BSAI Tanner Crab

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Management Reference Points

- Not overfished
- Not overfishing

- Preferred Model: Model A (same as 2014, new data)

Basis for the OFL (in 1000's t)

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
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	53.35	1.99	0.60 yr^{-1}	1982-2015	0.23 yr^{-1}

Management Performance (in 1000's t)

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2011/12	11.40	58.59	0.00	0.00	1.24	2.75	2.48
2012/13	16.77	59.35	0.00	0.00	0.71	19.02	8.17
2013/14	16.98	72.70	1.41	1.26	2.78	25.35	17.82
2014/15	13.40	71.57	6.85	6.16	9.16	31.48	25.18
2015/16		53.35				27.40	21.92

Action Items

Comment: "The CPT agrees that the September 2015 assessment should use the updated retained size frequencies and be based on an assessment that ignores the survey data from 1974."
Response: This has been done.

Comment: "The assessment author should report results in September 2015 using the new and original trawl survey data to allow the impact of updating these data to be quantified."
Response: This has been done.

Comment: "Future exploration…should consider the impact of handling mortality on the estimate of natural mortality and how the model behaves if Q for the most recent years is assumed known rather than being estimated."
Response: Model runs have been completed to address this issue, but time was not sufficient to complete the analysis.

Comment: "The CPT would like to see the results of analyses based on this (new) model at its September 2015 meeting".
Response: The new model is currently undergoing testing. Time constraints precluded presenting interim results at this point to the CPT. These will be presented at the Modeling Workshop (if there is one), or at the May 2016 CPT meeting.

Comment: "The CPT reiterates its suggestions from the September 2014 meeting, in particular that the sensitivity of the results to the prior on Q should be explored."
Response: Model runs have been completed to address this issue, but there was not sufficient time to complete the analysis.

Comment: The CPT recommends that model results for the four model configurations be provided to the September 2015 meeting: 1) the 2014 model with 2015 data added (Model 1), 2) Model 1, with revised trawl survey time series (Model 2), 3) Model 2, with survey selectivity constrained to 1 for at least one size class (Model 3), and 4) Model 3, with a lognormal likelihood for the fishery catch data.
Response: Results from these configurations are provided in the assessment.

Comment: "The CPT recommends that the change (in minimum preferred size in the area east of 166°W for TAC setting) be addressed for OFL calculation by setting the retention curves for the areas east and west of 166oW with the approach currently used to compute selectivity for the area west of 166°W."
Response: This has been addressed in the assessment.

Changes From 2014 Assessment

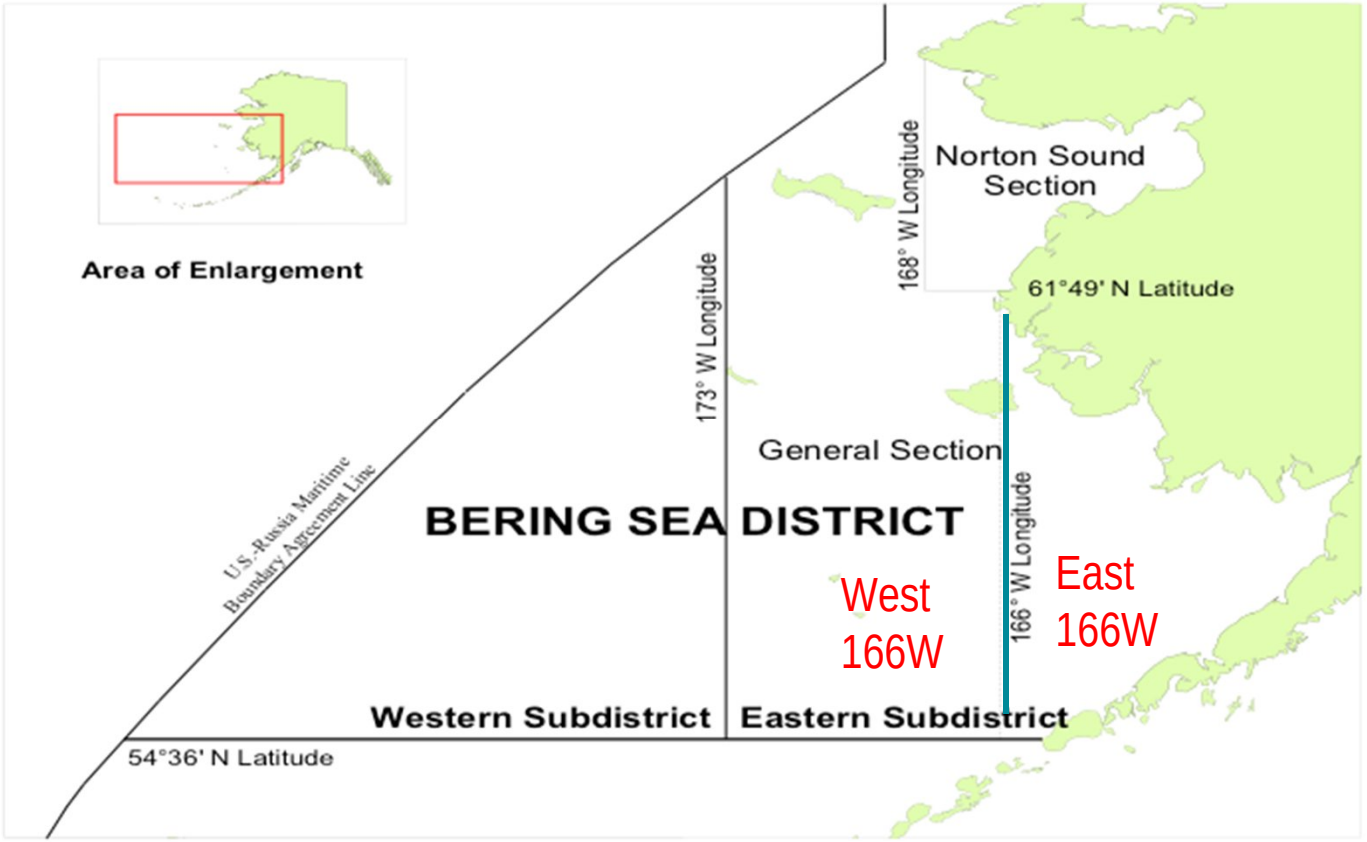
- 8 model configurations tested
  - Gmacs FM tested
  - lognormal likelihoods for fishery catch tested
  - Preferred model same as 2014
- New trawl survey data
  - 2015 size compositions by sex, shell condition, maturity
  - new standardized survey dataset (1975-2015)
  - standardized LW regressions (2010+ survey regressions)
- Revised/New Fishery Data for 2014/15
  - Tanner crab pot fishery
    - corrected 2013/14 retained catch abundance, biomass, size compositions
    - 2014/15 retained catch abundance, biomass
    - 2014/15 dockside size frequencies
    - 2014/15 sex-specific total bycatch (t)
    - 2014/15 sex-specific bycatch size compositions
  - snow crab pot fishery
    - sex-specific total bycatch, size compositions
    - effort (potlifts)
    - updated 2013/14, new 2014/15
  - BBRKC pot fishery
    - sex-specific total bycatch, size compositions
    - effort (potlifts)
    - updated 2013/14, new 2014/15
  - groundfish fisheries
    - total catch biomass, sex-specific size compositions
    - updated 2013/14, new 2014/15

Outline

- Fishery results
- Trawl survey results
- Alternative Models & Evaluation
  - Datasets
  - Model configurations
- Projection model considerations
- OFL and ABC
- Future directions

Fishery Results

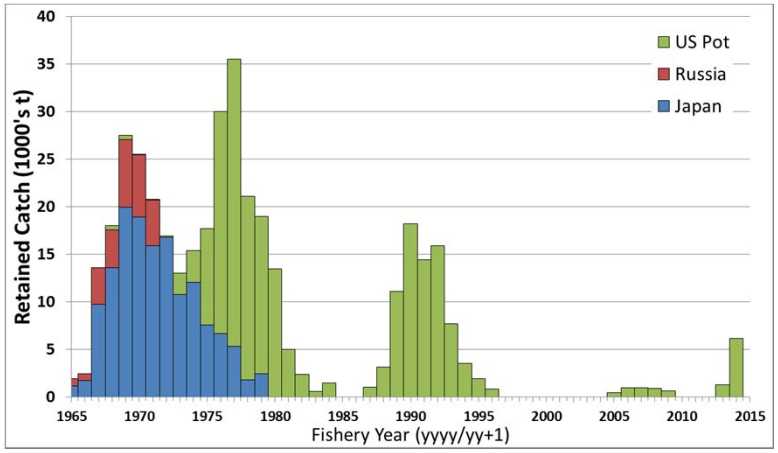
Management Regions

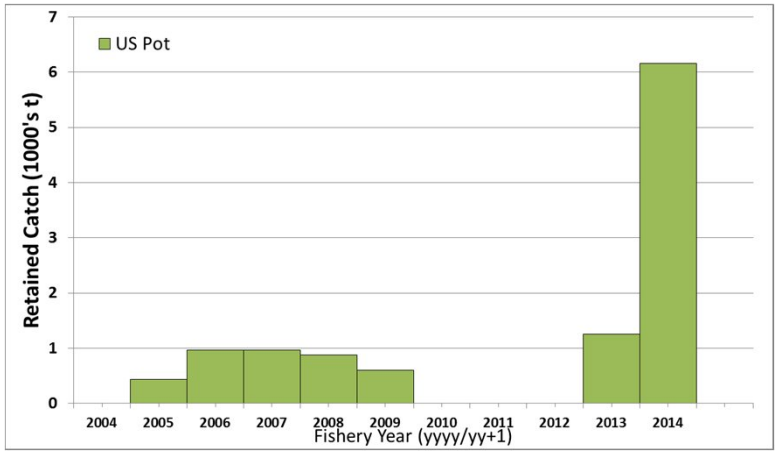


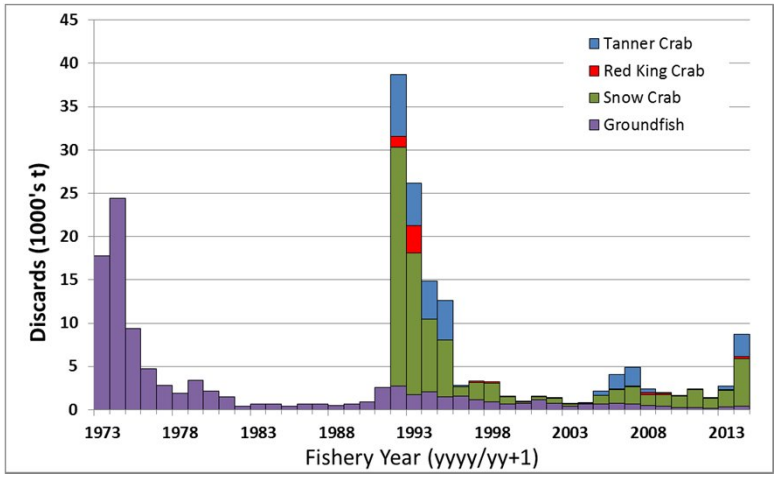
Fishery Trends

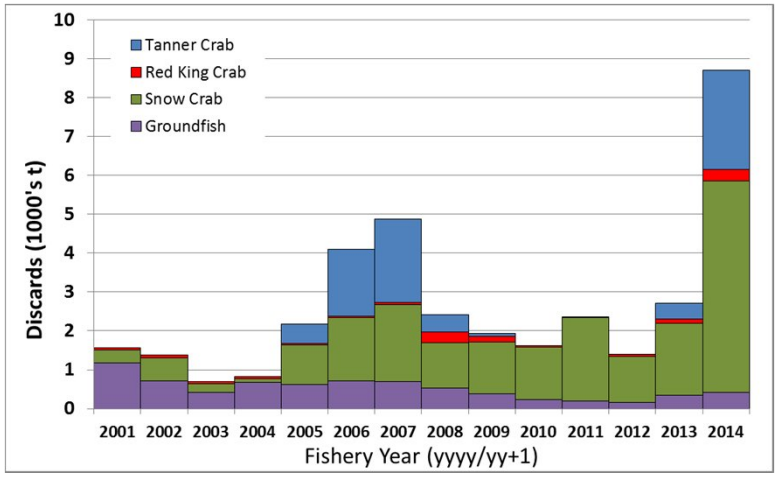
2014/15 Retained catch

- West 166W: GHL = 6,625,000 lbs; Catch = 77.5%
- East 166W: GHL = 8,480,000 lbs; Catch = 99.6%



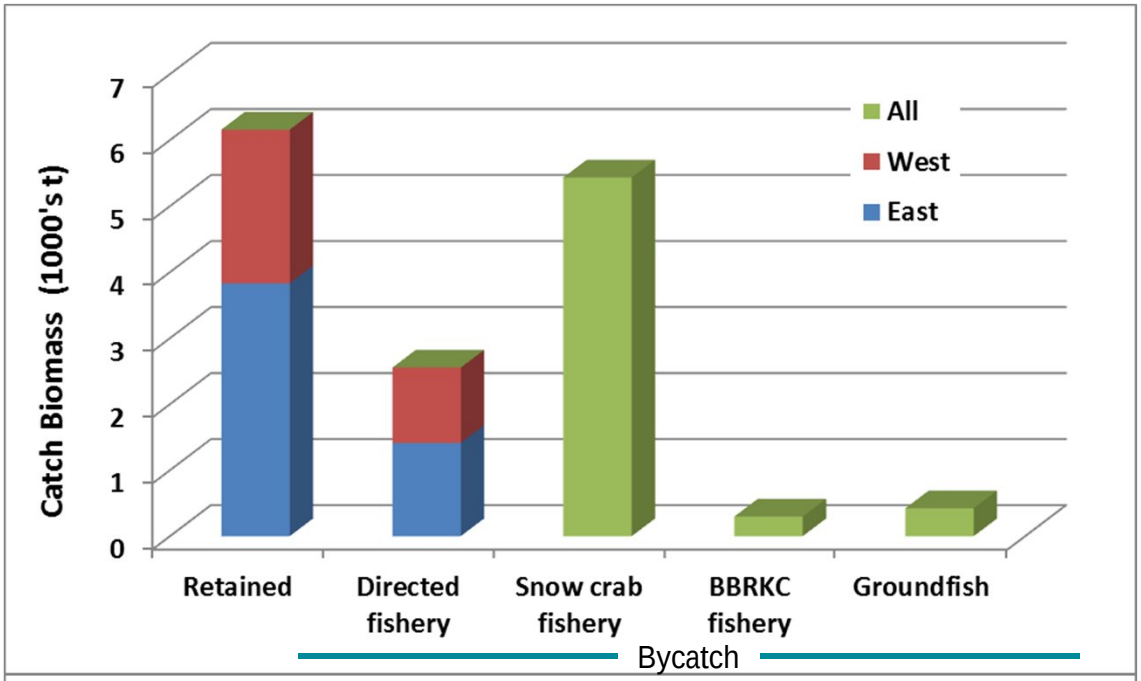




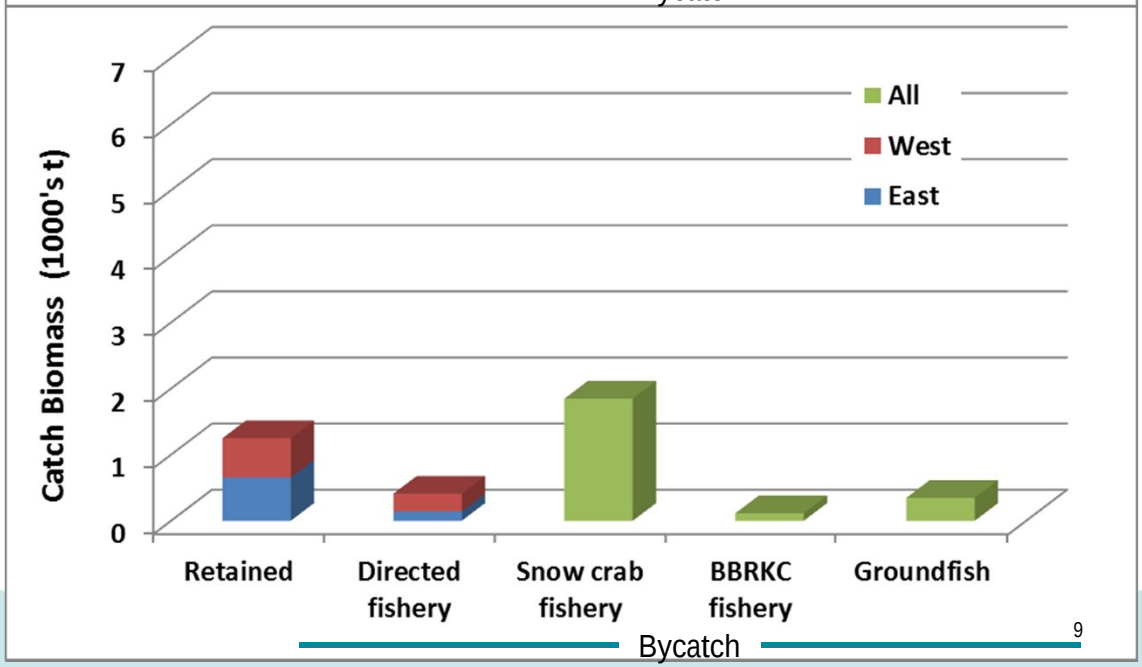


Fisheries

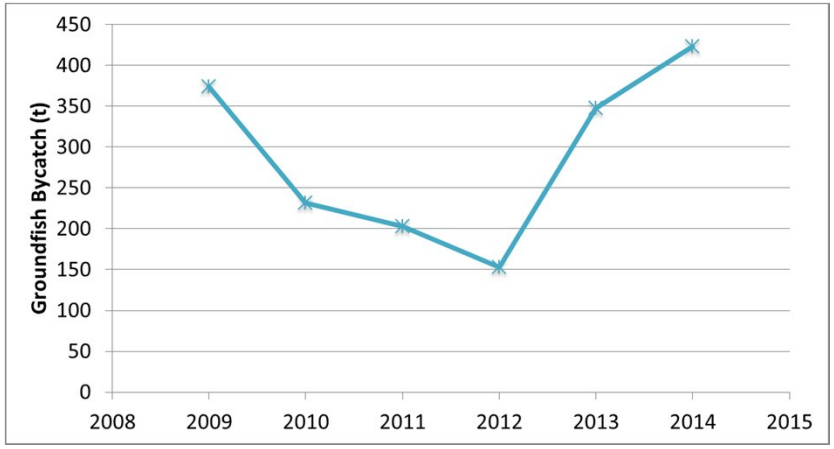
2014/15

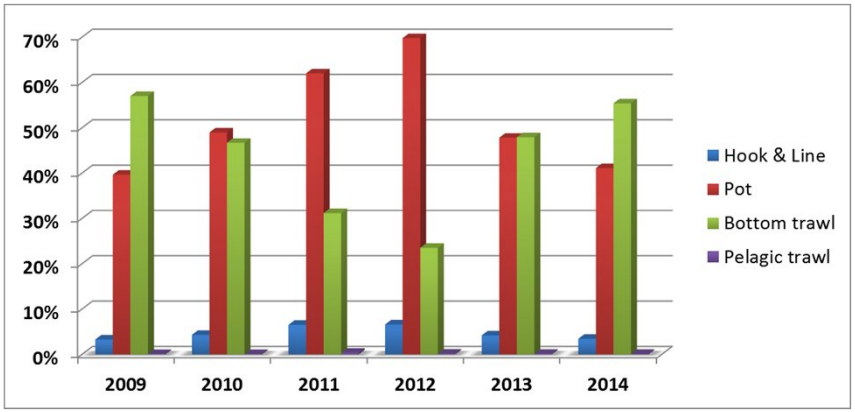


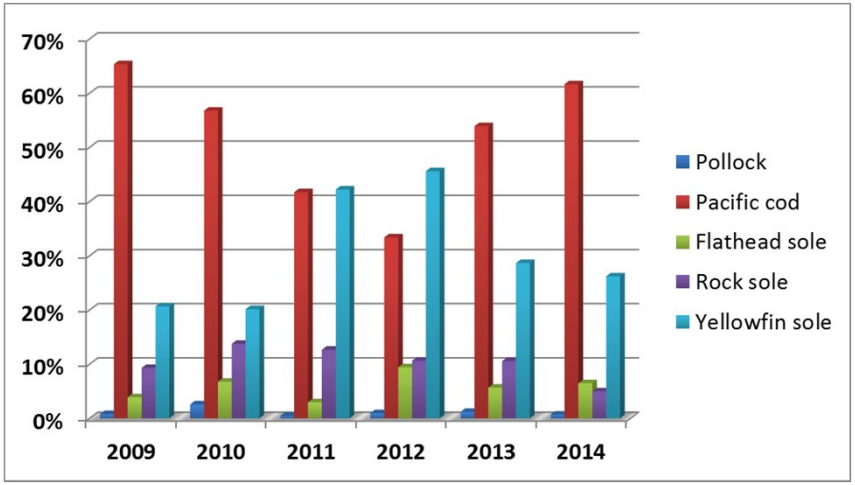
2013/14



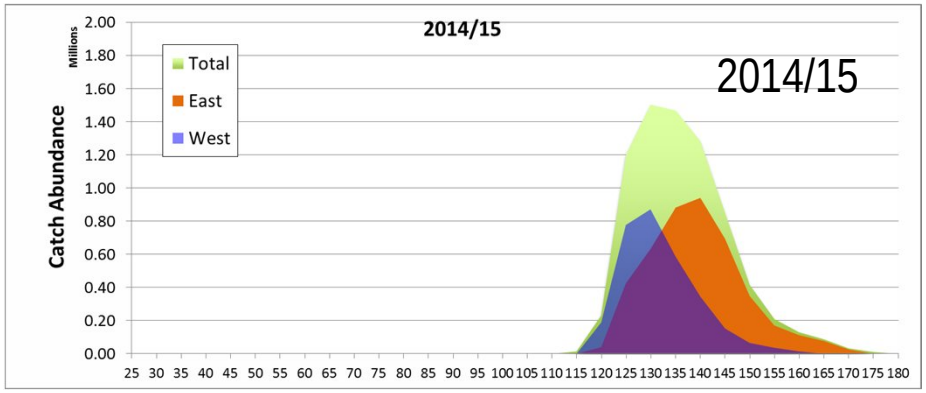
Bycatch in the Groundfish Fisheries



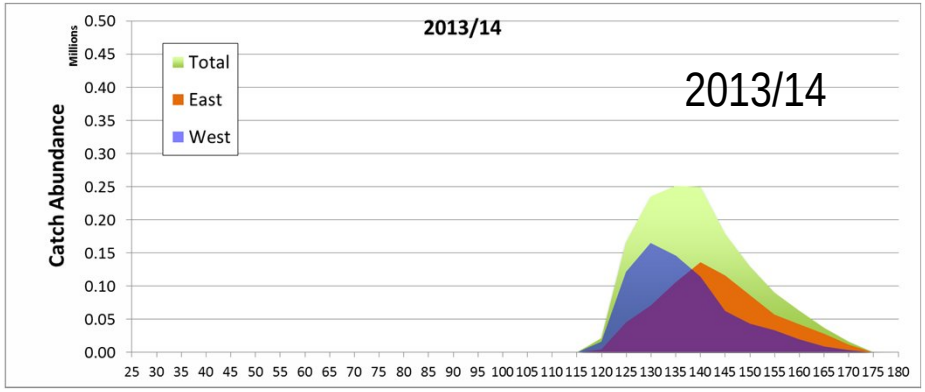




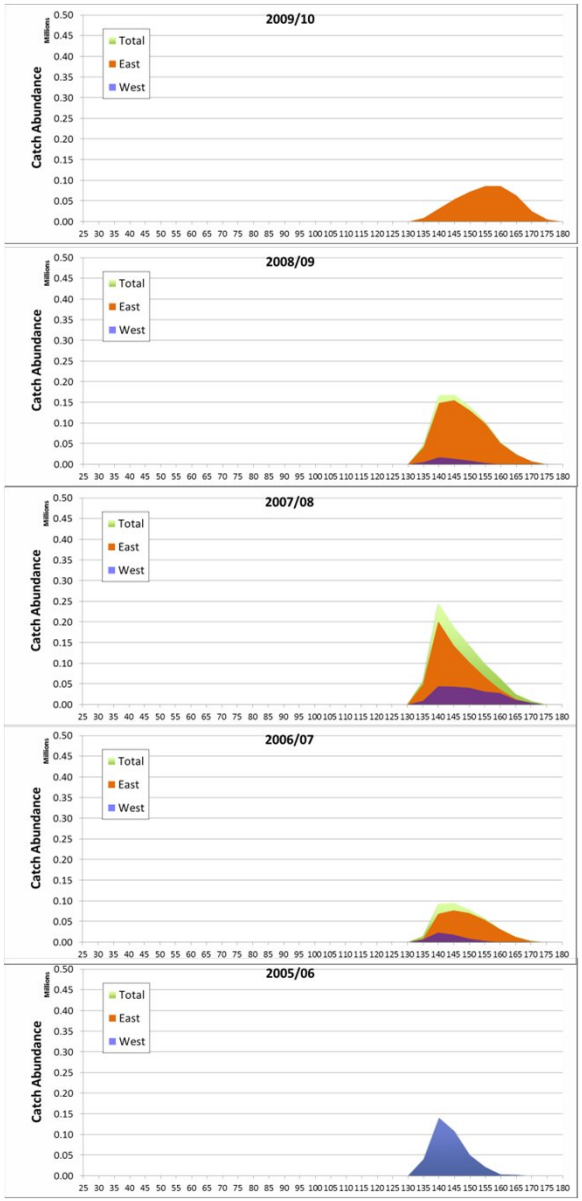
Retained Catch in the Tanner Crab Fishery



2014/15



2013/14



2009/10

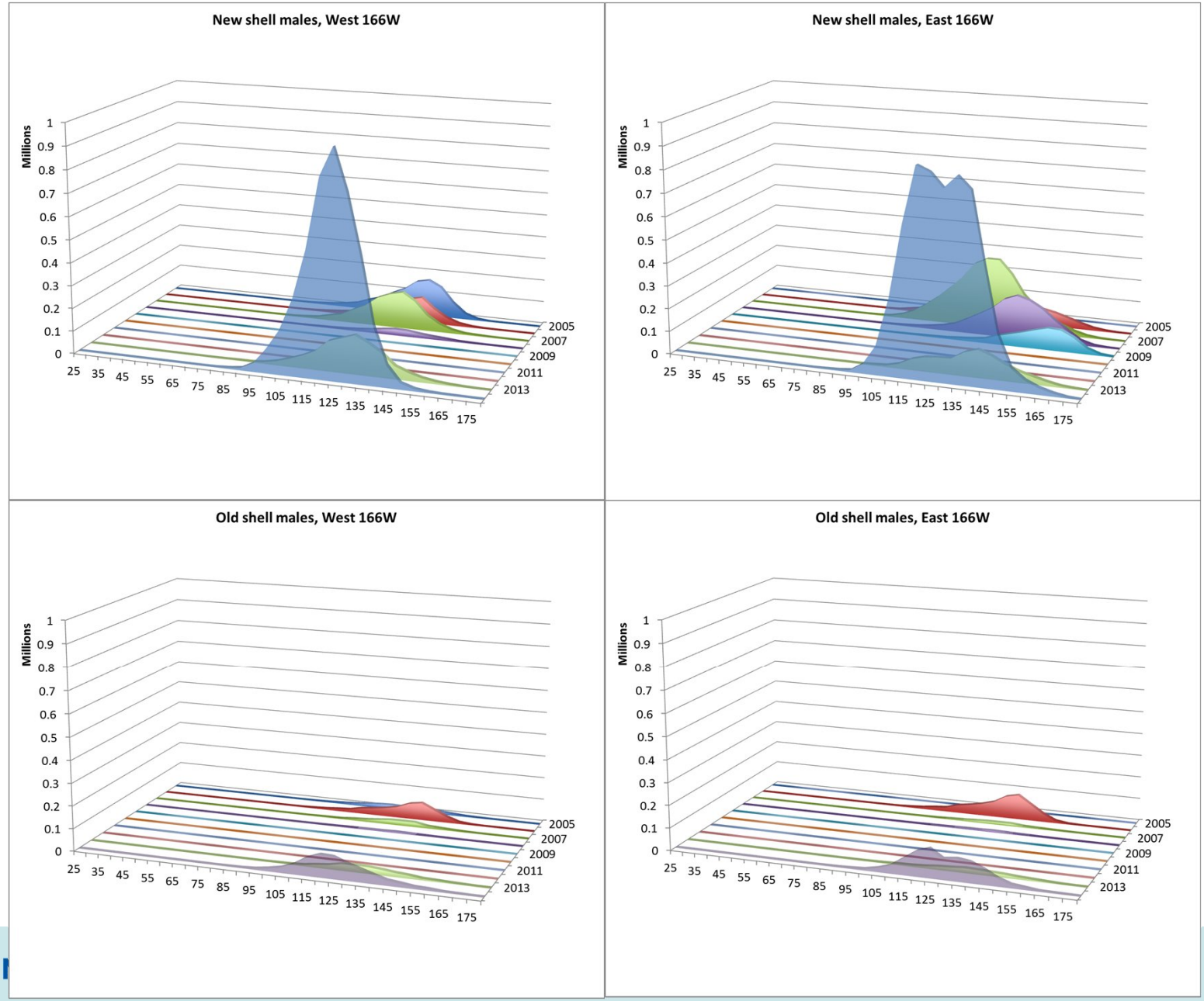
2008/09

2007/08

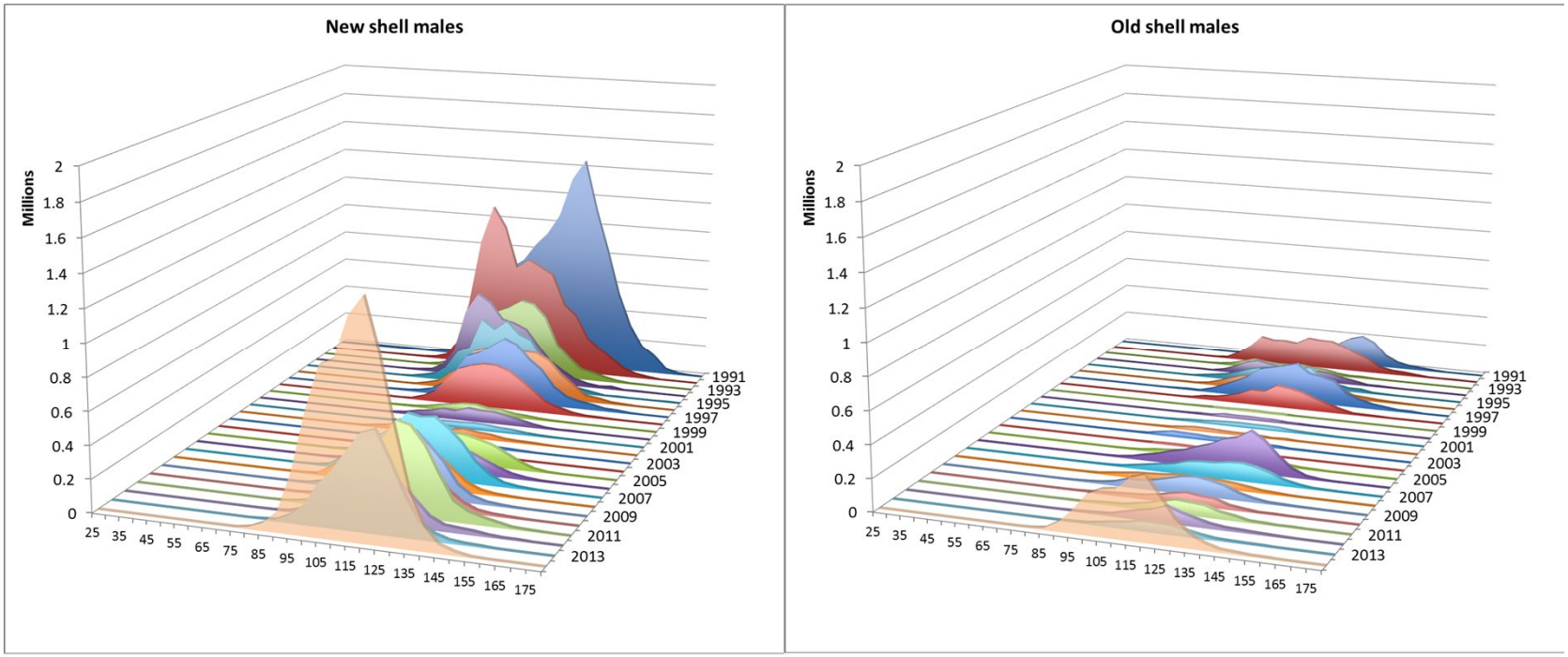
2006/07

2005/06

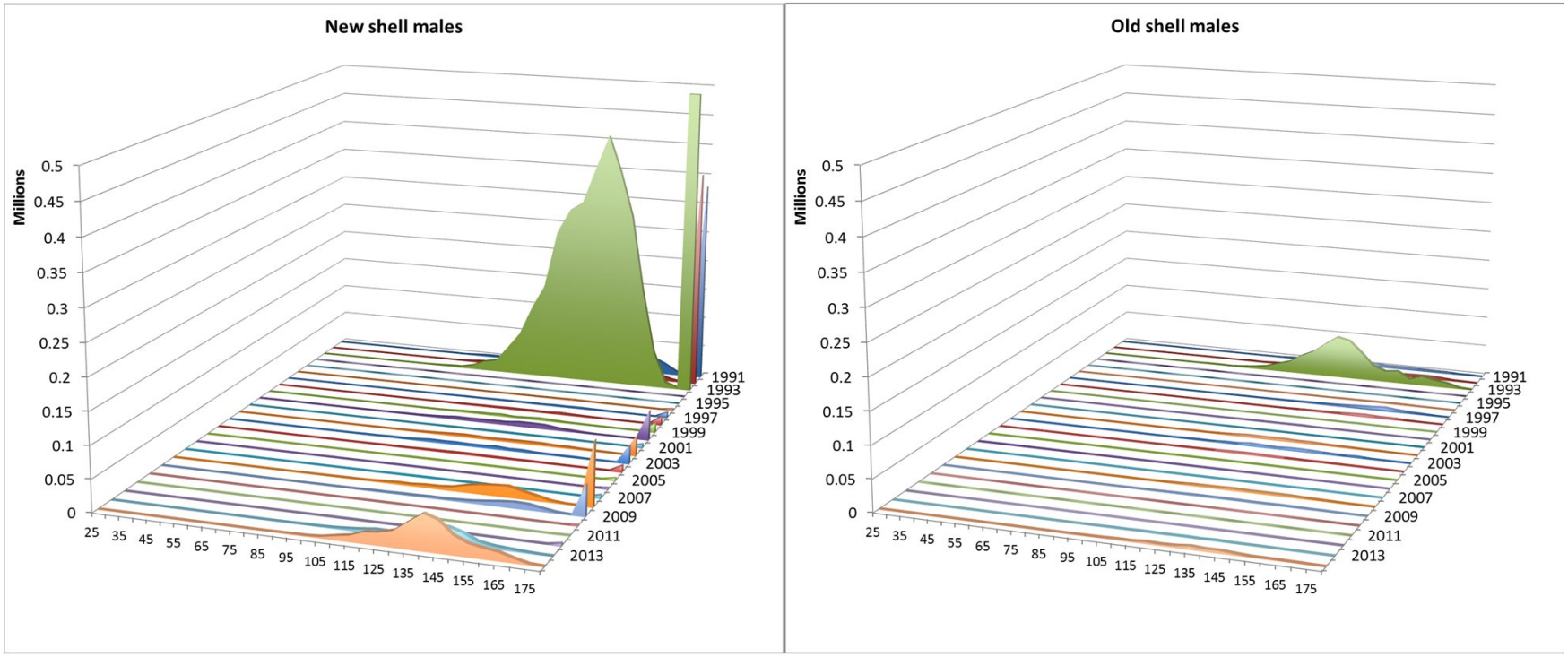
Total Male Catch (retained+discards) in the Directed Fishery



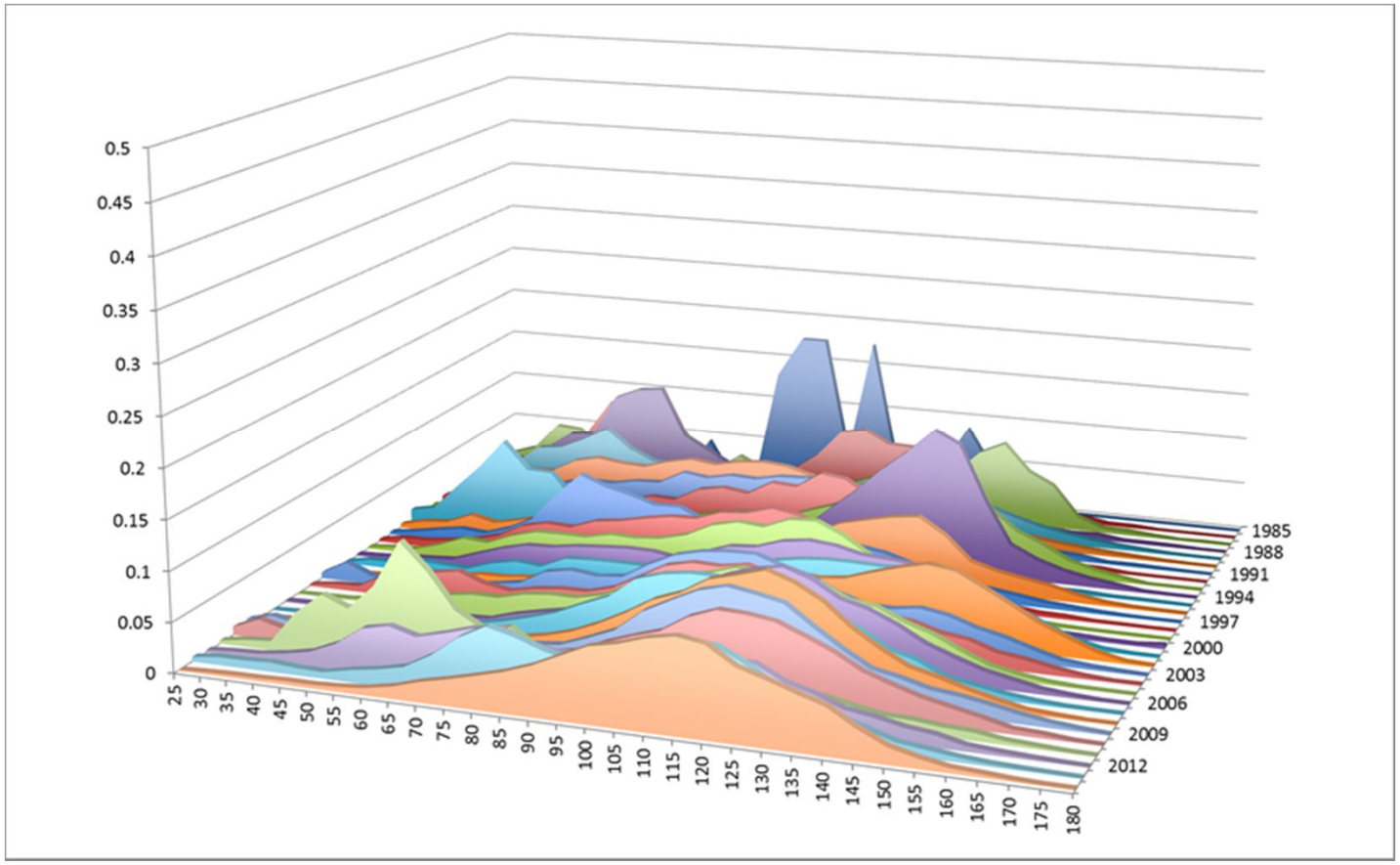
Male Bycatch in the Snow Crab Fishery



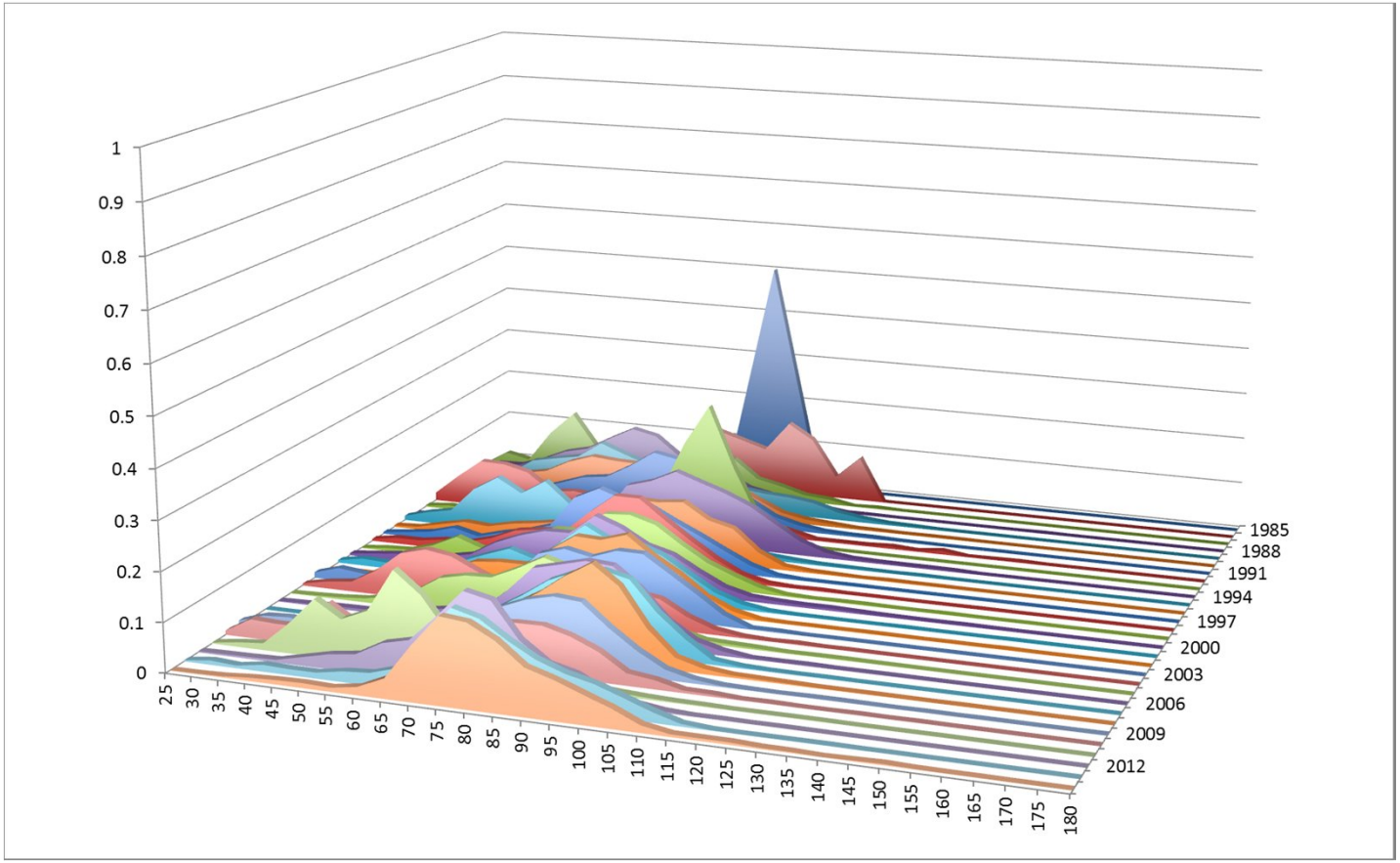
Male Bycatch in the BBRKC Fishery



Male Bycatch in the Groundfish Fisheries: Size Compositions



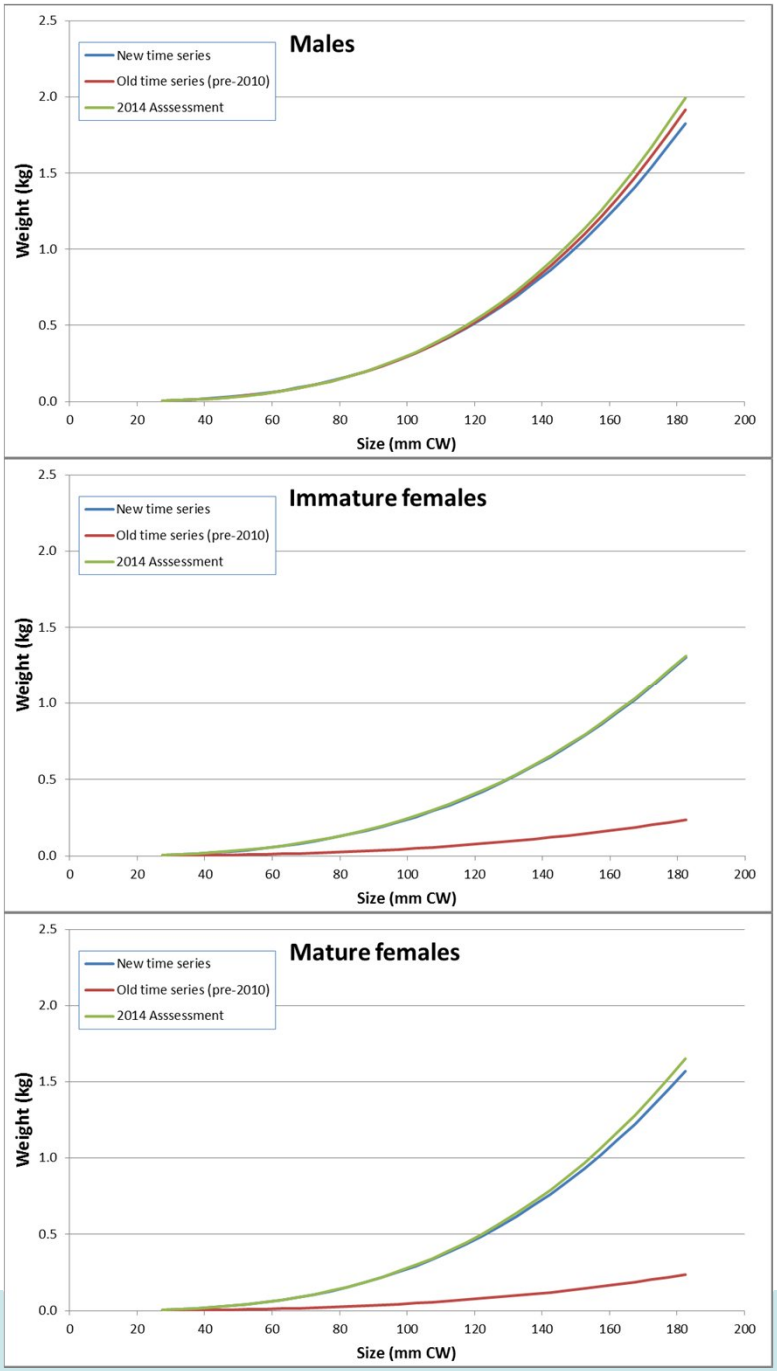
Female Bycatch in the Groundfish Fisheries: Size Compositions



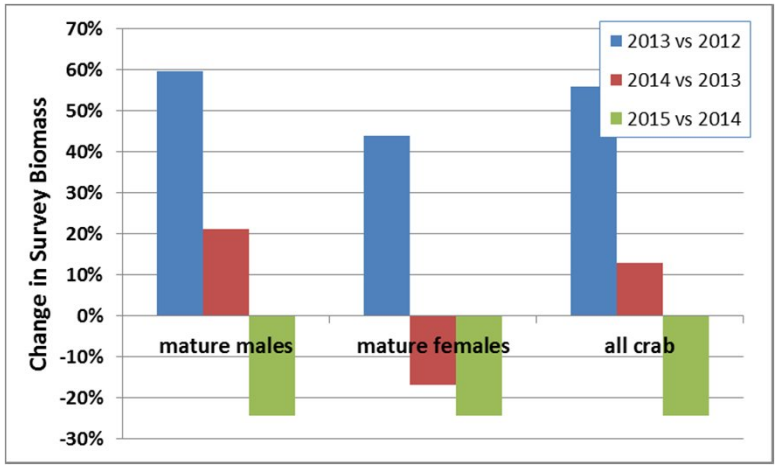
Survey Results

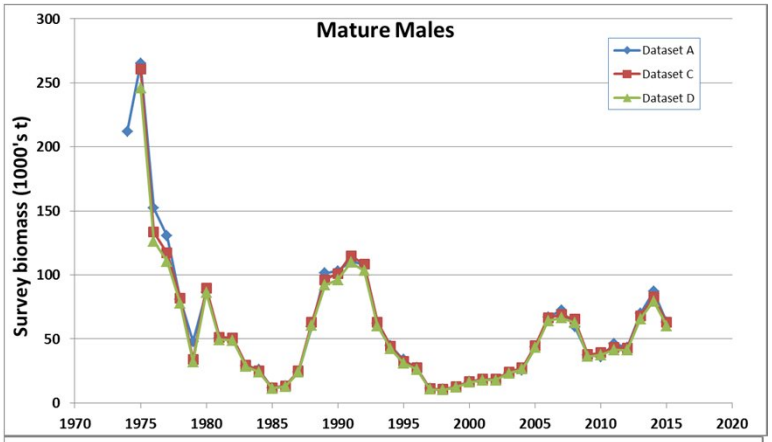
NMFS EBS Trawl Survey Standardization

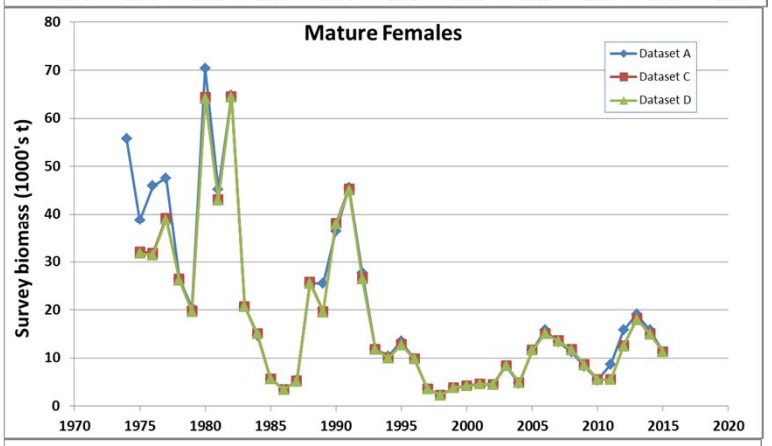
- Drop 1974 survey
- Standardize 1975+ dataset
  - no multiple haul stations
  - no re-tows
  - no “hot-spot” tows
  - standardized strata
  - 1 haul/1 station
  - standardized size-weight regressions
  - morphological female maturity

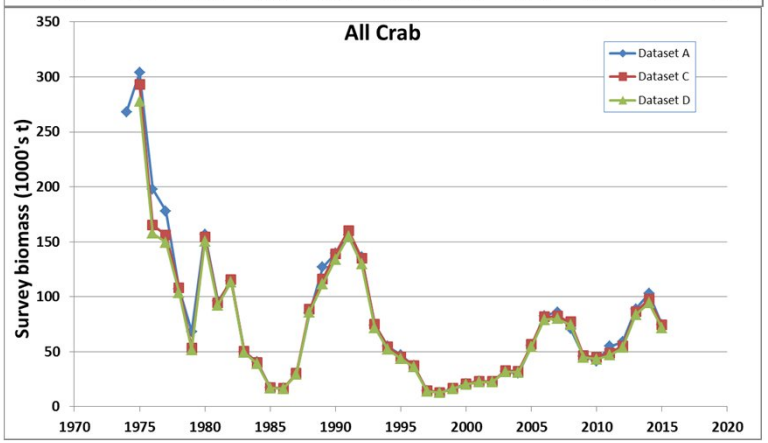


NMFS EBS Trawl Survey Trends

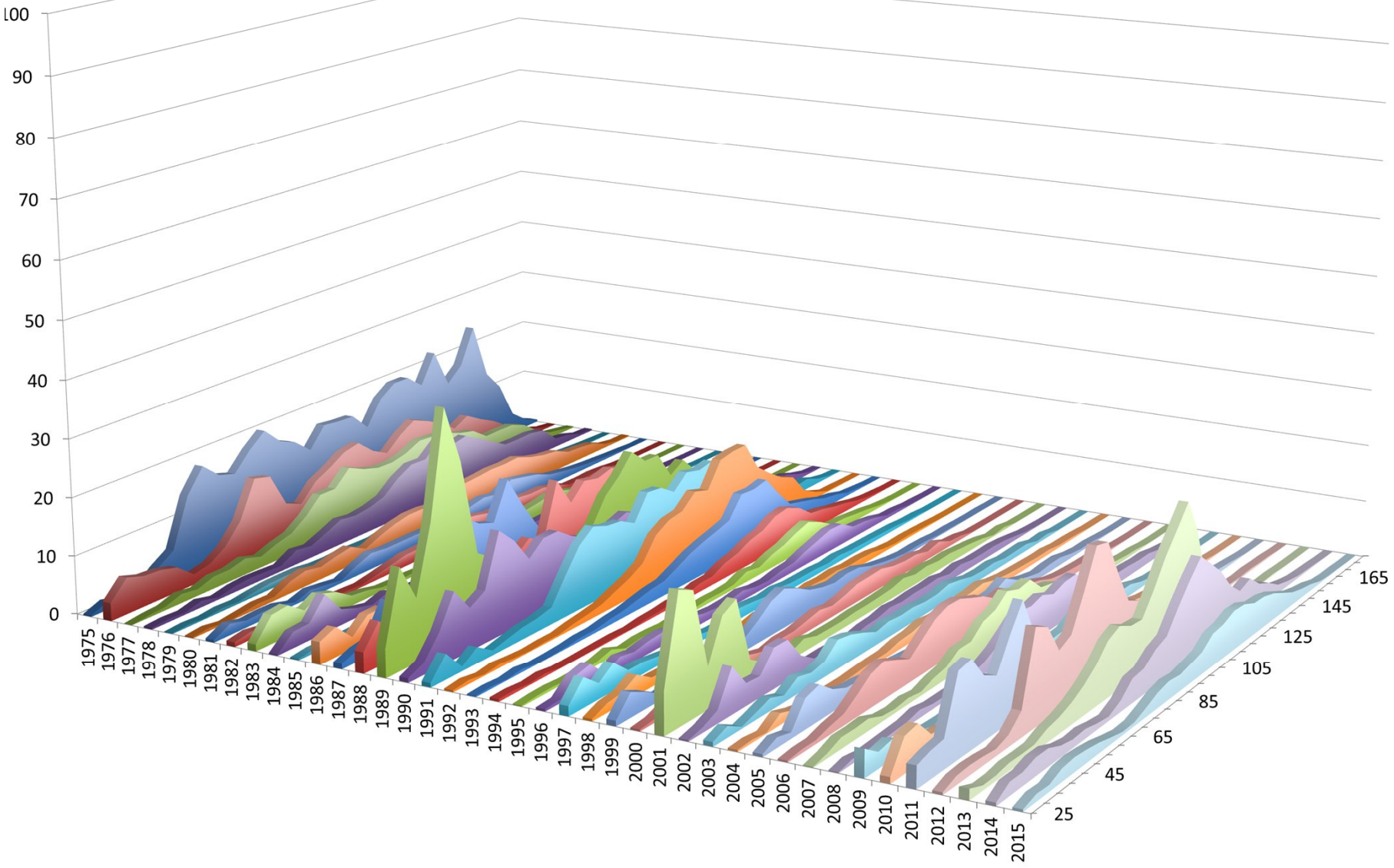




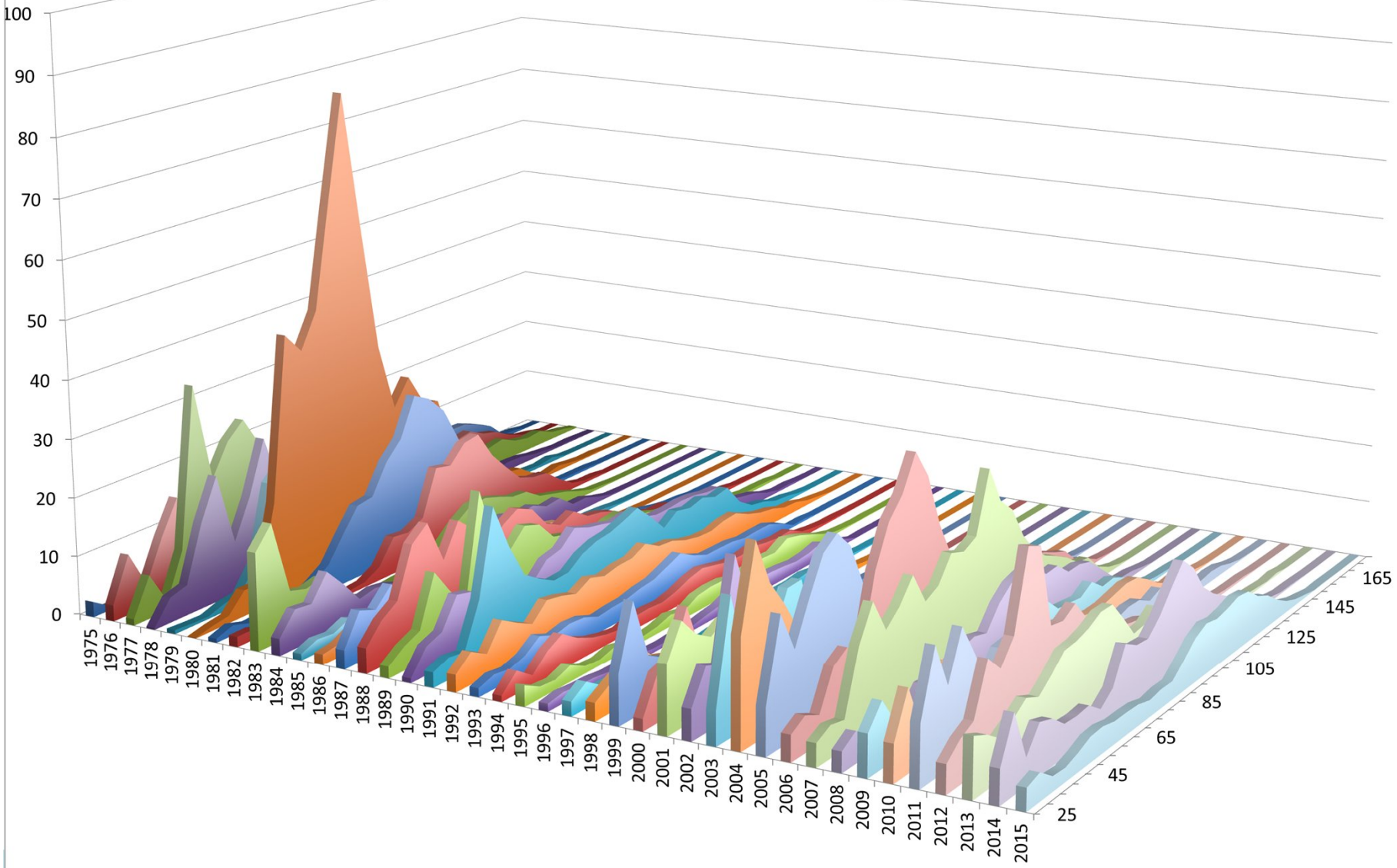




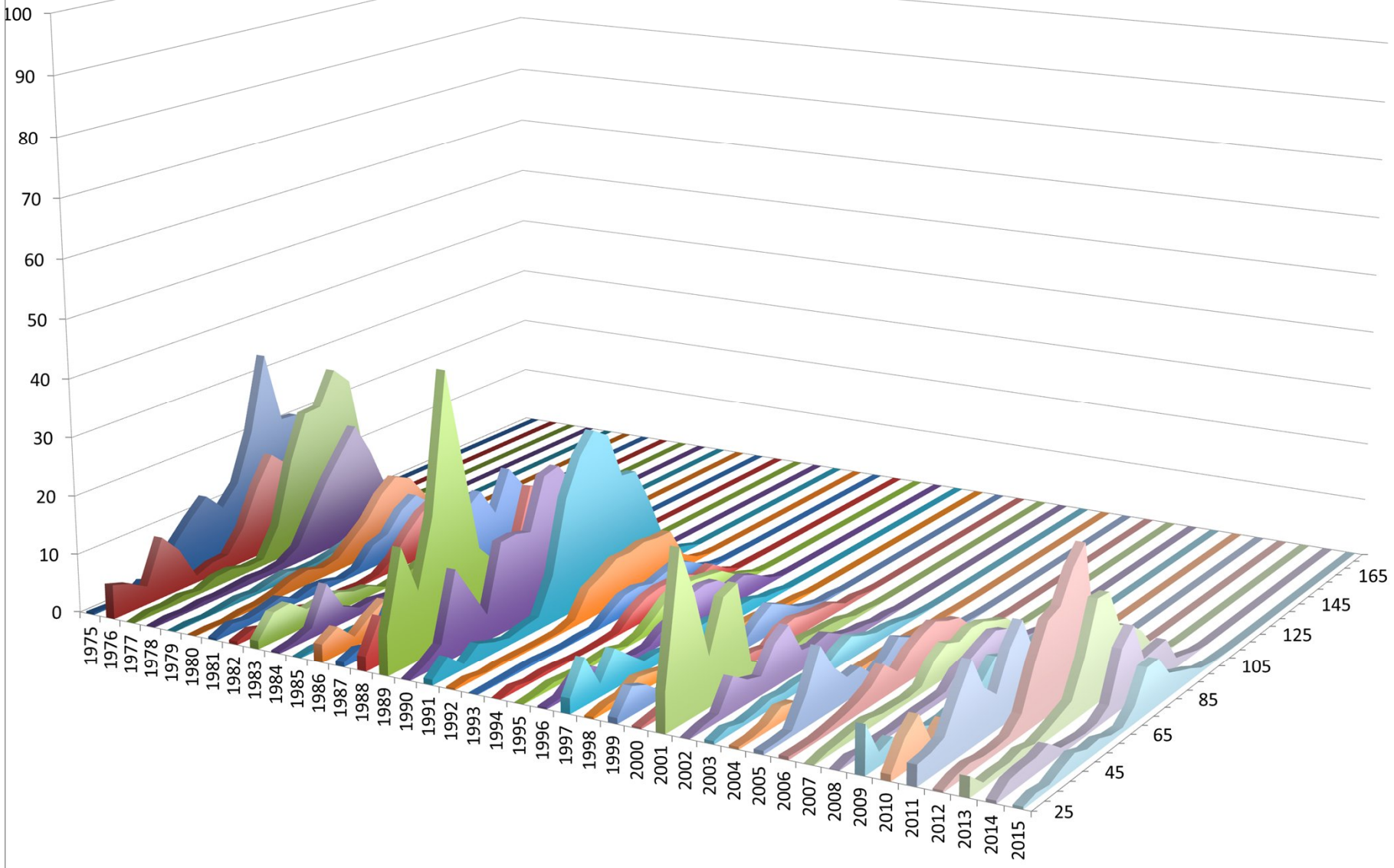
Trawl Survey Size Comps: Males, East 166W



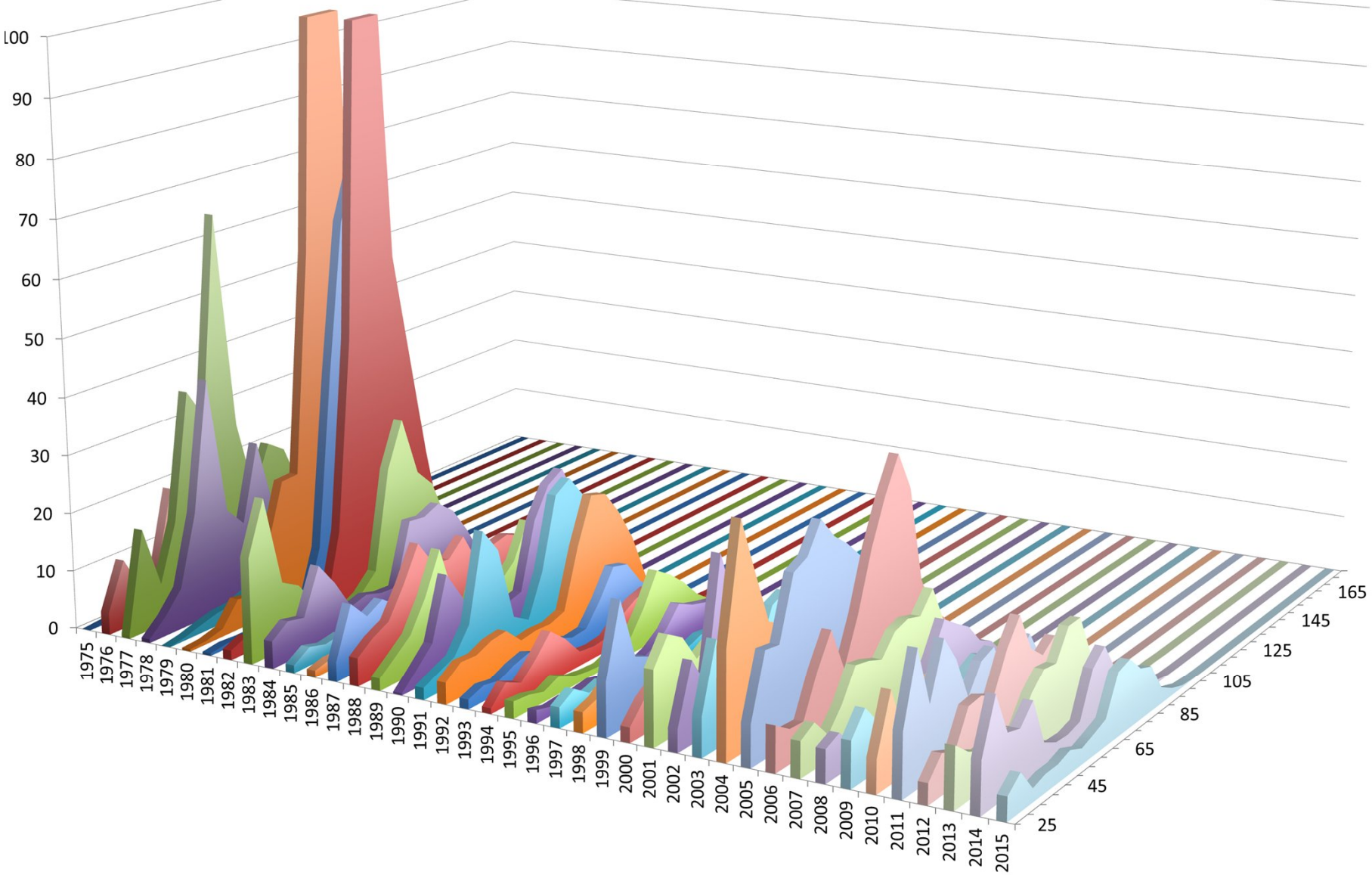
Trawl Survey Size Comps: Males, West 166W



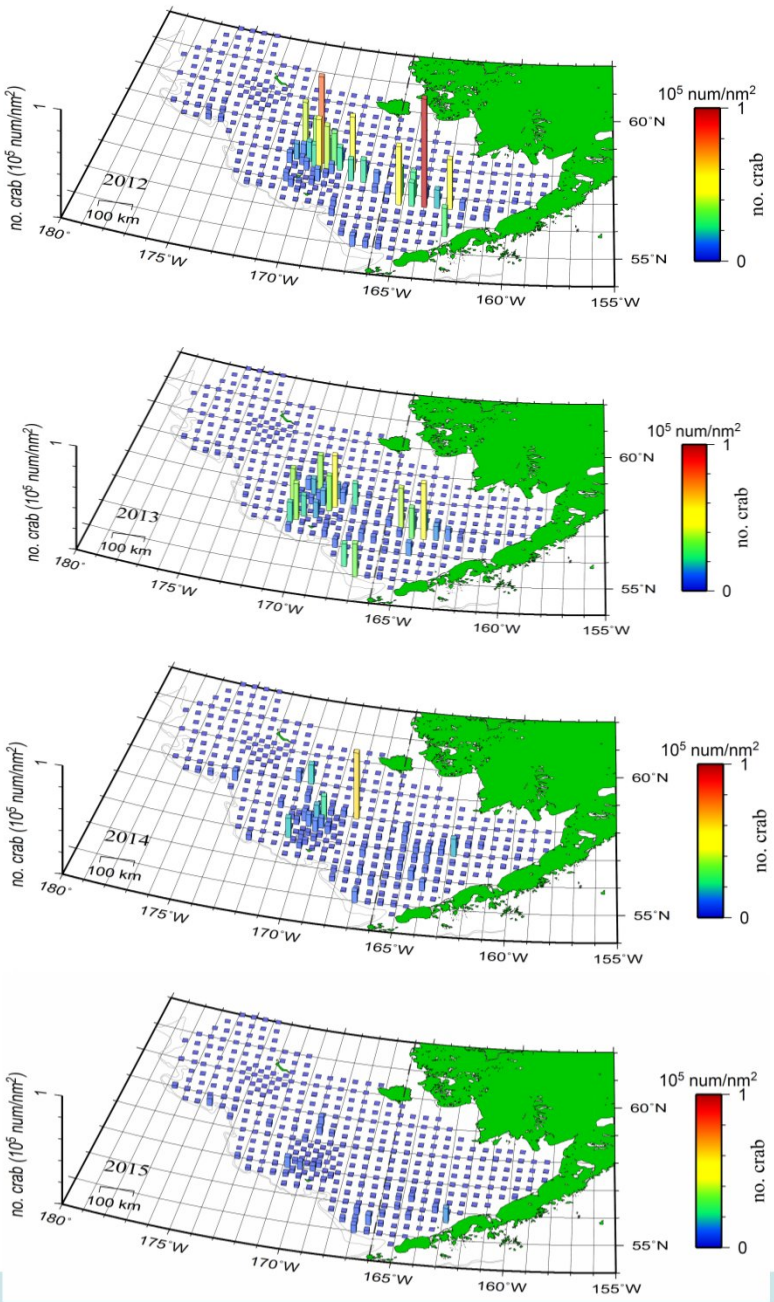
Trawl Survey Size Comps: Females, East 166W



Trawl Survey Size Comps: Females, West 166W

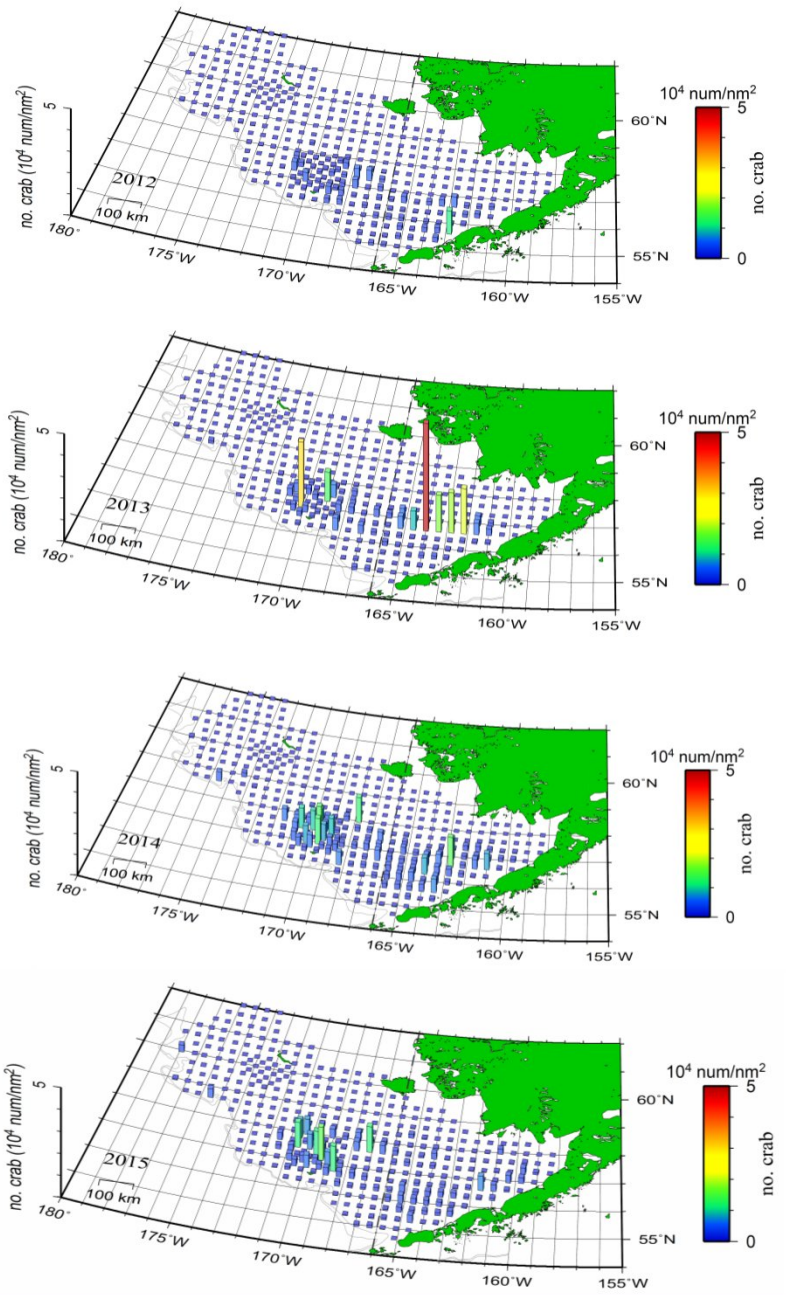


NMFS EBS Trawl Survey Trends: Immature Males

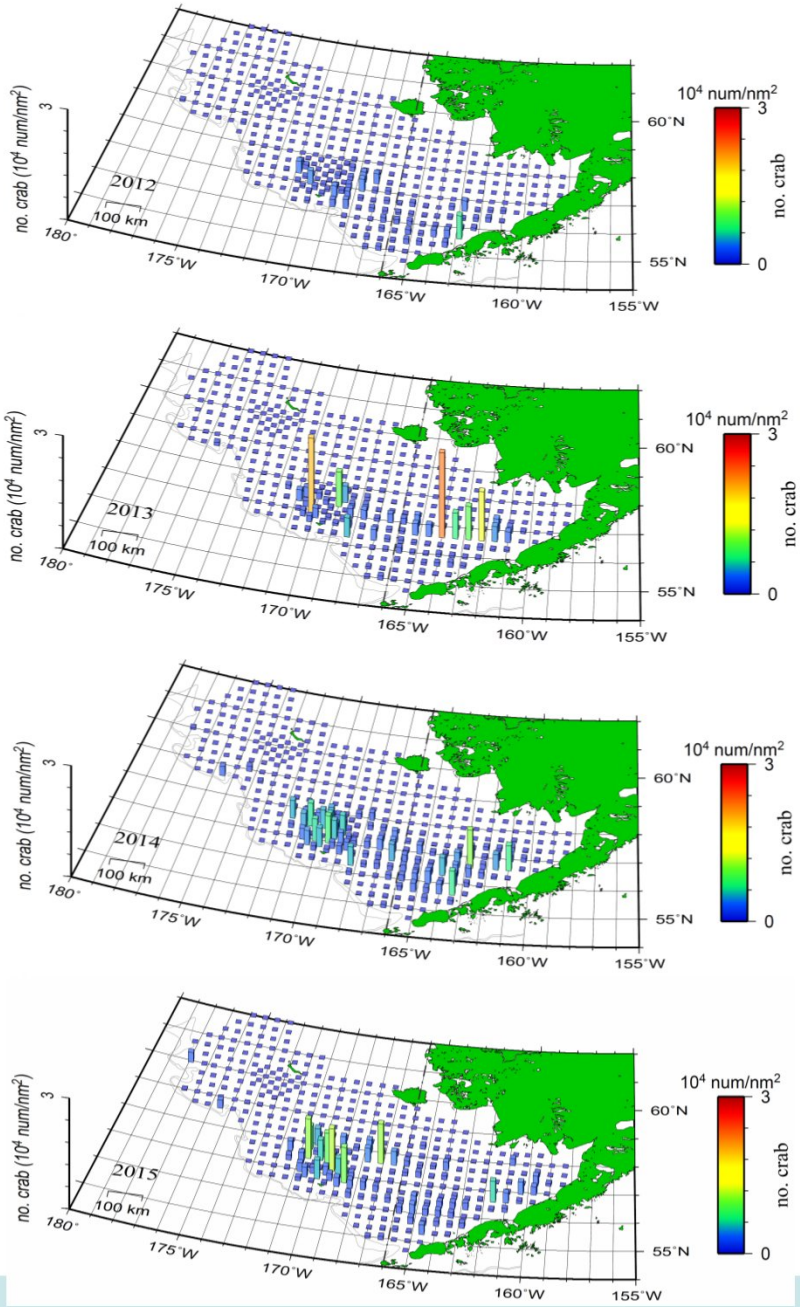


NOAA FISHERIES

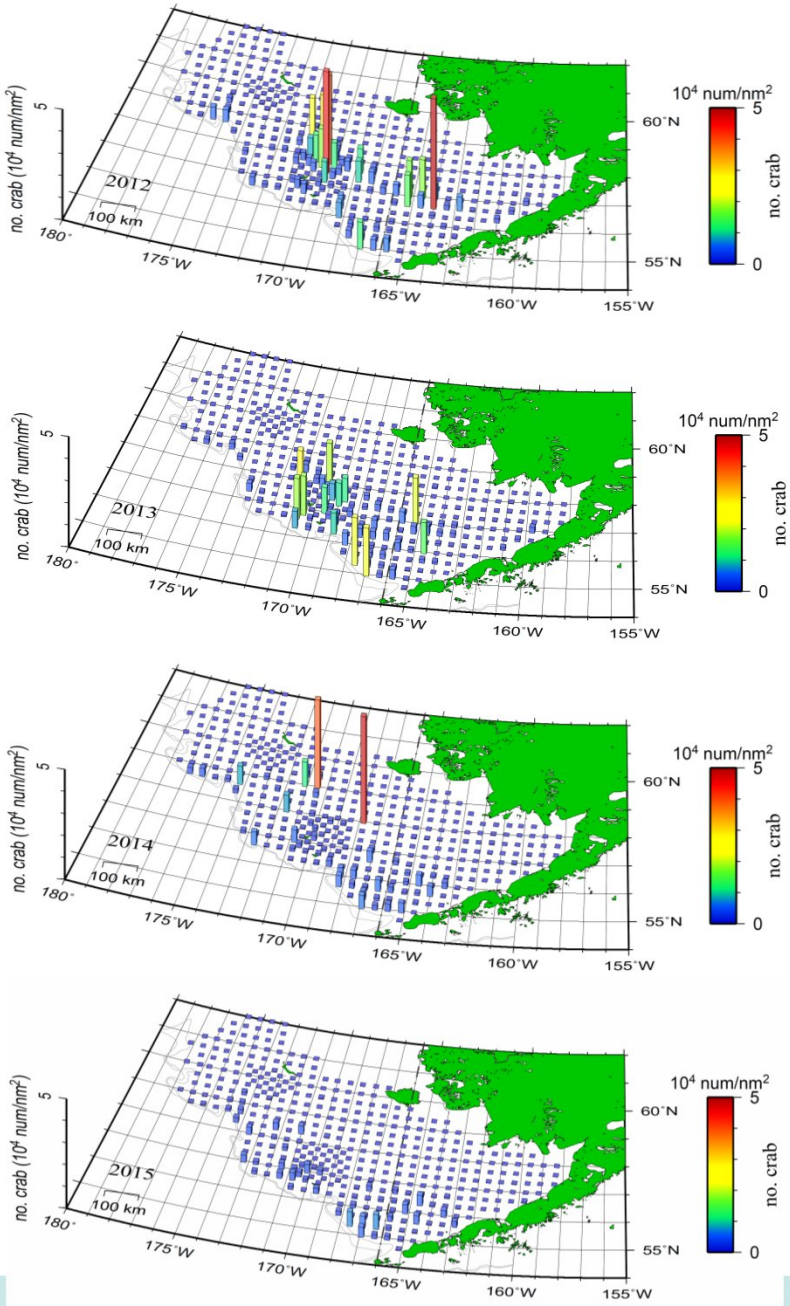
NMFS EBS Trawl Survey Trends: Mature Males



NMFS EBS Trawl Survey Trends: Legal Males

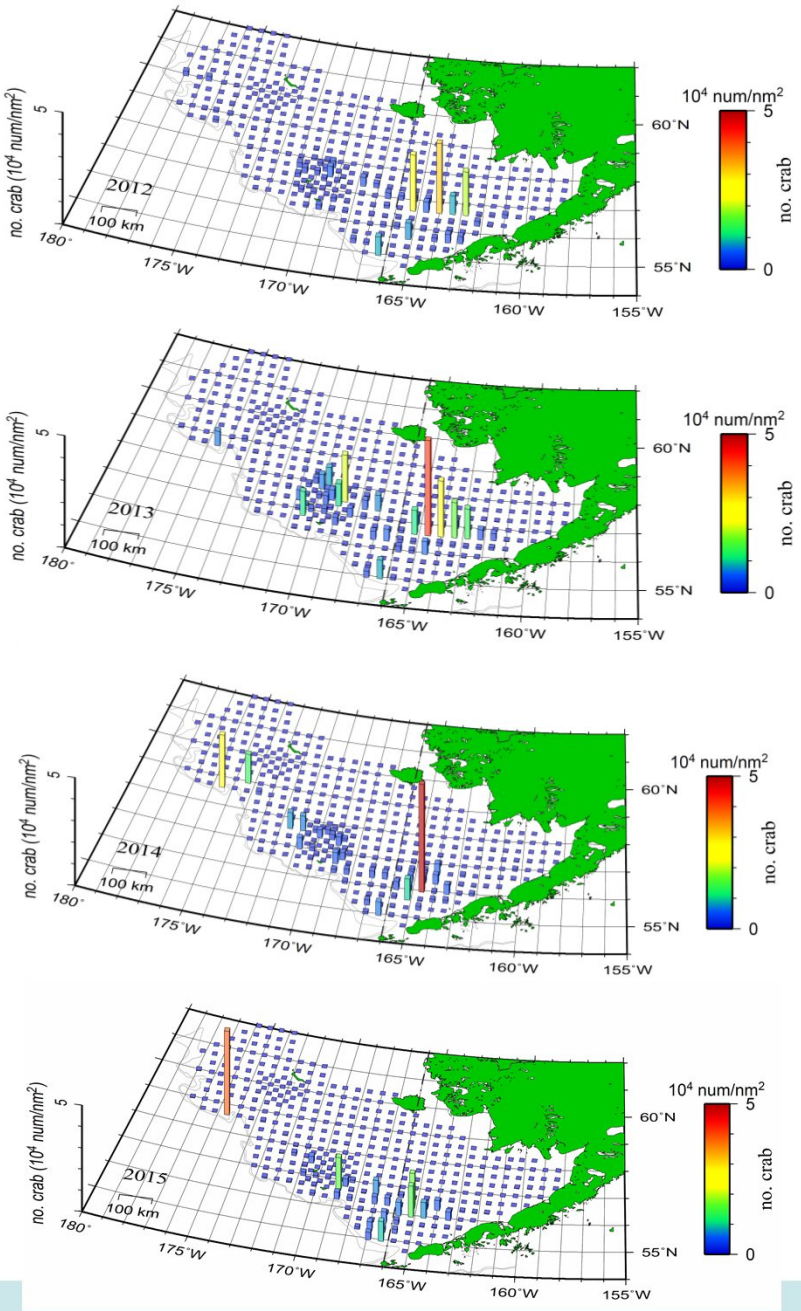


NMFS EBS Trawl Survey Trends: Immature Females

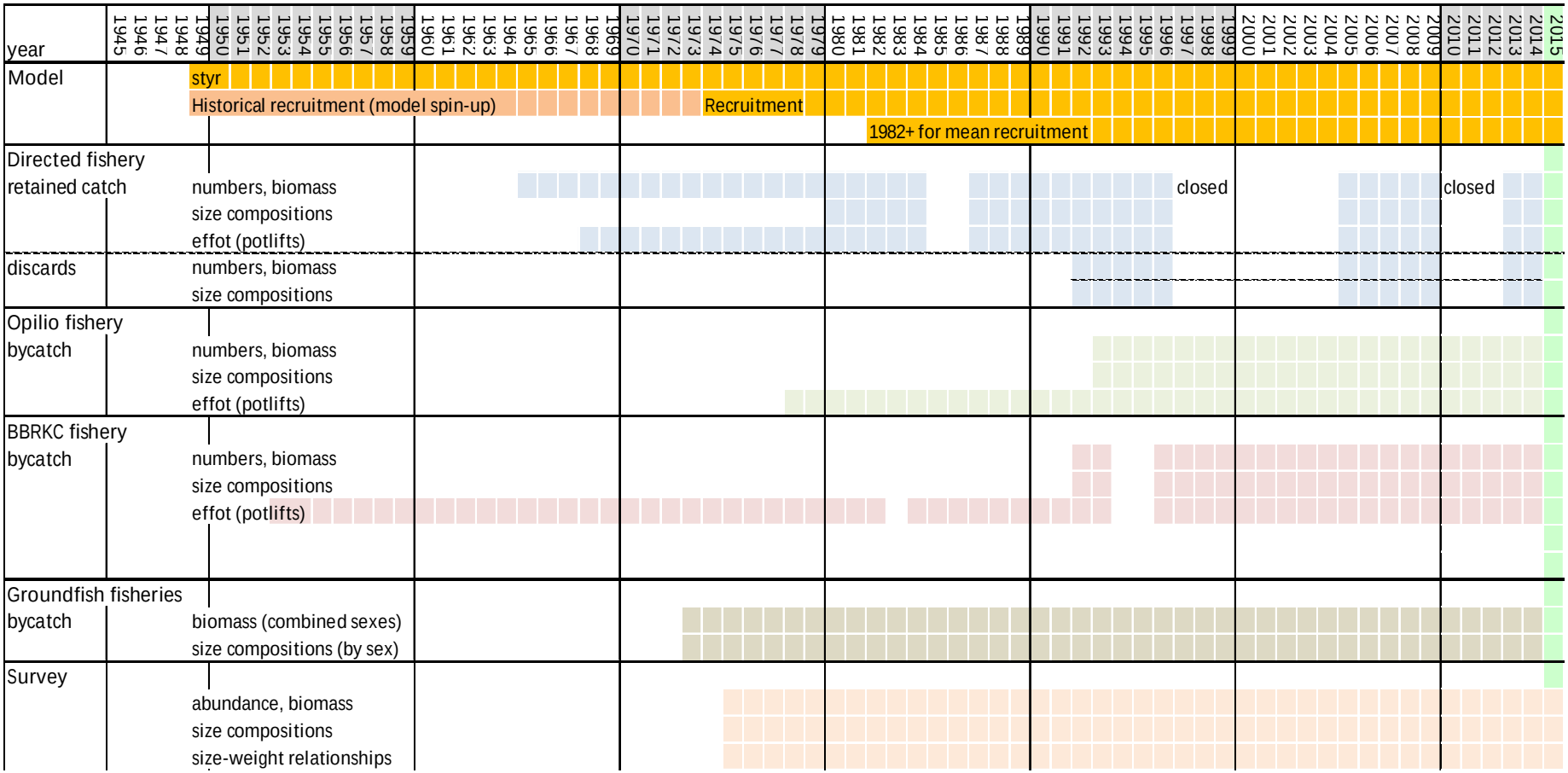


NOAA FISHERIES

NMFS EBS Trawl Survey Trends: Mature Females



Data Time Periods



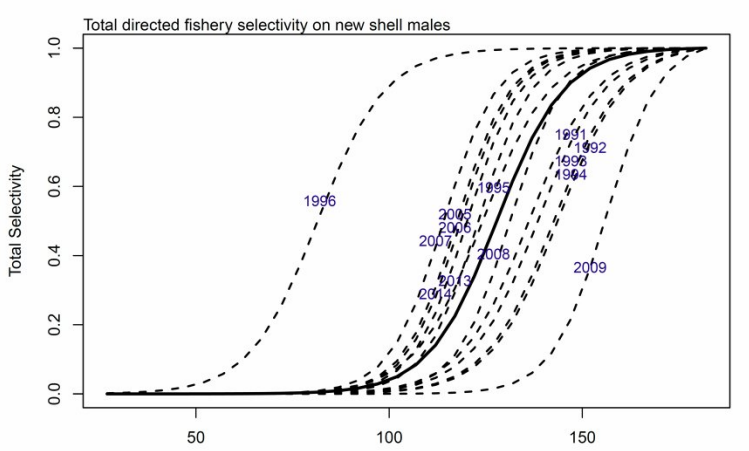
Model Overview

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 Description: Directed Fishery

- Stock-wide (single-fleet) model
- Annual fully-selected fishing mortality
    - ln-scale mean
    - annual ln-scale deviations
- Fishing mortality size dependence (“selectivity”)
    - logistic functions
    - males: 2 time periods
        - pre-1991/92
        - 1992/93+
            - mean z50
            - annually-varying deviations
    - females: 1 time period
- Male retention mortality function
    - pre-1991/92
    - 1991/92+



Model Description: Crab Bycatch Fisheries

- Snow crab pot fishery
  - fully-selected fishing mortality
    - annually-varying 1992/93+ (est.d)
    - proportional to effort pre-1992/93
  - Selectivity
    - males: double logistic selectivity
    - females: logistic selectivity
    - 3 periods:
      - 1949/50-1996/97
      - 1997/98-2004/05
      - 2005/06-2014/15

- BBRKC pot fishery
  - fully-selected fishing mortality
    - fixed
    - proportional to effort 1953/54-1992/93
  - Selectivity
    - sex-specific logistic functions
    - 3 periods:
      - 1949/50-1996/97
      - 1997/98-2004/05
      - 2005/06-2014/15
  - no fishery: 1984/85-1985/86, 1994/95-1996/97

Model Description: Groundfish Bycatch Fisheries

- annually-varying fully-selected mortality
  - 1973+
- logistic selectivity functions
  - sex-specific
  - 3 periods:
    - 1949/50-1986/87
    - 1987/88-1996/97
    - 1997/-2014/15

Model Description: Trawl Survey

- sex-specific survey Q's (catchabilities)
  - female Q-multiplier estimated
- sex-specific logistic selectivities
  - parameterized by Z_{50} and ΔZ_{95}
- 2 time periods
  - pre-1982
  - 1982+

Likelihood components

Fishery catch biomass mortality

- directed fishery
  - retained catch
  - total male catch mortality
  - female bycatch mortality
- total bycatch mortality in
  - snow crab pot fishery
  - BBRKC pot fishery
  - groundfish fisheries

$$\lambda \sum_{t=1}^{T} \left[(C_{t,fishery}) - (\hat{C}_{t,fishery}) \right]^2$$

Survey biomass

- mature biomass
  - males
  - females

$$\lambda \sum_{t=1}^{ts} \left[\frac{\log(SB_t) - \log(\hat{SB}_t)}{sqrt(2) * s.d.(\log(SB_t))} \right]^2$$

Fishery size compositions

- directed fishery
  - retained catch
  - total male catch composition
  - female bycatch composition
- bycatch compositions by sex in
  - directed fishery
  - snow crab, BBRKC pot fisheries
  - groundfish fisheries

$$-\sum_{t=1}^{T} \sum_{l=1}^{L} nsampwt_t * p_{t,l} \log(\hat{p}_{t,l} + o) - Offset$$

Survey size compositions

- immature males
- immature females
- mature males
- mature females

$$-\sum_{t=1}^{T} \sum_{l=1}^{L} nsampwt_t * p_{t,l} \log(\hat{p}_{t,l} + o) - Offset$$

Likelihood components

Penalties on

- recruitment dev.s
  - variance of ordinary recruitment dev.s (1974+)
  - 1st difference of "early" recruitment dev.s (1949-1973)
- natural mortality
  - immature crab
  - mature males, females
- smoothness of pr(molt to maturity)
- fisheries
  - 1st difference in change in size at 50% selectivity for males in directed fishery
  - fishing mortality dev.s

Priors on

- growth parameters
- survey
  - survey q
  - survey q for females

Model/Data Scenarios

Datasets

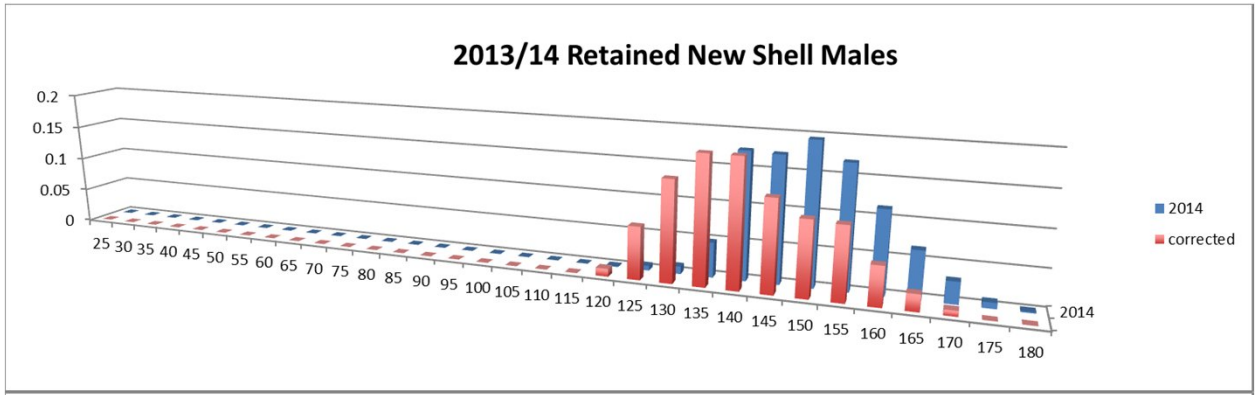
Dataset Name	Base Dataset	Modifications
base (2014 assesssment)	--	--
2014 Corrected	2014 assessment	corrects 2013/14 retained catch, size frequencies
A	2014 corrected	updates 2013/14 fisheries data, adds 2014/15 data; adds 2015 survey data
B	A	replaces old trawl survey data with new time series
C	B	updates 2009/10-present bycatch size compositions in the groundfish fisheries
D	C	uses the standardized trawl survey LW regressions

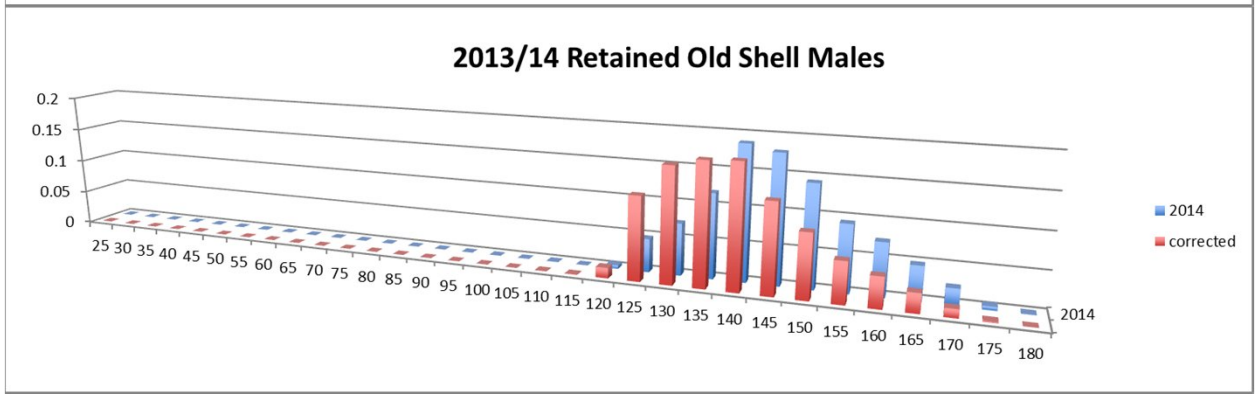
Models

Alternative Model	Base Model	ModelConfiguration			Datasets
		Fishing Mortality Model	Fishery Catch Likelihoods	Asymptotic Selectivity Forced?	
A	--	TCSAM2013	normal	no	2014 corrected, A, B, C, D
B	A	TCSAM2013	lognormal	no	D
C	A	Gmacs	normal	no	D
D	C	Gmacs	lognormal	no	D
E	A	TCSAM2013	normal	yes	D
F	B	TCSAM2013	lognormal	yes	D
G	C	Gmacs	normal	yes	D
H	D	Gmacs	lognormal	yes	D

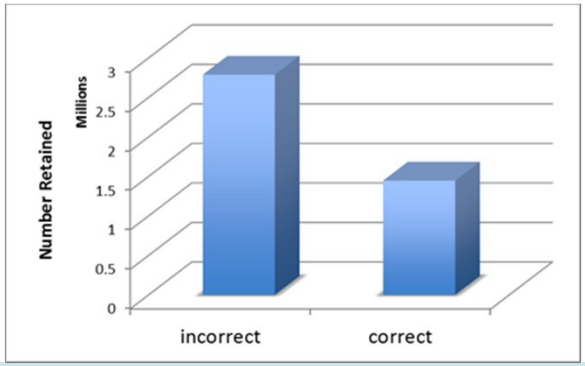
2014 Corrected Dataset: Retained Catch

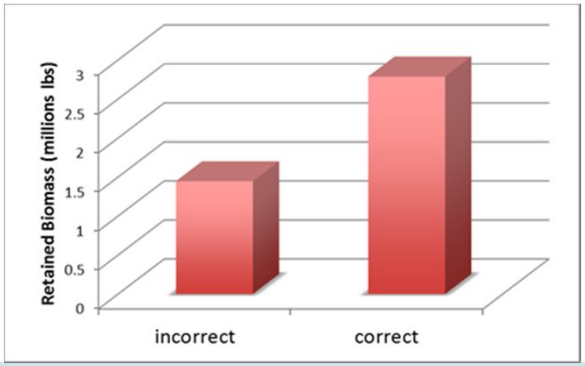
- 2013/14 relative size comps





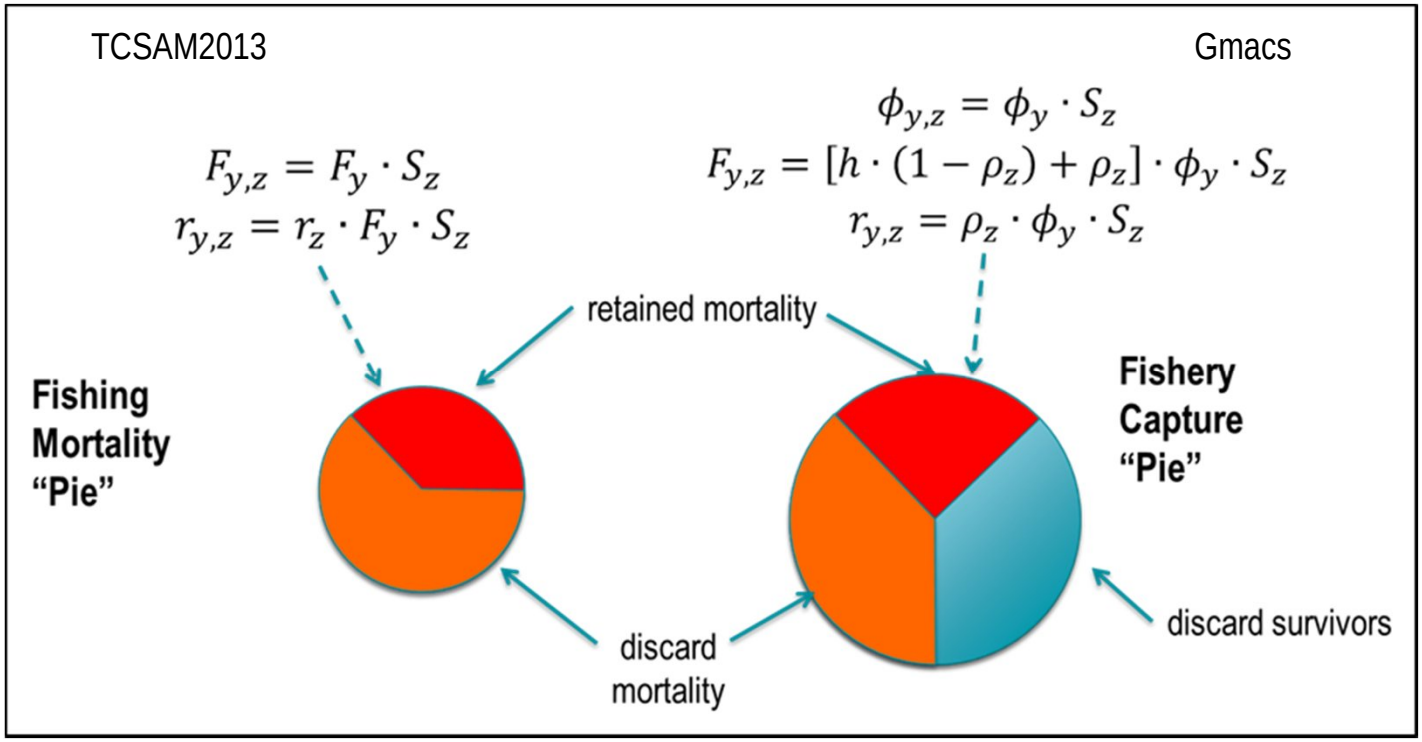
- 2013/14 abundance, biomass





Alternative Model Components

Alternative Fishing Mortality Model: Gmacs



TCSAM

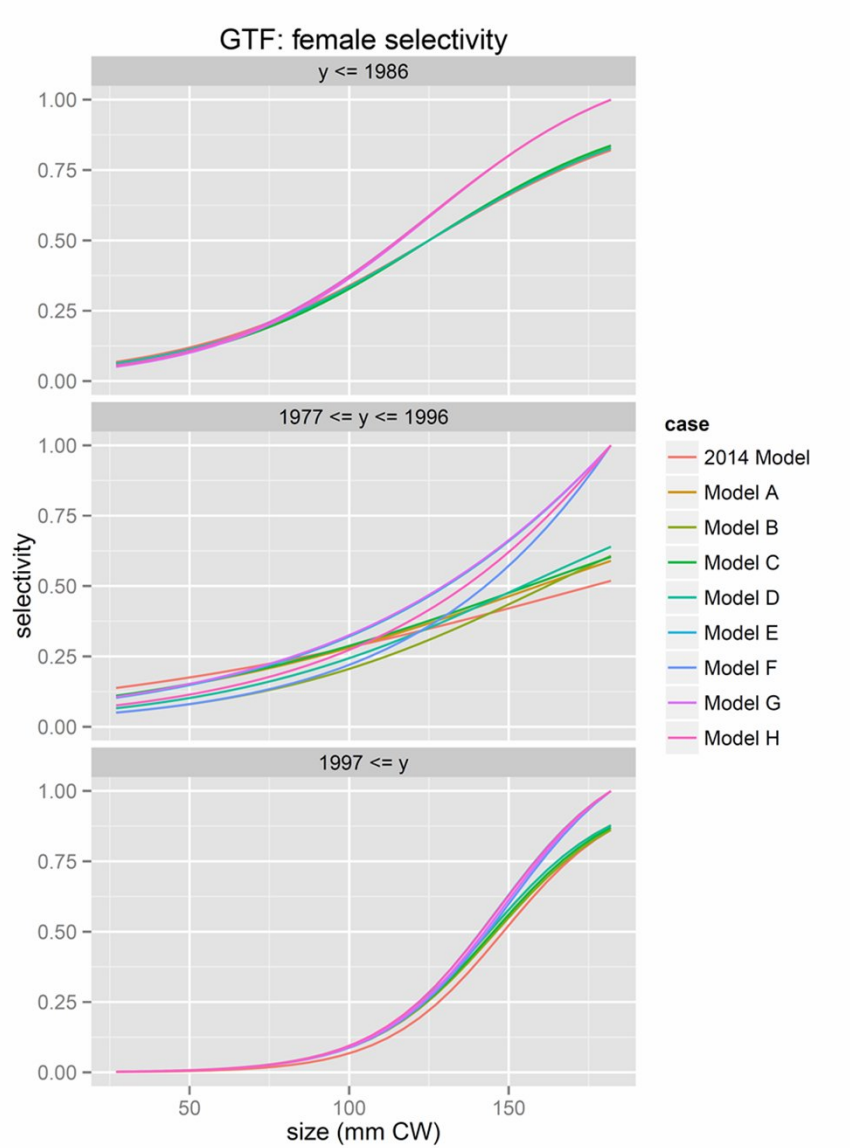
- Applies handling mortality to observed bycatch
- Fits "observed" total (retained + discard) mortality for males in directed fishery
- Fits "observed" discard mortality for females, males in bycatch fisheries

Alternative Fishery Catch Likelihood: Lognormal

$$\ln(\mathcal{L})_{?}^{?} \quad -? \quad \frac{??? \; ??_{?\,?\,?}^{???} \quad ?? - ?? \; ??_{?\,?\,?}^{?\;??} \quad ?\,??^{\acute{E}}}{\acute{E} \cdot \acute{U} \, \grave{A}\grave{E} \quad ??_{?\,?\,?}^{\acute{E}}}$$

Fishery	Data Source	Likelihood Component	Assumed CV
Directed fishery	fish tickets	retained catch	5%
	at-sea observers	total catch/discards	20%
snow crab	at-sea observers	total catch/discards	20%
BBRKC	at-sea observers	total catch/discards	20%
groundfish	at-sea observers	total catch/discards	20%

Alternative Selectivity Option: Force Asymptote to 1



Model/Data Scenarios

Datasets

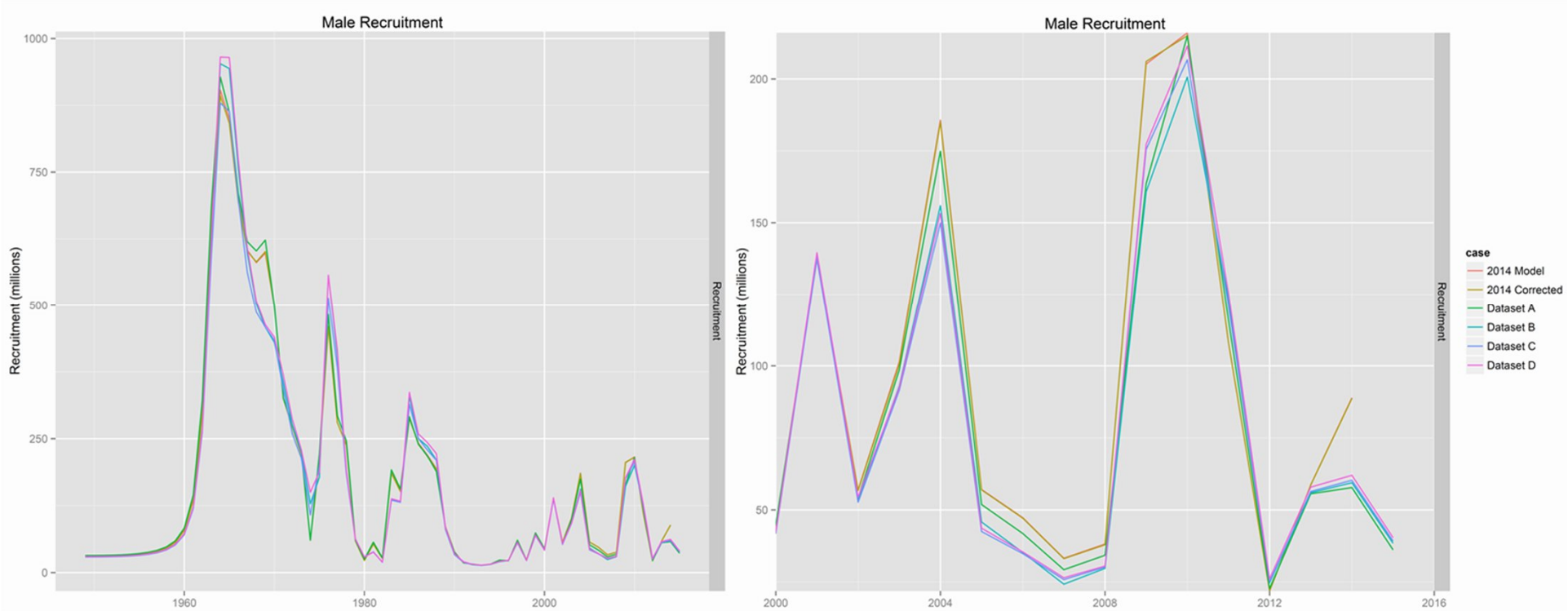
Dataset Name	Base Dataset	Modifications
base (2014 assesssment)	--	--
2014 Corrected	2014 assessment	corrects 2013/14 retained catch, size frequencies
A	2014 corrected	updates 2013/14 fisheries data, adds 2014/15 data; adds 2015 survey data
B	A	replaces old trawl survey data with new time series
C	B	updates 2009/10-present bycatch size compositions in the groundfish fisheries
D	C	uses the standardized trawl survey LW regressions

Models

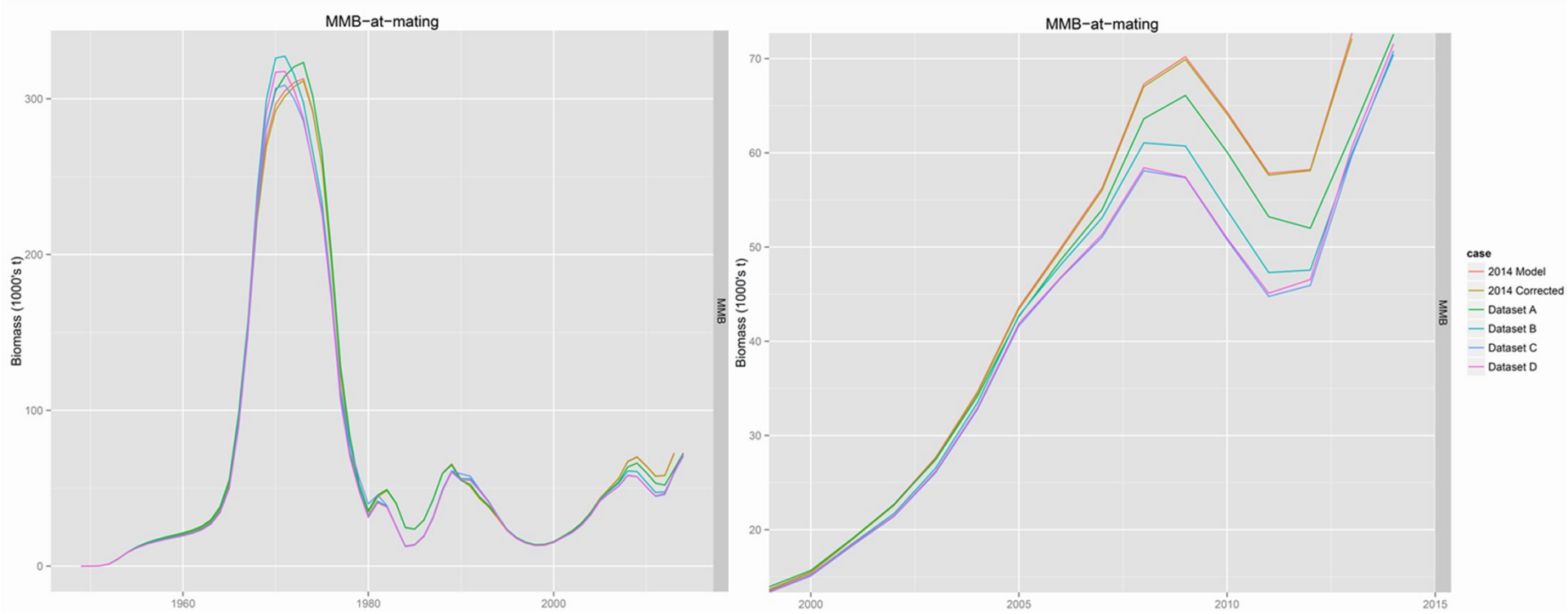
Alternative Model	Base Model	ModelConfiguration			Datasets
		Fishing Mortality Model	Fishery Catch Likelihoods	Asymptotic Selectivity Forced?	
A	--	TCSAM2013	normal	no	2014 corrected, A, B, C, D
B	A	TCSAM2013	lognormal	no	D
C	A	Gmacs	normal	no	D
D	C	Gmacs	lognormal	no	D
E	A	TCSAM2013	normal	yes	D
F	B	TCSAM2013	lognormal	yes	D
G	C	Gmacs	normal	yes	D
H	D	Gmacs	lognormal	yes	D

Evaluation of Dataset Changes

Data Changes: Recruitment



Data Changes: MMB



Data Changes: Summary

Model	Dataset	Description	Converged?	Positive-definite Hessian	Mean Recruitment (millions)		MMB (1000's t)			Objective Function Value
					1982+	2000+	1982+	last 3 years	final year	
A (2014)	2014	2014 assessment	Yes	Yes	187.9	186.8	40.5	62.9	72.7	1,701.2
A	2014 Corrected	2014 data with corrected retained catch and size compositions	Yes	Yes	187.1	186.3	39.1	65.1	72.1	1,722.9
A	A	2014 Corrected + 2014, 2015 Updates	Yes	Yes	178.6	166.7	40.5	62.2	72.6	1,847.8
A	B	A + Revised Trawl Survey Time Series	Yes	Yes	174.2	160.1	37.3	59.3	70.4	2,053.3
A	C	B + Revised Fishery Data	Yes	Yes	173.5	161.3	36.7	58.8	70.8	2,036.0
A	D	C + standard LW regressions	Yes	Yes	179.4	164.9	36.5	59.6	71.6	2,049.1

Model Selection

Alternative Model	Base Model	ModelConfiguration			Datasets
		Fishing Mortality Model	Fishery Catch Likelihoods	Asymptotic Selectivity Forced?	
A	--	TCSAM2013	normal	no	2014 corrected, A, B, C, D
B	A	TCSAM2013	lognormal	no	D
C	A	Gmacs	normal	no	D
D	C	Gmacs	lognormal	no	D
E	A	TCSAM2013	normal	yes	D
F	B	TCSAM2013	lognormal	yes	D
G	C	Gmacs	normal	yes	D
H	D	Gmacs	lognormal	yes	D

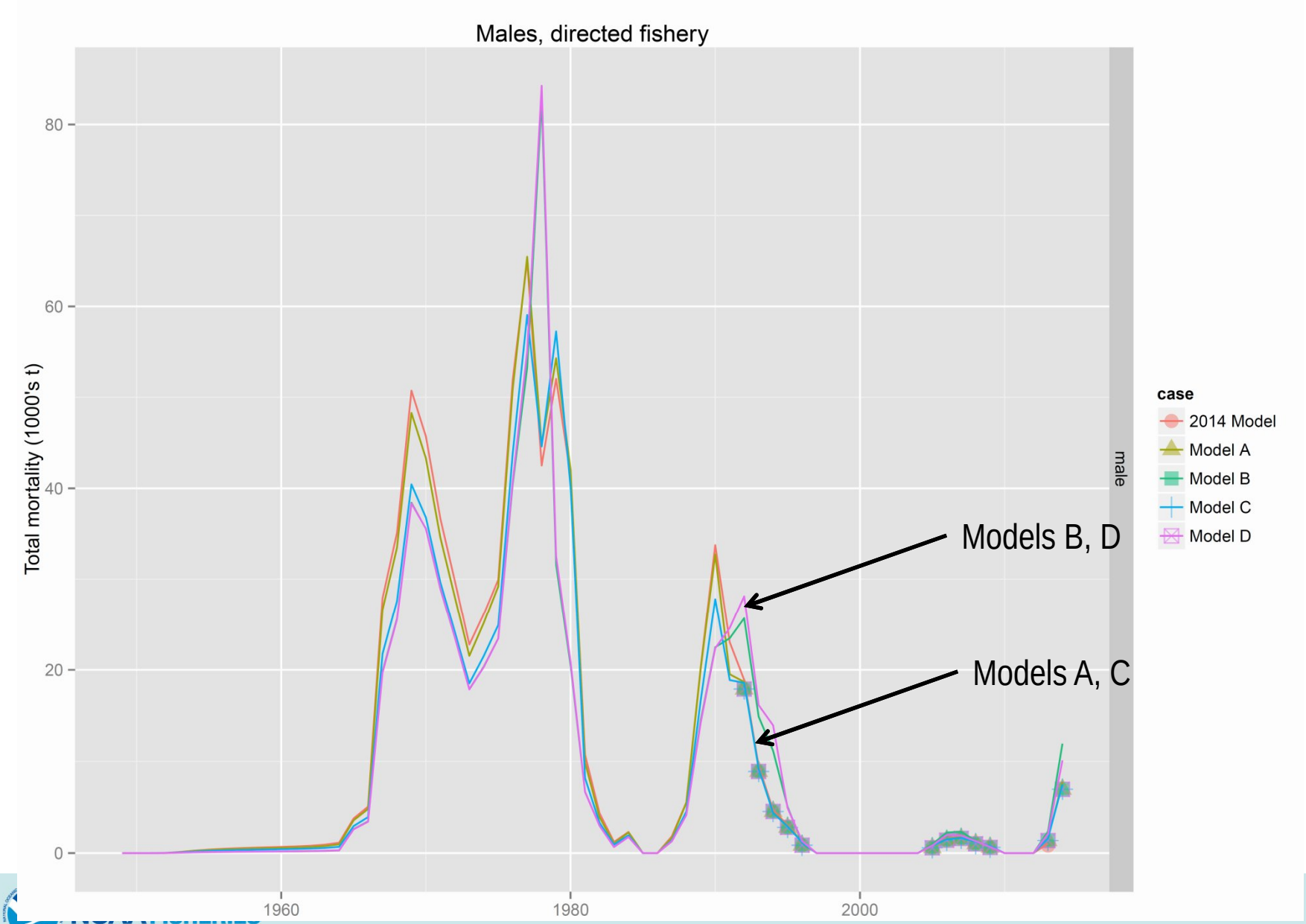
Model Selection

Model	Dataset	Fishing Mortality Model	Fishery Catch Likelihoods	Asymptotic Selectivity Forced?	Converged?	Positive-definite Hessian?	Mean Recruitment (millions)		MMB (1000's t)			Objective Function Value	Delta OFV
							1982+	2000+	1982+	3-year mean	2014/15		
A (2014)	2014	TCSAM2013	normal	No	Yes	Yes	187.9	186.8	40.5	62.9	63.8	--	--
A	D	TCSAM2013	normal	No	Yes	Yes	179.4	164.9	36.5	59.6	71.6	2,049.1	0.0
B	D	TCSAM2013	lognormal	No	Yes	Yes	133.2	110.8	23.1	37.2	42.4	3,761.6	0.0
C	D	Gmacs	normal	No	Yes	Yes	180.9	168.1	36.4	58.2	70.6	2,112.5	63.4
D	D	Gmacs	lognormal	No	Yes	Yes	154.8	135.9	23.2	43.1	56.6	3,912.4	150.7
E	D	TCSAM2013	normal	Yes	No	No	151.0	133.1	28.3	46.7	55.3	2,052.8	3.7
F	D	TCSAM2013	lognormal	Yes	No	No	147.6	126.6	25.6	41.0	47.2	3,768.7	7.0
G	D	Gmacs	normal	Yes	No	No	151.6	133.1	28.4	46.3	55.3	2,116.2	67.1
H	D	Gmacs	lognormal	Yes	No	No	149.9	130.6	27.3	45.3	53.0	3,929.5	167.8

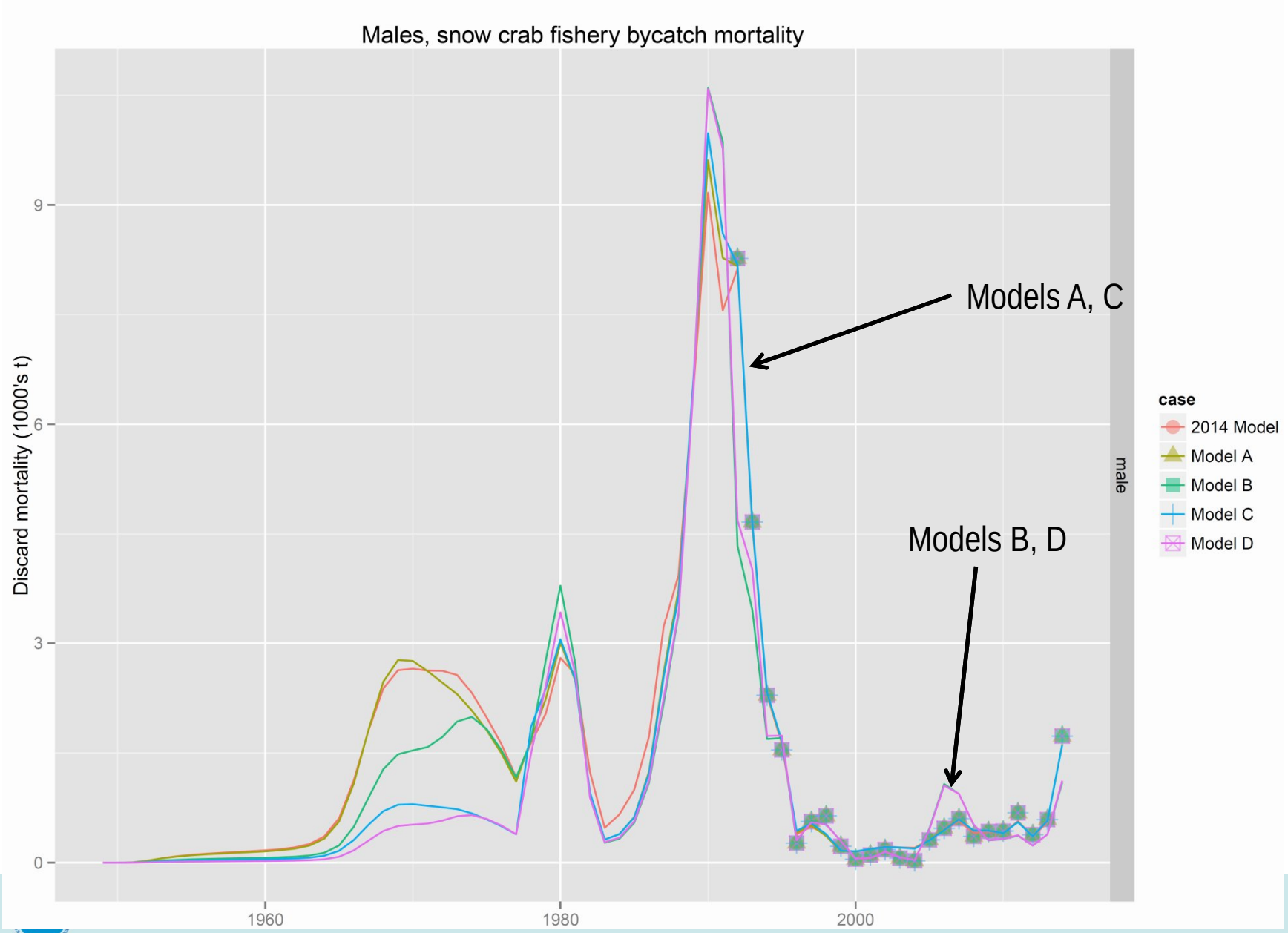
Model Selection: Models ABCD

Model	Dataset	Fishing Mortality Model	Fishery Catch Likelihoods	Asymptotic Selectivity Forced?	Converged?	Positive-definite Hessian?	Mean Recruitment (millions)		MMB (1000's t)			Objective Function Value	Delta OFV
							1982+	2000+	1982+	3-year mean	2014/15		
A (2014)	2014	TCSAM2013	normal	No	Yes	Yes	187.9	186.8	40.5	62.9	63.8	--	--
A	D	TCSAM2013	normal	No	Yes	Yes	179.4	164.9	36.5	59.6	71.6	2,049.1	0.0
B	D	TCSAM2013	lognormal	No	Yes	Yes	133.2	110.8	23.1	37.2	42.4	3,761.6	0.0
C	D	Gmacs	normal	No	Yes	Yes	180.9	168.1	36.4	58.2	70.6	2,112.5	63.4
D	D	Gmacs	lognormal	No	Yes	Yes	154.0	135.9	29.2	48.1	56.6	3,912.4	150.7

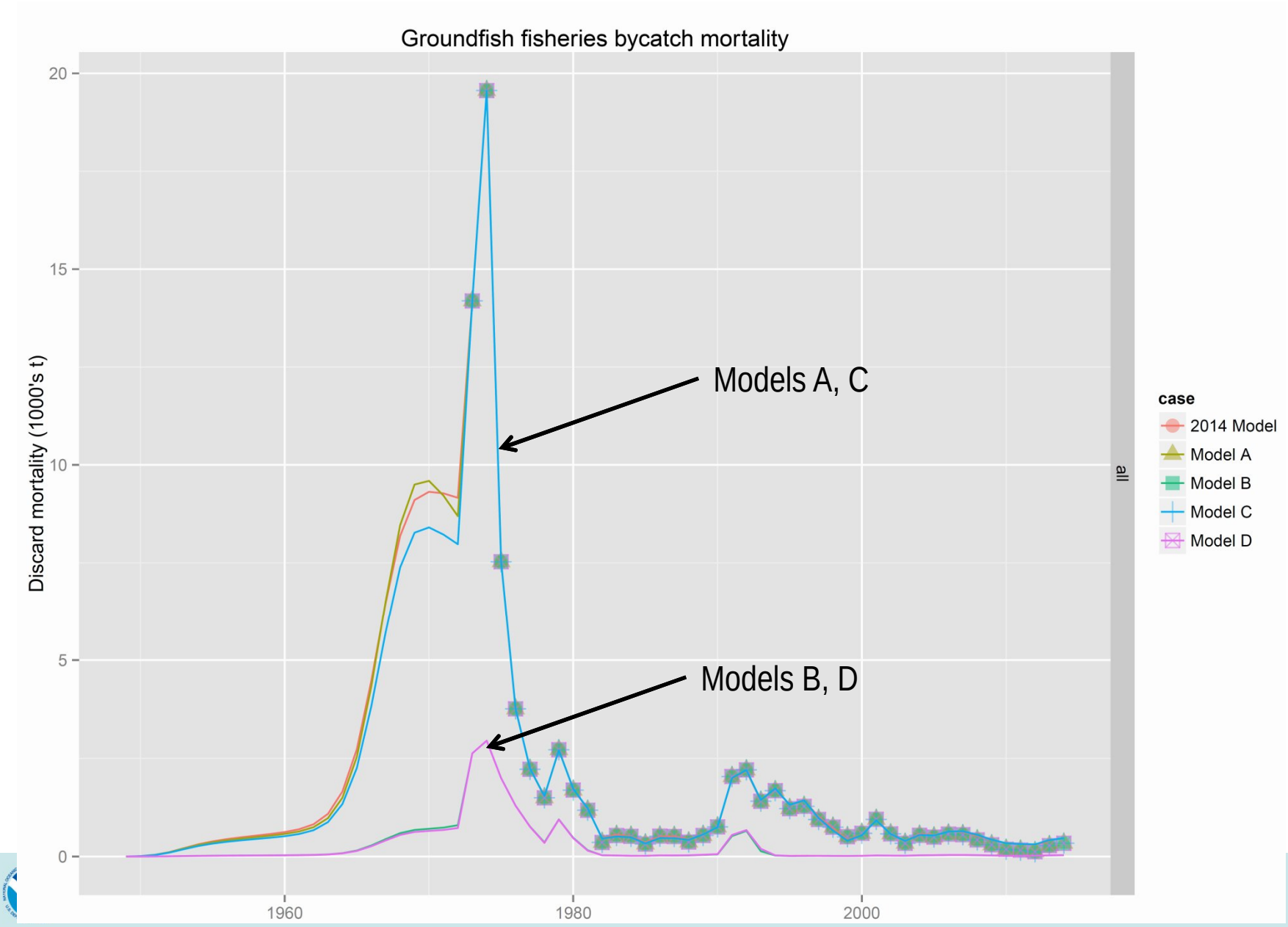
Model Selection: Models ABCD



Model Selection: Models ABCD



Model Selection: Models ABCD



Model Selection: Models ABCD

- Models B, D (lognormal fishery catch likelihoods)
  - exhibit poor fits to bycatch data
  - Non-optimal cv's chosen?

- Models B, D rejected

Model Parameters: Population Dynamics

Parameter	Limits		2014 Model			Model A			Description			
	min	max	estimate	std. dev	flag	estimate	std. dev	flag	Category 3	Period	Sex	Description
af1	0.4	0.7	0.70	0.000	1	0.70	0.000	1	growth	all	female	alpha, mean growth increment
bf1	0.6	1.2	0.88	0.001	0	0.88	0.001	0	growth	all	female	beta, mean growth increment
am1	0.3	0.6	0.43	0.022	0	0.41	0.022	0	growth	all	male	alpha, mean growth increment
bm1	0.7	1.2	0.97	0.005	0	0.98	0.005	0	growth	all	male	beta, mean growth increment
Mmult_imat	0.2	2	1.07	0.051	0	1.06	0.050	0	natural mortality	all	all	immature multiplier
mat_big[01]	0.1	10	1.12	0.098	0	1.49	0.092	0	natural mortality	1980-84	female	multiplier
Mmultf	0.1	1.9	1.44	0.037	0	1.51	0.035	0	natural mortality	all	female	mature multiplier
mat_big[02]	0.1	10	2.59	0.343	0	3.50	0.320	0	natural mortality	1980-84	male	multiplier
Mmultm	0.1	1.9	1.11	0.043	0	1.15	0.041	0	natural mortality	all	male	mature multiplier
pMnLnRecEarly	--	--	11.84	0.511	0	11.80	0.518	0	recruitment	1949-1973	all	mean ln-scale recruitment
pMnLnRec	--	--	11.17	0.071	0	11.14	0.062	0	recruitment	1974+	all	mean ln-scale recruitment

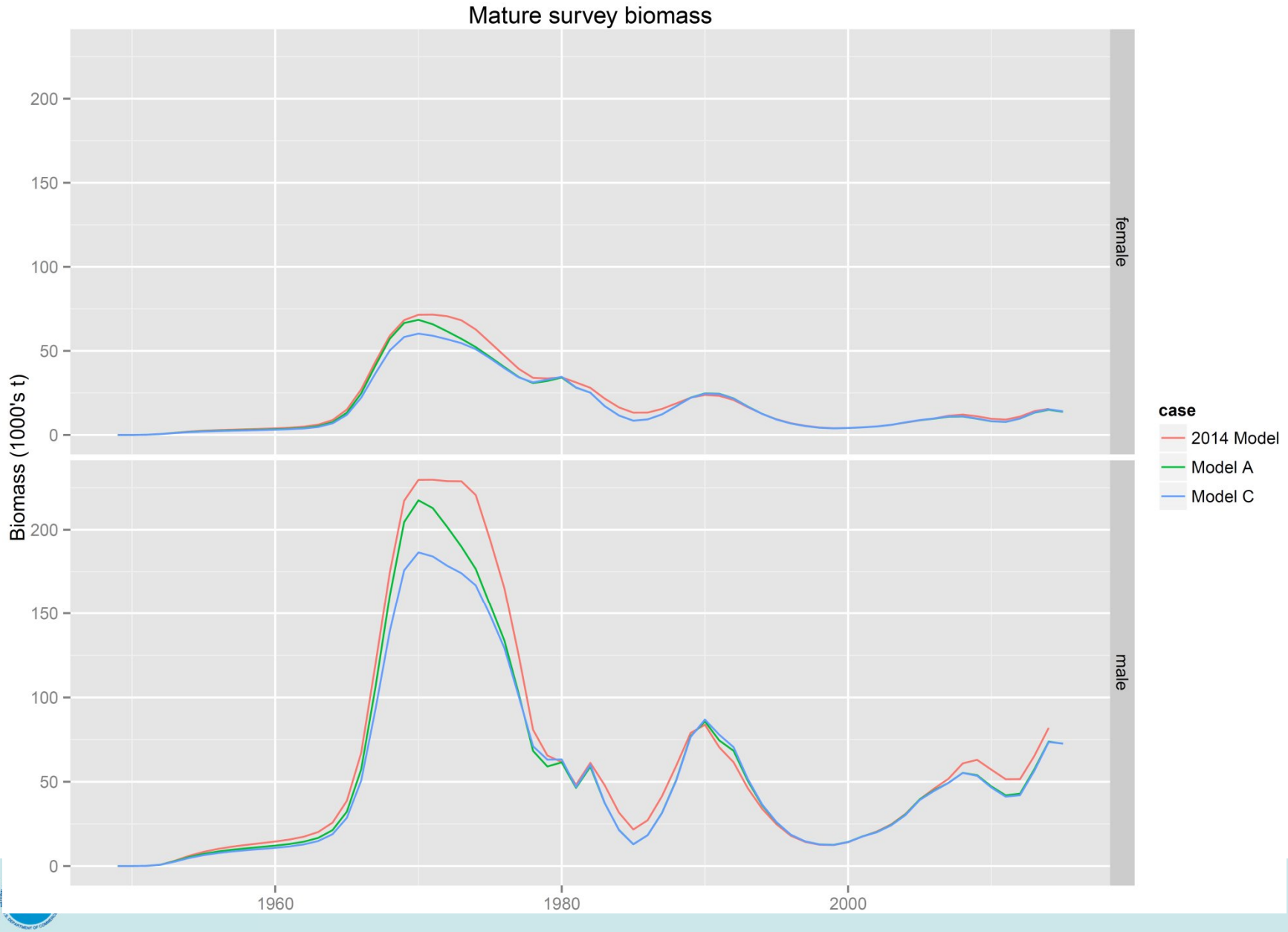
Model Parameters: Directed Fishery

Parameter	Limits		2014 Model			Model A			Description			
	min	max	estimate	std. dev	flag	estimate	std. dev	flag	Category 3	Period	Sex	Description
pAvgLnF_TCF	--	--	-1.62	0.087	0	-1.50	0.097	0	mortality	1965+	male	mean ln-scale fishing mortality
fish_fit_sel50_mn2	85	160	136.86	0.303	0	133.08	0.488	0	retention	1991+	male	50% selected size
fish_fit_slope_mn2	0.25	2.001	0.84	0.118	0	0.37	0.030	0	retention	1991+	male	slope
fish_fit_sel50_mn1	85	160	138.23	0.394	0	137.67	0.355	0	retention	pre-1991	male	50% selected size
fish_fit_slope_mn1	0.25	1.001	0.73	0.131	0	0.79	0.140	0	retention	pre-1991	male	slope
fish_disc_sel50_f	80	150	120.47	3.280	0	117.47	2.802	0	selectivity	all	female	50% selected size
fish_disc_slope_f	0.1	0.4	0.14	0.009	0	0.14	0.008	0	selectivity	all	female	slope
log_sel50_dev_3[01]	-0.5	0.5	0.05	0.018	0	0.08	0.033	0	selectivity	1991	male	dev, 50% selected size
log_sel50_dev_3[02]	-0.5	0.5	0.15	0.015	0	0.13	0.029	0	selectivity	1992	male	dev, 50% selected size
log_sel50_dev_3[03]	-0.5	0.5	0.10	0.016	0	0.10	0.030	0	selectivity	1993	male	dev, 50% selected size
log_sel50_dev_3[04]	-0.5	0.5	0.10	0.021	0	0.14	0.034	0	selectivity	1994	male	dev, 50% selected size
log_sel50_dev_3[05]	-0.5	0.5	0.00	0.030	0	-0.01	0.046	0	selectivity	1995	male	dev, 50% selected size
log_sel50_dev_3[06]	-0.5	0.5	-0.50	0.018	0	-0.43	0.287	0	selectivity	1996	male	dev, 50% selected size
log_sel50_dev_3[07]	-0.5	0.5	-0.05	0.020	0	-0.06	0.029	0	selectivity	2005	male	dev, 50% selected size
log_sel50_dev_3[08]	-0.5	0.5	-0.05	0.020	0	-0.06	0.030	0	selectivity	2006	male	dev, 50% selected size
log_sel50_dev_3[09]	-0.5	0.5	-0.08	0.018	0	-0.09	0.028	0	selectivity	2007	male	dev, 50% selected size
log_sel50_dev_3[10]	-0.5	0.5	0.06	0.017	0	0.05	0.027	0	selectivity	2008	male	dev, 50% selected size
log_sel50_dev_3[11]	-0.5	0.5	0.23	0.021	0	0.22	0.029	0	selectivity	2009	male	dev, 50% selected size
log_sel50_dev_3[12]	-0.5	0.5	0.00	0.020	0	-0.02	0.028	0	selectivity	2013	male	dev, 50% selected size
log_sel50_dev_3[13]	-0.5	0.5	0.00	0.000	0	-0.04	0.026	0	selectivity	2014	male	dev, 50% selected size
log_avg_sel50_3	4	5	4.83	0.009	0	4.83	0.023	0	selectivity	1991+	male	50% selected size
fish_slope_yr_3	0.1	0.4	0.14	0.009	0	0.14	0.009	0	selectivity	1997+	male	slope
fish_slope_1	0.05	0.75	0.12	0.007	0	0.11	0.007	0	selectivity	pre-1997	male	slope

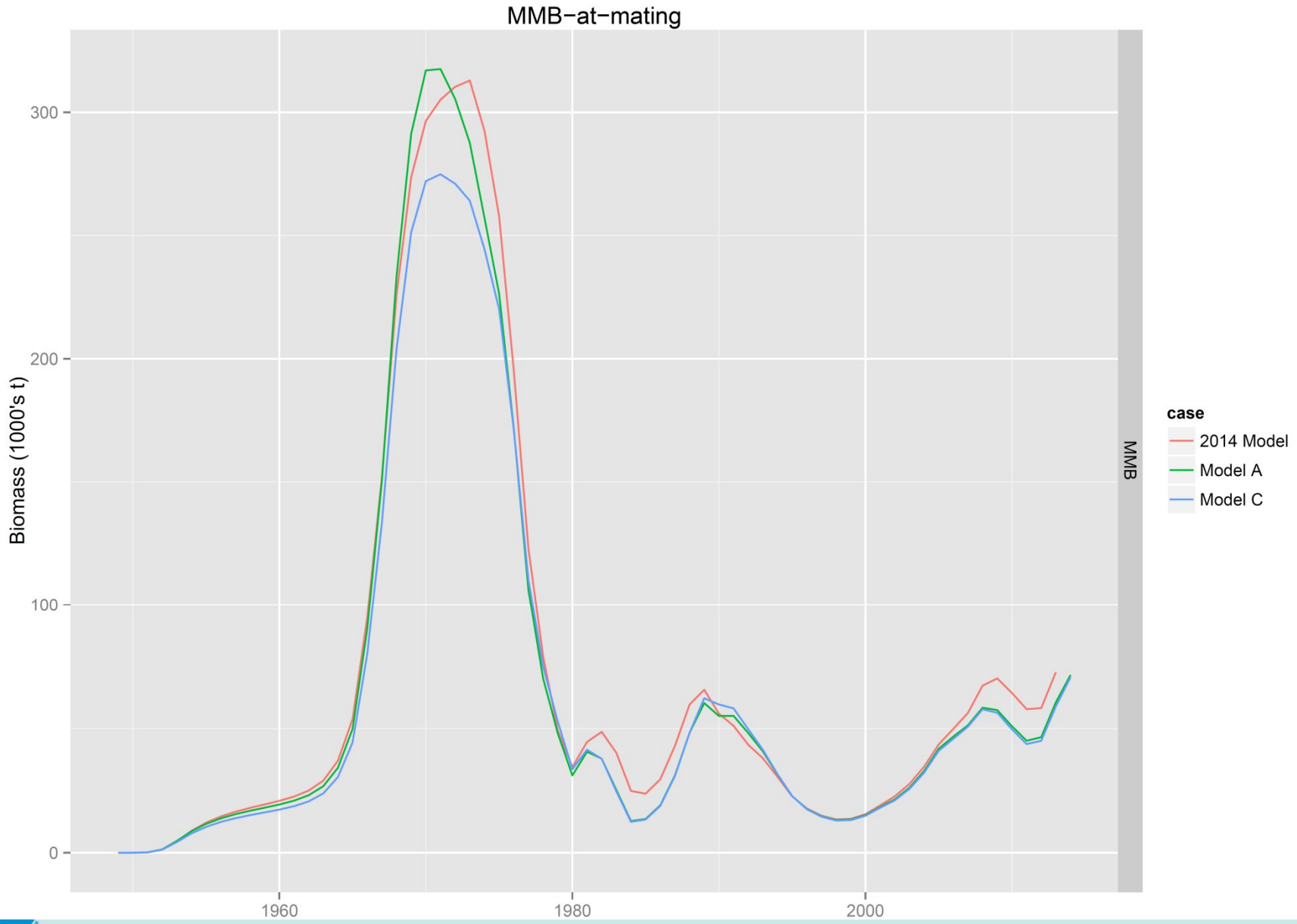
Model Parameters: Bycatch Fisheries

Parameter	Limits		2014 Model			Model A				Description			
	min	max	estimate	std. dev	flag	estimate	std. dev	flag	Category 2	Category 3	Period	Sex	Description
pAvgLnF_GTF	--	--	-4.21	0.075	0	-4.16	0.073	0	GTF	mortality	1973+	male	mean ln-scale fishing mortality
fish_disc_sel50_tf1	40	125.01	125.01	0.000	1	125.01	0.000	1	GTF	selectivity	1973-1987	female	50% selected size
fish_disc_slope_tf1	0.01	0.5	0.03	0.002	0	0.03	0.002	0	GTF	selectivity	1973-1987	female	slope
fish_disc_sel50_tf2	40	250.01	175.95	52.035	0	159.21	34.425	0	GTF	selectivity	1988-1996	female	50% selected size
fish_disc_slope_tf2	0.005	0.5	0.01	0.005	0	0.02	0.005	0	GTF	selectivity	1988-1996	female	slope
fish_disc_sel50_tf3	40	150.01	148.32	11.394	0	143.99	9.954	0	GTF	selectivity	1997+	female	50% selected size
fish_disc_slope_tf3	0.01	0.5	0.05	0.008	0	0.05	0.007	0	GTF	selectivity	1997+	female	slope
fish_disc_sel50_tm1	40	120.01	53.76	1.972	0	57.07	2.034	0	GTF	selectivity	1973-1987	male	50% selected size
fish_disc_slope_tm1	0.01	0.5	0.11	0.013	0	0.11	0.011	0	GTF	selectivity	1973-1987	male	slope
fish_disc_sel50_tm2	40	120.01	64.66	8.958	0	72.61	9.681	0	GTF	selectivity	1988-1996	male	50% selected size
fish_disc_slope_tm2	0.01	0.5	0.05	0.012	0	0.04	0.009	0	GTF	selectivity	1988-1996	male	slope
fish_disc_sel50_tm3	40	120.01	94.02	2.322	0	83.19	2.113	0	GTF	selectivity	1997+	male	50% selected size
fish_disc_slope_tm3	0.01	0.5	0.07	0.004	0	0.08	0.004	0	GTF	selectivity	1997+	male	slope
rkfish_disc_sel50_f1	50	150	150.00	1.140	1	98.35	13.410	0	RKF	selectivity	1989-1996	female	50% selected size
rkfish_disc_slope_f1	0.05	0.5	0.17	0.040	0	0.24	0.132	0	RKF	selectivity	1989-1996	female	slope
rkfish_disc_sel50_f2	50	150	103.08	45.740	0	103.26	44.773	0	RKF	selectivity	1997-2004	female	50% selected size
rkfish_disc_slope_f2	0.05	0.5	0.18	0.173	0	0.18	0.170	0	RKF	selectivity	1997-2004	female	slope
rkfish_disc_sel50_f3	50	170	157.07	354.400	0	157.07	337.590	0	RKF	selectivity	2005+	female	50% selected size
rkfish_disc_slope_f3	0.05	0.5	0.18	0.056	0	0.18	0.054	0	RKF	selectivity	2005+	female	slope
rkfish_disc_sel50_m1	95	150	150.00	0.001	1	150.00	0.001	1	RKF	selectivity	1989-1996	male	50% selected size
rkfish_disc_slope_m1	0.01	0.5	0.11	0.011	0	0.10	0.010	0	RKF	selectivity	1989-1996	male	slope
rkfish_disc_sel50_m2	95	150	132.31	11.907	0	133.22	12.448	0	RKF	selectivity	1997-2004	male	50% selected size
rkfish_disc_slope_m2	0.01	0.5	0.09	0.027	0	0.09	0.027	0	RKF	selectivity	1997-2004	male	slope
rkfish_disc_sel50_m3	95	150	150.00	0.001	1	150.00	0.001	1	RKF	selectivity	2005+	male	50% selected size
rkfish_disc_slope_m3	0.01	0.5	0.08	0.007	0	0.08	0.007	0	RKF	selectivity	2005+	male	slope
pAvgLnF_SCF	--	--	-3.80	0.132	0	-3.71	0.122	0	SCF	mortality	1992+	male	mean ln-scale fishing mortality
snowfish_disc_sel50_f_1	50	150	111.33	4.707	0	110.42	4.551	0	SCF	selectivity	1989-1996	female	50% selected size
snowfish_disc_slope_f_1	0.05	0.5	0.05	0.000	-1	0.05	0.000	-1	SCF	selectivity	1989-1996	female	slope
snowfish_disc_sel50_f_2	50	120	76.46	5.024	0	76.19	4.879	0	SCF	selectivity	1997-2004	female	50% selected size
snowfish_disc_slope_f_2	0.05	0.5	0.25	0.129	0	0.25	0.130	0	SCF	selectivity	1997-2004	female	slope
snowfish_disc_sel50_f_3	50	120	85.24	6.346	0	88.70	7.051	0	SCF	selectivity	2005+	female	50% selected size
snowfish_disc_slope_f_3	0.05	0.5	0.16	0.053	0	0.13	0.041	0	SCF	selectivity	2005+	female	slope
selSCF_lnZ50_md_1	2	4.5	3.97	0.053	0	3.97	0.041	0	SCF	selectivity	1989-1996	male	descending 50% selectivity
selSCF_Z50_ma_1	40	140	87.47	1.762	0	86.80	1.652	0	SCF	selectivity	1989-1996	male	ascending 50% selectivity
snowfish_disc_slope_m_1	0.1	0.5	0.36	0.126	0	0.40	0.147	0	SCF	selectivity	1989-1996	male	ascending slope
snowfish_disc_slope_m2_	0.1	0.5	0.37	0.249	0	0.50	0.004	1	SCF	selectivity	1989-1996	male	descending slope
selSCF_lnZ50_md_2	2	4.5	3.82	0.132	0	3.80	0.136	0	SCF	selectivity	1997-2004	male	descending 50% selectivity
selSCF_Z50_ma_2	40	140	93.81	3.066	0	93.91	3.100	0	SCF	selectivity	1997-2004	male	ascending 50% selectivity
snowfish_disc_slope_m_2	0.1	0.5	0.23	0.075	0	0.23	0.074	0	SCF	selectivity	1997-2004	male	ascending slope
snowfish_disc_slope_m2_	0.1	0.5	0.18	0.092	0	0.18	0.089	0	SCF	selectivity	1997-2004	male	descending slope
selSCF_lnZ50_md_3	2	4.5	3.48	0.115	0	3.53	0.082	0	SCF	selectivity	2005+	male	descending 50% selectivity
selSCF_Z50_ma_3	40	140	105.24	2.009	0	103.63	1.550	0	SCF	selectivity	2005+	male	ascending 50% selectivity
snowfish_disc_slope_m_3	0.1	0.5	0.17	0.017	0	0.18	0.018	0	SCF	selectivity	2005+	male	ascending slope
snowfish_disc_slope_m2_	0.1	0.5	0.17	0.030	0	0.18	0.028	0	SCF	selectivity	2005+	male	descending slope

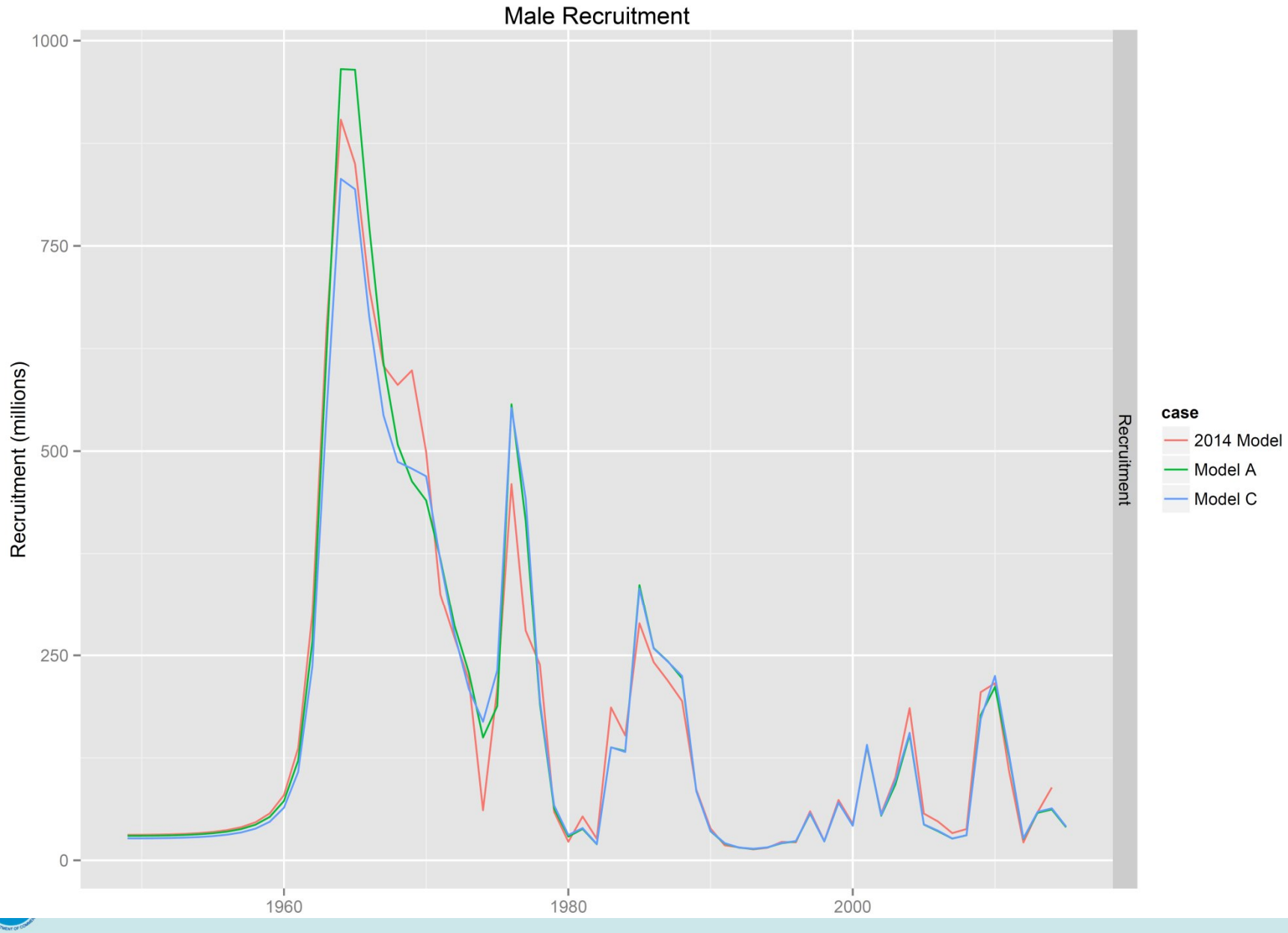
Model Selection: Models A, C



Model Selection: Models A, C

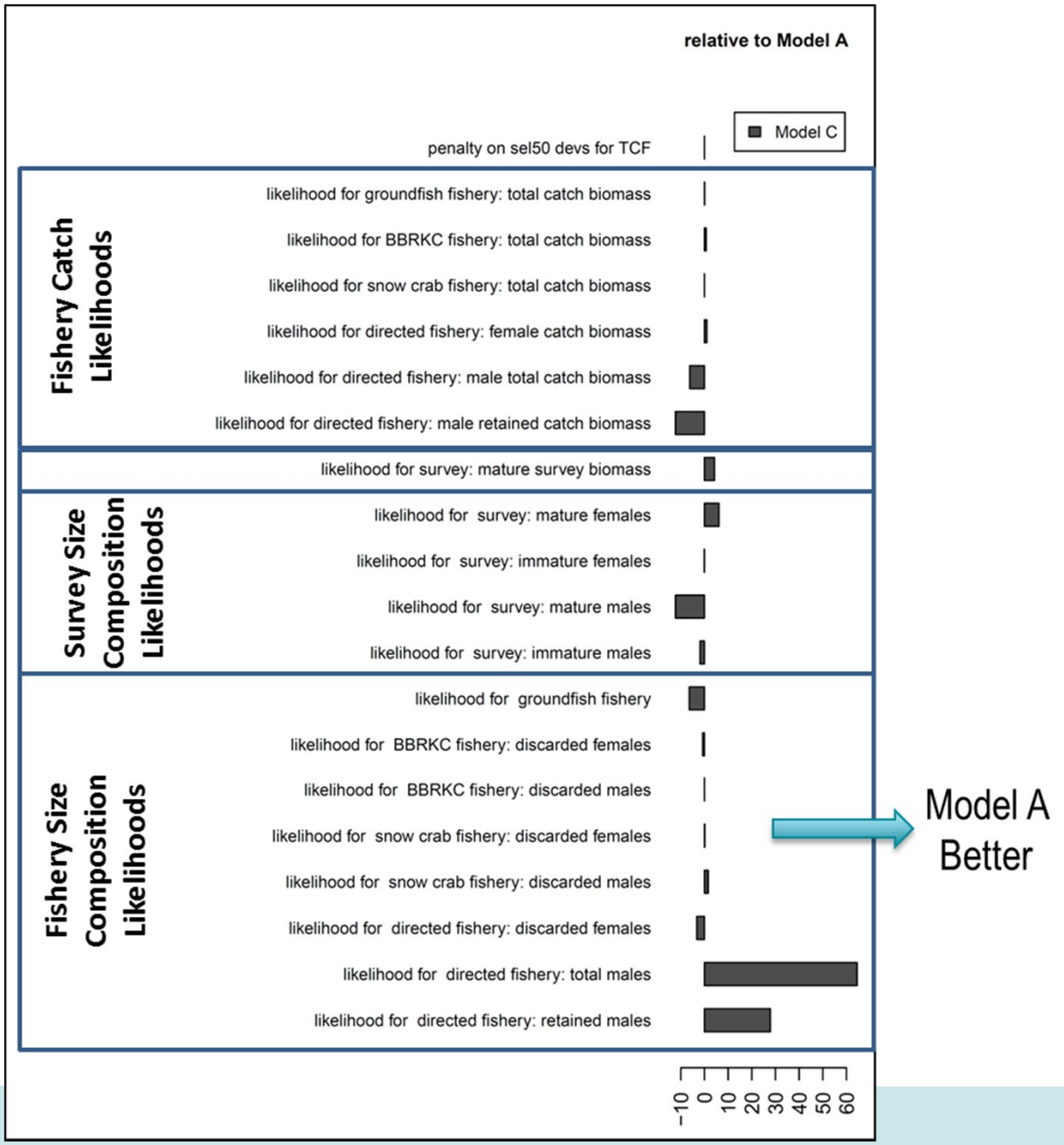


Model Selection: Models A, C

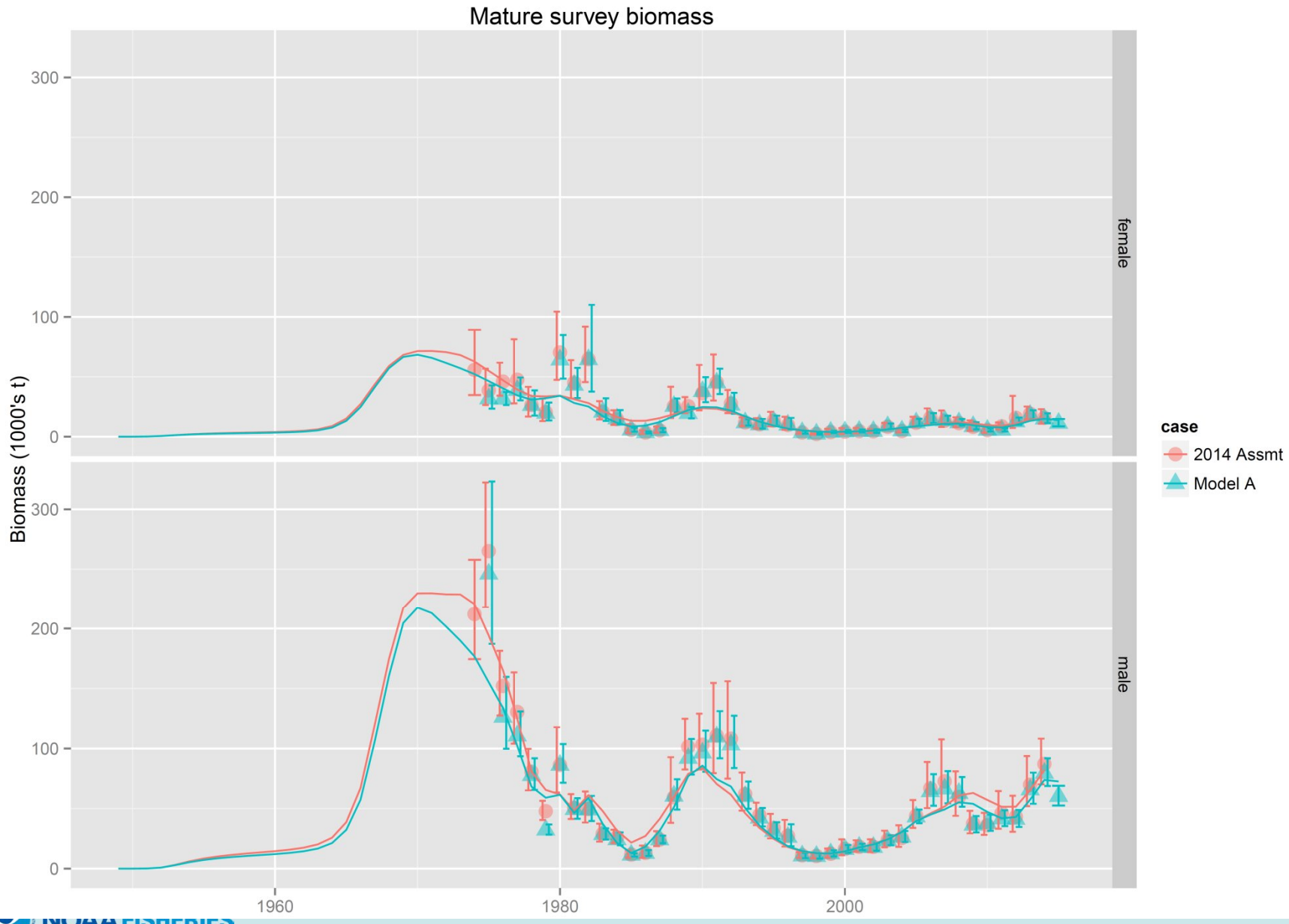


Model Selection: Models A, C

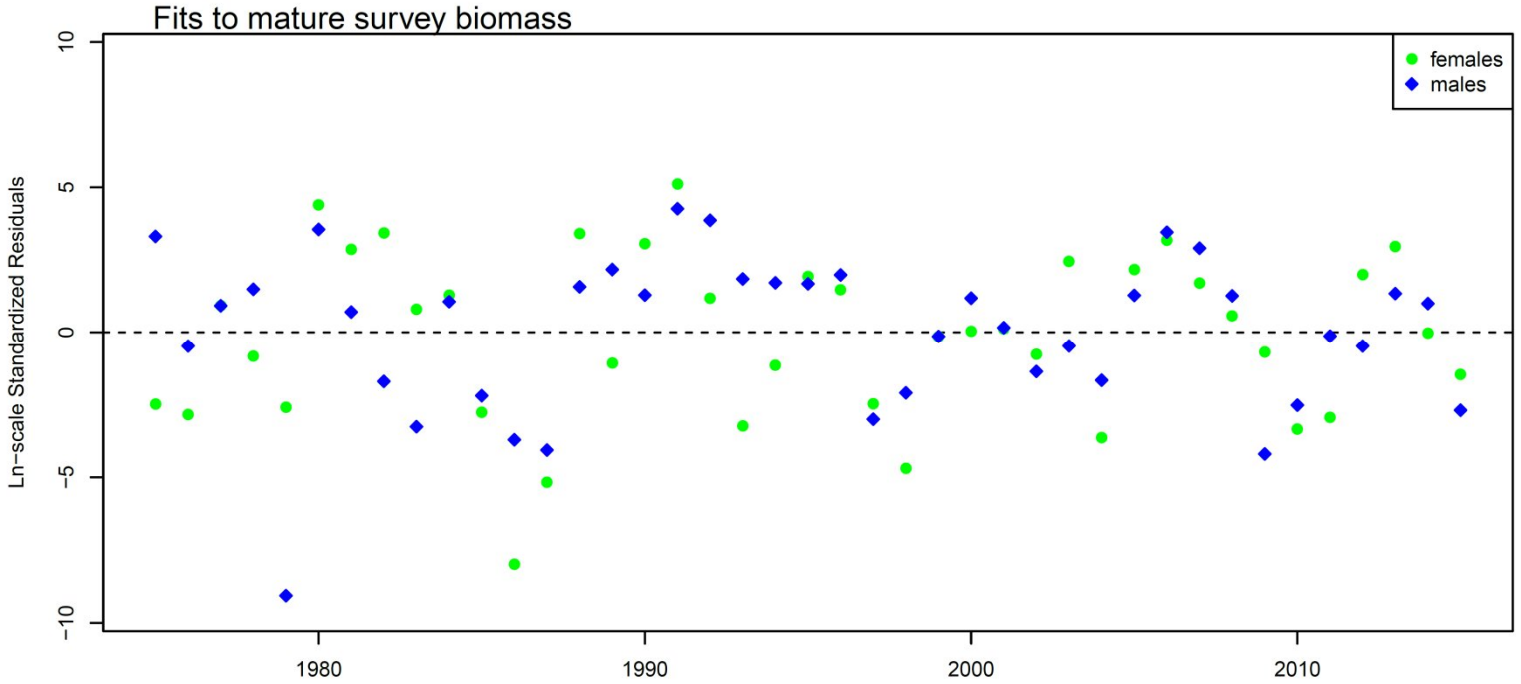
- Models A, C give very similar predictions
- Model A fits data better by 60 likelihood units
- Model A selected as preferred model



Comparisons: 2014 Assessment and Preferred Model A

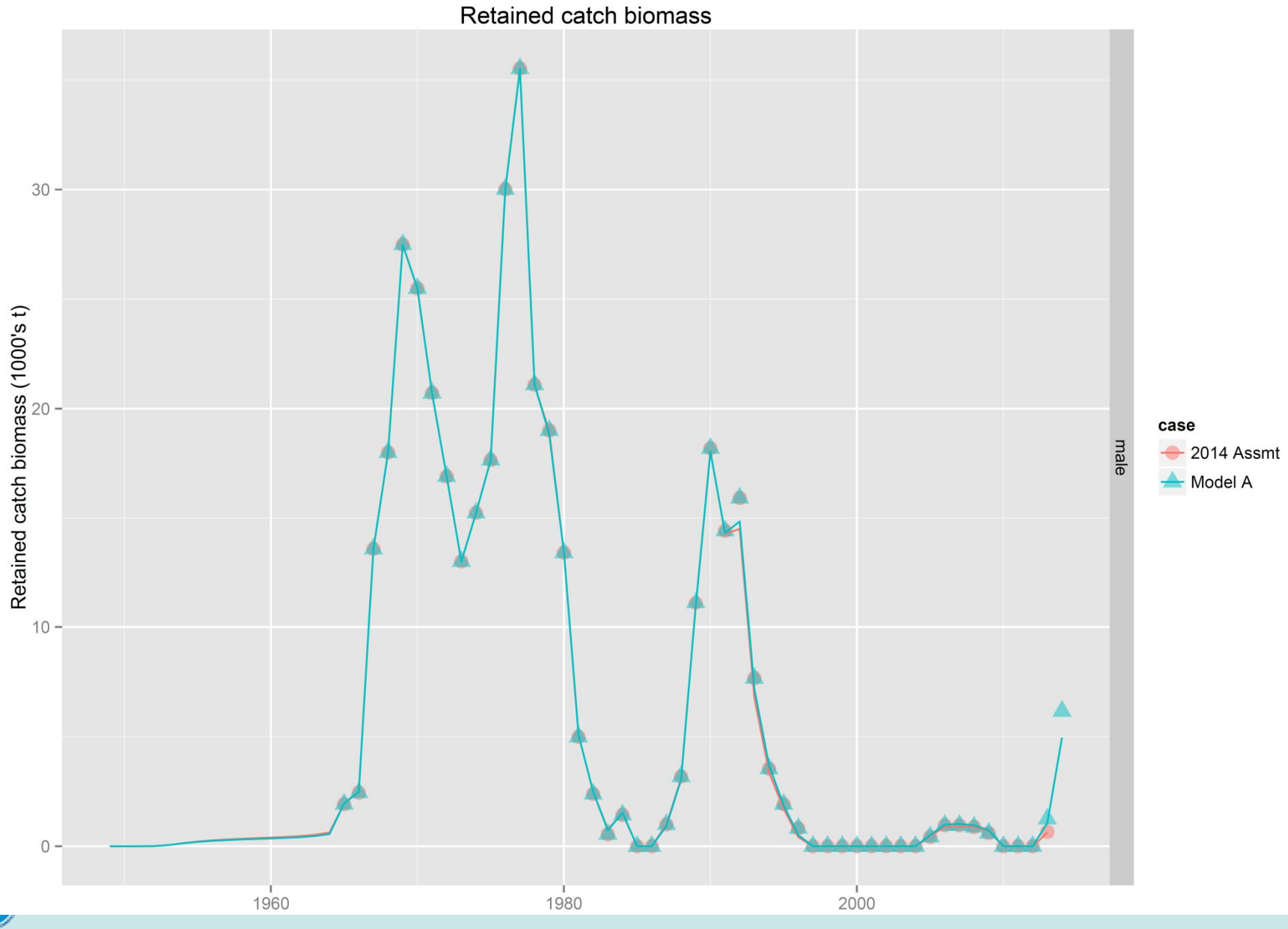


Comparisons: Model A fits to mature survey biomass

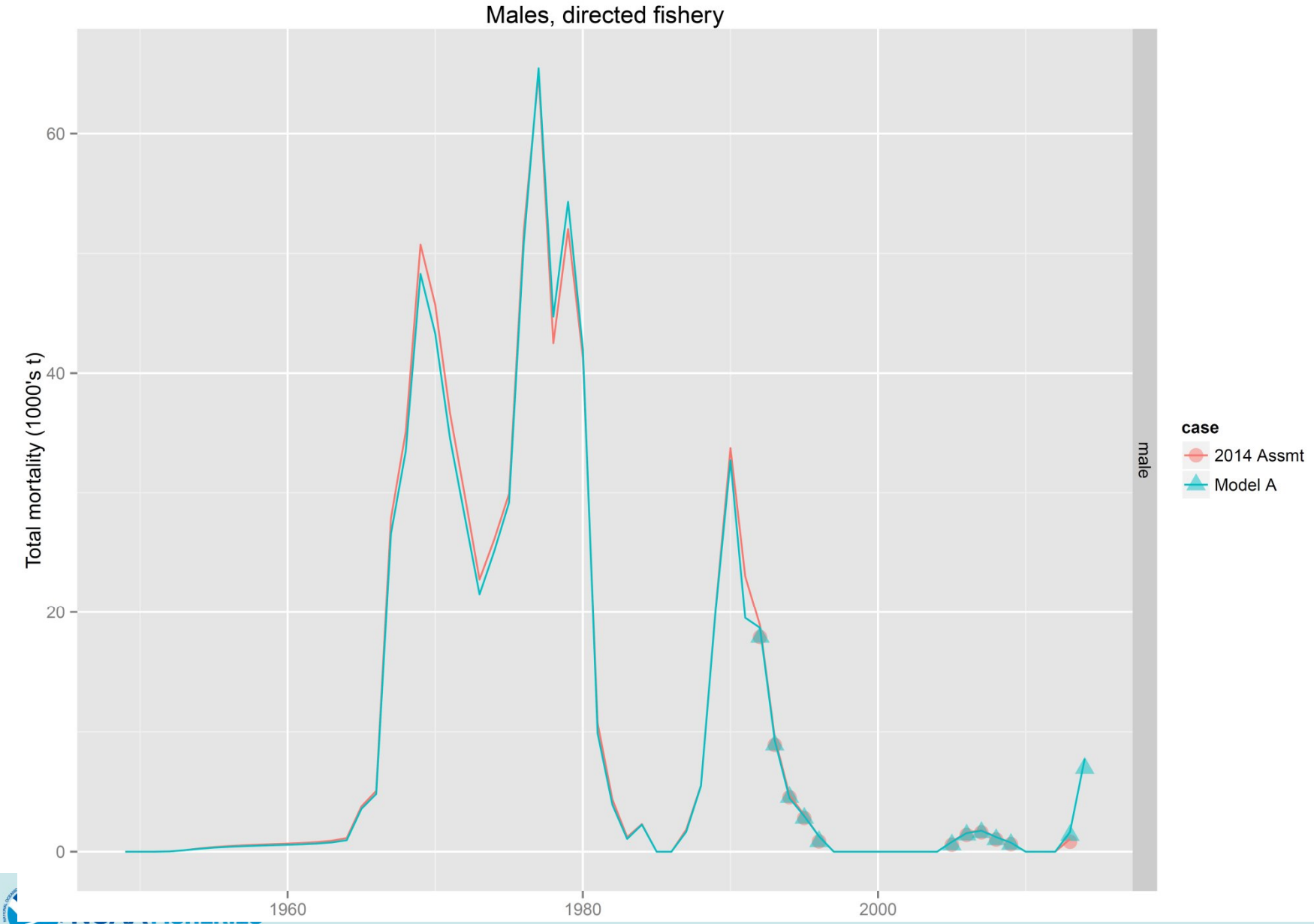


- positive residuals: observed > predicted

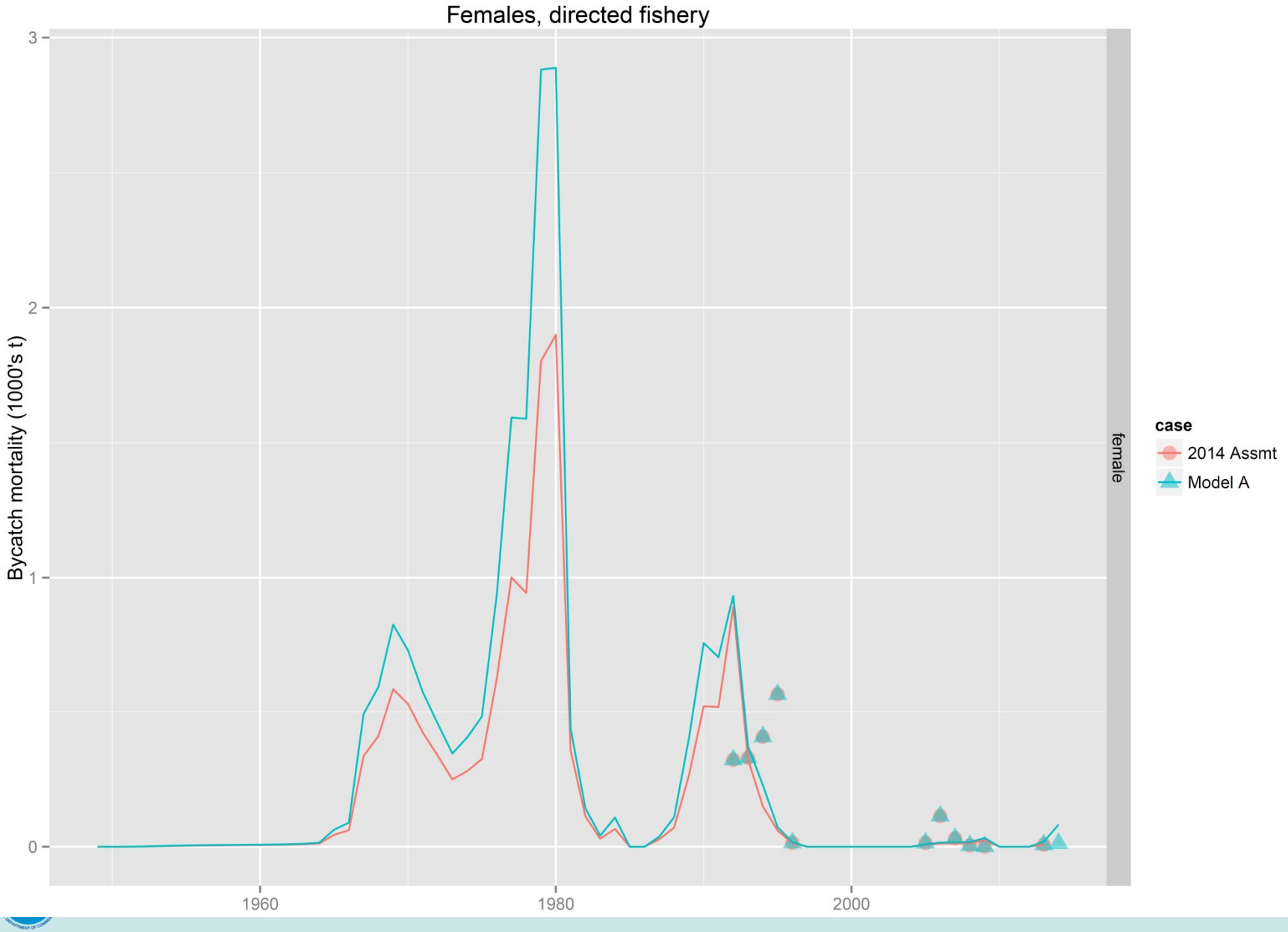
Comparisons: 2014 Assessment and Preferred Model A



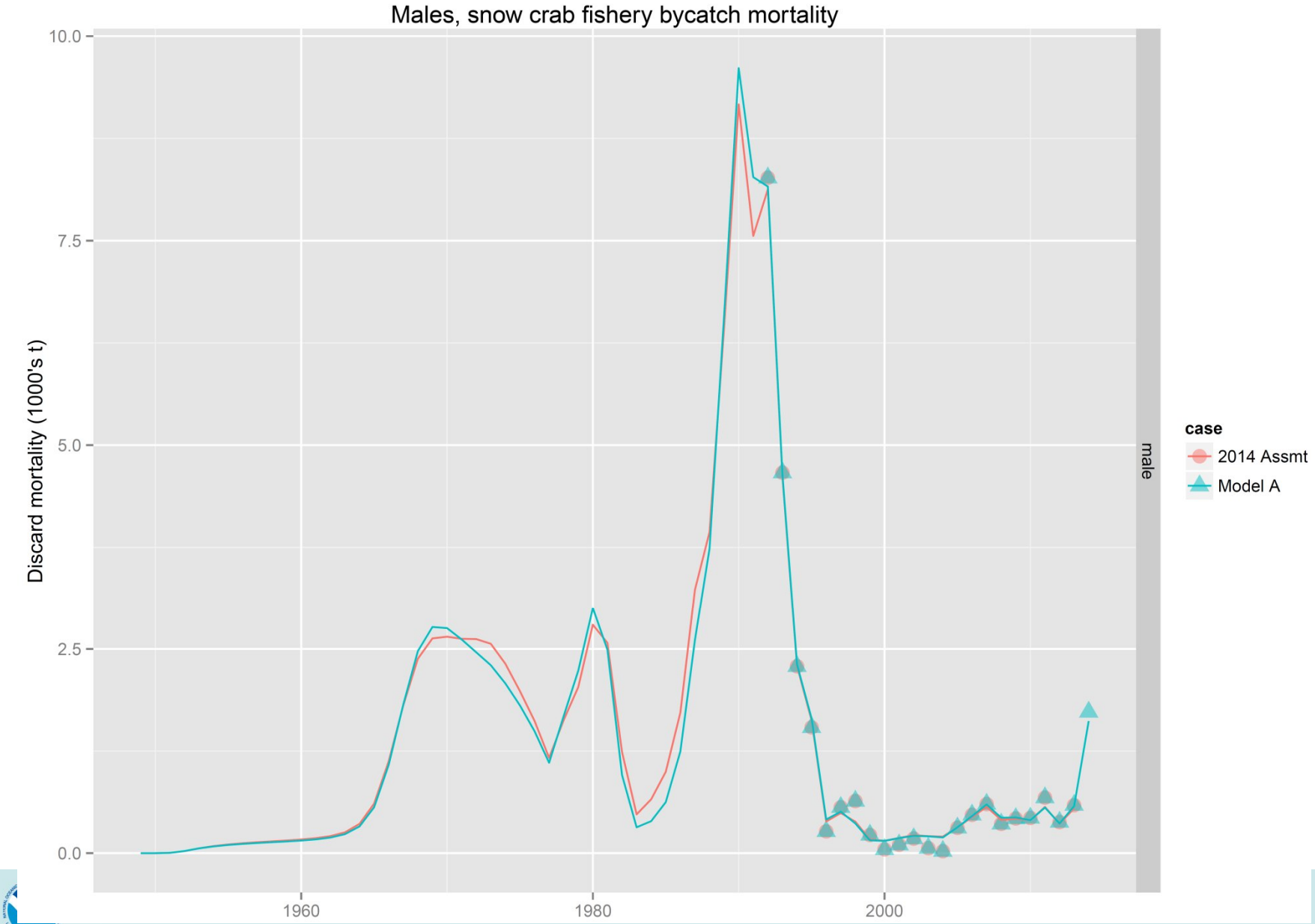
Comparisons: 2014 Assessment and Preferred Model A



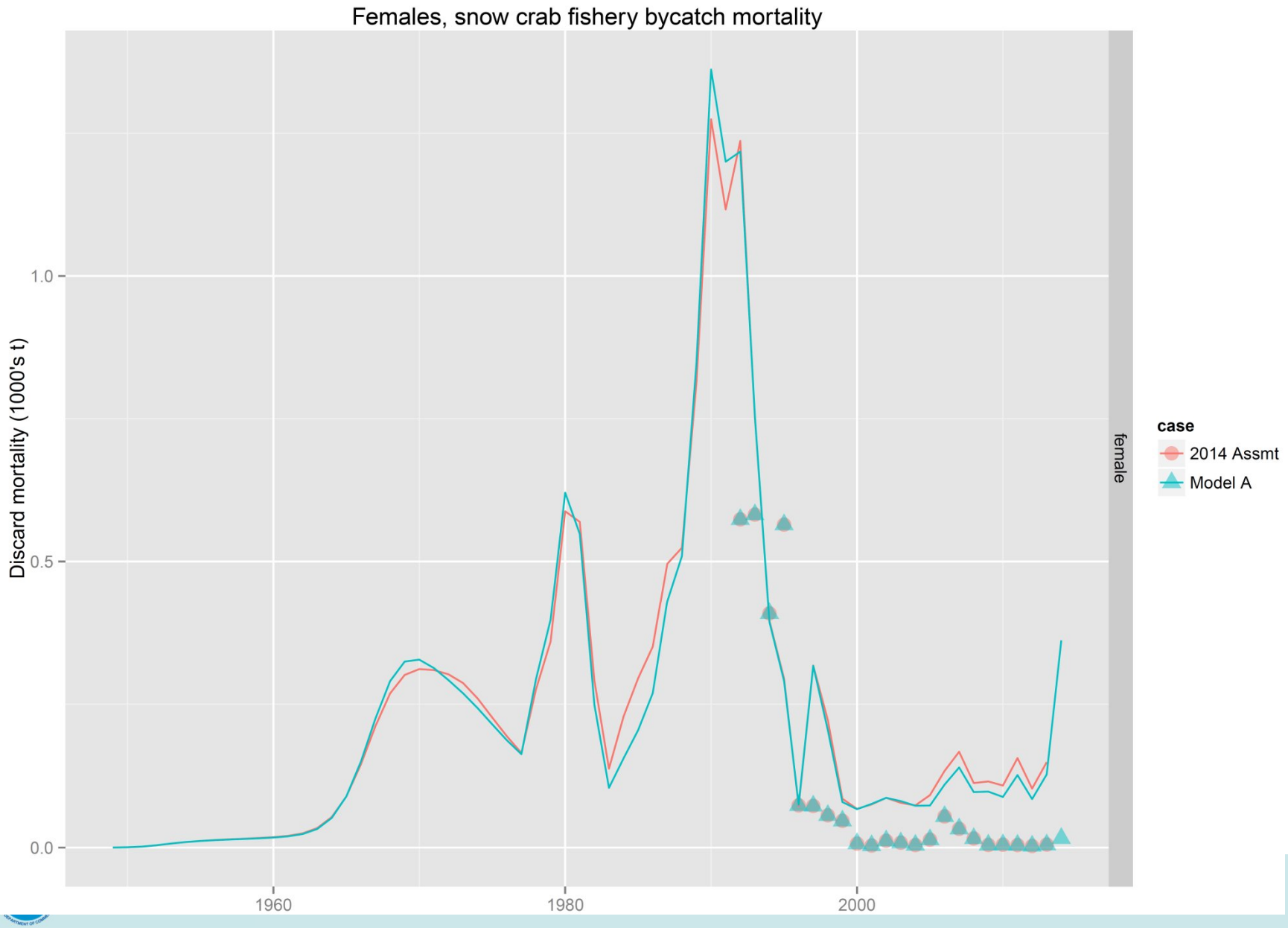
Comparisons: 2014 Assessment and Preferred Model A



Comparisons: 2014 Assessment and Preferred Model A

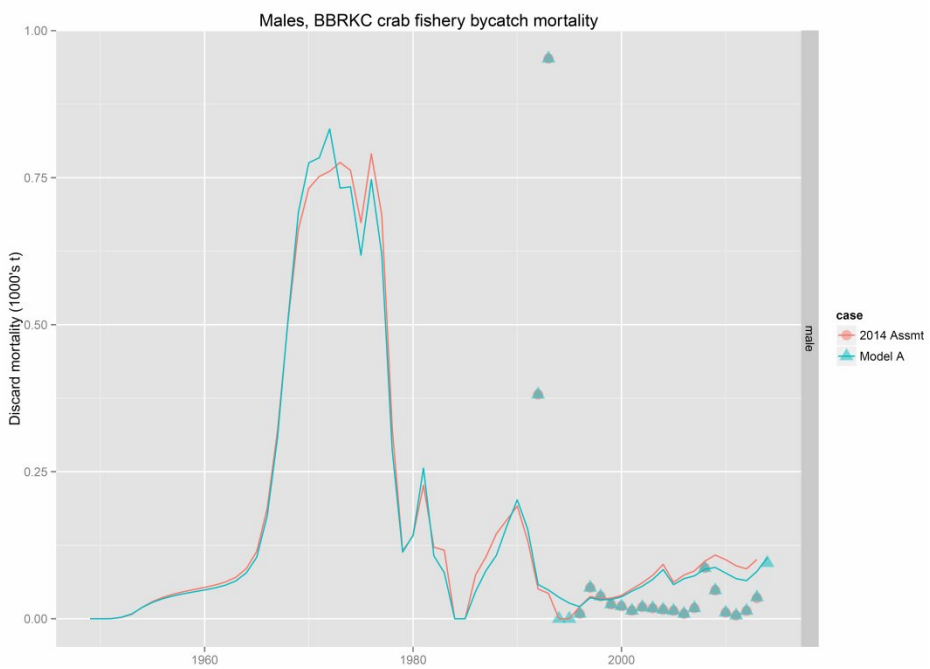


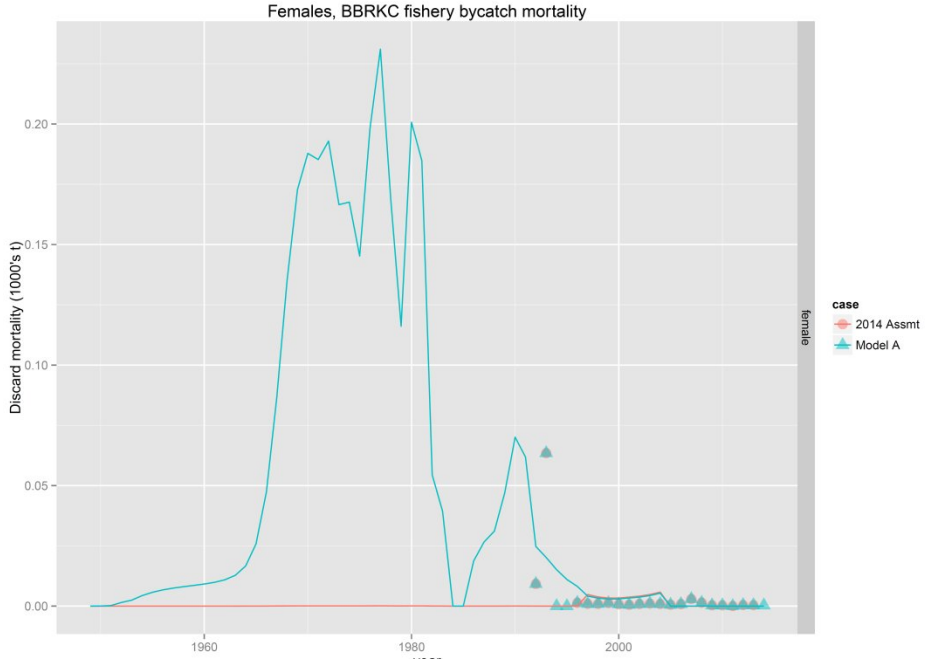
Comparisons: 2014 Assessment and Preferred Model A



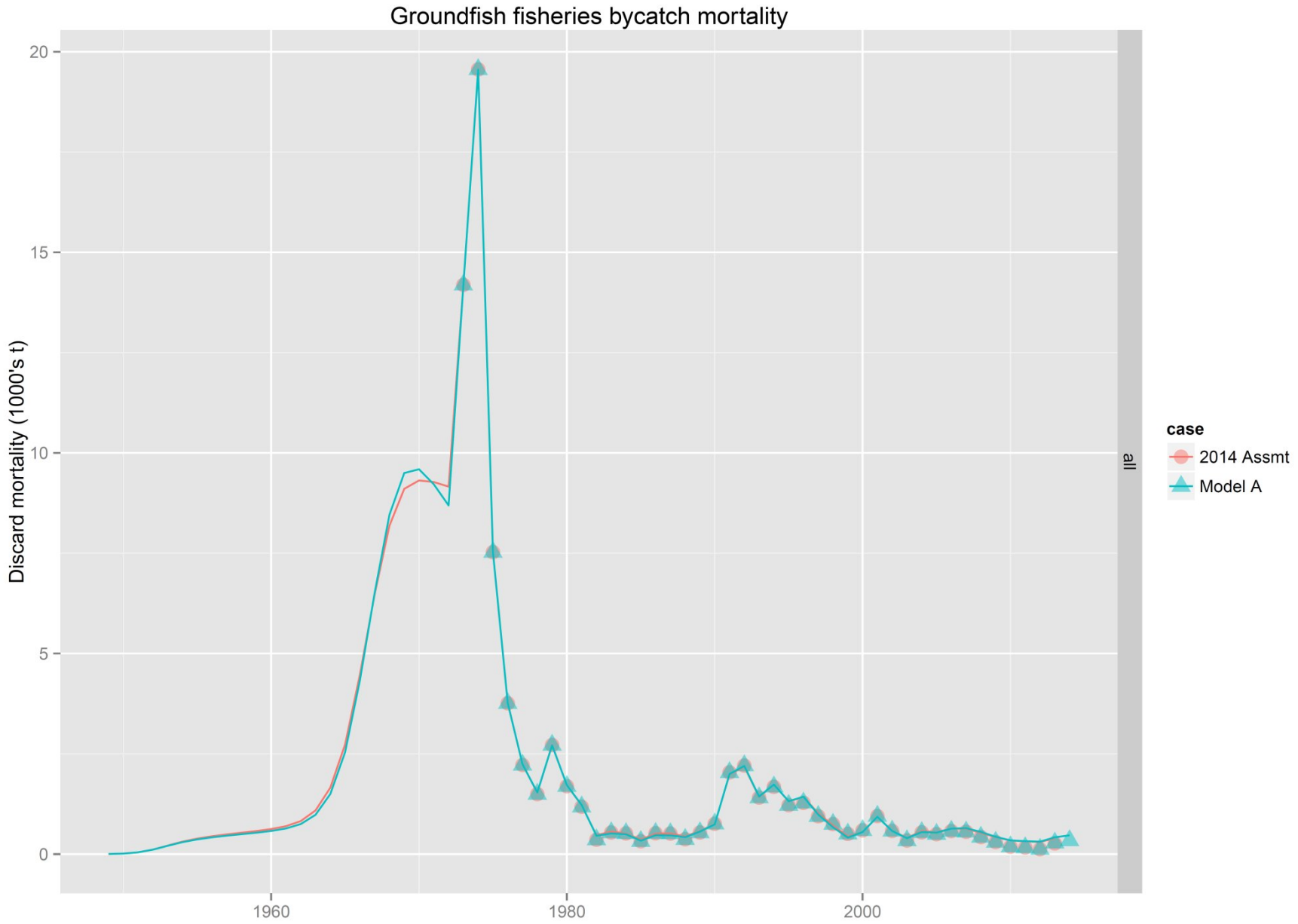
Comparisons: 2014 Assessment and Preferred Model A

BBRKC fishery bycatch

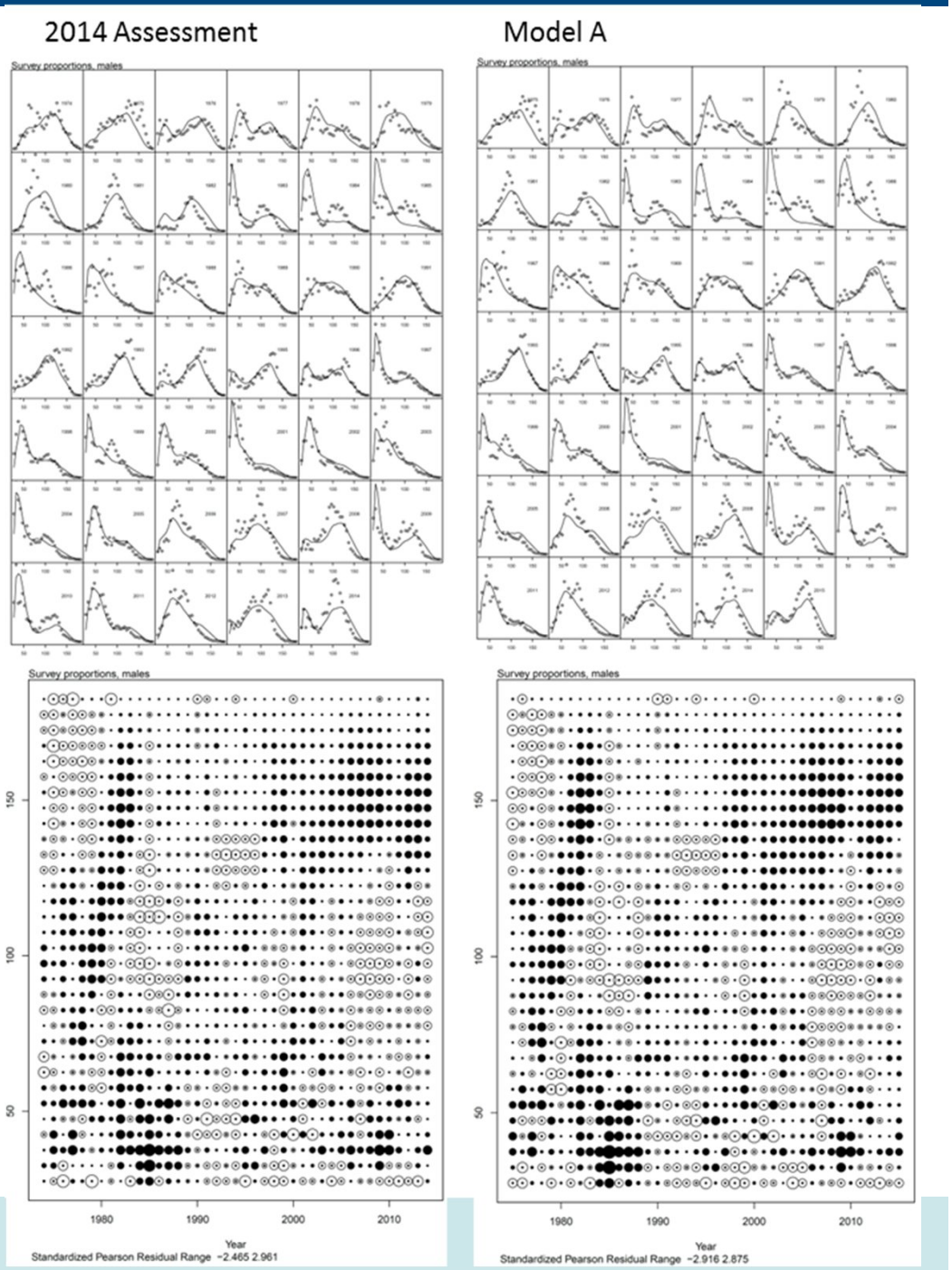




Comparisons: 2014 Assessment and Preferred Model A

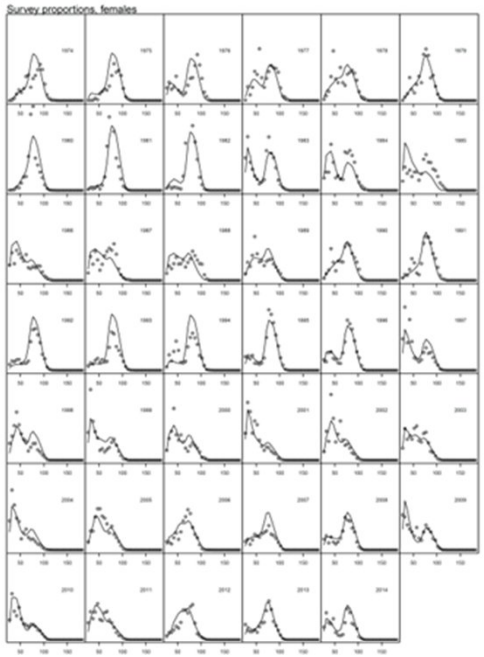


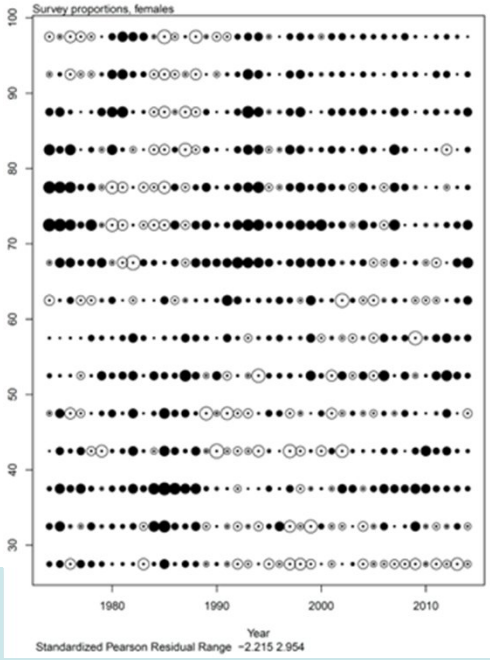
Comparisons: Male Survey Size Comps



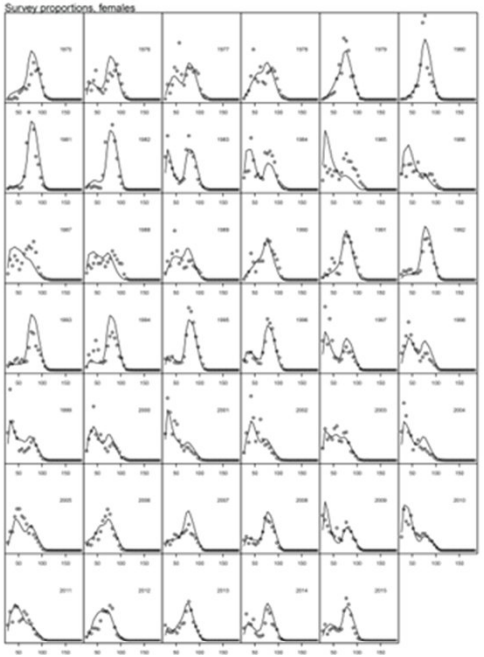
Comparisons: Female Survey Size Comps

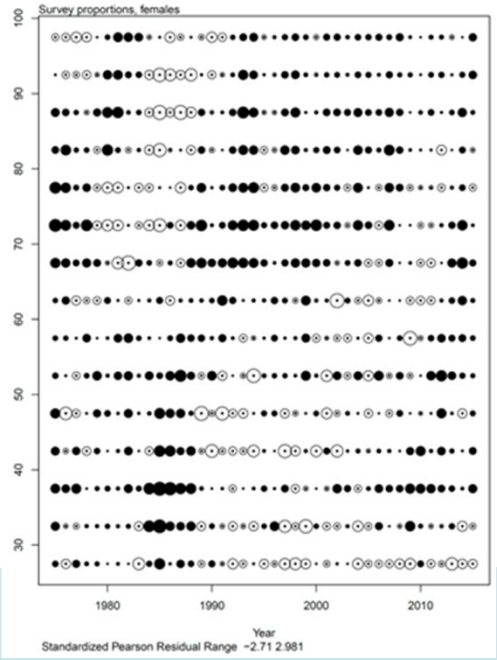
2014 Assessment





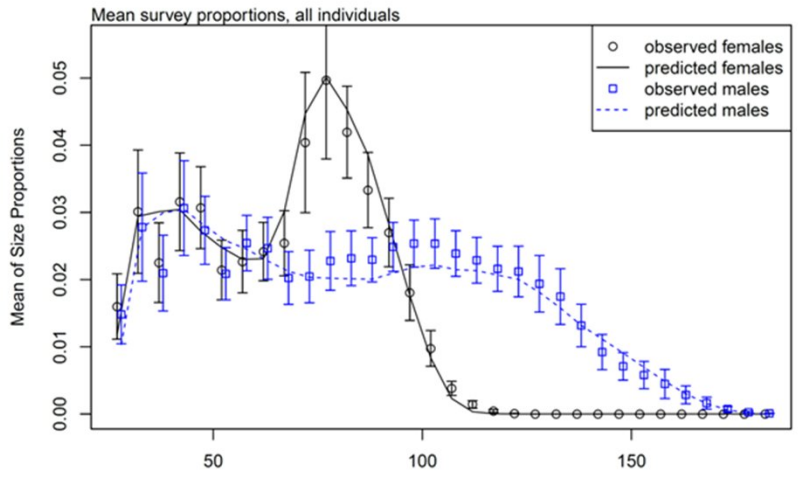
Model A

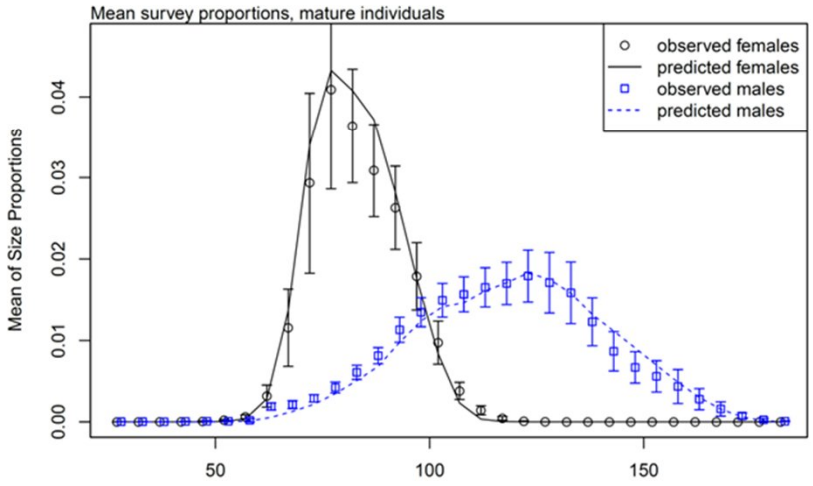




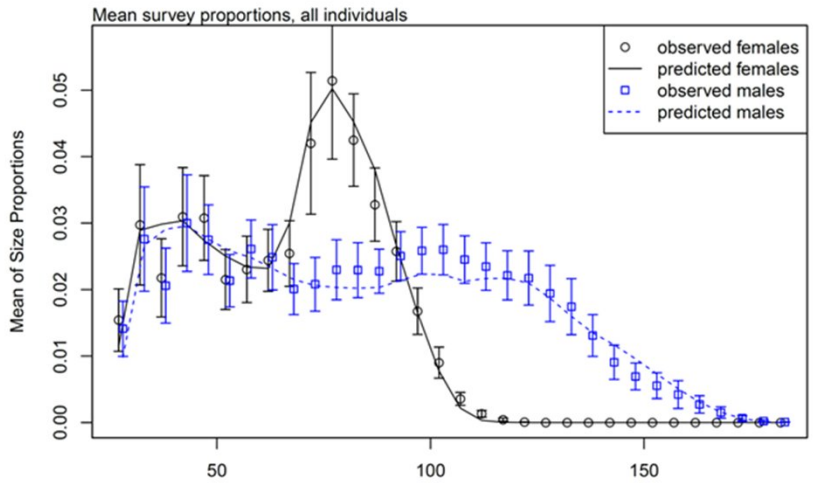
Comparisons: Marginal Survey Size Comps

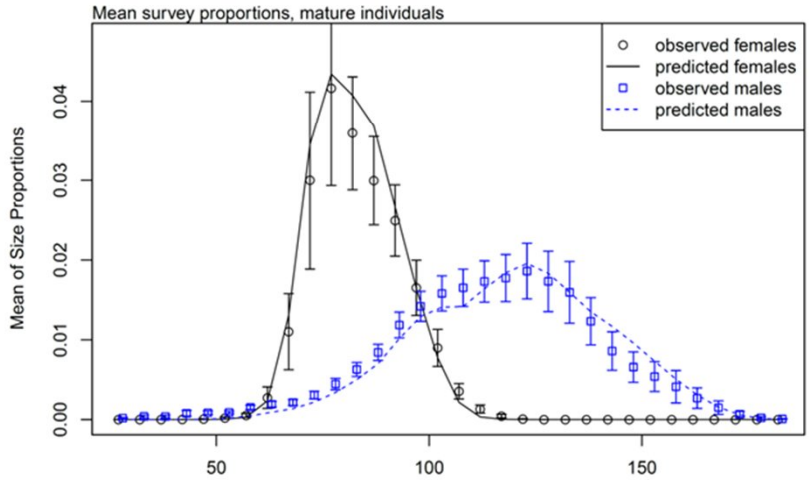
2014 Assessment





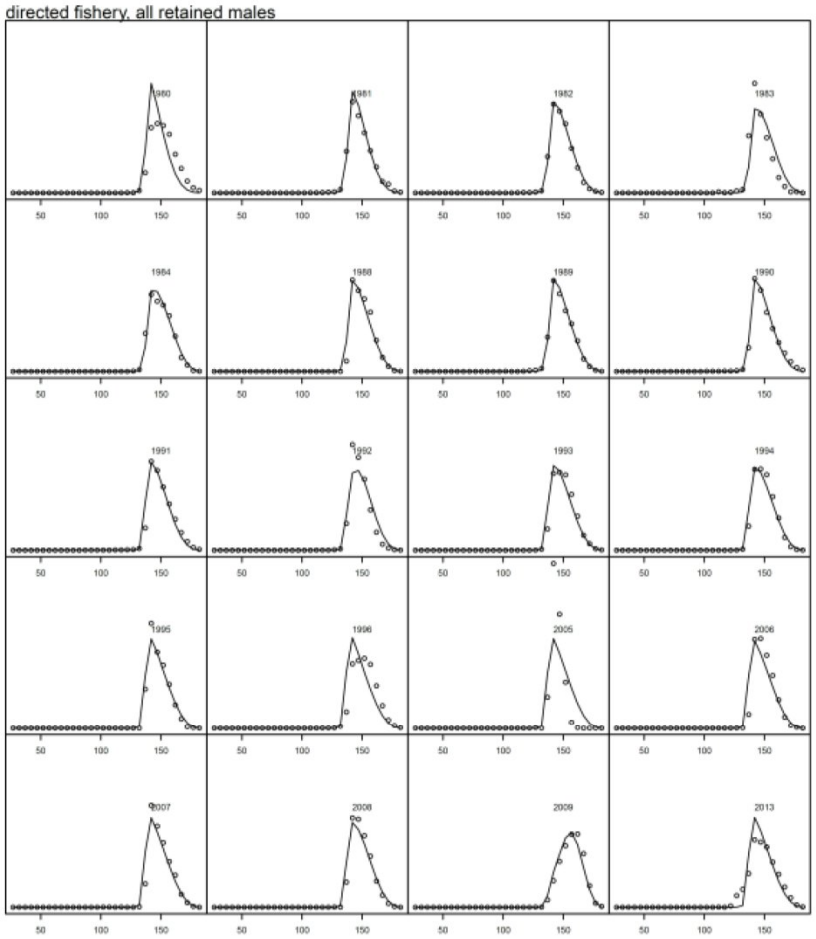
Model A



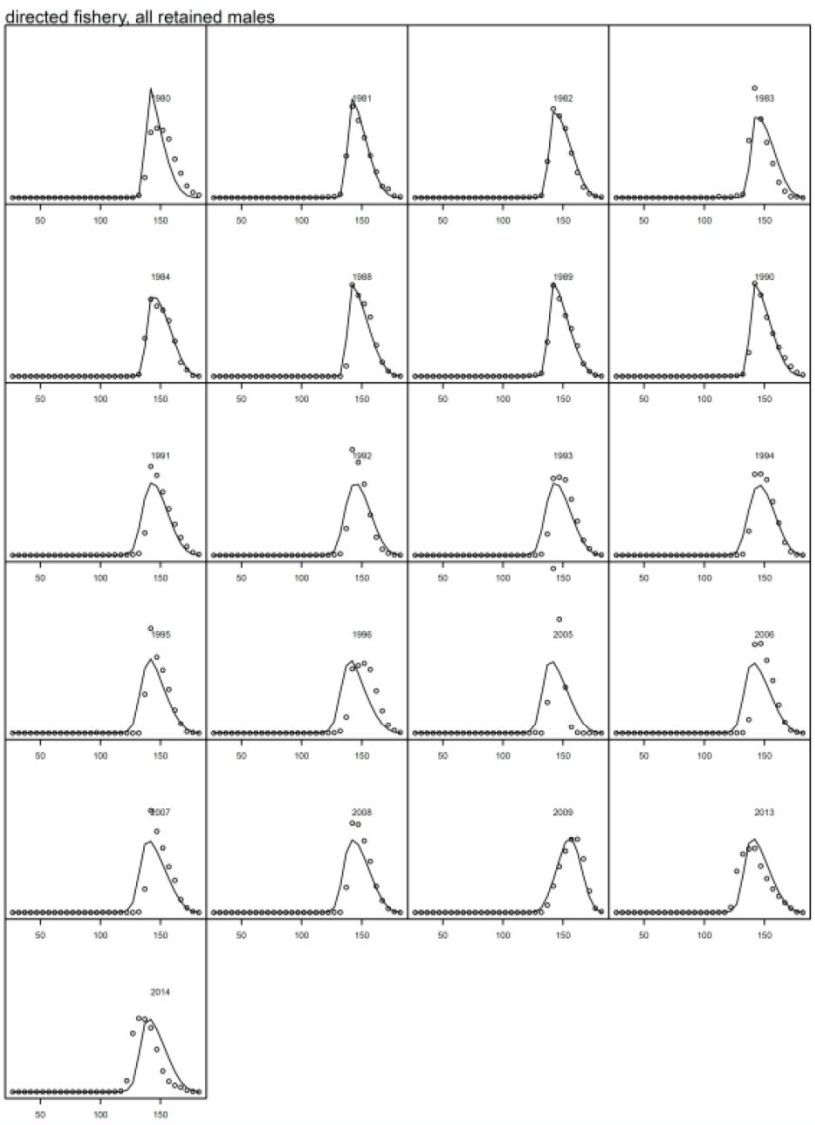


Comparisons: Retained Catch Size Comps

2014 assessment

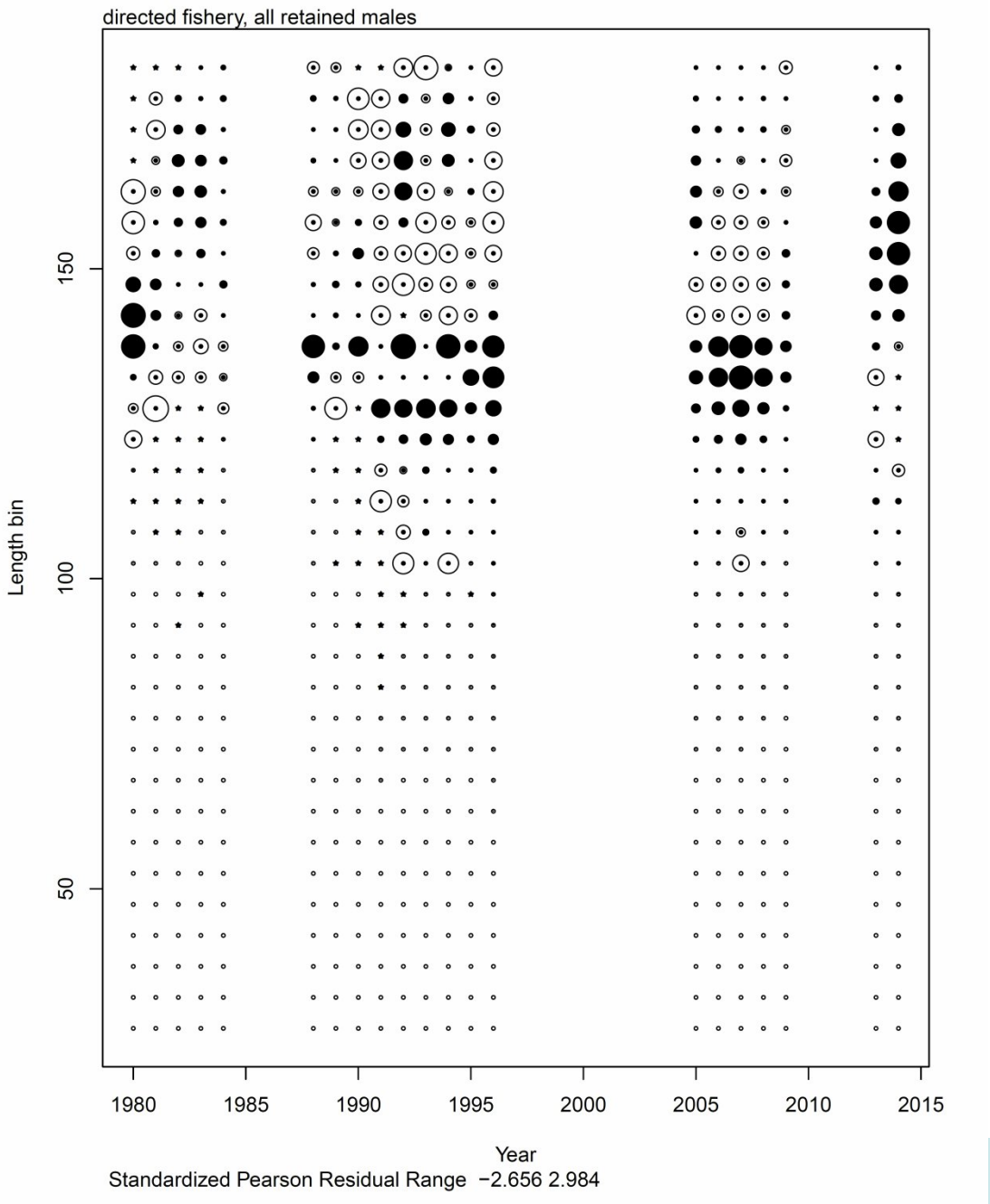


Model A (Dataset D)



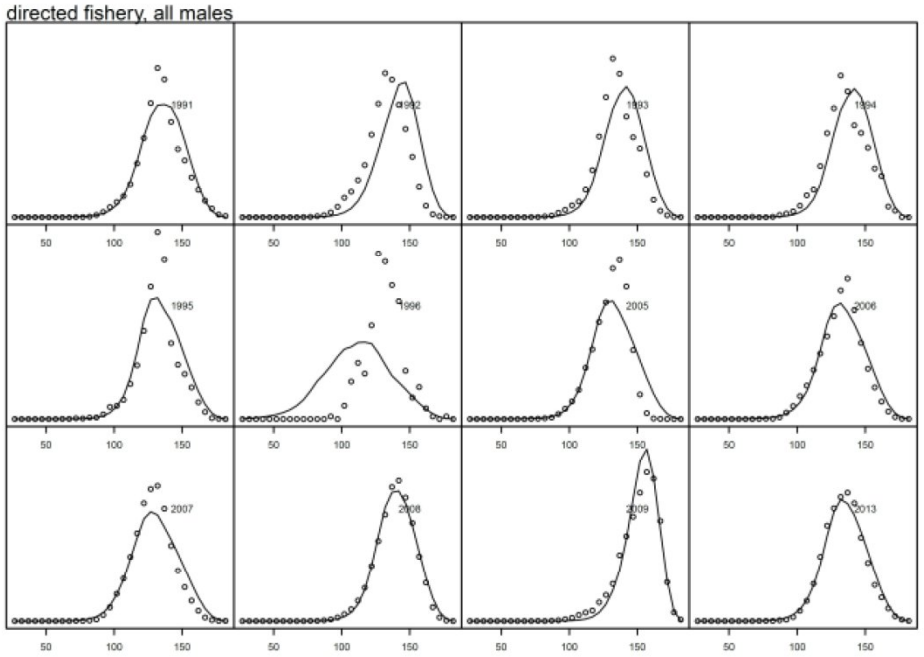
Model A: Retained Catch Size Comps Pearson's Residuals

- White circles: observed > model
- Black circles: observed < model

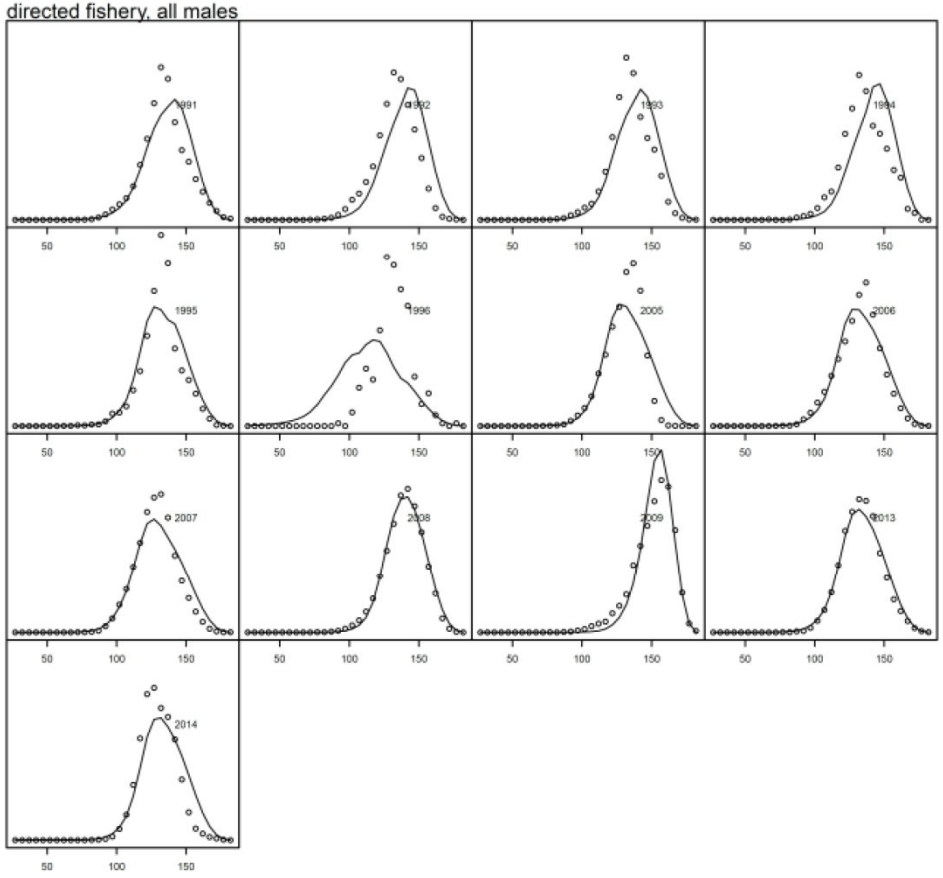


Comparisons: Directed fishery total male size comps

2014 assessment

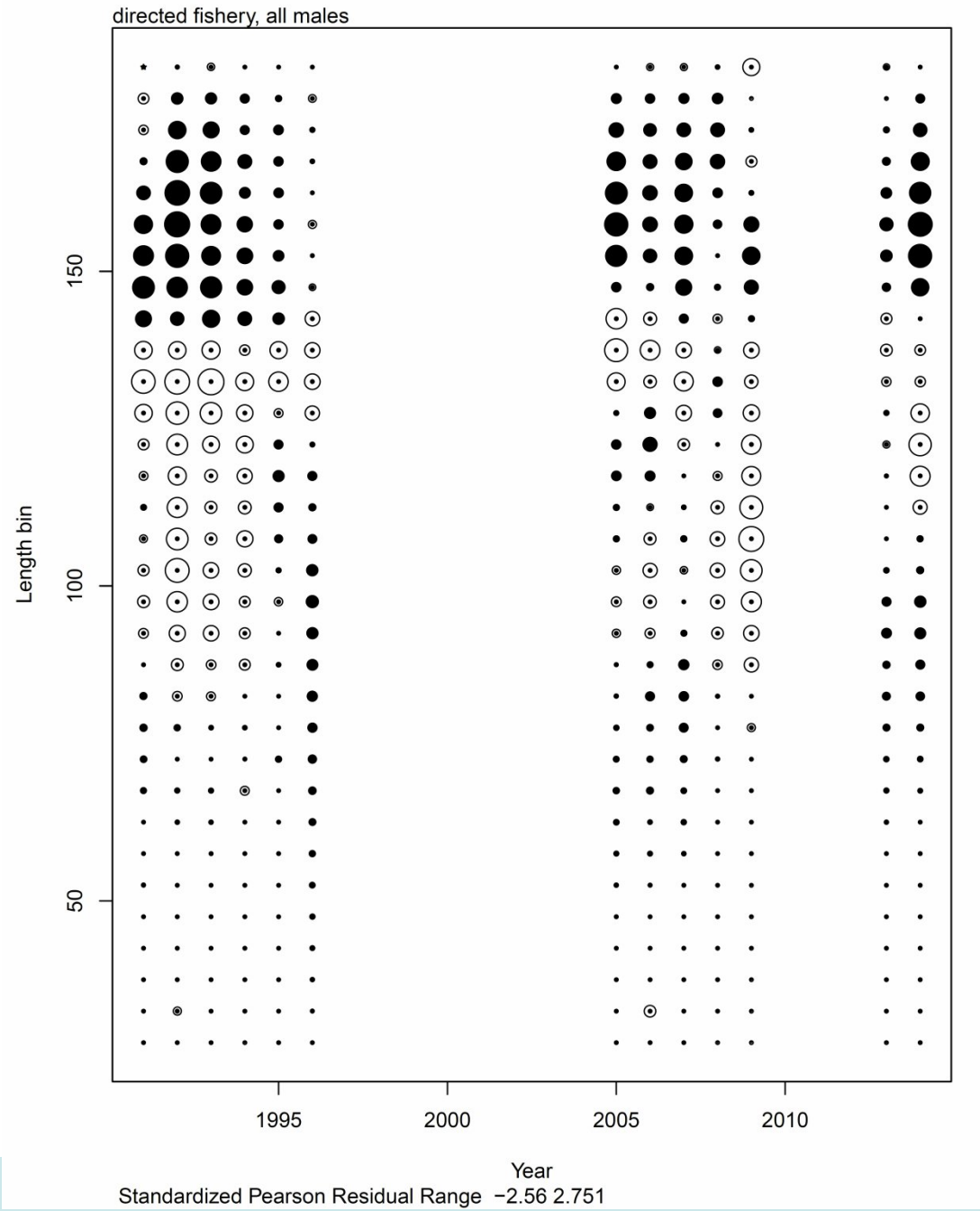


Model A (Dataset D)



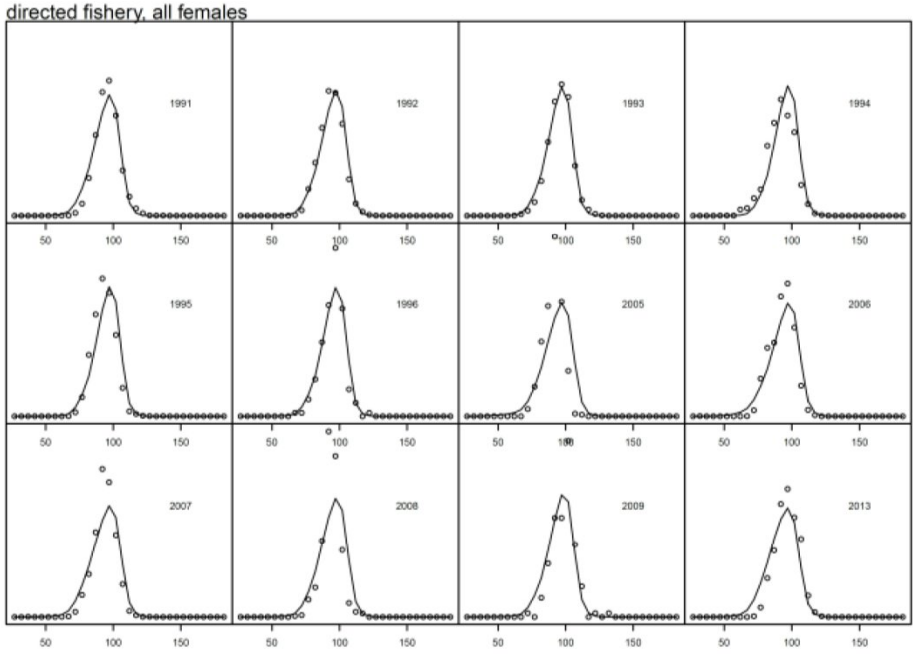
Model A: Total Male Catch Size Comps Pearson's Residuals

- White circles: observed > model
- Black circles: observed < model

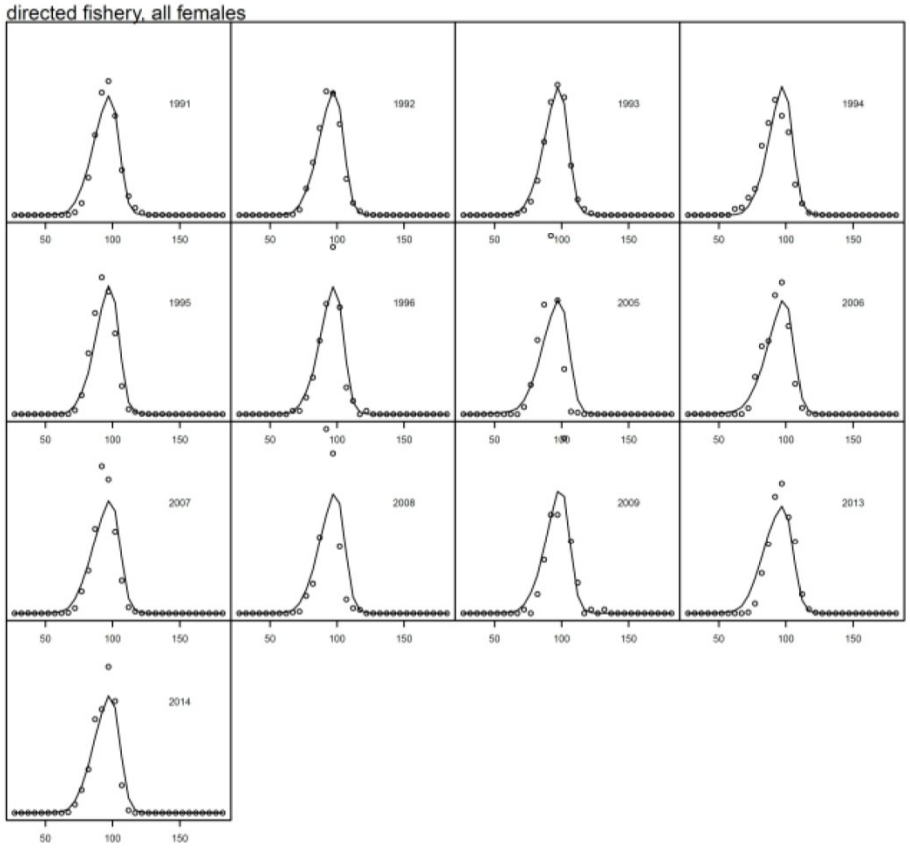


Comparisons: Directed Fishery Female Bycatch

2014 assessment

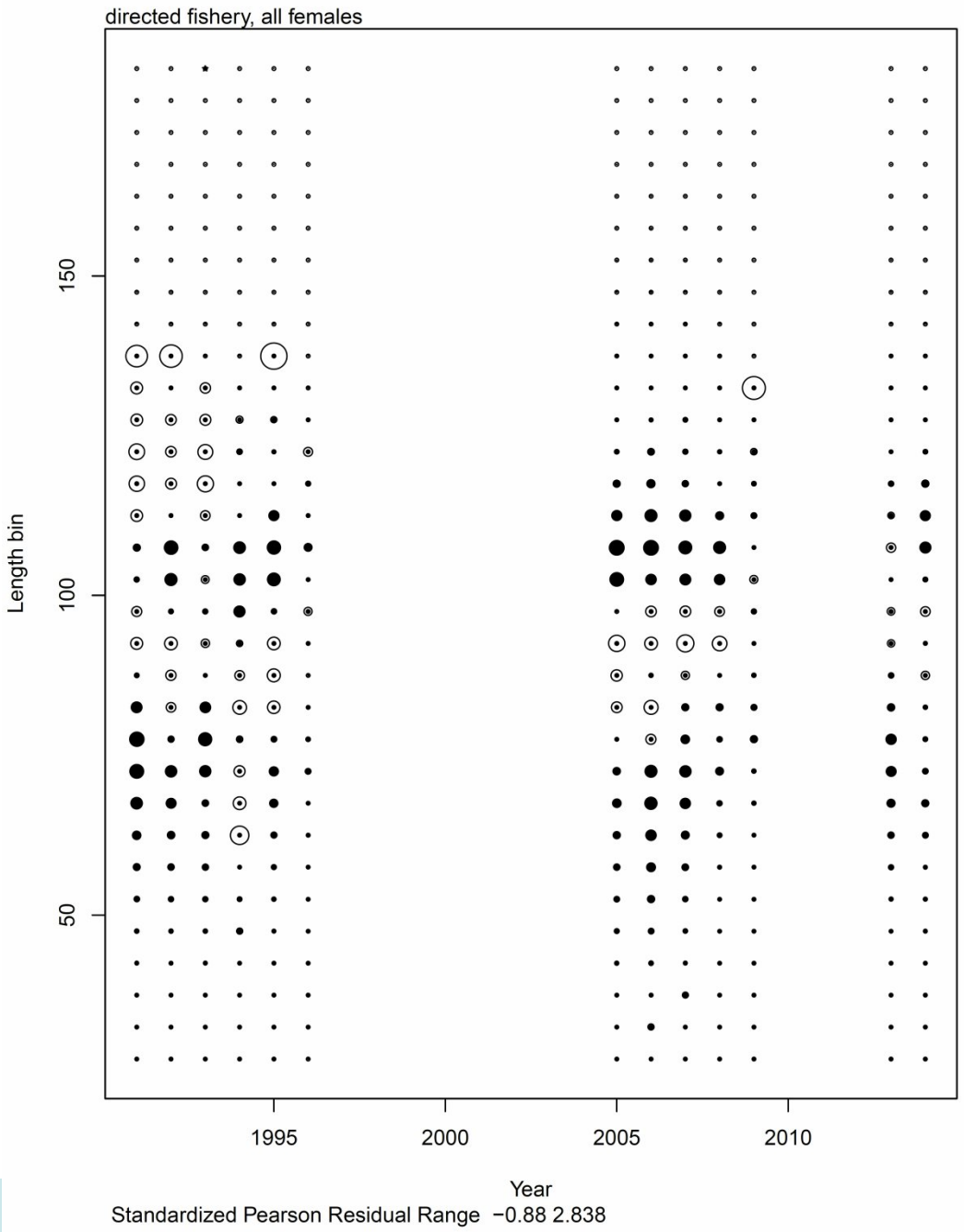


Model A (Dataset D)



Model A: Female Bycatch Size Comps Pearson's Residuals

- White circles: observed > model
- Black circles: observed < model



Comparisons: Directed Fishery Marginal Size Comps

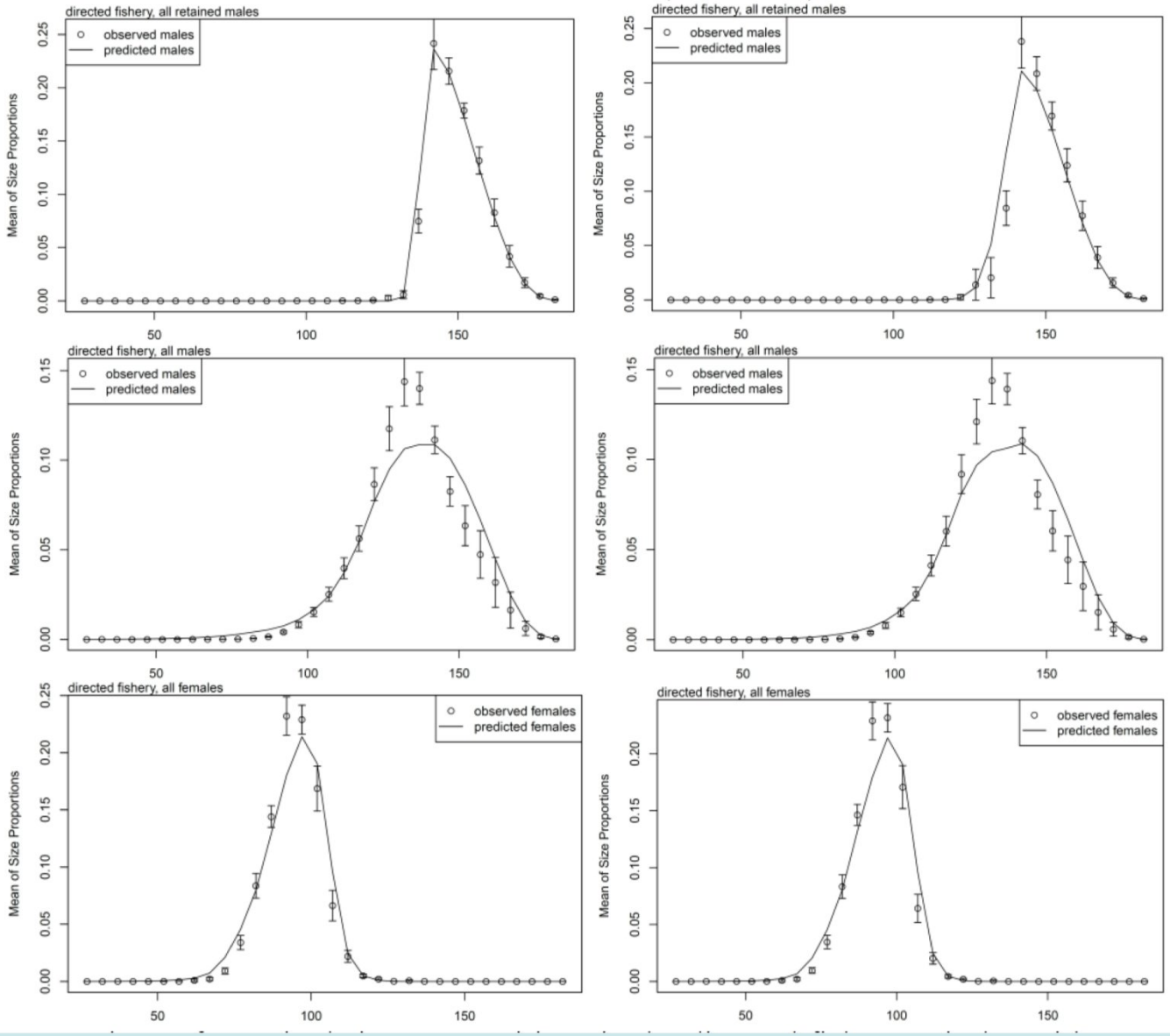
Retained Males

All Males

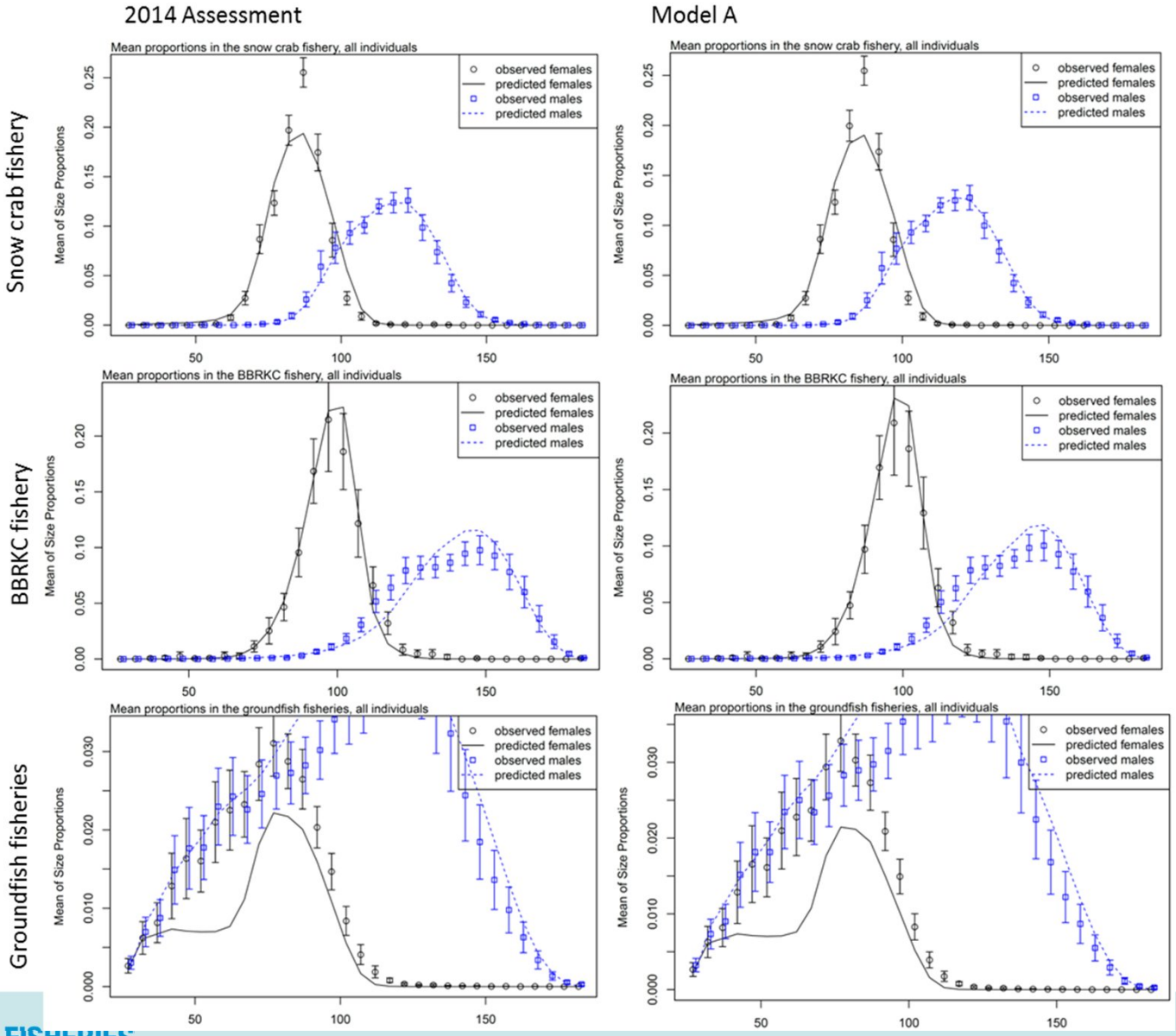
Females

2014 assessment

Model A (Dataset D)

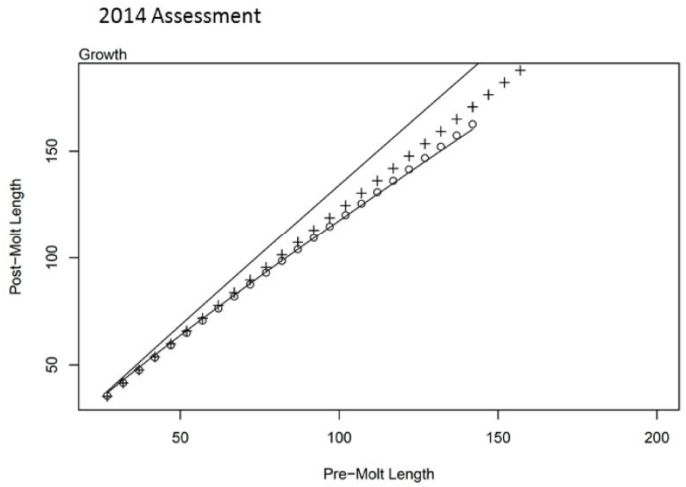


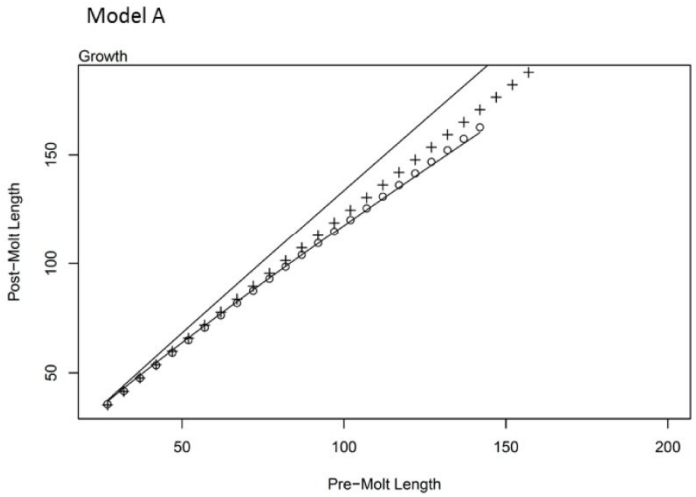
Comparisons: Marginal Bycatch Fishery Size Comps



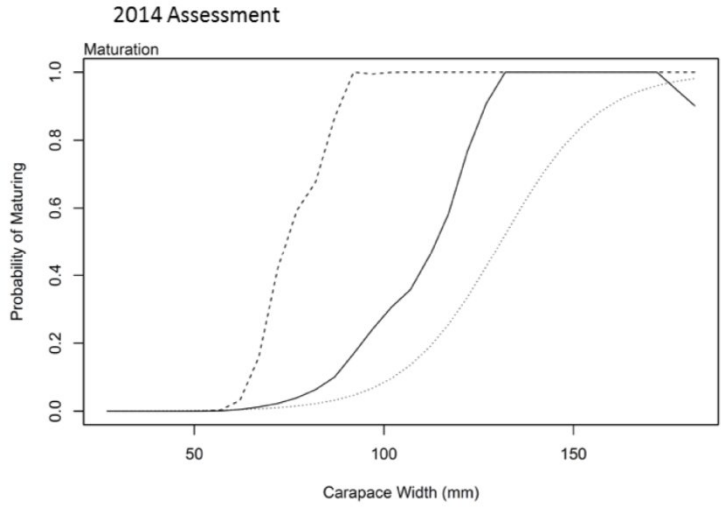
Comparisons: Growth and Maturity

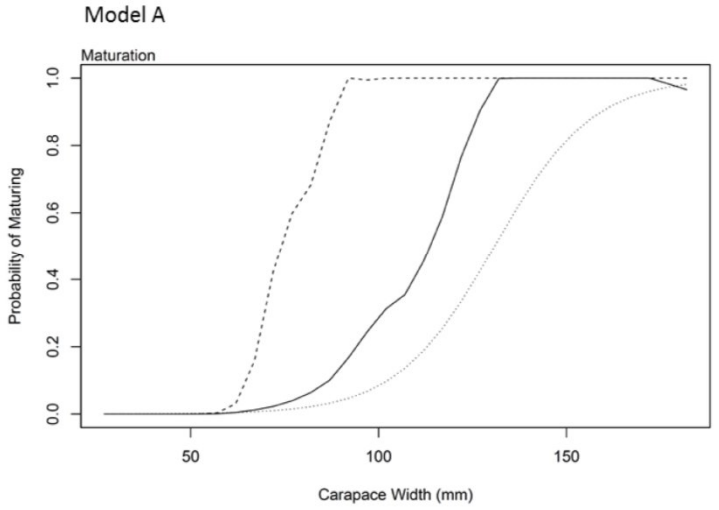
Growth





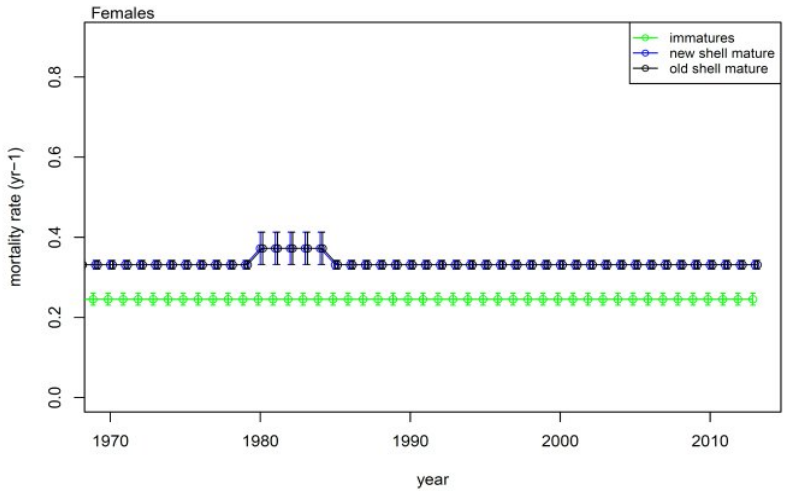
Probability of maturing

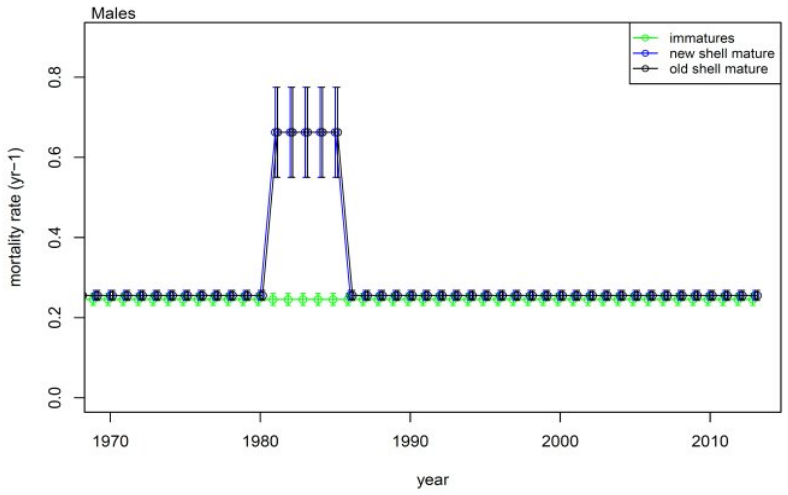




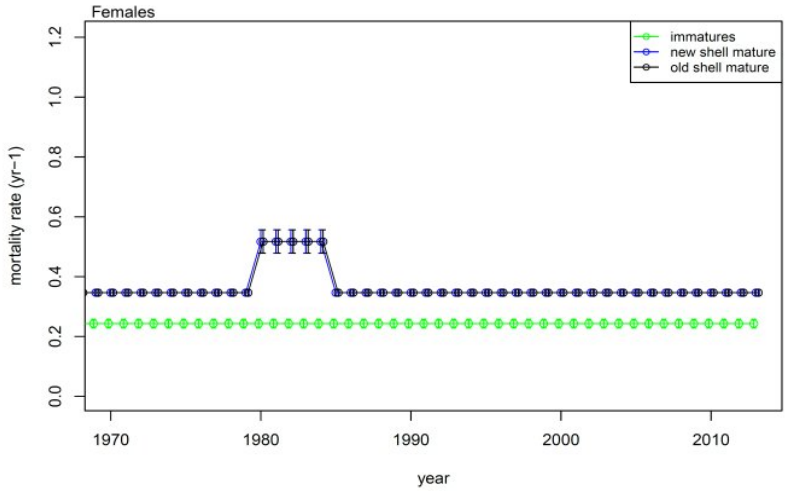
Comparisons: Natural Mortality

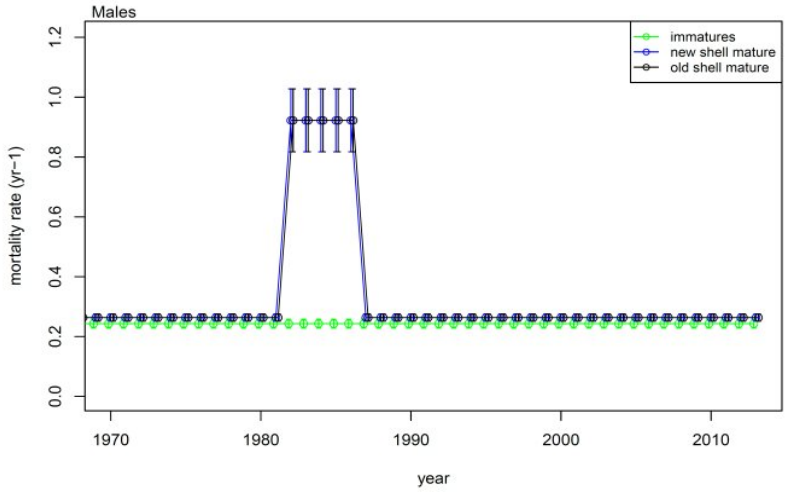
2014 Assessment



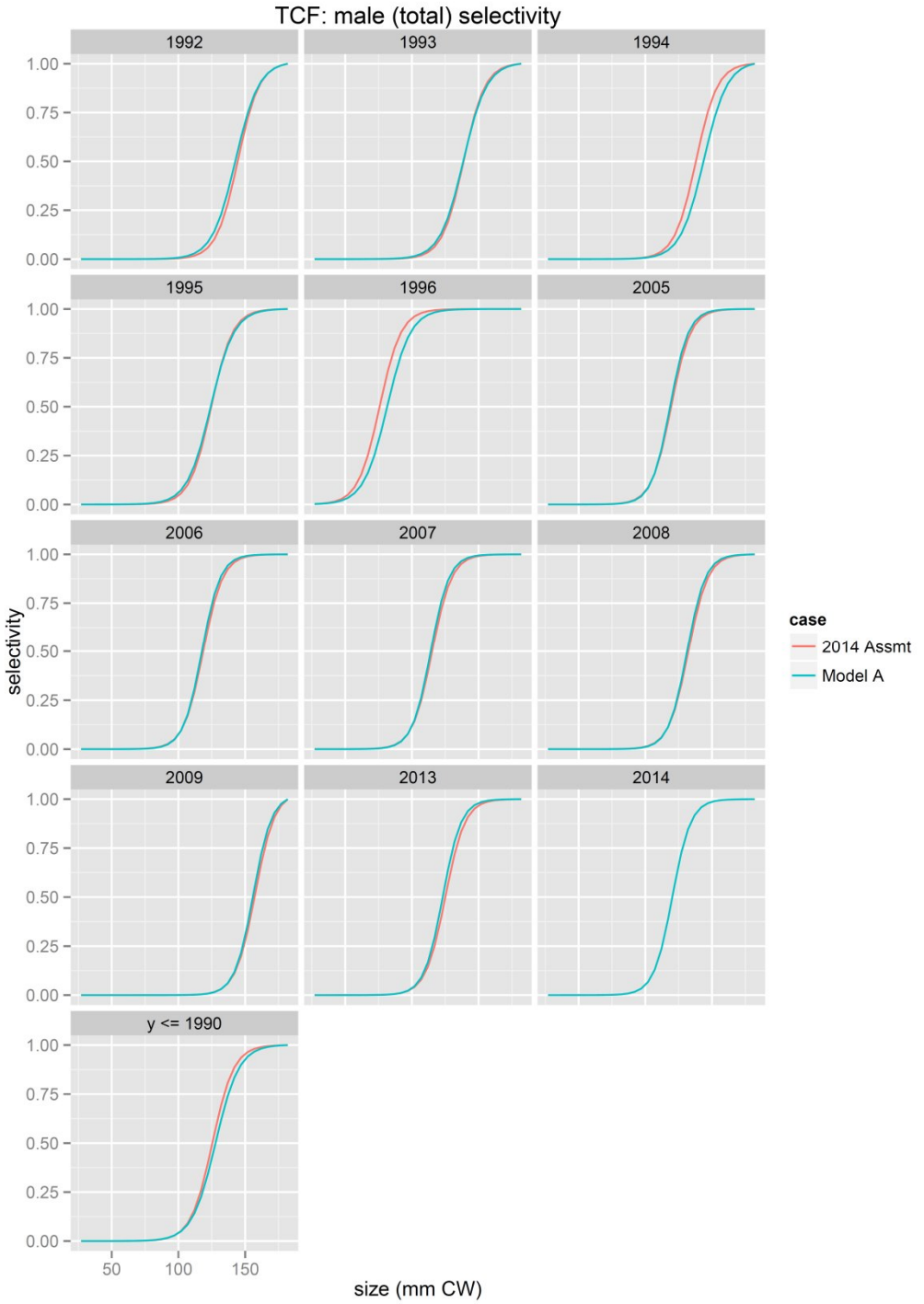


Model A

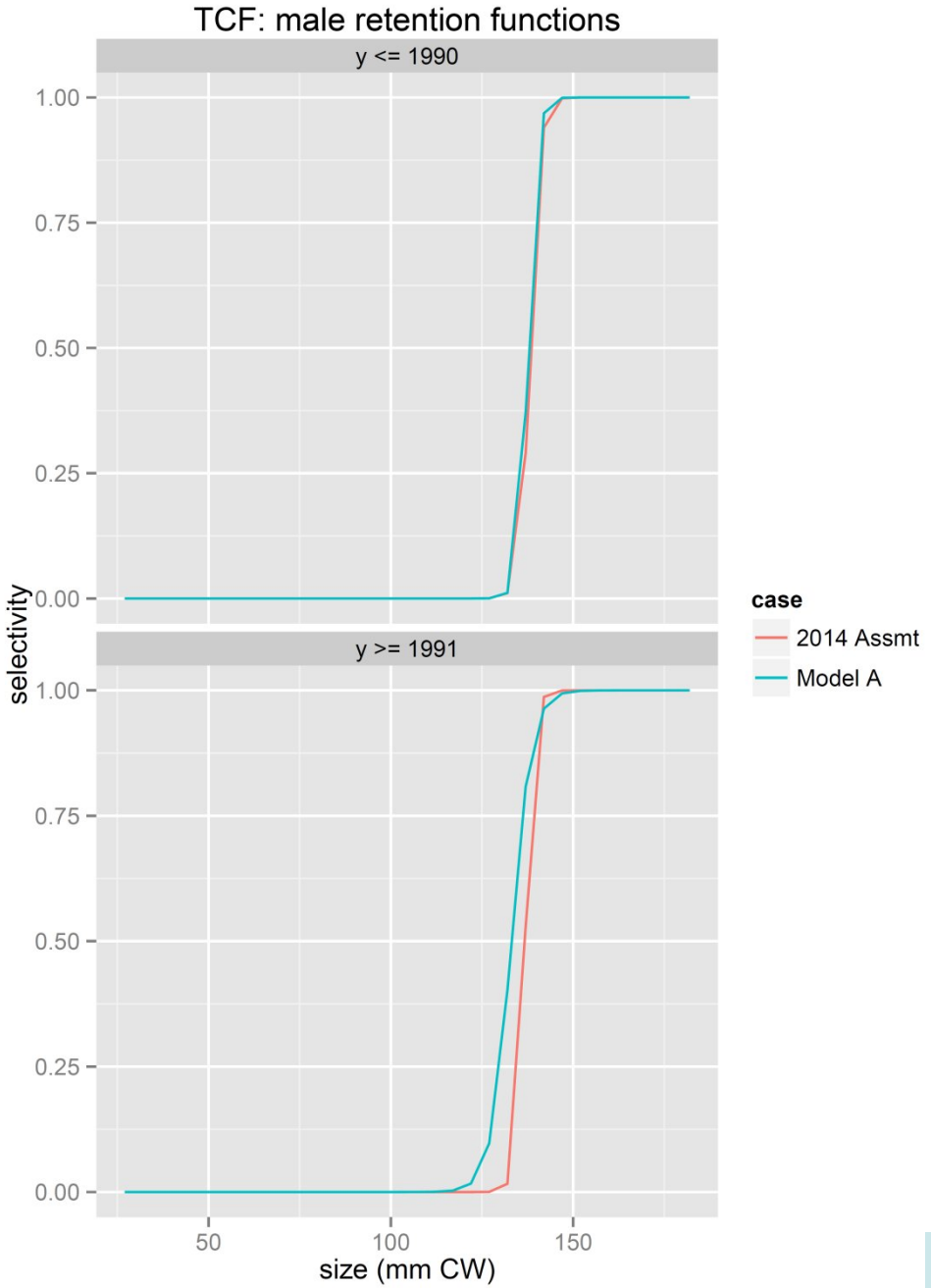


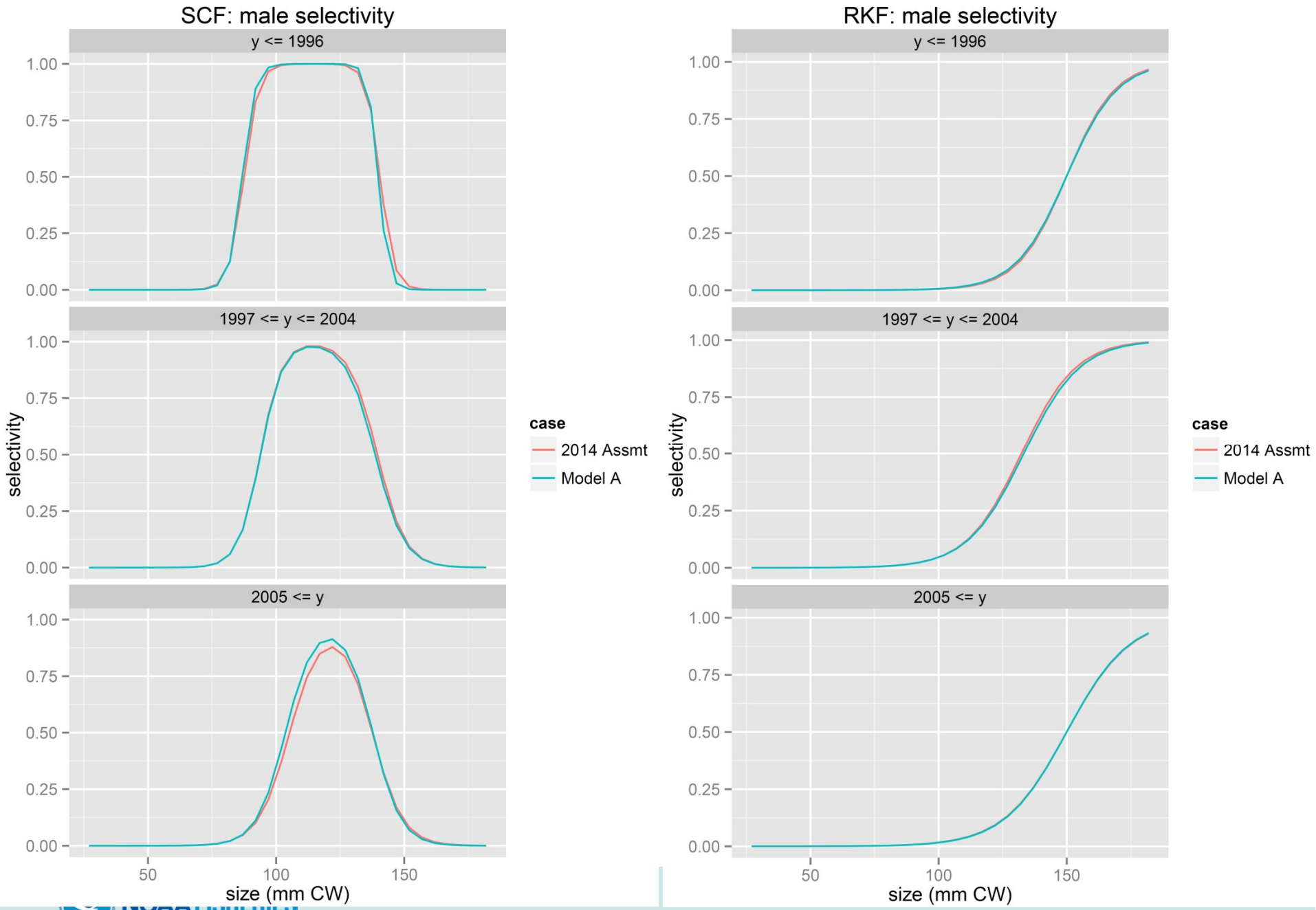


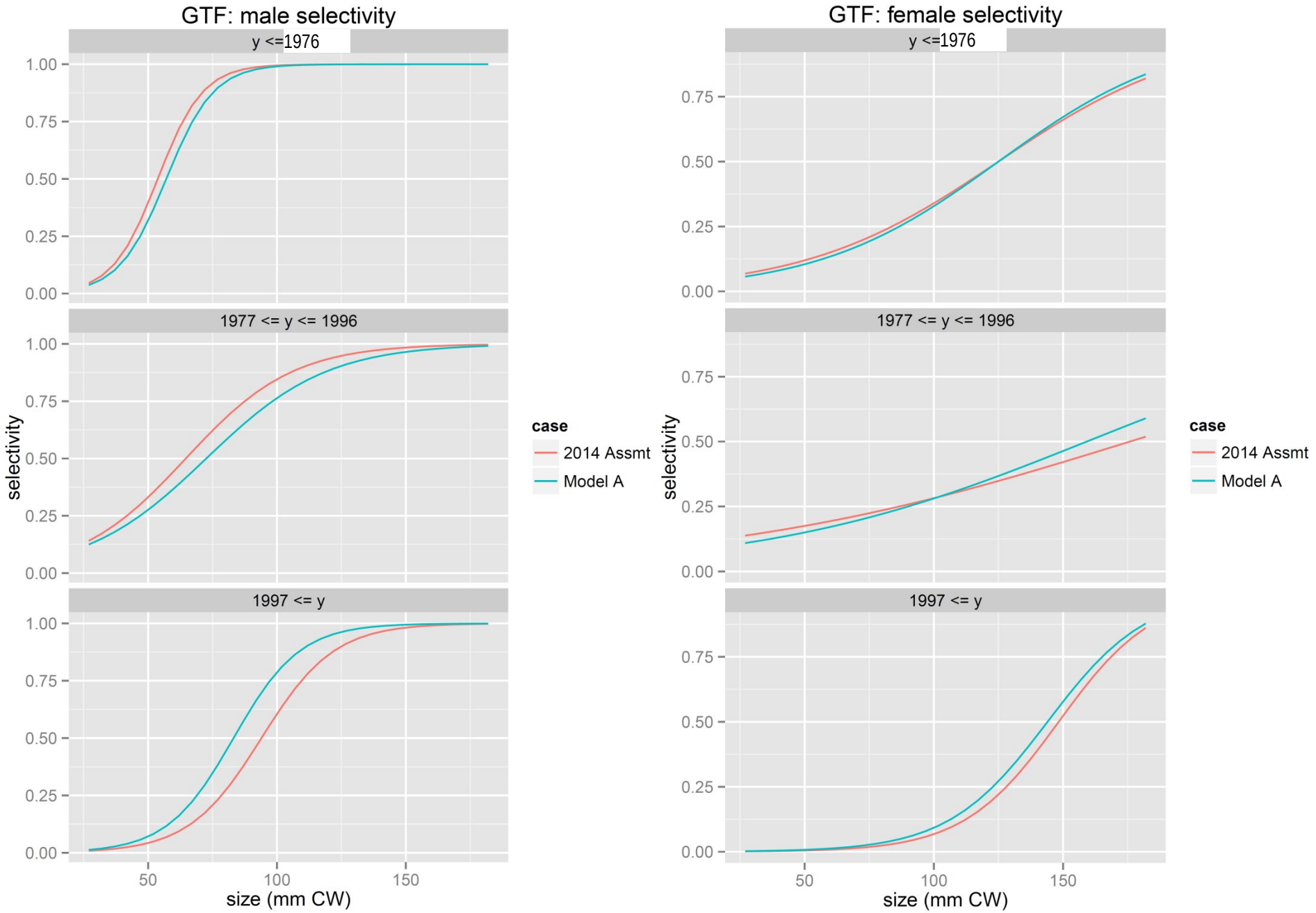
Comparisons: Directed fishery total male selectivity

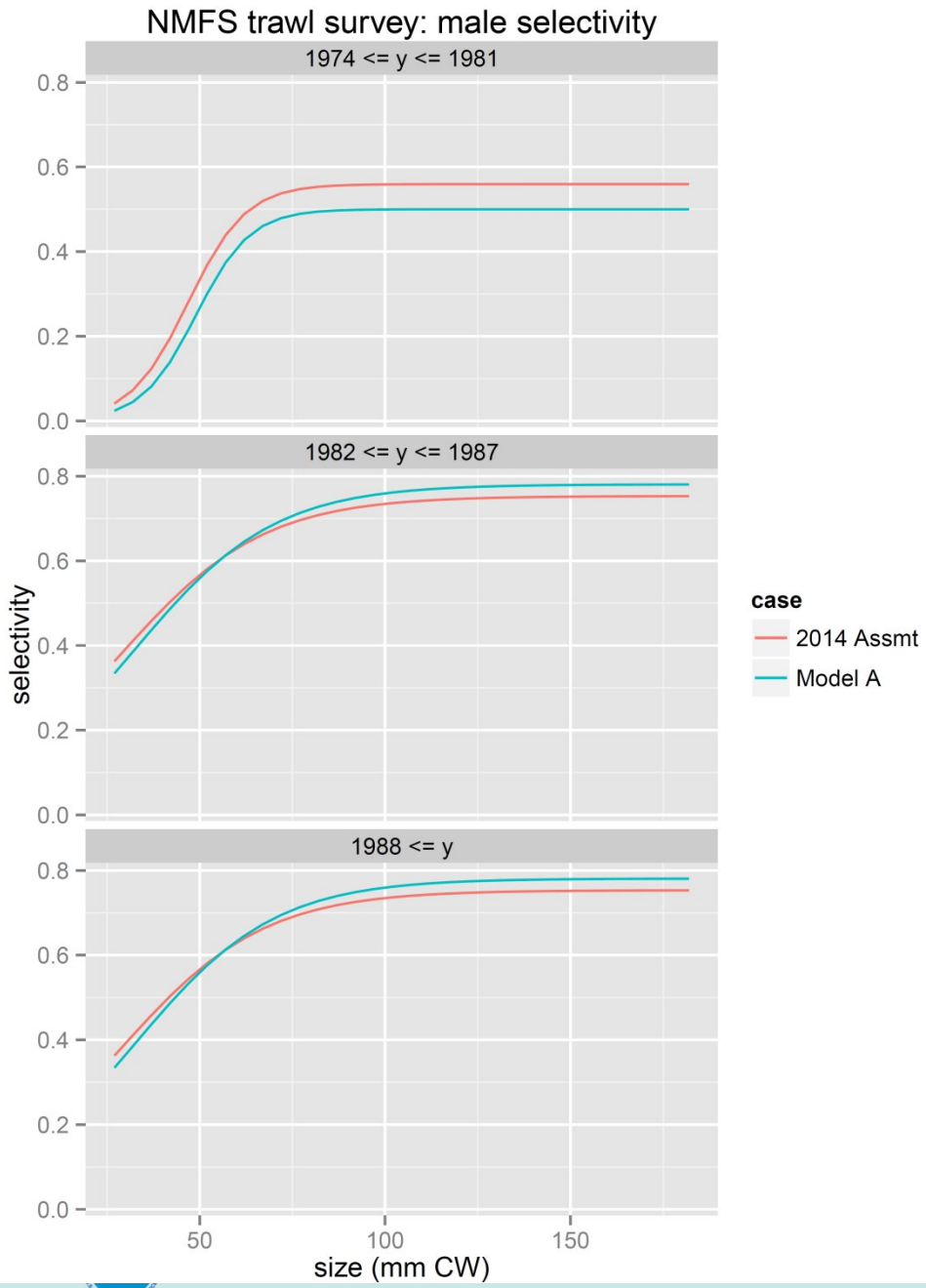


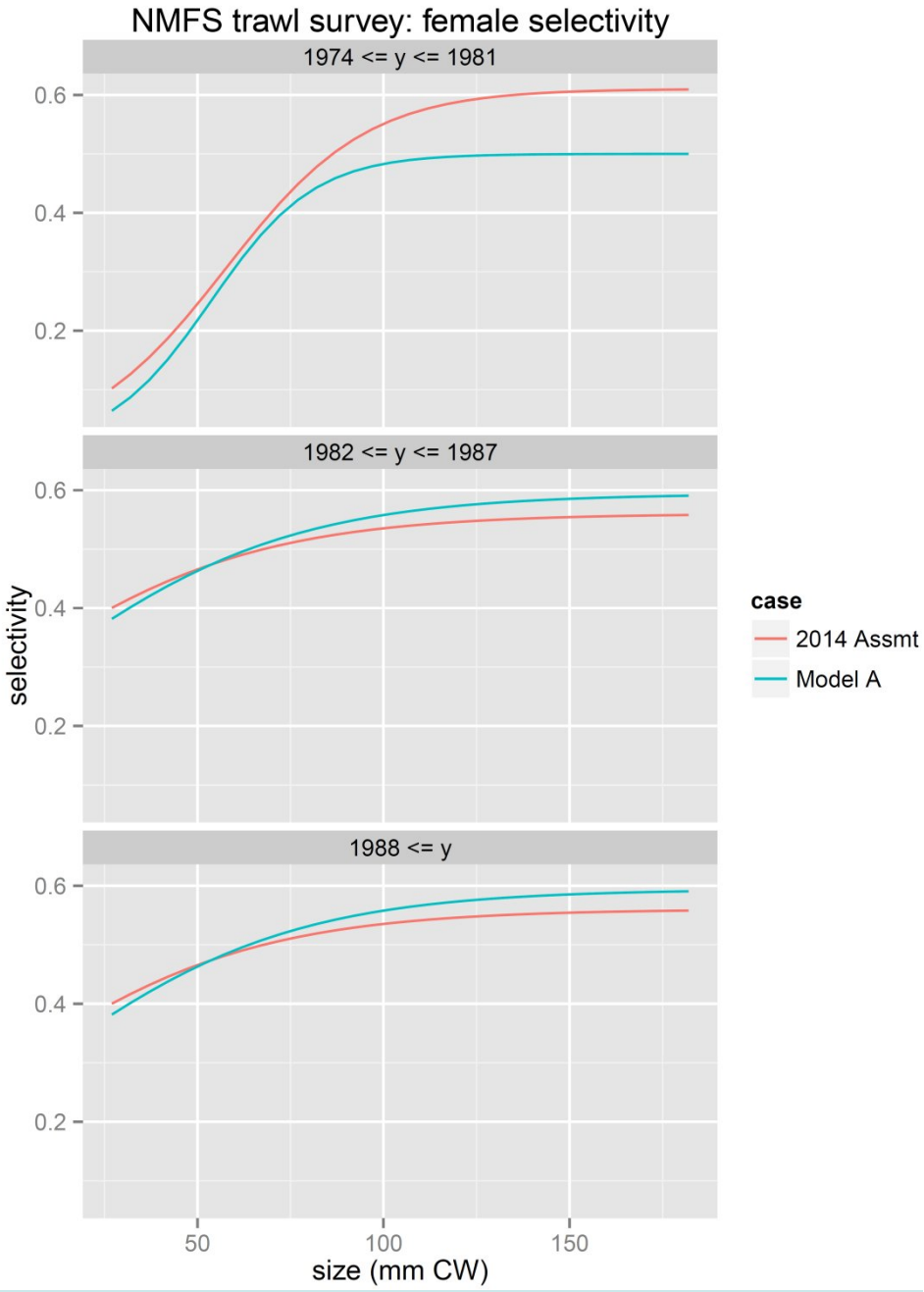
Comparisons



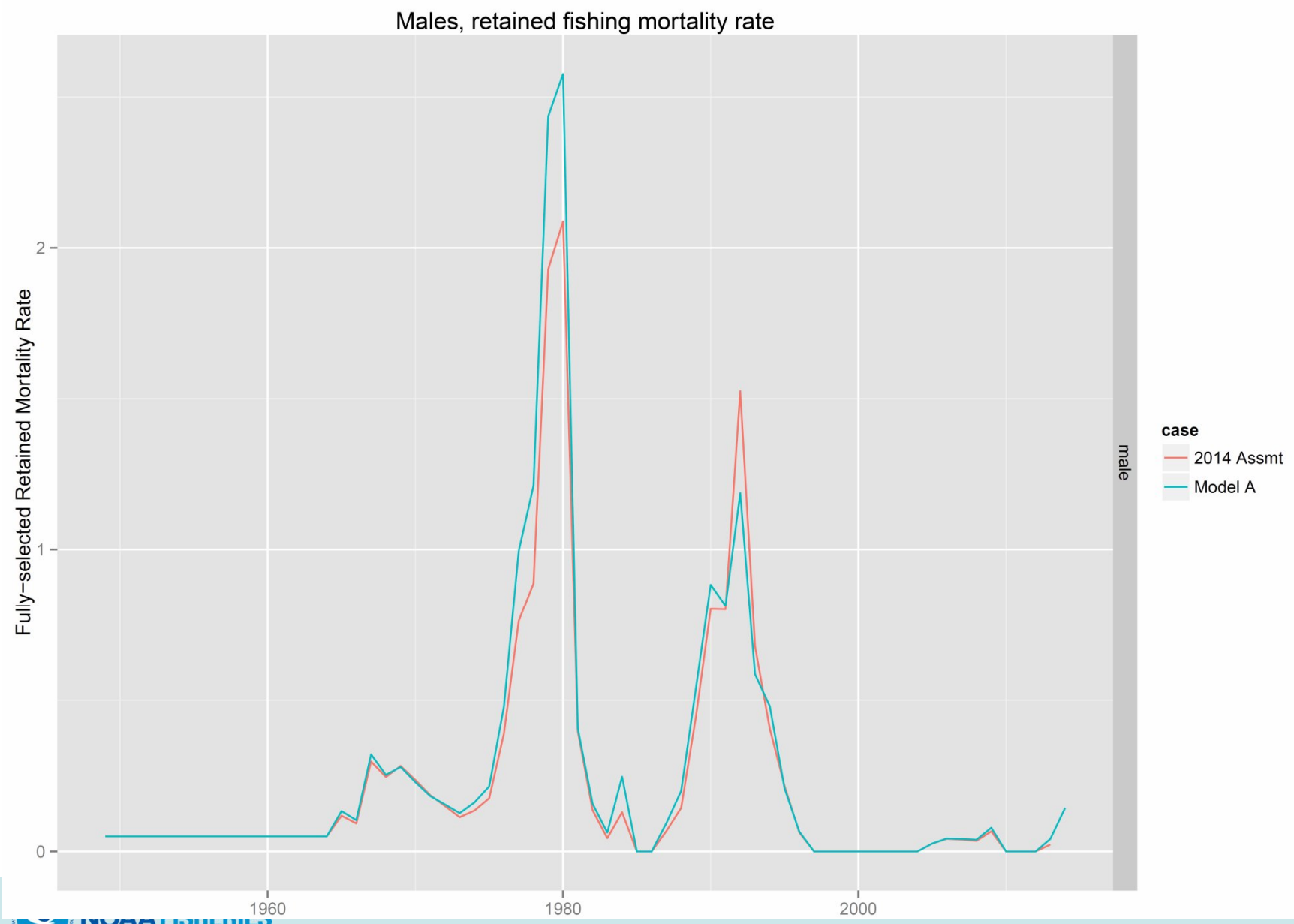

SCF: male selectivity
RKF: male selectivity
y <= 1996
1997 <= y <= 2004
2005 <= y
selectivity
size (mm CW)
case
2014 Assmt
Model A


GTF: male selectivity
y <=1976
1977 <= y <= 1996
1997 <= y
selectivity
1.00
0.75
0.50
0.25
0.00
50
100
150
size (mm CW)
case
2014 Assmt
Model A
GTF: female selectivity
y <=1976
1977 <= y <= 1996
1997 <= y
selectivity
0.75
0.50
0.25
0.00
50
100
150
size (mm CW)
case
2014 Assmt
Model A

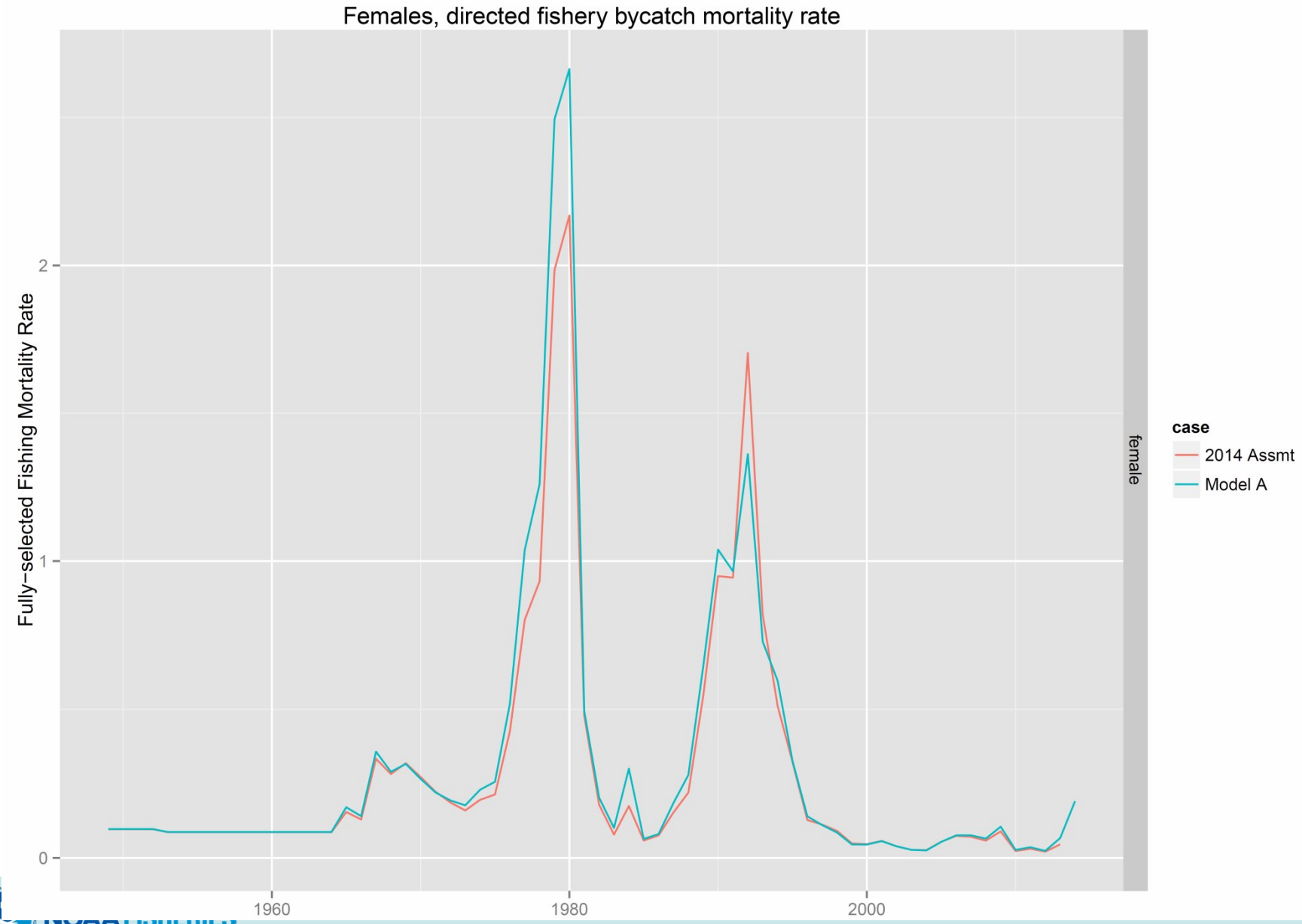

NMFS trawl survey: male selectivity
1974 <= y <= 1981
1982 <= y <= 1987
1988 <= y
selectivity
size (mm CW)
case
2014 Assmt
Model A


NMFS trawl survey: female selectivity
1974 <= y <= 1981
1982 <= y <= 1987
1988 <= y
selectivity
size (mm CW)
case
2014 Assmt
Model A

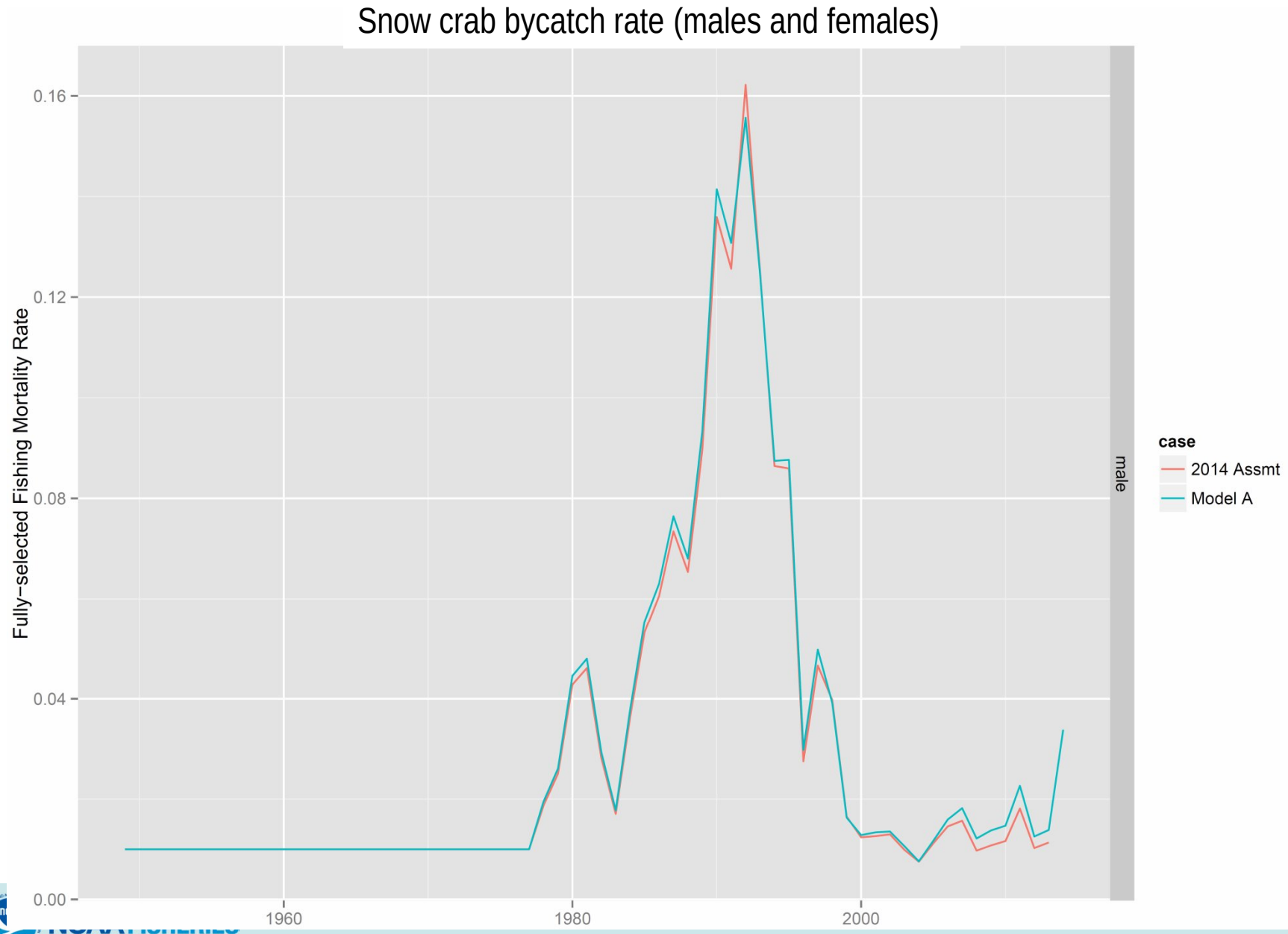
Comparisons



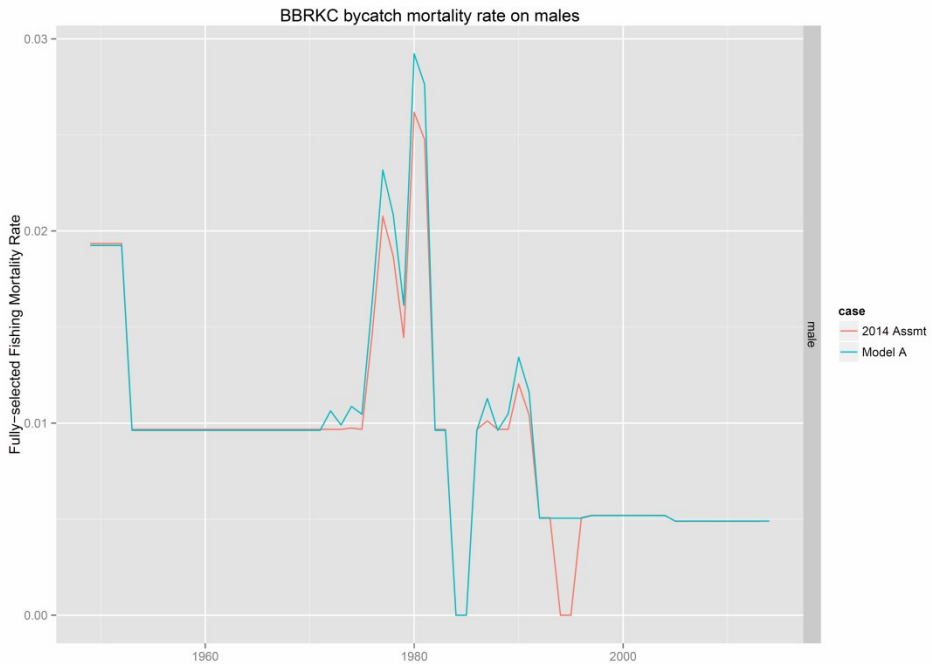
Comparisons

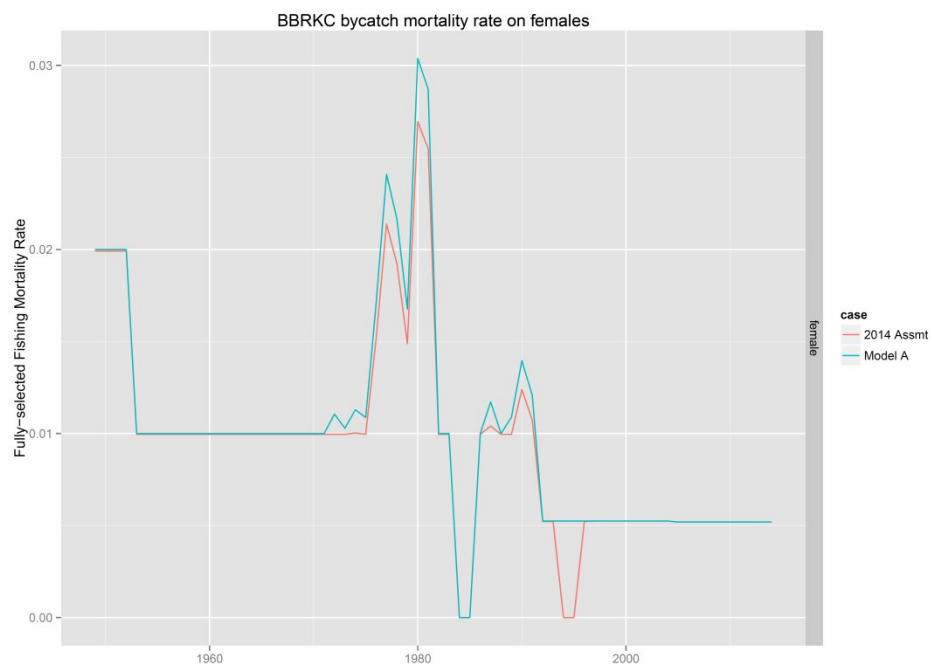


Comparisons

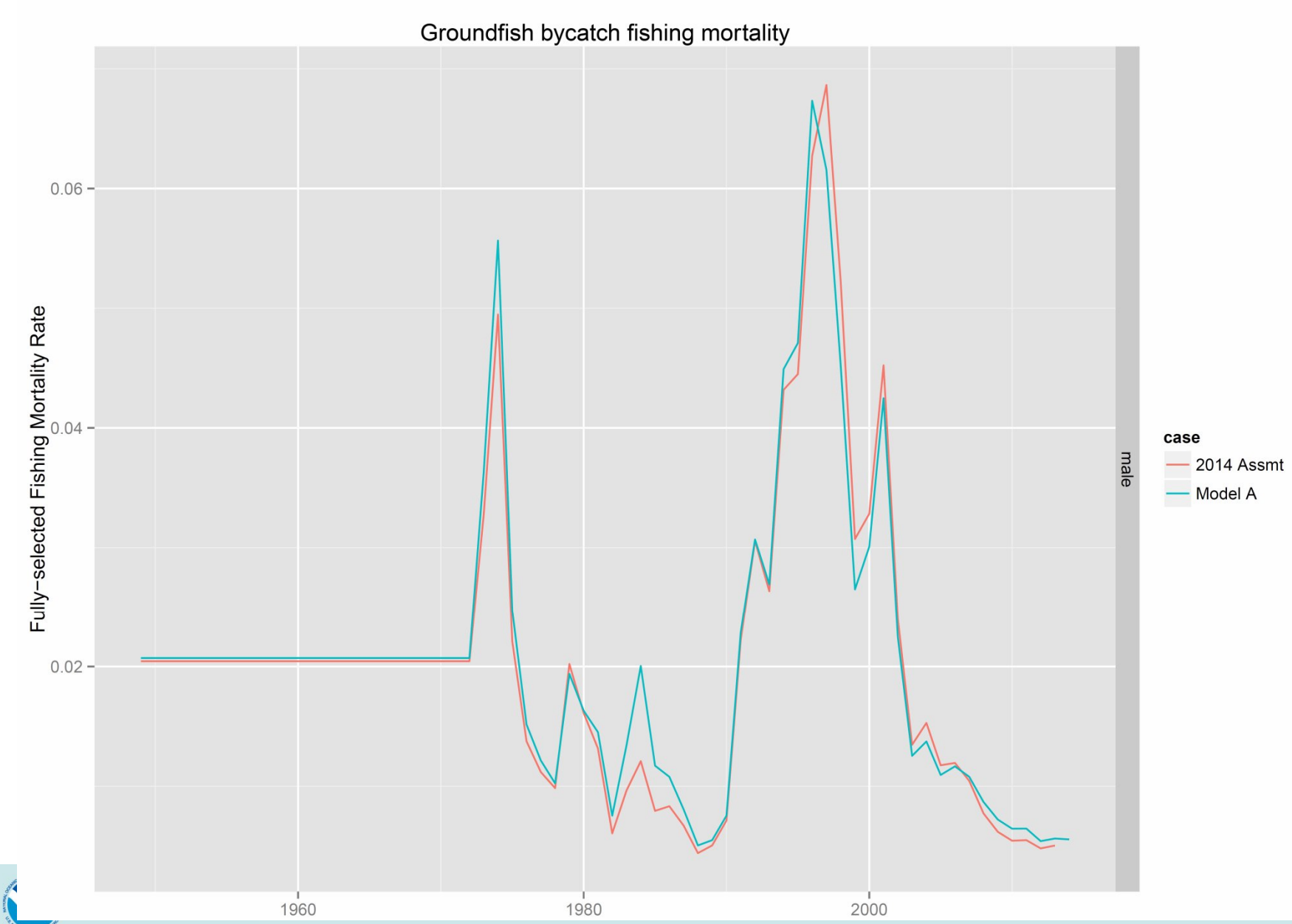


Comparisons

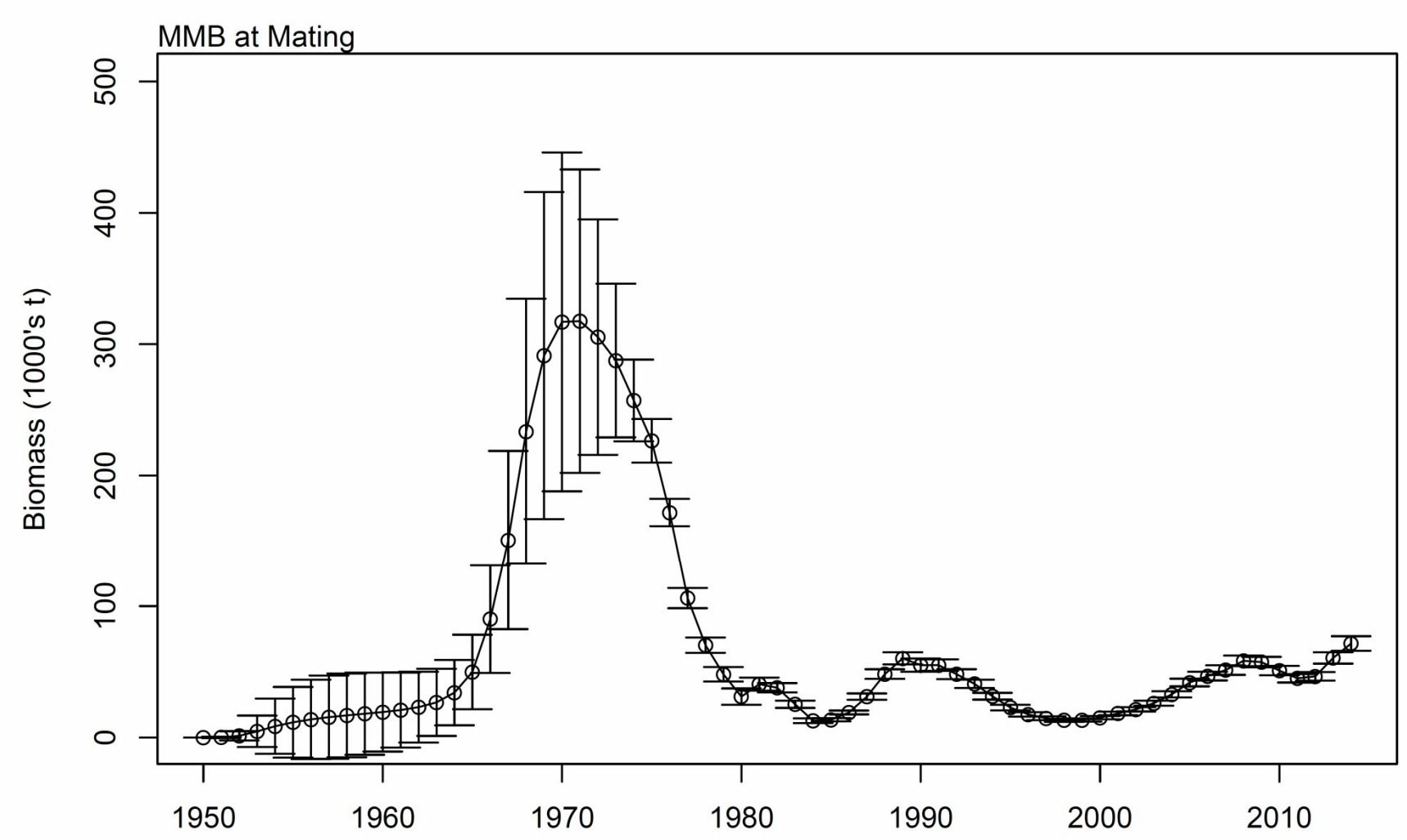




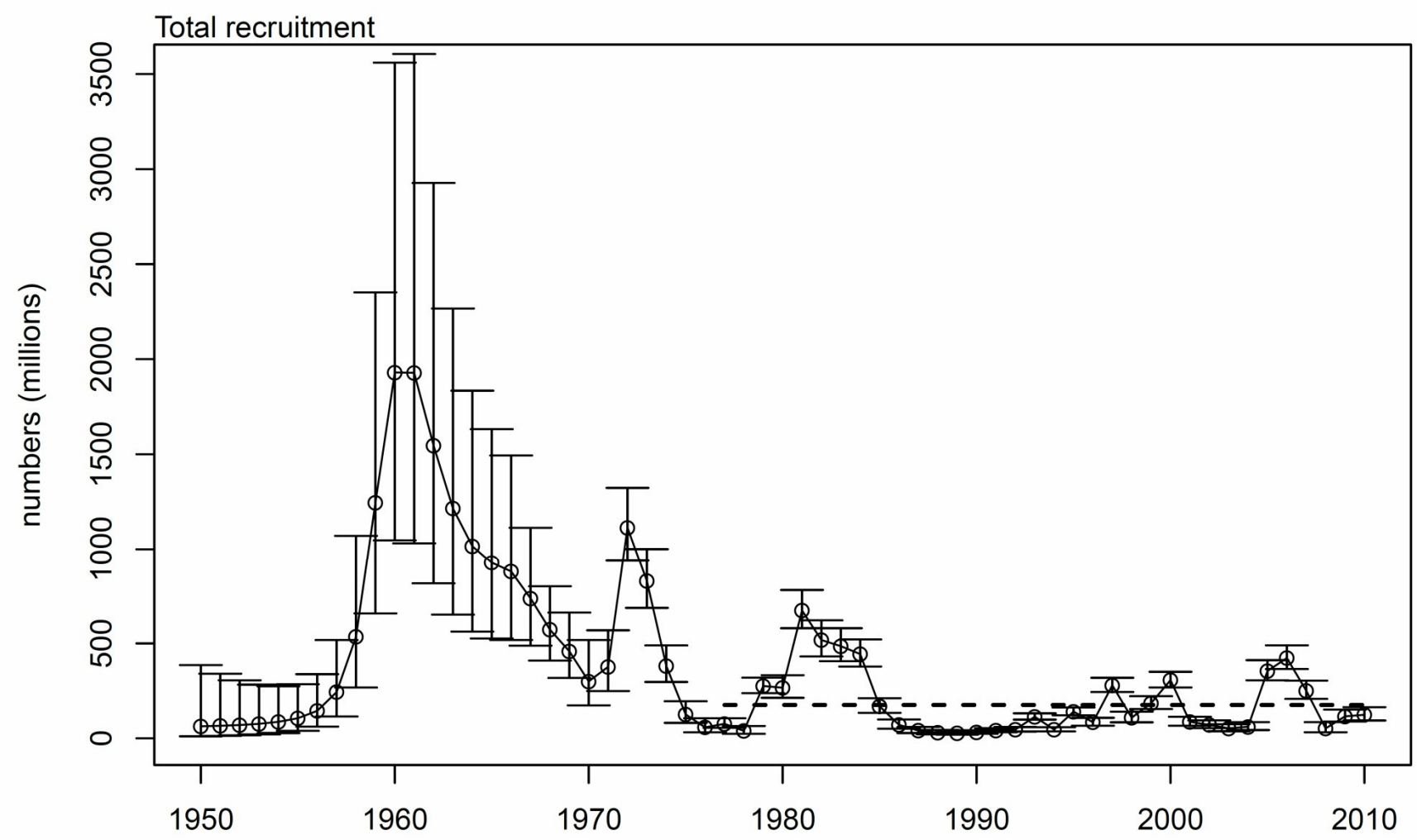
Comparisons



Model A: MMB


MMB at Mating
Biomass (1000's t)
0
100
200
300
400
500
1950
1960
1970
1980
1990
2000
2010

Model A: Recruitment



Status Determination, OFL, ABC

New SOA Harvest Strategy

- 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

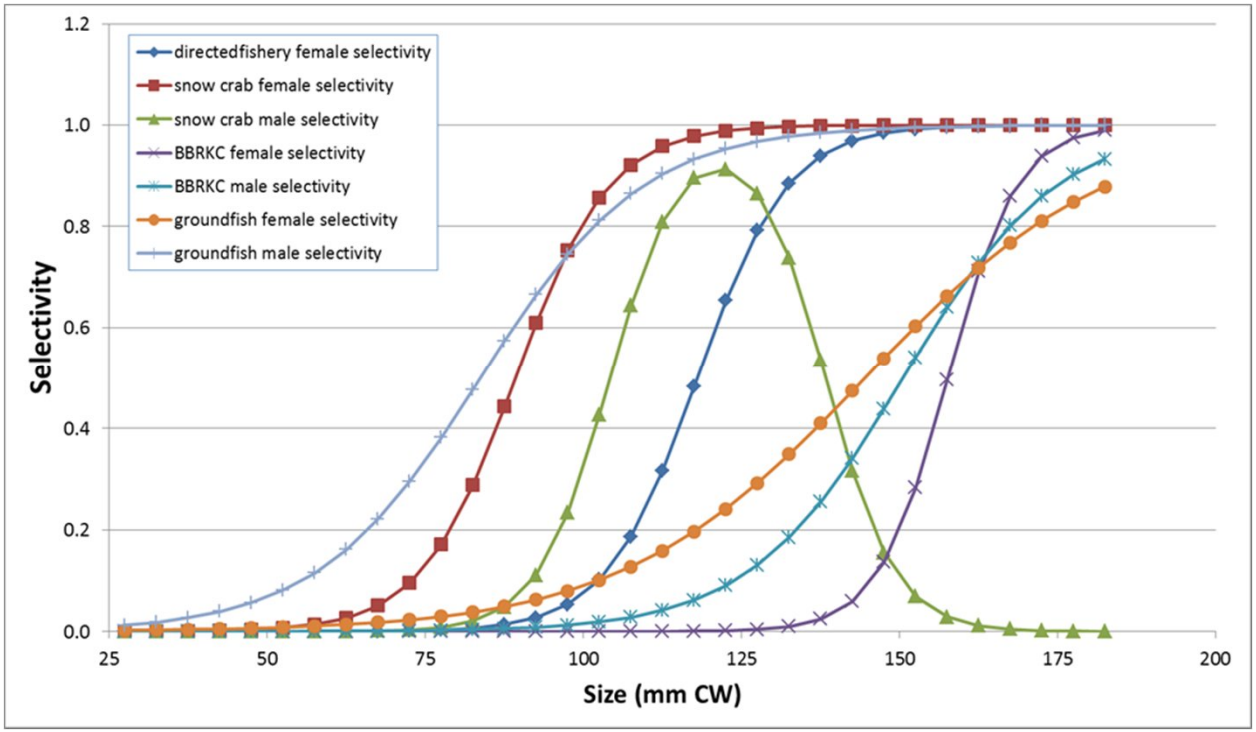
Calculating the OFL: Wrinkles for 2015/16

- B_{MSY}, "current" B, OFL depend on:
  - snow crab F_{OFL}
  - fishery selectivities assumed in 2015/16

- Two "likely" snow crab F_{OFL}s
  - Jack's preferred model: $F_{OFL} = 0.89\ yr^{-1}$
  - "2014" model: $F_{OFL} = 1.01\ yr^{-1}$

- Will new SOA harvest strategy impact fishing behavior?
  - Haven't seen fishing behavior for 2015/16
  - What to do?
    - Assume bycatch fisheries similar to recent past
    - 3 projection model scenarios for directed fishery

Selectivity Functions in the Bycatch Fisheries

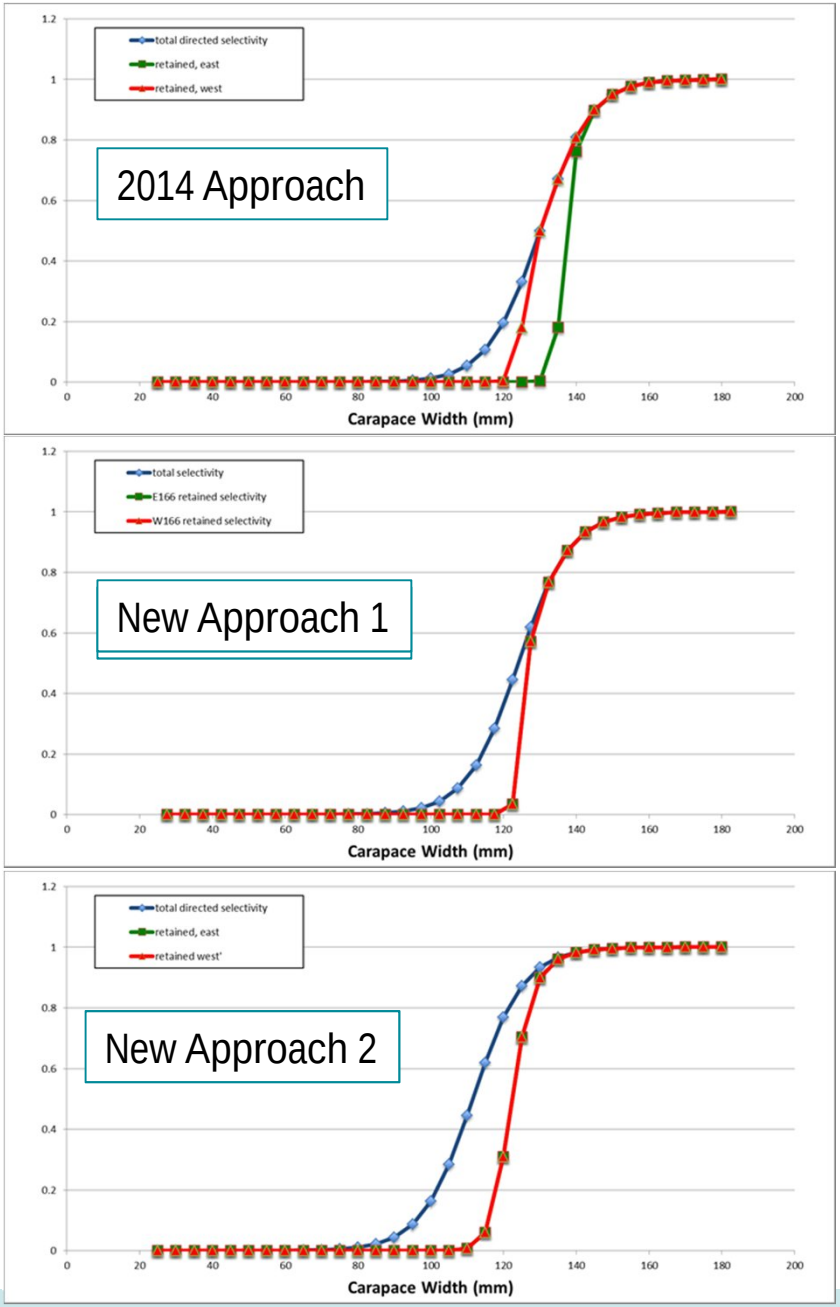


Changes in Selectivity in the Directed Fishery

- 2014 Approach (East = 5.5”, West = 5”)
  - Total mortality size dependence
    East/West= same as model
  - Retained mortality size dependence
    East = same as model
    West = left-shifted version of model

- Approach 1 (East, West = 5”)
  - Total mort. size dependence
    East/West = same as model
  - Retained mortality size dependence
    East = West = logistic w/ steep rise

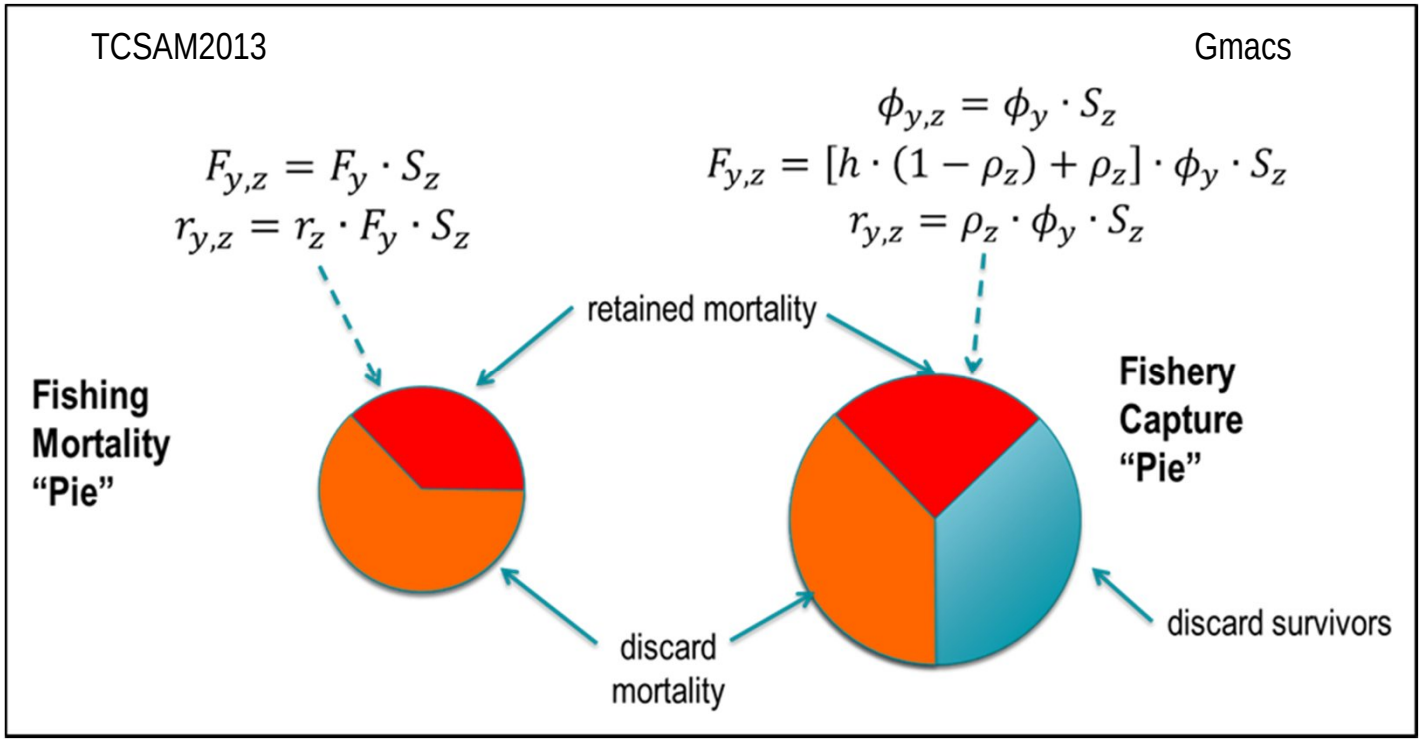
- Approach 2 (East, West = 5”)
  - Total mort. size dependence
    East/West = left-shifted version of model
  - Retained mortality size dependence
    East/West = left-shifted version of model



Projection Model Results

Model	Snow Crab Model	Snow Crab Fofl	Efffective Snow Crab F	Projection Approach	Average Recruitment	B	Fmsy	Bmsy	B/Bmsy	OFL	ABC P-star	ABC (20% buffer)
2014 Mode	–			2014	187.90	63.80	0.58	29.82	2.14	31.48	31.43	25.18
Model A	Model 5	1.26	0.0344	2014	179.37	53.35	0.60	26.79	1.99	27.40	27.36	21.92
Model A	Preferred	0.89	0.0123	2014	179.37	52.80	0.64	26.79	1.97	27.73	27.70	22.19
Model A	Preferred	0.89	0.0123	new (1)	179.37	52.80	0.64	26.79	1.97	27.73	27.70	22.19
Model A	Preferred	0.89	0.0123	new (2)	179.37	55.91	0.44	26.79	2.09	24.78	24.75	19.82
Model A	2014	1.01	0.0212	2014	179.37	53.02	0.62	26.79	1.98	27.60	27.56	22.08
Model A	2014	1.01	0.0212	new (1)	179.37	53.02	0.62	26.79	1.98	27.60	27.56	22.08
Model A	2014	1.01	0.0212	new (2)	179.37	56.02	0.43	26.79	2.09	24.76	24.72	19.80
Model C	Preferred	1.01	0.0123	2014	180.95	54.53	0.44	25.62	2.13	26.27	26.24	21.02
Model C	2014	0.89	0.0212	2014	180.95	54.88	0.41	25.62	2.14	26.15	26.12	20.92

Alternative Fishing Mortality Model: Gmacs

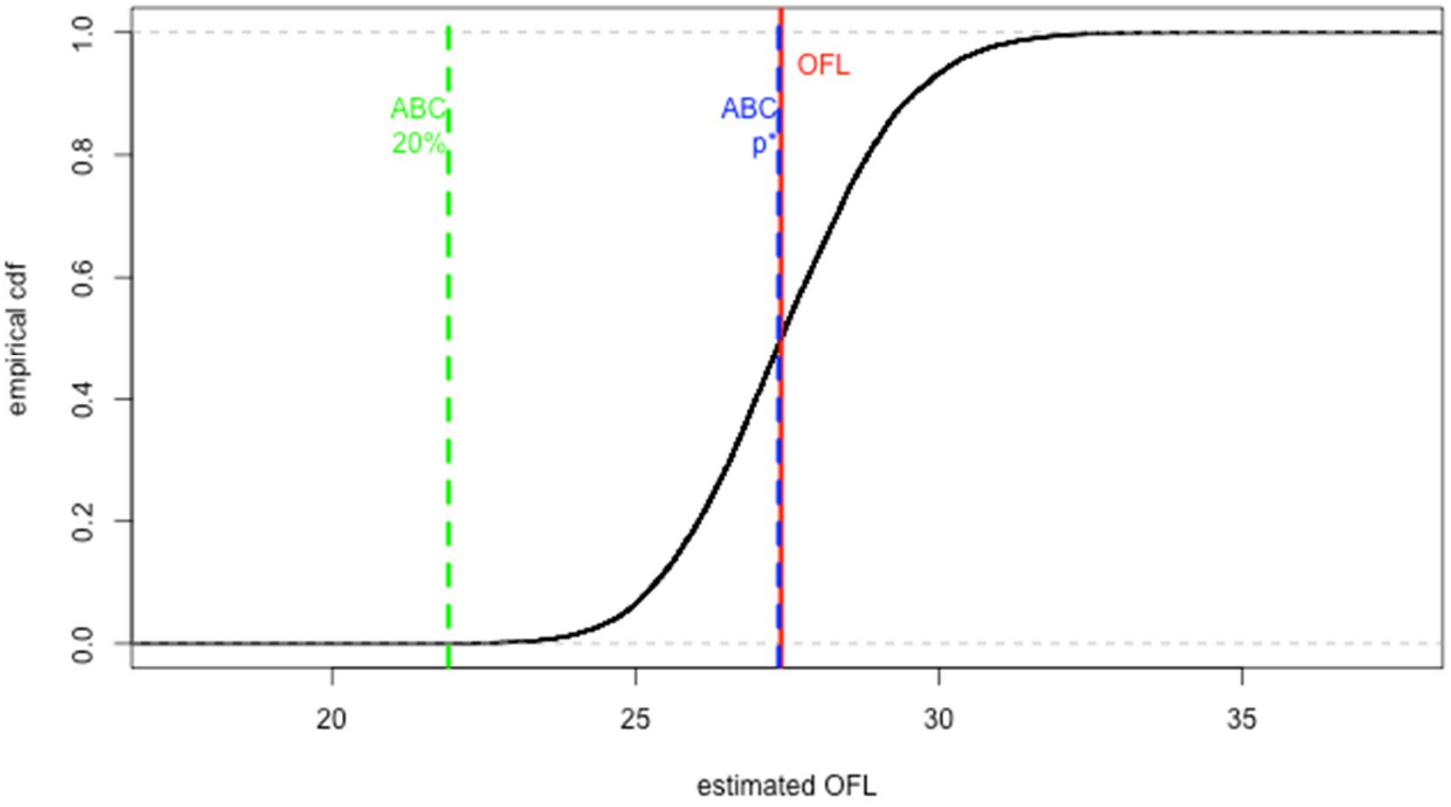


TCSAM

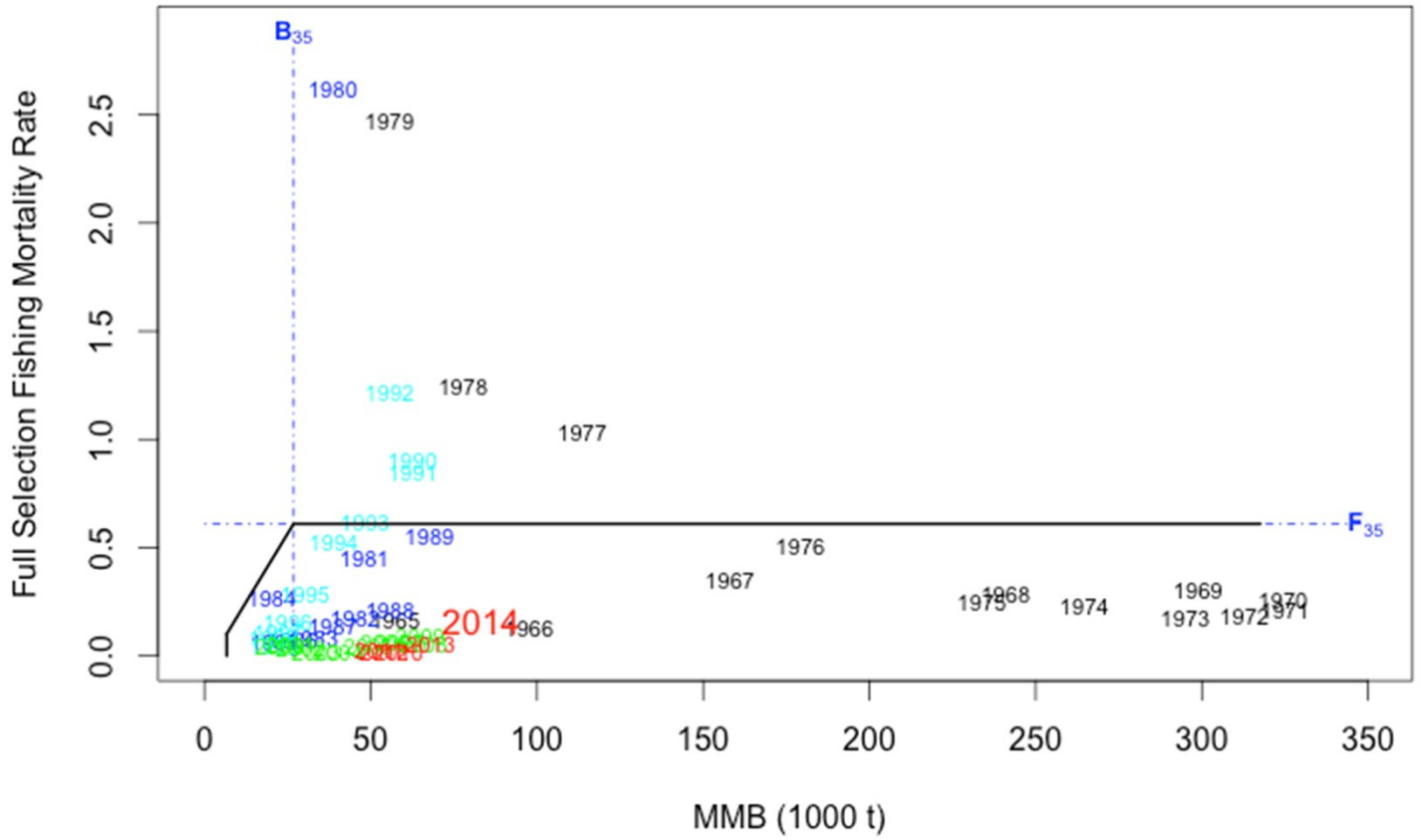
- Applies handling mortality to observed bycatch
- Fits "observed" total (retained + discard) mortality for males in directed fishery
- Fits "observed" discard mortality for females, males in bycatch fisheries

OFL Calculations

- Snow crab F_{OFL} = 1.26 (Model 5)



Management History



Basis for the OFL

- Not overfished
- Not overfishing

- Preferred Model: Model A (same as 2014, new data)

in 1000's t

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
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	53.35	1.99	0.60 yr^{-1}	1982-2015	0.23 yr^{-1}

in millions lbs

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
2012/13	3a	73.74	129.17	1.75	0.61 yr^{-1}	1982-2012	0.23 yr^{-1}
2013/14	3a	73.94	130.84	1.77	0.73 yr^{-1}	1982-2013	0.23 yr^{-1}
2014/15	3a	65.74	140.66	2.14	0.61 yr^{-1}	1982-2014	0.23 yr^{-1}
2015/16	3a	59.06	117.61	1.99	0.60 yr^{-1}	1982-2015	0.23 yr^{-1}

Management Performance

- Not overfished
- Not overfishing

- Preferred Model: Model A (same as 2014, new data)

in 1000's t

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2011/12	11.40	58.59	0.00	0.00	1.24	2.75	2.48
2012/13	16.77	59.35	0.00	0.00	0.71	19.02	8.17
2013/14	16.98	72.70	1.41	1.26	2.78	25.35	17.82
2014/15	13.40	71.57	6.85	6.16	9.16	31.48	25.18
2015/16		53.35				27.40	21.92

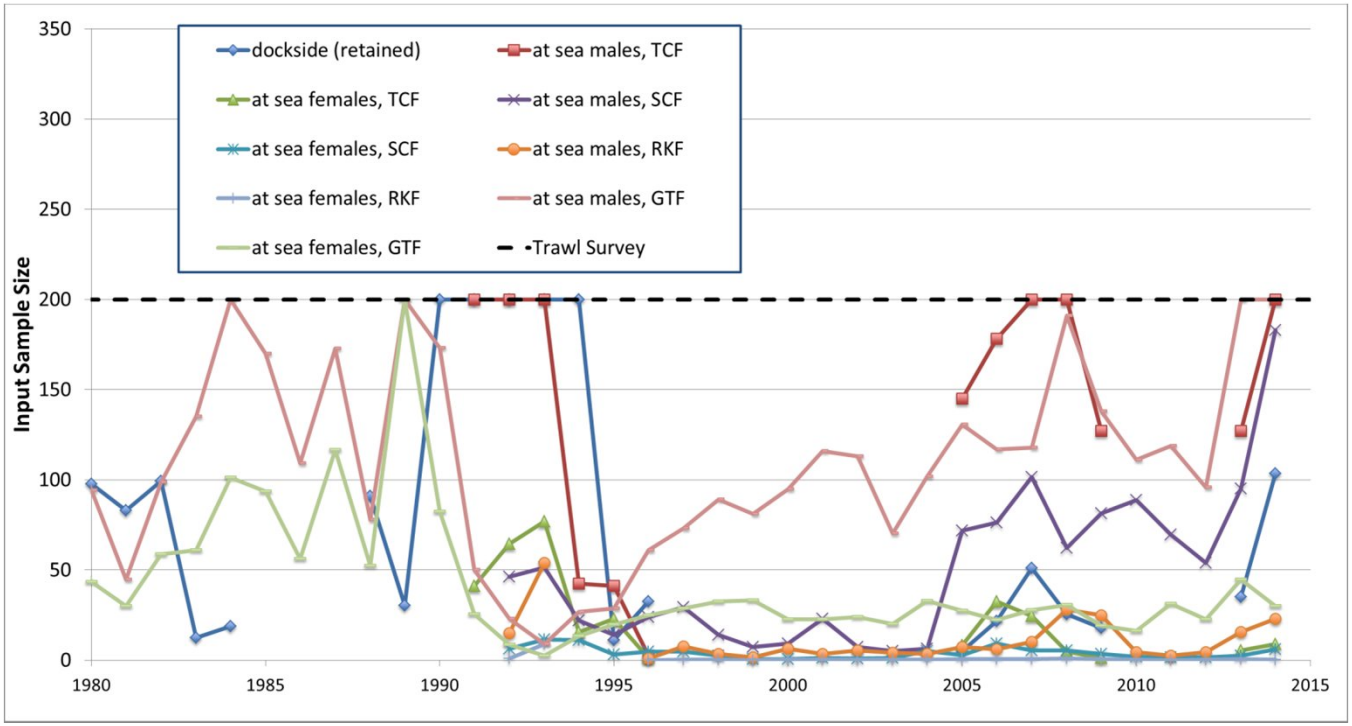
in millions lbs

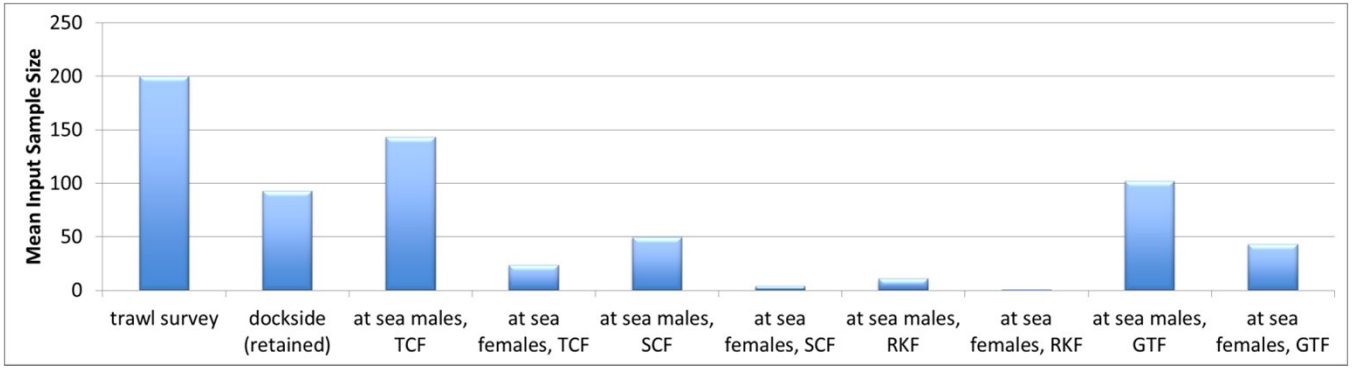
Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2011/12	25.13	129.17	0.00	0.00	2.73	6.06	5.47
2012/13	36.97	130.84	0.00	0.00	1.57	41.93	18.01
2013/14	37.43	160.28	3.11	2.78	6.14	55.89	39.29
2014/15	29.53	157.78	15.10	13.58	20.19	69.40	55.51
2015/16		117.61				60.40	48.32

Future Directions

Future Directions

- May 2016:
  - new model code (TCSAM2015)
    - implements Gmacs fishing mortality model
    - much more flexible than current version
      - arbitrary time periods for model processes
      - priors available on all model parameters
      - ability to simulate data/test model
      - ability to run retrospective analyses
      - can address some other outstanding CPT/SSC requests
  - implement Gmacs fishing mortality-based projection model
- Extended:
  - incorporate chela height data directly in model
  - disaggregate East/West directed fisheries in model
  - disaggregate groundfish bycatch (fixed gear, trawl fisheries) in model
  - incorporate new growth data
  - incorporate BSFRF survey results


dockside (retained)
at sea females, TCF
at sea females, SCF
at sea females, RKF
at sea females, GTF
at sea males, TCF
at sea males, SCF
at sea males, RKF
at sea males, GTF
Trawl Survey
Input Sample Size
350
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015


Mean Input Sample Size
250
200
150
100
50
0
trawl survey
dockside (retained)
at sea males, TCF
at sea females, TCF
at sea males, SCF
at sea females, SCF
at sea males, RKF
at sea females, RKF
at sea males, GTF
at sea females, GTF