BSAI Crab Management

SAFE Report and Crab Plan Team Report

Agenda Item C-1
October 2016

BSAI Crab Plan Team:

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Laura Stichert (ADF&G-Kodiak)

October 2016 Crab Plan Team Report

- General Recommendations
  - Authors should follow SAFE guidelines
    - CPT appreciates figures showing data available
    - Diagnostics need to be included (retrospectives and appropriate likelihoods)
    - Update previous year B_{MSY} and biomass to assess stock status
  - Consistent handling mortality should be used
    - January analysis for use in May

October 2016 Crab Plan Team Report

- Aleutian Islands golden king crab model
- EBS Survey update
- Recommend final OFL/ABC for 6 crab stocks
- NSRKC model update
- Economics Assessment
- Other business

Aleutian Island Golden king crab model

M.S.M. Siddeek, J. Zheng, and D. Pengilly
ADF&G

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Aleutian Islands Golden King Crab (*Lithodes aequispinus*) Model-Based Stock Assessment in Fall 2016

Authored by:
M.S.M. Siddeek, J. Zheng, and D. Pengilly
Alaska Department of Fish and Game, Juneau and Kodiak
3 October 2016, SSC presentation

OFLs for Aleutian Islands golden king crab stocks in the two management regions (EAG and WAG) are currently determined under a constant harvest policy through a Tier 5 assessment.

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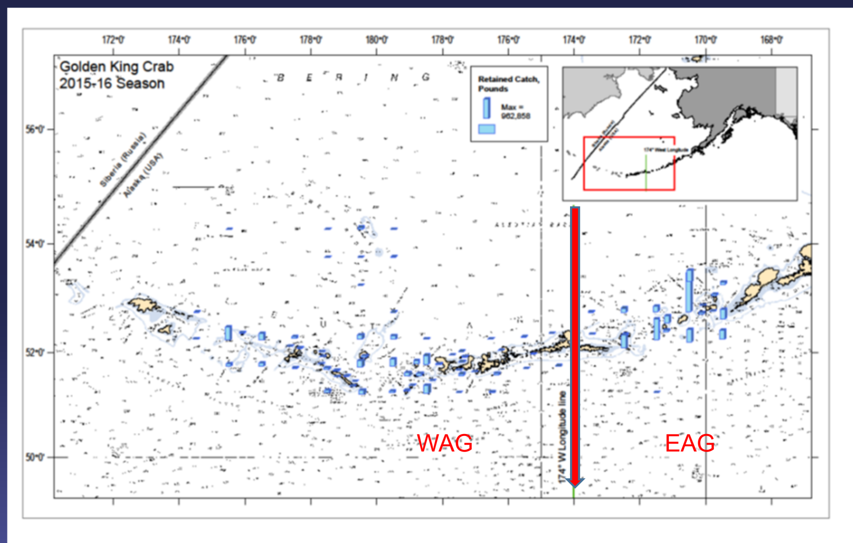
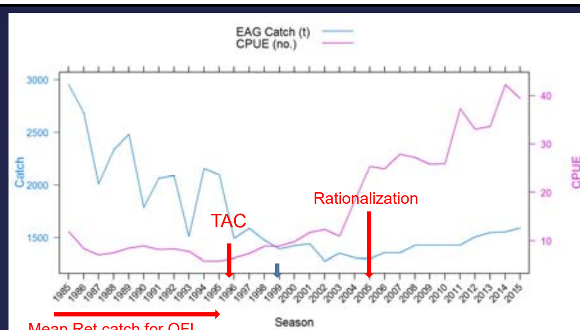


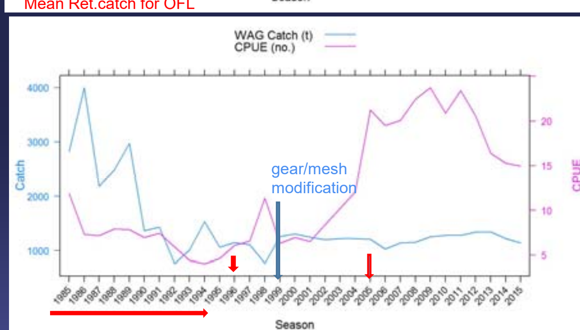
Catch (t) and CPUE (number of crab per pot lift) in 1985/86–2015/16 .

8

EAG



WAG



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Brief History of the Assessment process

- 2008-2010 Initial model development
- 2012 Model updates; CPUE standardization
- 2013 Model updates; CPUE standardization
- 2014 CPUE standardization “adopted” by the CPT
- 2014 Model refinements
- 2015 Model refinements: focus on understanding
- 2016 Now..

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Approach-I

- Single-sex (male) model (but two areas with one joint parameter)
  - Size-structured population dynamics model
    - Size-transition matrix is estimated
    - M is pre-specified (based on initial fits)
  - Removals: Landings in directed fishery, discards in the directed fishery; groundfish discards
    - Selectivity (and retention) is generally logistic (but double-logistic is considered in some model configurations)

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Approach-II

- Likelihood components
  - Catches and discards (directed fishery, groundfish fishery)
  - CPUE indices (pre- and post-rationalization based on observer data; perhaps a fish ticket data-based cpue index)
  - Length-frequency data
    - Landings; total catch; groundfish discards
  - Tagging data
    - Recapture-conditioned likelihood
  - Penalties
    - Fs & recruitment deviations

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Scenarios (factors)

- Key factors:
  - Use the fish ticket CPUE index?
  - Dome-shaped selectivity?
  - Value for M?
  - Use trawl bycatch data?
  - Basis for stage-1 weighting factors
- Other factors:
  - Basis for conducting the CPUE standardization
  - Number of selectivity patterns
  - Francis weighting

Overall 34 model scenarios considered; detailed results are only shown for 13 of them.

Sc.	Size-composition weighting	Catchability and total selectivity sets	Total selectivity type	CPUE data type	GLM predictor variable selection criterion	Treatment of trawl/total size composition and catch data	Natural mortality (M yr^{-1})
1a	Stage-1:Number of lengths	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
1b	Stage-1:Number of lengths	2	logistic	Observer	AIC	Trawl bycatch size-composition data included	0.2339
1c	Stage-1:Number of trips	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
1d	Stage-1:Number of trips	2	logistic	Observer	AIC	Trawl bycatch size-composition data included	0.2339
2a	Stage-1:Number of lengths	2	logistic	Observer & Fish ticket	R-squared	Trawl bycatch size-composition data included	0.2426
2b	Stage-1:Number of lengths	2	logistic	Observer & Fish ticket	AIC	Trawl bycatch size-composition data included	0.2426
2c	Stage-1:Number of trips	2	logistic	Observer & Fish ticket	R-squared	Trawl bycatch size-composition data included	0.2426
2d	Stage-1:Number of trips	2	logistic	Observer & Fish ticket	AIC	Trawl bycatch size-composition data included	0.2426
3a	Stage-1:Number of lengths	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included, groundfish selectivity estimated	0.2339
3c	Stage-1:Number of trips	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included, groundfish selectivity estimated	0.2339
4a	Stage-1:Number of lengths	2	logistic	Observer	R-squared	Dropped trawl bycatch & size-composition data	0.2339
4c	Stage-1:Number of trips	2	logistic	Observer	R-squared	Dropped trawl bycatch & size-composition data	0.2339
5a	Stage-1:Number of lengths	3	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
5c	Stage-1:Number of trips	3	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
6a	Stage-2:Number of lengths	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
6c	Stage-2:Number of trips	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
7a	Stage-2:Number of lengths	2	logistic	Observer & Fish ticket	R-squared	Trawl bycatch size-composition data included	0.2426
7c	Stage-2:Number of trips	2	logistic	Observer & Fish ticket	R-squared	Trawl bycatch size-composition data included	0.2426
8a	Stage-1:Number of lengths	2	dome shaped	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
8c	Stage-1:Number of trips	2	dome shaped	Observer	R-squared	Trawl bycatch size-composition data included	0.2339
9a	Stage-1:Number of lengths	2	logistic	Observer	R-squared	Total size composition and catch data started from 1996/97 (EAG) or -1995/96 (WAG)	0.2339
9c	Stage-1:Number of trips	2	logistic	Observer	R-squared	Total size composition and catch data started from 1996/97 (EAG) or -1995/96 (WAG)	0.2339
10a	Stage-1:Number of lengths	2	logistic	Observer & Fish ticket	R-squared	Total size composition and catch data started from 1996/97 (EAG) or -1995/96 (WAG)	0.2426
10c	Stage-1:Number of trips	2	logistic	Observer & Fish ticket	R-squared	Total size composition and catch data started from 1996/97 (EAG) or -1995/96 (WAG)	0.2426
11a	Stage-1:Number of lengths	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.18
11c	Stage-1:Number of trips	2	logistic	Observer	R-squared	Trawl bycatch size-composition data included	0.18
12a	Stage-1:Number of lengths	2	logistic	Observer & Fish ticket	R-squared	Trawl bycatch size-composition data included	0.18
12c	Stage-1:Number of trips	2	logistic	Observer & Fish ticket	R-squared	Trawl bycatch size-composition data included	0.18
14a	Stage-1:Number of lengths	2	logistic	Observer	R-squared	Dropped trawl bycatch size-composition data	0.18
14c	Stage-1:Number of trips	2	logistic	Observer	R-squared	Dropped trawl bycatch size-composition data	0.18
16a	Stage-1:Number of lengths	2	dome shaped	Observer	R-squared	Trawl bycatch size-composition data included	0.18
16c	Stage-1:Number of trips	2	dome shaped	Observer	R-squared	Trawl bycatch size-composition data included	0.18
19a	Stage-1:Number of lengths	2	logistic	Observer	R-squared, Interaction	Trawl bycatch size-composition data included	0.2339
19c	Stage-1:Number of trips	2	logistic	Observer	R-squared, Interaction	Trawl bycatch size-composition data included	0.2339

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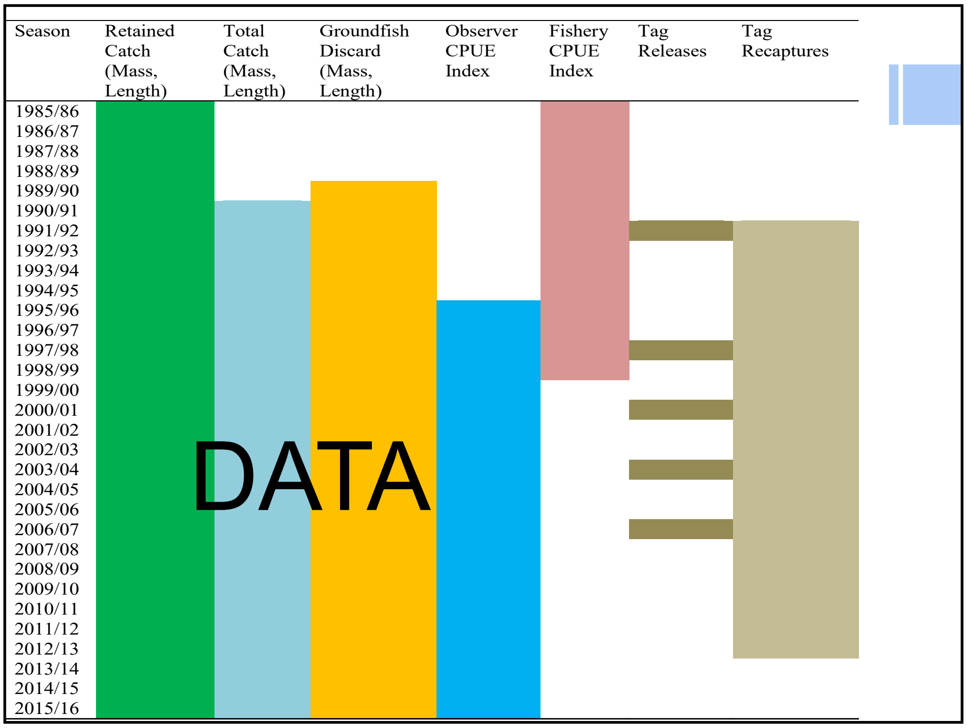
Model scenarios 2

- The “recommended” 8 out of 13 scenarios are:
  - 1a (base, Stage-1 effective sample size is the scaled number of length measurements),
  - 1c (base, Stage-1 effective sample size is the number of fishing trips),
  - 2a (1a with fish ticket CPUE likelihood),
  - 2c (1c with fish ticket CPUE likelihood),
  - 6a (1a with iteratively estimated Stage-2 effective sample sizes),
  - 6c (1c with iteratively estimated Stage-2 effective sample sizes),
  - 8a (1a with dome shaped selectivity), and
  - 8c (1c with dome shaped selectivity)
- All scenarios fit the data equally well.

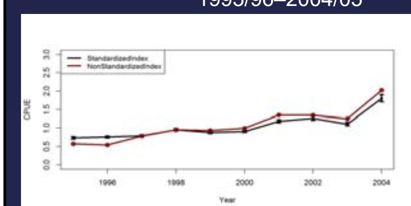


Figures B1 & B2. Trends in non-standardized and standardized (negative binomial GLM) observer CPUE indices with +/- 2 SE for EAG. Standardized indices: black line and non-standardized indices: red line. R^2 (top panels) and CAIC (bottom panels) criteria are used for variable selection.

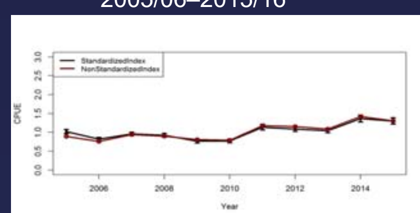
16

1995/96–2004/05

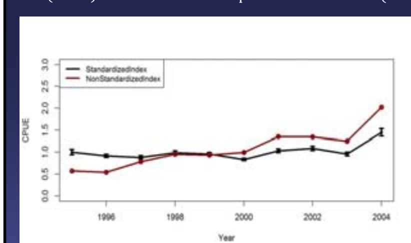
2005/06–2015/16



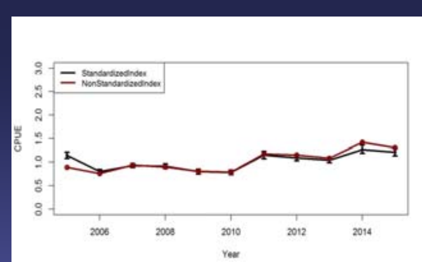
ln (CPUE) = Year + Gear + Captain + forced in: ns(Soak, 3)



ln(CPUE) = Year + Captain + Gear + ns(Soak, 11)



ln(CPUE) = Year + Gear + Captain + ns(Soak, 3) + *Month*



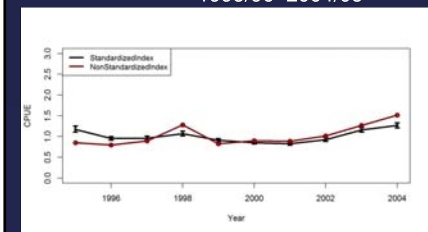
ln(CPUE) = Year + Vessel + Gear + ns(Soak, 11)

Figures B1 & B2. Trends in non-standardized and standardized (negative binomial GLM) observer CPUE indices with +/- 2 SE for WAG. Standardized indices: black line and non-standardized indices: red line. R^2 (top panels) and CAIC (bottom panels) criteria are used for variable selection.

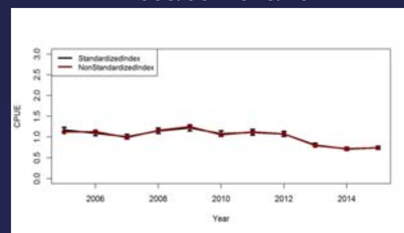
17

1995/96–2004/05

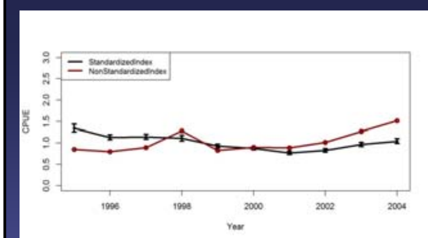
2005/06–2015/16



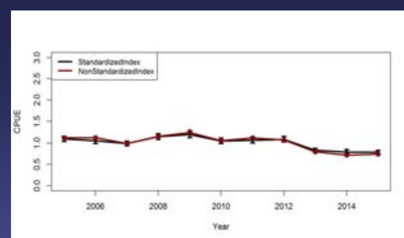
$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{Gear} + \text{ns}(\text{Soak}, 8)$



$\ln(\text{CPUE}) = \text{Year} + \text{Gear} + \text{forced in: } \text{ns}(\text{Soak}, 17)$



$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{ns}(\text{Soak}, 8) + Gear + Area + Month + Vessel$



$\ln(\text{CPUE}) = \text{Year} + \text{Gear} + \text{Vessel} + \text{Month} + \text{forced in: } \text{ns}(\text{Soak}, 17)$

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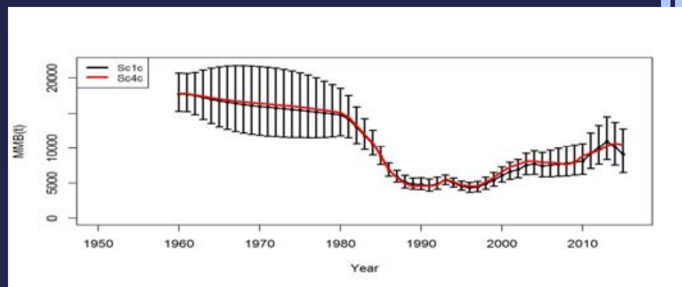
Key Consideration - "Scaling"

- Analyses to explore what determines absolute biomass:
  - The model now starts in 1960 in an equilibrium state, and is projected forward to 1985 (the first year with landings data in mass)
    - With estimated recruitment for 1960-1985
    - With catches in numbers for 1981-1984
  - Profiles on M
    - By region & for EAG and WAG combined.
  - Models with dome-shaped selectivity (to examine potential confounding between M and selectivity).
  - Drop the groundfish data (length compositions AND catches)
    - Impacts the assessment for the WAG

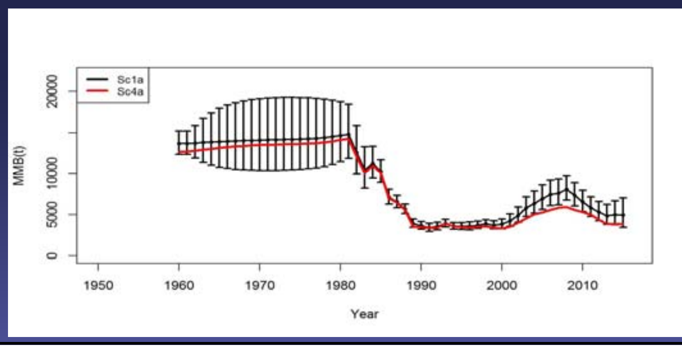
Rerun results after dropping only the groundfish length frequency data. Base scenario MMB have the 2SE confidence intervals.

19

EAG

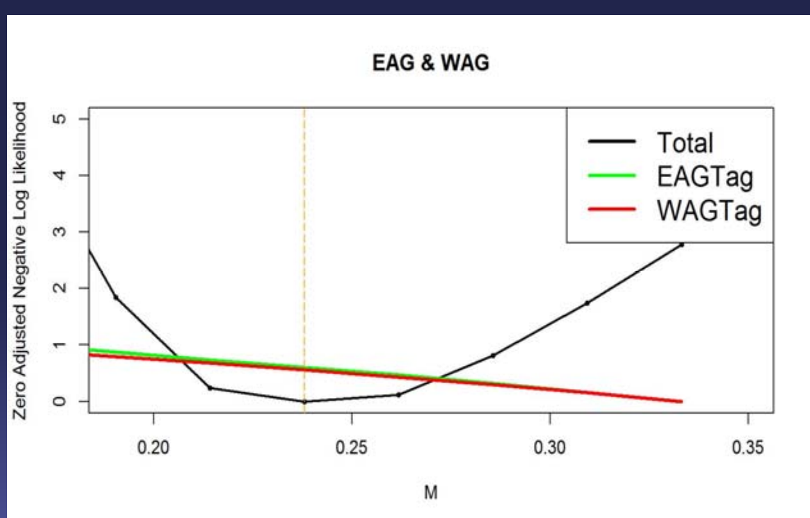


WAG



20

WAG+EAG data Scenario1c



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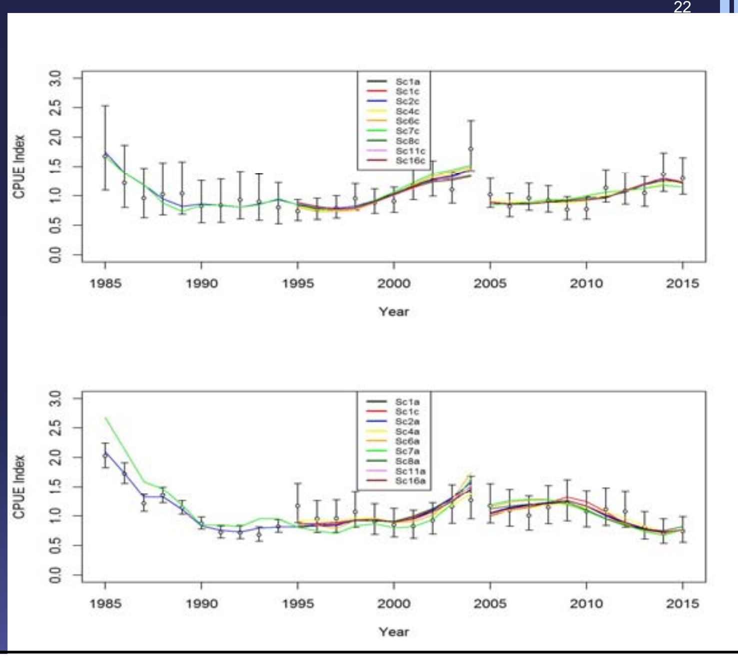
Summary of Fits

Figures 16 and 32. Comparison of input CPUE indices (open circles with +/- 2 SE) with predicted CPUE indices (colored solid lines) for Scs 1a, 1c, 2a, 2c, 4a, 4c, 6a, 6c, 7a, 7c, 8a, 8c, 11a, 11c, 16 a, and 16c fits,

22

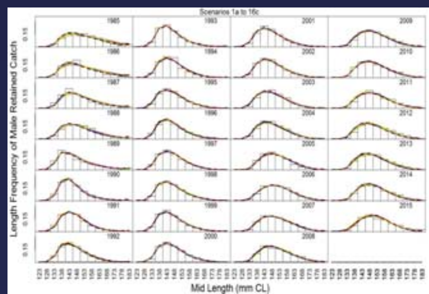
EAG

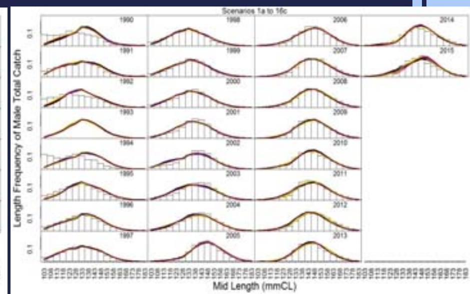
WAG

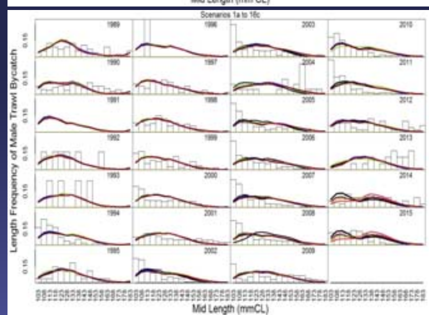


Figures 6, 7, and 8. Predicted (line) vs. observed (bar) retained (top left), total (top right), and groundfish discard (bottom left) catch length compositions for Scs 1a, 1c, 2c, 4c, 6c, 7c, 8c, 11c, and16c fits.

23



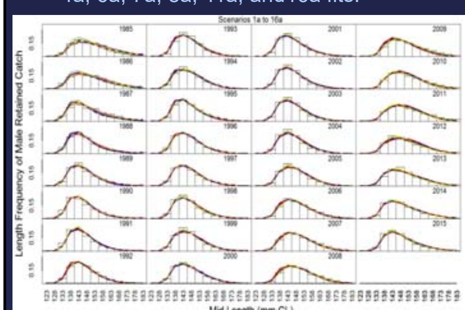


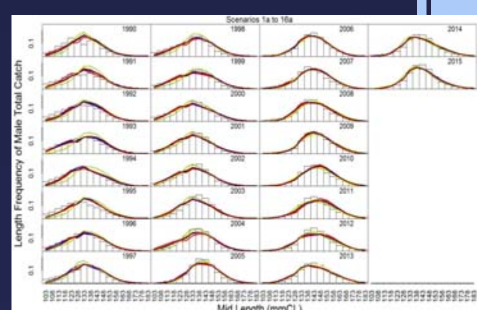


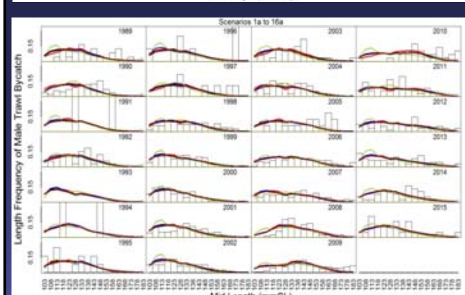
EAG

Figures 24, 25, and 26. Predicted (line) vs. observed (bar) retained (top left), total (top right), and groundfish discard (bottom left) catch length compositions for Scs 1a, 1c, 2a, 4a, 6a, 7a, 8a, 11a, and16a fits.

24







WAG

Figure 21. Observed (open circle) vs. predicted (solid line) retained catch (top left), total catch (top right), and groundfish bycatch (bottom left) for Scs 1, 1c, 2c, 4c, 6c, 7c, 8c, and 16c fits.

25

EAG

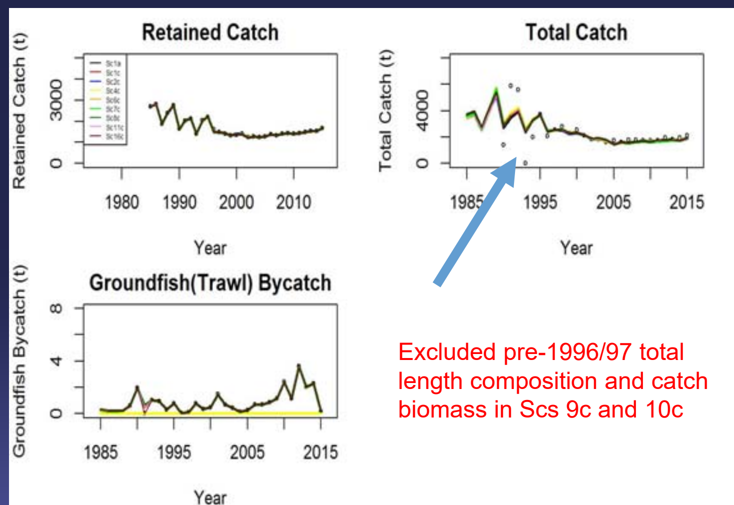
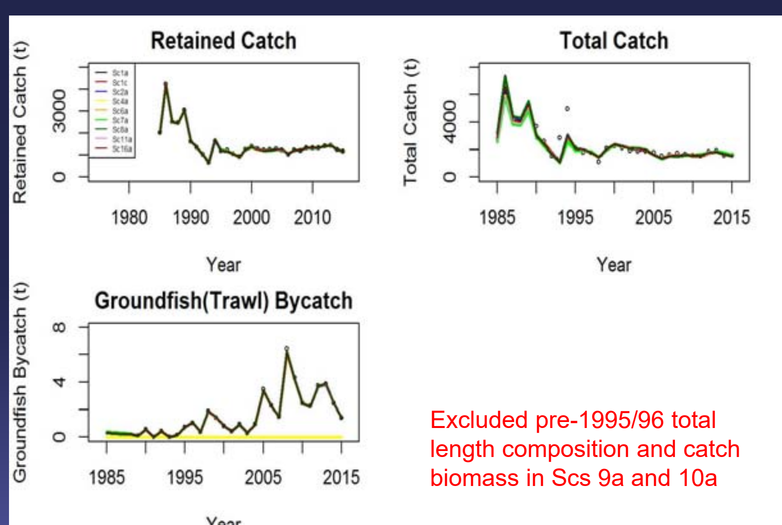


Figure 37. Observed (open circle) vs. predicted (solid line) retained catch (top left), total catch (top right), and groundfish bycatch (bottom left) for Scs 1a, 1c, 2a, 4a, 6a, 7a, 8a, 11a, and 16a fits.

26

WAG



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Key Model outputs

Figures 19 and 35. Trends in MMB for scenarios (Sc) 1a, 1c, 2a, 2c, 4a, 4c, 6a, 6c, 7a, 7c, 8a, 8c, 11a, 11c, 16a, and 16c fits, 1960/61–2015/16.

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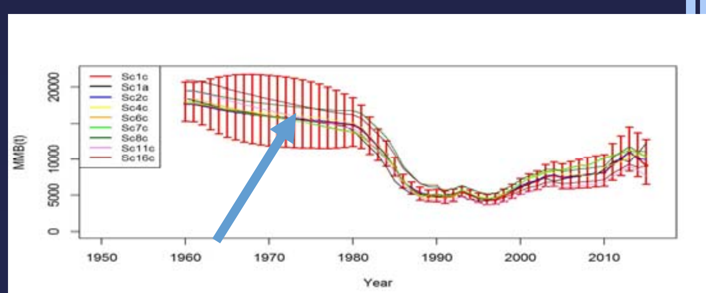
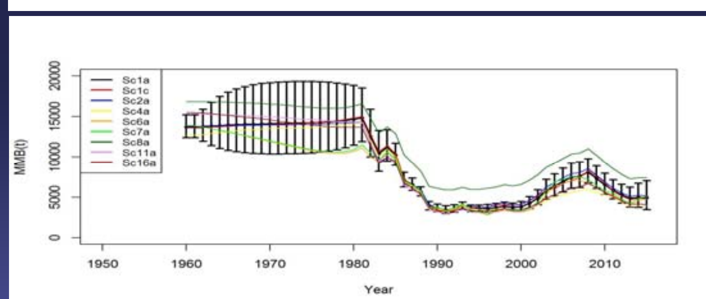
EAG

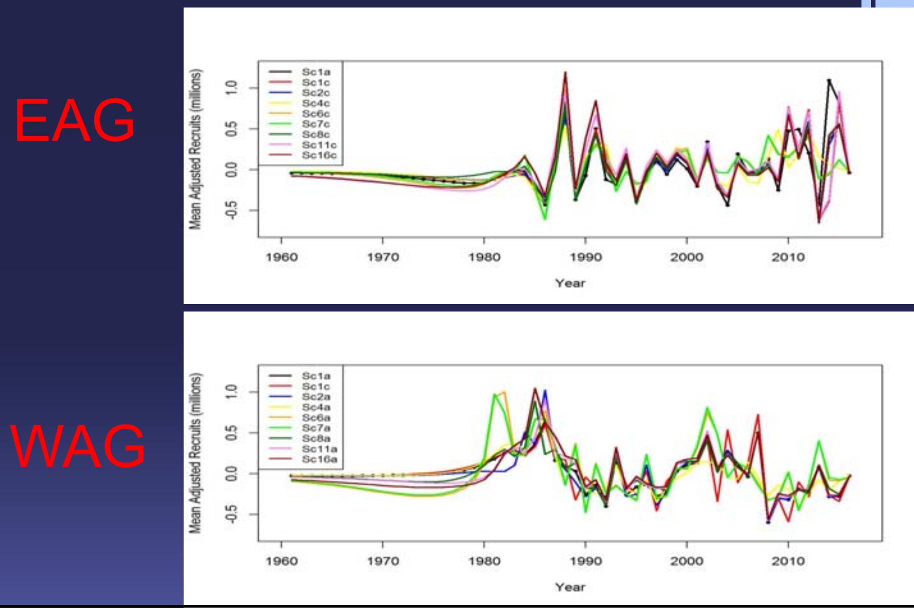


WAG



Figures 17 and 33. Number of male recruits for scenarios (Sc) 1a, 1c, 2a, 2c, 4a, 4c, 6a, 6c, 7a, 7c, 8a, 8c, 11a, 11c, 16a, and 16c fits , 1961–2016.

29



Figures 20 and 36. Trends in total pot fishery F for scenarios (Sc) 1a, 1c, 2a, 2c, 4a, 4c, 6a, 6c, 7a, 7c, 8a, 8c, 11a, 11c, 16a, and 16c fits, 1981–2015.

30

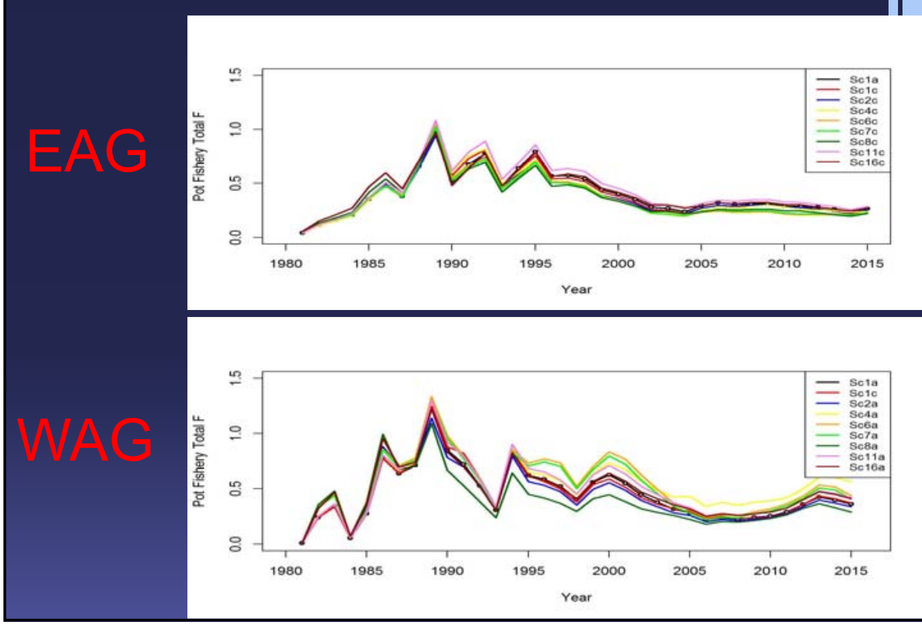


Figure 22. Retrospective fits of MMB by the model when terminal year's data were systematically removed until 2011/12 for scenarios (Sc) 1a, 1c, 2c, 6c, 7c, 8c, 11c, and 16c fits, 1960–2015.

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EAG

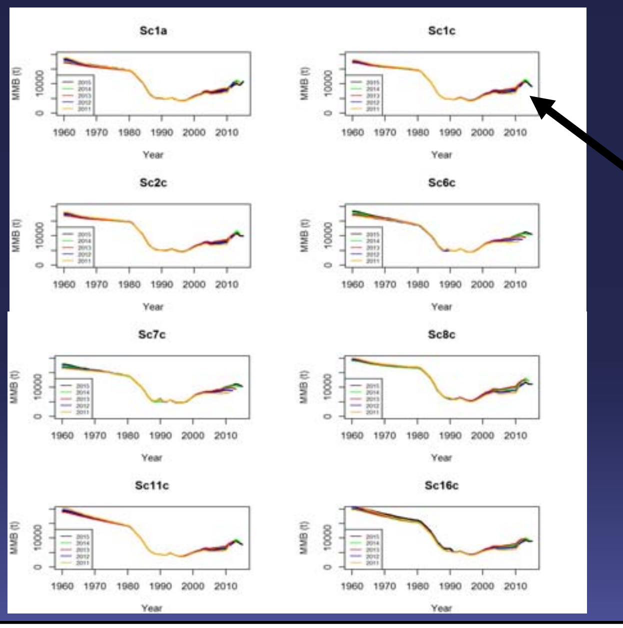
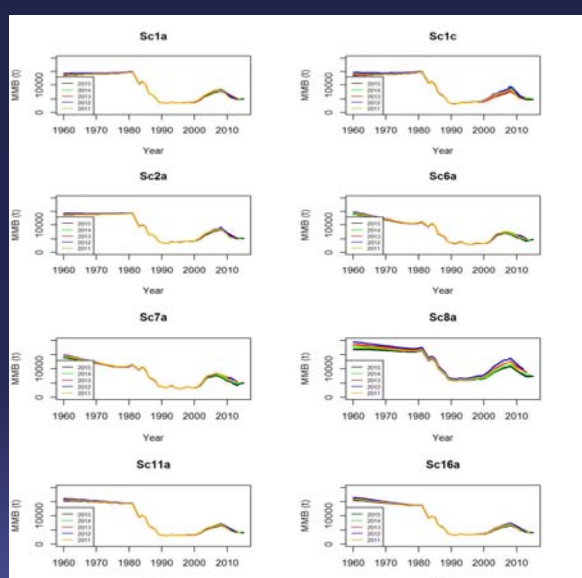


Figure 38. Retrospective fits of MMB by the model when terminal year's data were systematically removed until 2011/12 for scenarios (Sc) 1a, 1c, 2a, 6a, 7a, 8a, 11a, and 16a fits, 1960–2015.

32

WAG



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CPT Discussion

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CPT Discussion

- The CPT "therefore **recommends that the model be accepted for use in management**, including computation of OFLs and ABCs in May 2017".

- The assessment depends on CPUE, but:
  - The standardization process was thoroughly reviewed (but it is still CPUE).
  - Tier 5 control rule ignores all monitoring data when setting OFLs.
  - CPT comment: "**it has evaluated the method of standardization extensively and is confident that there is little additional benefit to further evaluation.**"

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Workplan-I

- January 2017
  - Review additional model runs (in particular why the EAG biomass is declining prior to 1981)
    - Drop the early length-frequency data (which show a rapid decline in the fraction of large animals)
    - Explore why models 6c and 7c predict a recruitment spike early in the time series
    - Show predicted catches for all years.
  - Select model configurations for May assessment
  - Evaluate:
    - whether advice should be based on Tier 3 or Tier 4 [AEP has a view]
    - the buffers between the OFL and the ABC

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Workplan-II

- January 2017
  - Potential base model
    - no groundfish length-frequency data (they should not be informative);
    - stage-1 sample sizes set to the number of DAYS on which sampling occurred;
    - set M to the value based on the fit to all the data; and
    - include the early fishticket CPUE index (it is comparable with the biomass trajectory even if not included).
  - Sensitivities
    - Many, but also CPUE is non-linearly relate to biomass

Data Gap and Research Priorities

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Tagging experiments:

a. Extensive tagging experiments or resource surveys are needed to investigate stock distributions.

b. An independent estimate of *M* is needed for this stock. Tagging is one possibility.

c. An extensive tagging study for molting probability and growth study.

Handling mortality study:

- An experimentally-based independent estimate of handling mortality is needed.

Survey:

- The Aleutian King Crab Research Foundation has recently initiated crab survey programs in the Aleutian Islands. This program needs to be strengthened and continued for golden king crab research to address some of the data gap.
- We have been using the length-weight relationship established based on 1997 data for golden king crab. The research foundation program can help us to update this relationship by collecting new length weight information.

CPUE standardization history

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2008-2011	(a) Nominal retained catch CPUE, triennial pot survey CPUE (EAG). (b) Observer nominal retained CPUE were standardized in relation to pot survey CPUE. (c) Zhou and Shirley (1997) non-linear soak time model was fitted to CPUE vs. Soak time and used the model to predict yearly CPUE based on yearly mean soak time.
2012-2013	CPUE standardization by GLM: (a) GLM with a Log-normal model for positive catches, a binomial model for zero catches and the two indices were combined to get the combined CPUE indices with standard errors (SE). The SE were estimated by bootstrap sampling. (b) Error distributions appeared not adequate for the combined indices fit and a negative binomial model provided a better error distribution and also ease the fitting procedure without having to do bootstrapping for standard errors.
CPT/SSC recommendations on CPUE estimation for model use in 2013	(a) Estimate CPUE indices separately for the pre- and post-rationalization time periods with soak time either selected by the GLM or forced in. (b) Use the negative binomial model in the GLM.

Table 29.

39

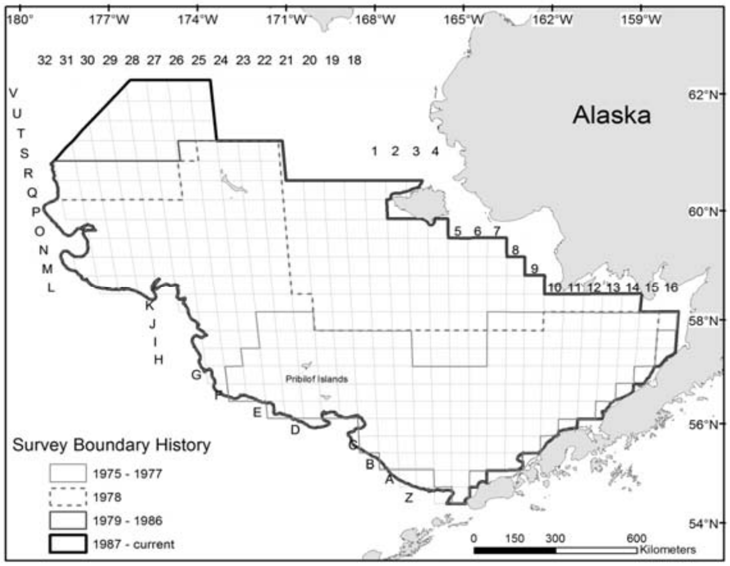
	EAG				WAG				
Sc	Tier 4 Total Catch OFL (t)	Tier 3 Total Catch OFL (t)	MMB_{2016} / $MMB_{initial}$	Sc	Tier 4 Total Catch OFL (t)	Tier 3 Total Catch OFL (t)	MMB_{2016} / $MMB_{initial}$	M yr^{-1}	Remarks
1a	1,669	3,799	0.66		822	1,484	0.38	0.2339	Equilibrium initial condition, asymptotic selectivity, ESS= no. of length measurements
1b	1,175	2,907	0.60		967	1,752	0.40	0.2339	Same as Sc1a, but CPUE predictor variables were selected by AIC
1c	1,506	3,822	0.56		785	1,431	0.37	0.2339	Same as Sc1a, but ESS = number of trips made by sampled vessels
1d	1,062	2,647	0.53		883	1,614	0.39	0.2339	Same as Sc1c, but CPUE predictor variables were selected by AIC
2a	1,696	3,866	0.64		894	1,644	0.39	0.2426	Sc1a with fish ticket CPUE
2b	1,323	3,268	0.63		1,043	1,904	0.41	0.2426	Same as Sc2a, but CPUE predictor variables were selected by AIC
2c	1,624	4,036	0.60		728	1,346	0.36	0.2426	Same as Sc2a, but ESS = number of trips made by sampled vessels
2d	1,158	2,884	0.55		939	1,762	0.40	0.2426	Same as Sc2c, but CPUE predictor variables were selected by AIC
3c	1,506	3,403	0.56	3a	646	1,254	0.38	0.2339	Estimate groundfish selectivity
4c	1,662	3,763	0.57	4a	594	1,140	0.37	0.2339	Drop groundfish bycatch and bycatch LF
5c	1,435	3,216	0.58	5a	814	1,298	0.37	0.2339	Three catchability and asymptotic total selectivity 1985/86–1994/95, 1995/96–2004/05, and 2005/06–
6c	1,730	3,745	0.55	6a	784	1,465	0.39	0.2339	Francis iterative estimation of ESS
7c	1,722	3,898	0.56	7a	861	1,654	0.41	0.2426	Francis iterative estimation of ESS with fish ticket CPUE
8c	1,764	3,579	0.60	8a	988	2,073	0.45	0.2339	Dome shaped selectivity
9c	1,452	3,368	0.55	9a	820	1,547	0.38	0.2339	Total catch & LF started from 1996/97 for EAG or 1995/96 for WAG.
10c	1,610	3,693	0.57	10a	933	1,782	0.40	0.2426	Sc 9.. with fish ticket CPUE
11c	1,049	2,138	0.45	11a	579	812	0.30	0.18	Same as Sc1a or Sc1c with lower M
12c	1,086	2,165	0.46	12a	621	880	0.30	0.18	Same as Sc2a or Sc2c with lower M
14c	1,238	2,468	0.47	14a	444	615	0.29	0.18	Drop groundfish bycatch and bycatch LF with lower M
16c	1,151	2,199	0.48	16a	576	807	0.30	0.18	Dome shaped selectivity with lower M
19c	1,204	2,771	0.52	19a	1,082	1,936	0.41	0.2339	Same as Sc1a or Sc1c, but CPUE predictor variables set contains the Year:Captain interaction term

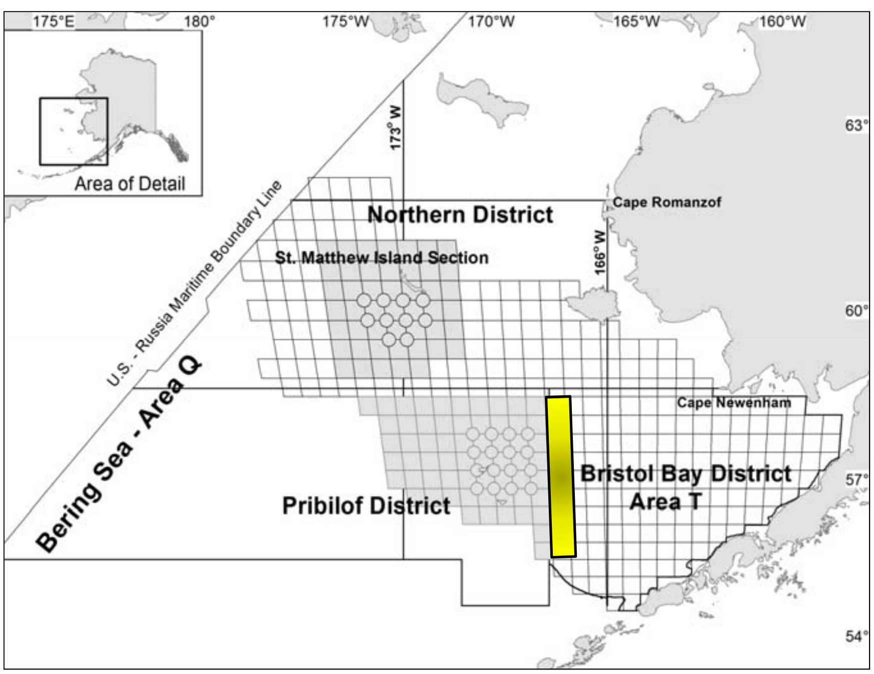
NOAA FISHERIES
Alaska Fisheries Science Center- Kodiak Lab

The 2016 Eastern Bering Sea Continental Shelf Bottom Trawl Survey: Results for Commercial Crab Species

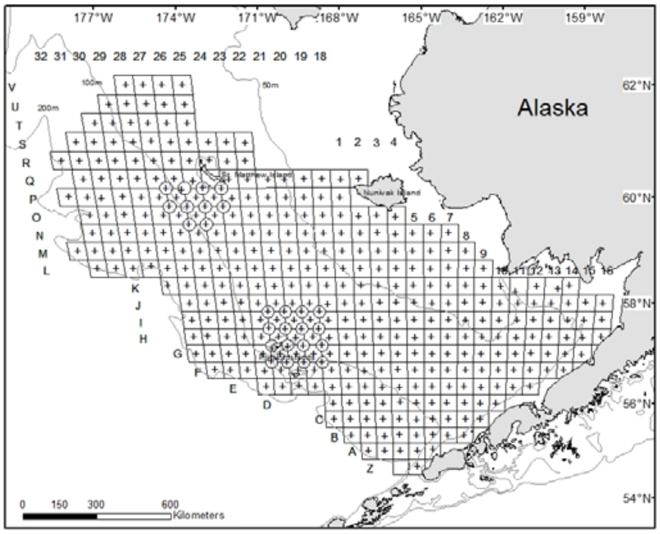
Ben Daly, Claire Armistead, Robert Foy, AFSC
SAP and GAP programs

Crab Plan Team
September 2016


Alaska
Pribilof Islands
Survey Boundary History
1975 - 1977
1978
1979 - 1986
1987 - current
Kilometers

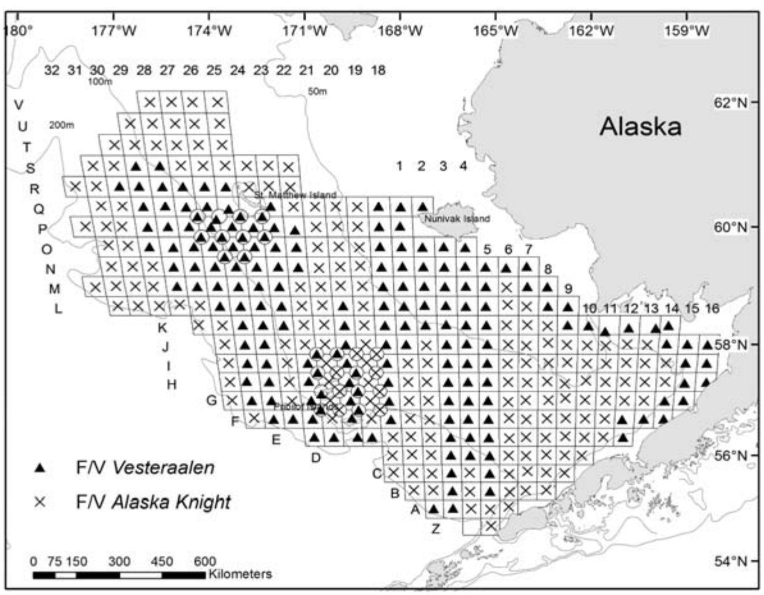

Area of Detail
U.S. - Russia Maritime Boundary Line
Bering Sea - Area Q
Northern District
St. Matthew Island Section
Cape Romanzof
Cape Newenham
Bristol Bay District
Area T
Pribilof District

2016 standard Bering Sea survey



HIGHLIGHTS
- May 31 – July 26
- 375 standard stations
- 139,949 nm^2
- 6 special crab projects
- Warm water!
- NO resample

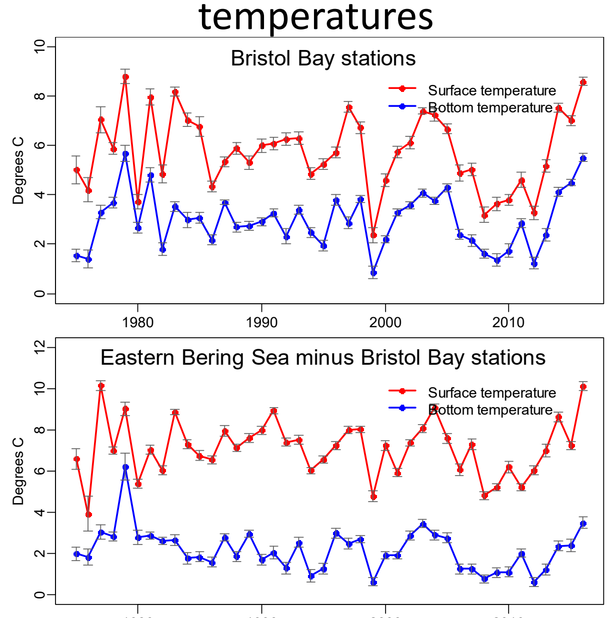
2016 standard Bering Sea survey

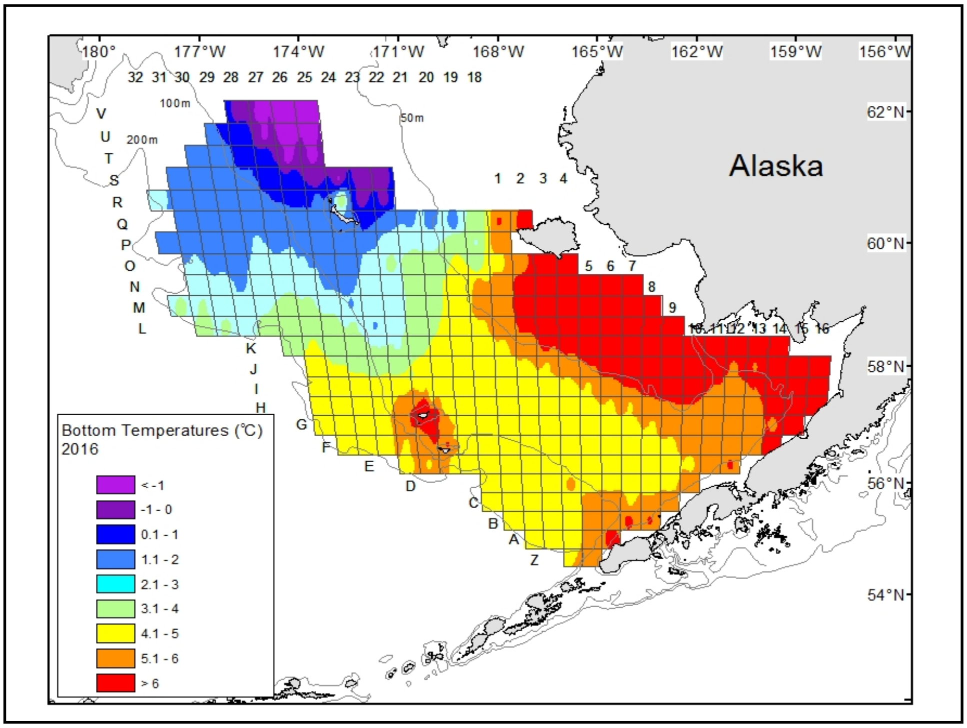


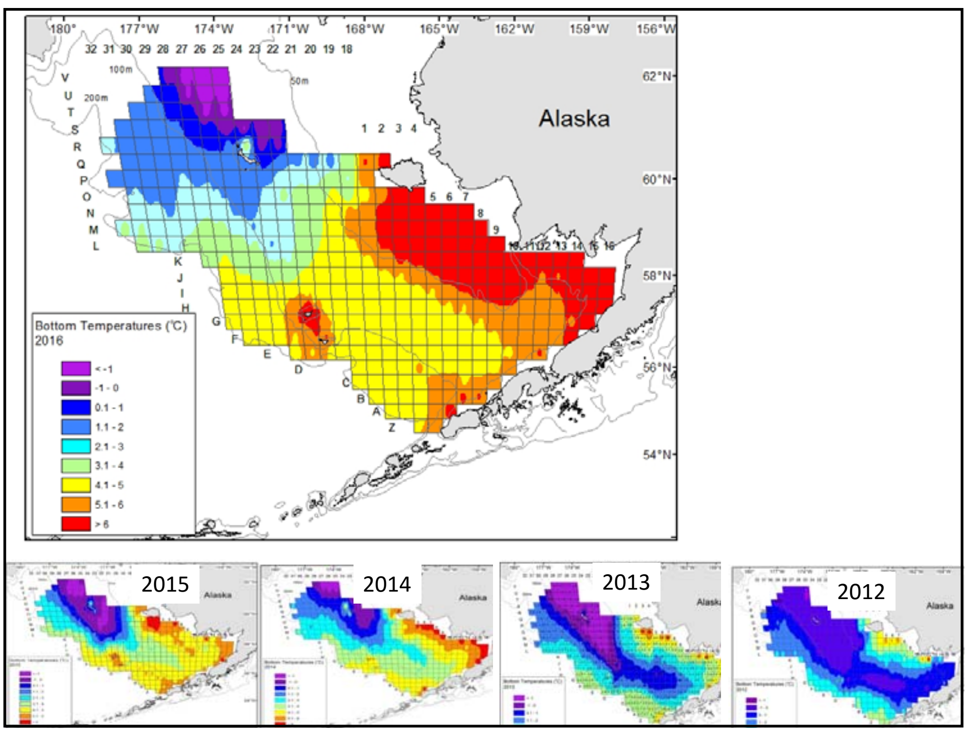
Special projects related to crab species

Project title	Principle Investigator	Agency
Bitter crab syndrome	Pam Jensen	RACE[1]-SAP[2]
Annual vs. biennial snow crab reproductive cycle	Kathy Swiney	RACE[1]-SAP[2]
Ocean acidification effects on red king crab	Kathy Swiney	RACE[1]-SAP[2]
Snow and Tanner crab growth	Cliff Ryer	RACE[1]-FBE[3]
Reproductive potential of female snow, Tanner, and Tanner hybrid crabs	Laura Slater	ADF&G[4]
Snow crab age determination	Joel Webb	ADF&G[4]

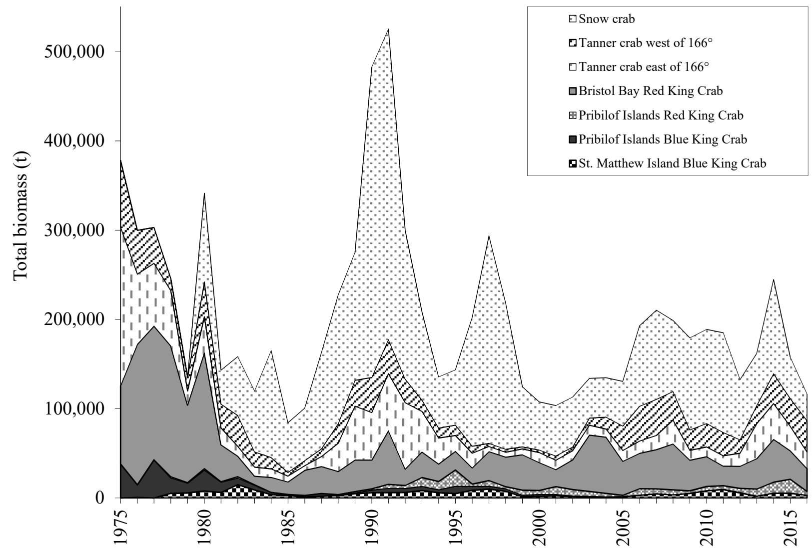
Bristol Bay Surface (red) and Bottom (blue) temperatures

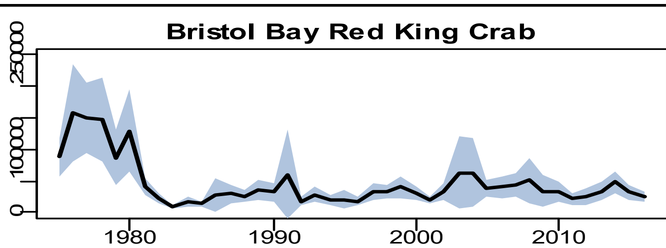



180°
177°W
174°W
171°W
168°W
165°W
162°W
159°W
156°W
62°N
60°N
58°N
56°N
54°N
Alaska
100m
200m
50m
Bottom Temperatures (℃)
2016
< -1
-1 - 0
0.1 - 1
1.1 - 2
2.1 - 3
3.1 - 4
4.1 - 5
5.1 - 6
> 6


Alaska
Bottom Temperatures (℃)
2016
< -1
-1 - 0
0.1 - 1
1.1 - 2
2.1 - 3
3.1 - 4
4.1 - 5
5.1 - 6
> 6
2015
2014
2013
2012

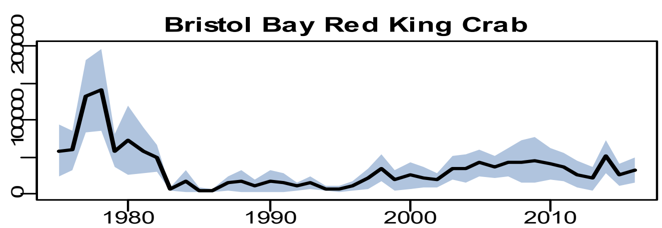
Mature male biomass





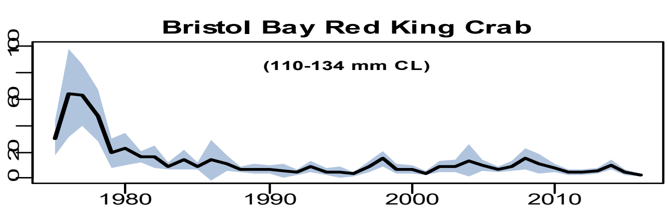
Mature male biomass (t)

-21%



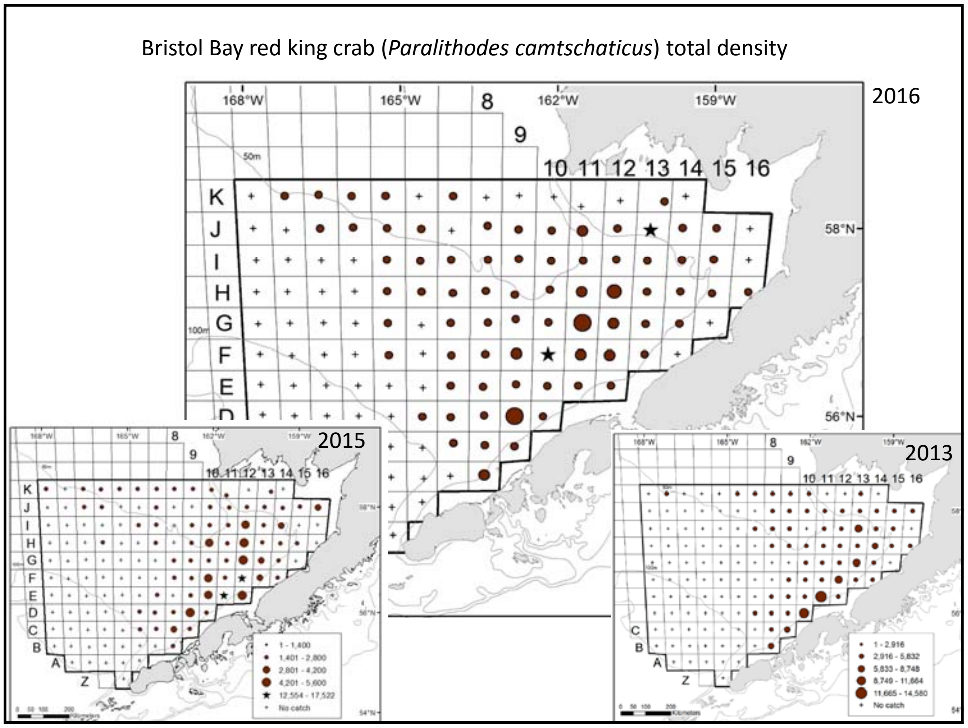
Mature females biomass (t)

+28%

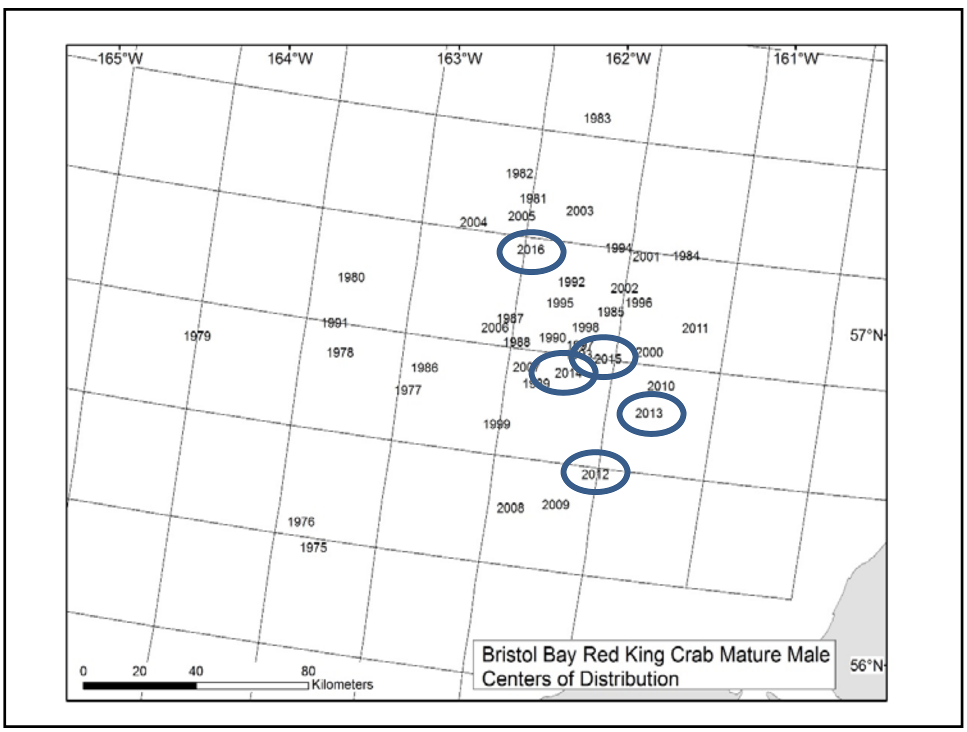


Juvenile abundance (millions)

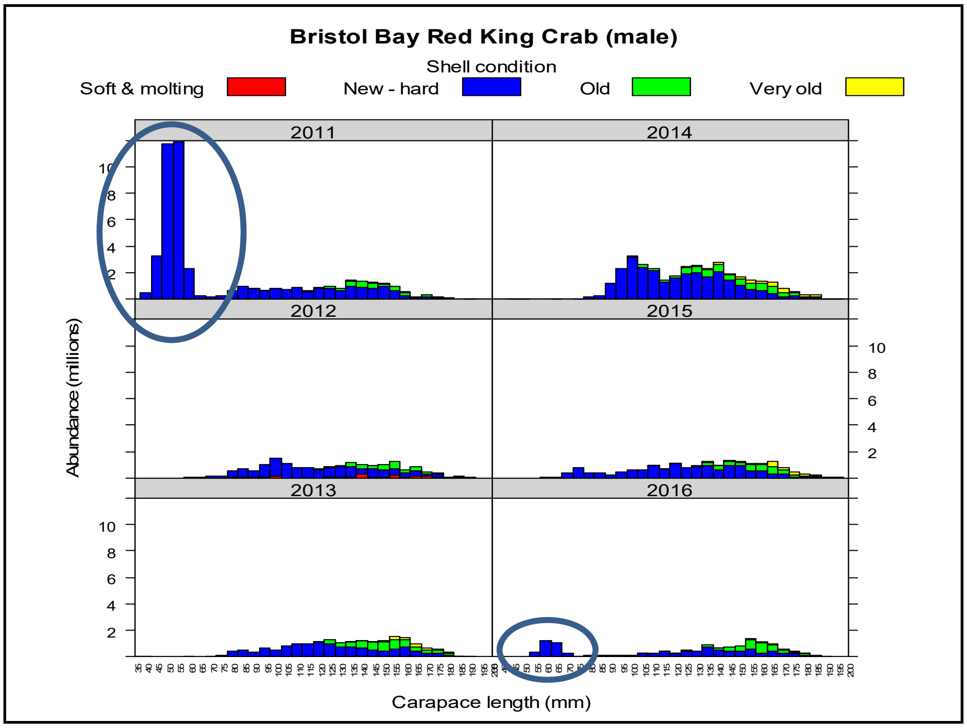
Male -21%
Female +47%



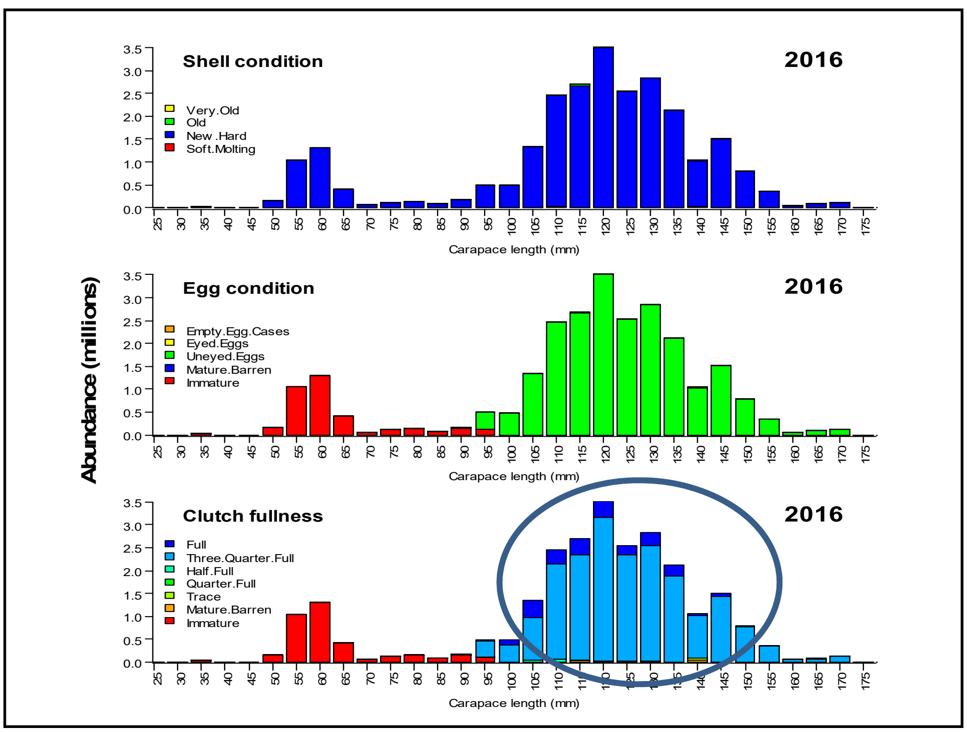
Bristol Bay red king crab (*Paralithodes camtschaticus*) total density
2016
2015
2013
168°W
165°W
162°W
159°W
8
9
10 11 12 13 14 15 16
K
J
I
H
G
F
E
D
C
B
A
Z
58°N
56°N



165°W
164°W
163°W
162°W
161°W
57°N
56°N
1983
1982
1981
2005
2003
2004
2016
1994
2001
1984
1980
1992
2002
1995
1996
1985
1991
1987
2006
1998
2011
1979
1978
1988
1990
2015
2000
1986
2014
2010
1977
2013
1999
2012
2008
2009
1976
1975
0 20 40 80 Kilometers
Bristol Bay Red King Crab Mature Male
Centers of Distribution

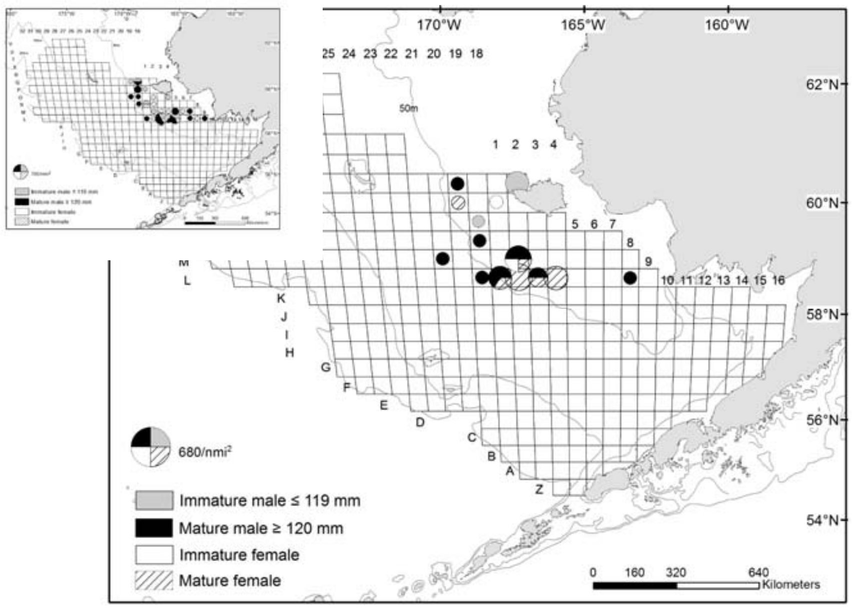


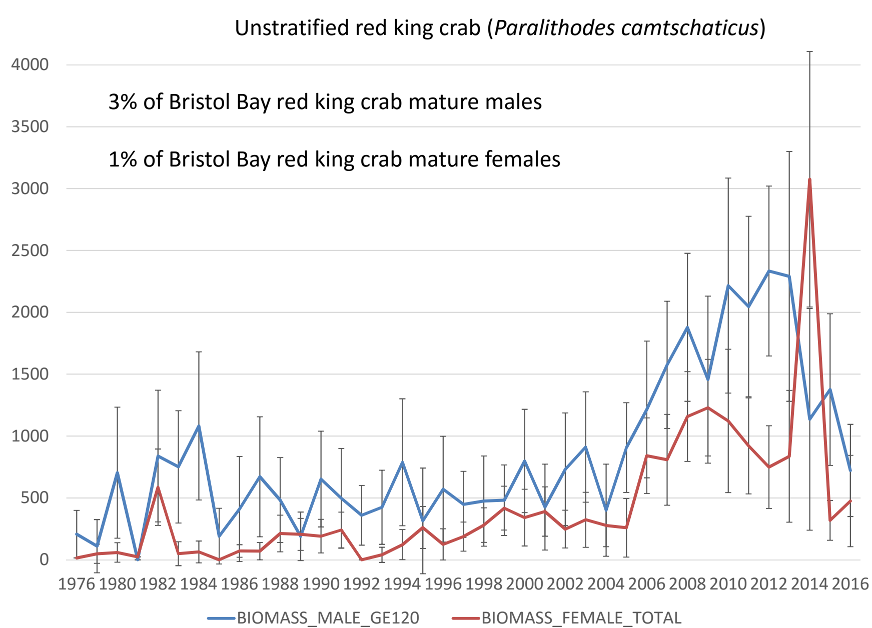
Bristol Bay Red King Crab (male)
Shell condition
Soft & molting
New - hard
Old
Very old
2011
2014
2012
2015
2013
2016
Abundance (millions)
Carapace length (mm)

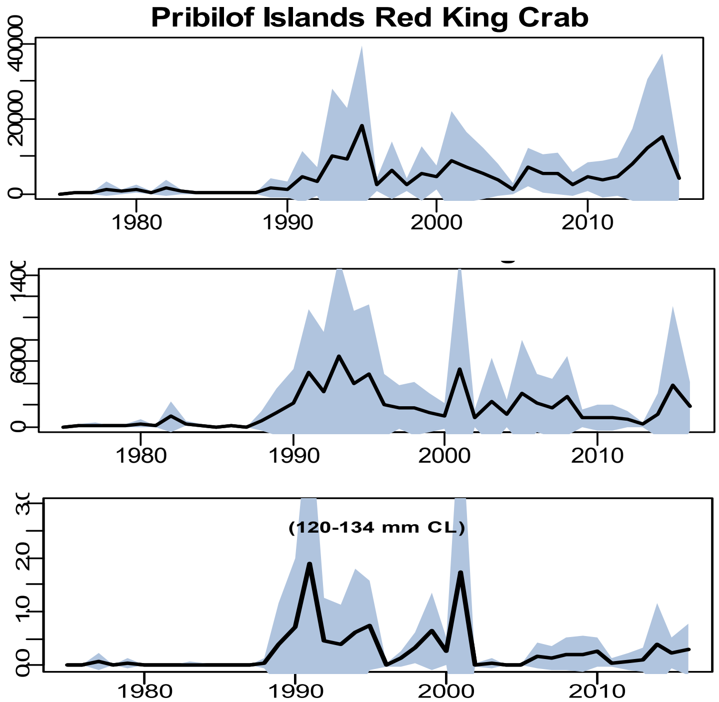


Shell condition
2016
Very.Old
Old
New .Hard
Soft.Molting
Carapace length (mm)
Egg condition
2016
Empty.Egg.Cases
Eyed.Eggs
Uneyed.Eggs
Mature.Barren
Immature
Carapace length (mm)
Clutch fullness
2016
Full
Three.Quarter.Full
Half.Full
Quarter.Full
Trace
Mature.Barren
Immature
Carapace length (mm)
Abundance (millions)

Unstratified red king crab (*Paralithodes camtschaticus*)







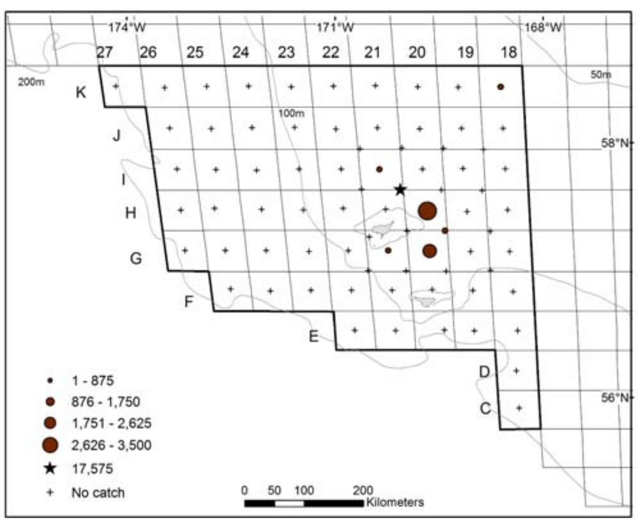
Mature male biomass (t)

-73%

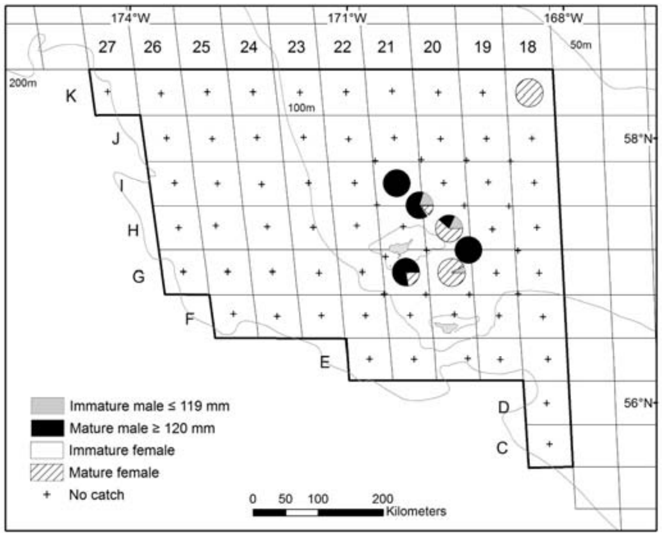
Mature females biomass (t)

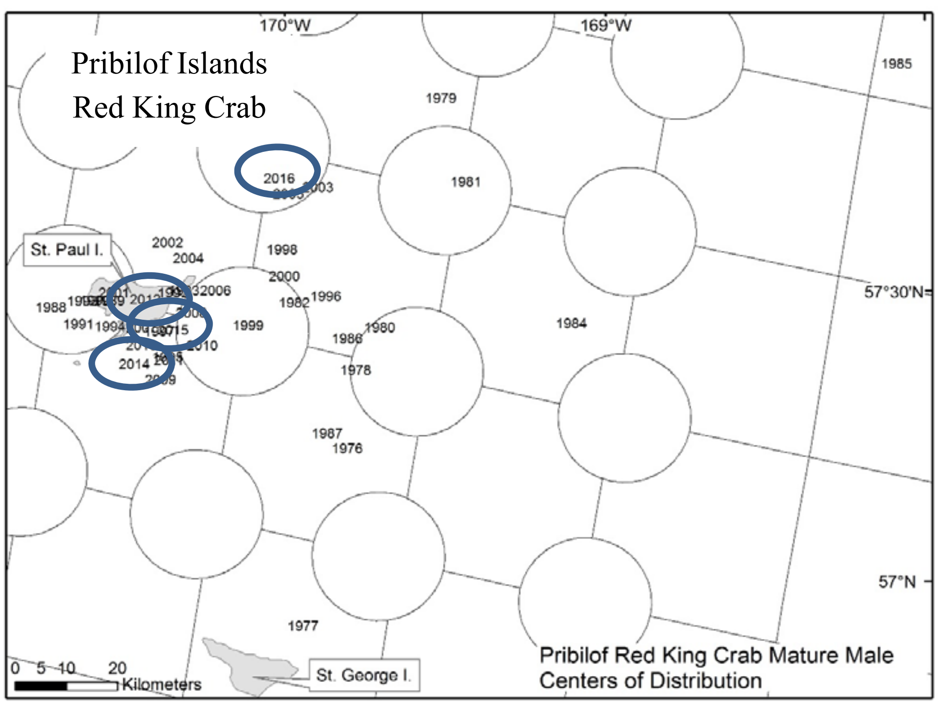
-51%

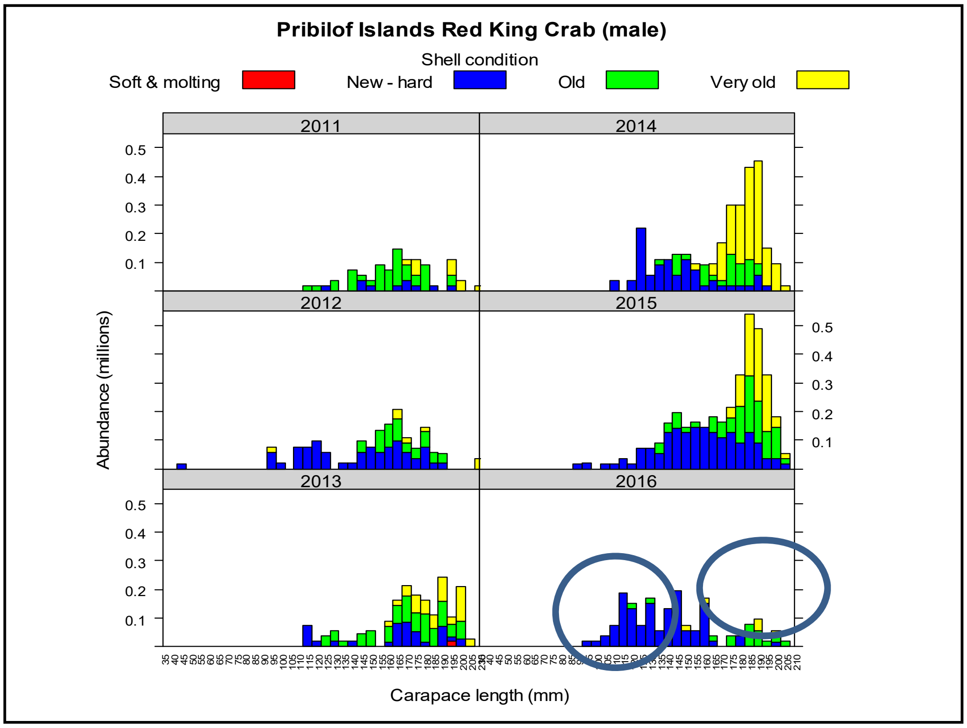
Juvenile abundance (millions)

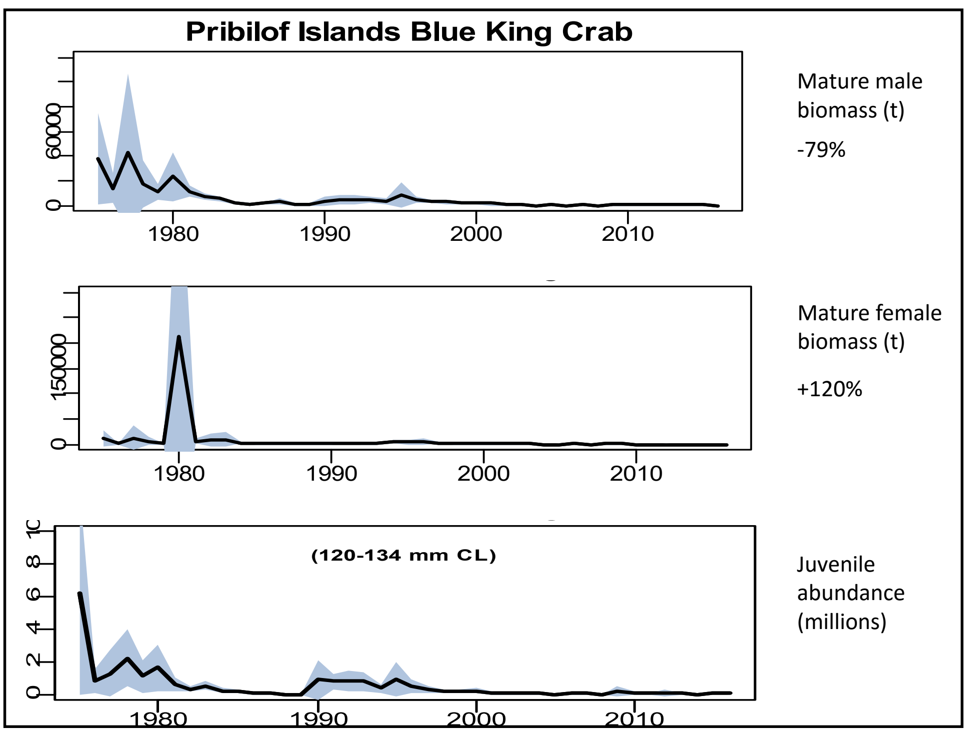


73% of mature males at star

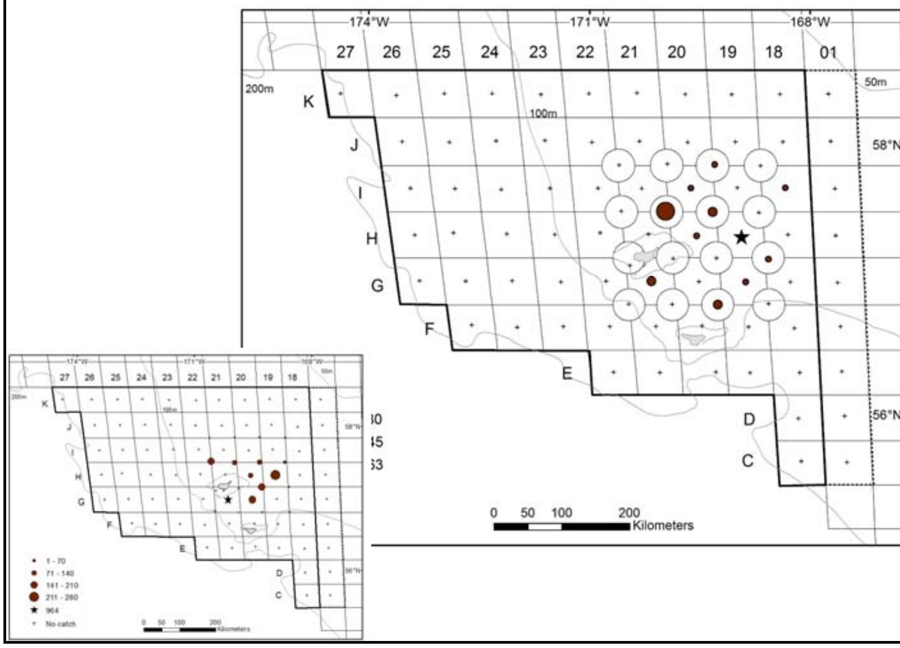

174°W
171°W
168°W
27 26 25 24 23 22 21 20 19 18
50m
200m
100m
K
J
I
H
G
F
E
D
C
58°N
56°N
Immature male ≤ 119 mm
Mature male ≥ 120 mm
Immature female
Mature female
No catch
0 50 100 200
Kilometers


Pribilof Islands
Red King Crab
170°W
169°W
1985
1979
2016
1981
St. Paul I.
2002
2004
1998
2000
1982
1996
1988
1991
1999
1986
1980
1984
57°30'N
2014
1978
1987
1976
57°N
1977
0 5 10 20
Kilometers
St. George I.
Pribilof Red King Crab Mature Male
Centers of Distribution

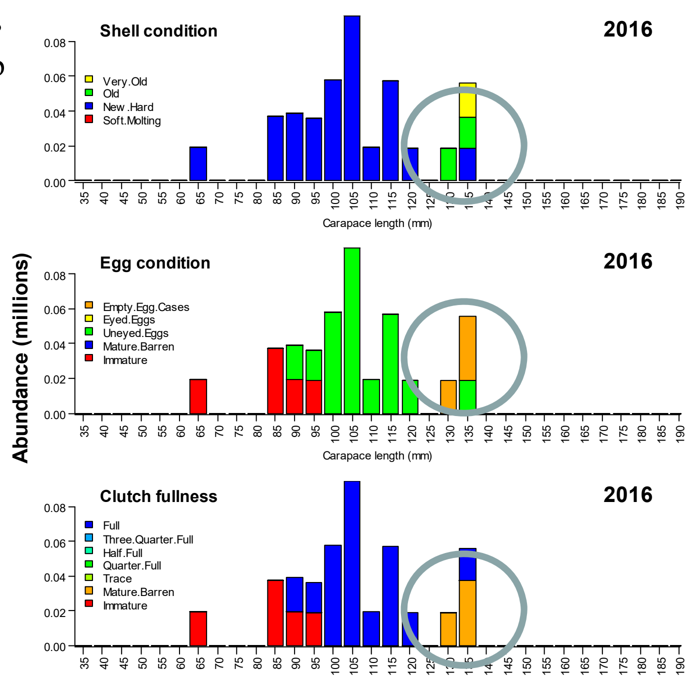

Pribilof Islands Red King Crab (male)
Shell condition
Soft & molting
New - hard
Old
Very old
2011
2014
2012
2015
2013
2016
Abundance (millions)
Carapace length (mm)

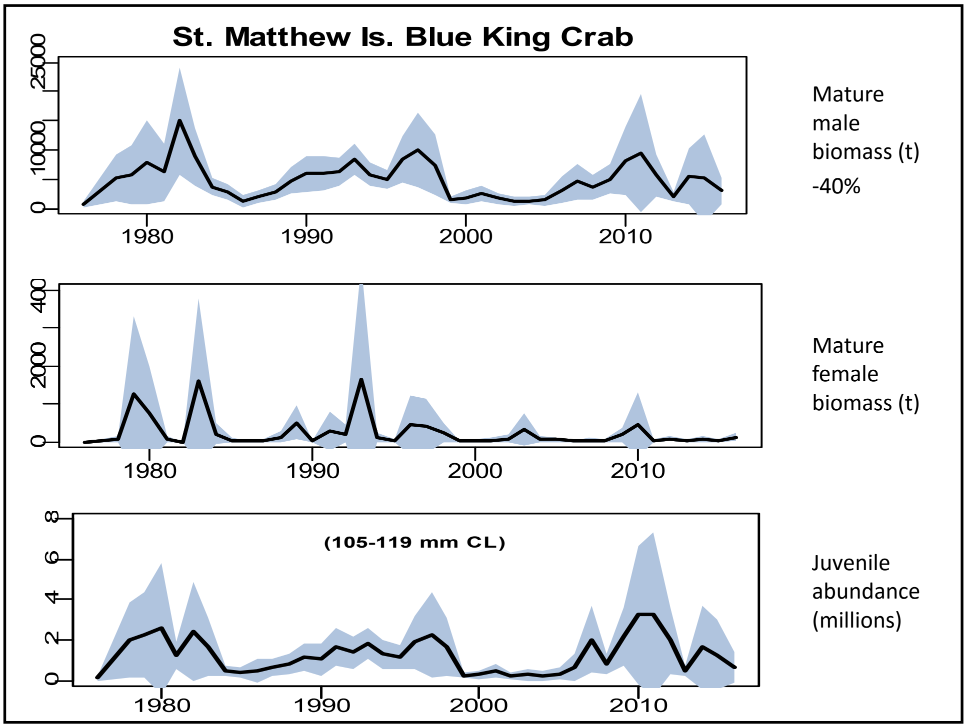

Pribilof Islands Blue King Crab
Mature male biomass (t)
-79%
Mature female biomass (t)
+120%
(120-134 mm CL)
Juvenile abundance (millions)

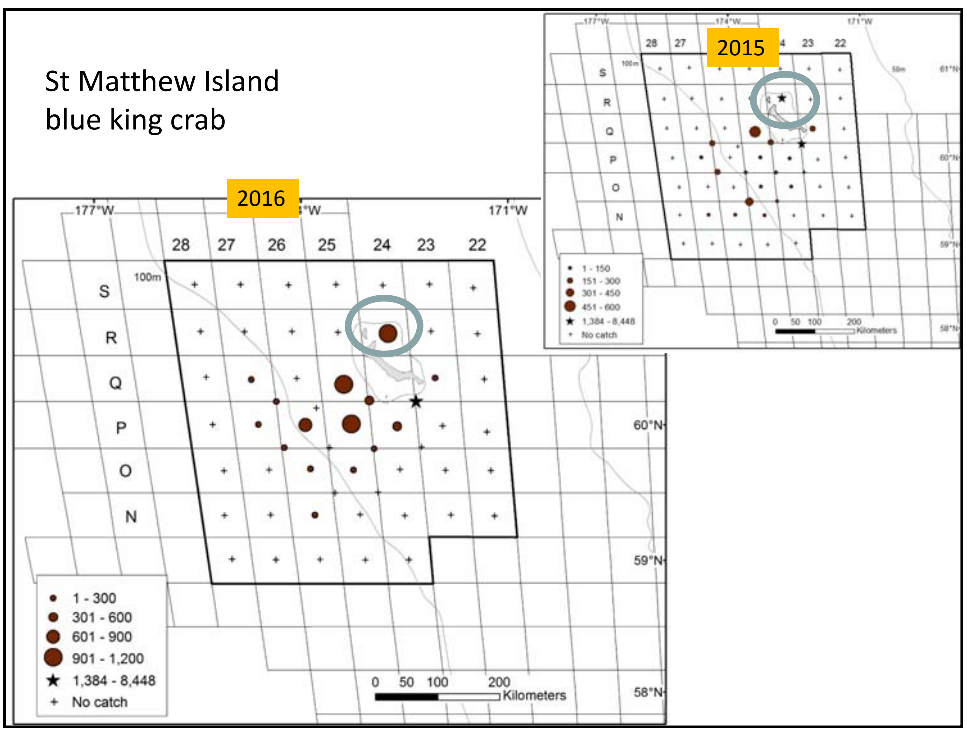
Pribilof Islands Blue King Crab



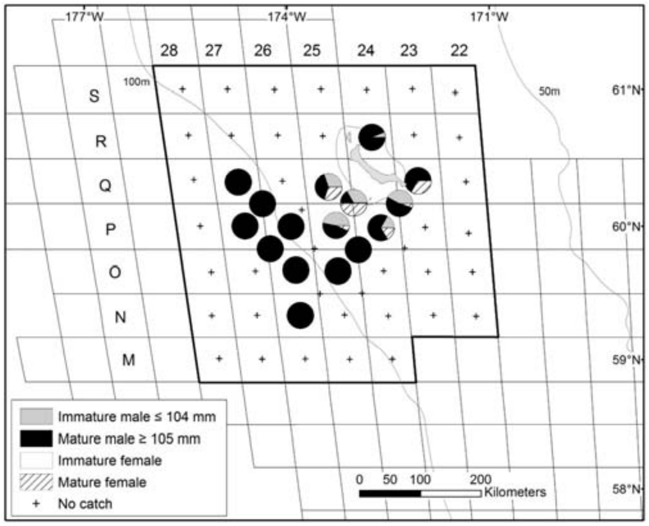
Pribilof Islands Blue King Crab



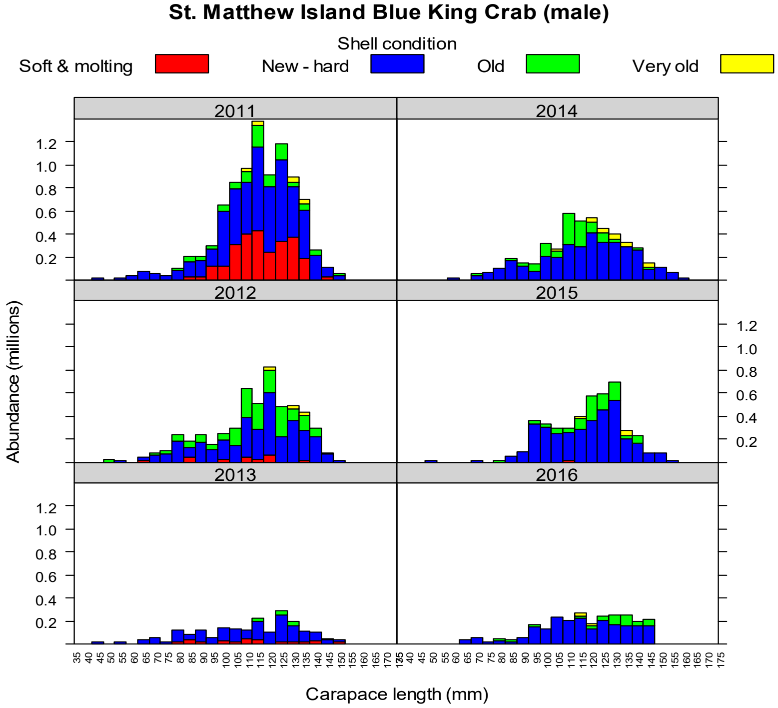

St. Matthew Is. Blue King Crab
25000
10000
0
1980
1990
2000
2010
400
2000
0
(105-119 mm CL)
8
6
4
2
0
Mature male biomass (t)
-40%
Mature female biomass (t)
Juvenile abundance (millions)

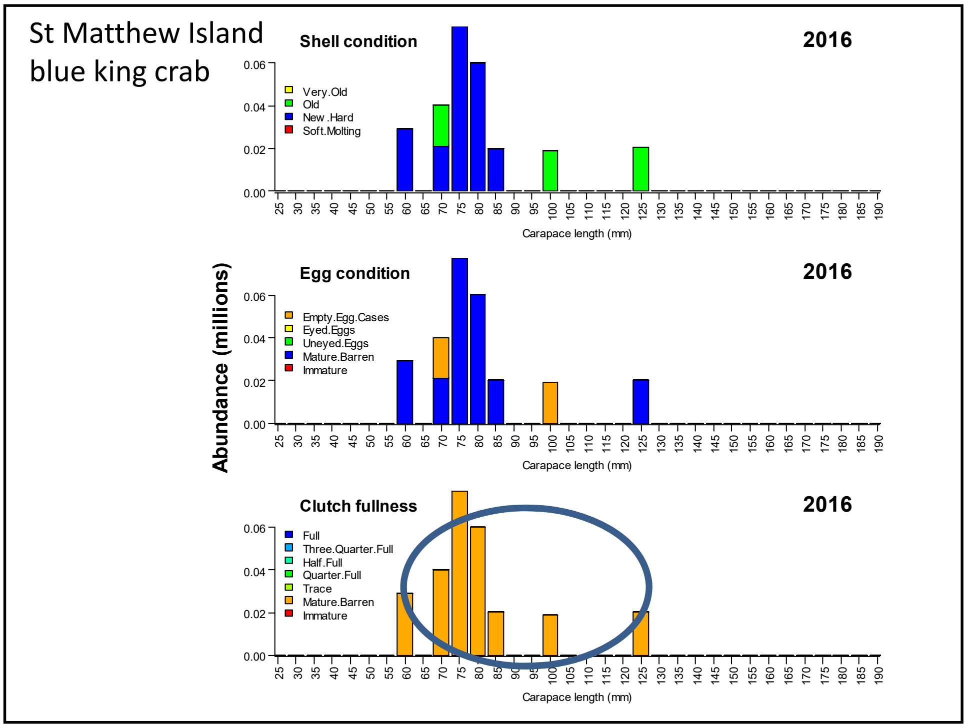

St Matthew Island
blue king crab
2015
2016
177°W
171°W
28
27
26
25
24
23
22
S
R
Q
P
O
N
100m
60°N
59°N
58°N
1 - 300
301 - 600
601 - 900
901 - 1,200
1,384 - 8,448
No catch
0
50
100
200
Kilometers

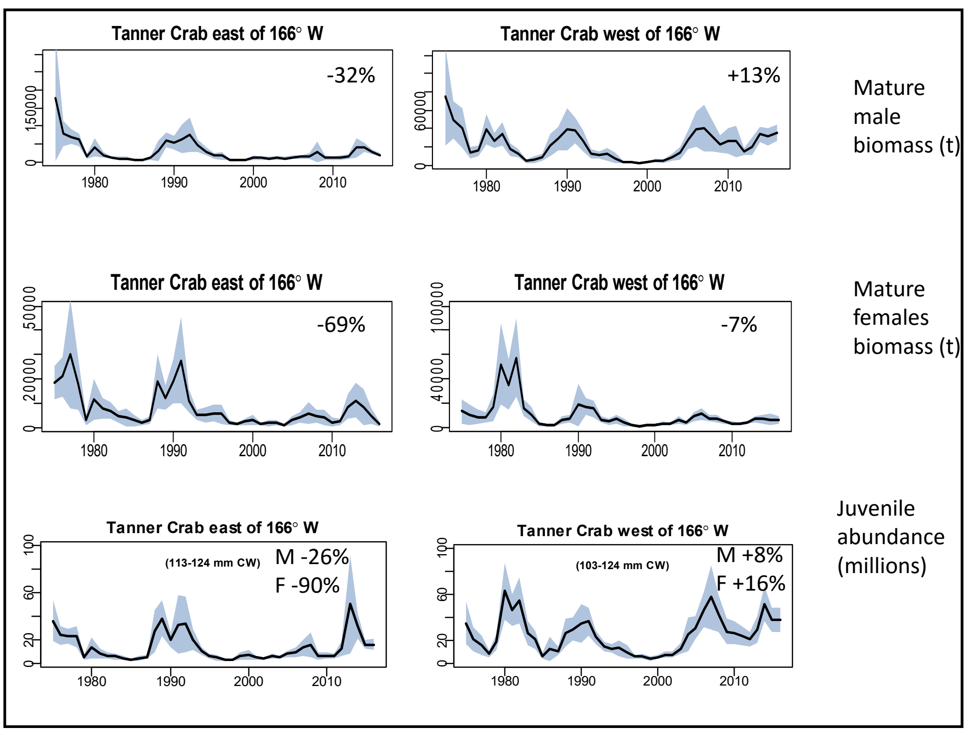
St Matthew Island blue king crab

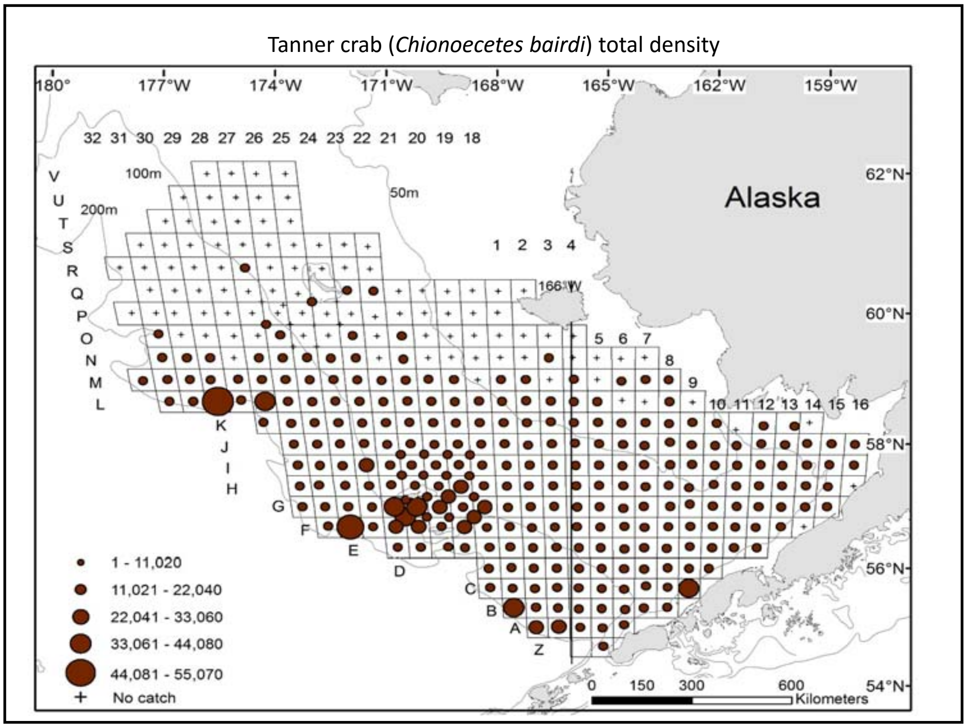


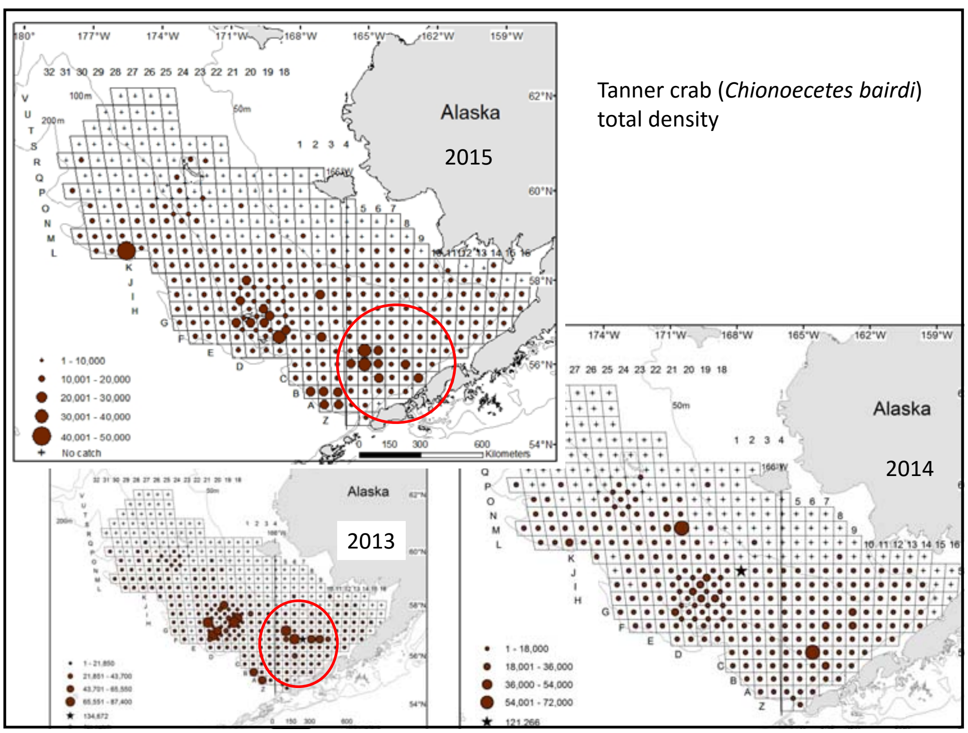
St. Matthew Island Blue King Crab (male)

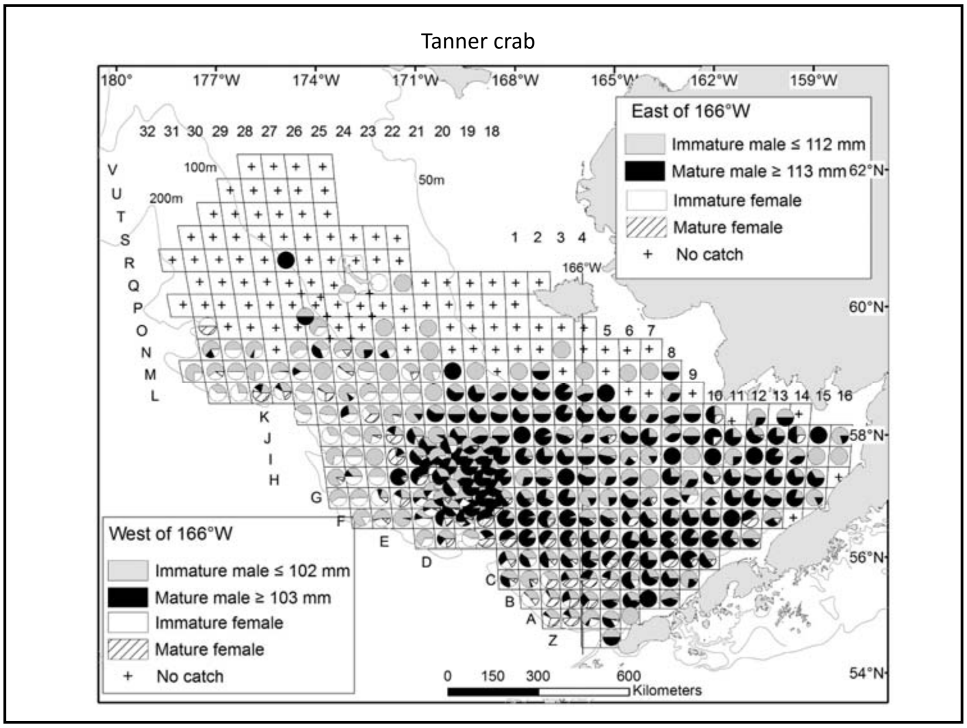


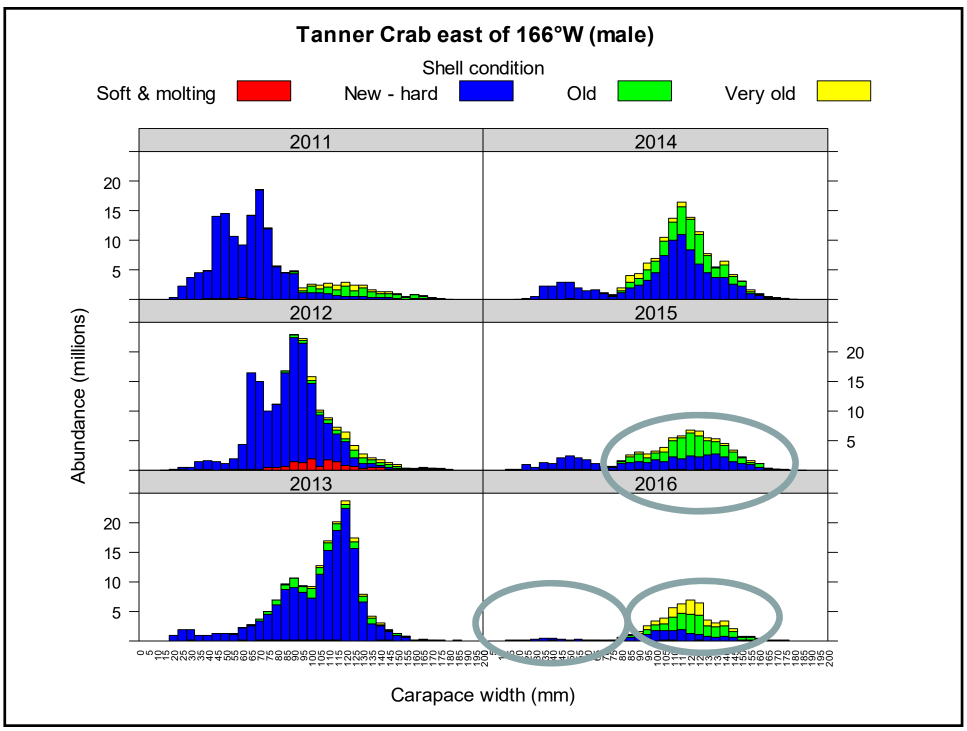

St Matthew Island
blue king crab
Shell condition
2016
Very.Old
Old
New.Hard
Soft.Molting
Egg condition
2016
Empty.Egg.Cases
Eyed.Eggs
Uneyed.Eggs
Mature.Barren
Immature
Clutch fullness
2016
Full
Three.Quarter.Full
Half.Full
Quarter.Full
Trace
Mature.Barren
Immature
Abundance (millions)
Carapace length (mm)

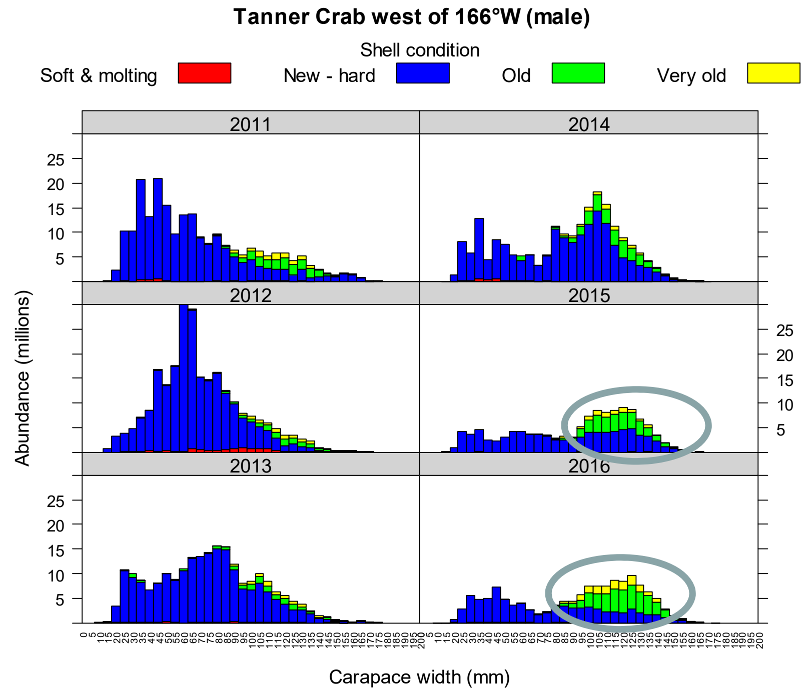

Tanner Crab east of 166° W
-32%
Tanner Crab west of 166° W
+13%
Mature male biomass (t)
Tanner Crab east of 166° W
-69%
Tanner Crab west of 166° W
-7%
Mature females biomass (t)
Tanner Crab east of 166° W
(113-124 mm CW)
M -26%
F -90%
Tanner Crab west of 166° W
(103-124 mm CW)
M +8%
F +16%
Juvenile abundance (millions)

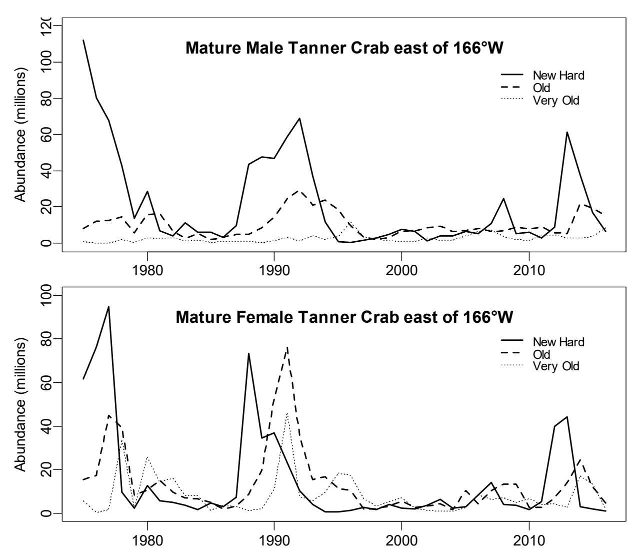

Tanner crab (*Chionoecetes bairdi*) total density
Alaska
1 - 11,020
11,021 - 22,040
22,041 - 33,060
33,061 - 44,080
44,081 - 55,070
No catch
0 150 300 600 Kilometers

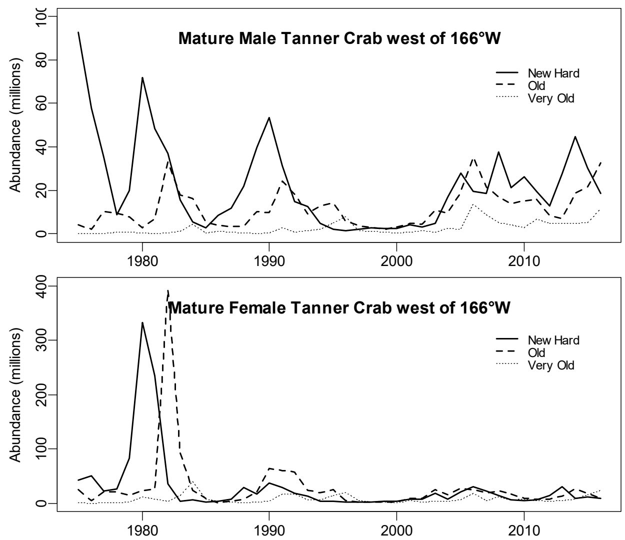

Tanner crab (*Chionoecetes bairdi*) total density
Alaska
2015
2014
2013
1 - 10,000
10,001 - 20,000
20,001 - 30,000
30,001 - 40,000
40,001 - 50,000
No catch
1 - 18,000
18,001 - 36,000
36,000 - 54,000
54,001 - 72,000
121,266

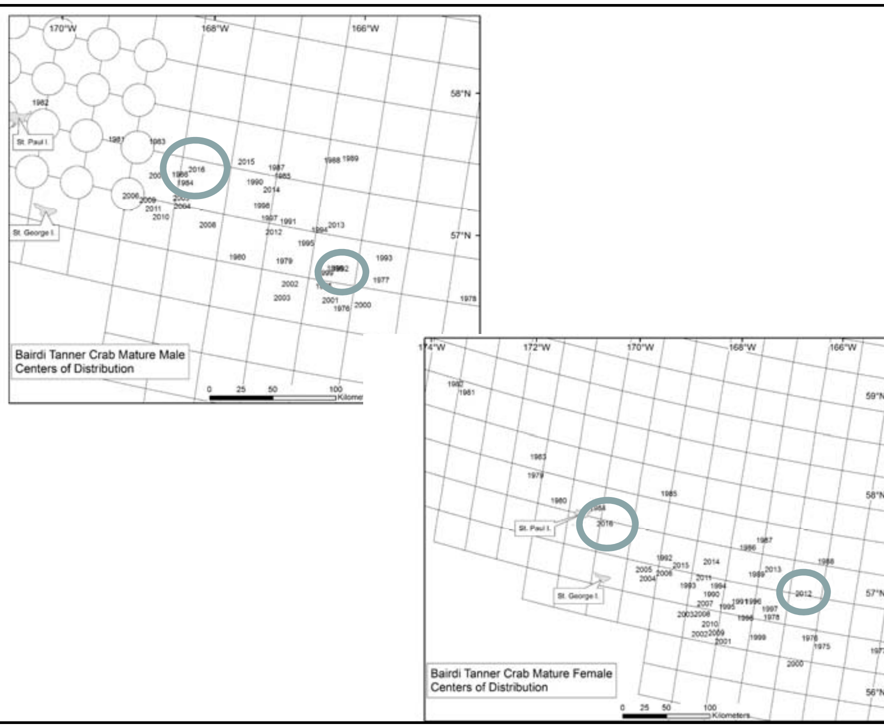

Tanner crab
East of 166°W
Immature male ≤ 112 mm
Mature male ≥ 113 mm
Immature female
Mature female
No catch
West of 166°W
Immature male ≤ 102 mm
Mature male ≥ 103 mm
Immature female
Mature female
No catch
0 150 300 600
Kilometers

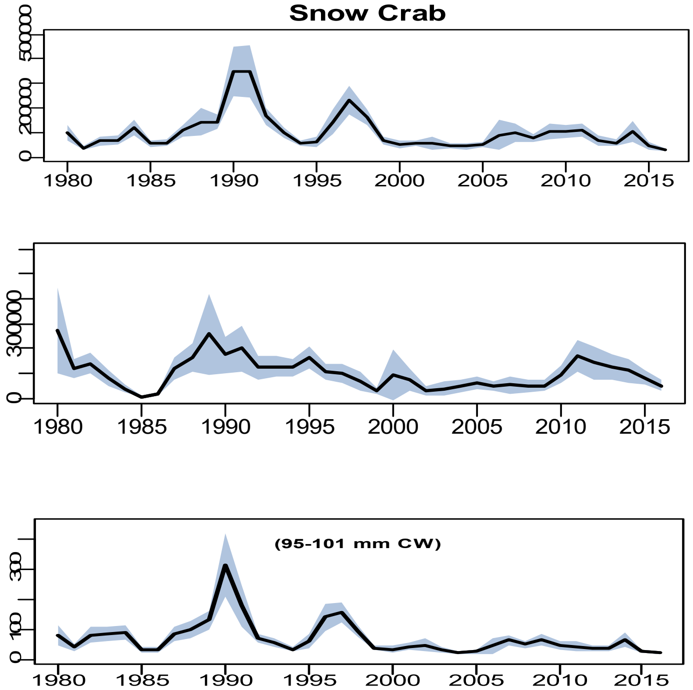

Tanner Crab east of 166°W (male)
Shell condition
Soft & molting
New - hard
Old
Very old
2011
2014
2012
2015
2013
2016
Abundance (millions)
Carapace width (mm)


Tanner Crab west of 166°W (male)
Shell condition
Soft & molting
New - hard
Old
Very old
2011
2014
2012
2015
2013
2016
Abundance (millions)
Carapace width (mm)


Mature Male Tanner Crab east of 166°W
New Hard
Old
Very Old
Abundance (millions)
Mature Female Tanner Crab east of 166°W
New Hard
Old
Very Old
Abundance (millions)


Mature Male Tanner Crab west of 166°W
Abundance (millions)
New Hard
Old
Very Old
1980
1990
2000
2010
Mature Female Tanner Crab west of 166°W
Abundance (millions)
New Hard
Old
Very Old


170°W
168°W
166°W
58°N
57°N
St. Paul I.
St. George I.
Bairdi Tanner Crab Mature Male
Centers of Distribution
174°W
172°W
59°N
56°N
Bairdi Tanner Crab Mature Female
Centers of Distribution
Kilometers



Mature male biomass (t)

-35%

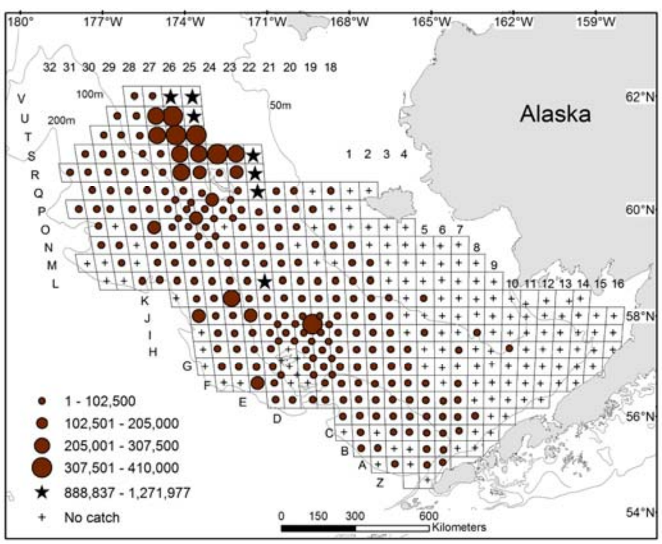
Mature female biomass (t)

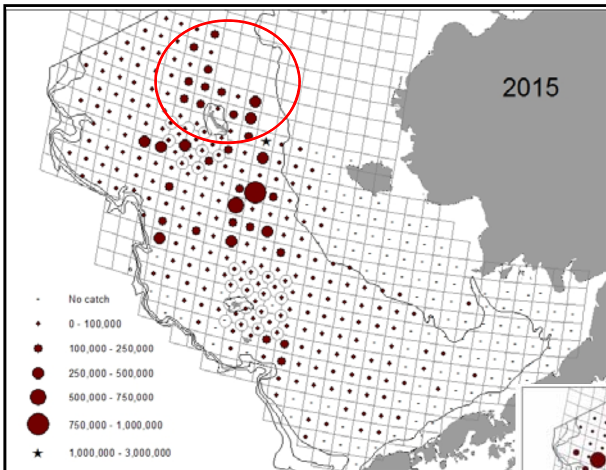
-60%

Juvenile abundance (millions)

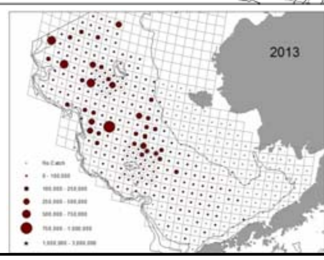
Male +57%
Female +46%

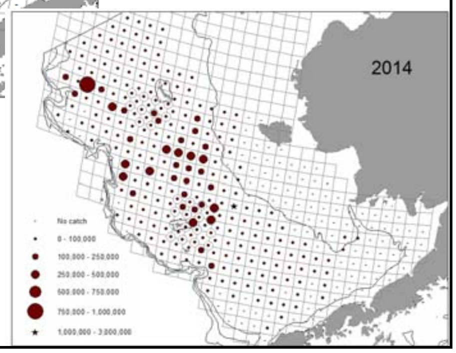
snow crab (*Chionoecetes opilio*) total density



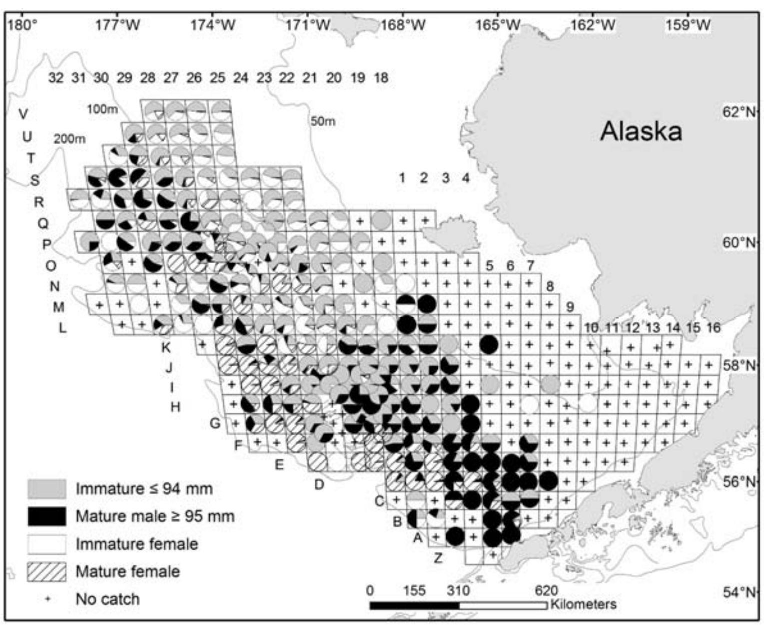


snow crab (*Chionoecetes opilio*)
total density

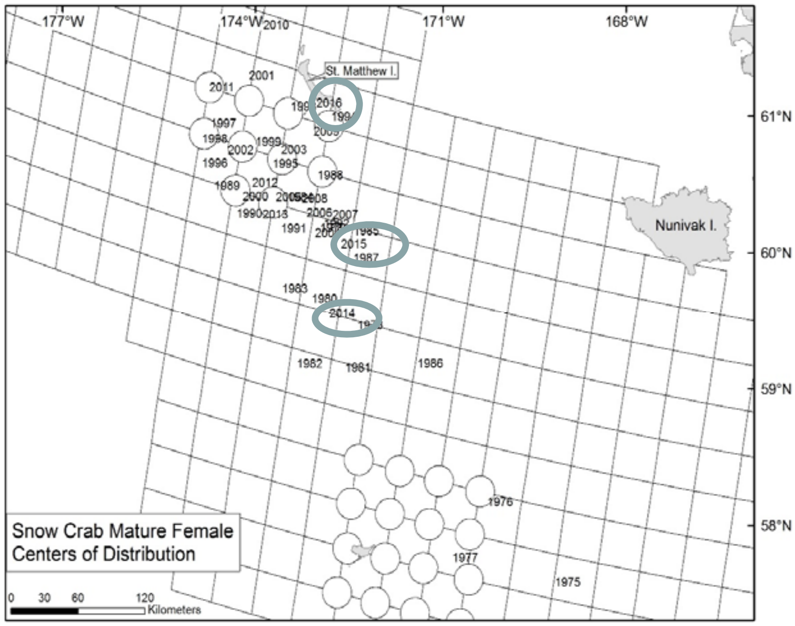




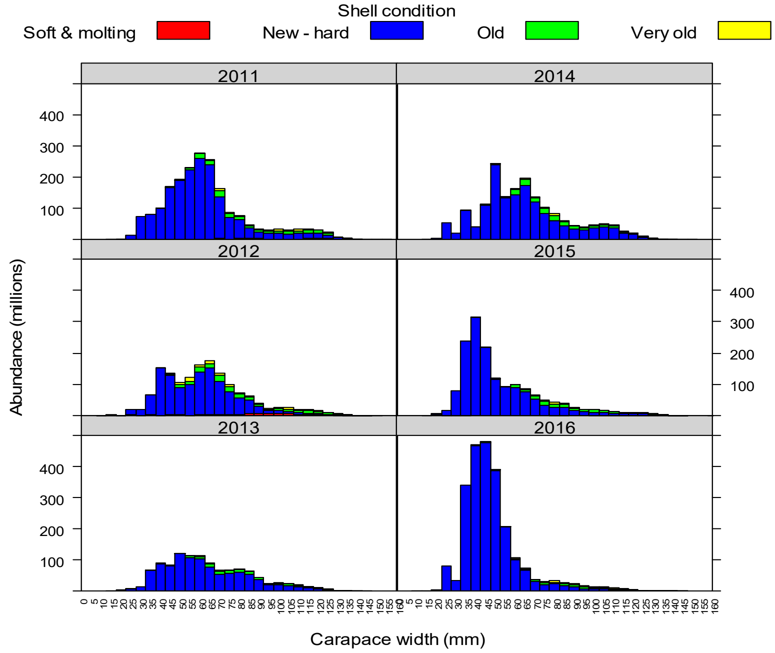
snow crab

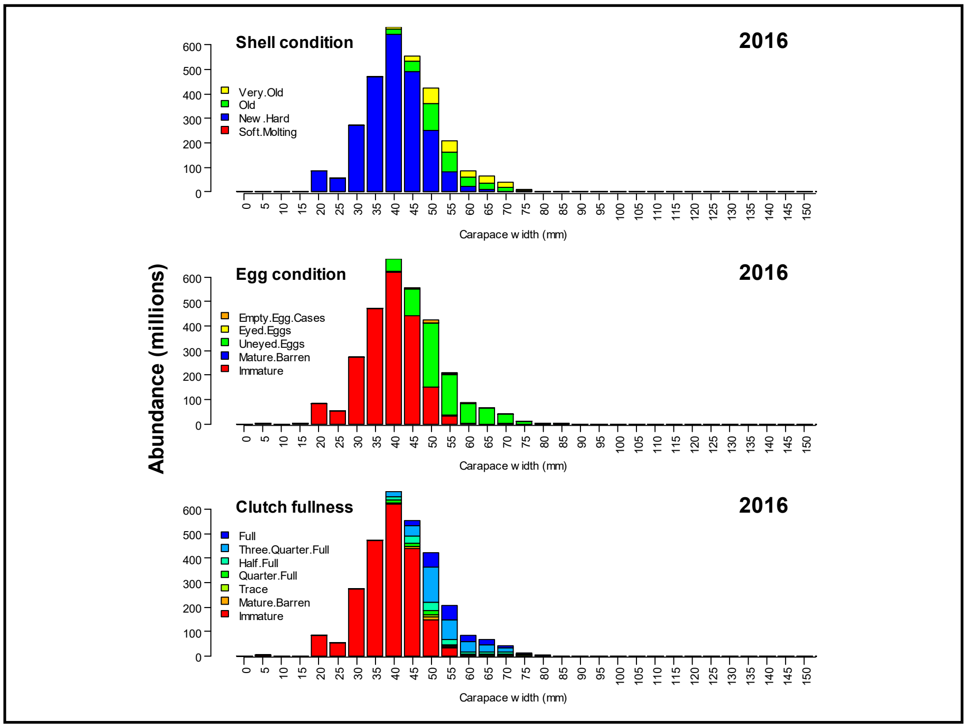


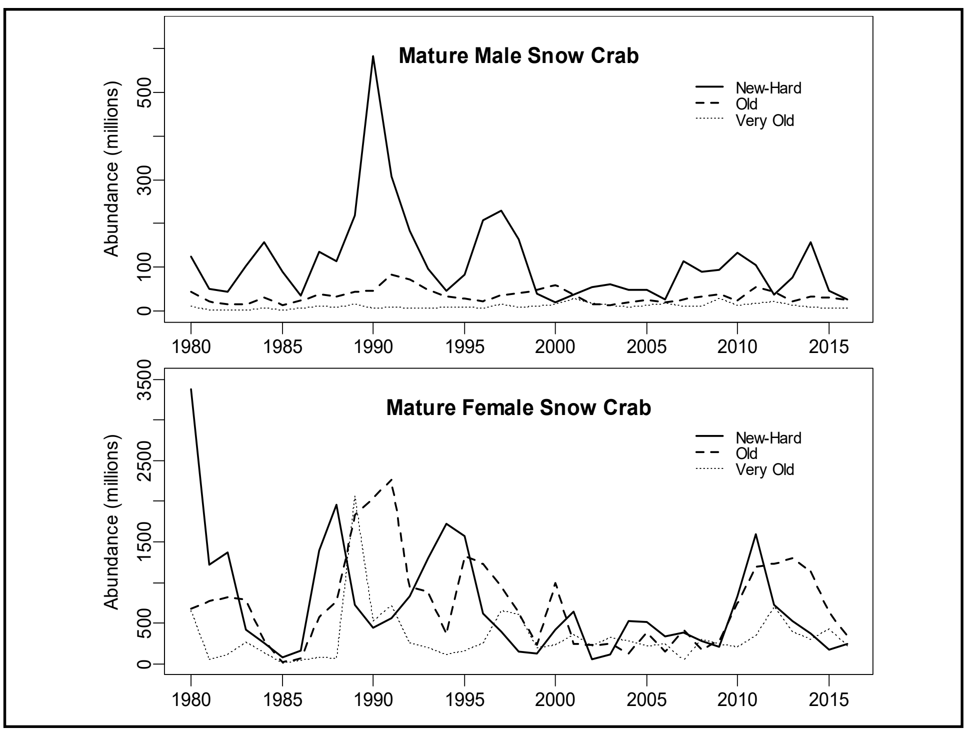
snow crab (*Chionoecetes opilio*)



Snow Crab (male)



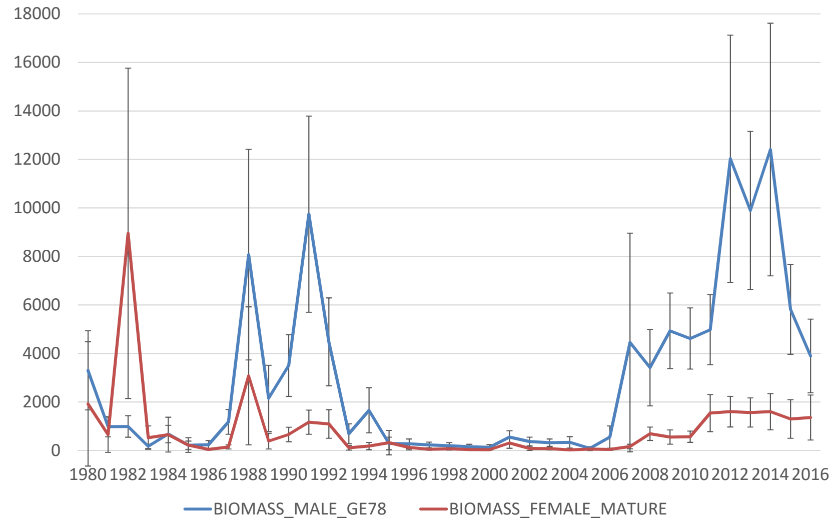

Shell condition
2016
Very.Old
Old
New.Hard
Soft.Molting
Carapace width (mm)
Abundance (millions)
Egg condition
2016
Empty.Egg.Cases
Eyed.Eggs
Uneyed.Eggs
Mature.Barren
Immature
Carapace width (mm)
Clutch fullness
2016
Full
Three.Quarter.Full
Half.Full
Quarter.Full
Trace
Mature.Barren
Immature
Carapace width (mm)


Mature Male Snow Crab
New-Hard
Old
Very Old
Abundance (millions)
Mature Female Snow Crab
New-Hard
Old
Very Old
Abundance (millions)

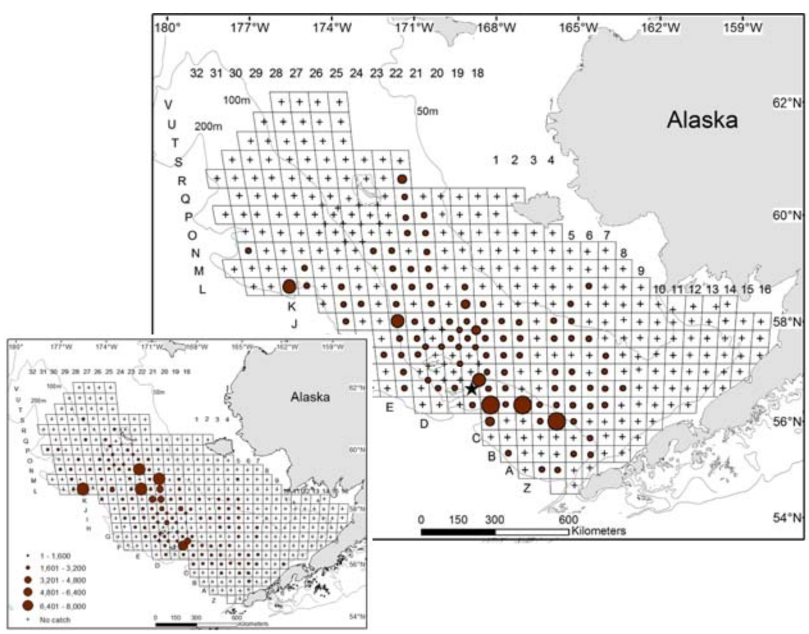
Chionoecetes bairdi/opilio **hybrid crab biomass (t)**

8% of legal male snow crab
3% of mature female snow crab

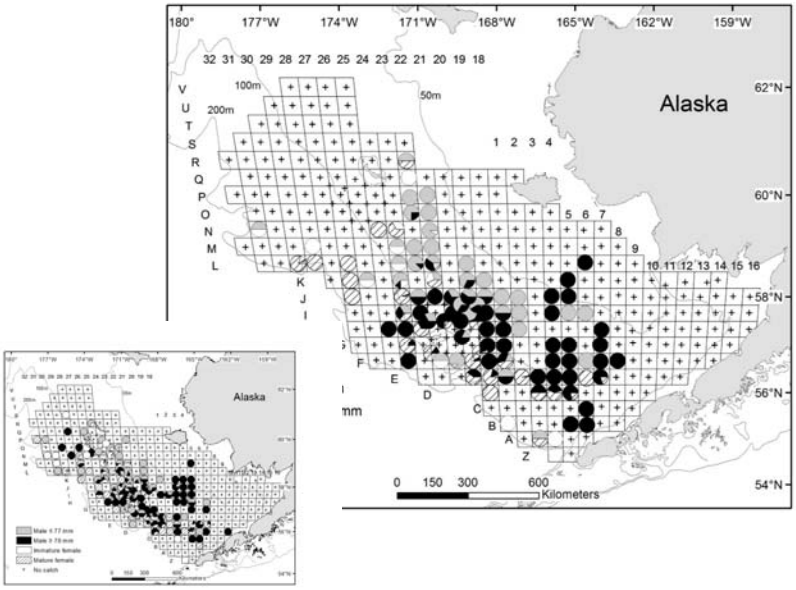
10% of legal male Tanner crab (west)
22% of mature female Tanner crab (west)



Chionoecetes bairdi/opilio **hybrid crab**



Chionoecetes bairdi/opilio **hybrid crab**



2016 Mature Males (2015 value in parentheses)

	# tows	#tows with crab	# caught	% measured	Biomass (t)
BB RKC	136	59 (53)	302 (387)	100%	25,481 (32,121)
PI RKC	77	5 (9)	69 (195)	100%	4,150 (15,173)
PI BKC	86	3 (8)	3 (13)	100%	129 (622)
SM BKC	56	16 (19)	83 (119)	100%	3, 072 (5,134)
TC east	120	99 (94)	1,011 (1,287)	100%	18,523 (27,241)
TC west	255	112 (108)	2,797 (2,624)	91%	35,119 (31,122)
SC	375	190 (180)	2,191 (3,128)	86% (97%)	29,961 (46,410)

Crab Management Process

Survey ended data sent to Kodiak	**July 26**
Trawl area swept data	**August 10**
Final abundance and biomass to SOA	**August 15**
Draft Survey Result Document to public	**August 30**
Crab Plan Team	Sept 20-23
SSC Meeting	Oct 3
TAC setting	Oct 3-10
TACs set	Oct 10
Fishery Start	Oct 15

http://www.afsc.noaa.gov/Kodiak/shellfish/crabEBS/2016EBSSurveyTechMemoDraft.pdf

Snow Crab
Final Stock Assessment

Cory Szuwalski
AFSC

Snow Crab

CPT Discussion and Recommendations

- General
  - Follow the SAFE guidelines for tables and figures
  - Consider laboratory relative growth data available from 2012 to inform model.
  - Provide more detailed MCMC diagnostics

Snow Crab

CPT Discussion and Recommendations

- Specific
  - CPT questioned magnitude of decrease in $F_{35\%}$ from 2015 model to model 0…due to downweighting size comps shifting fishery selectivity to left, decrease M, shifting prob of maturing to left
  - See PAGE 13 of CPT minutes.
  - CPT agreed with the author that use of Bayesian approach for OFL determination more appropriate and considers full uncertainty of the model

Snow Crab

Tier, OFL, and ABC Recommendations

- CPT concurred with author recommended model 3b and Tier status 3b.

-growth fit was reasonable, did not hit M bounds, better estimates of selectivity, catchability, and terminal MMB.

- Biomass (MMB) = 96.1 thousand t
- Total catch OFL = 23.71 thousand t
- ABC (less than max permissible) = 10% buffer = 21.34 thousand t
  - CPT recommended 25% last year due to model uncertainty, convergence issues addressed in this years model

Snow Crab

Stock Status

- 2015/2016 total catch = 21.4 thousand t
- 2015/2016 OFL = 83.1 thousand t

Overfishing did not occur

- 2015/2016 MSST = 75.8 thousand t
- 2015/2016 MMB = 91.6 thousand t

Stock is not overfished

- 2016/2017 MSST= 75.8 thousand t
- 2016/2017 MMB = 96.1 thousand t

Stock is not approaching overfished

Tanner Crab
Final Stock Assessment

William Stockhausen
Alaska Fisheries Science Center

CPT Discussion and Recommendations

- General
  - Growth from EBS and GOA should be incorporated in steps to see if there is an effect of adding new EBS data. Size comp weights should be reduced to let empirical growth data affect the model
  - Separate groundfish fisheries and apply separate handling mortality
  - Include extra likelihood component for the extrapolated effort

Tanner Crab

CPT Discussion and Recommendations

- Specific
  - Fishing mortality is high in early period: compare M to recruitment during that period; free up q to see how F is affected.
  - Run scenario with 1996 data removed from index used to inform pre-1991 selectivity data.
  - Penalties
    - Scenario with reduced penalties on F-deviations.
    - Why female survey q penalty?
    - Assess rationale for all penalties

Tanner Crab

CPT Discussion and Recommendations

- Specific
  - Model Fits:
    - Is a different retention function causing smaller sizes in catch to not be fit?
    - Model C underestimates large male crab size comp.
    - Overestimation of large male crab size comps
      - Larger growth rate than empirical data suggests?

Tanner Crab

Tier, OFL, and ABC Recommendations

- CPT agrees with author recommended model C.
- CPT and author recommended 20% buffer
- CPT concurred with Author recommendation for Tier 3a.

- Biomass (MMB) = 45.34 thousand t
- Total catch OFL = 25.61 thousand t
- ABC (less than max permissible) = 20% buffer = 20.49 thousand t

Tanner Crab

Stock Status

- 2015/2016 total catch = 11.38 thousand t
- 2015/2016 OFL = 27.19 thousand t

Overfishing did not occur

- 2015/2016 MSST = 12.82 thousand t
- 2015/2015 MMB = 73.93 thousand t

Stock is not overfished

- 2016/2017 MSST=12.83 thousand t
- 2016/2017 MMB = 45.34 thousand t

Stock is not approaching overfished

Bristol Bay Red King Crab Final Stock Assessment

J. Zheng and M.S.M. Siddeek
ADF&G, Juneau

Bristol Bay Red King Crab

Response to CPT Comments (from January 2016):

"CPT requests to the Bristol Bay red king crab assessment authors for May 2016 meeting: ***<u>The CPT requested two assessments in which data from the 2007 and 2008 BSFRF surveys and the 2013–2015 BSFRF</u>*** *side-by-side are used to estimate trawl survey selectivity using the aforementioned snow crab model "separate survey" approach: one assessment without a prior for survey Q from the Otto-Somerton double-bag study; one assessment with a prior for survey Q from the double-bag study.* ***<u>The CPT also recommended that an approach be developed where the paired design of 2013-2015 BSFRF surveys is used to directly estimate selectivity. This would involve adding size-structured tow-by-tow data in new likelihood component in the assessment model,</u>*** *and was considered as a project for model development. There was no expectation by the CPT that such a model would be a candidate base model for review at the May CPT meeting."*

Response: These comments were addressed in May 2016.

Bristol Bay Red King Crab

Response to CPT Comments (from May 2016):

*"The CPT had several comments about this approach. First, it was noted at **NMFS/BSRF ratios were highly variable, and that a better approach would be to consider the ratio of the NMFS survey to the sum of two surveys NMFS/(NMFS+BSFRF).** Second, an attempt should be made to **fit actual tow-by-tow data rather than survey aggregates**. Finally, catchability for the NMFS survey was estimated to be greater than one for some model runs (this only occurred when the prior was omitted).It was suggested that **catchability could be limited to values less than one** by parameterizing catchability on a logit scale. The CPT concluded that these issues needed to be addressed before scenario 3 could be adopted."*

Response: the ratio of the NMFS survey to the sum of two surveys NMFS/(NMFS+BSFRF) was also evaluated in May 2016 and the results were not presented to the CPT meeting but were added to the final draft report. We agree that this approach is better than the NMFS/BSRF ratios.

Due to very small amount of crab caught in each tow, it is not feasible to fit the actual tow-by-tow data.

We will examine the approach to parameterize catchability on a logit scale so that it is less or equal to 1.0 in the future work (May 2017).

"The CPT requests that the following models be brought forward in September 2016: scenario 1 (status quo), scenario 1n, and scenario 2. Since results from the 2016 BSFRF survey will be available on the same timetable as the 2016 NMFS survey, these data should be incorporated into scenarios 1n and 2."

Response: *These three scenarios are presented in the September 2016 SAFE report.*

Bristol Bay Red King Crab

Response to SSC Comments specific to this assessment (from October 2015):

*"The SSC reiterates its previous concern that improvement in model fit by increasing M is not a sufficient condition for accepting Model 1. The SSC reiterates its previous recommendation that the **author should test the hypothesis that natural mortality varies annually due to environmental change by running a research model with a random walk on M and then statistically evaluating relationships between time trends in estimated M relative to plausible mechanisms influencing M**. We agree that this model should not be used for setting biological reference points, however it may provide useful information on the appropriate time stanzas for time varying M. Mechanistic explanations for the resulting time stanzas could then be explored.*

The SSC agrees with the CPT that the author should explore a model that incorporates the 2013-2015 side-by-side BSFRF data."

Response: The side-by-side data were evaluated in May 2016. We have spent considerable time over last 20 years to identify mechanisms for change in natural mortality over time but without much success. It is a very complex problem and many factors might have played a role on it. We will continue to work on this issue in the future.

Bristol Bay Red King Crab

Response to SSC Comments specific to this assessment (from June 2016):

"The SSC supports the CPT recommendation to bring forward three scenarios for the stock assessment in fall 2016: (1) scenario 1, which is the status quo (2015) using BSFRF data from 2007 ad 2008 in which the two surveys are treated as independent surveys and survey selectivities are estimated separately and directly in the model; (2) scenario 1n, which is the same as scenario 1 but also includes the 2013-2015 BSFRF survey data, and (3) scenario 2, which is the same as scenario 1n but assumes that the BSFRF survey has capture probabilities of 1.0 for all length groups.

When these scenarios are presented, the terms "capture probabilities" and "selectivity" should be clearly defined. In the report, their descriptions seemed somewhat confusing and contradictory. For instance, Figure 6 implies catchabilities at small sizes in the BSFRF survey that are less than 1.0 for all scenarios, but from the text, this should not be the case. It is important that the definitions and procedures are clearly described."

Response: We reported the results of these three scenarios in this SAFE report and cleaned up the confusion of terms "capture probabilities" and "selectivity" throughout the report.

Bristol Bay Red King Crab

Summary of Major Changes in 2016

1. Changes to the input data:
   a. The new 2016 NMFS trawl survey data and BSFRF side-by-side trawl survey data during 2013-2016 were used.
   b. Catch and bycatch data were updated with 2016 data.
   c. Total NMFS survey biomass CVs were updated and they are slightly different from those in 2015 for some years.

Bristol Bay Red King Crab

Summary of Major Changes in 2015

2. Changes to the assessment methodology:

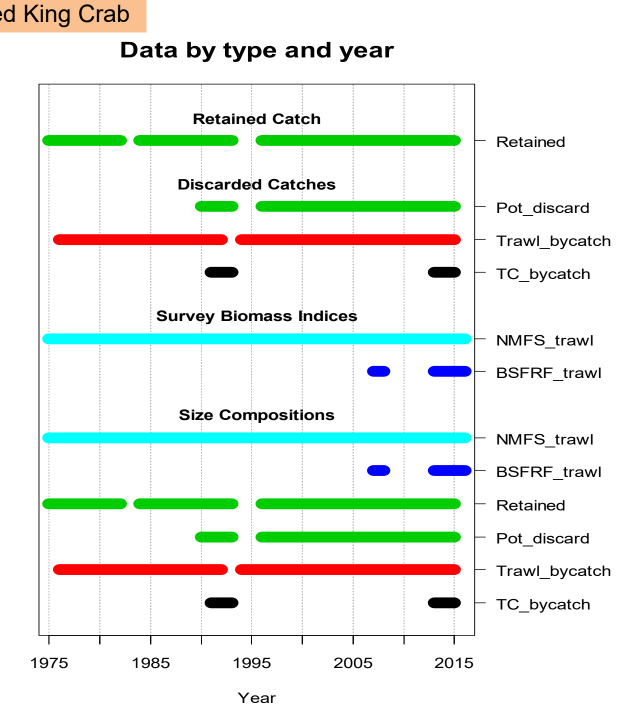
Three model scenarios are evaluated in this report:

Scenario1: the same as Scenario 1 in the SAFE report in September 2015 using BSFRF survey data in 2007 and 2008. The BSFRF survey is treated as an independent survey, and no assumption is made about the capture probabilities of the BSFRF survey. In effect, survey selectivities for both surveys are estimated separately and directly in the model.

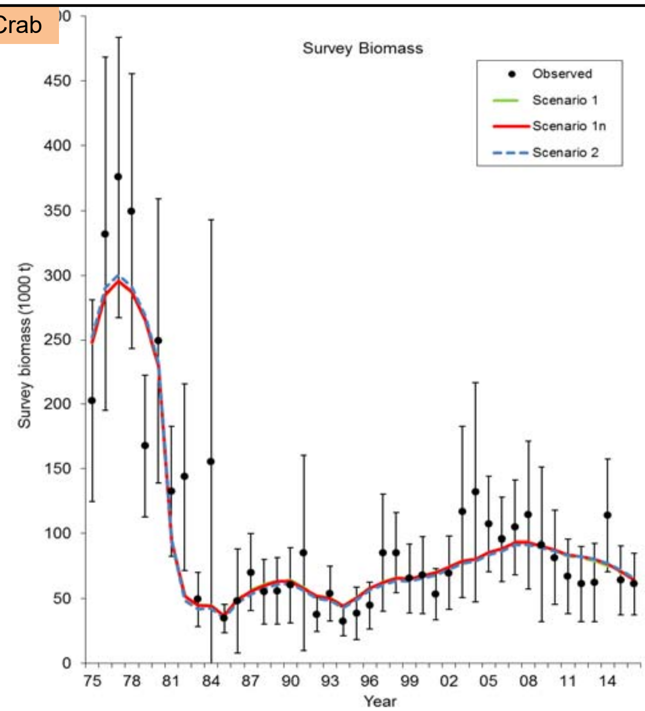
Scenario 1n: the same as scenario 1 plus additional BSFRF survey data in 2013-2016 (independent time series)

Scenario 2: the same as scenario 1n except for the assumption that BSFRF survey capture probabilities are 1.0 for all length groups. Under this assumption, NMFS survey selectivities are the products of crab availabilities (equal to BSFRF survey selectivities) and NMFS survey capture probabilities.

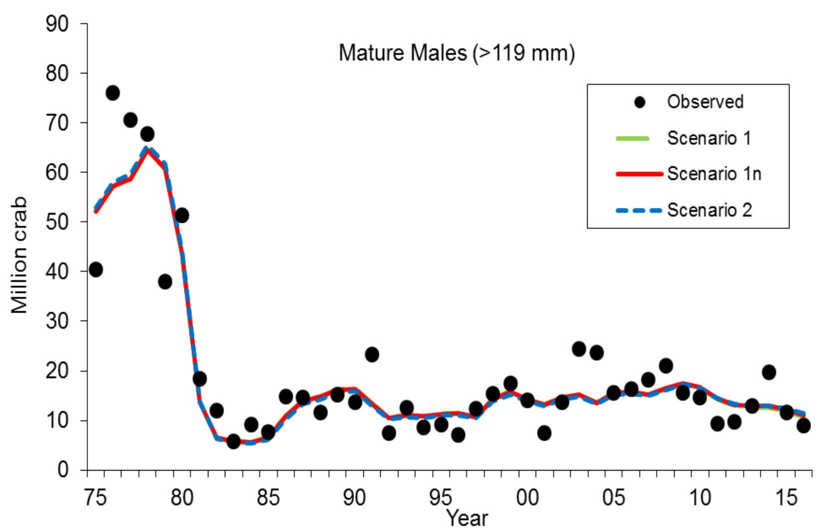
Bristol Bay Red King Crab

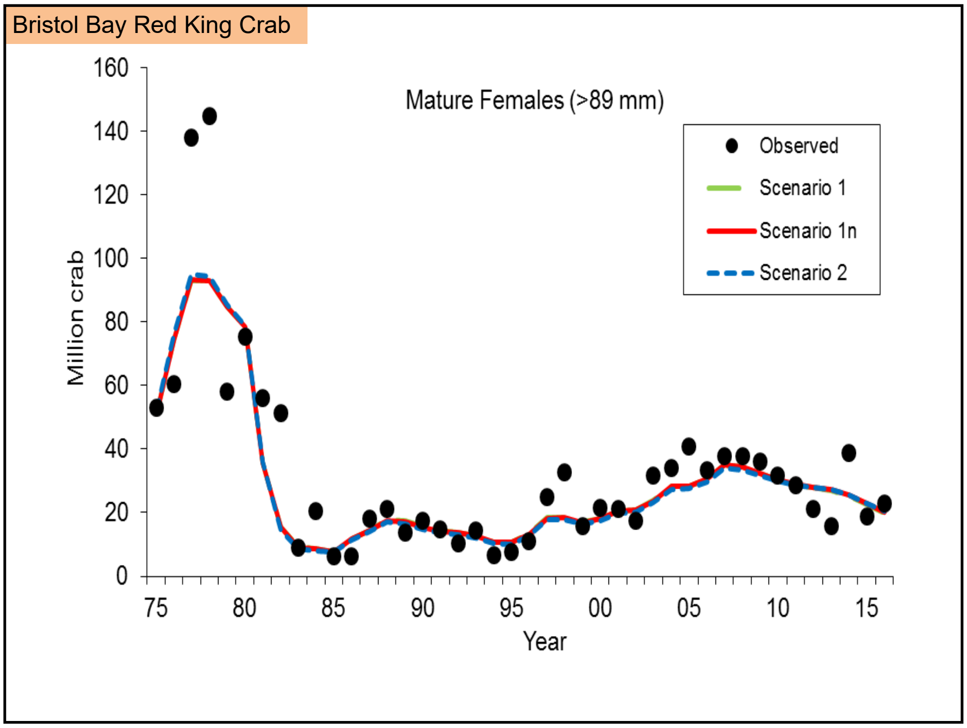


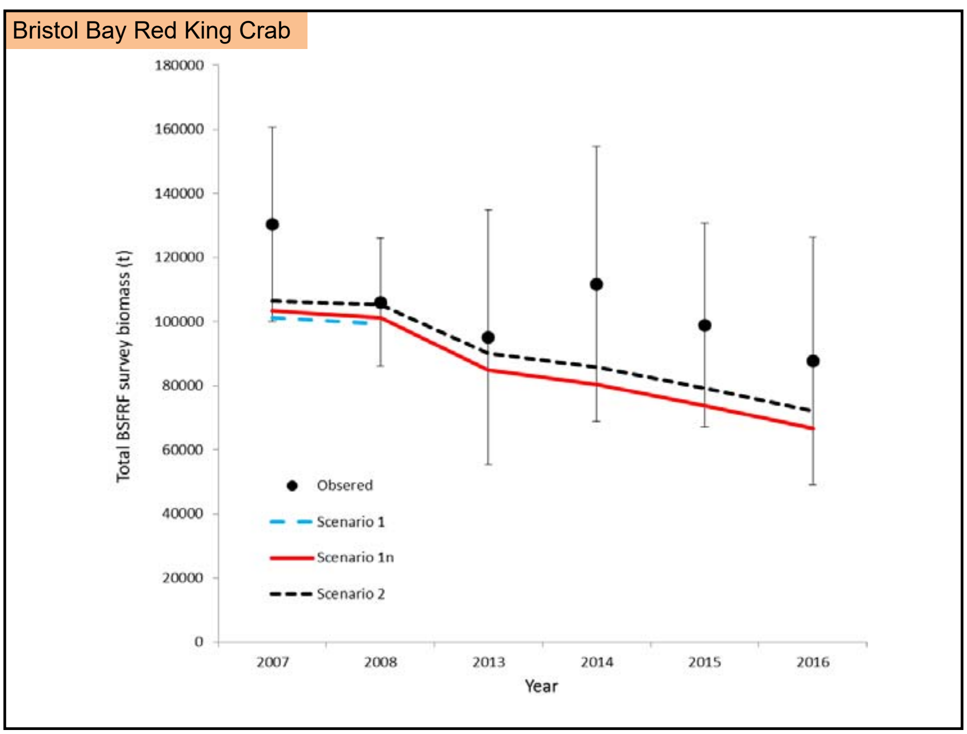
Bristol Bay Red King Crab



Bristol Bay Red King Crab




Bristol Bay Red King Crab
Mature Females (>89 mm)
Million crab
Year
0
20
40
60
80
100
120
140
160
75
80
85
90
95
00
05
10
15
Observed
Scenario 1
Scenario 1n
Scenario 2


Bristol Bay Red King Crab
Total BSFRF survey biomass (t)
Year
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
2007
2008
2013
2014
2015
2016
Obsered
Scenario 1
Scenario 1n
Scenario 2

Bristol Bay Red King Crab

Scenario

Negative log likelihood	1	1n	2	1 – 1n	1 - 2	1n – 2
R-variation	89.21	88.59	86.87	0.63	2.34	1.72
Length-like-retained	-1006.52	-1006.30	-1005.17	-0.22	-1.35	-1.13
Length-like-discmale	-1047.63	-1047.10	-1047.20	-0.53	-0.43	0.10
Length-like-discfemale	-2408.40	-2408.56	-2409.54	0.16	1.14	0.98
Length-like-survey	-47401.20	-47400.40	-47409.90	-0.80	8.70	9.50
Length-like-disctrawl	-2076.26	-2075.56	-2075.02	[illegible]	[illegible]	-0.54
Length-like-discTanner	-463.67	-464.55	-465.88	[illegible]	[illegible]	1.33
Length-like-bsfrfsurvey	-238.03	-650.31	-646.36	[illegible]	[illegible]	-3.95
Catchbio_retained	48.80	48.63	48.59	[illegible]	[illegible]	0.04
Catchbio_discmale	227.46	227.56	227.80	[illegible]	[illegible]	[illegible]
Catchbio-discfemale	0.13	0.14	0.13	[illegible]	[illegible]	[illegible]
Catchbio-disctrawl	0.90	0.91	0.92	[illegible]	[illegible]	[illegible]
Catchbio-discTanner	0.14	0.14	0.12	[illegible]	[illegible]	0.02
Biomass-trawl survey	94.80	94.91	97.75	-0.11	-2.95	-2.84
Biomass-bsfrfsurvey	-4.62	-7.75	-8.07	3.13	3.45	0.32
Q-trawl survey	1.10	1.22	2.76	-0.12	-1.66	-1.54
Others	20.79	20.84	21.00	-0.05	-0.21	-0.16
Total	-54163.00	-54577.60	-54581.20	414.60	418.20	3.60
Free parameters	279	279	279	0	0	0

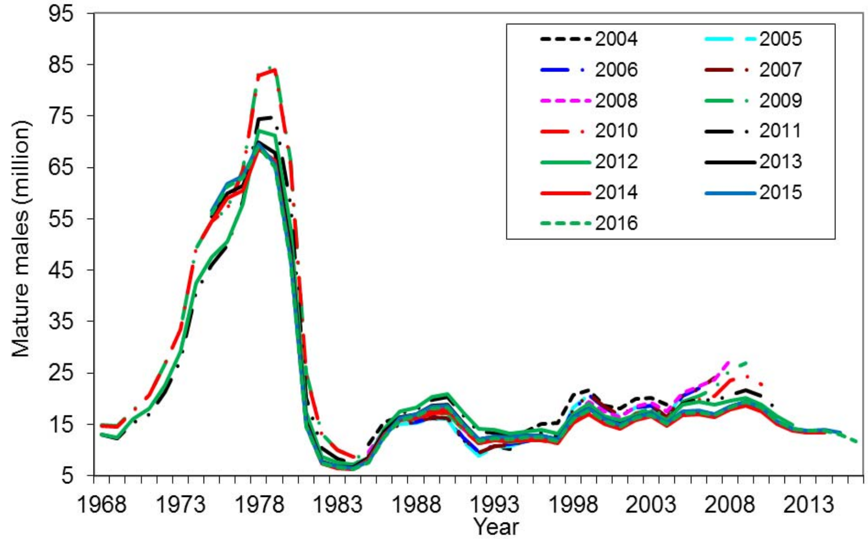
Take home message: small changes in log likelihood..some improvements in model fit to survey lengths and overall for model 2.

Bristol Bay Red King Crab

- ✓ In 2016, the survey mature male abundance is slightly less than expected while survey female abundance is higher than expected based on the survey abundances during the previous several years. **The disappointment is very low estimated recruitments, which are the lowest since 1973.**
- ✓ Model estimated relative survey biomasses are very similar among the three scenarios and fit the survey data quite well. The absolute population biomass estimates are slightly higher for scenario 2 than for scenarios 1 and 1n during recent years due to a slightly lower estimate of trawl survey selectivities for scenario 2 and additional BSFRF survey data for scenarios 1n and 2.

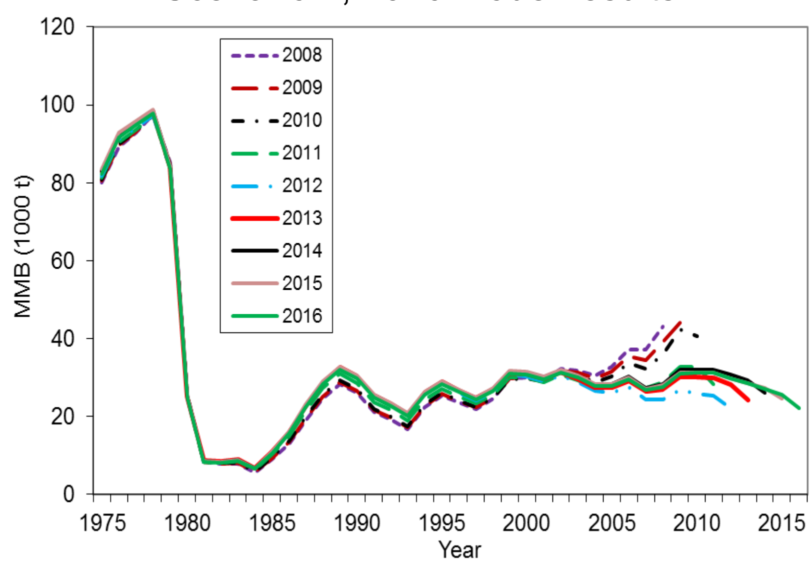
Bristol Bay Red King Crab

Scenario 1, historical results

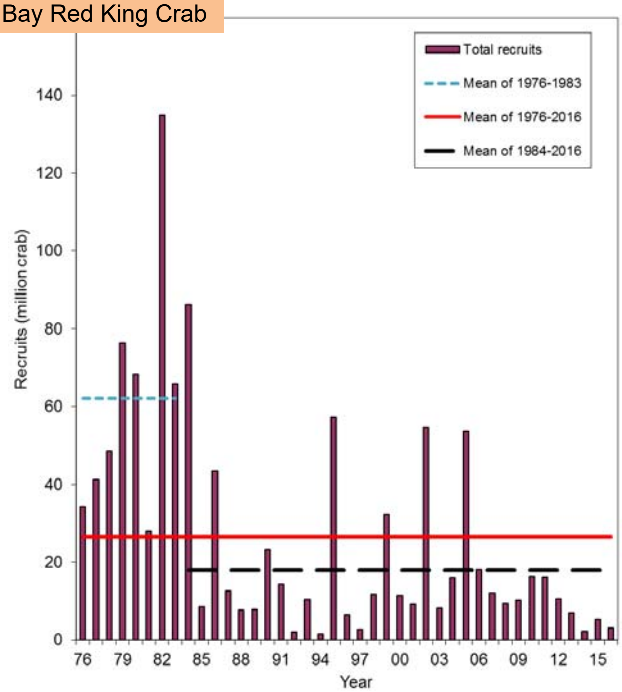


Bristol Bay Red King Crab

Scenario 1, 2016 model results

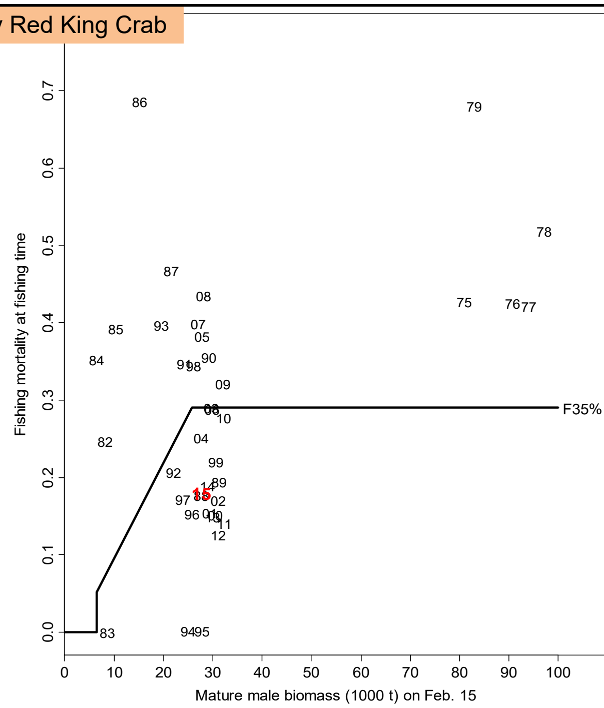


Bristol Bay Red King Crab



Scenario 2

Bristol Bay Red King Crab



Scenario 2

Bristol Bay Red King Crab

CPT Discussion and Recommendations

- Specific
  - Discussion about BSFRF net herding and q>1. The CPT requests information about trawl net configurations be discussed at May CPT meeting.
  - Are the 2004 underbag experiment data informative with new side by side data? CPT requests model runs with and without prior on catchability from the 2004 experiment.

Bristol Bay Red King Crab

Tier, OFL, and ABC Recommendations

- CPT recommended model 2n (different from author recommendation of model 1n).
  - Overall fit better (specifically NMFS survey lengths)
  - Consistent with snow crab use of BSFRF data
  - Selectivity curves for BSFRF data more plausible
- CPT and author recommended 10% buffer
- CPT concurred with Author recommendation for Tier 3b.

Bristol Bay Red King Crab

Tier, OFL, and ABC Recommendations

- Biomass (MMB) = 24.00 thousand t
- Total catch OFL = 6.64 thousand t
- ABC (less than max permissible) = 10% buffer = 5.97 thousand t

Bristol Bay Red King Crab

Stock Status

- 2015/2016 total catch = 5.34 thousand t
- 2015/2016 OFL = 6.73 thousand t

Overfishing did not occur

- 2015/2016 MSST=12.89 thousand t
- 2015/2016 MMB = 27.68 thousand t

Stock is not overfished

- 2016/2017 MSST=12.89 thousand t
- 2016/2017 MMB = 24.00 thousand t

Stock is not approaching overfished

Pribilof Islands Red King Crab
Final Stock Assessment

Jack Turnock
AFSC

Pribilof Islands Red King Crab

CPT comments May 2016

- *Continue the work on survey biomass and length frequency weighting issues to improve the model fits to abundance data;*
  - Addressed in #2 below.
- *Implement the Francis tuning method to estimate length composition effective sample sizes;*
  - The Francis effective N calculation was added to the model. In addition, other multipliers on the survey length frequencies were evaluated.
- *Provide results for a random effects model and three-year weighted average for the September meeting*
  - The random effects model was fit to the survey biomass data and MMB, OFL and ABC estimated. The estimates using the three-year weighted average are also included.

Pribilof Islands Red King Crab

Crab Plan Team September 2015 comments not addressed

- *Incorporate a mean-unbiased log normal likelihood for survey numbers*
  - Next time.
-
- *Discuss the poisson vs. negative binomial for survey estimates of abundance and CVs*
  - Currently all of the data in the model are those that are passed from Bob Foy and the Kodiak lab, but given the over-dispersion in the data, a negative binomial (or something similar) might be more appropriate, particularly for estimates of variance. The CVs sent by Bob are used in the assessment, but bootstrapped variances are much larger.
-
- *Consider ADFG pot survey data and retained catch size frequency data*
  - These data area not yet incorporated, but may be useful in exploring the mechanics of time-varying catchability.

Pribilof Islands Red King Crab

Summary of Major Changes:

- Management: None.
- Input data: Survey (2016) and bycatch (2015) data were incorporated into the assessment.
- Assessment methodology: Model output for male only fit is presented with the same integrated length based model configuration as 2015.
- Assessment results: Male biomass estimates from the 3-year running average and a random effects model fit to survey male biomass >=120mm are used to estimate MMB at mating, OFL and ABC.

Pribilof Islands Red King Crab

Survey biomass in 2016 declined to 4,150 t from 15,173 t in 2015

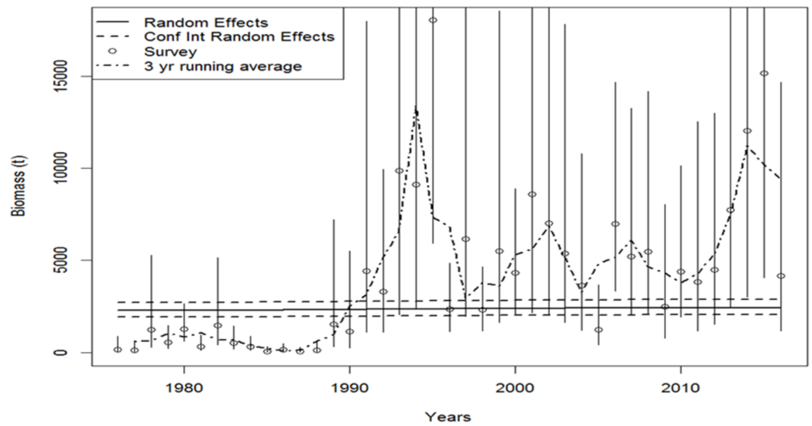


Figure 14. Three-year running average and random effects model fit to male biomass > 120mm at survey time.

Pribilof Islands Red King Crab

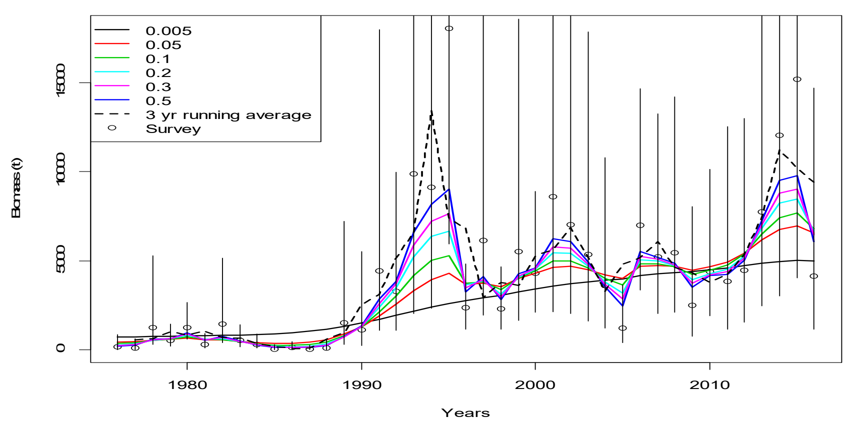


Figure 26. Random effects model estimates of biomass with process error fixed at 0.005, 0.05, 0.1,0.2,0.3 and 0.5.

Pribilof Islands Red King Crab

Integrated assessment model fit to male numbers (male only model)

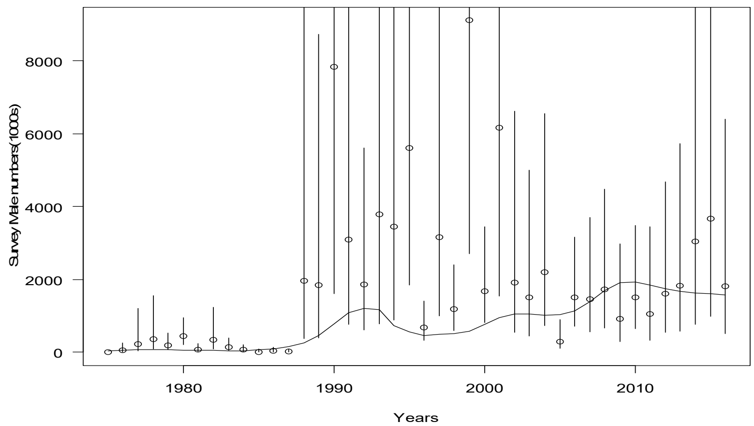


Figure 20. Model fit to survey male numbers.

Pribilof Islands Red King Crab

Survey length sample size reduction – Francis N multiplier 0.05

(model did not converge)

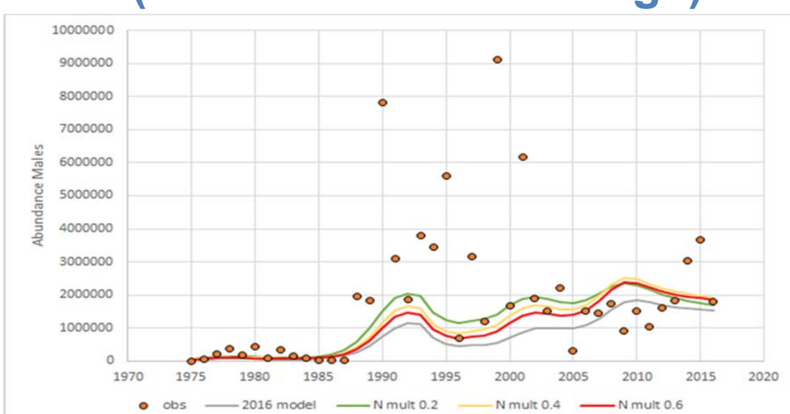


Figure 25. Fit to male abundance for the 2016 base model and model scenarios with multipliers on the survey length sample size of 0.2, 0.4 and 0.6.

Pribilof Islands red king crab

CPT Discussion and Recommendations

- General
  - Highly variable survey estimates may be driven by low density/aggregation behavior OR some portion of stock not available to survey.
  - Concern that low survey catches have the low survey CV…but uncertainty not likely changing among years.

Pribilof Islands red king crab

CPT Discussion and Recommendations

- Specific
  - Reduce effort on further evaluation of length based model
  - Continue to evaluate random effects model with universal weighting

Pribilof Islands red king crab

Tier, OFL, and ABC Recommendations

- CPT recommended 3 year running avg the model (author recc.)
- CPT and author recommended 25% buffer
- CPT concurred with Author recommendation for Tier 4a.

- Biomass (MMB) = 6.98 thousand t
- Total catch OFL = 1.46 thousand t
- ABC (less than max permissible) = 25% buffer = 1.10 thousand t

Pribilof Islands red king crab

Stock Status

- 2015/2016 total catch = 0.00032 thousand t
- 2015/2016 OFL = 2.12 thousand t

Overfishing did not occur

- 2015/2016 MSST= 2.76 thousand t
- 2015/2016 MMB = 9.06 thousand t

Stock is not overfished

- 2016/2017 MSST= 2.76 thousand t
- 2016/2017 MMB = 6.98 thousand t

Stock is not approaching overfished

Pribilof Islands Blue King Crab Final Stock Assessment

Buck Stockhausen
AFSC

Pribilof Islands Blue King Crab

Changes From 2015 Assessment

- **Same approach to OFL**
  - **Tier 4 status determination**
  - **Tier 5 OFL, ABC**
- **Random effects model smoothing survey MMB as part of estimating MMB-at-mating for B_{MSY}, current B**
- **New Fishery Data for 2015/16**
  - **directed fishery**
    - **no catch**
  - **crab fishery bycatch**
    - **updated**
  - **groundfish fisheries**
    - **2014/15 updated**
    - **2015/16 new**
- **New survey data**
  - **updated w/ 2016 EBS Trawl Survey**
  - **abundance, biomass**
  - **size compositions by sex, shell condition, maturity**

Pribilof Islands Blue King Crab

Management Performance

Overfishing occurred in 2015/16.
Stock remains overfished.

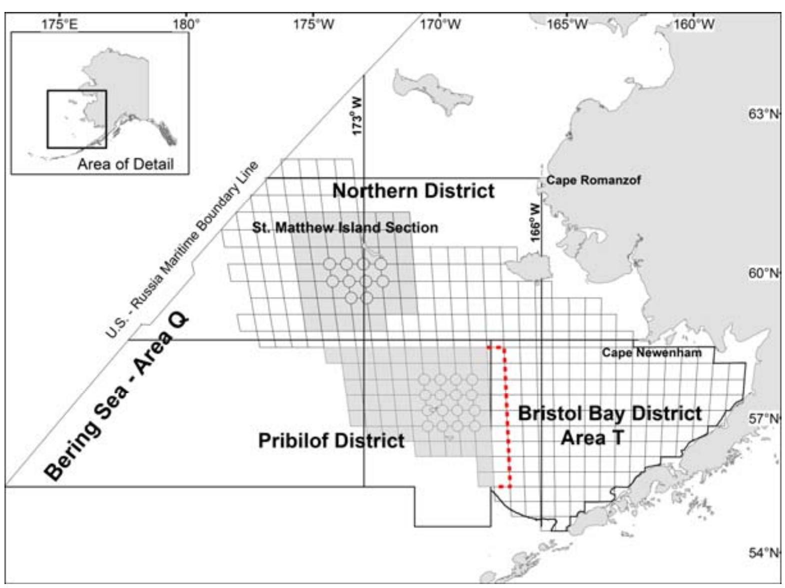
units in metric tons

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch Mortality	OFL	ABC
2012/13	1,994 A	579 A	closed	0	0.61	1.16	1.04
2013/14	2,001 A	225 A	closed	0	0.03	1.16	1.04
2014/15	2,055 A	344 A	closed	0	0.07	1.16	0.87
2015/16	2,058 A	361 A	closed	0	1.18	1.16	0.87
2016/17	--	233 B	--	--	--	1.16	0.87

- OFL based on average catch (1999/2000-2005/06)
- ABC based on 25% buffer (CPT rec'd, SSC approved 201

Pribilof Islands Blue King Crab

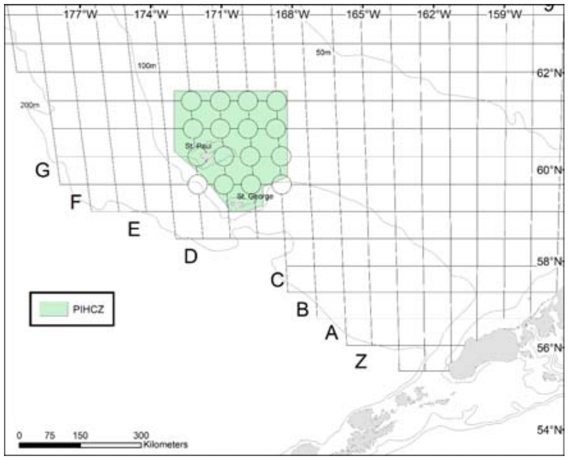
Management Area & Stock Definition



Pribilof Islands Blue King Crab

Spatial Closures in the Groundfish Fisheries

Pribilof Islands Habitat Conservation Zone



- Closed to non-pelagic trawl gear
- Closed to pot gear for Pacific cod

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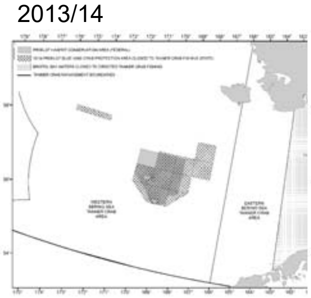
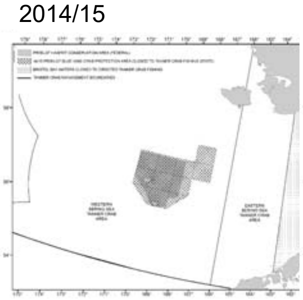
Pribilof Islands Blue King Crab

Closures in Western Tanner Crab Fishery

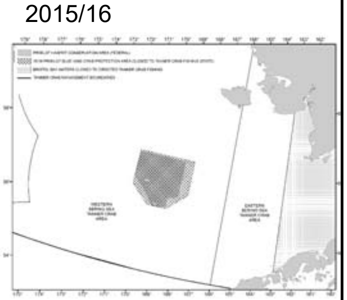
2013/14



2014/15



2015/16



Fishery	Sampled Pots	Total Effort (Pot lifts)	% Pots Observed	Expansion Factor
EBS snow	1,857	201,650	0.921	108.589
Tanner-West	898	85,244	1.053	94.927

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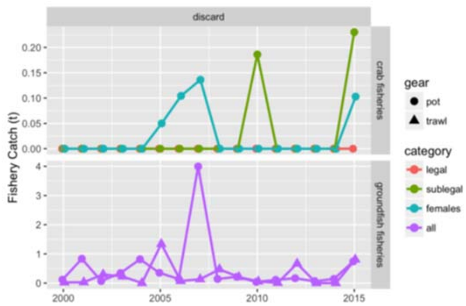
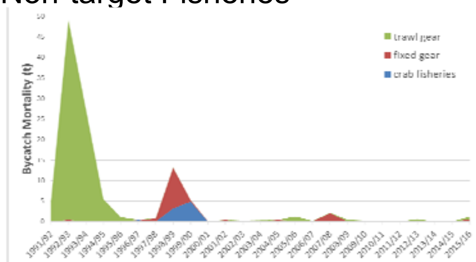
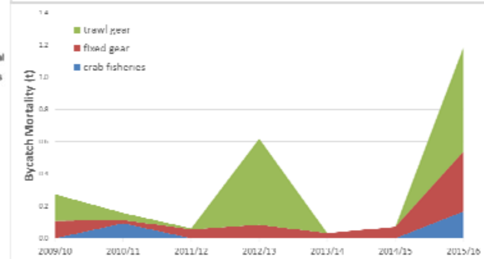
Pribilof Islands Blue King Crab

PIBKC Bycatch in Non-target Fisheries







$HM_{fixed} = 0.5$

$HM_{trawl} = 0.8$

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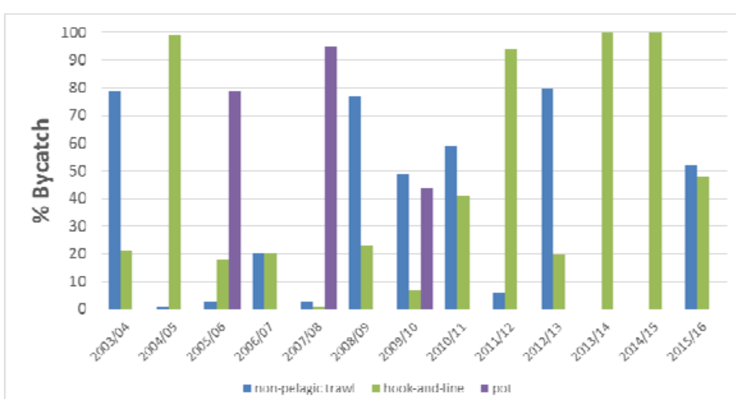
Pribilof Islands Blue King Crab

PIBKC Bycatch in the Groundfish Fisheries



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Pribilof Islands Blue King Crab

PIBKC Bycatch

Bycatch (t)

fishery year	crab (pot) fisheries (t) females	legal males	sublegal males	groundfish fisheries (t) fixed gear	trawl gear
1991/92	--	--	--	0.067	6.199
1992/93	--	--	--	0.879	60.791
1993/94	--	--	--	0.000	34.232
1994/95	--	--	--	0.035	6.856
1995/96	--	--	--	0.108	1.284
1996/97	0.000	0.000	0.807	0.031	0.067
1997/98	0.000	0.000	0.000	1.462	0.130
1998/99	3.715	2.295	0.467	19.800	0.079
1999/00	1.969	3.493	4.291	0.795	0.020
2000/01	0.000	0.000	0.000	0.116	0.023
2001/02	0.000	0.000	0.000	0.833	0.029
2002/03	0.000	0.000	0.000	0.071	0.297
2003/04	0.000	0.000	0.000	0.345	0.227
2004/05	0.000	0.000	0.000	0.816	0.002
2005/06	0.050	0.000	0.000	0.353	1.339
2006/07	0.104	0.000	0.000	0.138	0.074
2007/08	0.136	0.000	0.000	3.993	0.132
2008/09	0.000	0.000	0.000	0.141	0.473
2009/10	0.000	0.000	0.000	0.216	0.207
2010/11	0.000	0.000	0.186	0.039	0.056
2011/12	0.000	0.000	0.000	0.112	0.007
2012/13	0.000	0.000	0.000	0.167	0.669
2013/14	0.000	0.000	0.000	0.064	0.000
2014/15	0.000	0.000	0.000	0.142	0.000
2015/16	0.103	0.000	0.230	0.745	0.808

Bycatch mortality (t)

fishery year	crab (pot) fisheries (t) females	legal males	sublegal males	groundfish fisheries (t) fixed gear	trawl gear	total bycatch mortality (t)
1991/92	--	--	--	0.034	4.959	4.993
1992/93	--	--	--	0.440	48.633	49.072
1993/94	--	--	--	0.000	27.386	27.386
1994/95	--	--	--	0.018	5.485	5.502
1995/96	--	--	--	0.054	1.027	1.081
1996/97	0.000	0.000	0.404	0.016	0.054	0.473
1997/98	0.000	0.000	0.000	0.731	0.104	0.835
1998/99	1.857	1.148	0.234	9.900	0.063	13.202
1999/00	0.984	1.746	2.145	0.398	0.016	5.290
2000/01	0.000	0.000	0.000	0.058	0.018	0.076
2001/02	0.000	0.000	0.000	0.417	0.023	0.440
2002/03	0.000	0.000	0.000	0.036	0.238	0.273
2003/04	0.000	0.000	0.000	0.173	0.182	0.354
2004/05	0.000	0.000	0.000	0.408	0.002	0.410
2005/06	0.025	0.000	0.000	0.177	1.071	1.273
2006/07	0.052	0.000	0.000	0.069	0.059	0.180
2007/08	0.068	0.000	0.000	1.997	0.106	2.170
2008/09	0.000	0.000	0.000	0.071	0.378	0.449
2009/10	0.000	0.000	0.000	0.108	0.165	0.273
2010/11	0.000	0.000	0.093	0.020	0.045	0.158
2011/12	0.000	0.000	0.000	0.056	0.006	0.062
2012/13	0.000	0.000	0.000	0.084	0.535	0.619
2013/14	0.000	0.000	0.000	0.032	0.000	0.032
2014/15	0.000	0.000	0.000	0.071	0.000	0.071
2015/16	0.051	0.000	0.115	0.372	0.646	1.185

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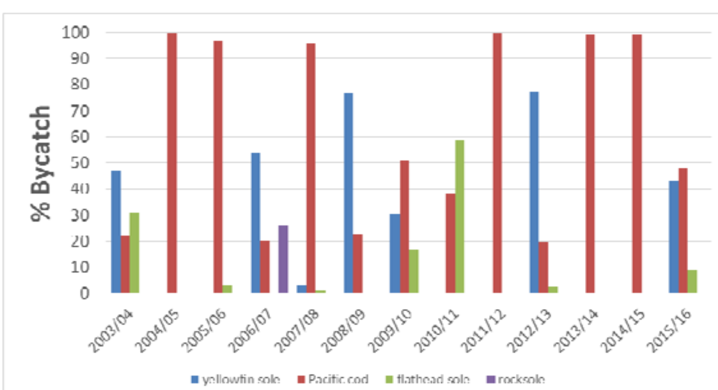
Pribilof Islands Blue King Crab

PIBKC Bycatch in the Groundfish Fisheries



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Pribilof Islands Blue King Crab

PIBKC Bycatch in Groundfish Fisheries

Crab Fishery Year	% bycatch (biomass) by trip target: yellowfin sole %	Pacific cod %	flathead sole %	rocksole %	total bycatch (# crabs)
2003/04	47	22	31	< 1	252
2004/05	< 1	100	< 1	< 1	259
2005/06	< 1	97	3	< 1	757
2006/07	54	20	< 1	26	96
2007/08	3	96	1	< 1	2,950
2008/09	77	23	< 1	< 1	295
2009/10	31	51	17	< 1	281
2010/11	< 1	39	59	< 1	48
2011/12	< 1	100	< 1	< 1	62
2012/13	77	20	3	< 1	410
2013/14	< 1	99	< 1	< 1	39
2014/15	< 1	99	< 1	< 1	64
2015/16	43	48	9	< 1	609

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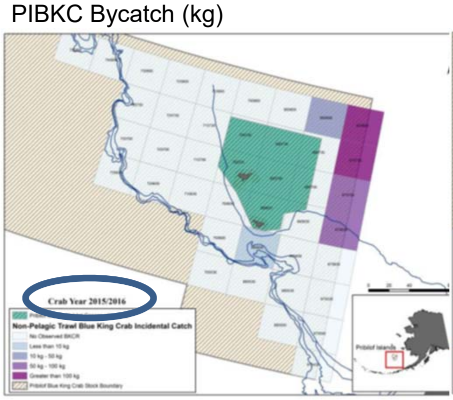
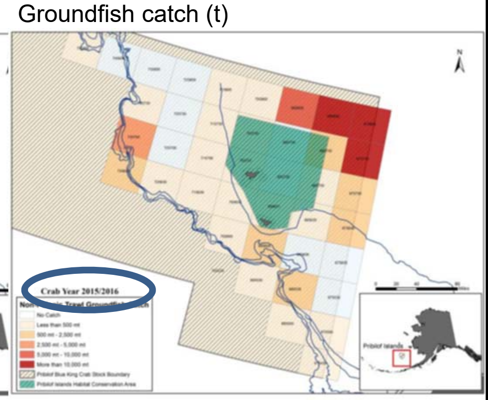
Pribilof Islands Blue King Crab

PIBKC Bycatch in Non-Pelagic Trawl Fisheries

PIBKC Bycatch (kg)



Groundfish catch (t)



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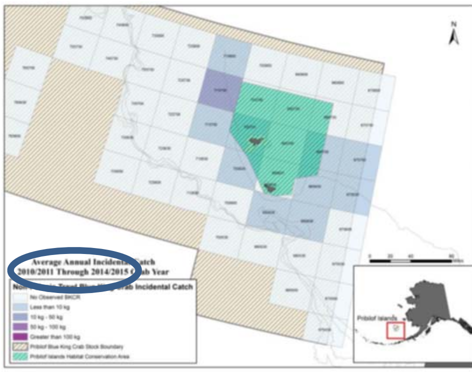
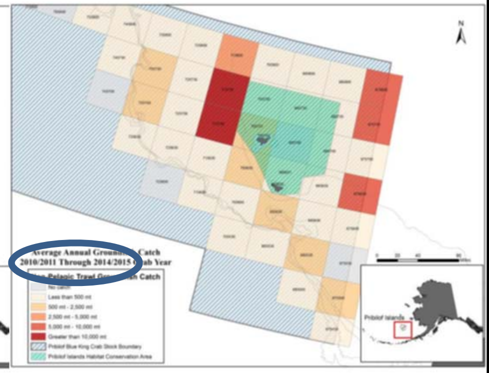
Pribilof Islands Blue King Crab

PIBKC Bycatch in Non-Pelagic Trawl Fisheries

5-year Average PIBKC Bycatch (kg)



5-Year Average Groundfish catch (t)



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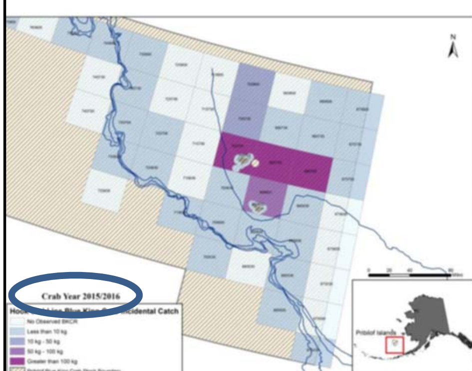
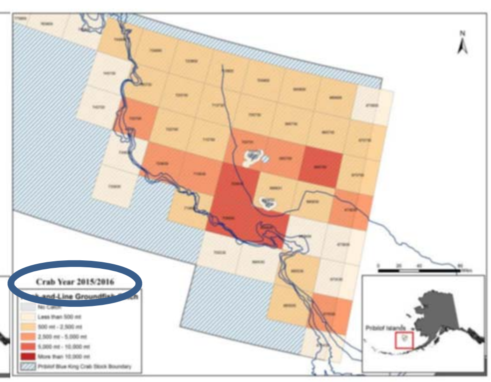
Pribilof Islands Blue King Crab

PIBKC Bycatch in Hook-and-Line Fisheries

PIBKC Bycatch (kg)



Groundfish catch (t)



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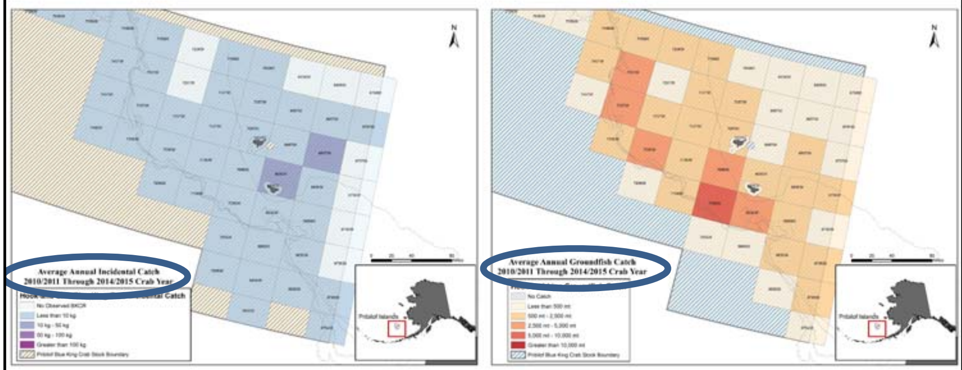
Pribilof Islands Blue King Crab

PIBKC Bycatch in Hook-and-Line Fisheries

5-year Average PIBKC Bycatch (kg) | 5-Year Average Groundfish catch (t)



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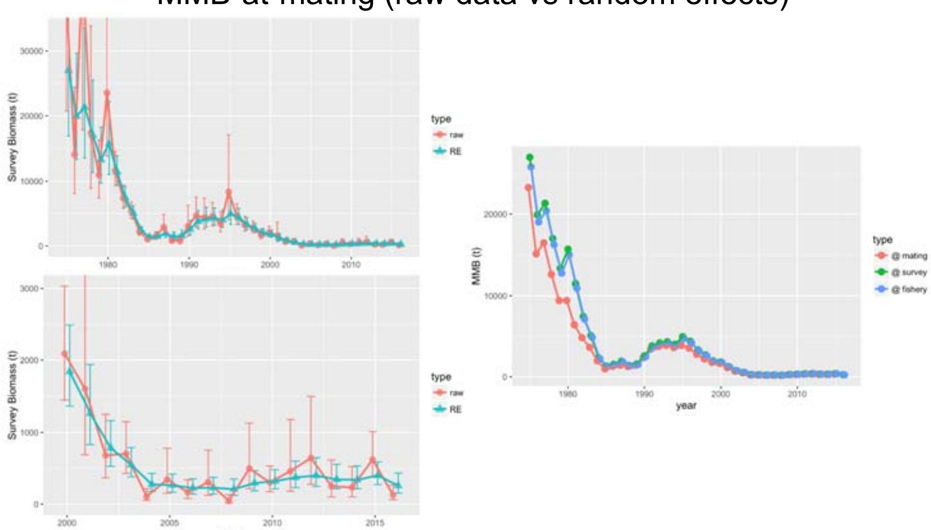
Pribilof Islands Blue King Crab

MMB-at-mating (raw data vs random effects)



Pribilof Islands Blue King Crab

B_{MSY} and “Current” MMB-at-mating

- B_{MSY} = mean(MMB-at-mating) over 1980-1984, 1990-1997
- “Current” B is projected MMB-at-mating for 2016/17 assuming OFL is take

Year	Tier	B_{MSY}	Current MMB_{mating}	B/B_{MSY} (MMB_{mating})	γ	Years to define B_{MSY}	Natural Mortality	P*
2012/13	4c	4,494	496	0.11	1	1980/81-1984/85 &1990/91-1997/98	0.18	10% buffer
2013/14	4c	3,988	278	0.07	1	1980/81-1984/85 &1990/91-1997/98	0.18	10% buffer
2014/15	4c	4,002	218	0.05	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2015/16	4c	4,109	361	0.09	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2016/17	4c	4,116	233	0.06	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer

Pribilof Islands blue king crab

CPT Discussion and Recommendations

- General
  - CPT requested that 20% handling mortality rates be used for bycatch mortality in crab fisheries (see general recommendation for all stocks).
  - Consider realigning stock boundaries with State statistical areas (instead of survey)

Pribilof Islands blue king crab

Tier, OFL, and ABC Recommendations

- CPT concurred with authors random effects model
- CPT and author recommended 25% buffer
- CPT concurred with Author recommendation for Tier 4c.

- Biomass (MMB) = 233 t
- Total catch OFL = 1.16 t
- ABC (less than max permissible) = 25% buffer =
  0.87 t

Pribilof Islands blue king crab

Stock Status

- 2015/2016 total catch = 1.16 t
- 2015/2016 OFL = 1.18 t

Overfishing DID occur

- 2015/2016 MSST= 2,060 t
- 2015/2016 MMB = 360 t

Stock IS overfished

- 2016/2017 MSST= 2,060 t
- 2016/2017 MMB = 233 t

Stock IS overfished

Pribilof Islands blue king crab

- Overfishing Memo from NMFS-AKRO to Council
  - Council and NMFS must immediately end and prevent overfishing
  - In-season management will be used to monitor bycatch in groundfish fishery

St. Matthew Island Blue King Crab Final Stock Assessment

- D’Arcy Webber, Jie Zheng, James Ianelli

AFSC, ADF&G

St. Matthew Island Blue King Crab

Summary

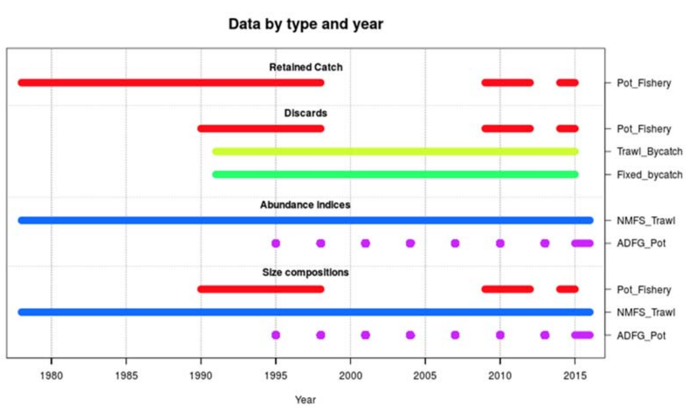
2016:
- NMFS trawl survey down
  - Assessment ~46% of average prediction
- ADFG Pot survey also low

Gmacs implementation (approved May/June 2016)
- Post-doc and ADFG scientists main contributors
- Document script-driven
- Status: mature male biomass ~60% of "Bmsy"

St. Matthew Island Blue King Crab

SMBKC crab

SMBKC: Data extent



St. Matthew Island Blue King Crab

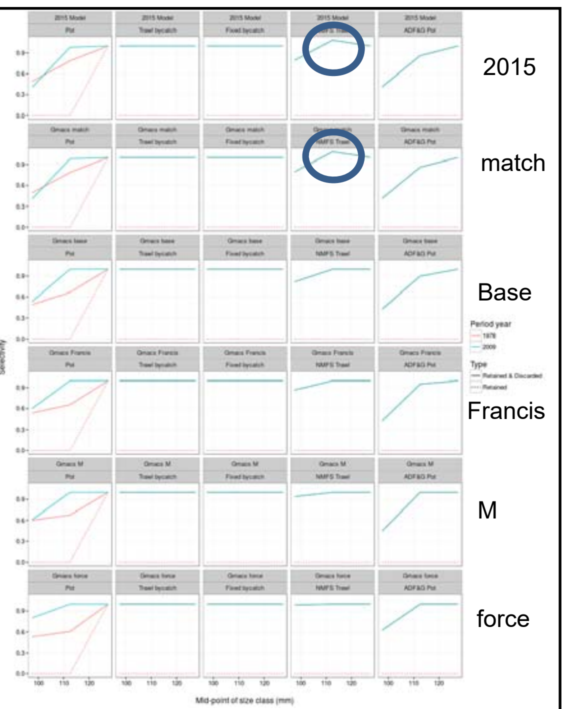
Model Scenarios

- 2015 Model (corrected)
- Gmacs match (2015 selectivity parameters)
- Gmacs base (selectivity estimated)
- Gmacs M (removes large 1998 M)
- Gmacs Francis (effective sample size estimated with Francis method)
- Gmacs force (increased wt on pot survey and trawl survey likelihood)…exploratory model.

St. Matthew Island Blue King Crab

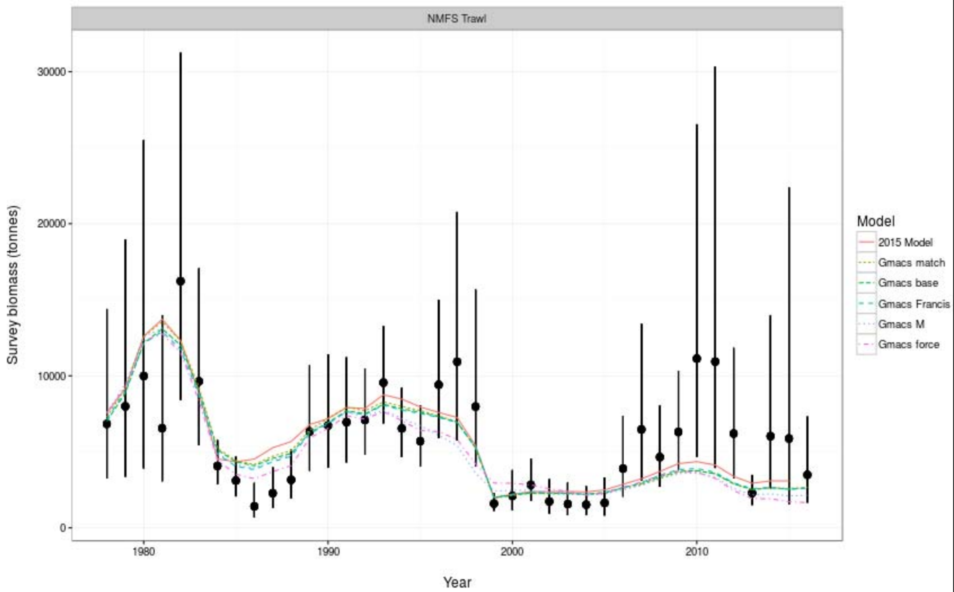
- Selectivity
  >1 for stage 2 in 2015 and match models

  Others bound at 1



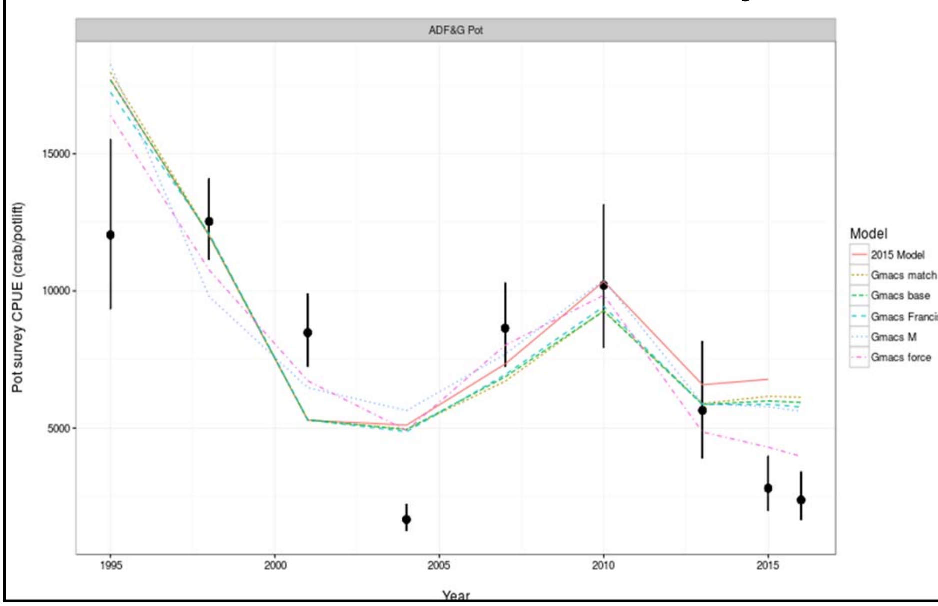
St. Matthew Island Blue King Crab

Trawl survey fits and model alternatives



St. Matthew Island Blue King Crab

Fit to ADFG Pot survey



St Matthew Island blue king crab

CPT Discussion and Recommendations

- Specific
  - CPT requested constant M model with no Francis weights…resulted in much lower ending biomass (too sensitive to high 1998 M)
  - Include likelihood equations and Francis weighting.
  - Continue to explore data weighting (Francis and other)
  - Continue to explore models without 1998 spike in M.

St Matthew Island blue king crab

Tier, OFL, and ABC Recommendations

- CPT and authors recommended model GMACS base.
  - Improves selectivity
  - Fits data better than M model
  - No Francis weights which up-weighted length-freq data

St Matthew Island blue king crab

Tier, OFL, and ABC Recommendations

- CPT and author recommended 20% buffer
- CPT concurred with Author recommendation for Tier 4b.

- Biomass (MMB) = 2.23 thousand t
- Total catch OFL = 0.14 thousand t
- ABC (less than max permissible) = 20% buffer = 0.11 thousand t

St Matthew Island blue king crab

Stock Status

- 2015/2016 total catch = 0.05 thousand t
- 2015/2016 OFL = 0.28 thousand t

Overfishing did not occur

- 2015/2016 MSST= 1.84 thousand t
- 2015/2016 MMB = 2.11 thousand t

Stock is not overfished

- 2016/2017 MSST= 1.84 thousand t
- 2016/2017 MMB = 2.23 thousand t

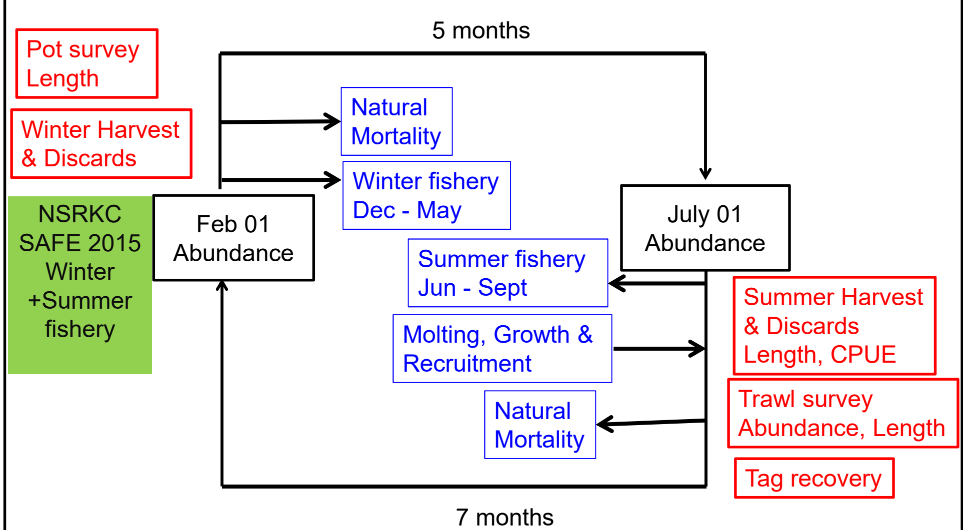
Stock is not approaching overfished

September 2015 Crab Plan Team Report

- Norton Sound King Crab
  - Survey and Model development

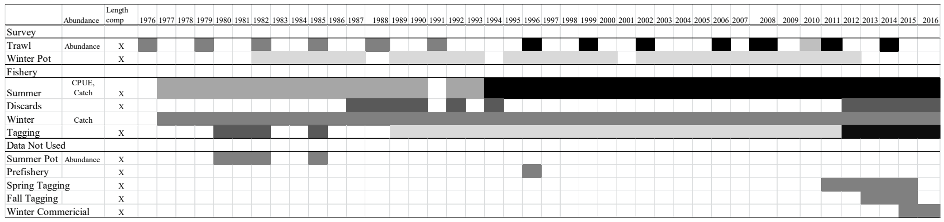
Toshihide “Hamachan” Hamazaki and Jie Zheng
Alaska Department of Fish & Game

NSRKC Stock Assessment Model
Modeling process
Available Data & model fit



Norton Sound red king crab model

Available Data



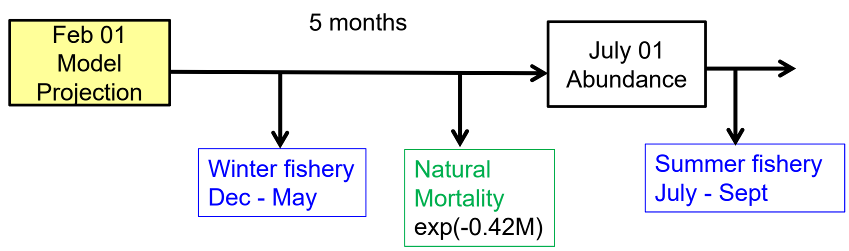
Norton Sound red king crab model

NSRKC Major Modeling Issues

- **Under the size invariant M, the model overestimates abundance of large sized (> 123mm) crab.**
  - Current Assumption: Higher M for large sized (> 123mm) crab
    - Pro: Model fits data better
    - Con: Biologically implausible
  - Alternative Assumptions
    - Large sized crab move out of fishing-survey area
      - Extended surveys did not find large crabs
      - Dome-shaped survey-commercial fishery selectivity was not supported by the model (see previous SAFE)
    - Crab does not grow large (non-linear growth)
      - Alternative model 1
    - Molting probability is not time invariant
      - Alternative model 2
    - M of only Largest (> 134mm) is high
      - Alternative model 3

Norton Sound red king crab model

NSRKC Stock Assessment Model
OFL Issue



OFL = Winter + Summer fishery

OFL = (1-exp(-F))B

How do we calculate B and OFL?

Norton Sound red king crab model

Responses to SSC

- Does the timing indicate that crab may go “missing” in association with the molting period?
  - Satellite tag deployed in March 2016, Bob?
- The SSC noted relatively high proportions of 134+ mm CL crab in the summer com catches 1980-1982. Investigate source data.
  - Data are probably lost. Even Doug (retired) didn’t know that ADFG Kodiak was in charge for NSRKC back in 1970-80s…
- The SSC was very interested in the conflicting observations about molt timing in Apr/May versus Aug/Sept.
  - There was no direct observation for molt timing in Apr/May
  - All observation-data suggest molt timing in Aug/Sept

Norton Sound red king crab model

Responses to CPT and SSC

- Evaluate whether using a growth function (slow down growth).
  - Alt. Model 1
- Consider non-parametric molting probability curve with a random walk penalty.
  - Only random walk considered: Alt Model 2.
- Evaluate higher M only to 134+ mm.
  - Alt. Model 3
- Separate summer fisheries in 2 periods
  - Alt. Model 4

Norton Sound red king crab model

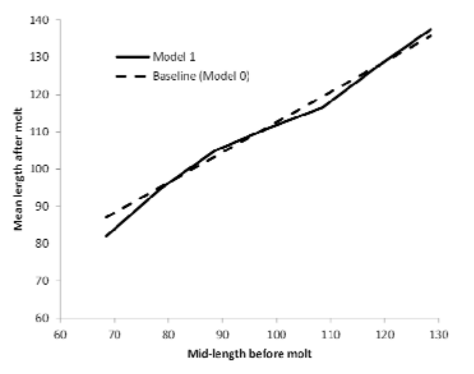
Modeling discussion for Jan 2017 SAFE

- Alternative Models:
- Model 0: Default 2016 SAFE model
- Model 1: Non linear growth, M = equal for all lengths
- Model 2: Random walk molting prob
- Model 3: High M only for 134+ mm length group
- Model 4: Separate fishery selectivity

Norton Sound red king crab model

Modeling discussion for Jan 2017 SAFE

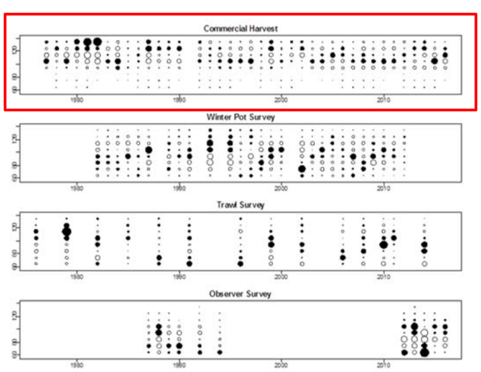
- Model 1: Non linear growth, M = equal for all lengths
  - Little evidence of “slow” growth



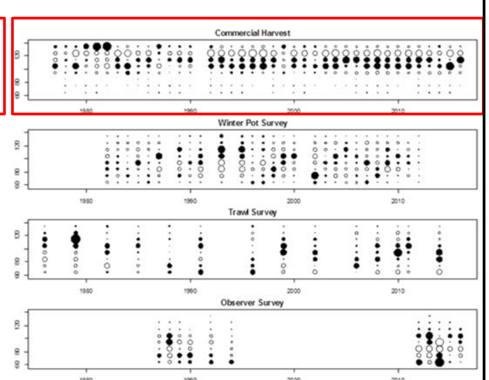
Norton Sound red king crab model

Modeling discussion for Jan 2017 SAFE

- Model 3: High M only for 134+ mm length group
- Model fit was worse.



Model 0

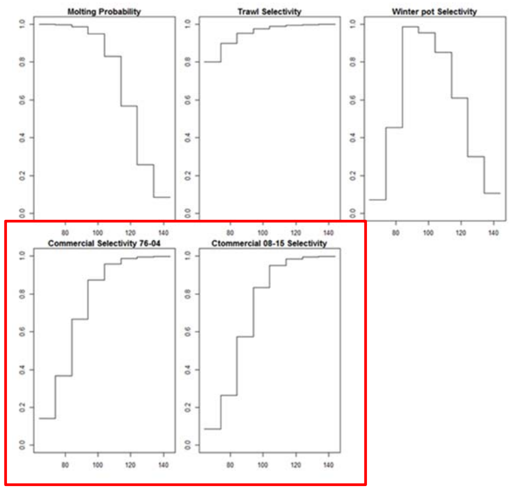


Model 3

Norton Sound red king crab model

Modeling discussion for Jan 2017 SAFE

- Model 4: Separate fishery selectivity
- No statistical difference between the two selectivity

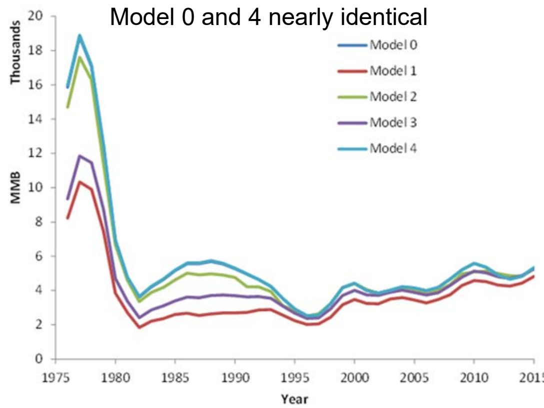


Norton Sound red king crab model

Modeling discussion for Jan 2017 SAFE

- Model 0: Default 2016 SAFE model
- Model 1: Non linear growth, M = equal for all lengths
- Model 2: Random walk molting prob
- Model 3: High M only for 134+ mm length group
- Model 4: Separate fishery selectivity

MMB time series:
Model 0 and 4 nearly identical



Norton Sound red king crab model

Modeling discussion for Jan 2017 SAFE

- Model 4: Separate fishery selectivity: Tagging data issue
  - All tagged crabs are recaptured by fisheries.
  - Observed length frequencies of recaptured crab are function of
    - Molting probability
    - Growth transition increments
    - Fishery size selective recapture probability
  - Tag recovery data must be separated by each fishery selectivity periods.
  - The more fishery selectivity separation, the less recovery data for each fishery period.

Norton Sound red king crab model

CPT Discussion and Recommendations

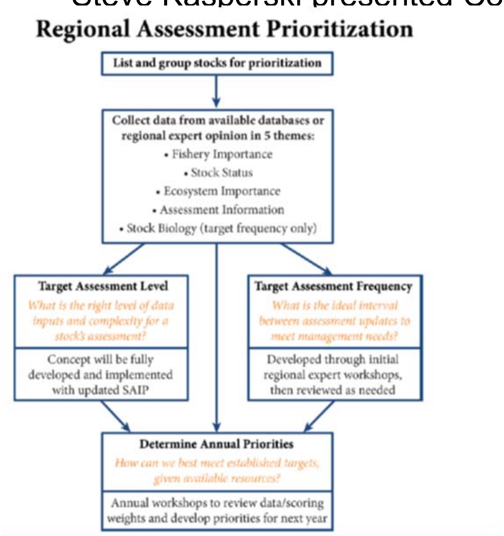
- Split OFL for winter and summer fisheries
- CPT recommends bringing model 0 and model 2 to January meeting. Model 2:
  - Consider calculating molt probabilities for each size class instead of a descending logistic
  - Estimate molt probabilities with 2 time series
  - Apply smoothing penalty on molt probabilities
  - Look at correlations between random walk and temperature (ocean temp or air temp in Nome)
  - Do not set molt probability of smallest size class at 1.

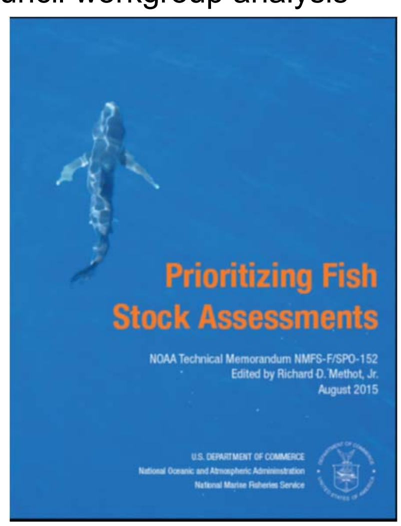
September 2016 Crab Plan Team Report

- Economic SAFE (Brian Garber-Yonts)
  - Ex-vessel and first wholesale revenue over all BSAI crab stocks increased from 2014-15 after longer term decline
  - Snow crab price showed opposite trend
  - Overall 2015 production and grow revenue up 7-13% in harvest and processing sectors.
  - Update on vessel earnings and leasing activity.
- Ecosystem Report
  - Stephanie Zador presented update
  - Lowest Aleutian Low since 1949; ENSO and PDO (+ phase) did not track as in previous years.
  - Crab ecosystem report cards delayed 1 year due to staffing changes

September 2016 Crab Plan Team Report

- Stock Prioritization
  - Steve Kasperski presented Council workgroup analysis





September 2016 Crab Plan Team Report

- Stock Prioritization
  - Steve Kasperski presented Council workgroup analysis
  - Crab scores

Stock	Commercial Index	Constituent Demand Index	Non-Catch Value Index	Recreational Index	Subsistence Index	Total Fishery Importance Score	Total Rank
Pribilof Islands Blue King Crab	0.00	2.95	2.28	0.08	0.47	5.78	71
St. Matthew Island Blue King Crab	3.72	3.88	2.14	0.03	1.32	11.09	21
Pribilof Islands Golden King Crab	2.92	3.57	1.76	0.00	0.53	8.78	43
Aleutian Islands Golden King Crab	4.27	4.25	2.42	0.04	0.58	11.56	18
Bristol Bay Red King Crab	4.51	5.00	2.78	1.10	2.74	16.14	1
Norton Sound Red King Crab	3.70	4.18	1.94	2.20	3.84	15.86	2
Pribilof Islands Red King Crab	0.00	2.61	1.59	0.31	0.96	5.48	72
Western Aleutian Islands Red King Crab	0.00	2.76	1.70	0.19	0.50	5.15	73
Bering Sea Snow Crab	4.76	4.48	2.17	0.34	1.17	12.92	11
Arctic Management Area Snow Crab	0.00	1.50	3.09	0.00	0.38	4.97	74
Bering Sea Southern Tanner Crab	4.06	4.43	2.03	0.03	0.77	11.33	19

September 2016 Crab Plan Team Report

- Stock Prioritization
  - Steve Kasperski presented Council workgroup analysis

- Should the crab stocks be included in this process?
  - Requires ADF&G authors to complete species importance scoring and rebuilding status
- Does CPT agree that primary focus should for NPFMC should be Target Frequency?
- Does CPT have a preferred scenario? Or recommendations for alternatives?
- How should criteria for out of cycle assessments be established?

September 2016 Crab Plan Team Report

- Stock Prioritization: CPT response
  - GPT prioritization may not work for crab
    - No age data which is important for target frequency estimation
    - Survey abundance, population volatility, and survey uncertainty not taken into account?
  - Variable importance of assessment frequency for established vs developing models.
  - Scoring from crab may no be as important as clarifying a process for identifying target frequency.
  - CPT agreed that a more qualitative approach would be preferred.
  - CPT formed working group to draft outline of prioritization process.
    - Will use working paper factors and survey uncertainty, stock volatility, model maturity, and role of ABC on SOA TAC.

September 2016 Crab Plan Team Report

- GMACS BB red king crab (Darcy Webber and Jim Ianelli)
  - Projections for Tier 3 or 4 OFLs
  - Francis iterative weighting
  - New transition matrix
  - Time varying season length
- BSFRF research update (Scott Goodman)
  - BBRKC side by side data intermediate to 2014 and 2013.
  - CPT emphasized importance of planning future data collection on Tanner crab so it can be incorporated into the assessment.
  - CPT supports continued efforts to inform Tanner crab recruitment and juvenile growth patterns.

September 2016 Crab Plan Team Report

- EFH 5 year review (Steve MacLean, Pete Hulson)
  - Fishing effects model (GOA POP and pollock examples)
  - CPT response
    - Fishing impacts should be evaluated on stock level as identified by individual stock assessment author.
    - Suggested a 25% threshold of a habitat disturbance be looked at (in addition to 50%) to compare. Might weight habitat disturbance proportional to abundance but issues of migration may affect the validity.
      - Might compare closed to open areas.
      - Impacts of fishing may not be possible without correlations (lack of data)
      - Might look at change in disturbance and then go back to look at changes in recruitment.
    - Not possible to address 10% habitat reduction threshold without model results.

September 2016 Crab Plan Team Report

- EFH 5 year review (Steve MacLean, Pete Hulson)
  - CPT response:
    - P-value=0.1 likely reasonable but need to see model results
    - CPT recommends showing maps by life history stage
    - CPT to meet via webex after January to discuss EFH results applied to crab

September 2016 Crab Plan Team Report

- AIGKC survey (John Hilsiger)
  - Concern about trawling in GKC fishing grounds
  - CPT recommended full analysis of trawl effort by depth, location, and habitat with bycatch of crab by size.
- Bristol Bay Closure Area (John Gauvin)
  - Exploratory flatfish fishing in closed area (under existing cap)…before SSC/Council in December
  - New power analysis and details about current bycatch presented
  - CPT questioned the change in habitat (benthic fauna)…pelagic trawl effects discussed.
  - CPT noted that whole haul catch data will be valuable.
  - CPT generally supported the EFP

September 2016 Crab Plan Team Report

- BOF proposals
- Hybrid Tanner crab discussion
- Emergency petition for Tanner crab
- January CPT meeting planning
  - See CPT minutes pg 27