2019 Pribilof Islands Blue King Crab Stock Assessment and Fishery Evaluation

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AFSC/NMFS

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Overview

- Biennial assessment schedule (last full assessment 2017)
- Approach to status determination identical to that in 2017 (approved 2015)
- Fishery data includes
  - 2017/18 bycatch
  - 2018/19 bycatch as of April 1, 2019
- NMFS survey data to 2018

Topics

- Responses to recent CPT/SSC comments
- Fishery data
- NMFS survey data
- Status determination

Responses to recent CPT/SSC Comments

CPT Comments (September 2017)

- *Comment*: Information regarding the model used for status determination criteria (in Appendix C) should be incorporated into the main assessment section.
- *Response*: Information regarding the model used for status determination criteria remains in Appendix C for this assessment. This appendix is produced using an R Markdown script that runs the assessment model and produces the appendix document simultaneously. The main assessment document, previously composed as a Microsoft Word document, has now been converted to an R Markdown script as well. It may be possible to merge these two documents more fully in the future.

- *Comment*: more information should be included in the presentation to the CPT (such as parameter tables and process error) in order to fully evaluate model performance.
- *Response*: Parameter tables and the estimated process error are included here.

SSC Comments (October 2017)

- *Comment*: None

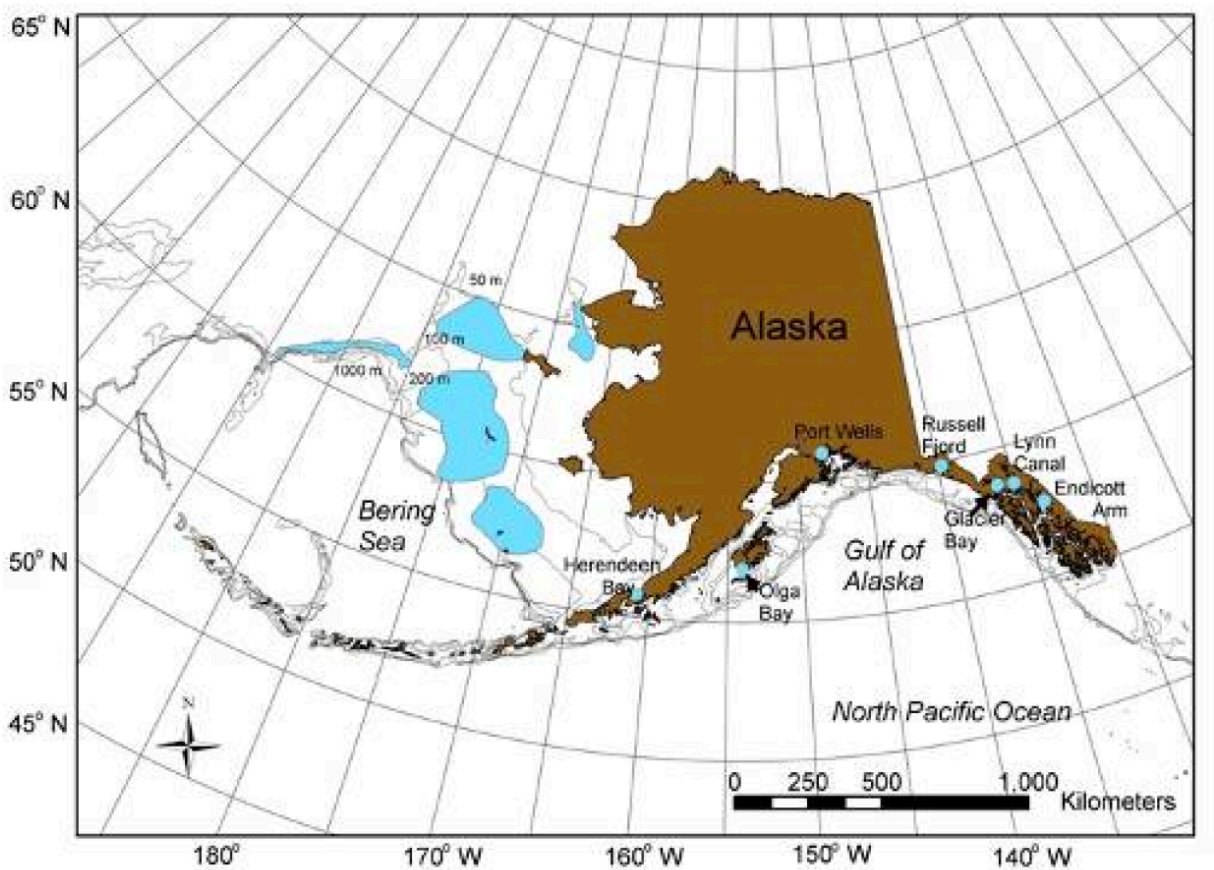
Summary

- PIBKC on biennial assessment cycle to coincide with required rebuilding status report
- stock remains overfished
- overfishing will evaluated in September (has not occurred yet)

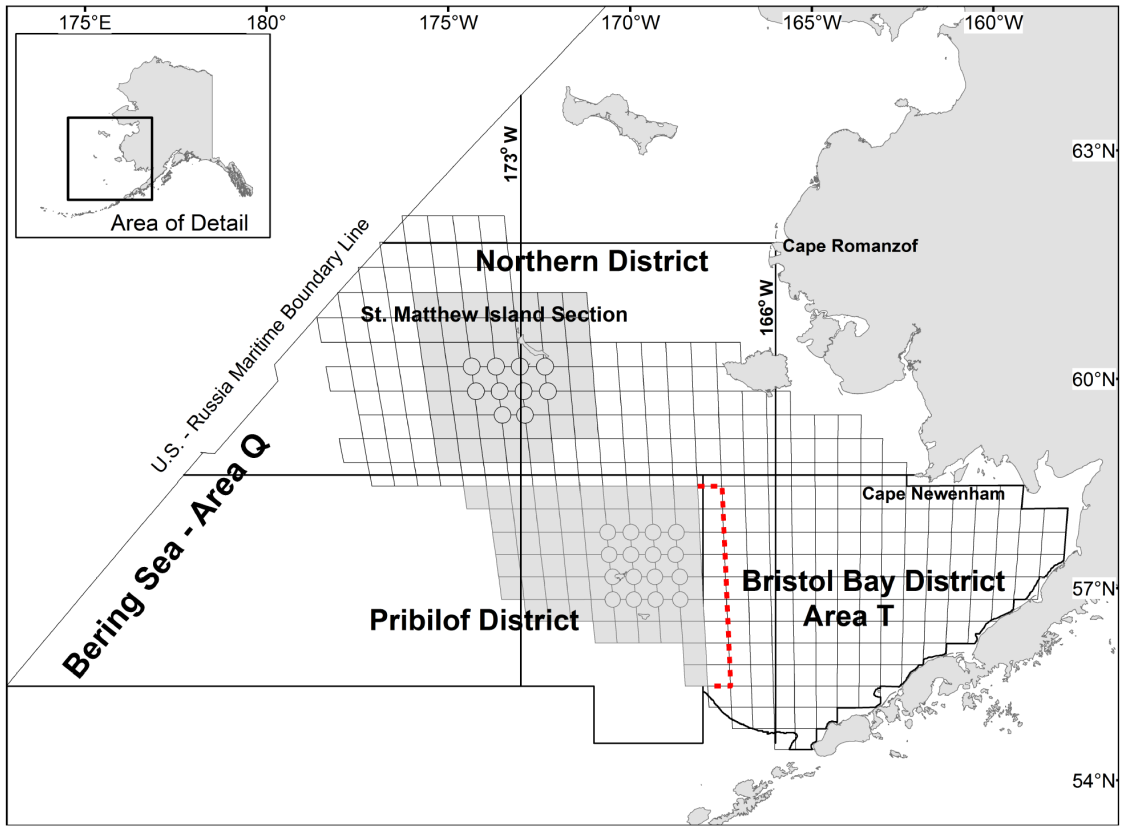
Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch Mortality	OFL	ABC
2015/16	2,058 A	361 A	closed	0	1.18	1.16	0.87
2016/17	2,053 A	232 A	closed	0	0.38	1.16	0.87
2017/18	2,053 A	230 A	closed	0	0.33	1.16	0.87
2018/19	2,053 A	230 A	closed	0	0.41	1.16	0.87
2019/20	--	175 B	--	--	--	1.16	0.87

Year	Tier	B_{MSY}	Current MMB_{mating}	B/B_{MSY} (MMB_{mating})	γ	Years to define B_{MSY}	Natural Mortality	P*
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	232	0.06	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2017/18	4c	4,106	230	0.06	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2018/19	4c	4,106	230	0.06	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2019/20	4c	4,106	175	0.04	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer

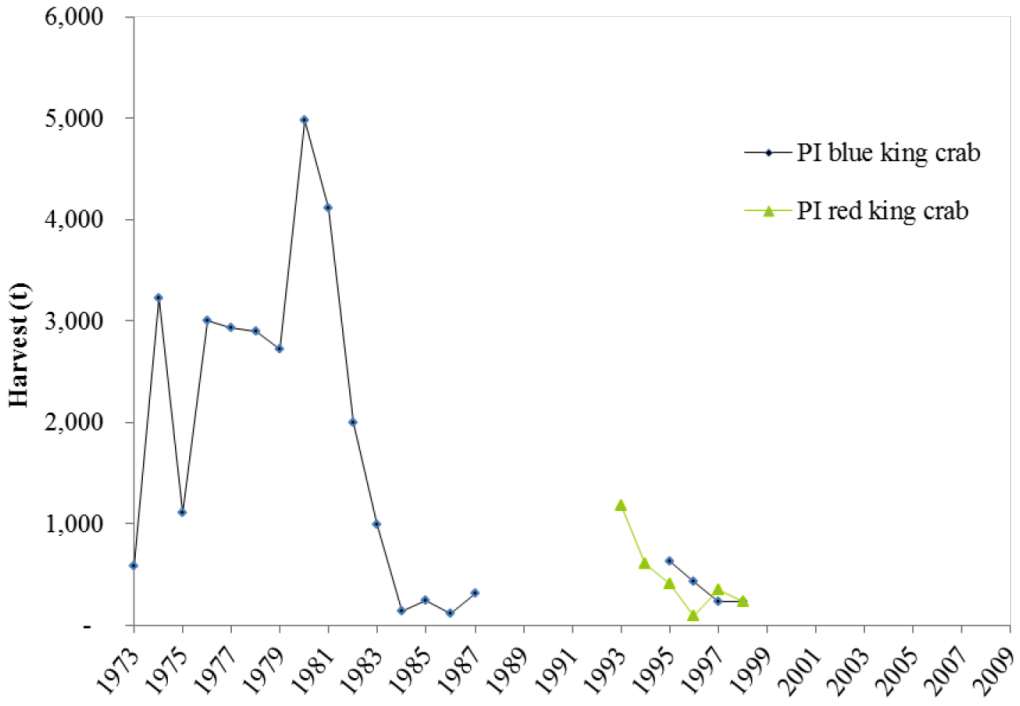
Stock Distribution



Fishery Districts



Retained catch history



- Directed fishery closed starting in 1999/2000
- Stock declared overfished in 2002

Year	Retained Catch		Avg. CPUE
	Abundance	Biomass (t)	legal crabs/pot
1973/1974	174,420	579	26
1974/1975	908,072	3,224	20
1975/1976	314,931	1,104	19
1976/1977	855,505	2,999	12
1977/1978	807,092	2,929	8
1978/1979	797,364	2,901	8
1979/1980	815,557	2,719	10
1980/1981	1,497,101	4,976	9
1981/1982	1,202,499	4,119	7
1982/1983	587,908	1,998	5
1983/1984	276,364	995	3
1984/1985	40,427	139	3
1985/1986	76,945	240	3
1986/1987	36,988	117	2
1987/1988	95,130	318	2
1988/1989	0	0	--
1989/1990	0	0	--
1990/1991	0	0	--
1991/1992	0	0	--
1992/1993	0	0	--
1993/1994	0	0	--
1994/1995	0	0	--
1995/1996	190,951	628	5
1996/1997	127,712	425	4
1997/1998	68,603	232	3
1998/1999	68,419	234	3
1999/2000 - 2018/2019	0	0	--

Bycatch and Bycatch Mortality for PIBKC

Estimated bycatch

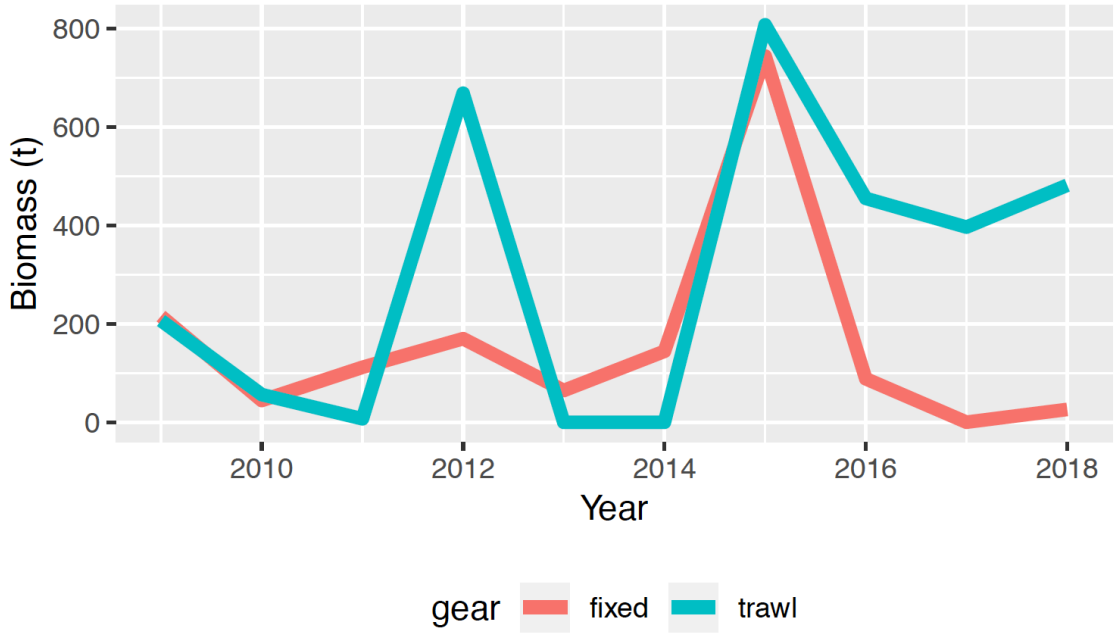
fishery year	crab (pot) fisheries (t)			groundfish fisheries (t)	
	females	legal males	sublegal males	fixed gear	trawl gear
1991/92	--	--	--	0.067	6.199
1992/93	--	--	--	0.879	60.791
1993/94	--	--	--	0.000	34.232
1994/95	--	--	--	0.035	6.856
1995/96	--	--	--	0.108	1.284
1996/97	0.000	0.000	0.807	0.031	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	0.044	0.056
2011/12	0.000	0.000	0.000	0.112	0.007
2012/13	0.000	0.000	0.000	0.170	0.669
2013/14	0.000	0.000	0.000	0.065	0.000
2014/15	0.000	0.000	0.000	0.144	0.000
2015/16	0.103	0.000	0.230	0.744	0.808
2016/17	0.000	0.000	0.000	0.090	0.455
2017/18	0.064	0.000	0.000	0.000	0.397
2018/19	0.000	0.000	0.101	0.026	0.482

Estimated bycatch mortality

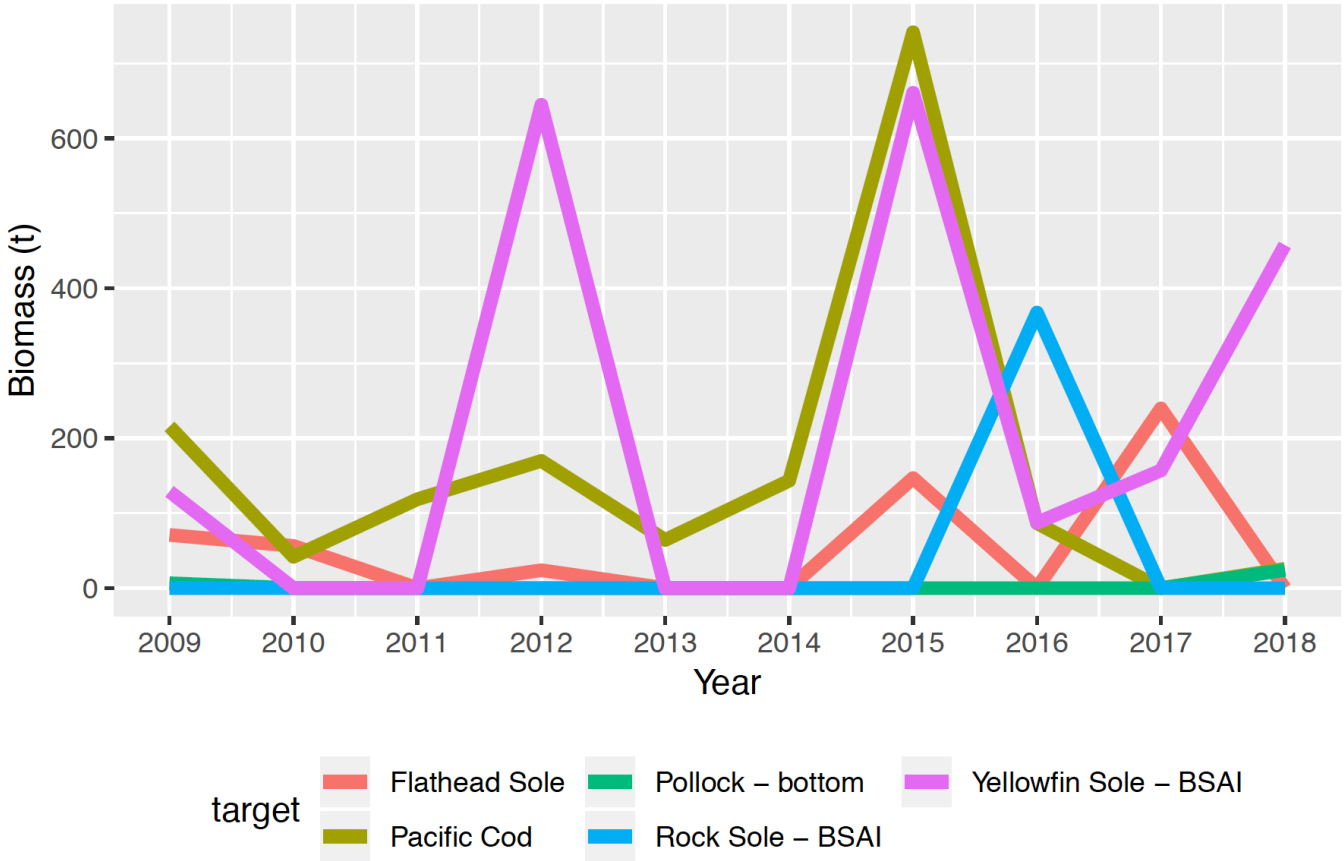
fishery year	crab (pot) fisheries (t)			groundfish fisheries (t)		total bycatch mortality (t)
	females	legal males	sublegal males	fixed gear	trawl gear	
1991/92	--	--	--	0.013	4.959	4.973
1992/93	--	--	--	0.176	48.633	48.809
1993/94	--	--	--	0.000	27.386	27.386
1994/95	--	--	--	0.007	5.485	5.492
1995/96	--	--	--	0.022	1.027	1.049
1996/97	0.000	0.000	0.161	0.006	0.054	0.221
1997/98	0.000	0.000	0.000	0.292	0.104	0.396
1998/99	0.743	0.459	0.093	3.960	0.063	5.319
1999/00	0.394	0.699	0.858	0.159	0.016	2.125
2000/01	0.000	0.000	0.000	0.023	0.018	0.042
2001/02	0.000	0.000	0.000	0.167	0.023	0.190
2002/03	0.000	0.000	0.000	0.014	0.238	0.252
2003/04	0.000	0.000	0.000	0.069	0.182	0.251
2004/05	0.000	0.000	0.000	0.163	0.002	0.165
2005/06	0.010	0.000	0.000	0.071	1.071	1.152
2006/07	0.021	0.000	0.000	0.028	0.059	0.108
2007/08	0.027	0.000	0.000	0.799	0.106	0.931
2008/09	0.000	0.000	0.000	0.028	0.378	0.407
2009/10	0.000	0.000	0.000	0.043	0.165	0.209
2010/11	0.000	0.000	0.037	0.009	0.045	0.091
2011/12	0.000	0.000	0.000	0.022	0.006	0.028
2012/13	0.000	0.000	0.000	0.034	0.535	0.569
2013/14	0.000	0.000	0.000	0.013	0.000	0.013
2014/15	0.000	0.000	0.000	0.029	0.000	0.029
2015/16	0.021	0.000	0.046	0.149	0.646	0.862
2016/17	0.000	0.000	0.000	0.018	0.364	0.382
2017/18	0.013	0.000	0.000	0.000	0.317	0.330
2018/19	0.000	0.000	0.020	0.005	0.385	0.411

Bycatch in the groundfish fisheries

By gear type

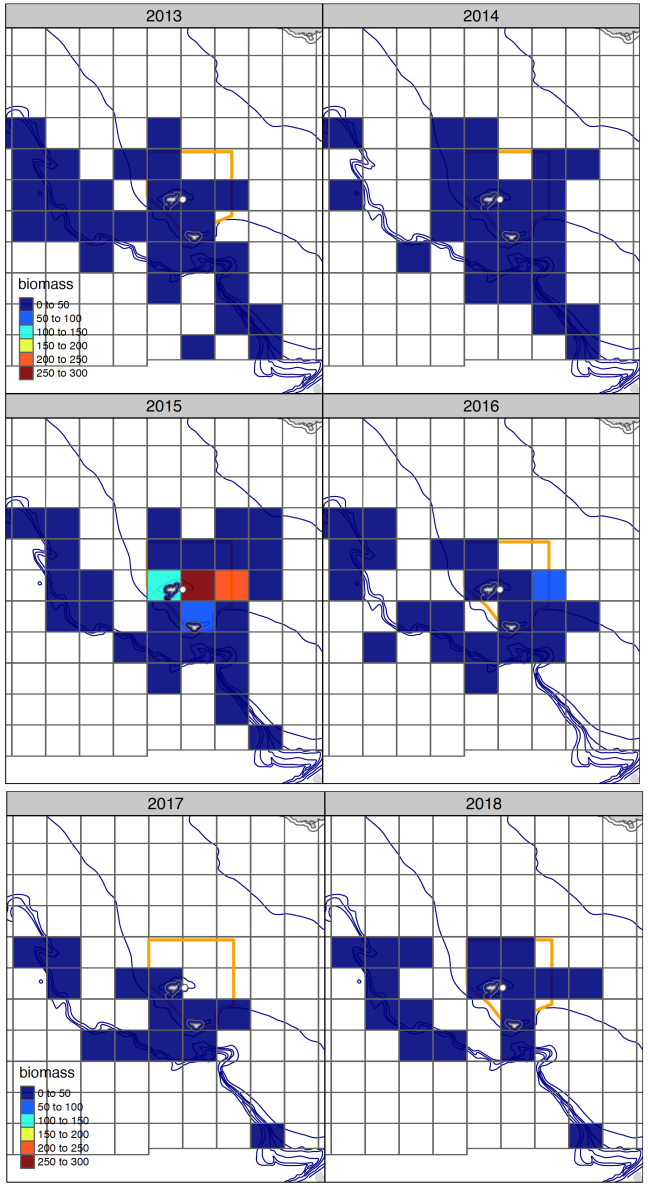


By target species

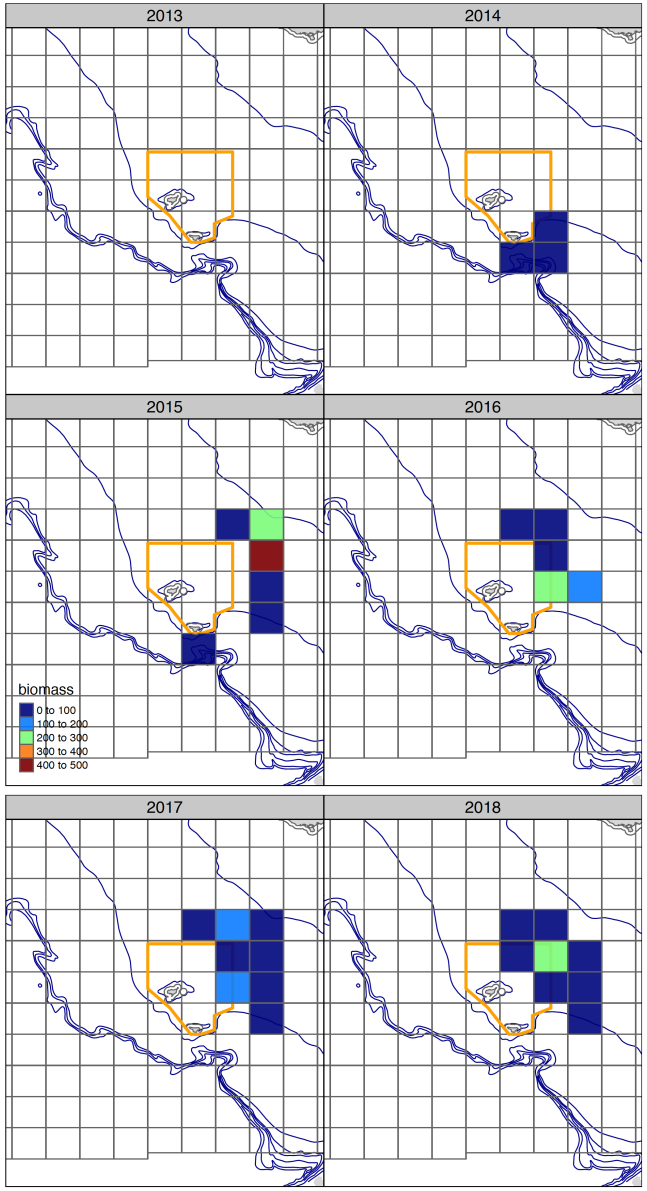


Spatial patterns of bycatch in the groundfish fisheries

fixed gear fisheries



trawl fisheries



NMFS EBS Survey Data

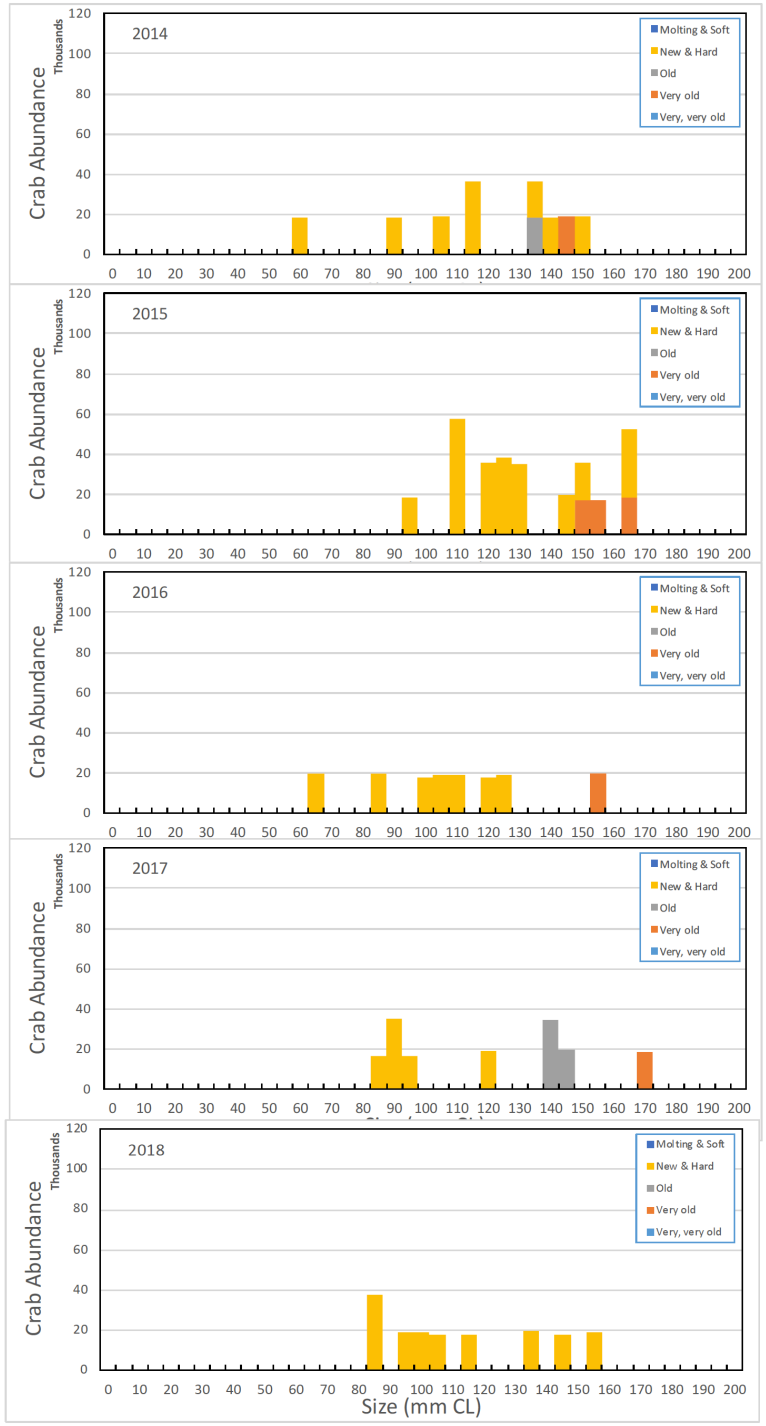
NMFS EBS Survey Data

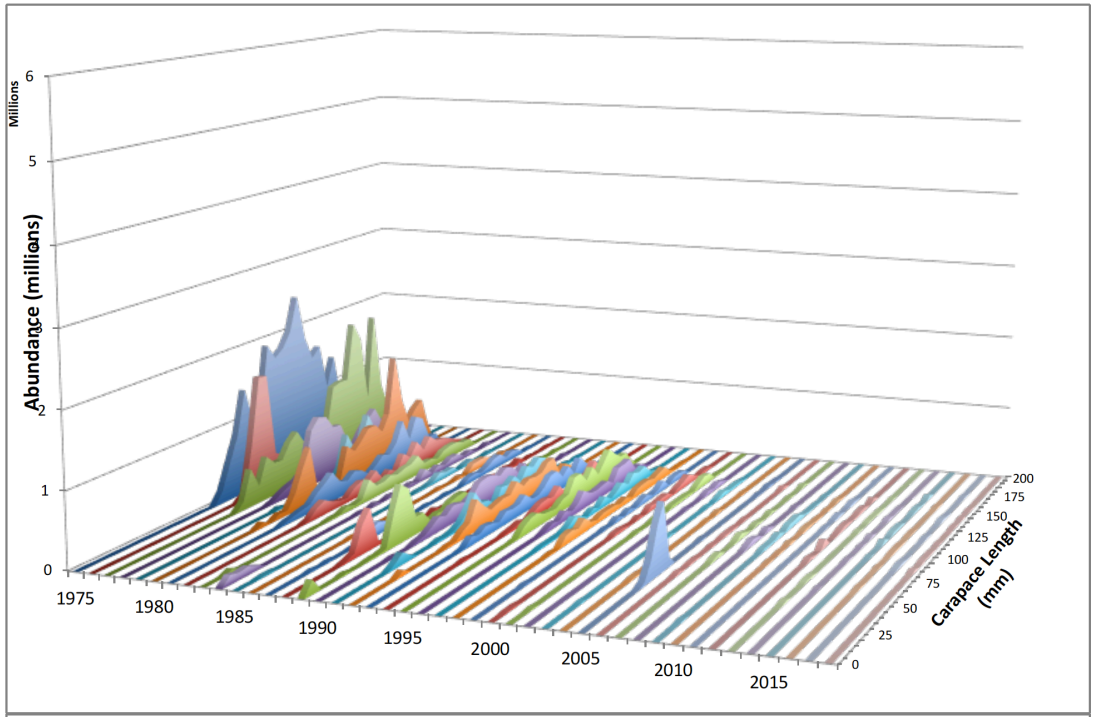
sex	size.range	category
female	< 100 mm CL	immature female
male	< 120 mm CL	immature male
female	> 99 mm CL	mature female
male	> 119 mm CL	mature male
male	< 135 mm CL	sublegal male
male	> 134 mm CL	legal male
female	all	all females
male	all	all males

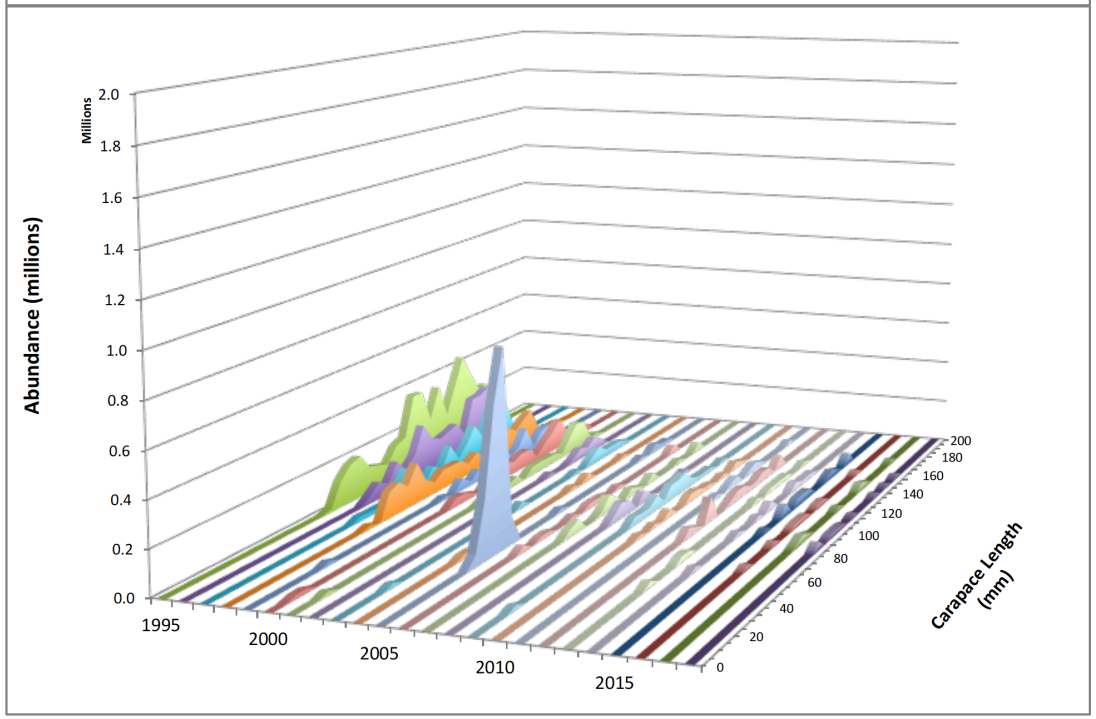
	survey	immature females		mature females		all females	
	number	non-0	no.	non-0	no.	non-0	no.
year	of hauls	hauls	crab	hauls	crab	hauls	crab
1975	45	6	72	7	193	9	265
1976	59	2	55	5	37	5	92
1977	58	3	45	5	100	5	145
1978	58	4	11	8	97	8	108
1979	58	3	4	3	21	5	25
1980	70	8	17	10	326	11	343
1981	84	16	49	19	184	23	233
1982	84	11	49	22	250	24	299
1983	86	8	23	16	280	18	303
1984	86	7	27	14	142	15	169
1985	86	7	15	8	28	12	43
1986	86	2	2	8	106	10	108
1987	86	5	23	7	35	11	58
1988	85	6	41	7	17	9	58
1989	86	8	144	9	27	13	171
1990	86	7	88	9	77	10	165
1991	85	10	57	12	105	15	162
1992	86	6	83	9	59	11	142
1993	85	8	46	13	88	15	134
1994	86	6	25	12	254	13	279
1995	86	5	43	11	215	12	258
1996	86	6	13	10	213	12	226
1997	86	4	17	11	137	13	154
1998	85	9	44	11	92	15	136
1999	86	3	10	10	145	10	155
2000	85	2	2	13	72	13	74
2001	86	1	1	9	93	10	94
2002	86	1	1	6	66	7	67
2003	86	4	4	7	69	9	73
2004	85	2	4	4	5	5	9
2005	84	1	43	5	15	6	58
2006	86	4	6	3	22	6	28
2007	86	2	6	3	10	5	16
2008	86	3	16	4	27	6	43
2009	86	3	5	3	33	4	38
2010	86	5	9	4	15	7	24
2011	86	2	2	1	1	3	3
2012	86	2	11	5	5	6	16
2013	86	3	4	2	6	5	10
2014	86	1	1	3	4	4	5
2015	86	2	2	4	9	4	11
2016	86	5	7	7	17	8	24
2017	86	3	7	4	8	6	15
2018	86	3	4	1	3	4	7

	survey	immature males		mature males		sublegal males		legal males		all males	
	number	non-0	no.	non-0	no.	non-0	no.	non-0	no.	non-0	no.
year	of hauls	hauls	crab	hauls	crab	hauls	crab	hauls	crab	hauls	crab
1975	45	11	305	13	553	11	530	13	328	13	858
1976	59	3	105	11	91	9	122	10	74	12	196
1977	58	7	56	10	129	9	73	9	112	10	185
1978	58	8	60	11	130	10	112	10	78	12	190
1979	58	2	2	14	90	8	25	13	67	14	92
1980	70	10	41	21	133	12	64	21	110	21	174
1981	84	19	99	36	184	23	128	36	155	38	283
1982	84	19	70	35	114	21	84	31	100	38	184
1983	86	15	47	32	93	18	74	29	66	35	140
1984	86	10	27	20	37	17	37	16	27	25	64
1985	86	3	4	14	24	8	13	11	15	14	28
1986	86	1	1	13	26	2	2	13	25	13	27
1987	86	5	34	15	50	6	38	14	46	16	84
1988	85	5	52	5	12	5	52	5	12	9	64
1989	86	8	160	4	11	8	160	4	11	10	171
1990	86	8	90	10	59	11	126	7	23	14	149
1991	85	16	92	19	103	20	129	14	66	22	195
1992	86	12	89	14	73	13	119	12	43	17	162
1993	85	12	75	19	96	15	115	17	56	21	171
1994	86	8	32	18	68	12	51	18	49	19	100
1995	86	7	66	18	177	15	118	14	125	19	243
1996	86	7	32	19	87	11	54	19	65	20	119
1997	86	7	25	17	65	10	39	16	51	19	90
1998	85	12	56	20	56	15	66	17	46	21	112
1999	86	7	9	13	34	9	18	11	25	15	43
2000	85	4	9	16	40	9	20	13	29	16	49
2001	86	3	5	6	28	4	9	5	24	7	33
2002	86	0	0	6	12	1	1	6	11	6	12
2003	86	2	2	7	14	3	3	7	13	9	16
2004	85	3	5	3	3	5	7	1	1	6	8
2005	84	3	54	2	5	3	54	2	5	4	59
2006	86	4	7	3	3	4	8	2	2	6	10
2007	86	4	14	2	6	4	17	2	3	4	20
2008	86	2	13	1	1	2	13	1	1	3	14
2009	86	5	16	3	15	5	27	3	4	5	31
2010	86	2	6	5	8	3	10	4	4	5	14
2011	86	0	0	3	9	2	2	2	7	3	9
2012	86	1	9	4	13	1	14	4	8	4	22
2013	86	1	3	2	6	2	5	2	4	3	9
2014	86	3	5	2	5	3	5	2	5	4	10
2015	86	2	4	8	13	6	10	5	7	9	17
2016	86	4	5	3	3	5	7	1	1	5	8
2017	86	2	4	4	4	3	5	3	3	5	8
2018	86	4	6	3	3	4	6	3	3	5	9

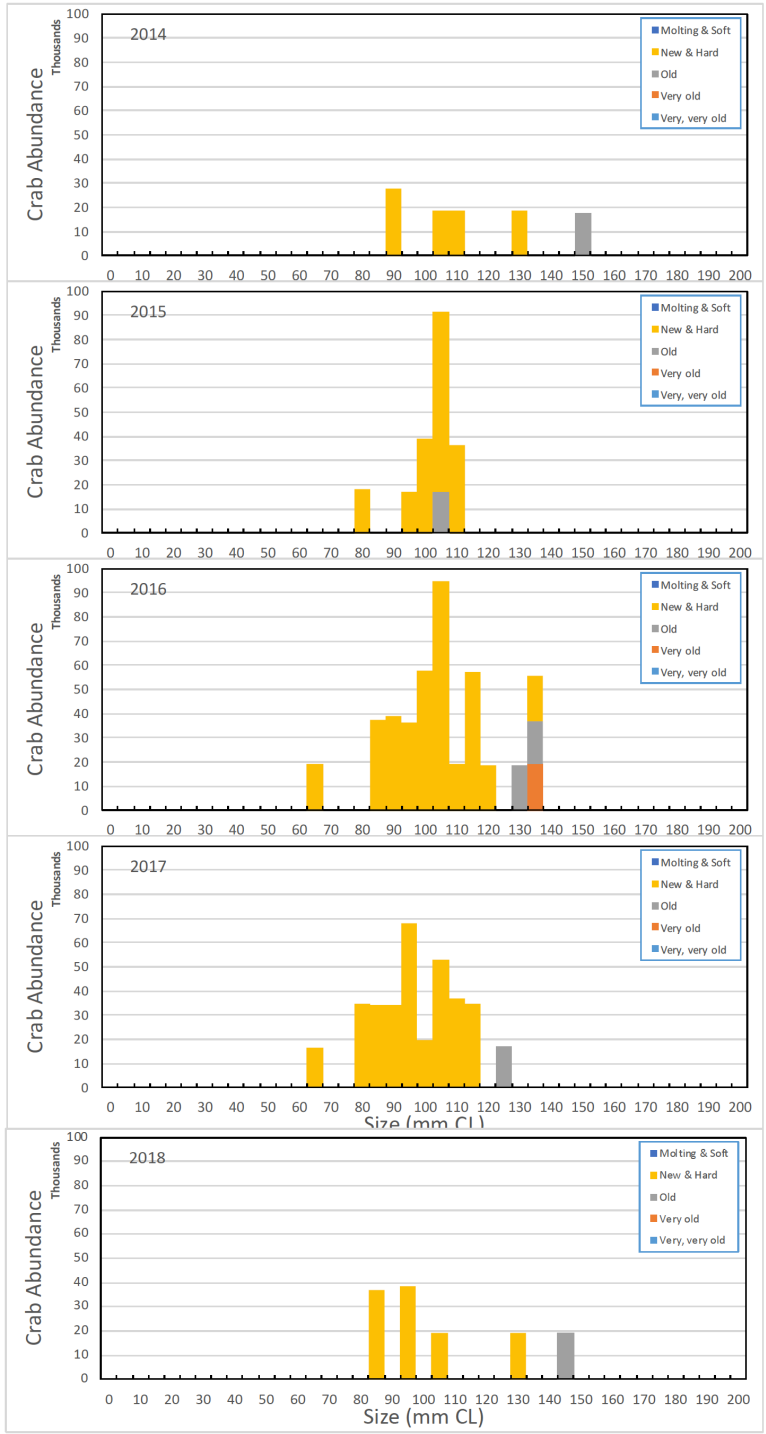
Males


2014
2015
2016
2017
2018
Crab Abundance
Thousands
Molting & Soft
New & Hard
Old
Very old
Very, very old
Size (mm CL)


Millions
Abundance (millions)
Carapace Length (mm)


Millions
Abundance (millions)
Carapace Length (mm)

Females


2014
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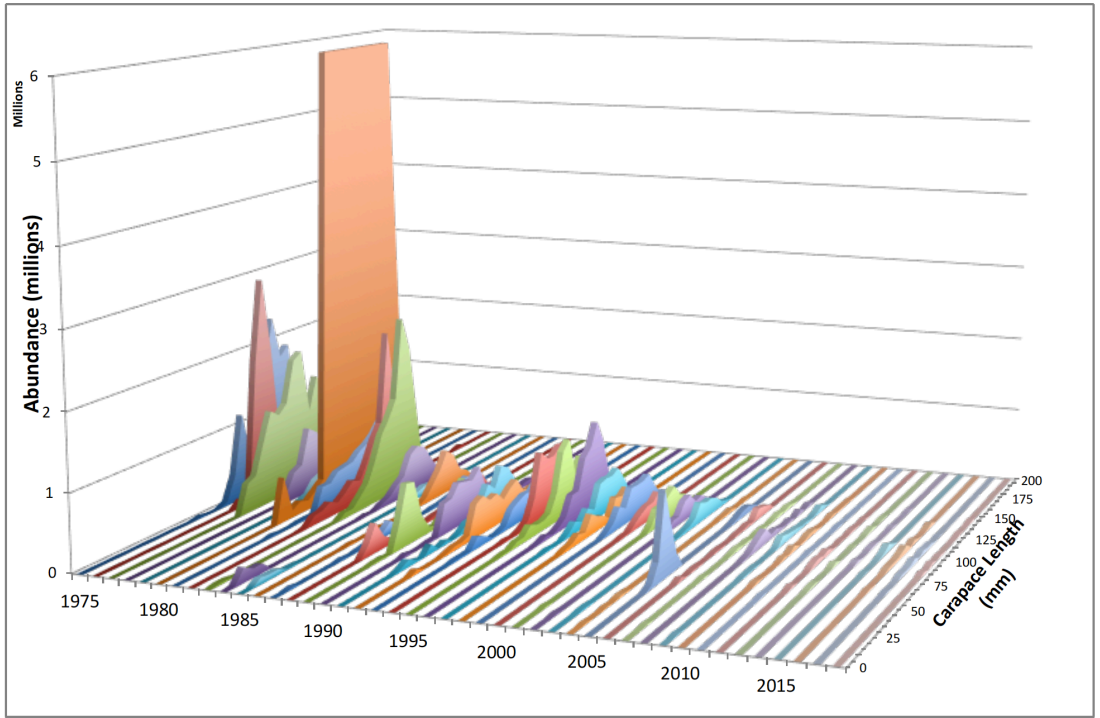
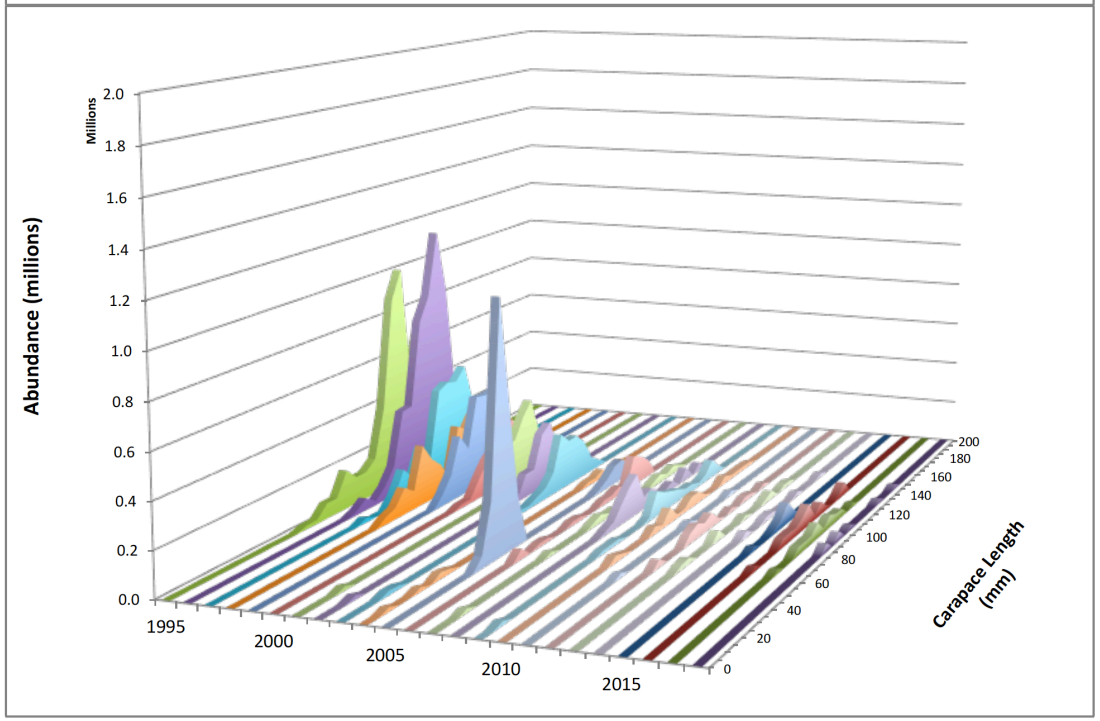
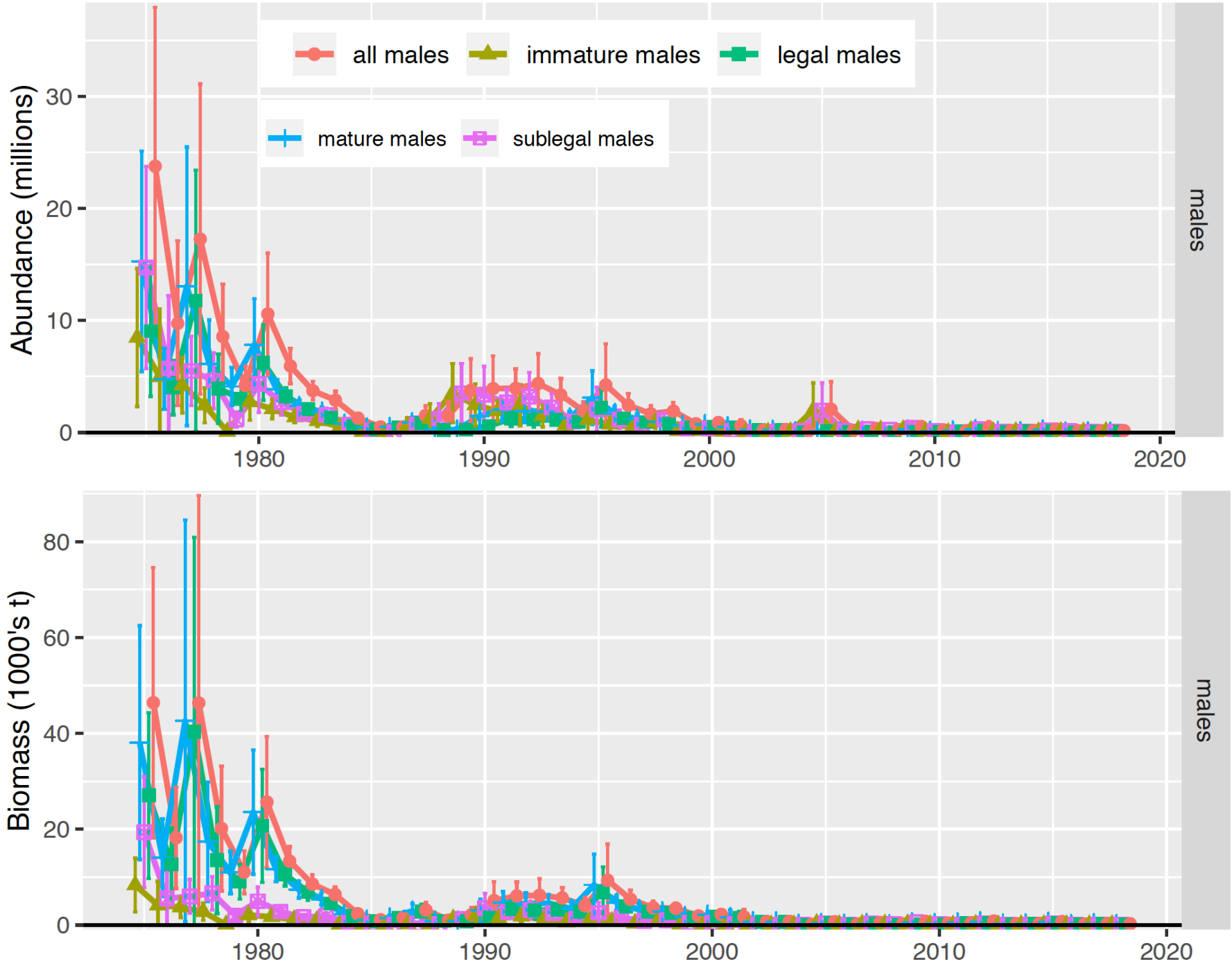

Millions
Abundance (millions)
Carapace Length (mm)


Millions
Abundance (millions)
Carapace Length (mm)

Males

Note: annual values are slightly offset to improve visibility



Males

Note: annual values are slightly offset to improve visibility

Females

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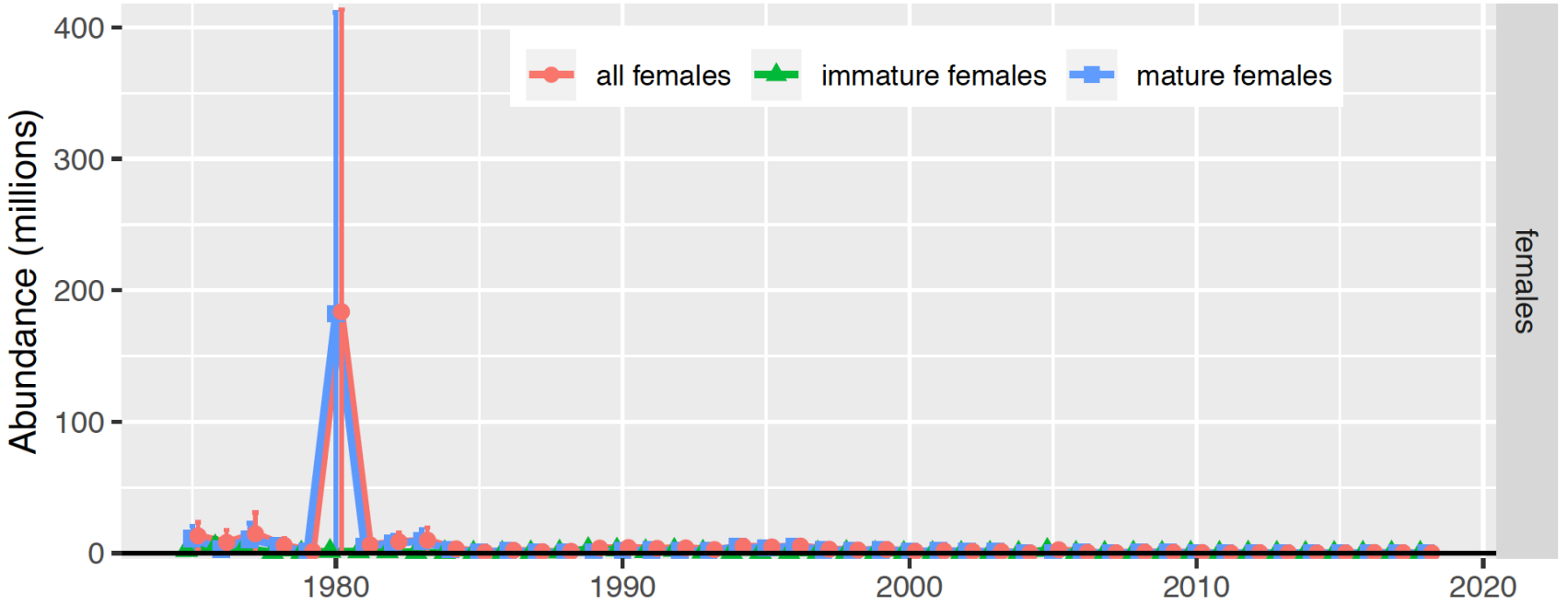
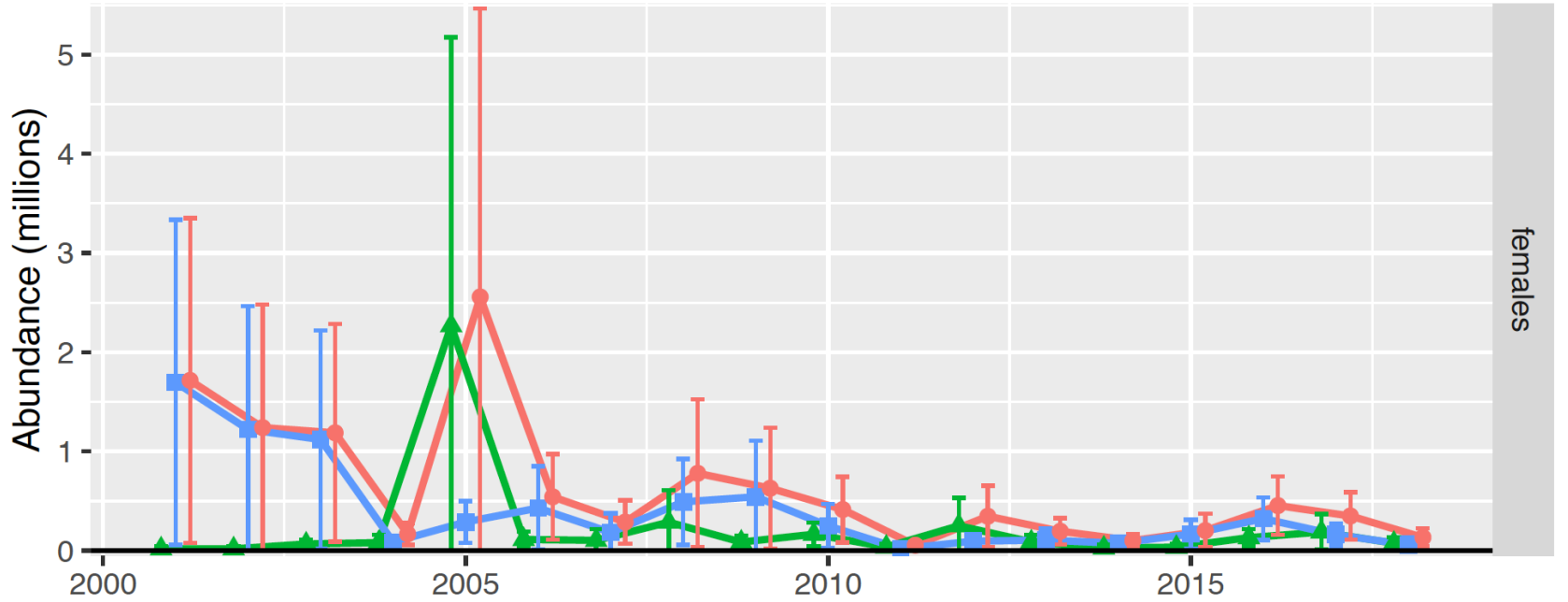
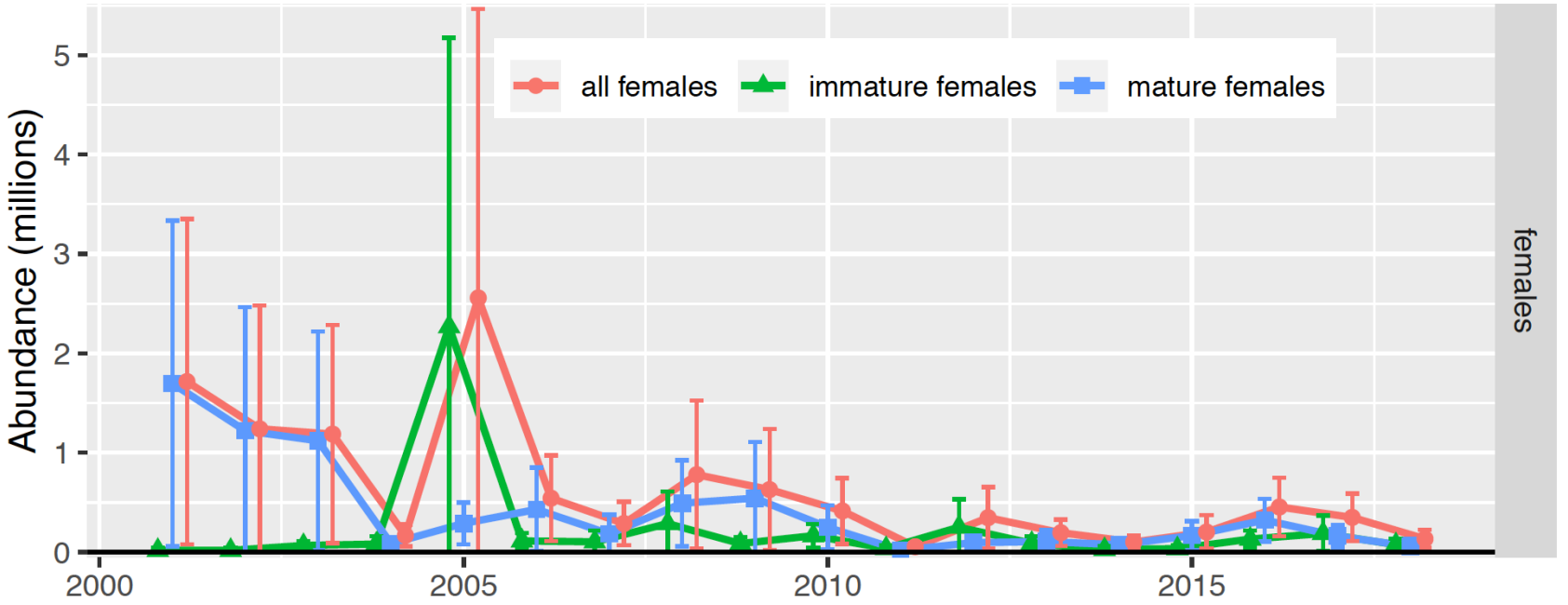
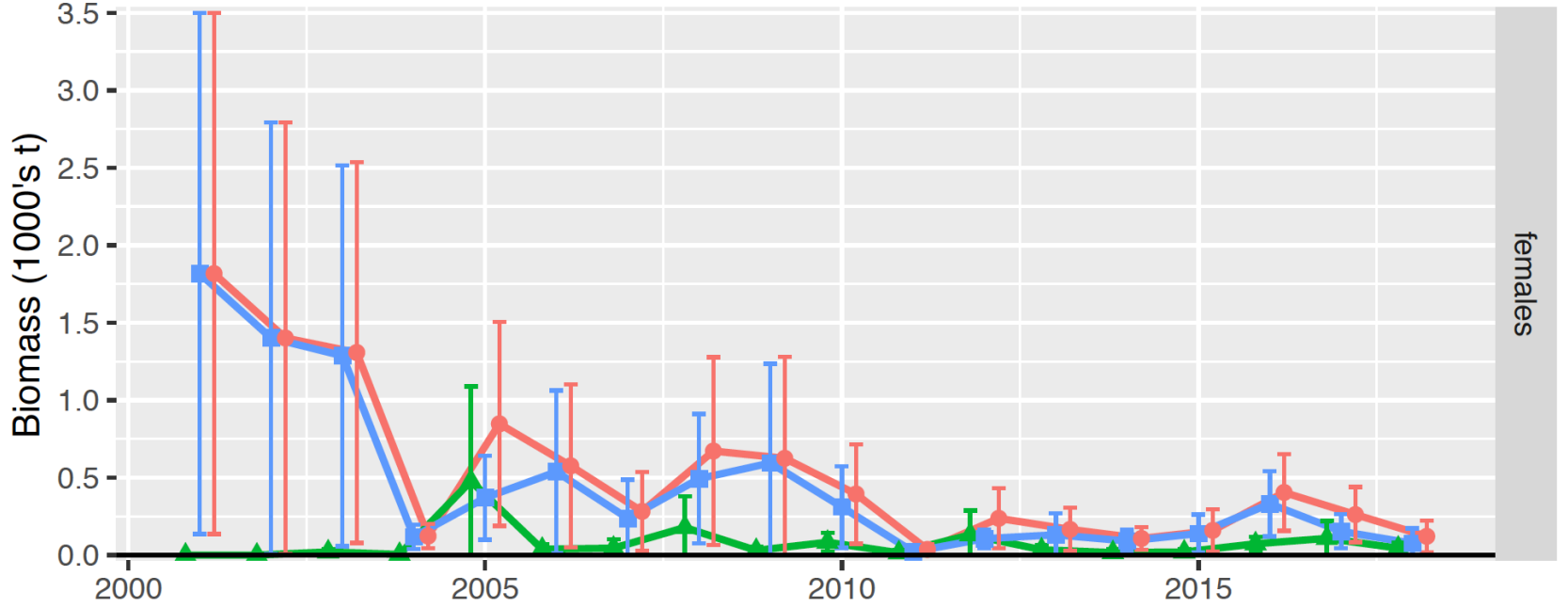




Females

Note: annual values are
slightly offset to improve visibility





Status Determination and OFL-setting

Random effects model for ”smoothed” survey MMB

State transition model (with process error)

$$< ln(MMB_s) >_y = < ln(MMB_s) >_{y-1} + \epsilon_y, \text{ where } \epsilon_y \sim N(0, \phi^2)$$

Observation model (with observation error)

$$ln(MMB_{s_y}) = < ln(MMB_s) >_y + \eta_y, \text{ where } \eta_y \sim N(0, \sigma^2_{s_y})$$

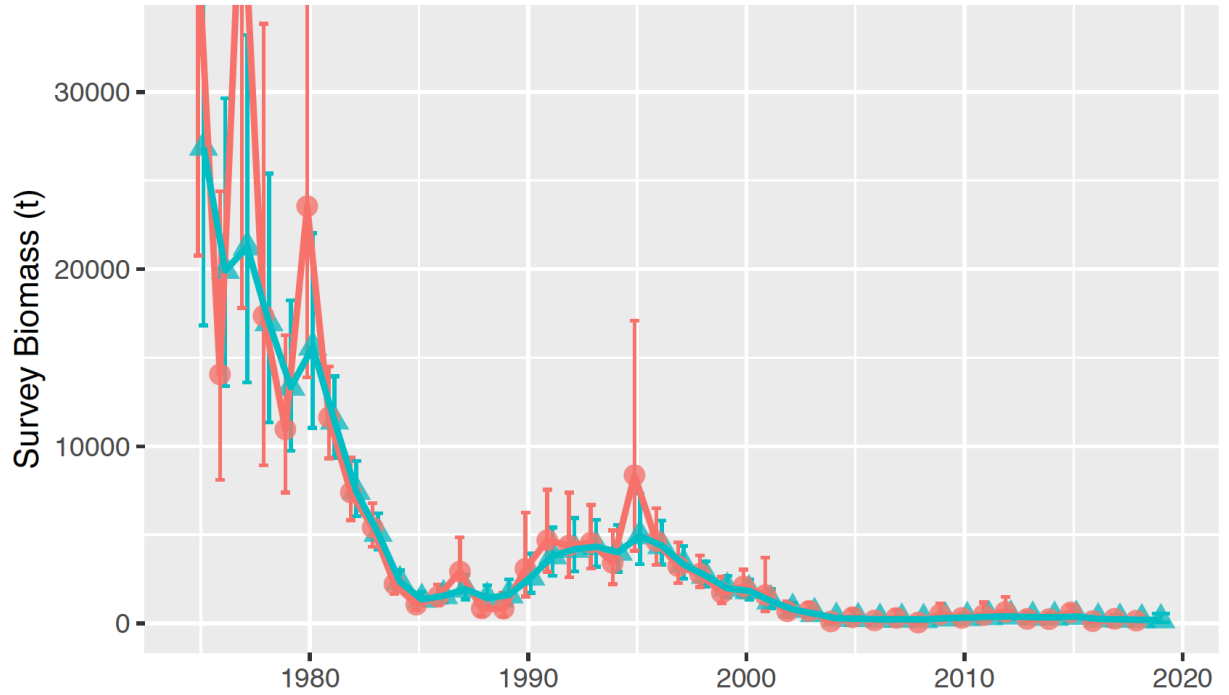
Likelihood components

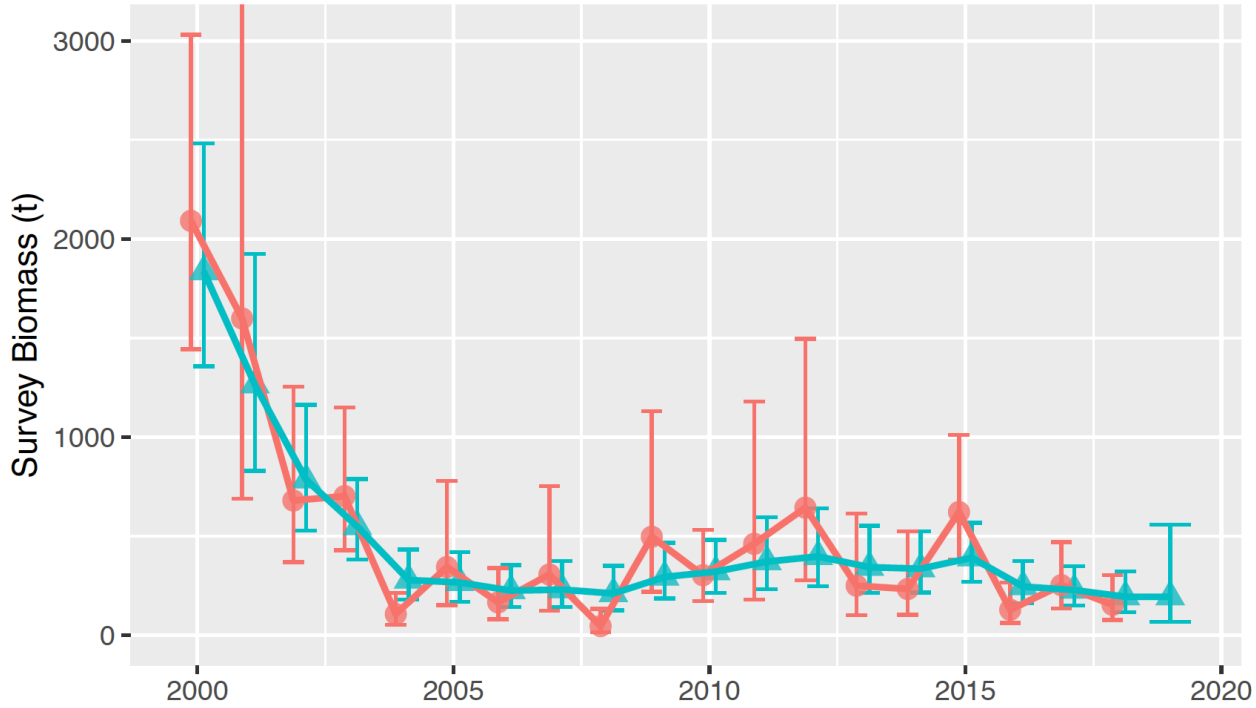
$$\Lambda = \sum_y \left[ln(2\pi\phi) + \left(\frac{< ln(MMB_s) >_y - < ln(MMB_s) >_{y-1}}{\phi} \right)^2 \right] + \sum_y \left(\frac{ln(MMB_{s_y}) - < ln(MMB_s) >_y}{\sigma_{s_y}} \right)^2$$

Smoothing results

number of parameters	1
objective function	46.81
max. gradient	1.11E-05

parameter	ln-scale estimate	ln-scale std. deviation	CV
std. dev. for Process Error	-0.824	0.182	0.986



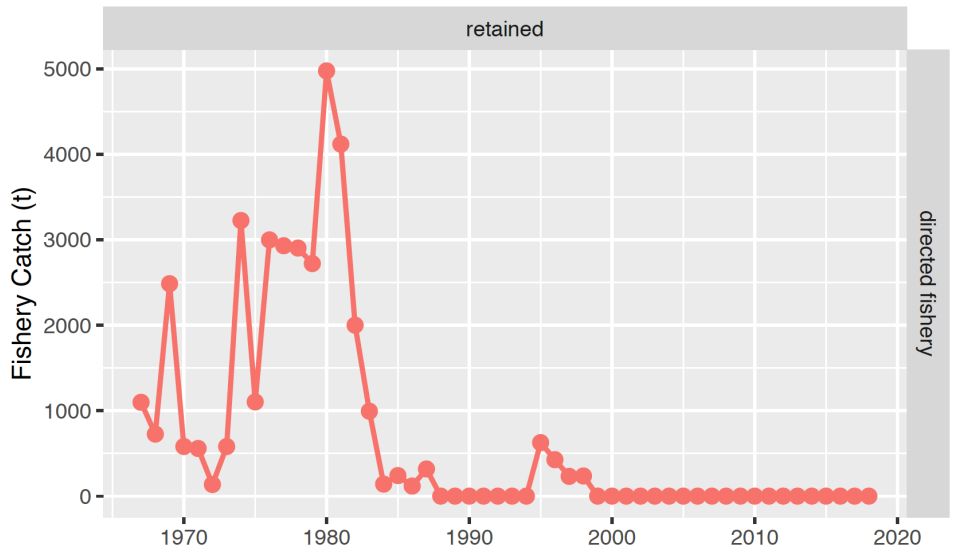


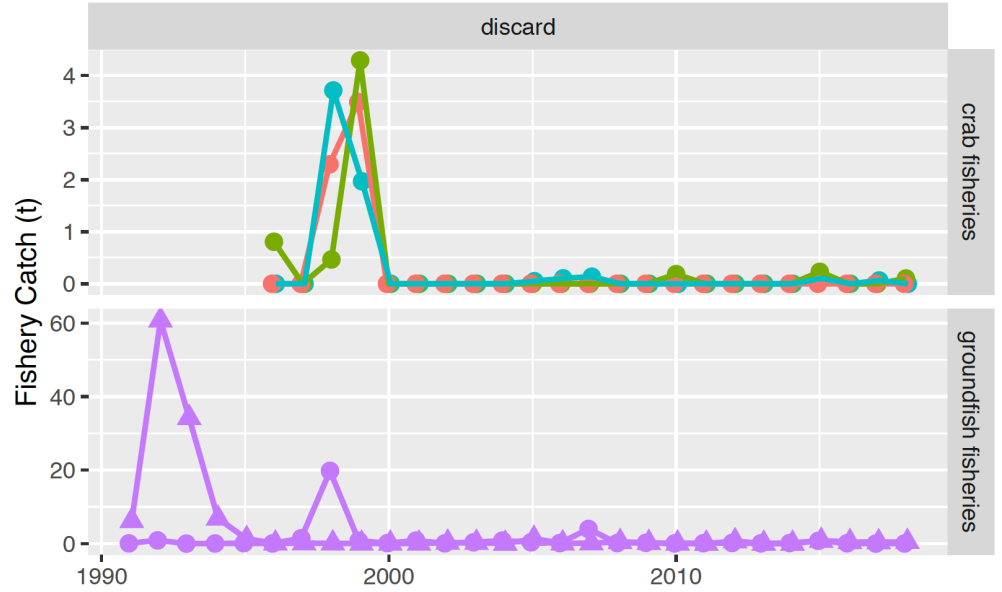
Historical MMB-at-mating calculations

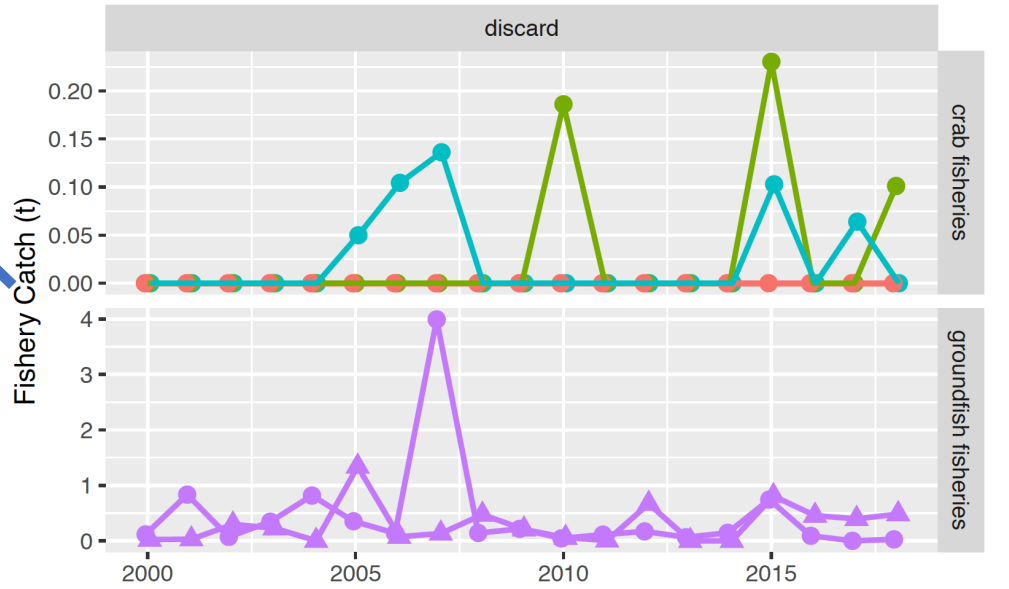
$$MMB_{s_y} = \sum_z w_z \cdot P_z \cdot n_{z,y}$$

$$MMB_{f_y} = MMB_{s_y} \cdot e^{-M \cdot t_{sf}}$$

$$MMB_{m_y} = \left[MMB_{f_y} - RM_y - DM_y \right] \cdot e^{-M \cdot t_{fm}}$$

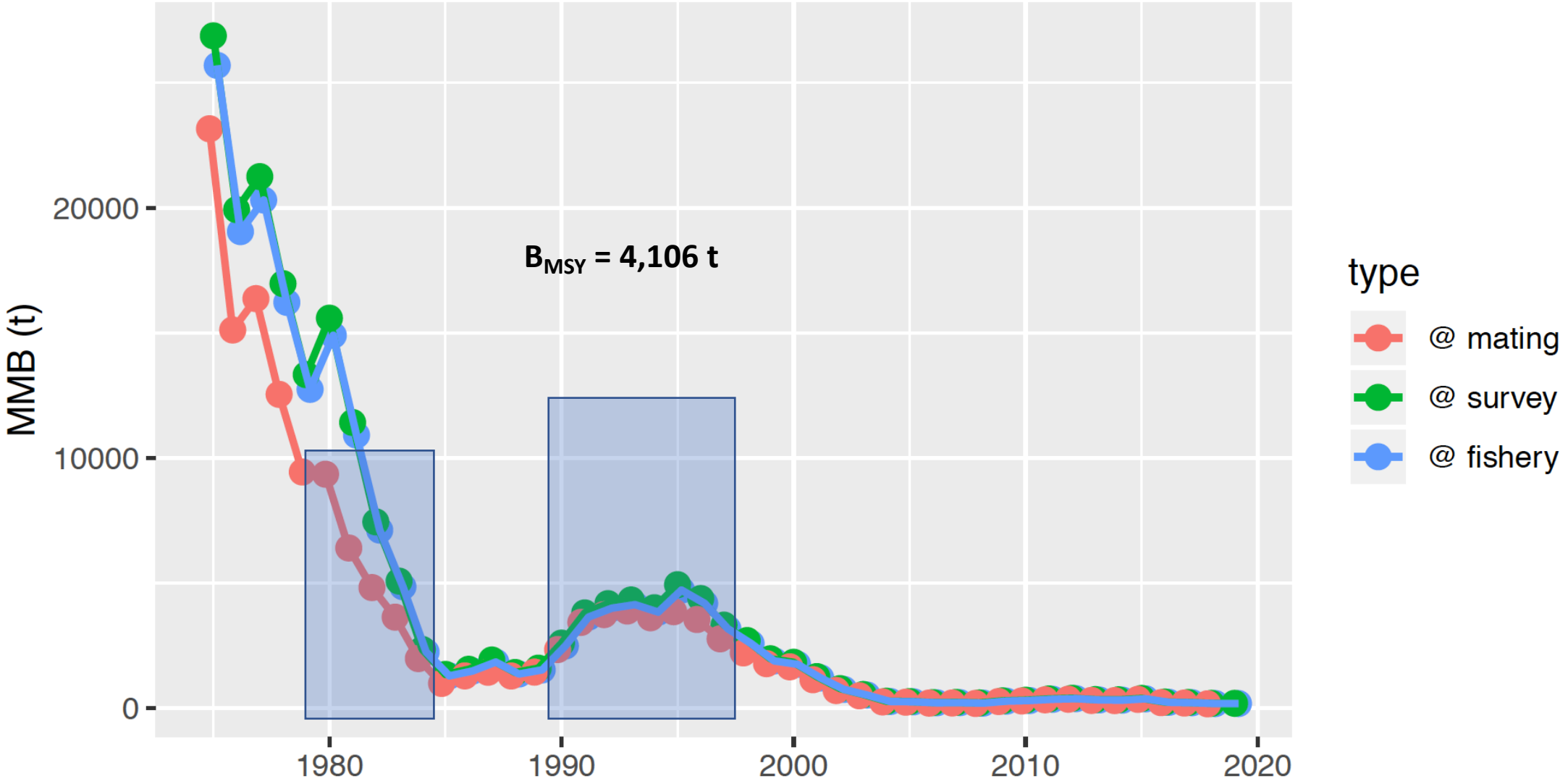






Historical MMB-at-mating

Time period to determine B_{MSY}: 1980/81-1984/85; 1990/91-1997/98



"Current" MMB-at-mating (Tier 4 calculations)

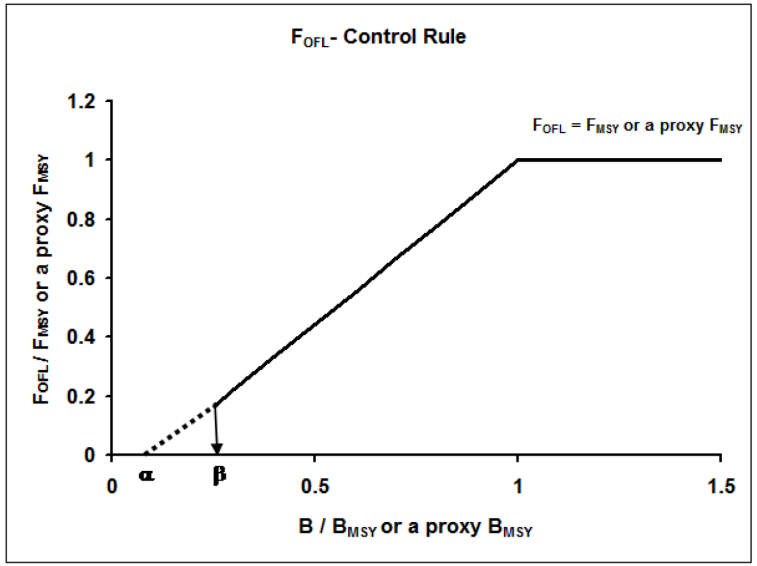
$$F_{OFL_{max}} = \gamma \cdot M$$

$$MMB_f = MMB_s \cdot e^{-M \cdot t_{sf}}$$

$$RM_{OFL} = \left(1 - e^{-F_{OFL}}\right) \cdot MMB_s \cdot e^{-M \cdot t_{sf}}$$

$$DM_{OFL} = \theta \cdot \frac{MMB_f}{p_{male}} \qquad \theta = \frac{1}{N} \sum_y \frac{DM_{MMB_y}}{MMB_{f_y}}$$

$$MMB_m = \left[MMB_{f_y} - \left(RM_{OFL} + p_{male} \cdot DM_{OFL}\right)\right] \cdot e^{-M \cdot t_{fm}}$$



Estimation Type	theta
RE-smoothed	0.0008647

quantity	units	RE.smoothed
B ("current" MMB)	t	174.67
B_{MSY}	t	4,106.40
stock status	–	overfished
F_{OFL}	$year^{-1}$	0.00
RM_{OFL}	t	0.00
DM_{OFL}	t	0.32

Status Determination and OFL

- stock remains overfished
- overfishing will evaluated at September CPT meeting (but has not occurred yet)
- Tier 5 OFL based on average fishing mortality 1999/2000-2005/06: 1.16 t
- ABC is based on a 25% buffer to the OFL: 0.87

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch Mortality	OFL	ABC
2015/16	2,058 A	361 A	closed	0	1.18	1.16	0.87
2016/17	2,053 A	232 A	closed	0	0.38	1.16	0.87
2017/18	2,053 A	230 A	closed	0	0.33	1.16	0.87
2018/19	2,053 A	230 A	closed	0	0.41	1.16	0.87
2019/20	--	175 B	--	--	--	1.16	0.87

Year	Tier	B_{MSY}	Current MMB_{mating}	B/B_{MSY} (MMB_{mating})	γ	Years to define B_{MSY}	Natural Mortality	P*
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	232	0.06	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2017/18	4c	4,106	230	0.06	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2018/19	4c	4,106	230	0.06	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer
2019/20	4c	4,106	175	0.04	1	1980/81-1984/85 &1990/91-1997/98	0.18	25% buffer

So long, and thanks for the fish!

PIBKC will return in two years!