BSAI Tanner Crab

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Changes From 2013 Assessment

- Essentially same model as 2013
  - Models using Gmacs fishing mortality formulation considered
- New handling mortality rate
  - 32.1% vs. 50% for pot fisheries
- New trawl survey data for 2014
  - total abundance
  - size compositions by sex, shell condition, maturity
  - corrected 2013 size composition for immature females
- Revised/New Fishery Data for 2013/14
  - Tanner crab pot fishery
    - revised/new effort (potlifts) time series
    - new retained catch abundance, biomass
    - revised/new dockside size frequencies
    - sex-specific total bycatch (t)
    - revised/new female bycatch size compositions
    - revised/new male total-catch size comps by shell condition
  - snow crab pot fishery
    - effort (potlifts)
    - sex-specific total bycatch (t)
    - revised/new female size compositions
    - revised/new male size comps by shell condition
  - BBRKC pot fishery
    - effort (potlifts)
    - sex-specific total bycatch (t)
    - revised/new female size compositions
    - revised/new male size comps by shell condition
  - groundfish fisheries
    - revised/new total catch biomass
    - revised/new size compositions by sex

Management Reference Points: Spoilers Alert!

- Preferred Model: Revised Data, Old Fishing Mortality, Pot Fishery Handling Mortality = 50%
- 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	33.95	70.77	2.08	0.58 yr^{-1}	1982-2014	0.23 yr^{-1}

- Management Performance (in 1000's t)

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Catch Mortality	OFL	ABC
2009/10	41.90	28.44	0.61	0.60	1.64	2.27	
2010/11	41.67	26.73	0.00	0.00	0.87	1.45	
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	53.10	1.41	1.26	2.78	25.35	17.82
2013/14		70.77				33.81	22.51

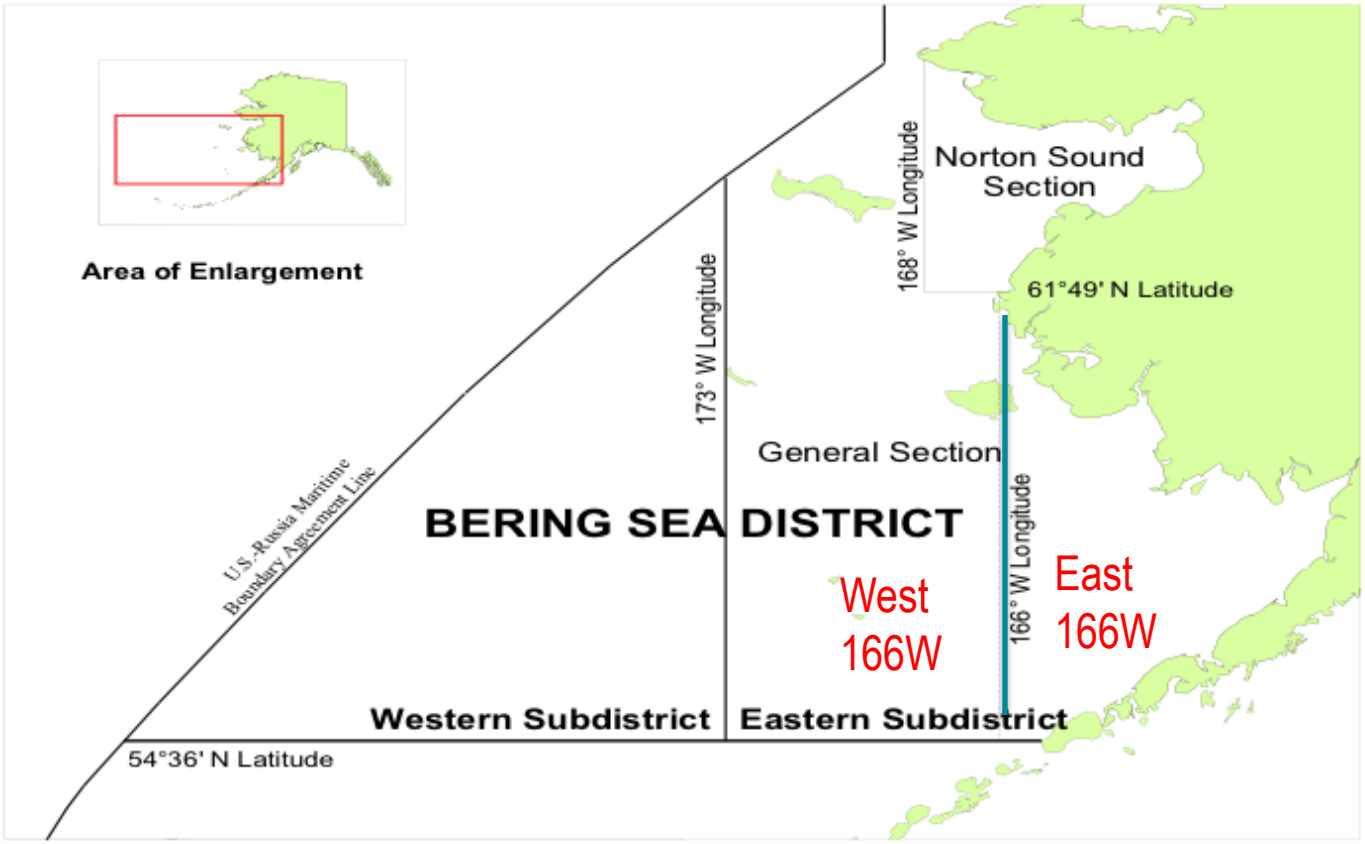
- Not overfished
- No overfishing

Outline

- 2013/14 Overview
  - Fishery results
  - Trawl survey results
- Changes from 2013 assessment
  - Corrections and revised fishery data
  - Pot fishery handling mortality
  - Gmacs fishing mortality equations
- Alternative Models & Evaluation
- OFL and ABC
- Future directions

2013/14 Overview: Fishery Results

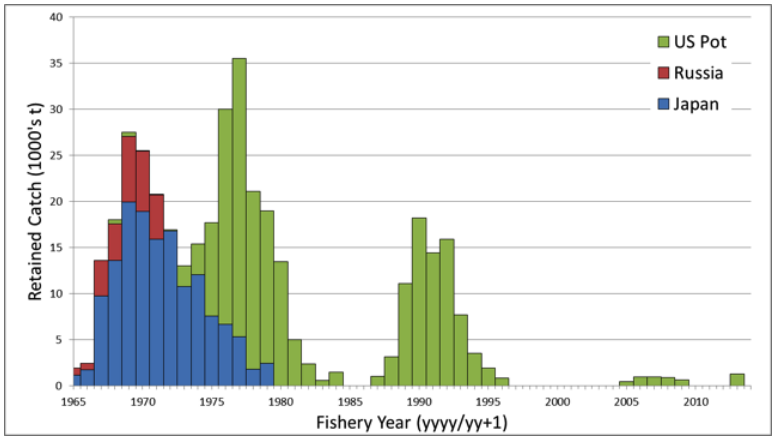
Management Regions

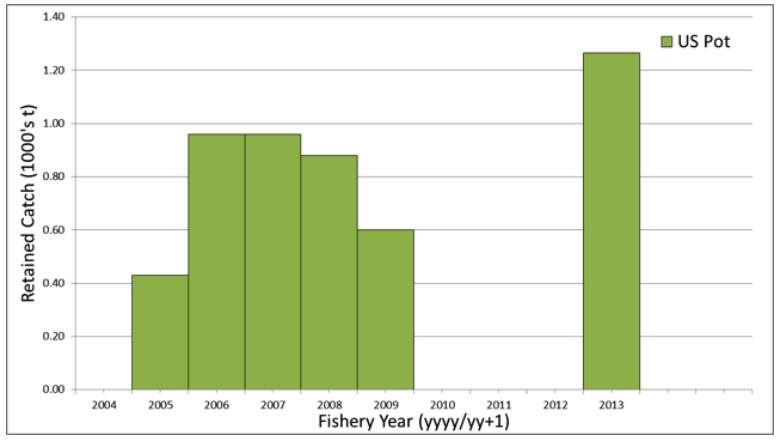


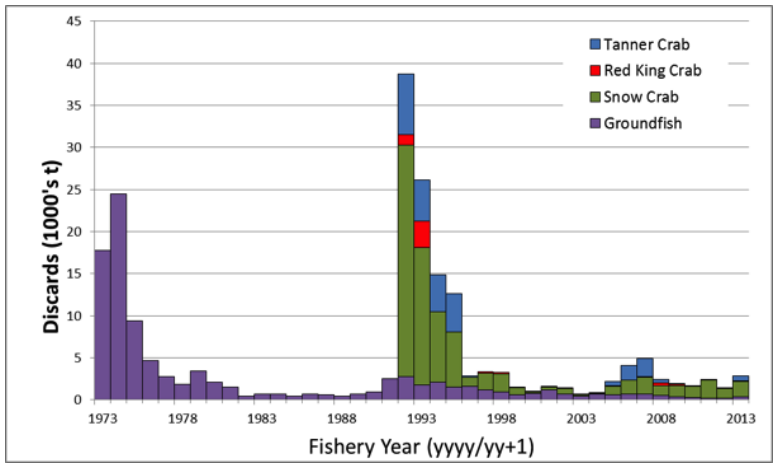
Fishery Trends

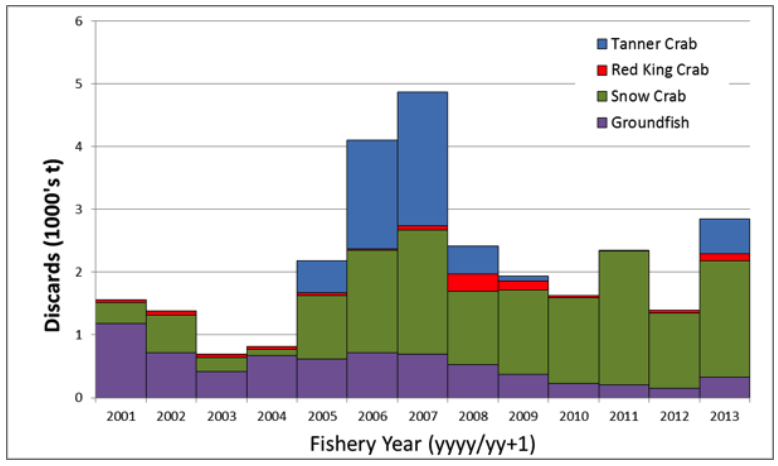
2013/14 Retained catch

- West 166W: GHL = 1,645,000 lbs; Catch = 80.9%
- East 166W: GHL =1,463,000 lbs; Catch = 99.5%

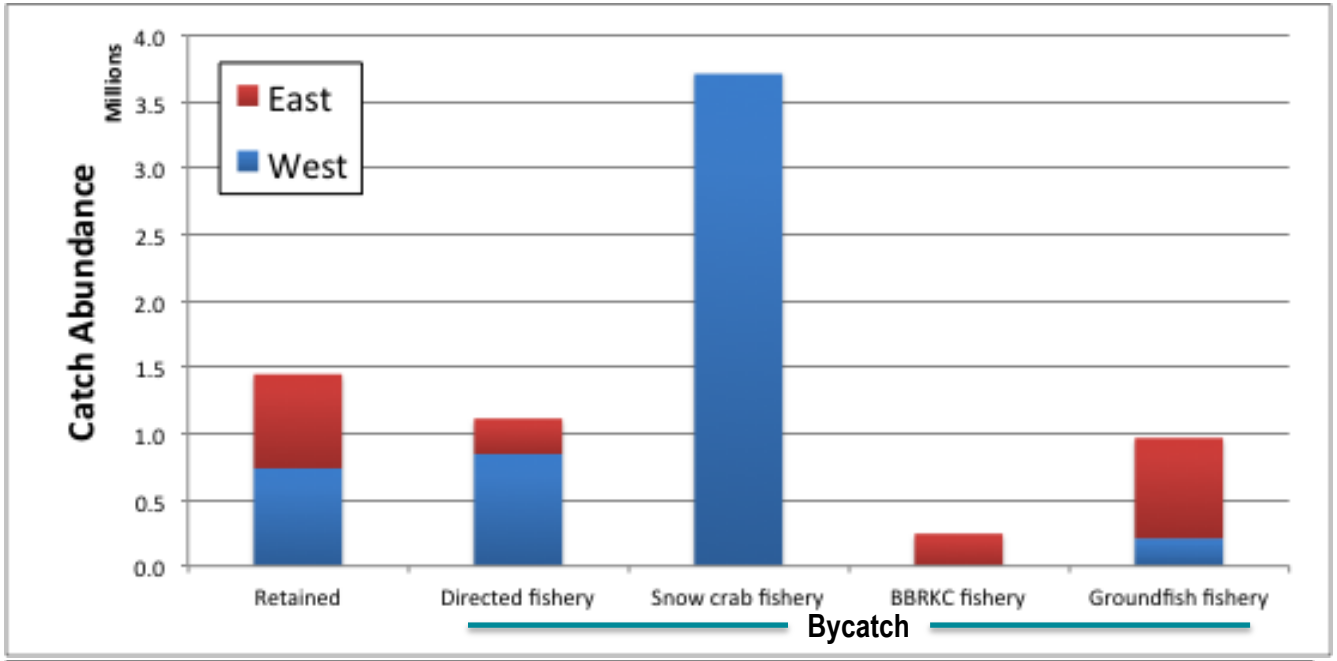


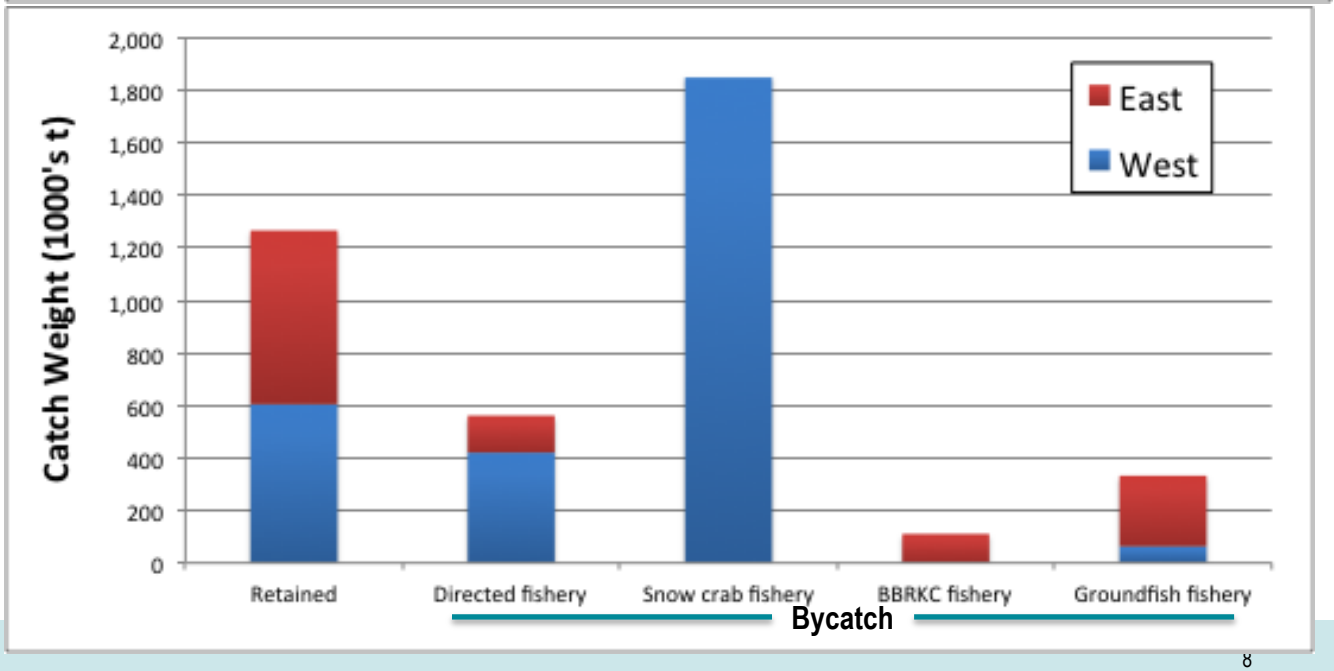




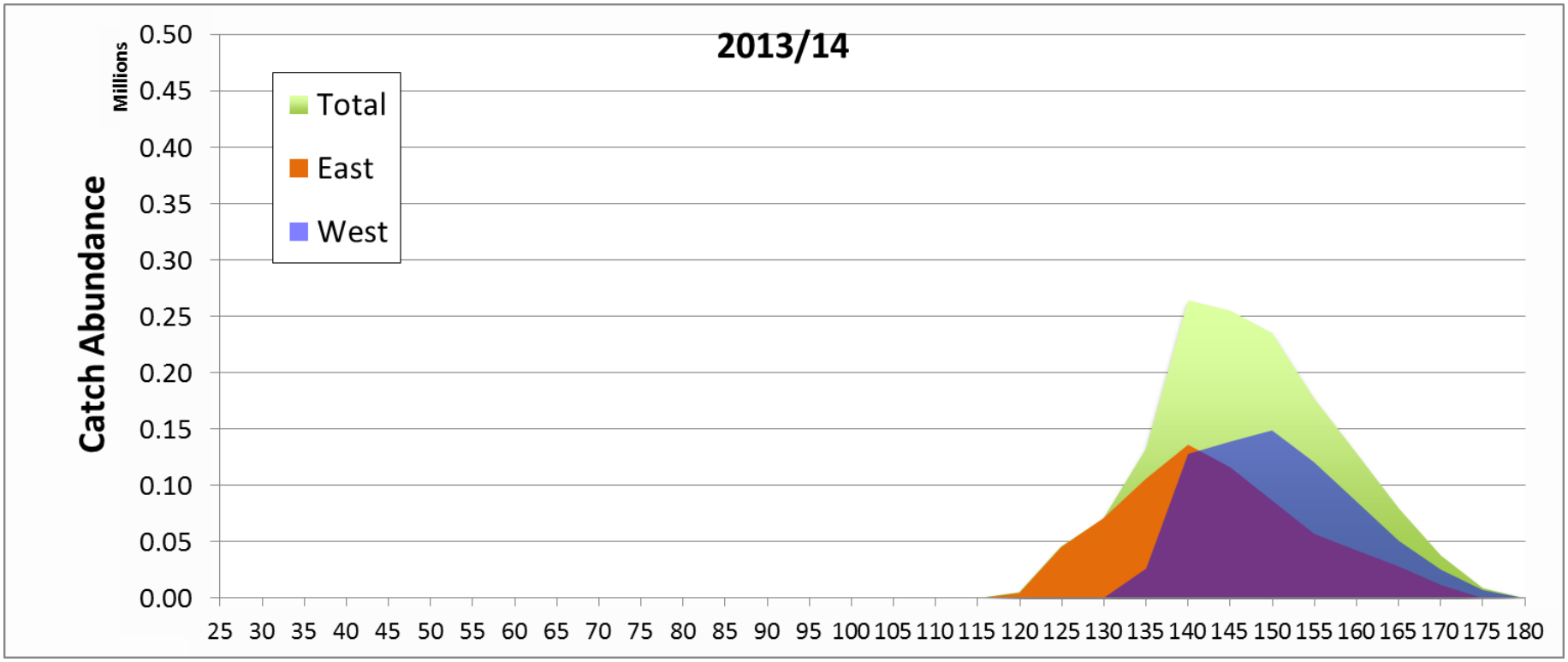


2013/14 Fisheries



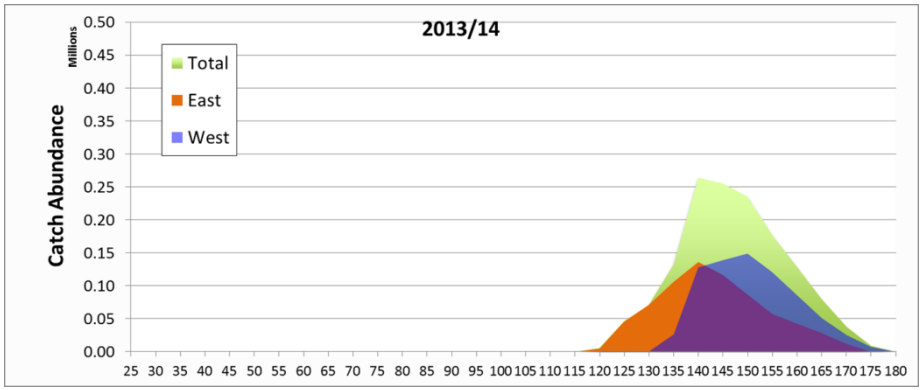


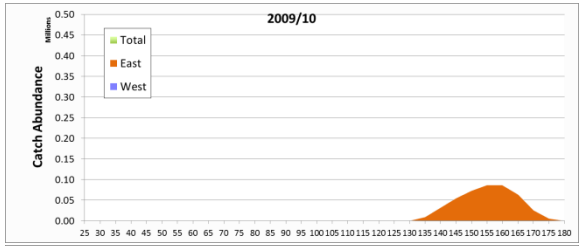
Retained Catch in the Tanner Crab Fishery



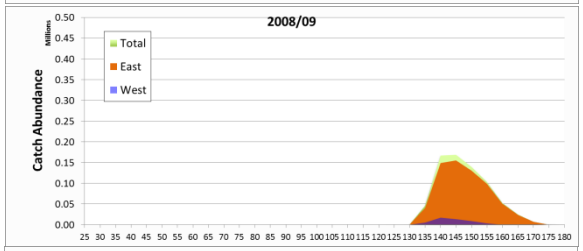
Retained Catch in the Tanner Crab Fishery

2013/14

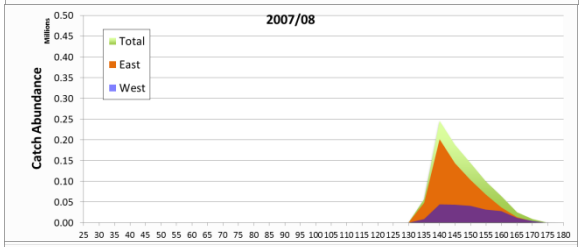




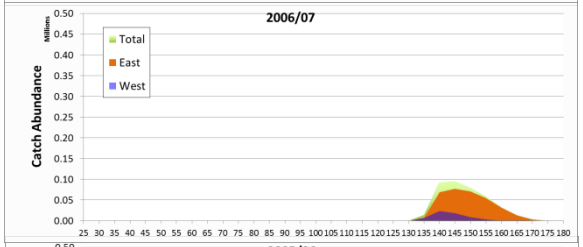
2009/10



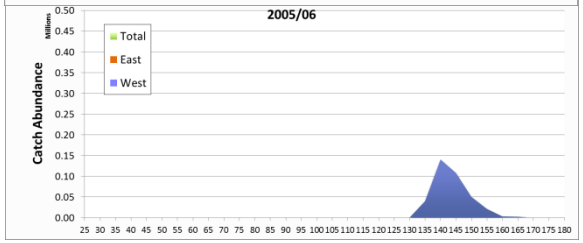
2008/09



2007/08

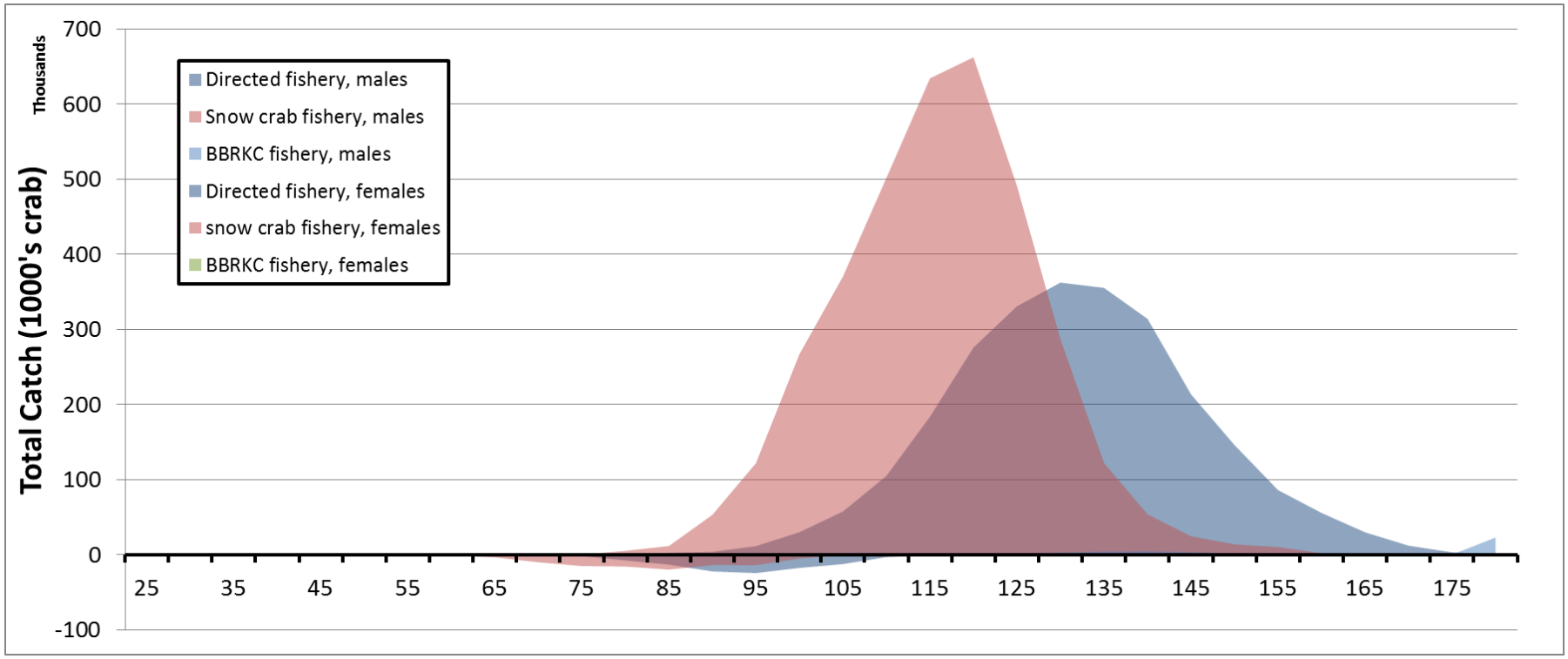


2006/07

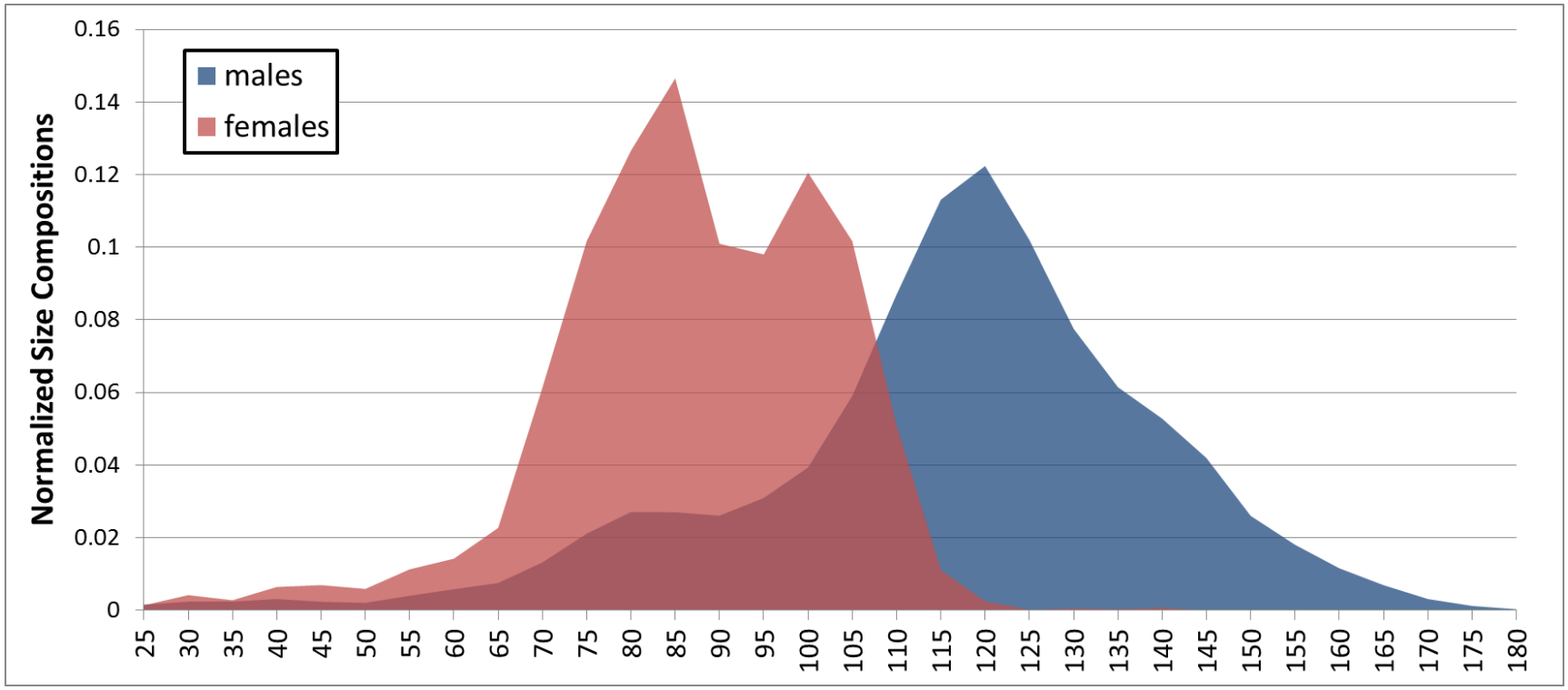


2005/06

Total Tanner Catch in the Crab Fisheries

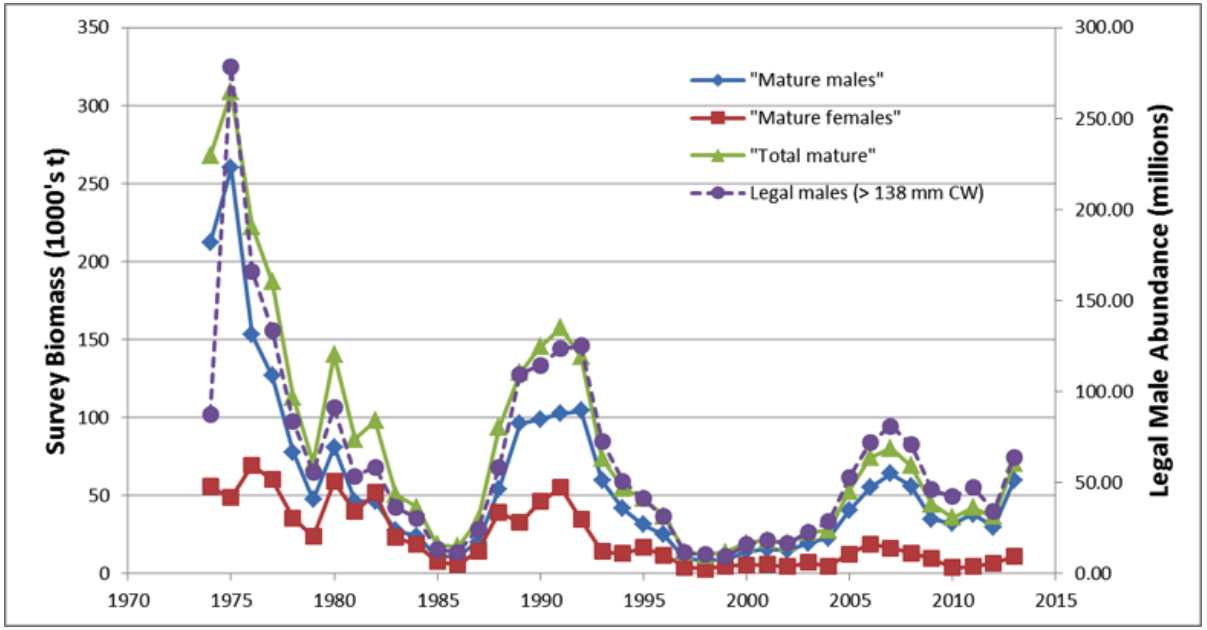


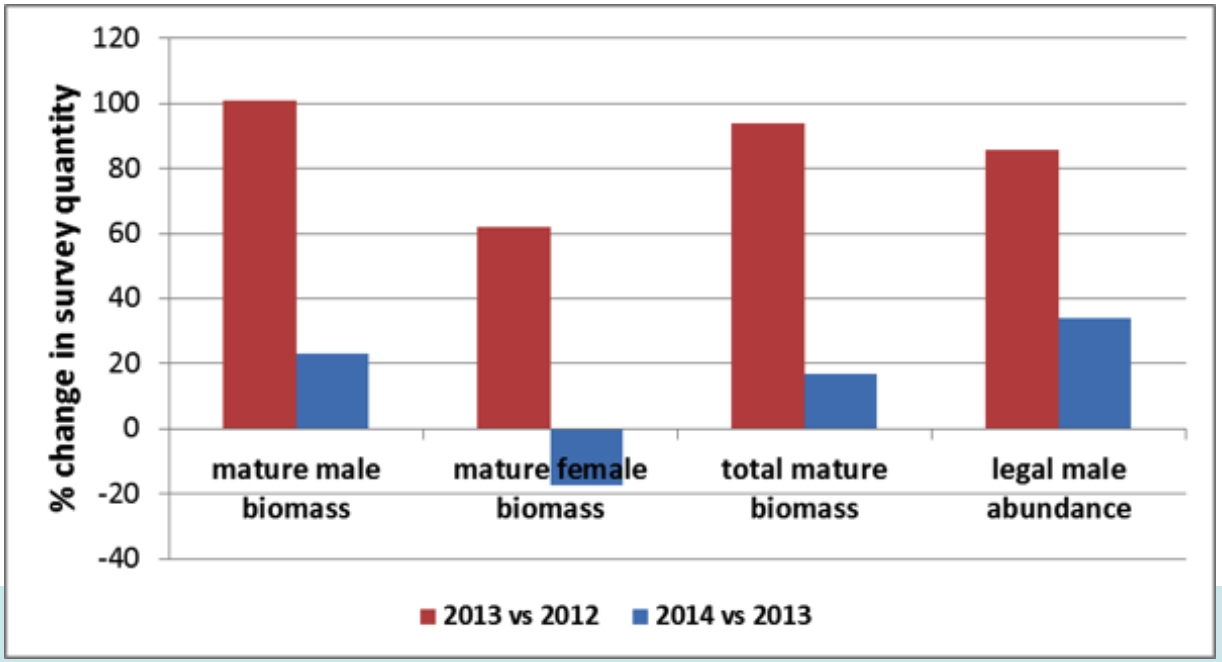
Tanner Bycatch in the Groundfish Fisheries



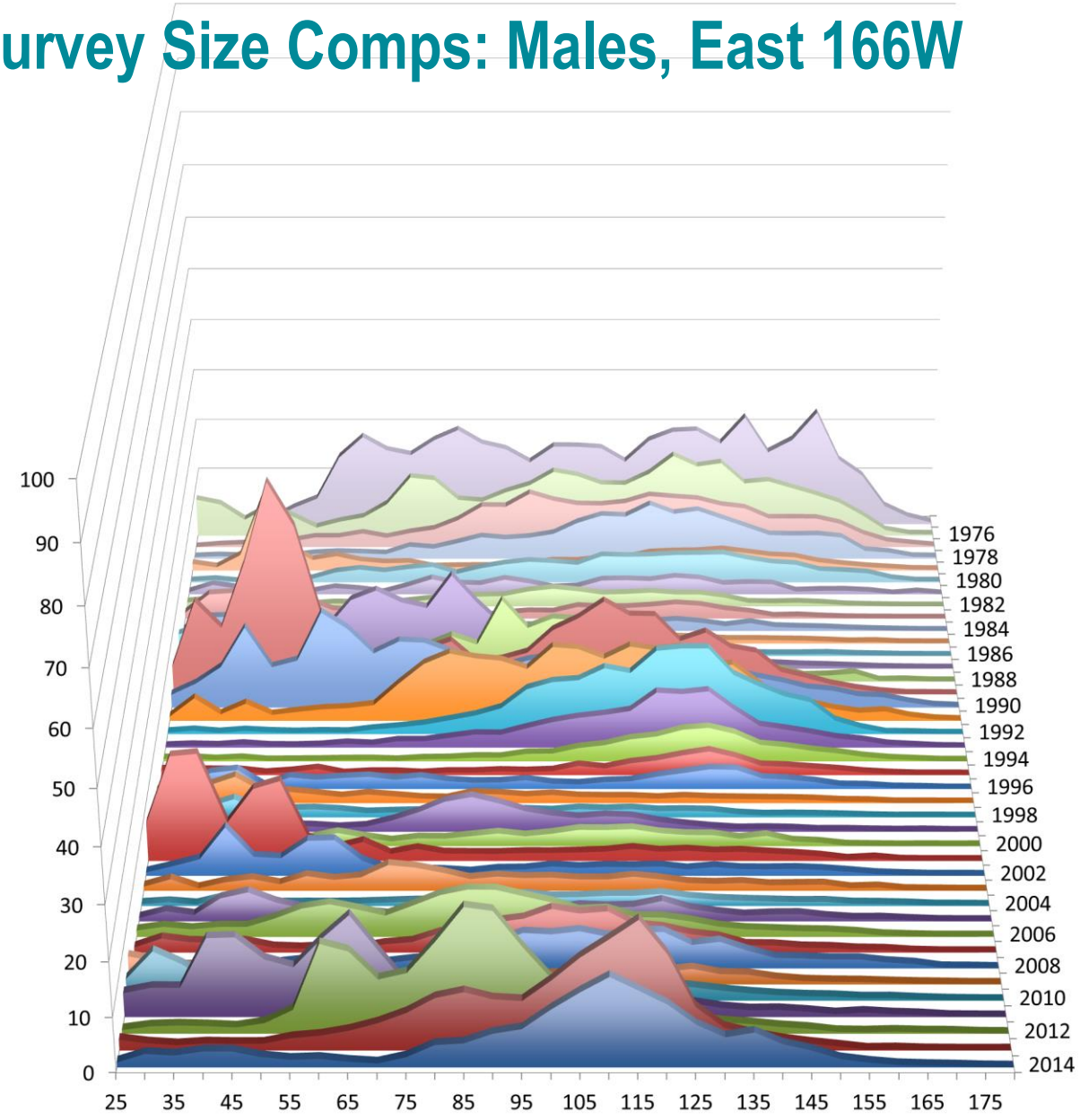
2013/14 Overview: Survey Results

Trawl Survey Trends

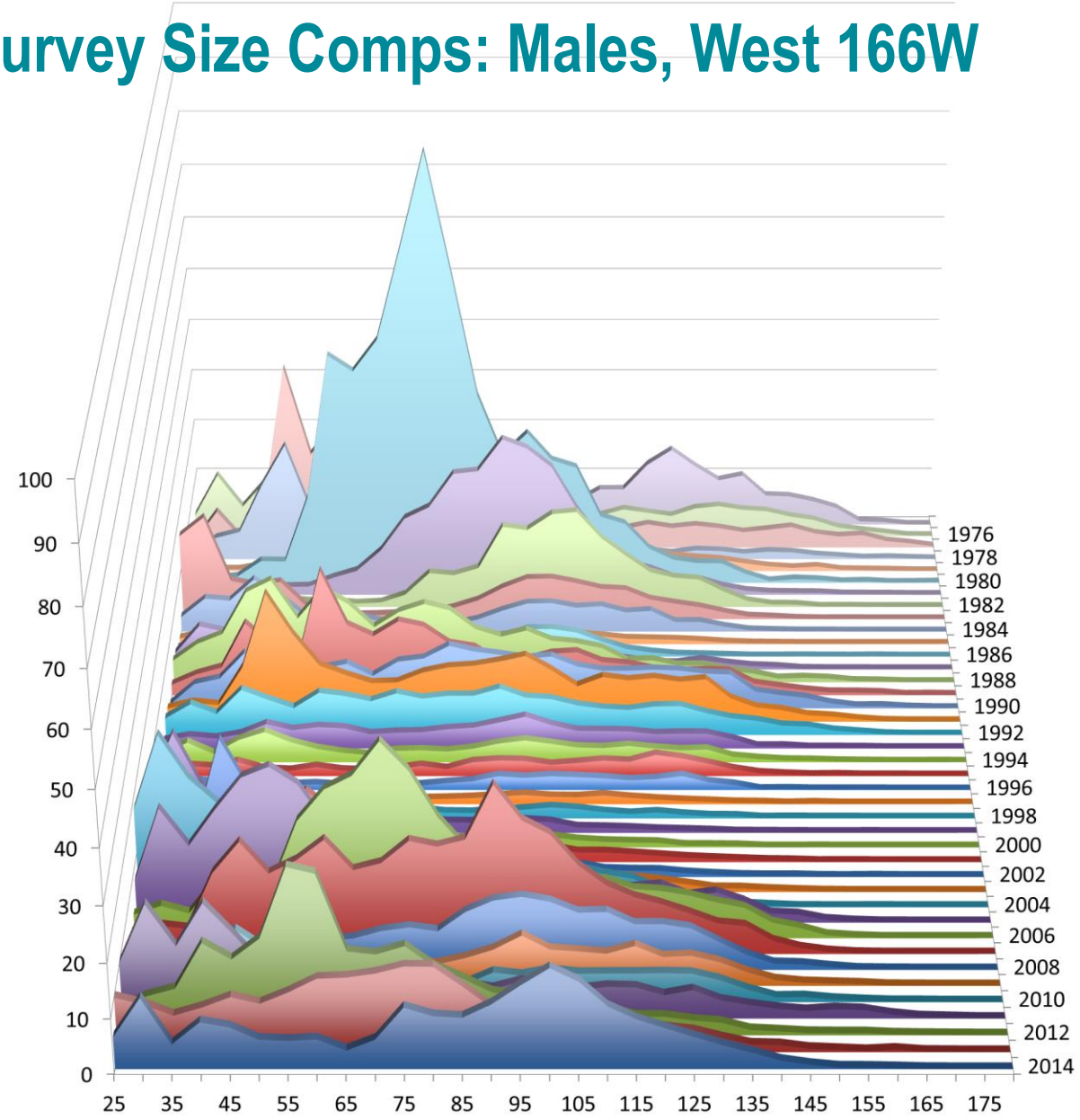




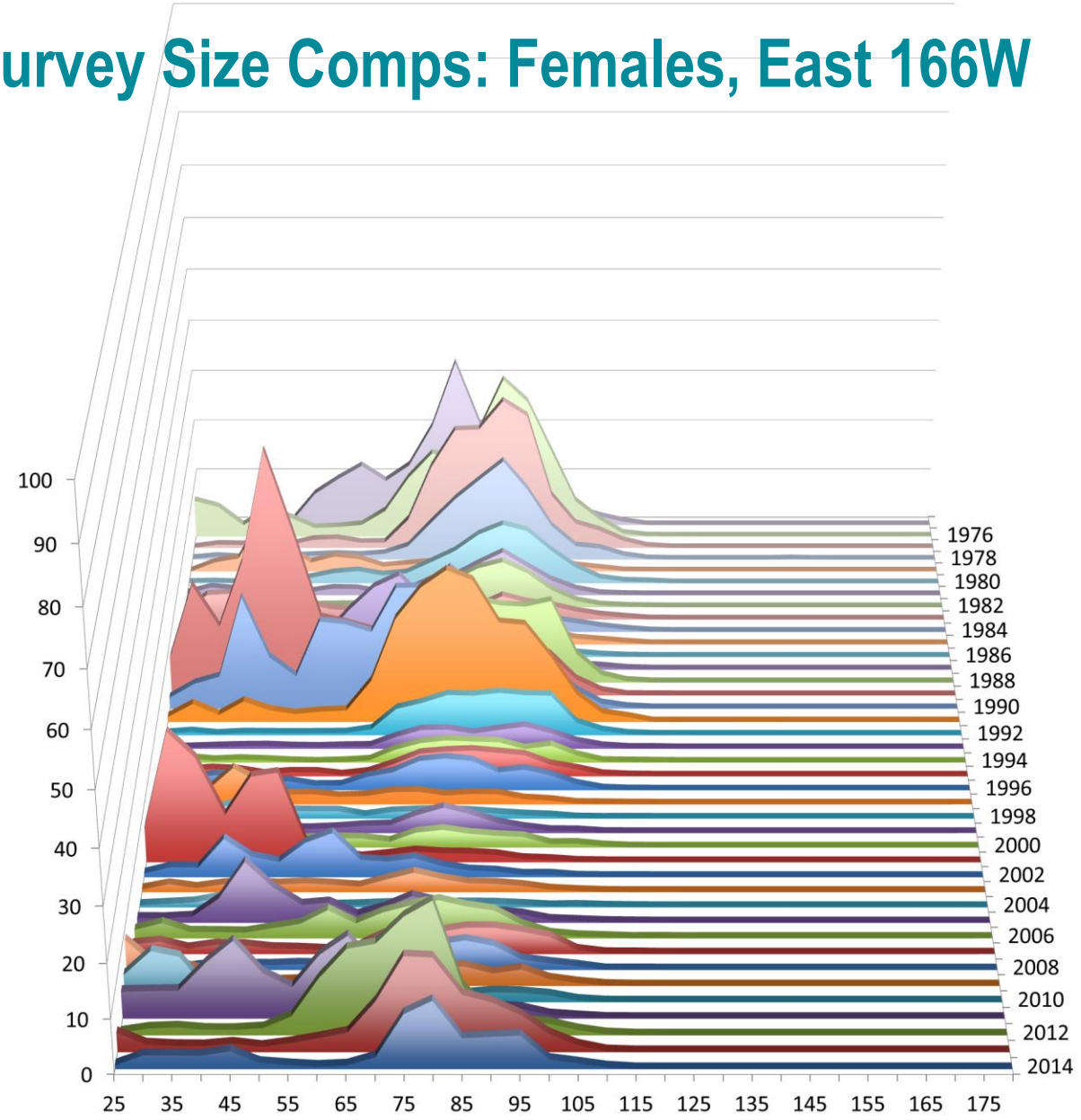
Trawl Survey Size Comps: Males, East 166W



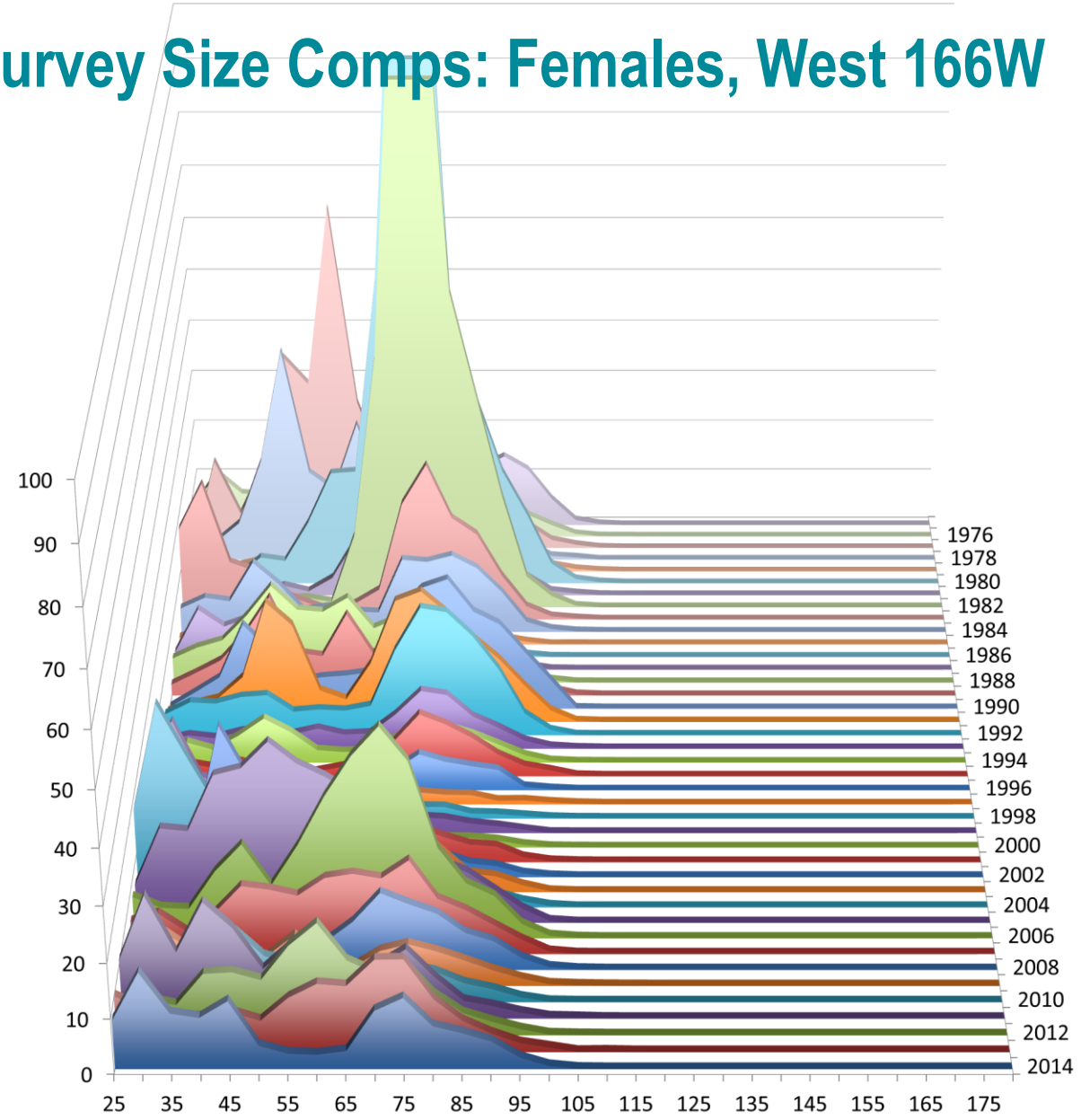
Trawl Survey Size Comps: Males, West 166W



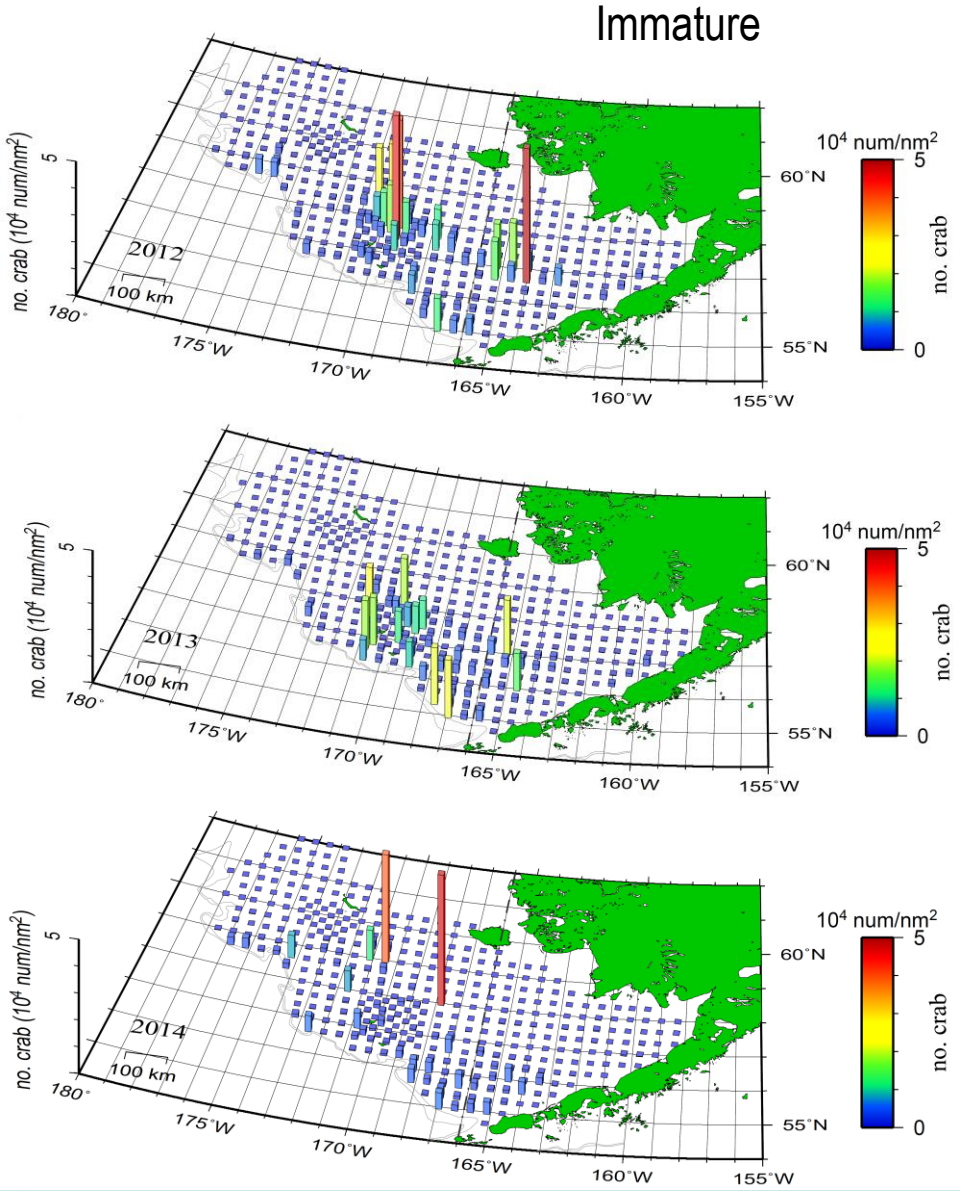
Trawl Survey Size Comps: Females, East 166W

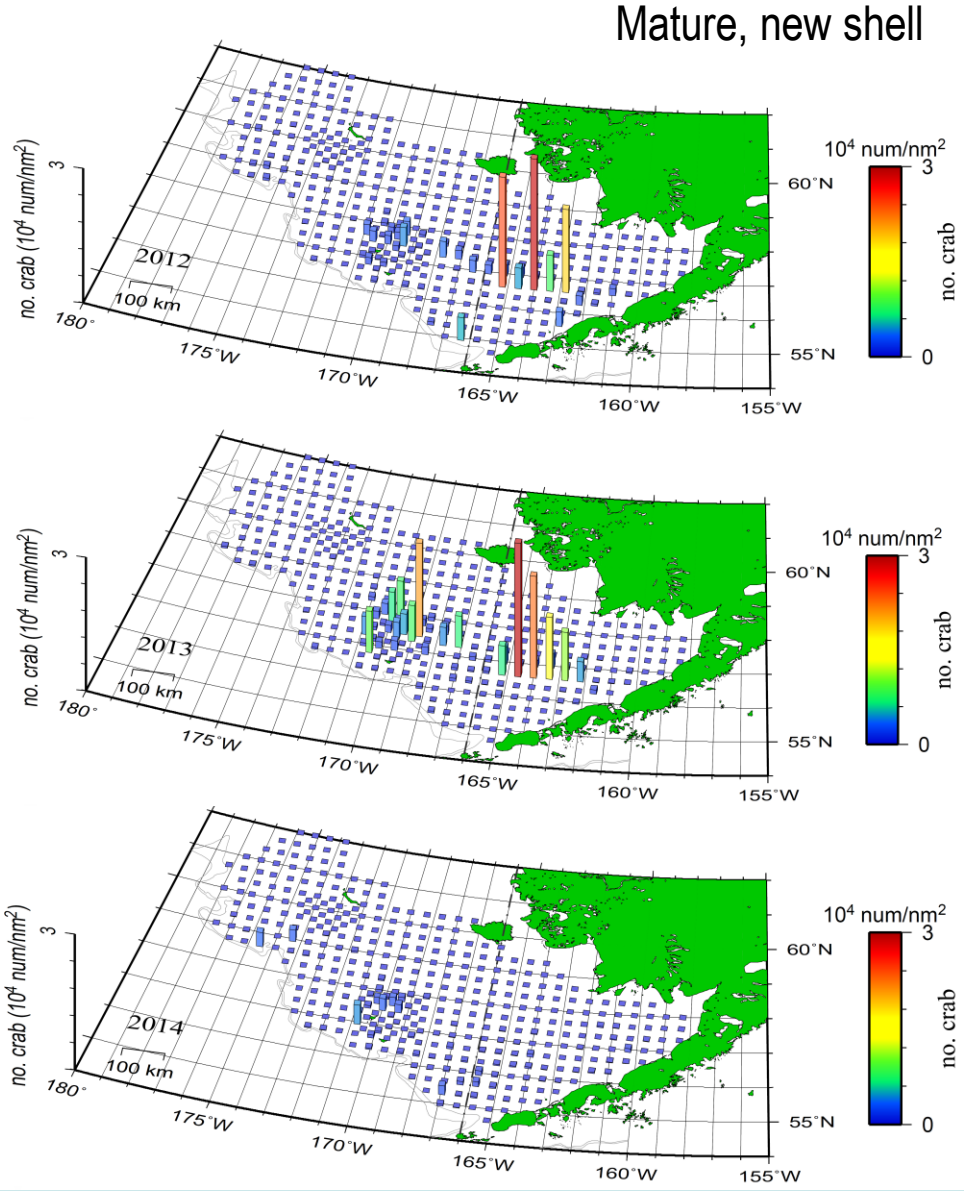


Trawl Survey Size Comps: Females, West 166W



Trawl Survey Results: Females

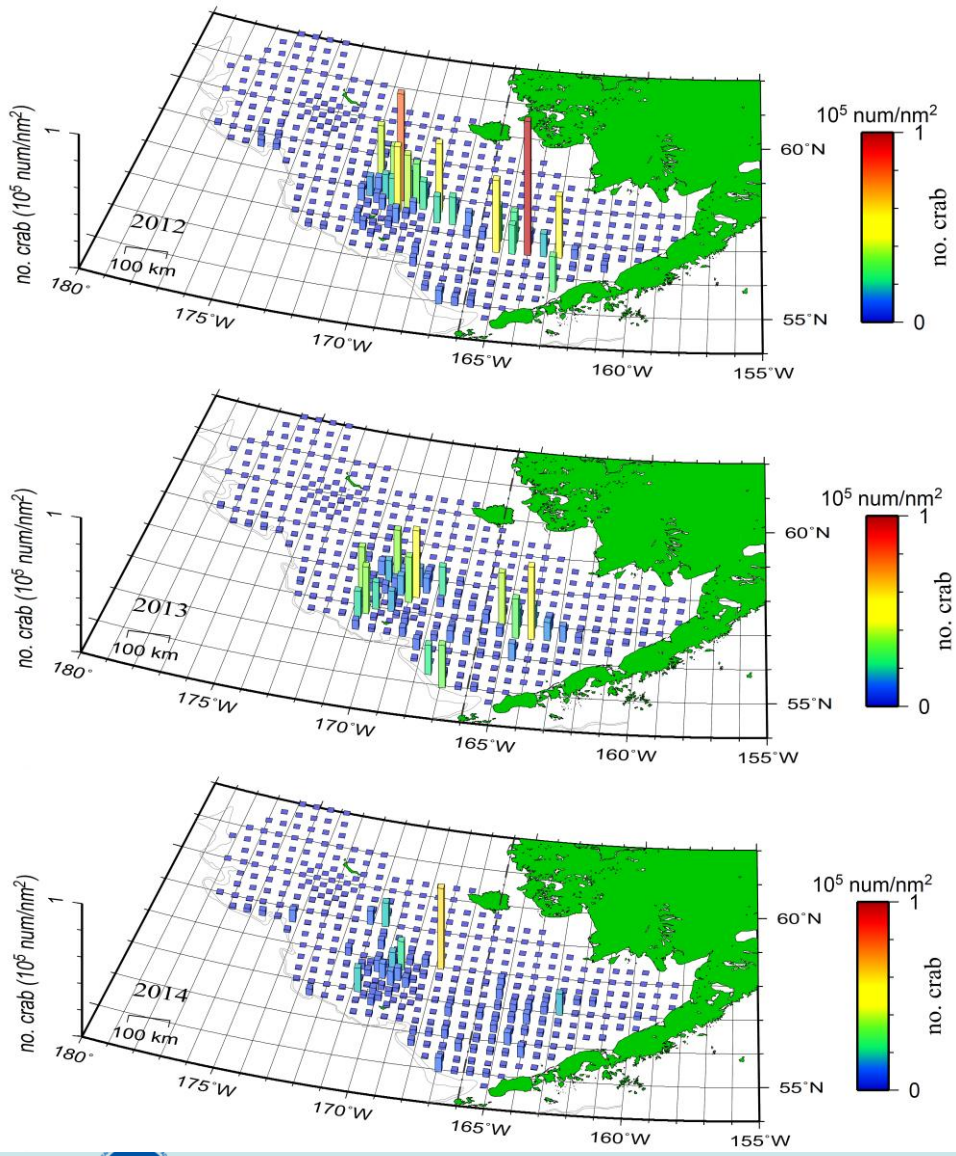


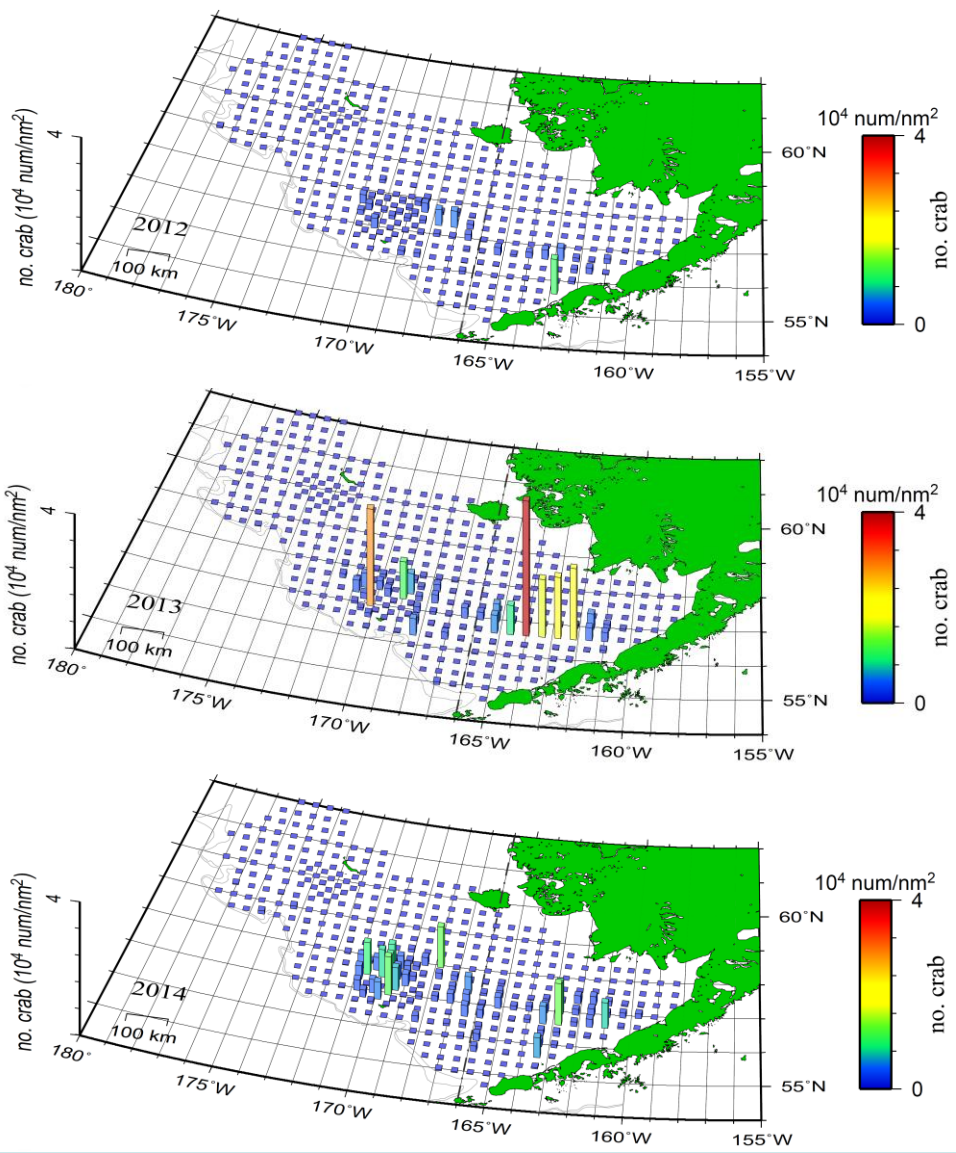


Trawl Survey Results: Males

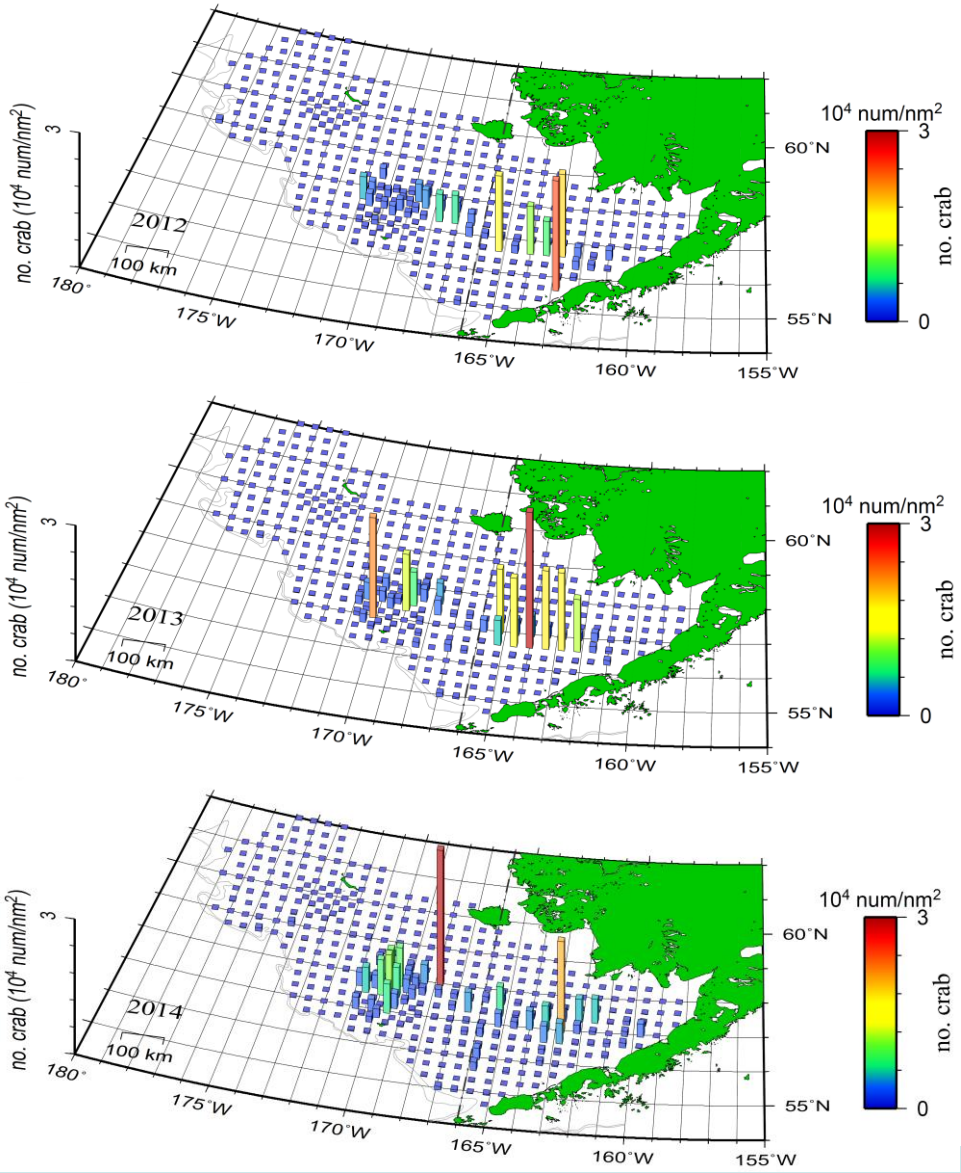
Immature

Mature, new shell





Trawl Survey Results: Pre-recruits (males)



NOAA FISHERIES

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: Fisheries

- Tanner crab pot fishery
  - male catch: total, retained selectvities
    - start-1990/91: logistic selectivity
    - 1991/92-1996/97: logistic selectivity, annually-varying 50% sel. parameter
    - 2005/06-2013/14: logistic selectivity, annually-varying 50% sel. parameter
  - female bycatch: logistic selectivity
  - no fishery:
    - 1985/86-1986/87
    - 1997/98-2004/05
    - 2010/11-2012/13
- Snow crab pot fishery
  - males: double logistic selectivity
  - females: logistic selectivity
  - 3 periods:
    - 1949/50-1996/97
    - 1997/98-2004/05
    - 2005/06-2013/14
- BBRKC pot fishery
  - sex-specific logistic selectivity
  - 3 periods:
    - 1949/50-1996/97
    - 1997/98-2004/05
    - 2005/06-2013/14
  - no fishery: 1984/85-1985/86, 1994/95-1996/97
- Groundfish fisheries
  - sex-specific logistic selectivity
  - 3 periods:
    - 1949/50-1986/87
    - 1987/88-1996/97
    - 1997/-2013/14

Model Description: Trawl Survey

- sex-specific catchabilities (survey q's)
- sex-specific logistic selectivities
  - parameterized by Z_{50} and ΔZ_{95}
- 3 time periods
  - pre-1982
  - 1982-1987
  - 1988+

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
  - immatures
  - 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
- survey
  - survey q
  - survey q for females

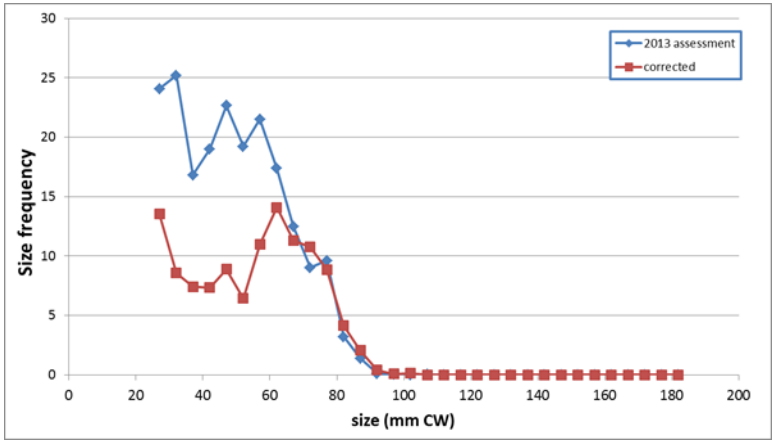
Priors on

- growth parameters

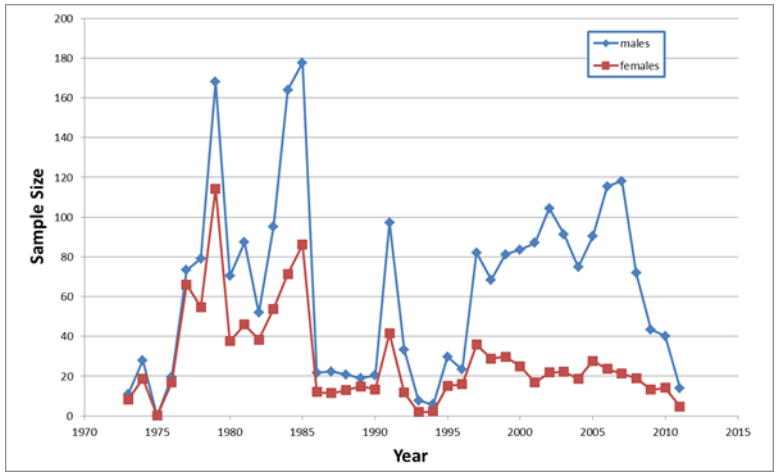
Corrections From 2013 and Revised Fishery Data

Data Corrected From 2013

- 2013 trawl survey size frequency for immature, new shell females

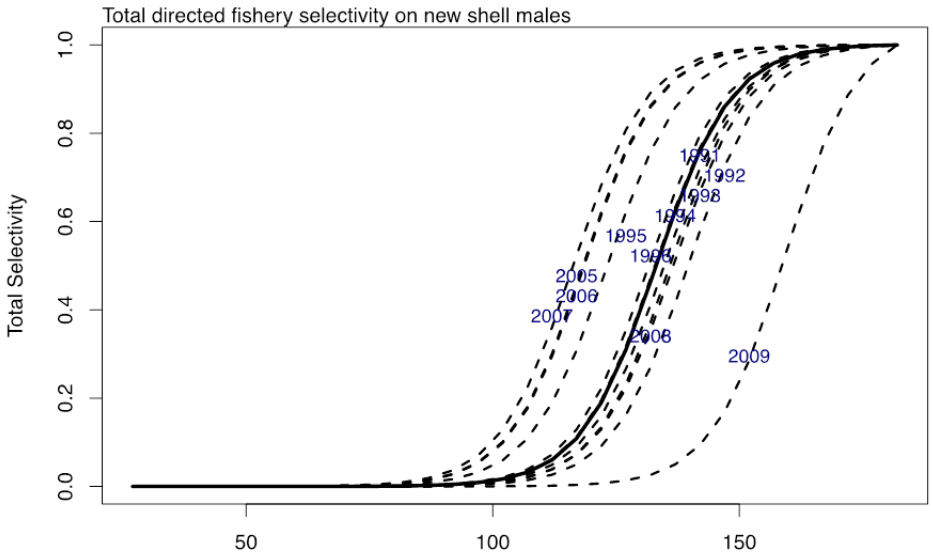


- input sample sizes for bycatch size compositions from the groundfish fisheries

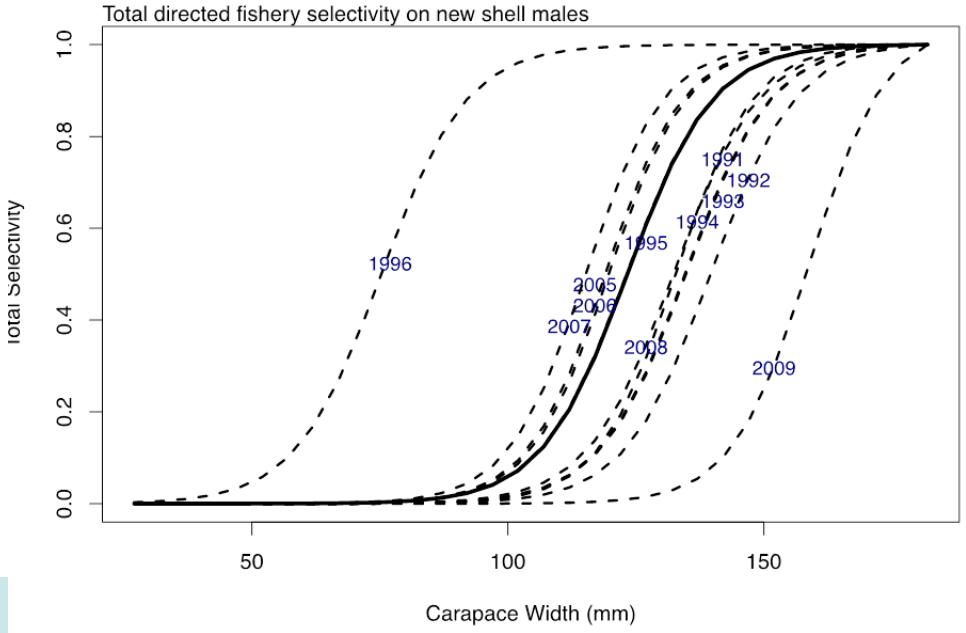


Data Corrected From 2013: Implications

- total selectivity on males in the directed fishery using 2013 data

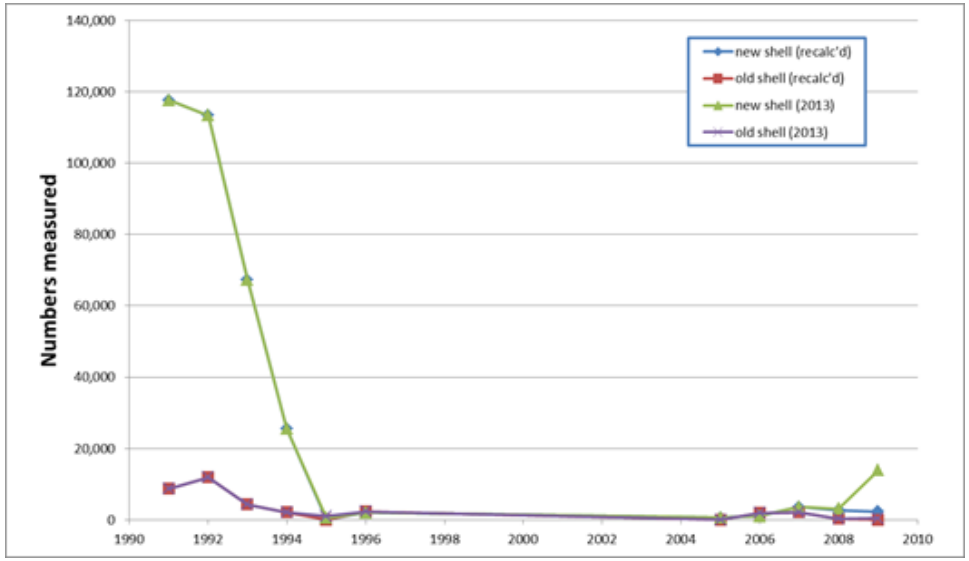


- total selectivity on males in the directed fishery with corrected sample sizes for bycatch size compositions in the groundfish fisheries

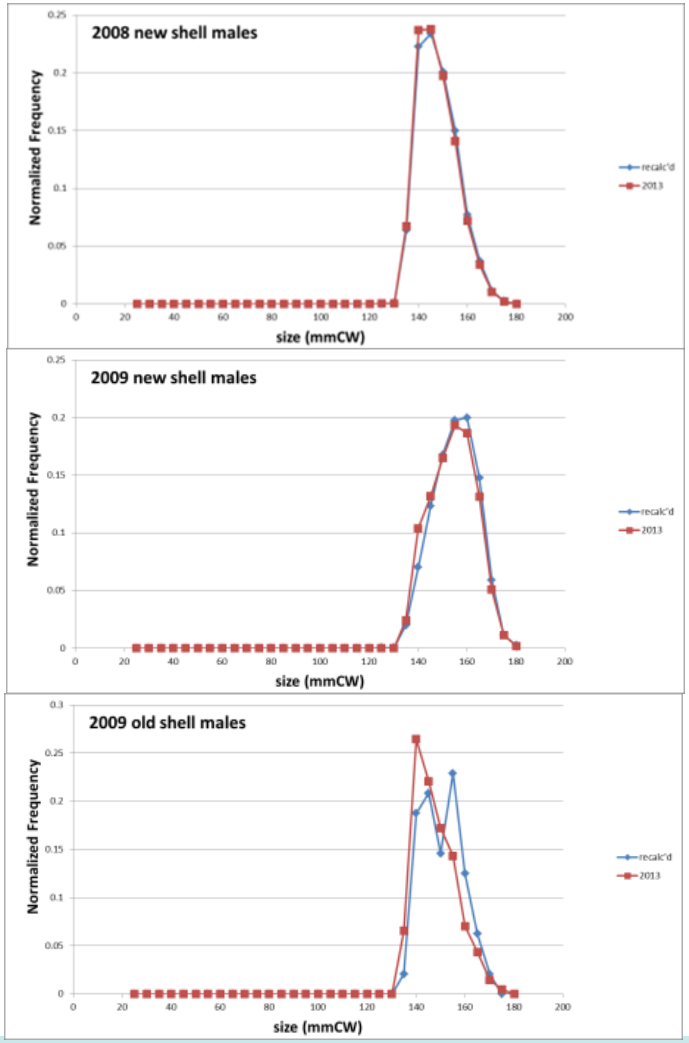


Pre-2013/14 Fishery Data Revised

- Retained crab size compositions from dockside sampling in the directed fishery
  - Numbers measured



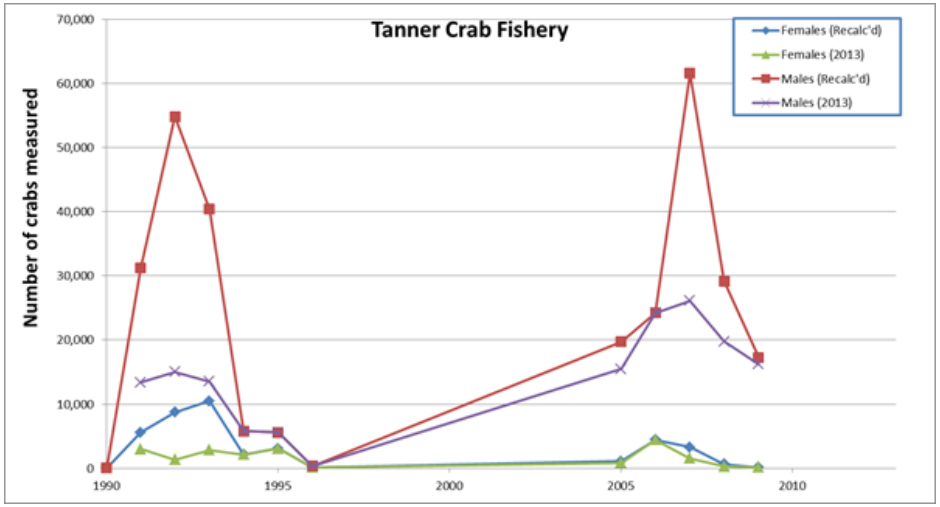
- example changes in size compositions



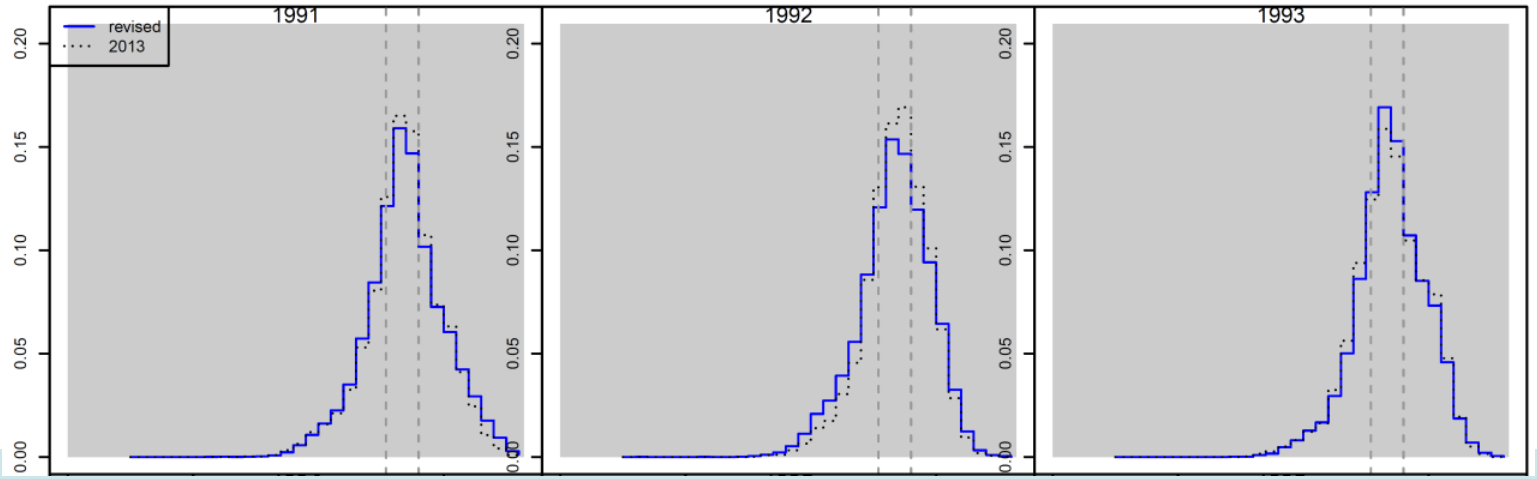
Pre-2013/14 Fishery Data Revised

- Total crab size compositions from at-sea observer sampling in the directed fishery

- Numbers measured



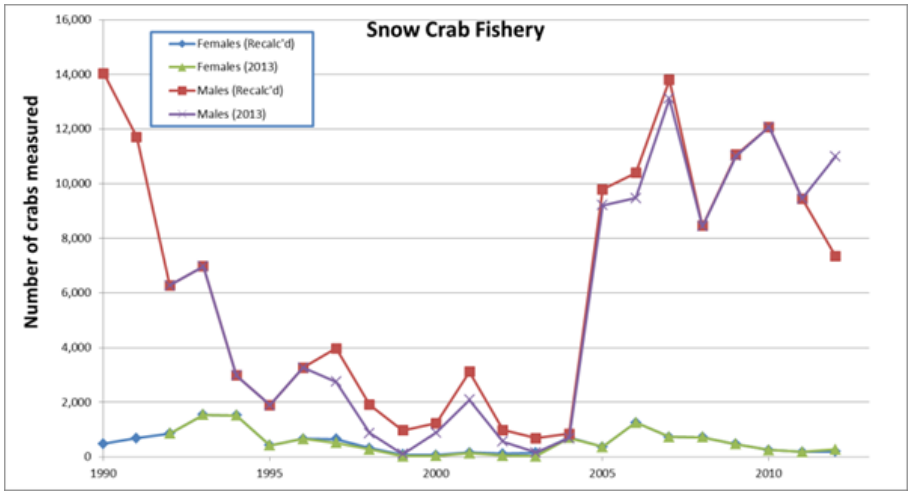
- example changes in size compositions (males)



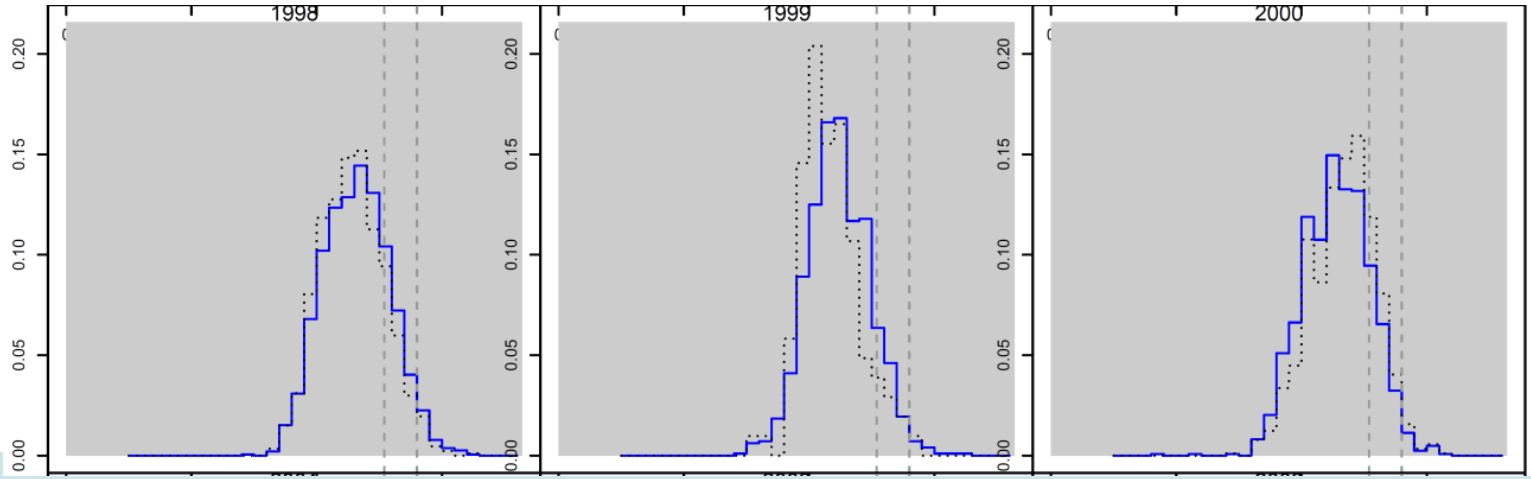
Pre-2013/14 Fishery Data Revised

- Total Tanner crab size compositions from at-sea observer sampling in the snow crab fishery

- Numbers measured



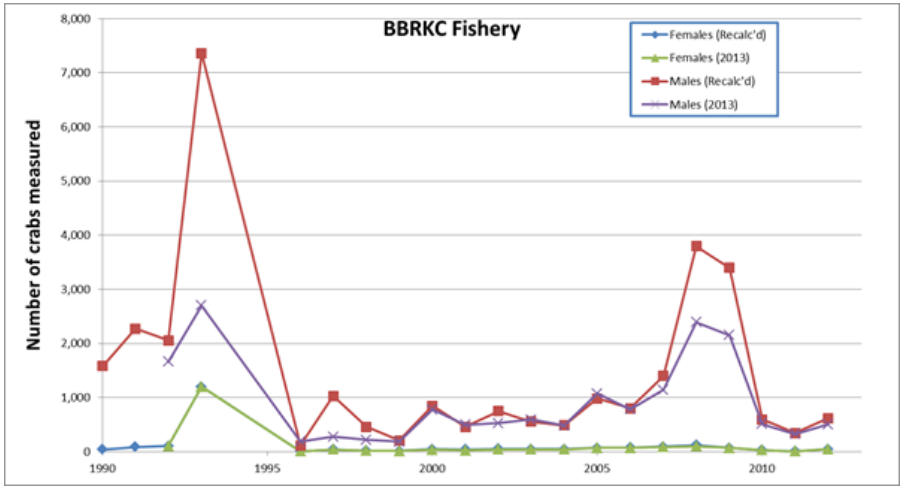
- example changes in size compositions (males)



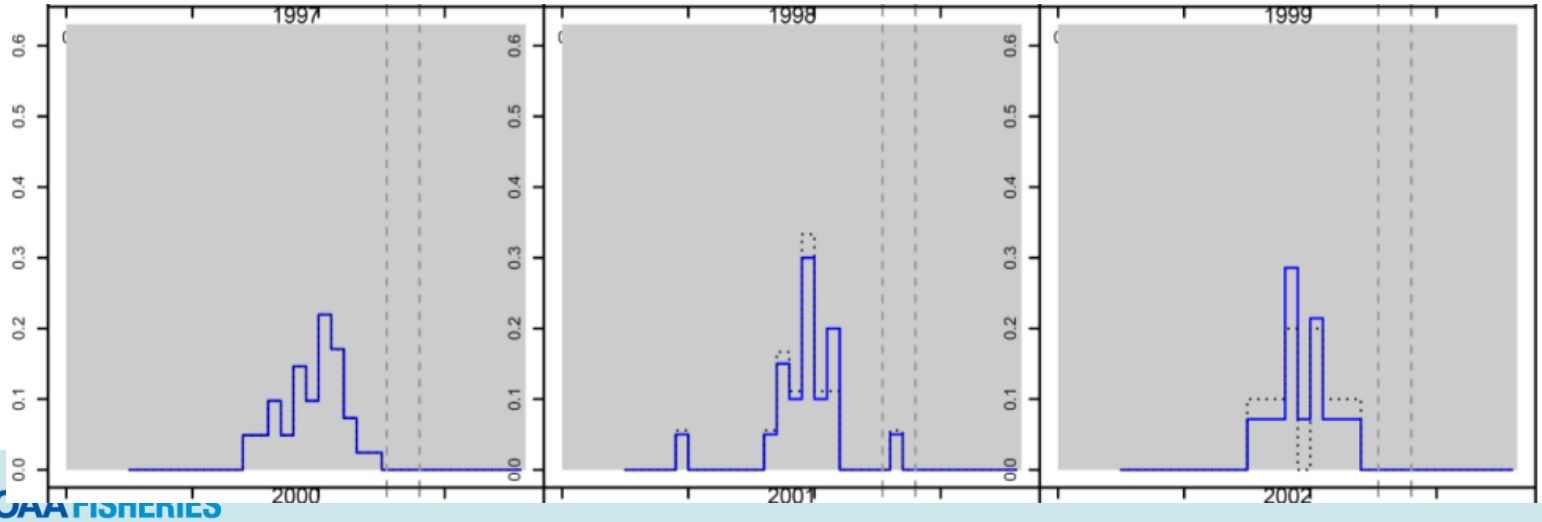
Pre-2013/14 Fishery Data Revised

- Total Tanner crab size compositions from at-sea observer sampling in the BBRKC fishery

- Numbers measured



- example changes in size compositions (females)

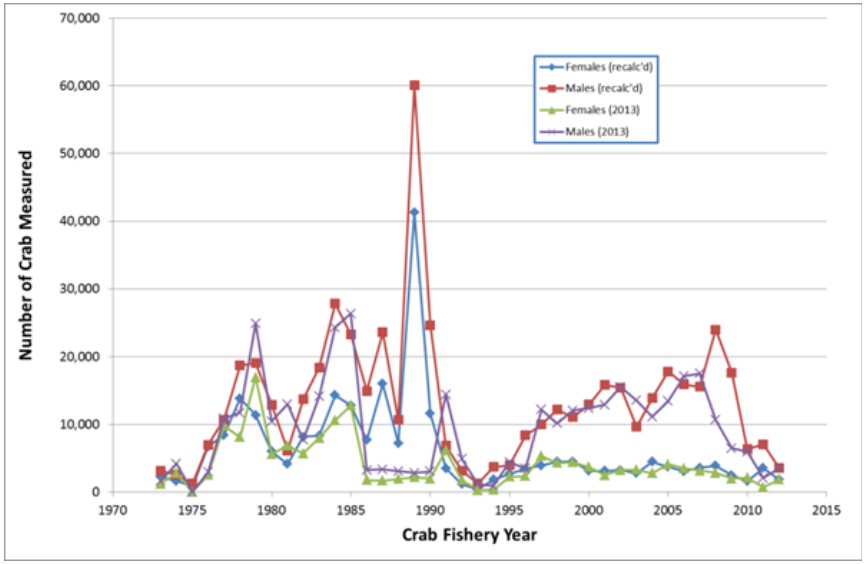


Pre-2013/14 Fishery Data Revised

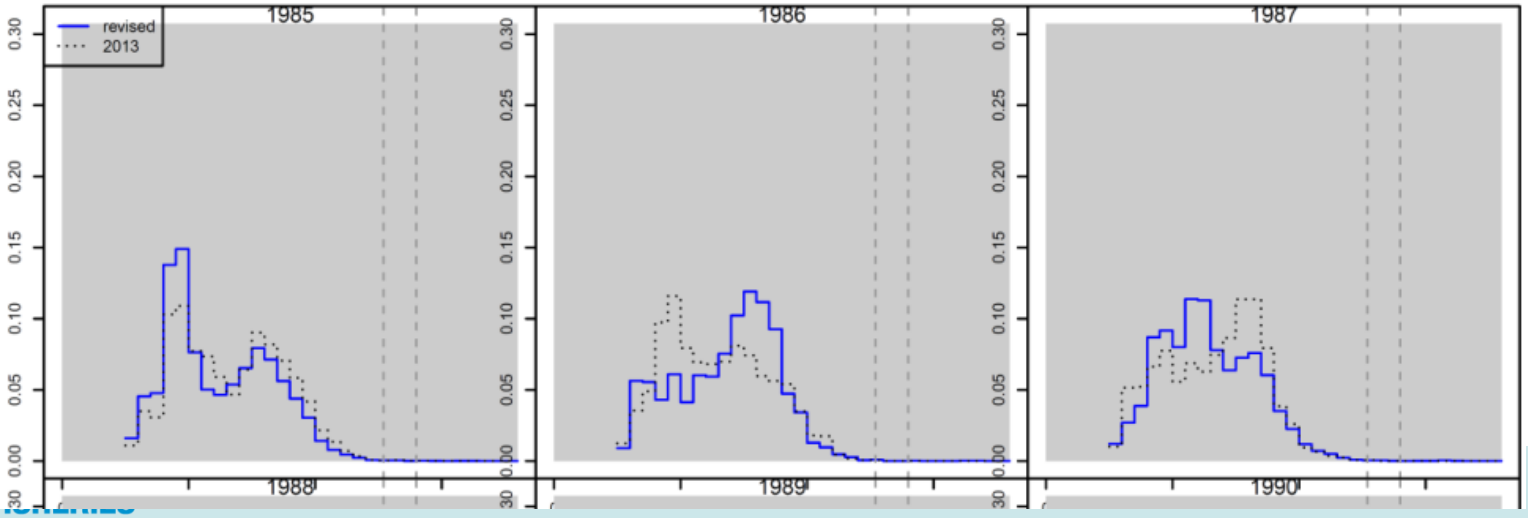
- Total Tanner crab size compositions from at-sea observer sampling in the groundfish fisheries

  - Adjusted to crab fishery year

- Numbers measured



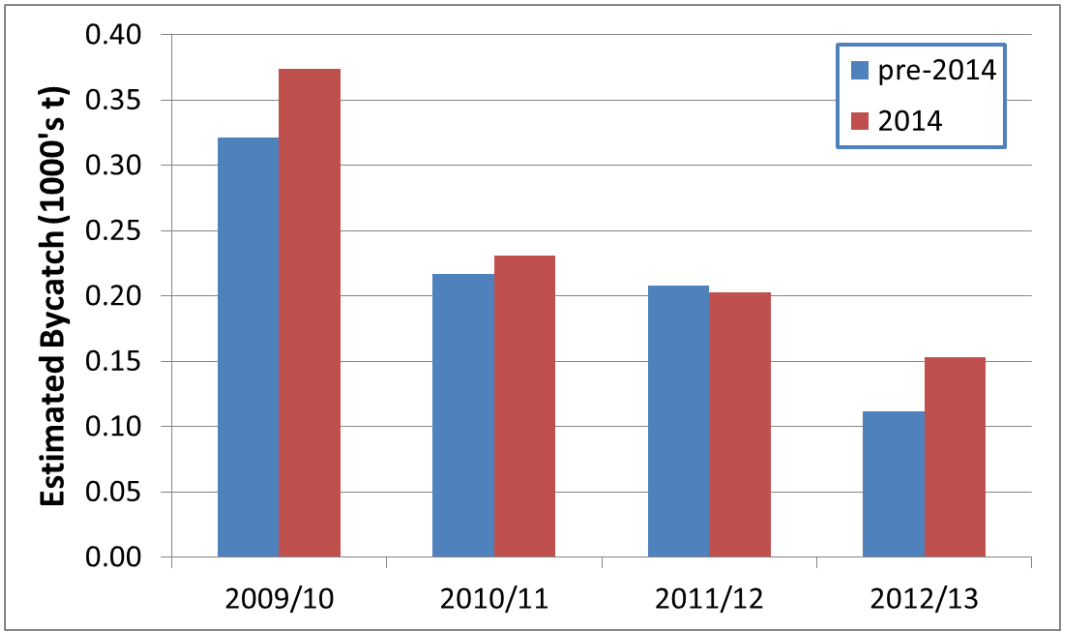
- example changes in size compositions (females)



Pre-2013/14 Fishery Data Revised

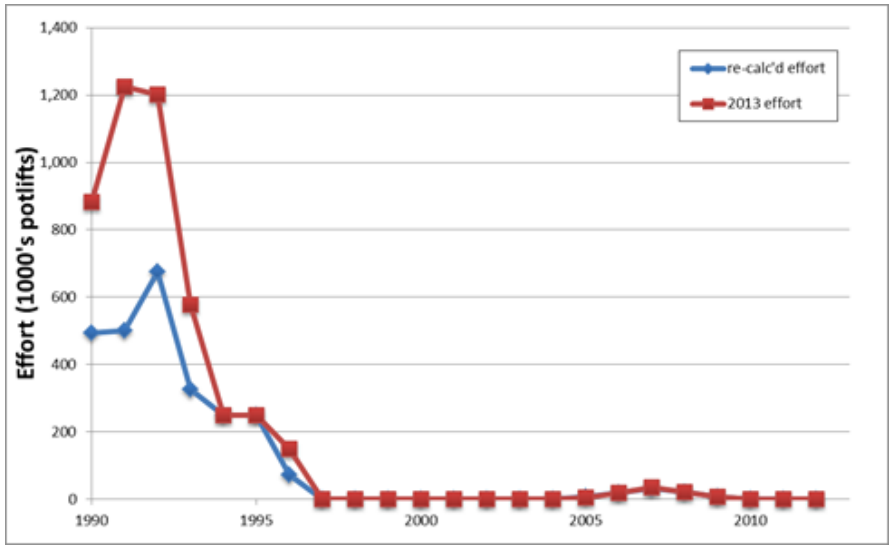
- Expanded biomass of Tanner crab bycatch in the groundfish fisheries

  - Revised algorithms for expanding unobserved catch based on state statistical areas

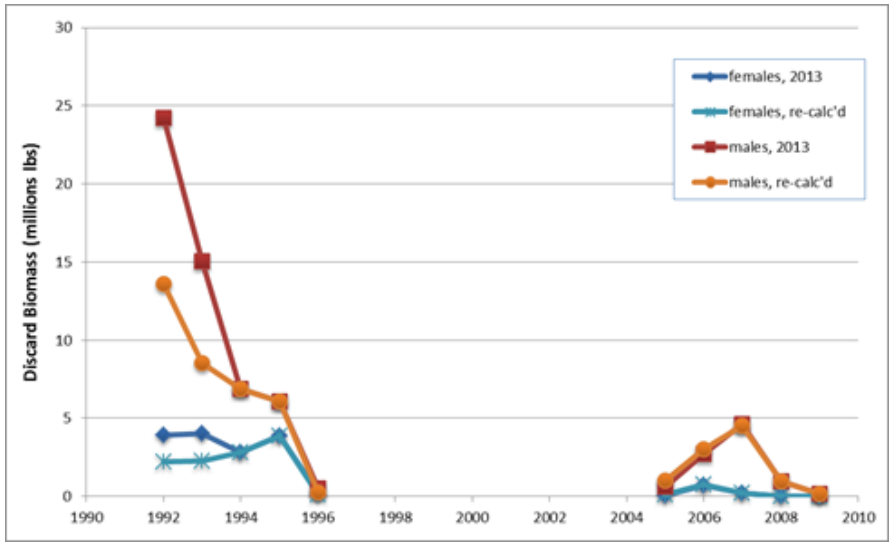


Pre-2013/14 Fishery Data Revised

- Effort in the directed Tanner crab fishery

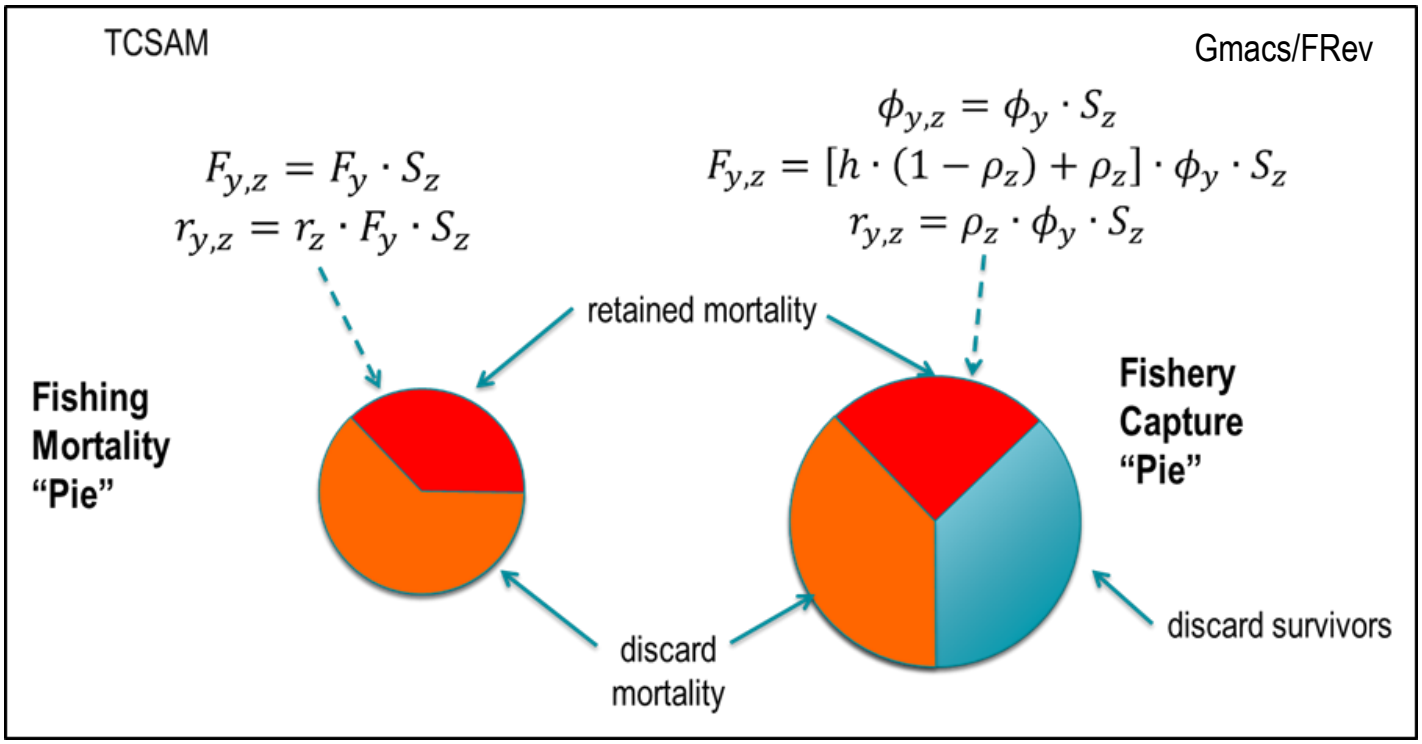


- Consequent changes in discard biomass in the directed fishery



Revised Fishing Mortality Equations: Gmacs/FRev

Revised Fishing Mortality Model: Gmacs/FRev



TCSAM

- Applies handling mortality to **observed bycatch**
- *Fits "observed" discard mortality*

FRev

- Applies handling mortality to **predicted bycatch**
- *Fits total catch*

Pot Fishery Handing Mortality

- At May 2014 CPT Meeting, Dan Urban (AFSC) presented information on
  - short-term handling mortality for Tanner crab in the pot fisheries
    - based on Reflex Action Mortality Predictor (RAMP) scores
    - applied by observers to over 10,000 Tanner crab caught in the 2013/14 crab fisheries
    - results:
      - average predicted mortality was 11.4%
      - no apparent temperature dependence on survival
  - injury rates on discarded Tanner crab
    - average: 4.1%; high: 10.2%
- The CPT estimated that total discard mortality in the pot fisheries was likely 32.1%, given consideration of the short-term effects, maximum injury rates and probable unobserved but longer-term effects on survival
- The previous value used was 50%
- Assessment author was directed to bring forward models using both values for the fall assessment

Alternative Models & Evaluation

Model Scenarios

- Pot Fishery Handling Mortality Rate: 50% (old) vs. 32.1% (adopted May CPT meeting)
- Legacy vs. re-calculated fishery data
- "Old" fishing mortality model vs. Gmacs fishing mortality model
- Also considered:
  - increased weights on fitting 1996 directed fishery discards
  - ln-scale fishing mortality offsets for females in all fisheries

Model Scenario	Model converged?	Handling Mortality	Data	Model Type	Model Options
Alt0a	yes	50.0%	2013 data + 2014	TCSAM2013	base model: same as 2013 model
Alt0b	yes	32.1%	2013 data + 2014	TCSAM2013	base model
Alt1a	yes	50.0%	2014 revised data	TCSAM2013	base model with sample sizes corrected for groundfish bycatch size frequencies
Alt1b	yes	32.1%	2014 revised data	TCSAM2013	base model with sample sizes corrected for groundfish bycatch size frequencies
Alt2a	no	50.0%	2014 revised data	TCSAM-FRev	options same as base TCSAM2013 model with corrected sample sizes
Alt2b	no	32.1%	2014 revised data	TCSAM-FRev	options same as base TCSAM2013 model with corrected sample sizes
Alt2c	no	50.0%	2014 revised data	TCSAM-FRev	increased weights on fitting 1996 directed fishery discards
Alt2d	no	32.1%	2014 revised data	TCSAM-FRev	increased weights on fitting 1996 directed fishery discards
Alt3a	no	50.0%	2014 revised data	TCSAM-FRev	ln-scale female fsihing mortality offsets estimated
Alt3b	no	32.1%	2014 revised data	TCSAM-FRev	ln-scale female fsihing mortality offsets estimated

Model Selection

Model Scenario	Model converged?	Handling Mortality	Data	Model Type	Model Options
Alt0a	yes	50.0%	2013 data + 2014	TCSAM2013	base model: same as 2013 model
Alt0b	yes	32.1%	2013 data + 2014	TCSAM2013	base model
Alt1a	yes	50.0%	2014 revised data	TCSAM2013	base model with sample sizes corrected for groundfish bycatch size frequencies
Alt1b	yes	32.1%	2014 revised data	TCSAM2013	base model with sample sizes corrected for groundfish bycatch size frequencies
Alt2a	no	50.0%	2014 revised data	TCSAM-FRev	options same as base TCSAM2013 model with corrected sample sizes
Alt2b	no	32.1%	2014 revised data	TCSAM-FRev	options same as base TCSAM2013 model with corrected sample sizes
Alt2c	no	50.0%	2014 revised data	TCSAM-FRev	increased weights on fitting 1996 directed fishery discards
Alt2d	no	32.1%	2014 revised data	TCSAM-FRev	increased weights on fitting 1996 directed fishery discards
Alt3a	no	50.0%	2014 revised data	TCSAM-FRev	ln-scale female fsihing mortality offsets estimated
Alt3b	no	32.1%	2014 revised data	TCSAM-FRev	ln-scale female fsihing mortality offsets estimated

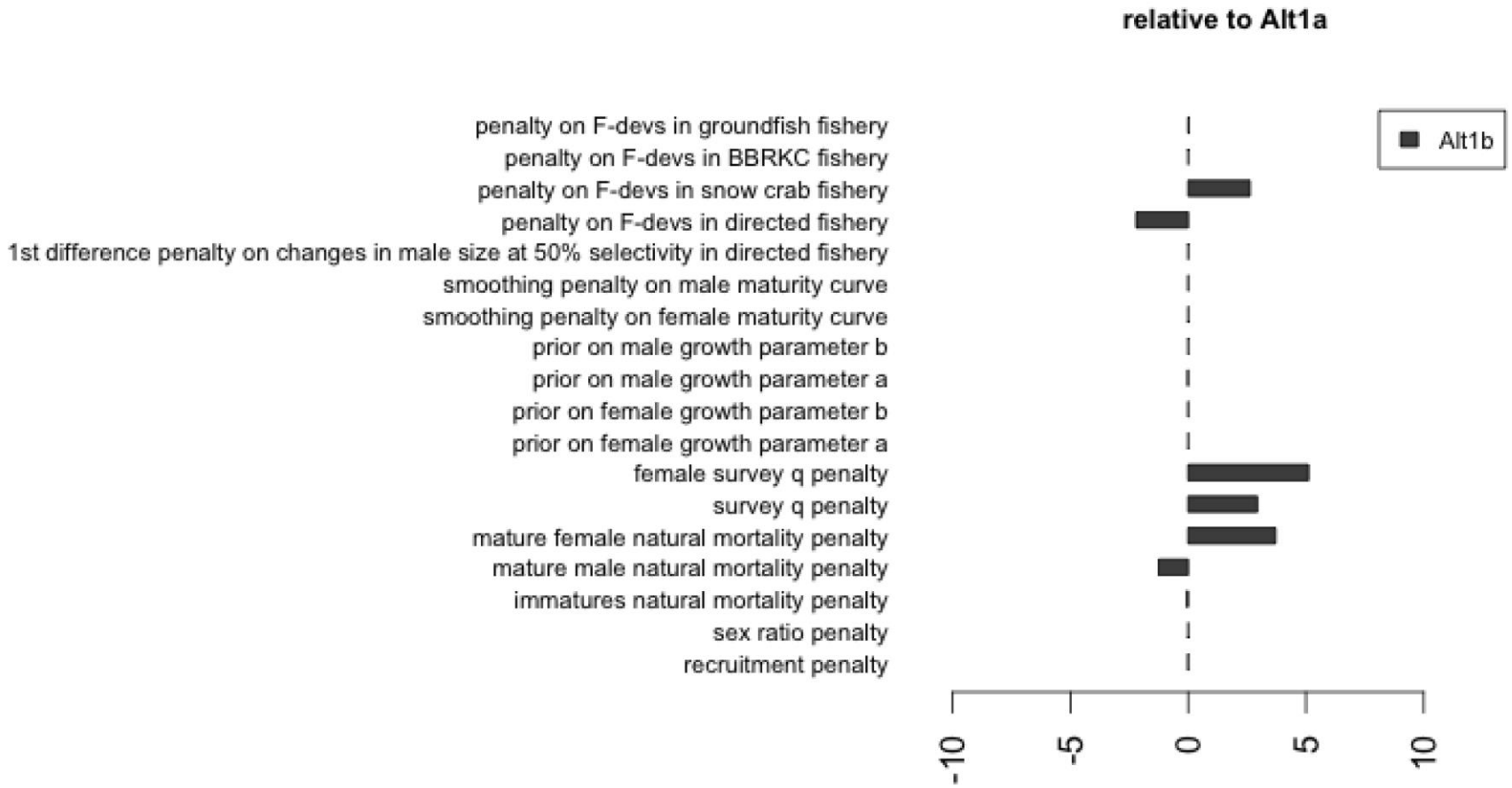
- Preferred model: Alt1a
  - based on recalculated data
  - “old” handling mortality

Model Selection: Alt1a is preferred model

Rationale:

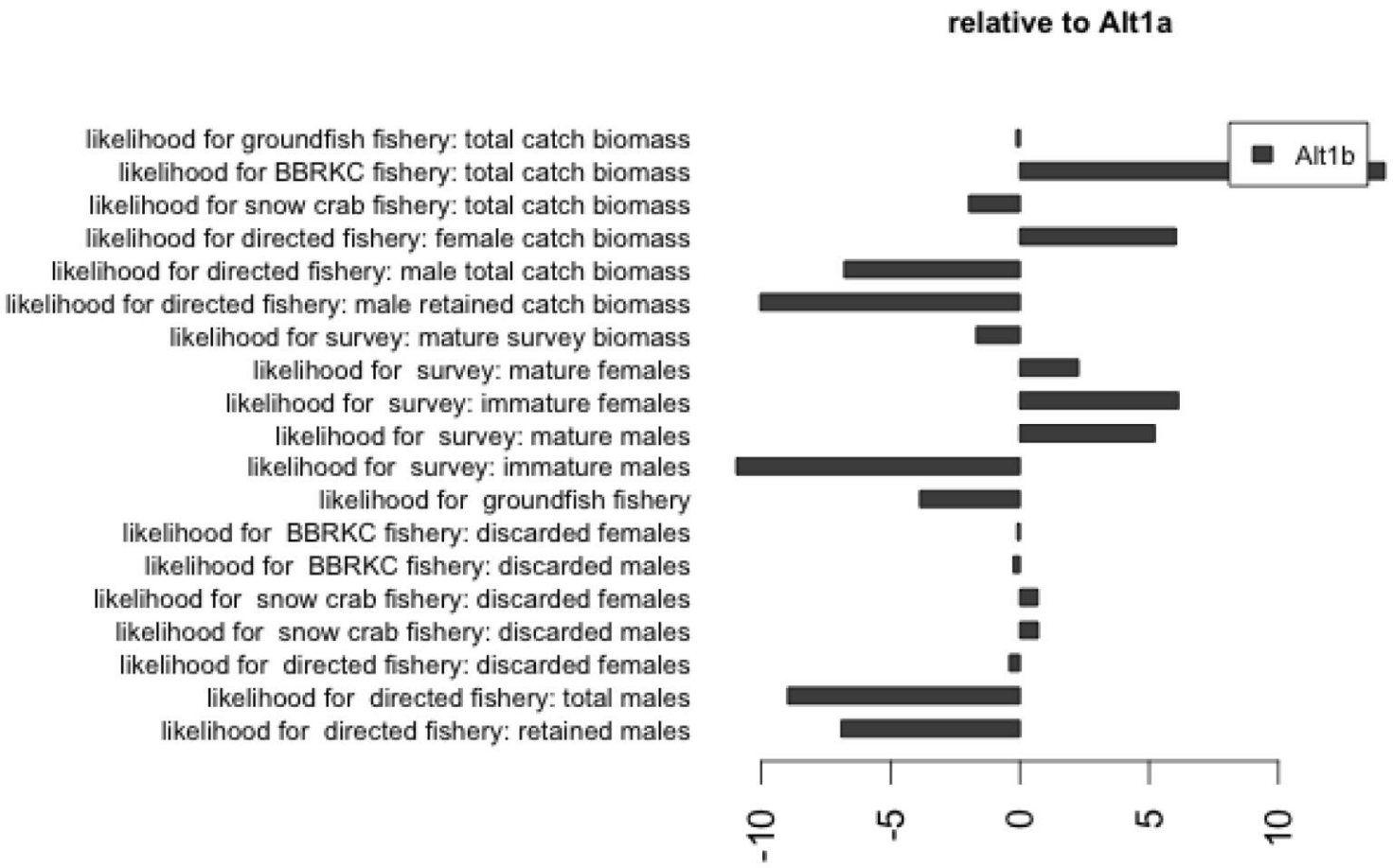
- Alt0- models rejected because they were based on “legacy” fishery data that cannot be recreated
- Alt2-, Alt3- models rejected because none of these models converged despite some extensive parameter searches
- Alt1b model rejected because:
  - Alt1a achieved better fit to data (lower objective function value)
  - Alt1b failed to estimate sensible selectivity curve for male bycatch in snow crab fishery in 1997-2004 time period

Model Selection: Likelihood Criteria



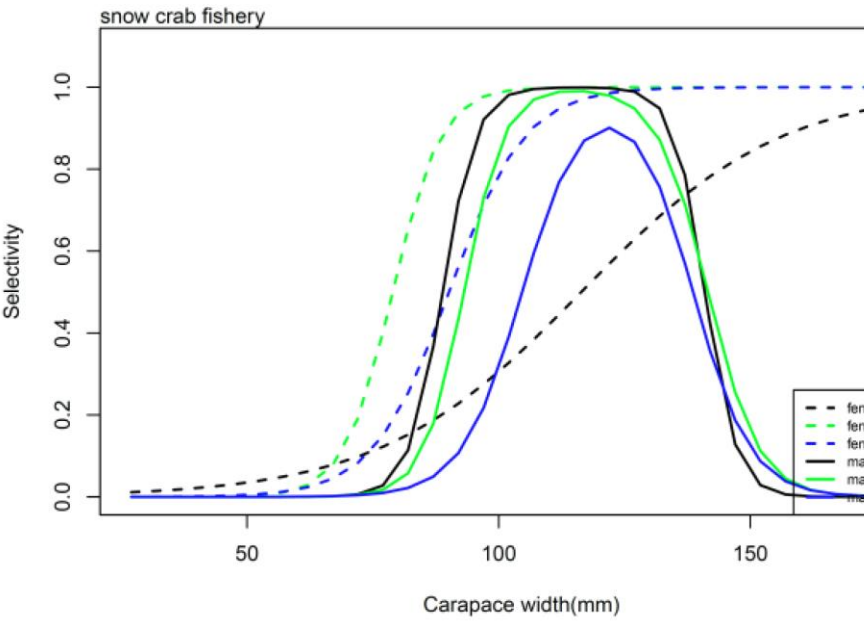
Model Selection: Likelihood Criteria

- Alt1a fits better than Alt1b by at least 6 likelihood units

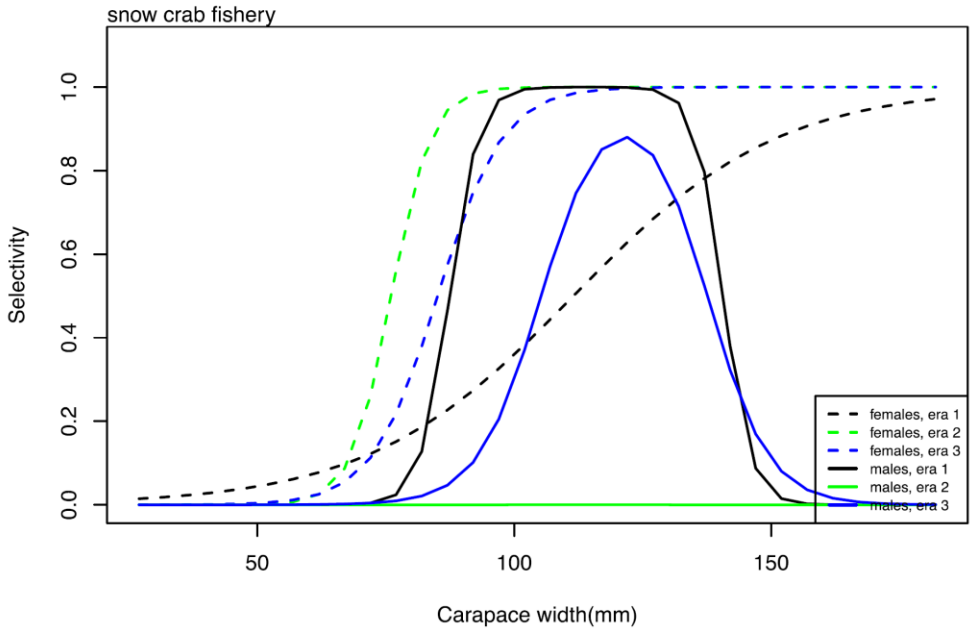


Model Selection: Reasonable Parameter Estimates

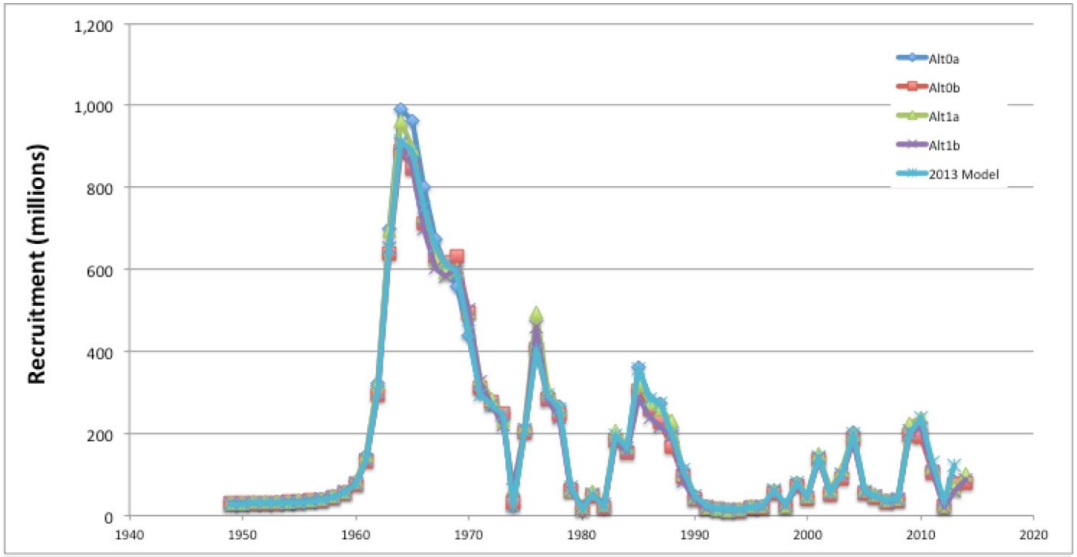
Alt1a

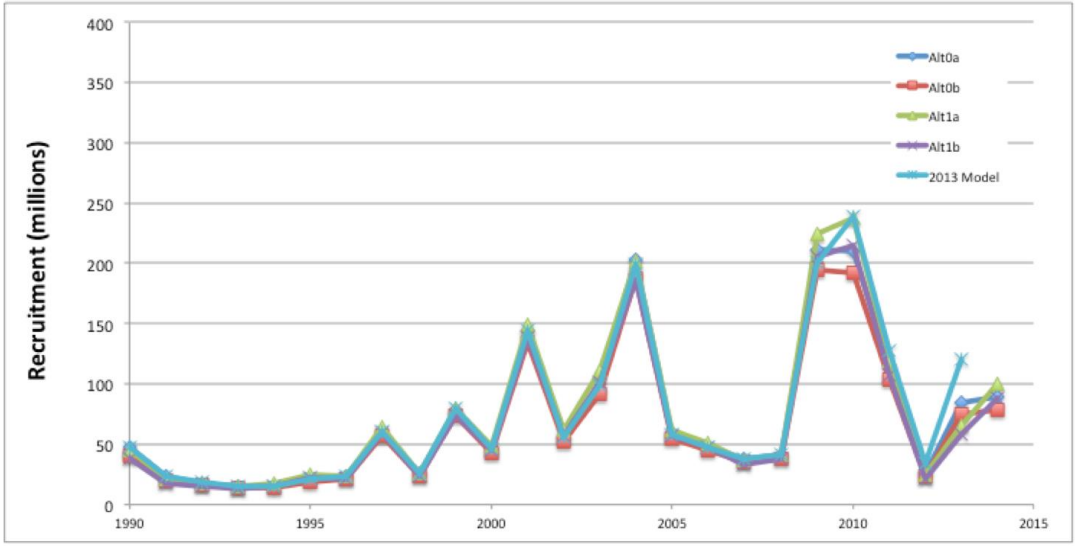


Alt1b

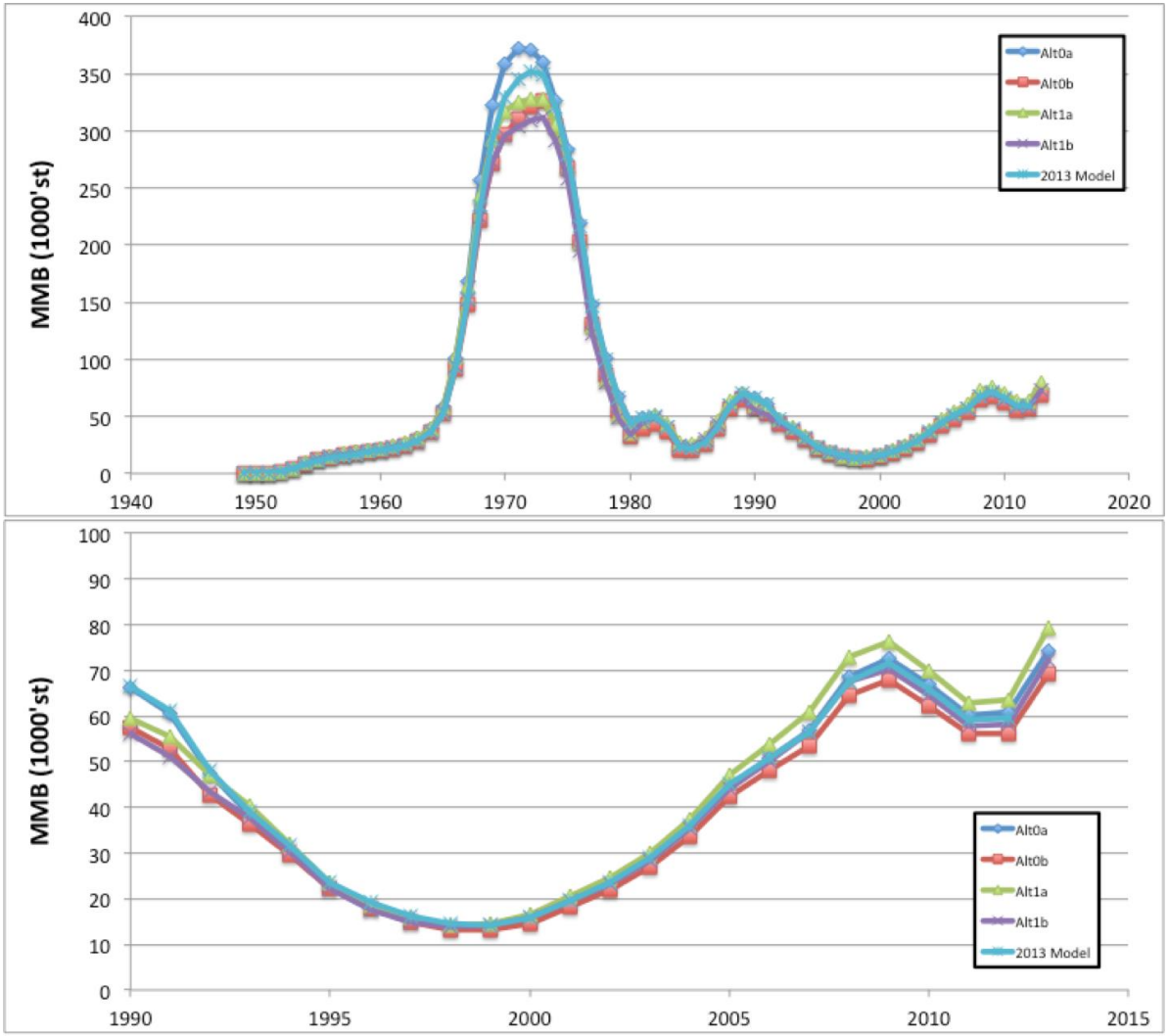


Recruitment Estimates

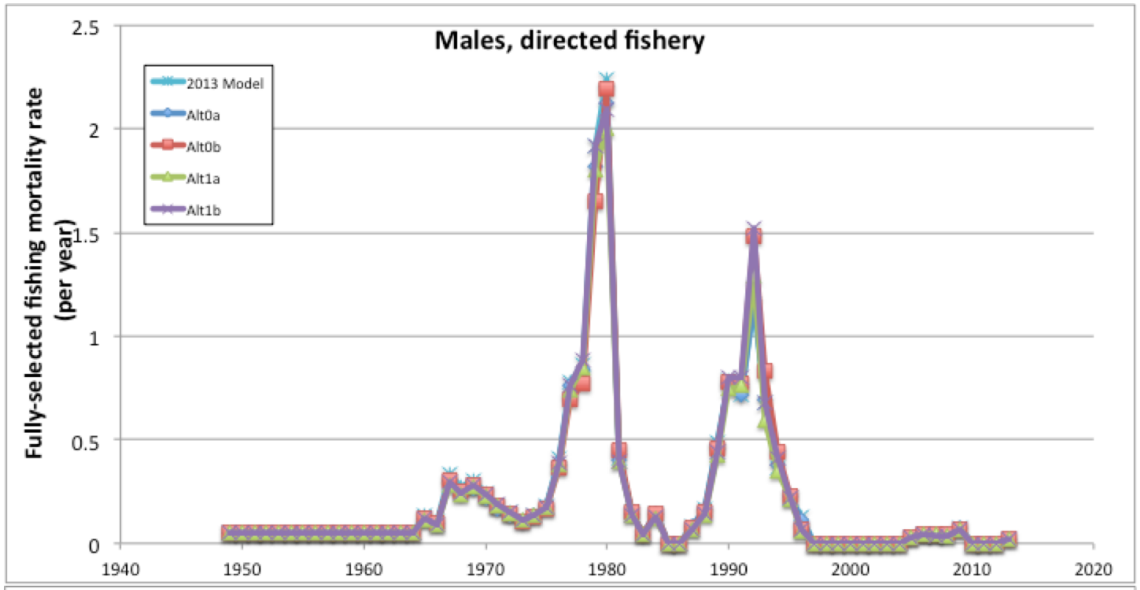


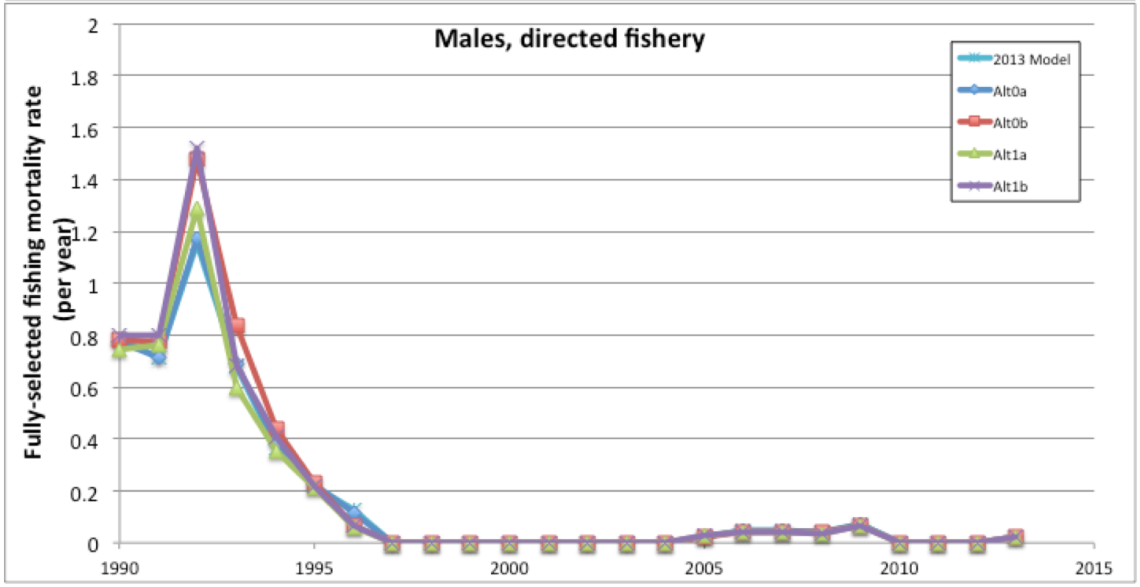


MMB Estimates

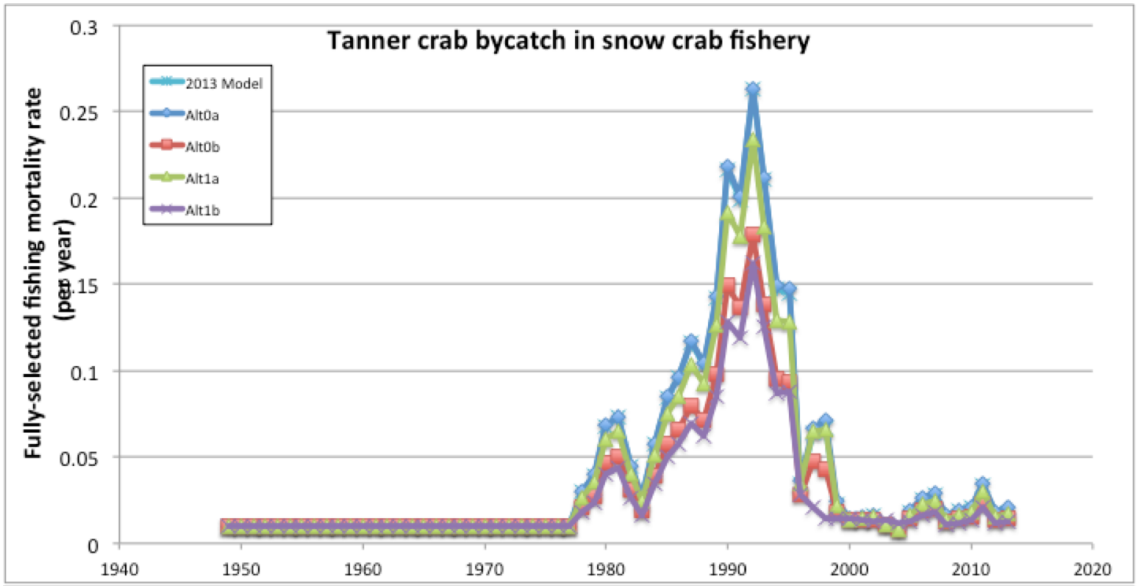


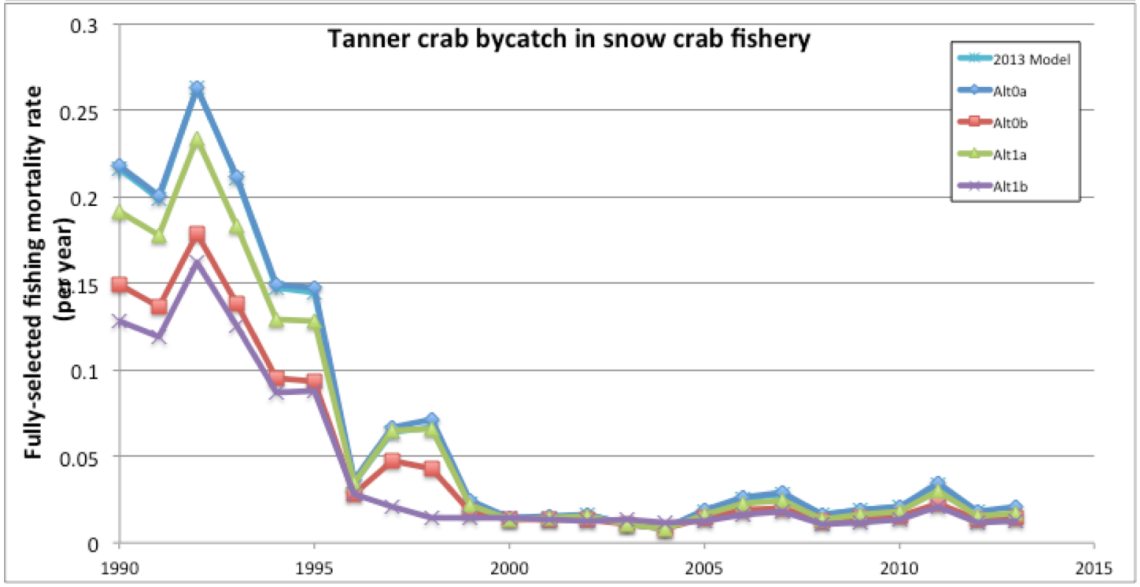
Fully-selected fishing mortality (directed fishery)



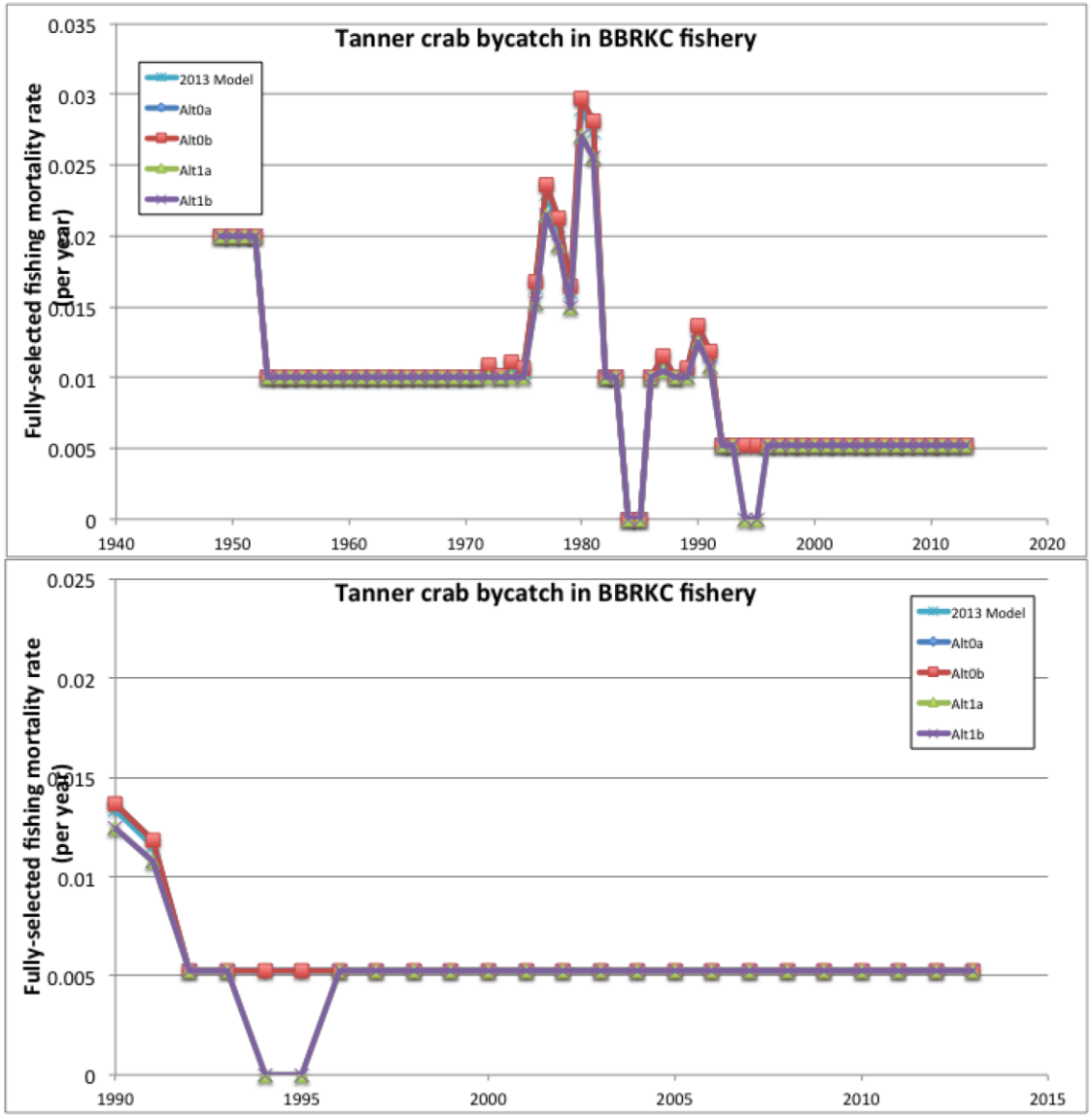


Fully-selected fishing mortality (snow crab fishery)

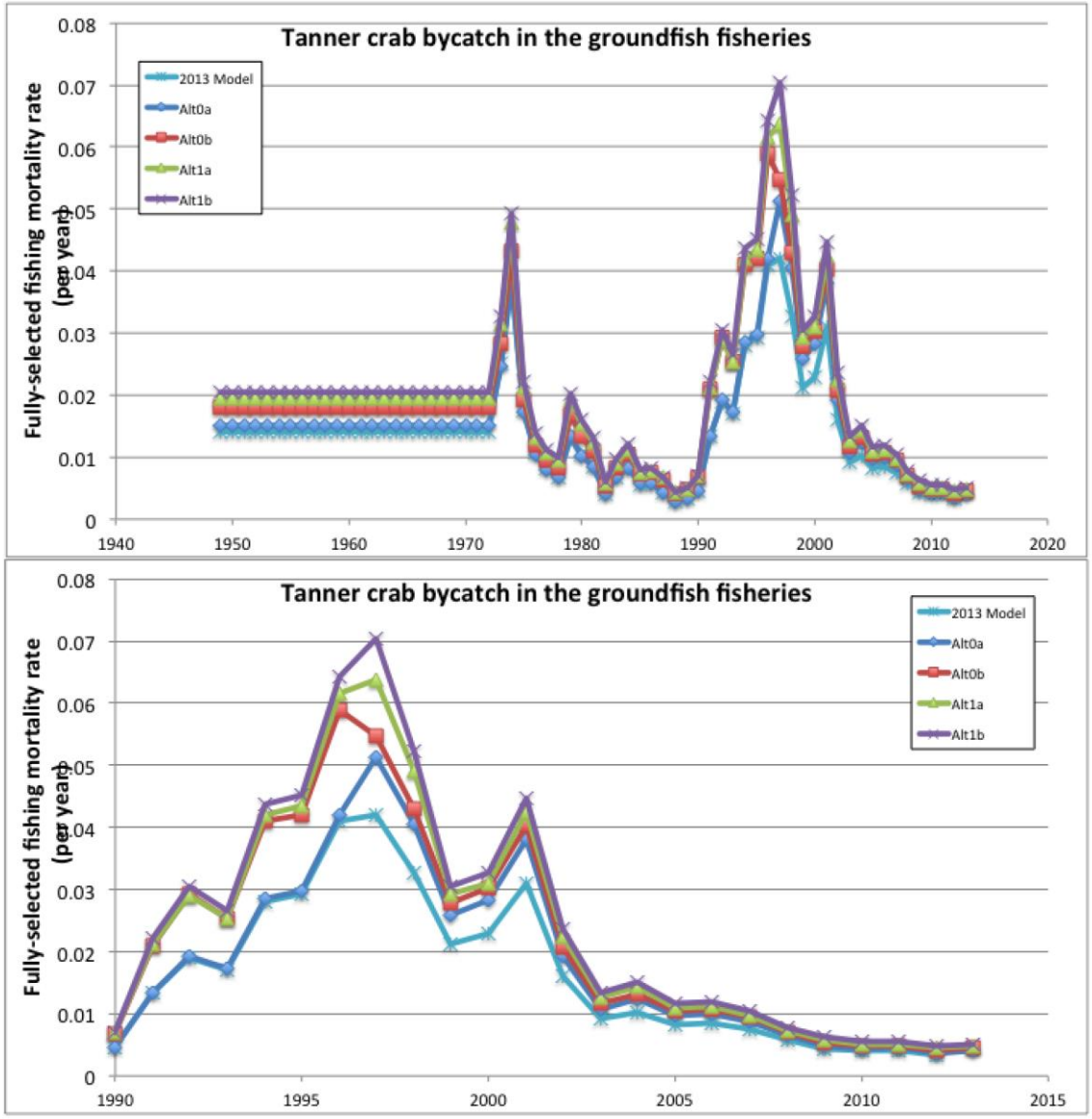




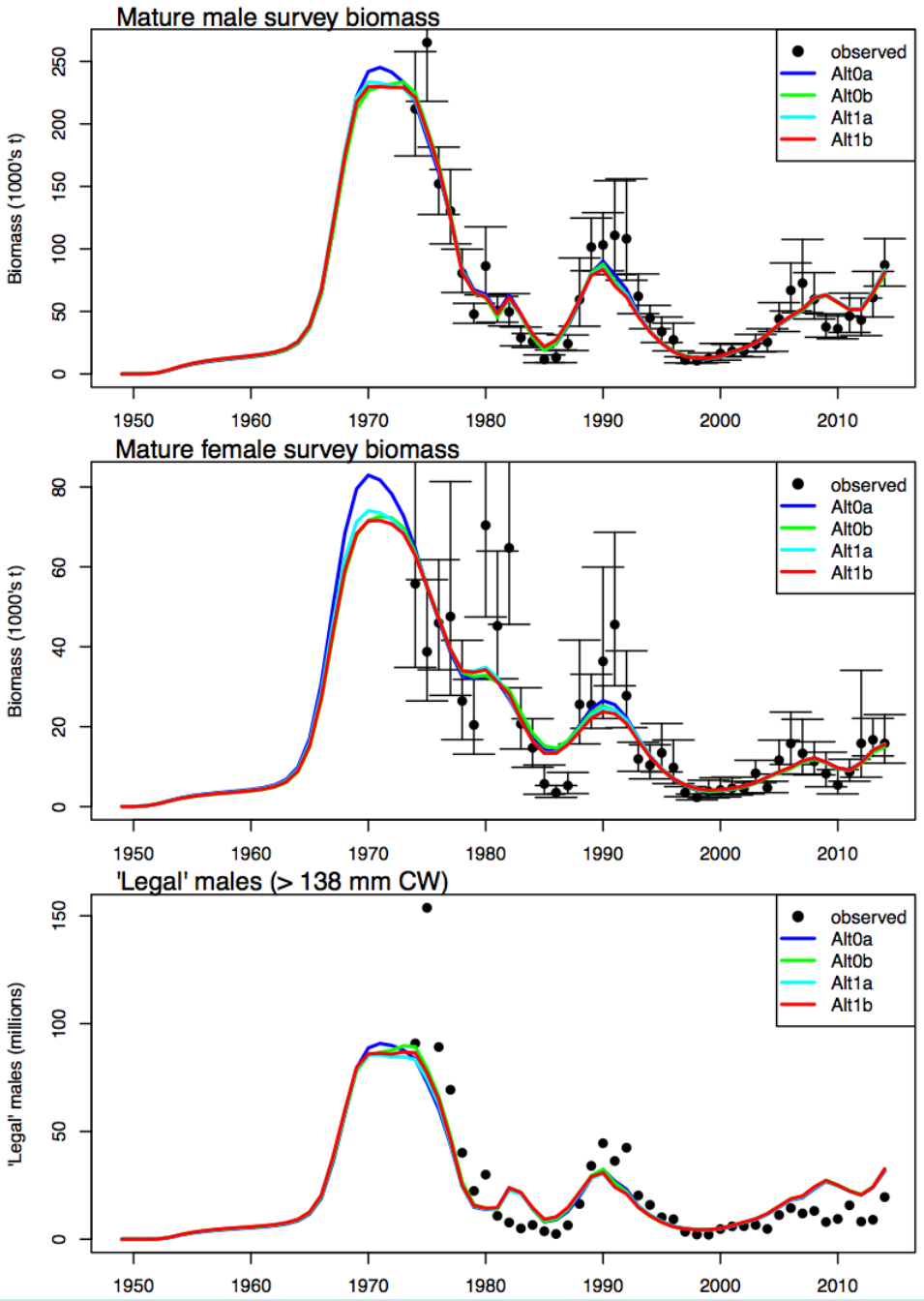
Fully-selected fishing mortality (BBRKC fishery)



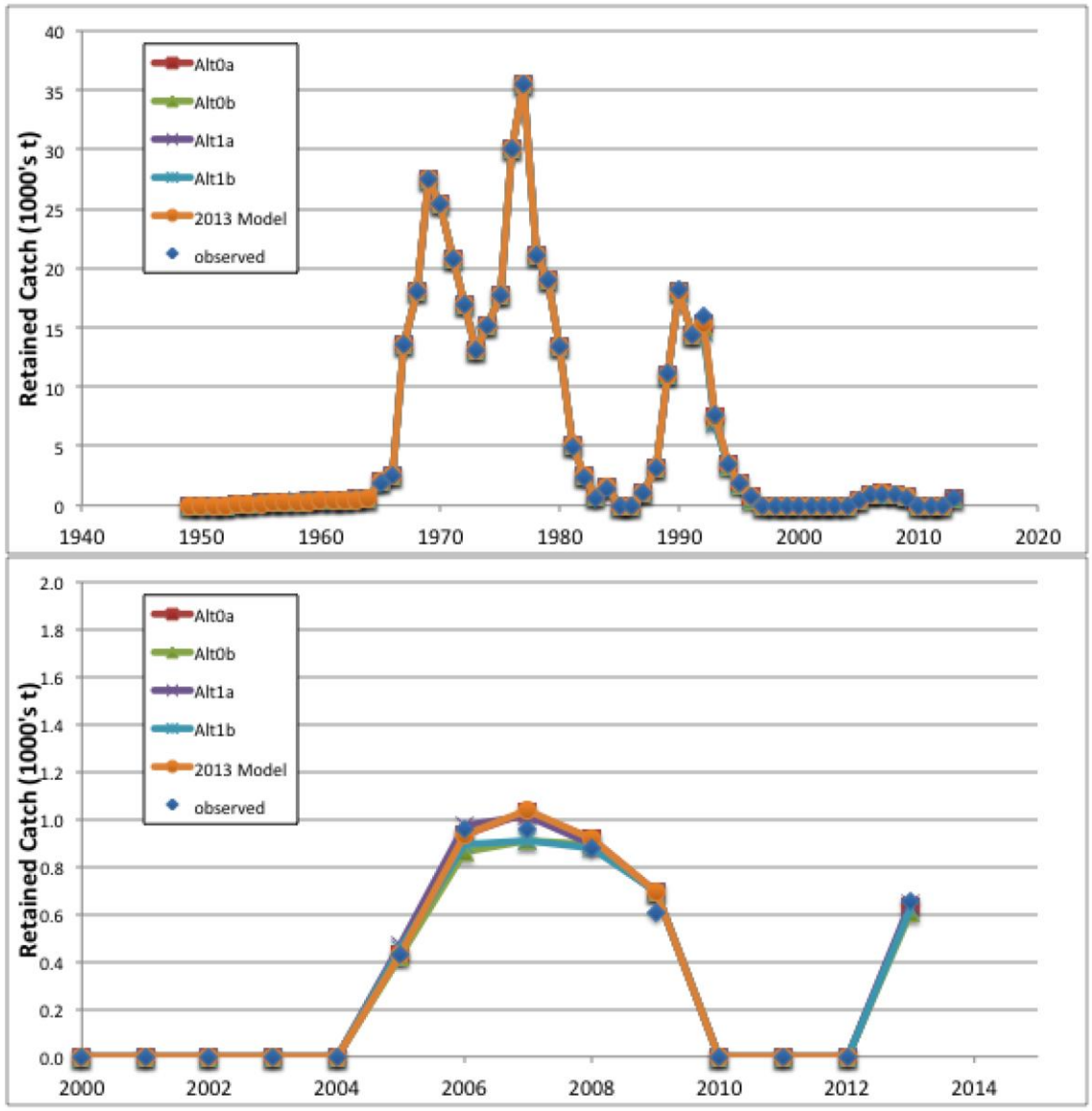
Fully-selected fishing mortality (groundfish fisheries)



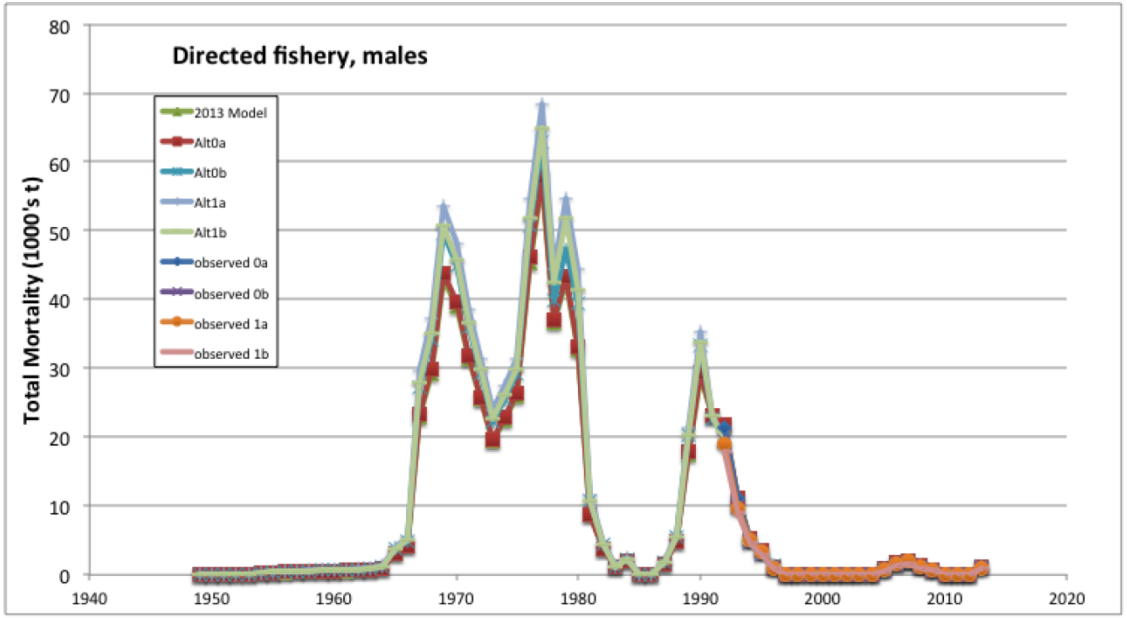
Fits to survey biomass

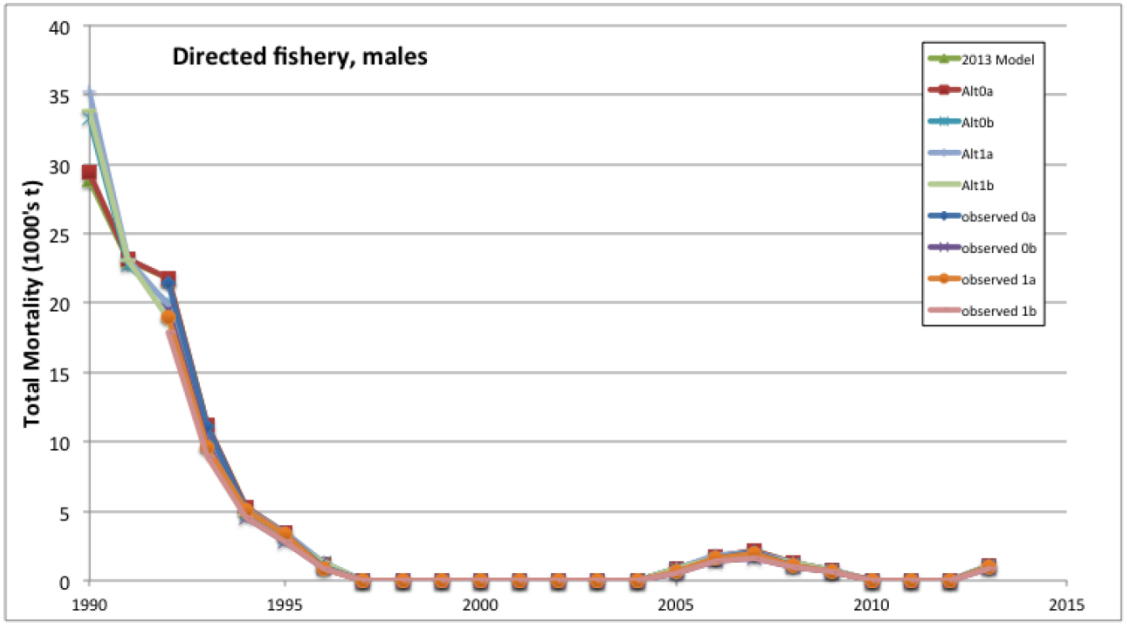


Fits to retained catch

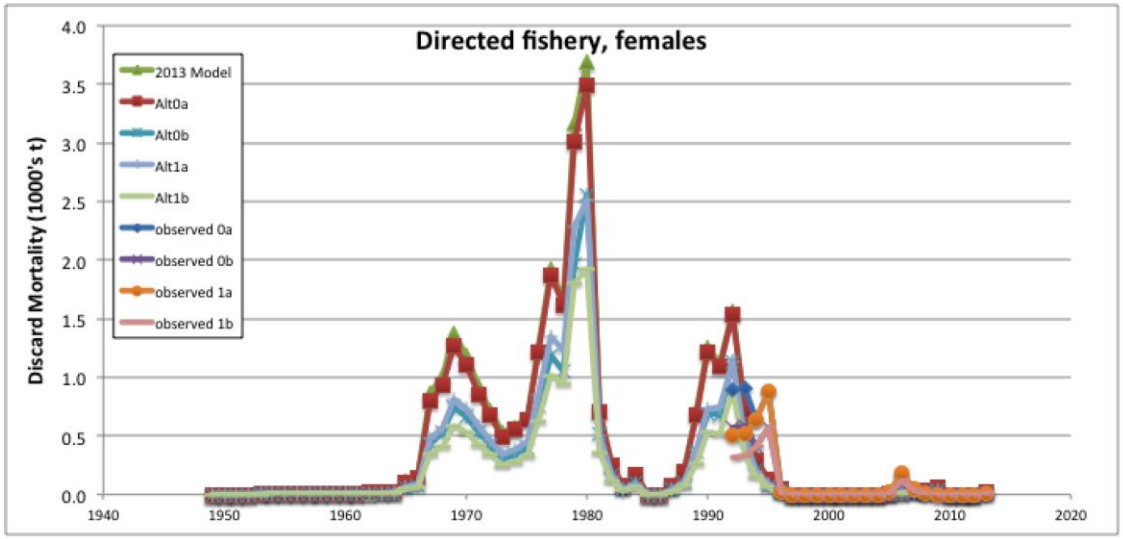


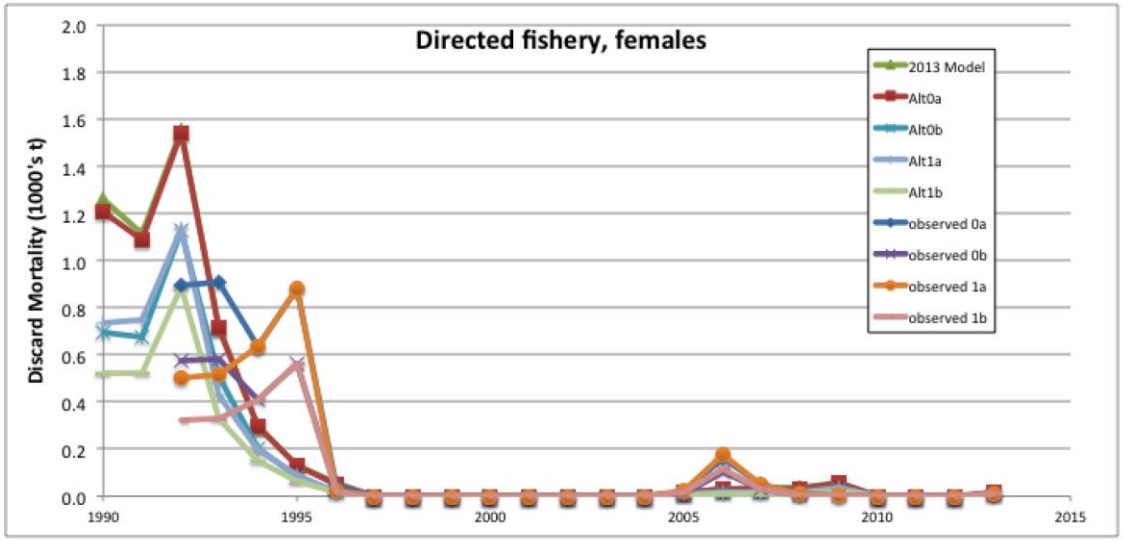
Fits to total male catch in the directed fishery





Fits to female bycatch in the directed fishery

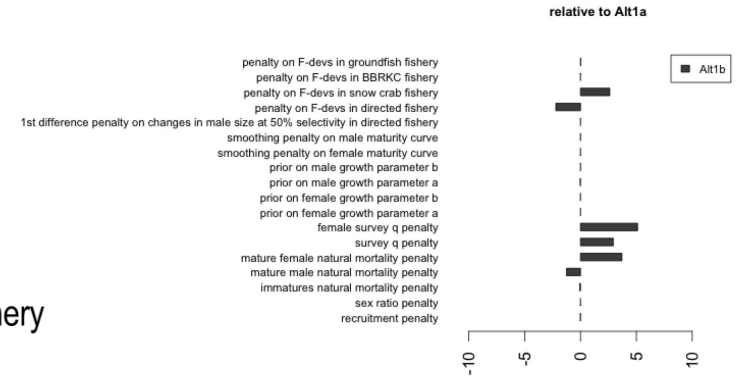


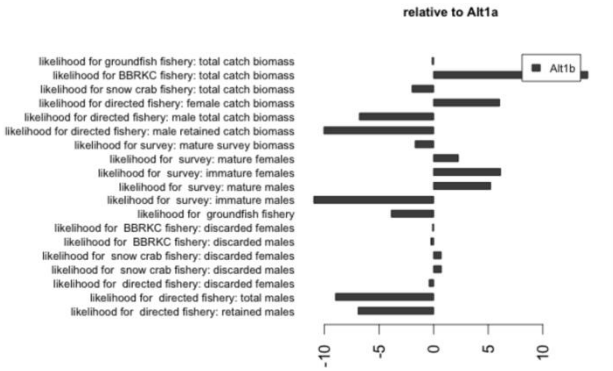


Preferred Model: Alt1a

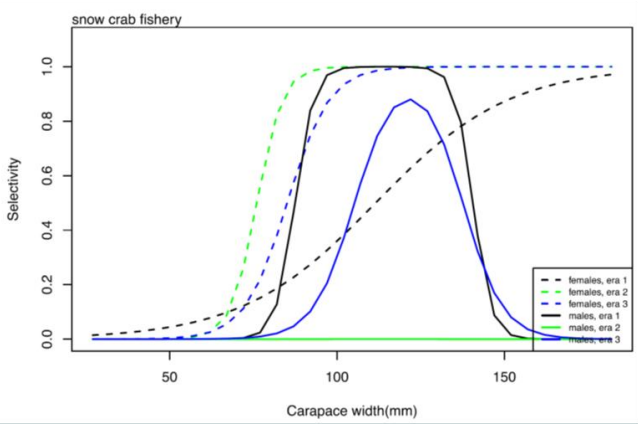
Rationale:

- Alt0- models rejected because they were based on “legacy” fishery data that cannot be recreated
- Alt2-, Alt3- models rejected because none of these models converged despite some extensive parameter searches
- Alt1b model rejected because:
  - Alt1a achieved better fit to data (lower objective function value)
  - Alt1b failed to estimate sensible selectivity curve for male bycatch in snow crab fishery in 1997-2004 time period

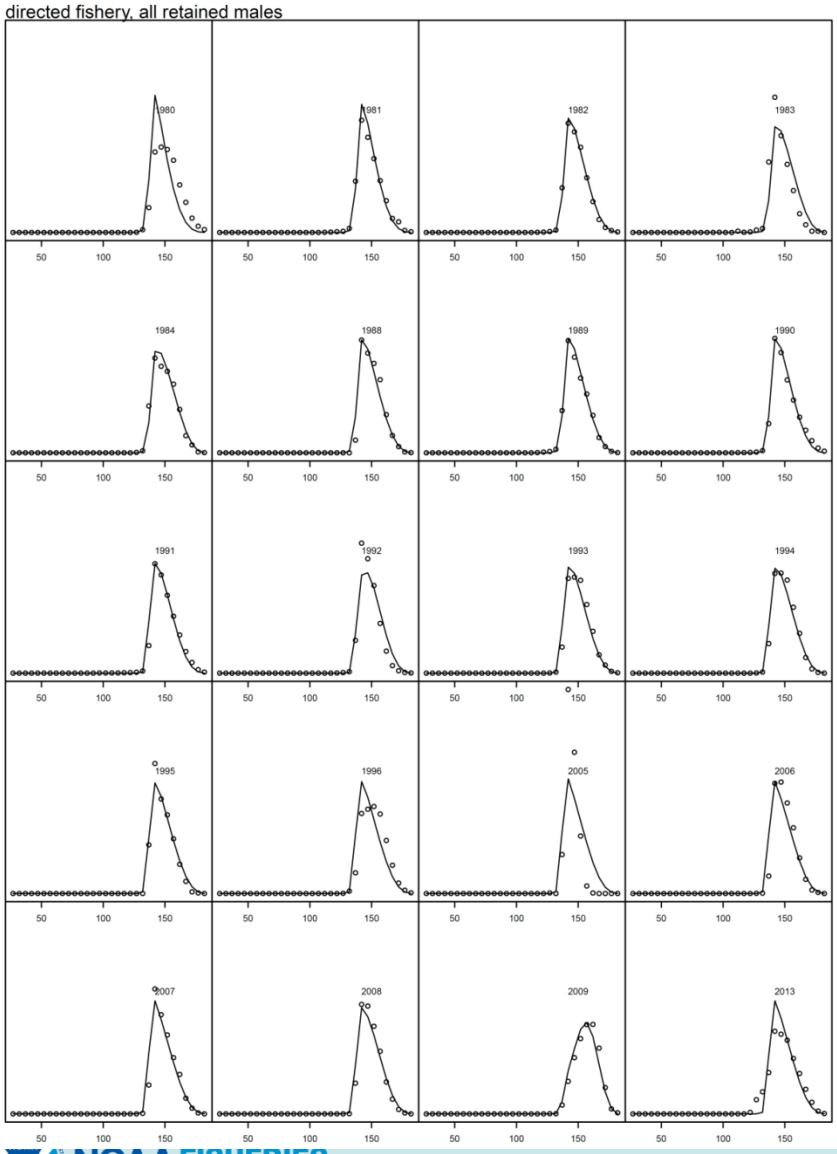


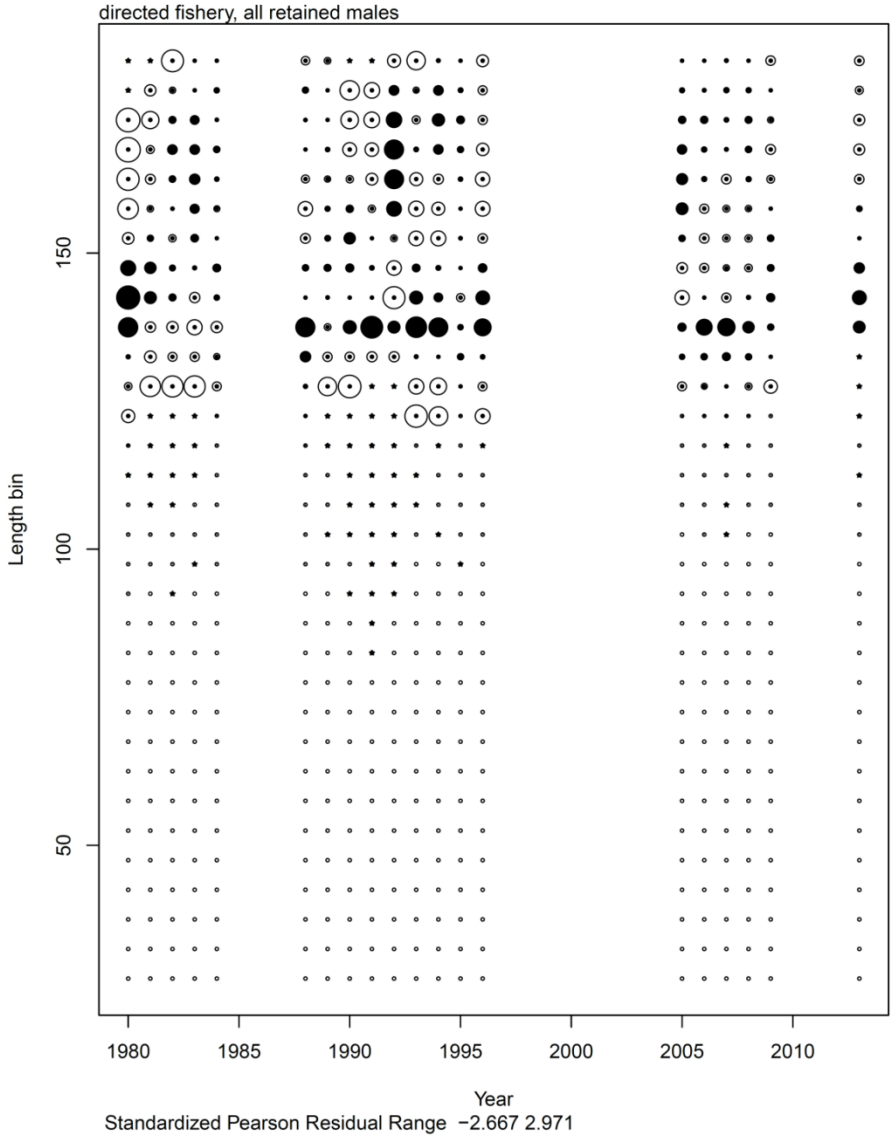


Alt1b

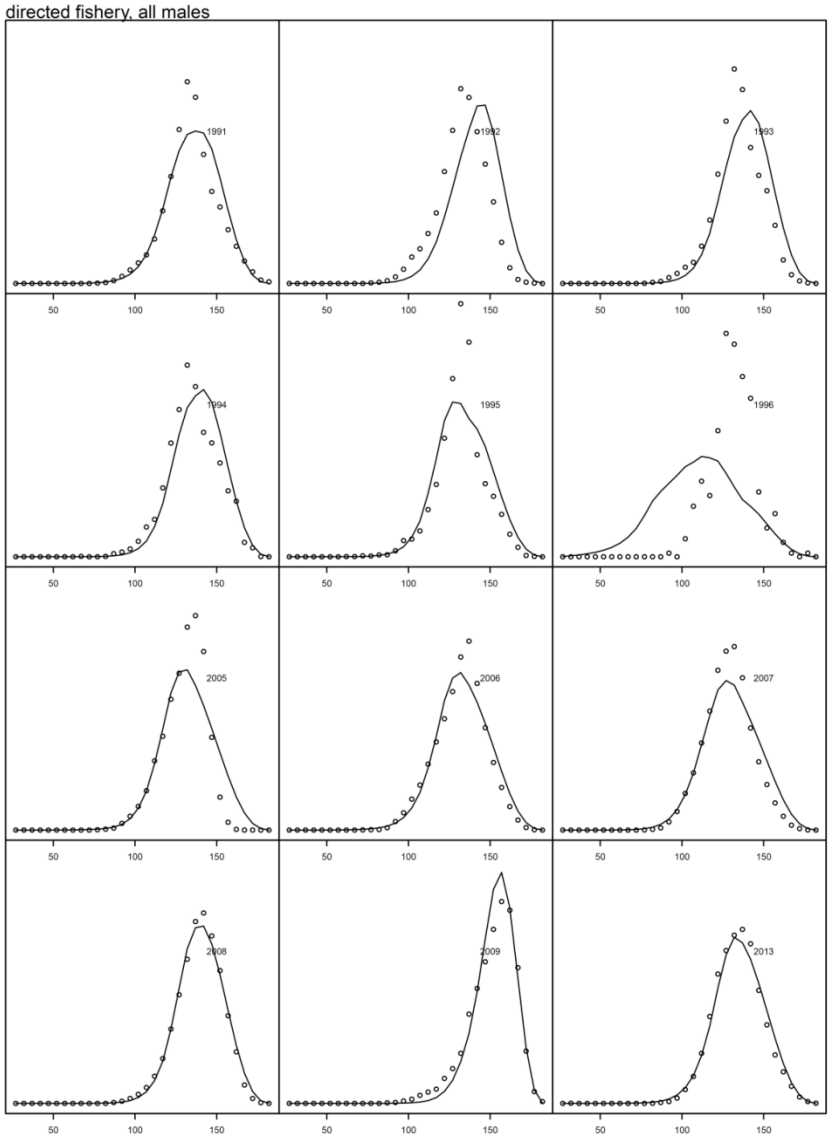


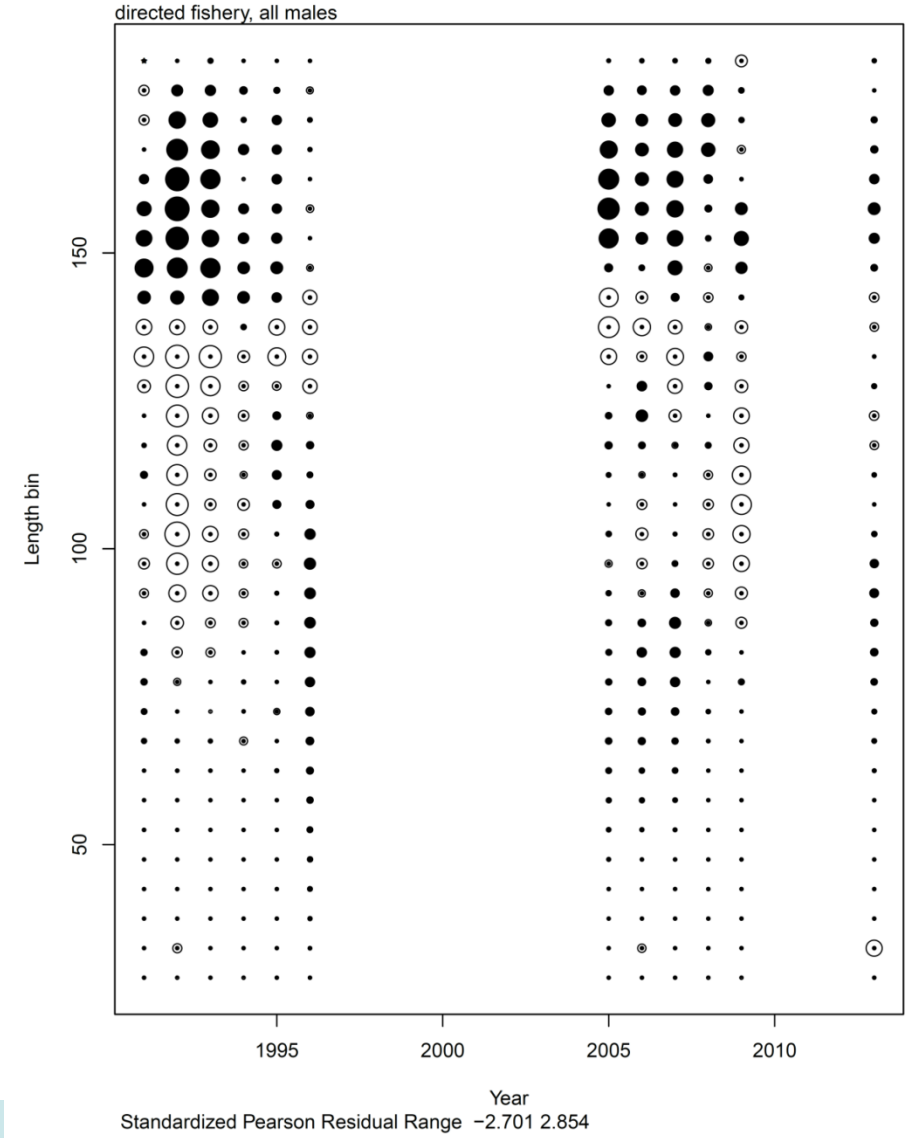
Fits to size compositions: retained males



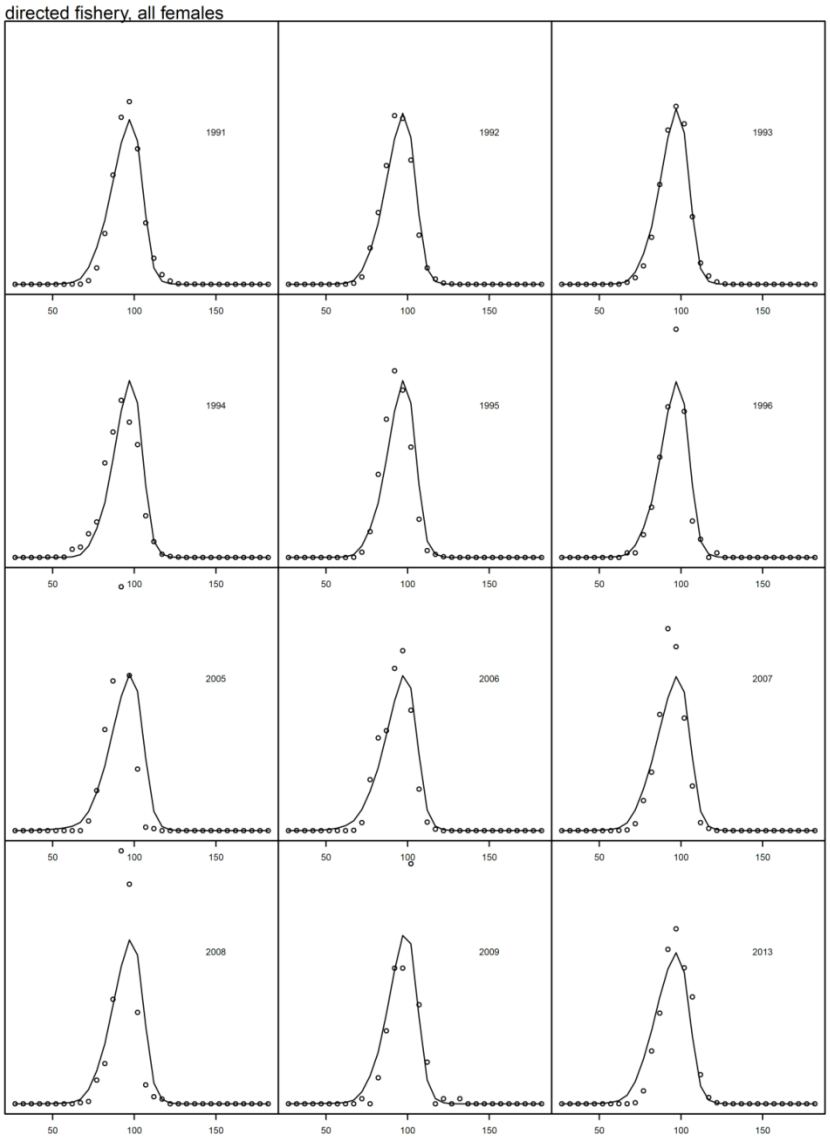


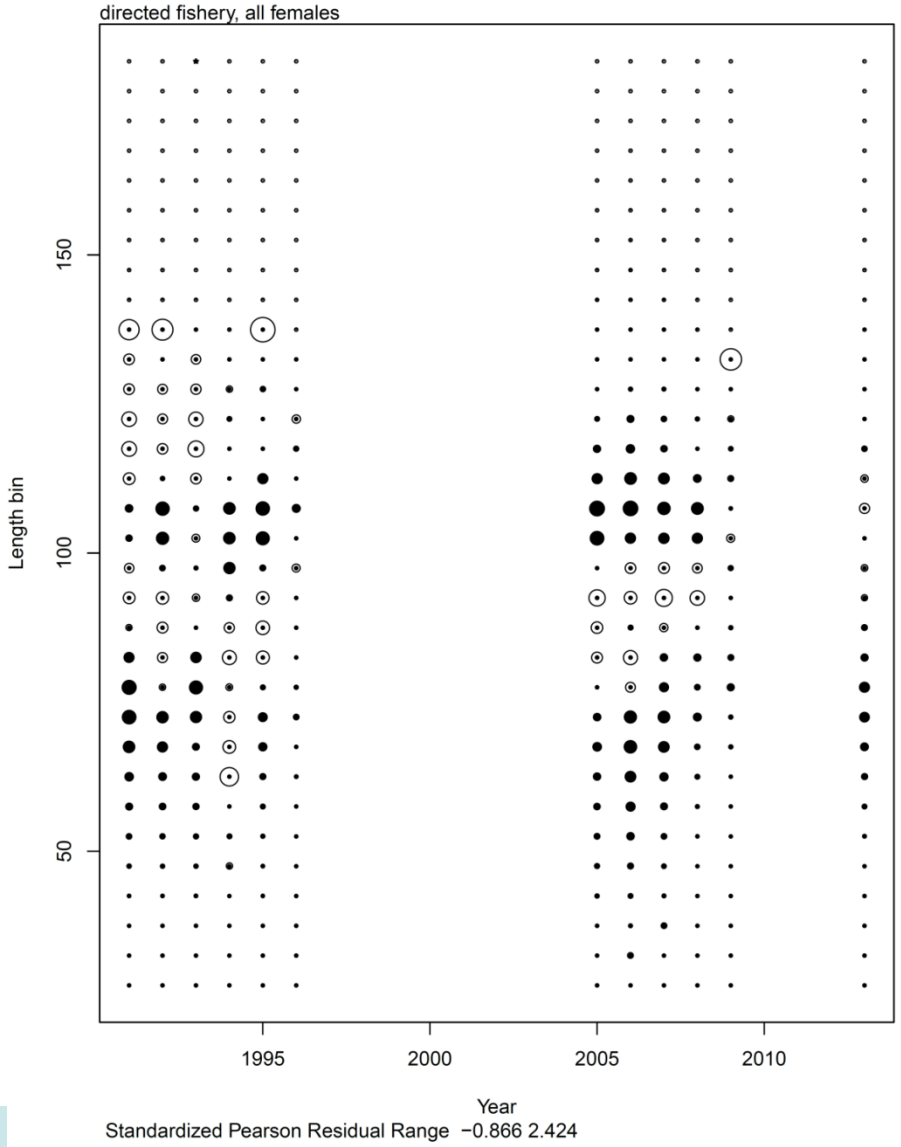
Fits to size compositions: males in directed fishery



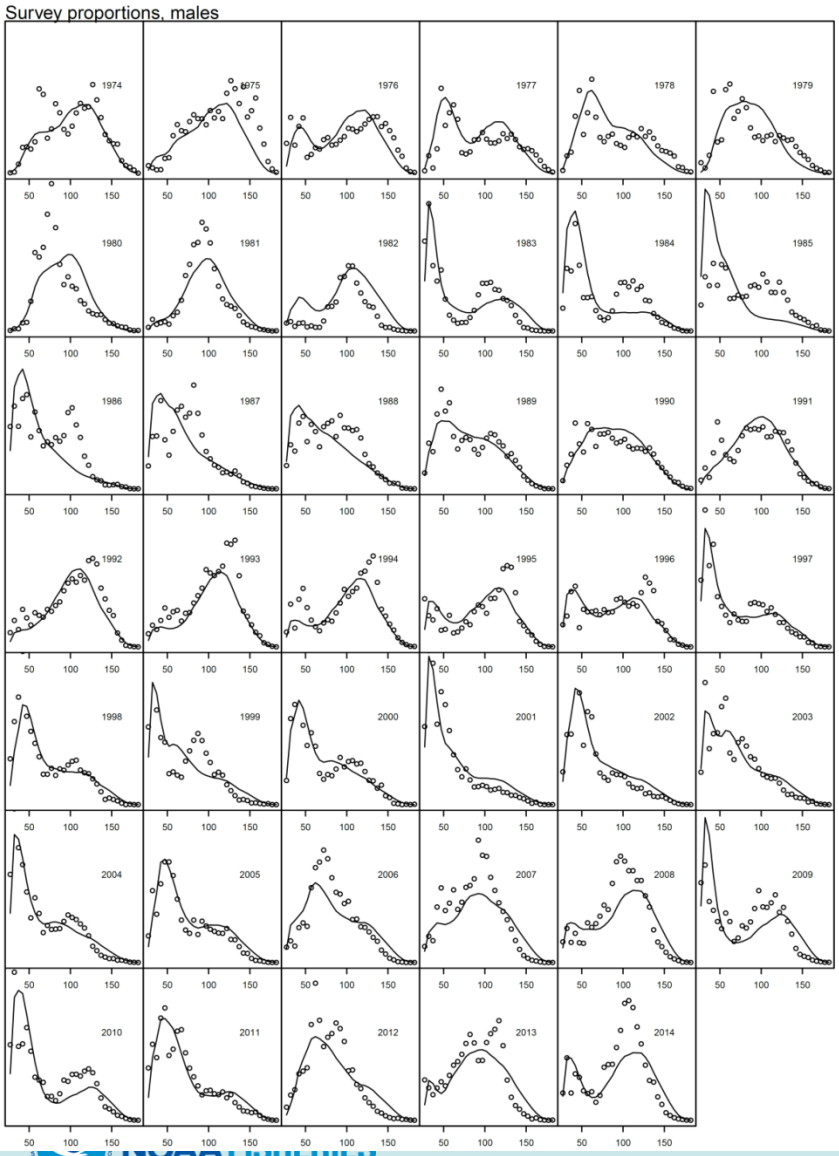


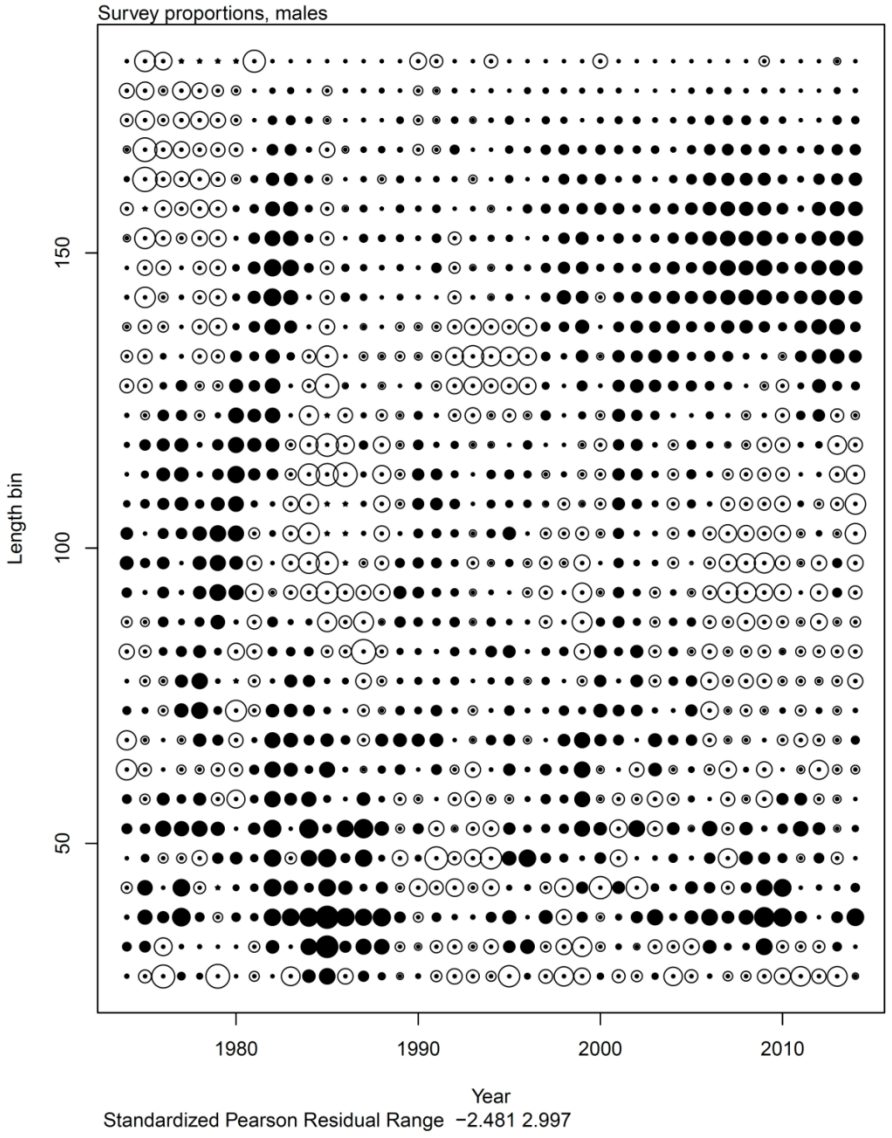
Fits to size compositions: females in directed fishery



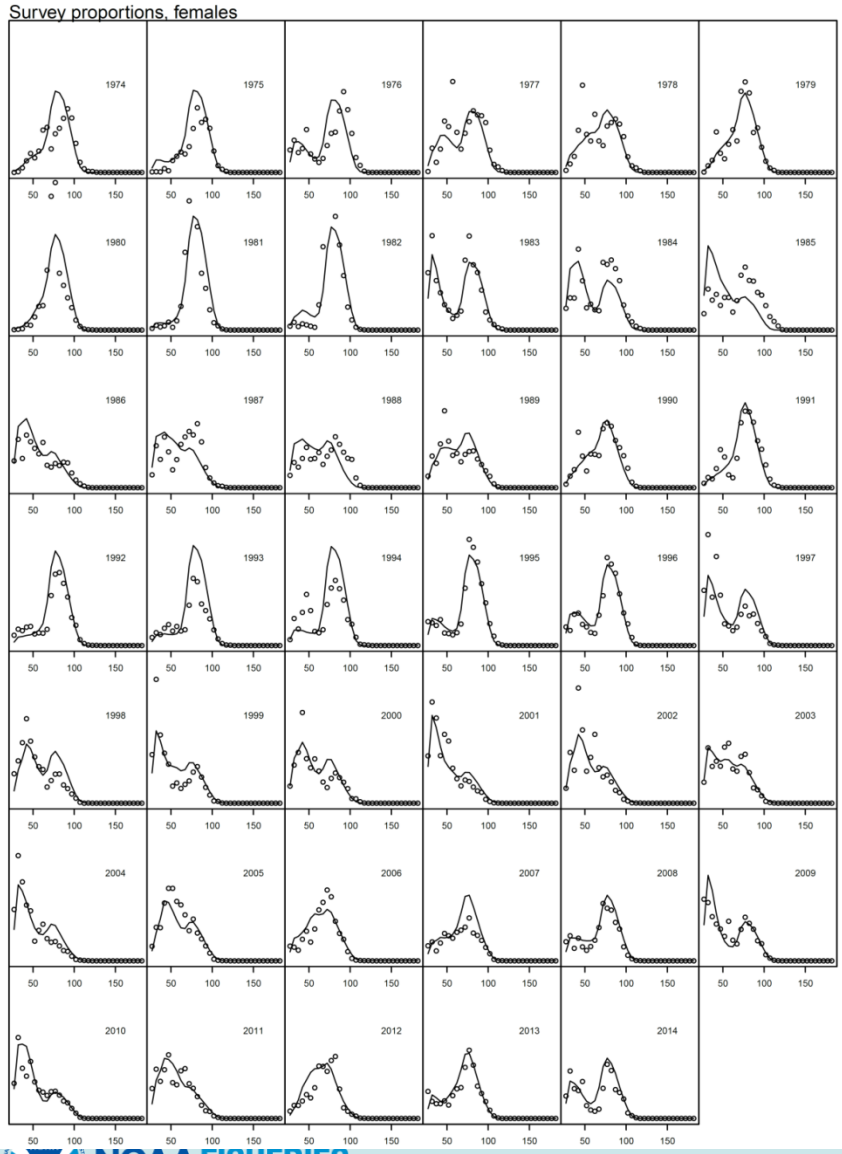


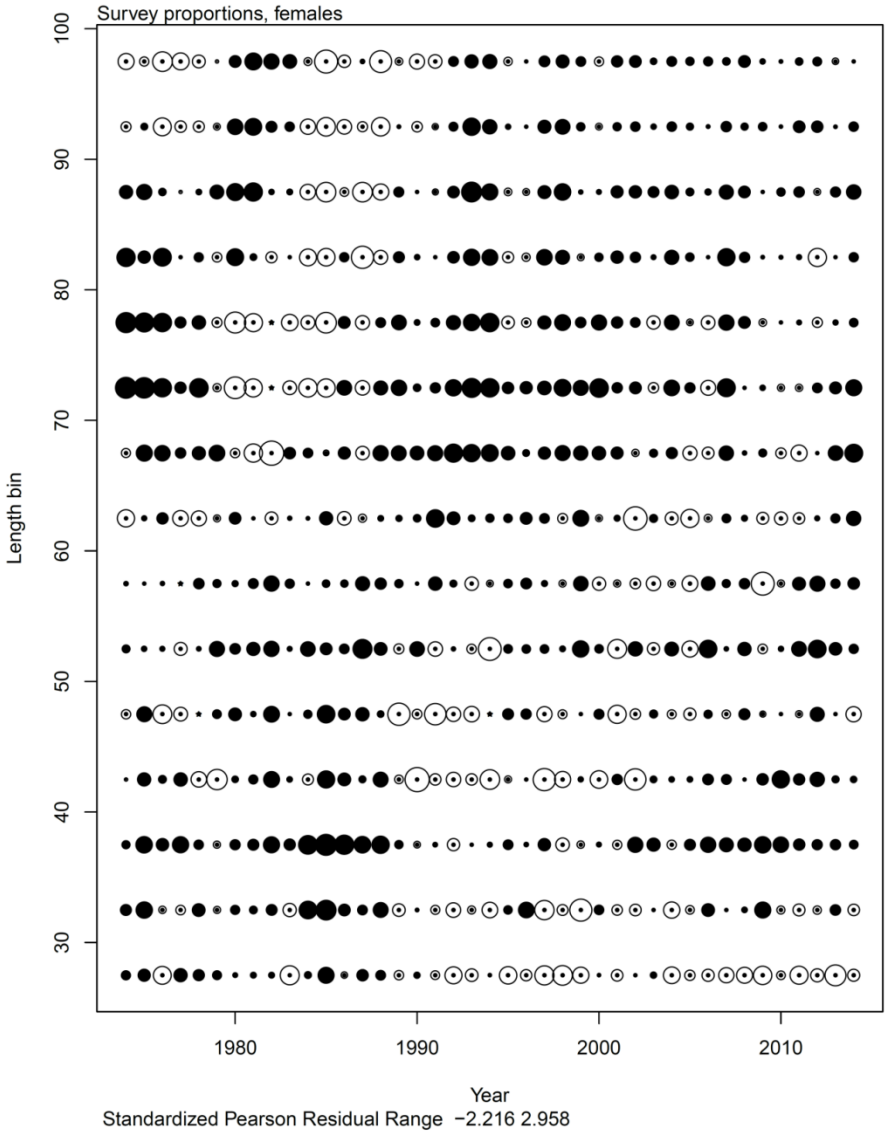
Fits to size compositions: males in the trawl survey





Fits to size compositions: females in the trawl survey





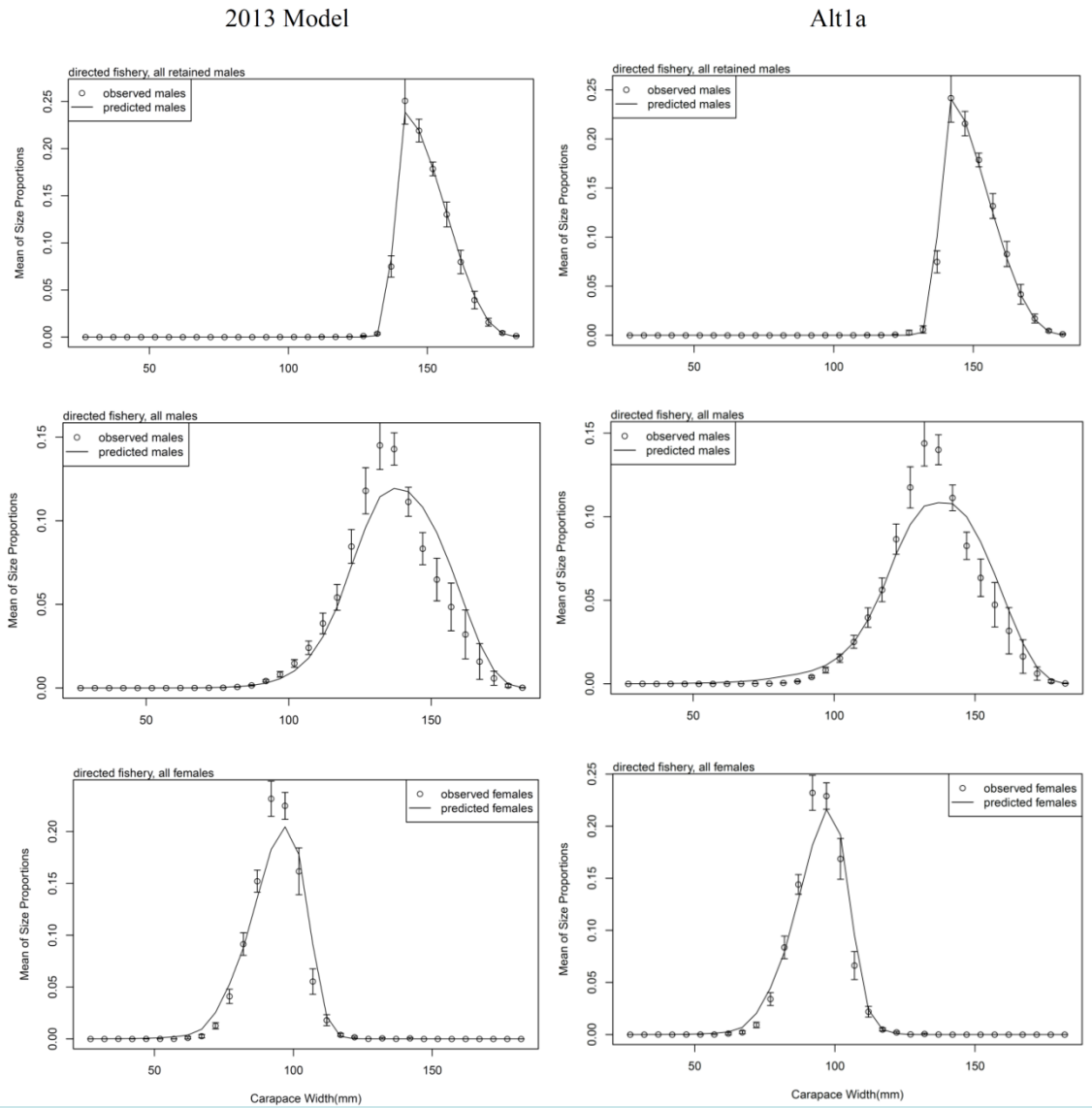
NOAA FISHERIES

Fits to marginal size compositions: directed fishery

Retained males

All males

All females

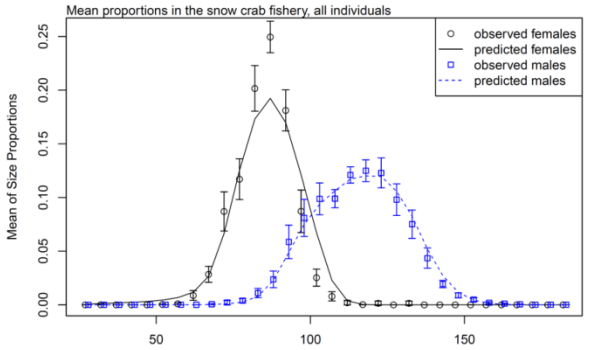


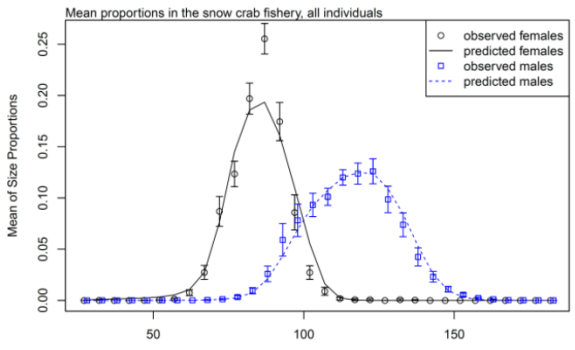
Fits to marginal size compositions: other fisheries

2013 Model

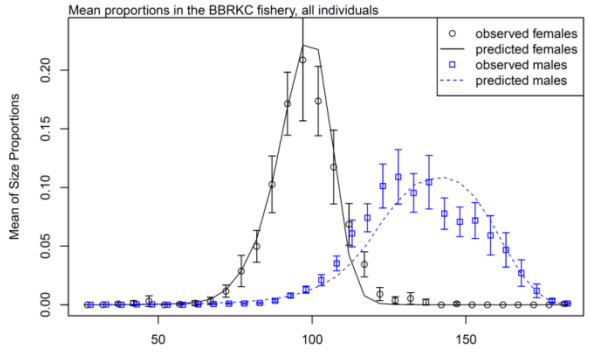
Alt1a

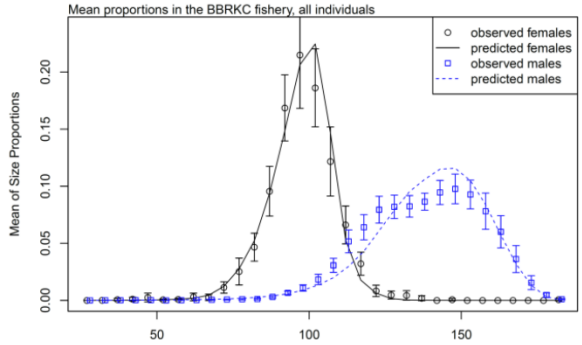
Snow crab fishery



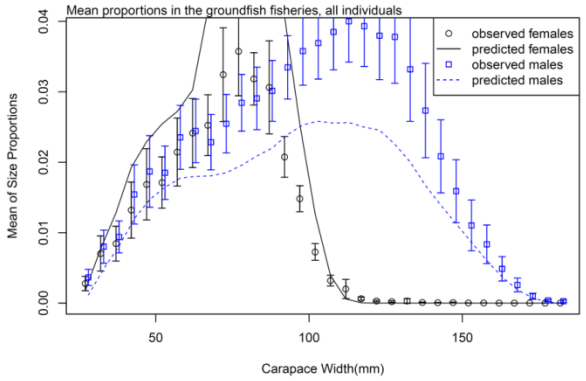


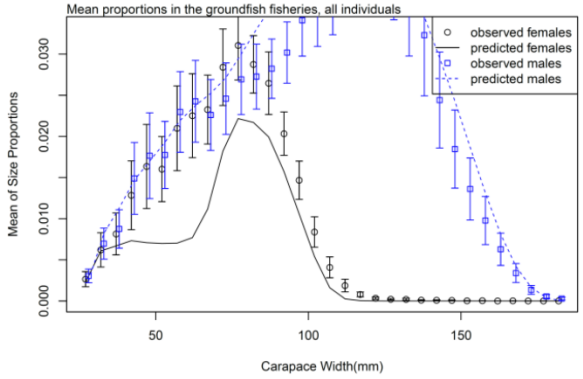
BBRKC fishery





Groundfish fisheries





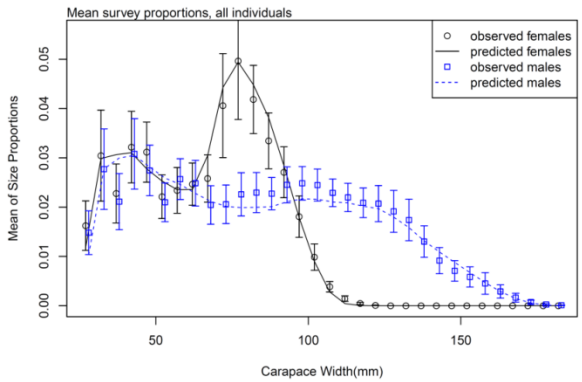
NOAA FISHERIES

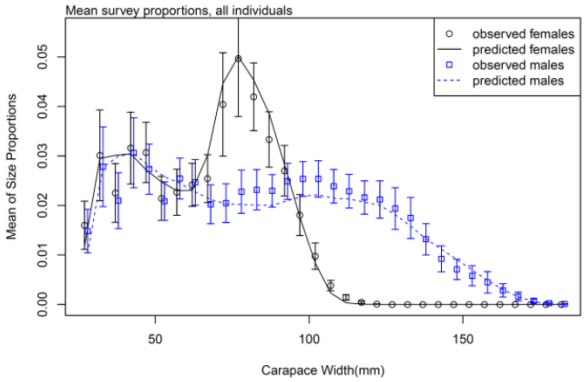
Fits to marginal size compositions: trawl survey

2013 Model

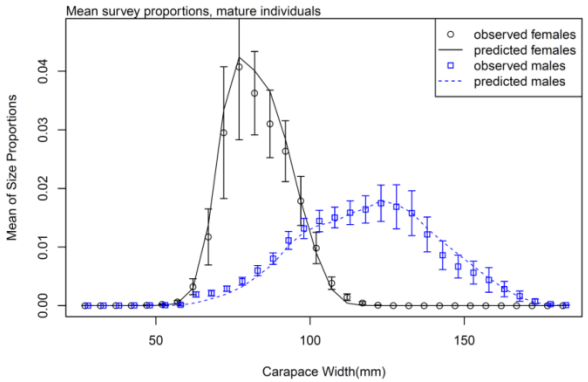
Alt1a

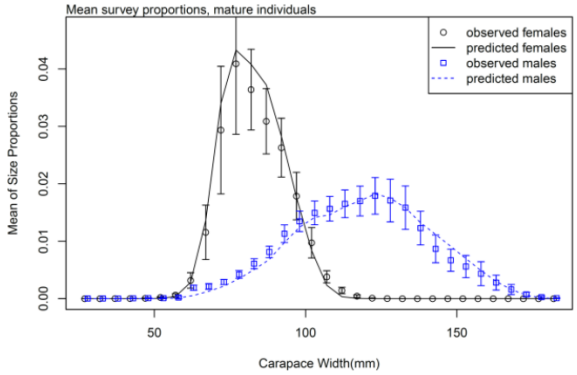
All crab



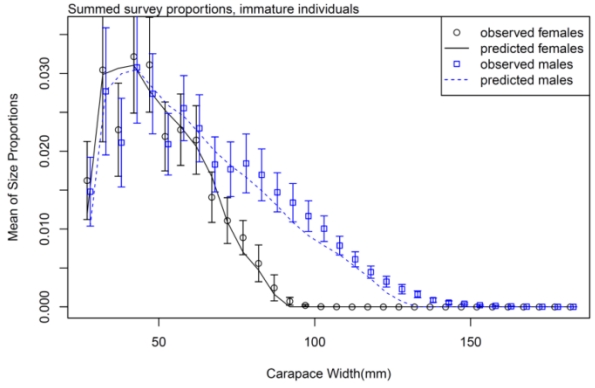


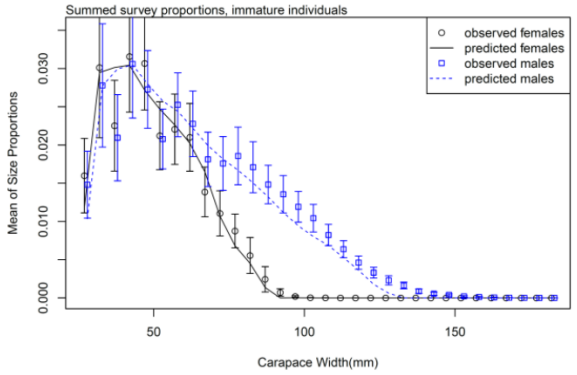
Mature crab





Immature crab

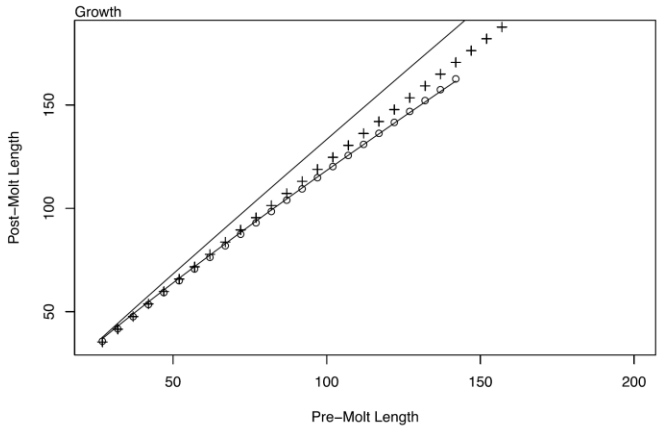




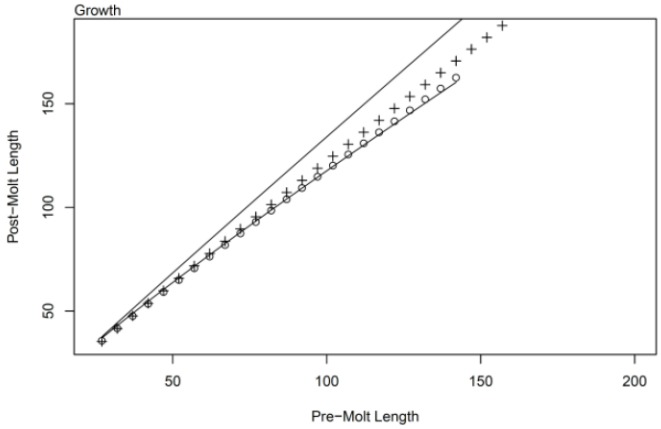
Comparisons with 2013 model

Growth

From 2013 Model

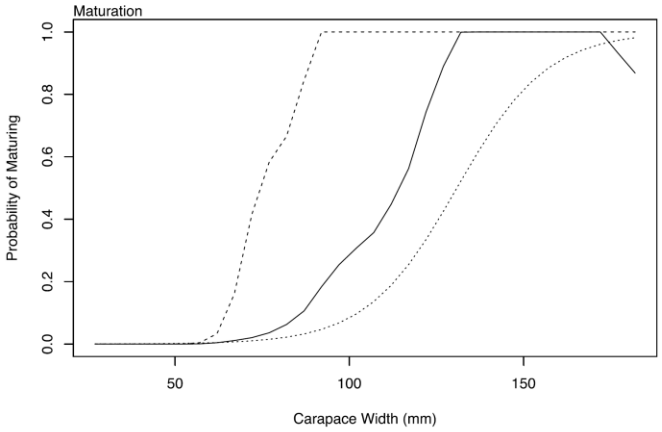


Model Alt1a

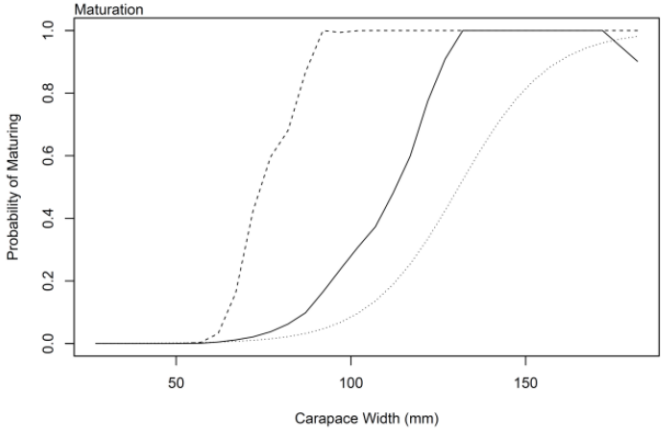


Maturity

From 2013 Model



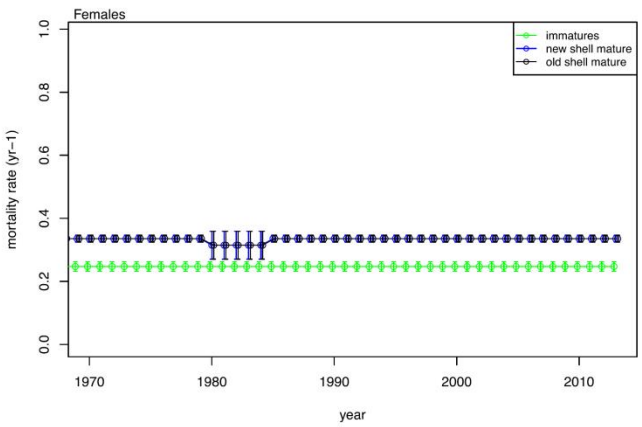
Model Alt1a

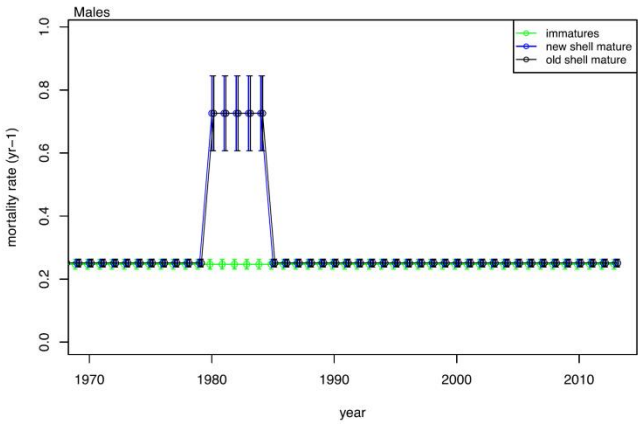


Comparisons with 2013 model

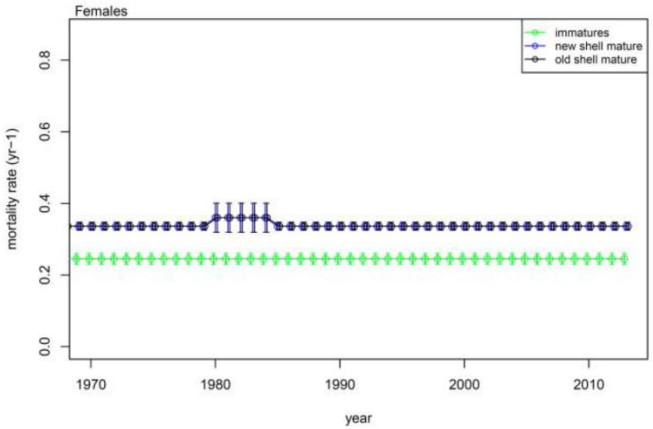
Natural Mortality

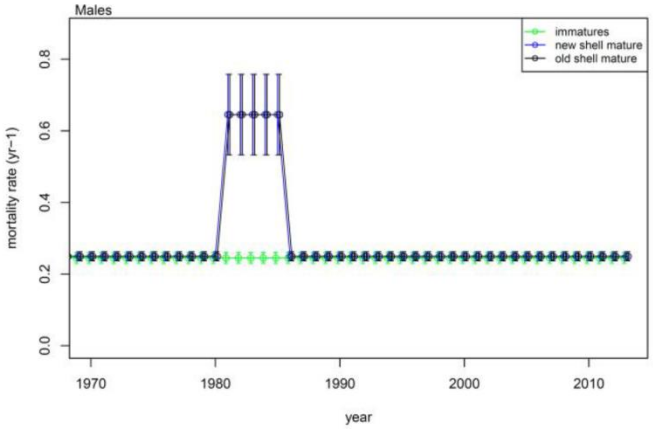
From 2013 Model





Model Alt1a



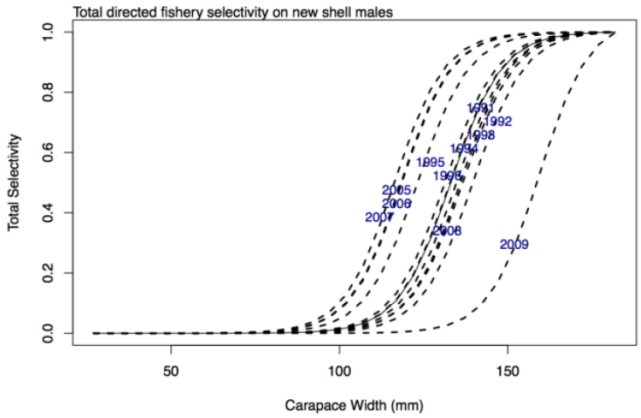


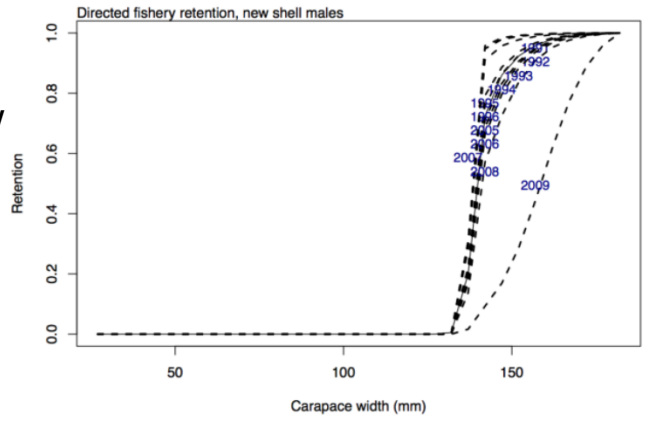
Comparisons with 2013 model

Selectivity on males in the directed fishery

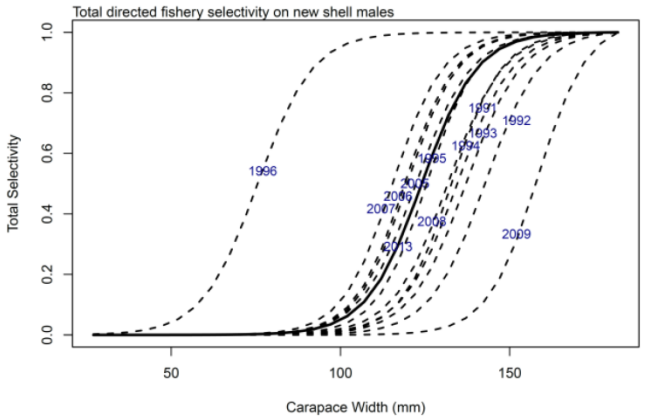
Retention in the directed fishery

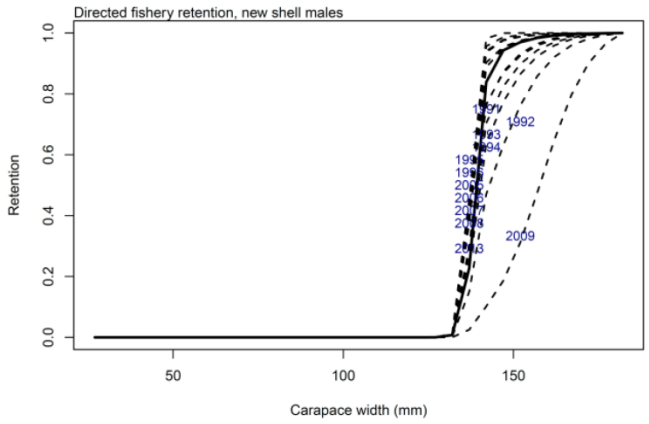
From 2013 Model





Model Alt1a

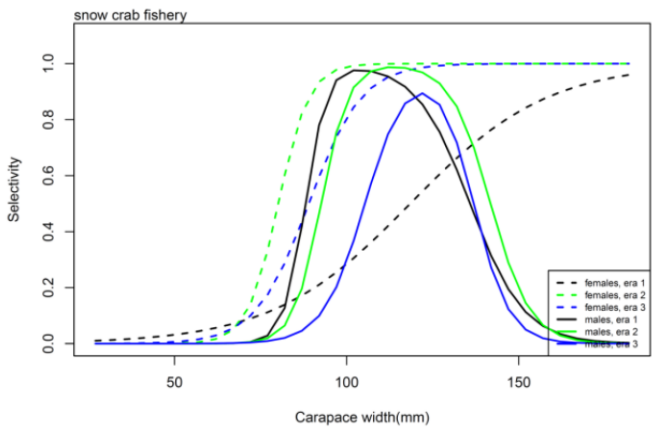




Comparisons with 2013 model

Selectivity in the snow crab fishery

2013 Model



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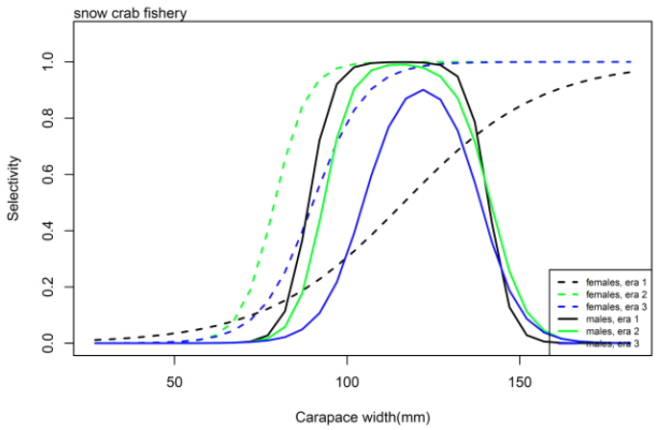
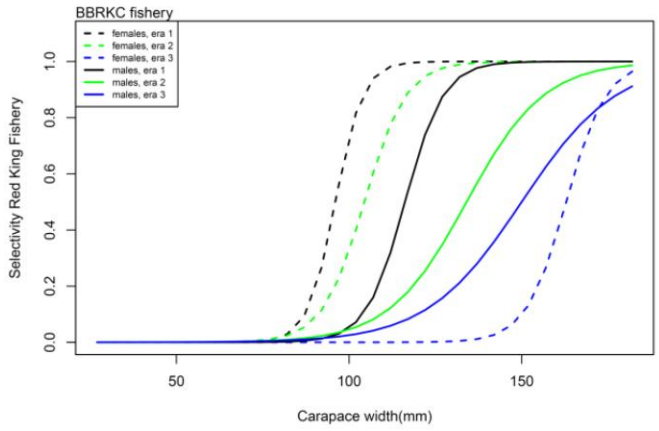


Selectivity in the BBRKC fishery

2013 Model



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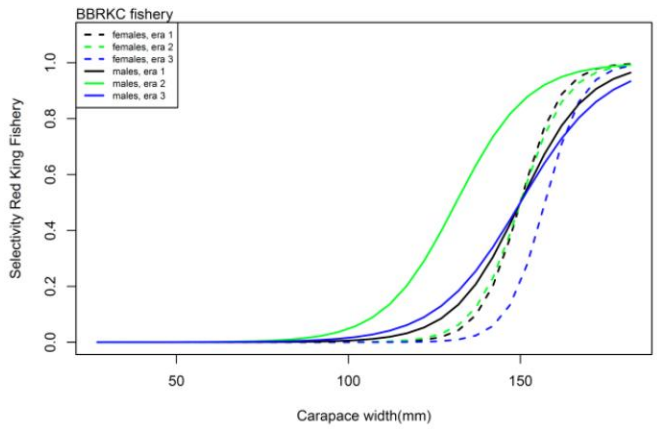
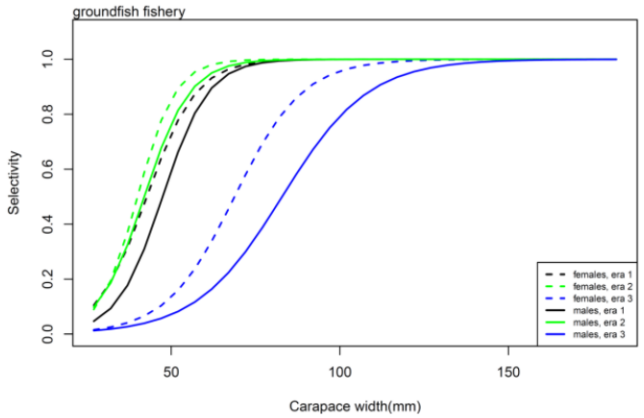


Comparisons with 2013 model

Selectivity in the groundfish fisheries

2013 Model



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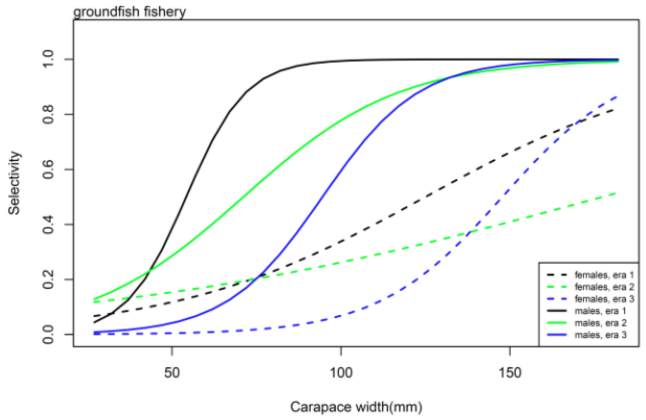
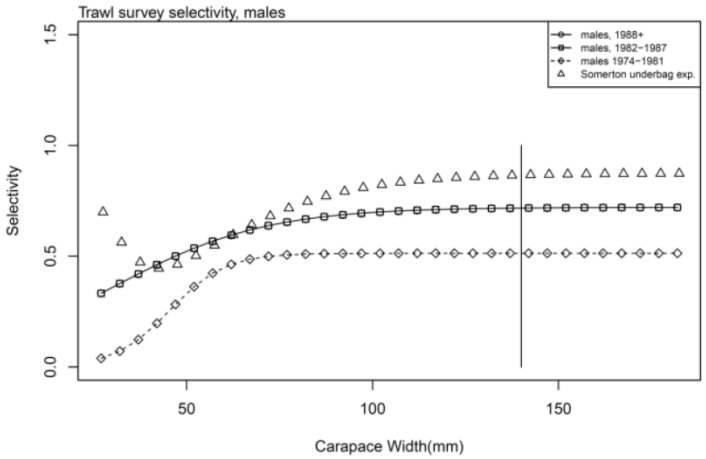
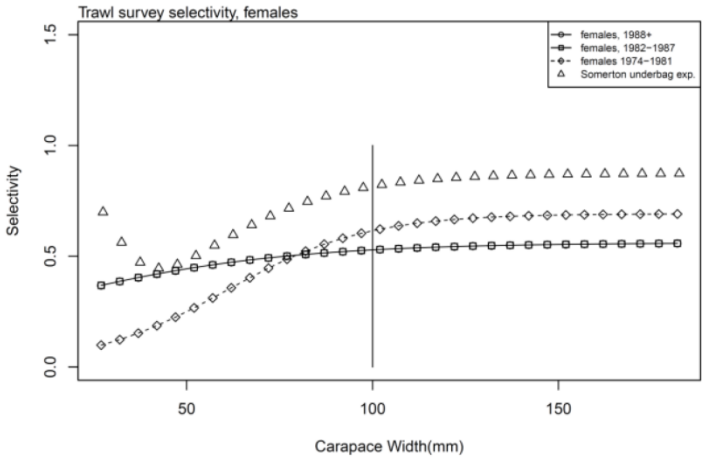


Comparisons with 2013 model

Selectivity in the trawl survey

2013 Model





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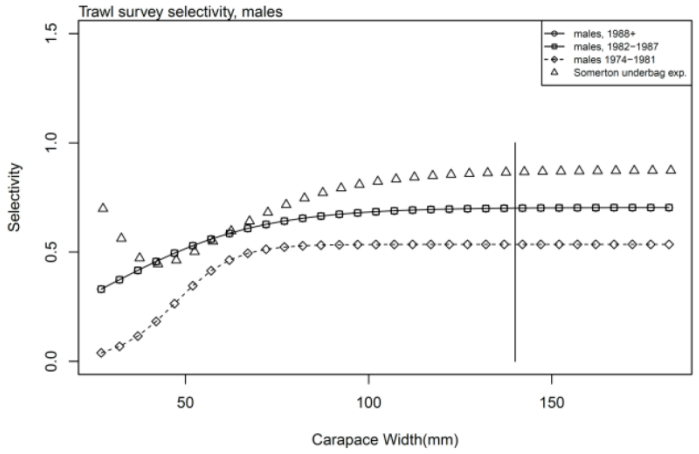
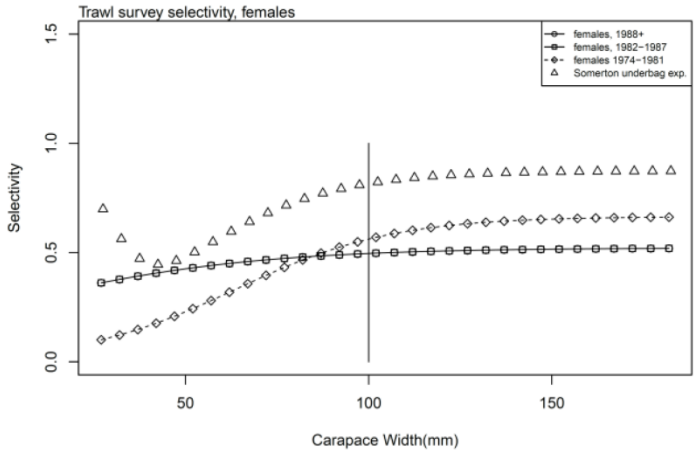
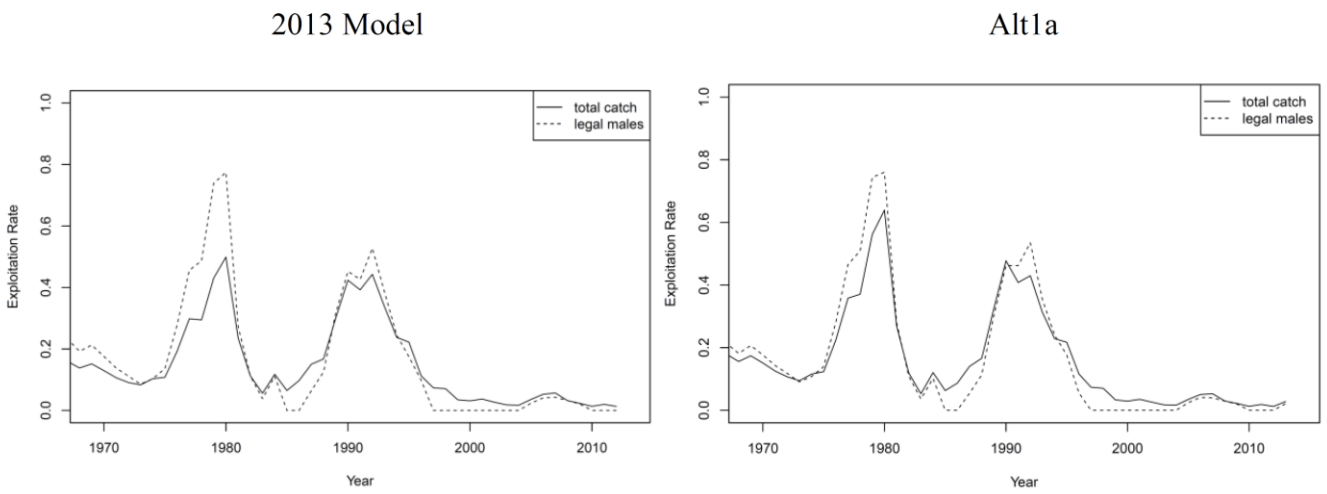




Comparisons with 2013 model

Selectivity in the groundfish fisheries

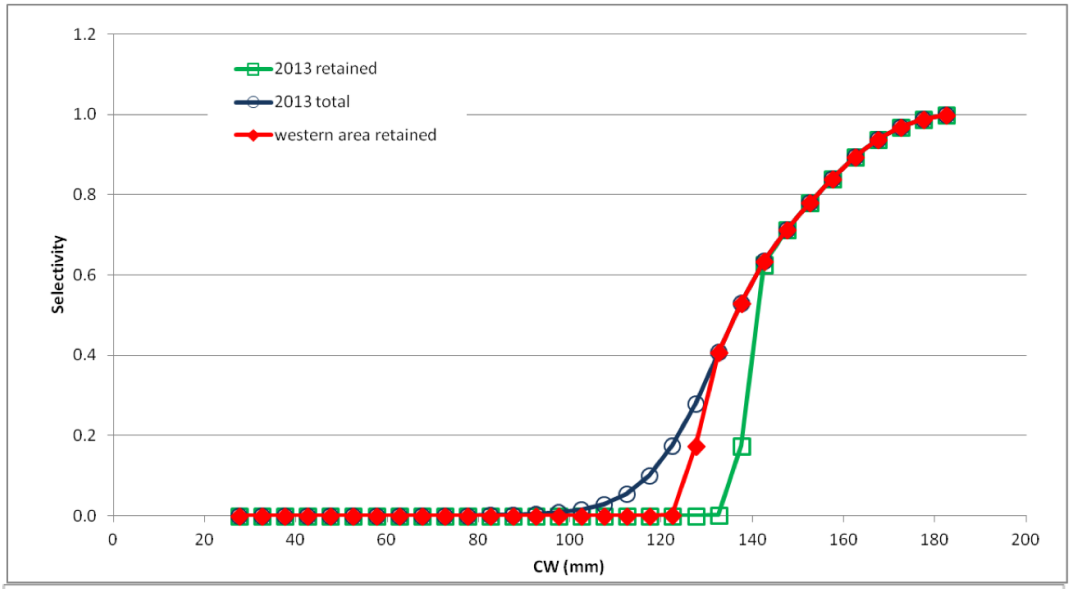
Exploitation rates in the directed fishery



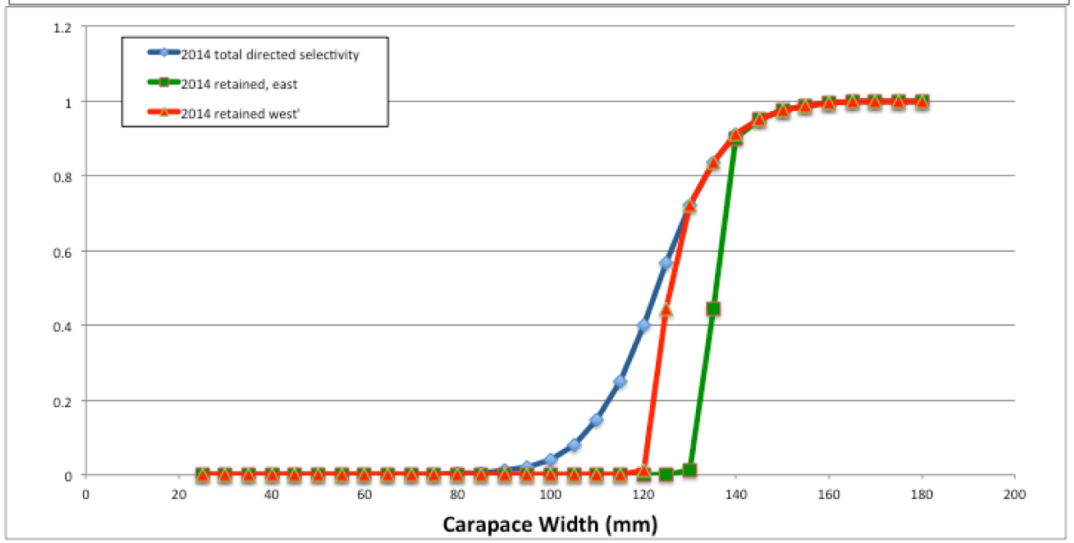
Status Determination, OFL, ABC

Selectivity Curves: Directed Fishery

2013

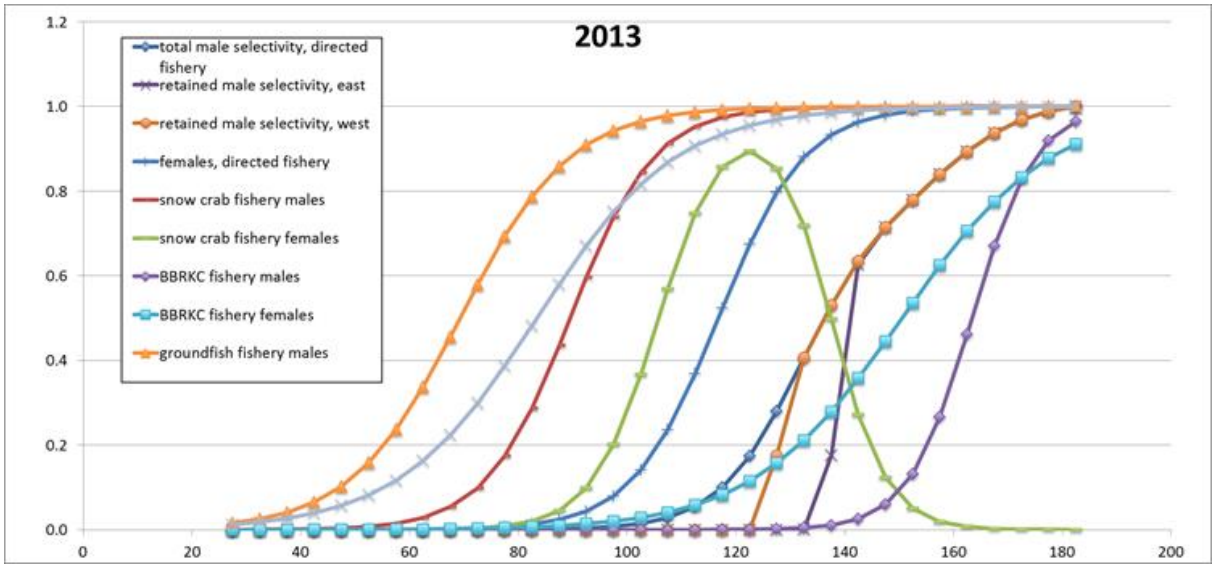


2014

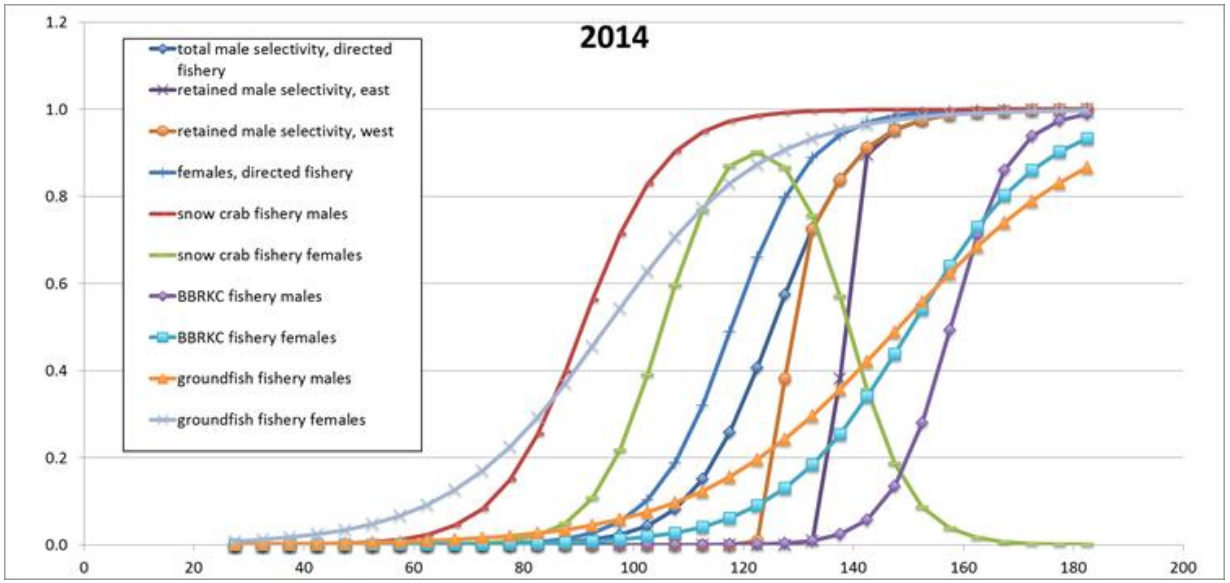


Selectivity Curves: All Fisheries

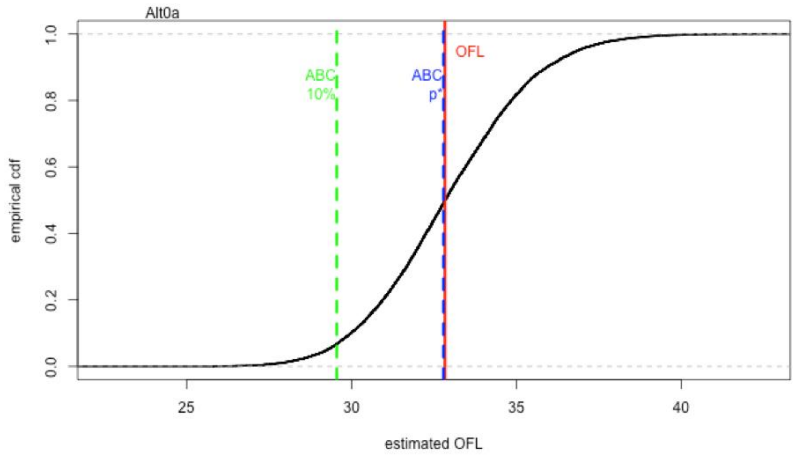
2013

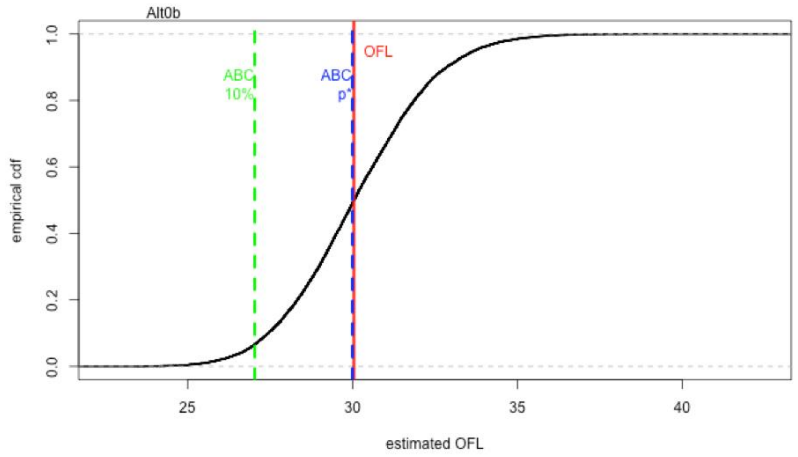


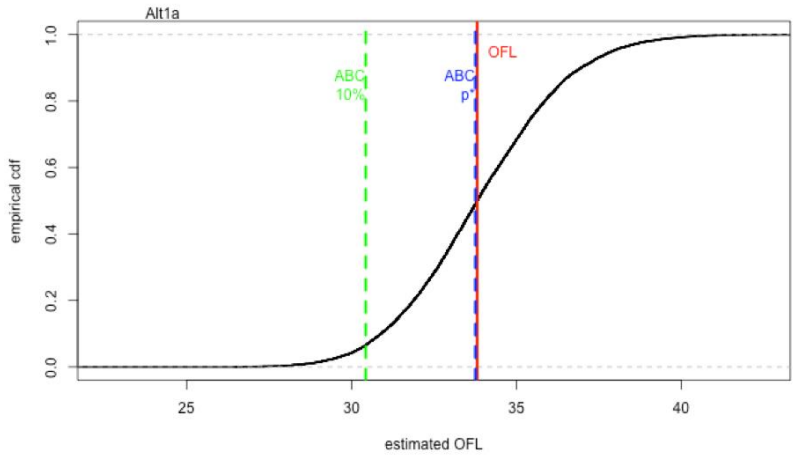
2014

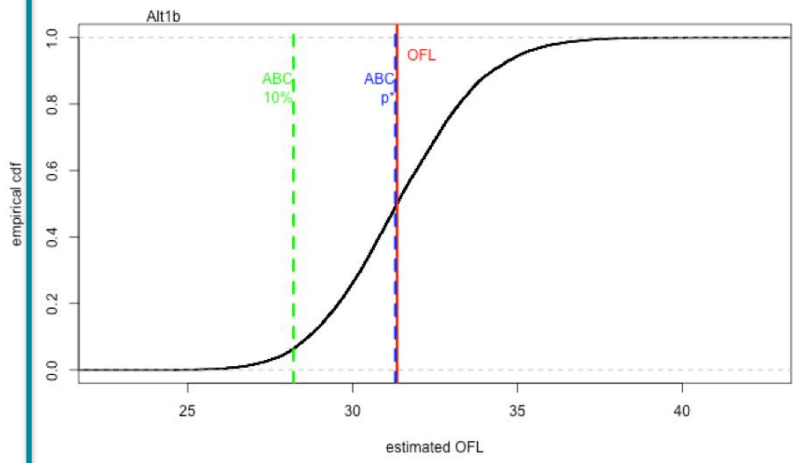


OFL Calculations







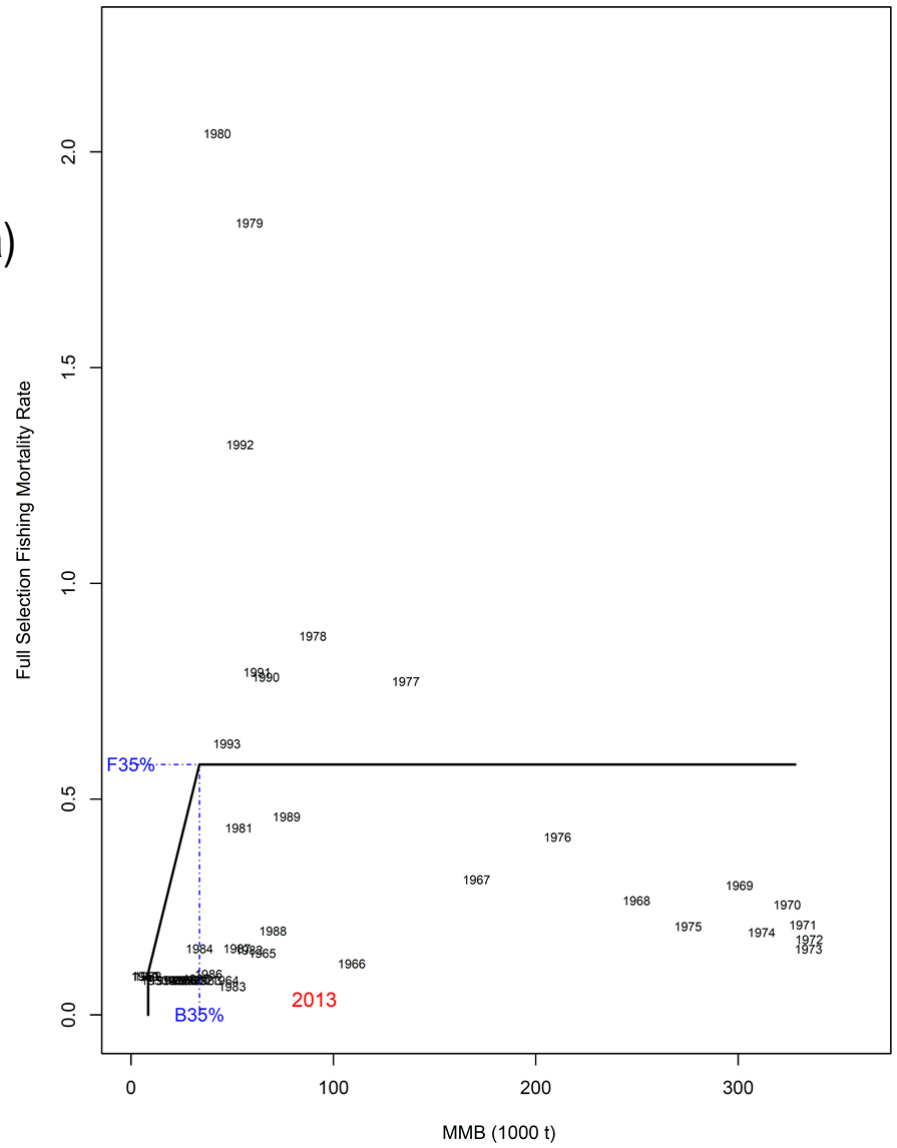


OFL Results

Model Case	average recruitment (millions)	B (1000's t)	Fmsy	Bmsy (1000's t)	B/Bmsy	OFL (1000's t)	ABC (p*) (1000's t)	ABC (10% buffer) (1000's t)
2013	211.9	59.35	0.73	33.54	1.77	25.35	25.31	22.82
Alt0a	206.6	63.91	0.69	32.95	1.94	32.84	32.78	29.55
Alt0b	185.4	59.65	0.61	29.12	2.05	30.04	30.00	27.04
Alt1a	209.7	70.77	0.58	33.95	2.08	33.81	33.76	30.43
Alt1b	187.0	63.37	0.61	29.51	2.15	31.35	31.30	28.21

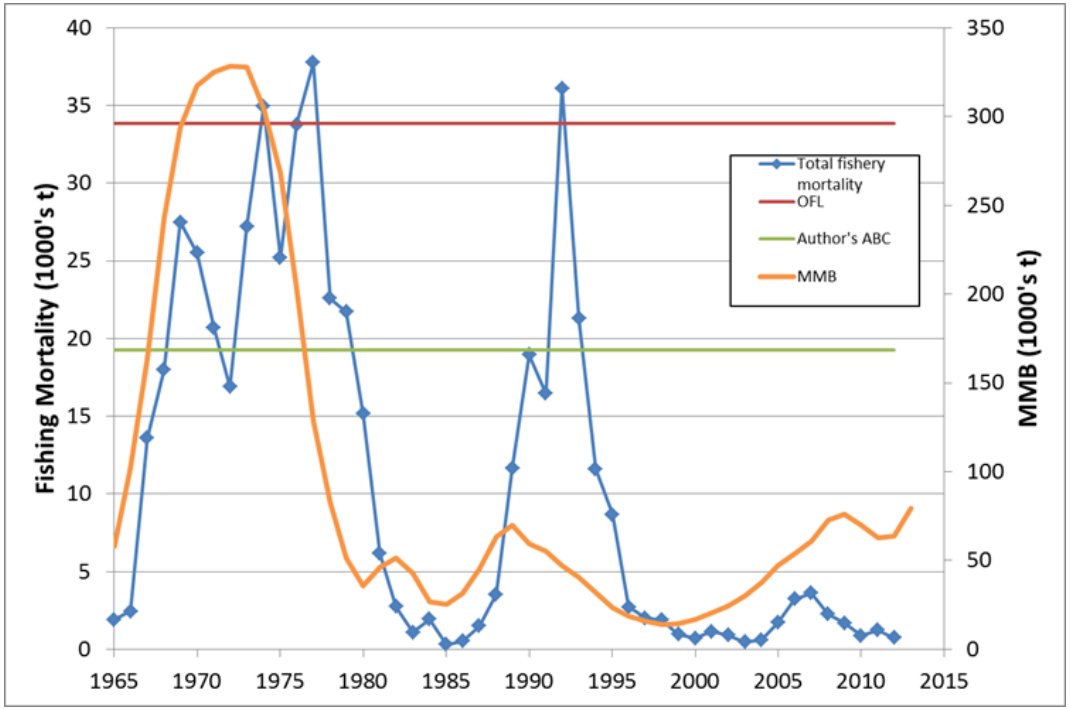
Tier 3 Quad Plot

- Author's preferred model (Alt1a)



Author's Recommended ABC

- p* ABC = 33.76 thousand t
- 10%Buffer ABC = 30.43 thousand t
- Last year, ABC set using step 2 of a 3-step staircase to ABC_{max}
- Author suggests remaining at step 2 based on:
  - uncaptured model uncertainty
  - uncertainty in stock productivity
- Author's ABC
  - 2/3*[p* ABC] = 22.51 thousand t



Basis for the OFL

- Preferred Model: Revised Data, Old Fishing Mortality, Pot Fishery Handling Mortality = 50%
- 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	33.95	70.77	2.08	0.58 yr^{-1}	1982-2014	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	74.85	156.02	2.08	0.58 yr^{-1}	1982-2014	0.23 yr^{-1}

- **Not overfished**

Management Reference Points

- Management Performance (1000's t)

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Catch Mortality	OFL	ABC
2009/10	41.90	28.44	0.61	0.60	1.64	2.27	
2010/11	41.67	26.73	0.00	0.00	0.87	1.45	
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	53.10	1.41	1.26	2.78	25.35	17.82
2013/14		70.77				33.81	22.51

- Management Performance (millions lbs)

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2009/10	92.37	62.70	1.34	1.32	3.62	5	
2010/11	91.87	58.93	0.00	0.00	1.92	3.2	
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	37.42	117.07	3.11	2.78	6.14	55.89	39.29
2013/14		156.02				74.54	49.63

- **No overfishing**

Future Directions

Future Directions

- May 2015: Finish developing TCSAM2015
  - new model code
  - 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
  - revisit handling mortality issue with more thorough analysis
  - incoroporate revised trawl survey data
- Extended:
  - incorporate chela height data directly in model
  - disaggregate East/West directed fisheries in model
  - disaggregate bycatch in groundfish pot, trawl fisheries in model