Norton Sound Red King Crab SAFE2017 Final Assessment OFL/ABC

January 17 2017

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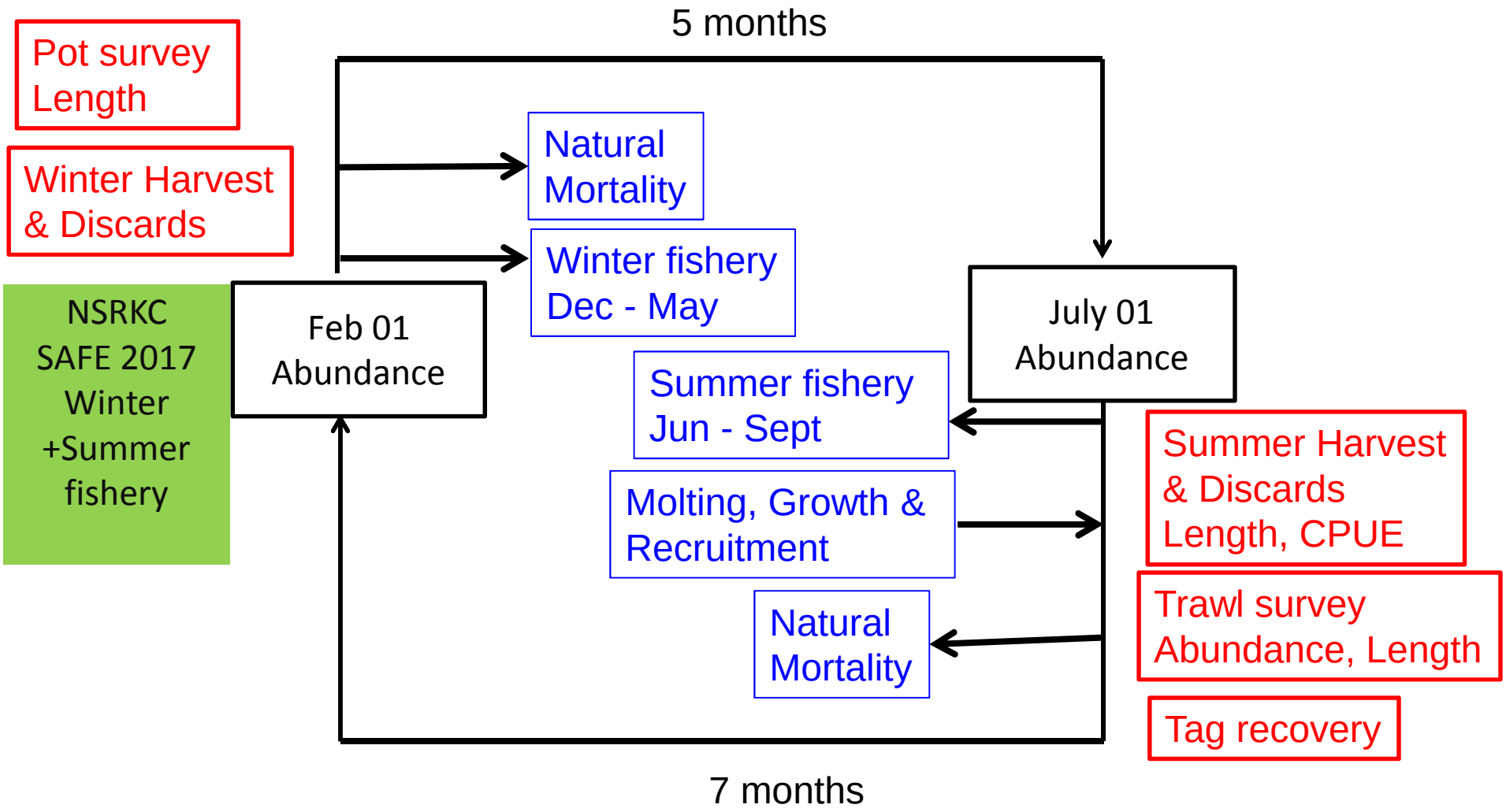
NSRKC Stock Assessment Model

Modeling process

Available Data & model fit



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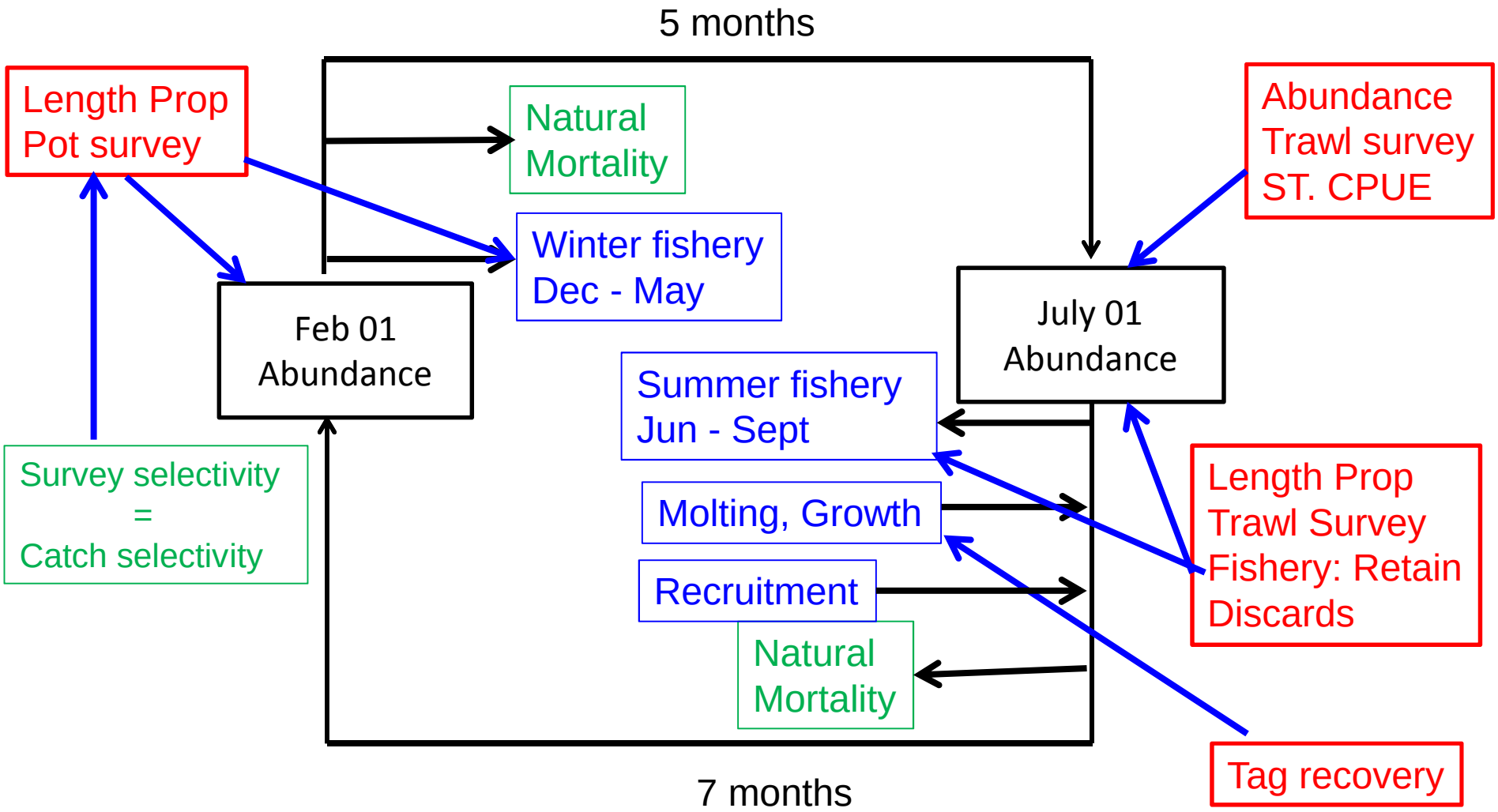


Available Data

	Abundance	Length comp	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Survey																																											
Trawl	Abundance	X																																									
Winter Pot		X																																								
Fishery																																											
Summer	CPUE, Catch	X																																									
Discards		X																																								
Winter	Catch																																										
Tagging		X																																									
Data Not Used																																											
Summer Pot	Abundance	X																																									
Prefishery		X																																									
Spring Tagging		X																																									
Fall Tagging		X																																									
Winter Commericial		X																																									

Assumptions

- M = 0.18 for length class 1-5, and 0.648 for class 6
- Same selectivity and catchability for New and Old Shells
- Discards mortality = 0.2
- Fishery harvests occur instantly:
  - Winter fishery: Feb 01: Nov – May
  - Summer fisher: July 01: Jun – Sept
- Winter catch selectivity = winter pot survey selectivity

Changes Fishery & Data

- Winter fishery 2016
  - Commercial: 29,792 (79,980 lb.) The highest ever.
  - Subsistence: 5,340 (13,350 lb.). About average.
- Summer commercial fishery 2015
  - 6/27-7/21: 138,997 (420,159 lb.)
- Total retained harvest: 168,789 (0.50 mill. lb.) < ABC (0.57 mill. lb.)
- All harvest data finalized.
- Standardized CPUE update (Appendix A2)
- Recalculation of com crab harvest during the trawl survey.
- ADMB code cleaning up underway
  - Discards estimate equation was bit wrong (changed < 10%).
- Changes in fishery regulation: None

Changes Fishery & Data

- ADMB code cleaning up and revision
  - Discards estimate equation was bit wrong
  - Model description Appendix A

$$\text{Discards} = \text{Legal Catch}\,\frac{NS_f(\text{p.sublegal})}{NS_f(\text{p.legal})}\,DM \quad \text{(Correct)}$$

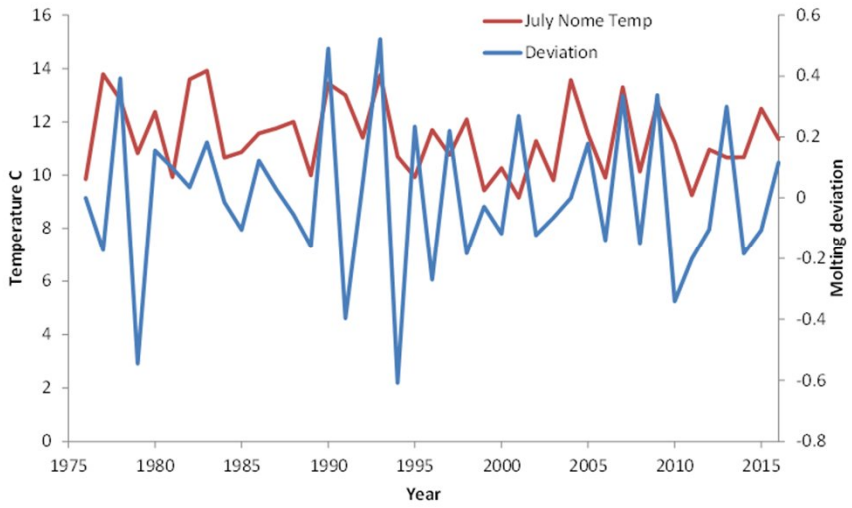
ADMB code

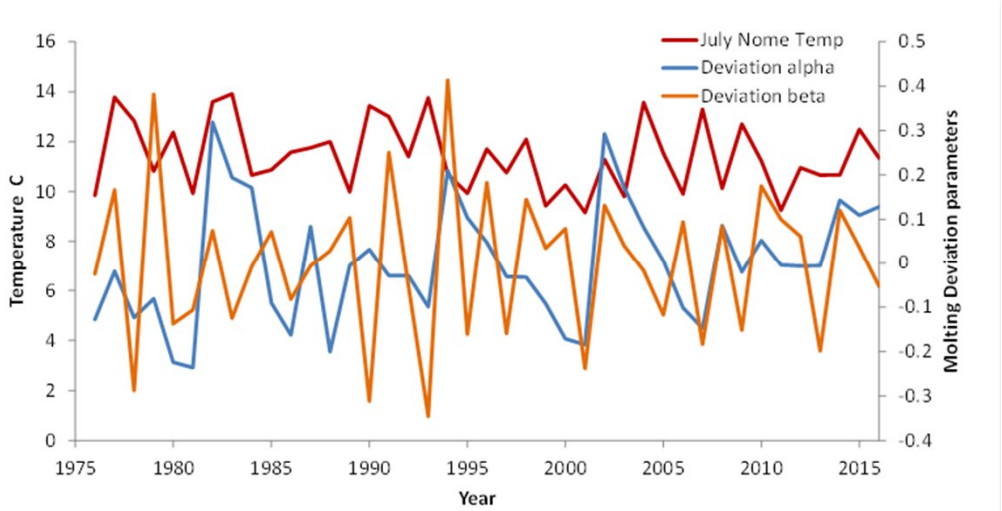
$$\text{Discards} = \text{Legal Catch}\,\frac{NS_f(\text{p.sub}-\text{legal})}{N\,(\text{p.legal})}\,DM \quad \text{(Wrong)}$$

Code was corrected for Jan 2017 SAFE Assessment

Responses to CPT-SSC

- Consider calculating molt probability for each size class. Don't set the molt probability for the smallest size class at 1.0.
  - Alt Model 1: with 2nd order smoothing penalty
  - Alt Model 3: Reverse logistic without constraints
- Explore for correlation between Model 2 random walk and temperature





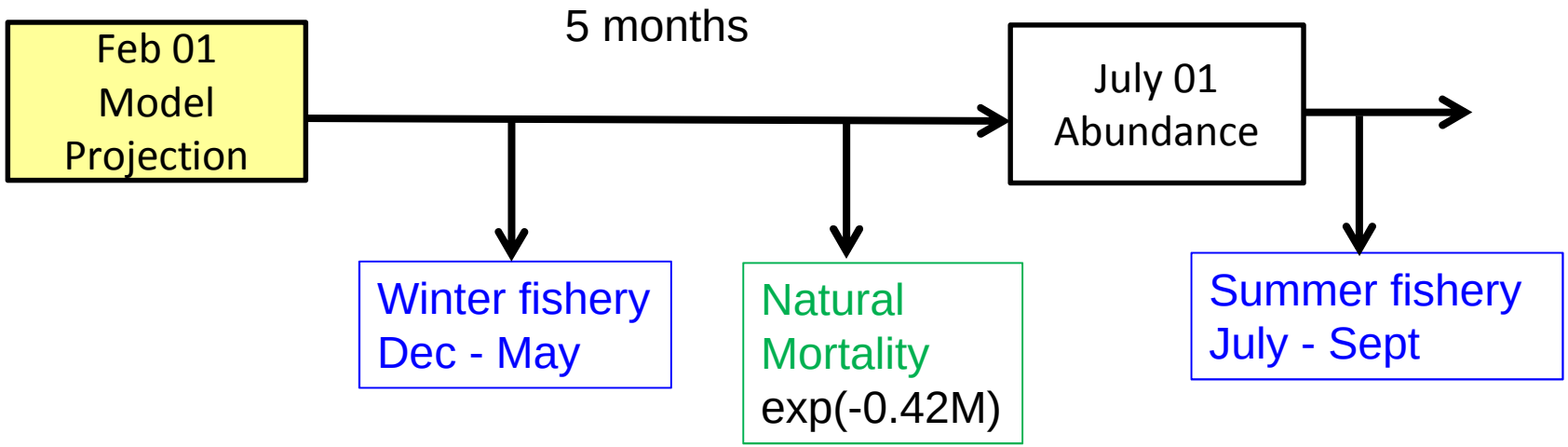
No correlations

NSRKC Major Modeling Issues

- Under the size invariant M=0.18, the model overestimate 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
    - Molting probability is not reverse log-normal
      - Alternative model 1, 2
    - Molting probability of the smallest size crab is not 1.0
      - Alternative model 3
    - Molting probability is not time invariant
      - Alternative model 4
    - Large sized crab move out of fishing-survey area
      - Alternative model 5
    - M is not 0.18
      - Alternative model 6

NSRKC Stock Assessment Model

OFL Issue



OFL = Winter + Summer fishery

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

How do we calculate B and OFL?

Revised OFL formula

- 2017 CPT-SSC proposed OFL formula: Assume p% of OFL from winter fishery (p: 8%, or average winter harvest %).
- Let B_w : Projected winter biomass, Winter mortality = exp(-0.42M), B_s : Projected summer biomass

$$OFL = (1-e^{-x\cdot F_{\tilde{o}\,\grave{o}}} \quad \acute{I}\ e^{-\acute{I}-\cdot F_{\tilde{o}\,\grave{o}}}\ V$$

$$\frac{\acute{I}-e^{-x\cdot F_{\tilde{o}\,\grave{o}}}}{OFL}H\ V \quad \acute{I}\ e^{-x\cdot F_{\tilde{o}\,\grave{o}}} \quad e^{-\grave{I}\ \ddot{I}\hat{I}\acute{O}}$$

$$\tilde{O}\ \grave{O} \quad \left[1-e^{-\ \tilde{o}\,\grave{o}\grave{I}\ \ddot{I}\hat{I}\acute{O}}-(1-e^{-\grave{I}\ \ddot{I}\hat{I}\acute{O}})\left(\frac{???\text{Æ}??-\ \tilde{O}\ \grave{O}\grave{I}\ \ddot{I}\hat{I}\acute{O}}{???\text{Æ}??-\grave{I}\ \ddot{I}\hat{I}\acute{O}}\right)\right]$$

$$\text{Ù W T Õ Ò Ü}$$

$$\text{Ò W W F} \quad \text{õ Ò H Ü} \quad \text{Ì Ï Î Ó}$$

$$\text{Õ Ò} \quad \text{Í } e^{-x\cdot F} \quad \text{Í } e^{-\text{Í} - \cdot F} \quad \text{v} \quad \frac{\text{Í}_{-?}^{-x\cdot F}}{???}$$

$$\text{v} \quad \text{Í } e^{-x\cdot F} \; e^{-Ü} \quad e^{-x\cdot F \; Ü}$$

$$\text{Õ Ò} \quad \text{Í } e^{-x\cdot F} \; e^{-(x\cdot F \; Ü} - e^{-(1-x)\cdot F} e^{-(x\cdot F \; Ü}]$$
$$\text{Í } e^{-x\cdot F} \; e^{-(x\cdot F \; Ü} - e^{-F \; Ü}]$$
$$\text{Í } e^{-F \; Ü} \; \text{Í } e^{-Ü} \; e^{-x\cdot F}$$

$$\frac{\text{Í}_{-?}^{-x\cdot F}}{???} \quad \frac{?_{-?}^{-x\cdot F}}{[\text{Í}_{-?}^{-F \; Ü} - \text{Í}_{-?}^{-Ü} \; ?^{-x\cdot F}} \quad e^{-x\cdot F} \; \frac{???\text{Á}??^{-F \; Ü}}{???\text{Á}_{-?}^{-Ü}}$$

$$\text{Õ Ò} \quad \text{Í } e^{-F \; Ü} \; \text{Í } e^{-Ü} \; \frac{???\text{Á}??^{-F \; Ü}}{???\text{Á}_{-?}^{-Ü}}$$

$$\text{Õ Ò} \quad \left[1 - e^{-} \; \text{Õ Ò Ì Ï Î Ó} - (1 -\right.$$

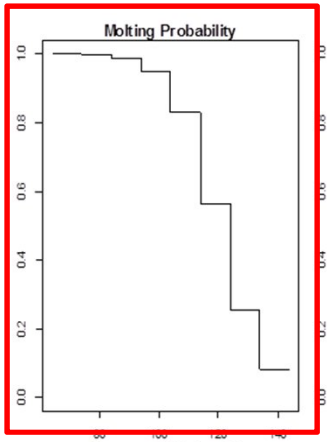
$$e^{-\text{Ì Ï Î Ó}}) \left(\frac{???\text{Á}??^{-} \; \text{Õ Ò Ì Ï Î Ó}}{???\text{Á}??^{-\text{Ì Ï Î Ó}}} \right) \Bigg]$$

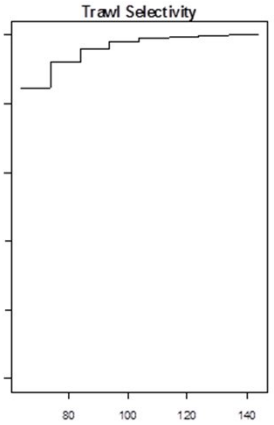
W WÙ Ó T V Î Ì Í N

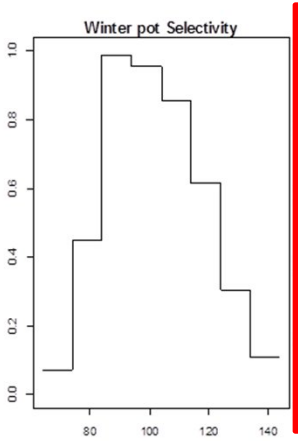
- W WÙ Ó T V
- Ó T ÌJM WÎÌ Í NÜ T OÙ V
- Ó T ÍJ NWWÙÜ W Ü WÙ ÙÙX U W W
- Ó T ÎJ Ó T Í Ó Ì Í W W V
- Ó T JÓ T ÌH ÙW W WÙV Ü WÙ Í Ì W VÜ WW W W
- Ó T ÏJ Ó T ÙW T Ü ÛÜ WÙ ÙÙX
- Ó T JÓ T Î WÙÜ W Ü TØ V WÙÙX U W W ÑÙT V
- Ó T JÓ T WÙÜ WÓ W W V OÙ WV X

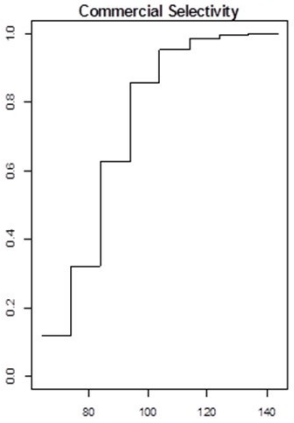
W WÙ Ó T Ì VÍ

Model 0

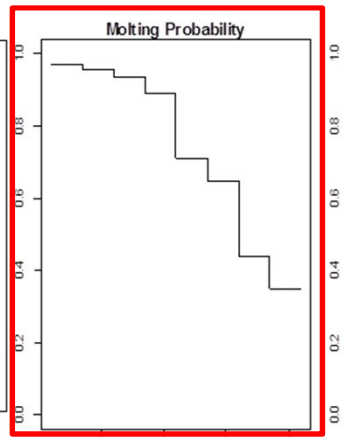


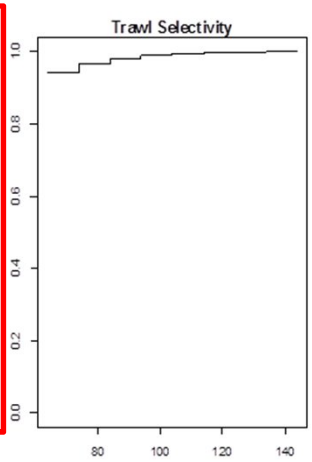


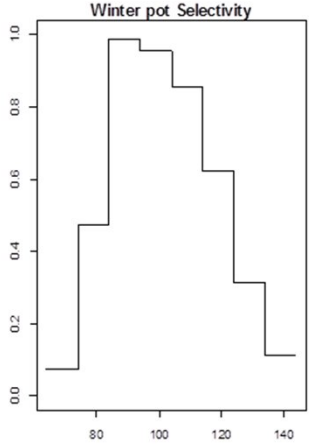


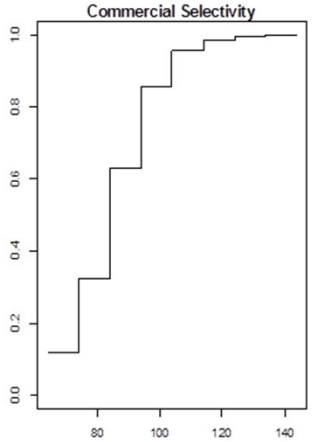


Model 1





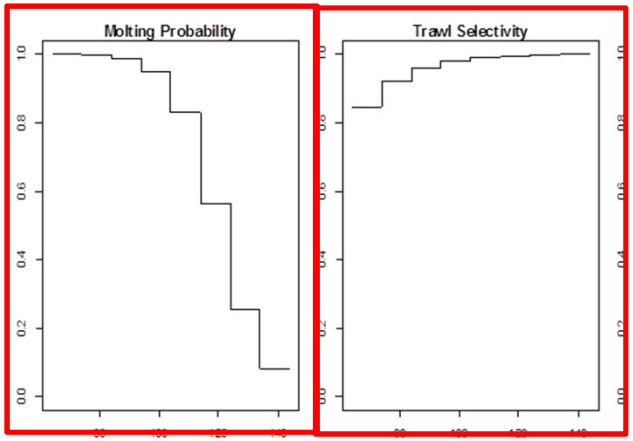




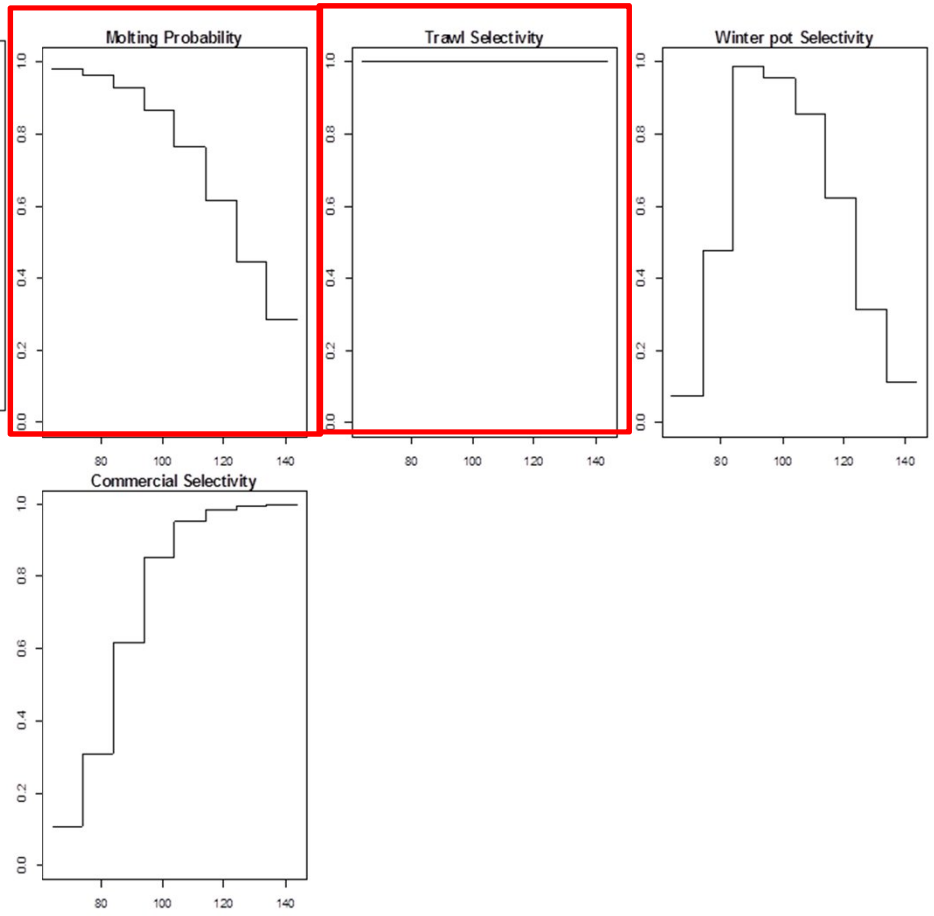
Slightly higher molting probability

W WÙ Ó T Ì V

Model 0



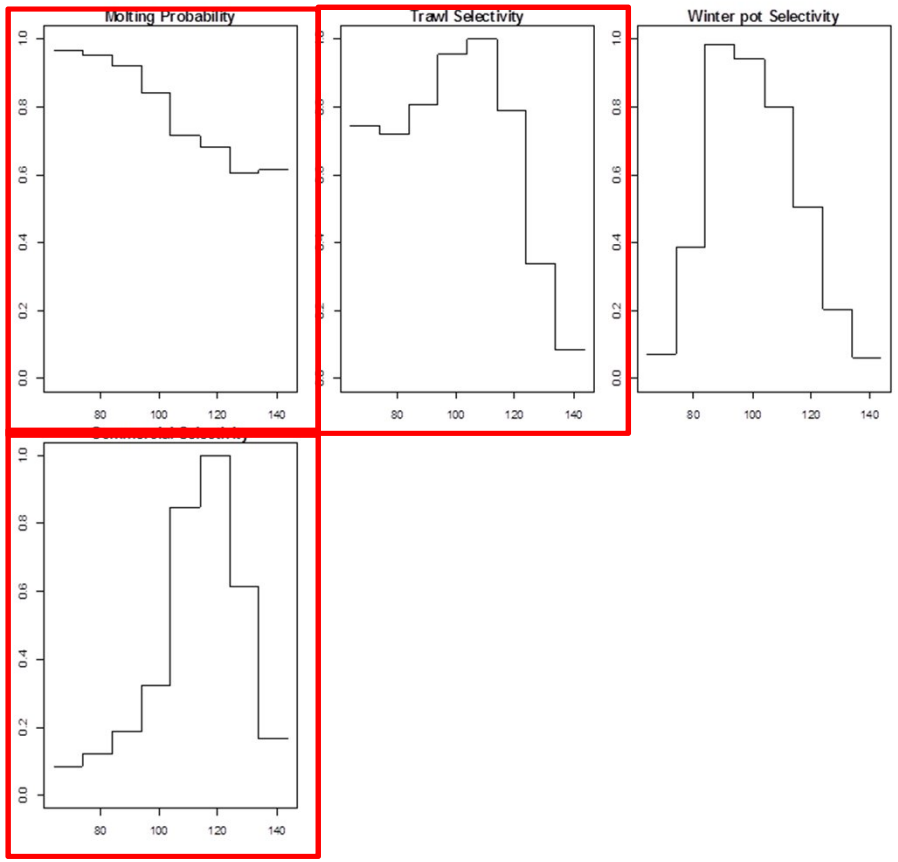
Model 3



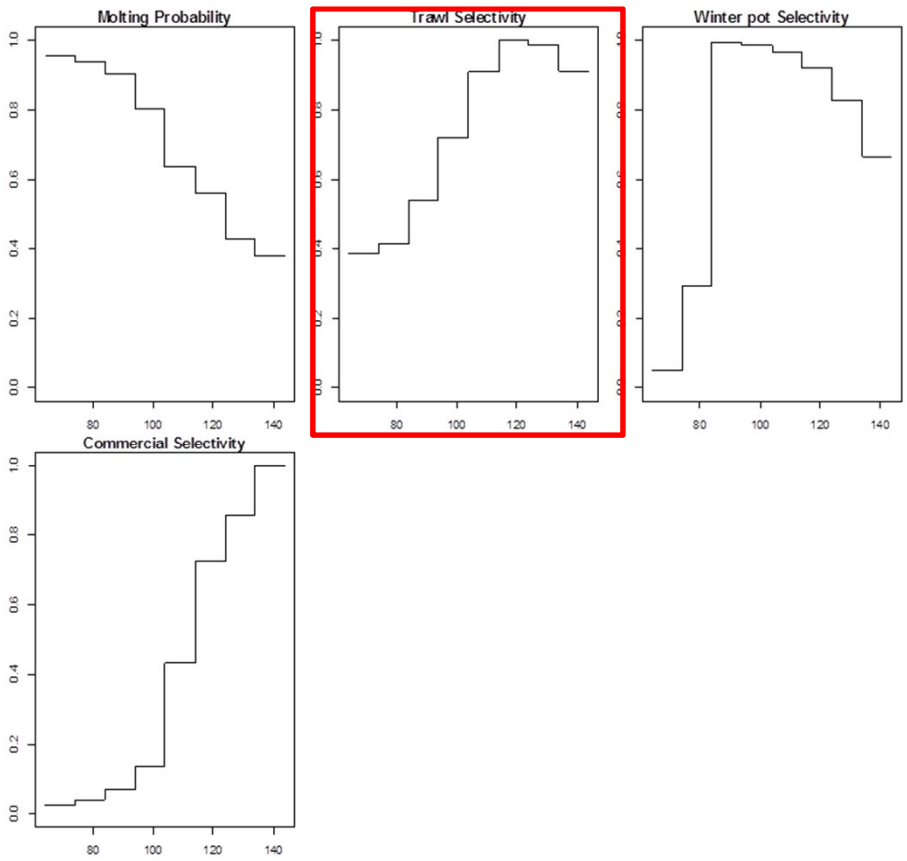
Slightly higher molting probability
Flat trawl selectivity

W WÙ Ó T T

Model 5 (Hide large crabs)



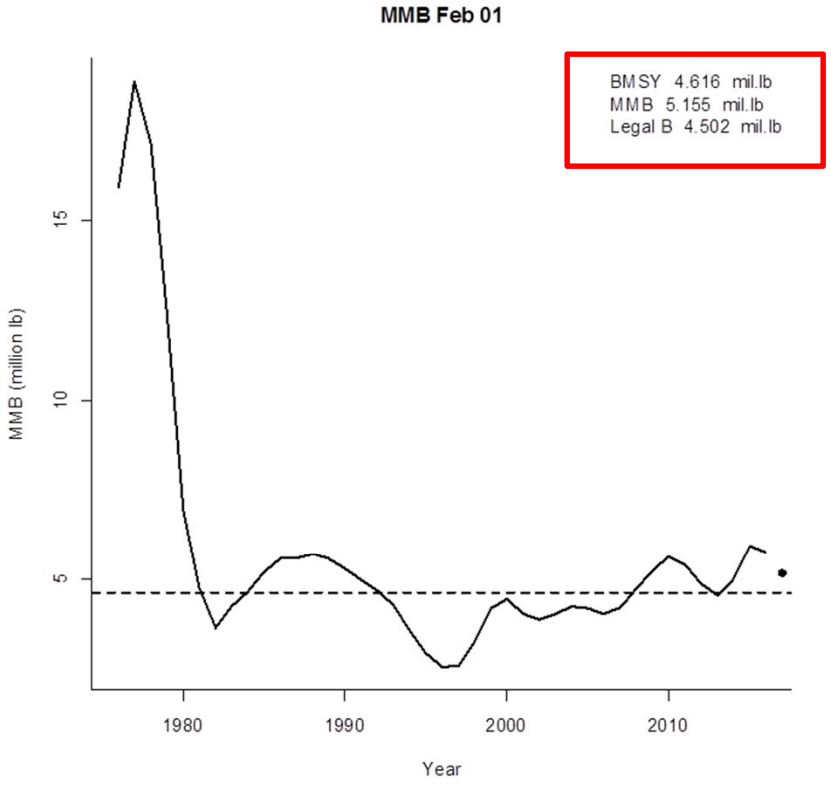
Model 6 (Kill all crabs equally)



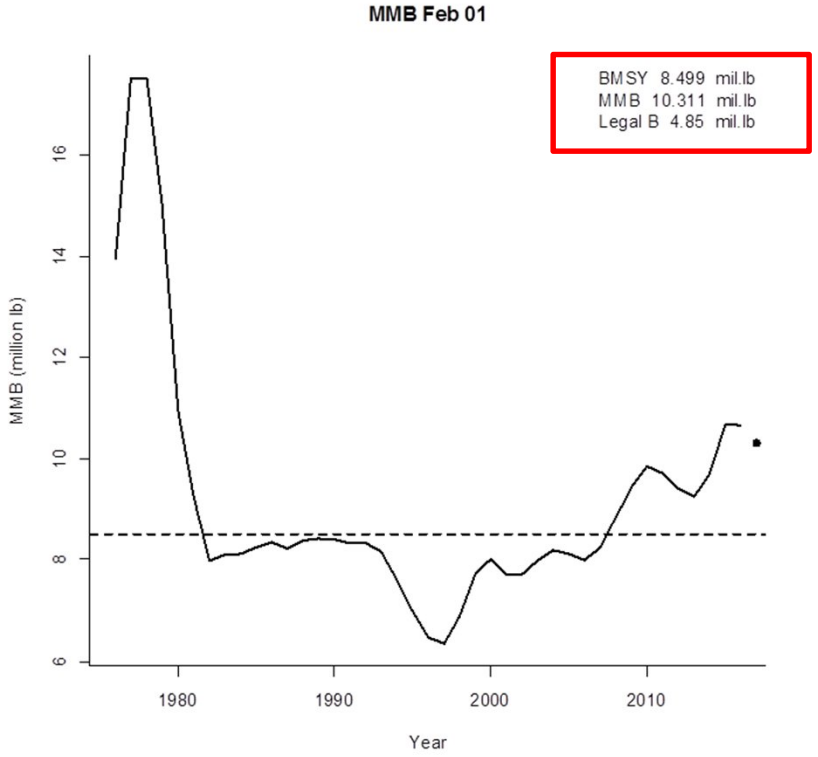
Higher molting probability
Dome shaped selectivity

W WÙ Ó T Ì V

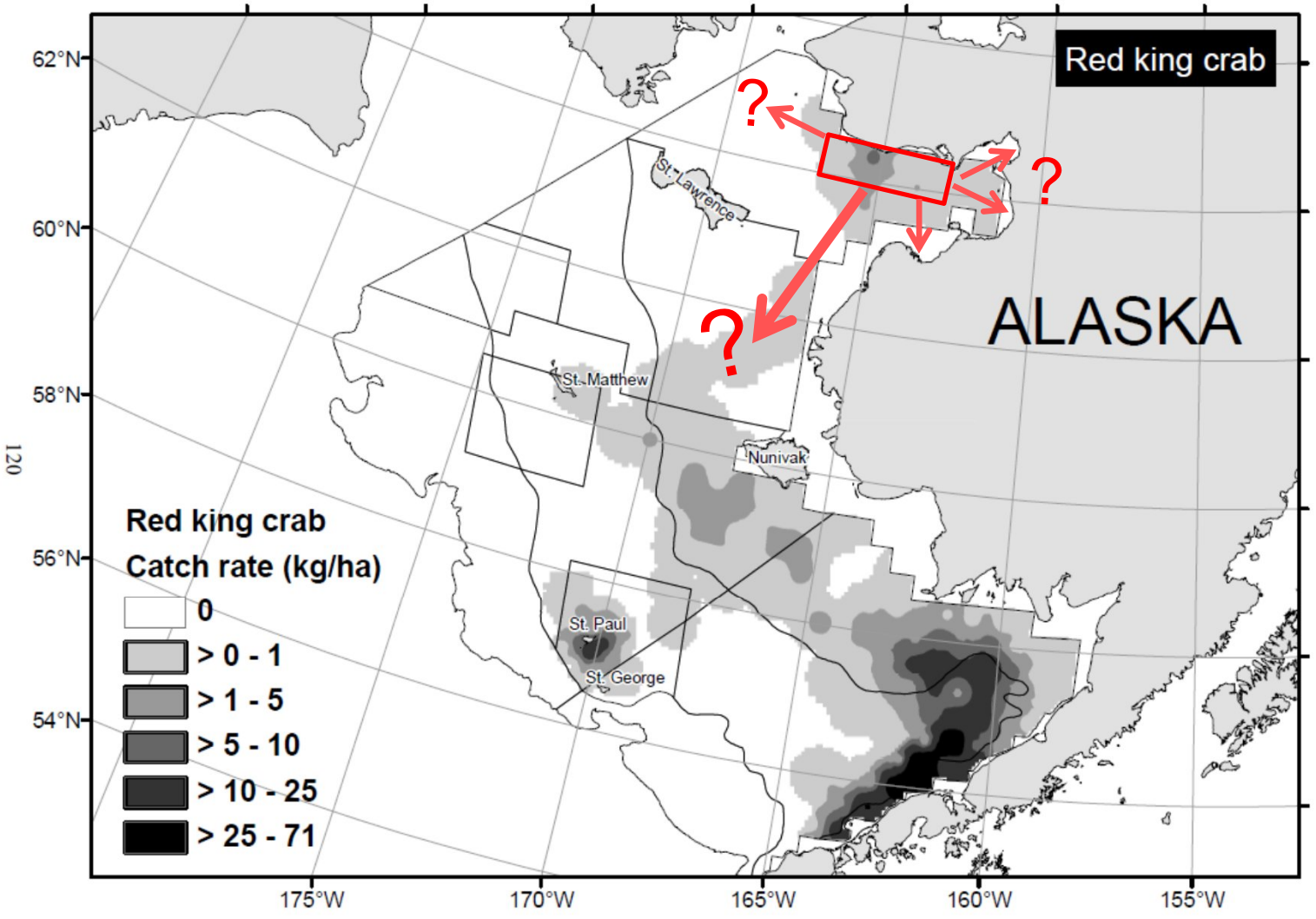
Model 0



Model 5

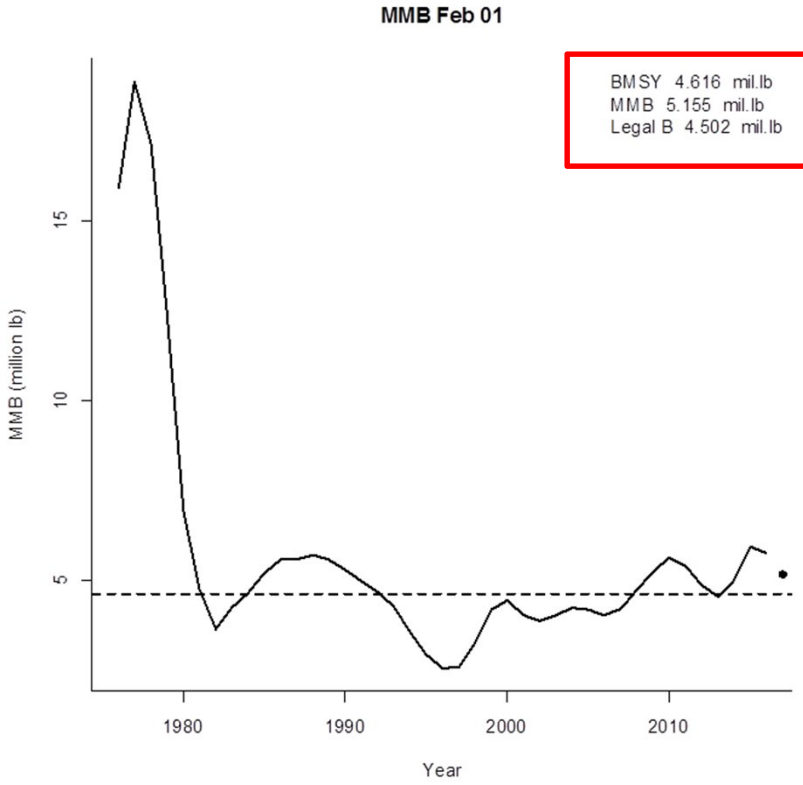


W ÜÙ WW W W WW Ó T ÙV WV
P U TÙT V

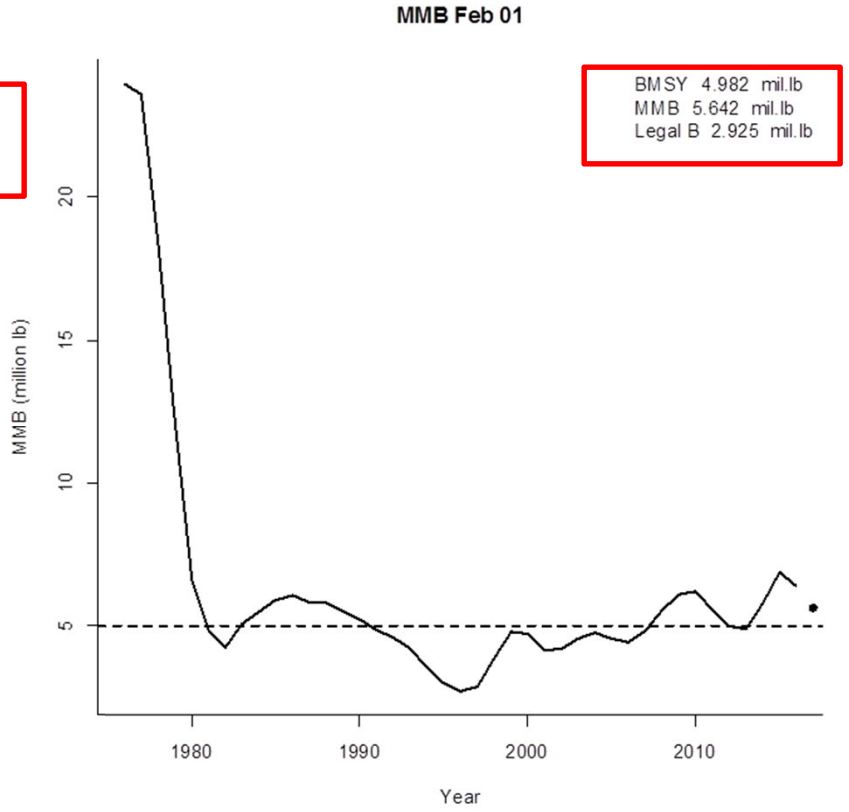


W WÙ Ó T Ì V

Model 0



Model 6



Ó T Ù TÙW WÙ ÎÌÍ N

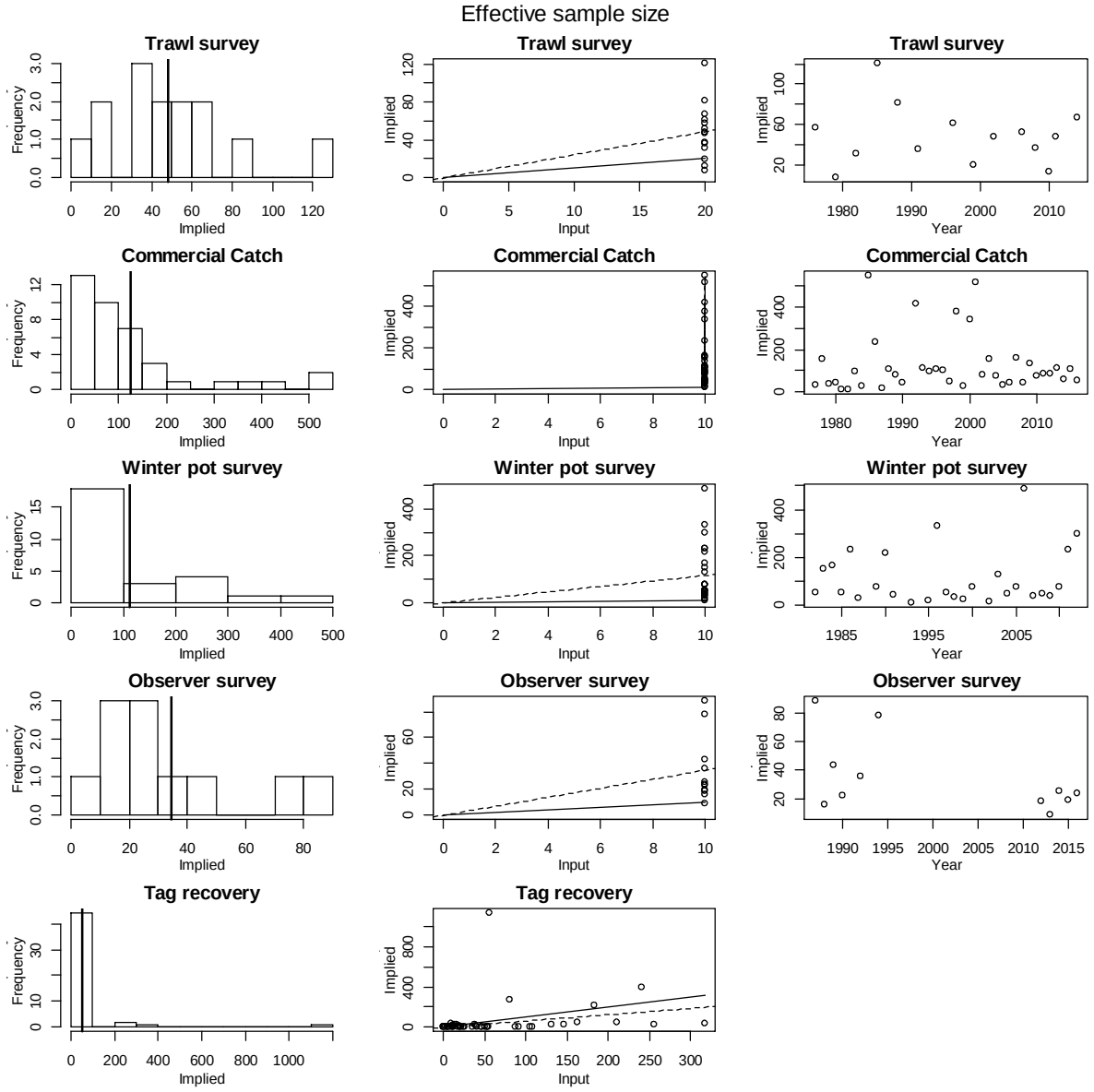
Model	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
No. Parameters	65	72	71	66	148	85	86
Total	311.9	266.8	317.3	271.5	208.3	272.1	252.0
TSA	9.1	9.2	14.3	9.1	8.8	6.7	9.5
St.CPUE	-22.7	-22.5	-22.0	-22.5	-22.3	-21.0	-22.1
TLP	104.3	83.7	98.4	82.8	47.2	80.8	76.0
WLP	42.5	38.5	38.5	39.3	37.4	46.4	43.6
CLP	79.0	47.9	69.3	48.5	36.8	51.0	47.0
OBS	32.2	22.9	22.0	22.8	12.2	29.9	20.2
REC	12.6	12.4	14.2	12.4	13.6	12.8	13.1
TAG	74.8	74.4	86.4	79.2	70.9	65.4	60.8
Smth		0.50	0.23			8.3	2.9
Mol.R					3.8		
MMB(mil.lb)	5.16	5.16	5.60	5.08	5.02	10.31	5.64
Legal (mil.lb)	4.50	4.44	5.05	4.35	4.45	4.85	2.93
OFL(mil.lb)	0.70	0.69	0.78	0.67	0.69	0.75	0.89

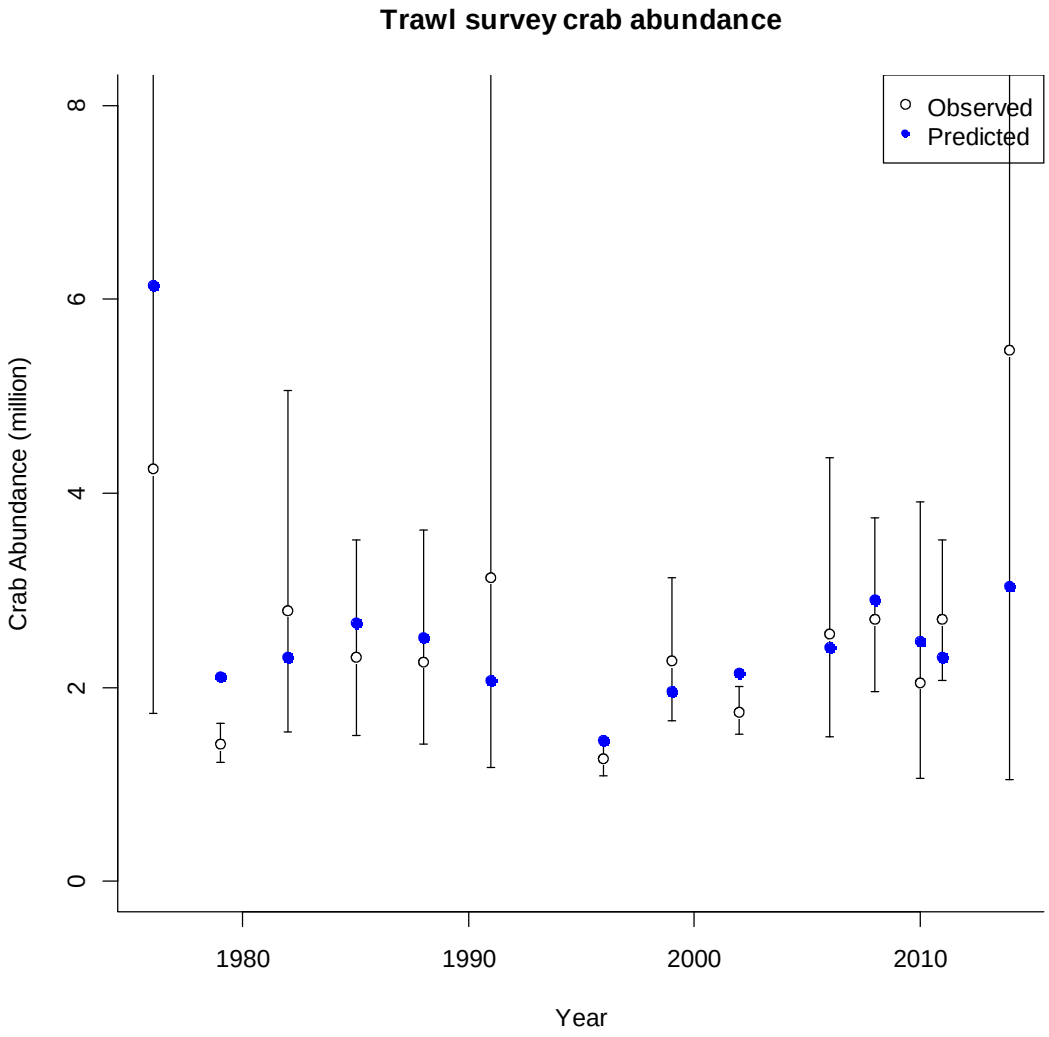
Ù Ó T WÙ

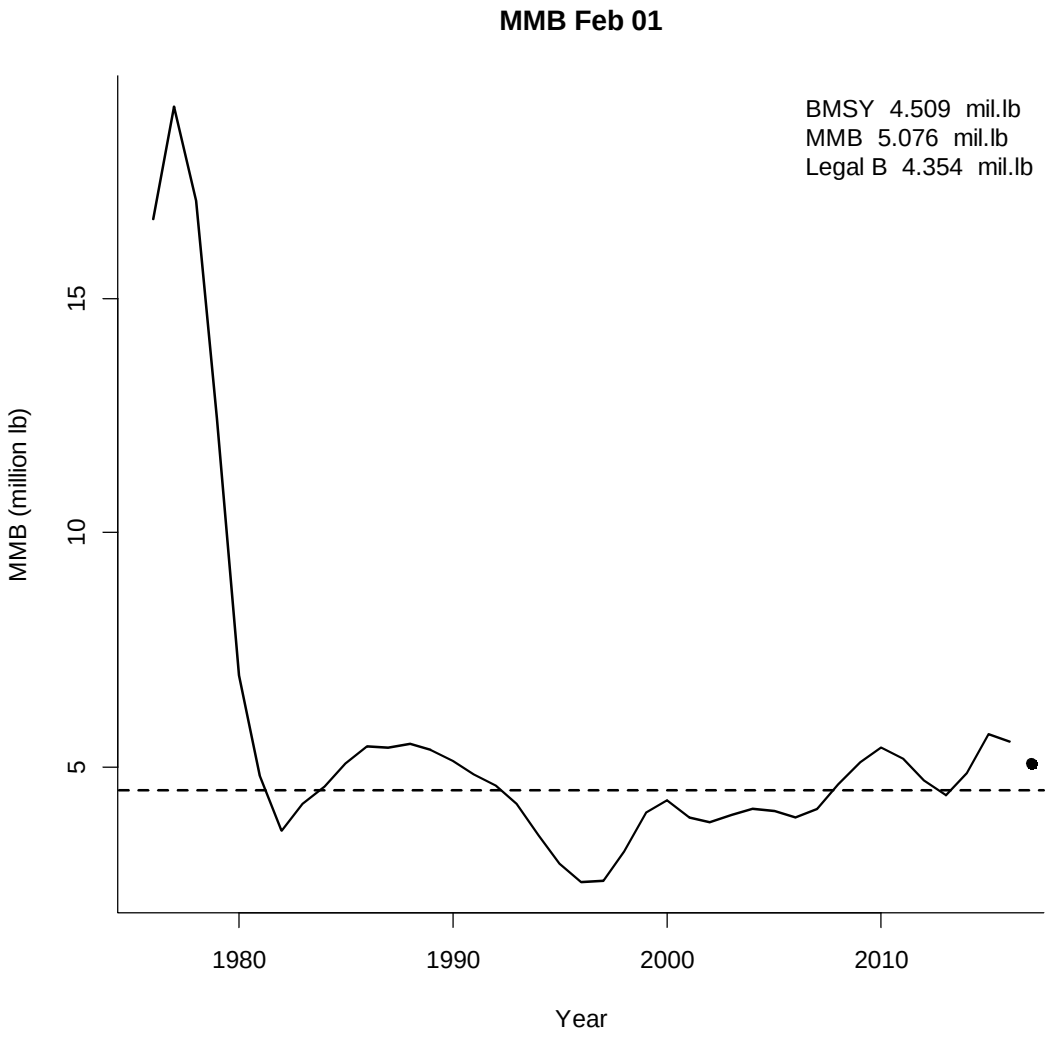
- VÙ H T ÙWW W WÙ ÙWV
  Ô W T TOÙ Ù UÙWW XWW W X ÙÛ XÙ
  W ÜV Ü T ÙW WÙ Ù X V

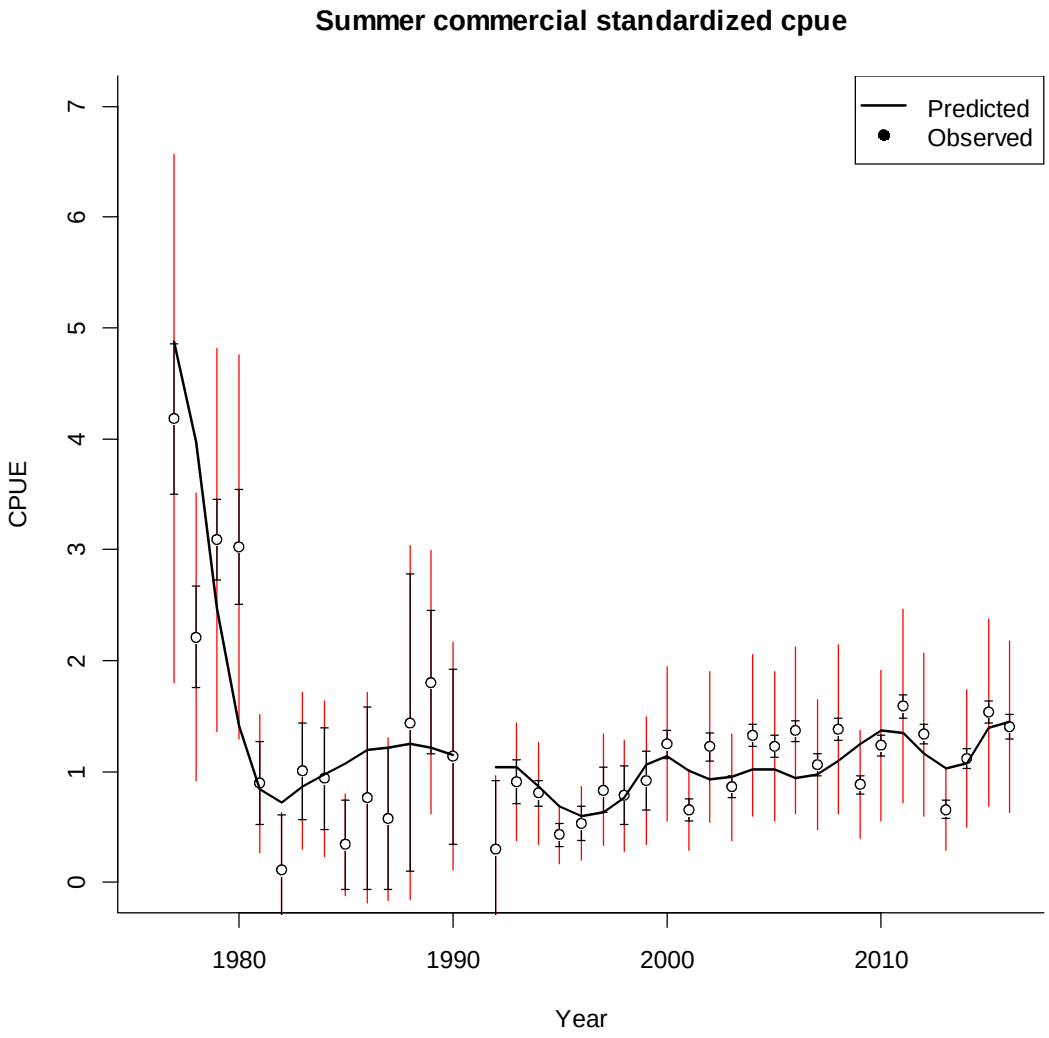
- Í Ï Ì WÙÜ VUÙU W Ü WÙX VÙY T
  Ó T VÌ HÍH
- Î Ò V VÙWÙ Ì ÓÓ Ü W Ô W
  T ÙWU X TV X Ó T
- Î WÙÜ VUÙU W Ü WÙX Ó Ì Ï Ï
  WV Ó T

W ÜÜ T WÙ Ó T
Ü W VH WÙ ÙÛ ÙW T

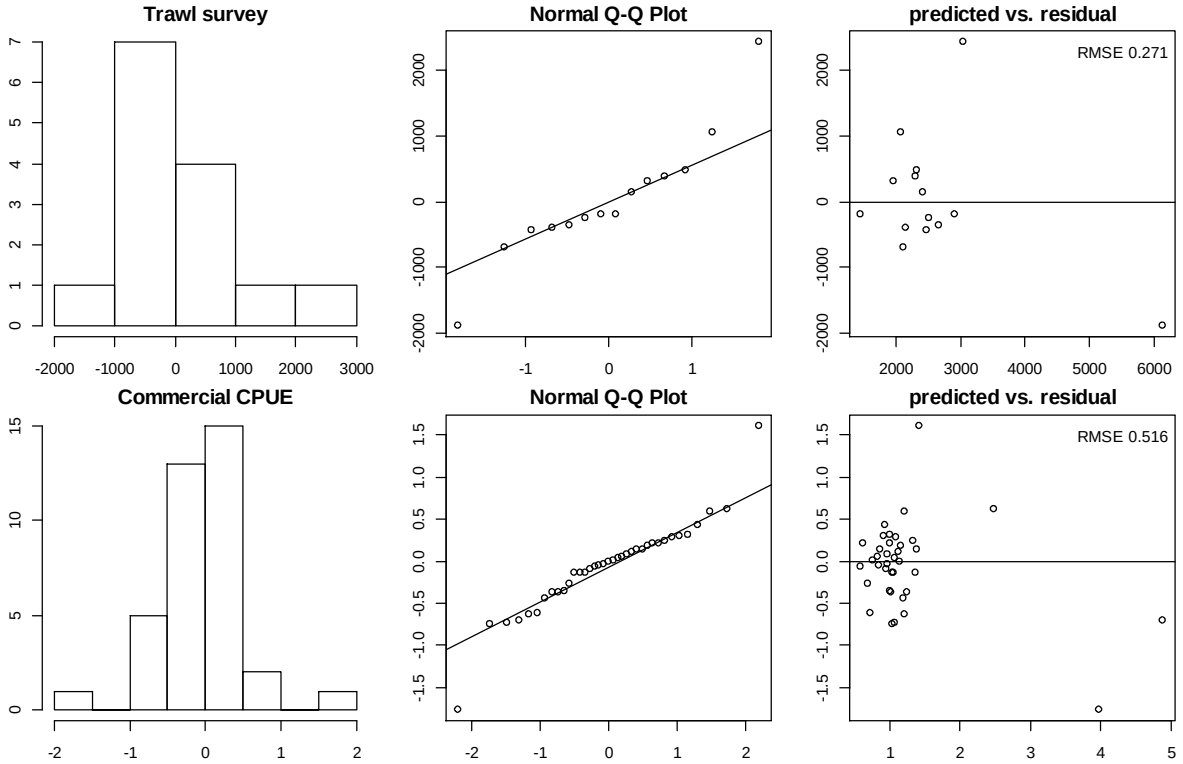

Effective sample size
Trawl survey
Frequency
Implied
Trawl survey
Implied
Input
Trawl survey
Implied
Year
Commercial Catch
Frequency
Implied
Commercial Catch
Implied
Input
Commercial Catch
Implied
Year
Winter pot survey
Frequency
Implied
Winter pot survey
Implied
Input
Winter pot survey
Implied
Year
Observer survey
Frequency
Implied
Observer survey
Implied
Input
Observer survey
Implied
Year
Tag recovery
Frequency
Implied
Tag recovery
Implied
Input

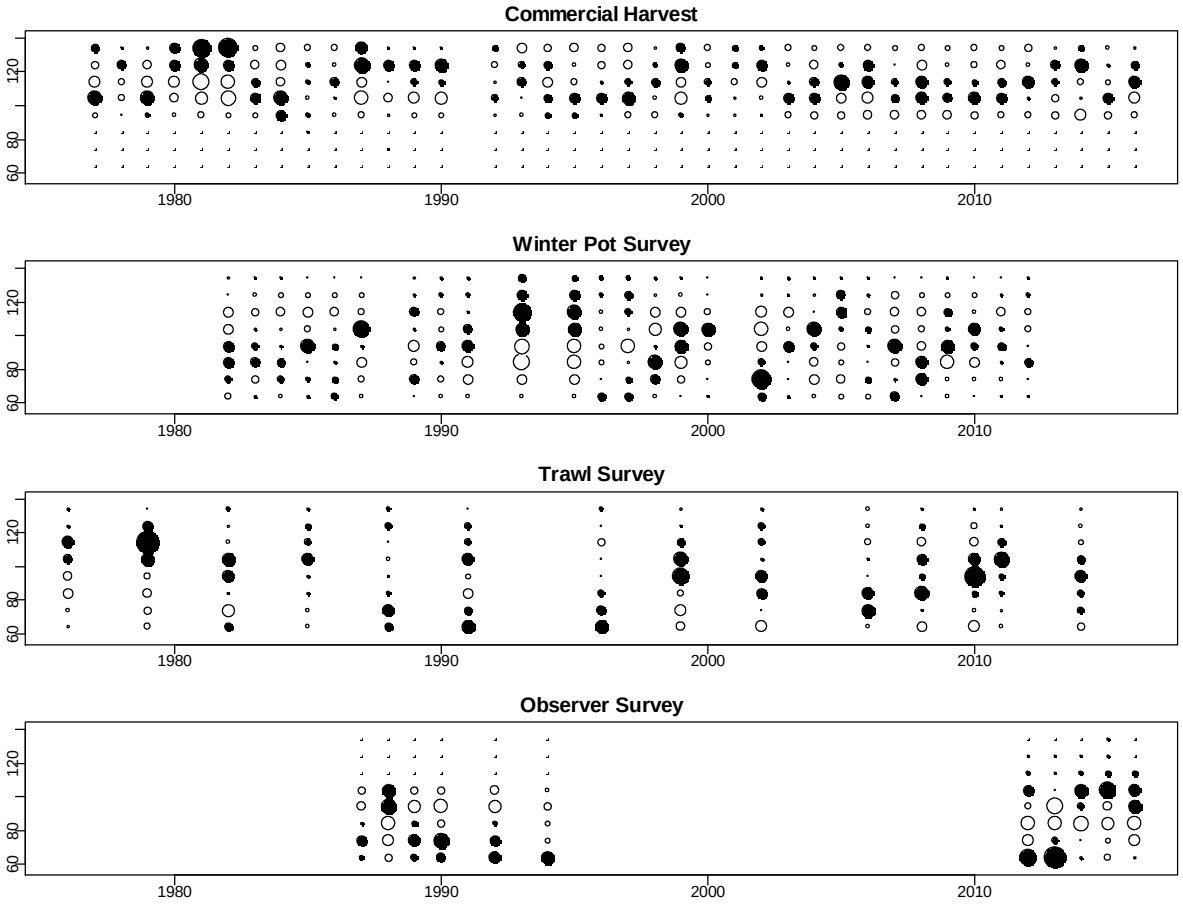

Trawl survey crab abundance
Observed
Predicted
Crab Abundance (million)
0
2
4
6
8
1980
1990
2000
2010
Year

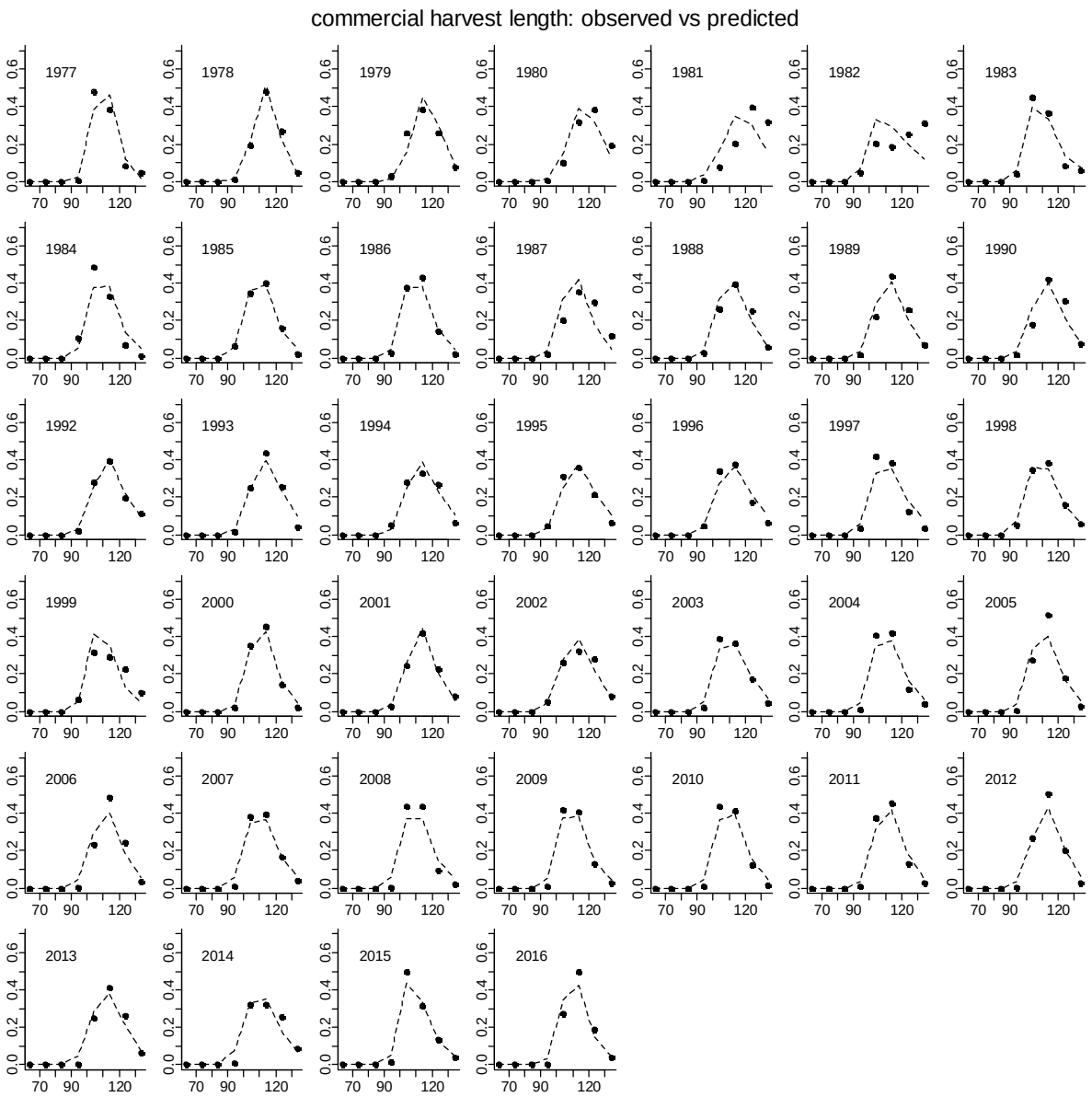

MMB Feb 01
BMSY 4.509 mil.lb
MMB 5.076 mil.lb
Legal B 4.354 mil.lb
MMB (million lb)
5
10
15
1980
1990
2000
2010
Year

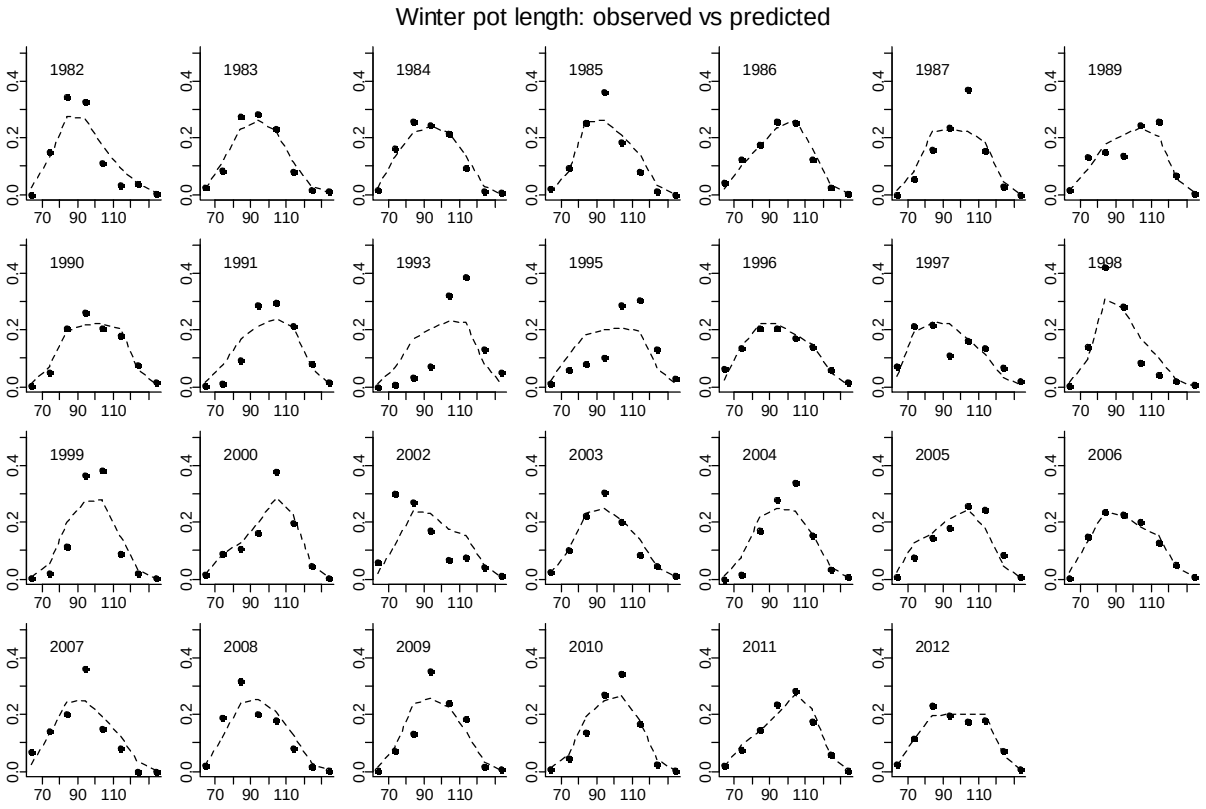

Summer commercial standardized cpue
Predicted
Observed
CPUE
0
1
2
3
4
5
6
7
1980
1990
2000
2010
Year

Residuals Histogram, Q-Q Plot, Predicted vs. Residual

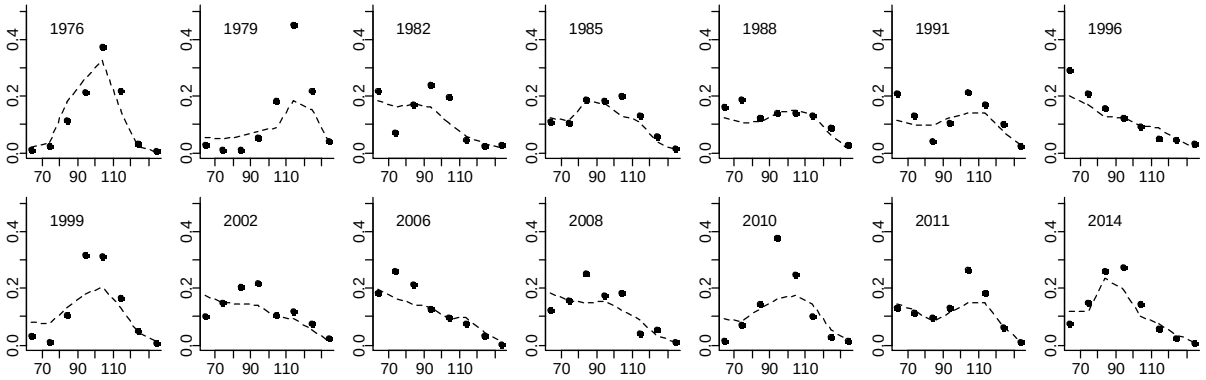



Commercial Harvest
Winter Pot Survey
Trawl Survey
Observer Survey
60
80
120
1980
1990
2000
2010

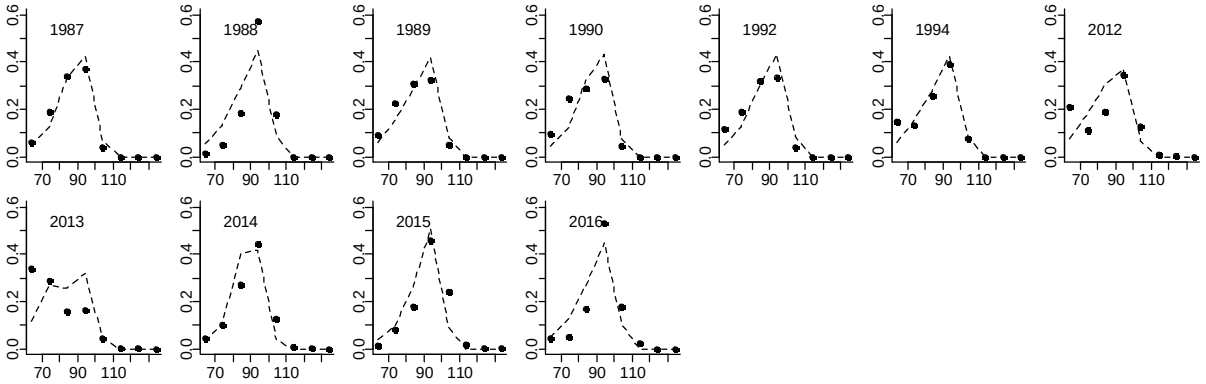

commercial harvest length: observed vs predicted
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
0.0
0.2
0.4
0.6
70
90
120

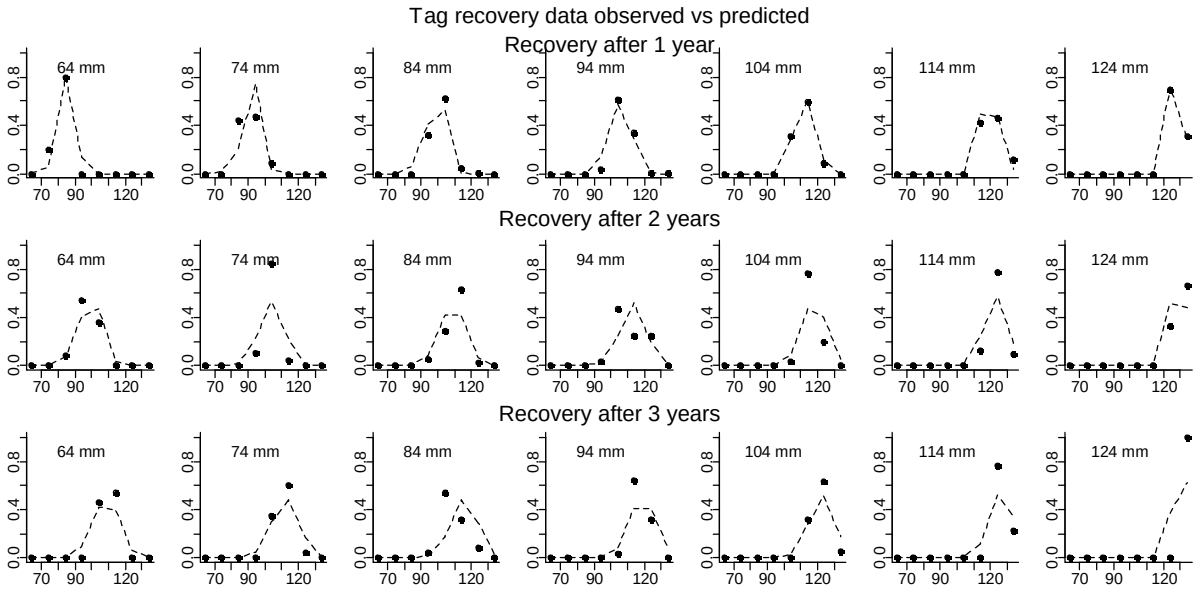

Winter pot length: observed vs predicted
1982
1983
1984
1985
1986
1987
1989
1990
1991
1993
1995
1996
1997
1998
1999
2000
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
0.0
0.2
0.4
70
90
110

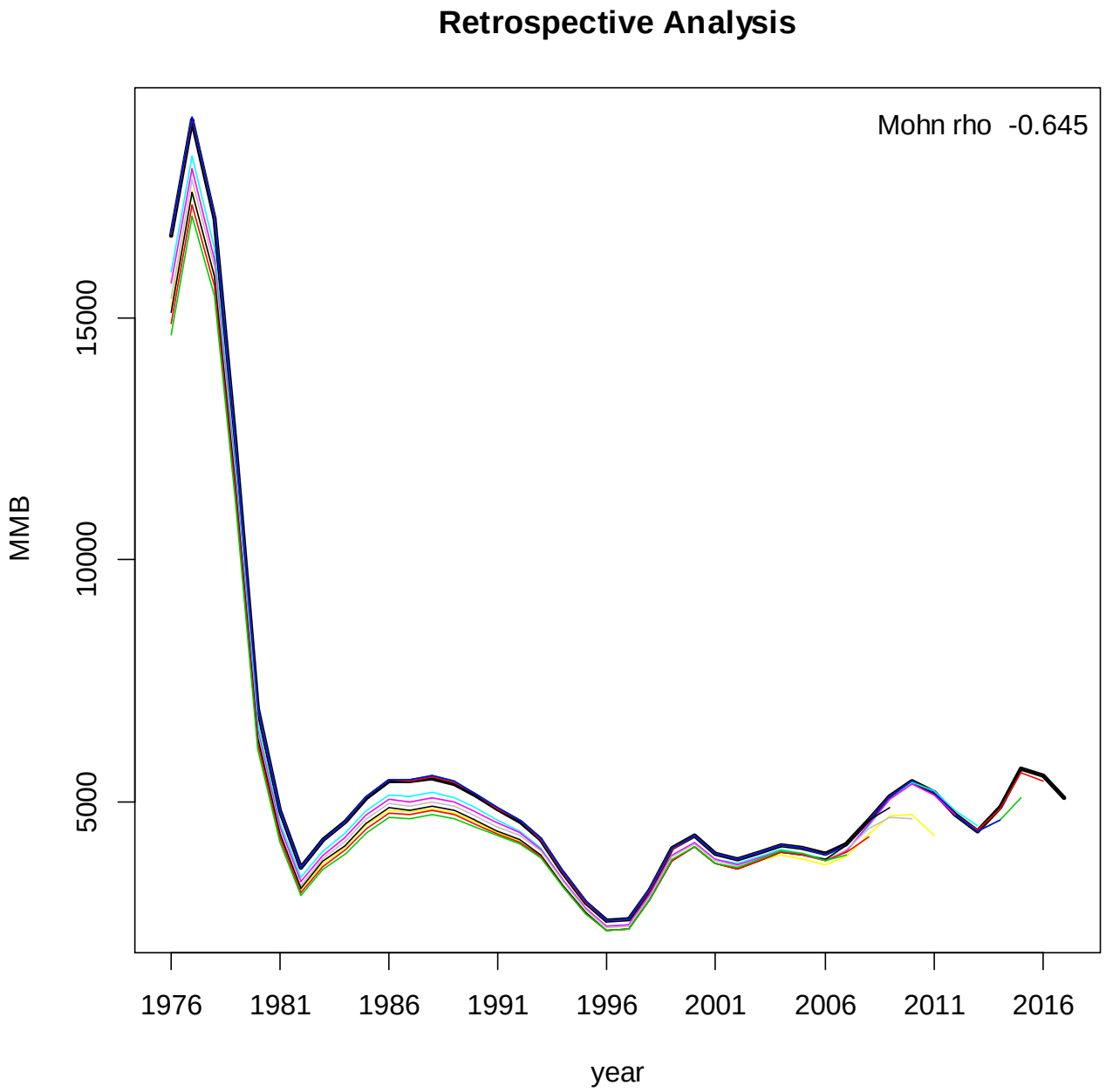
Trawl length: observed vs predicted



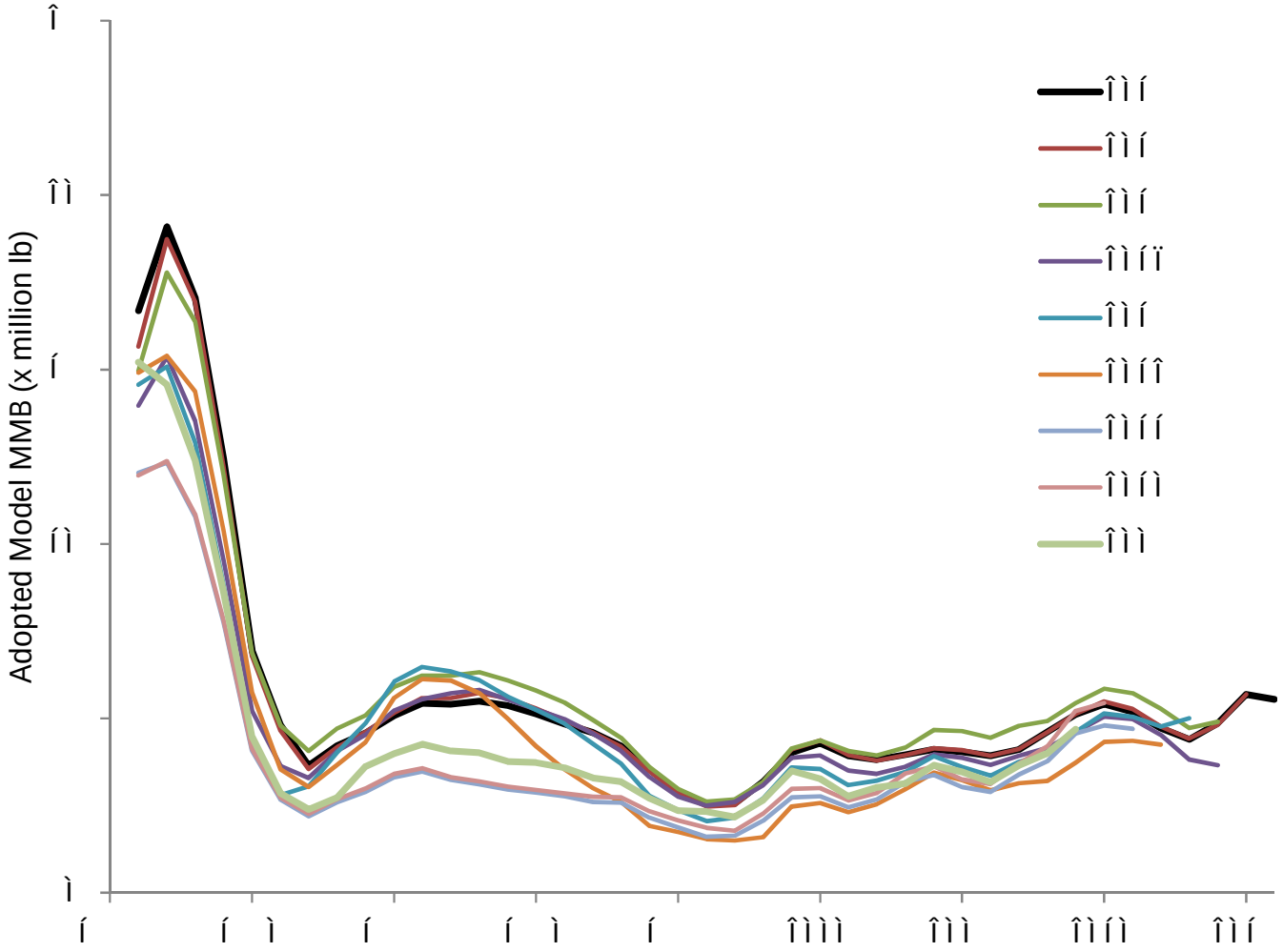
Discards length: observed vs predicted




Tag recovery data observed vs predicted
Recovery after 1 year
64 mm
74 mm
84 mm
94 mm
104 mm
114 mm
124 mm
Recovery after 2 years
64 mm
74 mm
84 mm
94 mm
104 mm
114 mm
124 mm
Recovery after 3 years
64 mm
74 mm
84 mm
94 mm
104 mm
114 mm
124 mm
0.0
0.4
0.8
70
90
120


Retrospective Analysis
Mohn rho -0.645
MMB
5000
10000
15000
1976
1981
1986
1991
1996
2001
2006
2011
2016
year

Assessment Model Historical Perspective



Õ ÒF

- ó QÖ x
  – ÓÓ Ü í ì îìí ï Î ÜÙÙ
- ÓÓ
  – ÓÓ Îìí íï ÜÙÙ
- ÓÓ L ó QÖ x J ØÙ Ï
- F_{OFL} *M* Ì Í
- Ò Ó ÙÜ W ÌíHÎìí JÏ Î MÌ
- Õ Ò ì ÜÙÙ
- ì Õ Ò ì Ï ÜÙÙ Ì Î Ï Í Ì Ì Ì W