BSAI Crab Management

AIGKC specs and Crab Plan Team Report

Agenda Item C-3
June 2018

May 2018 Crab Plan Team Report

Administration

- Membership: Jack Turnock (NMFS) retired, CPT will seek nominations for this and other vacancies
- General Recommendation: A standard set of plots should be prepared to summarize the B0 calculations for each model-based crab assessment.
  - Plot 1 should compare dynamic B0 and the estimated time series of mature male biomass.
  - Plot 2 should plot the B0 depletion ratio, MMB/B0.
  - Plot 3 should plot the estimated recruitment time series.
  - These plots should be collated, and used to develop recommendations on the use of B0 in Bering Sea crab assessments at the September 2018 CPT meeting for subsequent SSC review.

May 2016 Crab Plan Team Report

- Recommend final OFL/ABC for AIGKC
- Tanner, snow, BBRKC model updates
- Crab aging study
- **G**eneralized **M**odeling for **A**laskan **C**rab **S**tocks (GMACS) for BBRKC
- Norton Sound RKC discussion
- Research Priorities
- Crab Economic SAFE
- Other updates (Tanner MSE, BSFRF, NPRB growth project, crab observer data)

BSAI Crab Stocks Management Timing

Aleutian Islands golden king crab
Pribilof Islands golden king crab *
Western Aleutian Islands(Adak) red king crab *

Assessed in May/June

Now on triennial cycle, next assessment in 2020

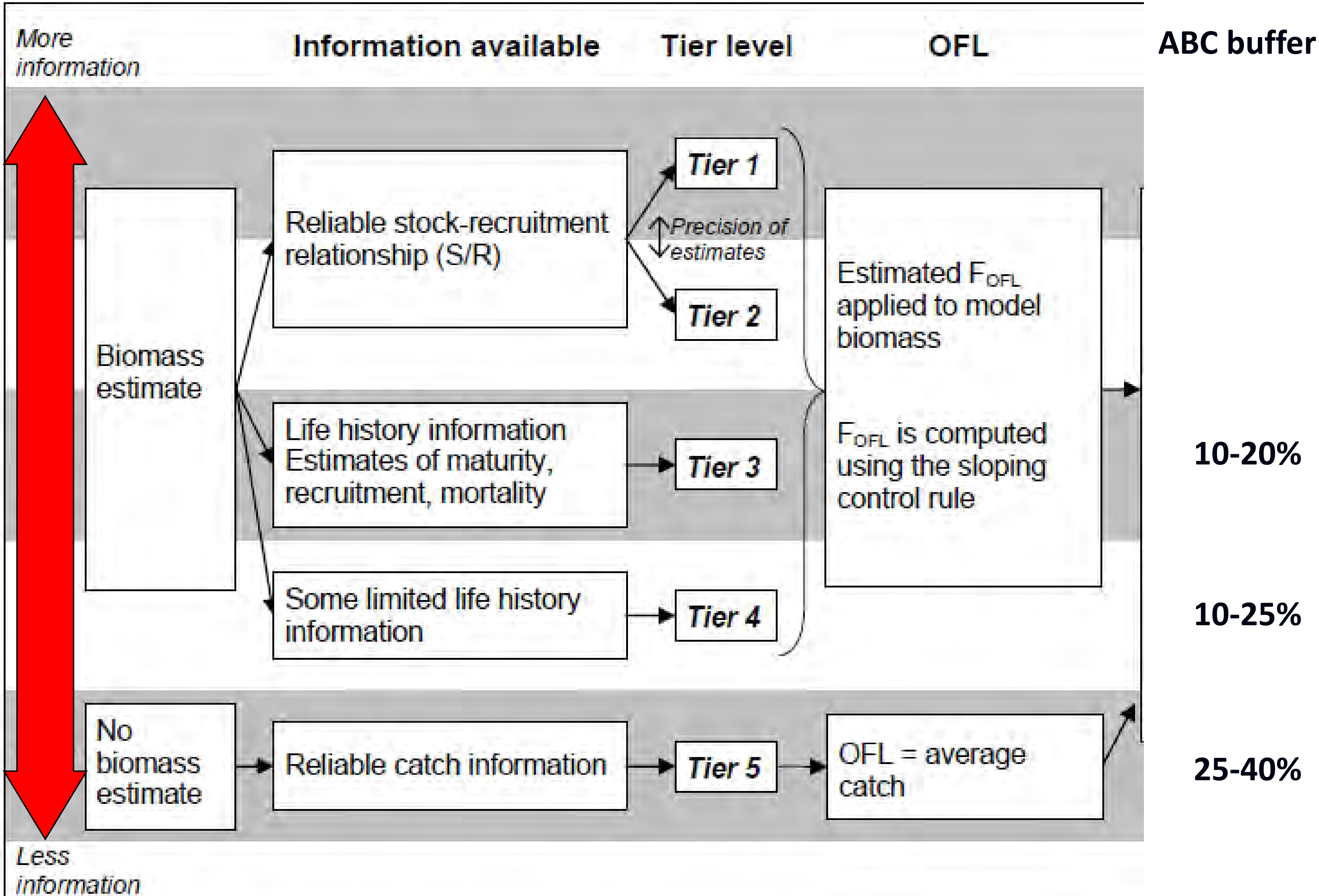
EBS snow crab
Bristol Bay red king crab
Tanner crab
Pribilof Islands red king crab *
Pribilof Islands blue king crab *
St. Matthew blue king crab

Assessed in September/October

Norton Sound red king crab

Assessed in January/February

BSAI Crab Stocks Management



Aleutian Islands Golden King Crab Final Stock Assessment

M.S.M. Siddeek et al

Alaska Department of Fish and Game

CPT comments September 2017

Comment 1: The CPT recommended moving forward with the modeling convention adopted by the Groundfish Plan Teams.

Response:

Followed this naming convention: 17_0 refers to model was established in 2017 and carried forward to 2018; no major changes occurred in 2018 and remain at the 0-level. 17_0a refers to a minor change to 17_0;

Comment 2: a) Reconsider what crabs are mature vs immature via breakpoint analysis; b) Repeat the breakpoint analysis using log (CH/CL) vs CL, rather than the logCH vs. logCL; c) Because it was based on an inappropriate analysis, there is no need to show models with a logistic maturity curve, unless an improved approach can be found.

Response:

We used the log(CH/CL) vs. CL plot to get a better delineation of points for breakpoint analysis (see Appendix C figures). We used the breakpoint 50% maturity length for maturity determination in all scenarios. Sizes ≥111 mm CL were treated as mature and below those sizes immature.

Comment 3: It is appropriate to use only the equilibrium abundance as a starting point.

Response:

We used the equilibrium starting point in all scenarios.

CPT comments September 2017

Comment 4: Moving forward, do not look at the core data.

Response:

We are not using the core data, but we have analyzed the independent pot survey data to estimate CPUE indices and incorporated them in the model as a separate scenario (17_0f). In the future we intend to use a spatio-temporal model to analyze the independent pot survey data.

Comment 5: Continue analysis of spatio-temporal variation of the fishery using a program like VAST.

Response:

We did a preliminary analysis of observer data using a spatio-temporal deltaGLMM (VAST) and estimated an additional set of CPUE indices (see Appendix B) for scenario 17_0a. VAST requires spatially explicit catch data and some measure of 'area fished'. This type of information is available from the observer data, which include soak time, lat. and long., and depth. These types of data are not available from dock side sampling; therefore, observer data are more suitable for VAST type of analysis.

However, unlike the open West Coast Sea or Bering Sea, the Aleutian Islands areas provide additional constraints for spatial analysis due to the edge effects from the many islands. More work is needed for improvement of spatial analysis.

CPT comments September 2017

Comment 6: Show a scenario with the McAllister and Ianelli re-weighting for comparison when choosing preferred model.

Response:

We provide scenario 17_0e, which considers McAllister and Ianelli method of re-weighting (see Appendix D).

Comment 7: Consider interaction terms, specifically area x year interaction for CPUE standardization.

Response:

We standardized the CPUE considering the Year: Area interaction for scenario 17_0c (see Appendix B). The problem with this interaction analysis is that a lot of NAs occurred for many missing factor levels over the years. Anyway, we used the resulting CPUE indices in scenario 17_0c.

Comment 8: Consider scenarios with catchability and/or total selectivity breaking at a third point in 2010 (or a better year).

Response:

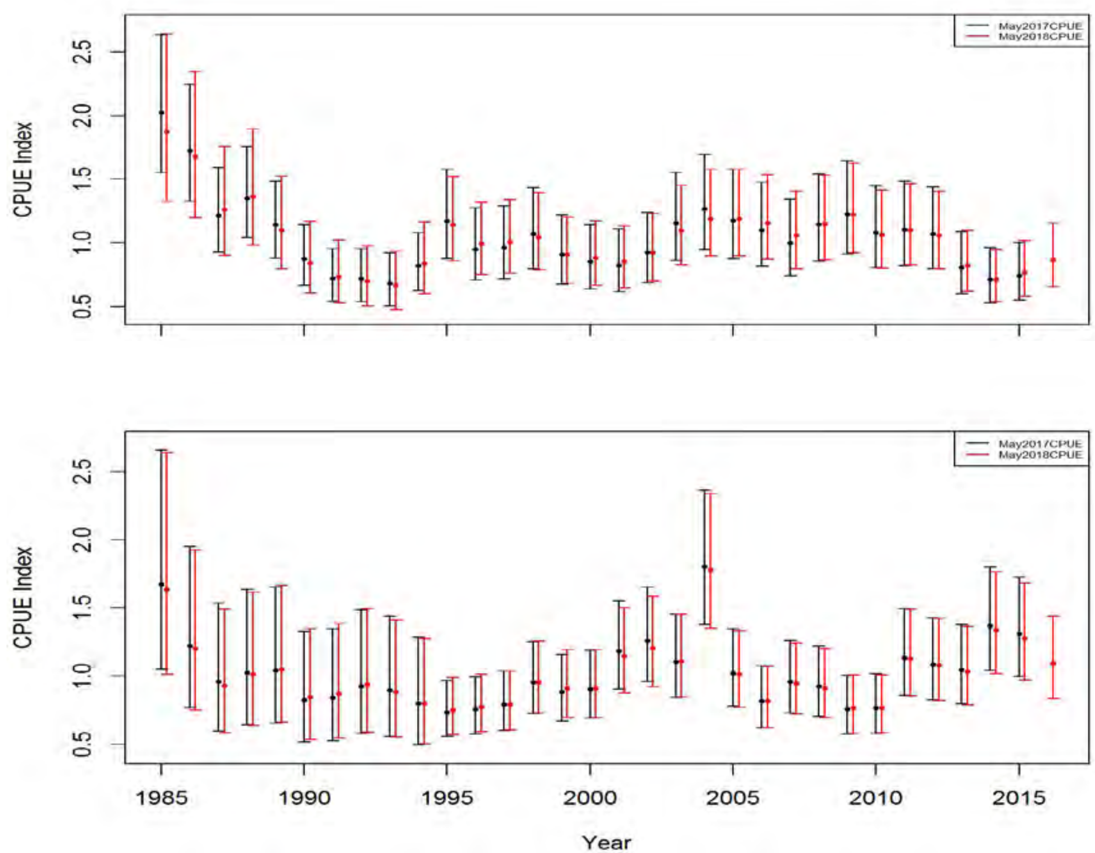
We considered scenario 17_0d with different sets of catchability and total selectivity for 1985/86–2004/05; 2005/06–2012/13; and 2013/14–2016/17.

CPT comments September 2017

Comment 9: Provide a comparison between the previous CPUE standardization and any new standardization methods that are applied. [Different area definitions: ADF&G statistical areas vs groups of ADF&G statistical areas]

Response:

Effect negligible



CPT comments September 2017

Comment 10: Include last year's model as a scenario for consideration.

Response:

We have included last year's model as scenario May17Sc9 to reflect scenario 9 with knife-edge maturity selectivity, which was accepted.

Comment 11: Overall model recommendation for May 2018: base model from last year (equilibrium initial abundance, knife edge maturity, both CPUE analyses with any significant interaction terms).

Response:

Done.

SSC comments October 2017

Comment 1: The SSC appreciates the CPT's consideration of model number convention and their recommendation to move forward with the modelling convention adopted by the Groundfish Plan Teams.

Response:

Done

Comment 2: Although the use of chela height-carapace size regression lines has been validated for *Chionoecetes* crabs (snow, Tanner), the SSC expressed concern that the use of this approach to determine maturity may not be appropriate for lithodid (king) crabs. The SSC recommends that efforts be made to verify this relationship in lab or field experiments, as well as to review the available literature and application of this approach for other non-*Chionoecetes* species.

Response:

After analyzing a number of lithodid (king) crab stocks for size at maturity, Somerton and Otto (1986) observed that golden king crab provided a better separation of chela height growth at the onset of maturity than either red or blue king crabs (see Appendix C). We have also provided a literature review on king crab maturity determination in Appendix C, which supports the breakpoint type of analysis for male 50% maturity determination.

SSC comments October 2017

Comment 3: The SSC supports the exploration of the VAST geospatial model for investigation of fishery catch rate data, but cautions that the nonrandom nature of fisheries data adds an additional challenge to the standard assumptions of independence between the underlying density and the process of observation beyond that of standard statistically-designed survey programs.

Response:

We did a preliminary run of VAST for observer CPUE standardization and described its advantage and limitation (see response to CPT comment 5).

Comment 4: The SSC encourages the author to explore observer data and to discuss with the participants in the fishery potential changes in fisher behavior that may influence the relationship between fishery catch rates and crab abundance.

Response:

This is an ongoing process. We continue to explore this with the industry input and external experts.

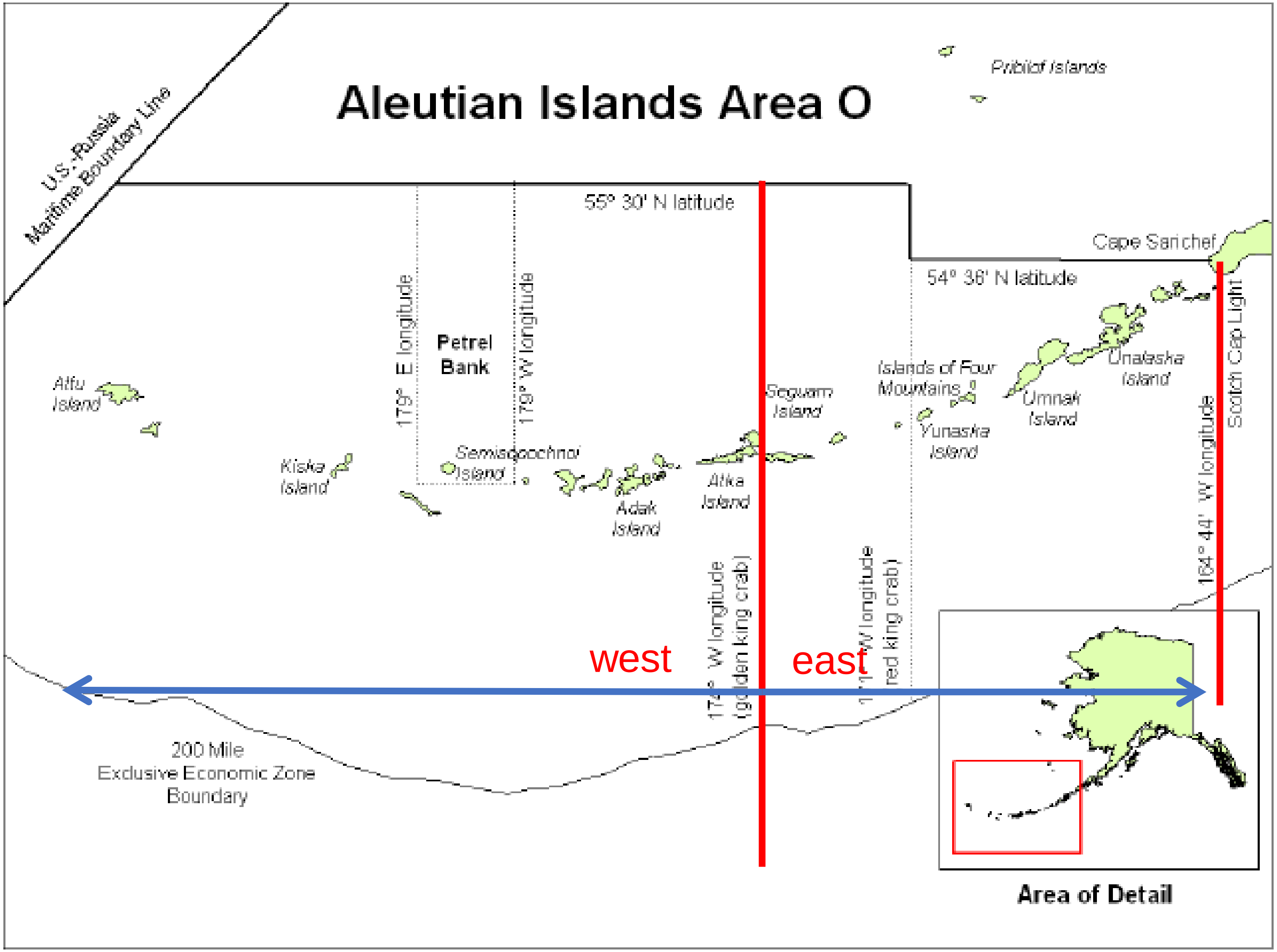
SSC comments October 2017

Comment 5: The SSC reiterates previous concerns that this stock assessment relies solely on fishery data, and therefore carries a higher degree of uncertainty than other model-based assessments for crab stocks. The SSC encourages recent and future efforts by the industry to include survey pots in their fishing activity in order to generate additional data to inform this analysis. The SSC extends its appreciation to the industry for their generous cooperative research efforts on this important crab stock.

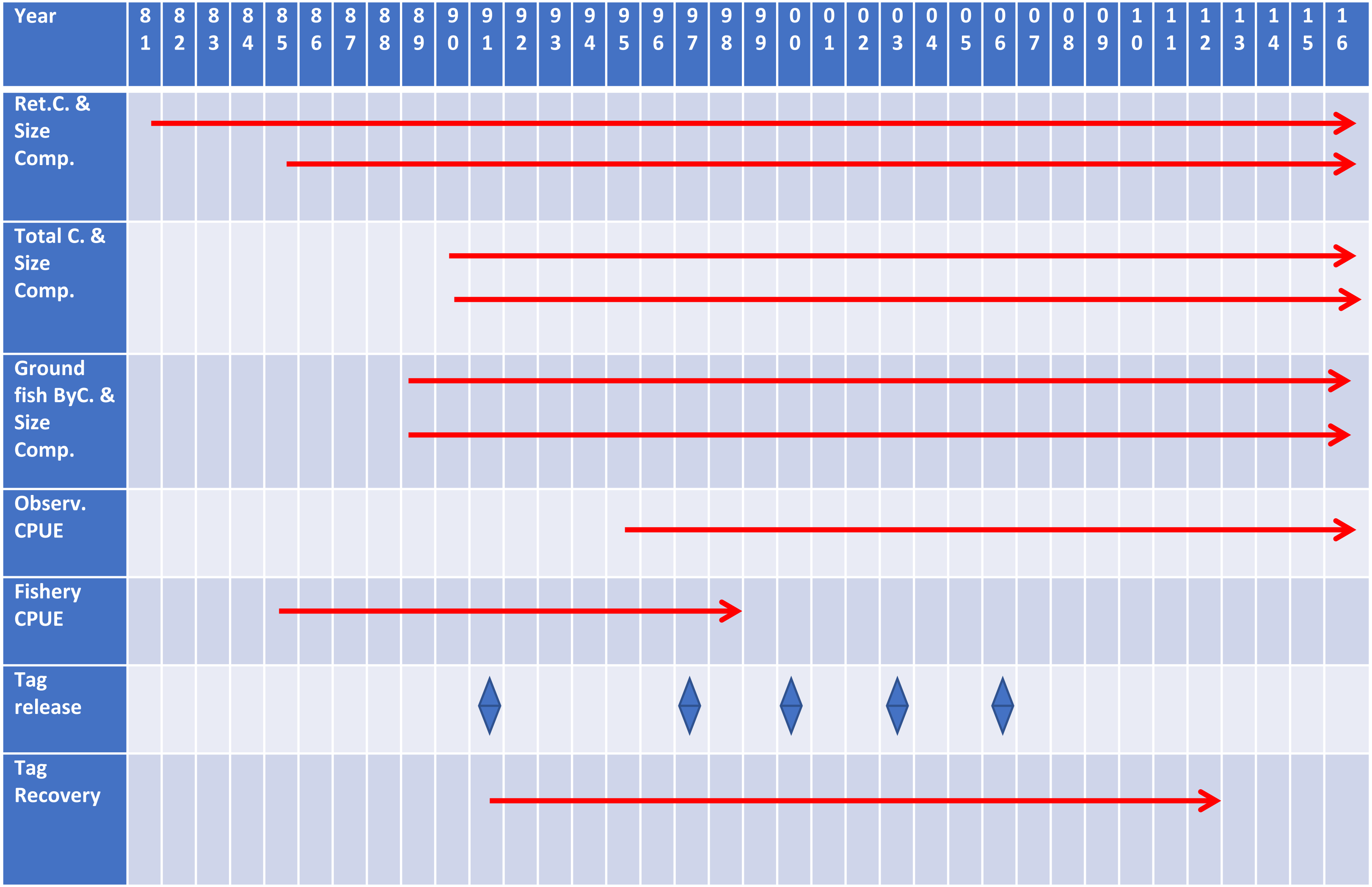
Response:

We recognized the higher degree of uncertainty in the assessment and therefore set the ABC using 25% buffer level. For the first time, we used the independent pot survey data in the model even though the time series is too short (2015 to 2017).

Aleutian Islands Golden King Crab



Data


Year
81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Ret.C. & Size Comp.
Total C. & Size Comp.
Ground fish ByC. & Size Comp.
Observ. CPUE
Fishery CPUE
Tag release
Tag Recovery

CPT Discussion

Timing mismatch of assessment and TAC setting

- Fishery ends in May, OFL/ABC set in May
- Most recent fishery data not included in OFL/ABC setting
  - 2017/18 data not included in this assessment
- However, model simulations CAN be completed after the OFL/ABC are approved by the CPT/SSC (but before TAC setting) with the most recent fishery data

How to improve timeliness of scientific advice

- Use best estimate of most recent total catch for assessment

CPT Discussion

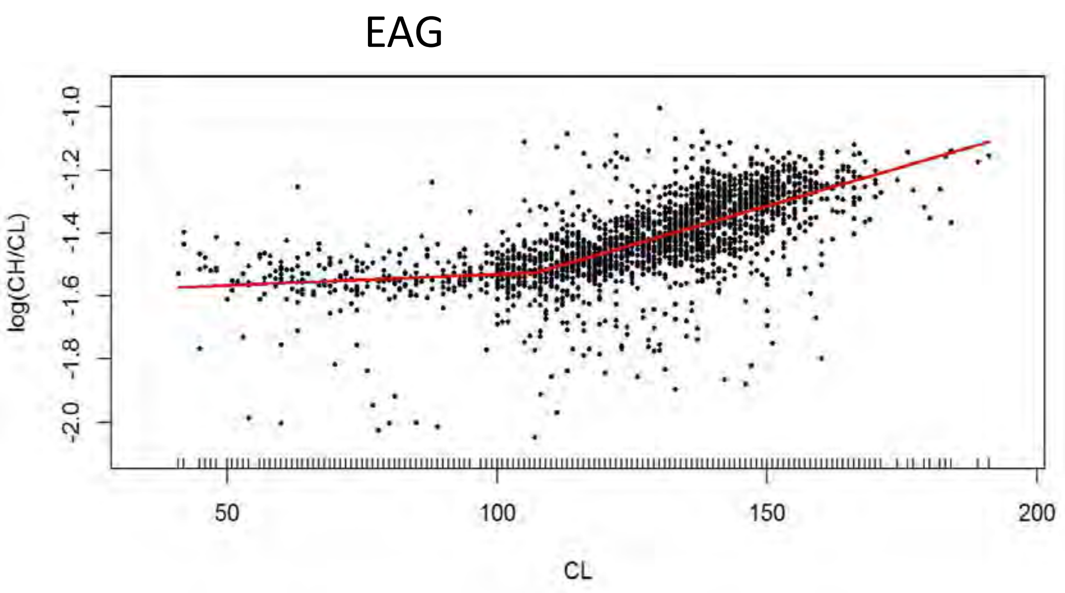
Length at maturity breakpoint analysis

- Revised: log(chela-height/carapace-length) vs. carapace-length
- Estimate of breakpoint did not change: 111 mm CL was used as knife-edge breakpoint for maturity

Some concerns about over-estimating mature biomass

Additional chela measurement data will be collected by ADF&G observers and dockside samplers in upcoming AIGKC fishery

New techniques being developed by AFSC Kodiak lab for snow and Tanner should be explored for AIGKC

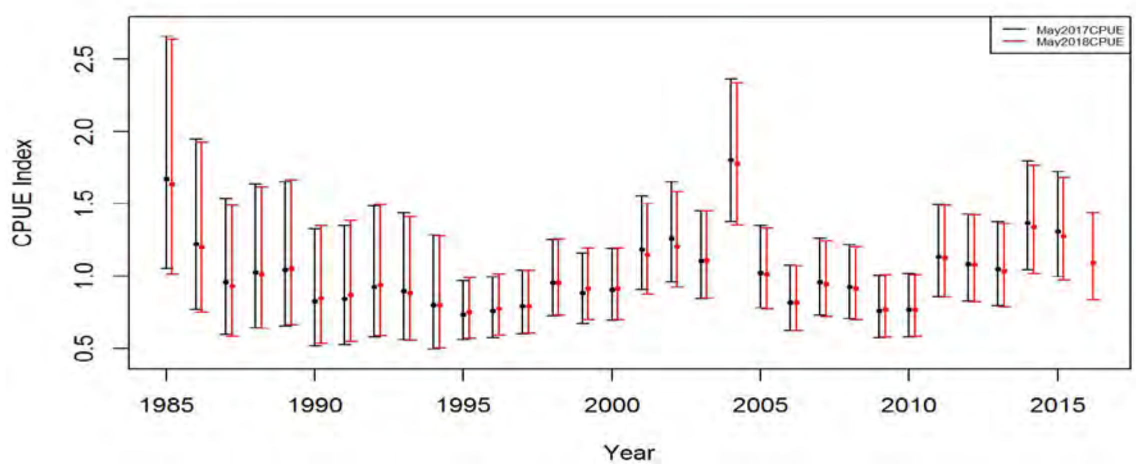


Model scenarios

Model 17_0: Base model from last year updated with new data

- Compared area definitions for CPUE analysis:
  - ADF&G statistical areas (40-50 areas total)
  - Groups of ADF&G statistical areas (10 areas total)

EAG



Model scenarios

Model 17_0a: used an abundance index from a VAST analysis of CPUE data rather than the standard GLM approach.

- Exploratory in nature
- Challenges in Aleutians Islands because of elongated shape of the area, complex bathymetry, and the presence of numerous islands

Model 17_0b. uses AIC rather than r^2 for model selection

- CPT did not recommend AIC for CPUE standardization
- AIC selection usually results in overly complex models being selected

Model scenarios

Model 17_0c: included year-area interaction terms in the CPUE analysis.

- Better approach: obtain separate indices for each area, use area weights to obtain an overall index.
    - Area weights should be based on a measure of the fishing footprint within an area and not the total area.

Model 17_0d: included third catchability and selectivity period for 2013-2016.

- Had the largest impact on estimated abundance trends and harvest projections.
- Four years too short to estimate catchability, concerns that model was simply fitting noise in the CPUE index.
- CPT concern: large change in catchability for the EAG model, but almost no change for the WAG model

Model scenarios

Model 17_0e: McAllister and Ianelli used for tuning the length composition data

- The Francis method has been used
- Little impact on abundance trends and harvest estimates
  - CPT concluded that it was appropriate to continue using the Francis method

Model 17_0f: included a three-year abundance index from collaborative pot survey

- Only used for EAG
- Survey GLM analysis used fixed effects for year, unique strings, and unique pots
- Concerns about estimating more parameters than data points
- Considered work in progress

CPT model recommendations

- Authors recommended three model scenarios: 17_0 (base), 17_0d (3 catchability and total selectivity periods), 17_0e (McAllister and Ianelli reweighting)
- CPT recommended 17_0 (base) for OFL/ABC
- **OFL** = 5,514 t
- **ABC** = 25% buffer = 4,136 t
  - Largely relies on fisheries data: Observer and fisheries CPUE
  - Natural mortality estimated in model
  - Time period for average recruits (1987-2012) as "a time period determined to be representative of the production potential of the stock."
  - Bycatch data not available for 1981/82-1989-90
  - Additional uncertainties

Stock Status

- 2016/17 total catch = 2.83 thousand t
- 2016/17 OFL = 5.69 thousand t
- Overfishing did not occur; 2017/18 data not available

- 2017/18 MSST = 6.044 thousand t
- 2017/18 MMB = 14.205 thousand t
- Stock is not overfished

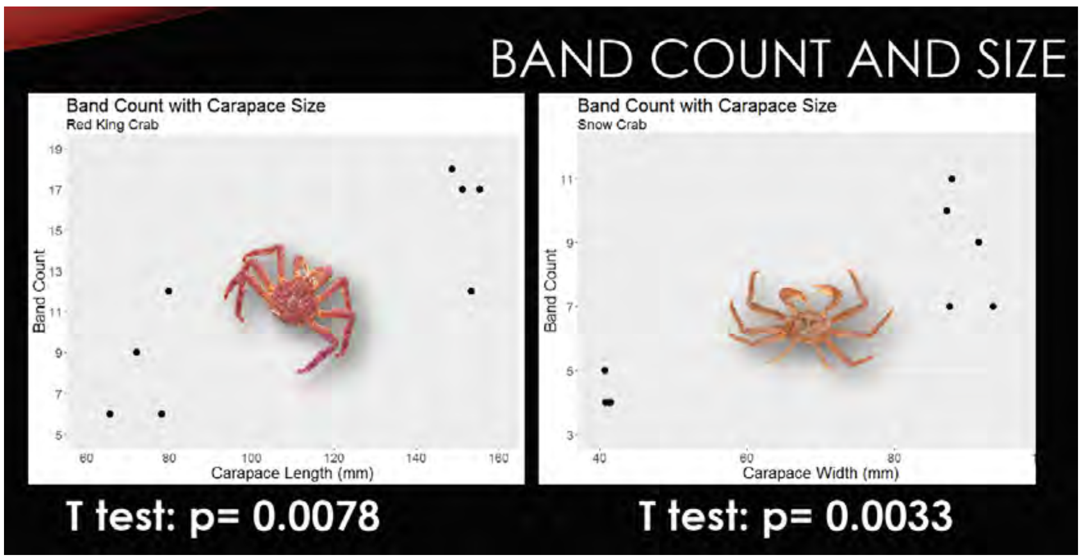
- 2018/19 MSST = 6.046 thousand t
- 2018/19 MMB = 17.952 thousand t
- Stock not approaching overfished status

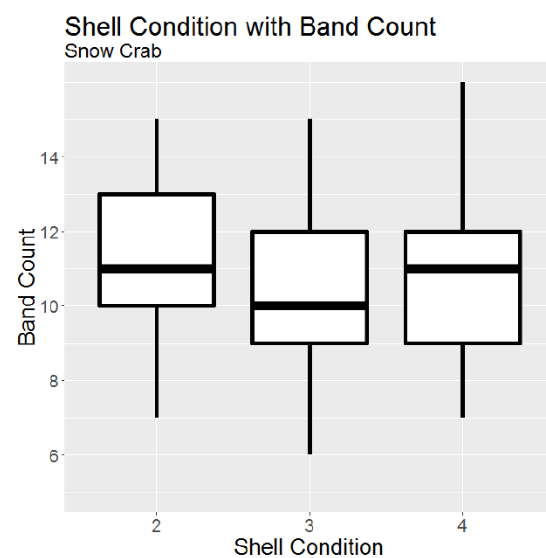
May 2018 CPT Recommendations

- OFL and ABC recommendations for the coming fishing year should include total catch for the concluded fishing year
- Reanalyze chela measurement data for AIGKC using new analytical techniques developed for snow crab and Tanner crab.
- Work on appropriate statistical models for analysis of ADF&G cooperative pot survey that reflect the nested sampling design of vessels, strings within vessel, and pots within strings and consider the use of random effects as appropriate.
- Continue work on the VAST spatial modeling approach.
- Continue exploration of year-area interactions using appropriate analytical methods, and develop area weights using fishing footprint calculations.

Crab Aging Study: April Rebert, UAF

- Evaluated age structures of RKC and snow crab in Alaska: Eye stalks, stomach parts (zygocardiac, mesocardiac)
- Zygocardiac most readable, but only 25% in RKC and 35% in snow crab
- Relationship between band counts and size lengths, but not shell condition





More work is needed to validate that bands are connected to molting or growth

GMACS Update: Dr. Andre Punt, UW

Previously major discrepancies between Dr. Jie Zheng's BBRKC model and GMACS

Objective 1:

- match values for growth, natural mortality, and selectivity, and modify code as necessary (completed)
- check the N-matrix given assumptions: about fishing mortality by fleet (directed fishery, bycatch in the trawl fishery, bycatch in the fixed gear fishery, bycatch in the Tanner crab fishery) (completed)
- check the model predictions that are included in the likelihood (still underway)
- check the likelihood value (not started yet)

Objective 2: estimate parameters once the likelihood can be replicated (not started yet)

Objective 3: compare predicted values of management-related quantities (not started yet)

GMACS Update: Dr. Andre Punt, UW

Issues relative to GMACS that have yet to be addressed:

a. whether M-devs should be devs or parameters
b. GMACS cannot have different numbers of size-classes for males and females
c. Dr. Zhengs' model: fishing mortality for EBS Tanner crab is related **directly** to effort; GMACS: this option does not exist
d. discard mortality is independent of sex but read in by sex
e. there is no ability to have sex-specific recruitment distributions
f. there is no ability to impose a maximum on the number of classes to which recruitment occurs
g. there is no ability to have time-varying size-transition matrices (which is needed for BBRKC)
h. GMACS does not compute landed + discarded (i.e. total) catch
i. the method to include effort-predicted F needs to be checked
j. how to handle instantaneous fisheries using the GMACS catch equation needs to be addressed

GMACS Update: Dr. Andre Punt, UW

Goal: results from the two models should be closer

Plan for September CPT meeting: reproduce Dr. Zheng's model results when using the same data inputs

Long-term plan: to be discussed at the September CPT meeting

- Likely fall to NOAA and ADF&G to determine the future direction of the BBRKC assessment in GMACS

Norton Sound RKC

Commercial and subsistence fisheries overview (Justin Leon, ADF&G Nome)

- Subsistence: open year round, no sex/size restrictions
- Commercial (winter): through ice, Jan-April, CDQ + open access harvesters, 20 pot limit (high pot loss), biological data from processors, voluntary observer program since 2012
- Commercial (summer): June-Sept, 40 pot limit, most vessels 20-40 ft, voluntary observer program since 2012 (sample 1-2% harvested crab)

Overview of biology and available data (Jenn Bell, ADF&G Nome)

- Move from Tier 4 to Tier 3?
  - CPT: concerns about data (ADF&G triennial survey, consistent survey area, small number of observed harvesters, skip molting, info on sublegals)
  - Size at maturity (>70 mm?): arbitrary without supporting data, but core to assessment and Tier 3 designation

*CPT discussed desire to reduce Tier status, but emphasized the importance of data quality.

Research Priorities

Reviewed all current Council research priorities

- Recommended some status changes
- Recommended revisions to existing titles
- Social and economic research priorities important, but do not directly relate to CPT stock assessment discussions
  - Recommended Social Science Planning Team be tasked with ranking

Identified new research priority

- "Understanding benthic production expectations with climate change"

Prioritized a "Top 5" (urgent/important category)

Research ID	Title	CPT Priority	Priority Rank
148	Spatial distribution and movement of crabs relative to environmental variability, life history events, and fishing	Urgent	1
232	Develop management strategy evaluations that incorporate changing climate and economic conditions and impacts to coastal communities	Urgent	2
196	Genetics, population dynamics, and management implications of hybridization between Tanner and snow crab in the Bering Sea	Important	3
592	Maturity estimates for Bering Sea and Aleutian Island crab stocks	Urgent	3
174	Develop spatially-explicit stock assessment models	Important	4

Research Priorities: Top 5 discussion

148: Spatial distribution and movement of crabs relative to environmental variability, life history events, and fishing

- *Critical for the development of the complex models needed to predict future stock abundance, stock boundaries, stock production, and management strategies.*

232: Develop management strategy evaluations that incorporate changing climate and economic conditions and impacts to coastal communities

- *Lead to better-informed harvest strategies.*

196: Genetics, population dynamics, and management implications of hybridization between Tanner and snow crab in the Bering Sea

- *Unknown portion of population, identification difficulties, presence of back-crosses, complicates OFL and TAC setting.*

592: Maturity estimates for Bering Sea and Aleutian Island crab stocks

- *Needed to better characterize mature biomass (key parameters uncertain for many stocks)*

174: Develop spatially-explicit stock assessment models

- *Not currently used in stock assessments, but life history parameters likely vary spatially. Could account for spatial trends in catch data and stock boundaries.*

Economic SAFE (Brian Garber-Yonts, NOAA)

Upcoming SAFE

- New analysis of vessel operating costs
- Analysis of vessel ownership entities and IFQ ownership entities
  - Resolve unknown extent of quota leasing (leaseholders vs quota owners)
- Economic report card: social and economic component for each stock

2016 economic status and performance indicators

- Ex-vessel landings 30% decrease in 2016
- Ex-vessel revenue decreased 3.6% ($259M) and first wholesale revenue decreased 3.9% ($349M) over all BSAI crab stocks
- Decline mitigated by increase in ex-vessel and wholesale prices
- 2016: overall crew positions decreased 10%, processing hours decreased 33%
- BBRKC: crew daily wages increased (lower TACs), vessel income averaged 500K in 2016
- Overall, most fishery profit going to quota share sector

Economic SAFE (Brian Garber-Yonts, NOAA)

Future Economic SAFEs

- Include report card matrices
- Use price forecasts to represent estimates of revenue for most recent year
- Add demographic and ownership details
- More detail on processing sector income

Other Crab Plan Team Updates

Tanner crab MSE (Maddison Shipley, UW)

- Masters project, collaborating with ADF&G
- Could inform ADF&G harvest strategy revision

BSFRF (Scott Goodman)

- 2018 survey plans: Tanner crab selectivity + recruitment patterns
- CPT requested Tanner crab workshop report

NPRB growth project (Dr. Punt + student Lee Cronin-Fine, UW)

- Improving mathematical form of size-transition matrices
- Implemented in GMACS

Crab observer data (Ben Daly, ADF&G Kodiak)

- ADF&G no longer collecting legal retention status information - subjectively determined by observer
- Implications for assessments discussed

June 2018 SSC Meeting

William Stockhausen
Alaska Fisheries Science Center
NOAA/NMFS

Outline

- Bristol Bay red king crab
- Snow crab
- Tanner crab

- Retrospective analysis for terminal year of recruitment averaging period
- Dynamic B_0 results (preliminary)

BBRKC

- Report presented by Jie Zheng (ADFG)

- Major concerns from 2017 assessment
  - High estimates for survey q

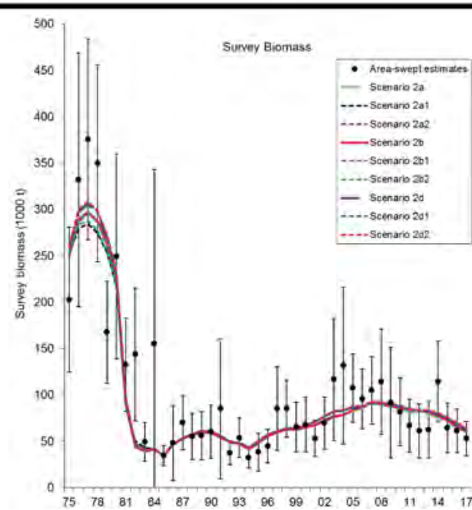
- Major topics
  - Estimates of high survey q
  - Assessment model updates
    - "subtraction method" to fit fishery observer data without legal retention status
    - implemented Dynamic B0 calculations
  - Investigated 5 candidate model scenarios for Fall assessment
  - Retrospective analysis for recruitment averaging terminal year

BBRKC

- Tier 3b

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	12.85	27.12	3.90	3.99	4.56	7.07	6.36
2014/15	13.03	27.25	4.49	4.54	5.44	6.82	6.14
2015/16	12.89	27.68	4.52	4.61	5.34	6.73	6.06
2016/17	12.53	25.81	3.84	3.92	4.28	6.64	5.97
2016/17		21.31	3.0	3.0		5.60	5.04

units: 1000's t



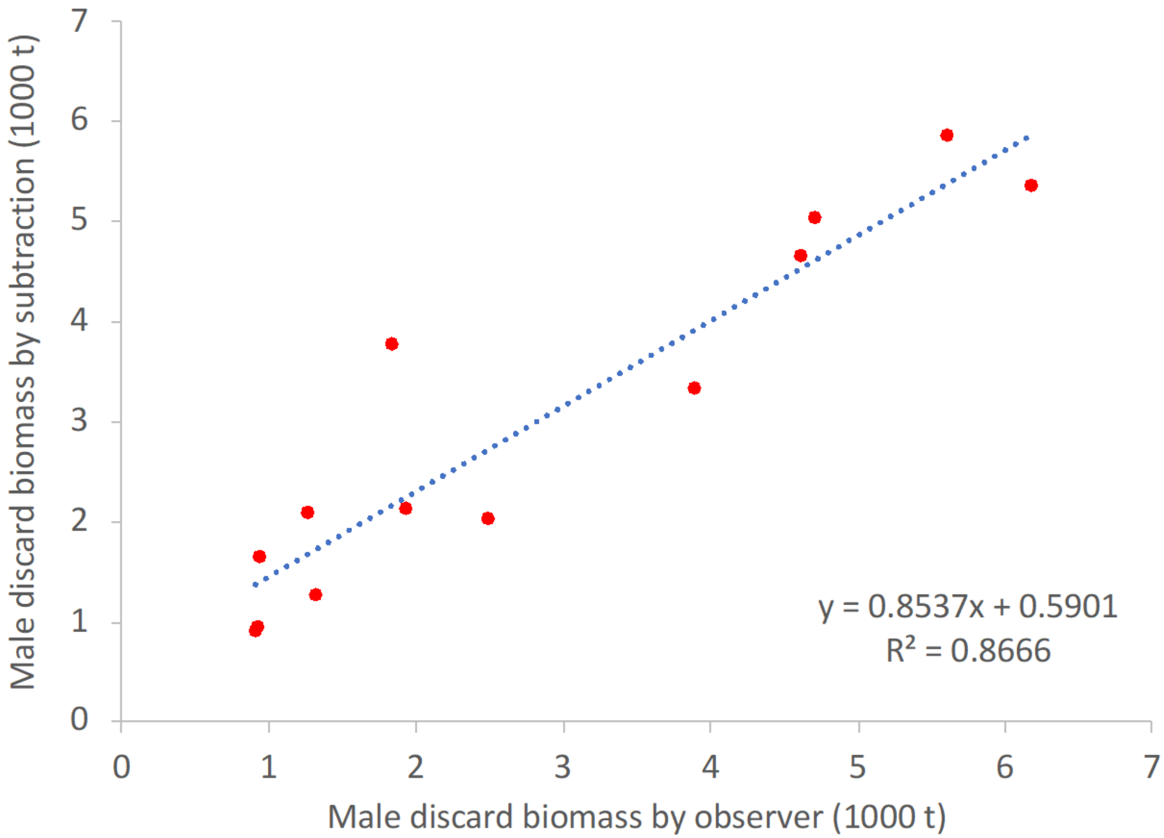
“Subtraction” Method for male discard biomass in directed fishery

- Retention status (legal retained vs. legal not-retained)

- Previously, male discard abundance and biomass were estimated directly from observer size composition data using observer-assigned legal retained/not-retained designations
  - discard size compositions fit in likelihood (sublegal + legal/not-retained)

- Subtraction Method (similar to AIGKC):
  - D = T - C
    - D = total legal male discard abundance or biomass
    - T = total legal male catch (abundance or biomass) from observer sampling
    - C = total commercial catch (abundance or biomass) from fish ticket data
  - total catch selectivity assumed to follow logistic function
  - retention curve assumed to follow logistic function

"Subtraction" Method for male discard biomass in directed fishery



CPT Recommendation

- don't use "subtraction" method
- fit the following separately:
  - total catch estimated from at-sea observer data
  - total retained catch

Model scenarios

- 2b: same as scenario 2b in the Sept 2017 SAFE
- 2bn1: 2b +
  - Subtraction Method (App. C) used to estimate male discards in directed fishery
  - 2 retention curves (pre/post-rationalization) are estimated to address differences in high-grading
- 2bn2: 2bn1 +
  - only 1 retention curve estimated
  - annual retention factors estimated post-rationalization
- 2b85: same as Scenario 2b except model starts in 1985
- 2c85: same as Scenario 2b except
  - no prior on catchability from double-bag experiment (same as 2c from May 2017)
  - model starts in 1985
  - natural mortality is constant (0.18) for all years.

Address hypotheses regarding survey q estimates

Model scenarios

Total selectivity for males is assumed to be a logistic curve:

$$S_l^{dirt,mal} = \frac{1}{1+e^{-\beta^{dir,mal}\,(l-L_{50}^{dir,mal})}} \qquad \text{(C1)}$$

and the retained proportions of legal males also follow a logistic function:

$$S_l^{dirt,ret} = \frac{1}{1+e^{-\beta^{dir,ret}\,(l-L_{50}^{dir,ret})}} \qquad \text{(C2)}$$

Two approaches to adjust annual retained proportions:

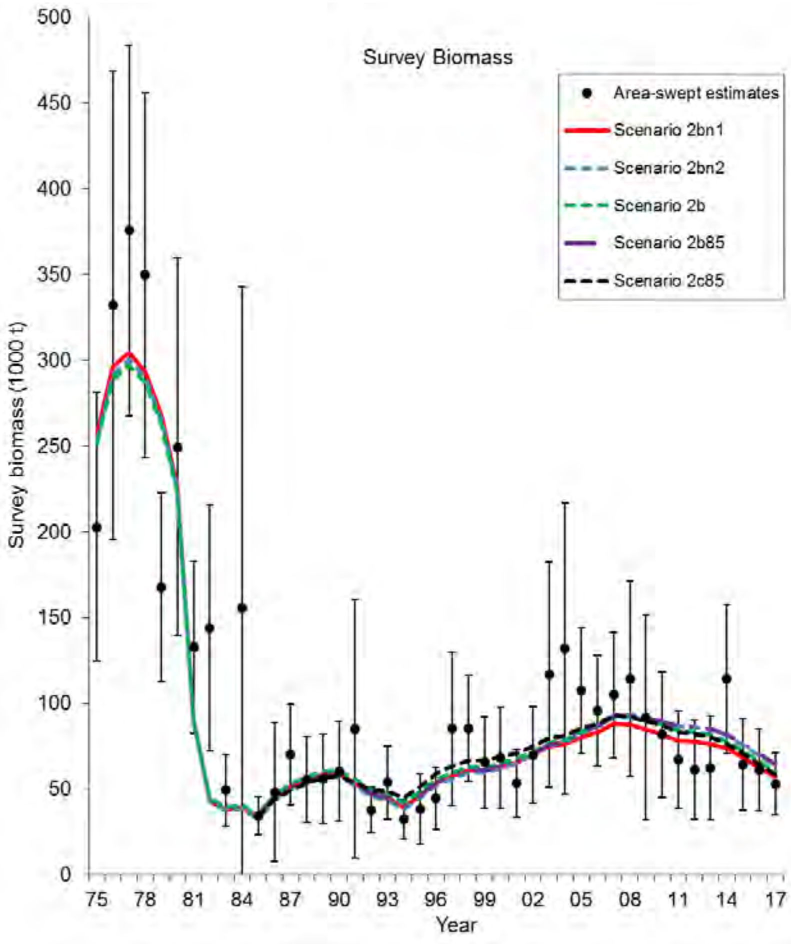
1. Scenario 2bn1: two logistic curves for retained proportions: the first one for 1975-2004, before rationalization, and the second one for 2005-present.
2. Scenario 2bn2: only one logistic curve for retained proportions for all years; annual adjusted factor parameter, x_t, is estimated for each year after 2004 and a logit transformation is used to make sure the adjusted factor, u_t, be <1.0:

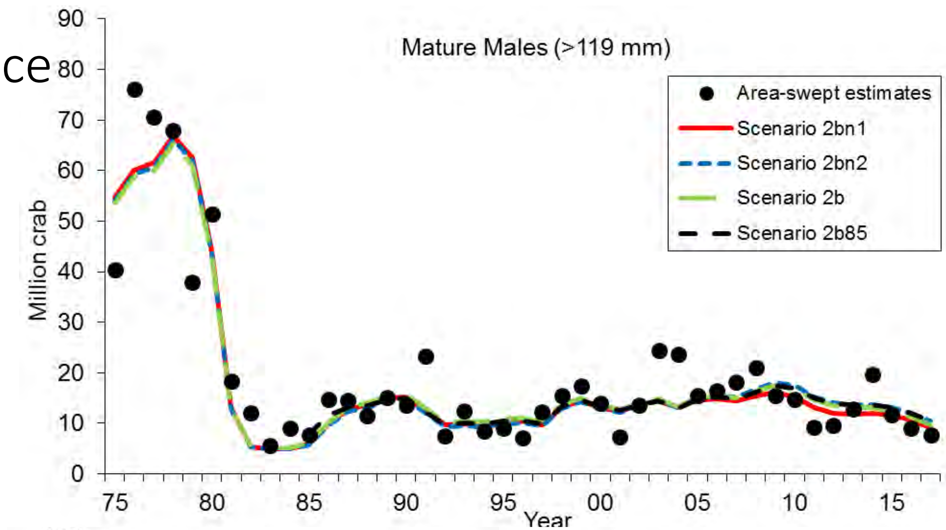
$$u_t = \frac{e^{x_t}}{1+e^{x_t}} \qquad \text{(C3)}$$

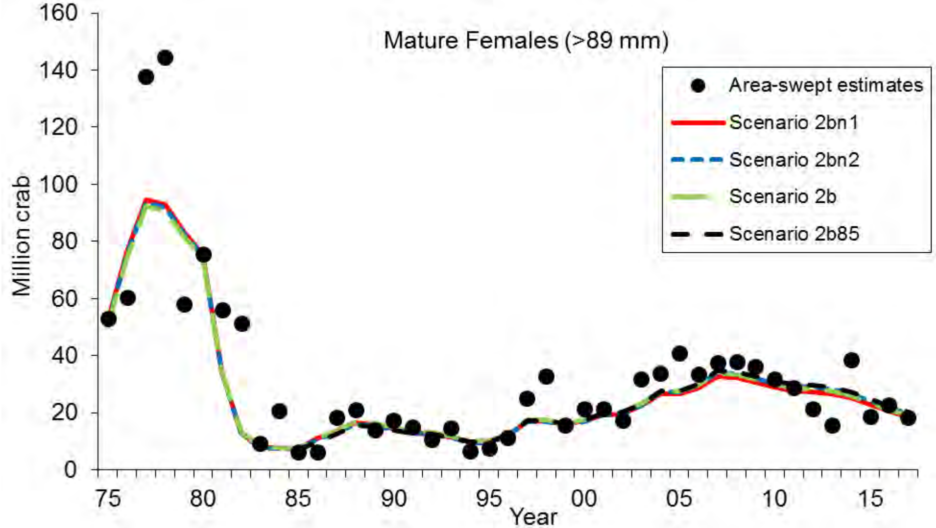
Annual retained proportions after 2004 are estimated as:

$$S_{l,t}^{dirt,ret} = u_t\, S_l^{dirt,ret} \qquad \text{(C4)}$$

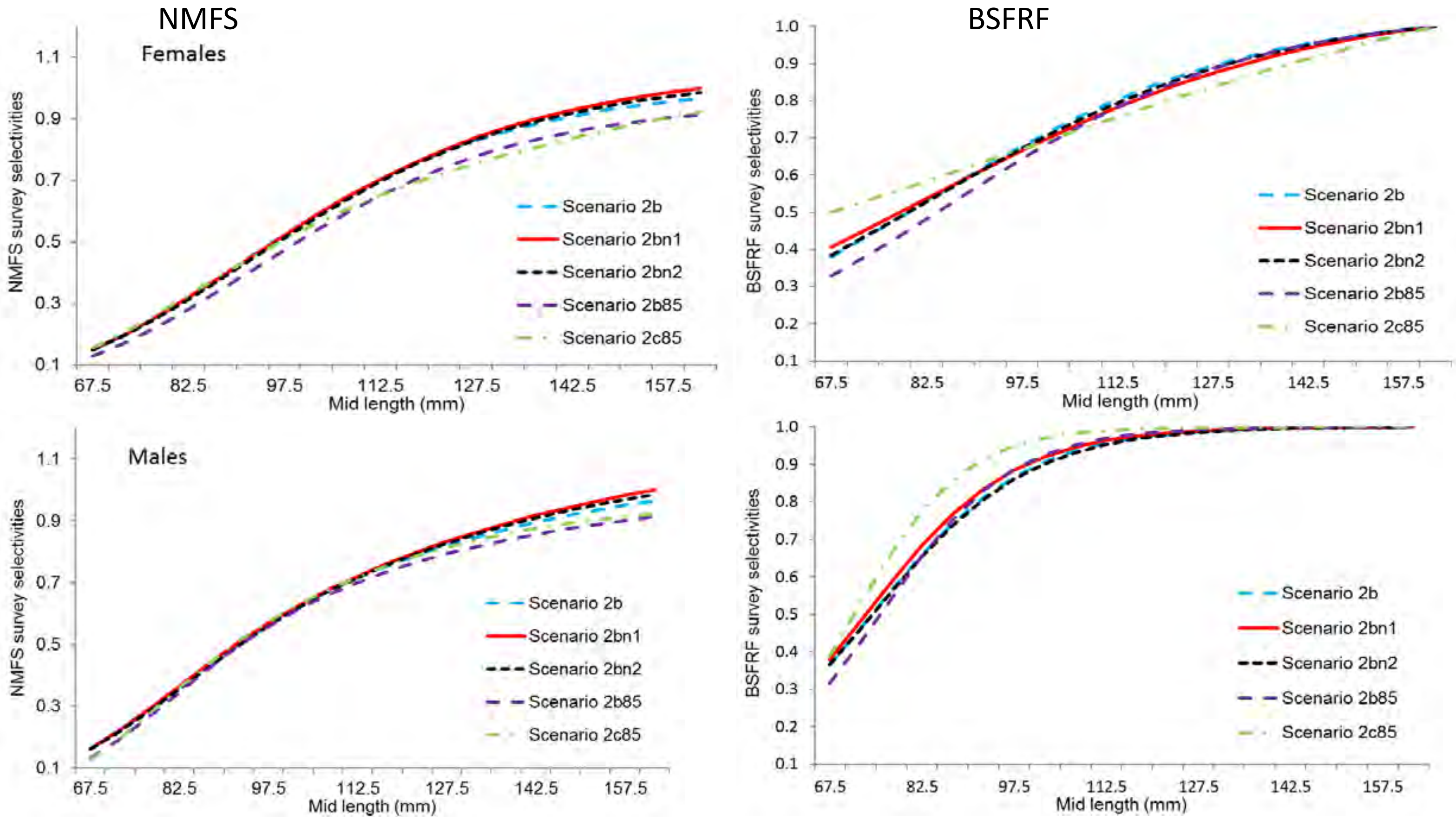
Model results: Survey Biomass/Abundance





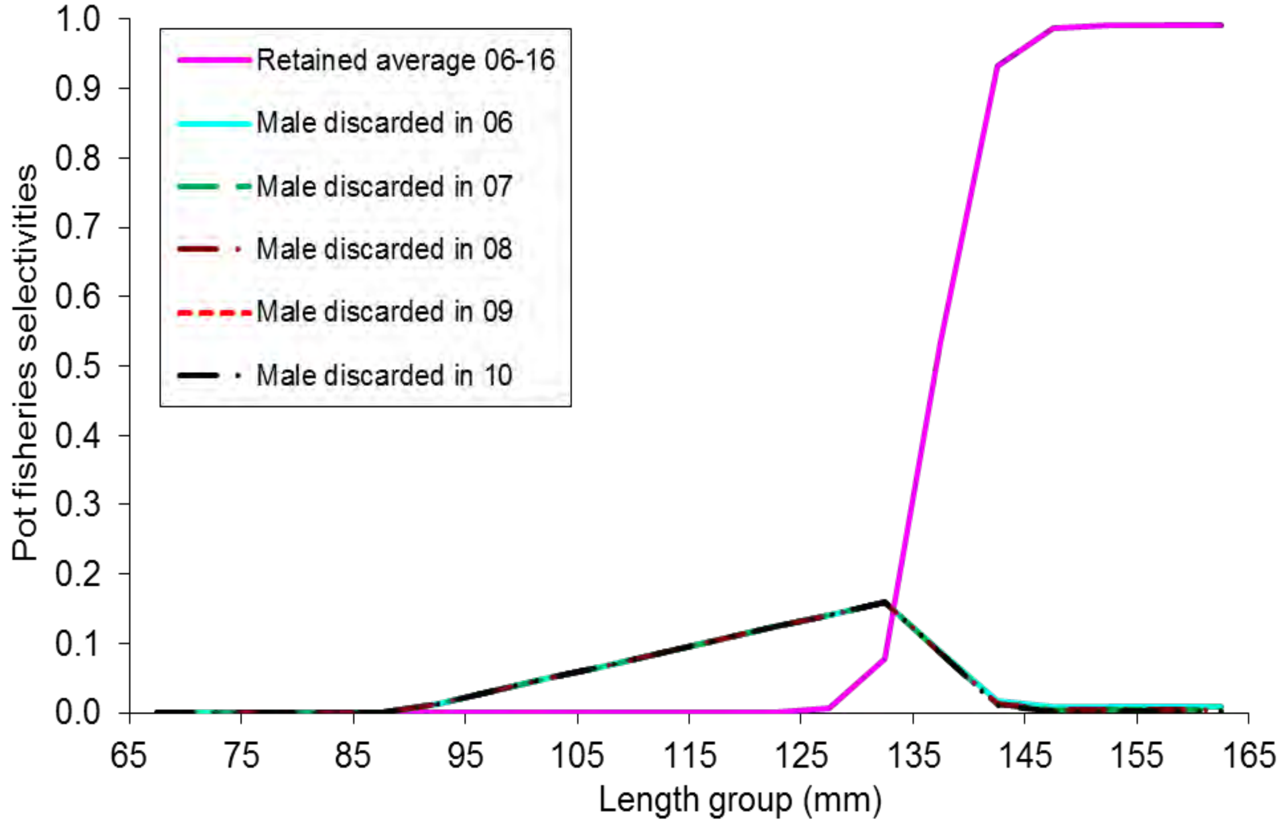


Model results: Survey Selectivity

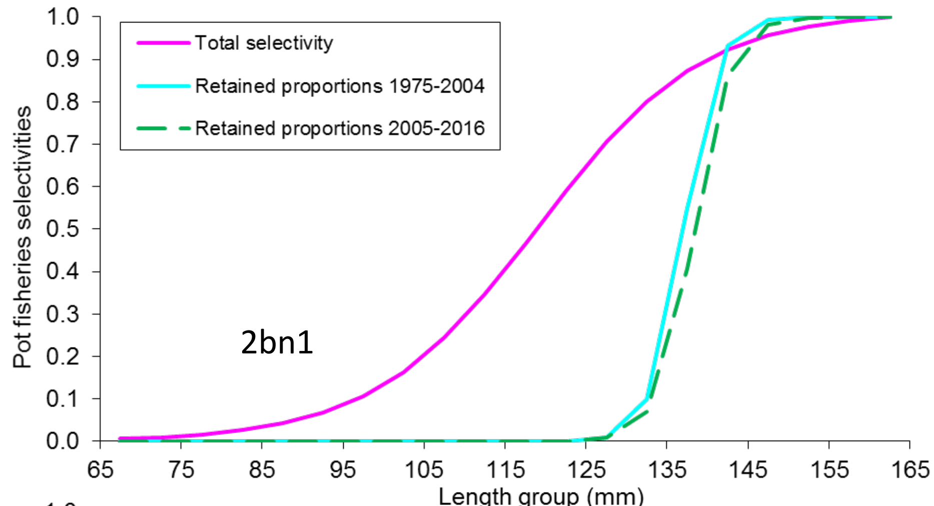


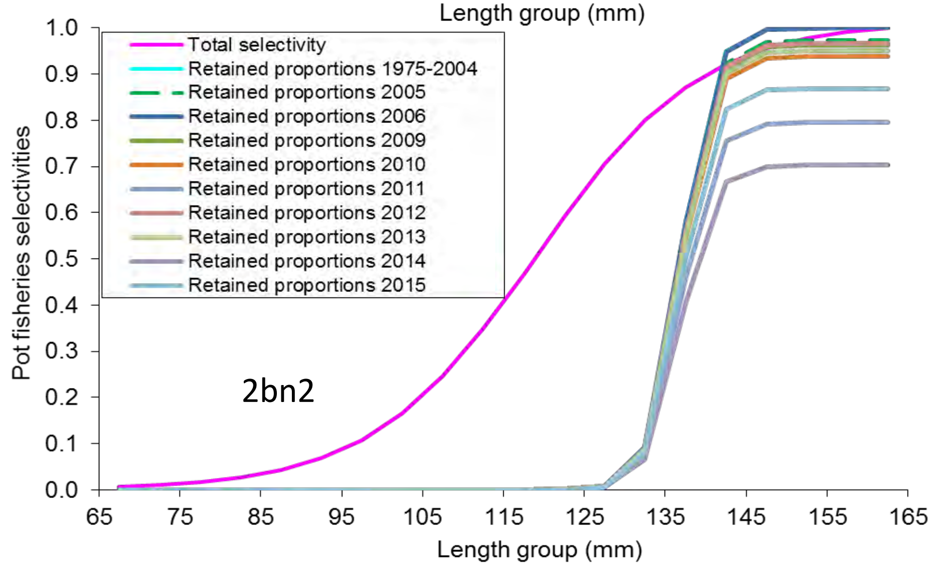
Model results: Fishery Discard and Retained Selectivity Curves

Scenario 2b only



Model results: Fishery Capture and Retention Curves





Directed pot fishery Selectivity

Scenario 2bn1:
Three logistic curves:

1. Total selectivity,
2. Retained proportion (1975-2004),
3. Retained proportion (2005-present)

Scenario 2bn2:
Two logistic curves:

1. Total selectivity,
2. Retained proportion, and annual adjusted factors, 2005-present.

All other no-plotting retained proportions are within the ranges of max and min proportions here.

CPT Recommendations

- Model Scenarios:
  - don’t use “subtraction” method to estimate legal discards
    - i.e., ***not*** 2bn1, 2bn2
  - fit the following separately (discards are implicit)
    - total catch estimated from at-sea observer data
    - total retained catch separately
  - incorporate time-varying fishery selectivity and annual retained proportions

Snow Crab

Snow Crab

- Report presented by Cody Szuwalski (UCSB, now AFSC)

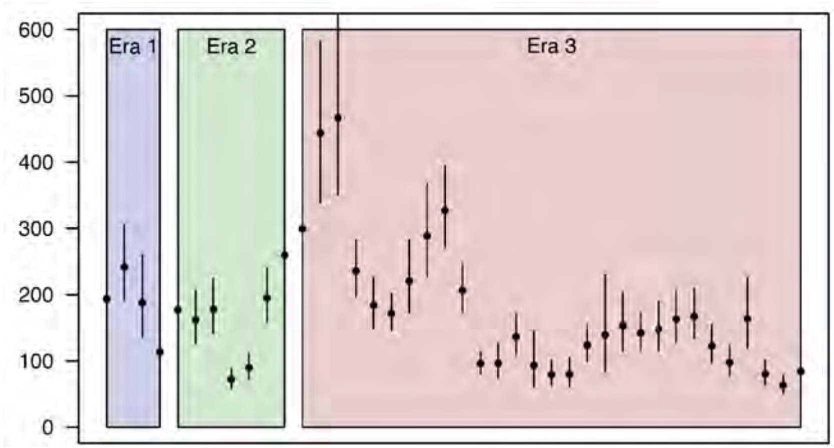
- Major concerns from 2017 (and previous) assessments
  - 2016: multi-modal solutions
  - 2017: used Bayesian methods to integrate over multiple modes in posterior distribution for management-related quantities (stop-gap measure)

- Major topics
  - Explorations
    - Additional molt increment data
    - Estimating M for mature females
  - Assessment model updates
    - adapted model to use MLE over Bayesian approaches
      - faster, less computationally expensive
  - investigated 4 model scenarios

Snow Crab

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	71.5	126.5	24.5	24.5	28.1	78.1	70.3
2014/15	78.9	168.0	30.8	30.8	34.3	69.0	62.1
2015/16	75.8	91.6	18.4	18.4	21.4	83.1	62.3
2016/17	69.7	94.4	9.7	9.7	11.0	23.7	21.3
2017/18		99.6	8.6	8.6		28.4	22.7

units: 1000's t

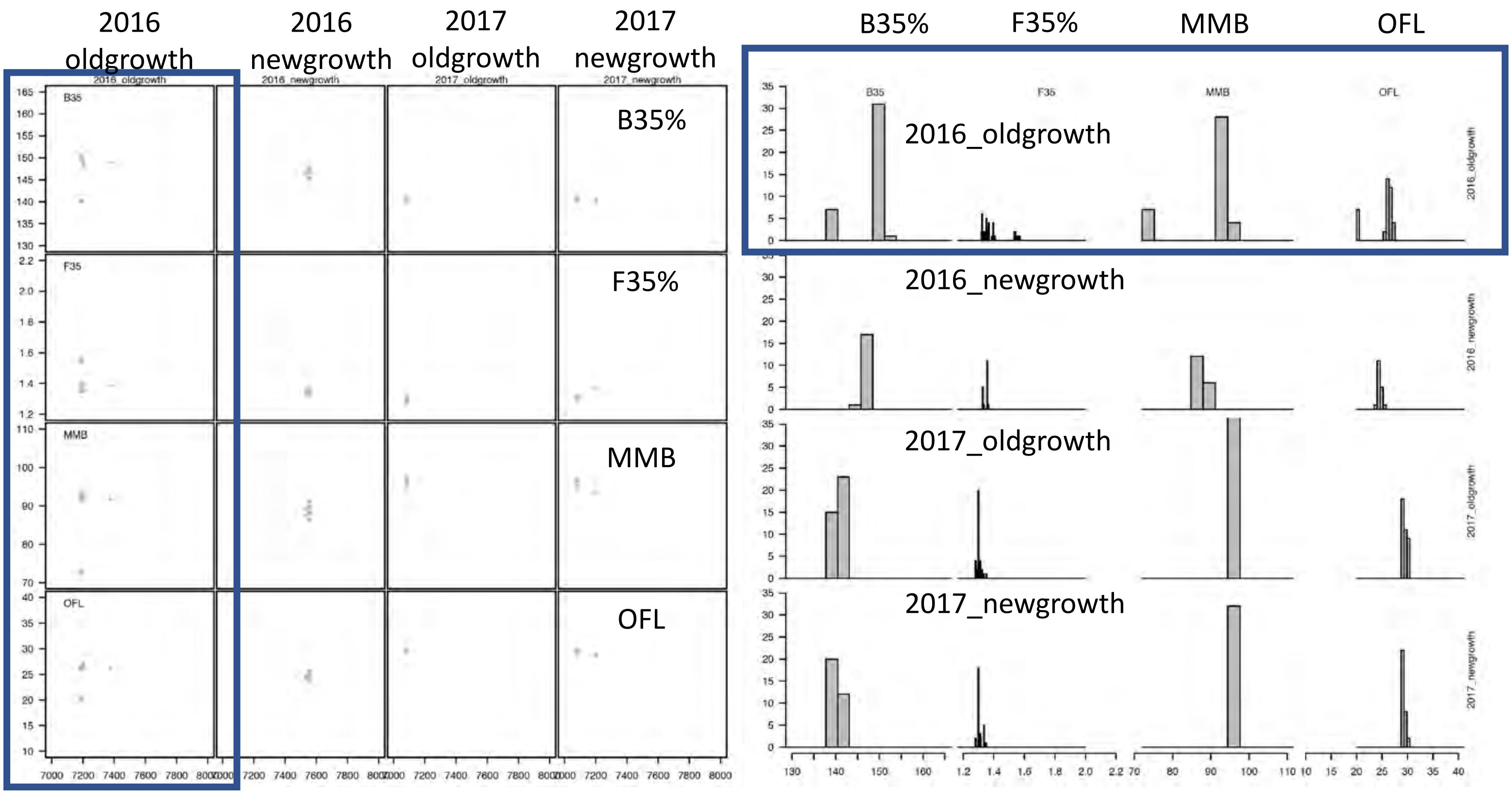


- Tier 3b

Model scenarios

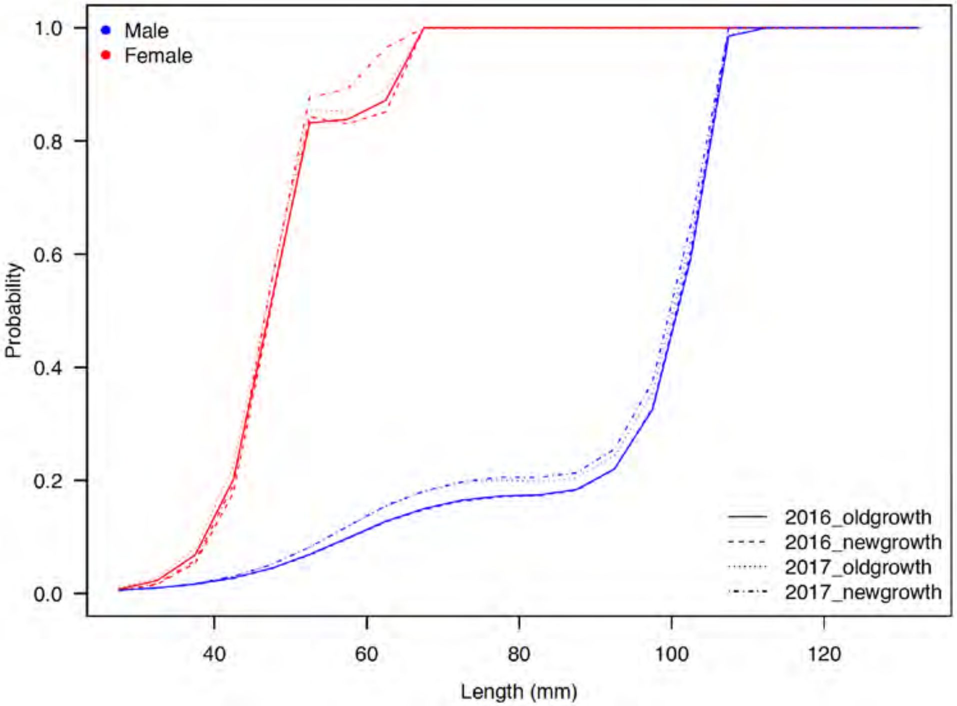
- 2016_oldgrowth (~2016 assessment model + 2017 catch, survey data)
  - Survey data before 1982 dropped, survey selectivity estimated pre/post-1987
  - Estimate survey availability parameters for BSFRF survey in logit space
  - Uses growth data from 2016 and 2017 assessments (18 F, 22 M)
  - Natural mortality fixed for mature females
- 2016_newgrowth: 2016_oldgrowth +
  - New molt increment data (45 F, 25 M)
- 2017_oldgrowth (2017 assessment model)
  - Natural mortality estimated for mature females
- 2017_newgrowth: 2017_oldgrowth +
  - New molt increment data

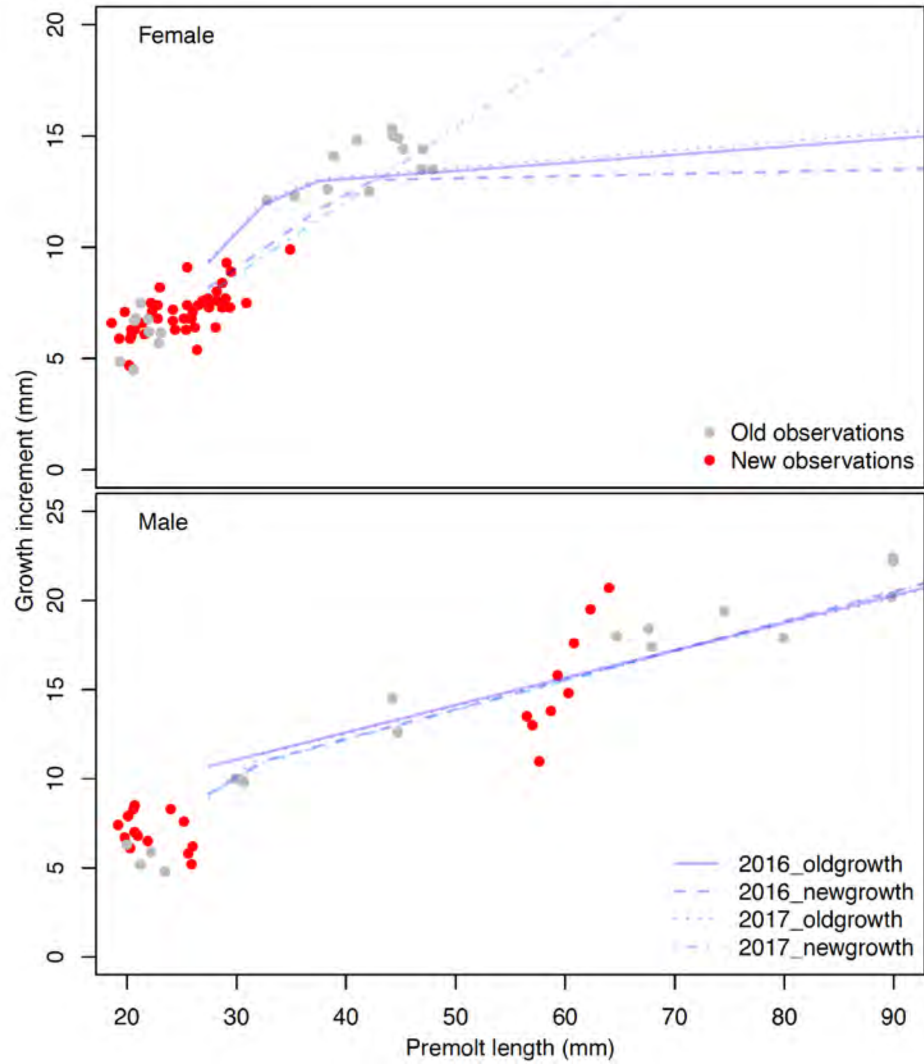
Model results: modality



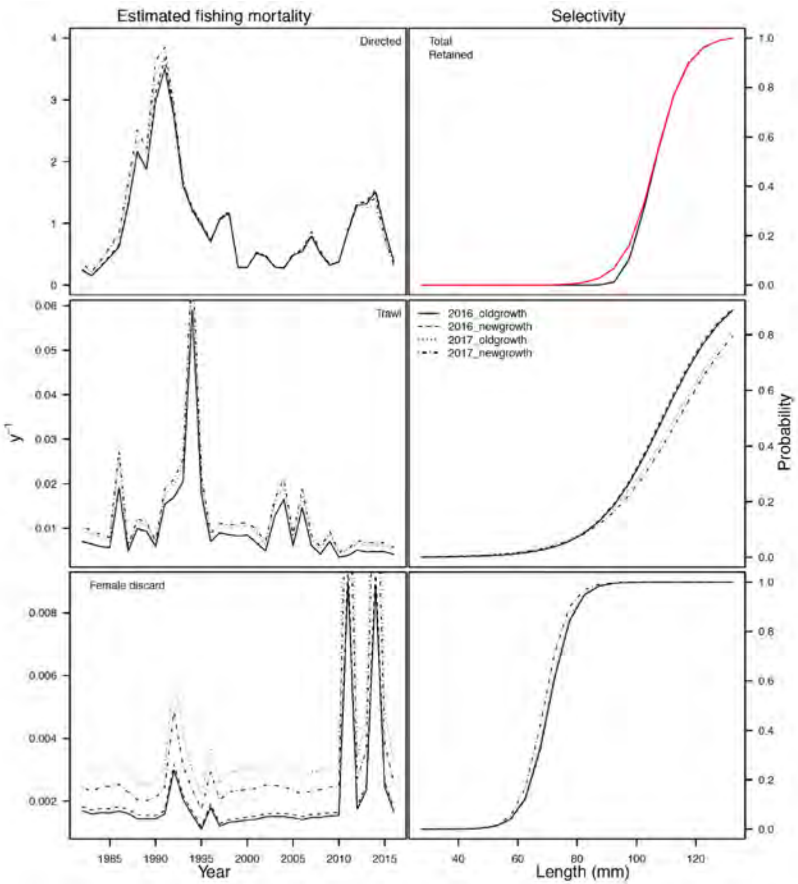
bimodality eliminated in new scenarios

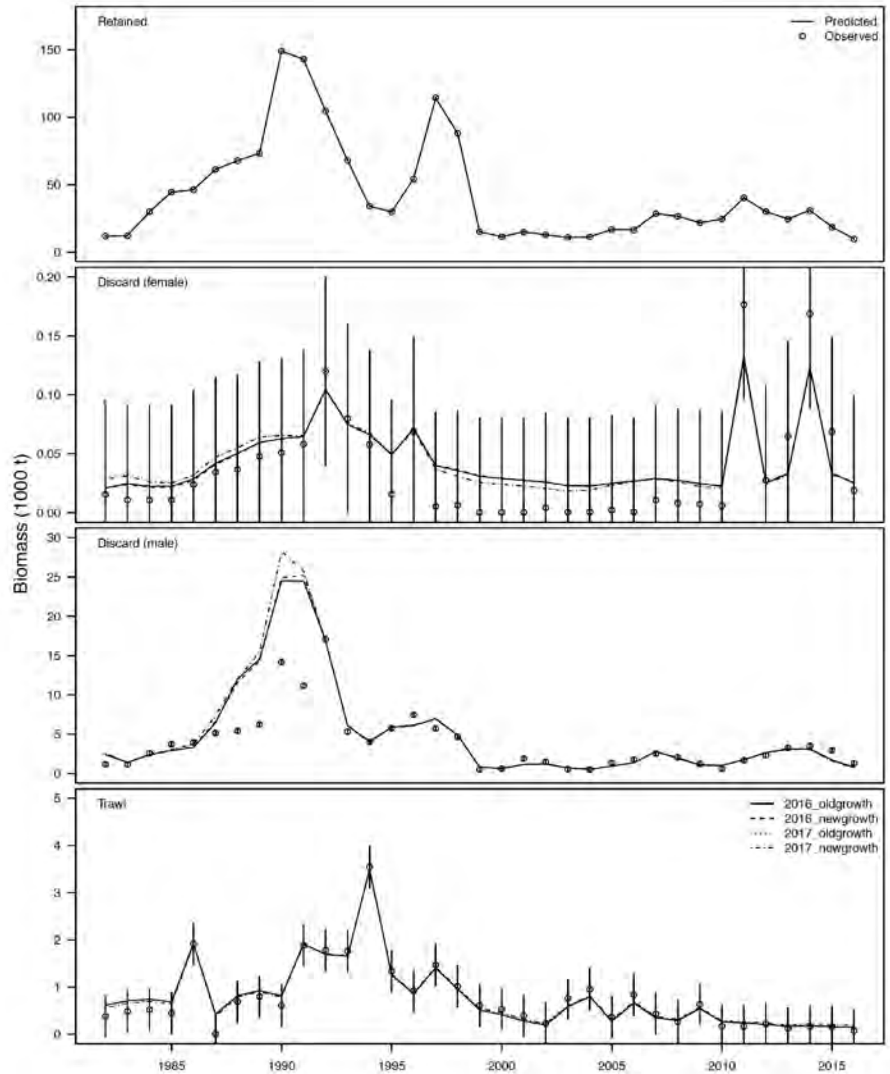
Model results: maturity and growth



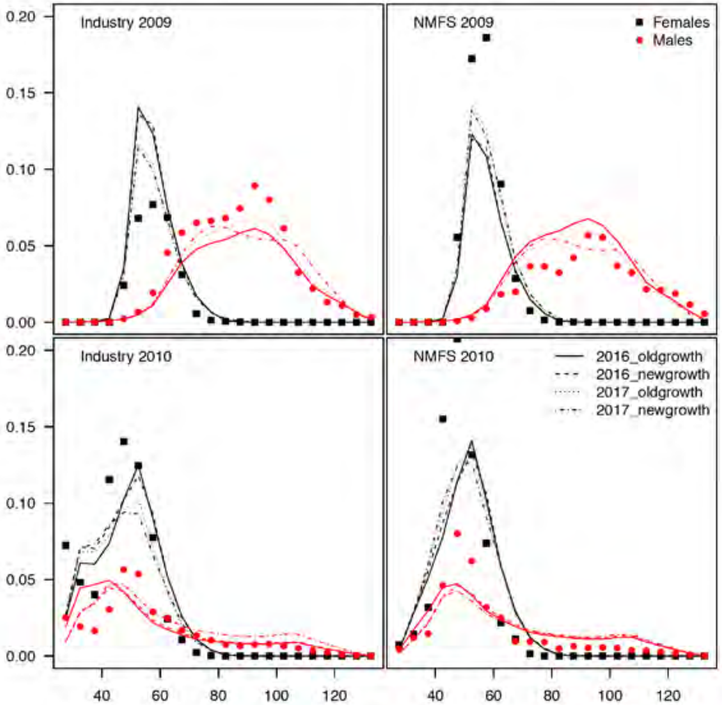


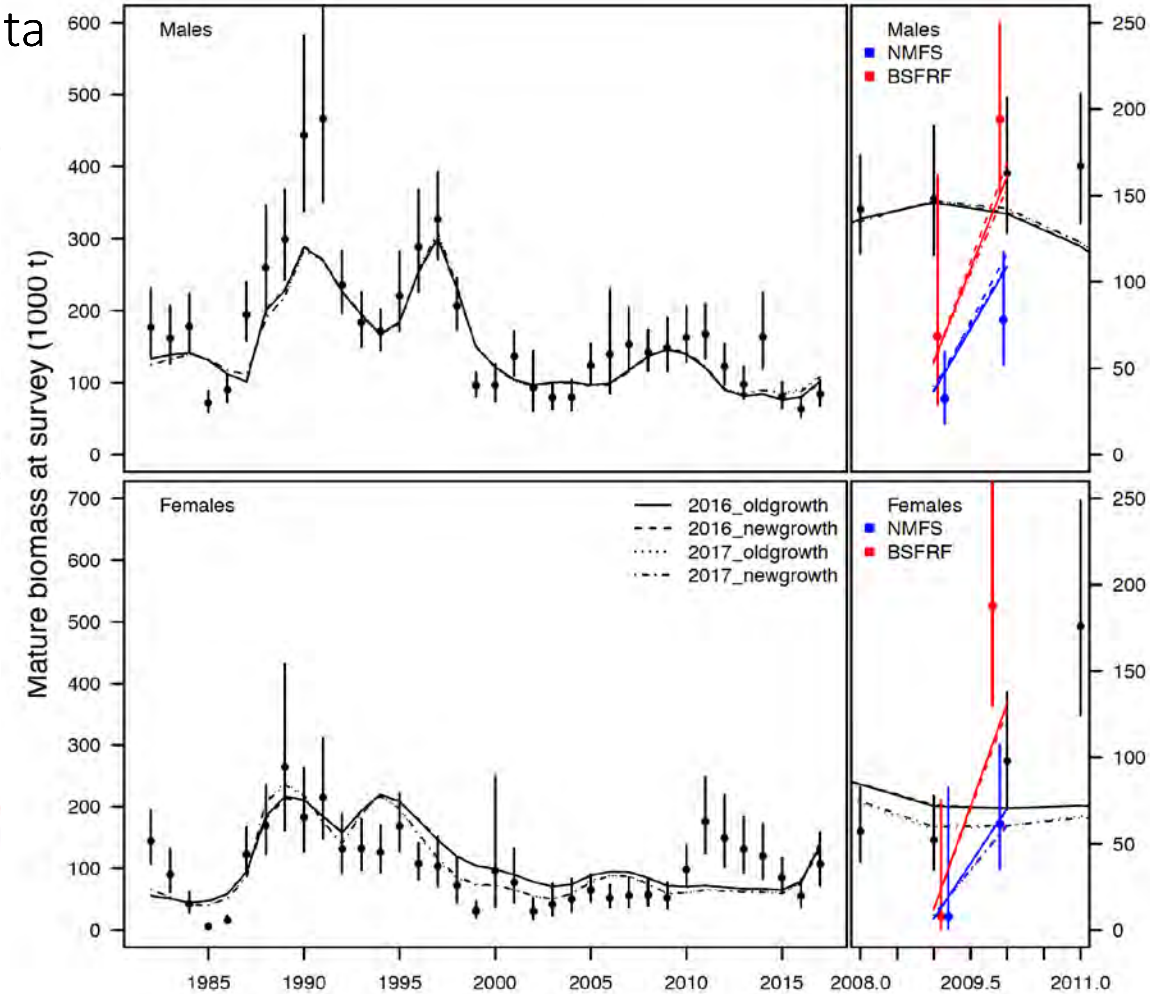
Model results: fishery data



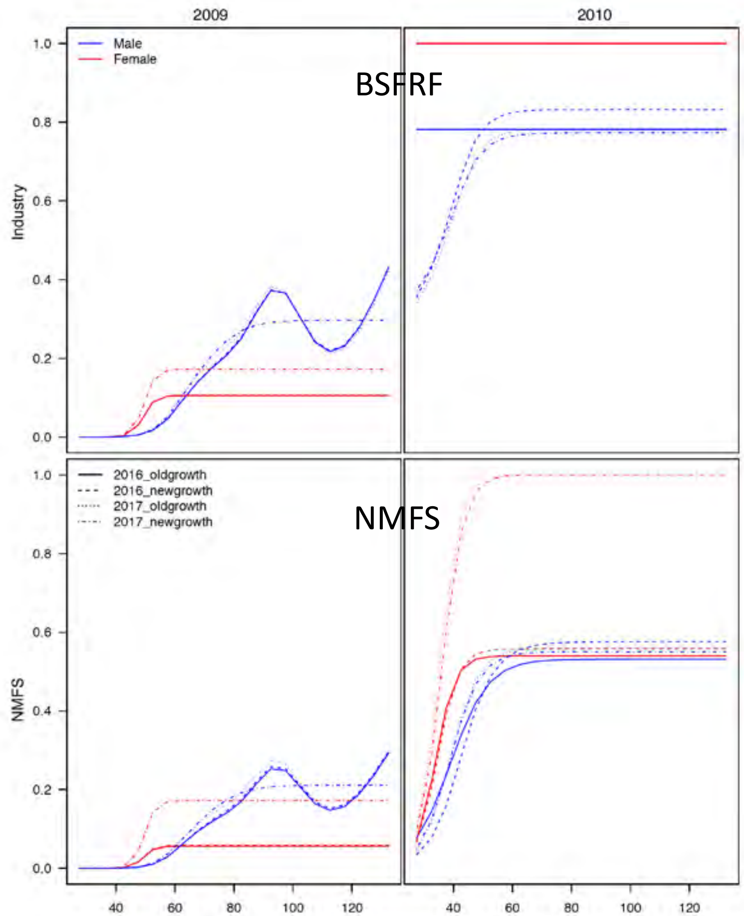


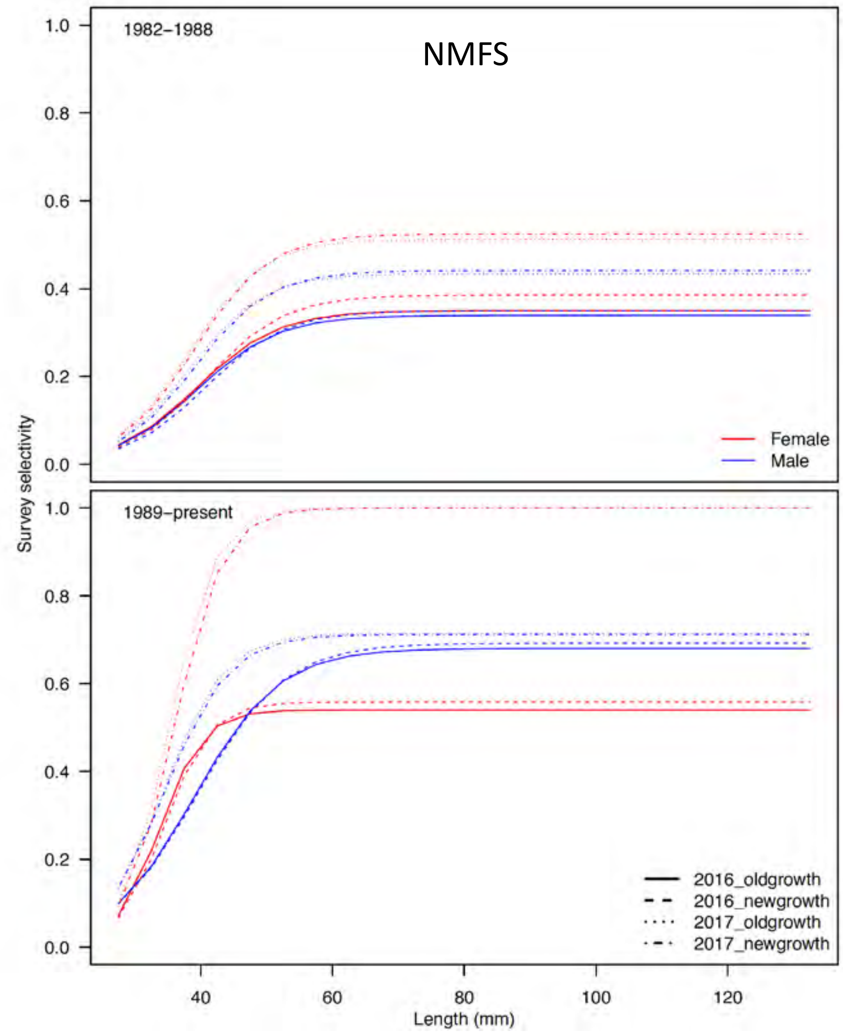
Model results: fits to survey data



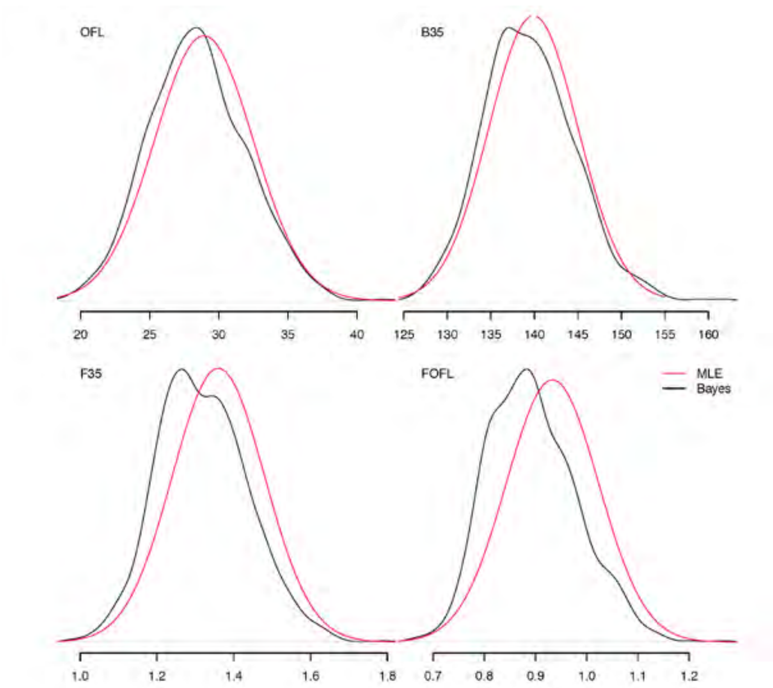


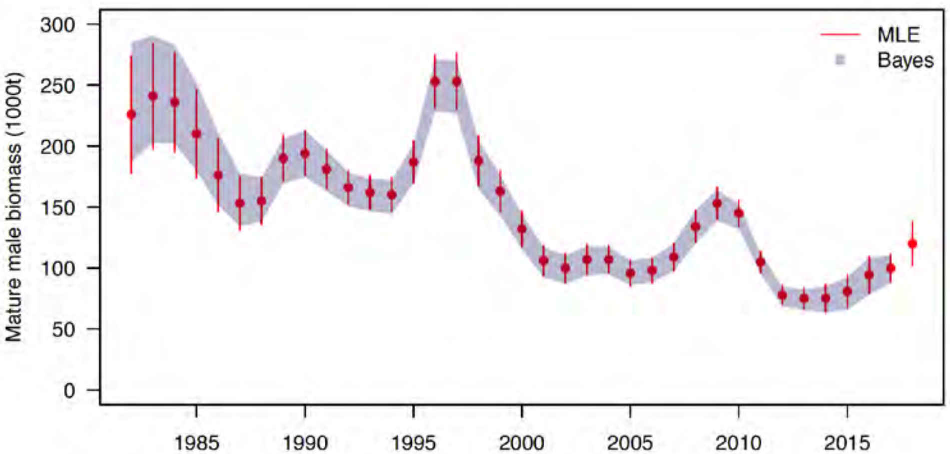
Model results: survey selectivity





MLE- vs. Bayesian-derived Management Quantities





- reasonably small differences in derived quantities

Author Recommendations

- Estimating, rather than fixing, mature female natural mortality resulted in
  - better fits to the data
  - eliminated the bimodality in management quantities
  - restored the proper relationship between estimated M for females and males
  - However, survey catchability increased to 1 for females

- Adding the additional growth data also eliminated the bimodality from management quantities when fixing mature female M.

- Recommended to
  - estimate natural mortality
  - incorporate the new growth data

CPT Recommendations

- Would like to see future model runs that include male growth with and without kink to understand sensitivity of model results
- Consider including likelihood profiles for M
- Address poor fits to female survey biomass data and assumption that q is 1 for females
- Use MLE approach with jittering (as opposed to full Bayesian integration) to determine management-related quantities

- Recommended scenarios for Fall 2018:
  - Models should be fit to total and retained size comps rather than total and discarded size comps
  - Sept 2017 version M17A-D17A (split survey era in 1987)
  - Sept 2017 version M17C-D17A (estimate mature female M)

Tanner Crab

Tanner Crab

- Report presented by Buck Stockhausen (AFSC)

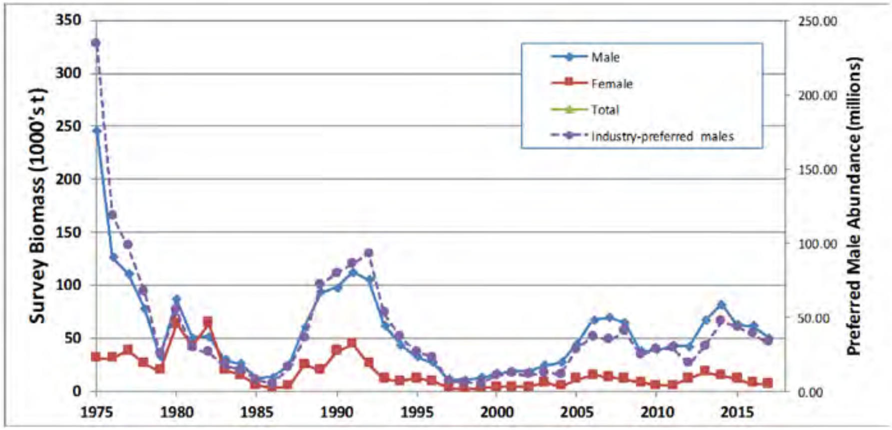
- Major concerns from 2017 assessment
  - Number of parameters hitting bounds
  - Over-prediction of large male crab in NMFS trawl survey

- Major topics
  - Data explorations
    - bootstrapped NMFS survey size compositions for input sample sizes
    - sex ratio at small sizes (selectivity implications)
  - Assessment model updates
    - fits to annual male maturity ogives from chela height data
    - new "devs" formulation
    - Dynamic B0 calculation
    - new recruitment likelihood component (CV as estimable parameter)
  - Investigated 42 candidate model scenarios for Fall assessment
  - Retrospective analysis for recruitment averaging terminal year

Tanner Crab

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
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	12.82	73.93	8.92	8.91	11.38	27.19	21.75
2016/17	14.58	77.96	0.00	0.00	1.14	25.61	20.49
2017/18		43.31	1.1	1.1		25.42	20.33

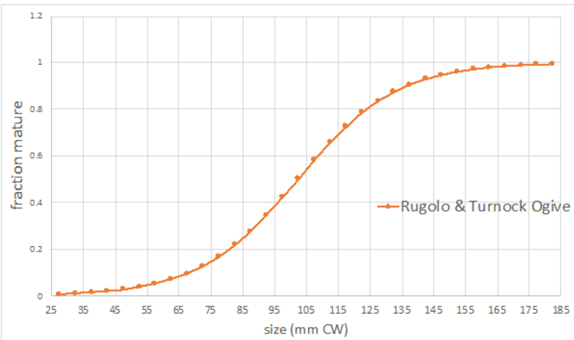
units: 1000's t

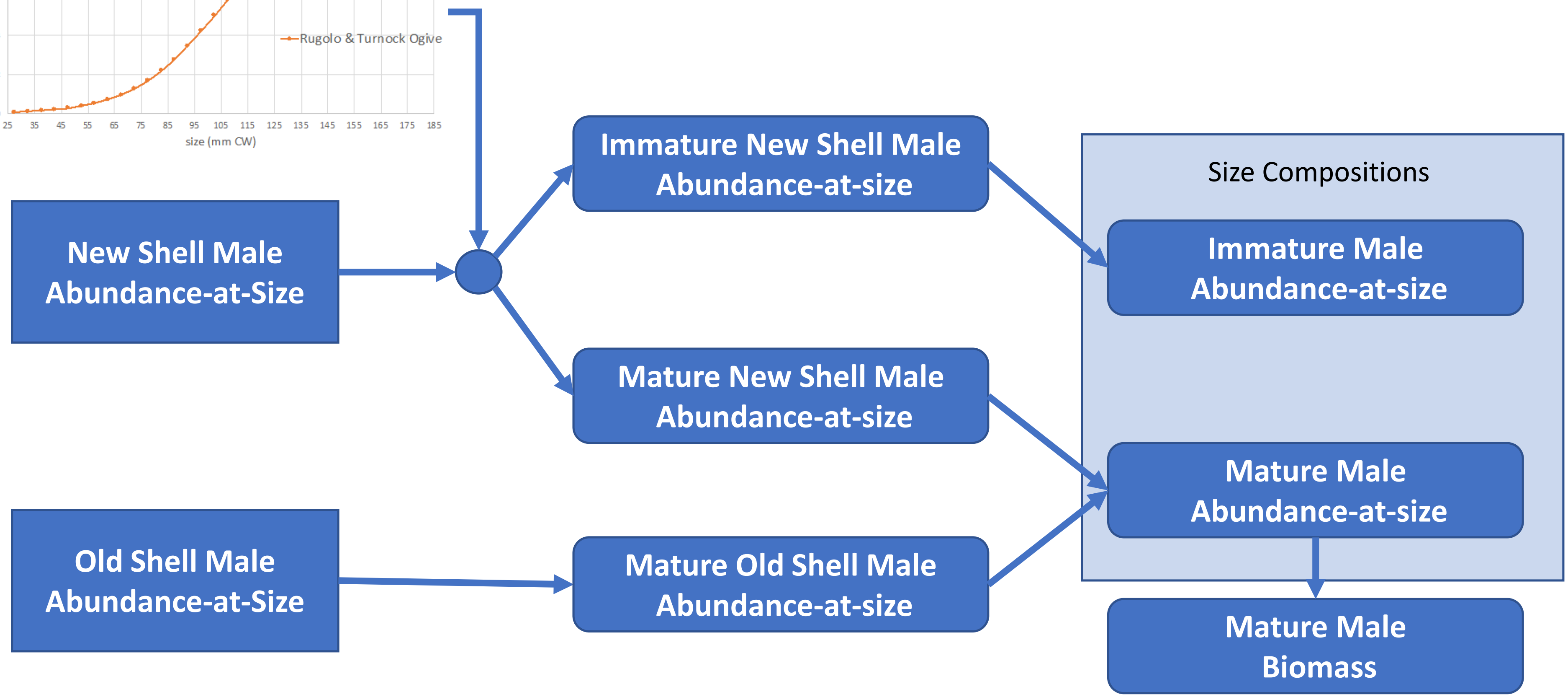


- Tier 3a

Data: Male Chela Height Data

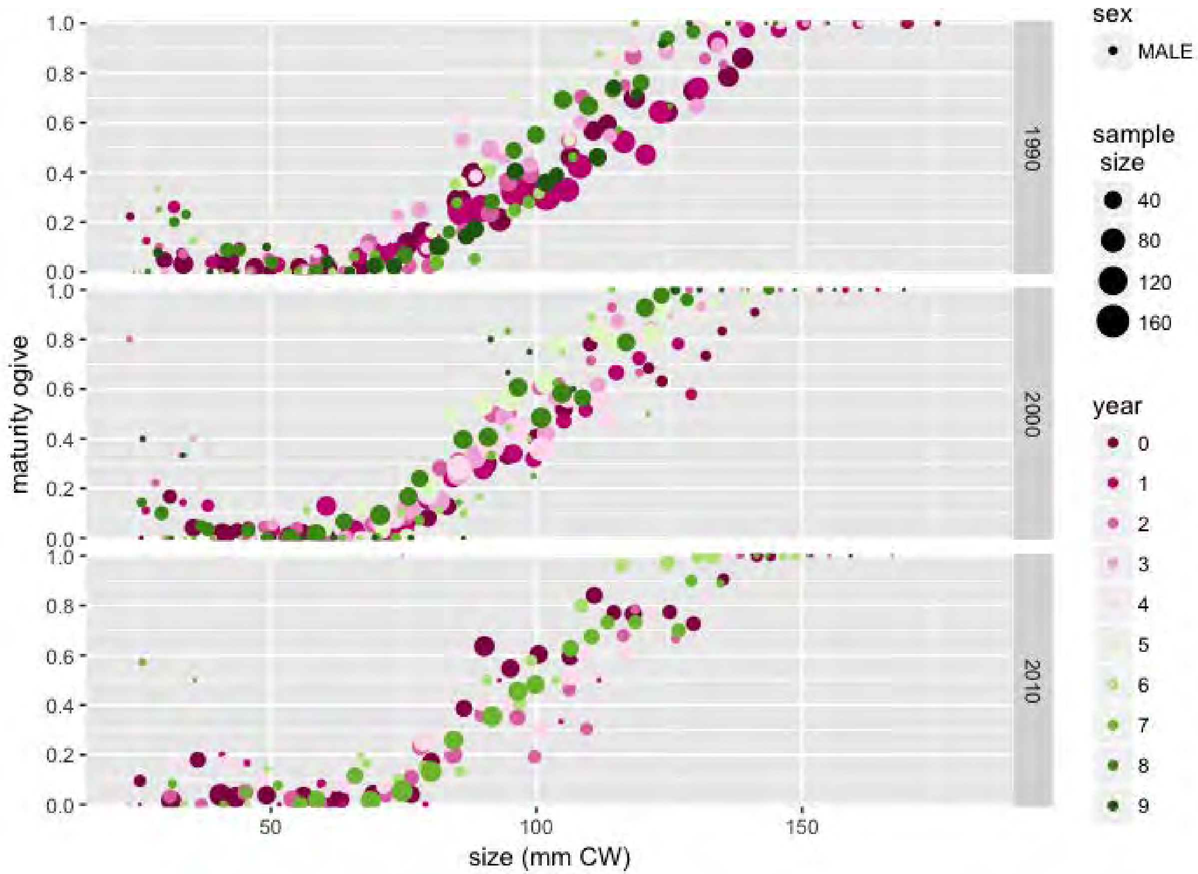
Current Male Maturity Classification





Empirical maturity ogives

- CH measured to 1 mm 1975-1989
- CH measured to 0.1 mm 1990+



Assessment Model Development: Male Maturity Ogive Data

- Assign male maturity status outside assessment model only for males with measured CHs
  - use size-specific CH:CW cutpoints to classify new shell males with CHs as immature or mature
  - calculate ”observed” maturity ogive by size bin for years when CHs are taken

- Fit to NMFS survey total male biomass, total male size compositions *by shell condition*

- Fit observed male maturity ogives (new shell mature : total new shell) using model-predicted ratios for the NMFS survey

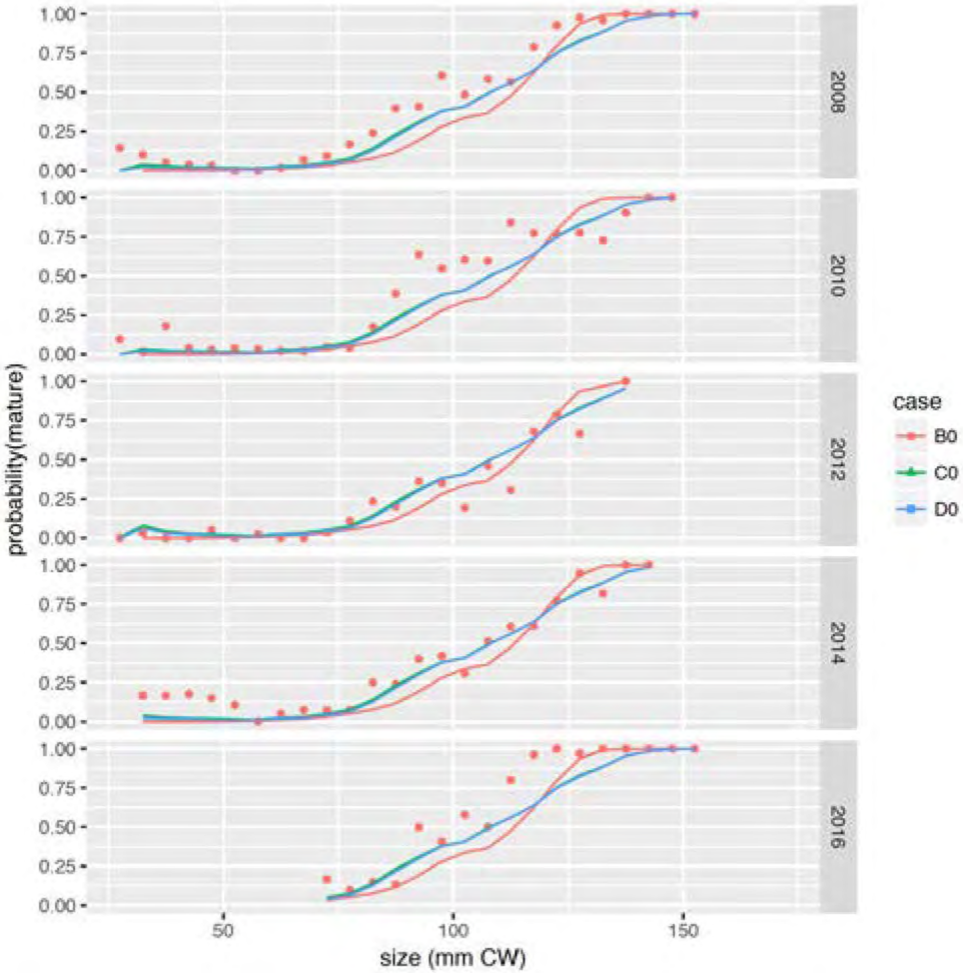
- Objective function components are based on size-specific binomial likelihoods:

$$p_{y,z} = \frac{M_{y,z}}{I_{y,z} + M_{y,z}} \sim B(\hat{p}_{y,z} = \frac{\widehat{M}_{y,z}}{\hat{I}_{y,z} + \widehat{M}_{y,z}} | n_{y,z} = I_{y,z} + M_{y,z})$$

- $M_{y,z}$ = observed number of mature, new shell males
- $I_{y,z}$ = observed number of immature (new shell) males
- $\widehat{M}_{y,z}$ = predicted number of mature, new shell males
- $\hat{I}_{y,z}$ = predicted number of immature (new shell) males

$$-\ln(L) = \sum_{y,z} n_{y,z} \cdot \{p_{y,z} \cdot [\ln(\hat{p}_{y,z}) - \ln(p_{y,z})] + (1 - p_{y,z}) \cdot [\ln(1 - \hat{p}_{y,z}) - \ln(1 - p_{y,z})]\}$$

Assessment Model Development: Male Maturity Ogive Data



y	B0	C0	D0
1990	304.58	54.77	56.17
1991	238.43	56.32	59.48
1992	51.15	18.49	18.89
1993	103.06	26.55	29.01
1994	45.16	20.81	22.75
1995	27.10	13.69	13.83
1997	6.35	10.24	9.71
1998	109.34	24.26	27.14
1999	19.08	12.40	11.97
2000	117.77	21.02	21.80
2001	79.38	25.67	27.15
2002	47.44	18.65	20.10
2003	38.87	11.75	13.17
2004	51.75	17.22	18.70
2005	134.19	63.80	66.32
2008	150.95	45.97	56.33
2010	243.33	60.64	69.59
2012	34.71	15.75	15.44
2014	99.17	20.34	26.16
2016	37.35	38.25	39.00
2017	66.18	15.89	17.76

Assessment model scenarios: model configurations

Indicator	Description
0	2017 assessment model configuration: • model starts in 1948 • rec devs before 1975 have random walk priors • rec devs after 1974 have normal priors
1	0 +: • model starts in 1900 • no priors on rec devs • 1 mean ln-scale recruitment parameter, separate CVs are defined for pre-1975, post-1974 time blocks
a	+: • estimate recruitment CV in 1975+ time block • include new recruitment likelihood component in parameter optimization • drop priors on rec devs in 1975+ period
b	"a" + no prior on catch rate rec devs
c	"b" + • drop fits to survey data 1975-1981 • recruitment estimated in two time blocks: model start to 1981 and 1982 to 2017.
d	ln-scale mean fishery capture rates applied starting when effort or catch data are first available
e	probabilities of terminal molt are fixed at • 0 for smallest size classes • 1 for largest size classes
q	estimate single survey Q, selectivity function for males and females in each time block
-Fr	iteratively re-weight size comp.s using the Francis approach
-McI	iteratively re-weight size comp.s using the McAllister-Ianelli approach

Data Configuration B: 2017 assessment data

Name	component	type	Distribution	Likelihood
2017AM, 2018B0	TCF: retained catch	abundance	--	--
		biomass	norm2	males only
		size comp.s	multinomial	males only
	TCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	SCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	RKF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	GTF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	NMFS survey	abundance	--	--
		biomass	lognormal	by sex for mature only
		size comp.s	multinomial	by sex/maturity
		chela height data	--	--
	growth data	EBS only	gamma	by sex

Successive Data Configurations

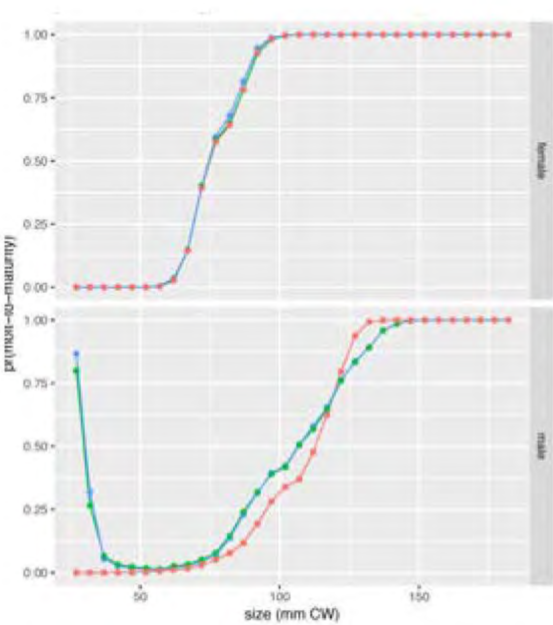
- C: B + Fit male maturity ogives from chela height data
- D: C
  - minus male survey biomass, size compositions classified by maturity status
  - plus male survey biomass, size compositions by shell condition
- E: D + NMFS survey abundance by sex, shell condition, maturity (females only)
- F: E + increased weight (5 *x*) on fitting growth data, male maturity ogives
- G: F + lognormal error structure for fishery catch data

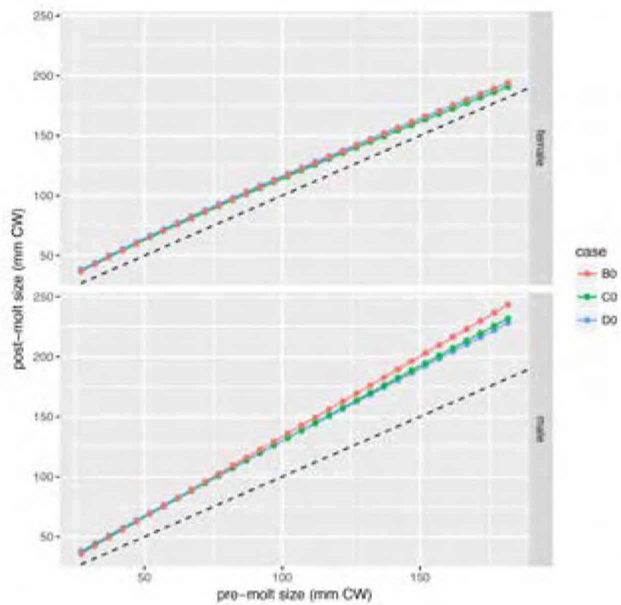
Assessment model scenarios

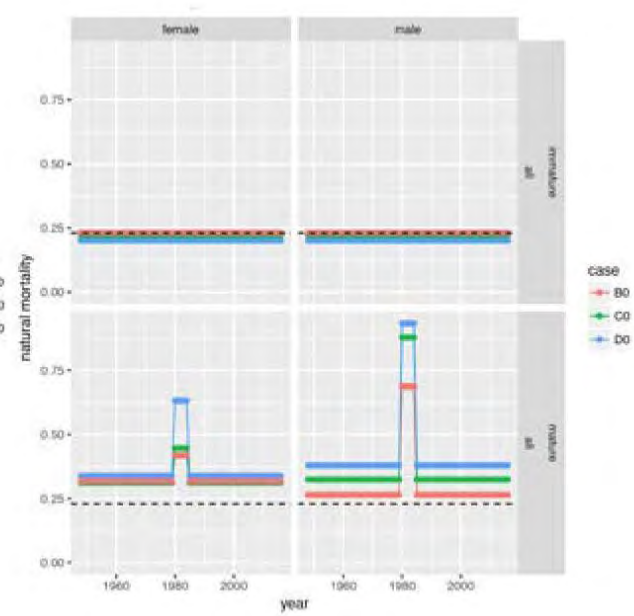
Name	Description
2018B0	2018B- data + “0” configuration (i.e., the 2017AM)
2018B0q	2018B0 + “q” configuration
2018B0-Fr	2018B0 + “-Fr” configuration
2018B0-McI	2018B0 + “-McI” configuration
2018B0a	2018B0 + “a” configuration
2018B0b	2018B0a + “b” configuration
2018B0c	2018B0b + “c” configuration
2018B1	2018B0 + “1” configuration
2018B1b	2018B1 + “b” configuration
2018B1c	2018B1b + “c” configuration
2018C0	2018C- data + “0“ configuration
2018C0a	2018C0 + “a” configuration
2018C0b	2018C0a + “b” configuration
2018C0c	2018C0b + “c” configuration
2018C1	2018C0 + “1” configuration
2018C1b	2018C1 + “b” configuration
2018C1c	2018C1b + “c” configuration
2018D0	2018D- data + “0“ configuration
2018D0a	2018D0 + “a” configuration
2018D0b	2018D0a + “b” configuration
2018D0c	2018D0b + “c” configuration
2018D1	2018D0 + “1” configuration
2018D1b	2018D1 + “b” configuration
2018D1c	2018D1b + “c” configuration

Name	Description
2018E0	2018E- data + “0“ configuration
2018E0a	2018E0 + “a” configuration
2018E0b	2018E0a + “b” configuration
2018E0c	2018E0b + “c” configuration
20180	2018E0 + “1” configuration
2018E1b	2018E1 + “b” configuration
2018E1c	2018E1b + “c” configuration
2018F0	2018F- data + “0“ configuration
2018F0a	2018F0 + “a” configuration
2018F0b	2018F0a + “b” configuration
2018F0c	2018F0b + “c” configuration
2018G0	2018F- data + “0“ configuration
2018G0a	2018G0 + “a” configuration
2018G0b	2018G0a + “b” configuration
2018G0bd	2018G0b + “d” configuration
2018G0bde	2018G0bd + “e” configuration
2018G0bde-Fr	2018G0bde + “-Fr” config.
2018G0bde-McI	2018G0bde + “-McI” config.

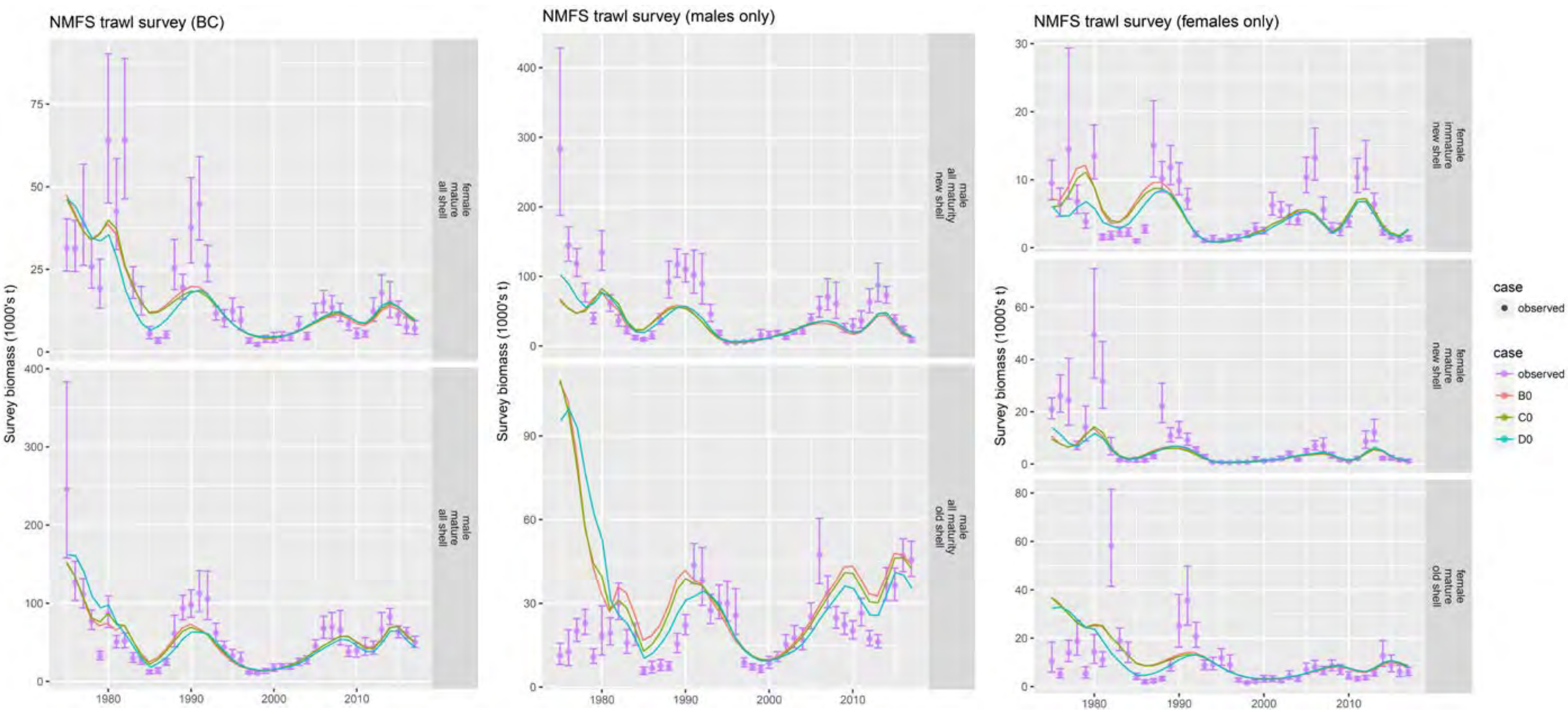
Assessment model results: B0, C0 and D0



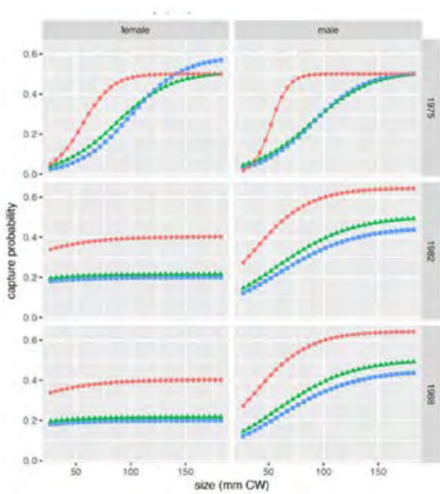


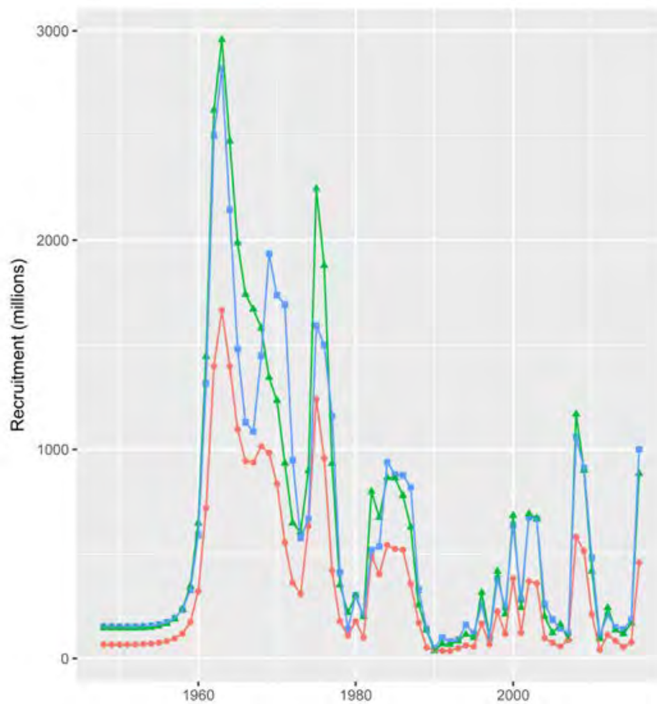


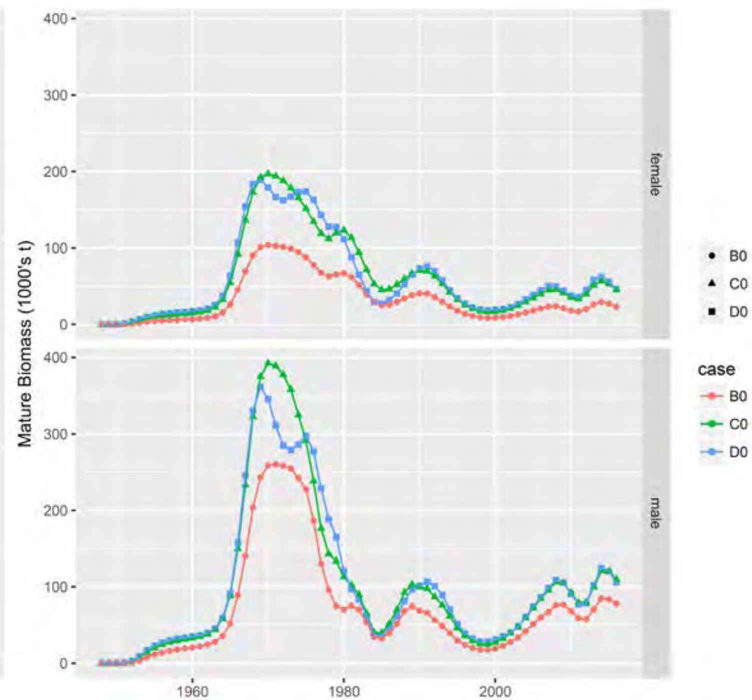
Assessment model results: B0, C0 and D0



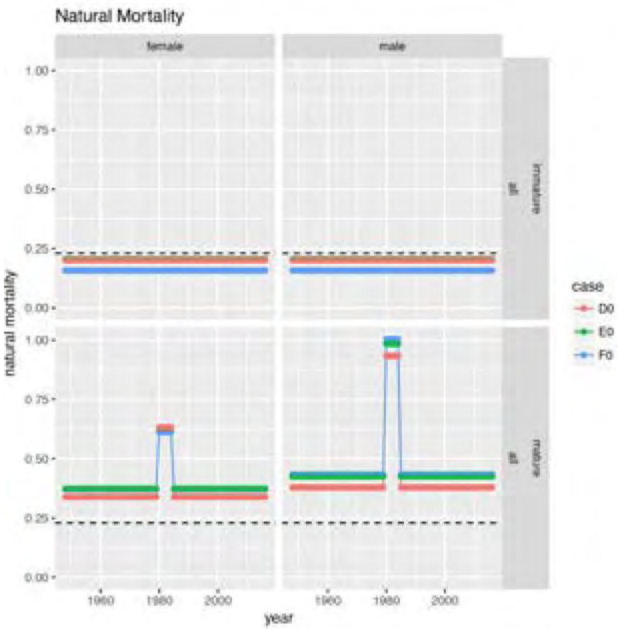
Assessment model results: B0, C0 and D0

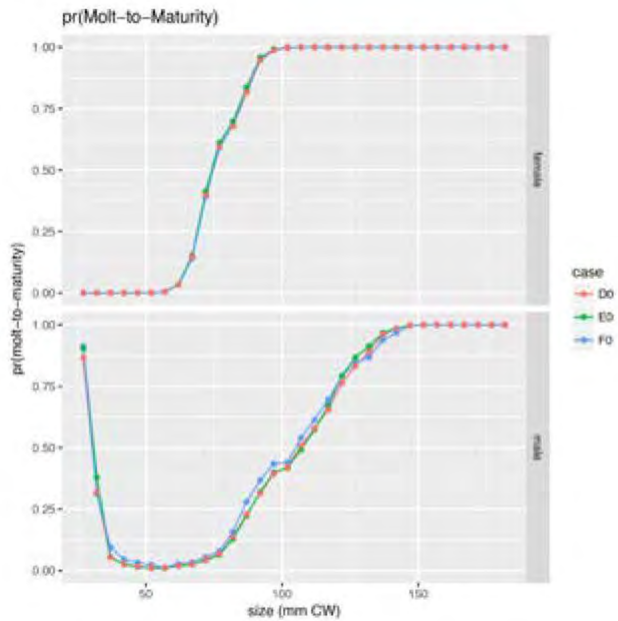


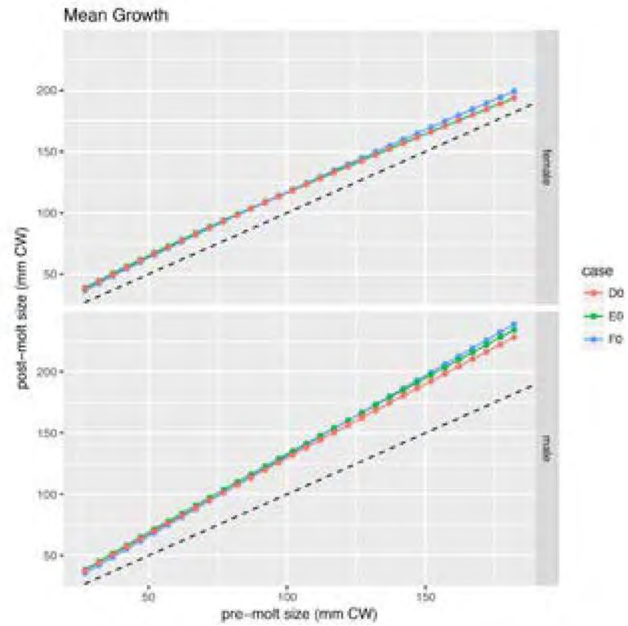




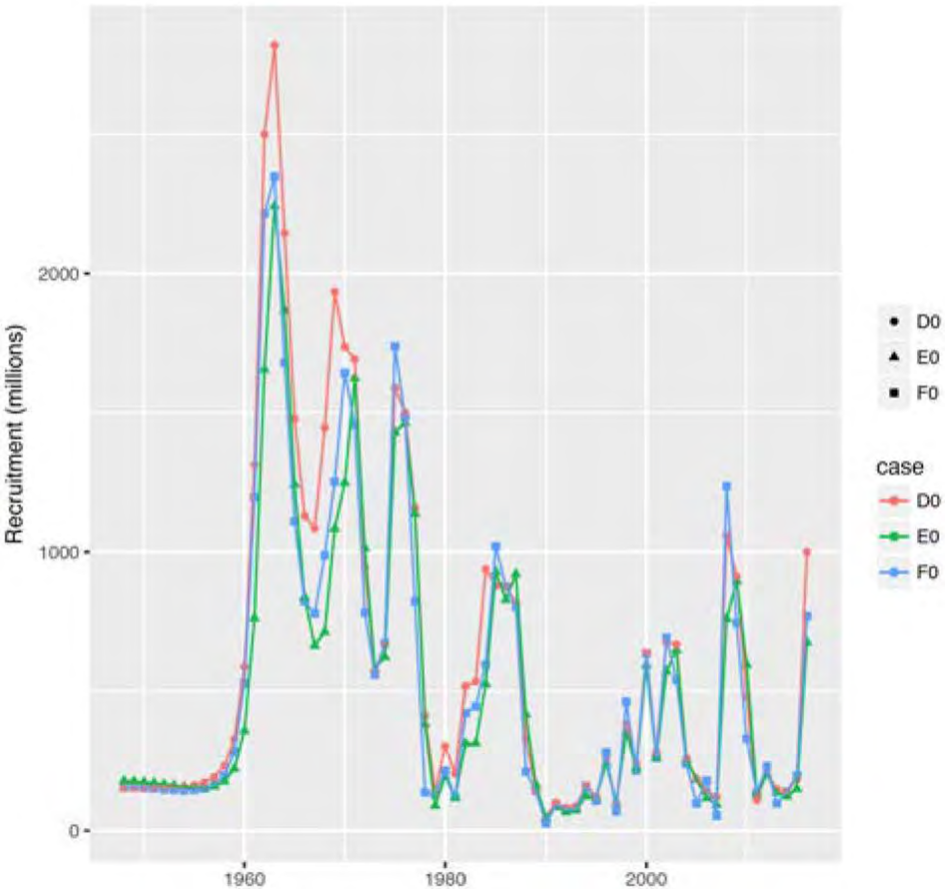
Assessment model results: D0, E0, F0

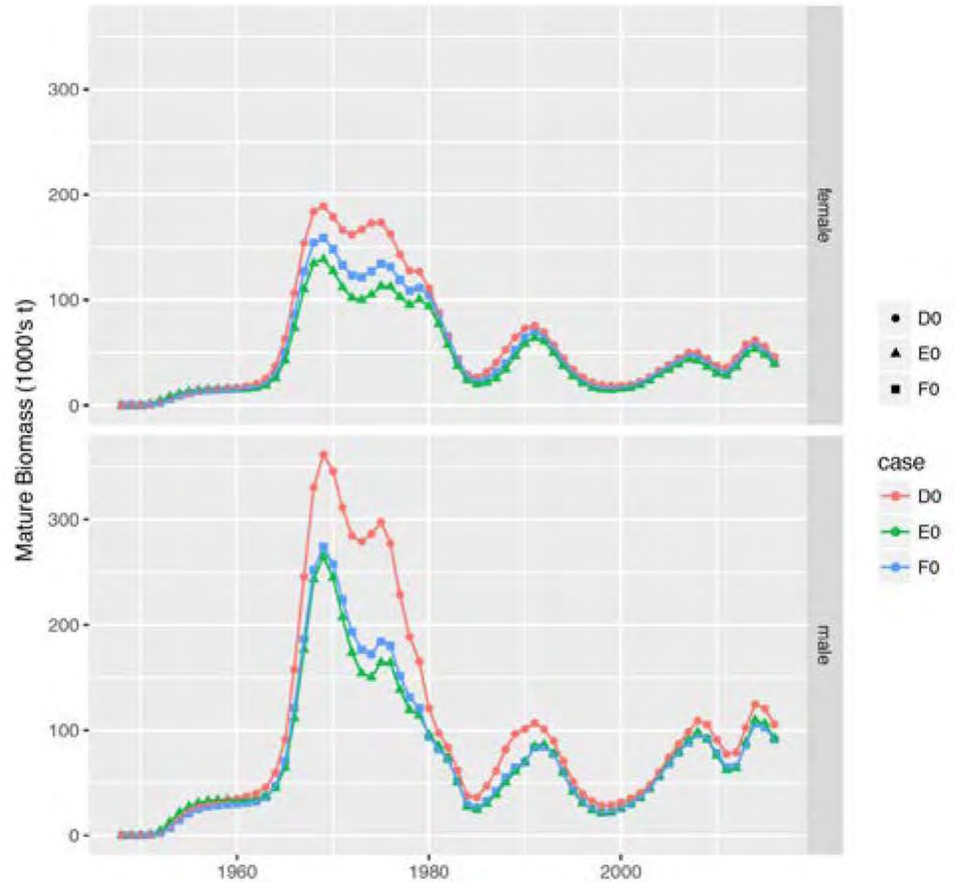




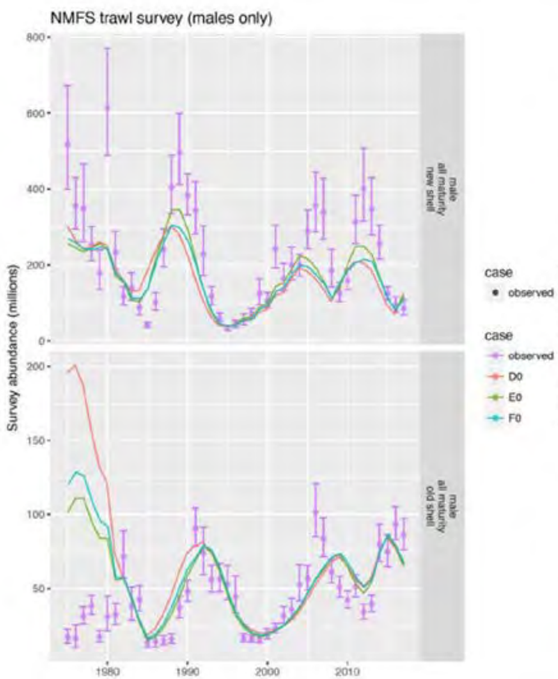


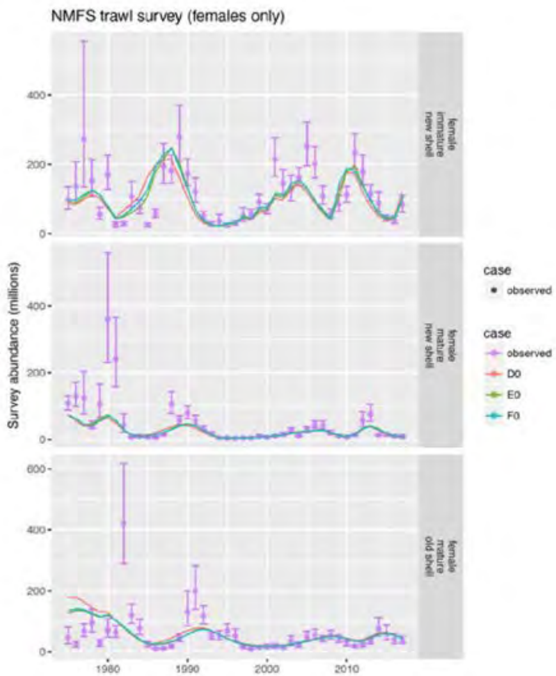
Assessment model results: D0, E0, F0

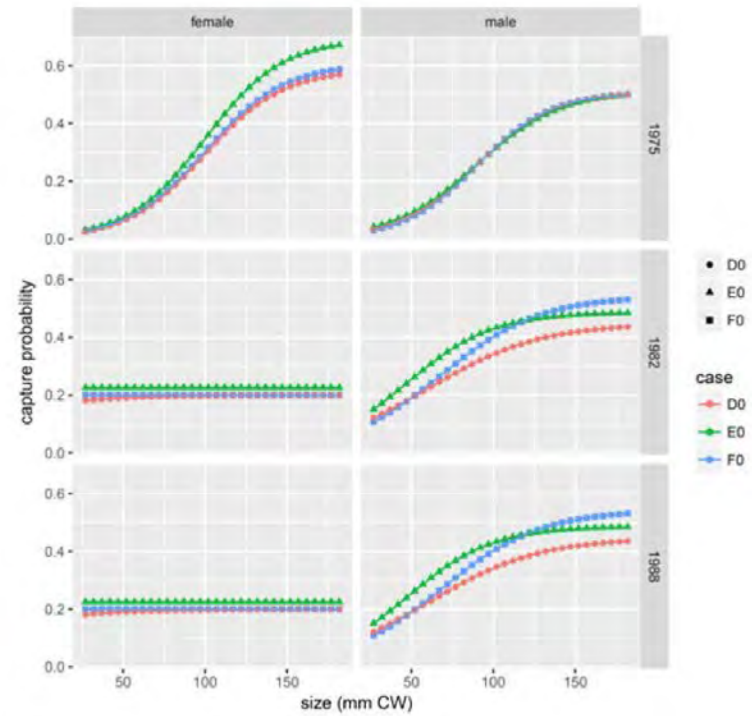




Assessment model results: D0, E0, F0







Assessment model results: Iterative re-weighting

- Francis method
  - Did not converge in 5 iterations for any dataset
  - substantially down-weighted all size compositions
    - most cumulative weights < 0.0001
  - Most parameters estimated at bounds of all scenarios
  - Very different results from non-weighted scenario

- McAllister-Ianelli
  - Converged for all fishery-related datasets
    - increased weights on fishery size composition data
    - most cumulative weights ~ 1.5 – 10
  - Did not converge in 5 iterations for survey datasets
    - decreased weights on survey size composition data
  - Similar results to non-reweighted scenario

CPT recommendations for Sept.

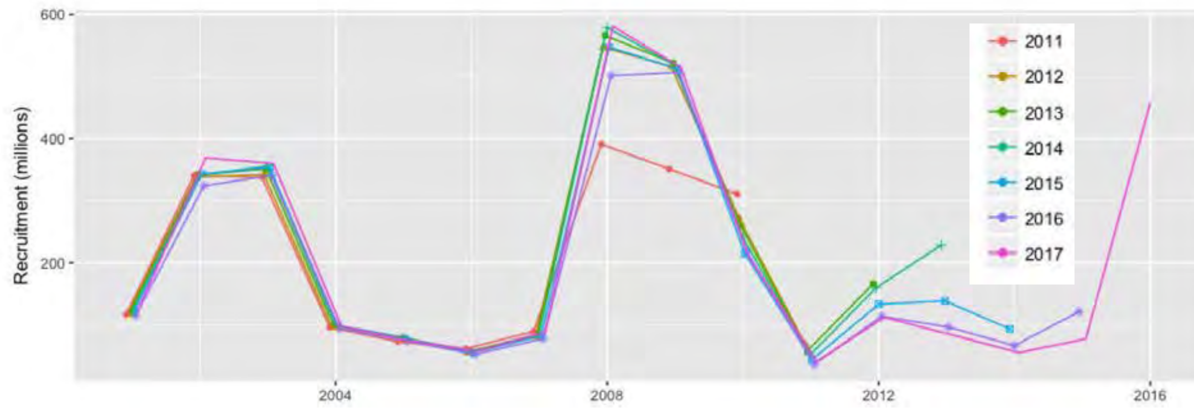
- 2017AM: the 2017 assessment model configuration
- 2018B0: the 2017 assessment model configuration with updated data for 2018.
- 2018B1: 2018B0 + include the male maturity ogive data in the model optimization, with the probability of the male molt-to-maturity fixed at 0 in size bins < 60 mm CW (bridging model only).
- 2018B2: 2018B1 + include the NMFS survey data as the total biomass by sex, and the size-composition for males by shell condition and for females by maturity status and shell condition
- 2018B3: 2018B1 + include the NMFS survey data as the total biomass by sex, and the size-composition for males aggregated over shell condition and for females by maturity status (aggregated over shell condition).
- 2018B4: 2018B2 + include aggregated NMFS survey abundance estimates in the model optimization
- 2018B5: 2018B3 + include aggregated NMFS survey abundance estimates in the model optimization

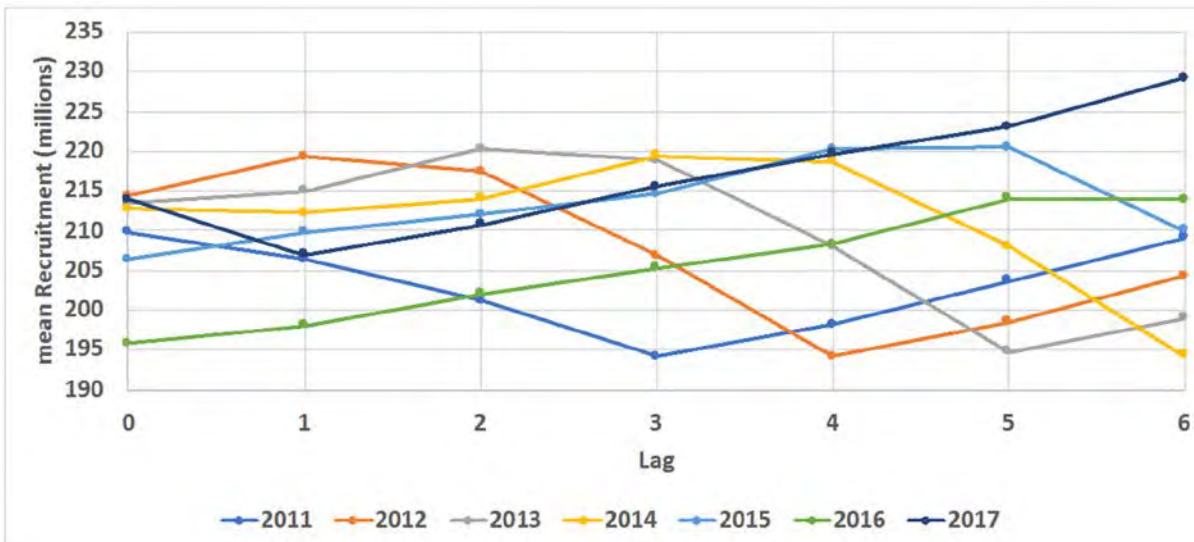
- Scenario 2018B1 **not** considered as a basis for management advice
  - informative for changes in methodology, but essentially uses same data twice
- CPT did not see value in addressing model scenarios in which catch data are considered lognormal

Retrospective Analyses for Terminal Year of Time Period for Recruitment Averaging

Tanner crab

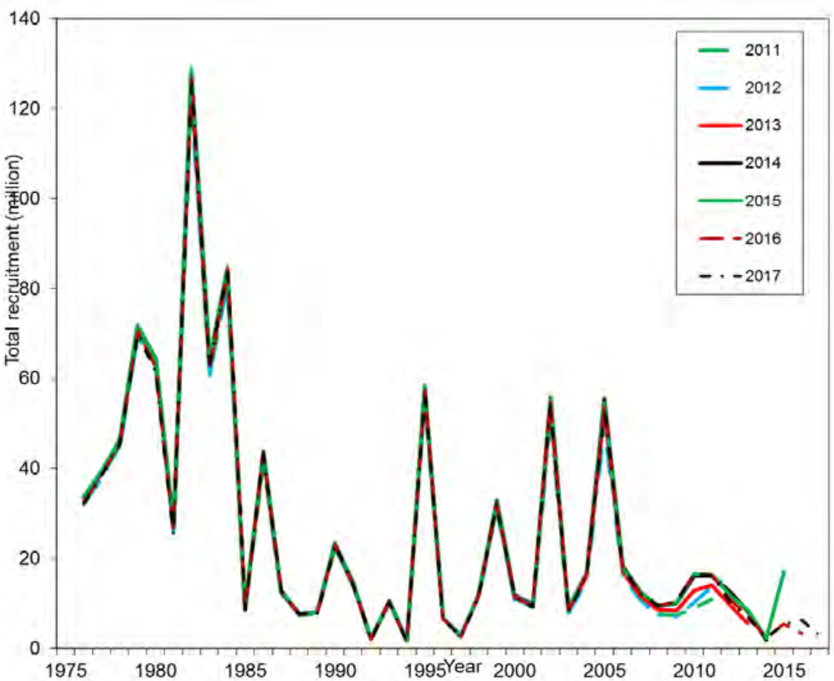
- Retrospective runs using 2017AM
- Terminal years 2011-2017
- Look at variability in average recruitment dropping estimates from final 0-6 years



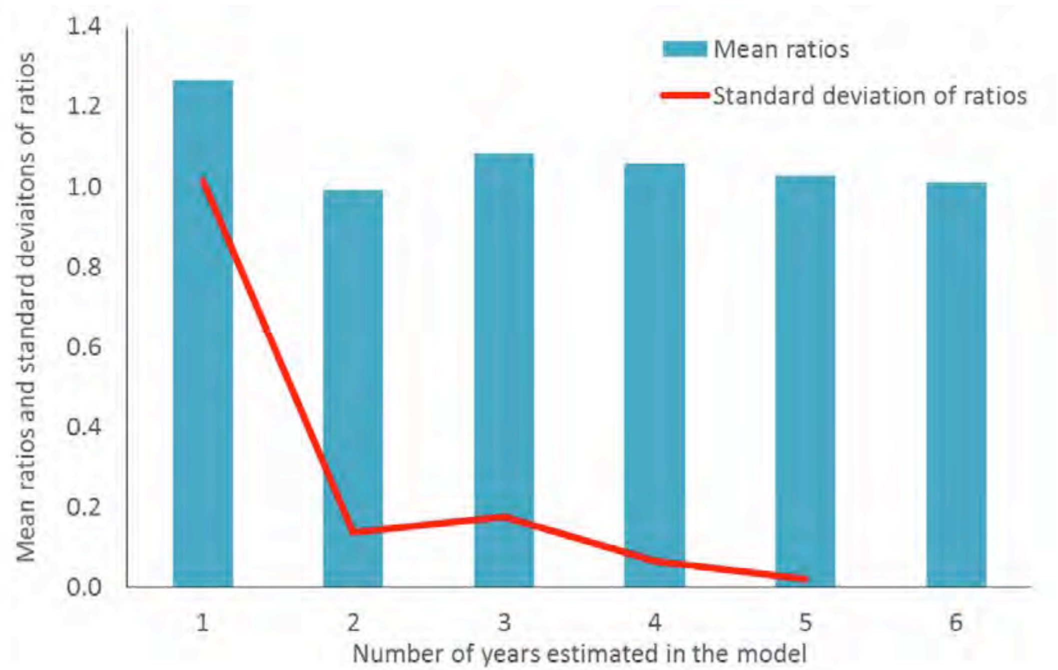


BBRKC

Retrospective Recruitment Results from Scenario 2b



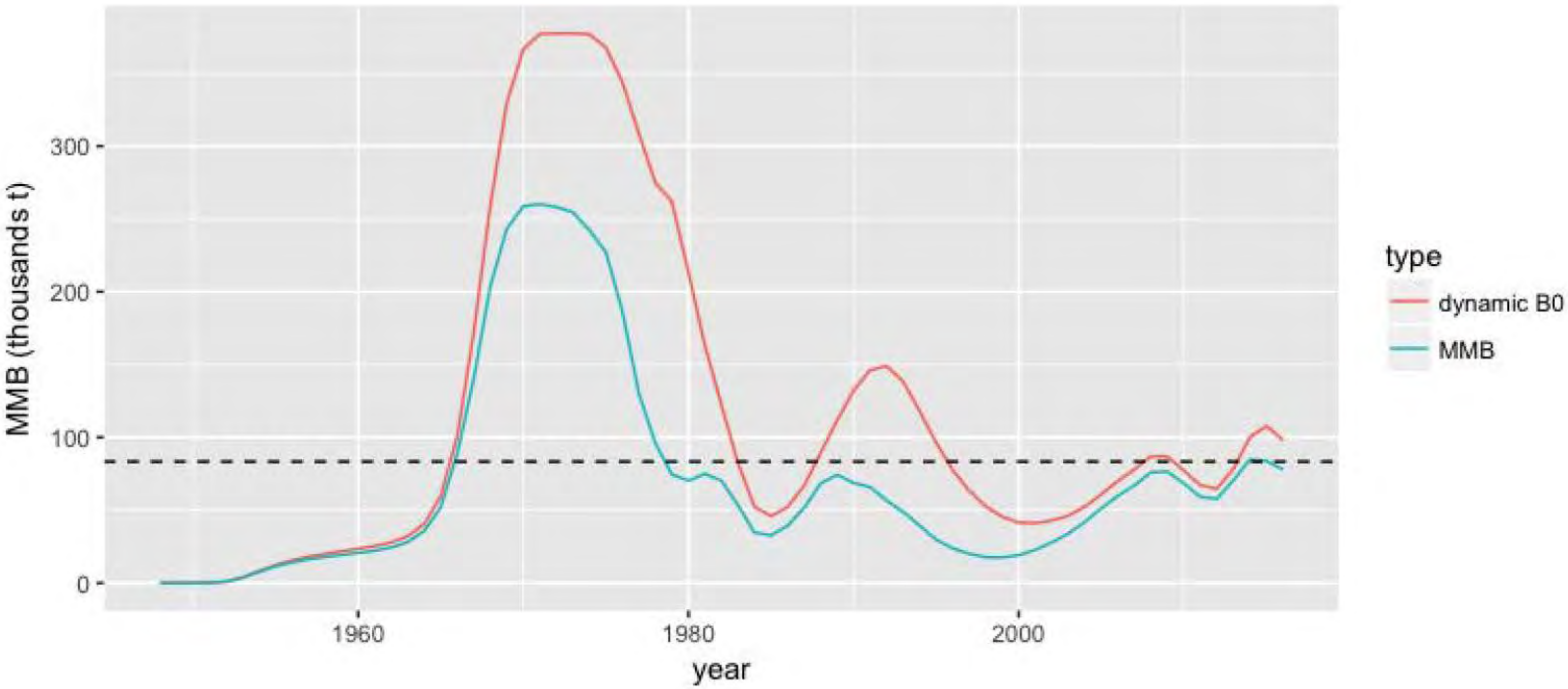
Mean ratios of retrospective estimates of recruitments to those estimated in the most recent year (2017)



- the recruitment in the terminal year should not be used for estimating B35%
- mean recruitment should be estimated using recruitments from 1984 to endyear – 1

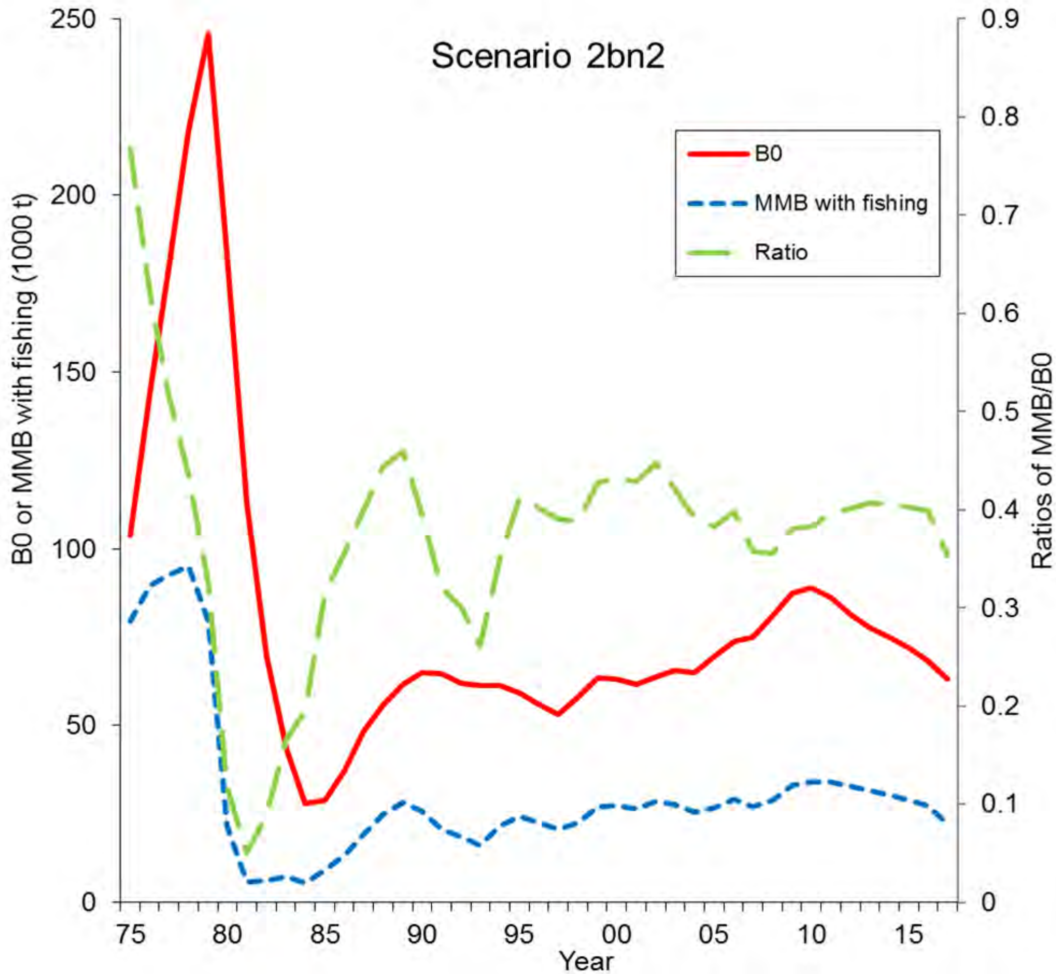
Dynamic B0

Tanner crab



MMB (thousands t)
300
200
100
0
1960
1980
2000
year
type
dynamic B0
MMB

BBRKC



Scenario 2bn2
B0
MMB with fishing
Ratio
B0 or MMB with fishing (1000 t)
Ratios of MMB/B0
Year
250
200
150
100
50
0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
75
80
85
90
95
00
05
10
15