

Estimation of Red Snapper Bycatch from Gulf of America Shrimp Trawls

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Research Team:

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Background

- GOM shrimp trawl fishery: one of the premier US fisheries for many decades
- 1990s-early 2000s: fleet outfitted with TEDs and BRDs to reduce impact on non-target species
- 2007: IFQ for red snapper; prompted development of Shrimp Observer Program

Project Team, 2021

- Concerns about reliability of bycatch estimates from shrimp trawls
- Small project team came up with a cross-check procedure to evaluate reliability
- Focused on 2014-2020, period with most reliable input data sources

Fleet Effort

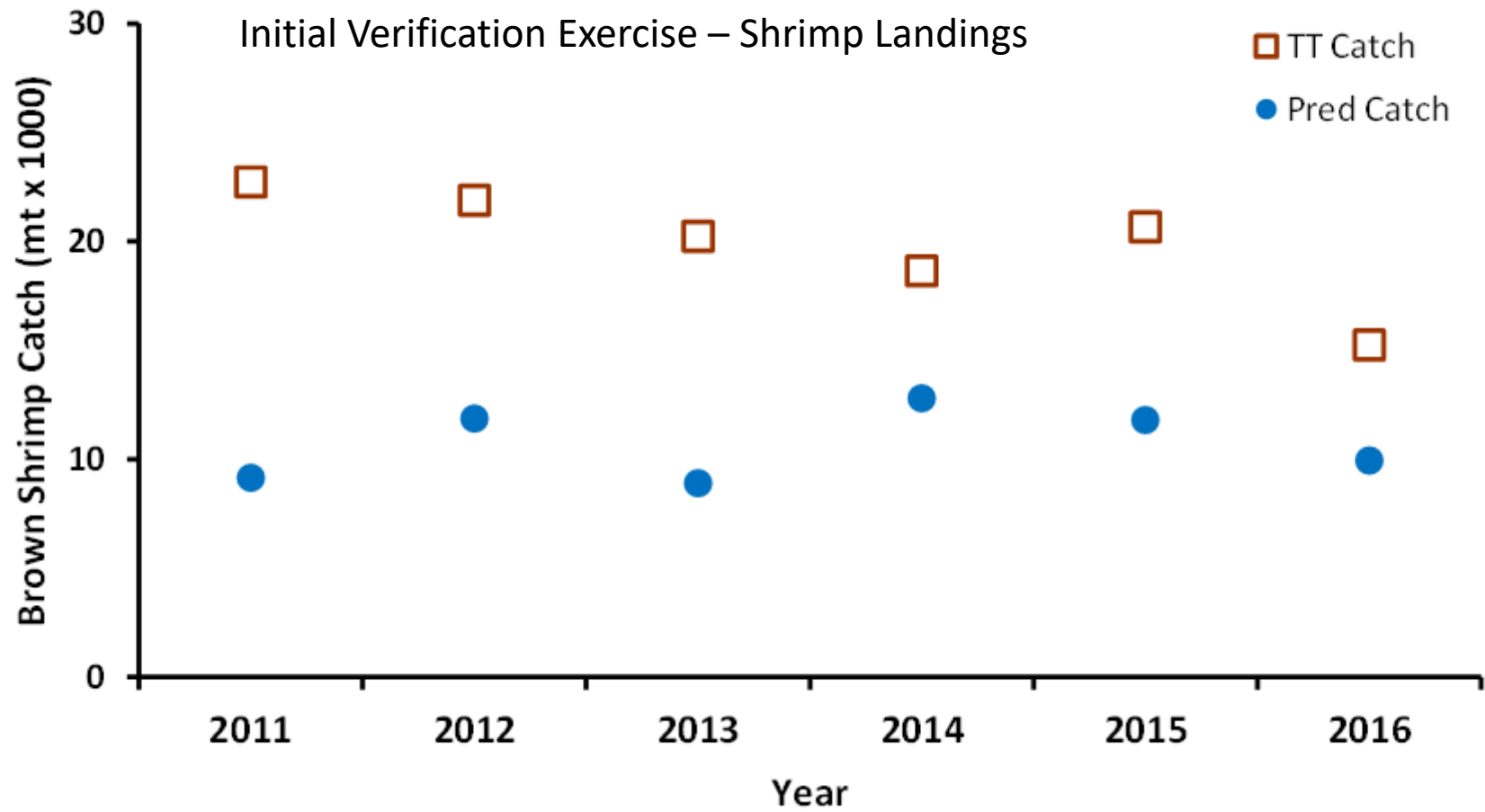
$$\frac{C_{ELB}}{f_{ELB}} = \frac{C_{fleet}}{f_{fleet}}$$

$$\hat{f}_{fleet} = \frac{C_{fleet} \times f_{ELB}}{C_{ELB}}$$

Fleet Catch/Bycatch

$$\frac{C_{obs}}{f_{obs}} = \frac{C_{fleet}}{f_{fleet}}$$

$$\hat{C}_{fleet} = \frac{C_{obs} \times \hat{f}_{fleet}}{f_{obs}}$$



Bias Likely Due to Problems with Input Data and/or Processing Procedures:

- Observer CPUE
- Fleet Effort
- Trip-Ticket Landings

'Legacy Code' for processing: developed in 2000's, passed on to subsequent analysts; developers retired or no longer with NOAA.

Also, bycatch estimation used an annual fleet-wide scalar for the average nets/vessel (2-net or 4-net configurations).

Concurrently:

- Responsibility for Gulf shrimp programs shifted in 2021-22 from Galveston to SEFSC Fisheries Statistics Division (FSD) as part of realignment.
- Need by FSD to gain a better understanding of data sources, processing, and estimation for bycatch.

Project Team, 2022-2023

- A reformulated and expanded project team was assembled by FSD in 2022
- Goal: improve the methodology for estimating bycatch
- Objectives:
 - 1) Comprehensive understanding of the fundamental data sources, and refining/modernizing data processing procedures
 - 2) Investigate potential additional stratification variables: gear characteristics, diurnal period, etc.
 - 3) Cross-check the refined methodology for penaeid shrimps
 - 4) Review of methodology by CIE

Reports for CIE Review:

Bycatch Estimation

Smith, S.G., S. Atkinson, C. Peterson, J. Williams, K. Dettloff, A. Lowther. 2023.
Improving estimation of bycatch from shrimp trawls in the Gulf of Mexico.
Report to Council of Independent Experts. SEDAR Reference Document
SEDAR98-RD-01. SEDAR, North Charleston, SC. 37 pp.

Shrimp Fleet Effort Estimation

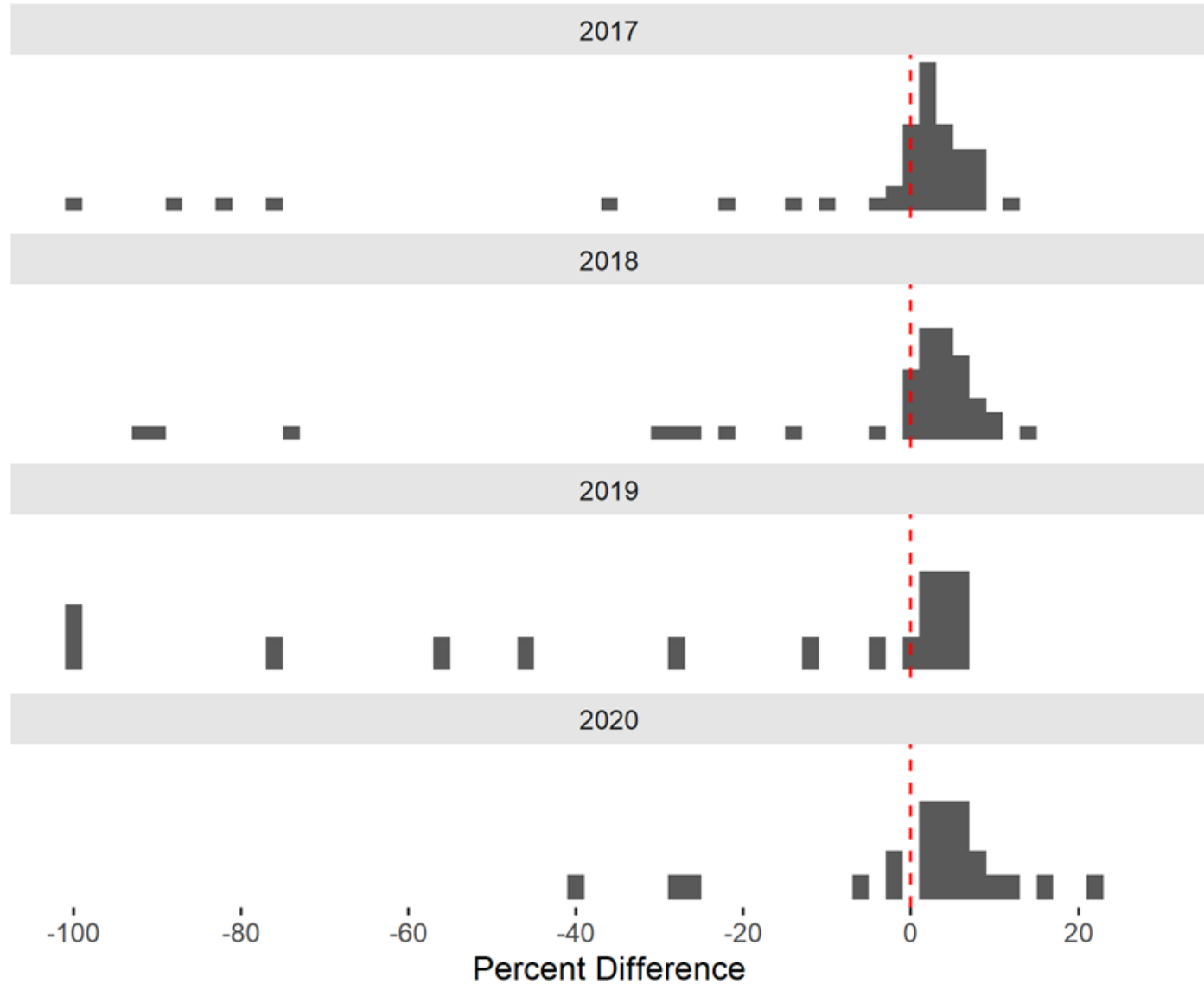
Dettloff, K. 2023. Estimation of commercial shrimp effort in the Gulf of Mexico.
Report to Council of Independent Experts. NOAA SEFSC, 22 pp.

Seven Key Findings/Improvements for Bycatch Estimation

1. Refinement & modernization of observer data processing
2. Cross-checks for observer effort & catch

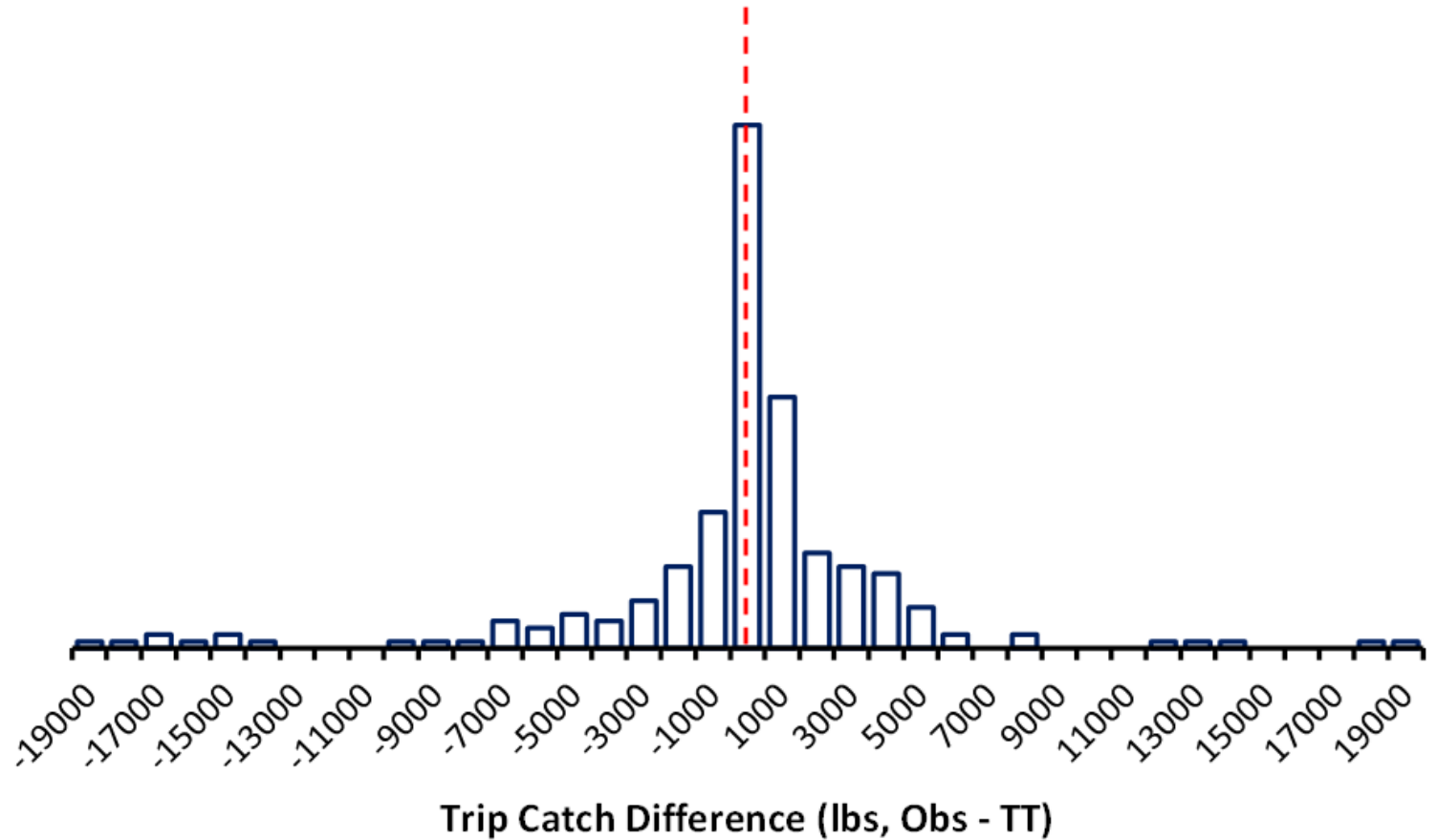
2A: Effort Cross-Check: Observer vs. GPS tracklogs

- Observer trips on vessels with tracklog devices
- No systematic bias in trip effort; negative skew, observers recorded trip effort but partial or missing tracklog effort
- Malfunctioning or switched-off tracklogs



2B: Catch Cross-Check: Observer vs. Trip-Ticket

- No bias between observer and trip-ticket catches
- Check on scale-up procedures for observer sub-sampling during trips
- Subsampling:
 - Tows within trip
 - Nets within tow
 - Catch within net
 - Species within catch



Improvements (cont.)

3. Observer CPUE estimation

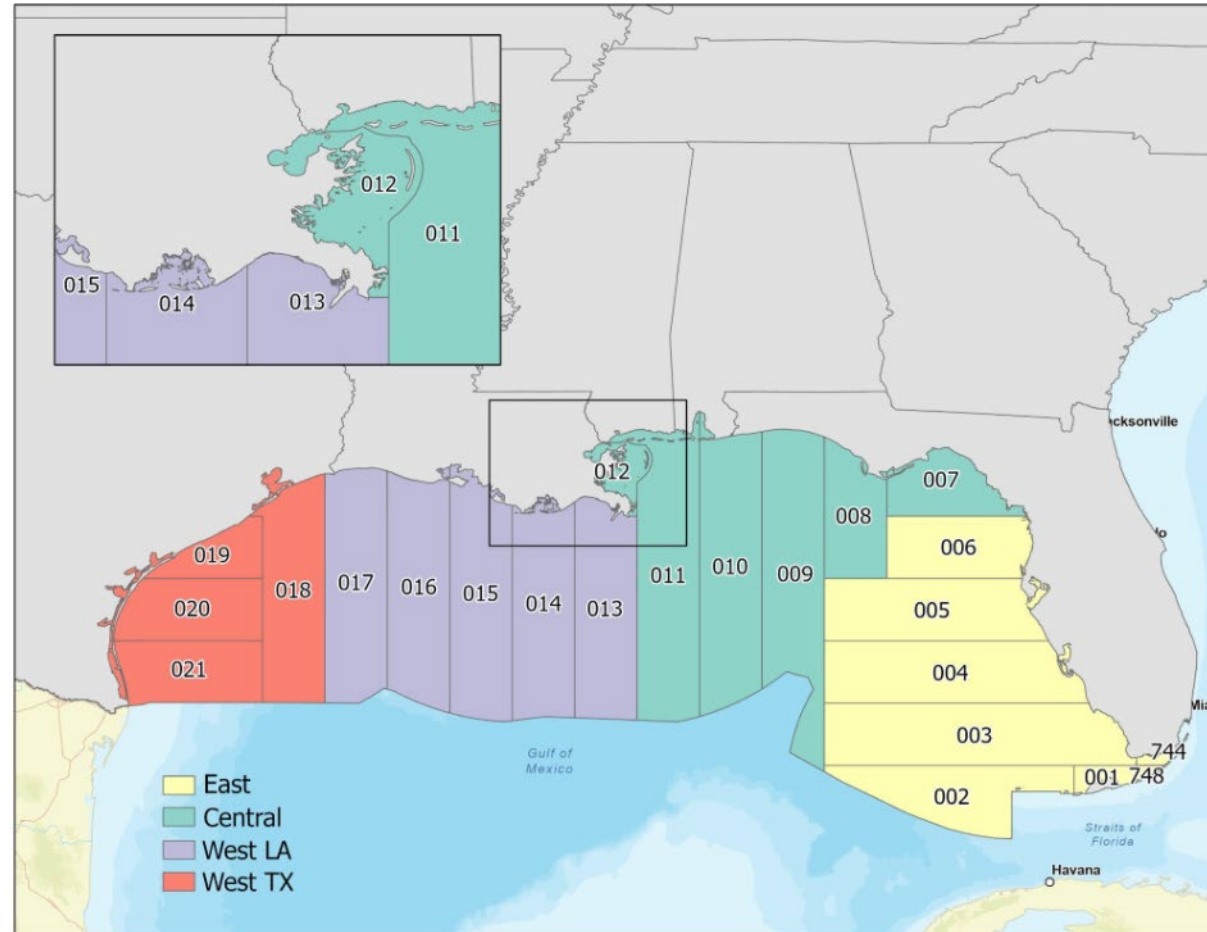
- Horvitz-Thompson ratio-of-means estimator for stratified sample frame

Historical Time-Space Strata:

Region (4)

Depth (3)

Season (3)



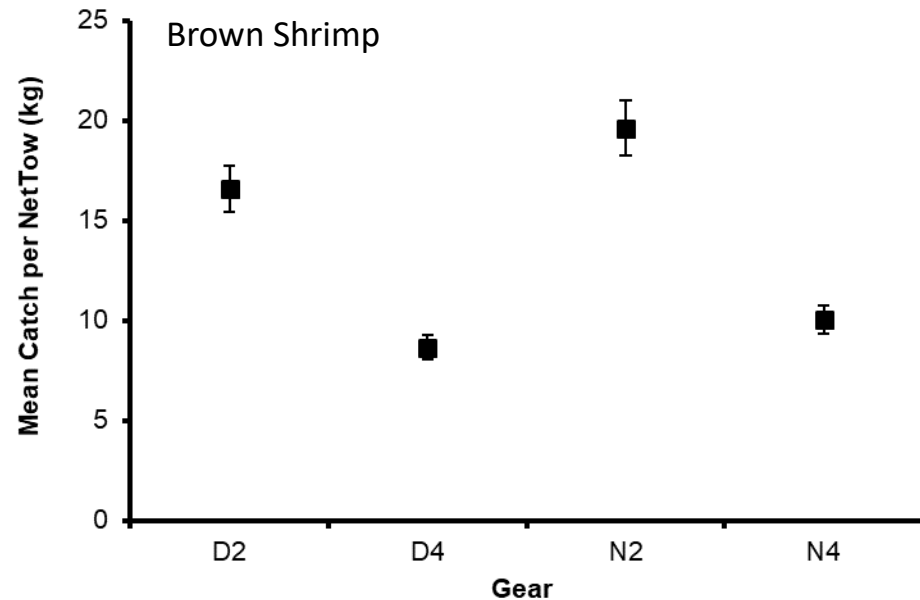
- Accommodated varying levels of fishing effort among observer samples

Improvements (cont.)

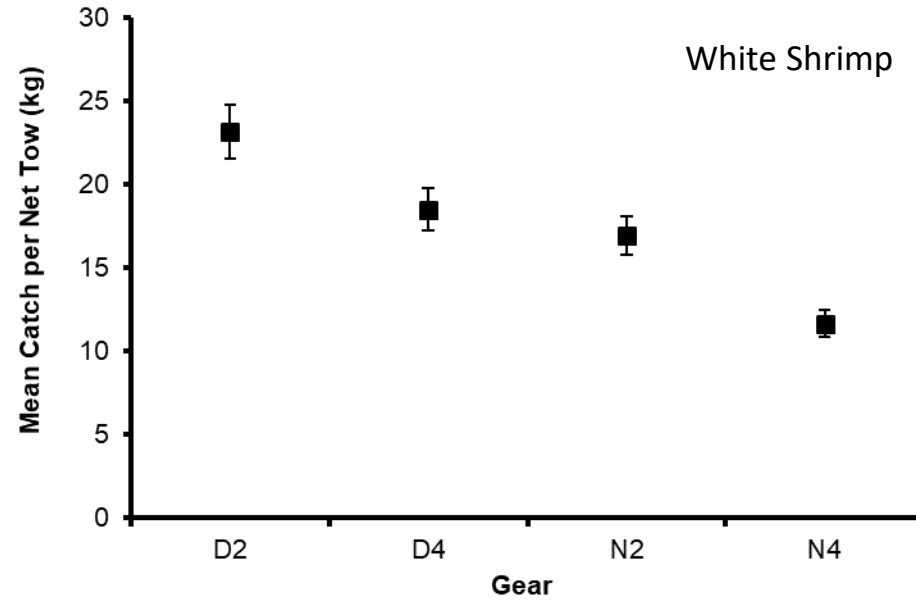
4. Additional stratification variables

- GLMs were developed of the general form, $Catch = f(effort, addtl. covariates) + \varepsilon$, to evaluate potential stratification variables
- Trawl characteristics: headrope length, mesh size, configuration (2-net, 4-net)
- Diurnal Period: day, night
- Results: created 'Gear' strata, combo of net-configuration and diurnal period: D2, day 2-net
D4, day 4-net
N2, night 2-net
N4, night 4-net

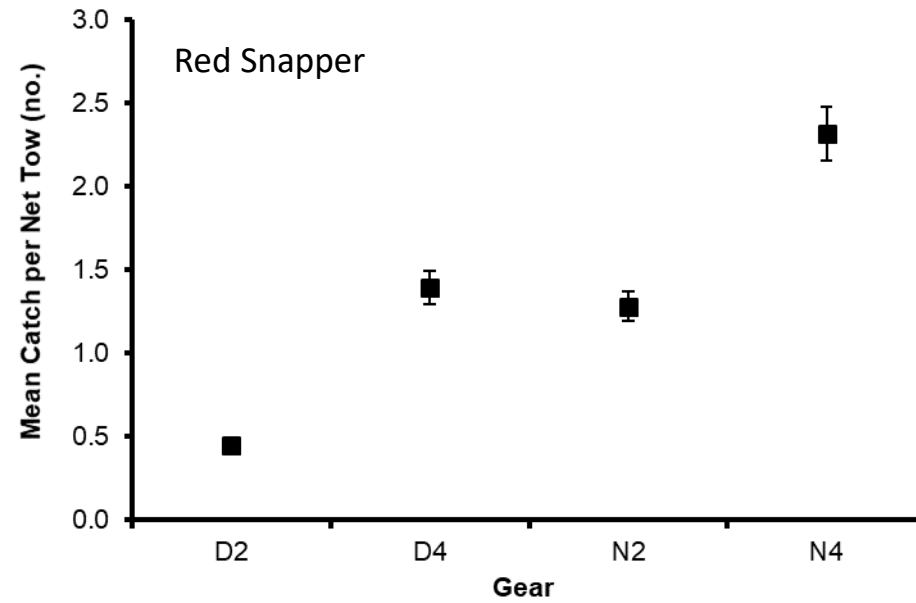
GLM main effects predicted catch rate by gear categories



- Major: 2 > 4
- Minor: N > D
- Max Diff: N2 > D4 by 226%



- Major: $D > N$
- Minor: $2 > 4$
- Max Diff: $D2 > N4$ by 199%



- Major: $N > D, 4 > 2$
- Max Diff: $N4 > D2$ by 515%

Improvements (cont.)

5. Annual Landings & Gear Survey

- Previously unused data source, SEFSC Annual Landings and Gear Survey, enabled assignment of 2-net and 4-net gear types to fleet vessels for tracklog effort and trip-ticket landings

6. Sparse sampling procedures for observer data

A. Pooling of groups of years within season-region-depth-gear strata

- Within-strata interannual variability analyses: no systematic bias introduced in strata CPUE estimates by pooling years
- Variance of mean CPUE used annual average stratum sample size; avoided inflation of precision (i.e., treating pooled years as single survey)

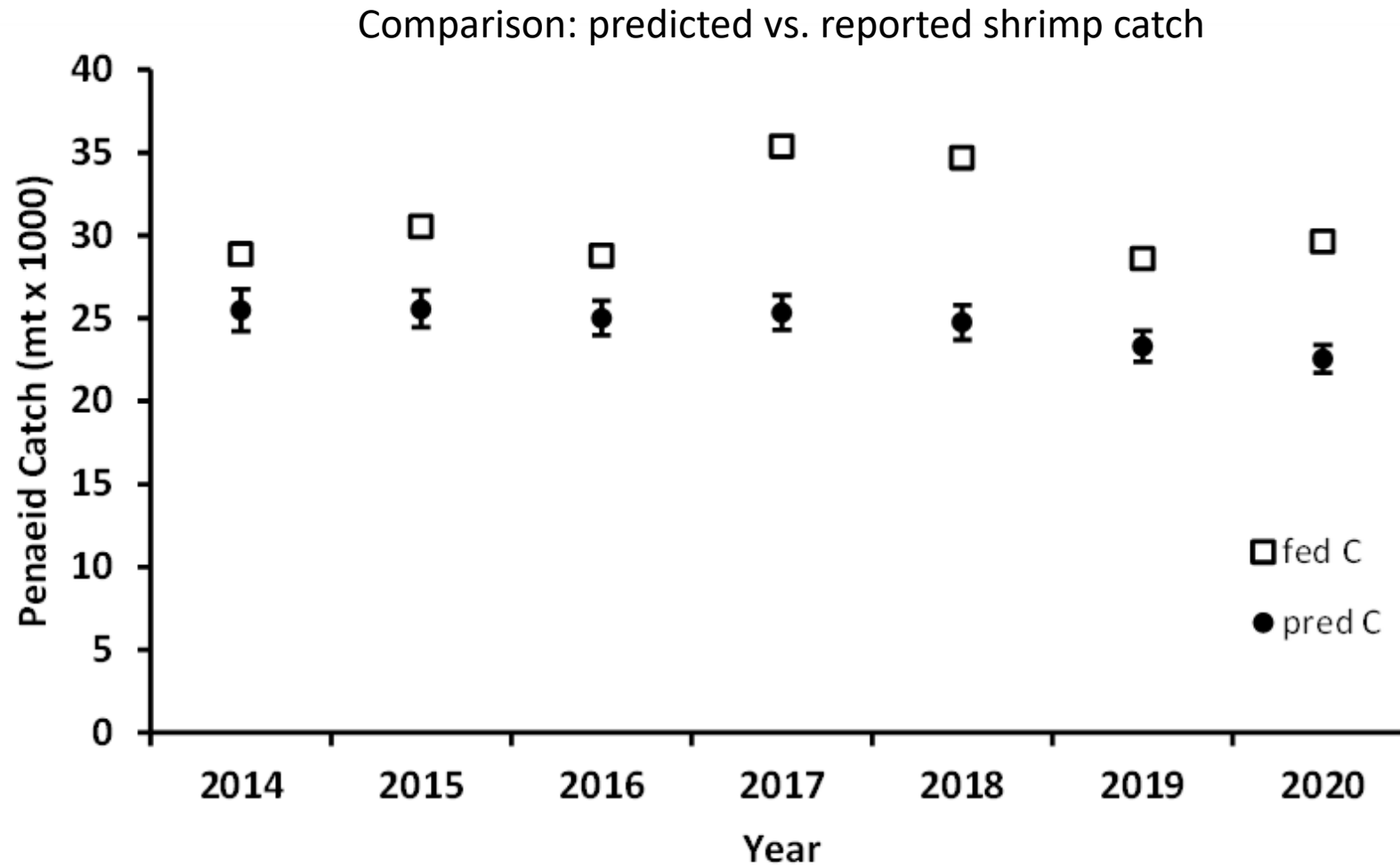
B. GLM imputation procedure

- Developed for remaining sparsely-sampled gear types (N2,D2,N4,D4) within specific season-area-depth strata
- Imputed strata accounted for 11% of fleet effort

Improvements (cont.)

7. Verification procedure

- Trip-ticket vs. observer-estimated landings differed by 10-20%
- Improvement from previous 45-50% difference, but bias issues remain



Our Conclusions

- Analyses indicated unbiased observer trip catch and effort
- Remaining bias likely due to issues with total fleet effort, and in turn, total fleet landings

CIE Reviewers

- Bycatch methodology: sound approach, appropriate
- Agreed with our conclusions about remaining sources of bias
- Major recommendation #1: outfit entire fleet with tamper-proof GPS device
- #2: overhaul Shrimp Observer Program, especially statistical design and allocation of observer effort among strata
- Numerous additional suggestions: alleviating bias in fleet effort estimation, improving estimation of uncertainty, refining stratification scheme, etc.

Follow-on Work, SEDAR 98 (Gulf Red Snapper) and SEDAR 87 (Gulf Penaeid Shrimp)

- Bycatch methodology refined per CIE suggestions
- Applied to full observer time period 2007-2023
- SEDAR 98 Working Paper:

Smith, S.G., S. Atkinson, S., C. Peterson, K. Dettloff. 2025. Estimation of Red Snapper bycatch from Gulf of America shrimp trawls. SEDAR98-DW-23. SEDAR, North Charleston, SC. 22 pp.

- Concurrent research focused on more accurate commercial fleet shrimp landings and effort
- SEDAR Working Papers:

SEDAR 98 (Red Snapper)

Atkinson, S., K. Dettloff, C. Peterson, S.G. Smith. 2025. Estimation of commercial shrimp effort in the Gulf of Mexico from 1984-2023. SEDAR98-DW-23. SEDAR, North Charleston, SC. 22 pp.

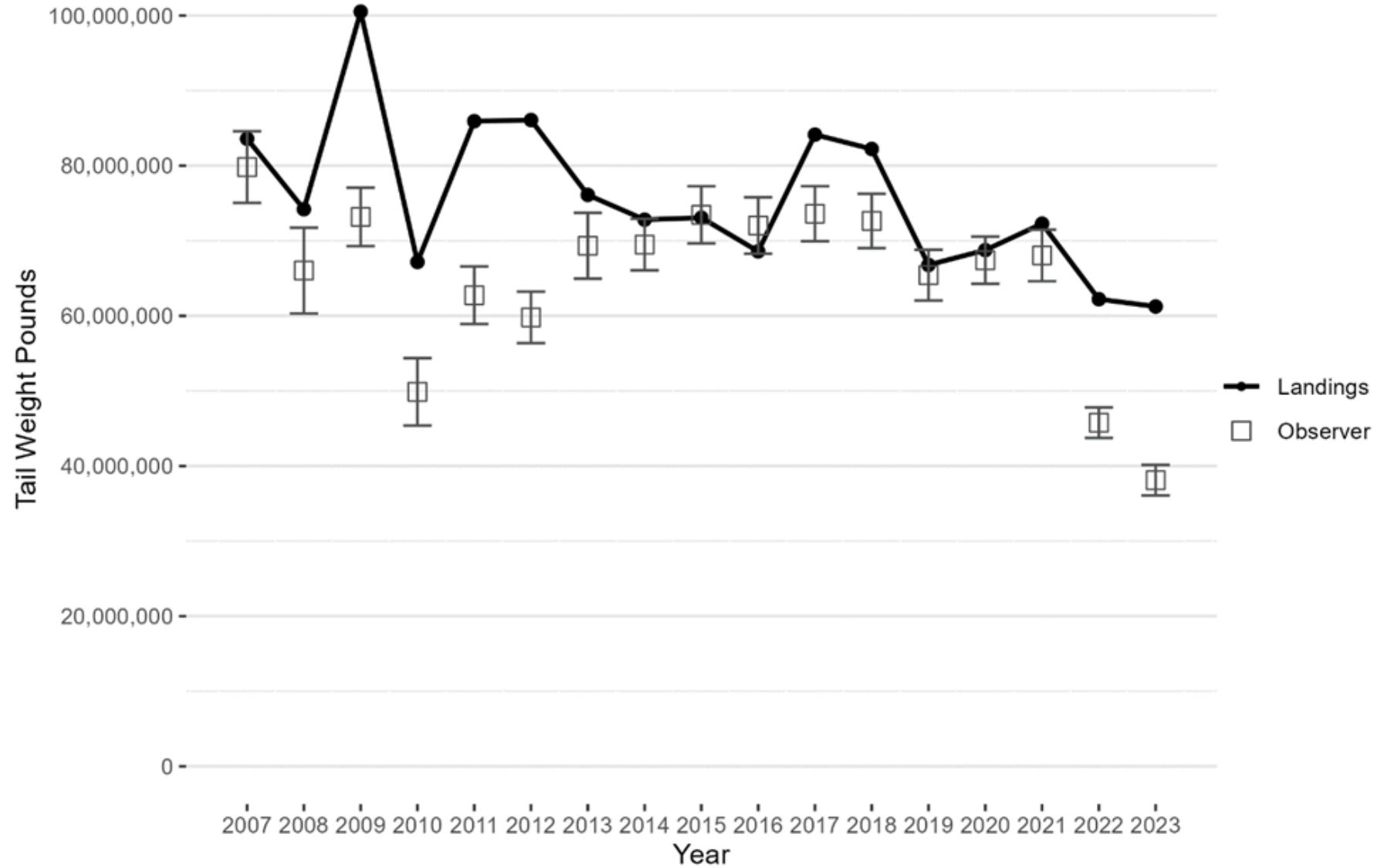
SEDAR 87 (Penaeid Shrimp)

Atkinson, S., A. Lowther, K. Dettloff, S.G. Smith. 2024. Gulf of Mexico commercial brown, pink and white shrimp landings. SEDAR Working Paper SEDAR87-DW-06. SEDAR, North Charleston, SC. 38 pp.

Dettloff, K. 2024. Estimation of commercial shrimp effort in the Gulf of Mexico. SEDAR Working Paper SEDAR87-DW-01. SEDAR, North Charleston, SC. 31 pp.

Verification procedure: predicted vs. reported shrimp catch

- Good match: 2014-2021
- General underestimation: 2007-2013, 2022-2023
- Correspondence appears related to changes in methods of effort data collection for GPS tracklogs

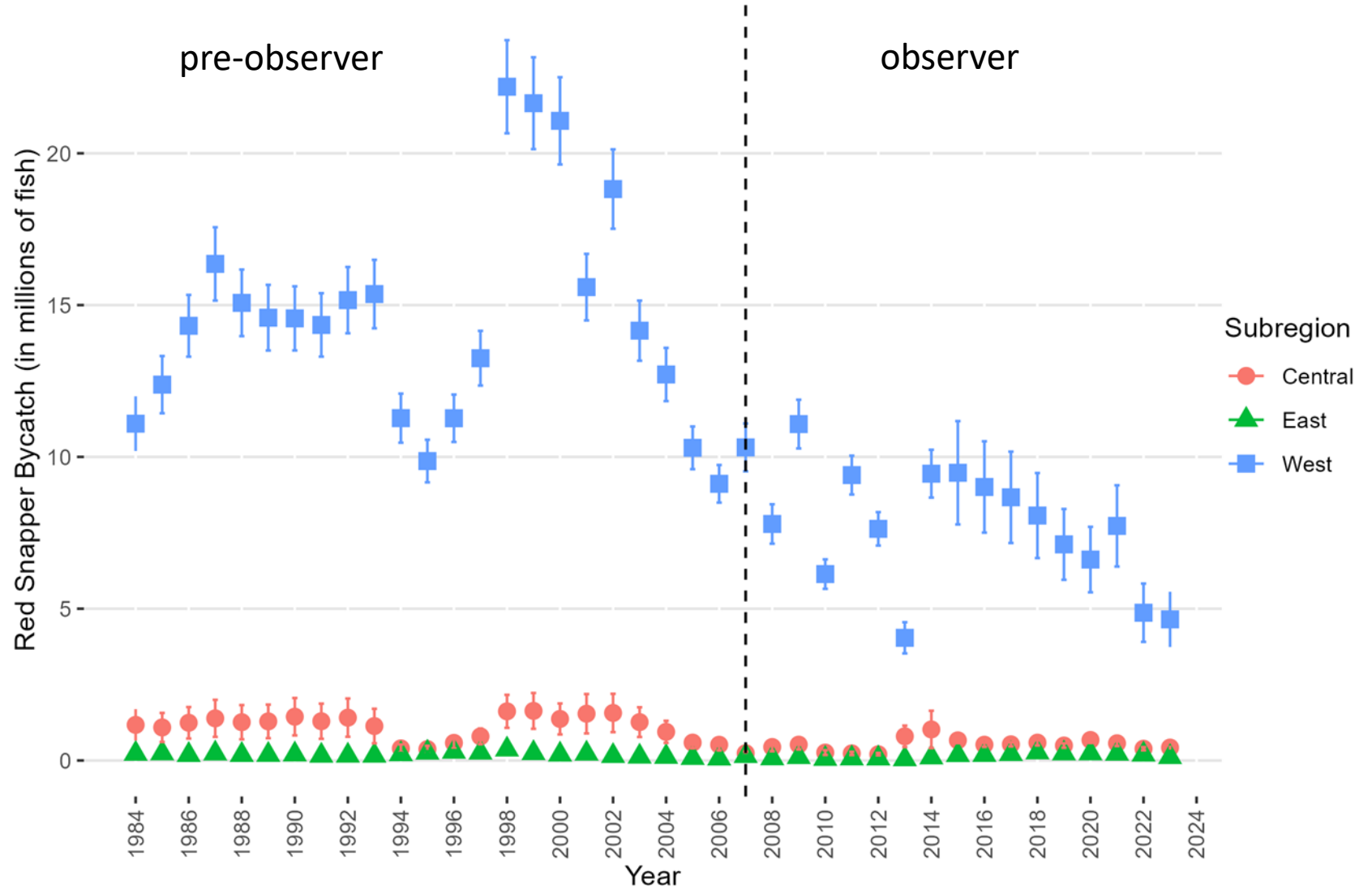


Hindcasting: Bycatch estimates for pre-observer, pre-tracklog years (1984-2006)

- Majority of work: time-series of shrimp landings and effort for season-region-depth-gear strata
- Port agent dealer & captain interviews: trip landings-effort by net configuration and diurnal period
- Detailed in SEDAR working papers cited above
- Hindcasting procedure: related strata catch rates of red snapper and penaeid shrimp for 2007-2013
- Applied relationship to estimate strata catch rates for red snapper for 3 historical periods:
 - 1984-1990: moderate fleet effort, no BRD requirement
 - 1991-1997: high fleet effort, no BRD requirement
 - 1998-2006: decreasing fleet effort, BRD requirement
- Key assumption: stable relationship between shrimp and red snapper catch rates during period
- BRD analysis: red snapper mean catch per tow 7.1% higher for nets without BRD; used for historical adjustment of bycatch estimates pre-1998

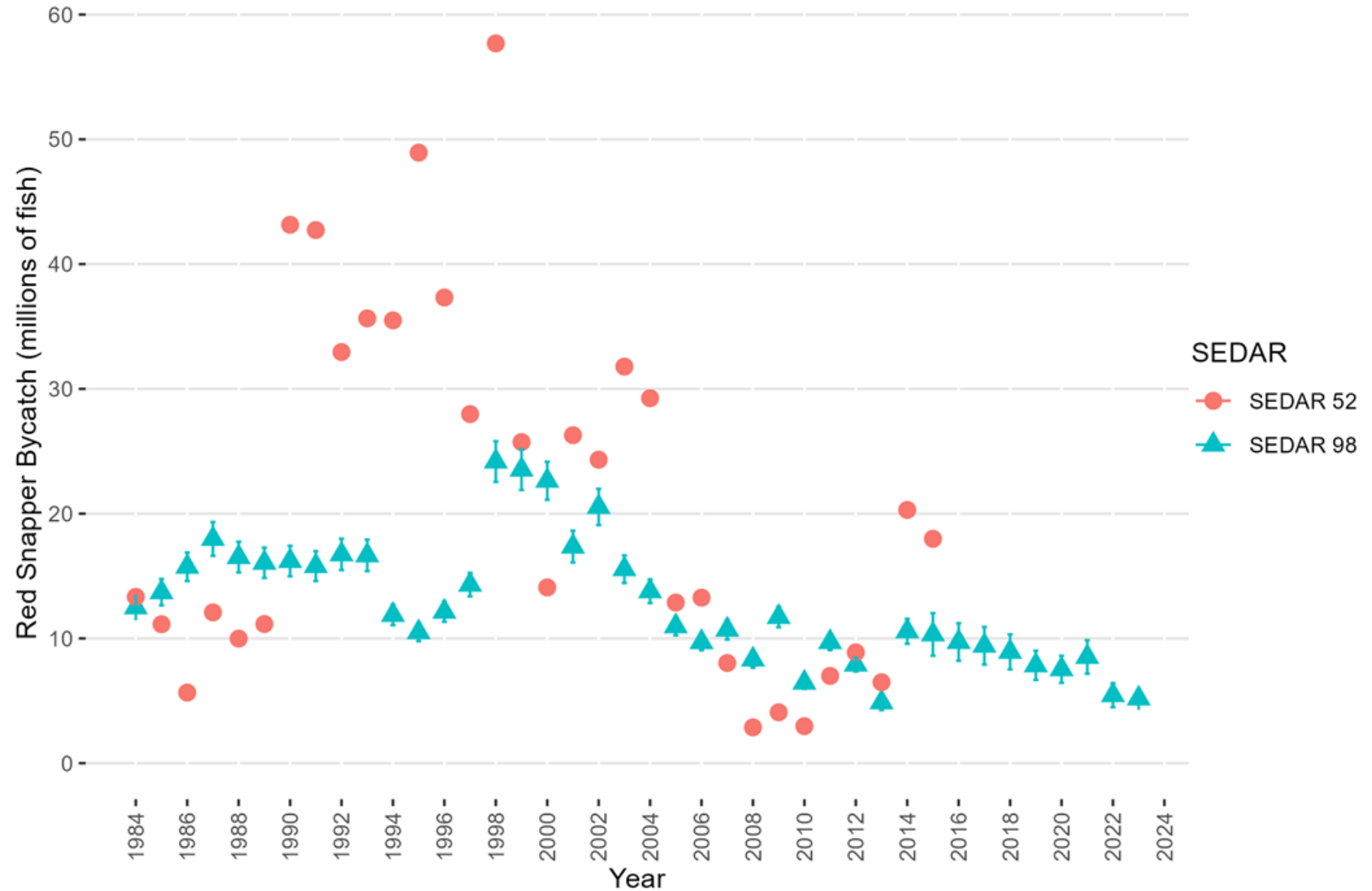
Red Snapper bycatch by Gulf zone, 1984-2023

- Majority: West (TX, LA)



Comparison with previous bycatch estimates

- Previous estimates (SEDAR 52) showed similar patterns of increases and decreases, but were more volatile in terms of magnitude
- SEDAR 98 key differences: incorporated gear strata, improved shrimp landings and effort time-series
- SEDAR 52 used SEAMAP trawl data as a proxy for commercial trawls for pre-observer time period (pre-2007)
- Given that catch rates of commercial trawl gear types can differ by over 500%, equating SEAMAP trawls to commercial trawls might not be scientifically valid



Next Steps for Improvement (SEFSC, CIMAS)

- Evaluating strategies for deploying modern GPS tracklog devices on commercial shrimp fleet
- New FIS project, Fall 2024 – Summer 2026: Overhaul of shrimp observer program
- Initial scoping of field experiments for calibrating SEAMAP and commercial shrimp trawls