# BSAI Tanner Crab

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# Changes From 2015 Assessment

- Changes to model
  - Gmacs fishing mortality
  - Female F multipliers
  - estimating Fs for BBRKC fishery
  - normalization for groundfish size comps
  - enforced logistic selectivity = 1 in max size bin
  - evaluating convergence with 200 runs with jittered initial parameter values
- New trawl survey data for 2016
  - mature survey biomass
    - new cv calculation
  - size compositions by sex, shell condition, maturity
  - EBS growth data! (not incorporated yet)
- New Fishery Data for 2015/16
  - Tanner crab pot fishery
    - 2015/16 catch, size compositions
  - snow crab pot fishery
    - 2015/16 bycatch, size compositions
  - BBRKC pot fishery
    - 2015/16 bycatch, size compositions
  - groundfish fisheries
    - 2015/16 bycatch, size compositions
- New ADFG Harvest Strategy for 2015/16
  - Old strategy: area-specific TAC's based on
    - 5" min preferred size West of 166°W
    - 5.5" min preferred size East of 166°W
  - New strategy: area-specific TAC's based on
    - 5" min preferred size West of 166°W
    - 5" min preferred size East of 166°W

# Management Reference Points

Not overfished
No overfishing

## Basis for the OFL

| Year | Tier[A] | $B_{MSY}$[A] | Current MMB[A] | $B/B_{MSY}$[A] | $F_{OFL}$[A] | Years to define $B_{MSY}$[A] | Natural Mortality[A,B] |
|---|---|---|---|---|---|---|---|
| 2012/13 | 3a | 33.45 | 58.59 | 1.75 | 0.61 $yr^{-1}$ | 1982-2012 | 0.23 $yr^{-1}$ |
| 2013/14 | 3a | 33.54 | 59.35 | 1.77 | 0.73 $yr^{-1}$ | 1982-2013 | 0.23 $yr^{-1}$ |
| 2014/15 | 3a | 29.82 | 63.80 | 2.14 | 0.61 yr-1 | 1982-2014 | 0.23 yr-1 |
| 2015/16 | 3a | 26.79 | 53.70 | 2.00 | 0.58 yr-1 | 1982-2015 | 0.23 yr-1 |
| 2016/17 | 3a | 25.65 | 45.34 | 1.77 | 0.79 $yr^{-1}$ | 1982-2016 | 0.23 $yr^{-1}$ |

## Management Performance

| Year | MSST | Biomass (MMB) | TAC (East + West) | Retained Catch | Total Catch Mortality | OFL | ABC |
|---|---|---|---|---|---|---|---|
| 2012/13 | 16.77 | 59.35[A] | 0.00 | 0.00 | 0.71 | 19.02 | 8.17 |
| 2013/14 | 16.98 | 72.70[A] | 1.41 | 1.26 | 2.78 | 25.35 | 17.82 |
| 2014/15 | 13.40 | 71.57[A] | 6.85 | 6.16 | 9.16 | 31.48 | 25.18 |
| 2015/16 | 12.82[C] | 73.93[A] | 8.92 | 8.91 | 11.38 | 27.19 | 21.75 |
| 2016/17 | | 45.34[B] | | | | 25.61[C] | 20.49[C] |



Biomass units: 1000's t

# Action Items

***The CPT outlined the base model to be used for this assessment, based on results presented by the author for a suite of models.***
*Response:* The base model recommended by the CPT is the base model used here (Model B).

***The CPT outlined a number of alternative models built on its recommended base model to be evaluated.***
*Response:* These models were evaluated for the assessment.

***Comment:*** **"The SSC was unable to fully compare models, as the summary tables in the assessment did not include the number of model parameters for evaluating differences in likelihoods."**
*Response:* The number of model parameters are included in at least one summary table.

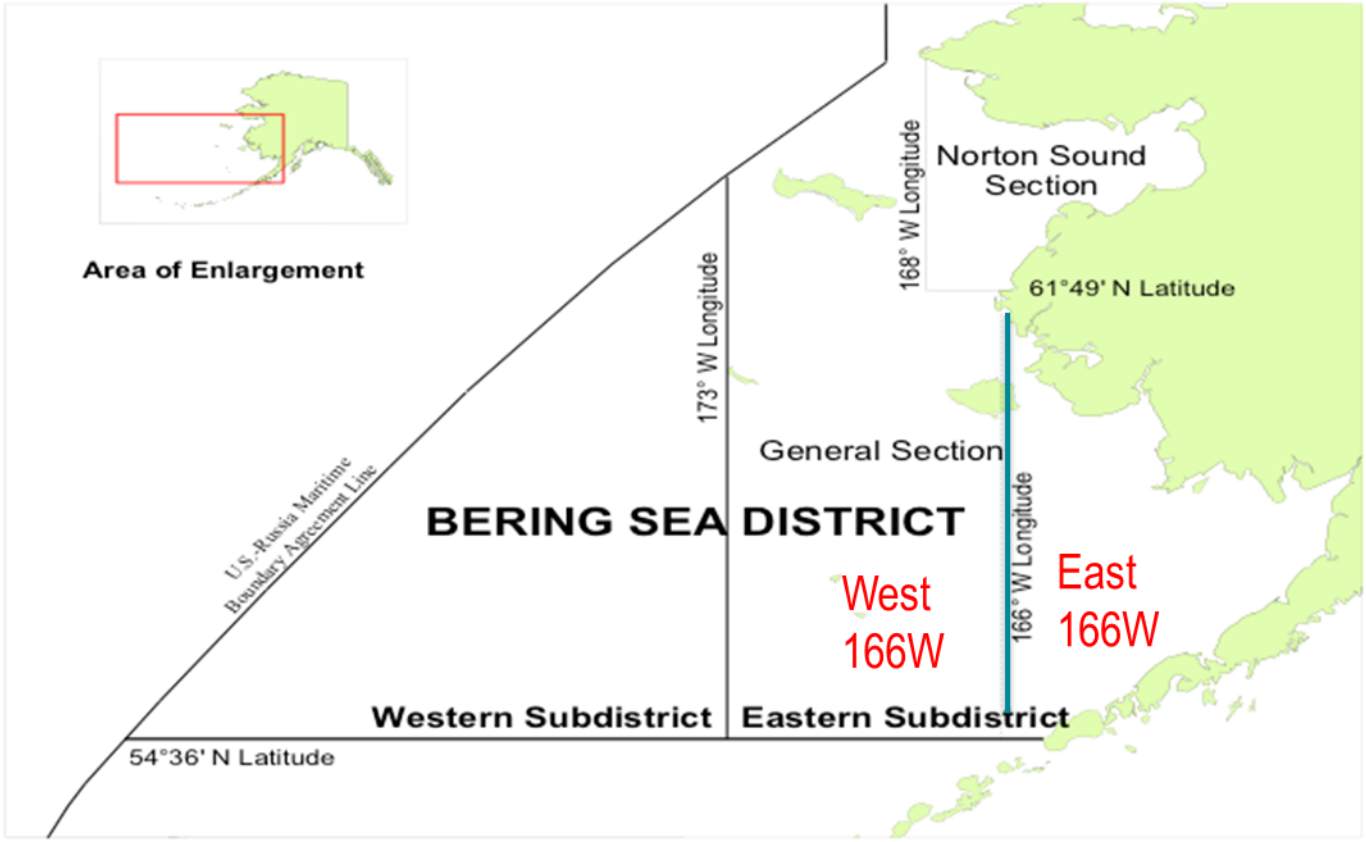
***Comment:*** **"There are continuing concerns about the most appropriate weights to use for different data components (CVs, effective N, etc.), and the SSC looks forward to recommendations from the data-weighting workshop."**
*Response:* The CPT endorsed using an iterative approach to weighting composition data (the "Francis method"), but it has not yet been implemented for this model.

***Comment:*** **"Strong residual patterns in numbers at size remain a concern and suggest model mis-specification with respect to growth."**
*Response:* Growth increment data for Tanner crab in the Bering Sea was collected in 2015 for sub-adults and April-June, 2016 for smaller crab. This data was made available to the author this summer, but time did not permit substantive results to include in this assessment. The data appears to be very consistent with previous growth data collected near Kodiak Island.

***Comment:*** **"It was not clear why the model estimates full selection [for males in the directed fishery] in 1996 at roughly 100 cm…"**
*Response:* This occurs due to a combination of two factors: 1) the sample size for male size comps from the directed fishery in 1996 is quite small, meaning that a poor fit to this size frequency has little effect on the overall likelihood, and 2) the size-at-50% selected in the directed fishery prior to 1992 is based on the mean size-at-50% selected in the directed fishery after 1991 (size-at-50% selected in the directed fishery is allowed to vary annually after 1991). Although it has cascading effects through many likelihood components because of its influence on underling population structure, the size-at-50% selected in the directed fishery prior to 1992 most directly influences (I think) fits to retained catch size compositions prior to 1992. If the fit to the pre-1992 retained catch size compositions can be improved by changing the size-at-50% selected in the pre-1992 directed fishery, there is little "cost" to doing so even by making the size-50%-selected in 1996 any value whatsoever.

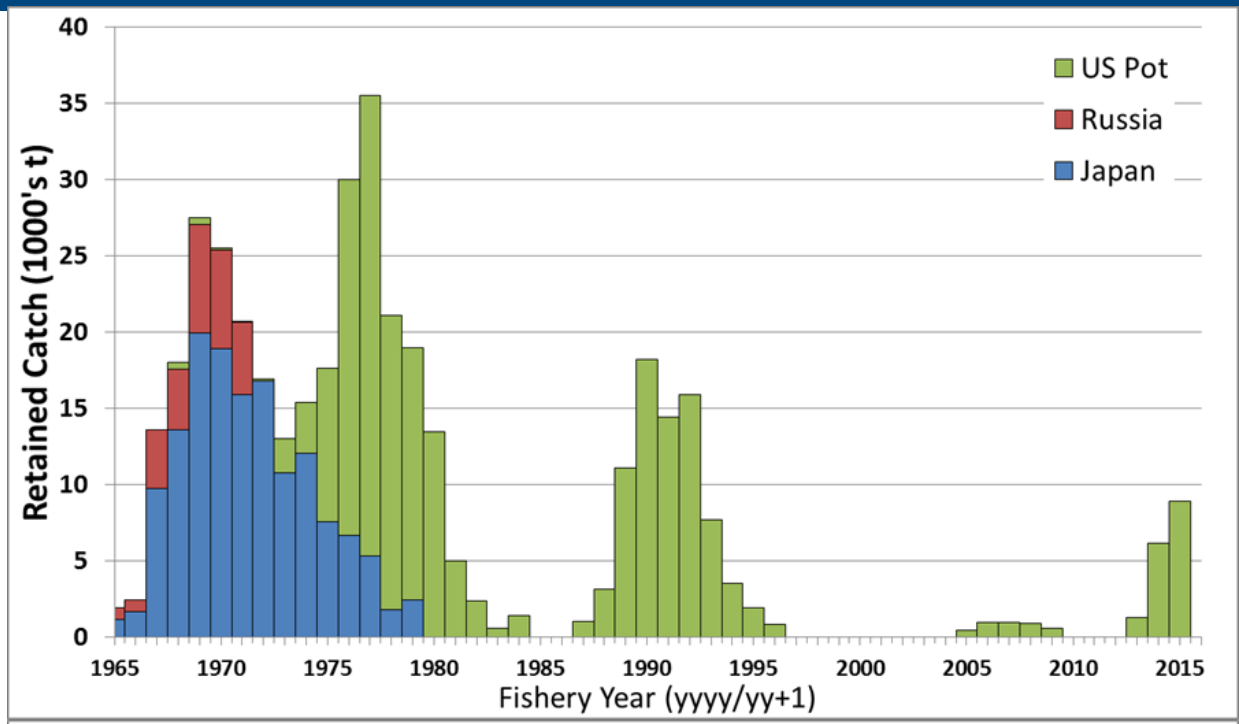
# Fishery Trends

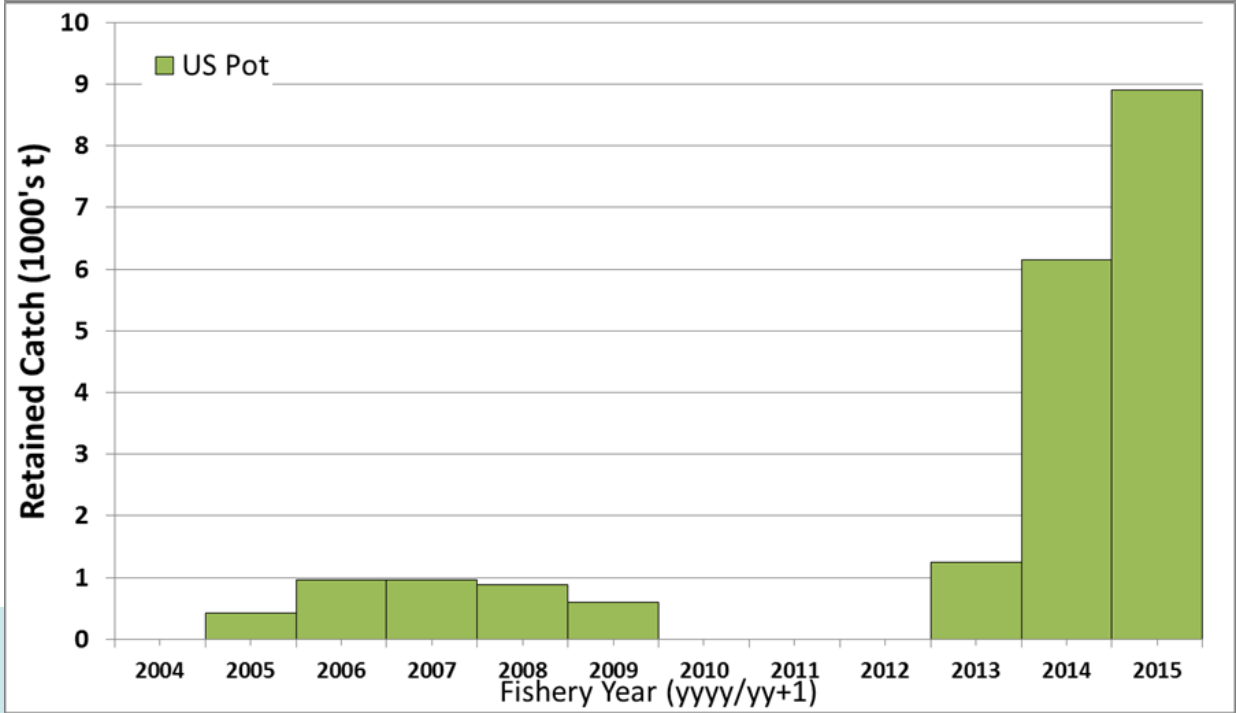
# Management Regions



# Fishery Trends

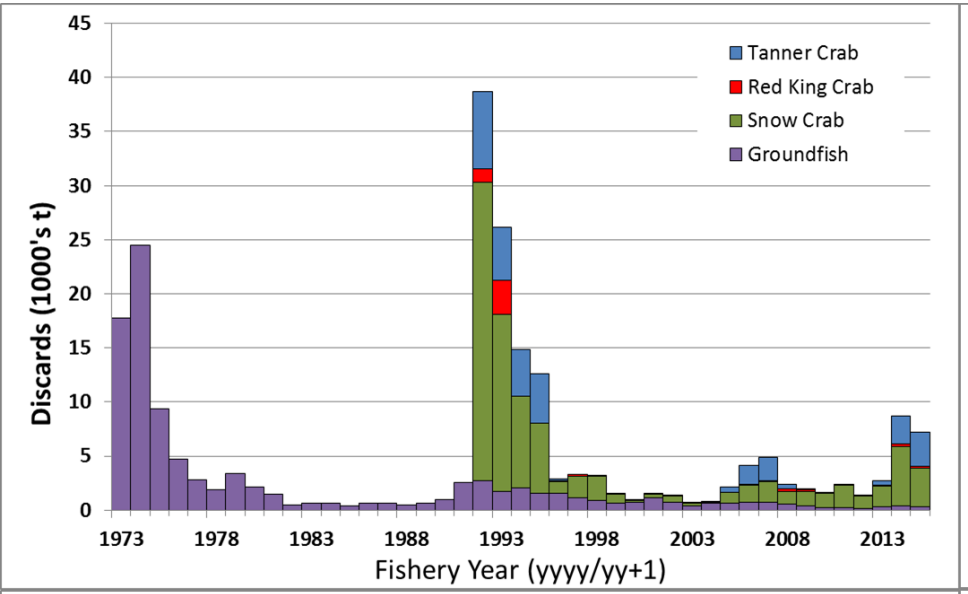
Retained catch

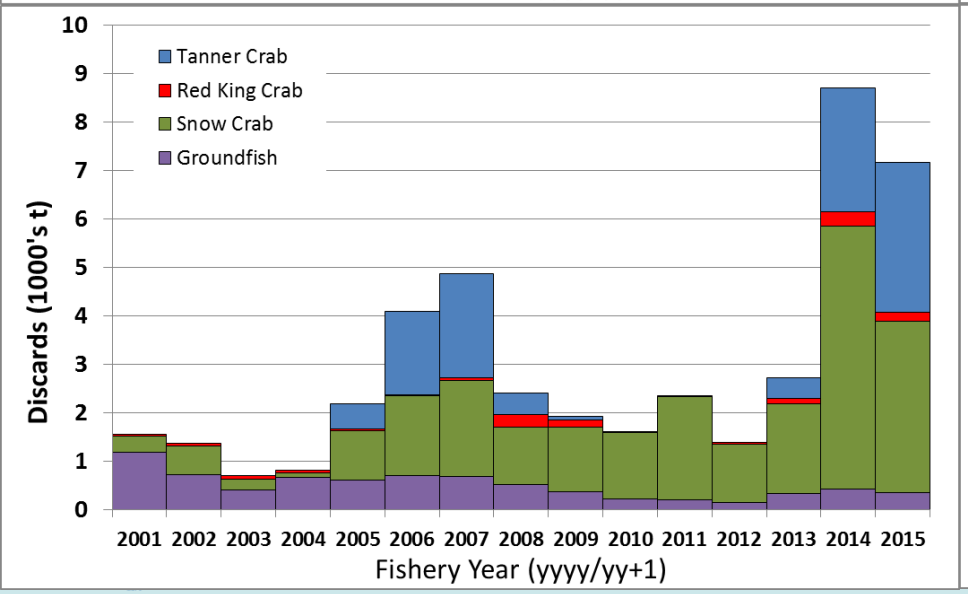


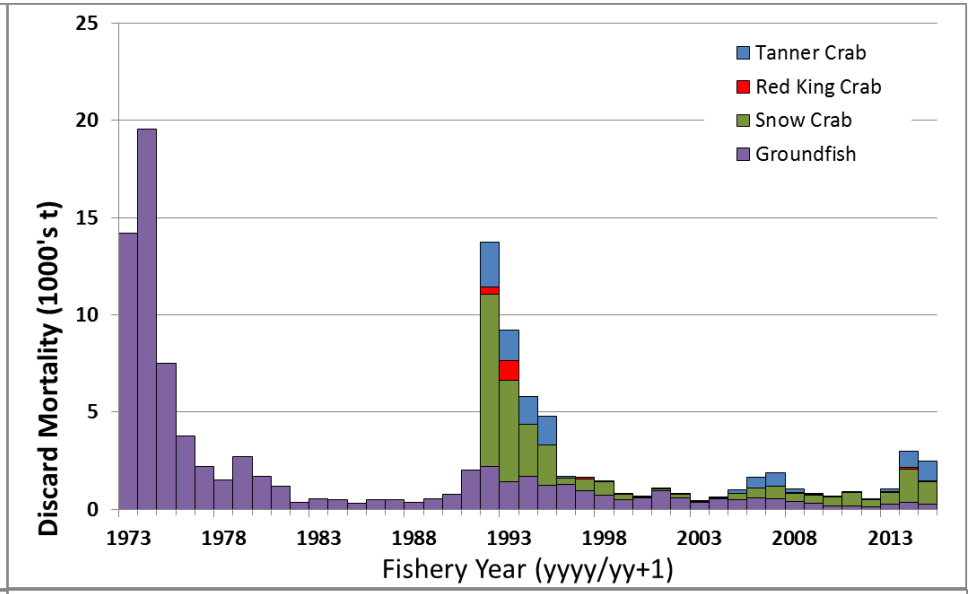
# Fishery Trends

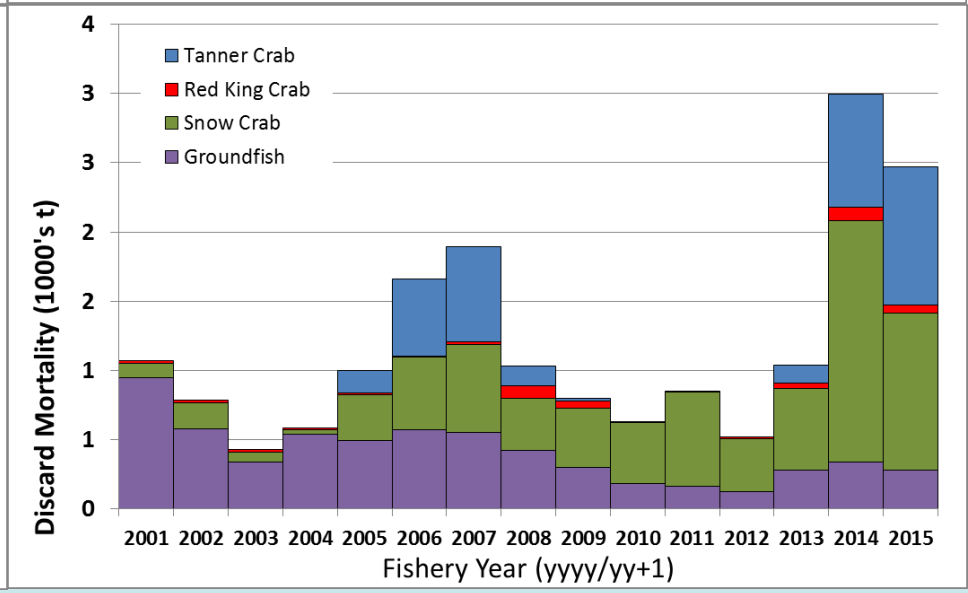
## Bycatch



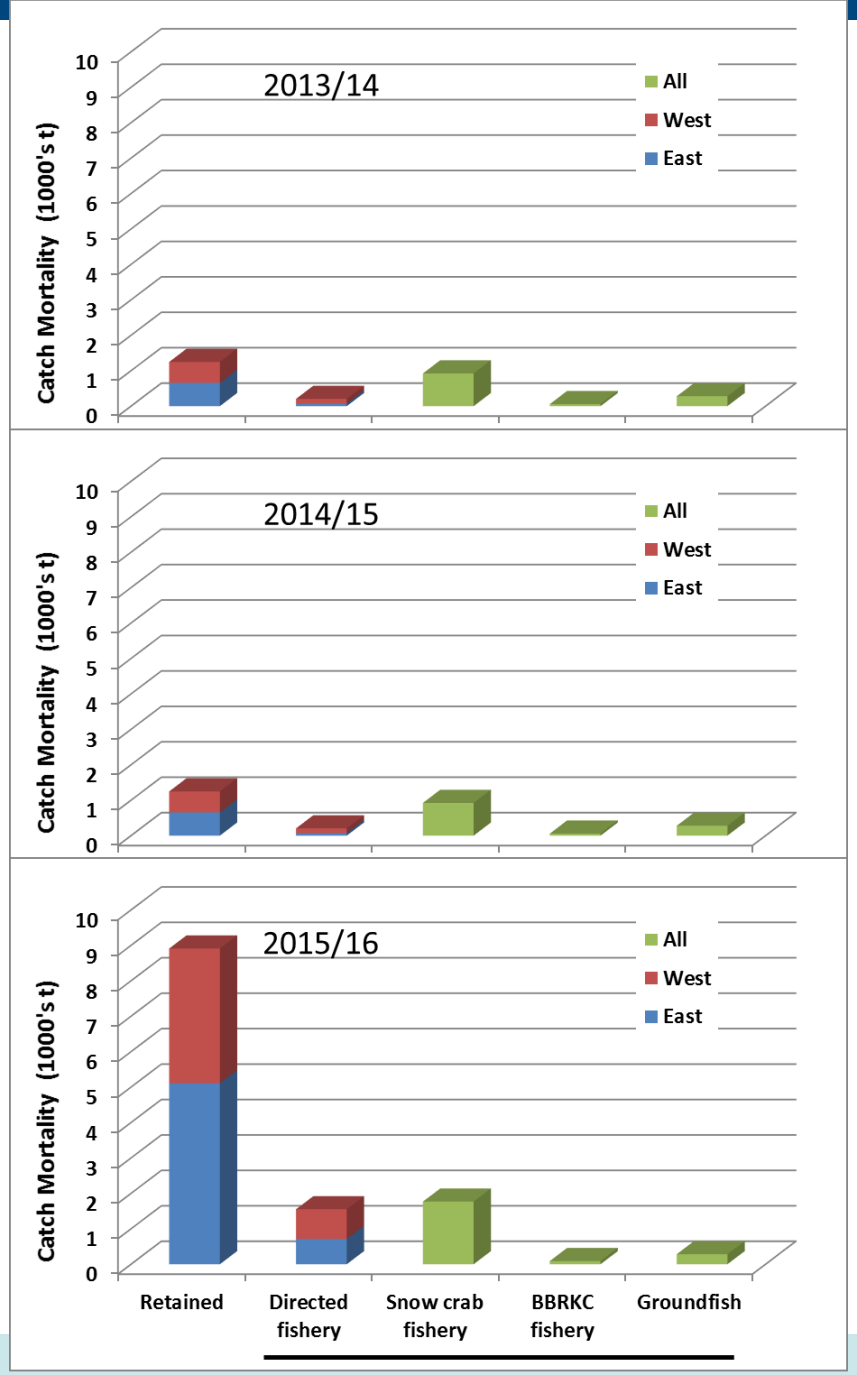




## Bycatch Mortality

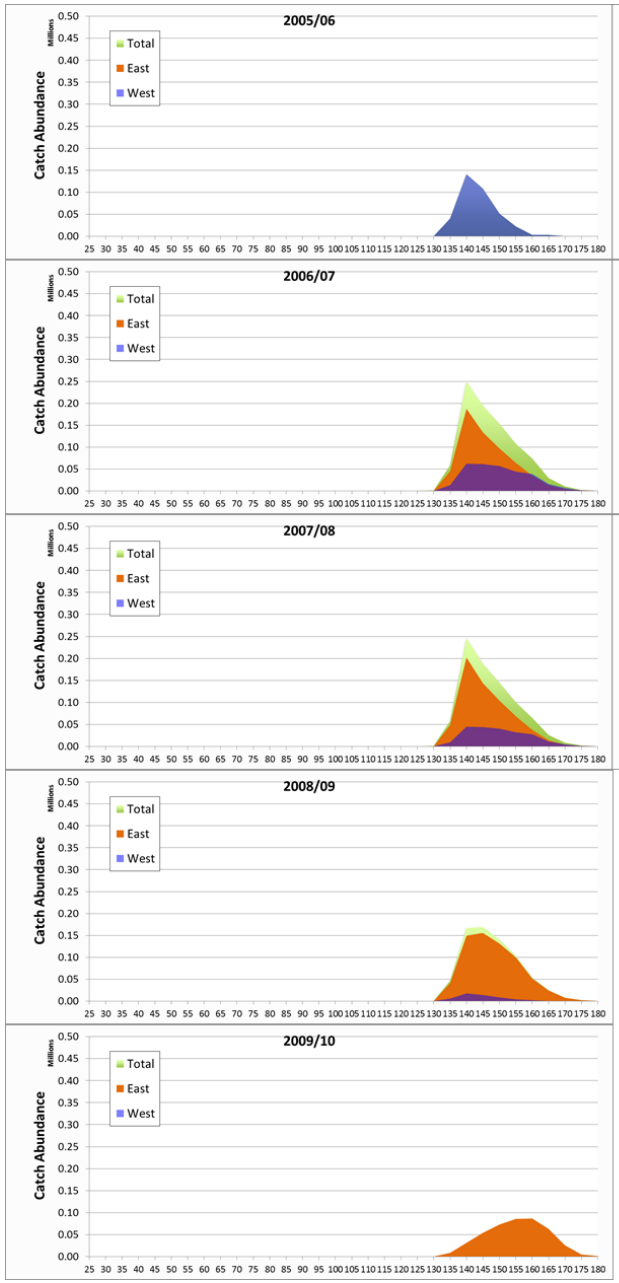


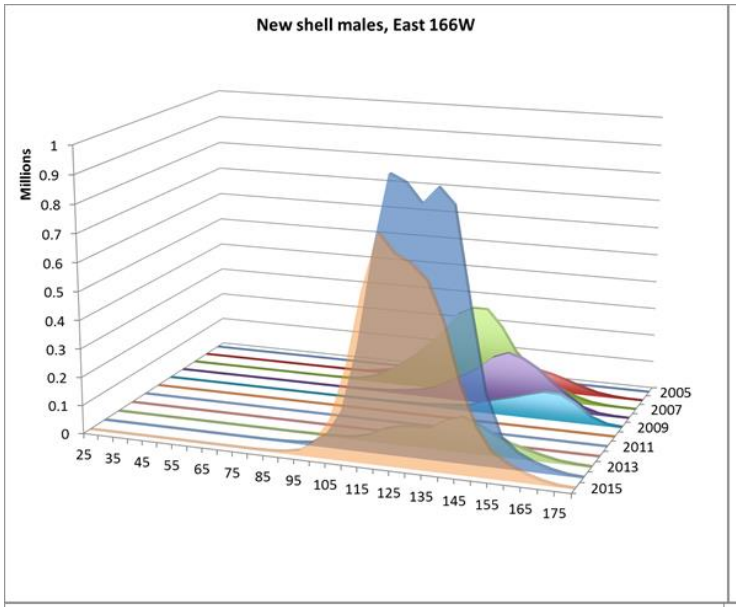
# Recent Fishery Trends

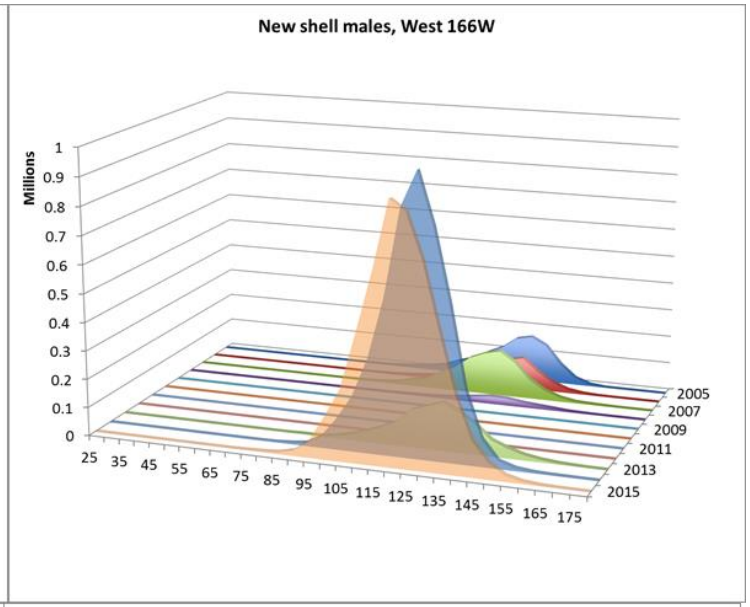


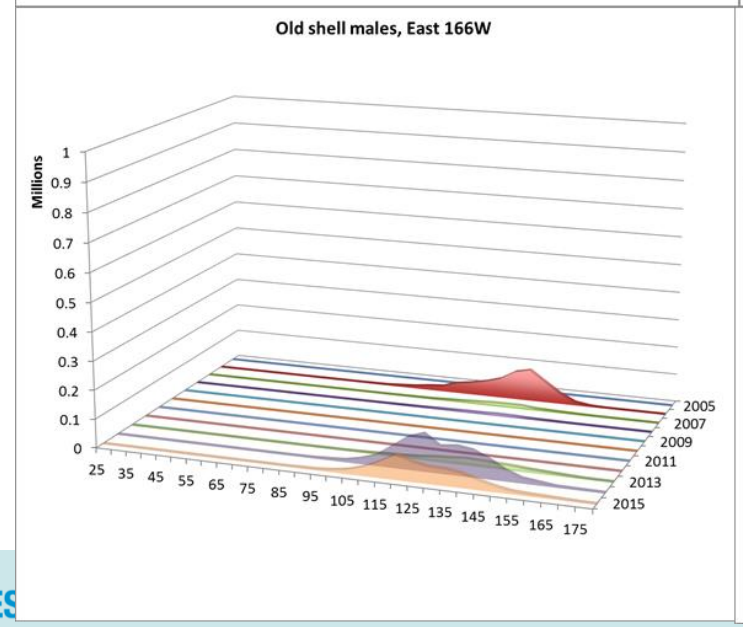
# Recent Fishery Trends: Retained Catch Size Compositions

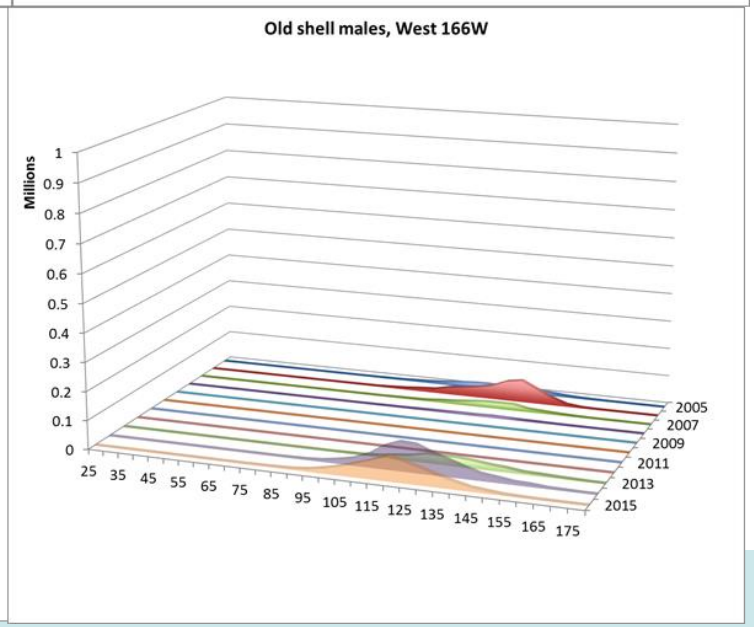


# Directed Fishery: Total Catch Male Size Compositions

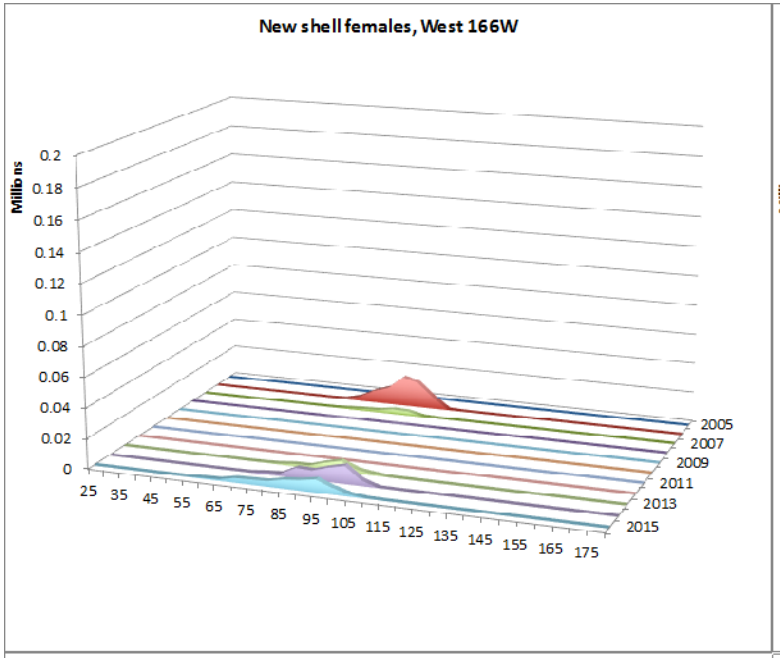


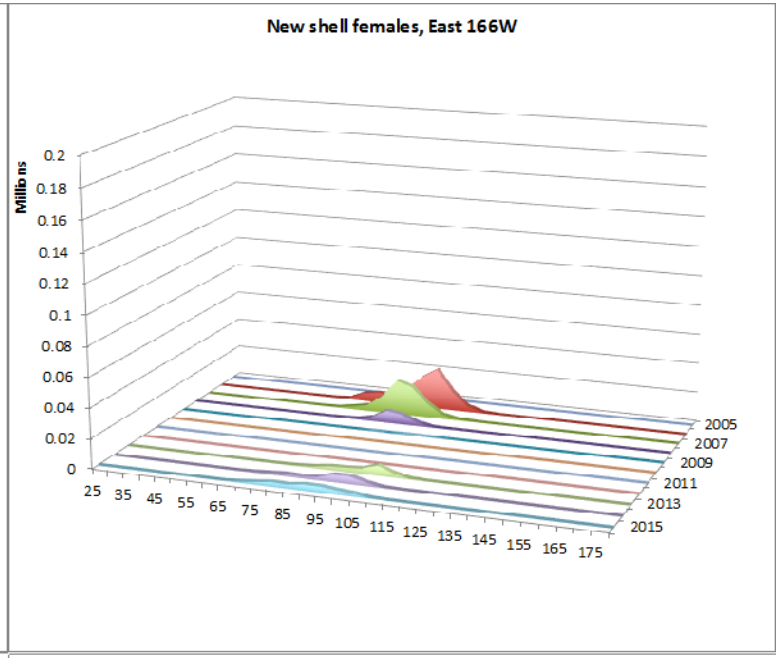



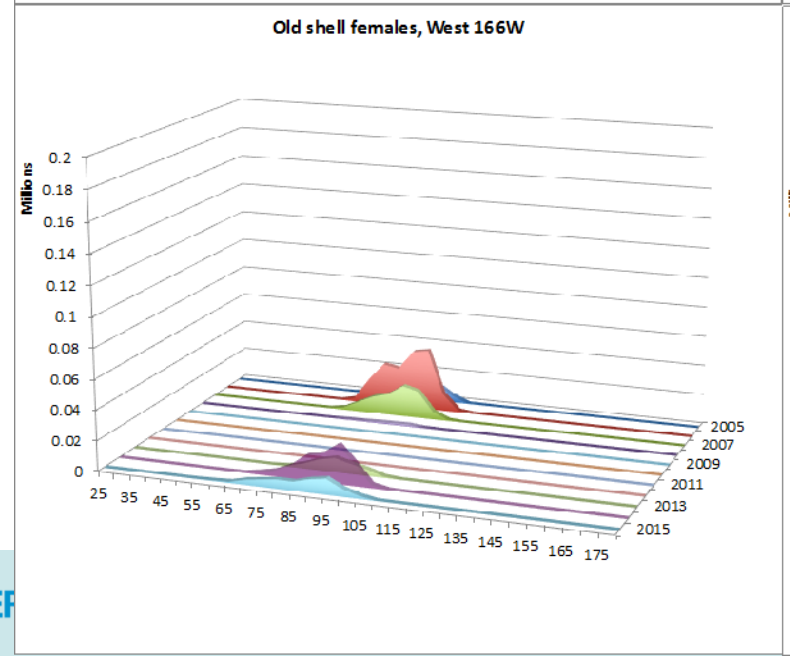



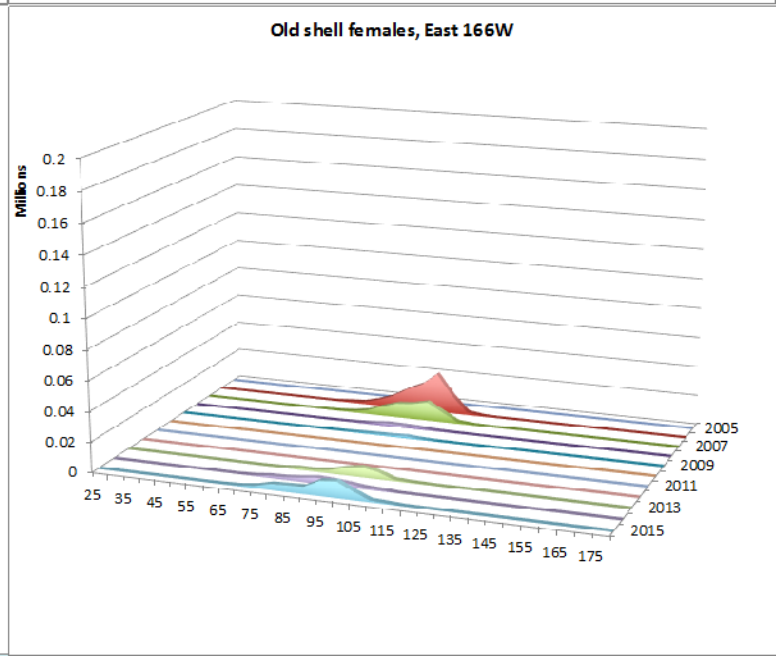



# Directed Fishery: Female Bycatch Size Compositions

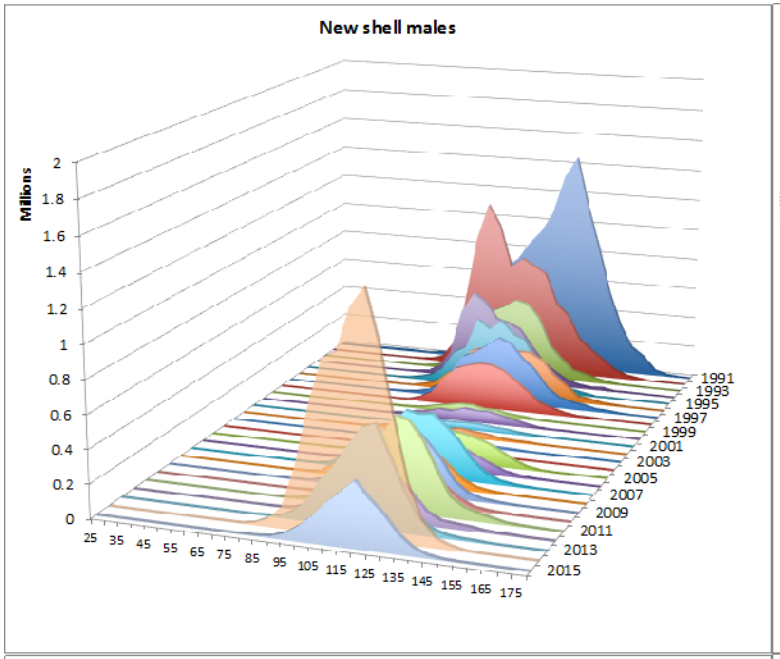


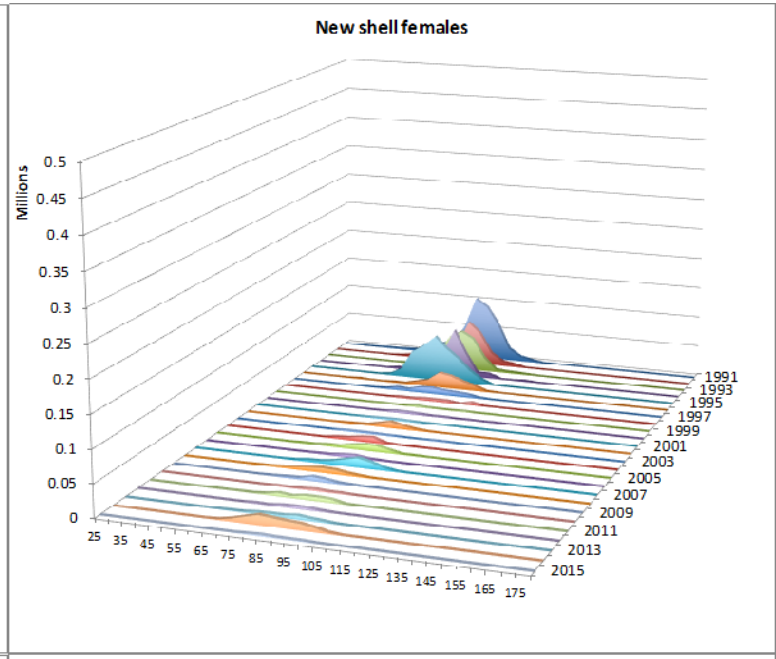



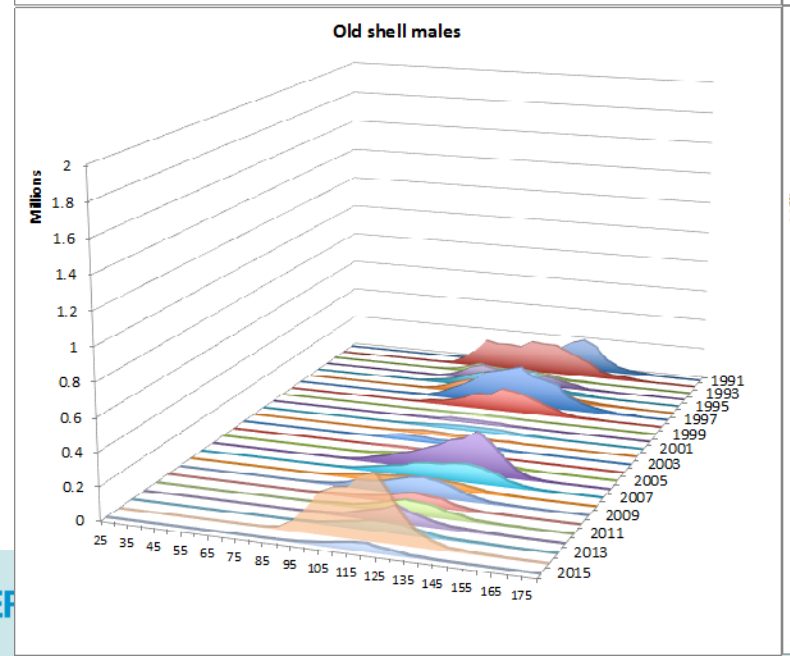



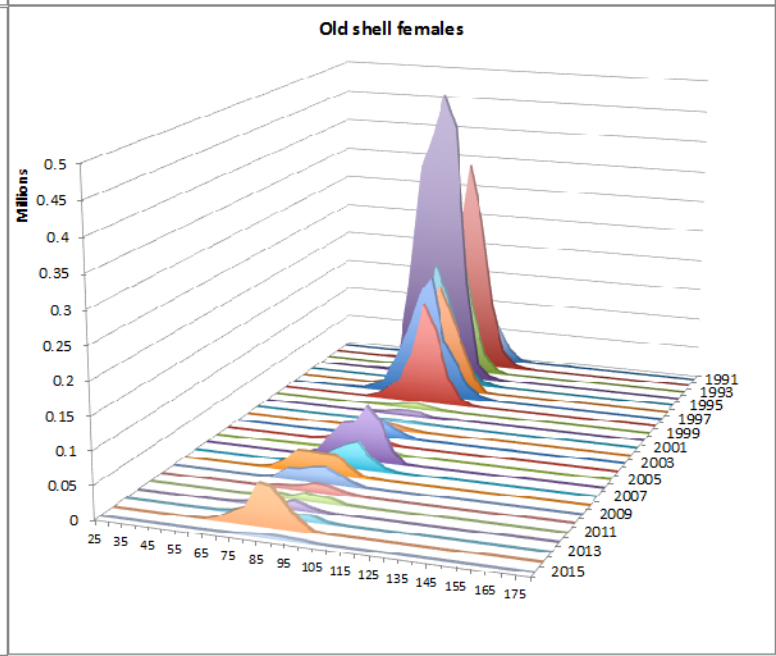



# Snow Crab Fishery: Bycatch Size Compositions

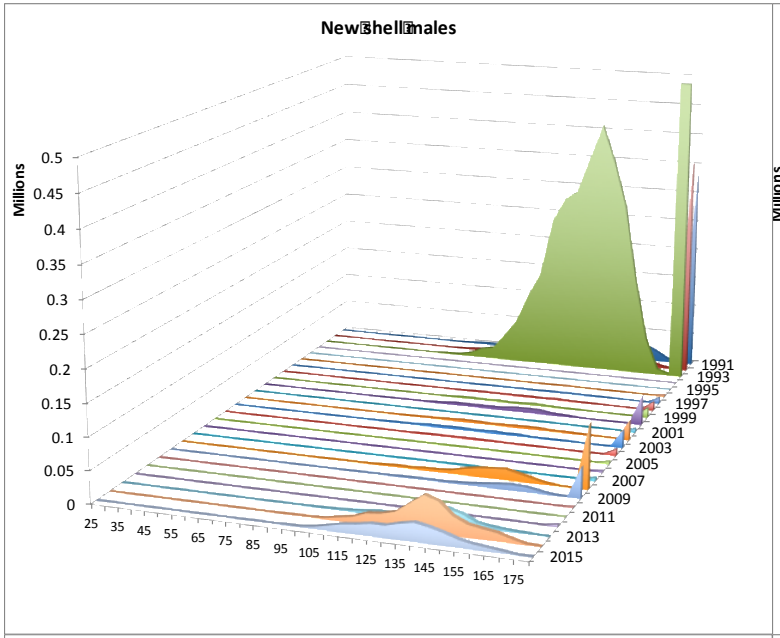


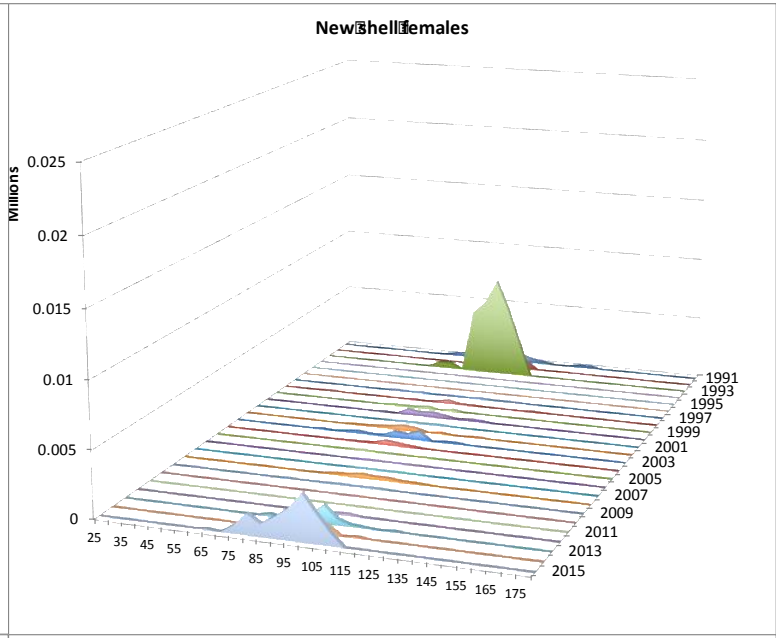



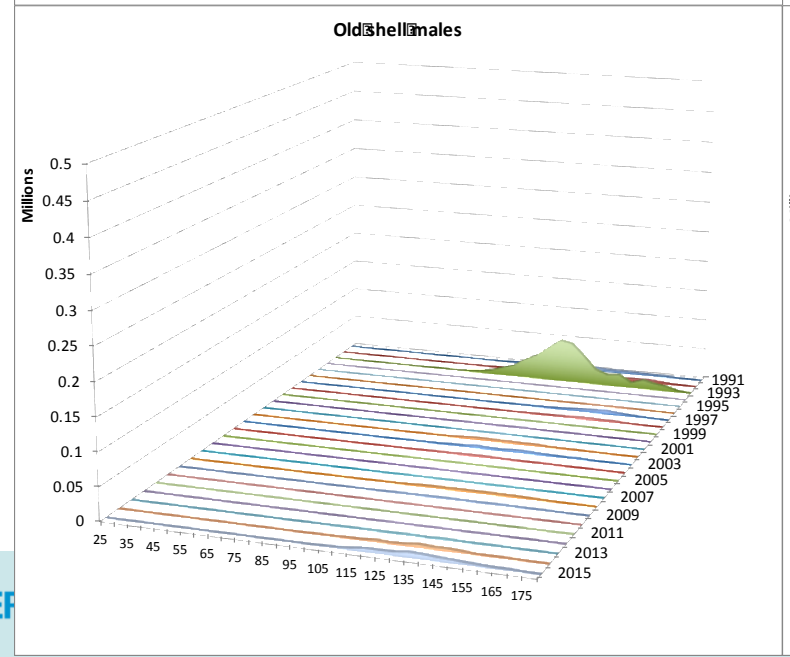



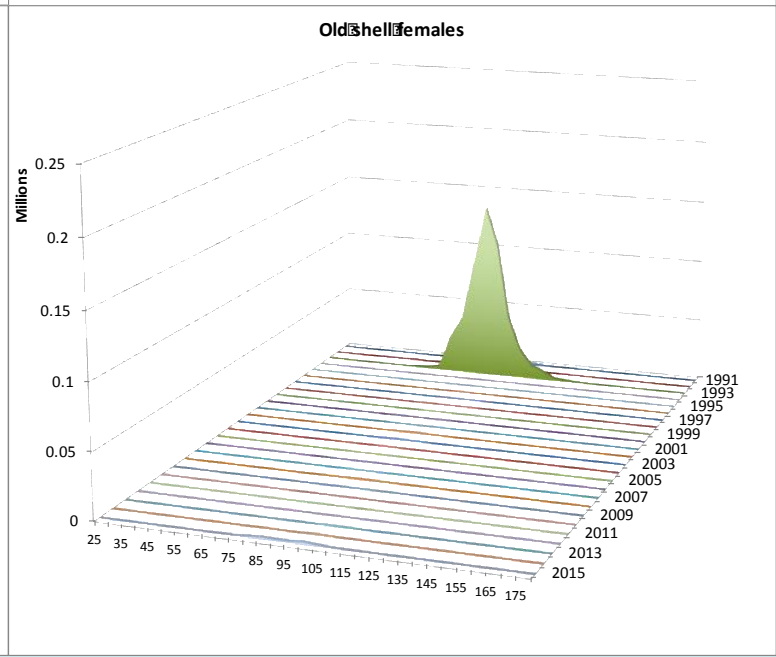



# BBRKC Fishery: Bycatch Size Compositions

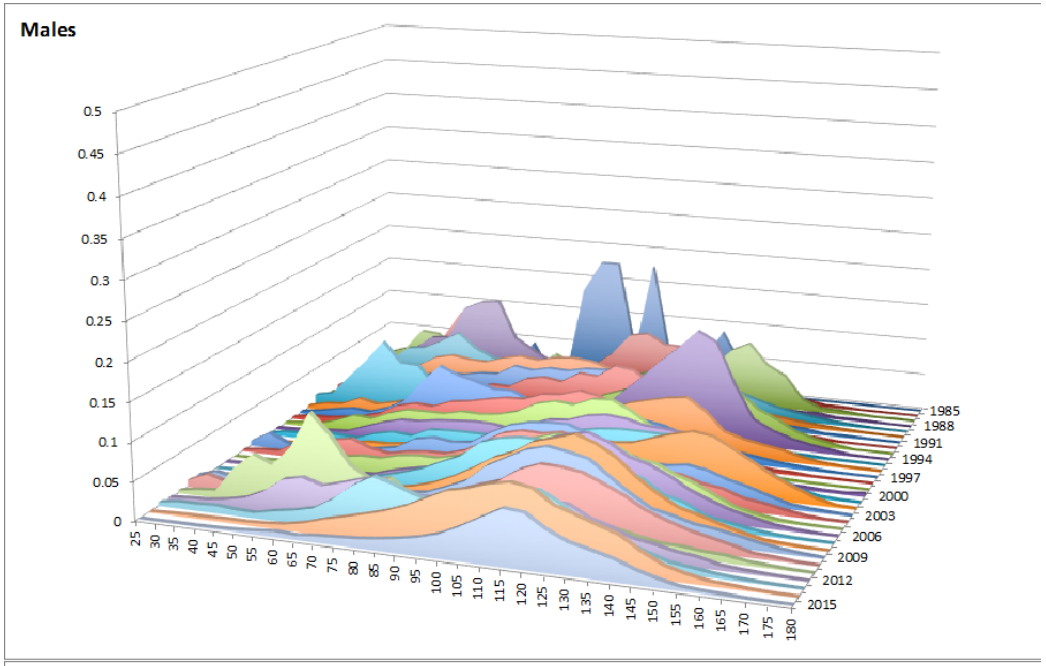


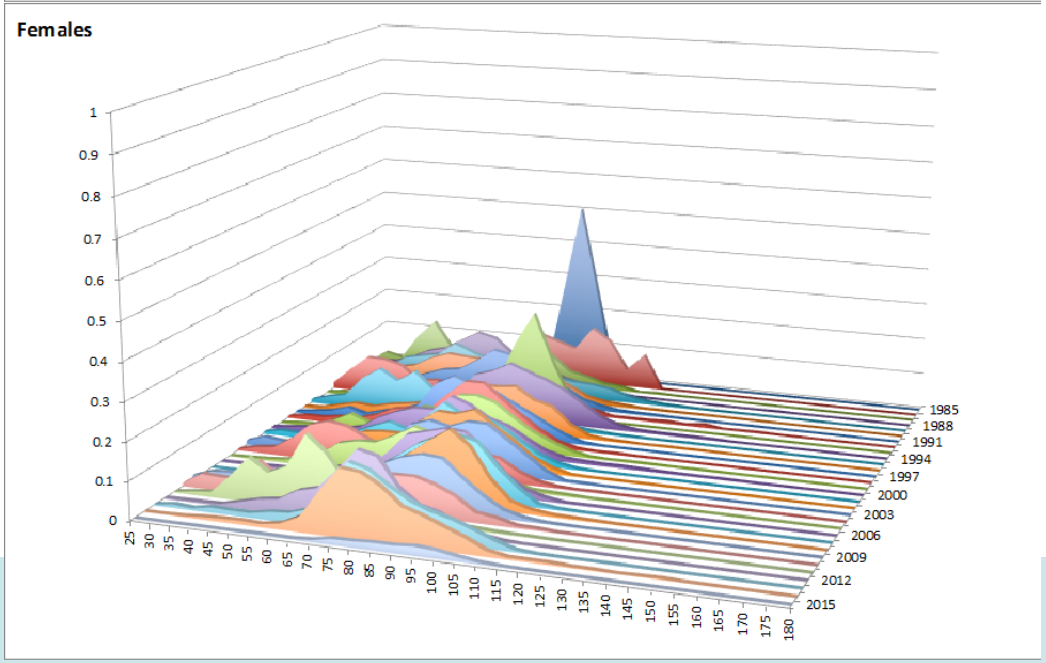



# Groundfish Fisheries: Bycatch Size Compositions



# NMFS EBS Trawl Survey Trends

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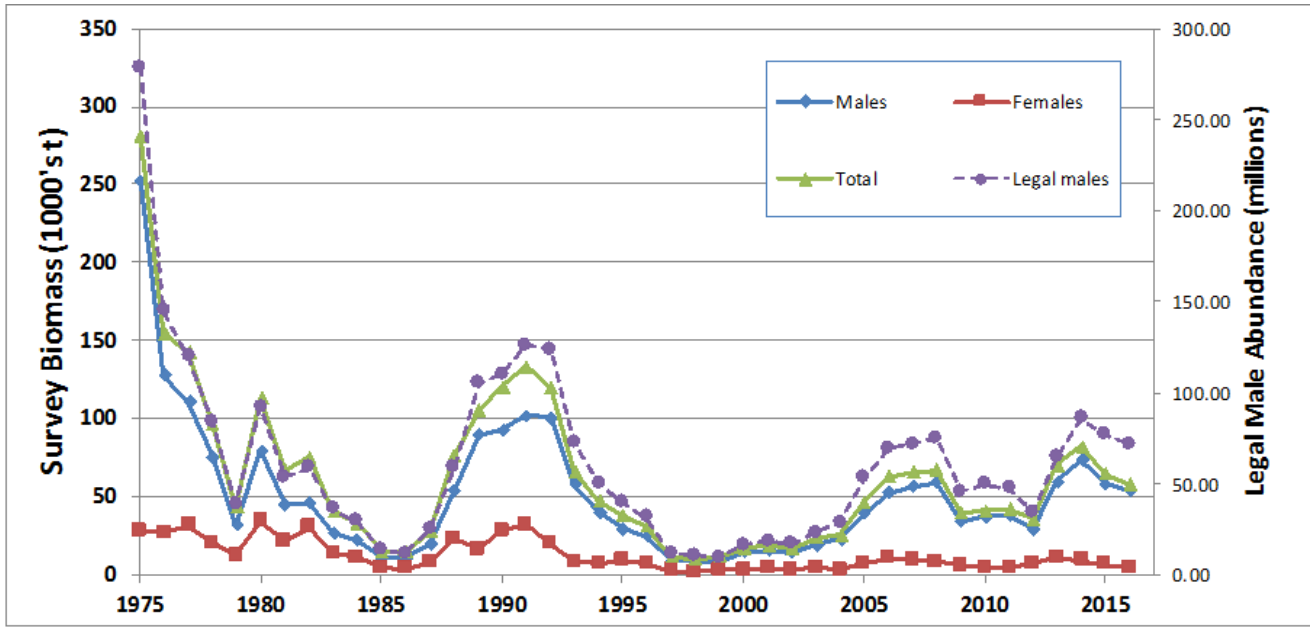
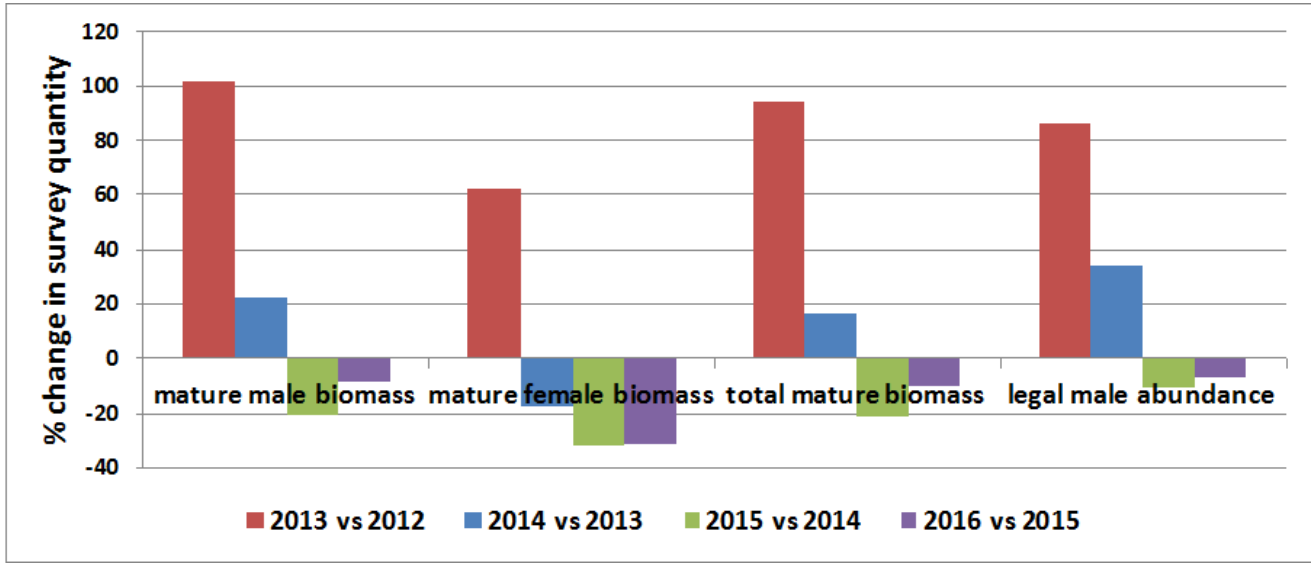
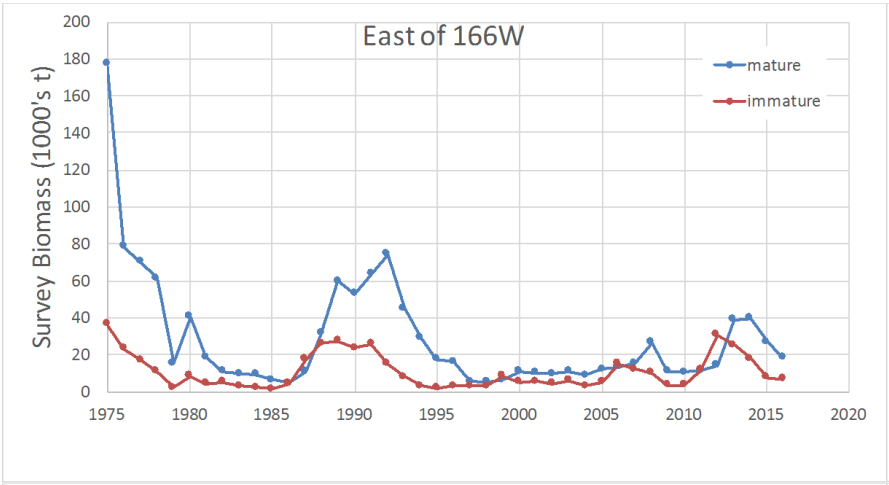
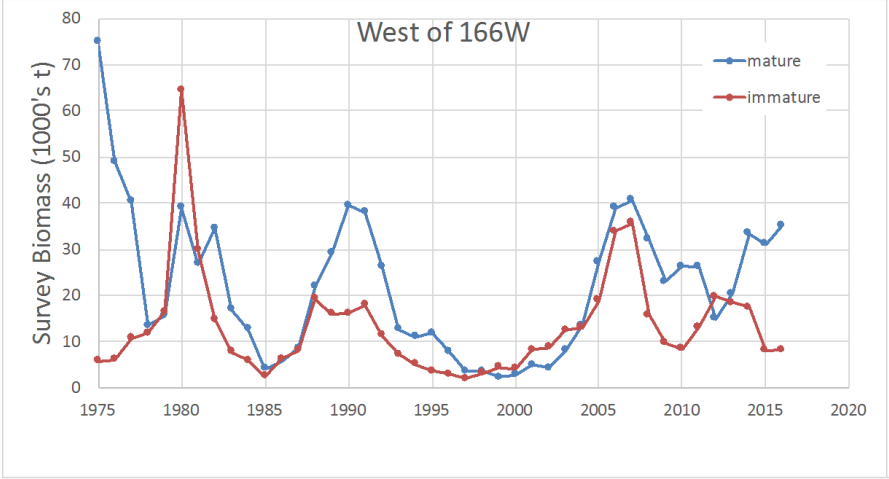


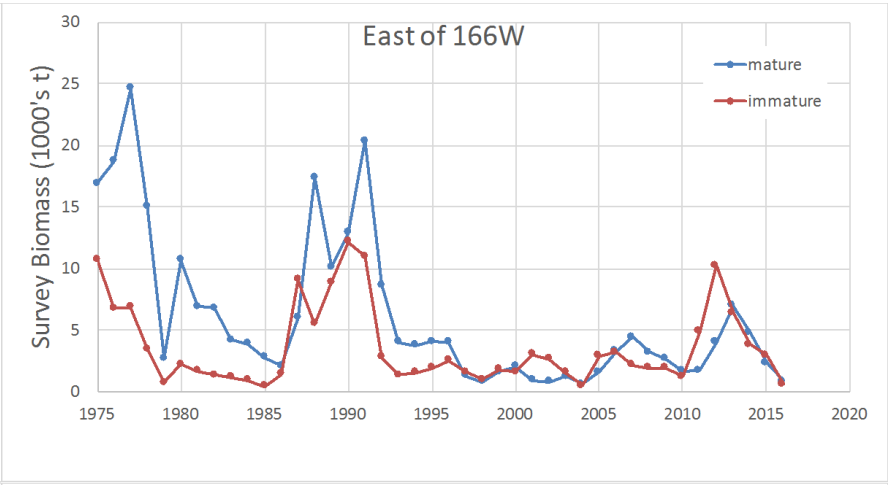
# NMFS EBS Trawl Survey Trends

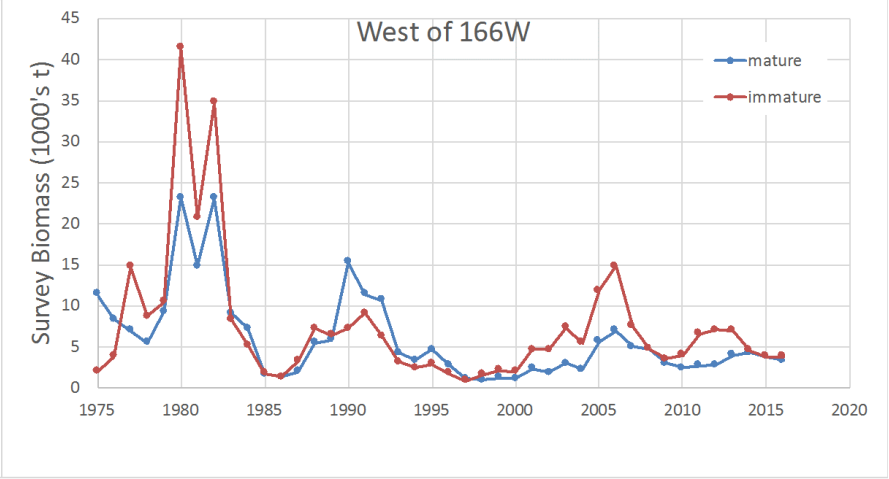
## Males




## Females



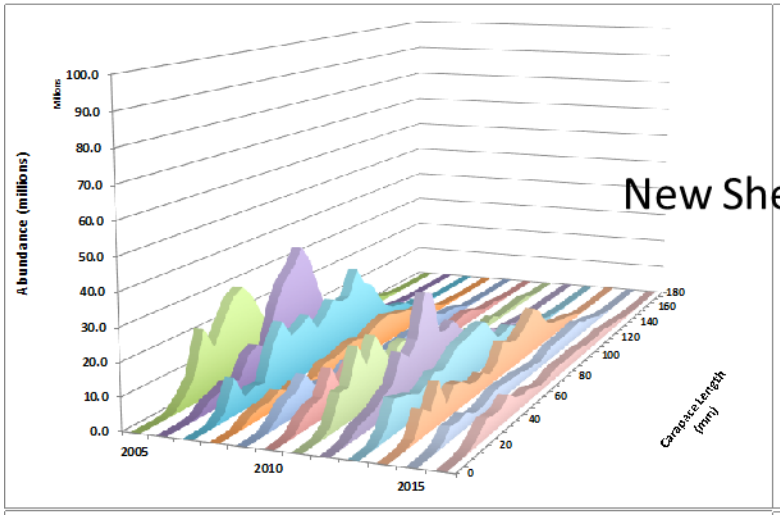



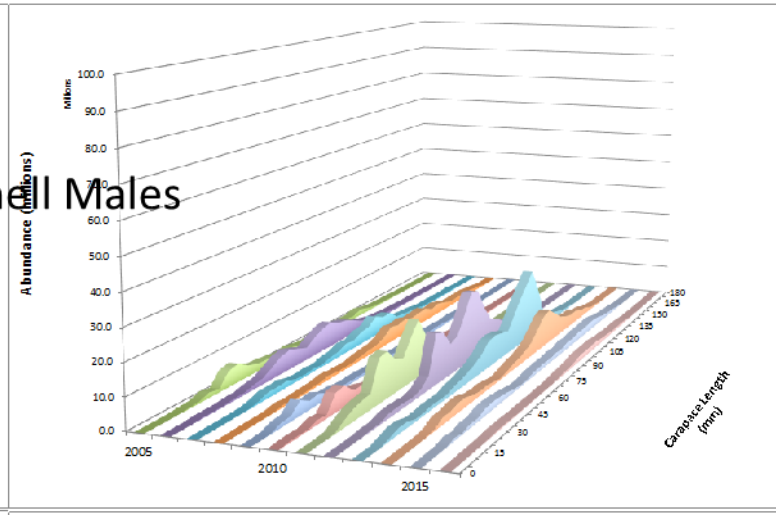
# Trawl Survey Size Comps: Males

West of 166W

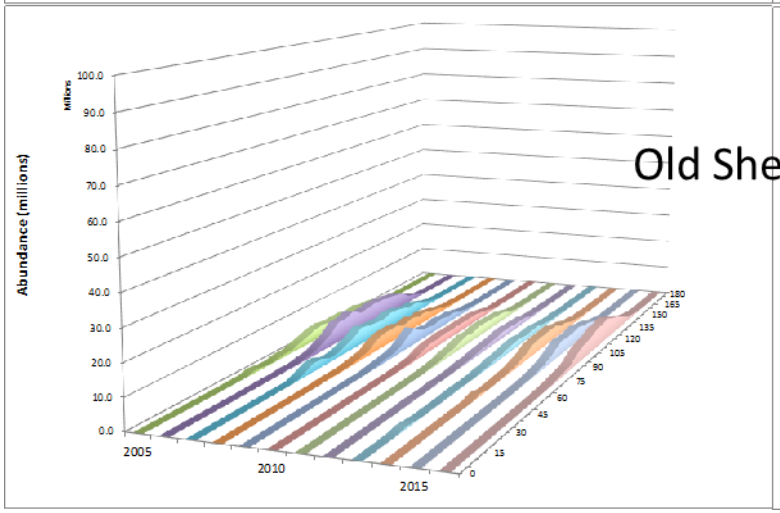
East of 166W

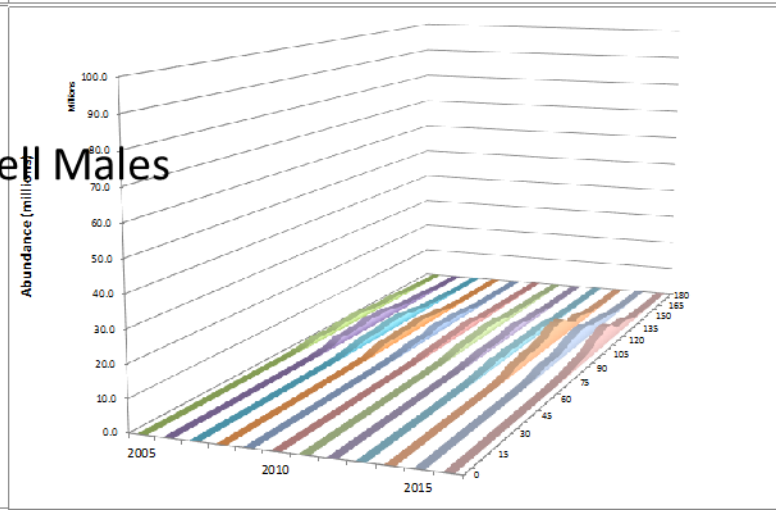
New Shell Males




Old Shell Males



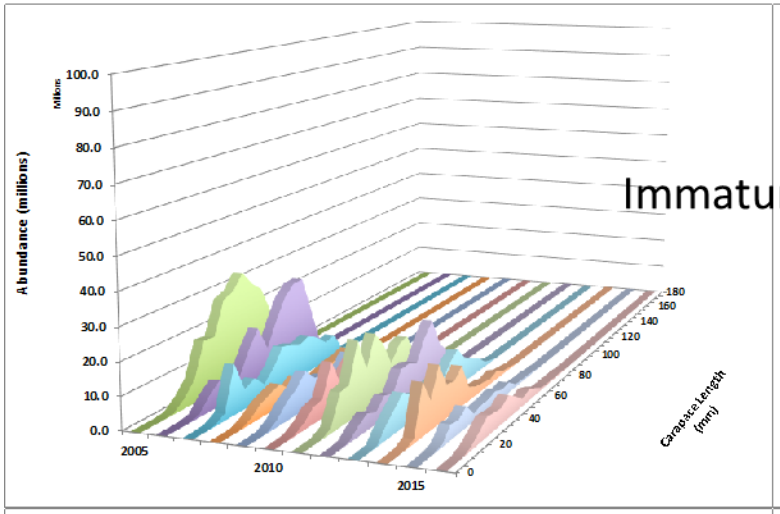



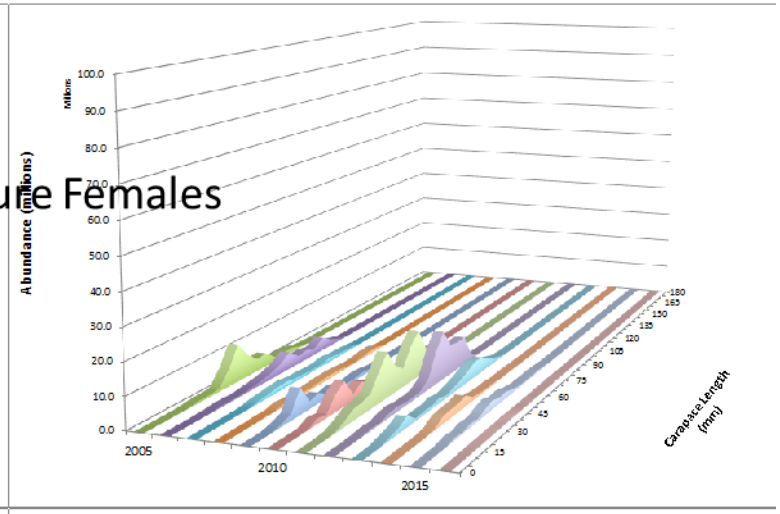
# Trawl Survey Size Comps: Females

West of 166W

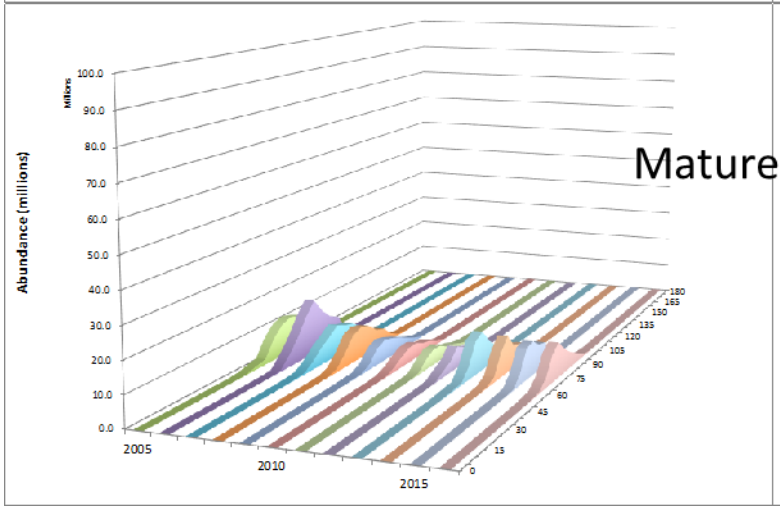
East of 166W

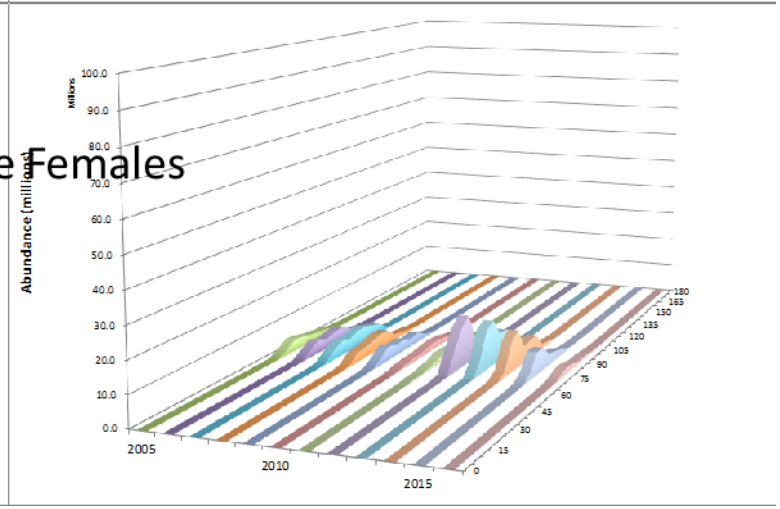
Immature Females



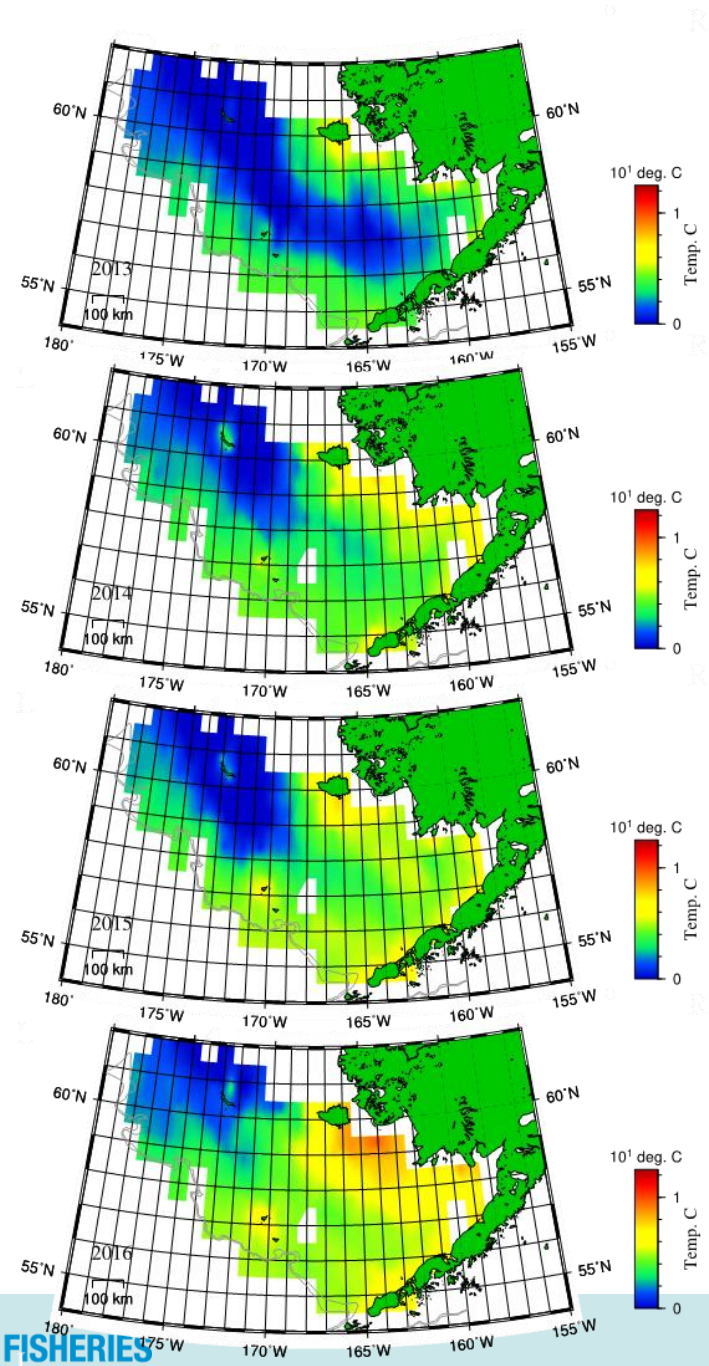



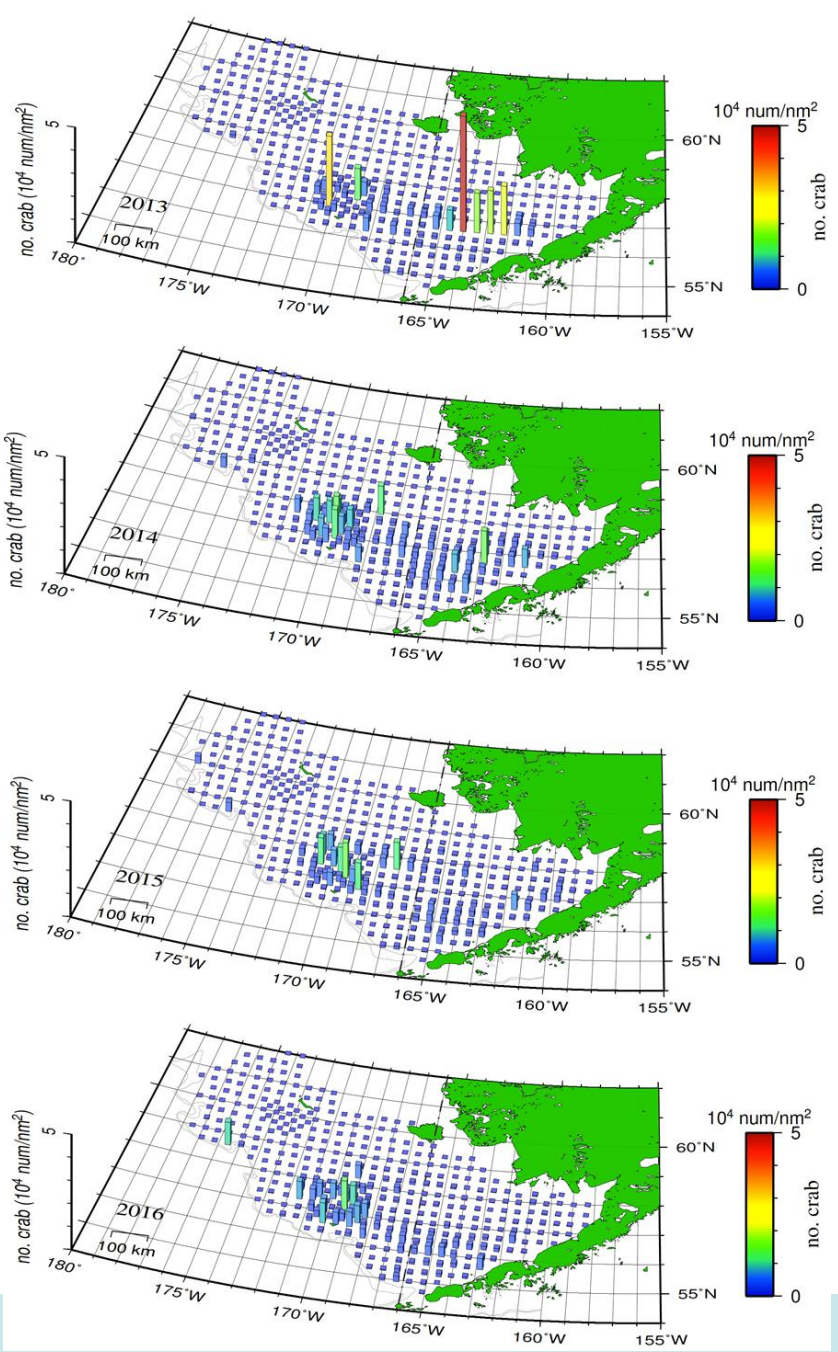

Mature Females



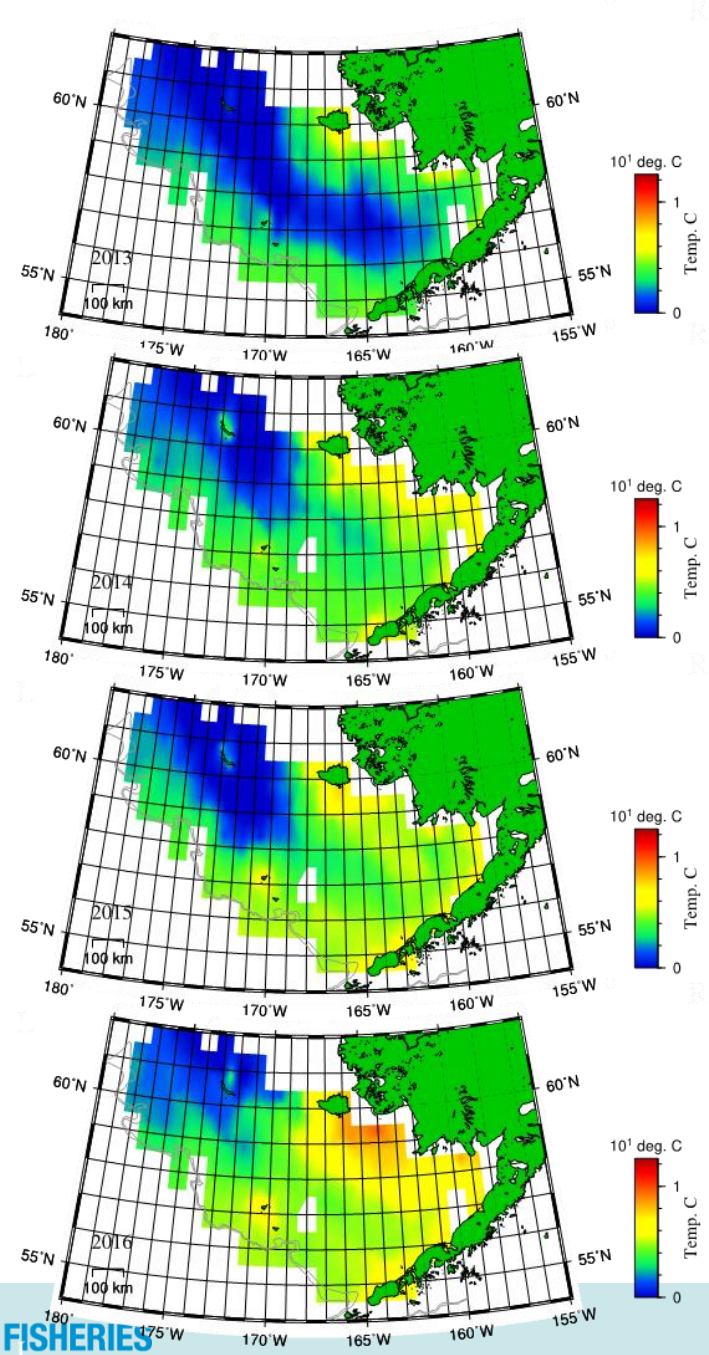



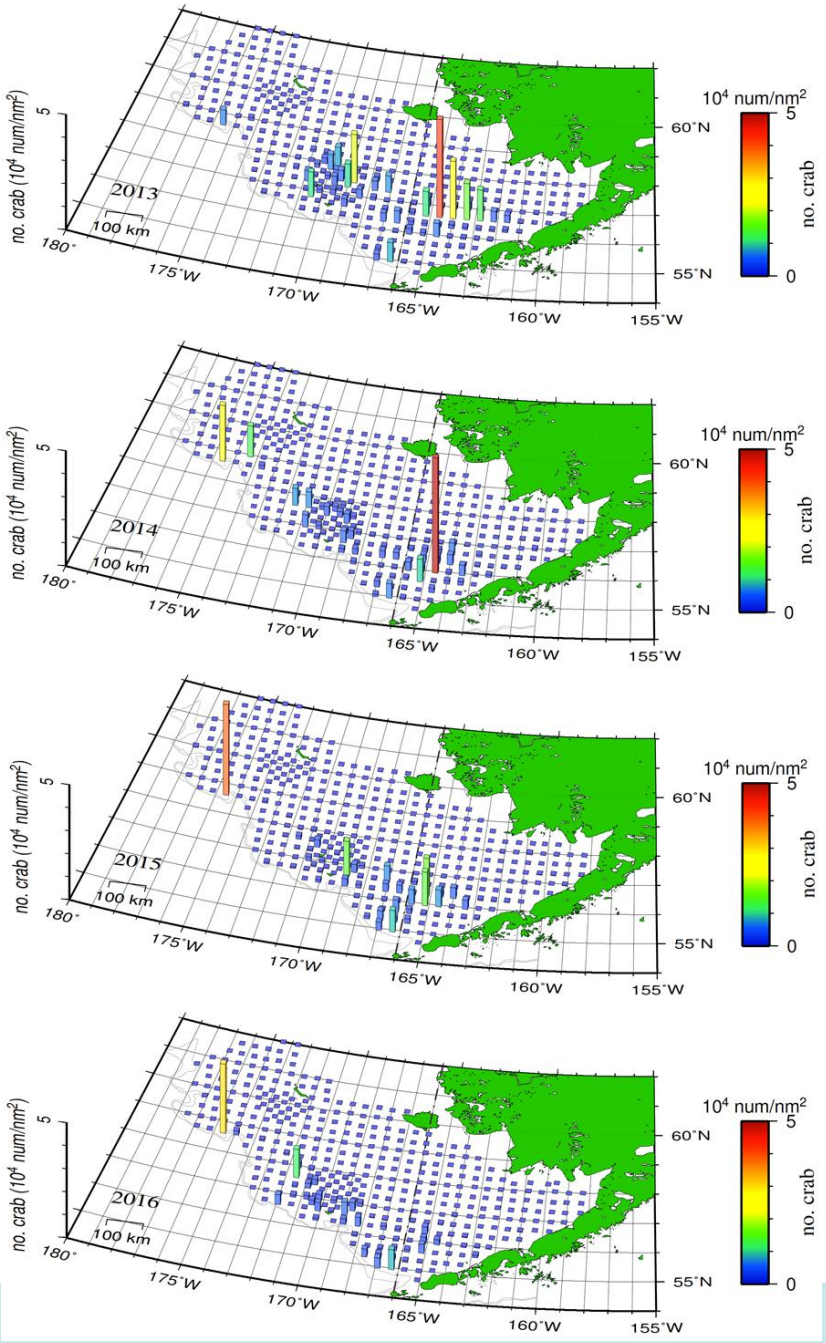
# Survey Results: Mature Males



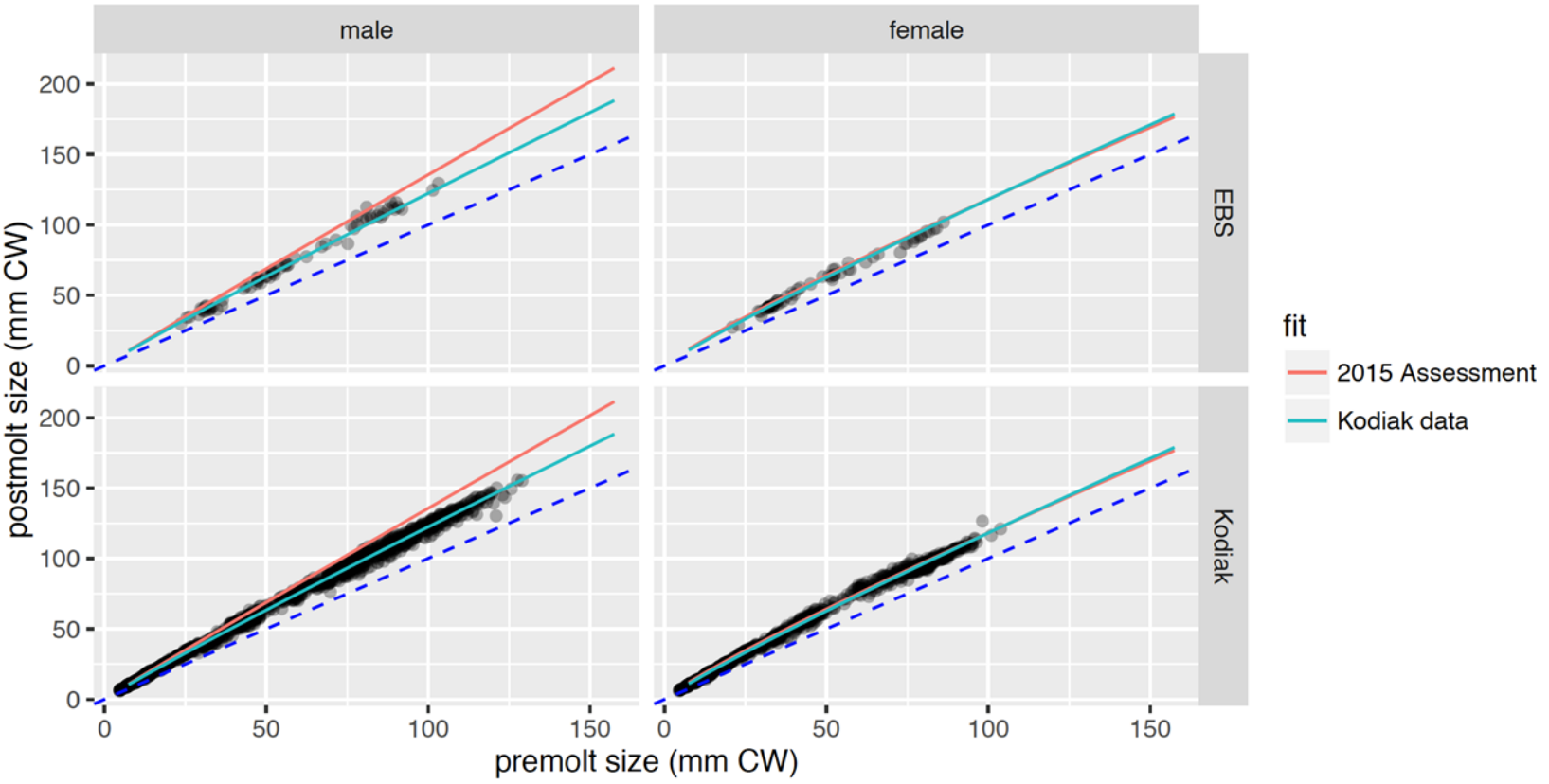
# Survey Results: Mature Females




NOAA FISHERIES

# EBS Growth Data



# Model Overview

# Tier 3 stage/size-based population dynamics model

- model year runs July 1 to June 30
- sex, shell condition, maturity state, carapace width
- sex/stage-based natural mortality (2 time stanzas)
- trawl survey occurs July 1
- fisheries occur Feb. 15
    - directed fishery (retained and bycatch)
    - bycatch in snow crab fishery
    - bycatch in BBRKC fishery
    - bycatch in groundfish fisheries
- sex-specific growth & maturity (after fisheries)
    - pre-molt/post-molt size transition matrix
    - size-specific probability of maturing on molt
    - terminal molt to maturity
- spawning stock (MMB) assessed at mating

# Model Inputs

Annual NMFS EBS Survey Data
- 1975-2016
- size compositions
  - sex x maturity x shell condition
- cv's for mature survey biomass

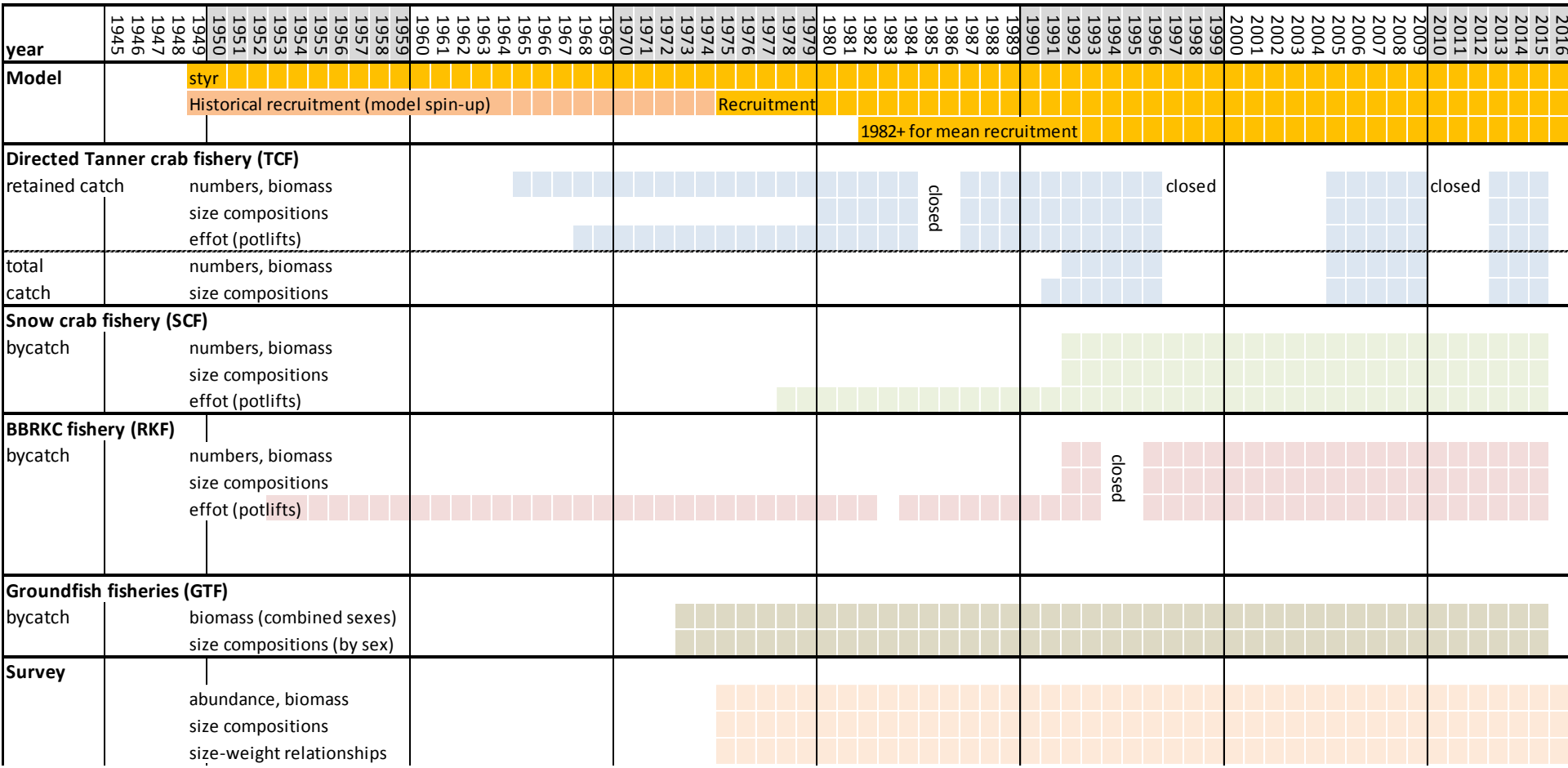
Retained catch in directed fishery
- from fish ticket data and "dockside" observer sampling
- Aggregated across 166°W
- catch biomass
- size compositions

Total catch data in crab fisheries
- from "at-sea" observer sampling
  - total (by)catch biomass (by sex)
  - size compositions (by sex, shell condition)
- directed Tanner crab fishery
- snow crab fishery
- BBRKC fishery

Total catch groundfish fisheries
- from "at-sea" observer sampling
  - bycatch biomass (aggregated over sexes)
  - size compositions (by sex)
- 1973/74-2015/16

Assumed discard mortality rates
- 0.321 for crab fisheries
- 0.800 for groundfish fisheries

# Model Data Coverage



# CV'S for Trawl Survey Biomass: An Aggregation Issue (1)

- Survey data (hosted by AKFIN)
  - estimates for "total" (EBS) biomass, by sex in 1-mm size bins
  - cv's for 1-mm size bins
- Need cv's for "total" (EBS) biomass, by sex $\geq$ 25 mm CW

Calculating size-aggregated cv from 1-mm bin cv's

$$X_T = \sum_z X_z \quad \sigma_T^2 = \sum_z \sigma_z^2$$

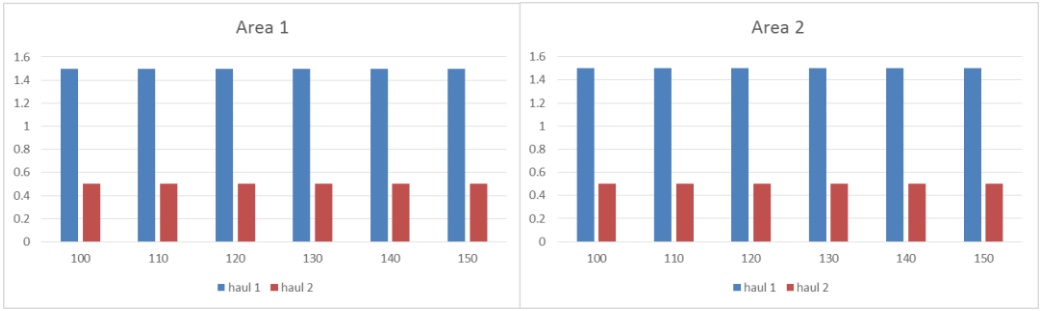
- assumes independence of variability across size bins
- ignores between-bin, within-haul correlations
- within-haul abundance tends to be positively correlated across nearby size bins

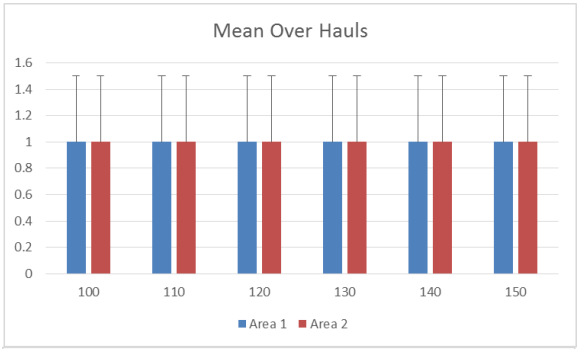
# An Aggregation Issue: An Alternative Approach

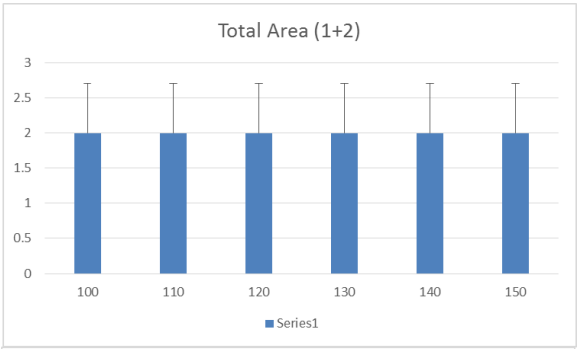
- 2015 (“Old”) approach:
  - Calculate mean CPUE, variance across hauls in stratum by 1-mm CW bins
  - scale by stratum area for total abundance/biomass by 1-mm CW bin
  - Sum across sizes to get aggregated abundance/biomass

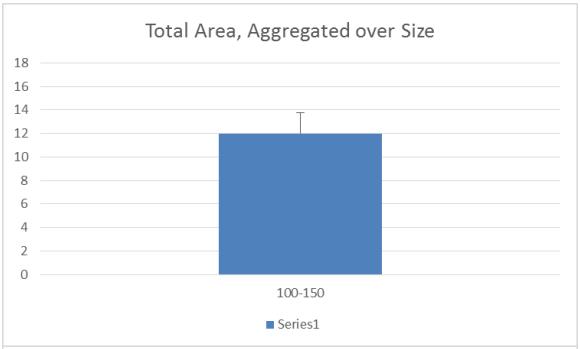
- 2016 (“New”) approach:
  - Aggregate across sizes at haul level
  - Calculate mean CPUE, variance across hauls in stratum
  - scale by stratum area for total abundance/biomass
  - actually: pre-2015 approach

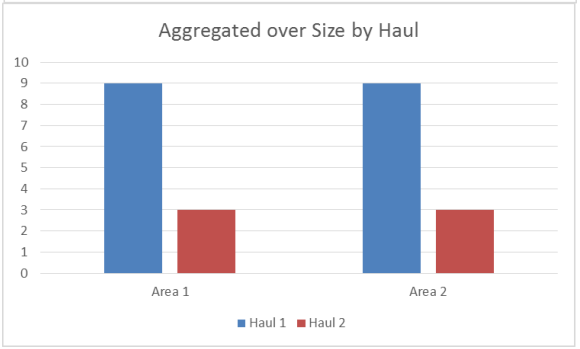
# An Aggregation Issue: A Simple Illustration

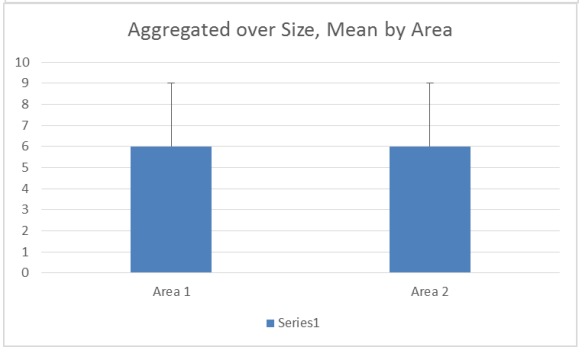


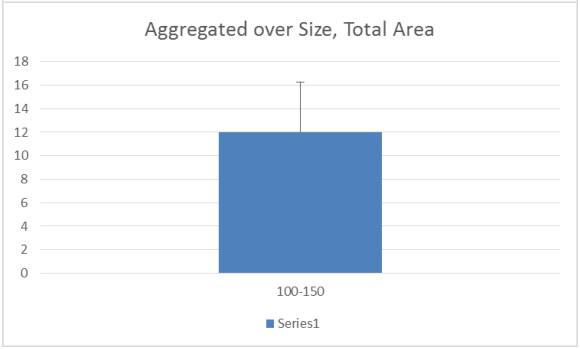



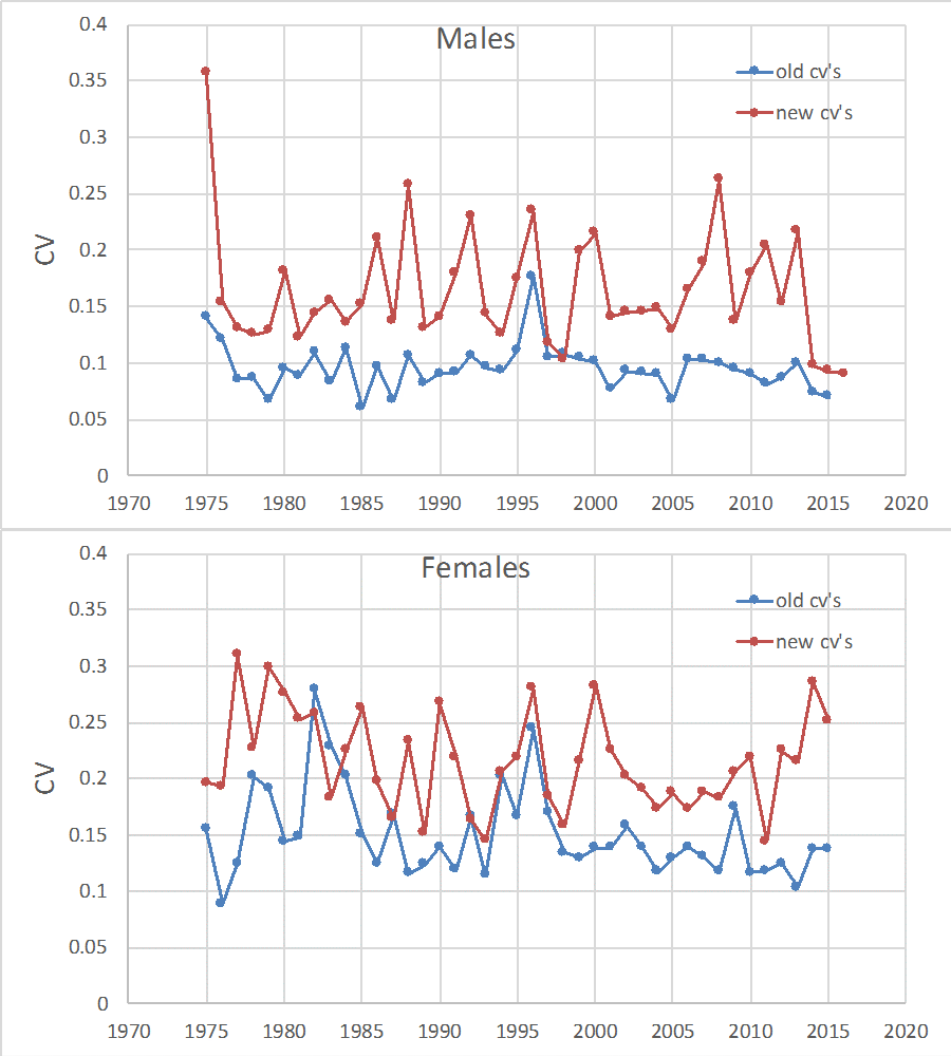



# An Aggregation Issue: Application to Trawl Survey Data

- Calculating cv's for aggregated estimates using cv's for 1-mm size bin results underestimates true cv's
- Using these cv's means model "overfits" survey data relative to other types



# Model Scenarios

## CPT "Base" Model for 2016 (from May CPT Meeting)

| Change | Description |
|---|---|
| A | start "current" recruitment estimation in 1975, instead of 1974 |
| B | normalize groundfish fishery size comps using original sample sizes, not input sample sizes |
| C | estimate log-scale fishing mortality/capture rate offsets for female crab |
| E | turn on fishing mortality/capture rate estimation for BBRKC |
| G | estimate probability of molt-to-maturity using logit-scale parameterization |
| I | enforce logistic selectivity = 1 in largest size bin |
| J | use GMACS fishing mortality model |

## Model Scenarios run for September

| Scenario | Description |
|---|---|
| 2015AMO | 2015 assessment model and data |
| 2015AMR | 2015AMO re-evaluated using parameter jittering |
| 2015AMN | 2015AMO + new approach to calculate CVs for mature survey biomass |
| 2015AM | 2015AMN + 2016 data (using new approach to calculate CVs for mature survey biomass) |
| Model A | Model B, but using old fishing mortality model |
| Model B | Model selected by CPT in May as "base" model for 2016 assessment |
| Model C | Model B + no minimum F's imposed on BBRKC fishery bycatch |
| Model D | Model C + effort extrapolation parameters estimated |
| Model E | Model D + penalty on F-devs reduced to 0 in final estimation phase |
| Model F | Model D + lognormal likelihoods assumed for fishery catch data (change L0 from May) |
| Model G | Model E + lognormal likelihoods assumed for fishery catch data (change L0 from May) |

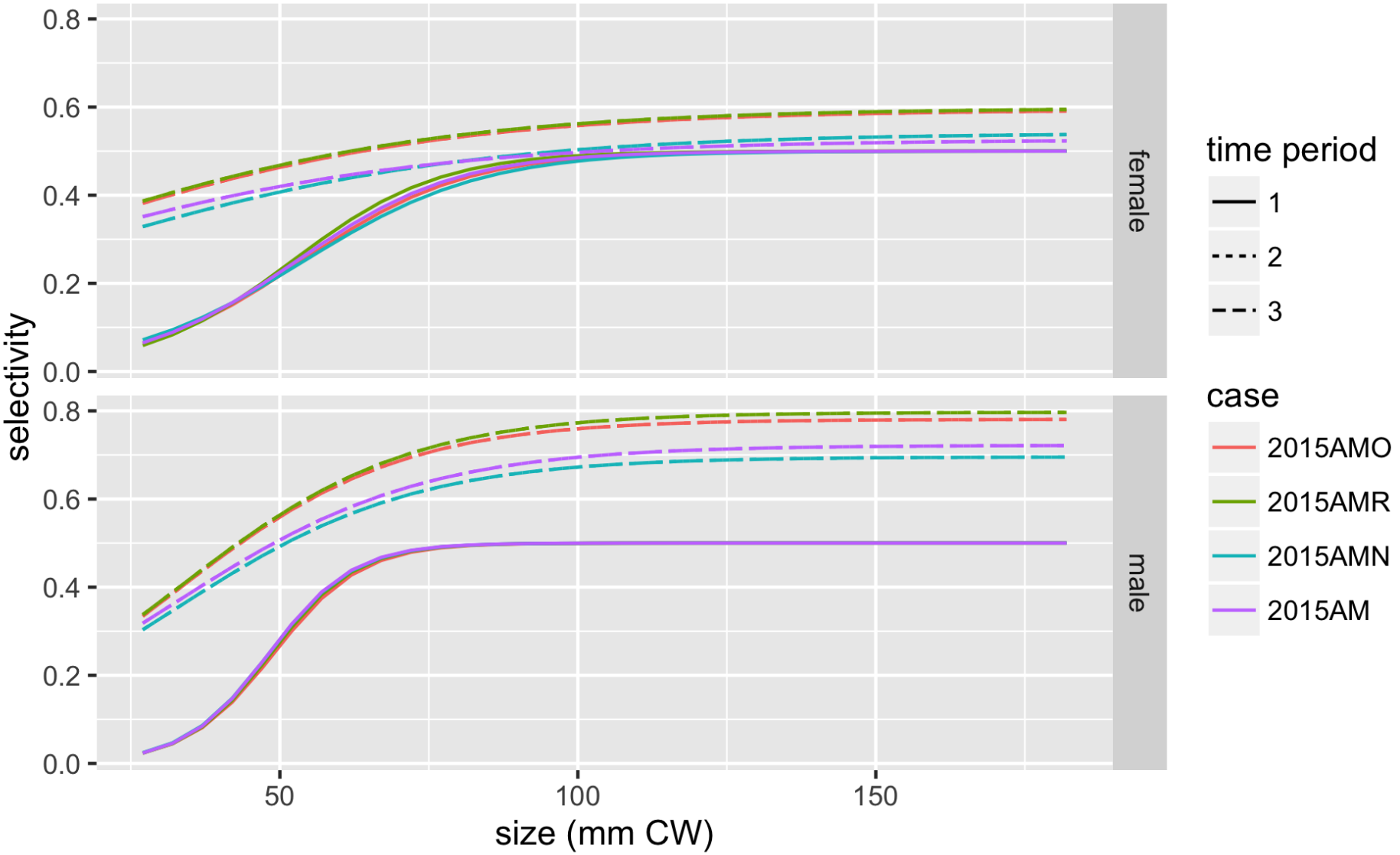
# Summary Results

| Model Scenario | Final Year | Data | # params | # of jitter runs | Objective Function | | invertible hessian? | Mean Recruitment | | MMB (1000's t) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | value | max gradient | | 1982+ | 2000+ | 1982+ | last 3 years | final year |
| 2015AMO | 2015 | old cv's | 307 | -- | 2049.07 | 0.0000875 | yes | 179.4 | 164.9 | 36.5 | 59.6 | 71.6 |
| 2015AMR | 2015 | old cv's | 307 | 200 | 2048.68 | 0.0002388 | yes | 176.8 | 163.9 | 35.8 | 57.7 | 69.3 |
| 2015AMN | 2015 | new cv's | 307 | 200 | 1838.14 | 0.0003343 | yes | 193.4 | 188.1 | 42.7 | 68.7 | 83.3 |
| 2015AM | 2016 | new cv's | 312 | 200 | 1952.73 | 0.0002182 | yes | 183.5 | 174.1 | 41.8 | 71.3 | 74.3 |
| Model A | 2016 | new cv's | 341 | 200 | 2338.77 | 1.5256000 | yes | -- | -- | -- | -- | -- |
| Model B | 2016 | new cv's | 341 | 200 | 2406.67 | 0.0002237 | yes | 182.2 | 171.4 | 39.7 | 70.2 | 73.9 |
| Model C | 2016 | new cv's | 341 | 200 | 2406.75 | 0.0004336 | yes | 182.3 | 171.5 | 40.7 | 70.2 | 73.9 |
| Model D | 2016 | new cv's | 343 | 200 | 2391.11 | 0.0004838 | yes | 168.8 | 165.2 | 37.9 | 63.7 | 67.2 |
| Model E | 2016 | new cv's | 343 | 200 | 2286.11 | 0.0000145 | yes | 174.2 | 176.0 | 40.1 | 68.3 | 72.4 |
| Model F | 2016 | new cv's | 343 | 200 | 2997.88 | 0.0003812 | yes | 163.6 | 160.8 | 37.6 | 61.8 | 63.3 |
| Model G | 2016 | new cv's | 343 | 200 | 2672.99 | 0.0000301 | yes | 172.7 | 175.6 | 40.5 | 68.8 | 70.9 |

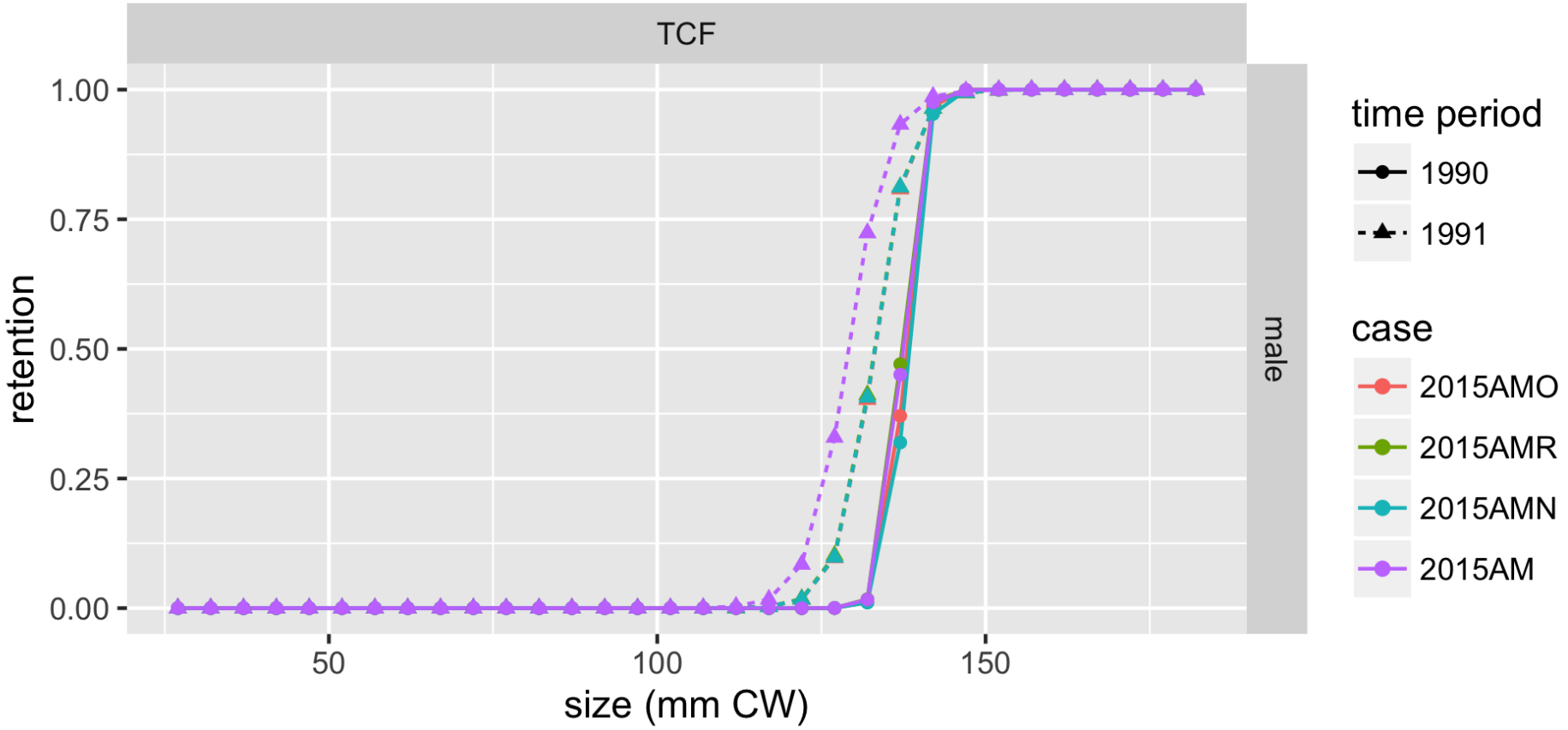
# Model Results: New CVs vs Old CVs

- AMO: original 2015 assessment model
- AMR: 2015 AM re-run 200 times with jittered initial parameters
- AMN: 2015 AM w/ new CVs (200 runs)
- AM: 2015 AM with 2016 data (new CVs, 200 runs)

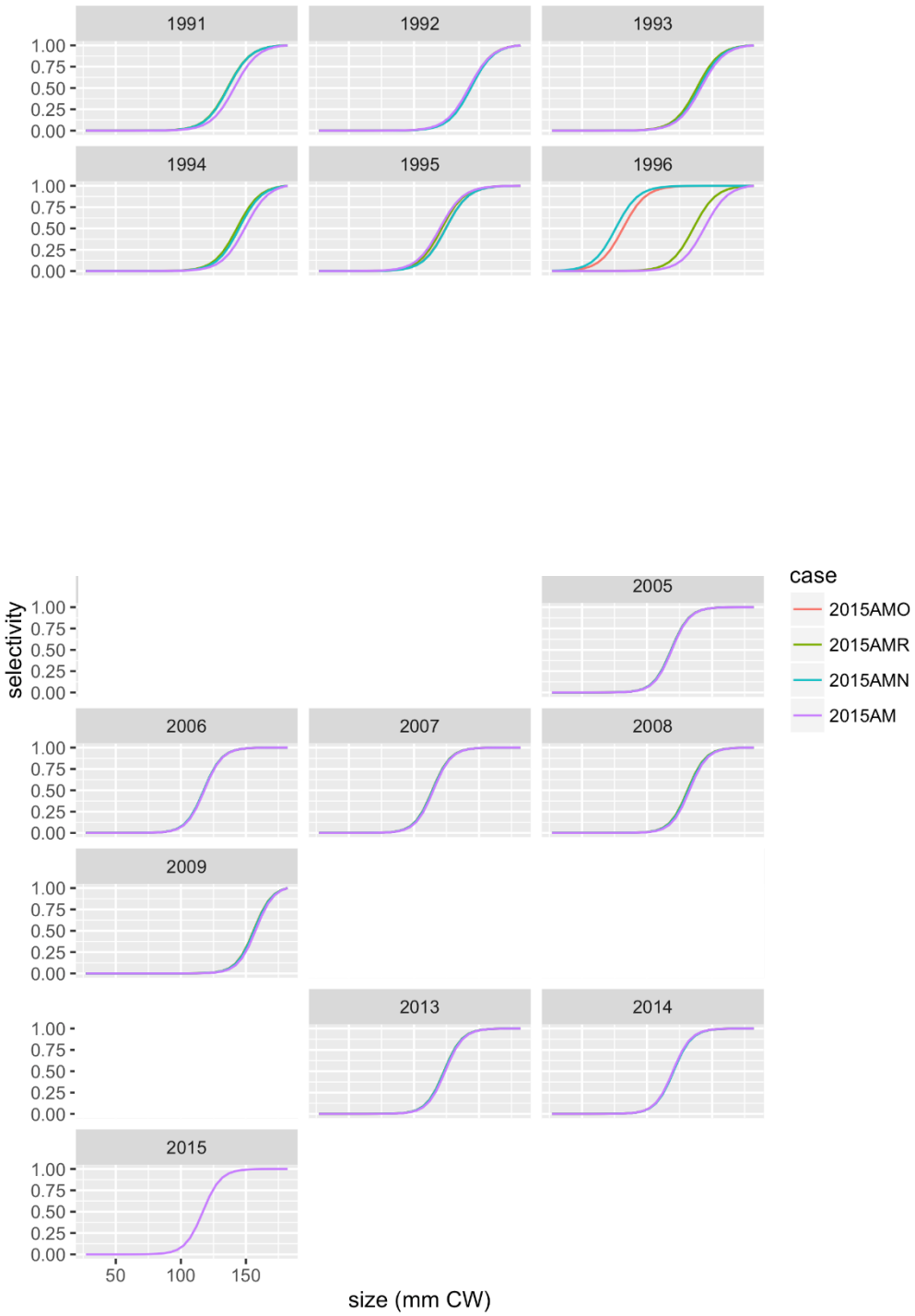
# New CVs vs Old CVs: Survey Selectivities



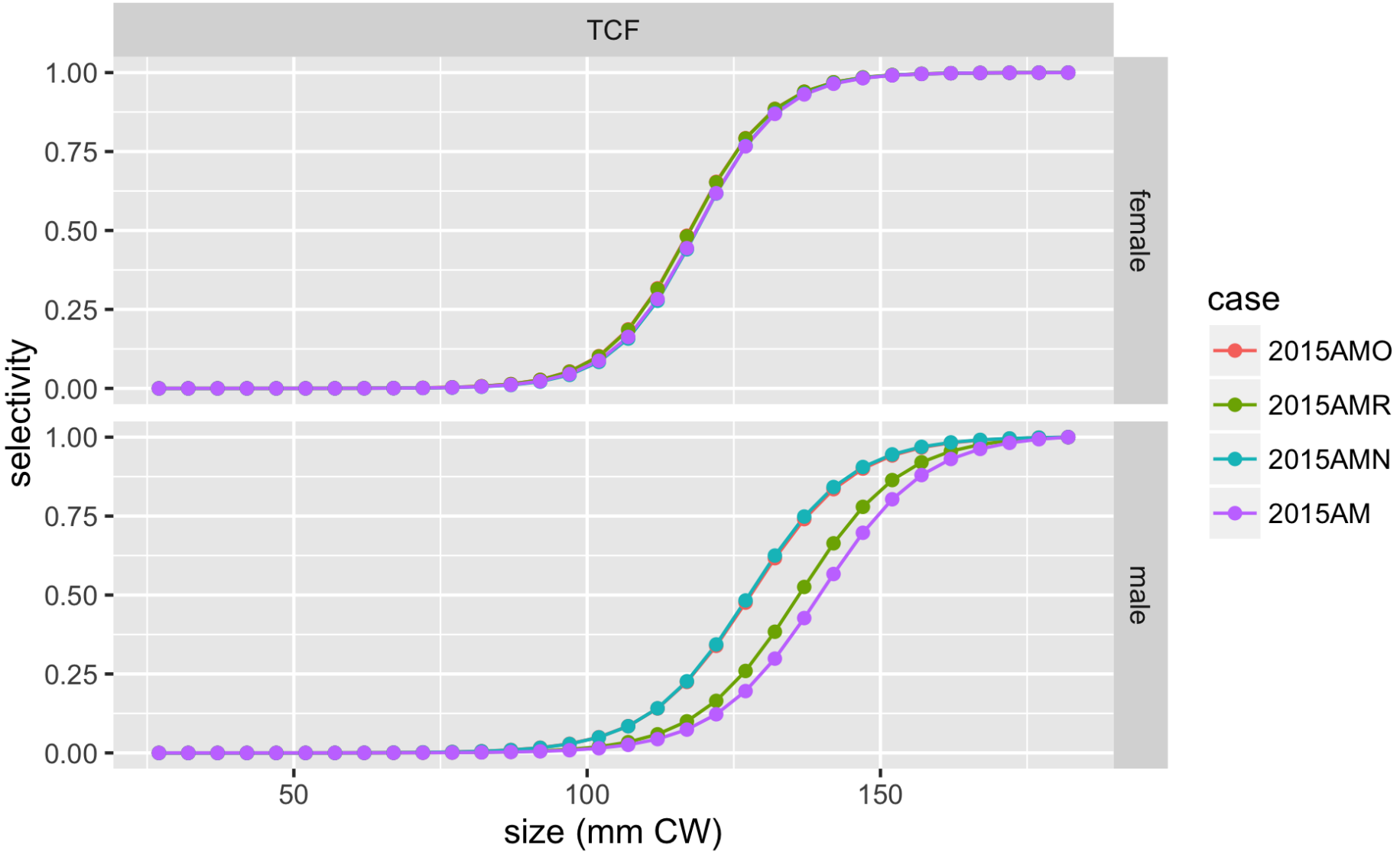
# New CVs vs Old CVs: Directed Fishery Retention Functions



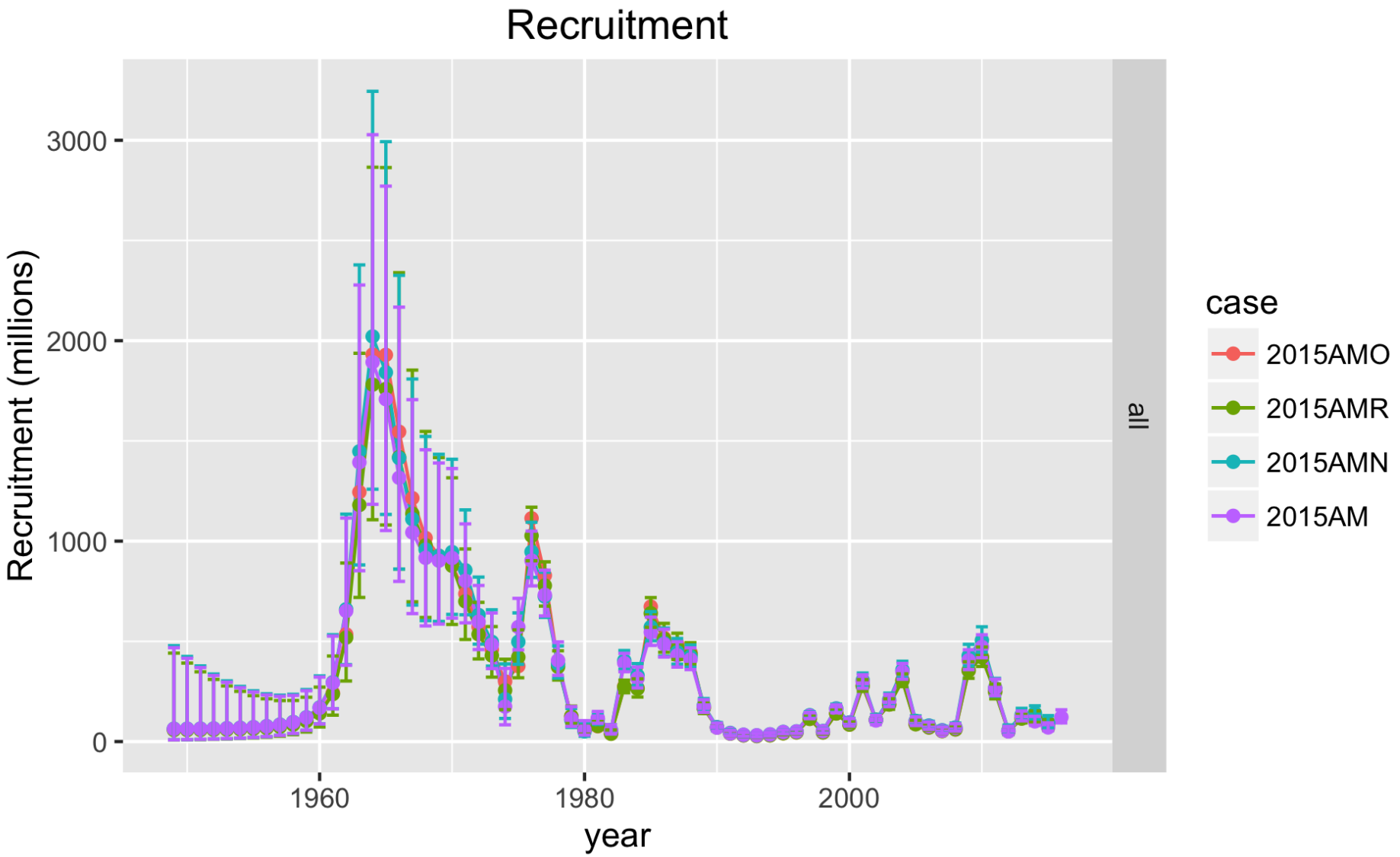
# New CVs vs Old CVs: Directed Fishery Selectivity Functions



# New CVs vs Old CVs: Directed Fishery Selectivity Functions

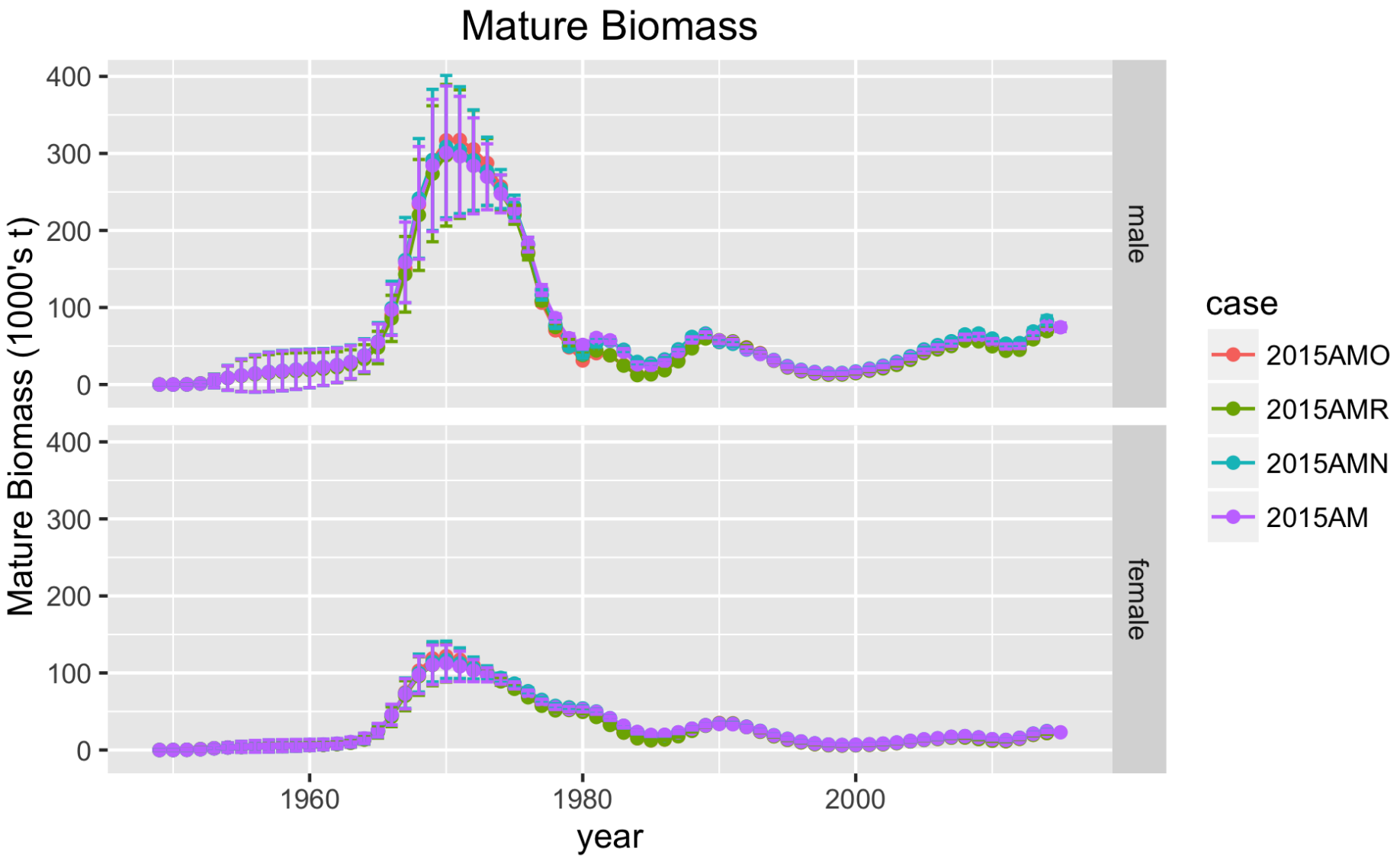


# New CVs vs Old CVs: Recruitment

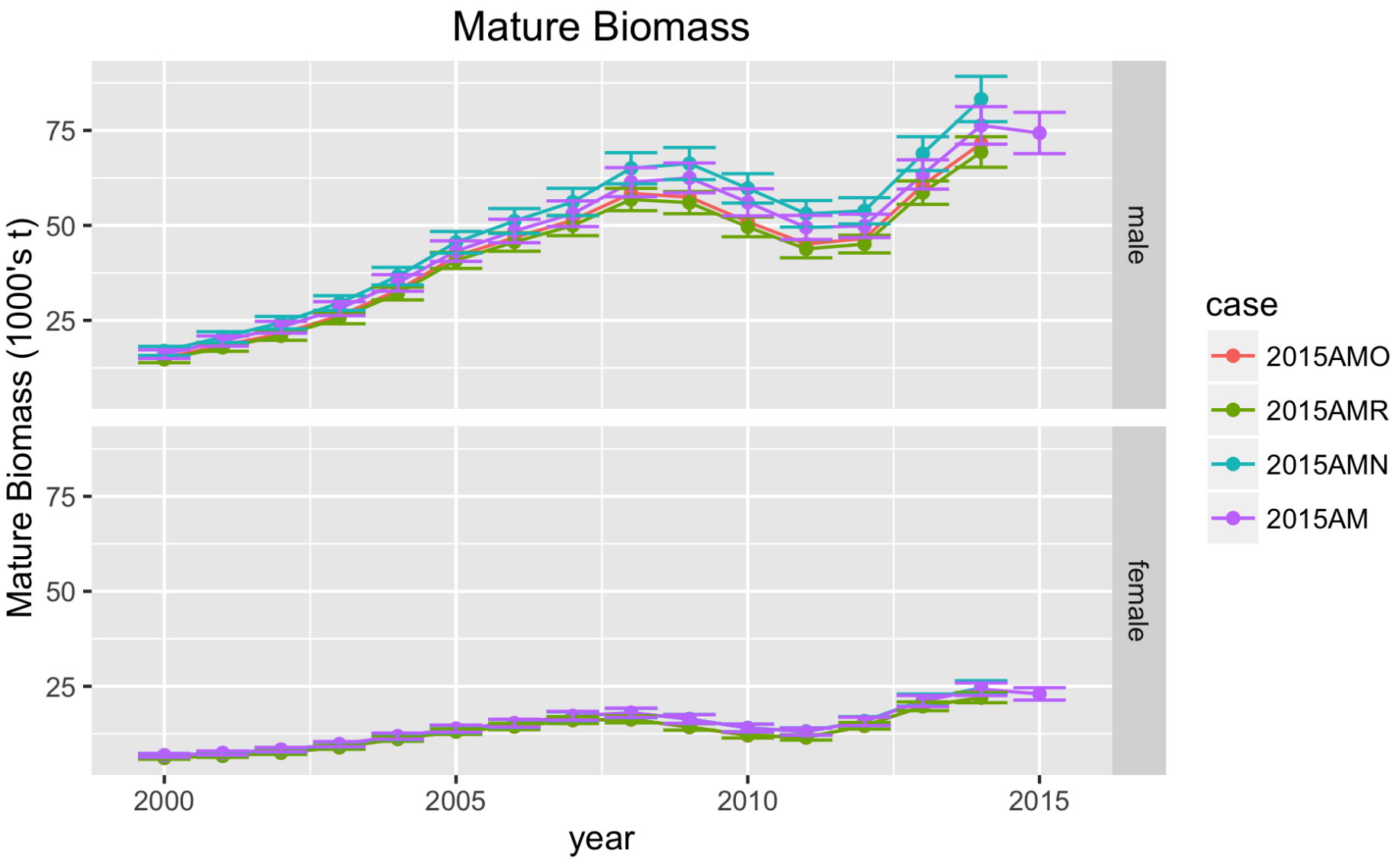


# New CVs vs Old CVs: Recruitment

# New CVs vs Old CVs: MMB



# New CVs vs Old CVs: MMB

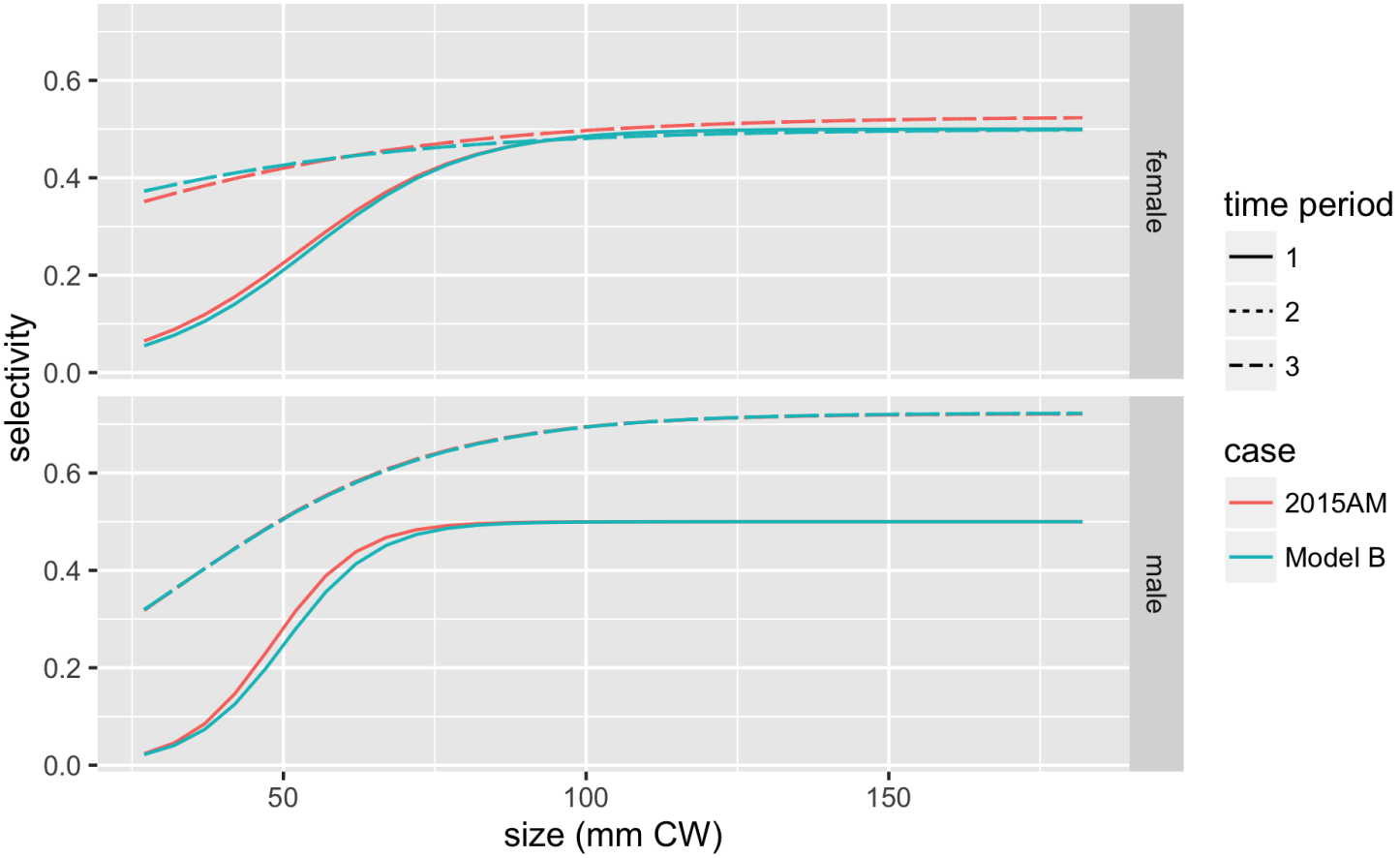


# Model Results: 2015AM To 2016 Base Model (Model B)

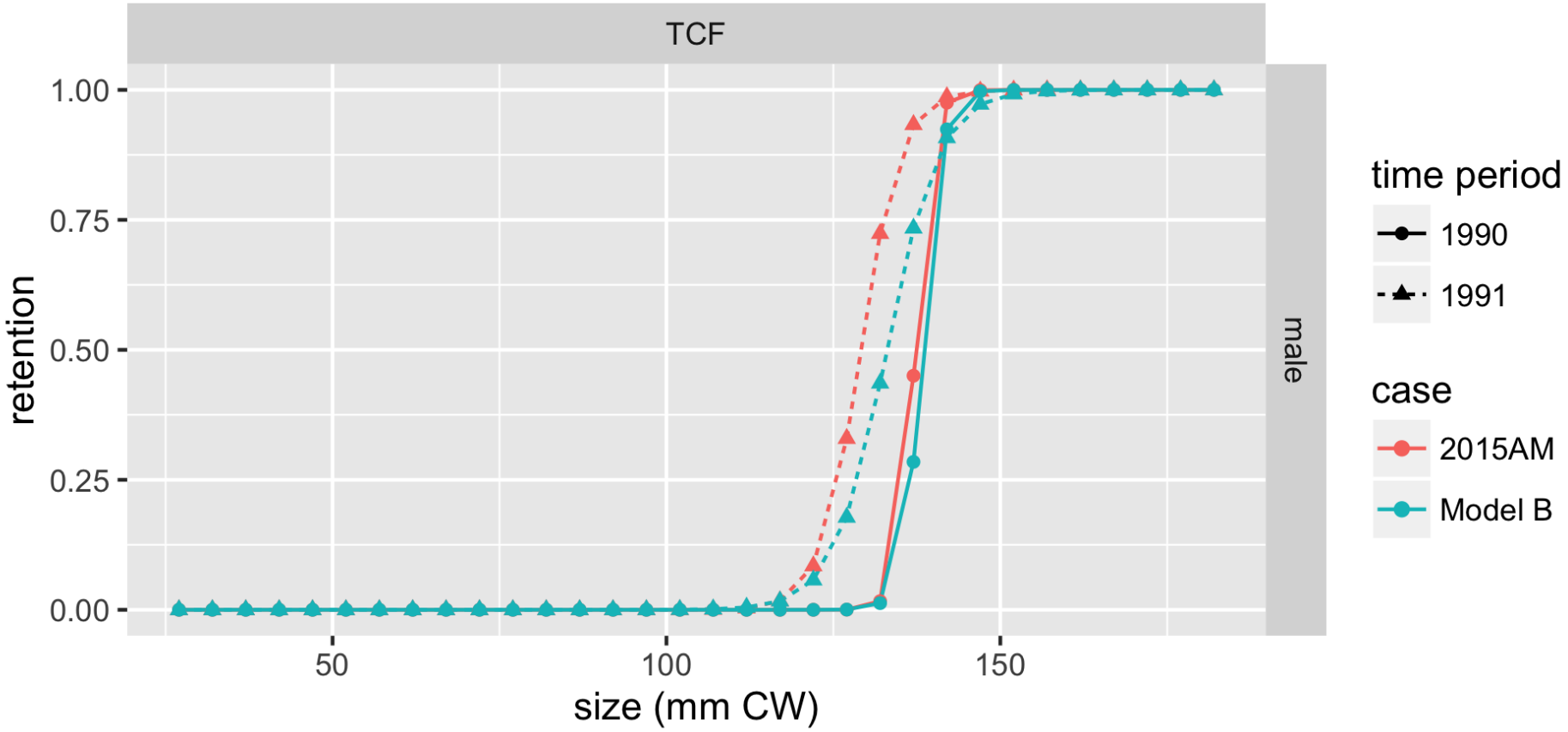
Model B

| Change | Description |
|---|---|
| A | start "current" recruitment estimation in 1975, instead of 1974 |
| B | normalize groundfish fishery size comps using original sample sizes, not input sample sizes |
| C | estimate log-scale fishing mortality/capture rate offsets for female crab |
| E | turn on fishing mortality/capture rate estimation for BBRKC |
| G | estimate probability of molt-to-maturity using logit-scale parameterization |
| I | enforce logistic selectivity = 1 in largest size bin |
| J | use GMACS fishing mortality model |

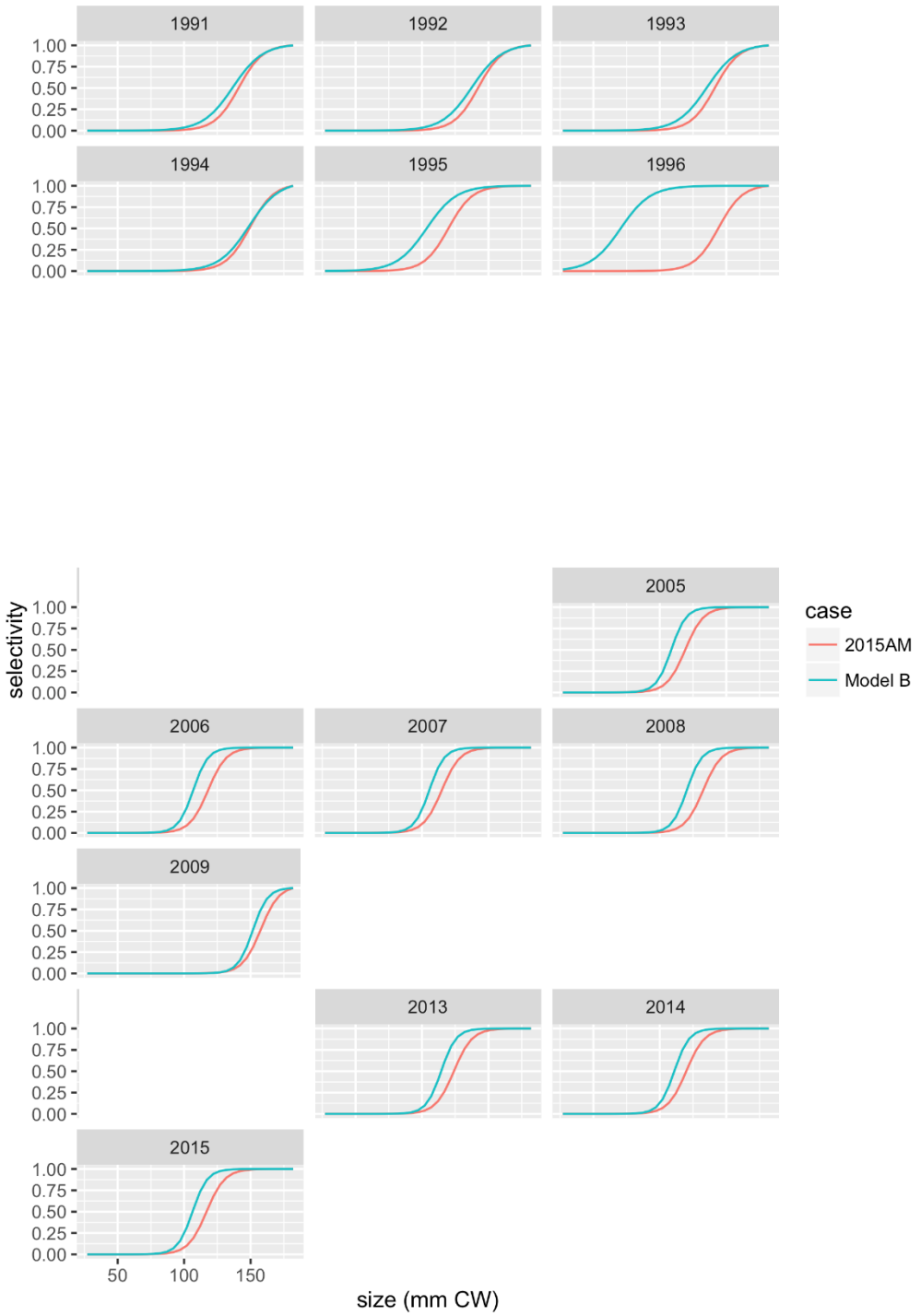
# 2015AM To Model B: Survey Selectivity



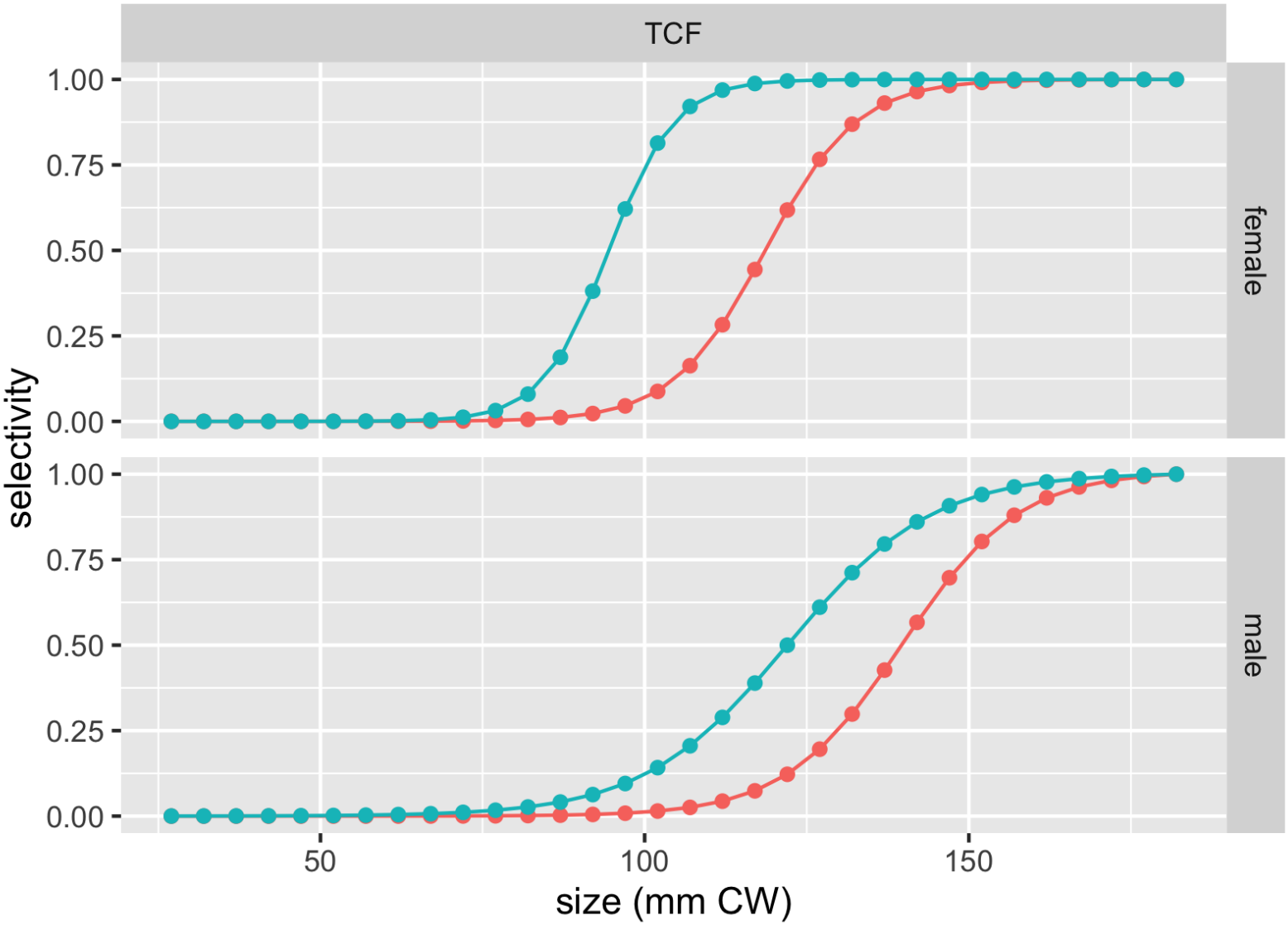
# 2015AM To Model B: Directed Fishery Retention



# 2015AM To Model B: Directed Fishery Male Selectivity



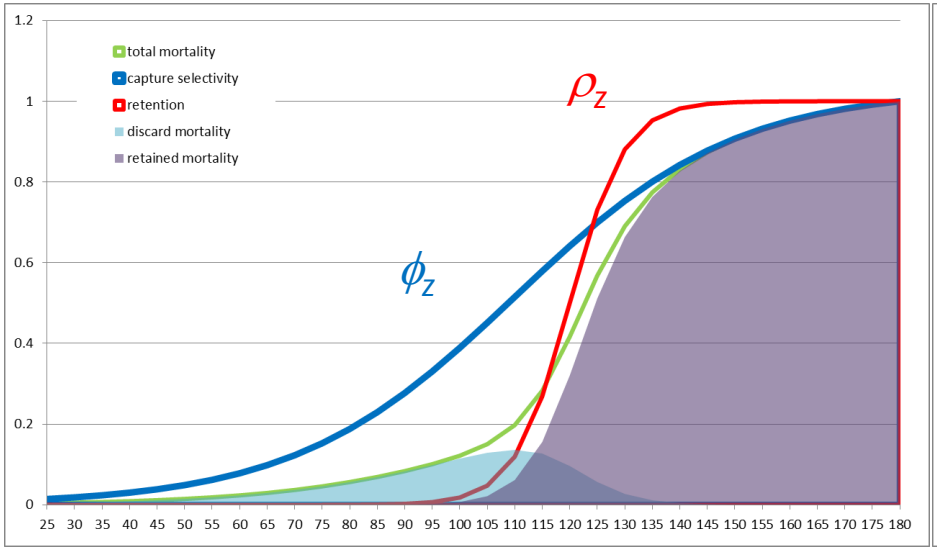
# 2015AM To Model B: Directed Fishery Selectivity



# Gmacs vs. TCSAM2013 Fishing Mortality & "Selectivity"

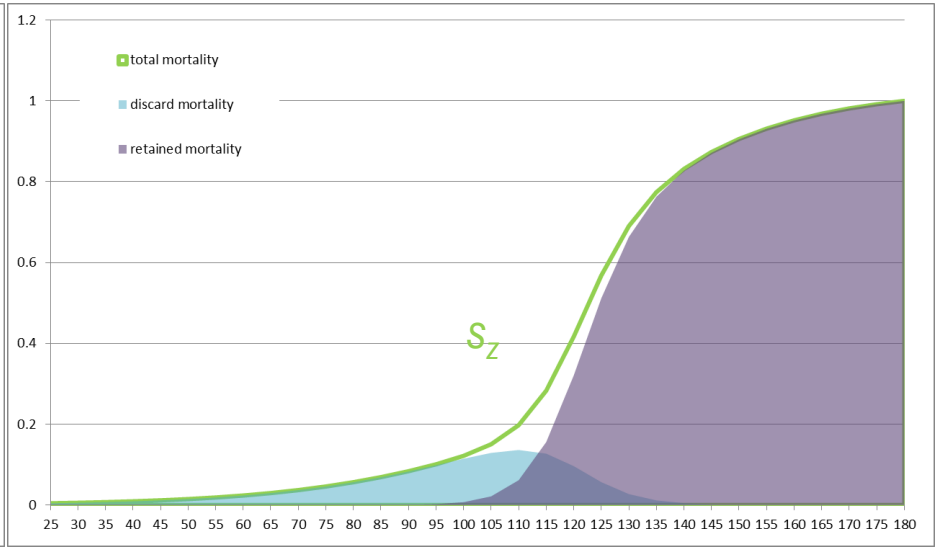
Gmacs

$$F_z = [h_m \cdot (1 - \rho_z) + \rho_z] \cdot \phi_z \cdot \kappa$$

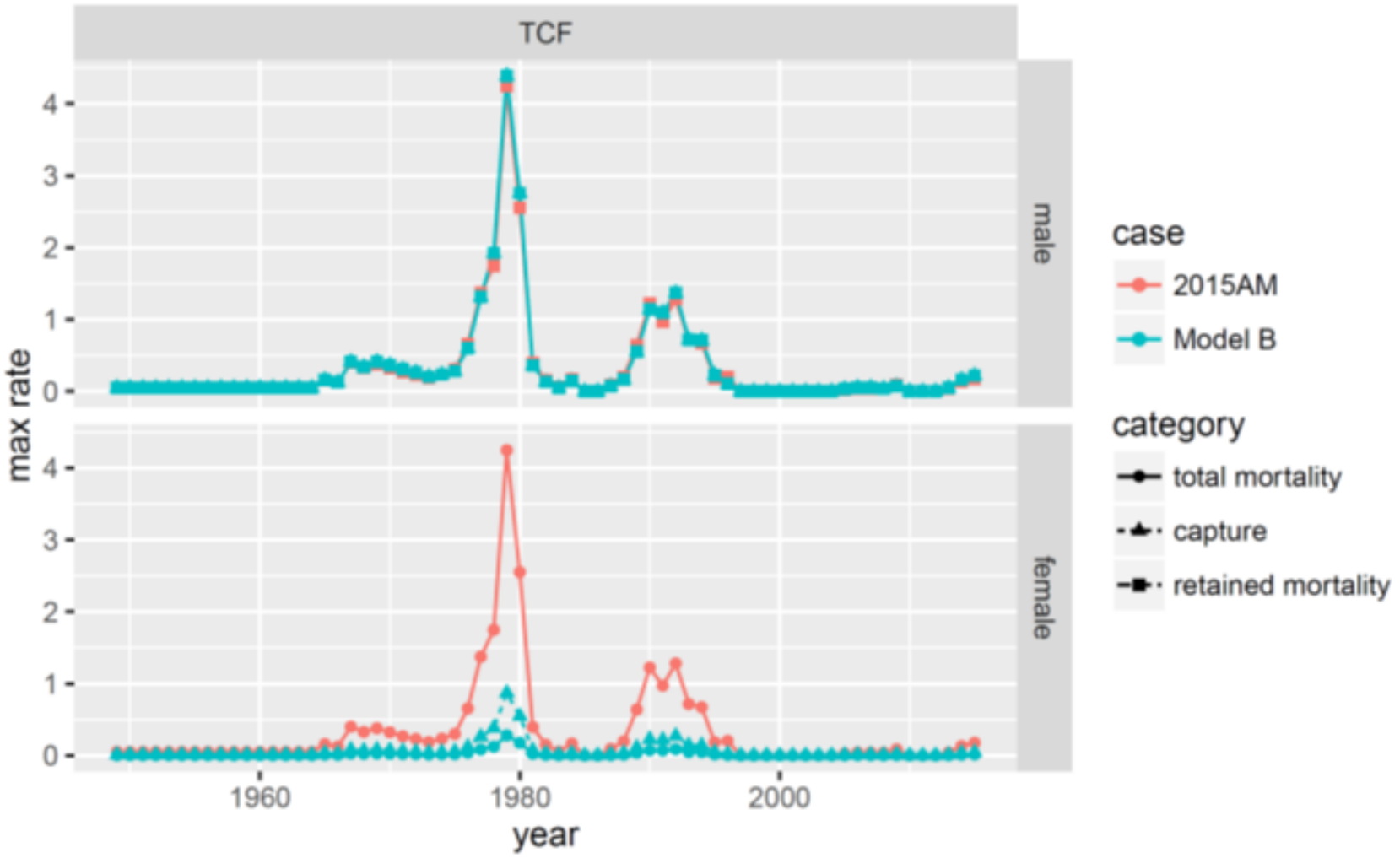



TCSAM2013

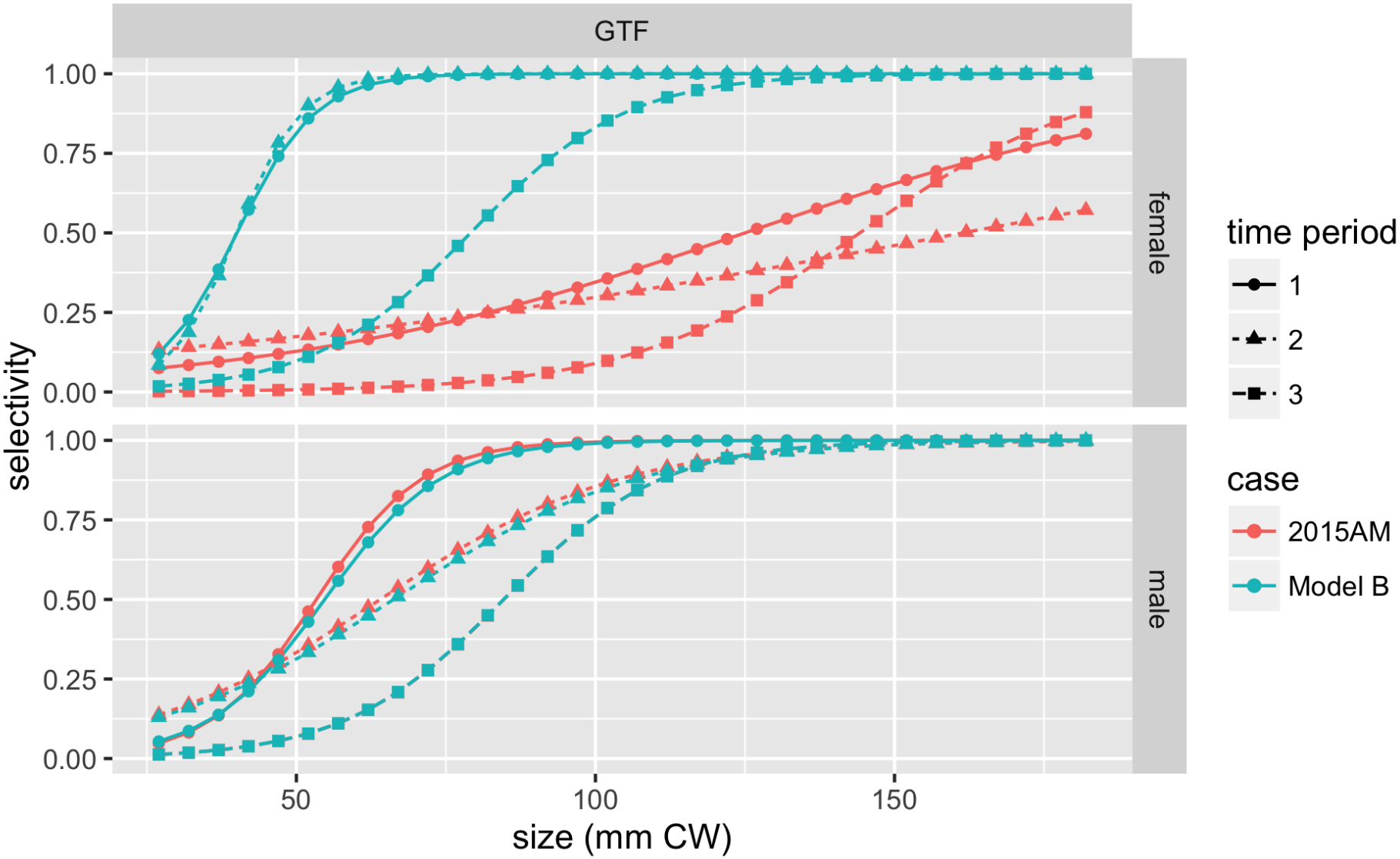
$$F_z = s_z \cdot F$$



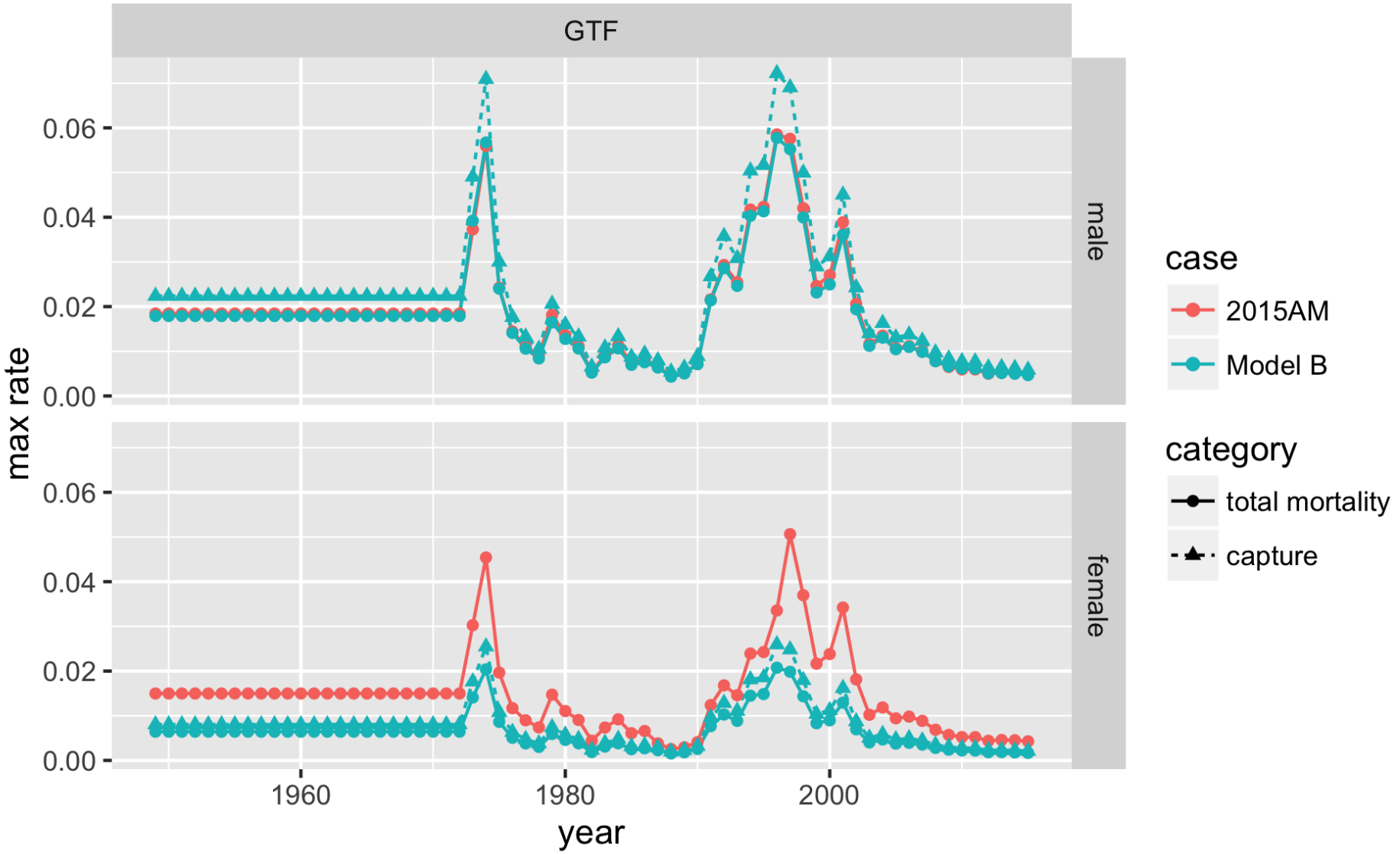
# 2015AM To Model B: Directed Fishery Fully-selected Rates



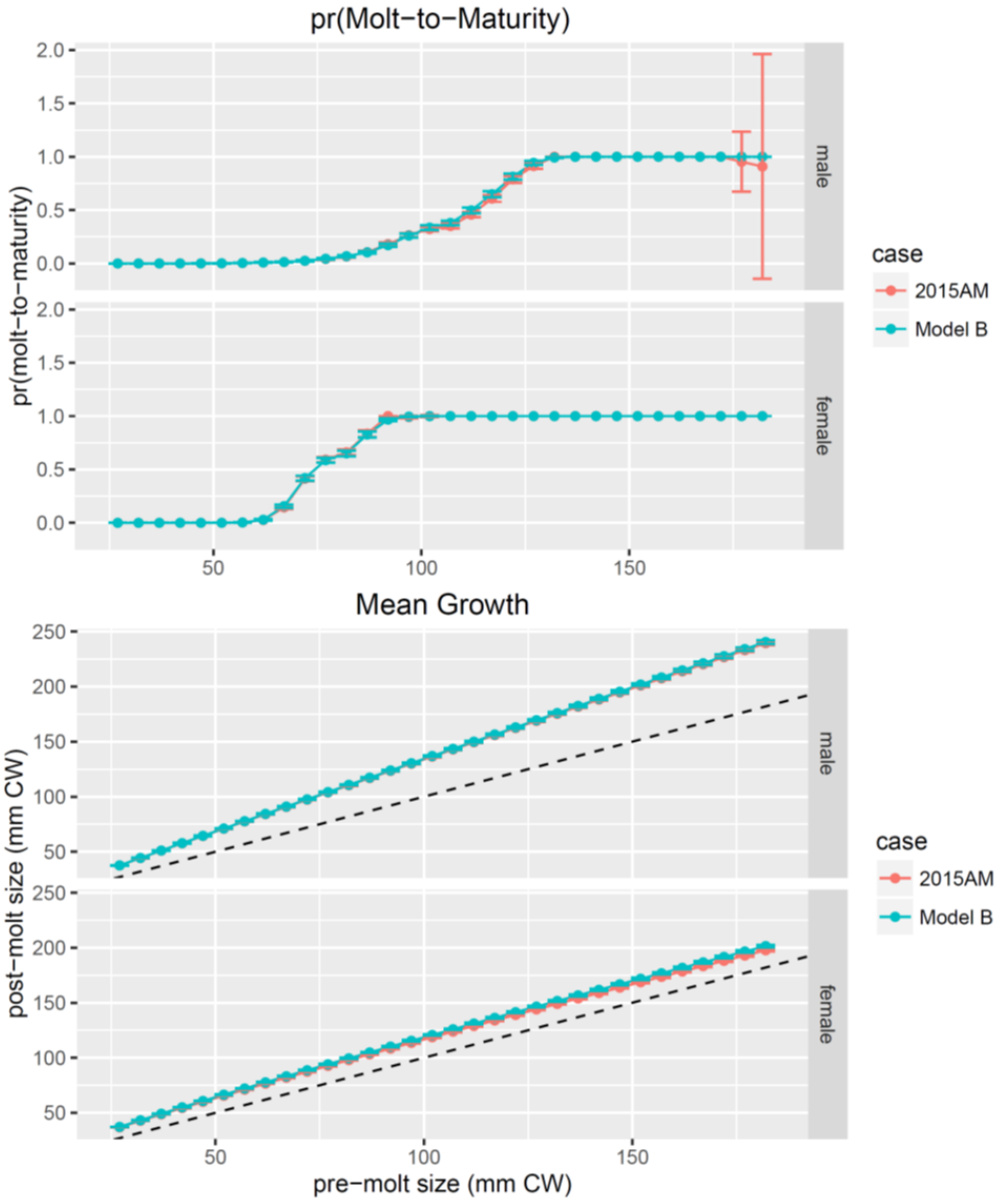
# 2015AM To Model B: Groundfish Fisheries Bycatch Selectivity



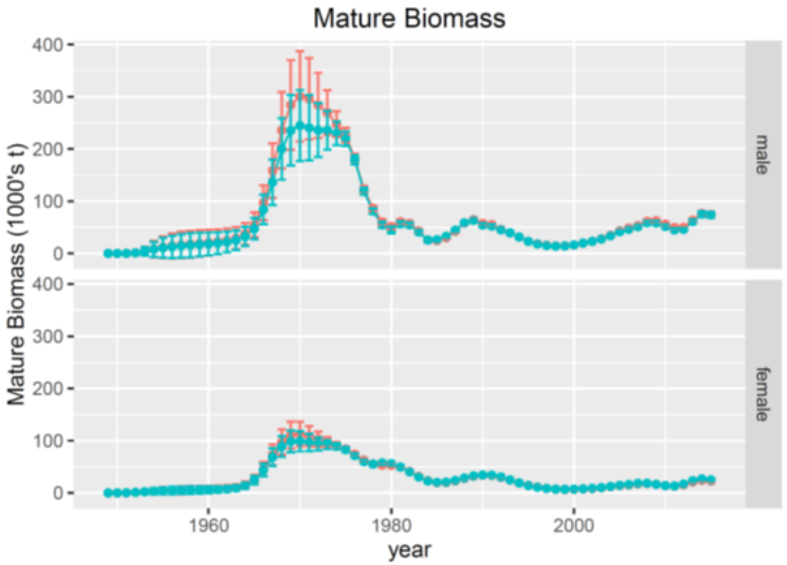
# 2015AM To Model B: Groundfish Fisheries Bycatch Rates

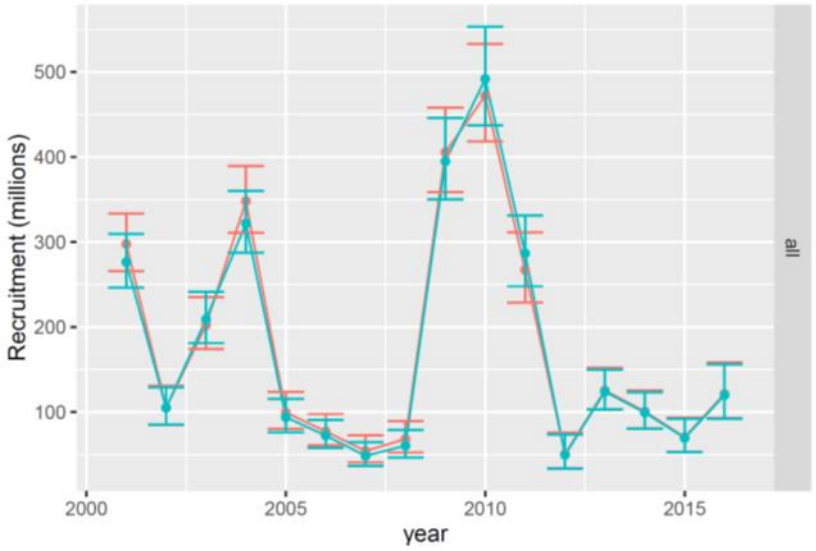


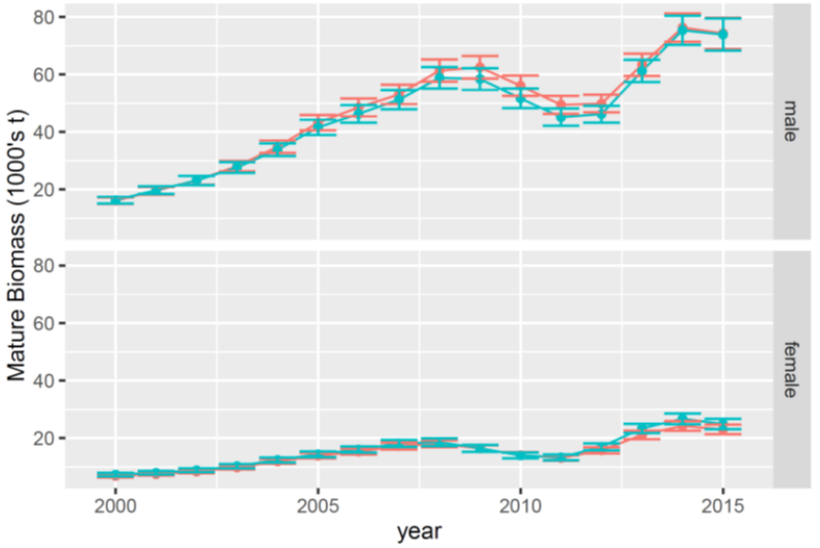
# 2015AM To Model B: Population Processes

# 2015AM To Model B: Population Quantities

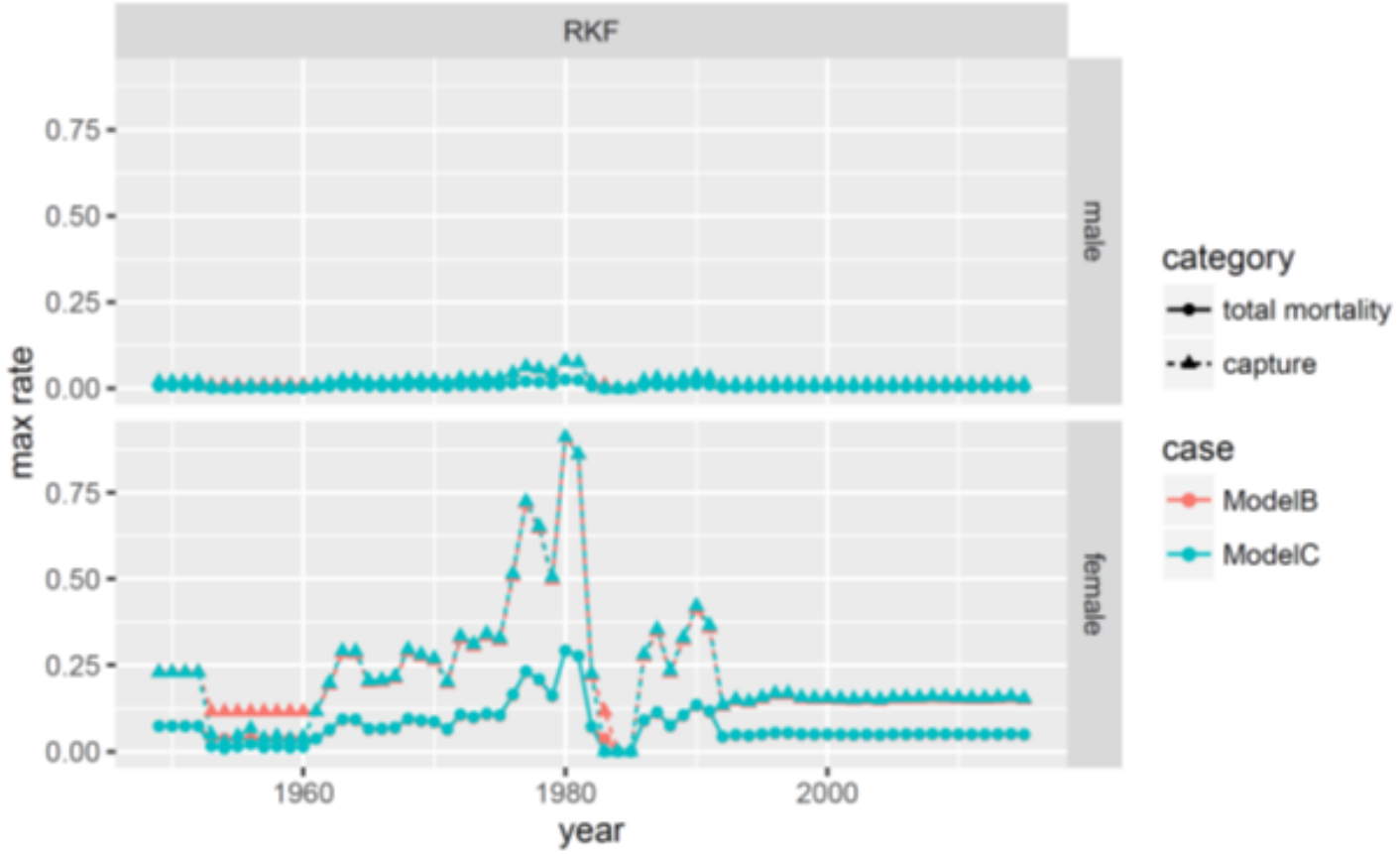



# Model Results: Model B vs. Model C

- Model C = Model B + no min F's for BBRKC bycatch rates




- Otherwise, results for Model C practically identical to Model B

# Model Results: Model C vs. Models D, E, F, G

| Scenario | Description |
|---|---|
| Model C | Model B + no minimum F's imposed on BBRKC fishery bycatch |
| Model D | Model C + effort extrapolation parameters estimated |
| Model E | Model D + penalty on F-devs reduced to 0 in final estimation phase |
| Model F | Model D + lognormal likelihoods assumed for fishery catch data (change L0 from May) |
| Model G | Model E + lognormal likelihoods assumed for fishery catch data (change L0 from May) |

Effort extrapolation: F = q E

Model C (and previous)

$$q = \frac{\sum_y E_y}{\sum_y F_y} \qquad y > 1991$$

$$F_y = q \cdot E_y \qquad y < 1992$$

Model D (and subsequent)

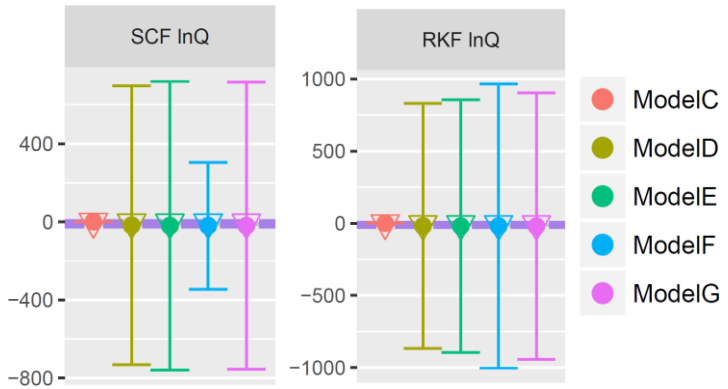
*lnQ* is an estimated *parameter* based on minimizing the objective function

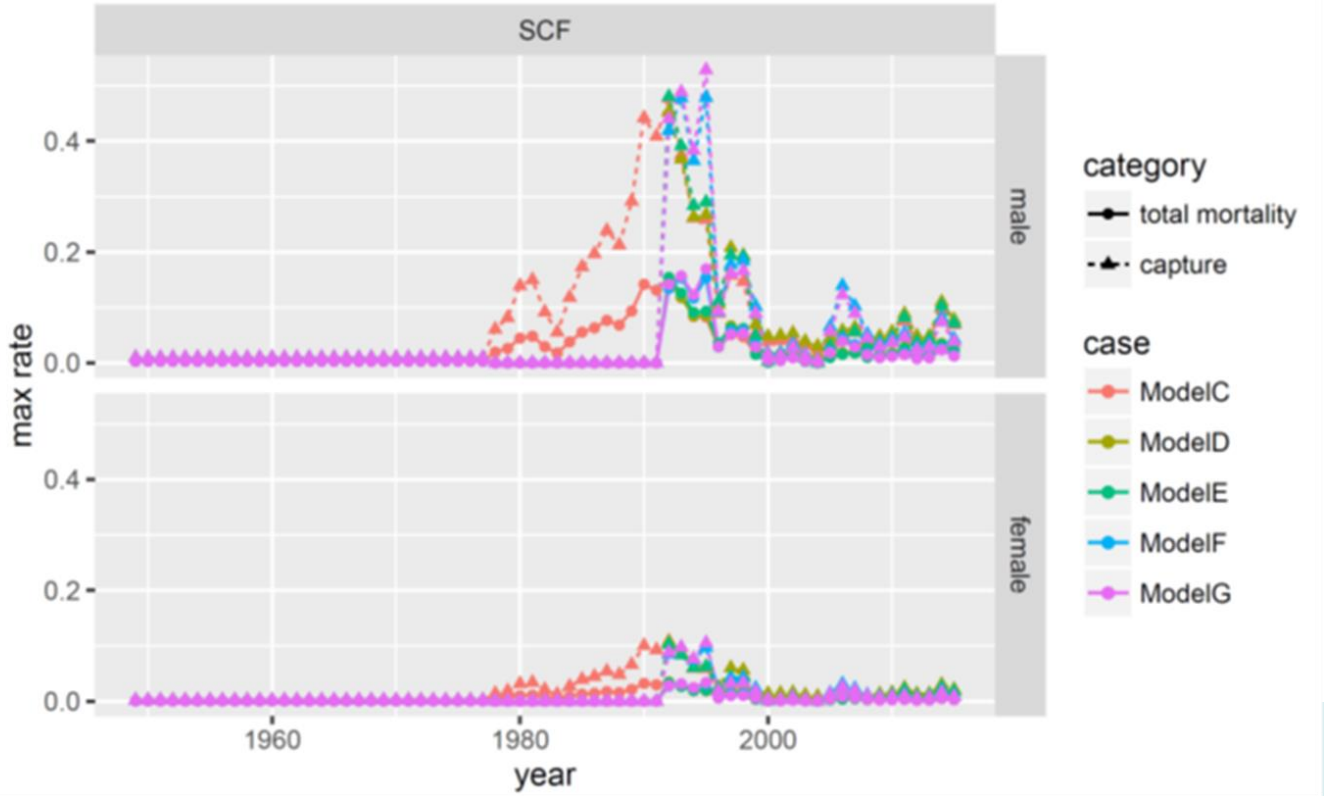
$$F_y = e^{lnQ} \cdot E_y \qquad y < 1992$$

# Model Results: Model C vs. Models D, E, F, G

Estimated effort extrapolation (Fishery q's)

| Fishery | Model C | Model D | Model E | Model F | Model G |
|---|---|---|---|---|---|
| BBRKC | 0.01 | 9.61E-09 | 2.57E-09 | 4.23E-09 | 2.59E-09 |
| snow crab | 0.11 | 1.82E-08 | 2.44E-09 | 2.44E-09 | 2.47E-09 |



# Model Comparisons: Summary & Author's Preferred Model

## Summary

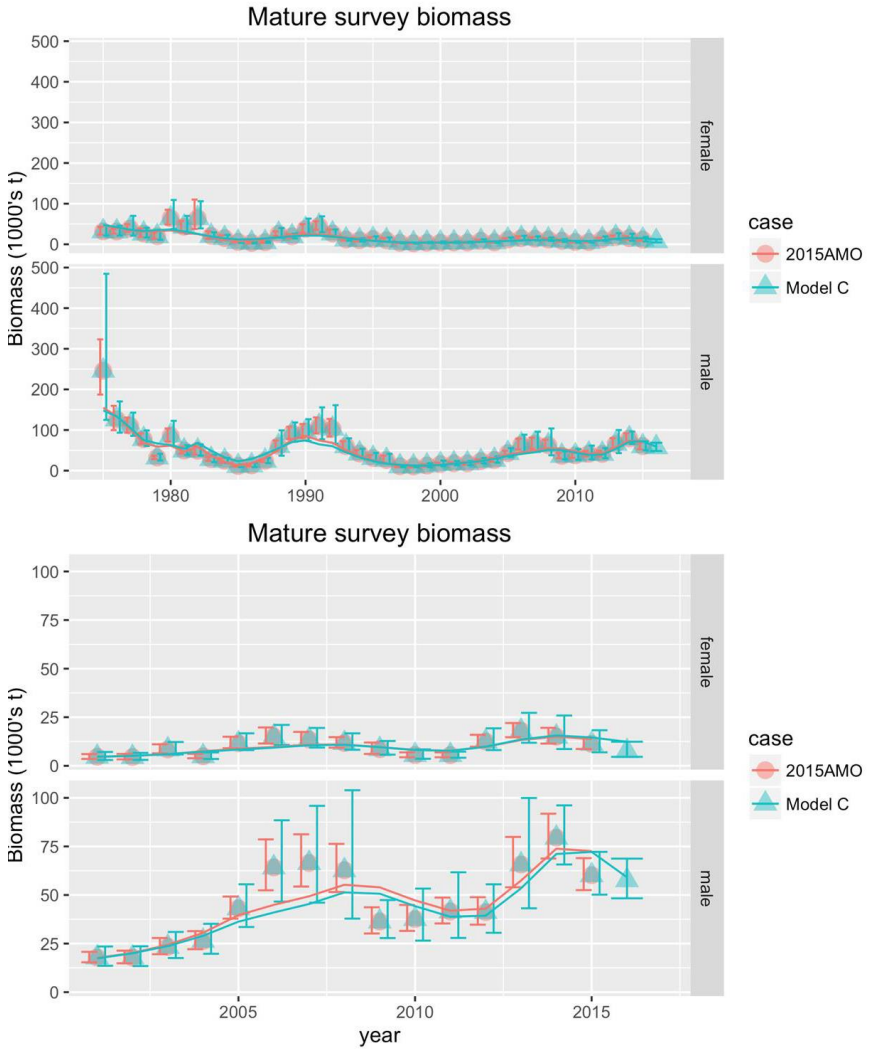
- Using new mature survey biomass CV's increased recruitment, MMB 10-15%
- Many model changes from 2015AM to Model B (Base Model), but almost no differences in population estimates (recruitment, MMB)
- Results from Models B and C almost identical
- Models D, E, F, G based on questionable effort extrapolation parameter values, unsure how this affects overall model performance. Needs further work.

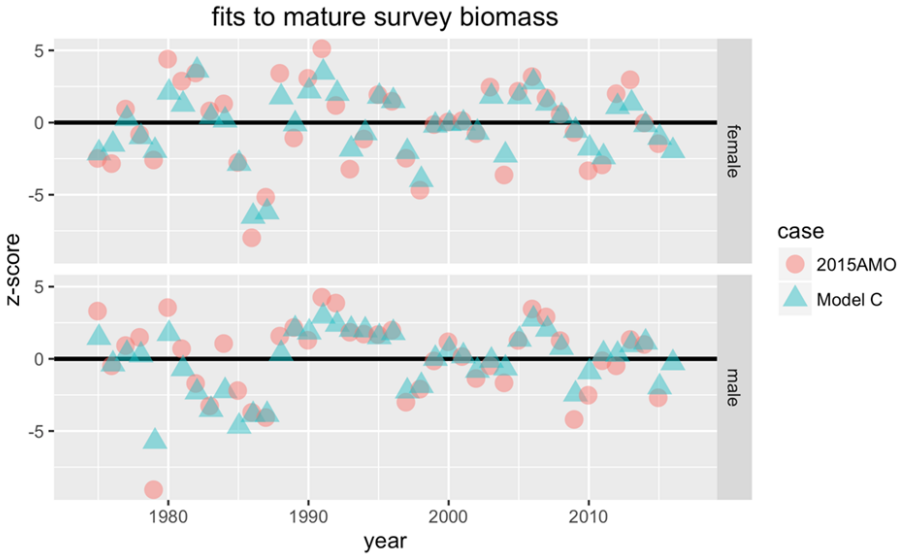
## Author's preferred model

- Model C (CPT Base Model + min F constraints in BBRKC fishery removed)

# 2015 Assessment Model vs. Model C (Preferred Model)

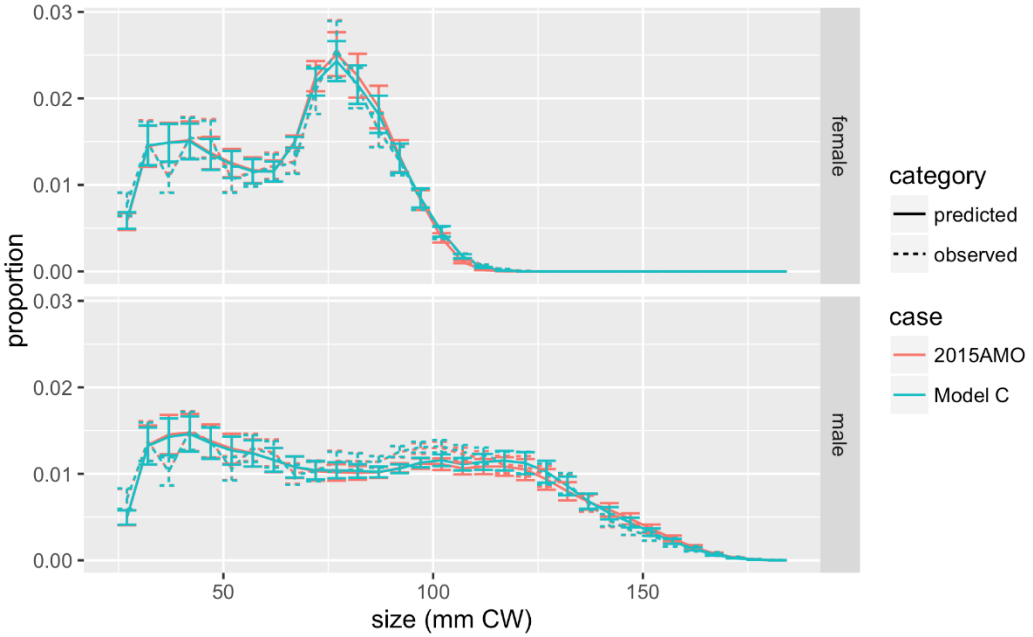
# Fits to survey data

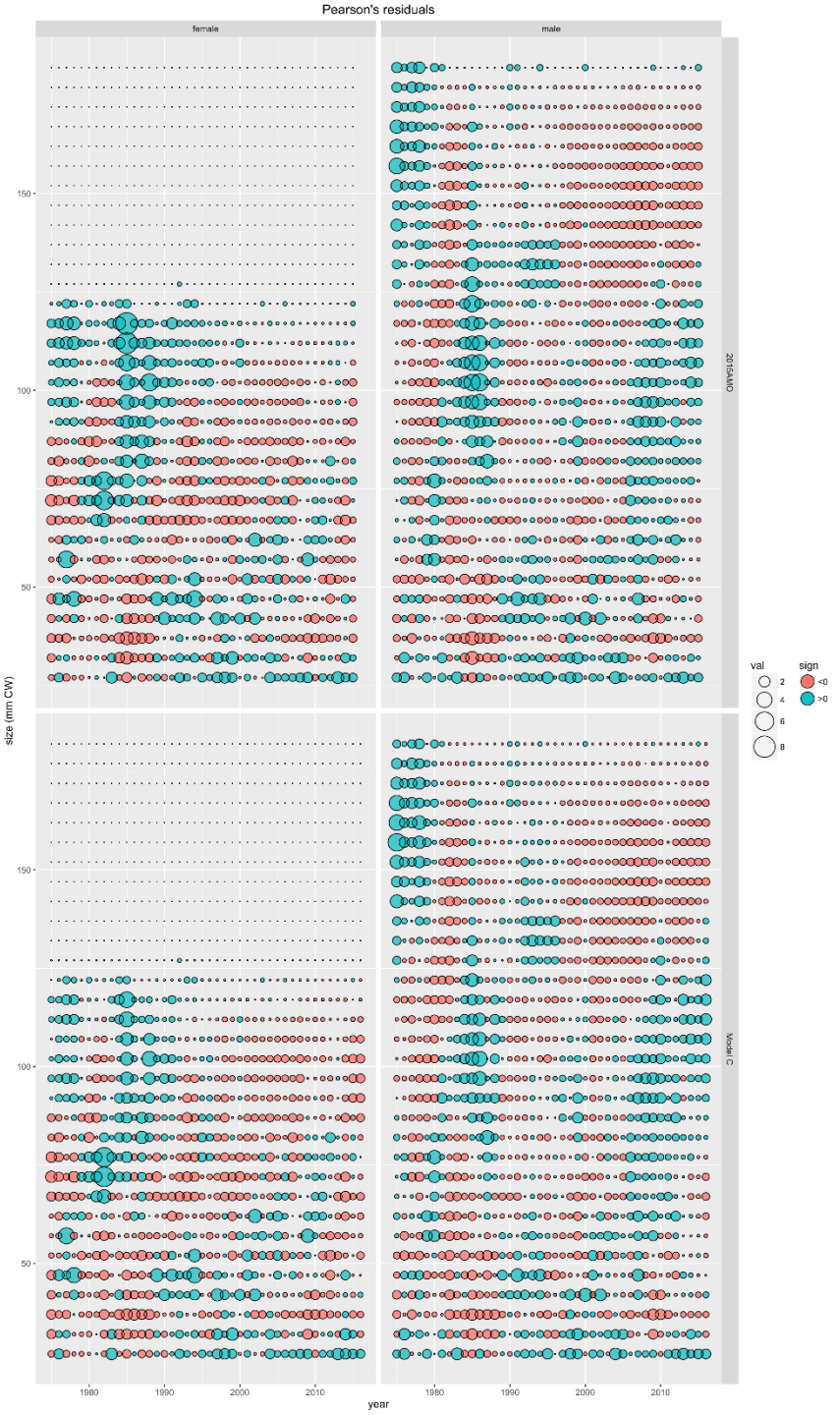


# Fits to survey data

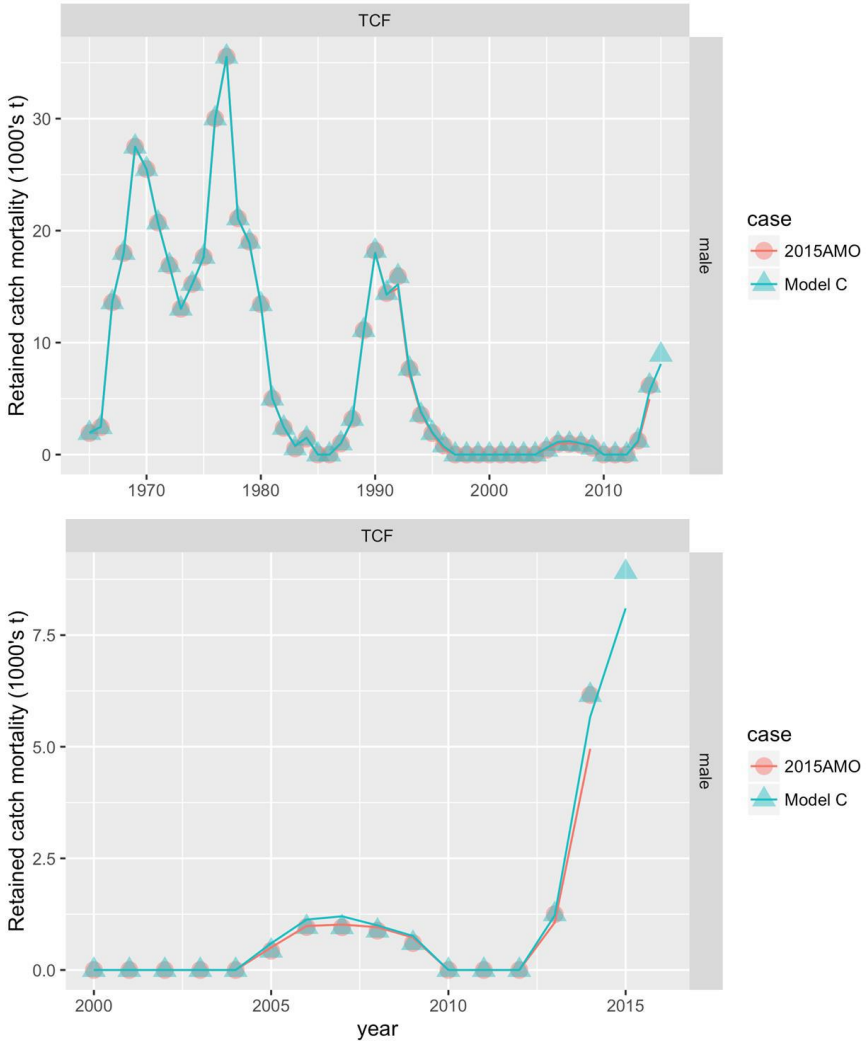

# Fits to survey data



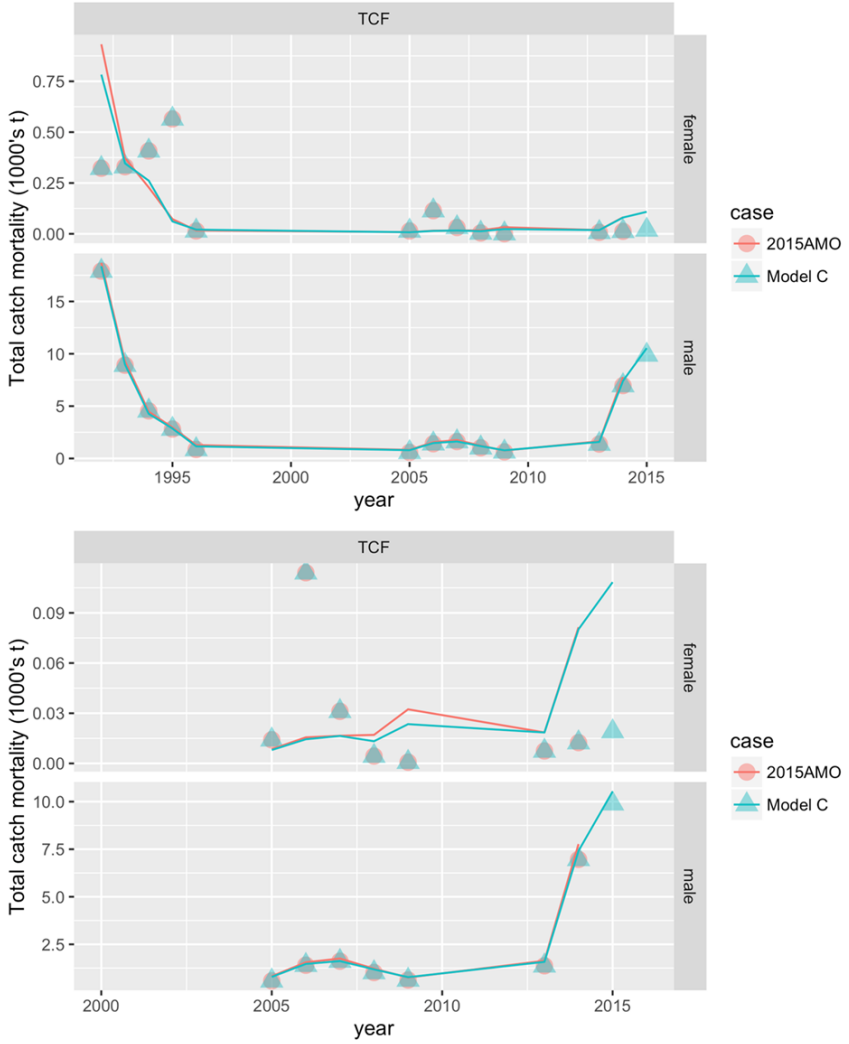



# Fits to fishery data

## Retained catch

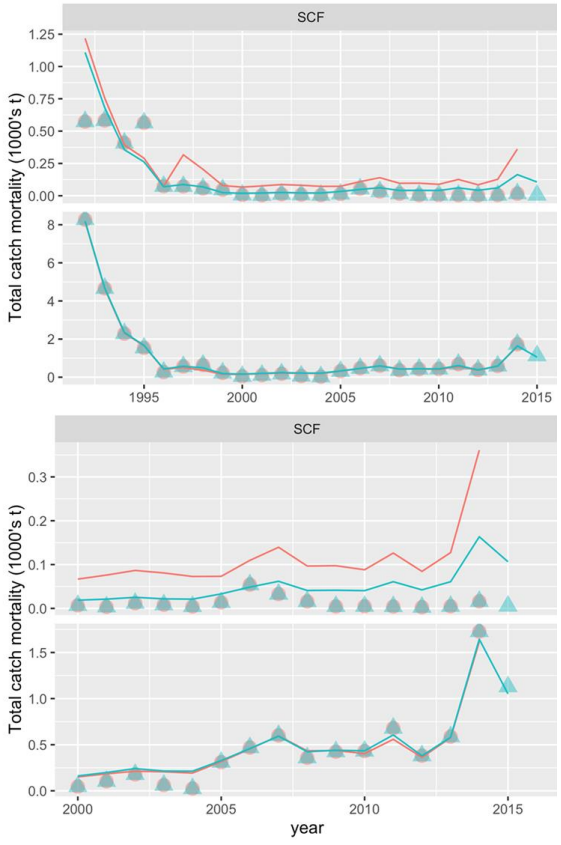



## Total catch in directed fishery

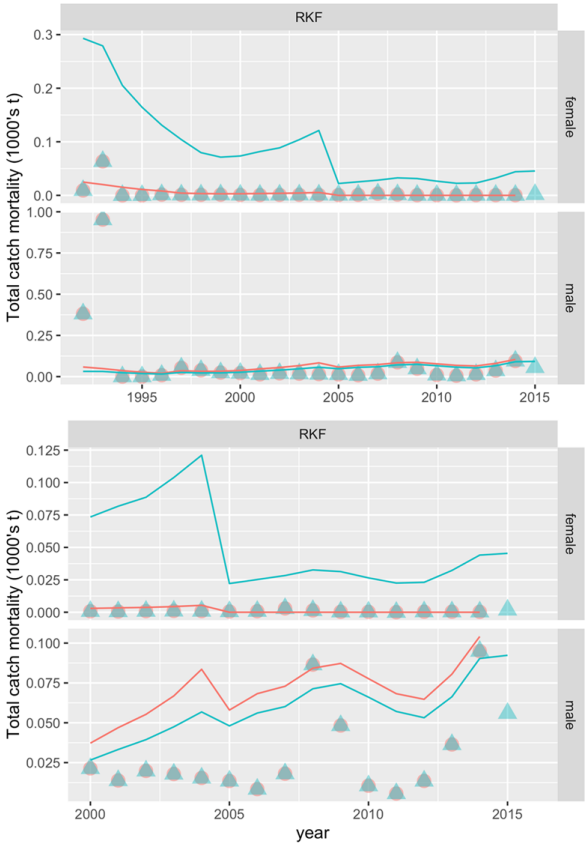


# Fits to fishery data

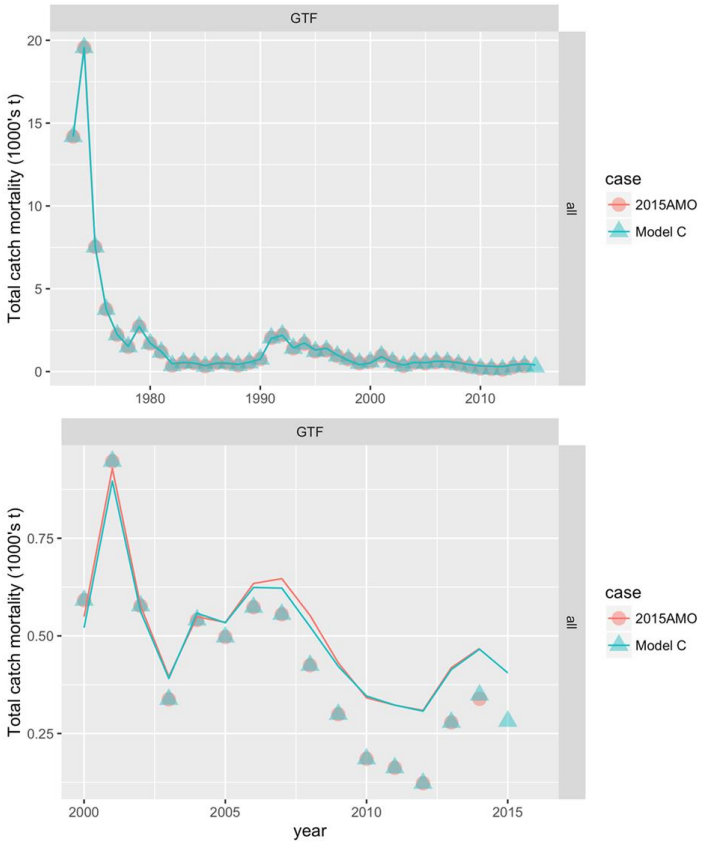
## Snow crab fishery



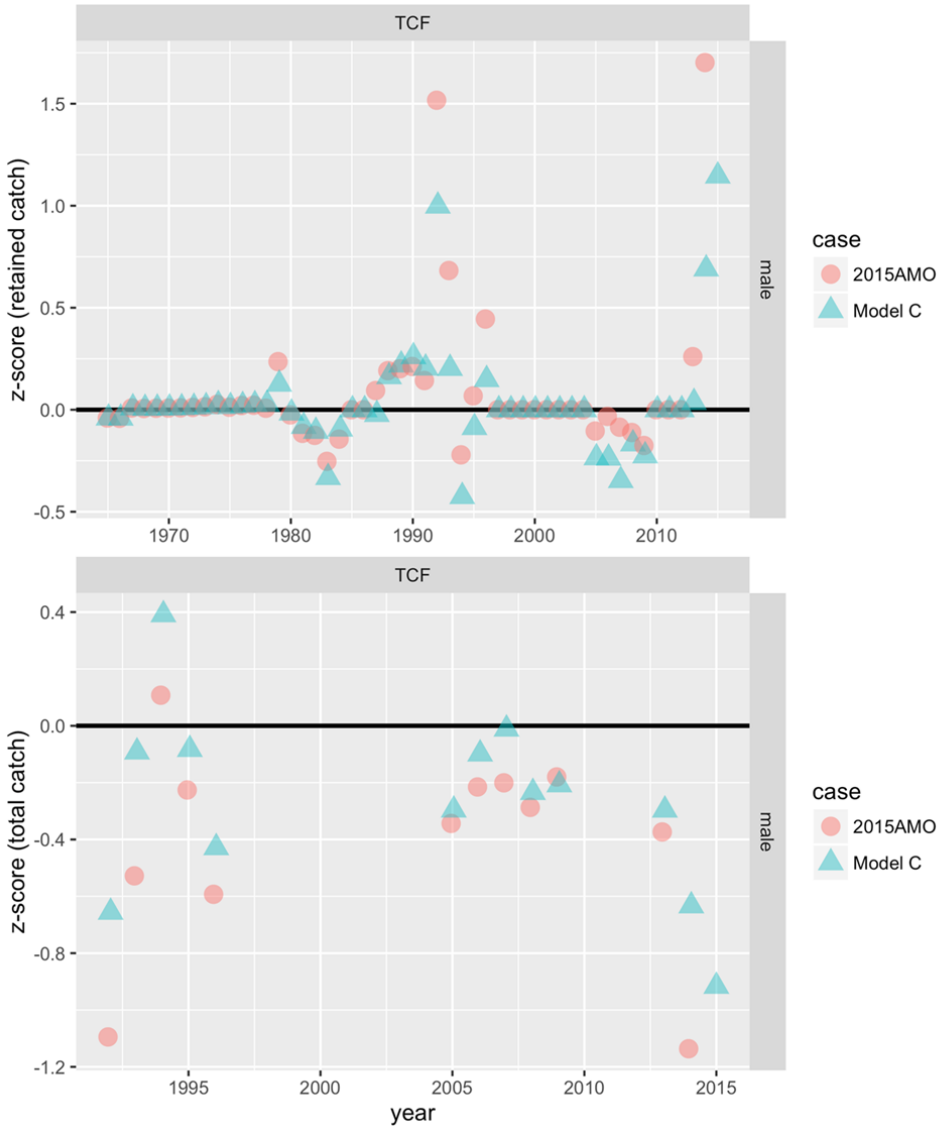

## BBRKC fishery

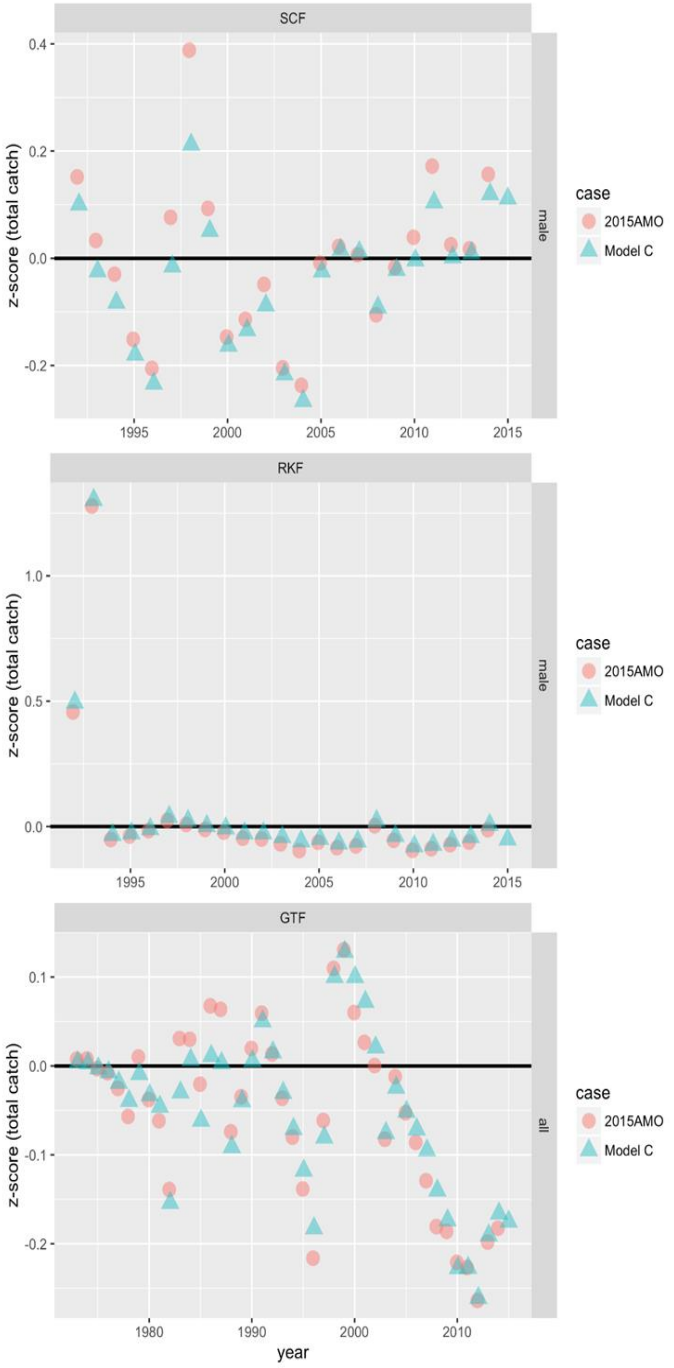



## Groundfish fisheries

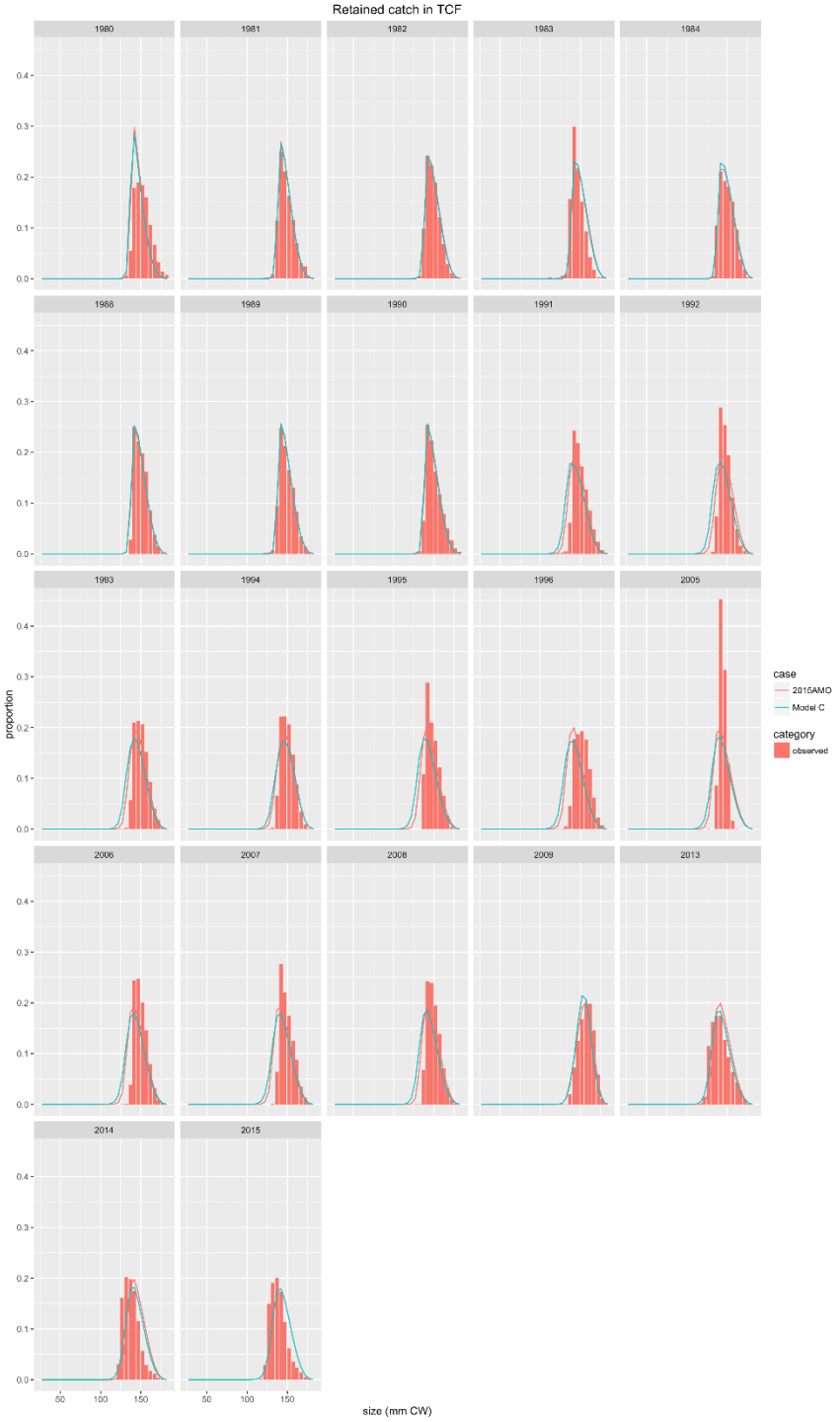


# Fits to fishery data



# Tanner crab fishery
# Retained catch

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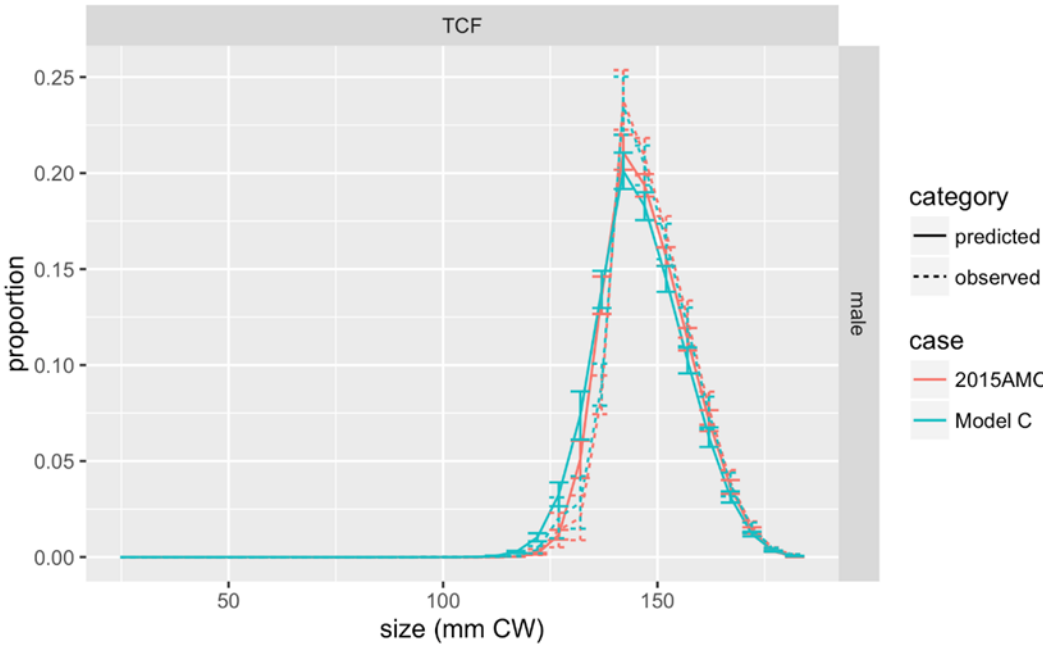
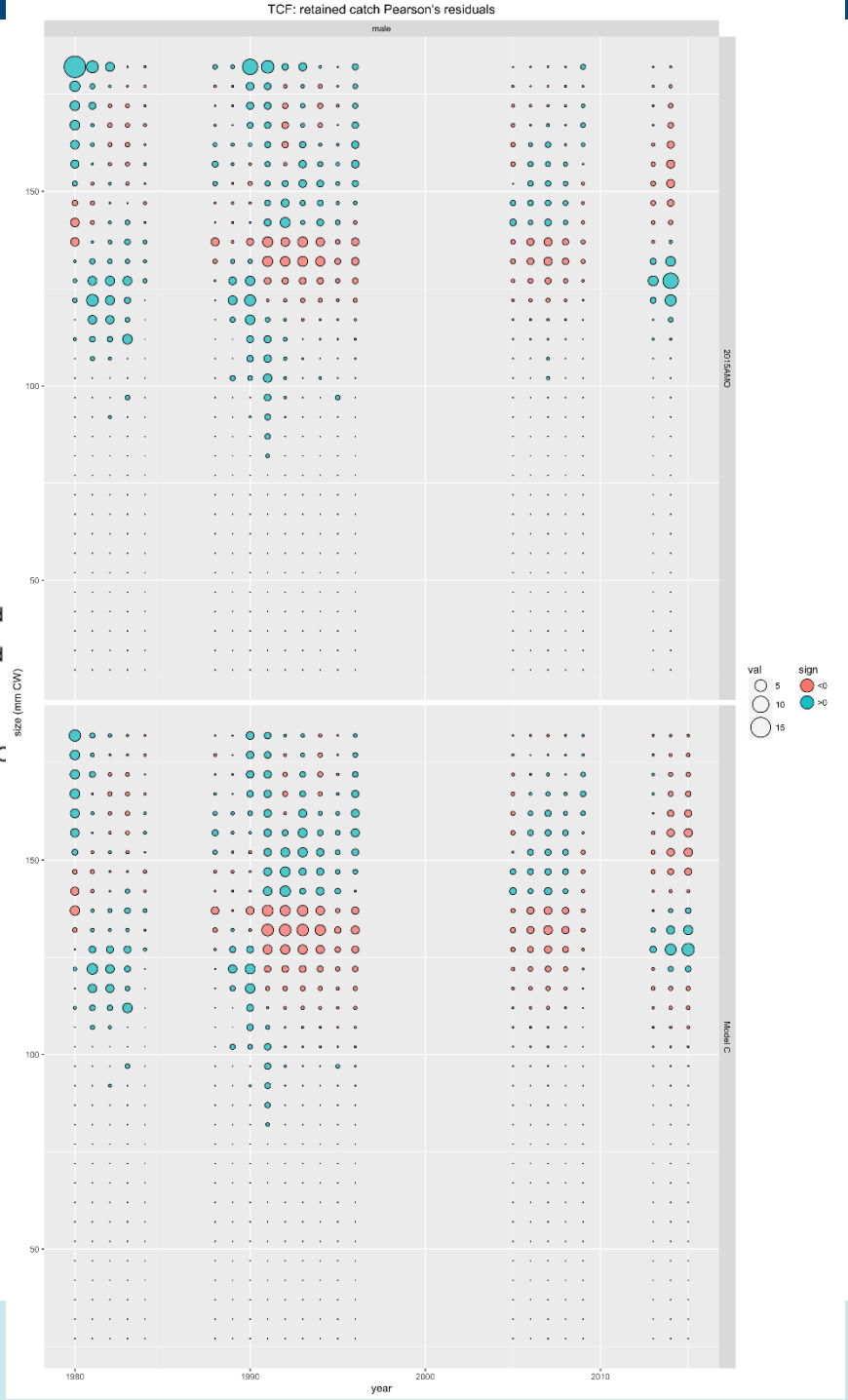
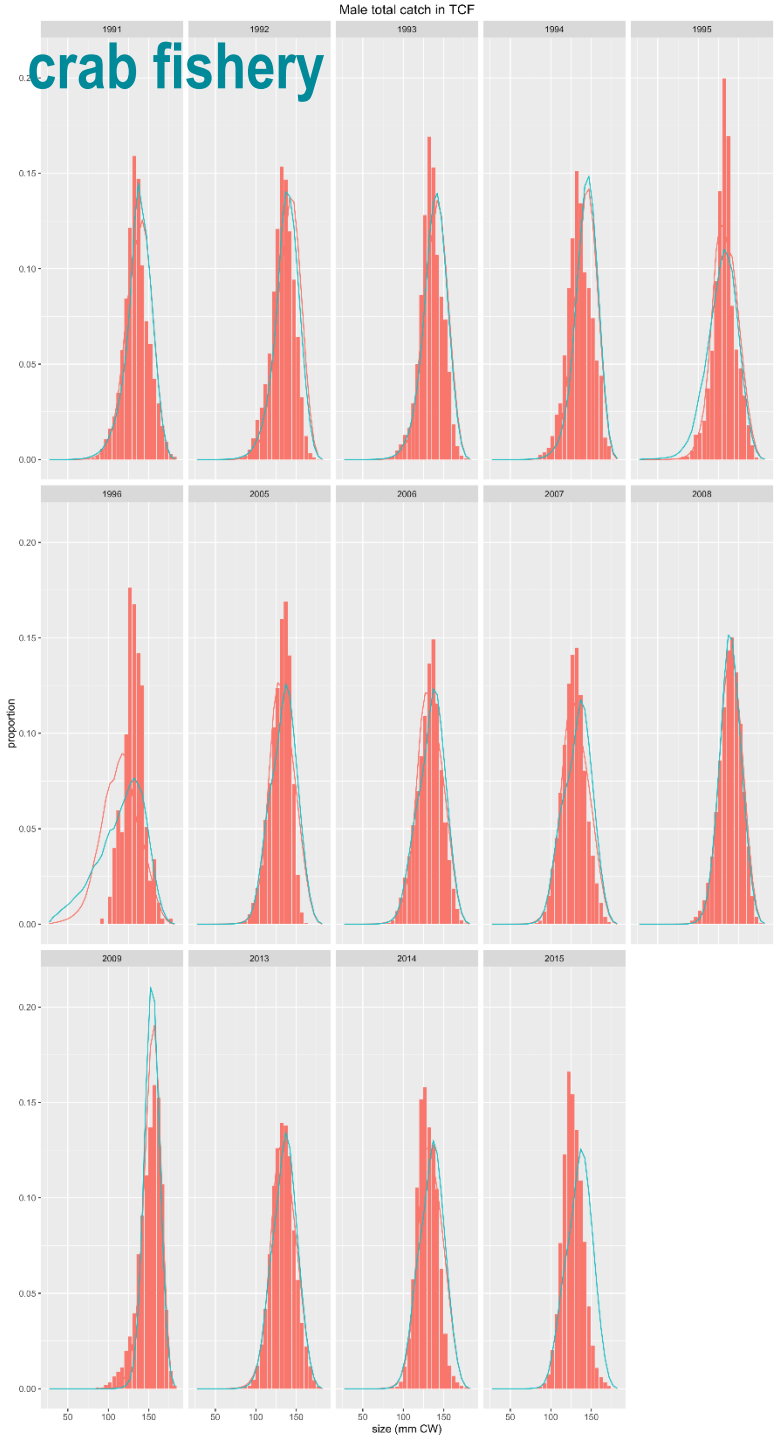
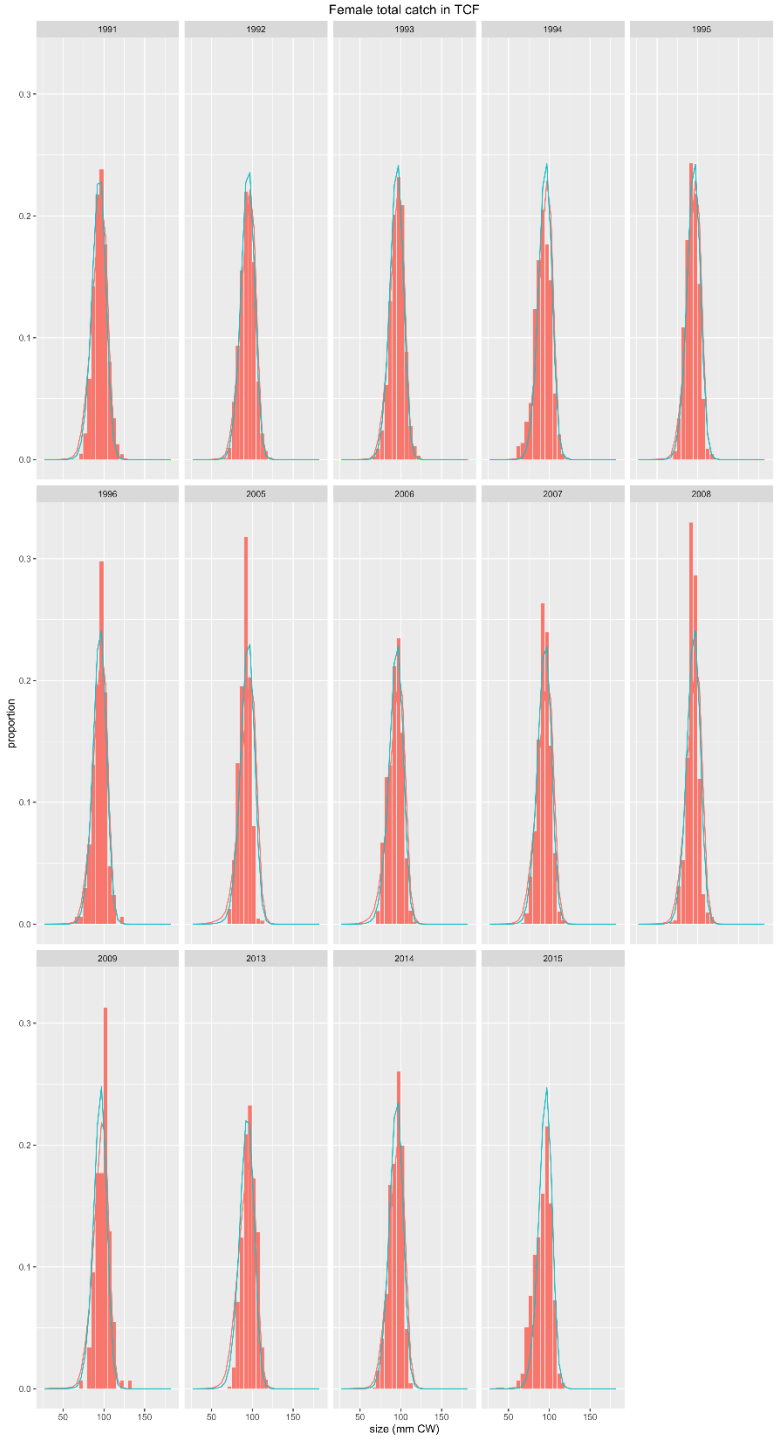
# Tanner crab fishery



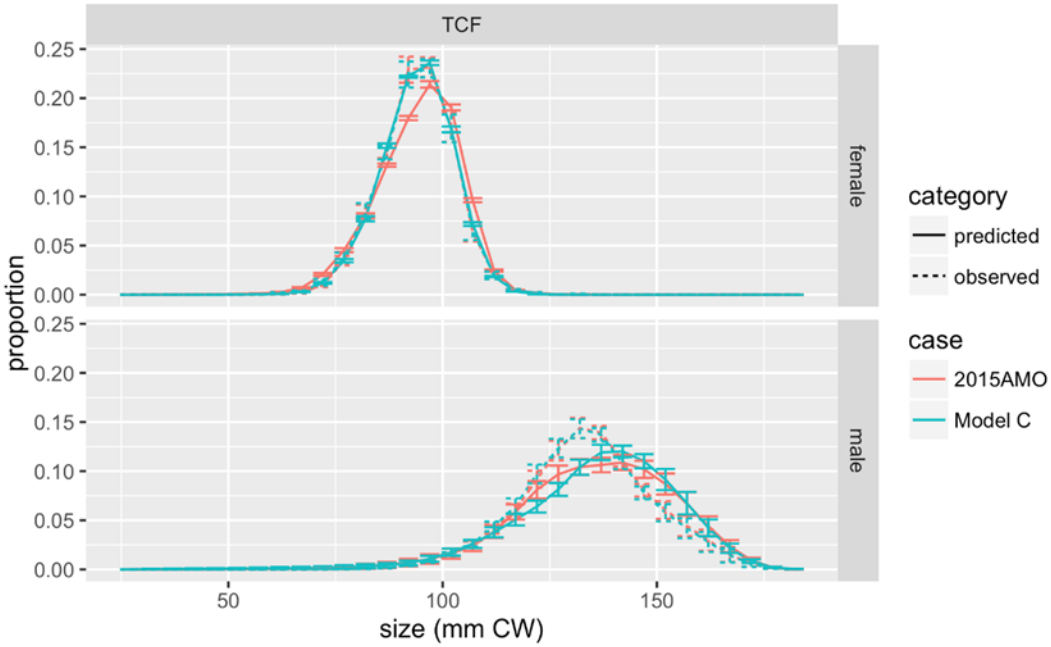



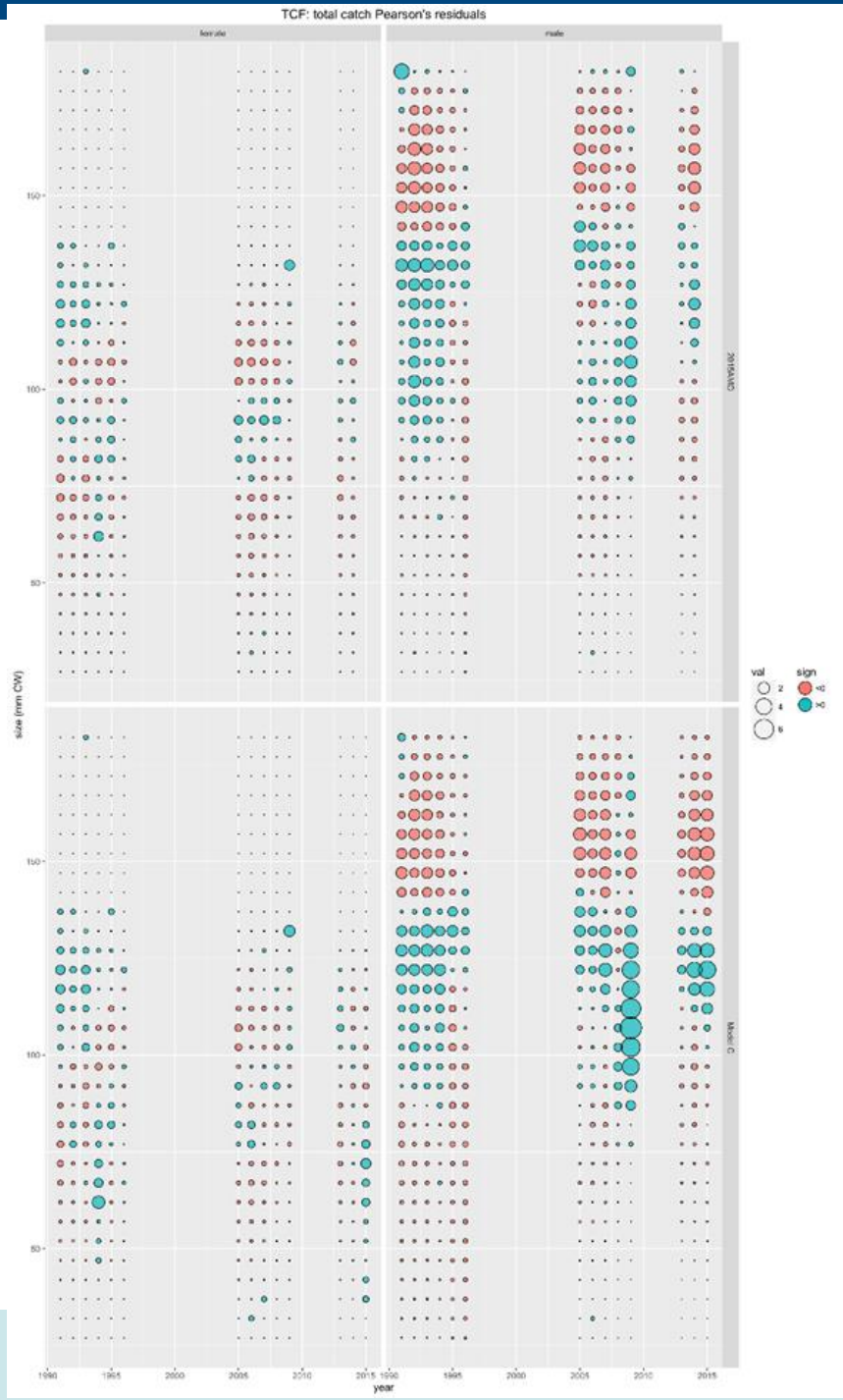
# Tanner crab fishery



# Tanner crab fishery

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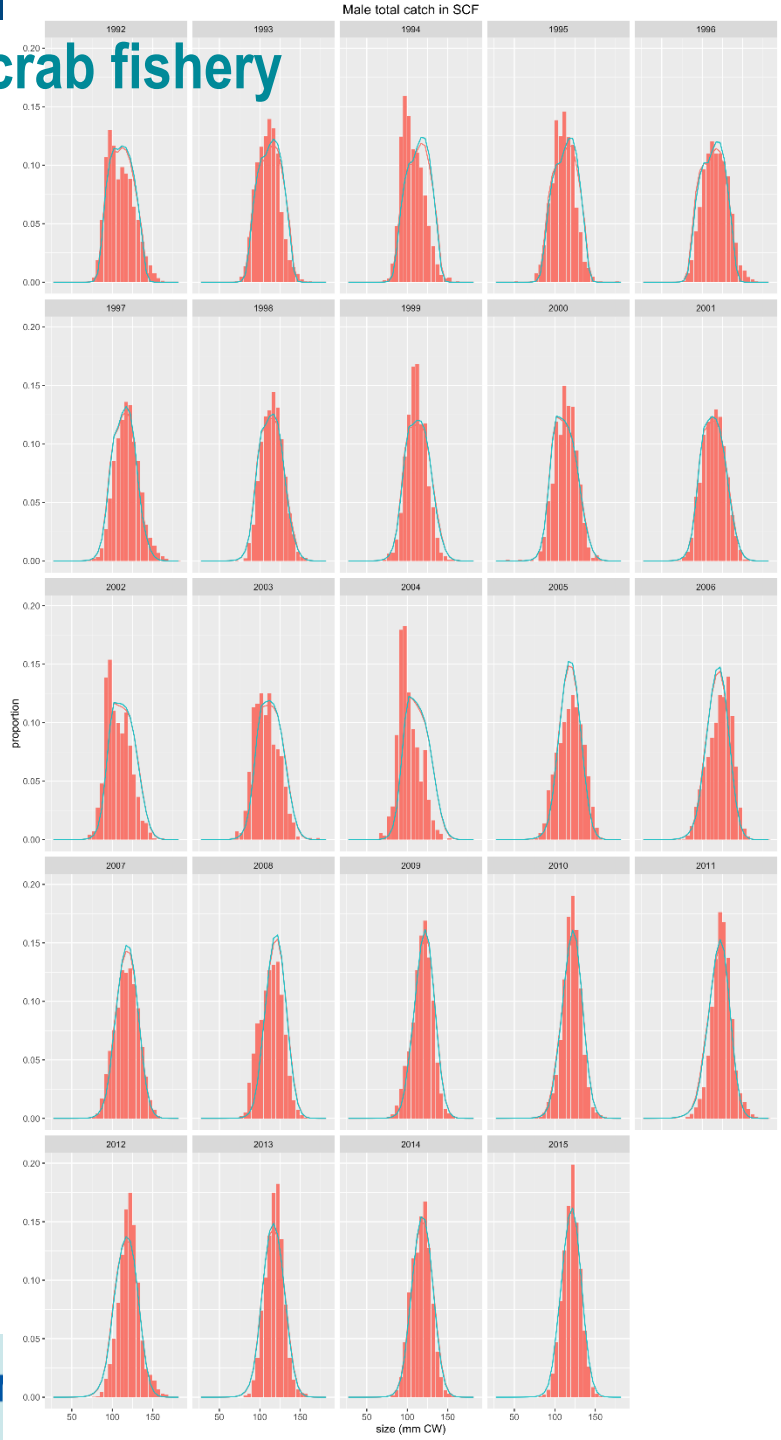
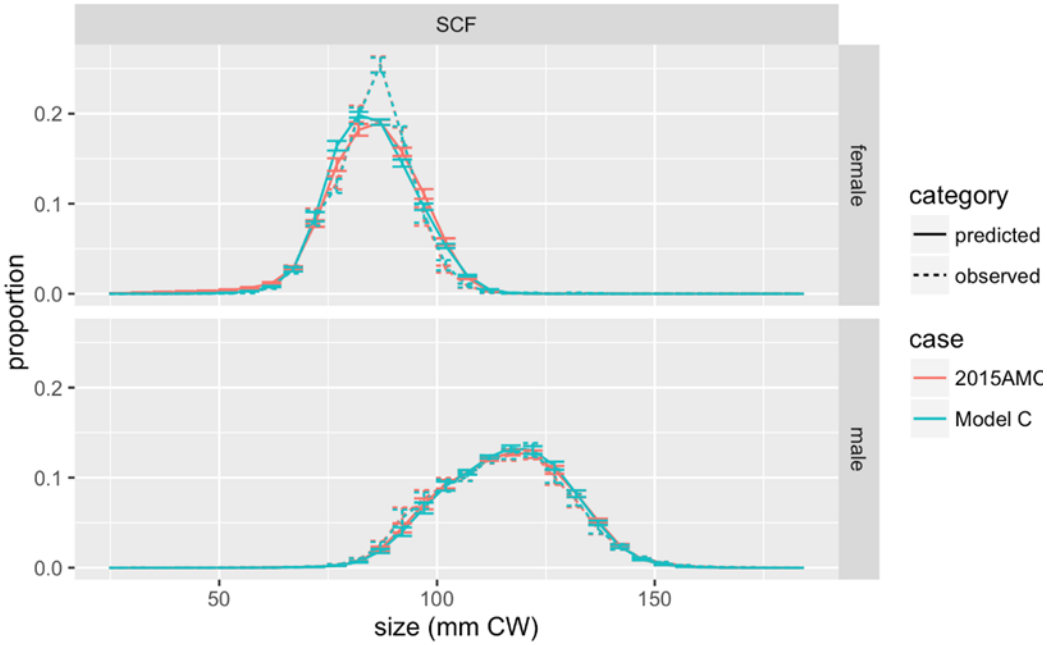
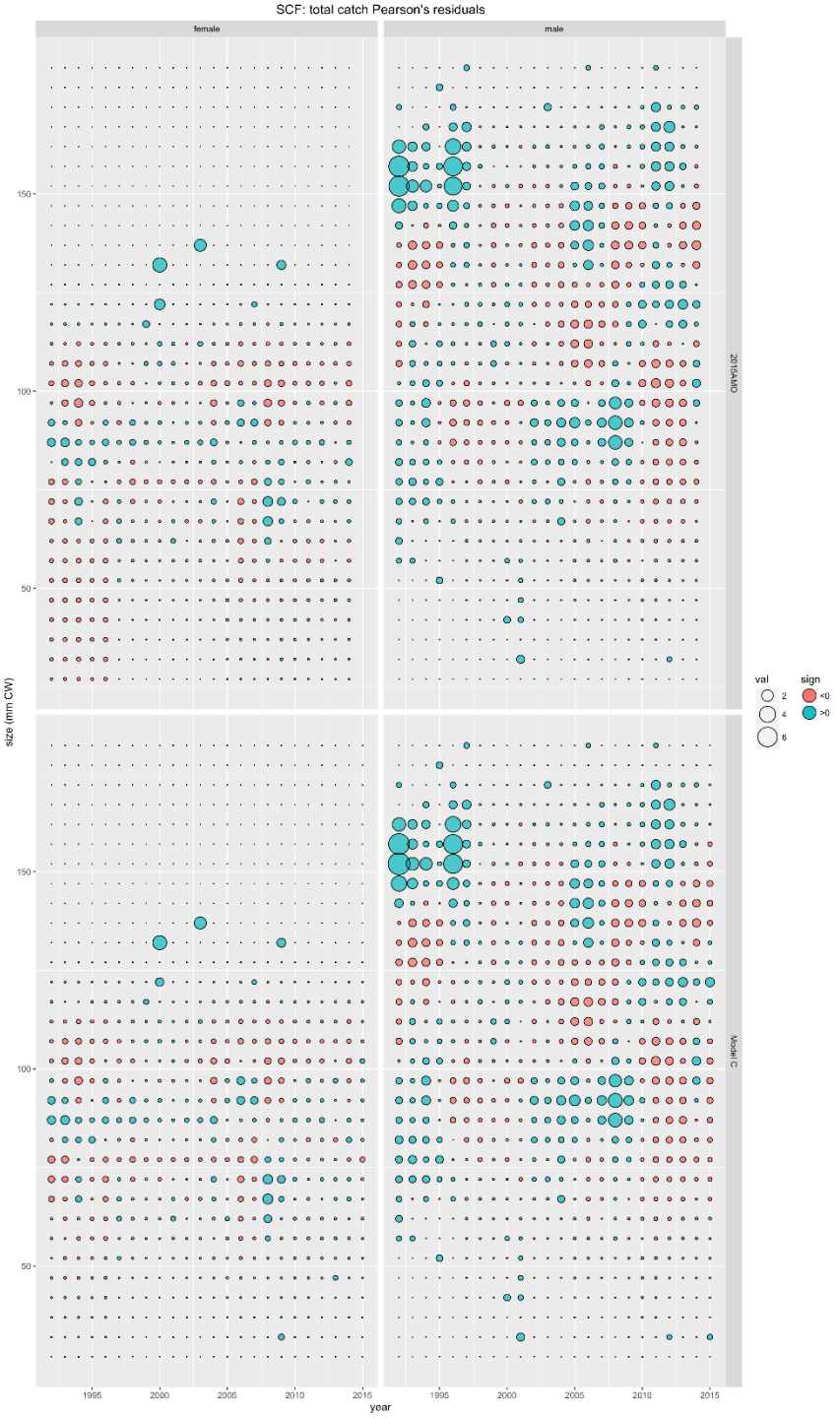
# Snow crab fishery

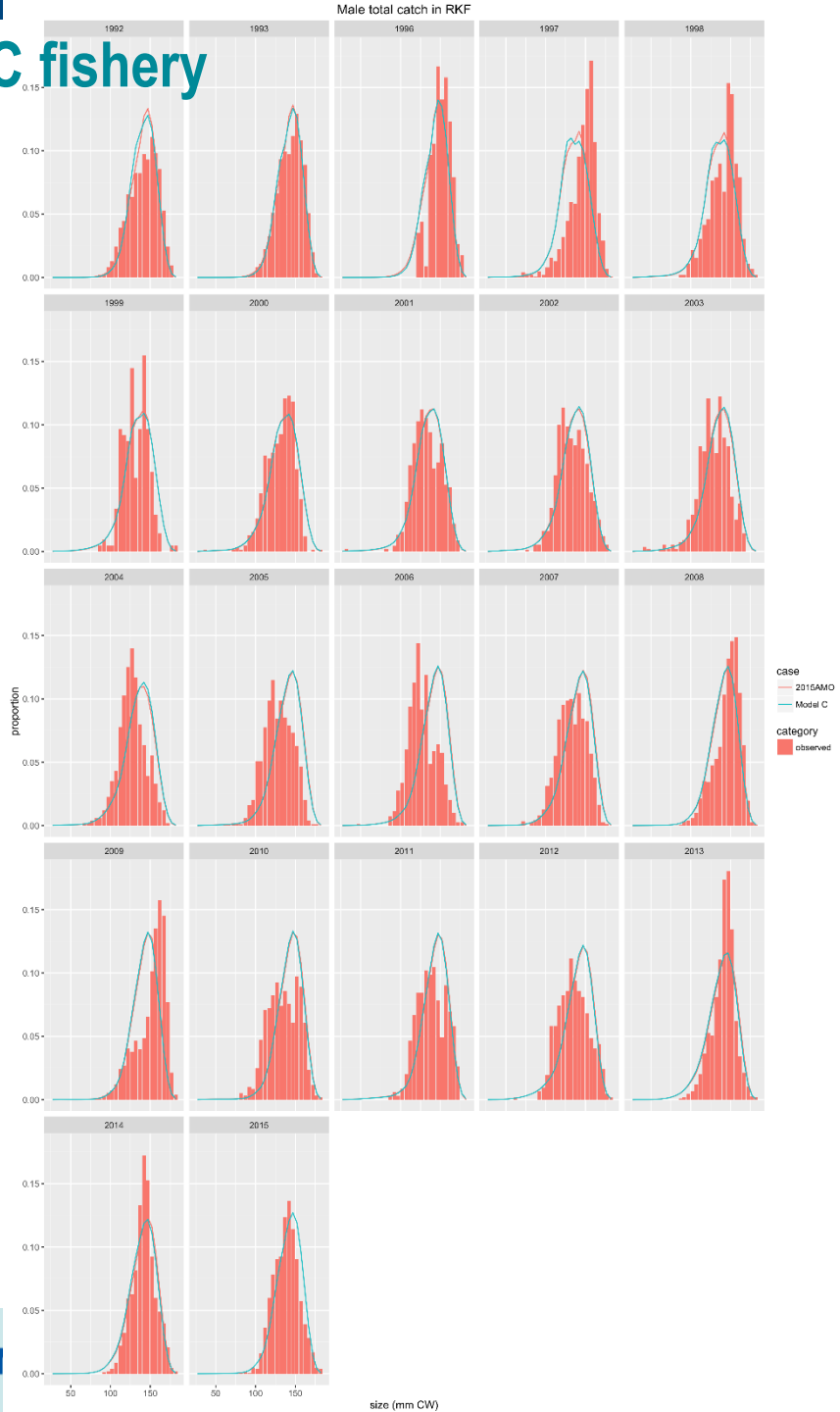


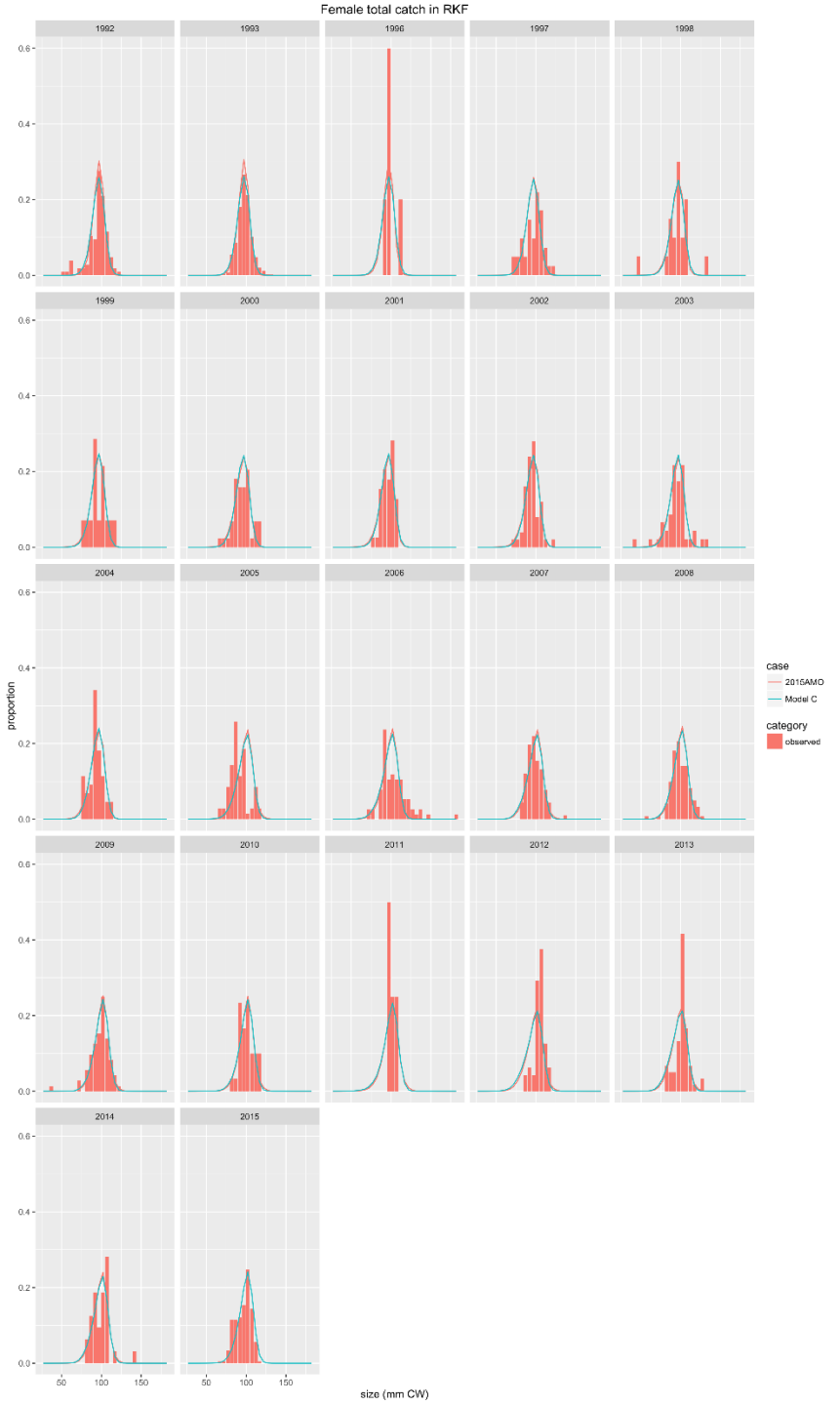

# Snow crab fishery



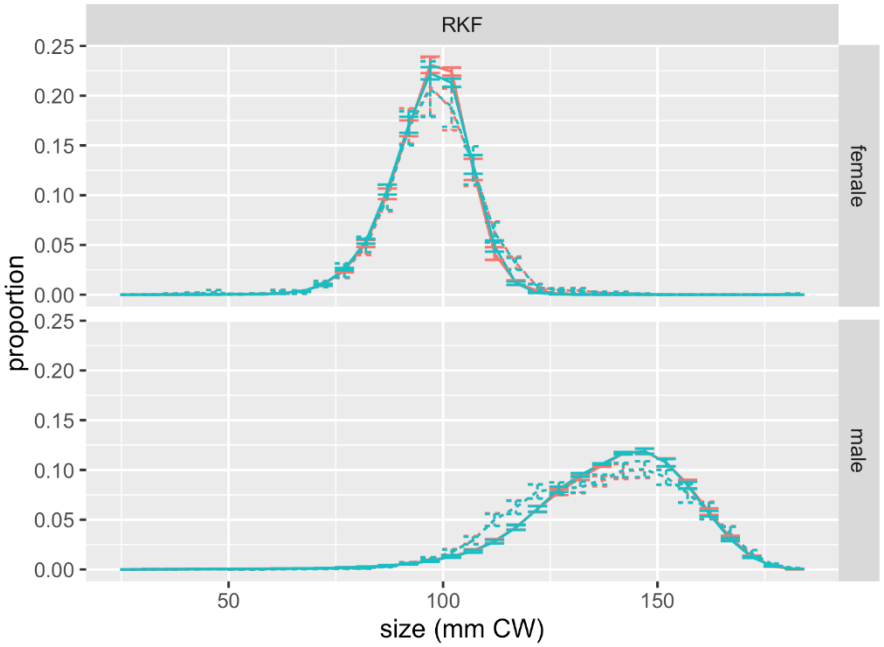



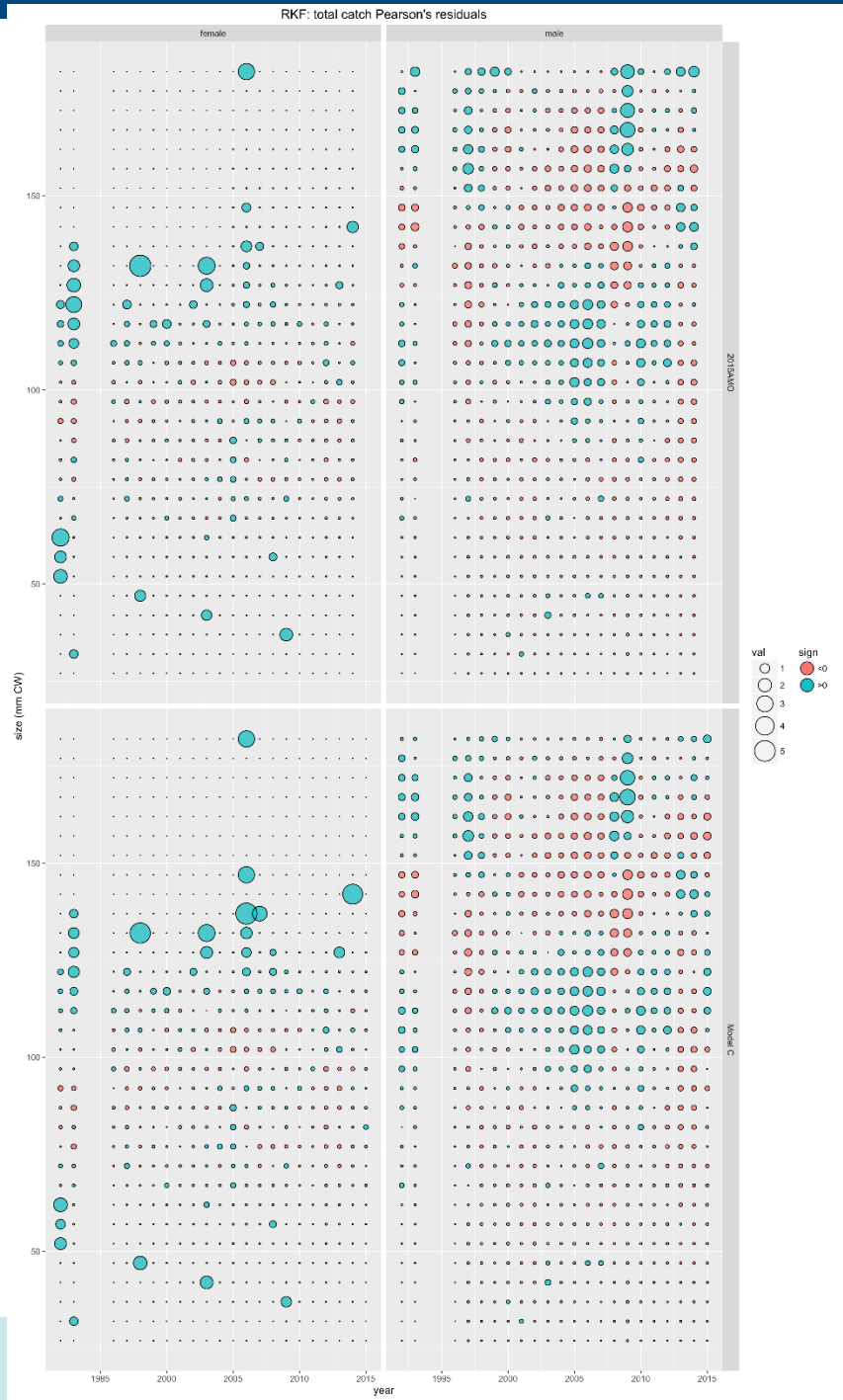
# BBRKC fishery



# BBRKC fishery

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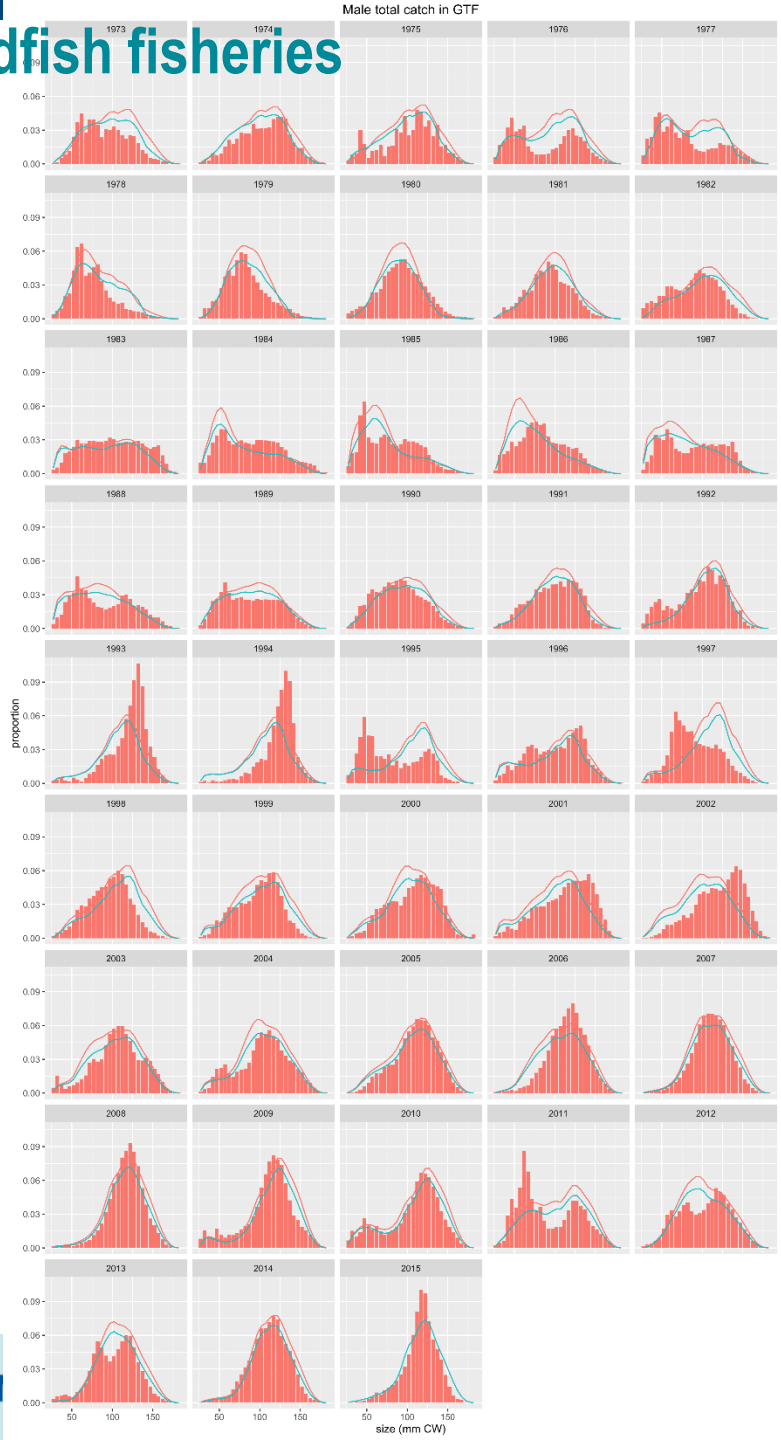
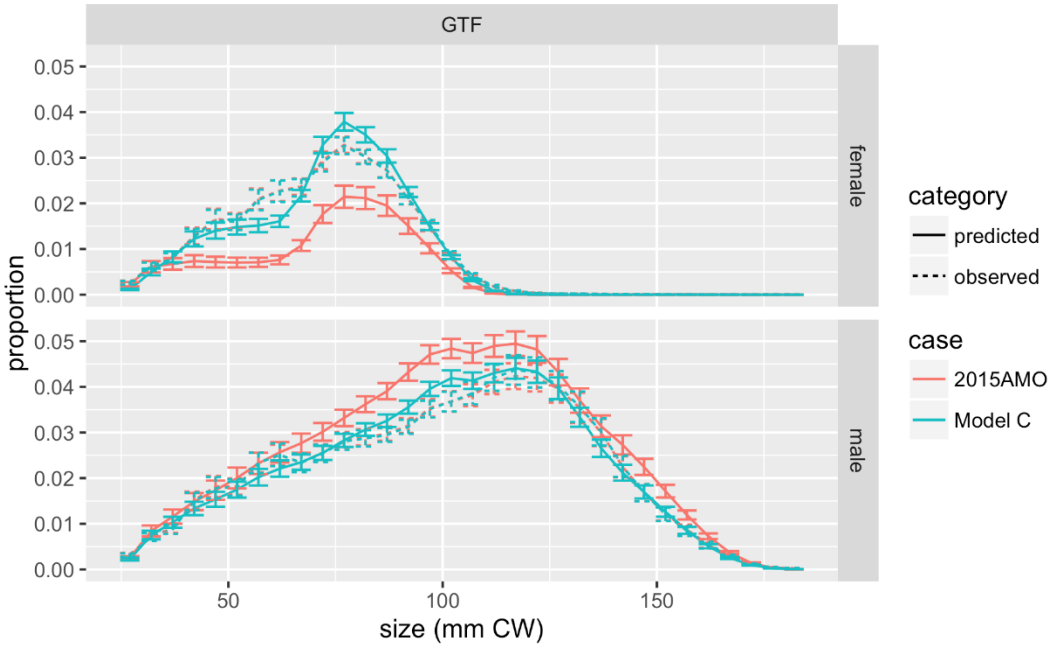
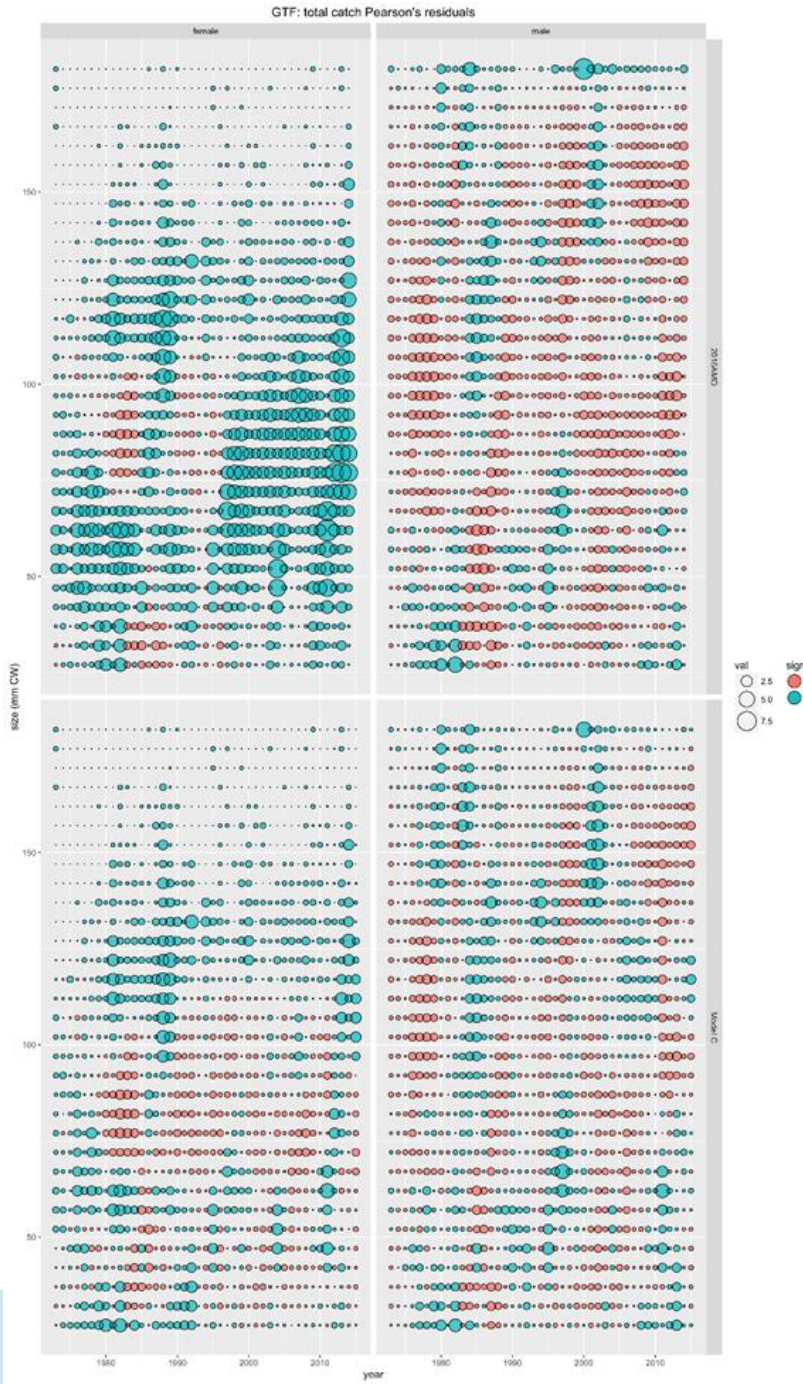
# Groundfish fisheries



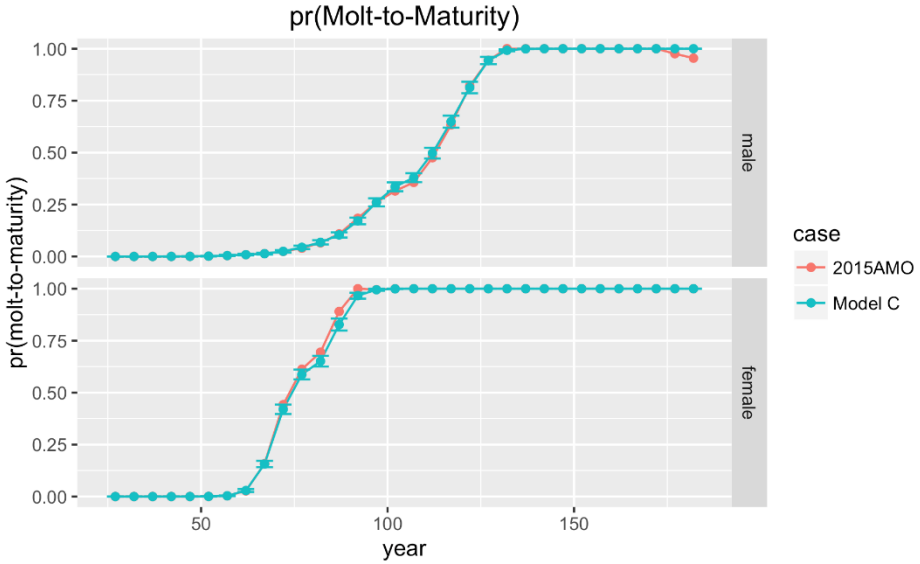

# Groundfish fisheries

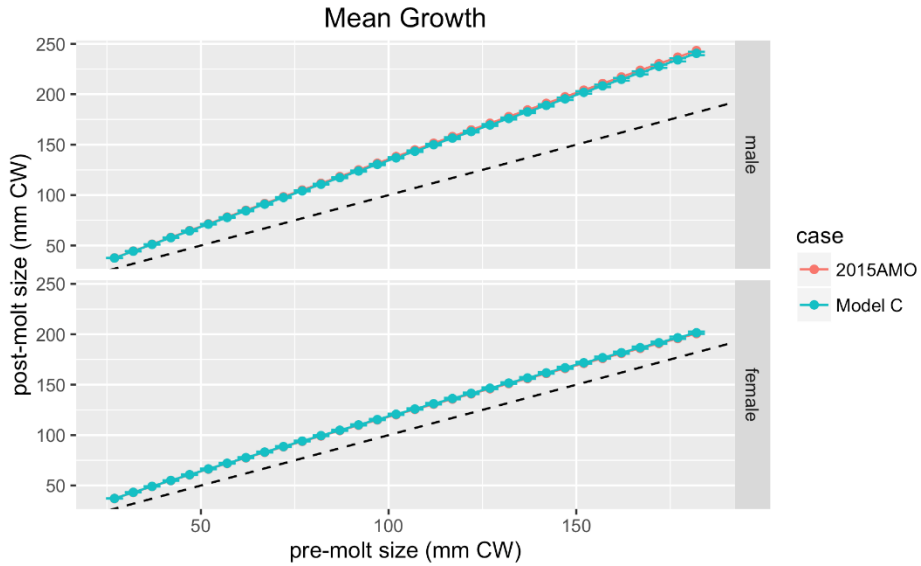


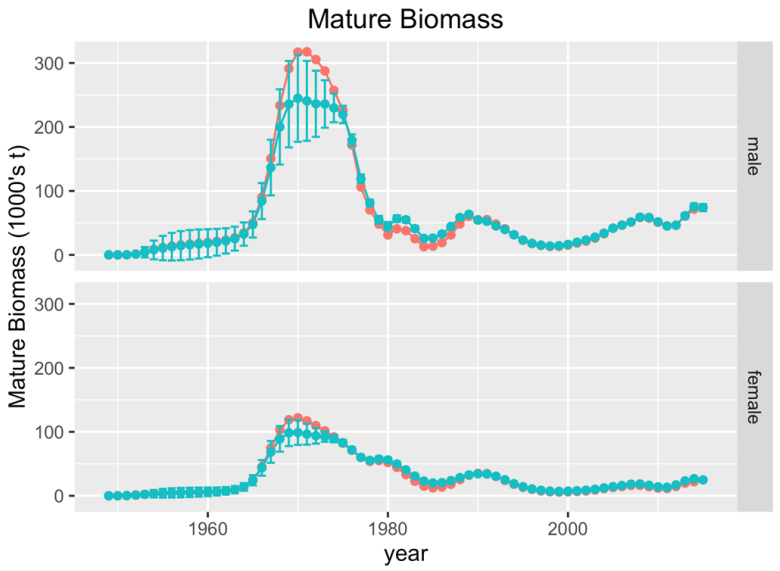

NOAA FISHERIES

# Population Processes

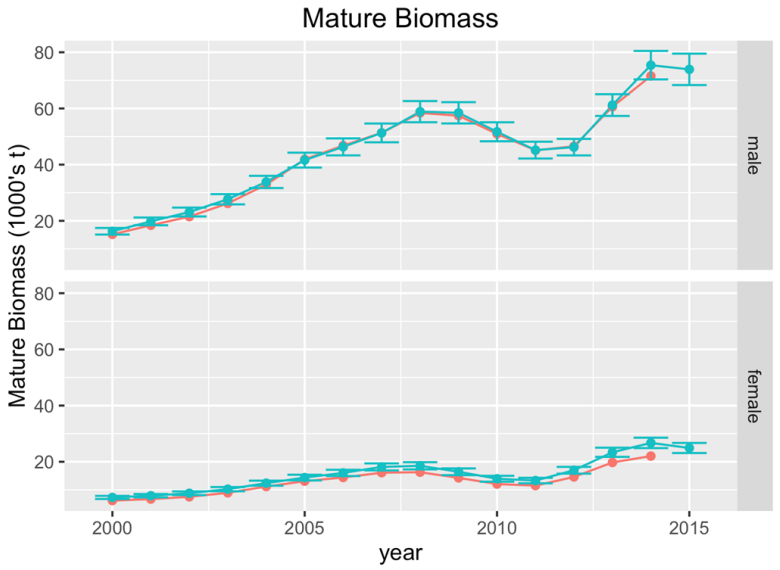



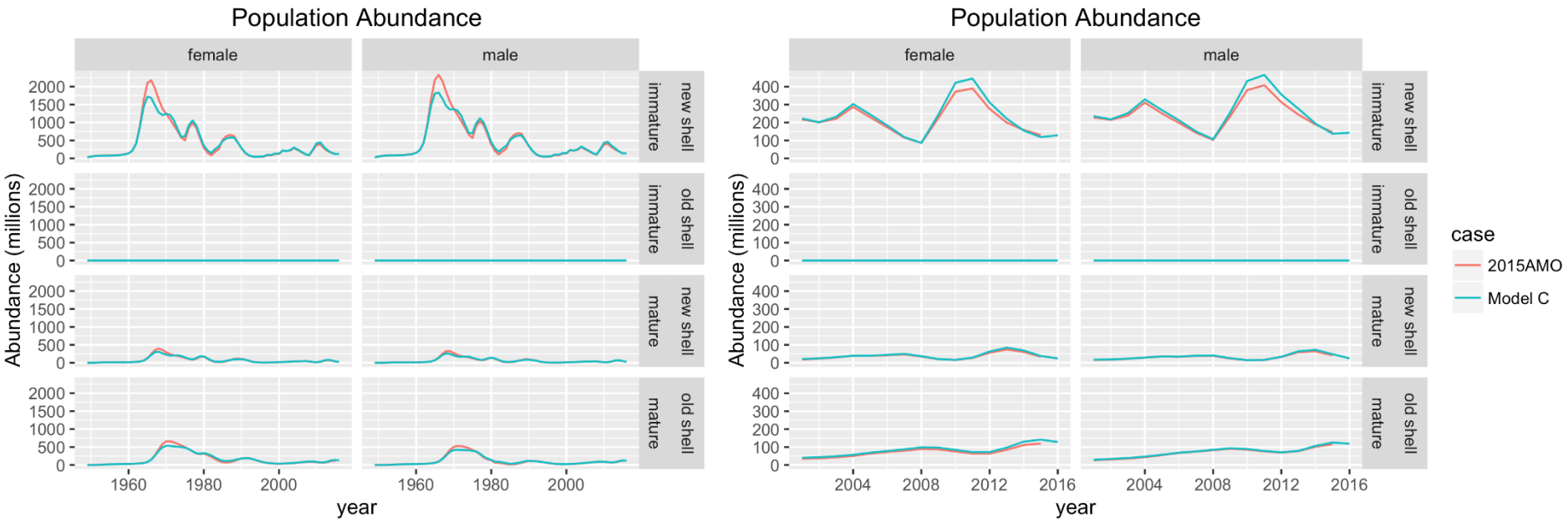
# Population quantities

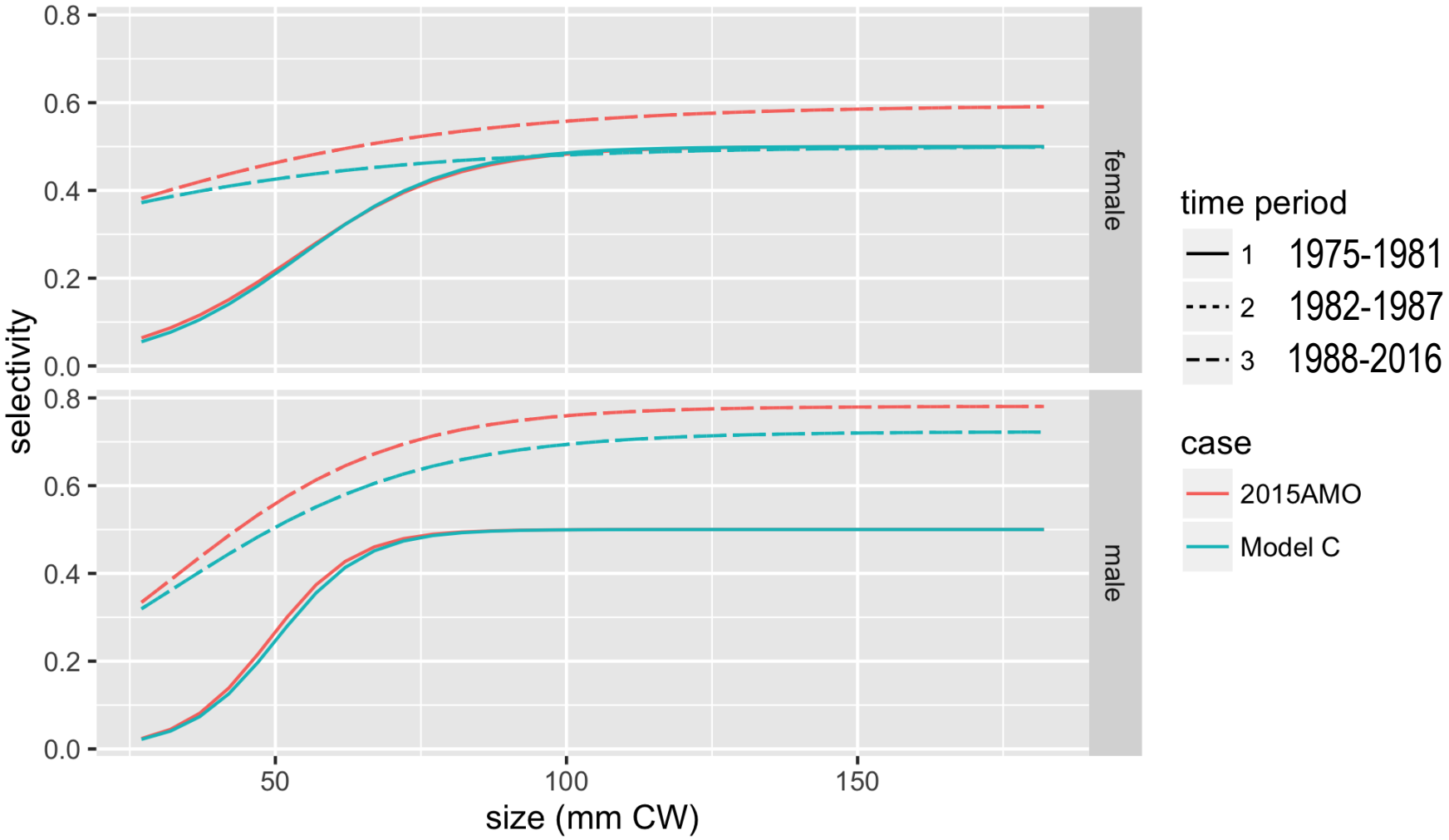




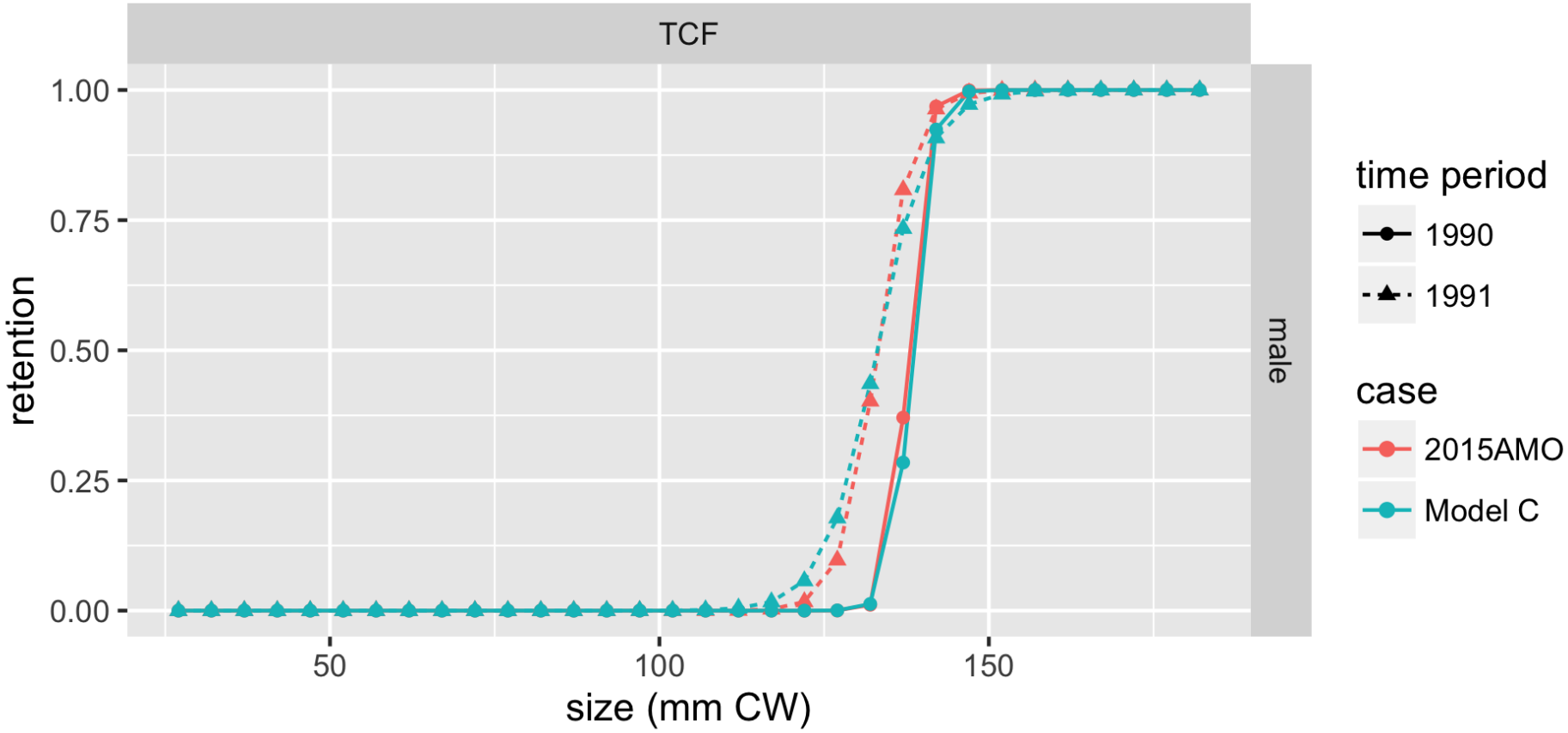
# Population quantities



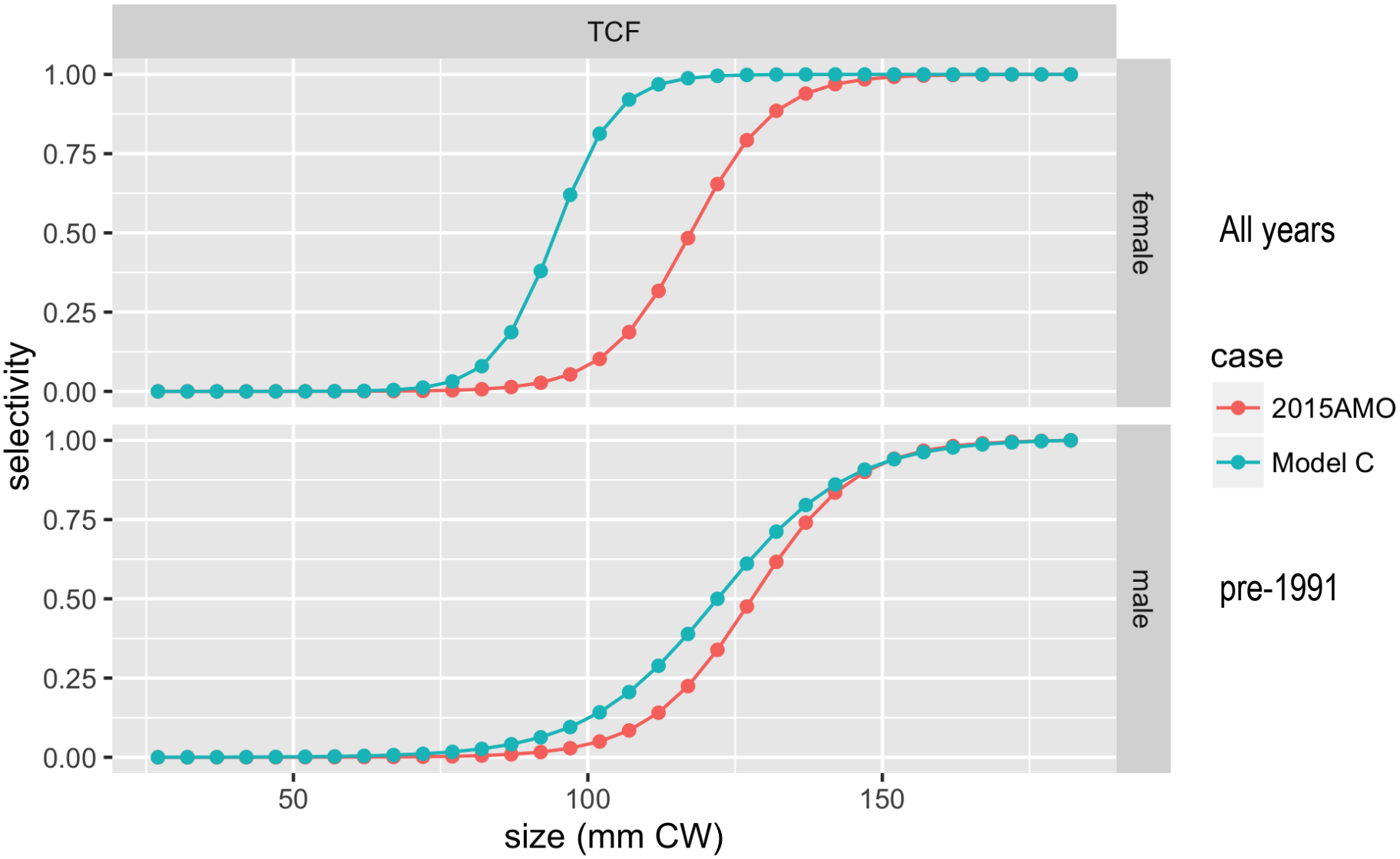
# Survey selectivity



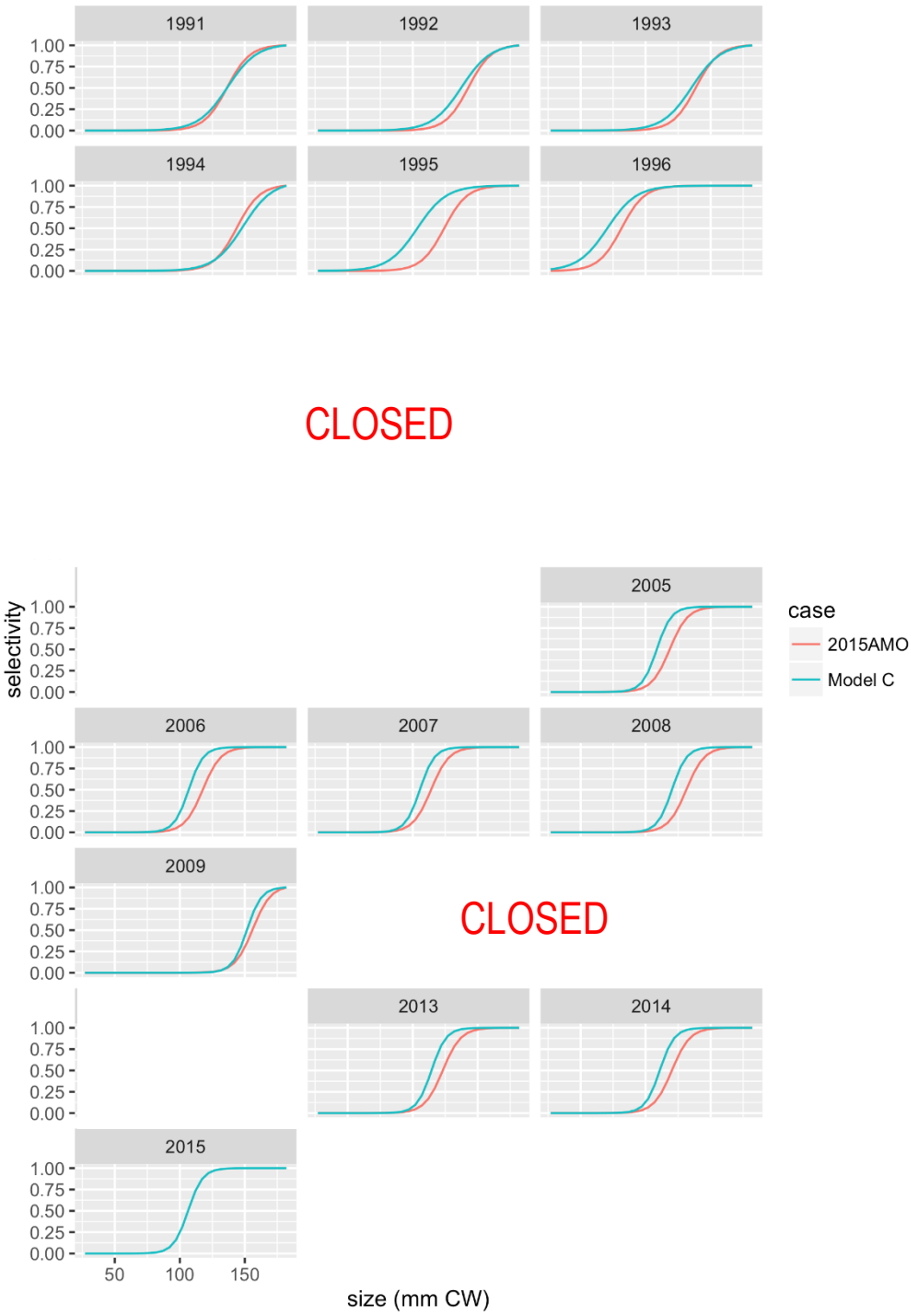
# Directed fishery retention functions



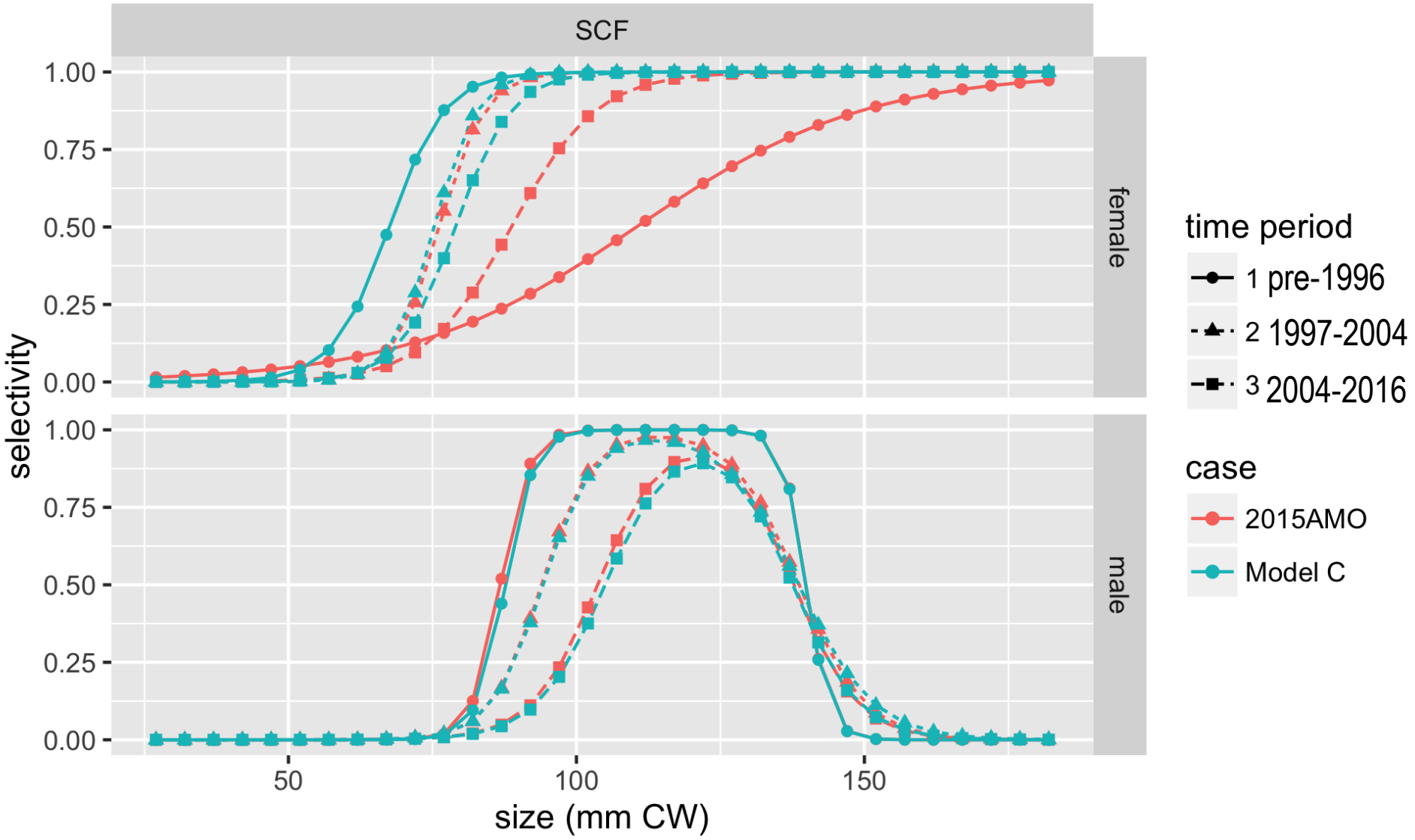
# Directed fishery selectivity functions



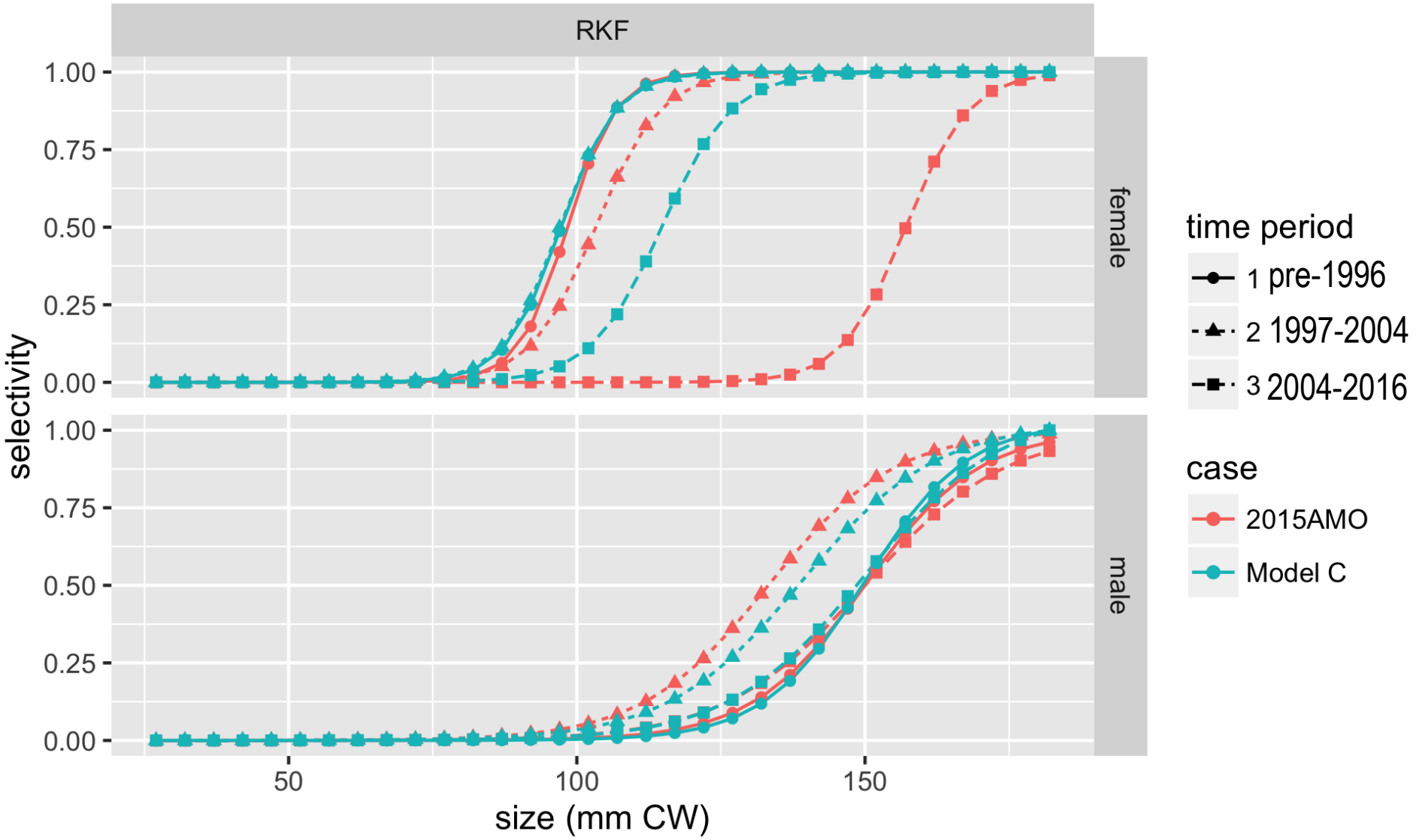
# Directed fishery
# male selectivity functions



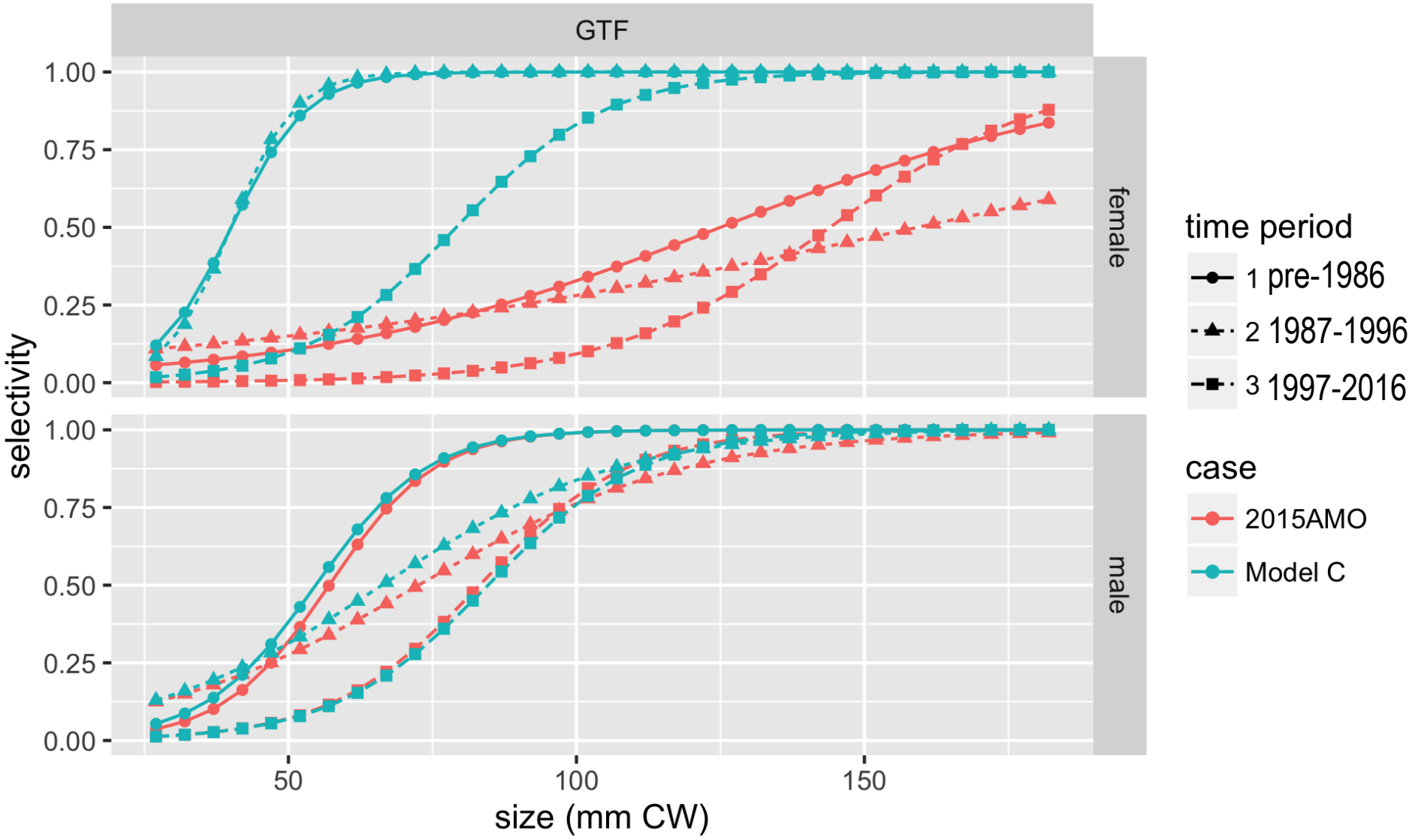
# Snow crab fishery selectivity functions



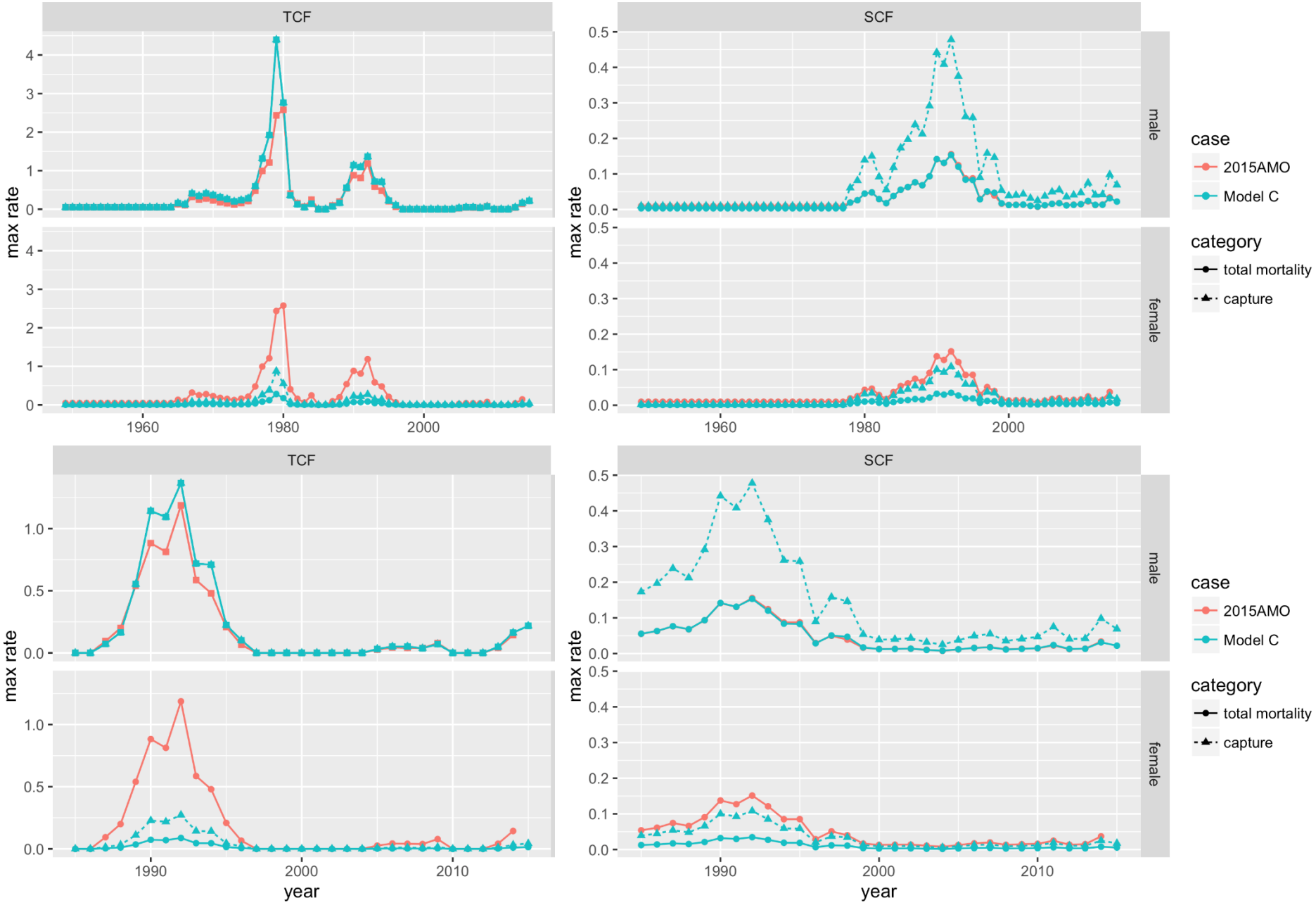
# BBRKC fishery selectivity functions



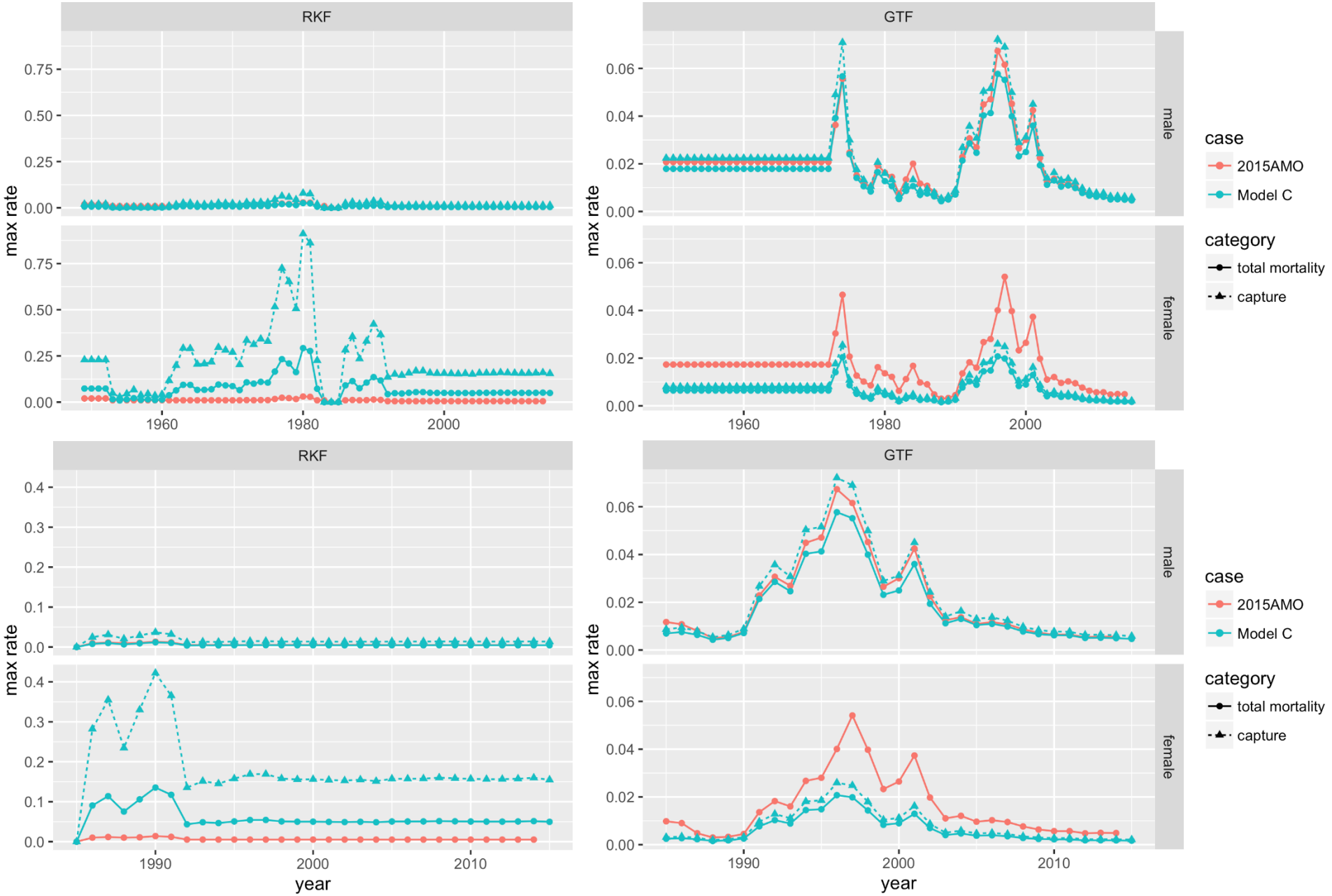
# Groundfish fisheries selectivity functions



# Fully-selected Fs



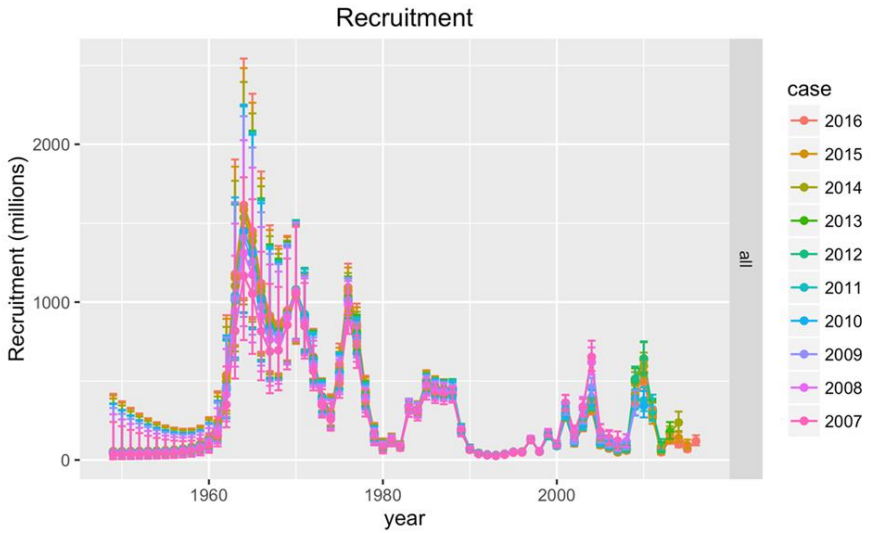
# Fully-selected Fs

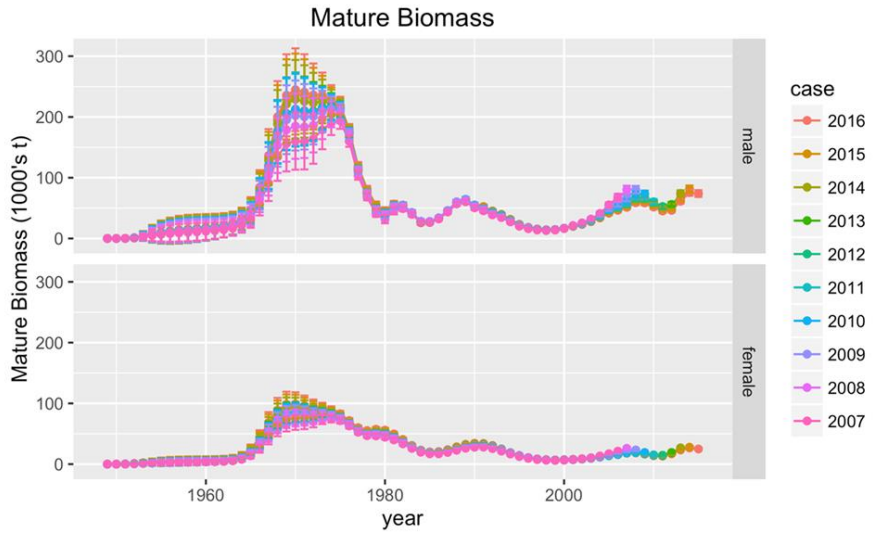


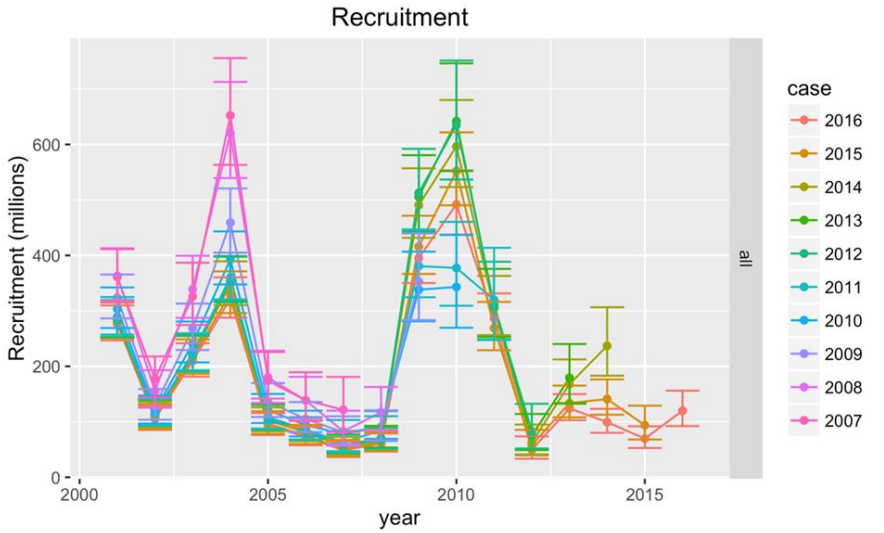
# Parameter values hitting bounds

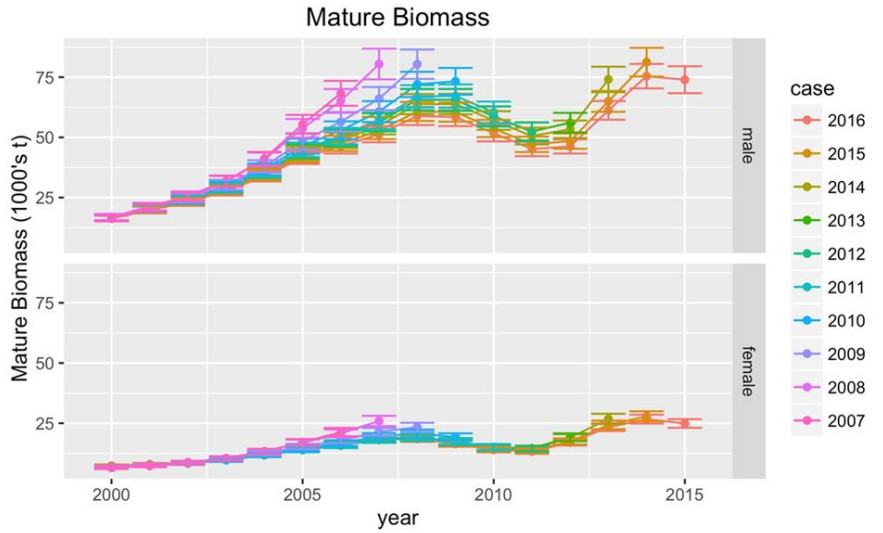
| Process | Parameter | Description | 2015AMO | Model C |
|---|---|---|---|---|
| growth | pGrAF1 | female mean growth a parameter | 0.7 | 0.7 |
| survey Q | pSrv1_QM | males [1975-1981] | 0.5 | 0.5 |
| survey Q | pSrv1_QF | females [1975-1981] | 0.5 | 0.5 |
| survey selectivity | pSrv2F_dz5095 | female offset to 95%-selected [1982+] | 100 | 100 |
| RKF selectivity | pSelRKFM_z50A1 | male size at 50%-selected [-1996] | 150 | 150 |
| GTF selectivity | pSelGTFF_z50A2 | female size at 50%-selected [1988-1996] | 159.214 | 40 |

# Retrospective Analysis: 2016 Preferred Model

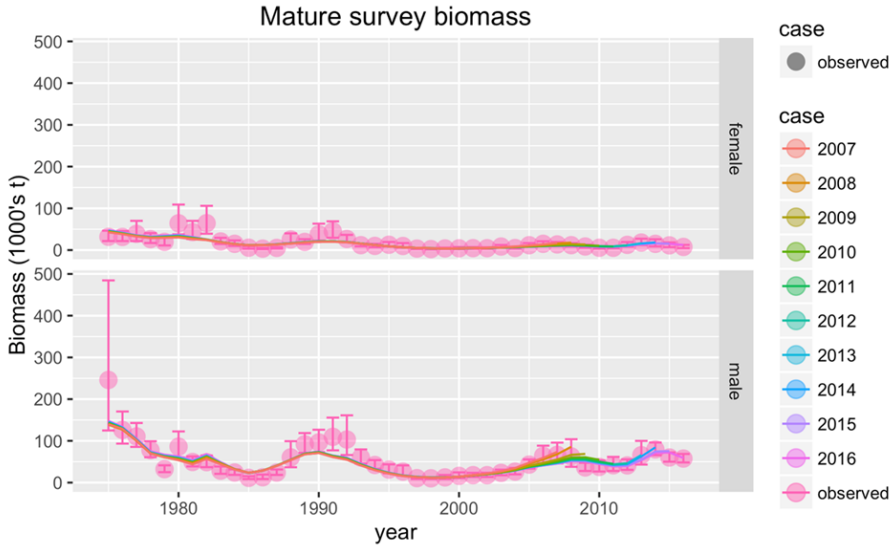


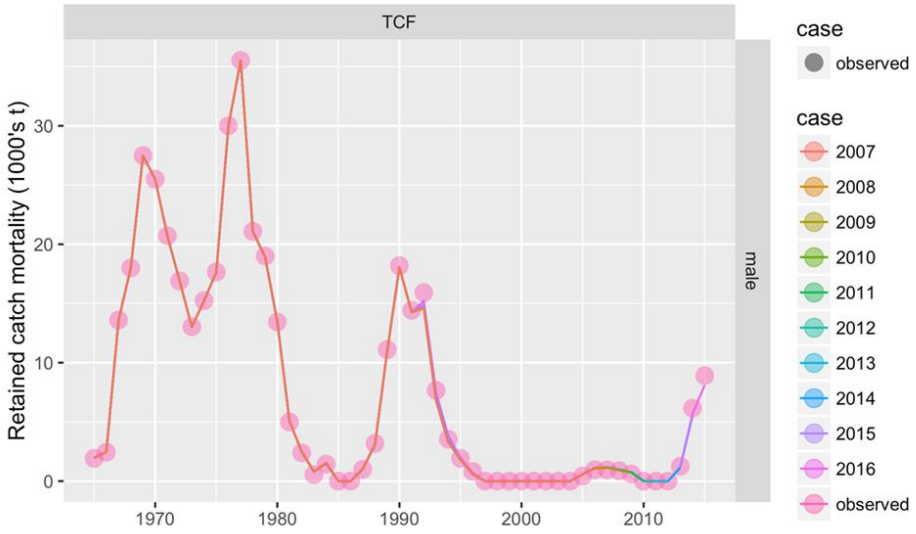



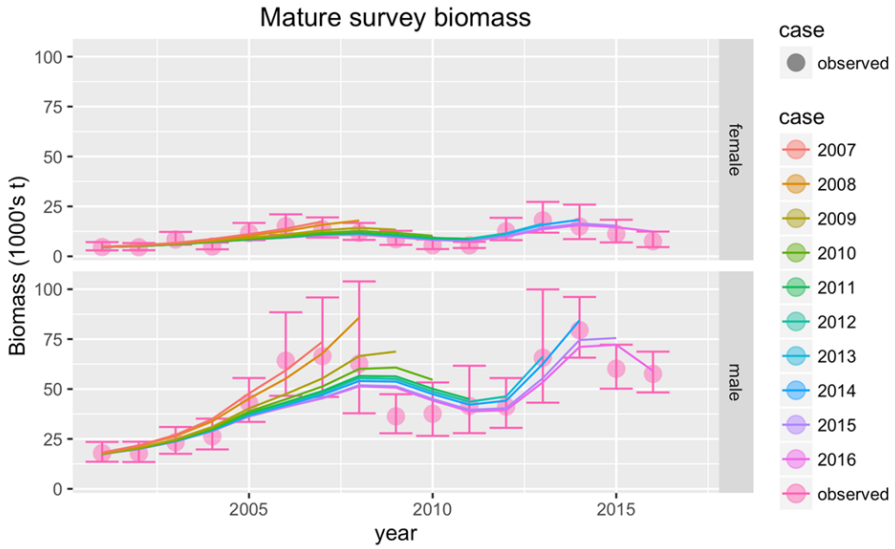



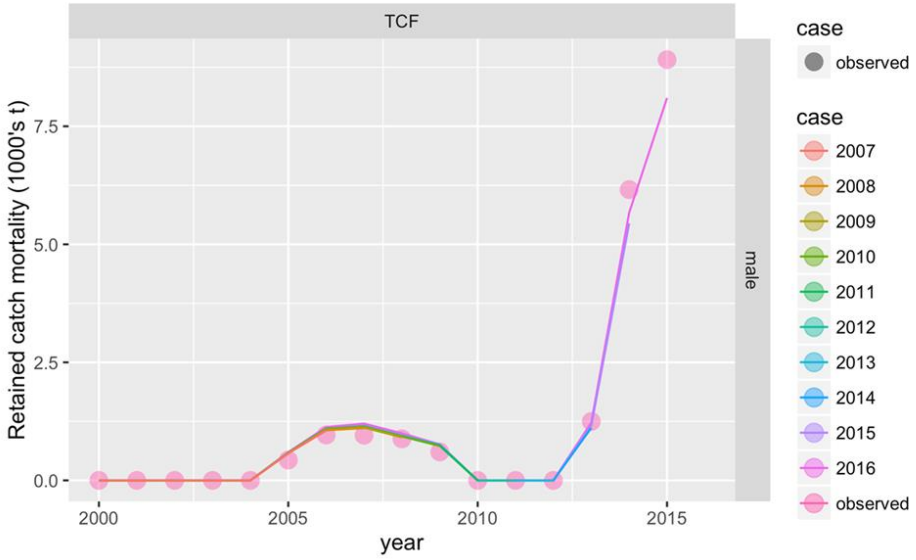



# Retrospective Analysis: 2016 Preferred Model

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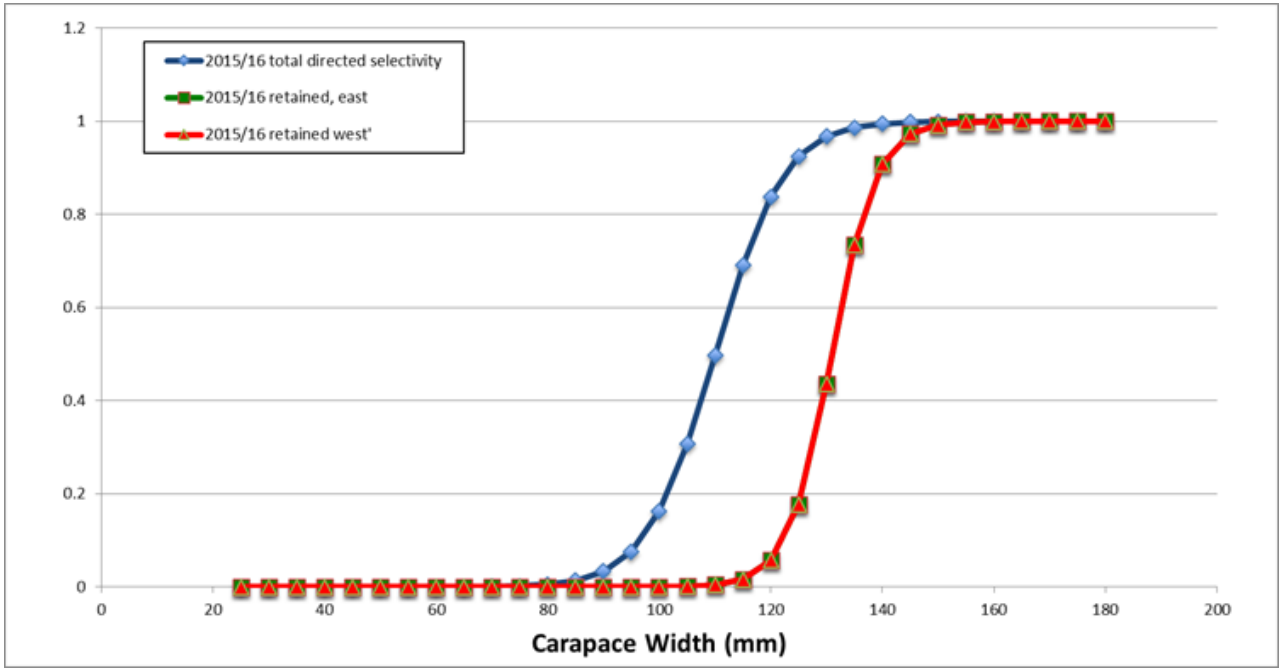
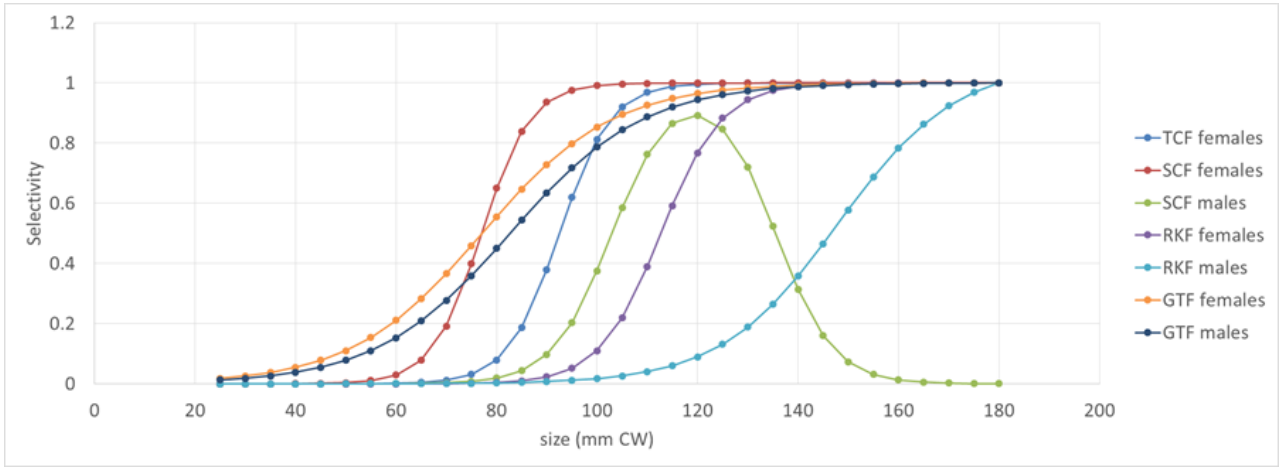
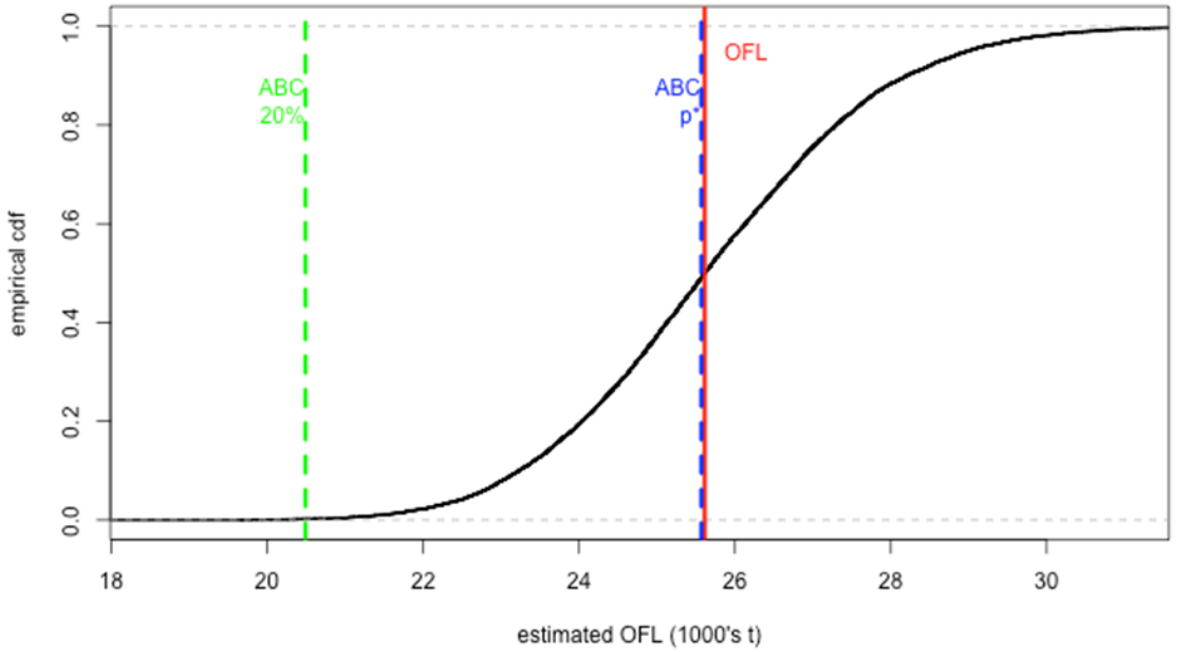
# Status Determination & OFL Calculation



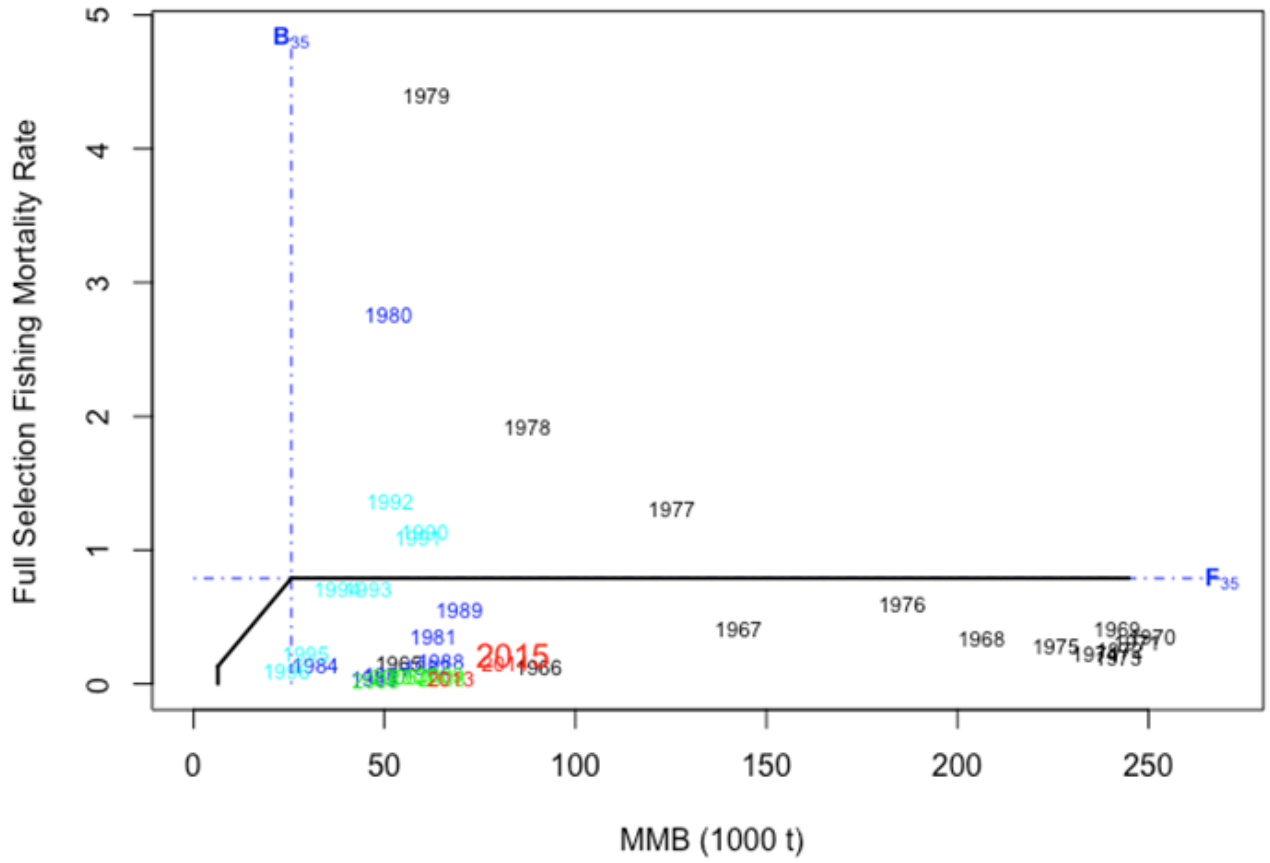



# Status Determination & OFL Calculation

- snow crab $F_{OFL}$ = 1.24 $yr^{-1}$
- effective $F_{snow\ crab}$ = 0.09 $yr^{-1}$
- $F_{MSY}$ = 0.79 $yr^{-1}$
- mean recruitment = 182.27 million
- $B_{MSY}$ = 25.65 thousand t
- 2016/16 MMB-at-mating = 45.34 thousand t
- B/BMSY = 1.77
- Tier = 3a



# Status Determination & OFL Calculation



# Management Reference Points

Not overfished
No overfishing

## Basis for the OFL

| Year | Tier[A] | $B_{MSY}$[A] | Current MMB[A] | $B/B_{MSY}$[A] | $F_{OFL}$[A] | Years to define $B_{MSY}$[A] | Natural Mortality[A,B] |
|---|---|---|---|---|---|---|---|
| 2012/13 | 3a | 33.45 | 58.59 | 1.75 | 0.61 $yr^{-1}$ | 1982-2012 | 0.23 $yr^{-1}$ |
| 2013/14 | 3a | 33.54 | 59.35 | 1.77 | 0.73 $yr^{-1}$ | 1982-2013 | 0.23 $yr^{-1}$ |
| 2014/15 | 3a | 29.82 | 63.80 | 2.14 | 0.61 yr-1 | 1982-2014 | 0.23 yr-1 |
| 2015/16 | 3a | 26.79 | 53.70 | 2.00 | 0.58 yr-1 | 1982-2015 | 0.23 yr-1 |
| 2016/17 | 3a | 25.65 | 45.34 | 1.77 | 0.79 $yr^{-1}$ | 1982-2016 | 0.23 $yr^{-1}$ |

## Management Performance

| Year | MSST | Biomass (MMB) | TAC (East + West) | Retained Catch | Total Catch Mortality | OFL | ABC |
|---|---|---|---|---|---|---|---|
| 2012/13 | 16.77 | 59.35[A] | 0.00 | 0.00 | 0.71 | 19.02 | 8.17 |
| 2013/14 | 16.98 | 72.70[A] | 1.41 | 1.26 | 2.78 | 25.35 | 17.82 |
| 2014/15 | 13.40 | 71.57[A] | 6.85 | 6.16 | 9.16 | 31.48 | 25.18 |
| 2015/16 | 12.82[C] | 73.93[A] | 8.92 | 8.91 | 11.38 | 27.19 | 21.75 |
| 2016/17 | | 45.34[B] | | | | 25.61[C] | 20.49[C] |



Biomass units: 1000's t

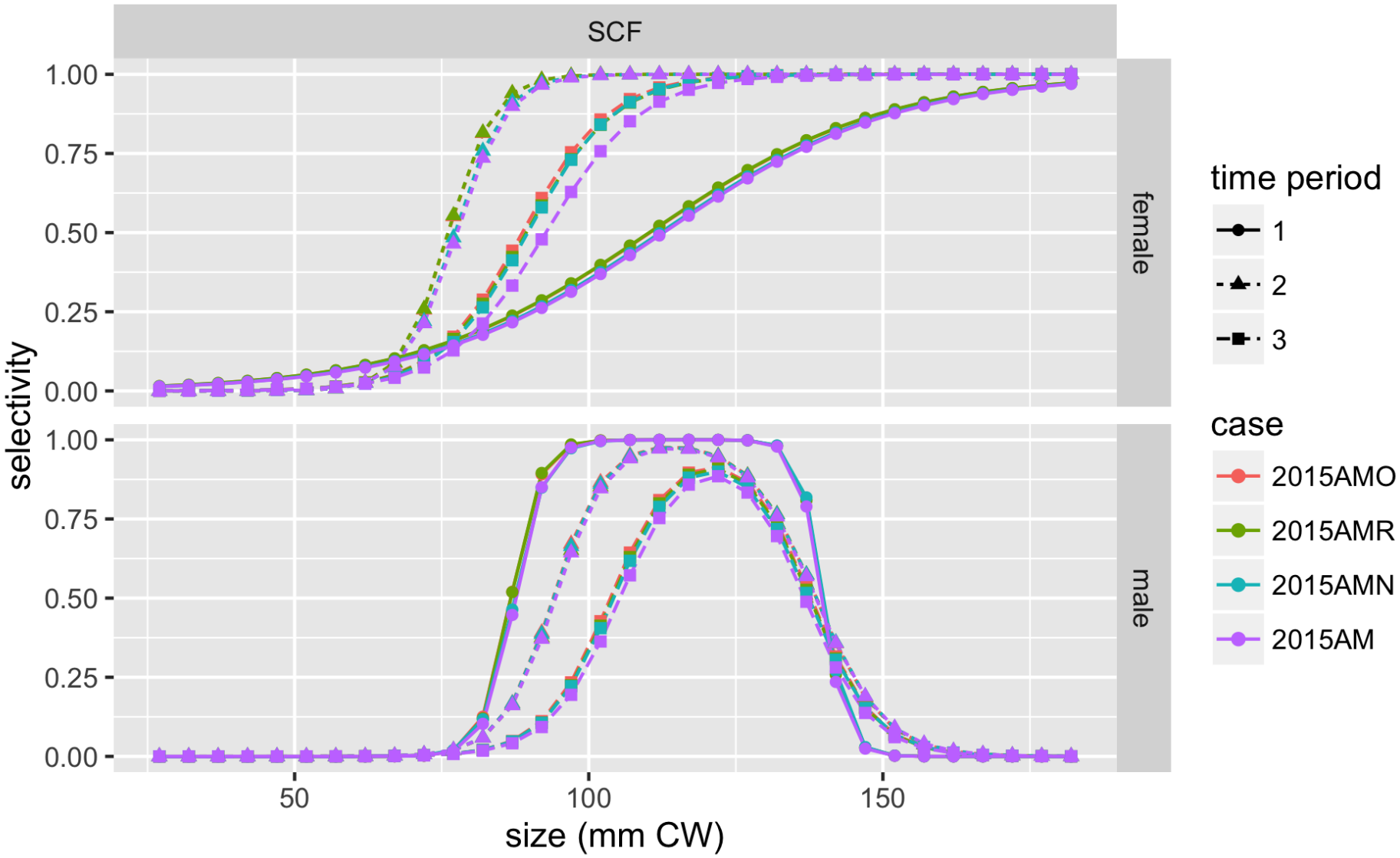
# Future Directions

- Modeling Workshop/May 2017: switch to new model code
  - TCSAM2015 (will be TCSAM2017)
  - much more flexible than current version
    - arbitrary time periods for model processes
    - priors available on all model parameters
    - status determination incorporated w/in model
      - separate projection model not necessary
      - uses analytic equilibrium solutions
    - ability to simulate data/test model
    - ability to easily run retrospective analyses
    - can address some other outstanding CPT/SSC requests
  - A transition to a Gmacs-based model
- Extended:
  - incorporate chela height data directly in model
  - incorporate growth data directly in model
  - incorporate BSFRF survey data
  - disaggregate East/West directed fisheries in model
  - disaggregate groundfish bycatch (fixed gear, trawl fisheries) in model
  - develop recruitment hindcasts/forecasts using early life biophysical IBM

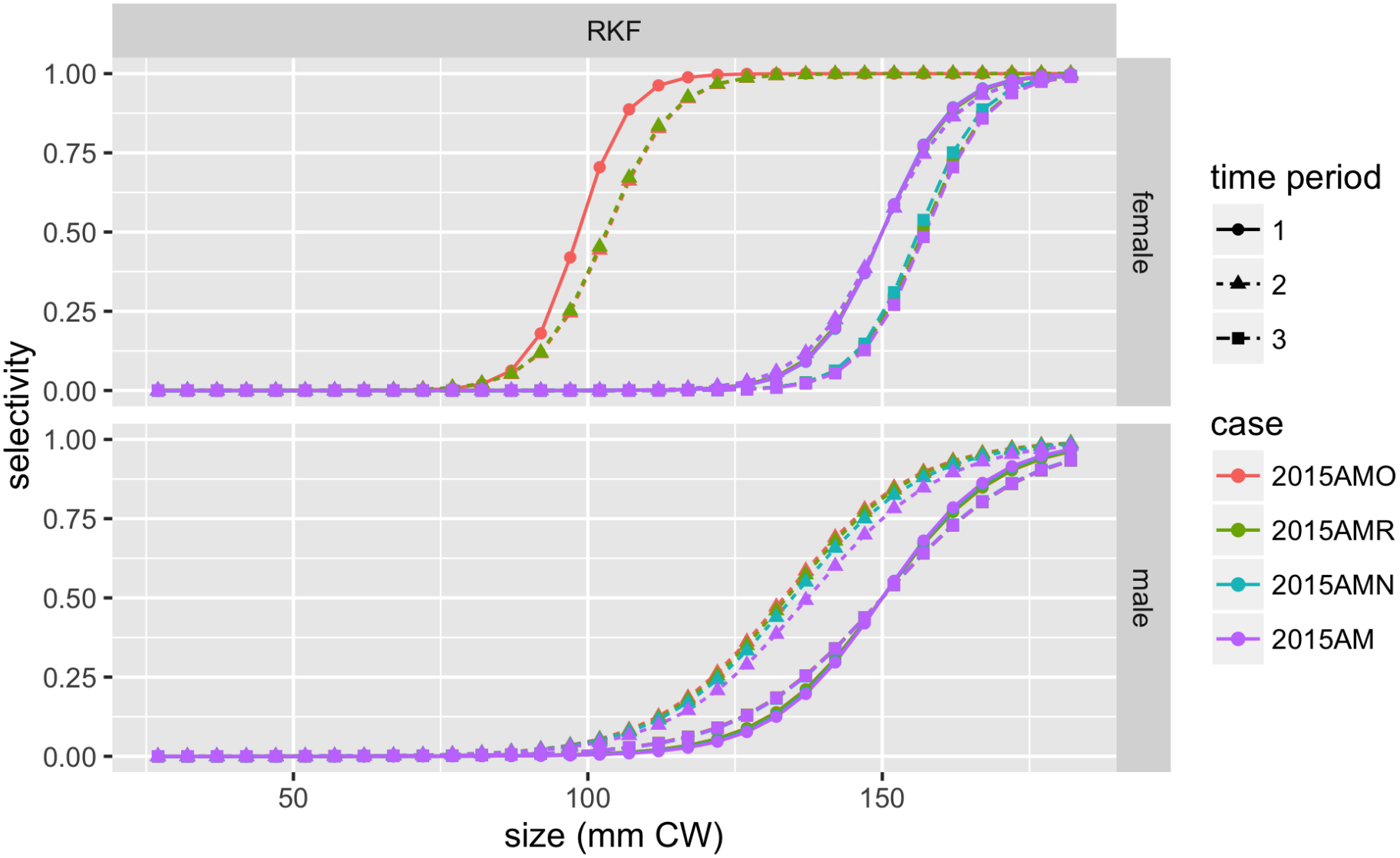
# Alternative Models: Status Determination & OFL Calculation

| Model | Snow Crab Fofl | Efffective Snow Crab F | Average Recruitment | B | Fmsy | Bmsy | B/Bmsy | OFL | ABC P-star | ABC (20% buffer) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2015 Model | 1.32 | 0.049 | 179.37 | 53.70 | 0.58 | 26.79 | 2.00 | 27.19 | 27.15 | 21.75 |
| 2015AMR | 1.32 | 0.051 | 176.78 | 51.41 | 0.64 | 25.68 | 2.00 | 27.27 | 27.23 | 21.82 |
| 2015AMN | 1.32 | 0.044 | 193.44 | 63.85 | 0.56 | 29.42 | 2.17 | 30.96 | 30.91 | 24.77 |
| 2015AM | 1.24 | 0.030 | 183.46 | 48.07 | 0.59 | 26.68 | 1.80 | 23.79 | 23.75 | 19.03 |
| Model A | – | – | – | – | – | – | – | -- | – | – |
| Model B | 1.24 | 0.092 | 182.17 | 45.32 | 0.79 | 25.64 | 1.77 | 25.60 | 25.56 | 20.48 |
| Model C | 1.24 | 0.092 | 182.27 | 45.34 | 0.79 | 25.65 | 1.77 | 25.61 | 25.57 | 20.49 |
| Model D | 1.24 | 0.111 | 168.84 | 39.06 | 0.09 | 22.85 | 1.71 | 25.79 | 25.75 | 20.63 |
| Model E | 1.24 | 0.097 | 174.24 | 42.19 | 0.44 | 23.06 | 1.83 | 27.36 | 27.31 | 21.89 |
| Model F | 1.24 | 0.070 | 163.57 | 39.52 | 0.96 | 22.41 | 1.76 | 21.83 | 21.79 | 17.46 |
| Model G | 1.24 | 0.061 | 171.74 | 43.26 | 1.02 | 23.70 | 1.83 | 24.55 | 24.51 | 19.64 |

# New CVs vs Old CVs: Snow Crab Fishery Bycatch Selectivity Functions



# New CVs vs Old CVs: BBRKC Fishery Bycatch Selectivity Functions



# New CVs vs Old CVs: Groundfish Fisheries Bycatch Selectivity Functions