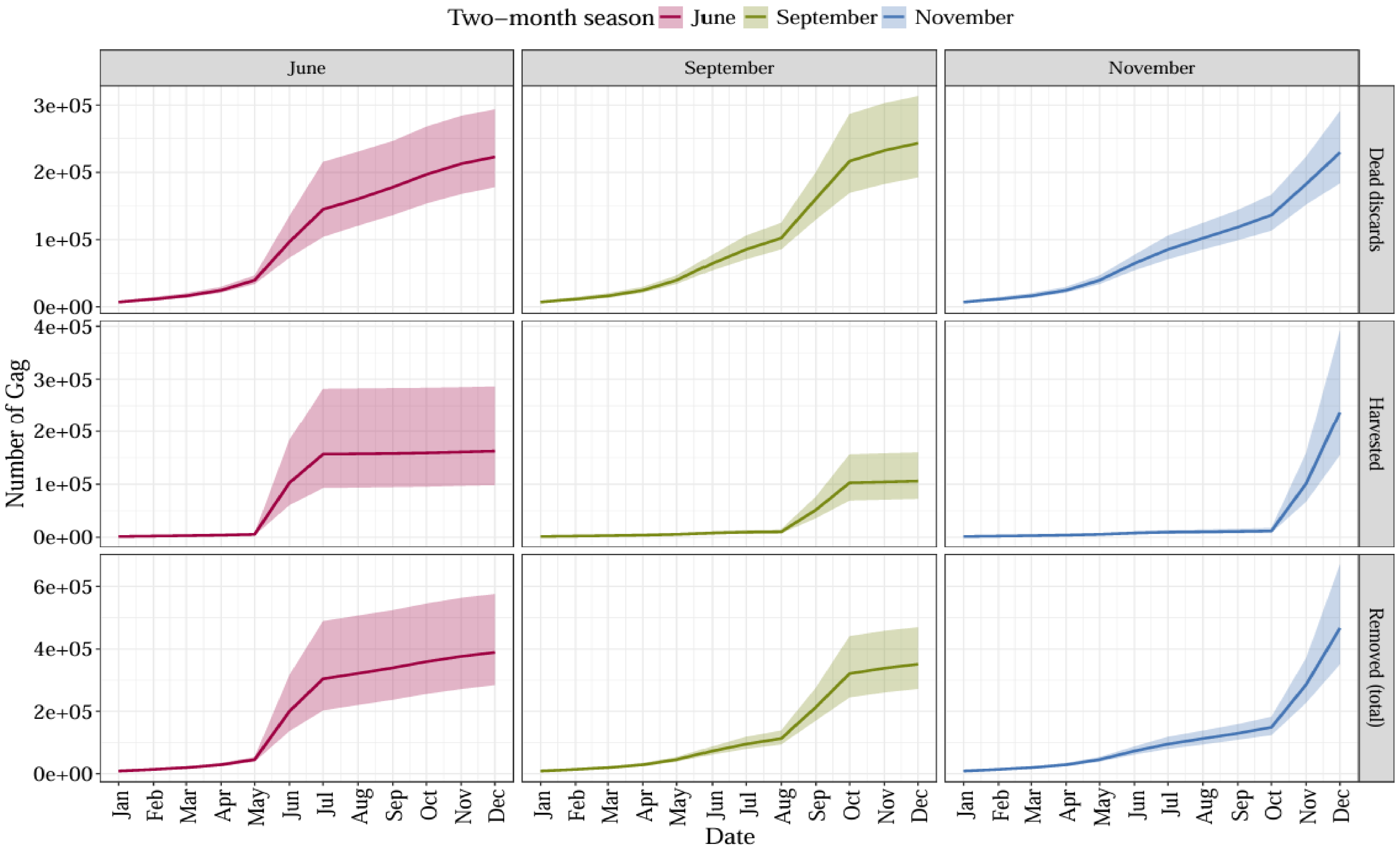
Month	Discards
1	300,000
2	300,000
3	600,000
4	1,000,000
5	1,000,000
6	1,500,000
7	1,500,000
8	1,400,000
9	800,000
10	400,000
11	300,000
12	300,000

1. Sum across regions
2. Cumulative sum for each month

Month	Discards
1	300,000
2	600,000
3	1,200,000
4	2,200,000
5	3,200,000
6	4,700,000
7	6,200,000
8	7,600,000
9	8,400,000
10	8,800,000
11	9,100,000
12	9,400,000



One−month season
June
September
November
June
September
November
Dead discards
Harvested
Removed (total)
Number of Gag
3e+05
2e+05
1e+05
0e+00
2e+05
1e+05
0e+00
6e+05
4e+05
2e+05
0e+00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date

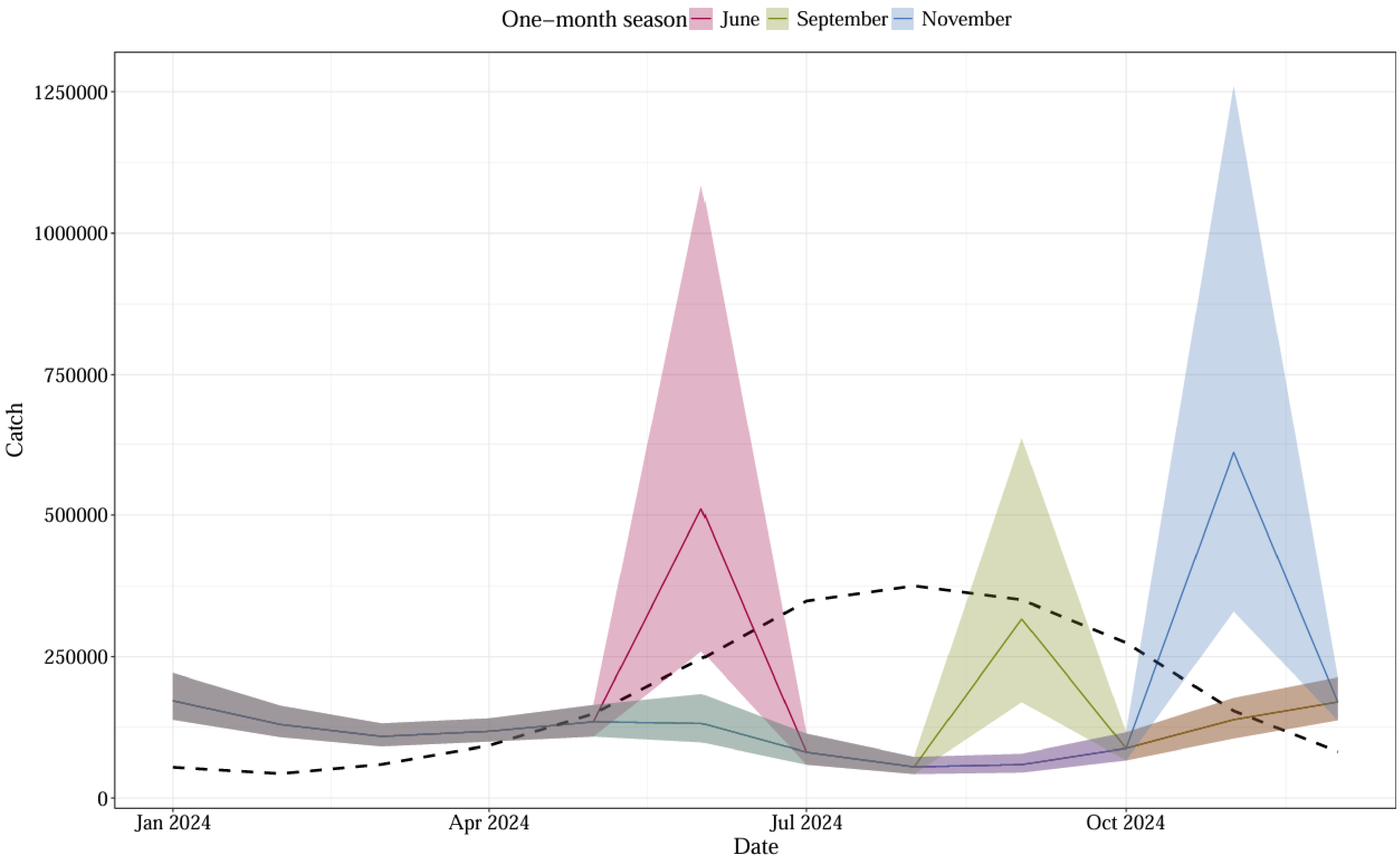


Two−month season
June
September
November
June
September
November
Dead discards
Harvested
Removed (total)
Number of Gag
3e+05
2e+05
1e+05
0e+00
4e+05
3e+05
2e+05
1e+05
0e+00
6e+05
4e+05
2e+05
0e+00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date

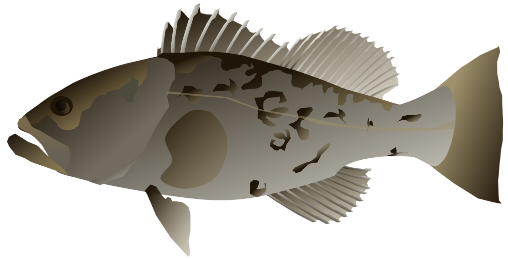
Changes to the catch rate affect both harvest and discards when season is open

Proportion of gag harvested relatively insensitive to season

Seasonal changes in discard mortality offset changes in catch rate, and do not produce noticeable shifts in cumulative dead discards



Takeaways and next steps



1. Cumulative harvest strongly affected by both season start date and season duration
   - Season duration increases harvest and discard rates, but in nonlinear fashion
   - Degree of increase varies by season start date
2. Cumulative dead discards largely insensitive to season start date
   - Hypothesized seasonal mortality curve offset by seasonal patterns in CPUE
3. Upshot: available evidence suggests managers should continue to manage seasons with the aim of controlling harvest

- Partner with FWC to use observer program data from charter trips to better understand gag discards and discard mortality
  - More detailed catch information
    - Depth of gag caught given time of year
    - Size of gag caught given time of year

Acknowledgements

- Mike Drexler, PhD
- John Froeschke, PhD
- Beverly Sauls
- Chloe Ramsay, PhD
- Tiffanie Cross

Why not SRFS?

- Pros: SRFS dataset has considerably more interviews with positive gag catch: more robust from harvest proportion perspective
- Cons: Only encompasses years 2015-present, when contrast in gag seasonal management was very low.
  - Difficult to extrapolate how changes to management affect gag fishery
  - Conversion tools exist for converting MRIP units to SRFS currency
    - Only for effort and total catch/harvest, not for proportion of animals harvested, which is the part of the framework uncertain
  - Tried to combine SRFS and MRIP using raw data only, but leads to erratic harvest proportions between 2010 and 2015 (when APAIS interviews with positive gag catch declined but before SRFS/GRFS was implemented)

Effort model

$$F_t \sim \text{Gamma}(\alpha_t, \sigma_t)$$

$$\alpha_t = \frac{\sigma_t}{\mu_t}$$

$$\mu_t = exp\left(\beta_0 + \sum_{p=1}^{P} x_{t,p}\beta_p\right)$$

$$\sigma_t = exp\left(\rho_0 + \sum_{q=1}^{Q} z_{t,q}\rho_q\right)$$

$$\beta, \rho \sim N(0, 10)$$

Estimated effort is product of total in party and FES-weight, summed across region-month-year

$$F_t = \sum_{i=1}^{I} \text{Party}_{t,i} \cdot W_{t,i}$$

Mean is a function of management, CPUE, economic, and seasonal terms

Shape is a function of seasonal terms

CPUE model

$$\text{CPUE}_t \sim HG(\iota_t, \tau_t, \theta_t)$$

$$\iota_t = \frac{\tau_t}{\eta_t}$$

$$\eta_t = \sum_{i=1}^{I} (k_{t,i}\psi_i)$$

$$\tau_t = exp\left(\sum_{s=1}^{S} z_{t,s}\zeta_s\right)$$

$$\theta_t = \frac{1}{1 + exp(\sum_{a=1}^{A} g_{t,a}\xi_a)}$$

$$\text{CPUE}_{s,t} = \frac{\sum_{i=1}^{I} W_{t,i} \cdot \frac{C_{s,t,i}}{\text{Party}_{t,i}}}{\sum_{i=1}^{I} W_{i,t}}$$

Mean is a function of management, effort, and seasonal terms

Shape is a function of effort

Hurdle is a function of management

Proportional harvest model

$$H_t \sim \text{Beta}(\lambda_t, \phi_t)$$

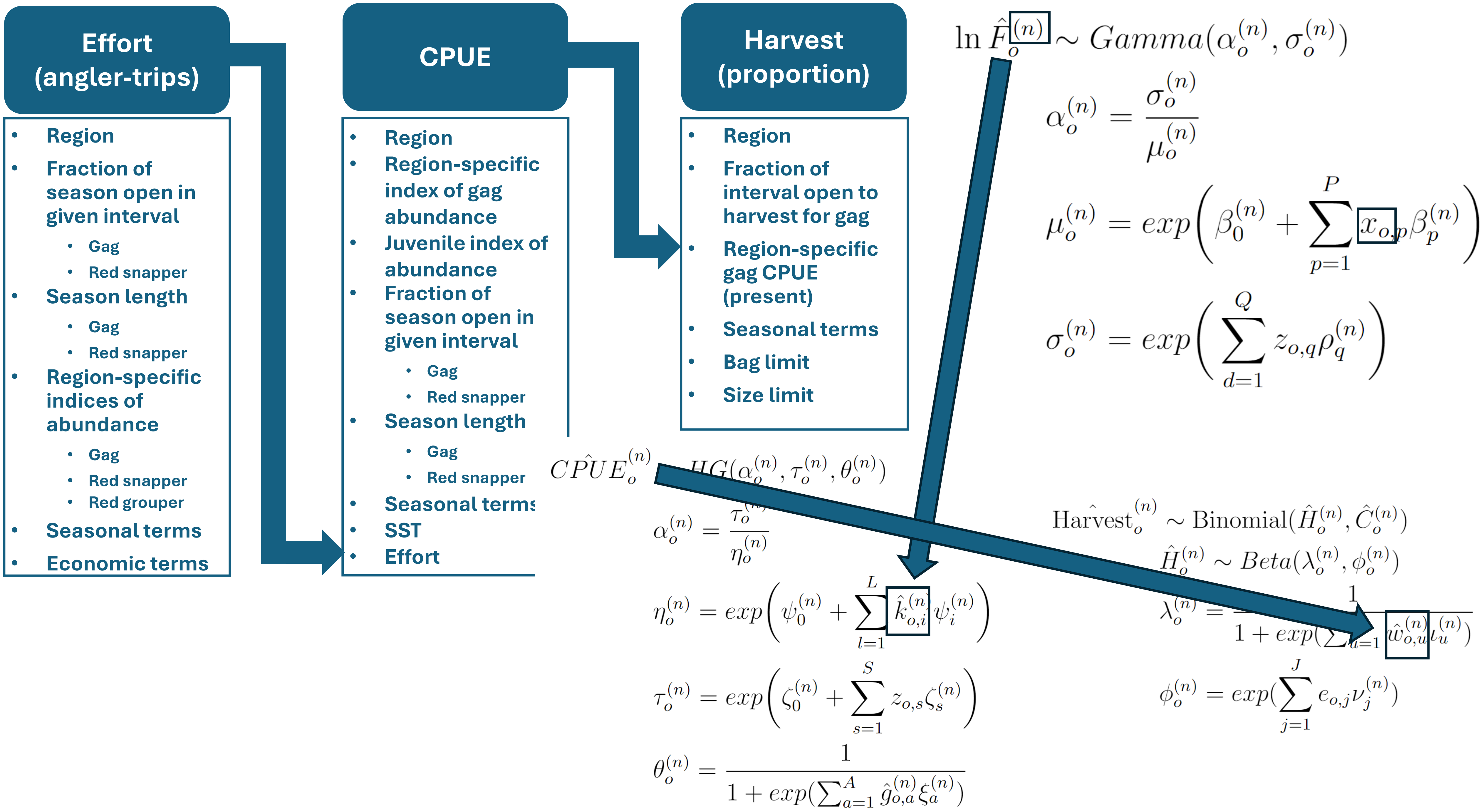
$$\lambda_t = \frac{1}{1 + exp(\sum_{u=1}^{U} w_{t,u} \iota_u)}$$

$$\phi_t = exp\left(\sum_{j=1}^{J} e_{t,j} \nu_j\right)$$

$$\text{H}_t = \frac{\sum_{i=1}^{I} W_{t,i} \cdot \frac{\text{Harvest}_{t,i}}{\text{C}_{t,i}}}{\sum_{i=1}^{I} W_{t,i}}$$

Mean is a function of management, CPUE, seasonal terms, bag limit, SST, and size limit

Precision is a function of management and CPUE



Effort (angler-trips)
Region
Fraction of season open in given interval
Gag
Red snapper
Season length
Gag
Red snapper
Region-specific indices of abundance
Gag
Red snapper
Red grouper
Seasonal terms
Economic terms
CPUE
Region
Region-specific index of gag abundance
Juvenile index of abundance
Fraction of season open in given interval
Gag
Red snapper
Season length
Gag
Red snapper
Seasonal terms
SST
Effort
Harvest (proportion)
Region
Fraction of interval open to harvest for gag
Region-specific gag CPUE (present)
Seasonal terms
Bag limit
Size limit
$\ln \hat{F}_o^{(n)} \sim Gamma(\alpha_o^{(n)}, \sigma_o^{(n)})$
$\alpha_o^{(n)} = \frac{\sigma_o^{(n)}}{\mu_o^{(n)}}$
$\mu_o^{(n)} = exp\left(\beta_0^{(n)} + \sum_{p=1}^{P} x_{o,p}\beta_p^{(n)}\right)$
$\sigma_o^{(n)} = exp\left(\sum_{d=1}^{Q} z_{o,q}\rho_q^{(n)}\right)$
$C\hat{PUE}_o^{(n)} \sim HG(\alpha_o^{(n)}, \tau_o^{(n)}, \theta_o^{(n)})$
$\alpha_o^{(n)} = \frac{\tau_o^{(n)}}{\eta_o^{(n)}}$
$\eta_o^{(n)} = exp\left(\psi_0^{(n)} + \sum_{l=1}^{L} \hat{k}_{o,i}^{(n)}\psi_i^{(n)}\right)$
$\tau_o^{(n)} = exp\left(\zeta_0^{(n)} + \sum_{s=1}^{S} z_{o,s}\zeta_s^{(n)}\right)$
$\theta_o^{(n)} = \frac{1}{1 + exp(\sum_{a=1}^{A} \hat{g}_{o,a}^{(n)}\xi_a^{(n)})}$
$\hat{Harvest}_o^{(n)} \sim Binomial(\hat{H}_o^{(n)}, \hat{C}_o^{(n)})$
$\hat{H}_o^{(n)} \sim Beta(\lambda_o^{(n)}, \phi_o^{(n)})$
$\lambda_o^{(n)} = \frac{1}{1 + exp(\sum_{u=1} \hat{w}_{o,u}^{(n)}\iota_u^{(n)})}$
$\phi_o^{(n)} = exp(\sum_{j=1}^{J} e_{o,j}\nu_j^{(n)})$