Suppplementary Material

Modeling Discards in Stock Assessments: Red Grouper *Epinephelus morio* in the U.S. Gulf of Mexico

Gulf of Mexico Red Grouper Discard Modeling

This supplementary material compares model fits for landings, discards, length compositions, age compositions, and indices of relative abundance. In addition, estimated selectivity patterns and time−varying retention patterns are shown for each model run.

Table S1. Comparison of negative log−likelihood by data component and data source for the Gulf red grouper case study exploring different approaches to modeling discards. Note that negative log−likelihoods are not comparable for the separate−fleet model due to changes in data inputs.

Negative Log−Likelihood Component	Retention Model—2 Blocks (Base)	Retention Model–Annual Blocks	Separate Fleet Model
Catch	36.5	34.5	3.18
Commercial vertical line	8.3	9.0	0.1
Commercial longline	5.1	4.8	0.5
Commercial trap	10.2	10.2	0.0
Recreational	12.9	10.5	1.7
Discard	−30.1	−31.4	–
Commercial vertical line	−4.9	−3.0	–
Commercial longline	−15.9	−16.7	–
Commercial trap	10.3	10.3	–
Recreational	−19.7	−22.1	–
Indices	−102.6	−108	−98.9
Commercial vertical line CPUE	−13.8	−14.4	−13.3
Commercial longline CPUE	−18.3	−18.9	−17.1
Recreational Headboat CPUE	−19.1	−23.5	−19.1
Recreational Charter−Private CPUE	−11.7	−12.0	−8.6
Combined Video Survey	−19.9	−19.5	−21.0
Groundfish Survey	−8.3	−8.3	−7.9
Bottom Longline Survey	−8.4	−8.2	−9.0
Repetitive Time Drop	−3.1	−3.1	−2.9
Length composition	287.3	300.3	292.2
Commercial vertical line	20.4	25.4	31.0
Commercial longline	27.2	34.6	20.8
Recreational	20.0	20.3	16.3
Combined Video Survey	36.6	36.4	36.8
Groundfish Survey	34.9	34.9	37.6
Bottom Longline Survey	121.8	122.3	124.1
Repetitive Time Drop	26.4	26.5	25.5
Age composition	335.5	338.4	322.9
Commercial vertical line	88.4	92.1	84.9
Commercial longline	107.9	116.1	98.3
Commercial trap	35.0	35.2	33.0
Recreational	104.2	95.0	106.7

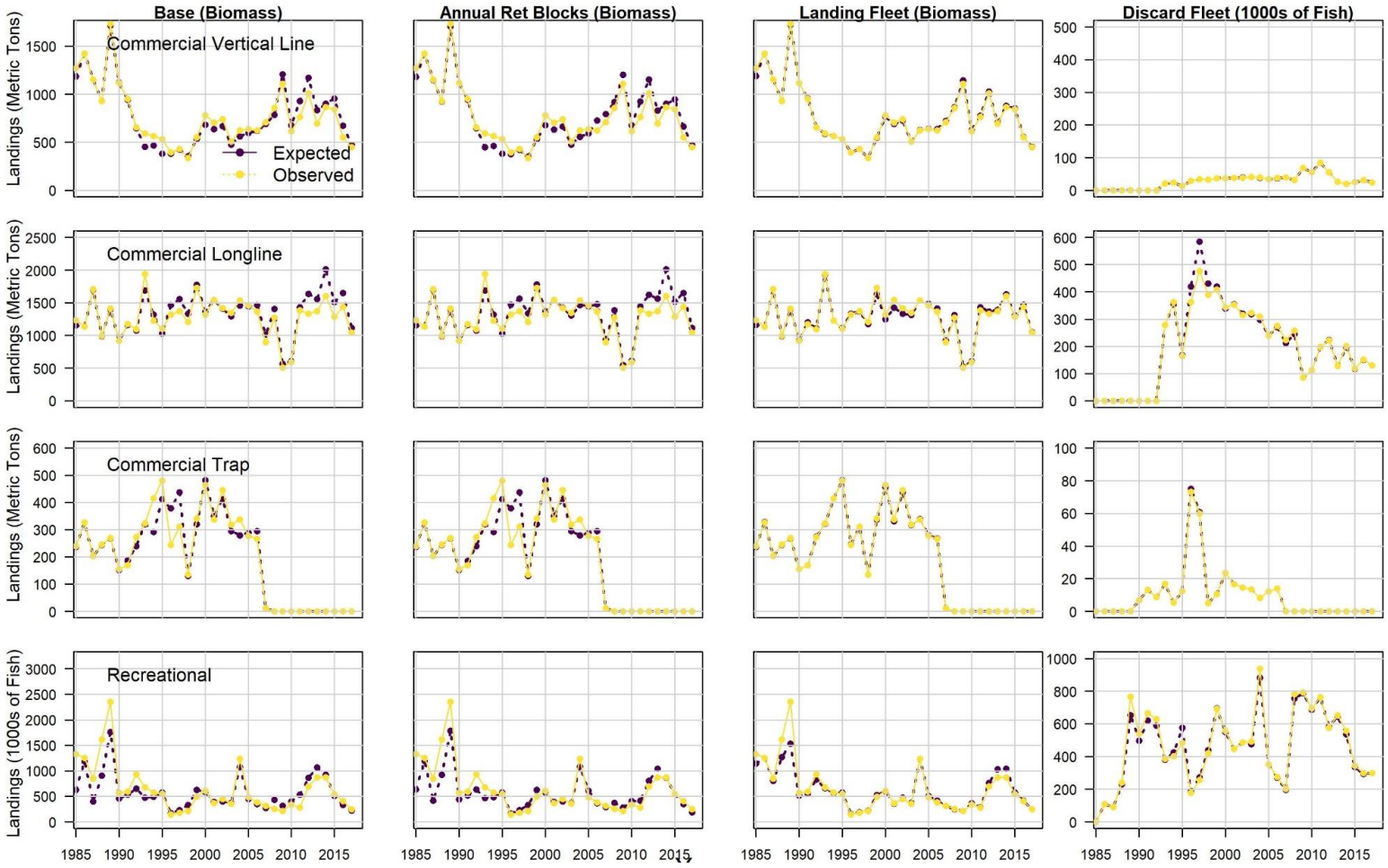
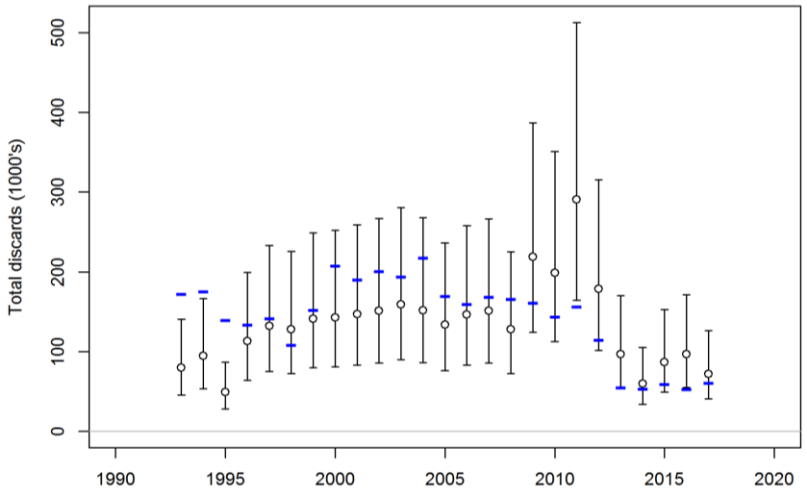
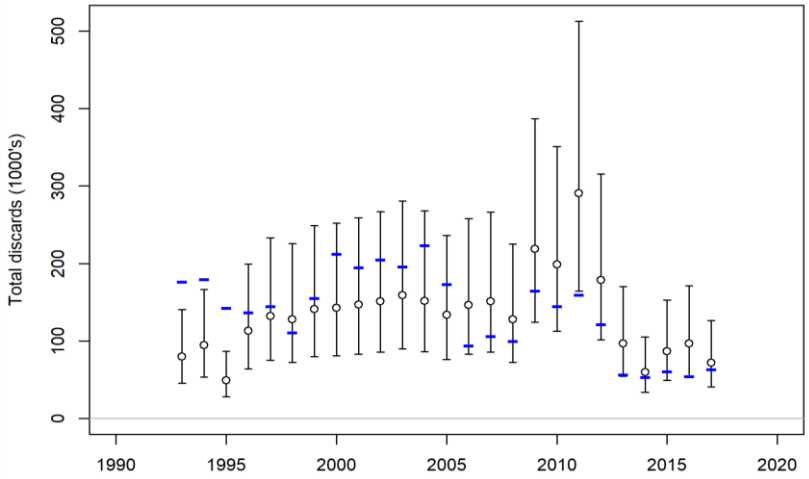


Figure S1. Input (dashed yellow line) and expected (purple lines) landings (or dead discards for the separate fleet model) of Gulf of Mexico Red Grouper for each fleet. Base refers to the 2 retention block model whereas the landing and discard fleets (columns 3 and 4) are from the separate fleet model. Note that the observed values for the discard fleet were input as a time series of dead discards in number of fish (total discards x discard mortality rate).

2 retention blocks (Base)



Annual retention blocks

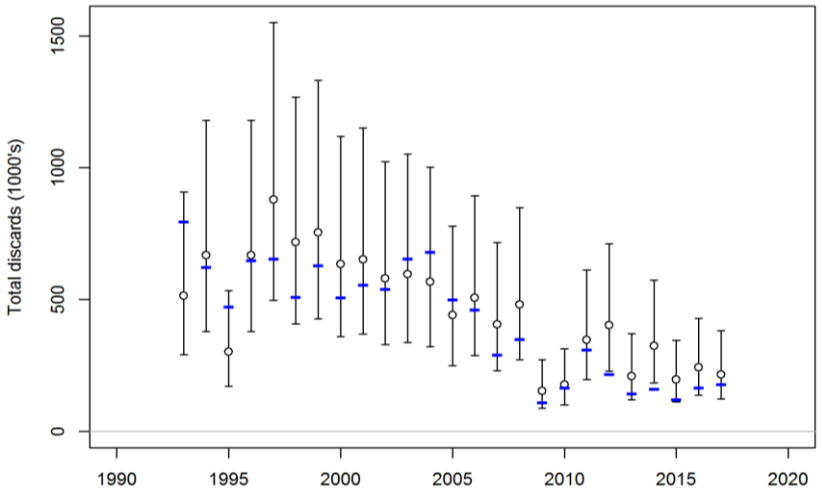


Separate fleets

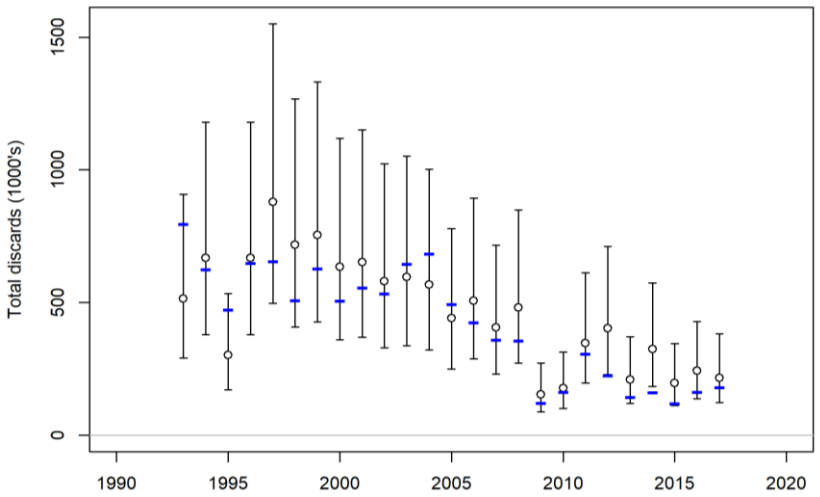
Not Fitting to Total Discards (fitting to dead discards – see column 4 of Figure S1)

(A). Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Commercial Vertical Line fleet for Gulf of Mexico Red Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

2 retention blocks (Base)



Annual retention blocks

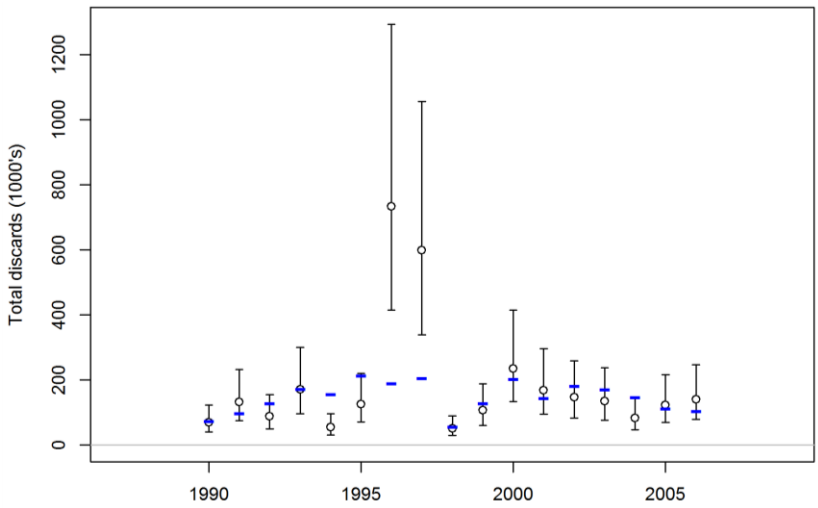


Separate fleets

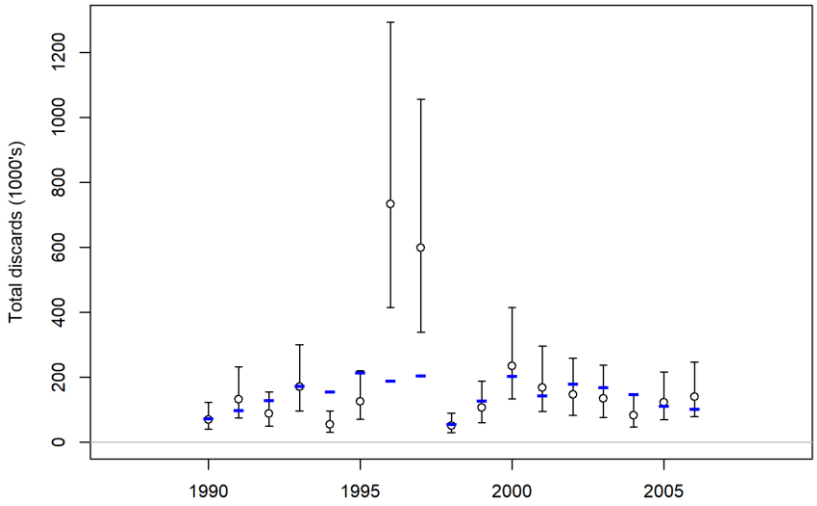
Not Fitting to Total Discards (fitting to dead discards – see column 4 of Figure S1)

(**B**). Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Commercial Longline fleet for Gulf of Mexico Red Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

2 retention blocks (Base)



Annual retention blocks

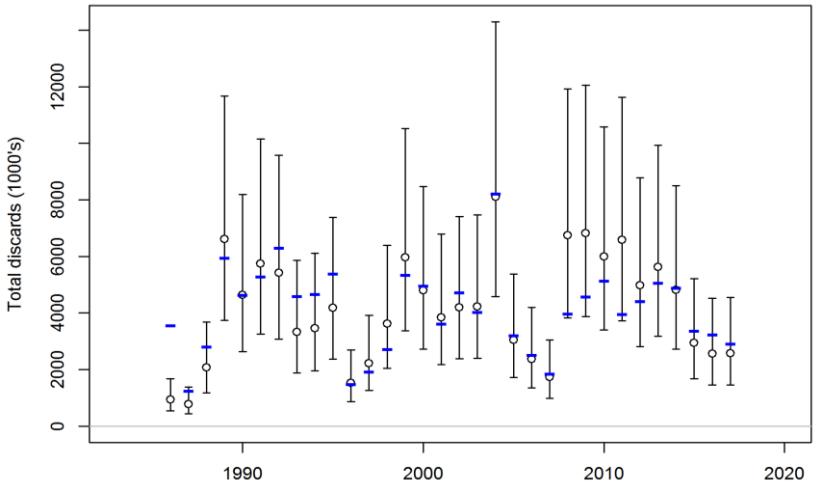


Separate fleets

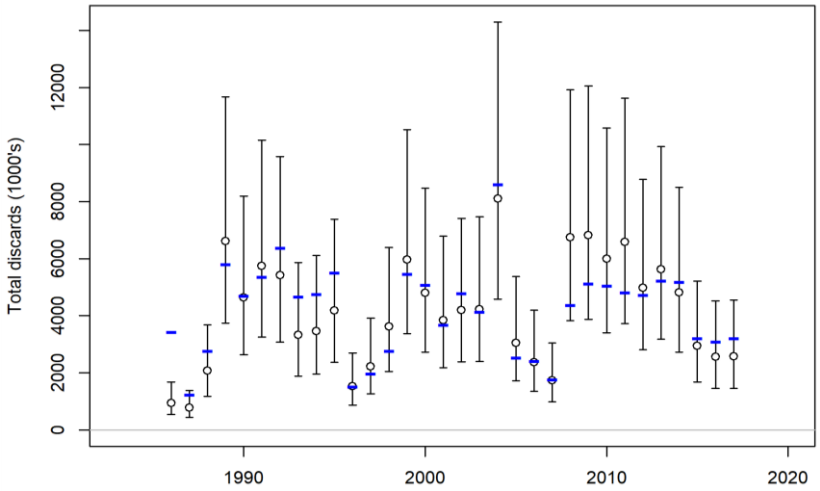
Not Fitting to Total Discards (fitting to dead discards – see column 4 of Figure S1)

(C). Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Commercial Trap fleet for Gulf of Mexico Red Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

2 retention blocks (Base)



Annual retention blocks



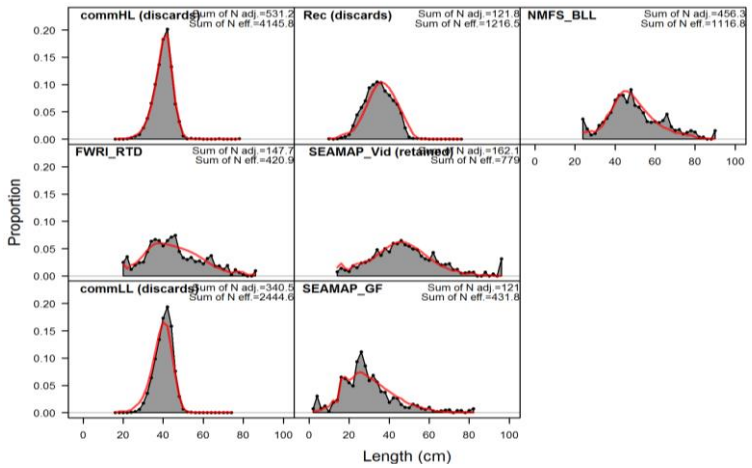
Separate fleets

Not Fitting to Total Discards (fitting to dead discards – see column 4 of Figure S1)

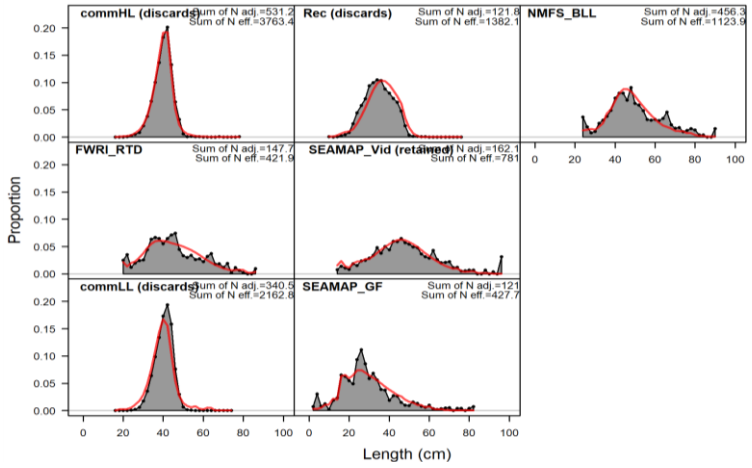
(**D**). Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Recreational fleet for Gulf of Mexico Red Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

Figure S2. Discards by fleet (**A**–**D**) for each model run.

2 retention blocks (Base)



Annual retention blocks



Separate fleets

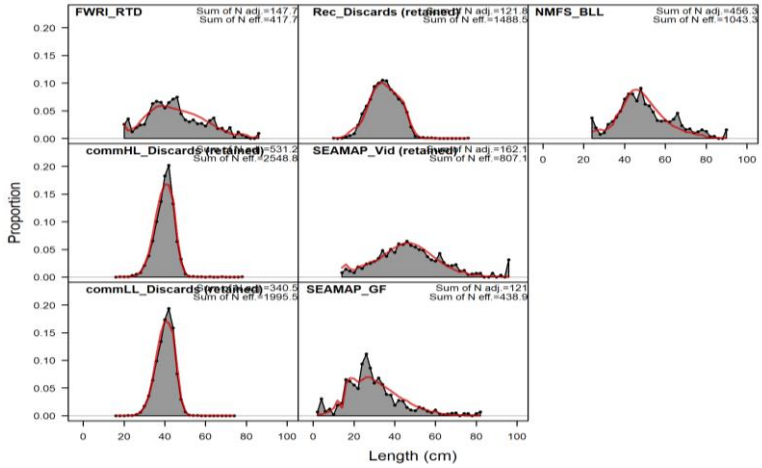
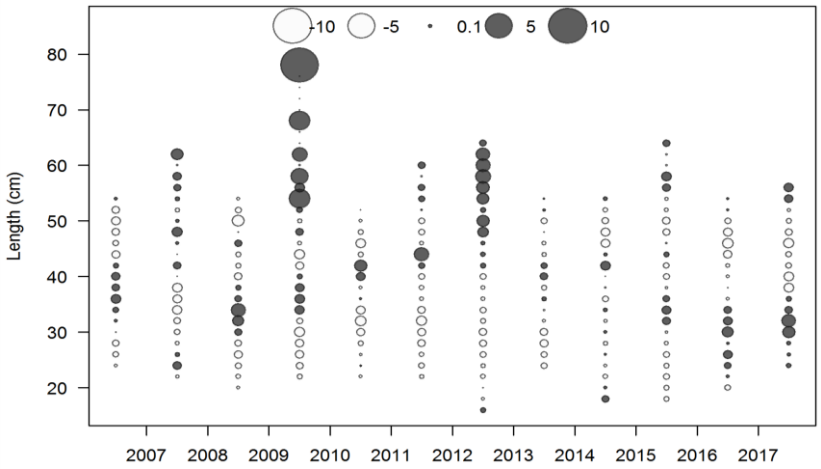
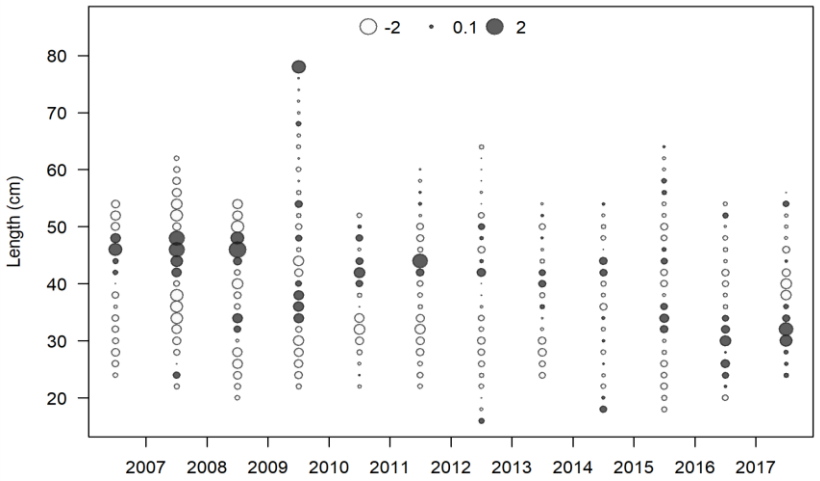


Figure S3. Model fits to the length composition of discarded or surveyed catch aggregated across years within a given fleet or survey for Gulf of Mexico Red Grouper. Red lines represent expected length compositions, while grey shaded regions represent observed length compositions. The input (N input) and adjusted (N adj) sample sizes are provided in the upper right corner of each panel.

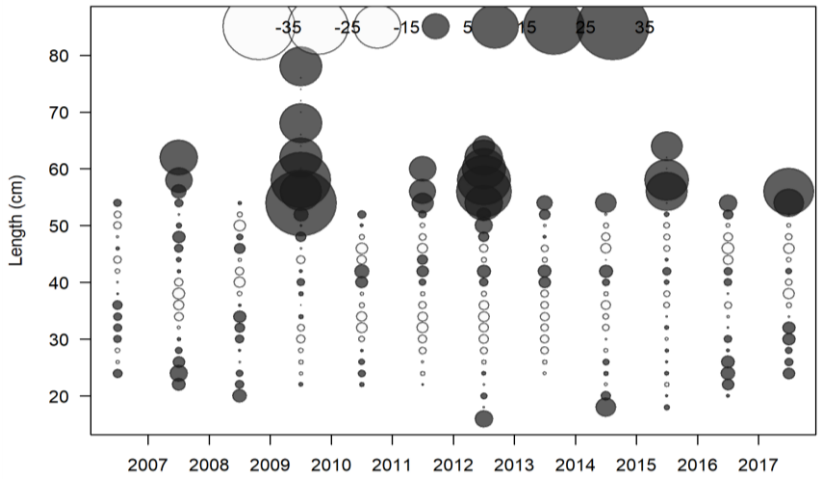
2 retention blocks (Base)



Annual retention blocks

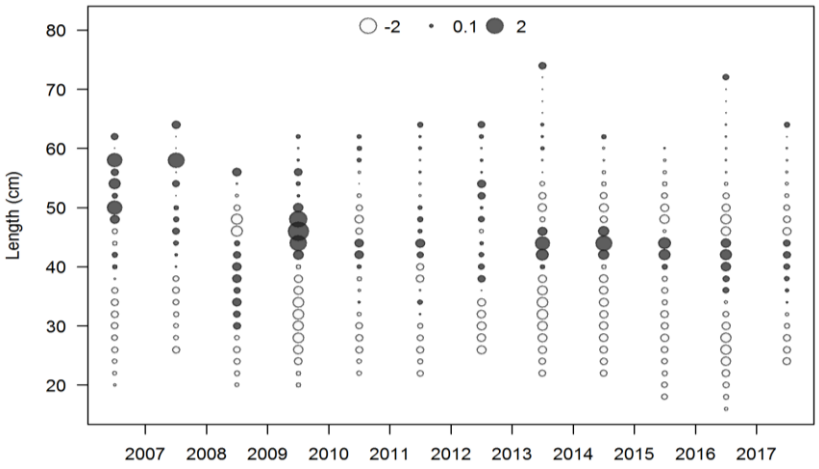


Separate fleets

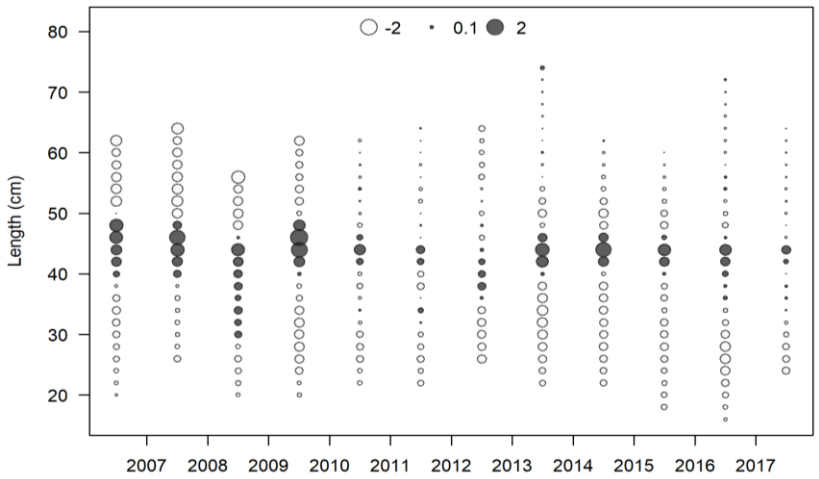


(A). Pearson residuals for Gulf of Mexico Red Grouper discarded by the Commercial Vertical Line fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < Expected).

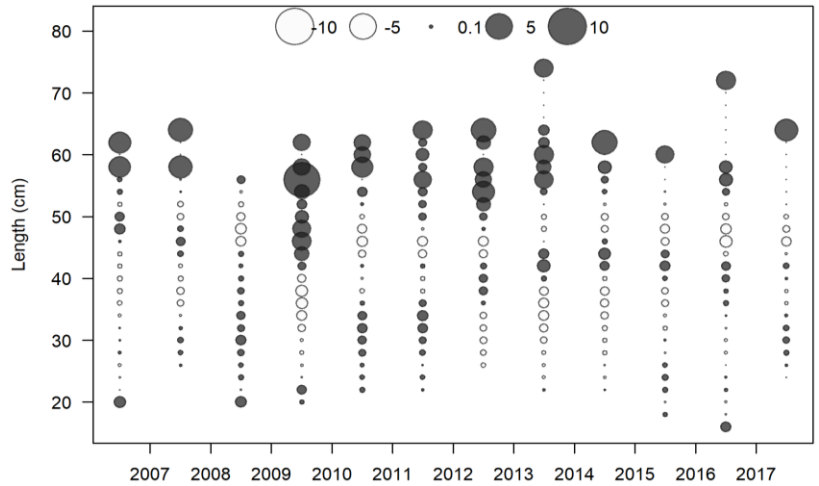
2 retention blocks (Base)



Annual retention blocks

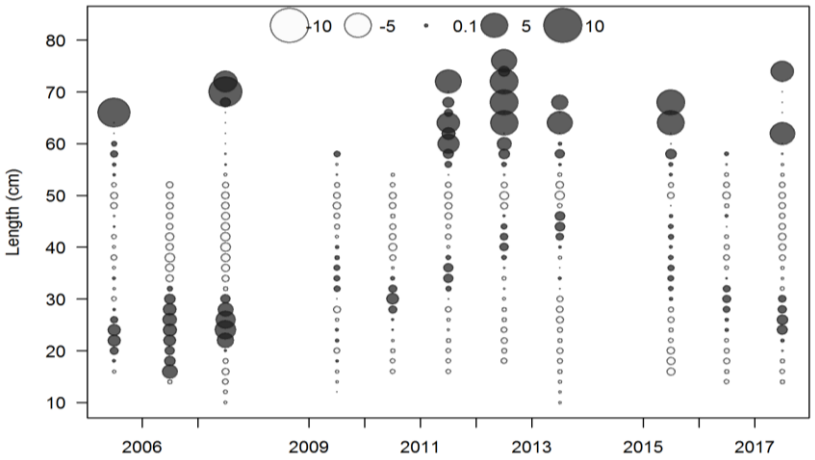


Separate fleets

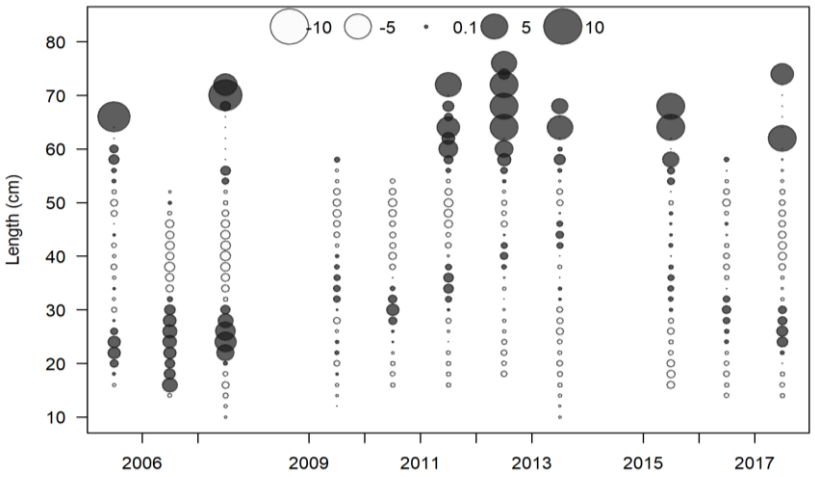


(B). Pearson residuals for Gulf of Mexico Red Grouper discarded by the Commercial Longline fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

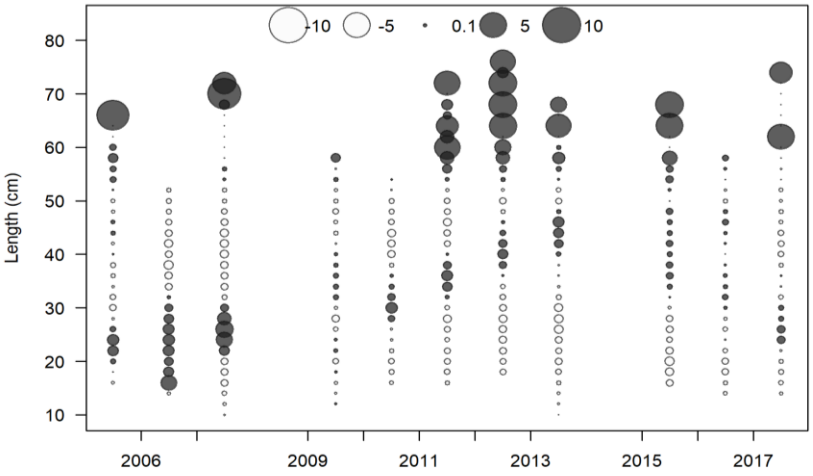
2 retention blocks (Base)



Annual retention blocks



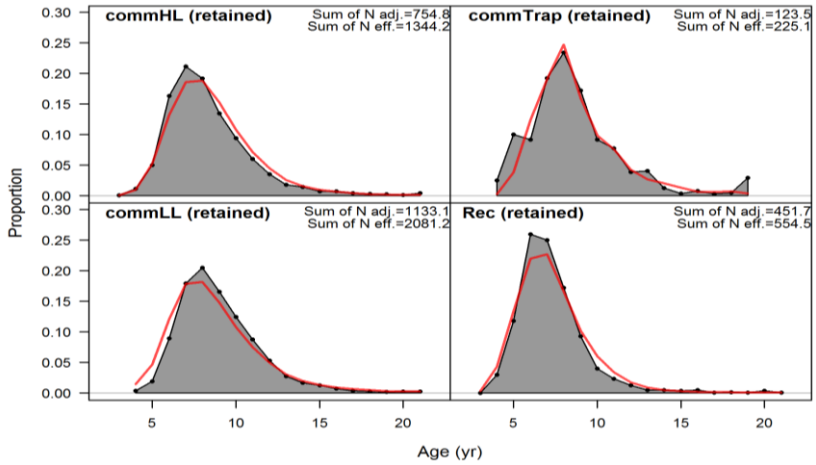
Separate fleets



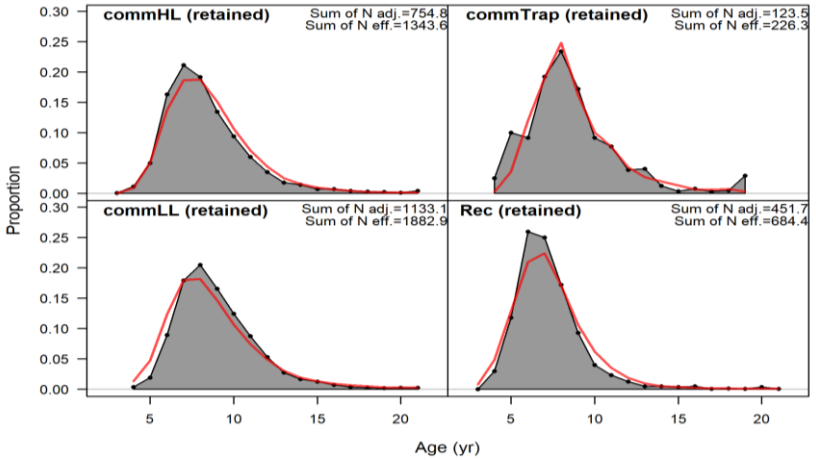
(**C**). Pearson residuals for Gulf of Mexico Red Grouper discarded by the Recreational fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

Figure S4. Pearson residuals for fits to the length compositions of red grouper discarded by each fleet (**A**–**C**) for each model run.

2 retention blocks (Base)



Annual retention blocks



Separate fleets

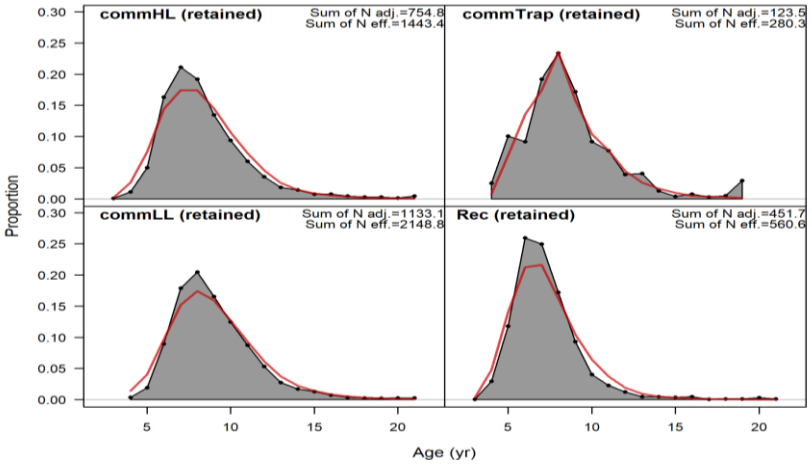
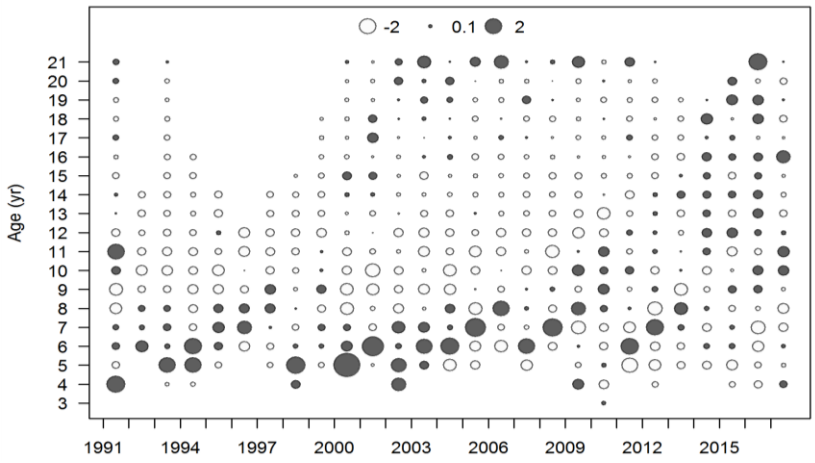
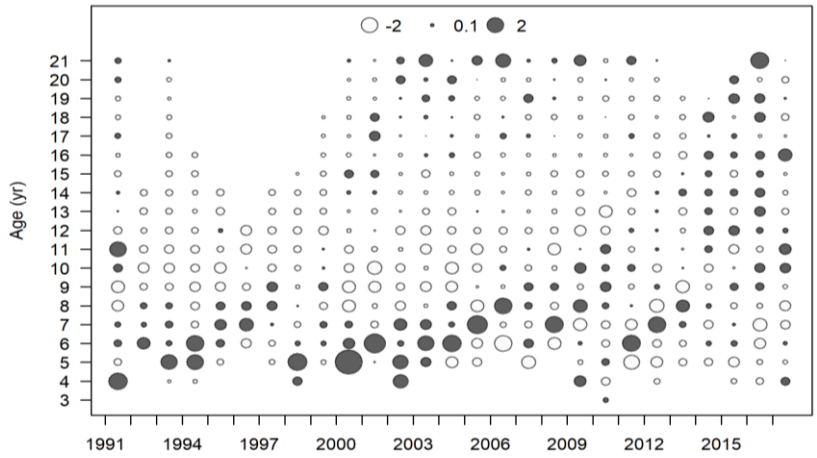


Figure S5. Model fits to the age composition of landed Red Grouper aggregated across years within a given fleet for the Gulf of Mexico. Red lines represent expected age compositions, while grey shaded regions represent observed age compositions. The input (N input) and adjusted (N adj) sample sizes are provided in the upper right corner of each panel.

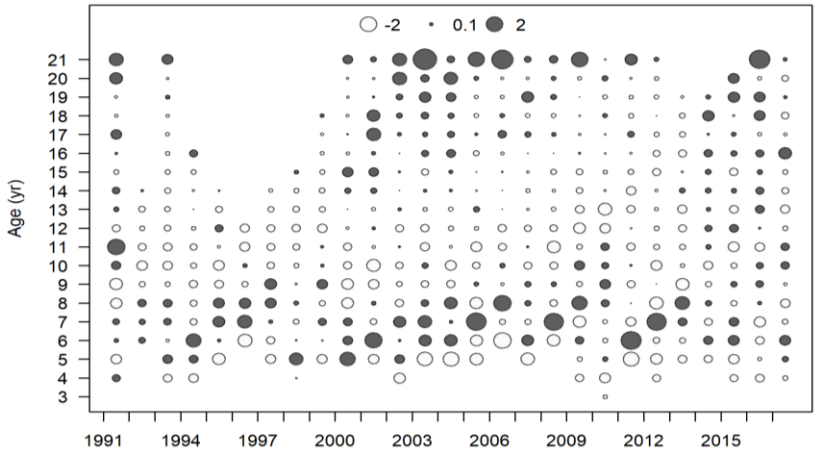
2 retention blocks (Base)



Annual retention blocks

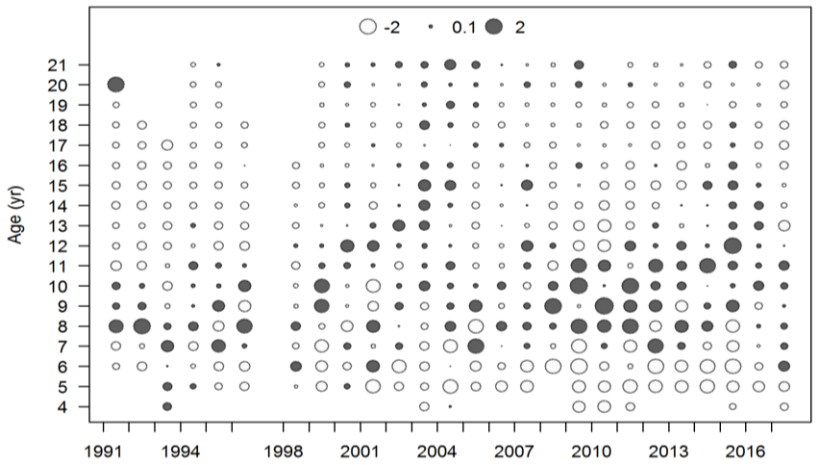


Separate fleets

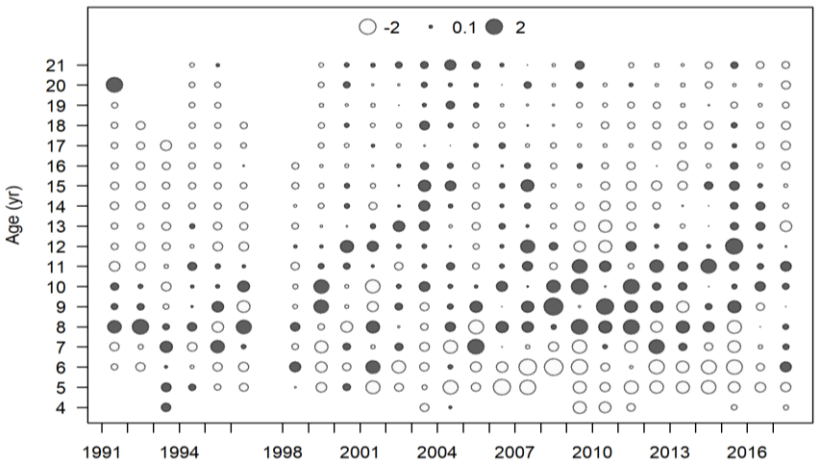


(A). Pearson residuals for Gulf of Mexico Red Grouper landed by the Commercial Vertical Line fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

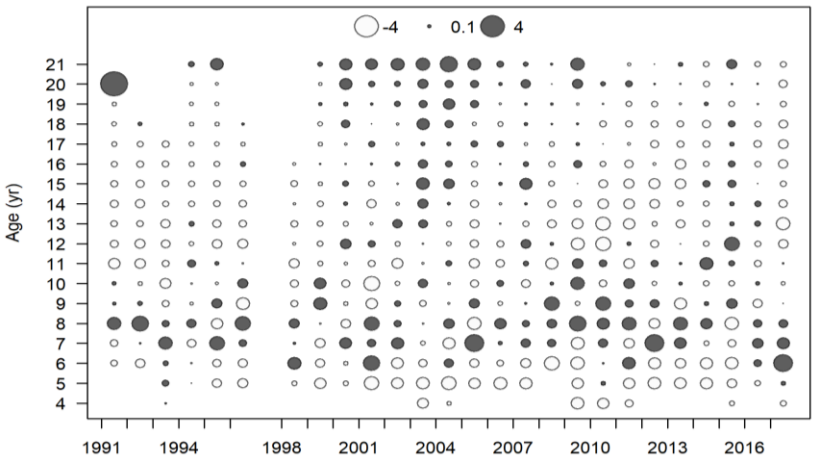
2 retention blocks (Base)



Annual retention blocks

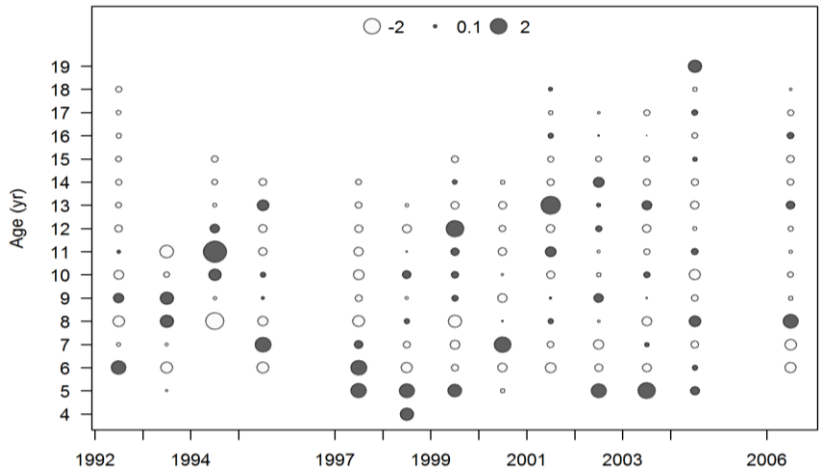


Separate fleets

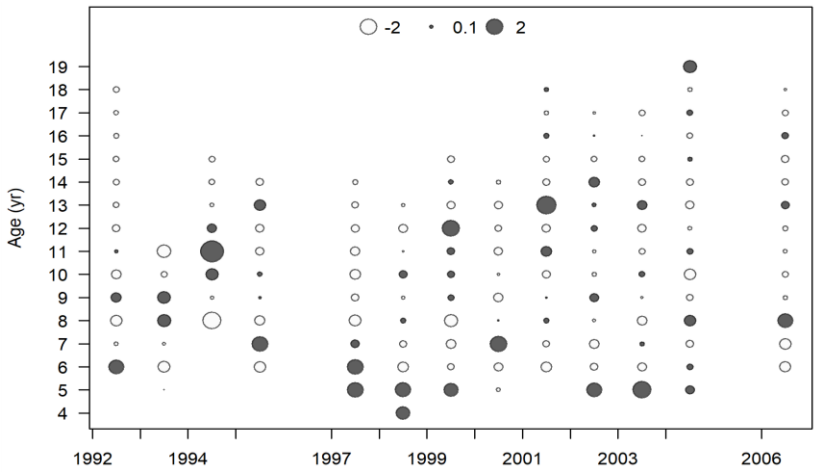


(**B**). Pearson residuals for Gulf of Mexico Red Grouper landed by the Commercial Longline fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

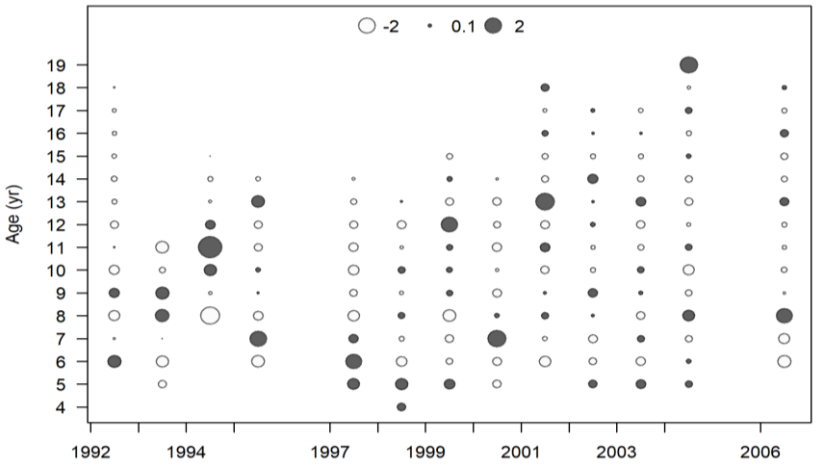
2 retention blocks (Base)



Annual retention blocks

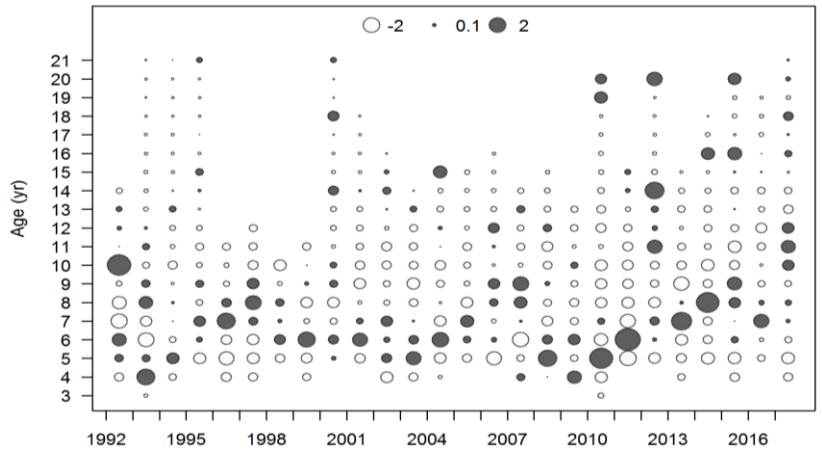


Separate fleets

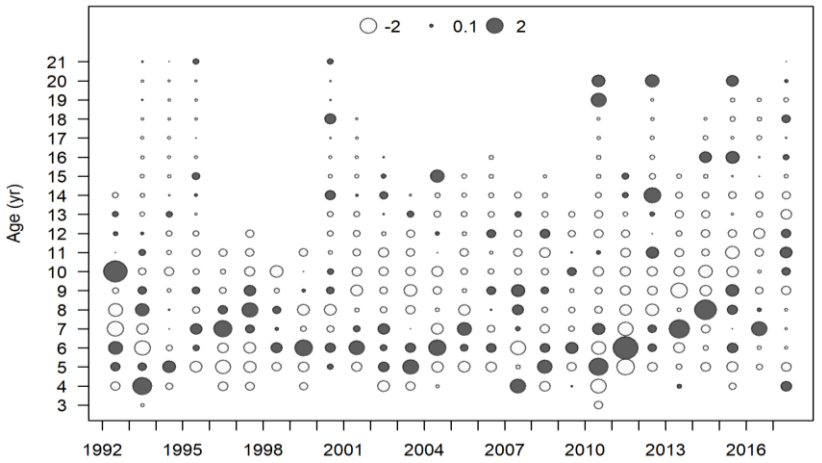


(**C**). Pearson residuals for Gulf of Mexico Red Grouper landed by the Commercial Trap fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

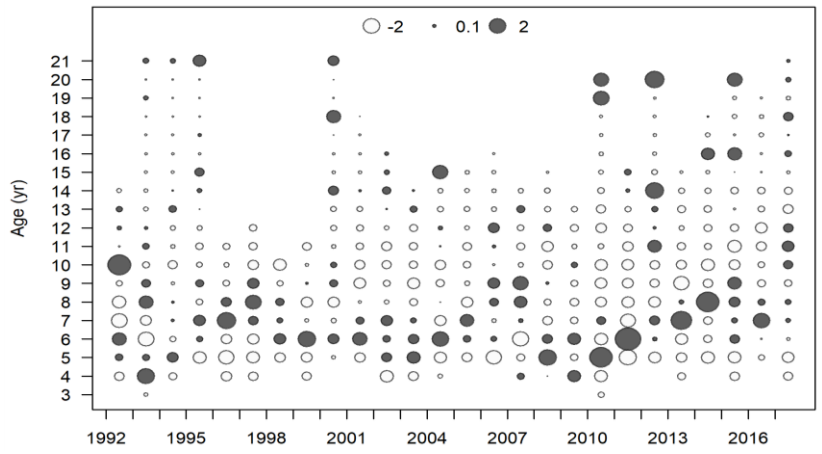
2 retention blocks (Base)



Annual retention blocks



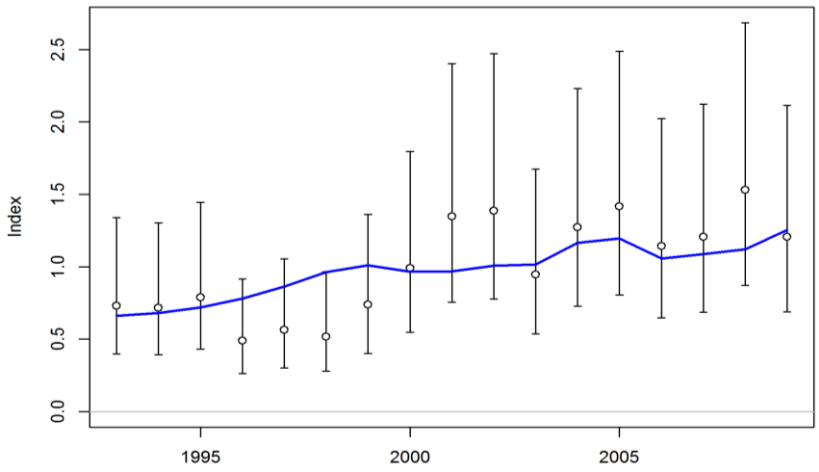
Separate fleets



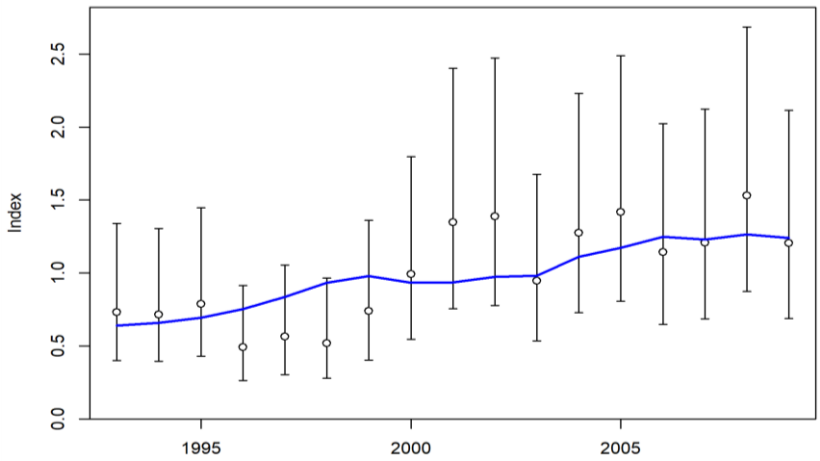
(**D**). Pearson residuals for Gulf of Mexico Red Grouper landed by the Recreational fleet. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

Figure S6. Pearson residuals for fits to the age compositions of red grouper landed by each fleet (**A–D**) for each model run.

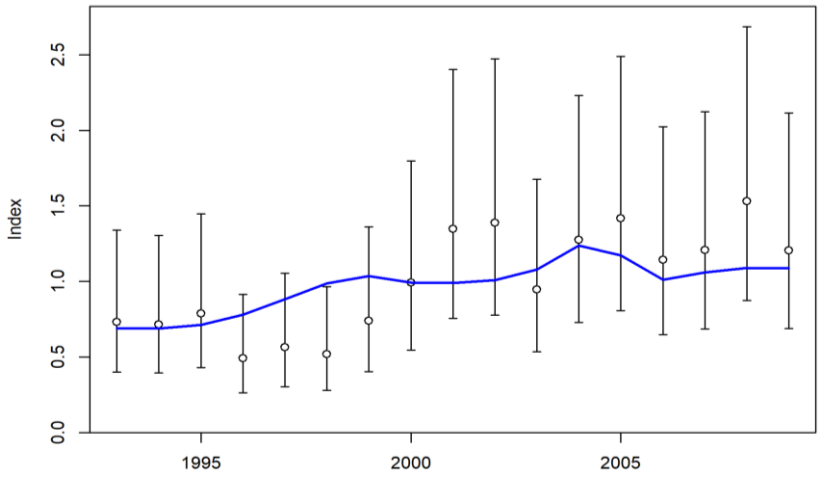
2 retention blocks (Base): root mean squared error = 0.273



Annual retention blocks: root mean squared error = 0.262

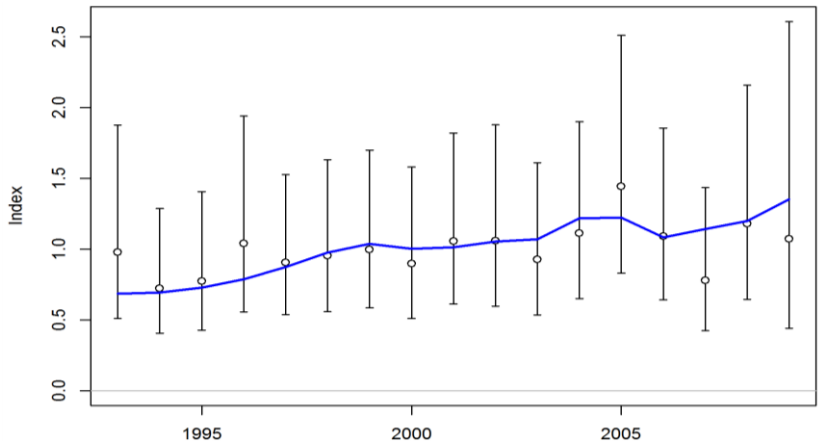


Separate fleets: root mean squared error = 0.283

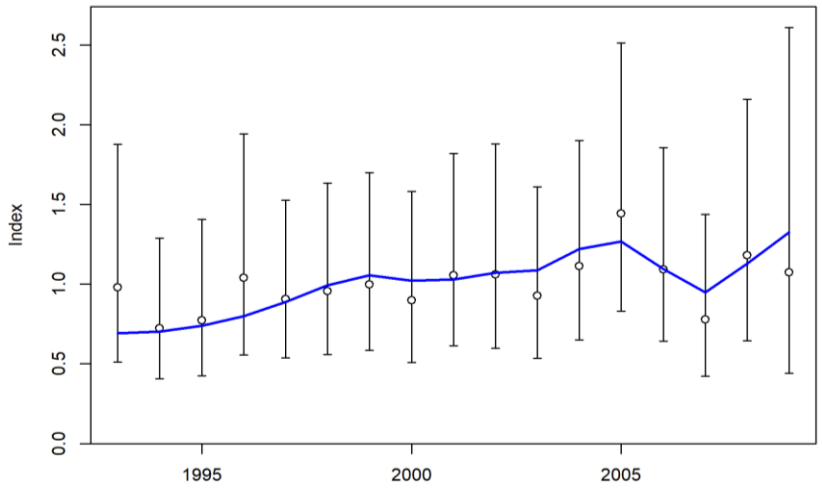


(**A**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper retained by the Commercial Vertical Line fleet prior to the implementation of the Grouper-Tilefish Individual Fishing Quota.

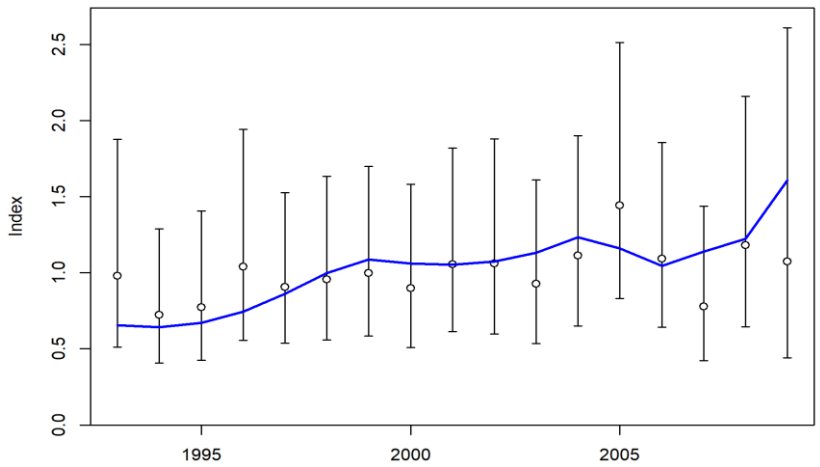
2 retention blocks (Base): root mean squared error = 0.168



Annual retention blocks: root mean squared error = 0.143

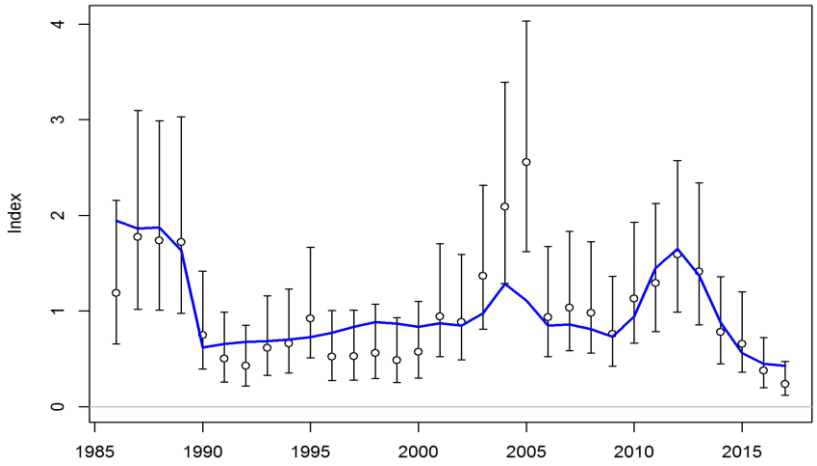


Separate fleets: root mean squared error = 0.211

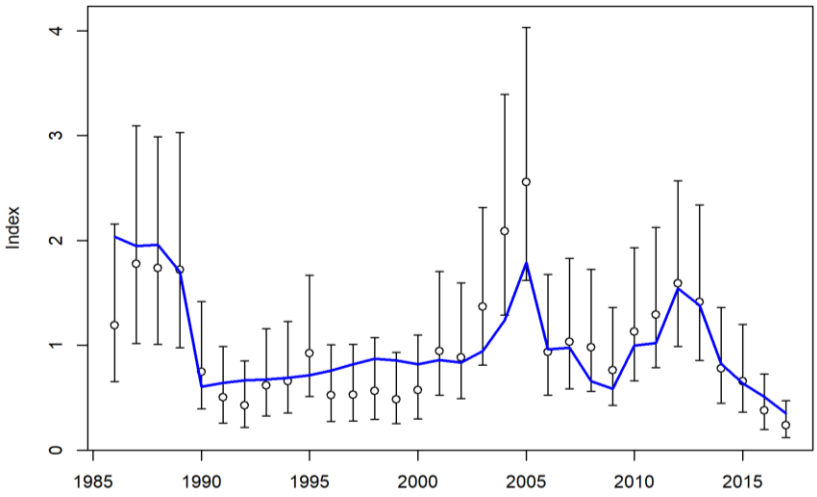


(**B**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper retained by the Commercial Longline fleet prior to the implementation of the Grouper-Tilefish Individual Fishing Quota.

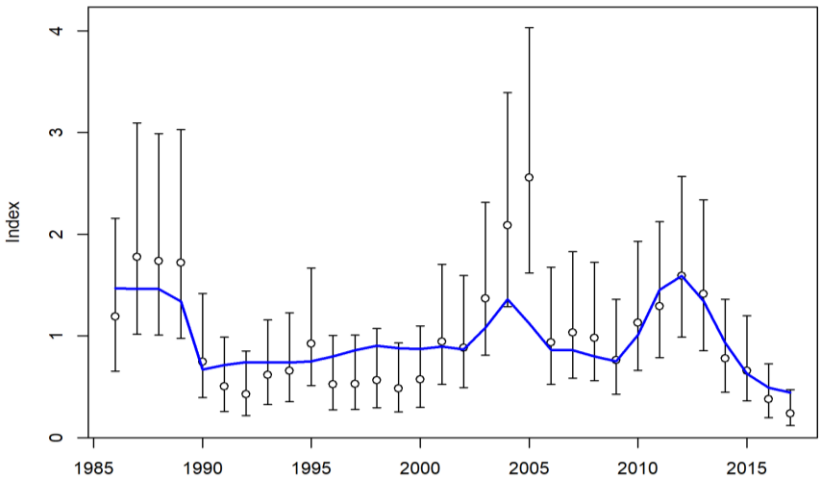
2 retention blocks (Base): root mean squared error = 0.321



Annual retention blocks: root mean squared error = 0.294

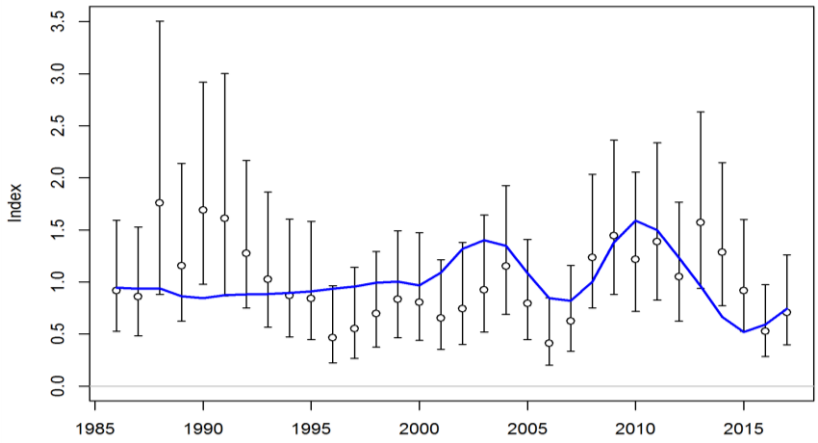


Separate fleets: root mean squared error = 0.326

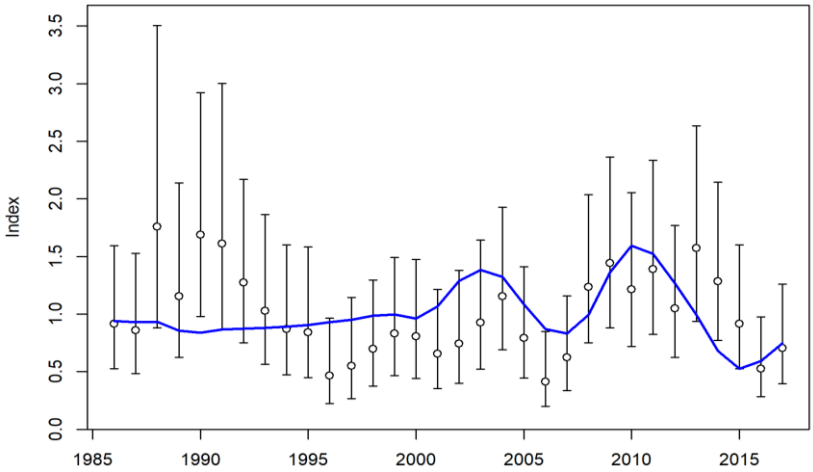


(**C**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper retained by the Recreational fleet based on the Southeast Region Headboat data.

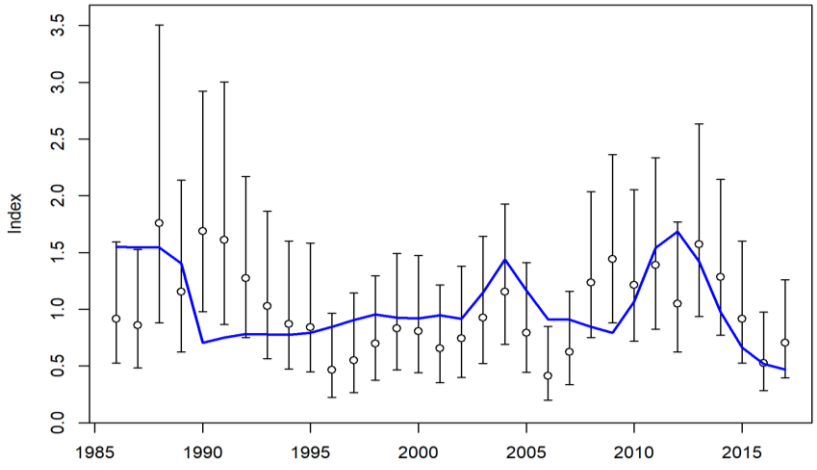
2 retention blocks (Base): root mean squared error = 0.400



Annual retention blocks: root mean squared error = 0.399



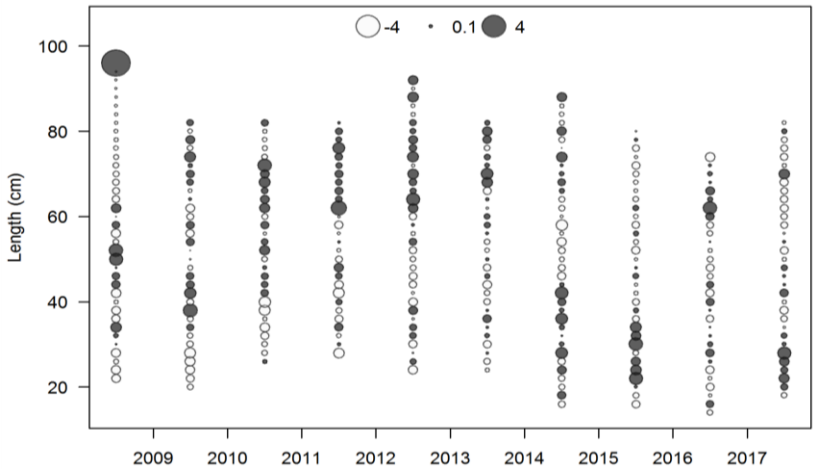
Separate fleets: root mean squared error = 0.411



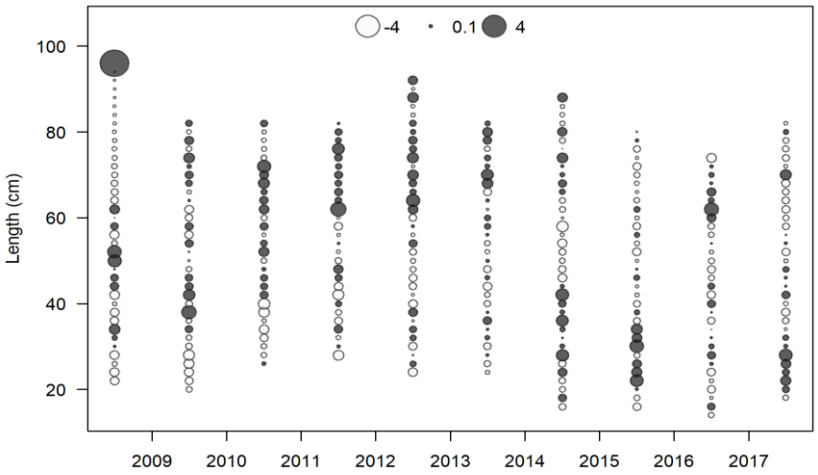
(**D**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper caught (retained or discarded) by the Recreational fleet based on the Marine Recreational Information Program Charter Private Survey.

Figure S7. Fits to the catch-per-unit-effort indices of relative abundance derived from each fleet (**A**–**D**) for each model run.

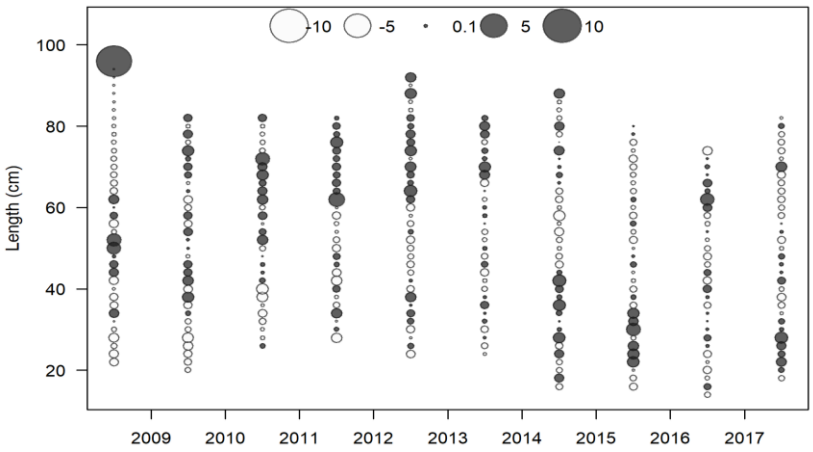
2 retention blocks (Base)



Annual retention blocks

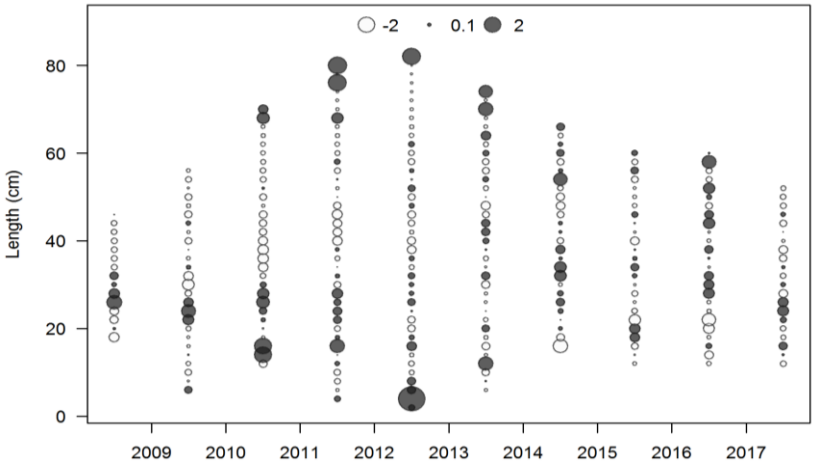


Separate fleets

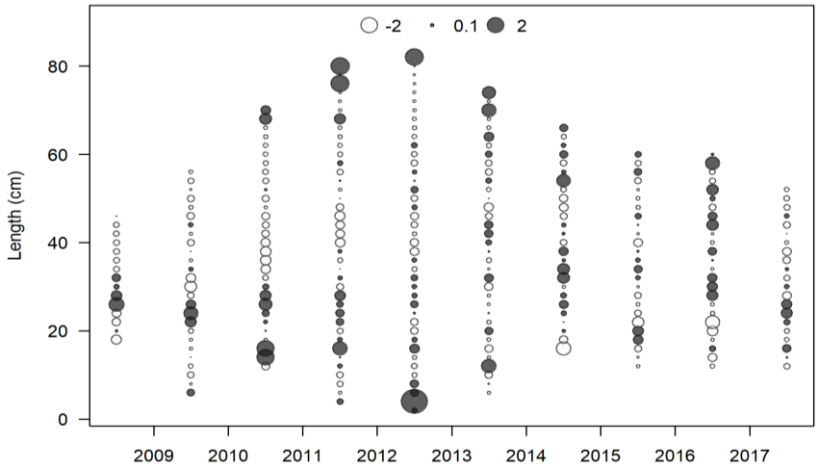


(**A**). Pearson residuals for Gulf of Mexico Red Grouper surveyed by the Combined Video Survey. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

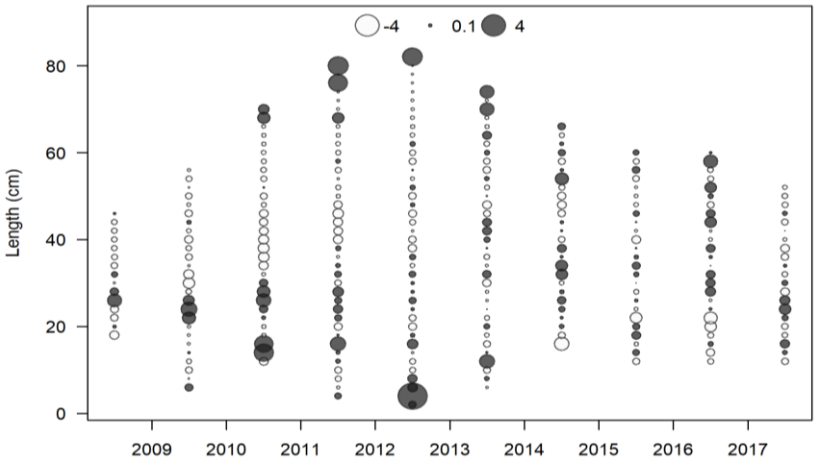
2 retention blocks (Base)



Annual retention blocks

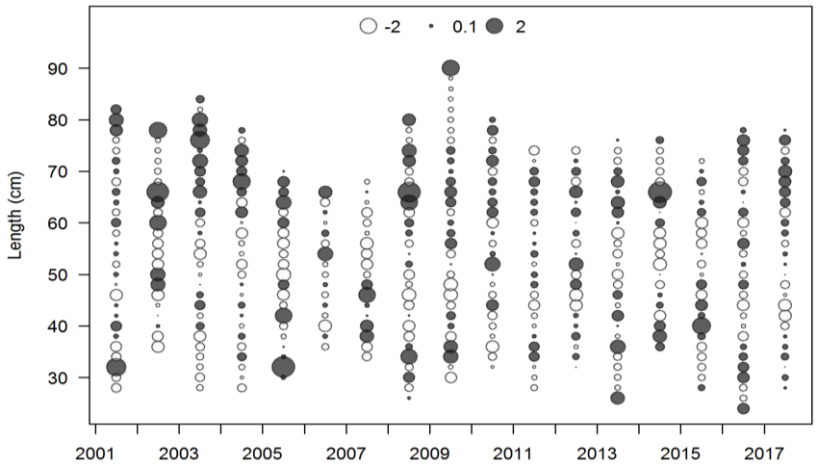


Separate fleets

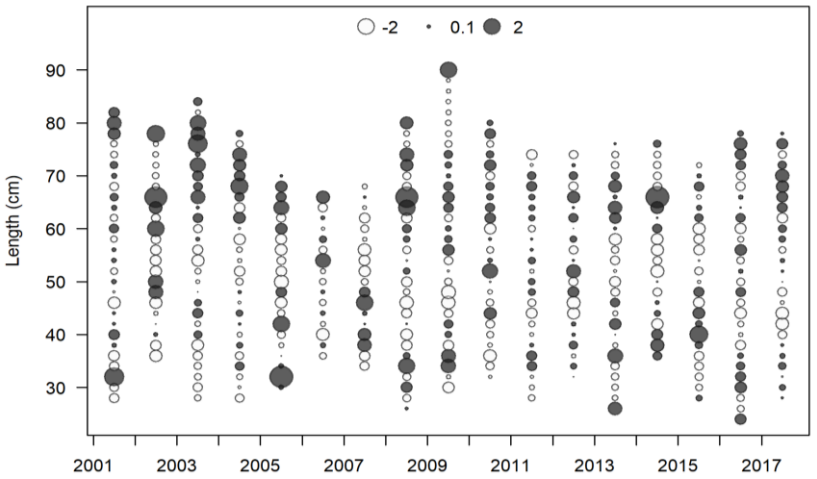


(**B**). Pearson residuals for Gulf of Mexico Red Grouper surveyed by the Southeast Area Monitoring and Assessment Program Summer Groundfish Trawl Survey. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

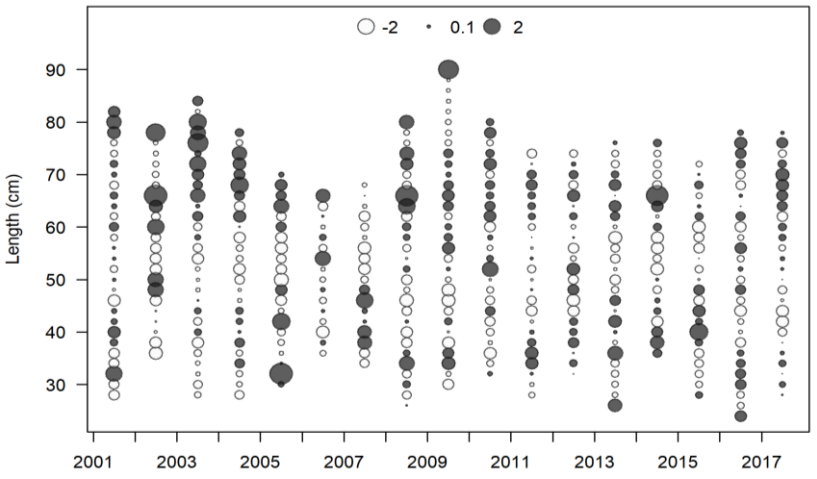
2 retention blocks (Base)



Annual retention blocks

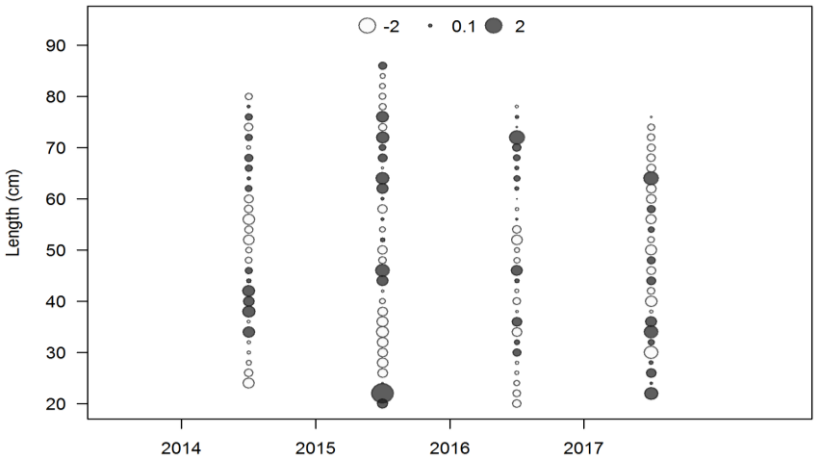


Separate fleets

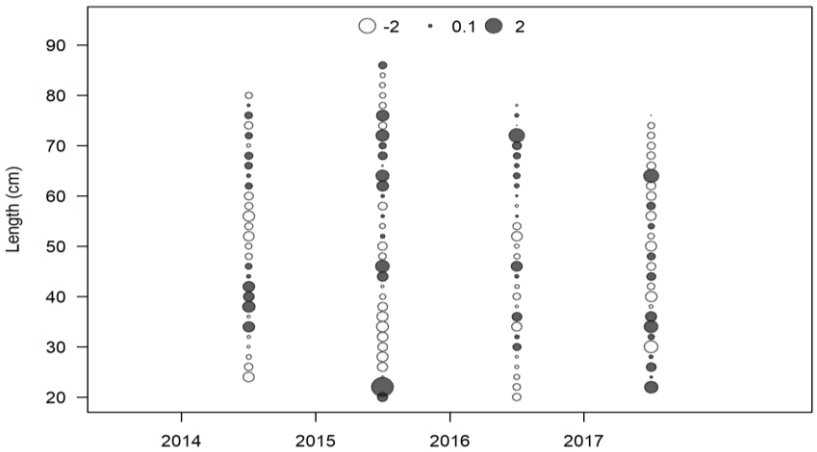


(**C**). Pearson residuals for Gulf of Mexico Red Grouper surveyed by the National Marine Fisheries Service Bottom Longline Survey. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

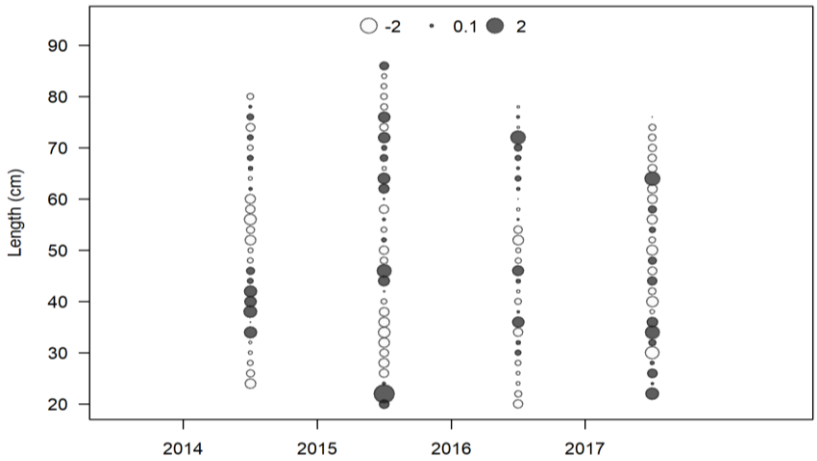
2 retention blocks (Base)



Annual retention blocks



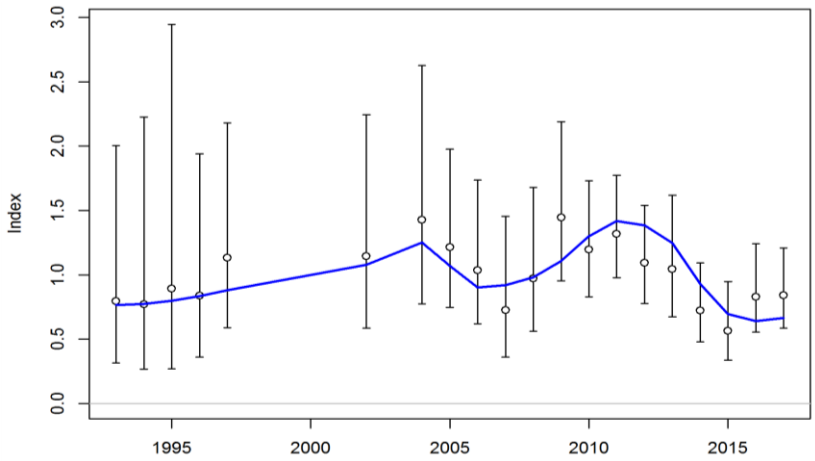
Separate fleets



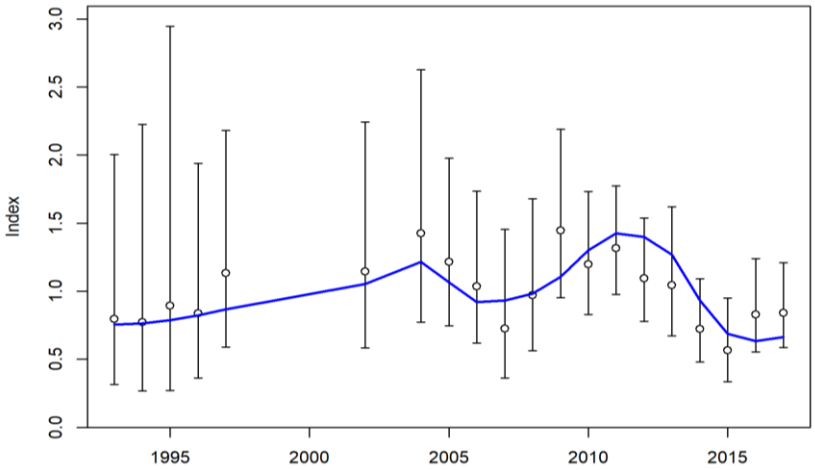
(D). Pearson residuals for Gulf of Mexico Red Grouper surveyed by the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute Repetitive Time Drop Vertical Line Survey. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

Figure S8. Pearson residuals for fits to the length compositions of encountered red grouper by each fishery-independent survey (**A–D**) for each model run.

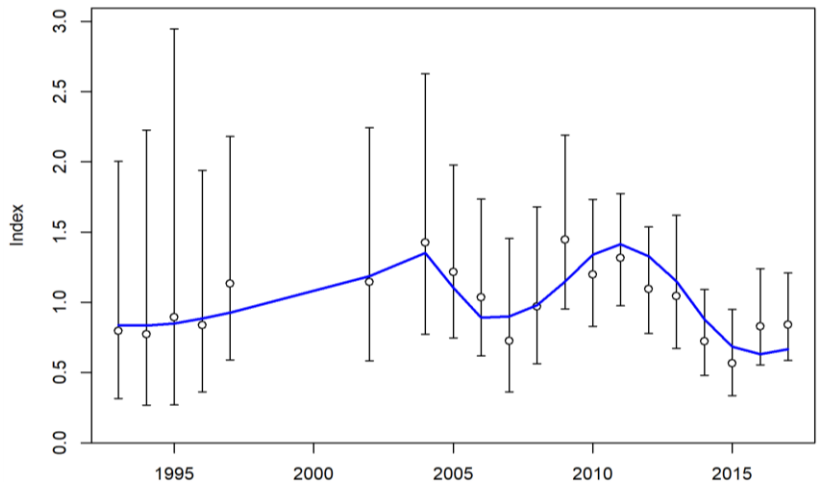
2 retention blocks (Base): root mean squared error = 0.171



Annual retention blocks: root mean squared error = 0.178

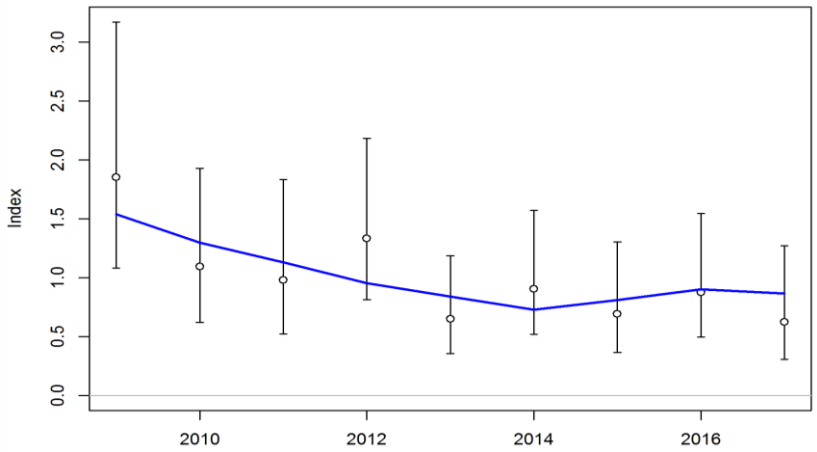


Separate fleets: root mean squared error = 0.151

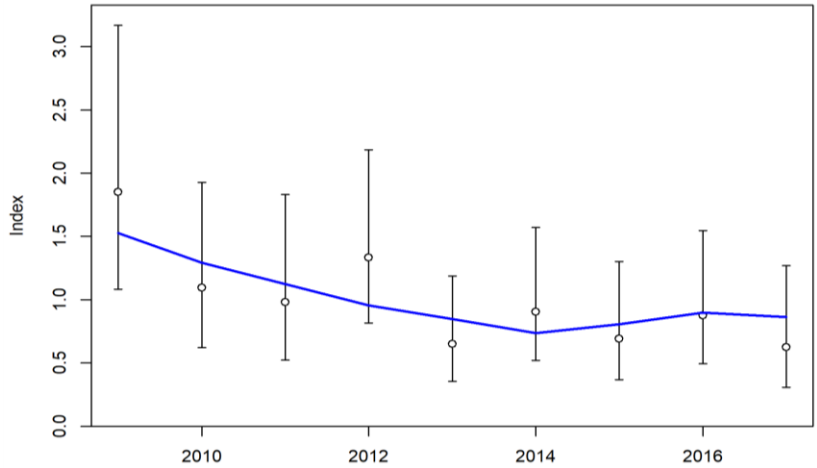


(**A**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper from the Combined Video Survey.

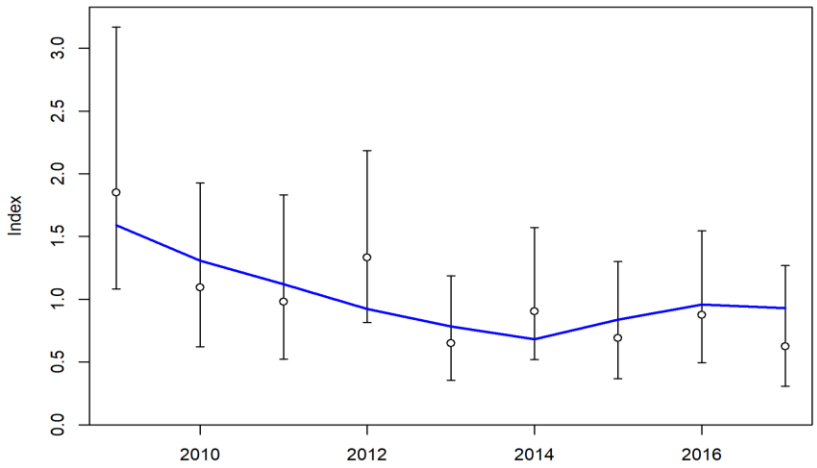
2 retention blocks (Base): root mean squared error = 0.221



Annual retention blocks: root mean squared error = 0.220

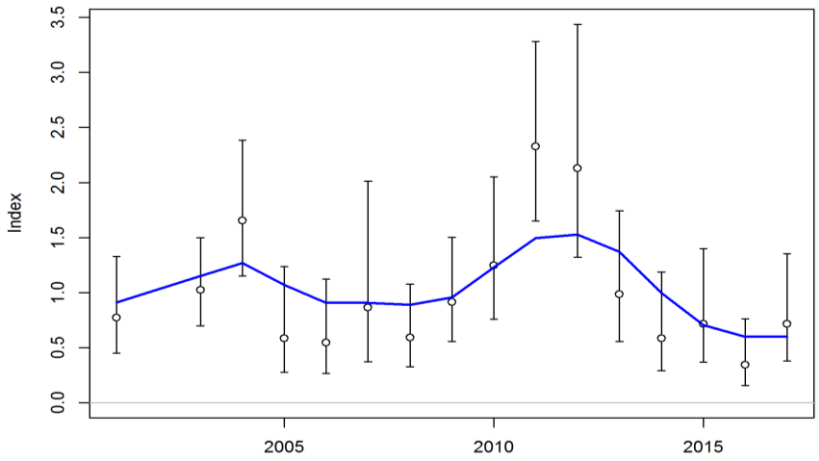


Separate fleets: root mean squared error = 0.241

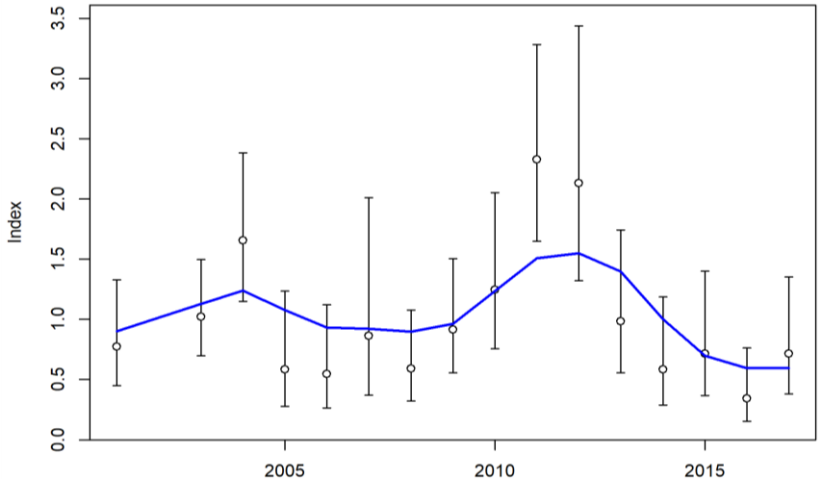


(**B**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper from the Southeast Area Monitoring and Assessment Program Summer Groundfish Trawl Survey.

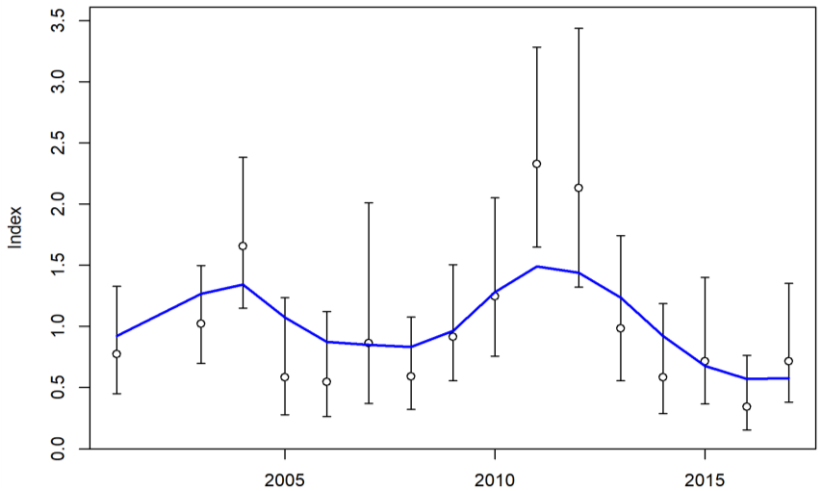
2 retention blocks (Base): root mean squared error = 0.349



Annual retention blocks: root mean squared error = 0.354

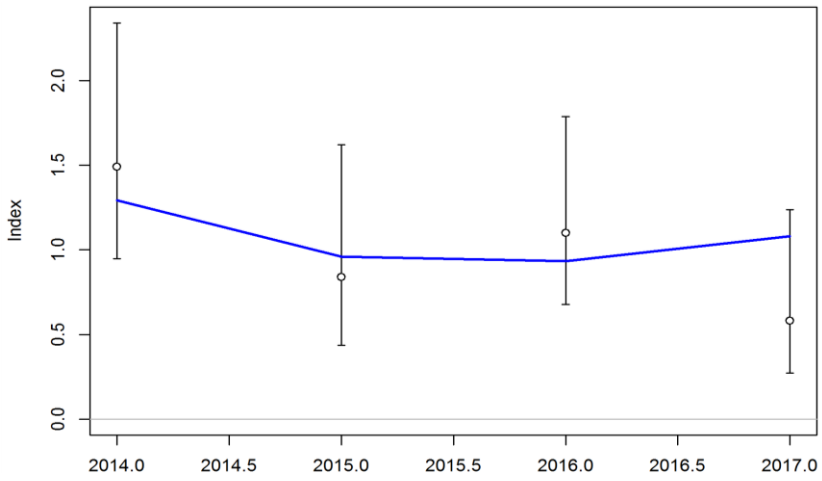


Separate fleets: root mean squared error = 0.332

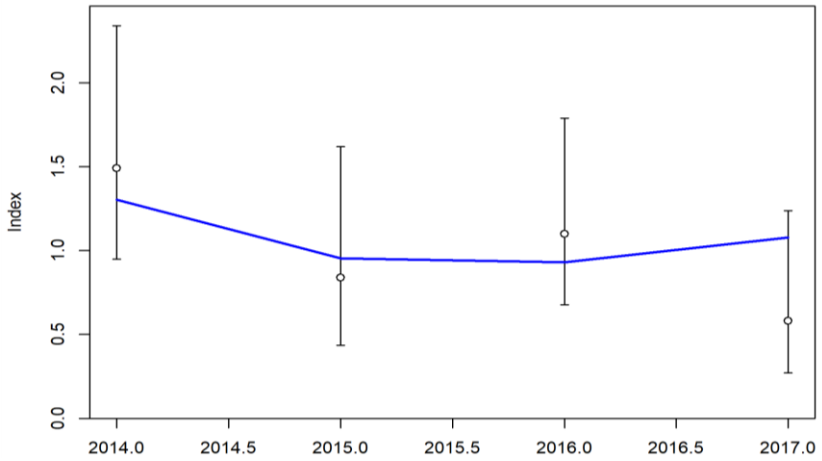


(**C**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper from the National Marine Fisheries Service Bottom Longline Survey.

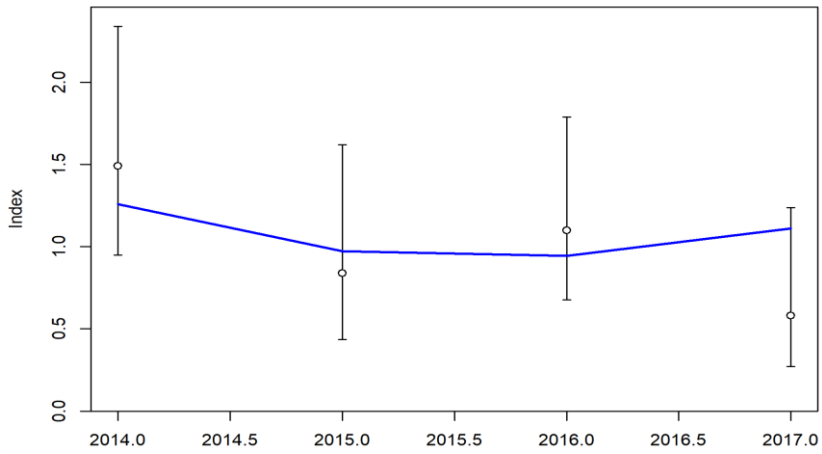
2 retention blocks (Base): root mean squared error = 0.336



Annual retention blocks: root mean squared error = 0.335



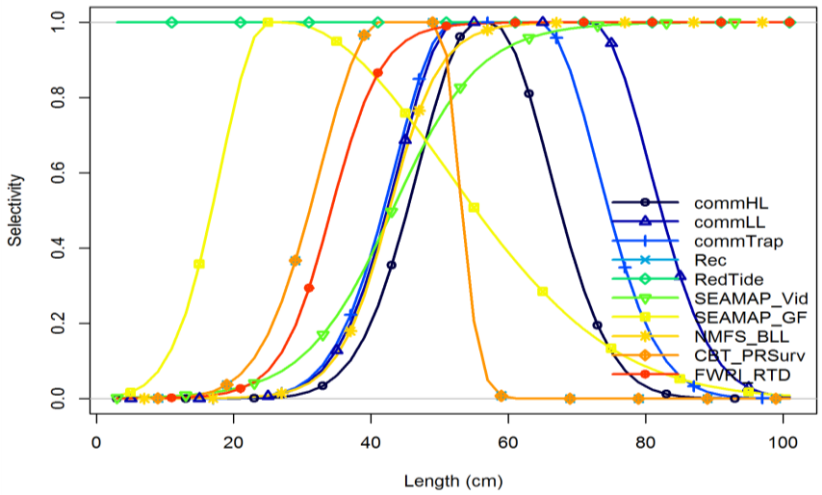
Separate fleets: root mean squared error = 0.352



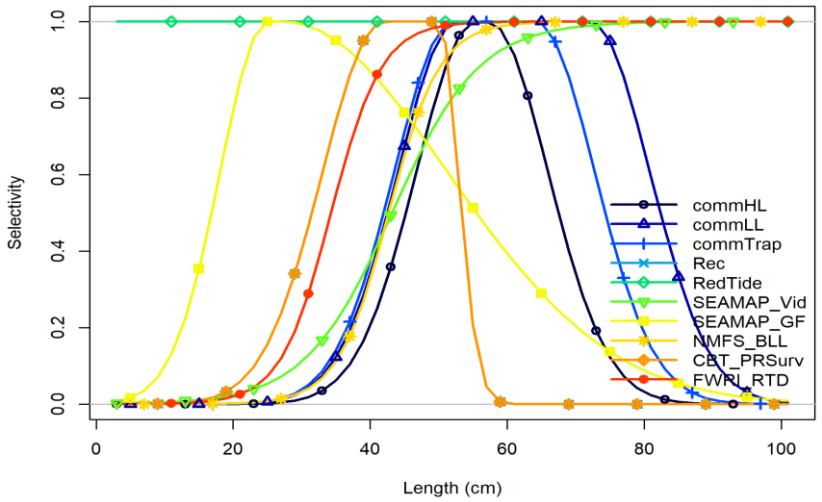
(**D**). Input (dots with 95% confidence intervals) and expected (blue lines) indices of relative abundance for Gulf of Mexico Red Grouper from the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute Repetitive Time Drop Vertical Line Survey.

Figure S9. Fits to the indices of relative abundance derived from fishery-independent surveys (**A**–**D**) for each model run.

2 retention blocks (Base)



Annual retention blocks



Separate fleets

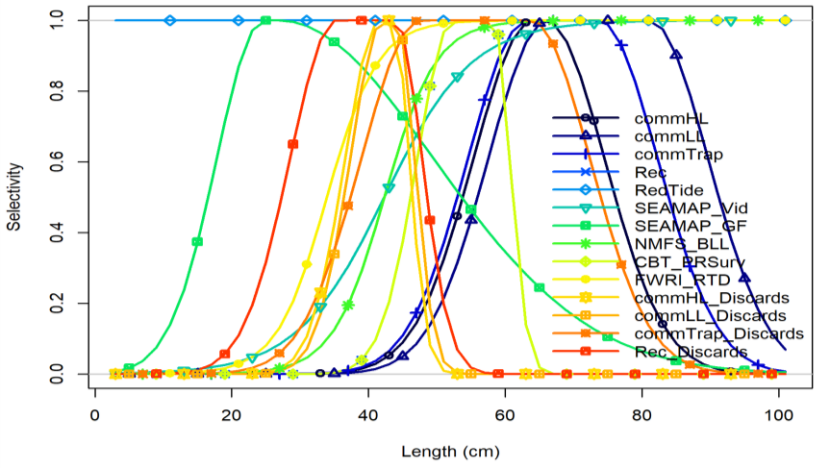
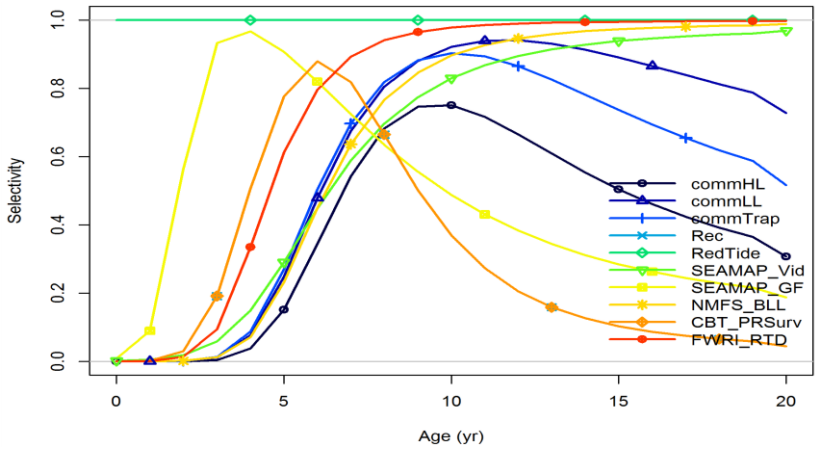
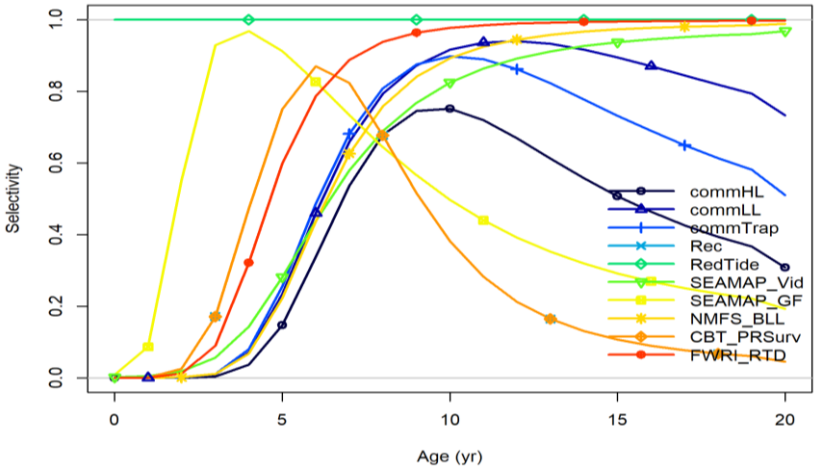


Figure S10. Estimated length-based selectivity in the terminal year, 2017.

2 retention blocks (Base)



Annual retention blocks



Separate fleets

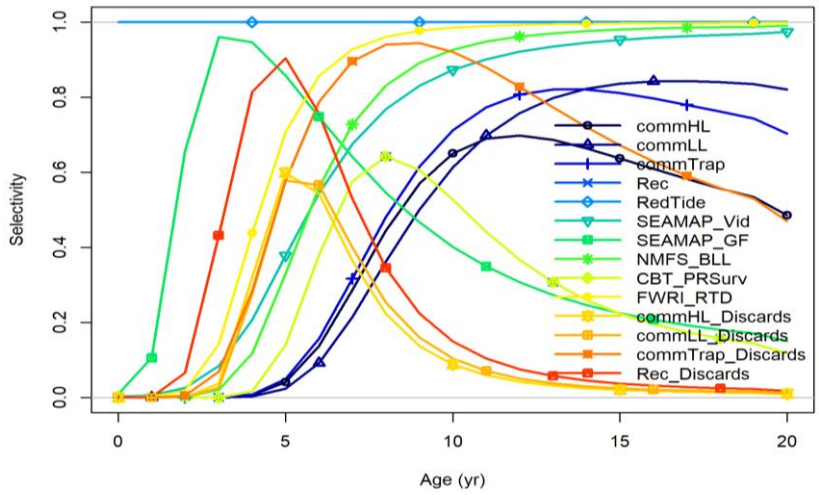
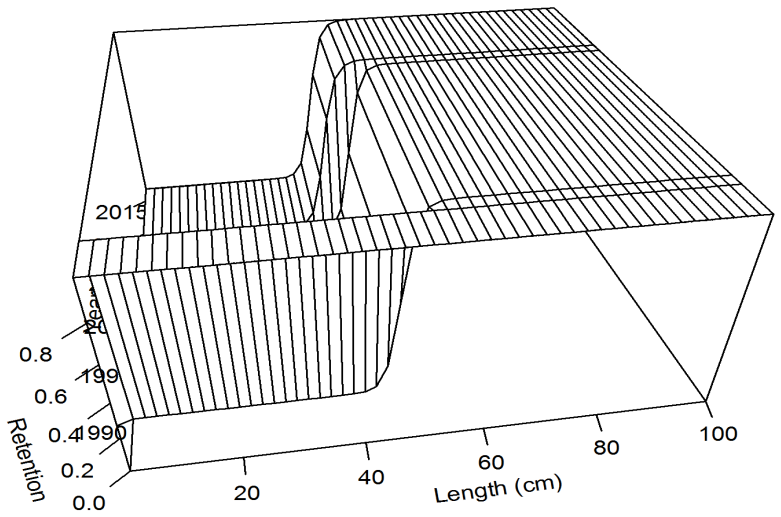
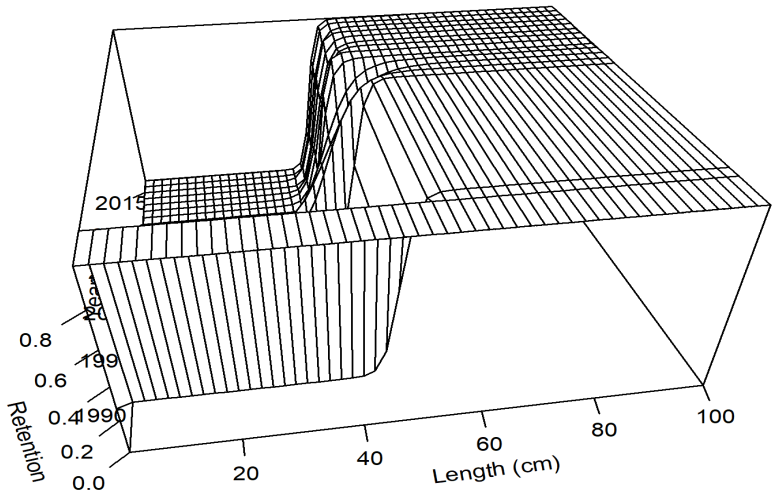


Figure S11. Derived age-based selectivity for each fleet and survey for Gulf of Mexico Red Grouper in the terminal year of the assessment, 2017.

2 retention blocks (Base)



Annual retention blocks

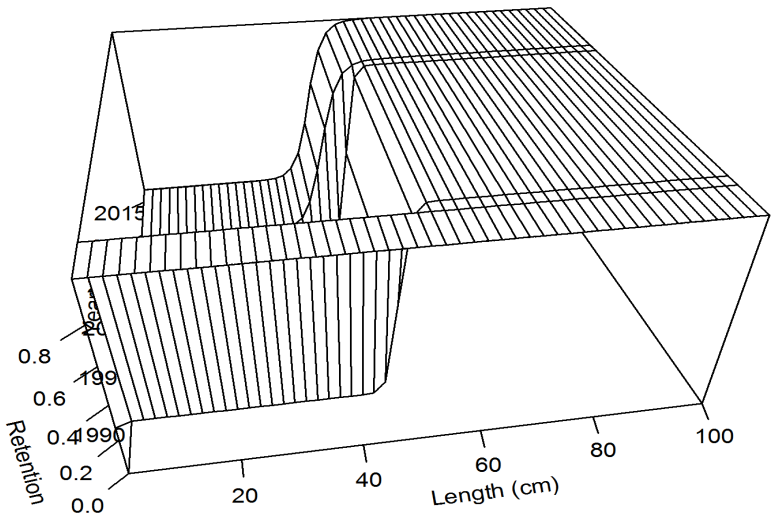


Separate fleets

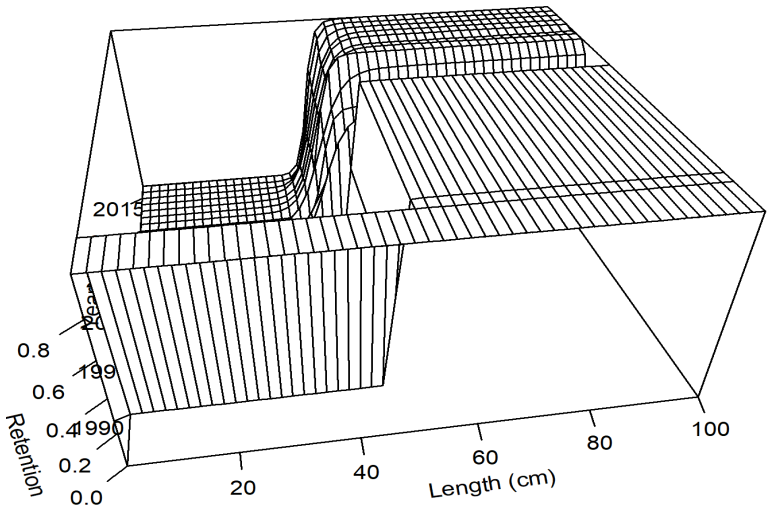
Retention not parameterized

(**A**). Time-varying retention at length for the Commercial Vertical Line fleet for Gulf of Mexico Red Grouper.

2 retention blocks (Base)



Annual retention blocks

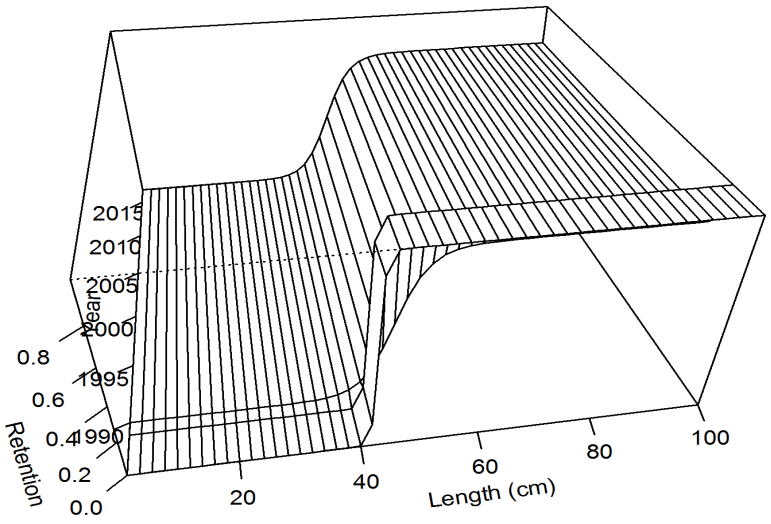


Separate fleets

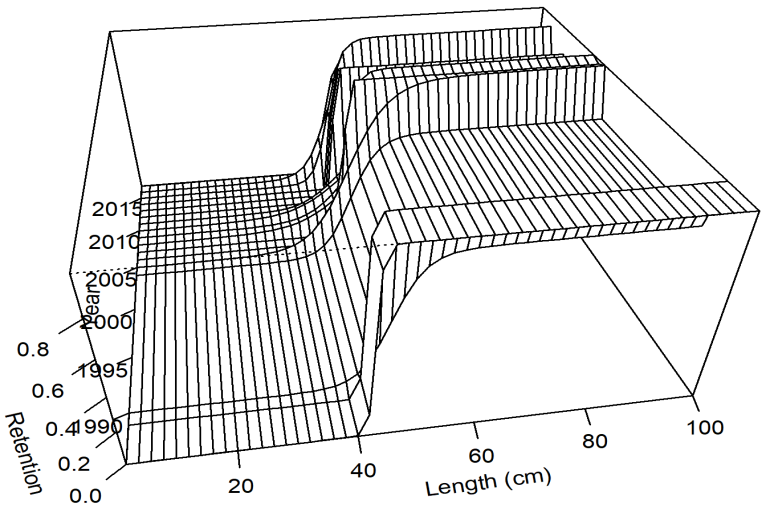
Retention not parameterized

(**B**). Time-varying retention at length for the Commercial Longline fleet for Gulf of Mexico Red Grouper.

2 retention blocks (Base)



Annual retention blocks



Separate fleets

Retention not parameterized

(**C**). Time-varying retention at length for the Recreational fleet for Gulf of Mexico Red Grouper.

Figure S12. Estimated time-varying retention patterns by fleet (**A**–**C**) for each model run.