Saint Matthew Island Blue King Crab Stock Assessment 2016

D’Arcy Webber, Jie Zheng, James Ianelli

Summary

2016:

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

Gmacs implementation

- Post-doc and ADFG scientists main contributors
- Document script-driven
- Status: mature male biomass ~60% of “Bmsy”

SMBKC crab

Saint Matthew Island Blue King Crab Stock Assessment 2016

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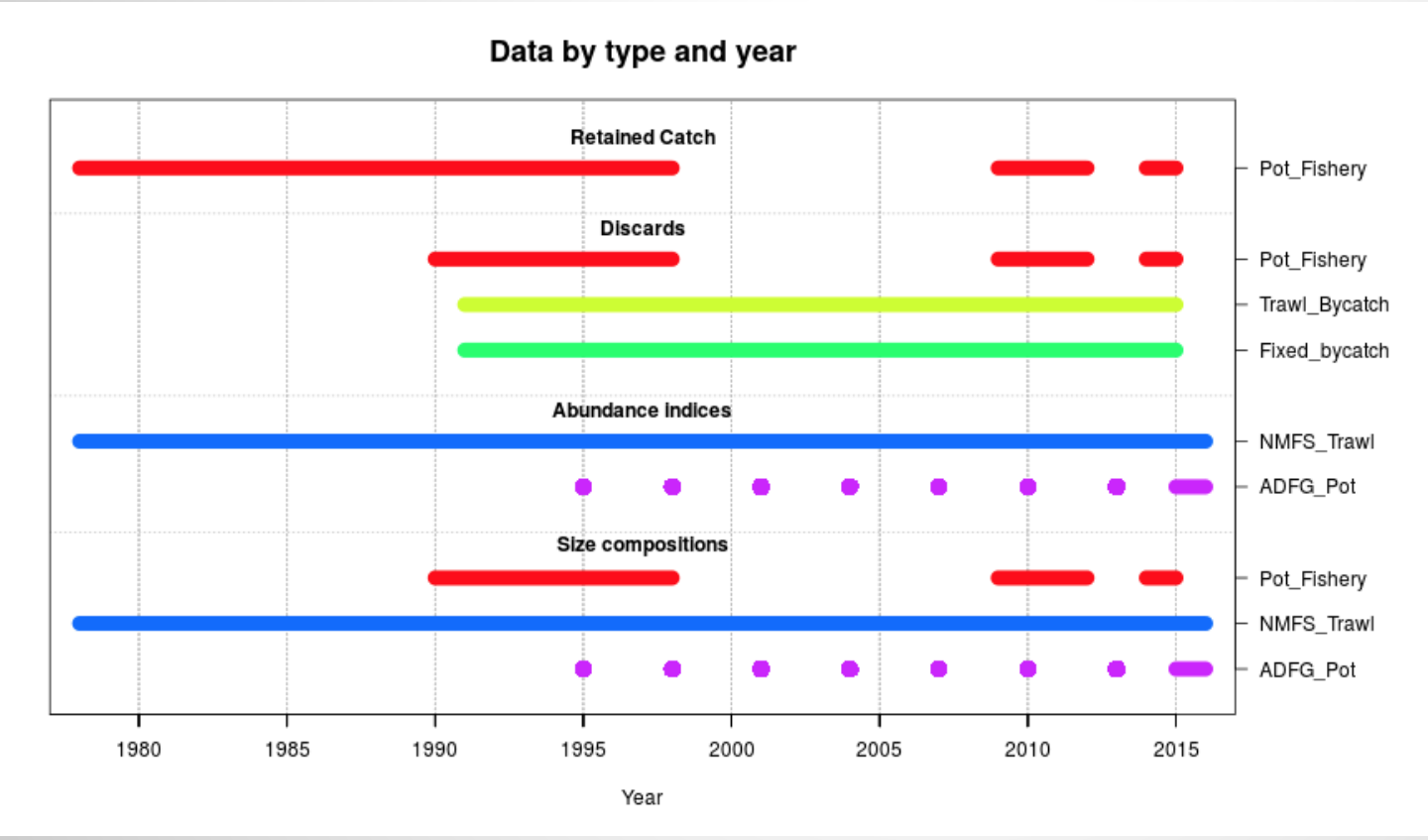
Executive Summary

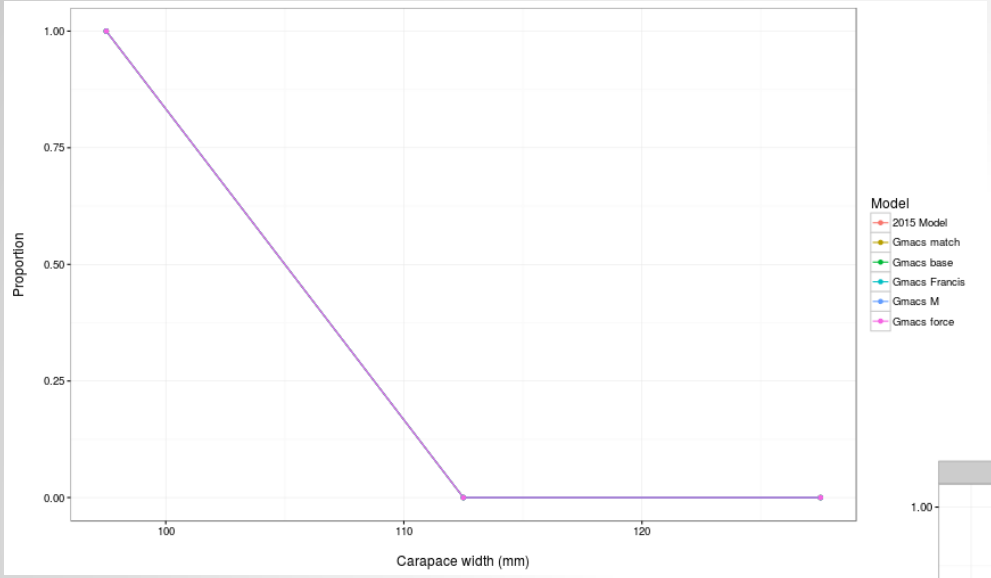
1. **Stock**: Blue king crab, *Paralithodes platypus*, Saint Matthew Island (SMBKC), Alaska.
2. **Catches**: Peak historical harvest was 4288 tonnes (9.454 million pounds) in 1983/84[1]. The fishery was closed for 10 years after the stock was declared overfished in 1999. Fishing resumed in 2009/10 with a fishery-reported retained catch of 209 tonnes (0.461 million pounds), less than half the 529.3 tonne (1.167 million pound) TAC. Following three more years of modest harvests supported by a fishery catch per unit effort (CPUE) of around 10 crab per pot lift, the fishery was again closed in 2013/14 due to declining trawl-survey estimates of abundance and concerns about the health of the stock. The directed fishery resumed again in 2014/15 with a TAC of 300 tonnes (0.655 million pounds), but the fishery performance was relatively poor with a retained catch of 140 tonnes (0.309 million pounds).
3. **Stock biomass**: Following a period of low numbers (below 30% of the 1978-2016 mean of 5,865 tonnes) after the stock was declared overfished in 1999, trawl-survey indices of SMBKC stock abundance and biomass generally increased to well above average from 2007-2012. In 2013 the survey biomass estimate was low (~40% of the mean value) but was followed by average biomass estimates in 2014 and 2015 (with sampling CVs of 77% and 45%, respectively). The 2016 survey biomass estimate was 3,500 tonnes

SMBKC: Data extent

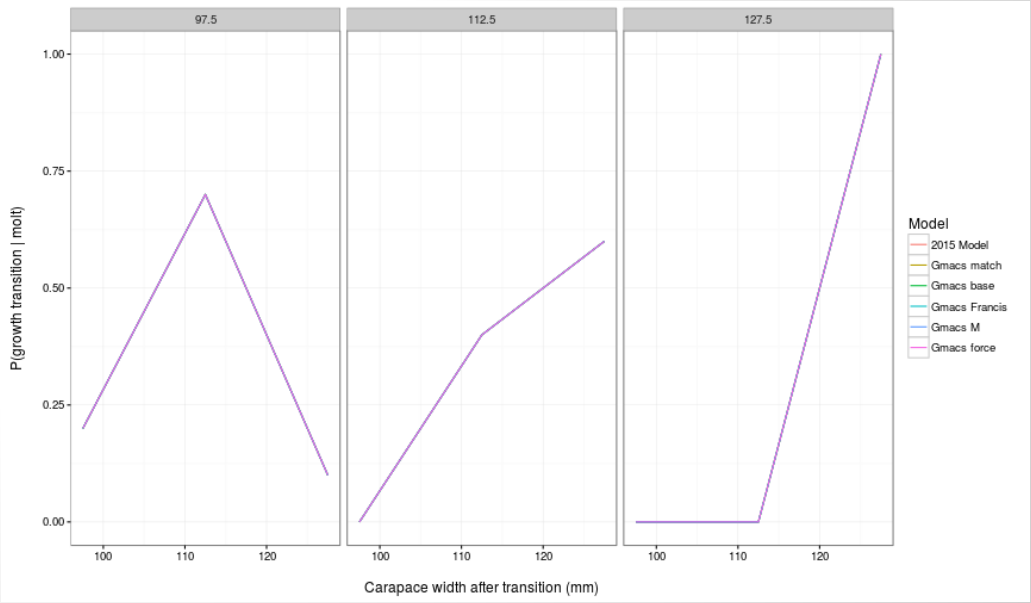


Model Scenarios

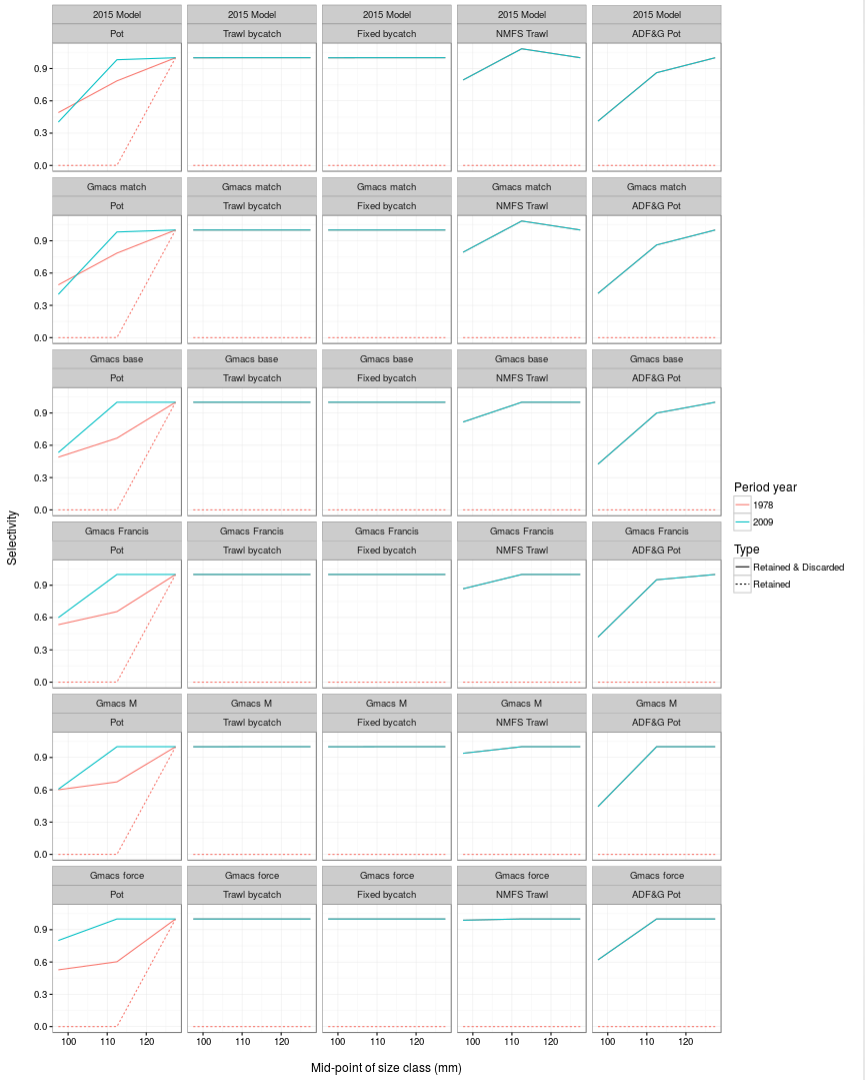
- 2015 Model
- Gmacs match
- Gmacs base
- Gmacs Francis
- Gmacs M
- Gmacs force



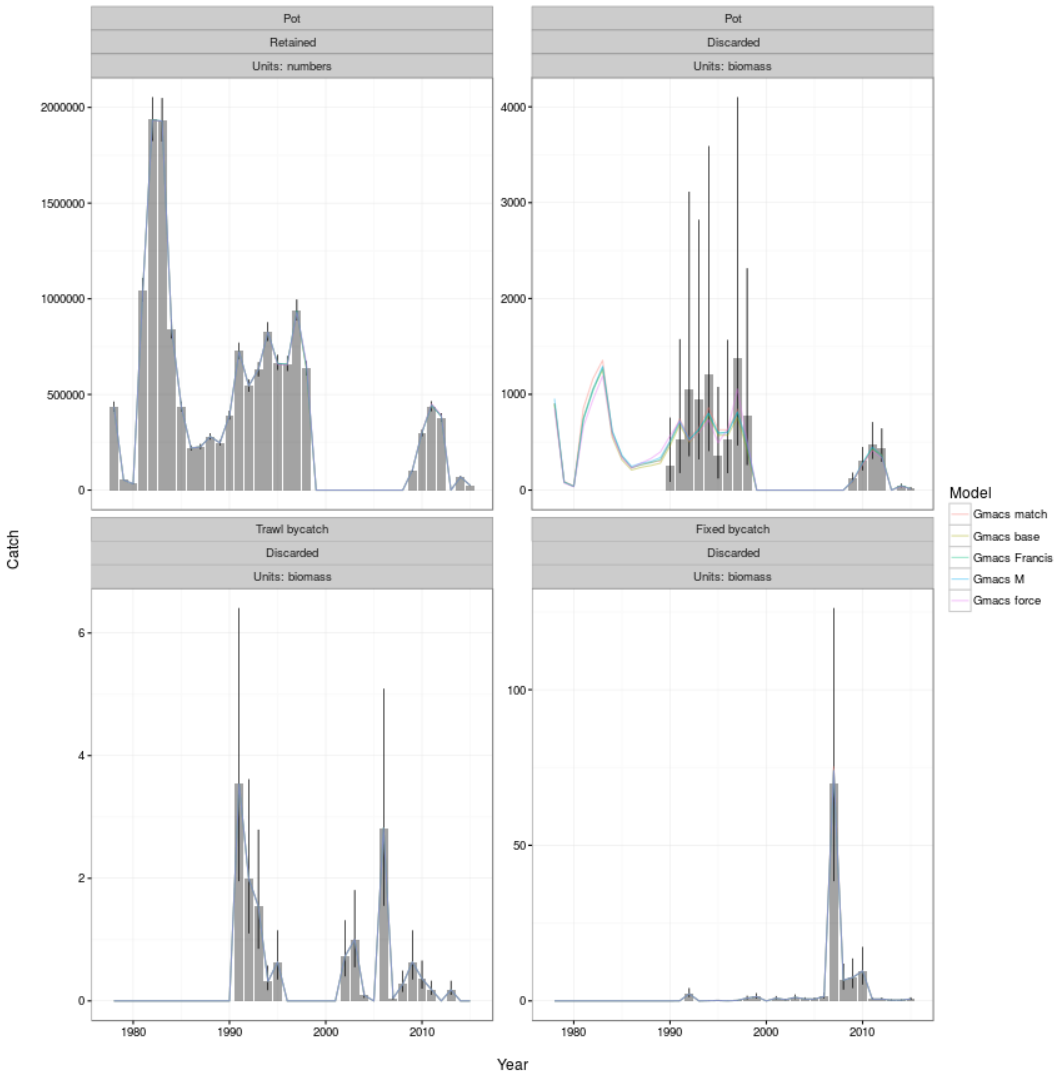
Recruitment size, growth and time-varying length-weight all the same



Selectivity

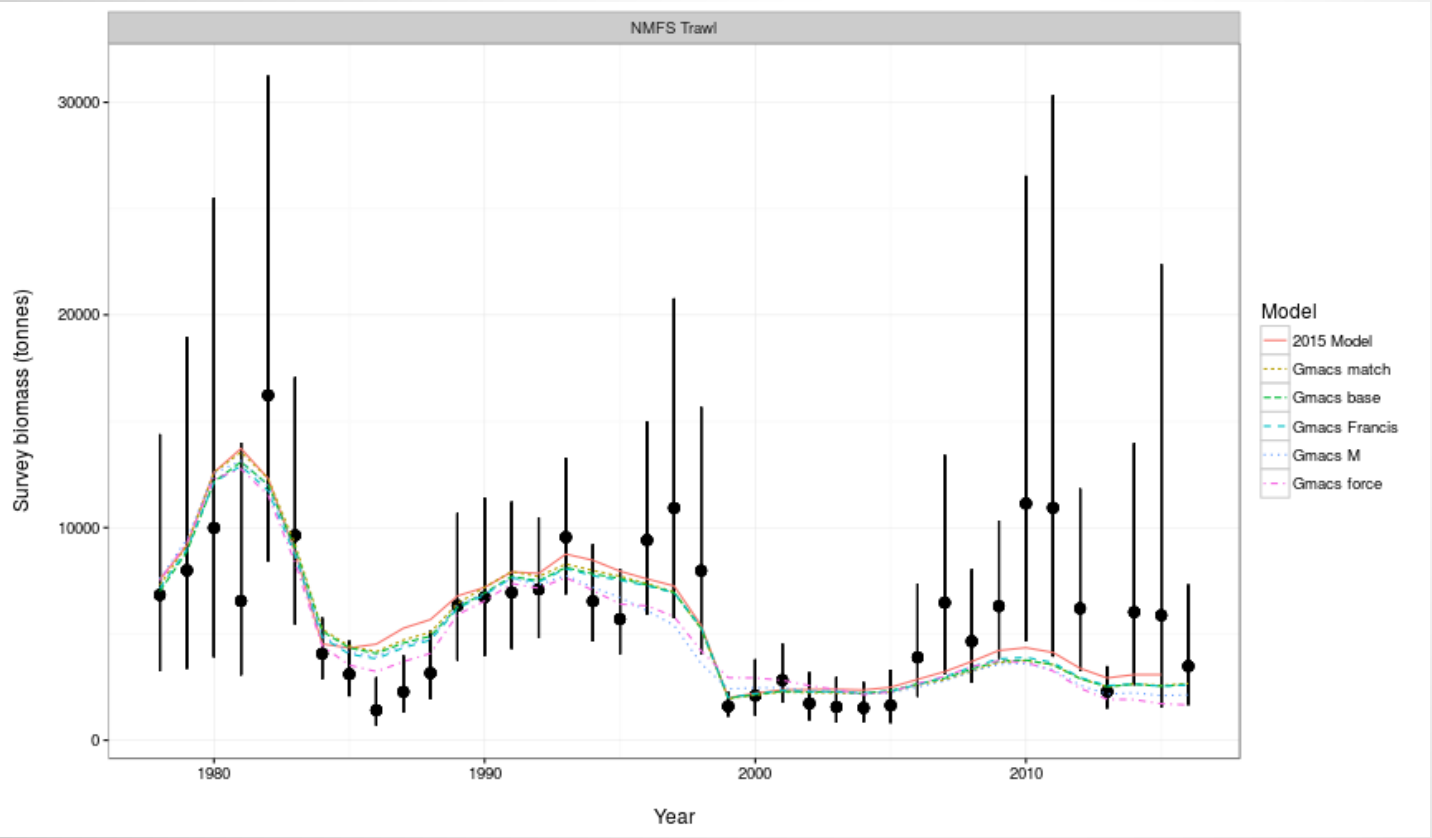


Fit To Fishery data

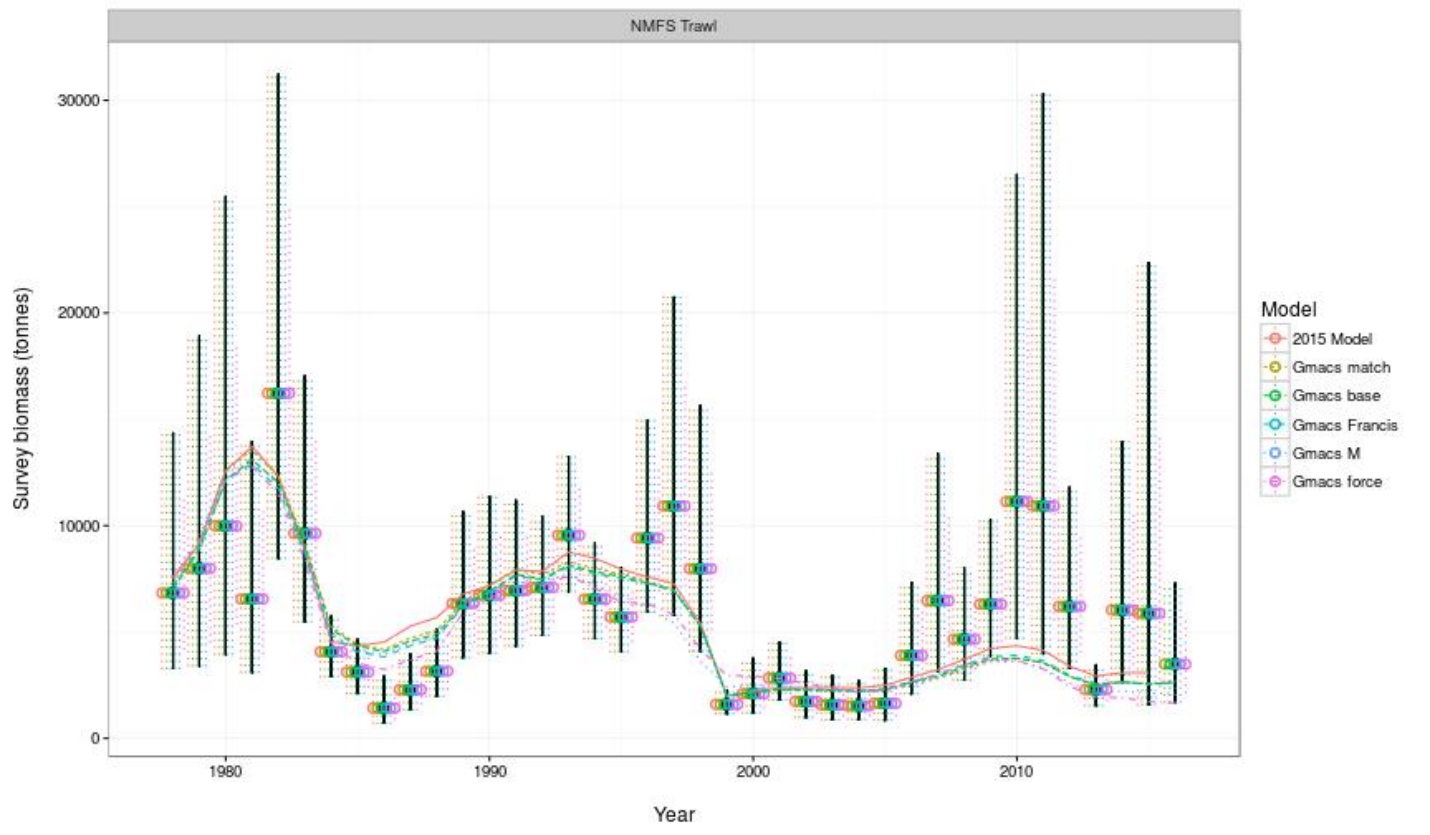


SMBKC crab

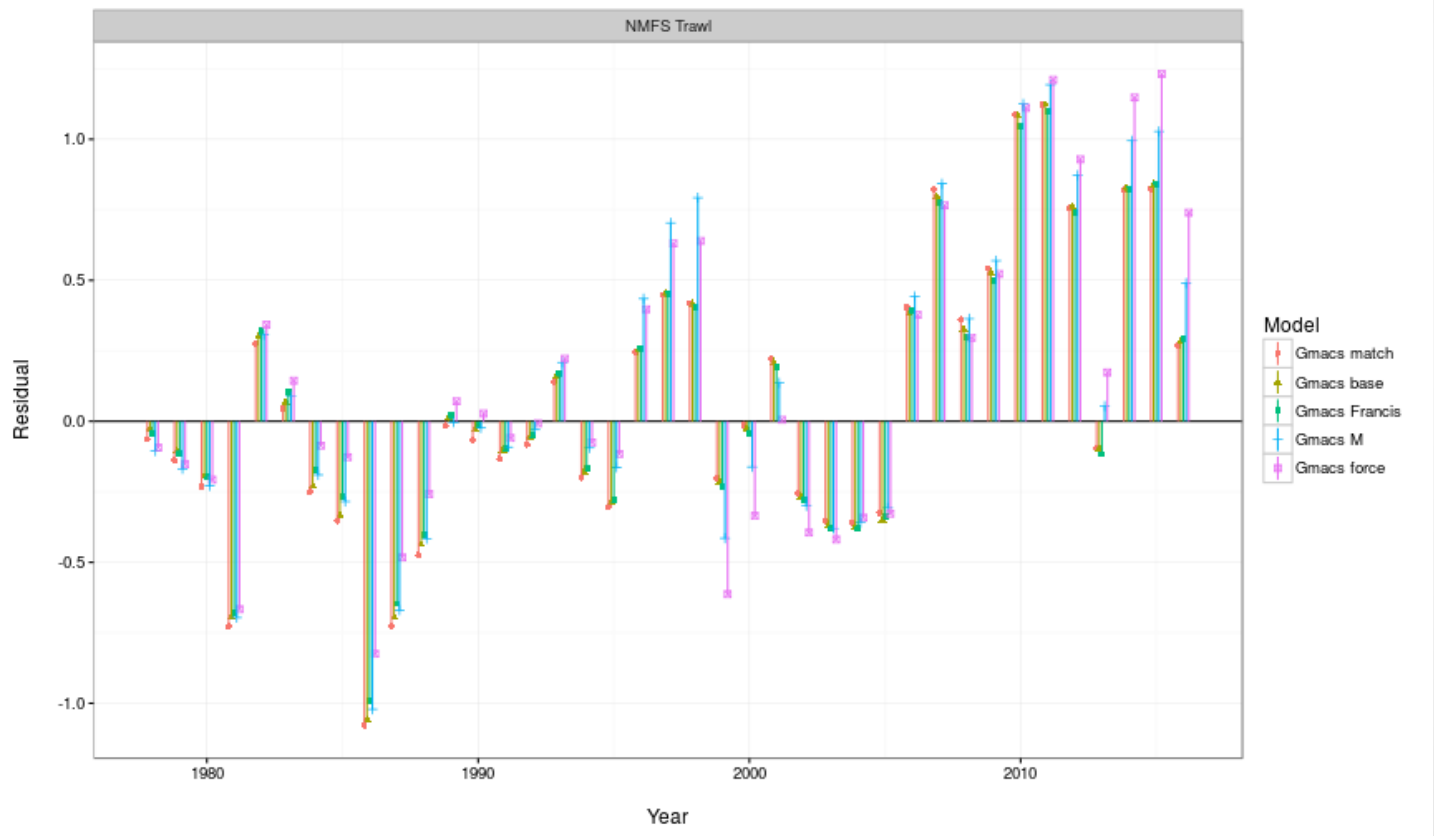
Trawl survey fits and model alternatives



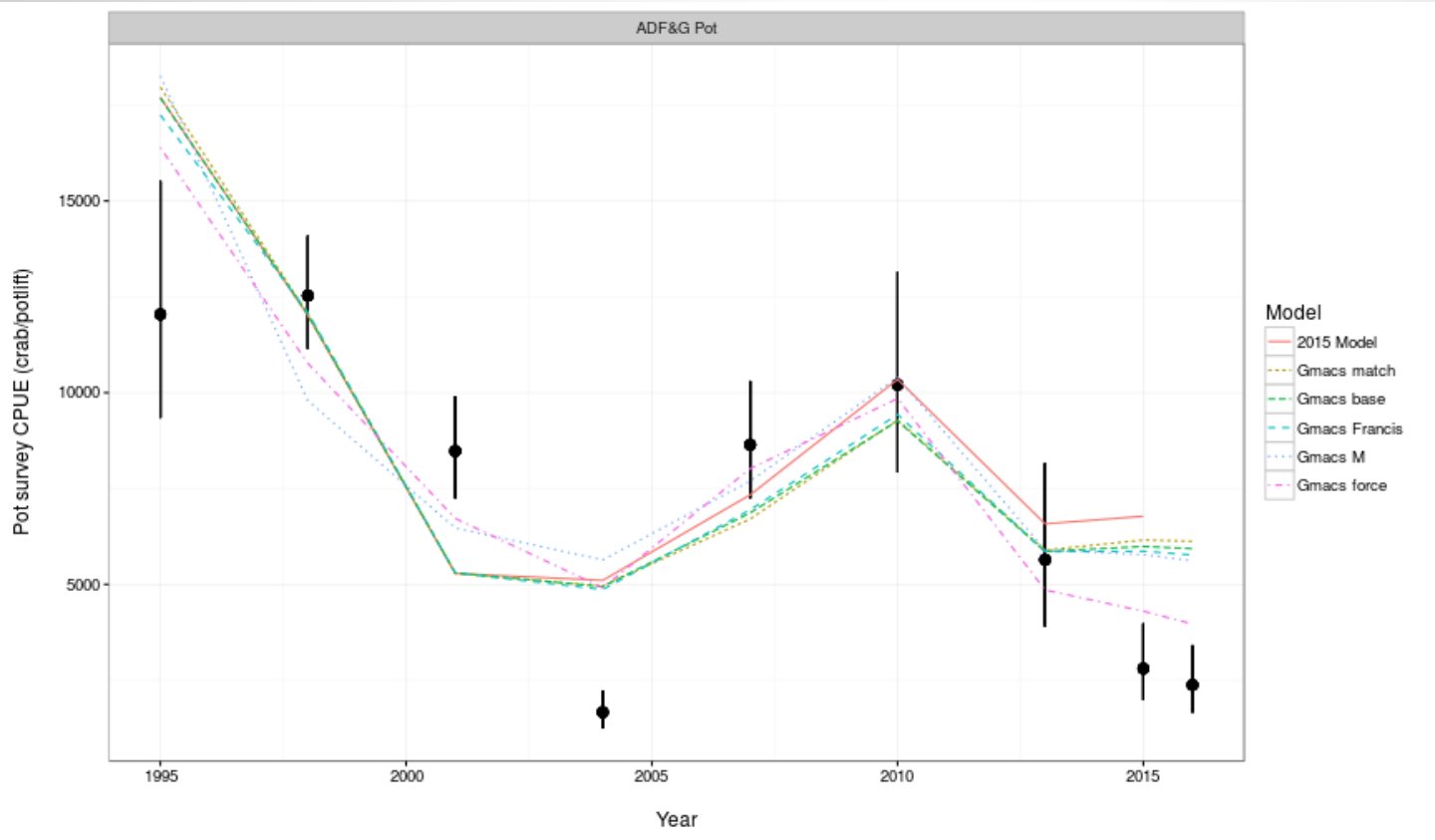
Trawl survey fits and model alternatives



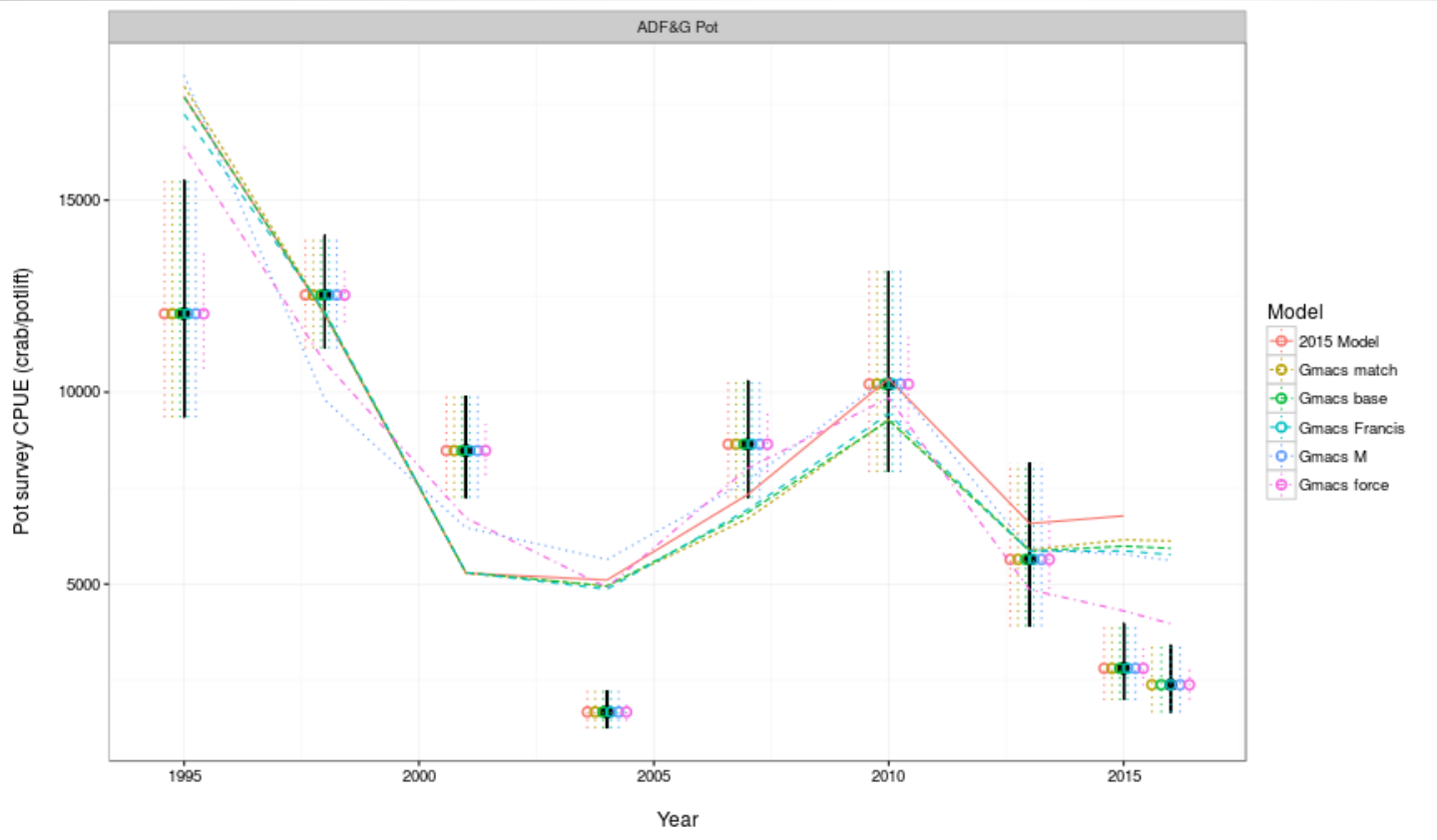
Residuals


NMFS Trawl
Residual
1.0
0.5
0.0
-0.5
-1.0
1980
1990
2000
2010
Year
Model
Gmacs match
Gmacs base
Gmacs Francis
Gmacs M
Gmacs force

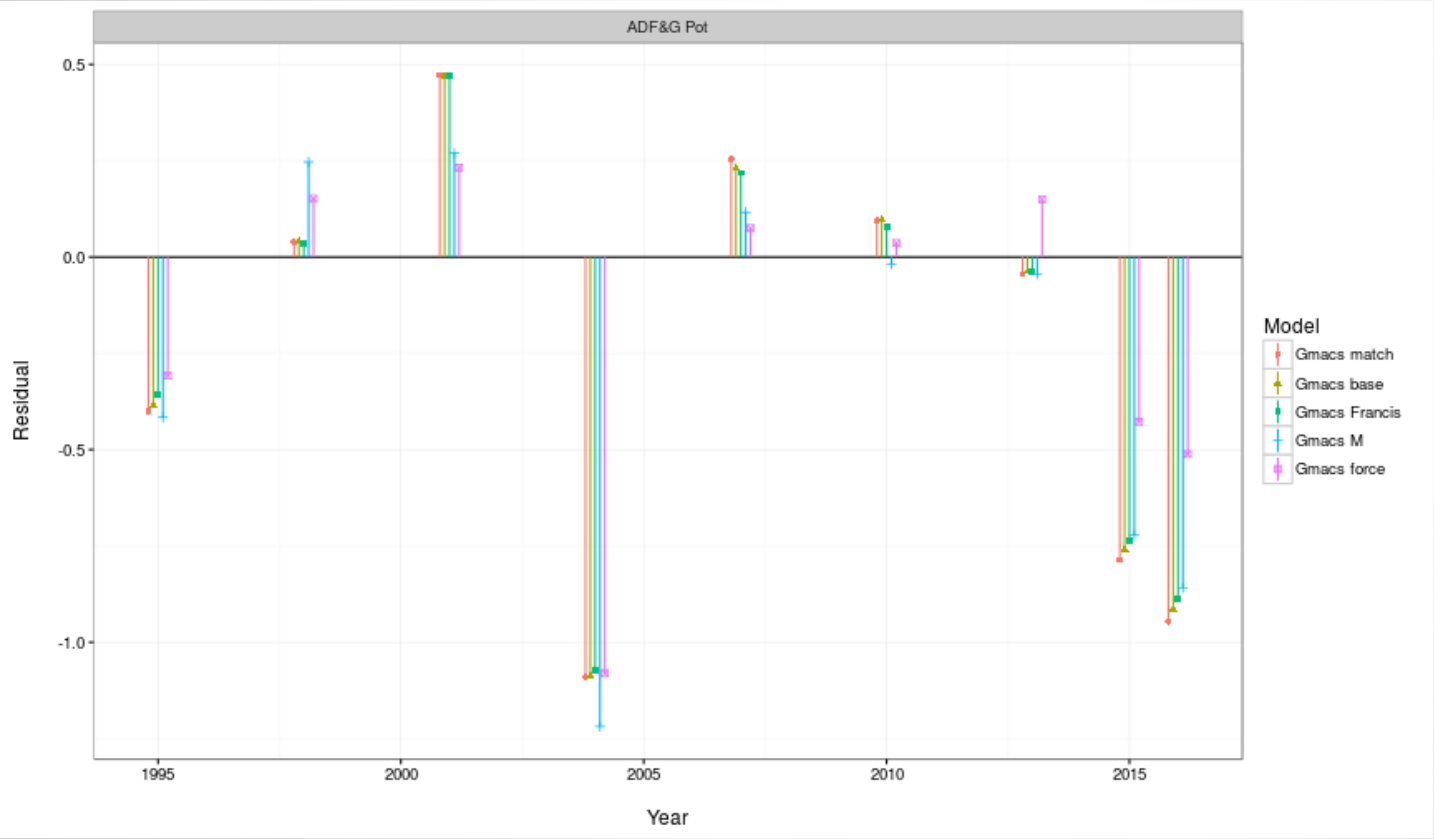
SMBKC: fit to ADFG Pot survey

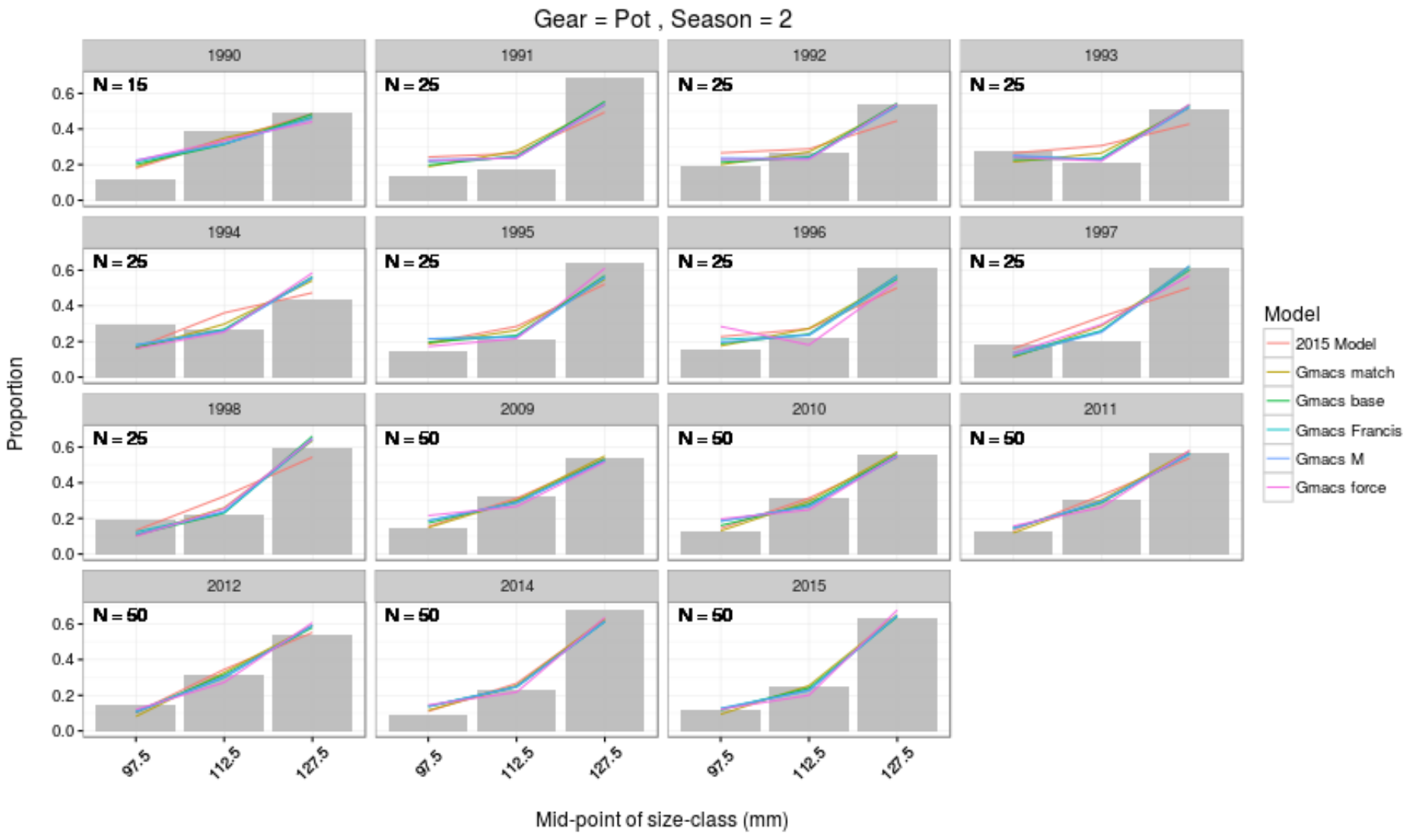


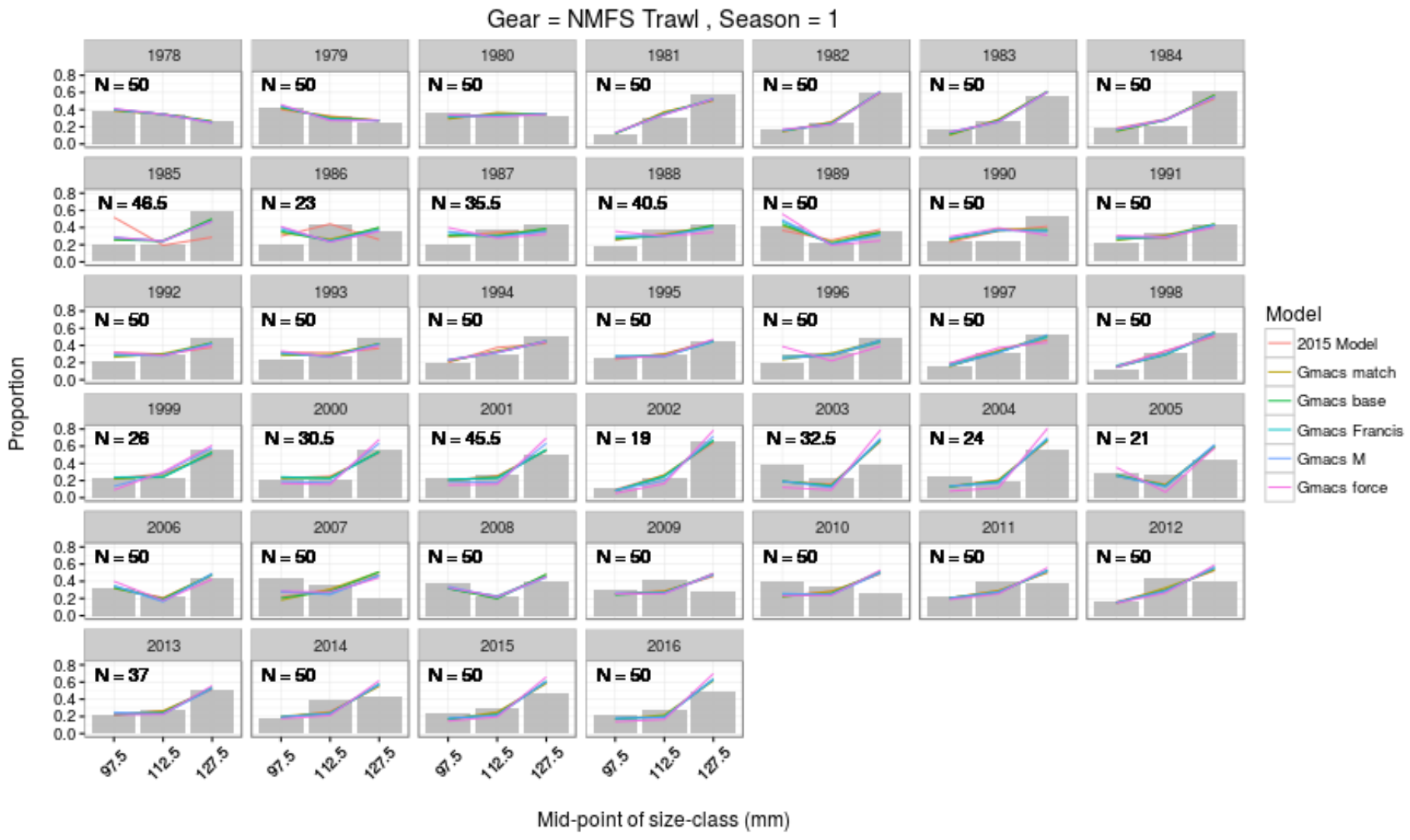
SMBKC: fit to ADFG Pot survey



Residuals


ADF&G Pot
0.5
0.0
-0.5
-1.0
Residual
1995
2000
2005
2010
2015
Year
Model
Gmacs match
Gmacs base
Gmacs Francis
Gmacs M
Gmacs force


Gear = Pot , Season = 2
1990
N = 15
1991
N = 25
1992
N = 25
1993
N = 25
1994
N = 25
1995
N = 25
1996
N = 25
1997
N = 25
1998
N = 25
2009
N = 50
2010
N = 50
2011
N = 50
2012
N = 50
2014
N = 50
2015
N = 50
Proportion
0.0
0.2
0.4
0.6
97.5
112.5
127.5
Mid-point of size-class (mm)
Model
2015 Model
Gmacs match
Gmacs base
Gmacs Francis
Gmacs M
Gmacs force


Gear = NMFS Trawl , Season = 1
1978
N = 50
1979
N = 50
1980
N = 50
1981
N = 50
1982
N = 50
1983
N = 50
1984
N = 50
1985
N = 46.5
1986
N = 23
1987
N = 35.5
1988
N = 40.5
1989
N = 50
1990
N = 50
1991
N = 50
1992
N = 50
1993
N = 50
1994
N = 50
1995
N = 50
1996
N = 50
1997
N = 50
1998
N = 50
1999
N = 26
2000
N = 30.5
2001
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2002
N = 19
2003
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2004
N = 24
2005
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N = 50
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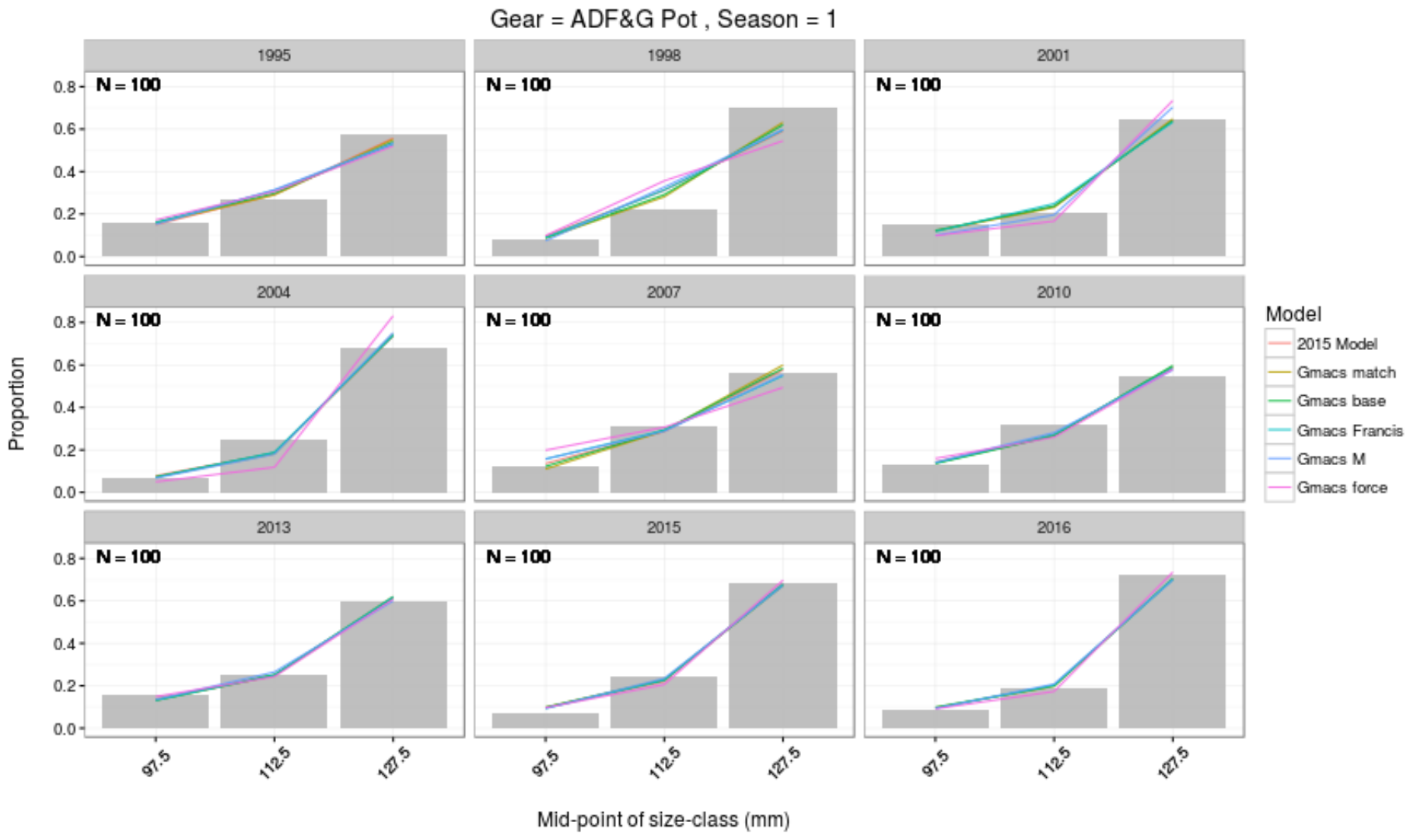
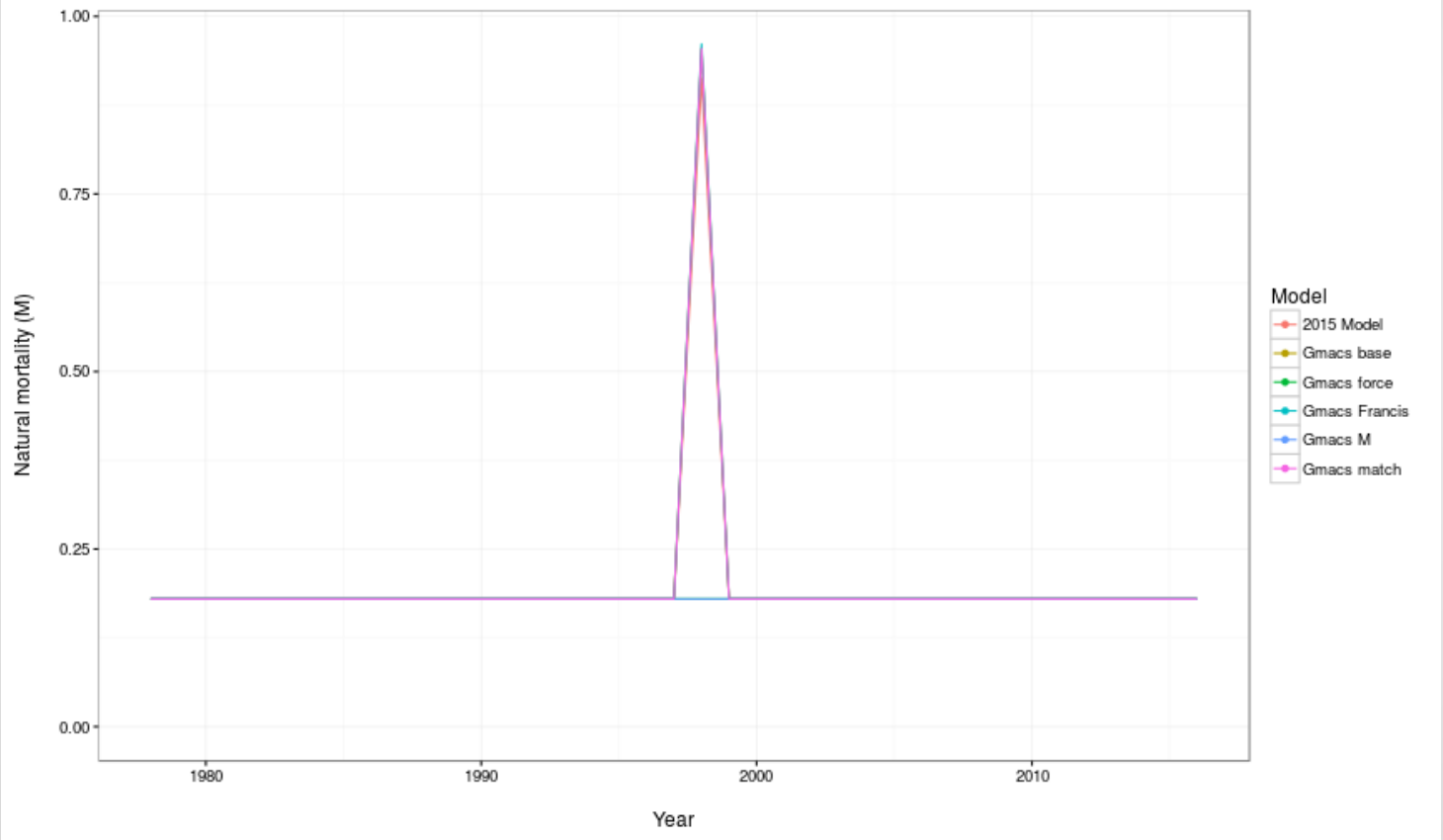
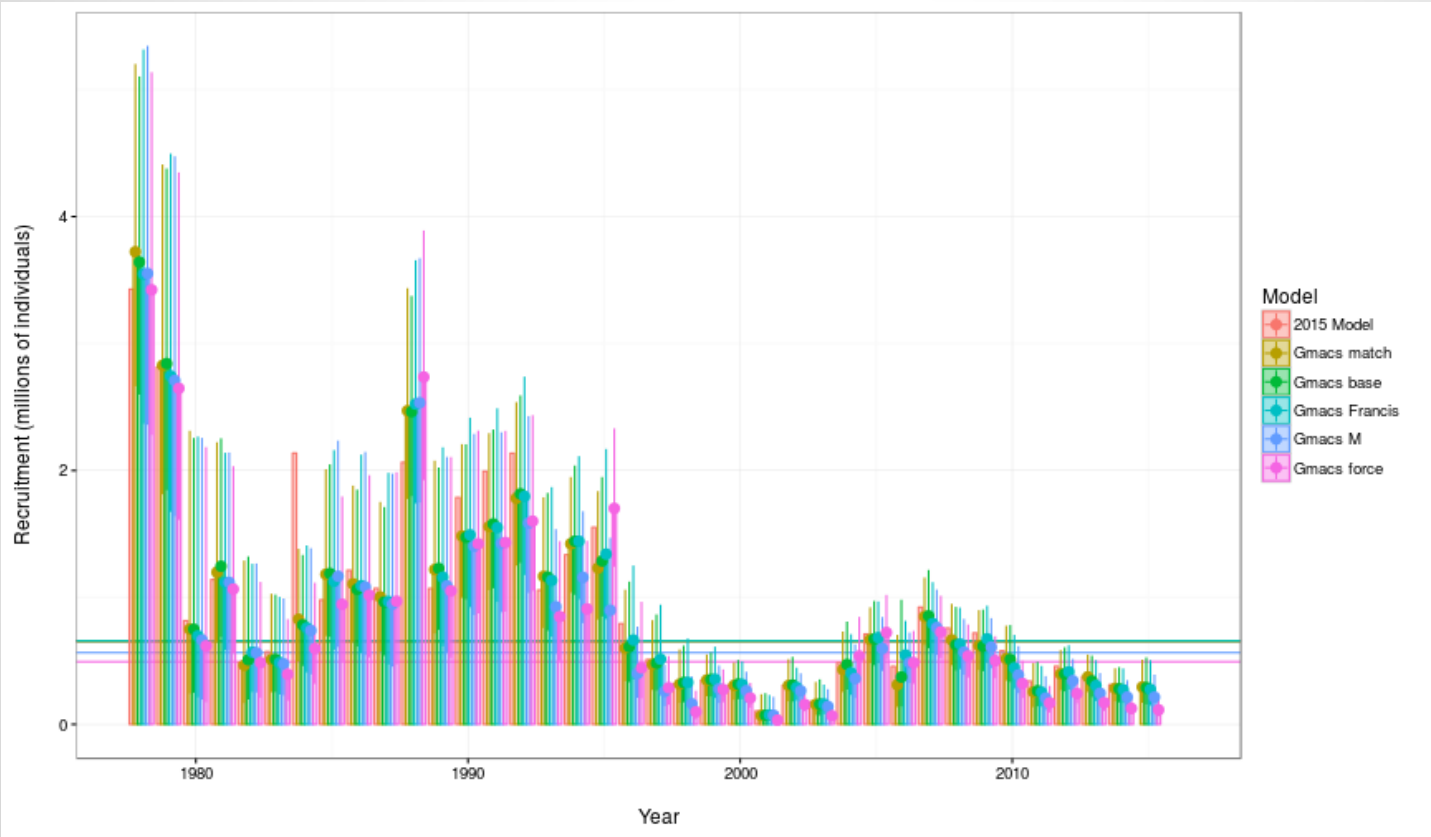
N = 50
2009
N = 50
2010
N = 50
2011
N = 50
2012
N = 50
2013
N = 37
2014
N = 50
2015
N = 50
2016
N = 50
0.0
0.2
0.4
0.6
0.8
97.5
112.5
127.5
Proportion
Mid-point of size-class (mm)
Model
2015 Model
Gmacs match
Gmacs base
Gmacs Francis
Gmacs M
Gmacs force


Gear = ADF&G Pot , Season = 1
1995
1998
2001
2004
2007
2010
2013
2015
2016
N = 100
Proportion
0.0
0.2
0.4
0.6
0.8
97.5
112.5
127.5
Mid-point of size-class (mm)
Model
2015 Model
Gmacs match
Gmacs base
Gmacs Francis
Gmacs M
Gmacs force

Natural mortality (M)



Recruitment



SMBKC Spawning biomass

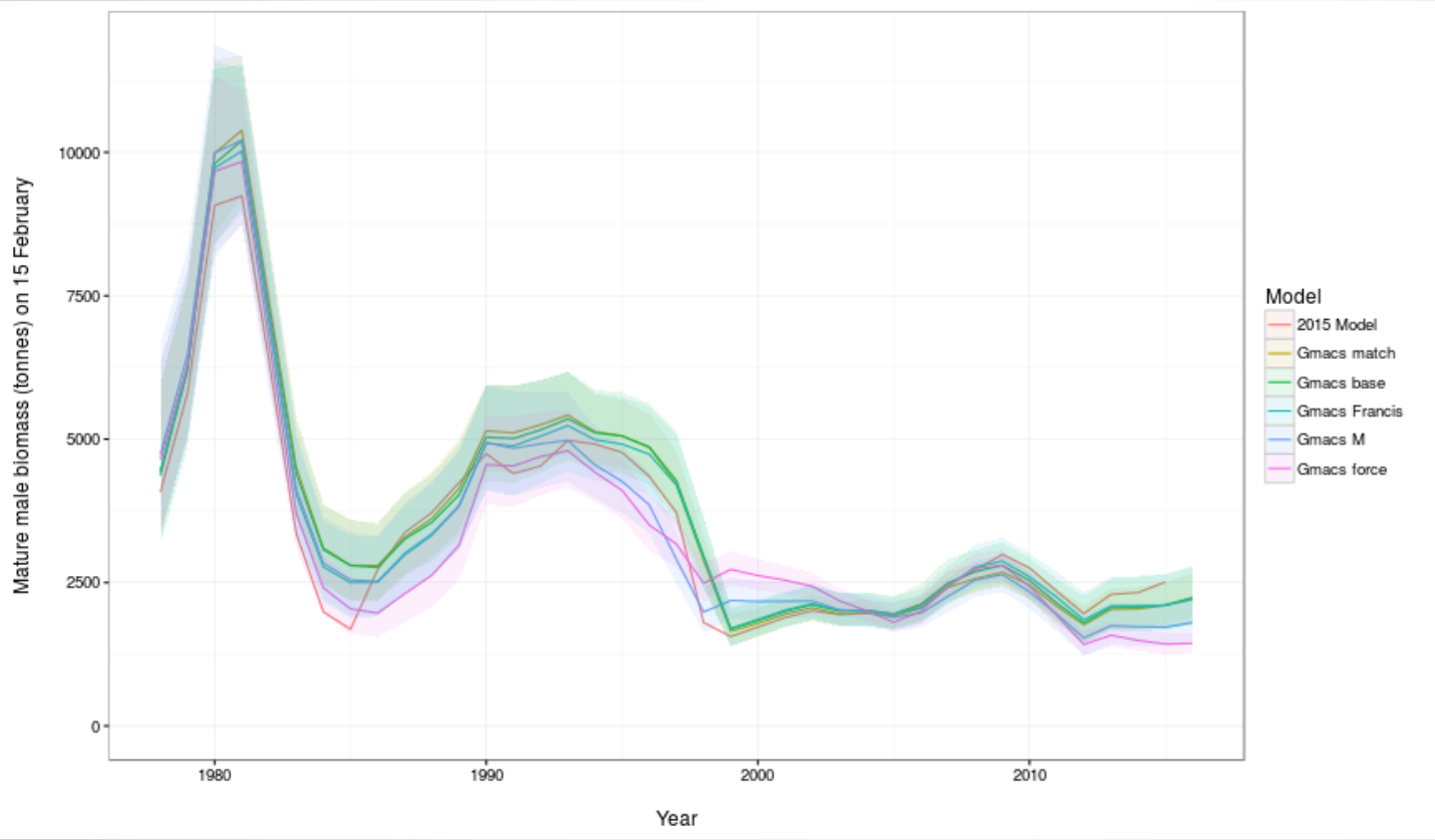


Table 18: Comparisons of model parameter estimates for the five Gmacs model scenarios.

Parameter	Match	Base	Francis	M	Force
ADF&G pot survey catchability (q)	-	3.967	3.881	4.573	4.129
$\log(\bar{F}^{\mathrm{df}})$	-1.519	-1.512	-1.483	-1.421	-1.335
$\log(\bar{F}^{\mathrm{fb}})$	-9.130	-9.147	-9.148	-9.056	-9.069
$\log(\bar{F}^{\mathrm{tb}})$	-12.228	-12.245	-12.245	-12.154	-12.168
$\log(\bar{R})$	13.390	13.399	13.394	13.245	13.110
$\log(n_1^0)$	14.894	14.860	14.836	14.836	14.785
$\log(n_2^0)$	14.477	14.524	14.544	14.608	14.600
$\log(n_3^0)$	14.285	14.224	14.235	14.280	14.255
log Stage-1 ADF&G pot selectivity	-	-0.856	-0.870	-0.812	-0.478
log Stage-1 directed pot selectivity 1978-2008	-	-0.713	-0.628	-0.510	-0.639
log Stage-1 directed pot selectivity 2009-2015	-	-0.629	-0.512	-0.502	-0.223
log Stage-1 NMFS trawl selectivity	-	-0.203	-0.143	-0.063	-0.012
log Stage-2 ADF&G pot selectivity	-	-0.106	-0.050	-0.000	-0.000
log Stage-2 directed pot selectivity 1978-2008	-	-0.406	-0.423	-0.396	-0.507
log Stage-2 directed pot selectivity 2009-2015	-	-0.000	-0.000	-0.000	-0.000
log Stage-2 NMFS trawl selectivity	-	-0.000	-0.000	-0.000	-0.000
Natural mortality deviation in 1998/99 (δ_{1998}^{M})	1.668	1.669	1.675	-	-

Table 19: Comparisons of data weights, Francis LF weights (i.e. the new weights that should be applied to the LFs), SDNR values, and MAR values for the five Gmacs model scenarios. Note that in the Gmacs Francis, M and Force scenarios, the Francis LF weights and the LF weights applied to each size composition are the same as the size compositions have been re-weighted using the Francis method.

Component	Match	Base	Francis	M	Force
NMFS trawl survey weight	1.00	1.00	1.00	1.00	1.50
ADF&G pot survey weight	1.00	1.00	1.00	1.00	2.00
Directed pot LF weight	1.00	1.00	1.75	1.59	1.35
NMFS trawl survey LF weight	1.00	1.00	0.54	0.55	0.28
ADF&G pot survey LF weight	1.00	1.00	1.82	1.31	0.39
Francis weight for directed pot LF	1.72	1.75	1.75	1.59	1.35
Francis weight for NMFS trawl survey LF	0.54	0.53	0.54	0.55	0.28
Francis weight for ADF&G pot survey LF	2.17	2.22	1.82	1.31	0.39
SDNR NMFS trawl survey	1.44	1.41	1.35	1.54	2.26
SDNR ADF&G pot survey	3.95	3.87	3.79	3.79	6.02
SDNR directed pot LF	0.68	0.64	0.66	0.69	0.81
SDNR NMFS trawl survey LF	1.22	1.27	1.27	1.32	1.74
SDNR ADF&G pot survey LF	0.78	0.80	0.90	0.98	1.63
MAR NMFS trawl survey	1.06	1.10	1.14	1.27	1.69
MAR ADF&G pot survey	3.03	2.90	2.71	3.42	4.75
MAR directed pot LF	0.47	0.45	0.54	0.51	0.57
MAR NMFS trawl survey LF	0.55	0.55	0.68	0.69	1.04
MAR ADF&G pot survey LF	0.53	0.53	0.48	0.58	0.88

Table 20: Comparisons of negative log-likelihood values for the five Gmacs model scenarios.

Component	Match	Base	Francis	M	Force
Pot Retained Catch	-69.05	-69.19	-69.24	-69.06	-67.31
Pot Discarded Catch	6.44	6.00	6.19	5.72	8.25
Trawl bycatch Discarded Catch	-6.88	-6.88	-6.88	-6.88	-6.88
Fixed bycatch Discarded Catch	-6.85	-6.86	-6.86	-6.87	-6.86
NMFS Trawl Survey	-6.21	-7.60	-10.33	1.49	41.40
ADF&G Pot Survey CPUE	56.31	53.35	50.38	52.51	149.86
Directed Pot LF	-12.12	-12.98	11.30	11.75	14.80
NMFS Trawl LF	16.82	22.39	52.14	55.70	93.15
ADF&G Pot LF	-7.05	-6.49	0.35	1.38	12.65
Recruitment deviations	57.24	57.11	57.04	58.08	62.34
F penalty	14.49	14.49	14.49	14.49	14.49
M penalty	6.47	6.47	6.47	0.00	0.00
Prior	13.72	13.71	13.71	13.71	13.71
Total	63.34	63.53	118.76	132.02	329.59
Total estimated parameters	282.00	291.00	291.00	289.00	289.00

Table 10: Comparisons of management measures for the five Gmacs model scenarios. Biomass and OFL are in tonnes.

Component	Gmacs match	Gmacs base	Gmacs Francis	Gmacs M	Gmacs force
MMB_{2016}	2240.516	2229.091	2206.231	1804.758	1439.655
B_{MSY}	3681.513	3671.965	3597.328	3459.060	3325.722
F_{OFL}	0.089	0.088	0.089	0.073	0.057
OFL_{2016}	140.623	140.253	141.374	95.567	62.115
ABC_{2016}	112.499	112.203	113.099	76.454	49.692

Table 1: Status and catch specifications (1000 tonnes) (scenario **Gmacs base**). Notes: A - calculated from the assessment reviewed by the Crab Plan Team in September 2013, B - calculated from the assessment reviewed by the Crab Plan Team in September 2014, C - calculated from the assessment reviewed by the Crab Plan Team in September 2015, D - calculated from the assessment reviewed by the Crab Plan Team in September 2016.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2012/13	1.80^A	2.85^A	0.74	0.73	0.82	1.02	0.92
2013/14	1.50^B	3.01^B	0.00	0.00	0.00	0.56	0.45
2014/15	1.86^C	2.48^C	0.30	0.14	0.15	0.43	0.34
2015/16	1.84^D	2.11^D	0.19	0.05	0.05	0.28	0.22
2016/17		2.23^D				0.14	0.11

Table 2: Status and catch specifications (million pounds) (scenario **Gmacs base**).

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2012/13	4.0^A	6.29^A	1.630	1.616	1.81	2.24	2.02
2013/14	3.4^B	6.64^B	0.000	0.000	0.0006	1.24	0.99
2014/15	4.1^C	5.47^C	0.655	0.309	0.329	0.94	0.75
2015/16	4.0^D	4.65^D	0.41	0.105	0.105	0.62	0.49
2016/17		4.91^D				0.31	0.25

6. **Basis for the OFL**: Estimated mature-male biomass (MMB) on 15 February is used as the measure of biomass for this Tier 4 stock, with males measuring 105 mm CL or more considered mature. The B_{MSY} proxy is obtained by averaging estimated MMB over a specific reference time period, and current CPT/SSC guidance recommends using the full assessment time frame as the default reference period (Table 3).

Table 3: Basis for the OFL (1000 tonnes) (scenario **Gmacs base**).

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	γ	Basis for B_{MSY}	Natural mortality
2012/13	4a	3.56	5.63	1.56	0.18	1	1978-2012	0.18
2013/14	4b	3.06	3.01	0.98	0.18	1	1978-2013	0.18
2014/15	4b	3.28	2.71	0.82	0.14	1	1978-2014	0.18
2015/16	4b	3.71	2.45	0.66	0.11	1	1978-2015	0.18
2016/17	4b	3.67	2.23	0.61	0.09	1	1978-2016	0.18

Base

Table 1: Status and catch specifications (1000 tonnes) (scenario **Gmacs** [redacted]). Notes: A - calculated from the assessment reviewed by the Crab Plan Team in September 2013, B - calculated from the assessment reviewed by the Crab Plan Team in September 2014, C - calculated from the assessment reviewed by the Crab Plan Team in September 2015, D - calculated from the assessment reviewed by the Crab Plan Team in September 2016.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2012/13	1.80^{A}	2.85^{A}	0.74	0.73	0.82	1.02	0.92
2013/14	1.50^{B}	3.01^{B}	0.00	0.00	0.00	0.56	0.45
2014/15	1.86^{C}	2.48^{C}	0.30	0.14	0.15	0.43	0.34
2015/16	1.73^{D}	1.72^{D}	0.19	0.05	0.05	0.28	0.22
2016/17		1.8^{D}				0.1	0.08

Table 2: Status and catch specifications (million pounds) (scenario **Gmacs** [redacted]).

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2012/13	4.0^{A}	6.29^{A}	1.630	1.616	1.81	2.24	2.02
2013/14	3.4^{B}	6.64^{B}	0.000	0.000	0.0006	1.24	0.99
2014/15	4.1^{C}	5.47^{C}	0.655	0.309	0.329	0.94	0.75
2015/16	3.8^{D}	3.8^{D}	0.41	0.105	0.105	0.62	0.49
2016/17		3.98^{D}				0.21	0.17

6. **Basis for the OFL**: Estimated mature-male biomass (MMB) on 15 February is used as the measure of biomass for this Tier 4 stock, with males measuring 105 mm CL or more considered mature. The B_{MSY} proxy is obtained by averaging estimated MMB over a specific reference time period, and current CPT/SSC guidance recommends using the full assessment time frame as the default reference period (Table 3).

Table 3: Basis for the OFL (1000 tonnes) (scenario **Gmacs** [redacted]).

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	γ	Basis for B_{MSY}	Natural mortality
2012/13	4a	3.56	5.63	1.56	0.18	1	1978-2012	0.18
2013/14	4b	3.06	3.01	0.98	0.18	1	1978-2013	0.18
2014/15	4b	3.28	2.71	0.82	0.14	1	1978-2014	0.18
2015/16	4b	3.71	2.45	0.66	0.11	1	1978-2015	0.18
2016/17	4b	3.46	1.8	0.52	0.09	1	1978-2016	0.18

M

Table 1: Status and catch specifications (1000 tonnes) (scenario **Gmacs** [redacted]). Notes: A - calculated from the assessment reviewed by the Crab Plan Team in September 2013, B - calculated from the assessment reviewed by the Crab Plan Team in September 2014, C - calculated from the assessment reviewed by the Crab Plan Team in September 2015, D - calculated from the assessment reviewed by the Crab Plan Team in September 2016.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2012/13	1.80^{A}	2.85^{A}	0.74	0.73	0.82	1.02	0.92
2013/14	1.50^{B}	3.01^{B}	0.00	0.00	0.00	0.56	0.45
2014/15	1.86^{C}	2.48^{C}	0.30	0.14	0.15	0.43	0.34
2015/16	1.66^{D}	1.43^{D}	0.19	0.05	0.05	0.28	0.22
2016/17		1.44^{D}				0.06	0.05

Table 2: Status and catch specifications (million pounds) (scenario **Gmacs b**[redacted]).

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2012/13	4.0^{A}	6.29^{A}	1.630	1.616	1.81	2.24	2.02
2013/14	3.4^{B}	6.64^{B}	0.000	0.000	0.0006	1.24	0.99
2014/15	4.1^{C}	5.47^{C}	0.655	0.309	0.329	0.94	0.75
2015/16	3.7^{D}	3.15^{D}	0.41	0.105	0.105	0.62	0.49
2016/17		3.17^{D}				0.14	0.11

6. **Basis for the OFL**: Estimated mature-male biomass (MMB) on 15 February is used as the measure of biomass for this Tier 4 stock, with males measuring 105 mm CL or more considered mature. The B_{MSY} proxy is obtained by averaging estimated MMB over a specific reference time period, and current CPT/SSC guidance recommends using the full assessment time frame as the default reference period (Table 3).

Table 3: Basis for the OFL (1000 tonnes) (scenario **Gmacs** [redacted]).

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	γ	Basis for B_{MSY}	Natural mortality
2012/13	4a	3.56	5.63	1.56	0.18	1	1978-2012	0.18
2013/14	4b	3.06	3.01	0.98	0.18	1	1978-2013	0.18
2014/15	4b	3.28	2.71	0.82	0.14	1	1978-2014	0.18
2015/16	4b	3.71	2.45	0.66	0.11	1	1978-2015	0.18
2016/17	4b	3.33	1.44	0.43	0.09	1	1978-2016	0.18

Force