ribilof Islands Red King Crab
PT comments May 2016

Continue the work on survey biomass and length frequency weighting issues to in the model fits to abundance data;

- Addressed in #2 below.

Implement the Francis tuning method to estimate length composition effective sa sizes;

- The Francis effective N calculation was added to the model. In addition, othe multipliers on the survey length frequencies were evaluated.

Provide results for a random effects model and three-year weighted average for t September meeting

- The random effects model was fit to the survey biomass data and MMB, OFL ABC estimated. The estimates using the three-year weighted average are also included.

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 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.

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 red king crab (biomass in tons)

	MSST	Biomass (MMB at mating)	TAC	Retained Catch	Total Catch	OFL	
0/11	2,255	2,754[A]	0	0	4.2	349	
1/12	2,571	2,775[B*]	0	0	5.4	393	
2/13	2,609	4,025[C**]	0	0	13.1	569	
3/14	2,582	4,679[D**]	0	0	2.25	903	
4/15	2,871	8,894[D**]	0	0	1.76	1,359	1
5/16	2,756	9,062[**]	0	0	0.32[1]	2,119	1

3 year running average of male biomass (>=120mm) at survey time was calculated using the weighted average with weights being the inverse of the variance,

$$BWRA_? = \frac{\sum_{??\,?}^{??\,?} \frac{MMB_?}{w_?}}{\sum_{??\,?}^{??\,?} \frac{1}{w_?}} \tag{4}$$

$MMB_?$	Estimated male biomass (>=120mm) from the survey data
$w_?$	The weight associated with the estimate of MMB in year t

$w_?$ is calculated as the variance of the log(biomass) using the CV estimates of MMB from the survey provided by the Kodiak lab:

$$w_? = \ln((CV_?^{?\ ?\ ?})^? + 1)$$

$CV_?^{?\ ?\ ?}$	Coefficient of variation associated with the estimate of MMB at

Random effects model Likelihood

$$\sum_{?? \; ?}^{? \; ??} \left\{ 0.5 \left(\log(2\pi\sigma_?^?) + \left(\frac{(\widehat{B_?} - B_?)^?}{\sigma_?^?} \right) \right) \right\} + \sum_{?? \; ?}^{? \; ??} \left\{ 0.5 \left(\log(2\pi\sigma_?^? \quad) + \left(\frac{(\widehat{B_?} - \hat{B}_{?? \; ?})^?}{\sigma_?^?} \right) \right) \right\}$$

log of observed biomass in year i

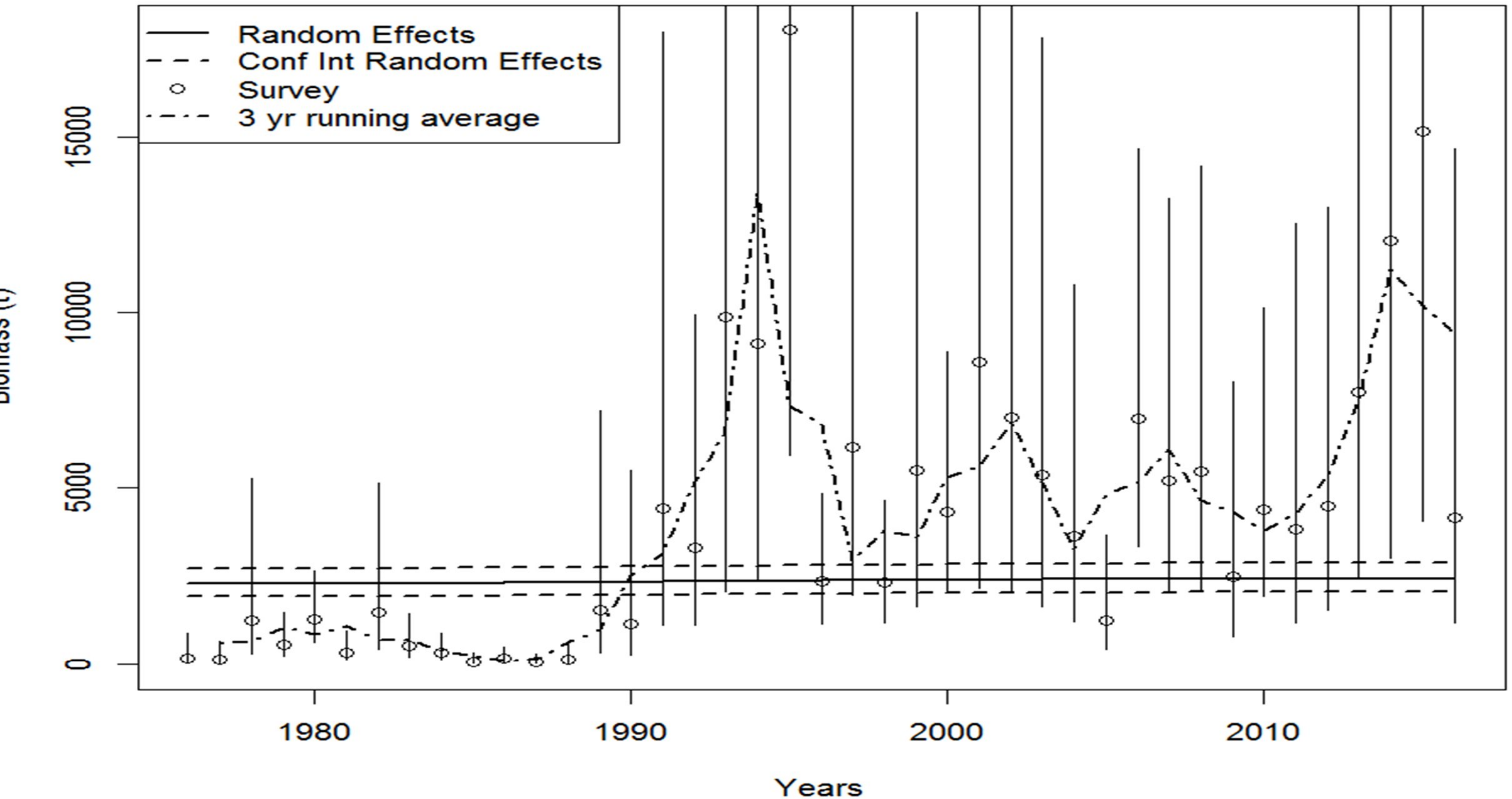
model estimated log biomass in year i

e variance of observed log biomass in year i

e variance of the deviations in log survey biomass between years (i.e. process error variance). $\sigma_?^?$ was estima
here α is a parameter estimated in the random effects model.

e number of years of survey biomass values

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



ure 14. Three-year running average and random effects model fit to male biomass > 120mm at surve
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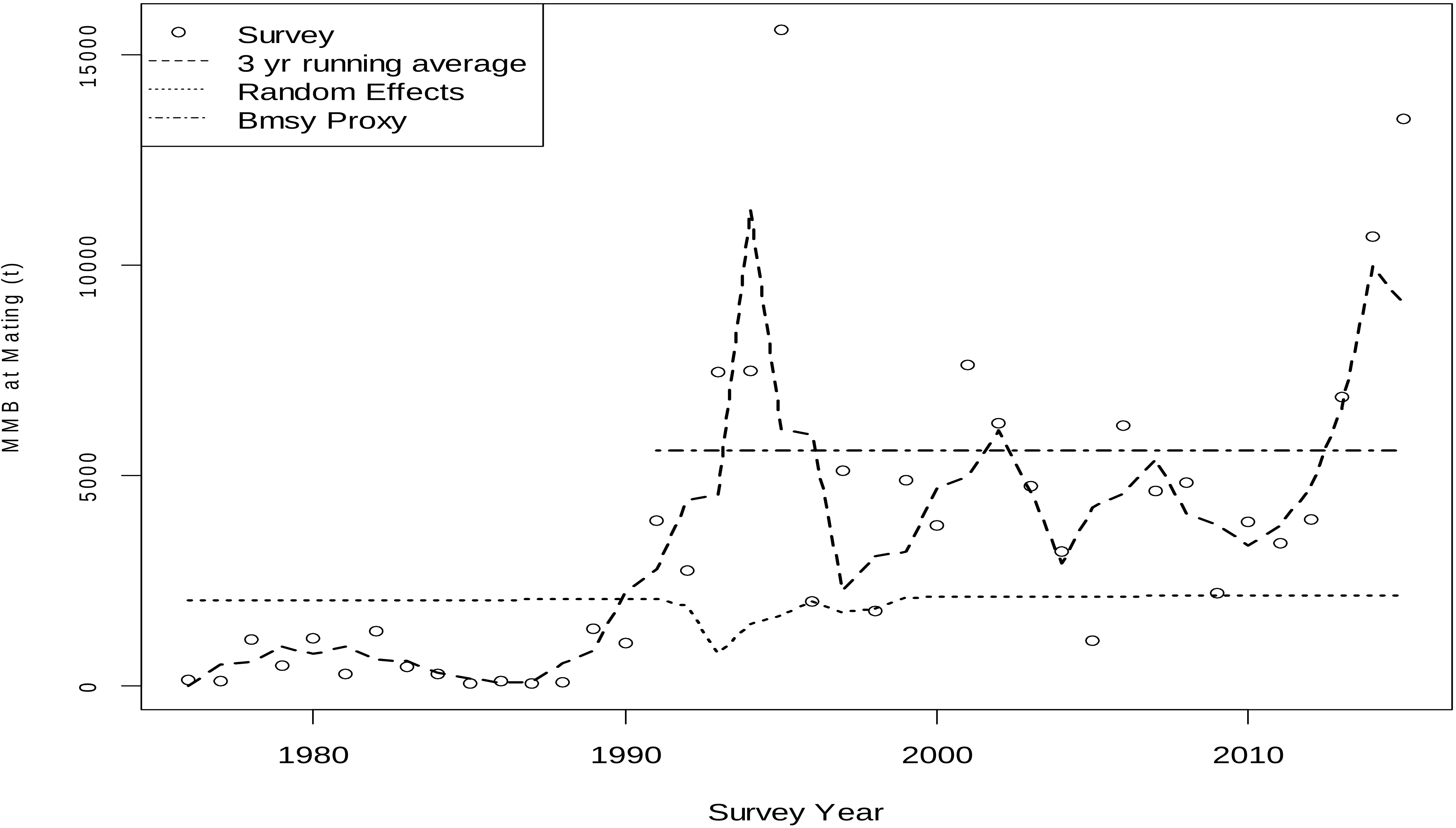
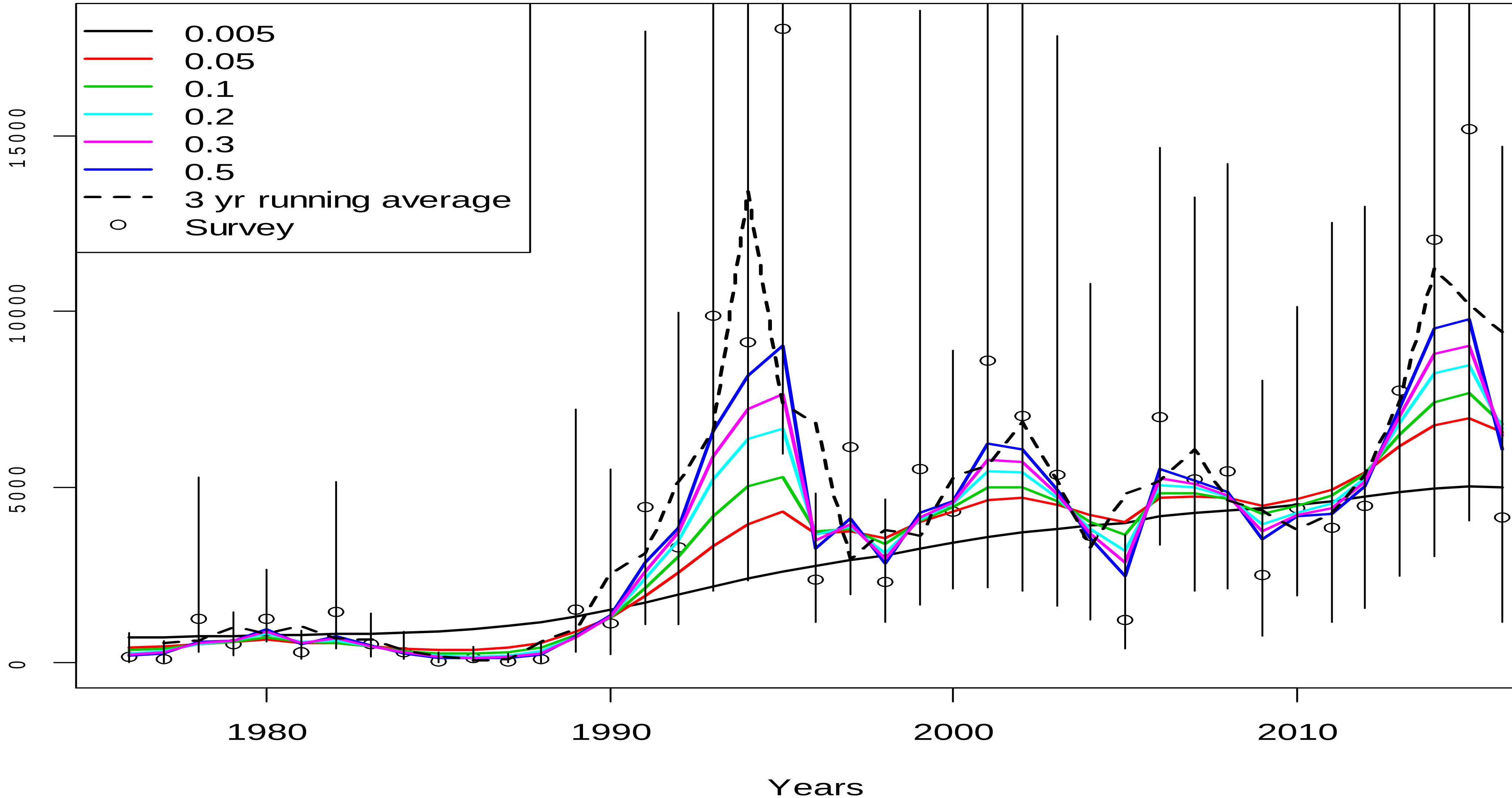


ure 15. MMB at mating (February 15 of survey year +1) estimated from the survey data, 3 yr running
rage and the Random effects model. Bmsy proxy is the average of the 1991 to 2015 MMB at mating
vey data (February 15 1992 to February 15 2016).

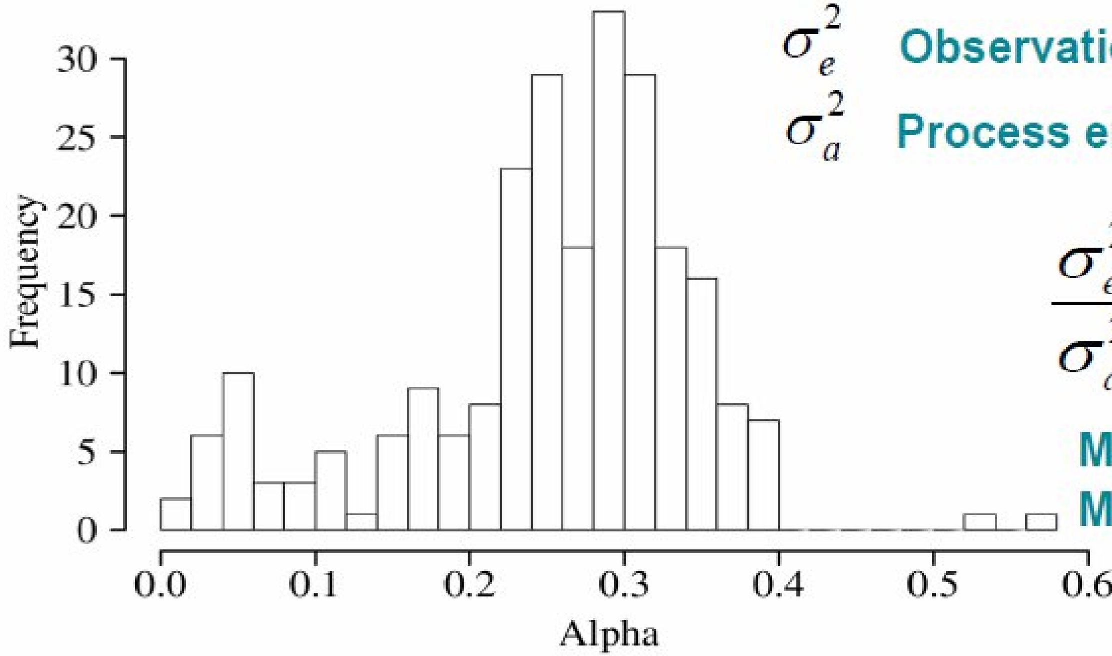


e 26. Random effects model estimates of biomass with process error fixed at 0.005, 0.05, 0.1,0.
.5.

From Spencer presentation at Wakefield 2015

A simple exponential smoothing model can give information on the ratio of variances

$$\hat{z}_t = (\alpha) y_t + (1-\alpha)\left[\alpha y_{t-1} + \alpha(1-\alpha) y_{t-2} + \alpha(1-\alpha)^2 y_{t-3} + \ldots\right]$$



σ_e^2 Observation error variance

σ_a^2 Process error variance

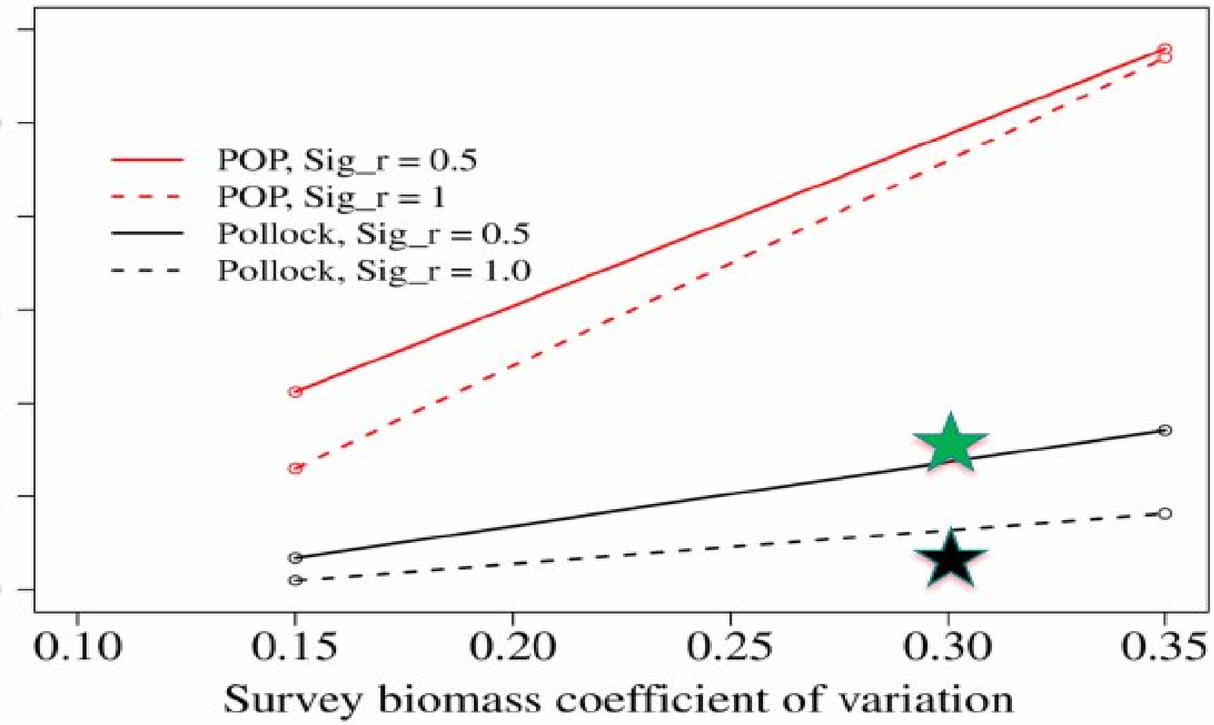
$$\frac{\sigma_e^2}{\sigma_a^2} = \frac{1-\alpha}{\alpha^2}$$

Mean α = 0.256

Mean ratio = 11.35

Spencer Wakefield 2015

he variance ratio is a function of stock longevity, ecruitment variability, and survey variability



Used as a prior to constrain the estimate of process error standard deviations

Implied from fit to GOA dogfish

Observation error variance on log scale is ln(cv^2+1)

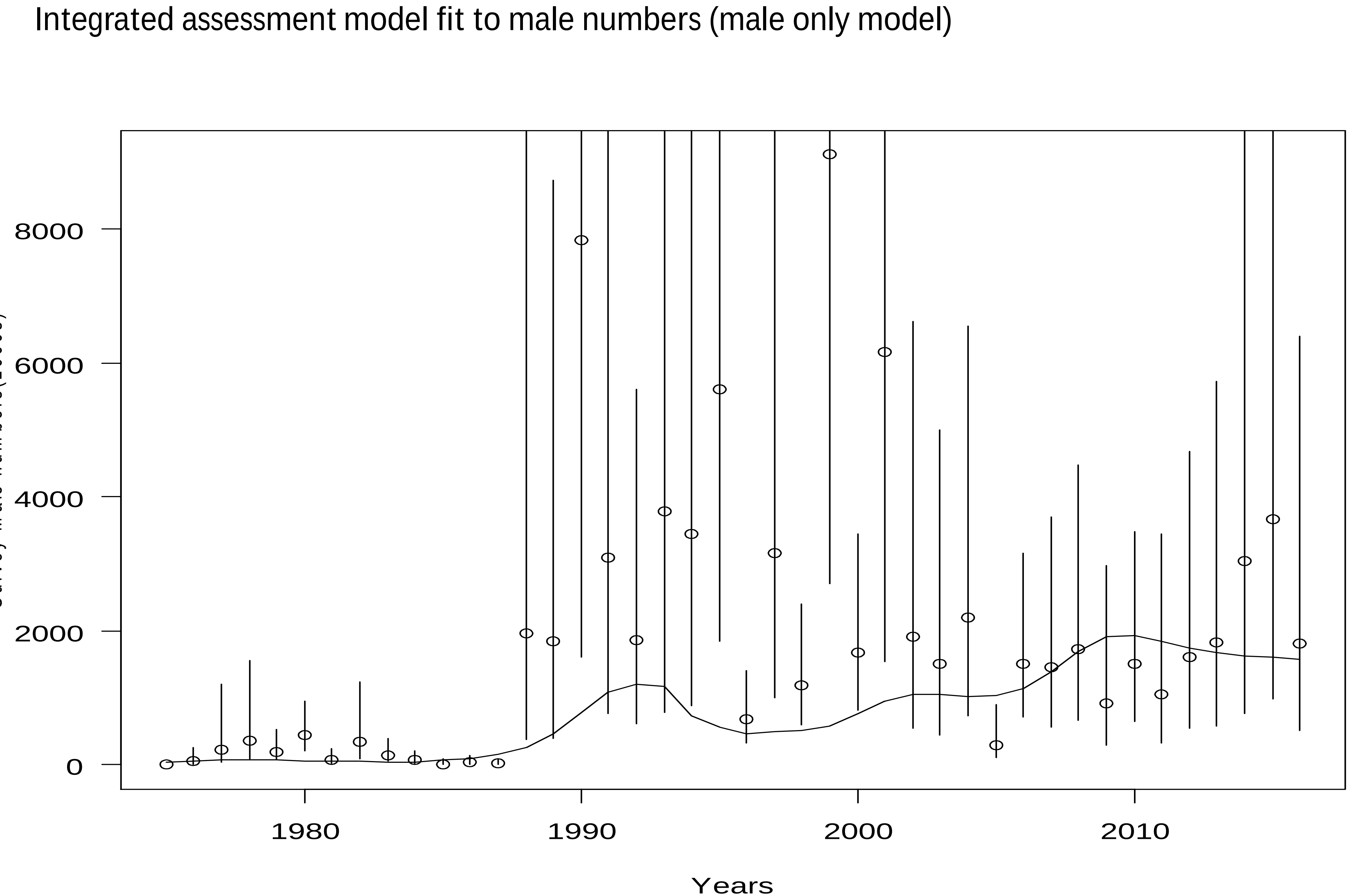
Mean cv of survey biomass is 0.67

Mean Observation Error variance on log scale = 0.38

Fitting a simple exponential model to Pribilof survey data using HoltWinters function in R gives,

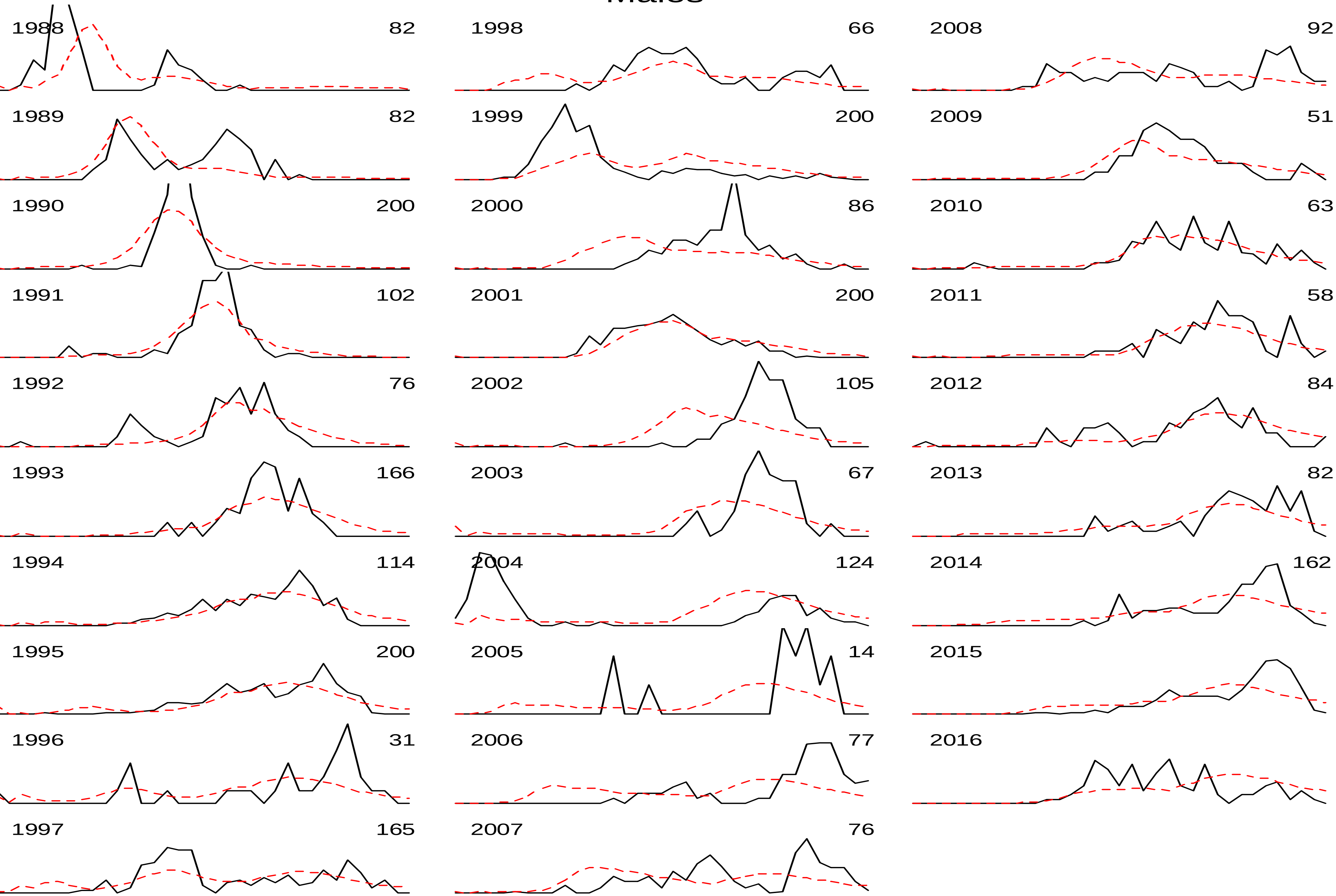
Alpha = 0.396, = variance ratio of 3.75 and process error of 0.38/3.75 = 0.102.

Pribilof red model variance of first difference in log biomass 0.046, Bristol Bay red king crab model 0.089.



gure 20. Model fit to survey male numbers.

Males


1988
82
1998
66
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105
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166
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67
2013
82
1994
114
2004
124
2014
162
1995
200
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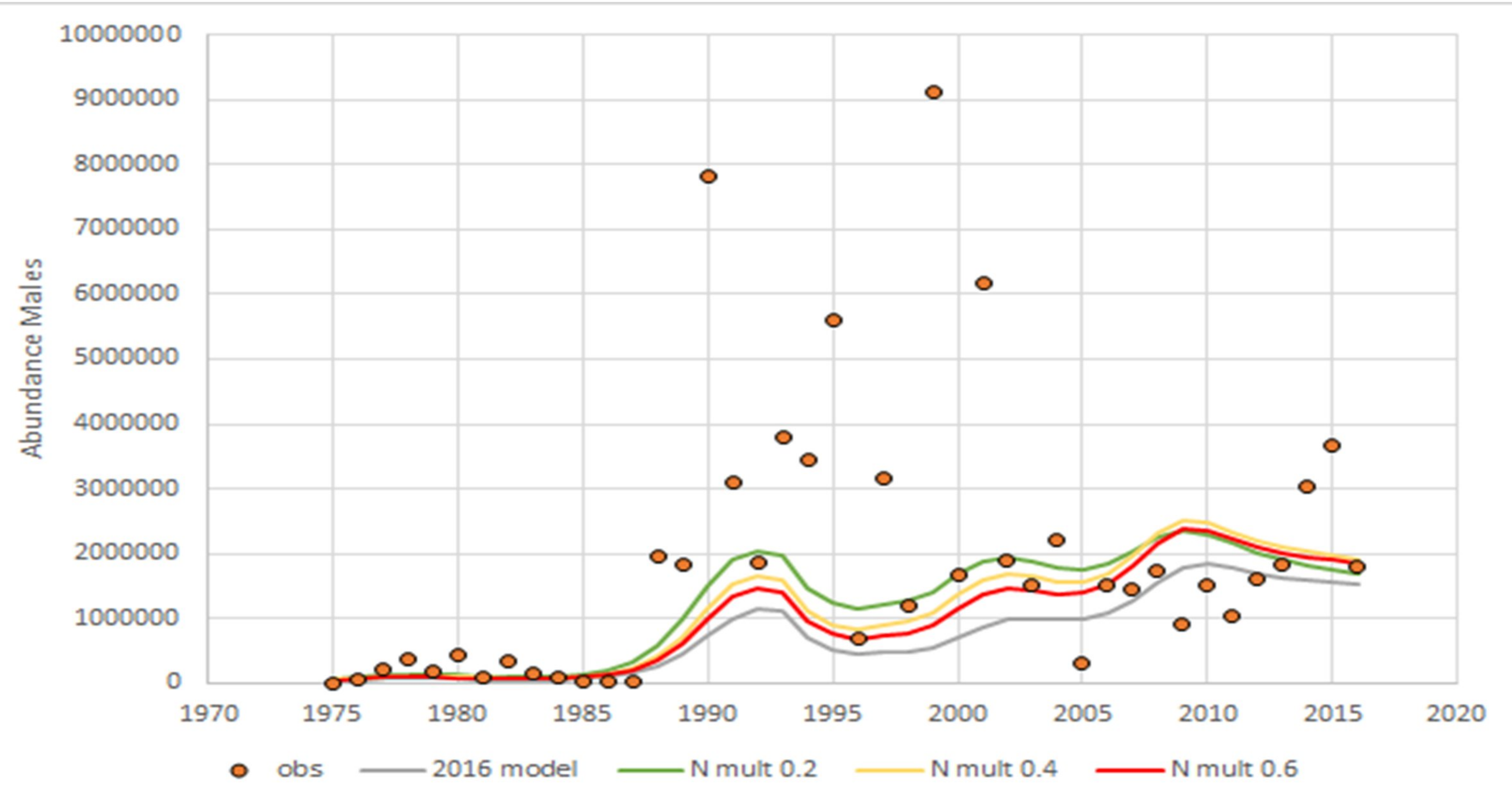
14
2015
1996
31
2006
77
2016
1997
165
2007
76

Survey length sample size reduction – Francis N multiplier 0.05 (model did not onverge)



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

A4. Likelihood component contribution to the likelihood and associated weights for the assessment model sce
h multipliers on the survey length sample sizes of 0.2, 0.4, 0.6 and the base model (1.0).

Likelihood component	Base Model (1.0)	0.2	0.4	0.6	Weighting
Survey numbers (males)	45.7	29.9	32.7	36.1	.36 -1 (CVs)
Survey length frequencies (male)	10,012.3	2018.9	4024.6	6023.7	18-200 (Base model sample size)
Catch	0.003	0.001	0.001	0.001	.005(CV)
Trawl	0.019	0.019	0.019	0.019	.01 (CV)
Smoothness penalties					
Trawl fishing mortality	38.6	38.4	38.3	38.4	1 (CV)
Fishing mortality	4.3	4.3	4.3	4.3	1 (CV)
Recruitment	48.9	20.4	30.1	37.5	1 (CV)

Pribilof red king crab alternatives (biomass in tons)

sessment ethod	OFL	B_{MSY}	MMB At mating Feb 15 2017 fishing at OFL	B/B_{MSY} (MMB)	MMB at mating Feb 15 2016	γ	Years to define B_{MSY} (MMB at mating)	F_{MSY}	ABC (p*=0.49
nning erage	1,462	5,512	6,980	1.25	9,062	1.0	1991/92-2015/16	0.18	1,43
ndom ects Model	119	5,512	2,044	0.37	2,154	1	1991/92-2015/16	0.05	11
served rvey	370	5,512	3,332	0.60	13,457	1	1991/92-2015/16	0.10	35
egrated sessment ales only)	822	3,881	5,160	1.33	6127	1	1991/92-2015/16	0.18	
egrated sessment ales only)	1,931	1,598	4,066	2.5	6127	1	1983-present recruitment	0.49	