NOAA FISHERIES

Alaska Fisheries Science Center

Assessment of Pacific cod in the eastern Bering Sea

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November 15, 2016

Team and SSC comments

Comments on assessments in general (1 of 2)

- Four comments on assessments in general were addressed in the preliminary assessment (Appendix 2.1)
- SSC14 (10/16 minutes): *"The SSC reminds groundfish and crab stock assessment authors to follow their respective guidelines for SAFE preparation."* Close attention was paid to the SAFE chapter guidelines as this assessment was being prepared

Comments on assessments in general (2 of 2)

- SSC15 (10/16 minutes): *"The SSC found the model numbering in the Eastern Bering Sea (EBS) Pacific cod model extremely helpful and looks forward to having more standardized model numbering across all stock assessment documents."* This assessment continues to use the model numbering convention adopted in last year's final assessment and this year's preliminary assessment
- SSC16 (10/16 minutes): *"The SSC requests that stock assessment authors bookmark their assessment documents and commends those that have already adopted this practice."* This assessment is fully bookmarked

Comments specific to this assessment (1 of 11)

- Eleven comments specific to this assessment, some of which contained multiple parts, were addressed in the preliminary assessment (Appendix 2.1)
- In the interest of efficiency, they are not repeated in this section, except for comments SSC7, SSC8, and SSC12
- SSC7 (12/15 minutes): *"While the model selection criteria proposed by the author are reasonable, we note that these criteria do not take into account the model fit itself. Model fit and retrospective performance should be more strongly considered in the selection of a final model for specifications."* Model fit and retrospective performance are considered in selection of the final model (see "Choice of Final Model")

Comments specific to this assessment (2 of 11)

- SSC8 (12/15 minutes): *"Although the SSC has repeatedly stressed the need to incrementally evaluate model changes, the SSC did not intend this to imply an automatic preference for the status quo model (as implied by the authors criterion #1) if alternatives with better performance are available."* The status quo model was not given automatic preference in this assessment

Comments specific to this assessment (3 of 11)

- SSC12 (6/16 minutes): *"The SSC encourages the author to conduct a retrospective analysis across historically used models in addition to the standard retrospective analysis using the current model."* In addition to the standard comparison of the spawning biomass and age 0 recruitment time series from the current assessment and last year's assessment, this assessment includes a retrospective analysis of the spawning biomass time series from all assessments since 2006 (Figure 2.13)

Comments specific to this assessment (4 of 11)

- BPT1 (9/16 minutes): *"The Team recommends bringing forward as many of the following six models, listed in prioritized order, as time permits, but Models 11.5 and 16.1 at a minimum:*
  - *A. Model 11.5*
  - *B. Model 16.1*
  - *C. Model 16.1 without empirical weight-at-age*
  - *D. Model 16.1 without empirical weight-at-age and including NMFS LL survey*
  - *E. Model 16.1 with time-varying survey selectivity*
  - *F. Model 16.1 with time-varying fishery selectivity"*
  - Response on next slide

Comments specific to this assessment (5 of 11)

- BPT1 response:
  - All six of the Team’s recommended models are included in this assessment
  - The “placeholder” names for the last four models in the above list (C, D, E, and F) have been replaced by the “final” model names 16.6, 16.7, 16.8, and 16.9

Comments specific to this assessment (6 of 11)

- SSC17 (10/16 minutes): *"The SSC agrees with the Plan Team recommendation to focus on model 16.1 for this assessment cycle and explore additional modifications as time allows. If time is available, we agree with the Plan Team that examining the incremental effects of empirical weight-at-age data and NMFS longline survey data in the model are reasonable next steps."* All of the Team's recommended models are presented in this assessment, including Model 16.1 and models that examine the incremental effects of empirical weight-at-age data (Model 16.6) and NMFS longline survey data (Model 16.7)

Comments specific to this assessment (7 of 11)

- SSC18 (10/16 minutes): *"The observed discrepancies among different models in these assessments are a good – if perhaps extreme – example of the model uncertainty that pervades most assessments. This uncertainty is largely ignored once a model is approved for specifications. We encourage the authors and Plan Teams to consider approaches such as multi-model inference to account for at least some of the structural uncertainty. We recommend that a working group be formed to address such approaches."* The procedure used to select a final model for this assessment includes a model-averaging aspect (see "Choice of Final Model")

Comments specific to this assessment (8 of 11)

- SSC19 (10/16 minutes): *“Regarding the mid-year model vetting process, the SSC re-iterates its recommendation from June to continue for now. The process has proven useful for the industry as an avenue to provide formal input and for the author to prioritize the range of model options to consider.”* Planning for next year’s assessment will include continuation of the mid-year model vetting process

Comments specific to this assessment (9 of 11)

- SSC20 (10/16 minutes): *"With regard to data weighting, the SSC recommends that the authors consider computing effective sample sizes based on the number of hauls that were sampled for lengths and weights, rather than the number of individual fish."* Because none of the SSC's requested models included computation of effective sample sizes on the basis of the number of sampled hauls, this recommendation will be forwarded to the Joint Team Subcommittee on Pacific Cod Models for consideration at next year's meeting

Comments specific to this assessment (10 of 11)

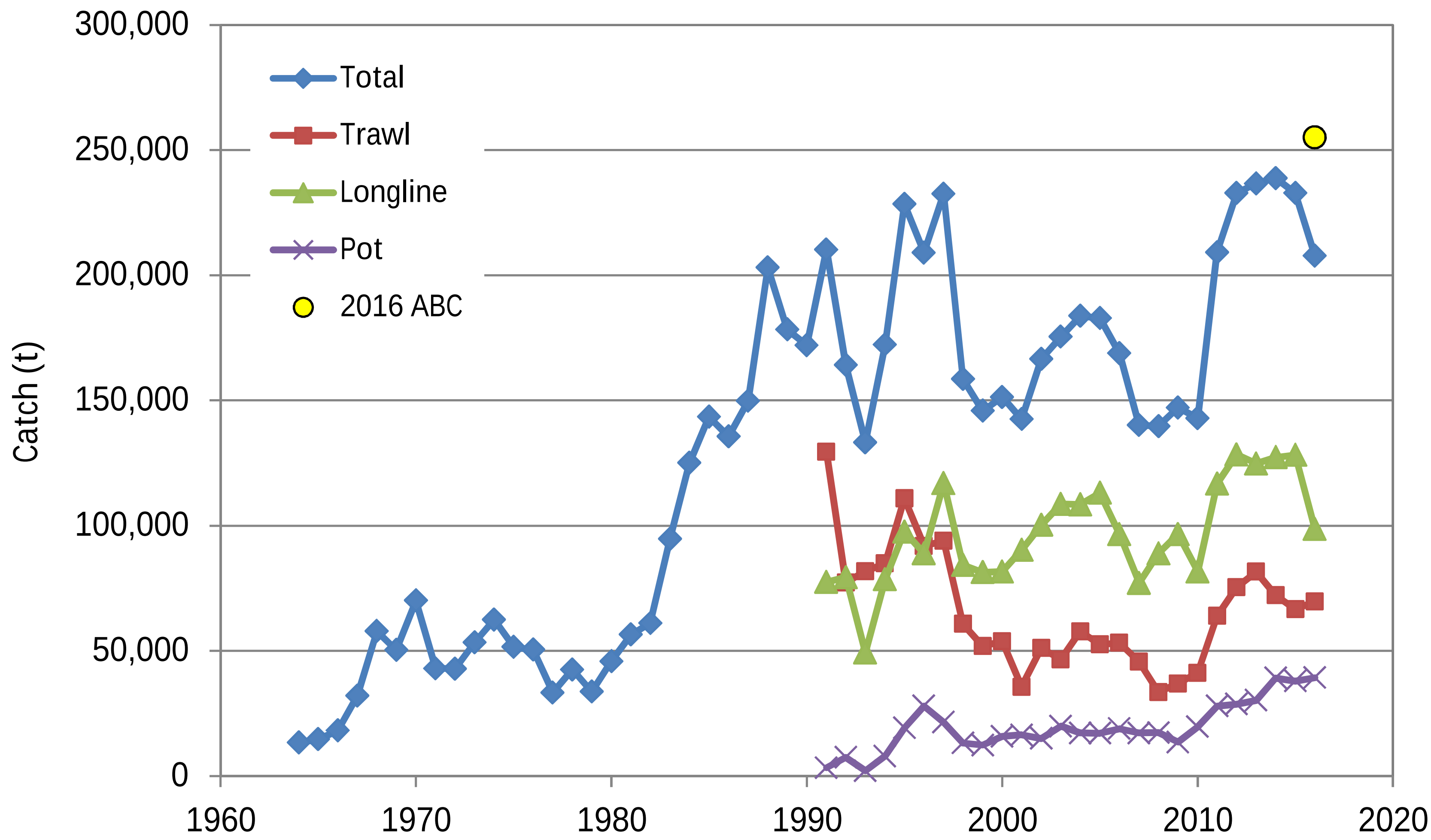
- SSC21 (10/16 minutes): *"The SSC notes that, in spite of the concerns over dome-shaped survey selectivity in the survey, there are many potential mechanisms relating to the availability of larger fish to the survey gear that could result in these patterns, regardless of the efficiency of the trawl gear to capture large fish in its path. For example, in the Bering Sea the patterns could be due to larger Pacific cod being distributed in deeper waters or in the northern Bering Sea at the time of the survey. The northern Bering Sea survey planned for 2017 should provide additional information on the latter possibility."* Data from the 2017 trawl survey of the northern Bering Sea will be examined when they become available

Comments specific to this assessment (11 of 11)

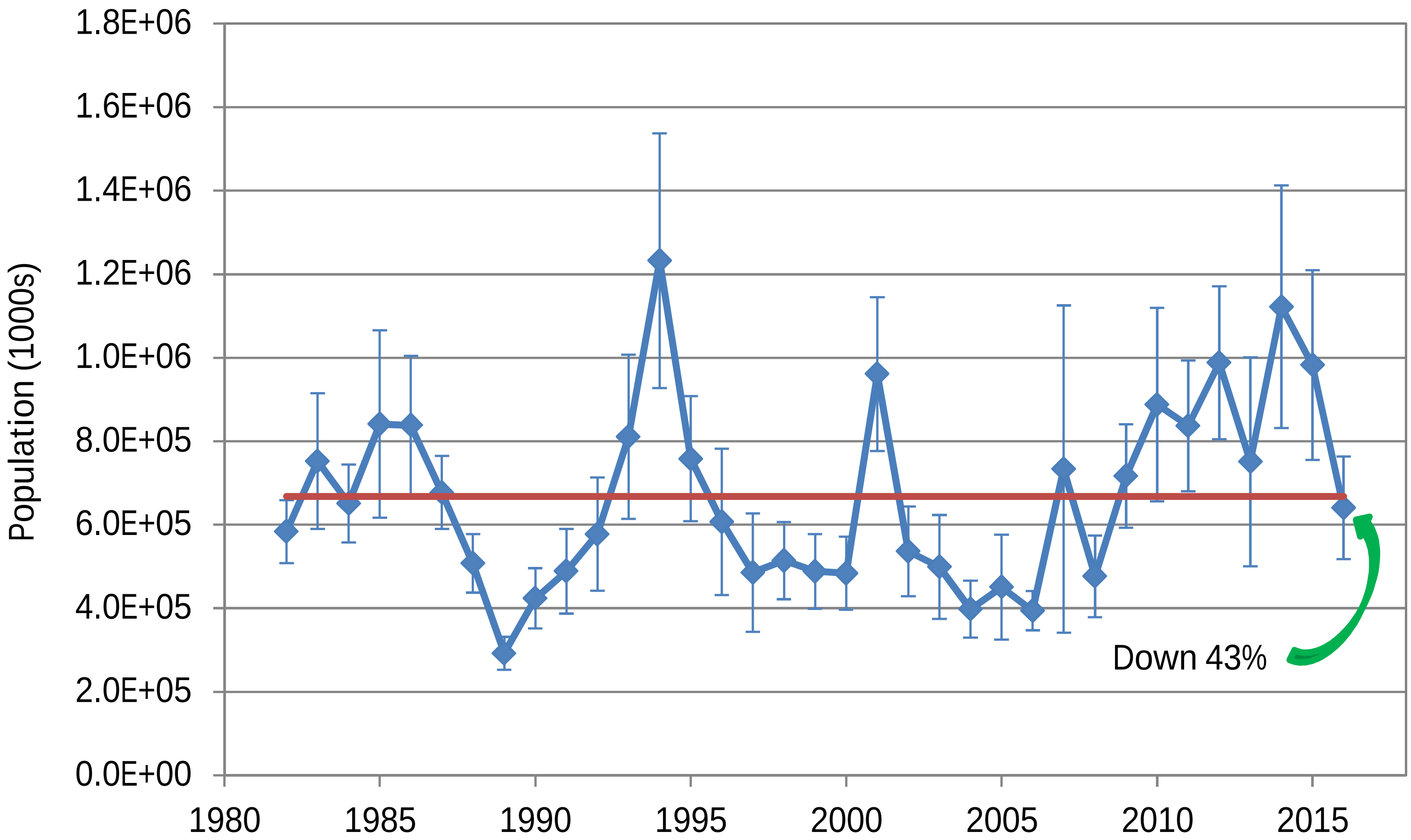
- SSC22 (10/16 minutes): *"Although there is genetic evidence for stock structuring within the Pacific cod population among regions, the uncertainty in model scale for all three regions seems to suggest that some sharing of information among the three assessments might be helpful. Over the long term, authors could consider whether a joint assessment recognizing the population structuring, but simultaneously estimating key population parameters (e.g., natural mortality, catchability or others) might lend more stability and consistency of assumptions for this species."* This recommendation will be forwarded to the Joint Team Subcommittee on Pacific Cod Models for consideration at next year's meeting

Data highlights

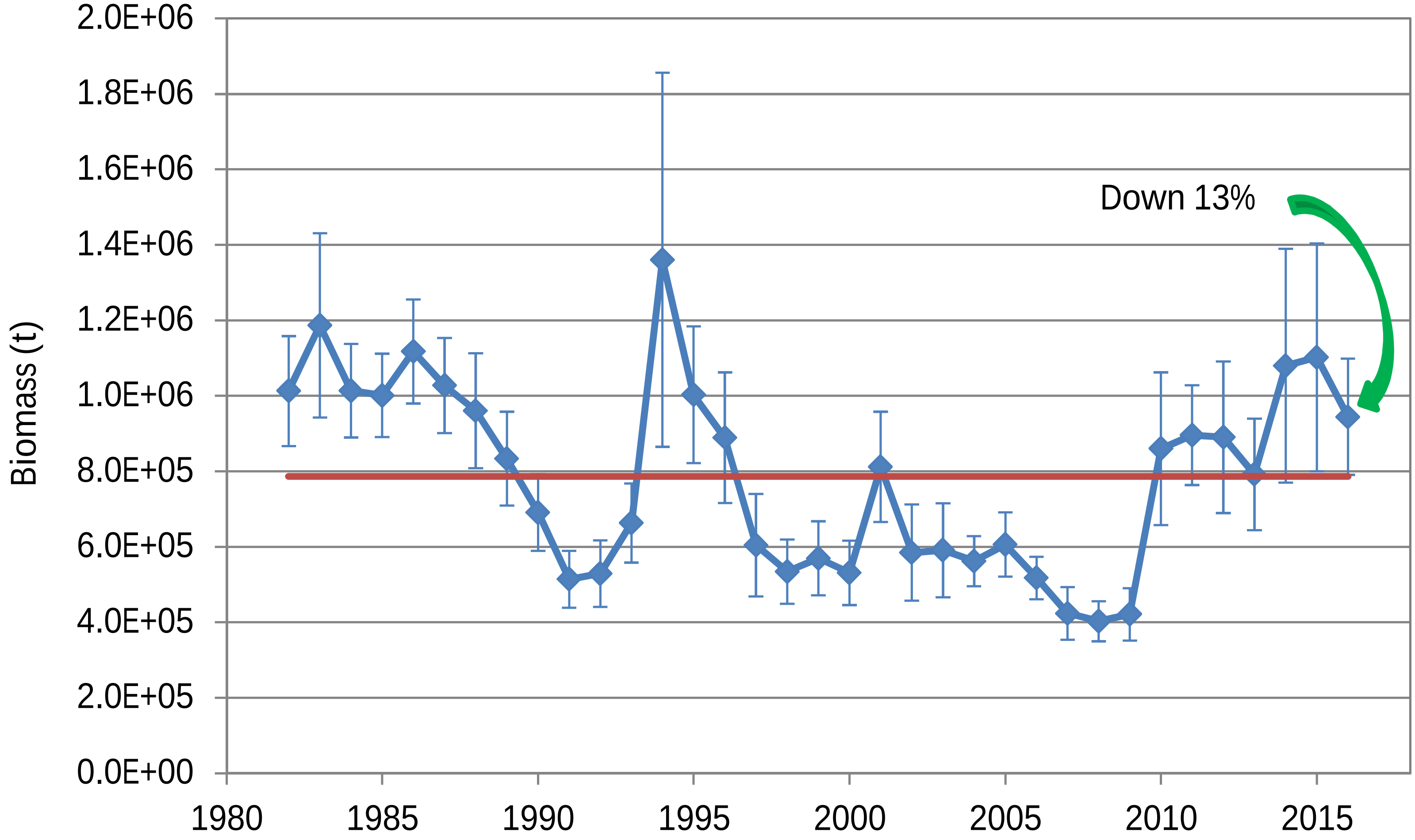
Catch history (2016 data are incomplete)



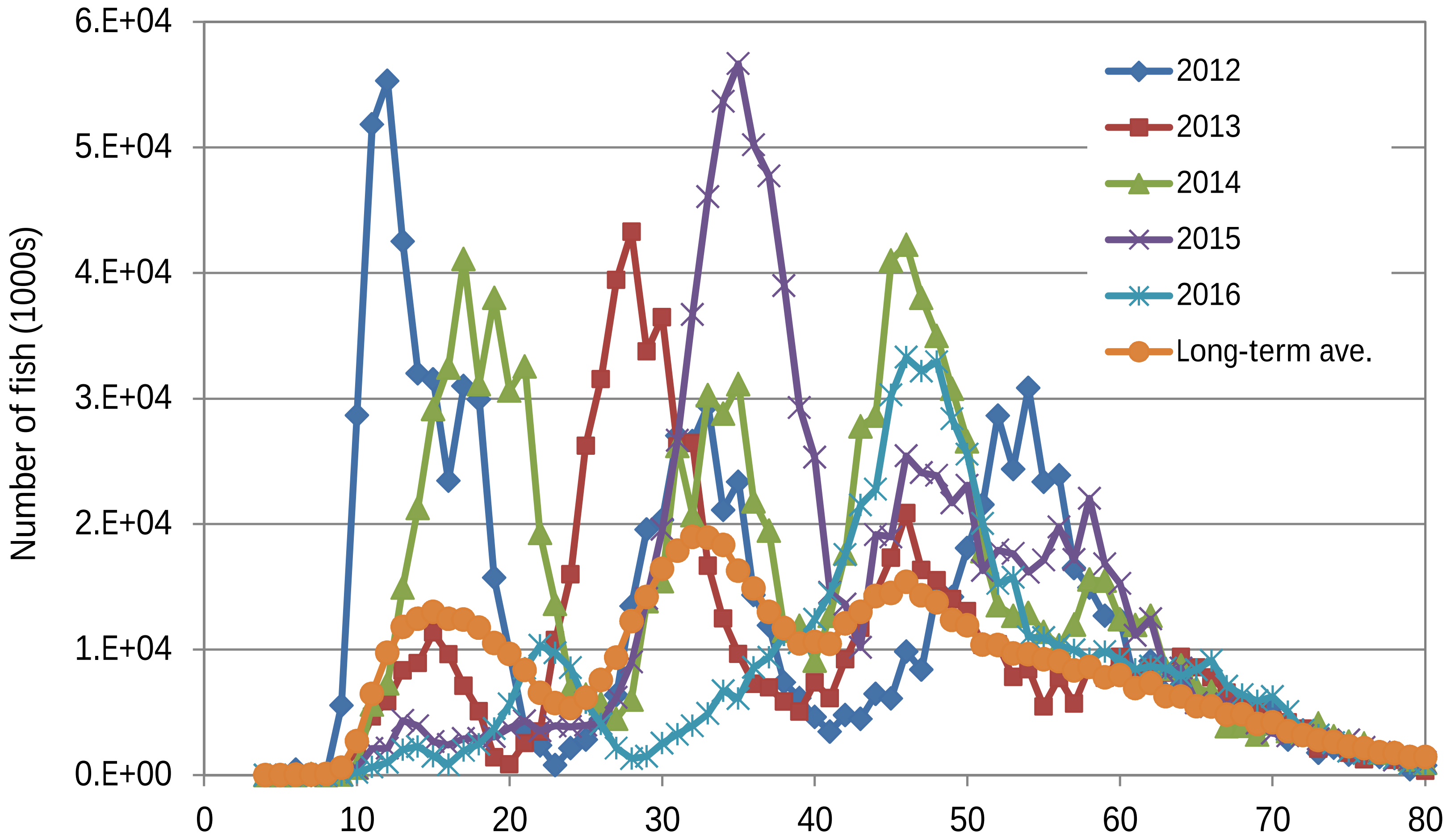
Survey numbers history



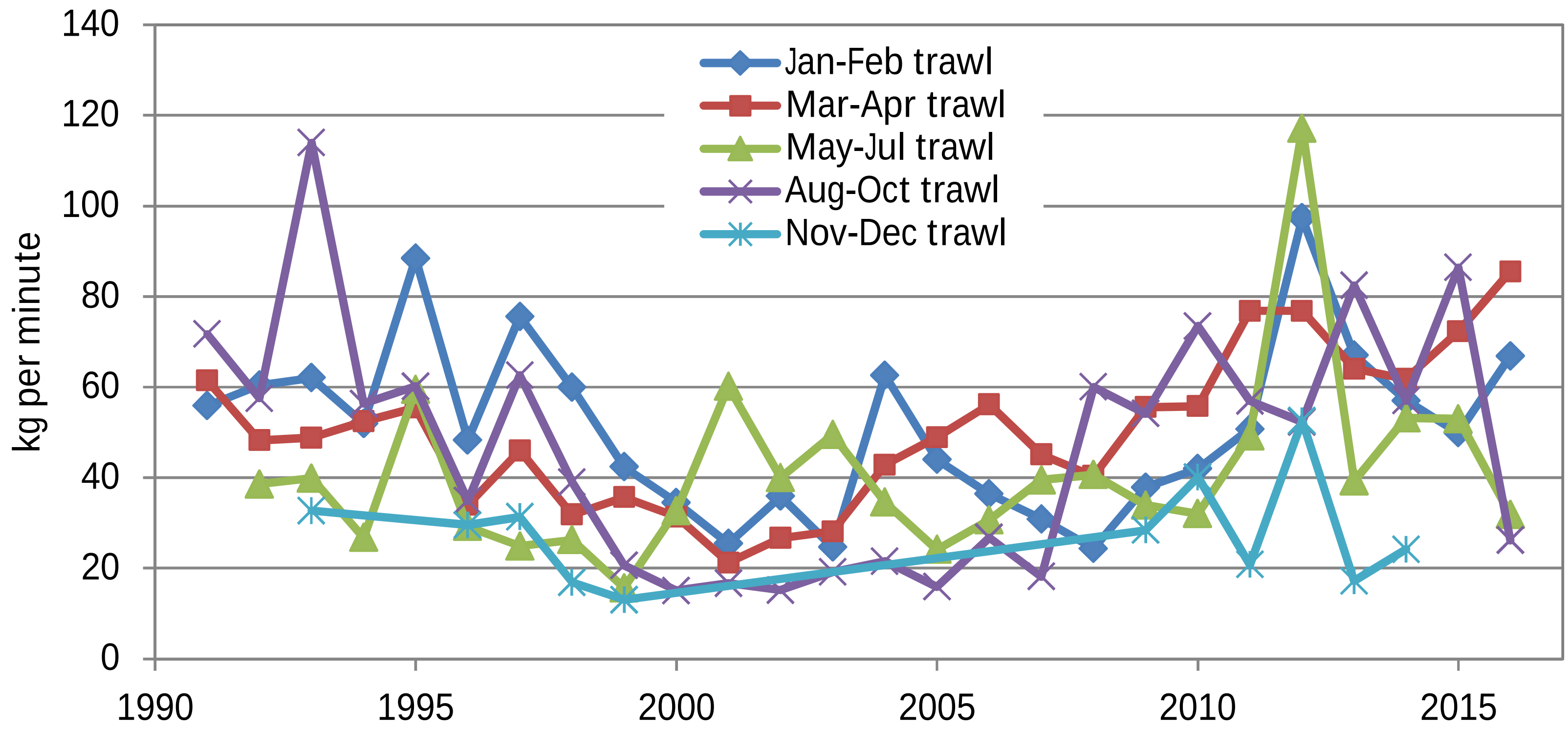
Survey biomass history (not used in models)



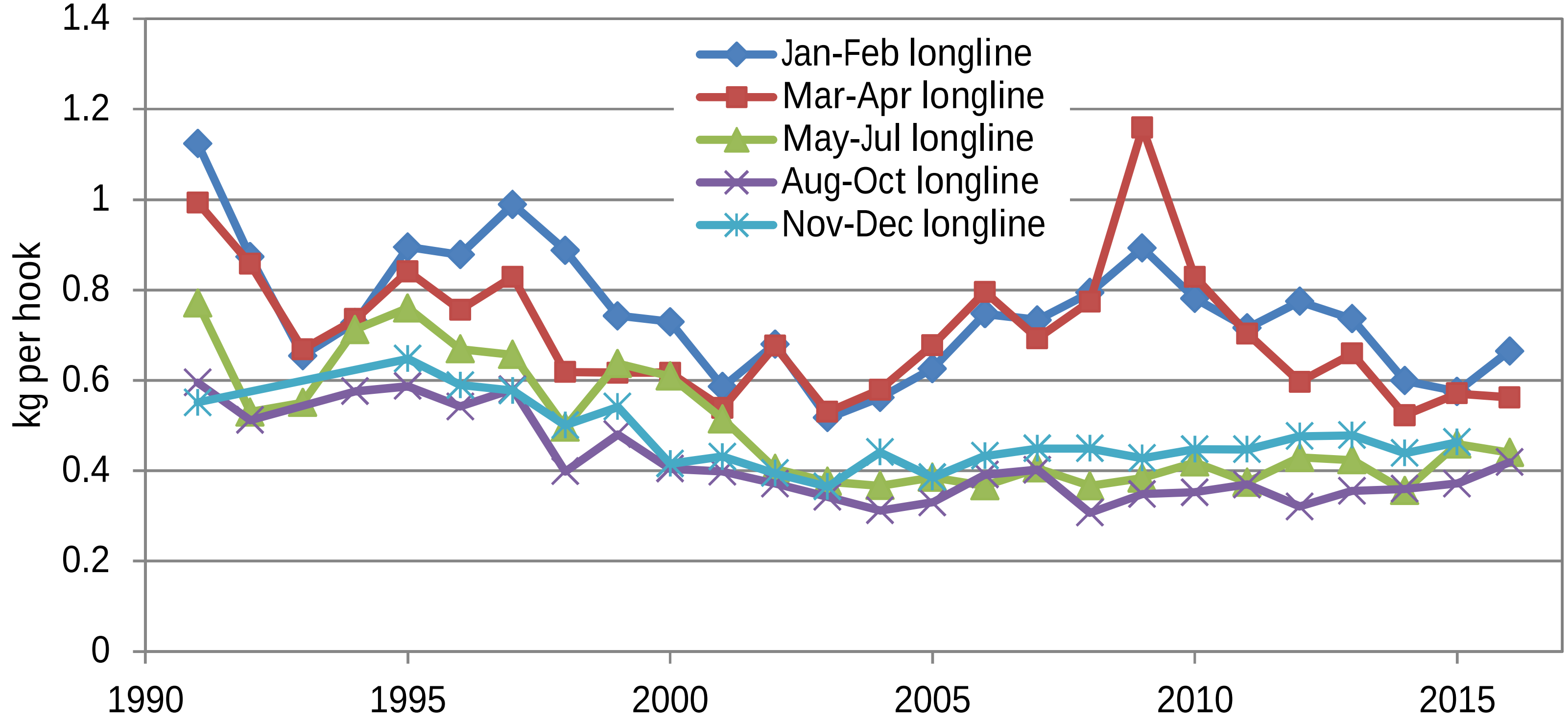
Recent survey length compositions



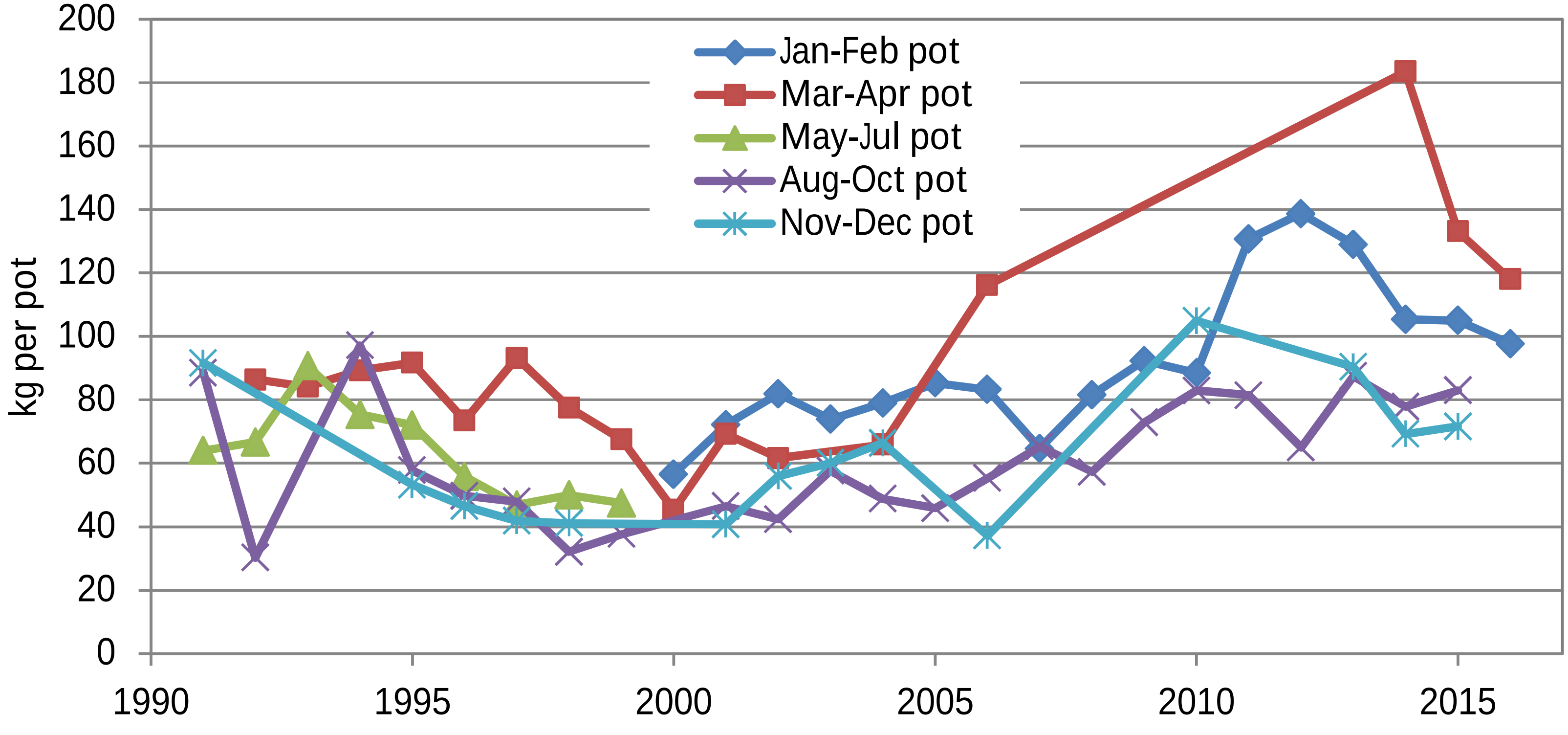
CPUE (not used in model): trawl fishery



CPUE (not used in model): longline fishery



CPUE (not used in model): pot fishery



Model structures

Models 11.5 and 16.1: compare and contrast

Features common to both models
Time-invariant natural mortality, survey catchability, and mean length at age
Parameters governing width of length-at-age distribution (for a given mean) estimated internally
Ageing bias parameters estimated internally
Survey size composition data used in all years, including years with age composition data

Features that differ between models	Model 11.5	Model 16.1
Seasons per year	5 (for catch), 3 (for fishery selectivity)	1
Number of initial age groups estimated	3	20
Natural mortality rate estimation	External (Jensen 1996)	Internal
Trawl survey catchability estimation	External (based on Nichol et al. 2007, 2009 assessment)	Internal
Mean length at age functional form	Von Bertalanffy (3 parameters, internal)	Richards (4 parameters, internal)
Mean length at age data	Included, but not used for estimation	Not included
Fishery CPUE data	Included, but not used for estimation	Not included
Weight at age	Internal length at age, external weight at length (seasonal)	External
SD of log age 0 recruitment (sR)	External (based on 2009 assessment)	Internal
"Fballpark" (like a weak prior on F)	Used	Not used
Selectivity functional form	Double normal (fishery and trawl survey)	Logistic (fishery and trawl survey)
Selectivity basis	Length (fishery), age (trawl survey)	Age (fishery and trawl survey)
Selectivity structure	Gear (3) and season (3)	None
Time-varying fishery selectivity	Estimated independently for 2 to 7 “blocks” of years	None
Time-varying survey selectivity	Annual *dev* s for the *ascending_width* parameter	None

Models 16.6-16.9 structures

- Model 16.6: Model 16.1 without empirical weight-at-age
  - Time-varying, externally estimated weight-at-length
- Model 16.7: Model 16.6 with NMFS longline survey
  - Logistic selectivity assumed for NMFS longline survey
- Model 16.8: Model 16.1 with time-varying survey selectivity
  - Very large s for A50% *dev*s
  - Parameter governing difference between A95% and A50% fixed at 0.01, with no devs (first full paragraph on page 19 should refer to Model 16.8 only)
- Model 16.9: Model 16.1 with time-varying fishery selectivity
  - Very large s for *dev*s on both selectivity parameters

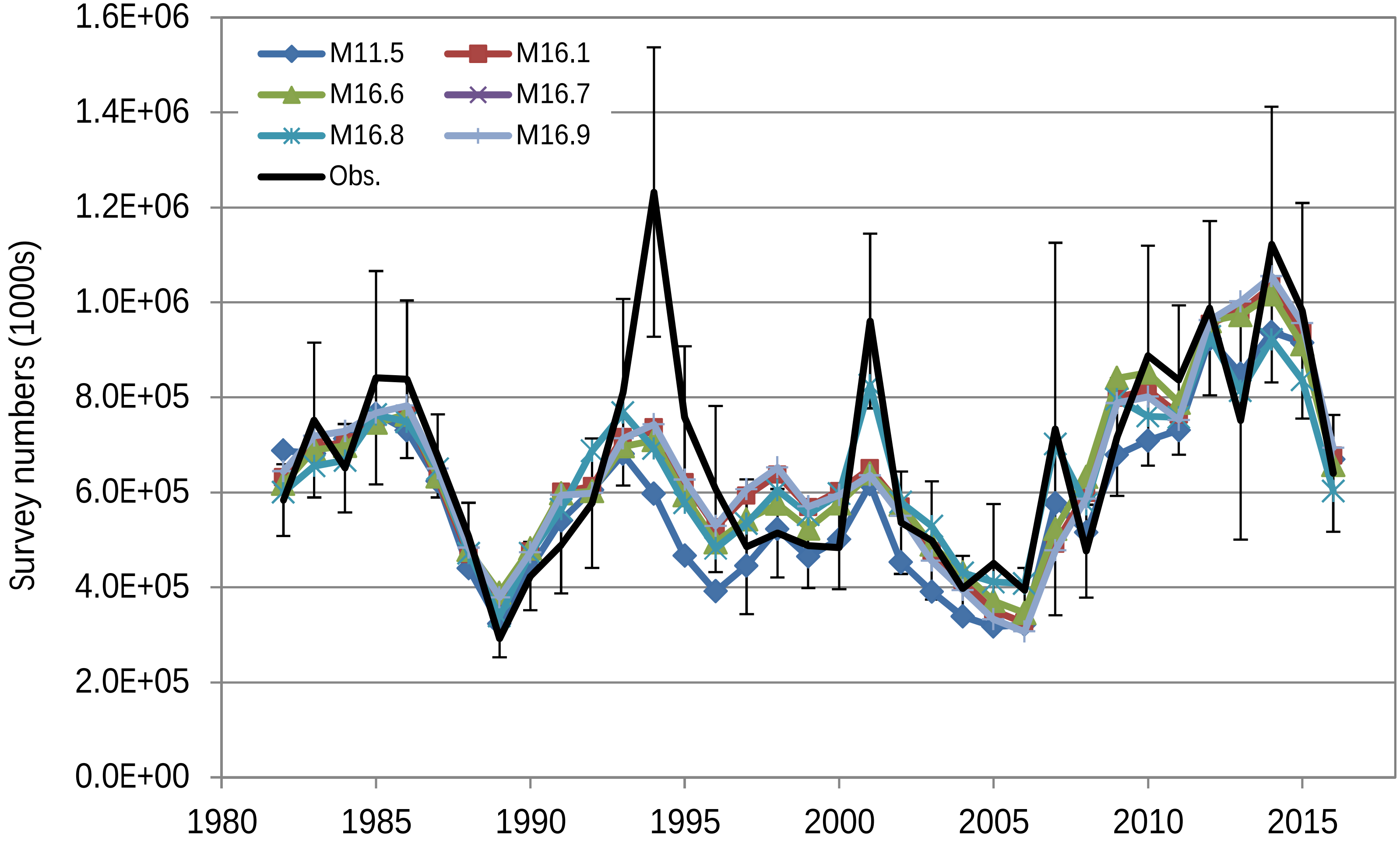
Results

Objective function values, parameter counts

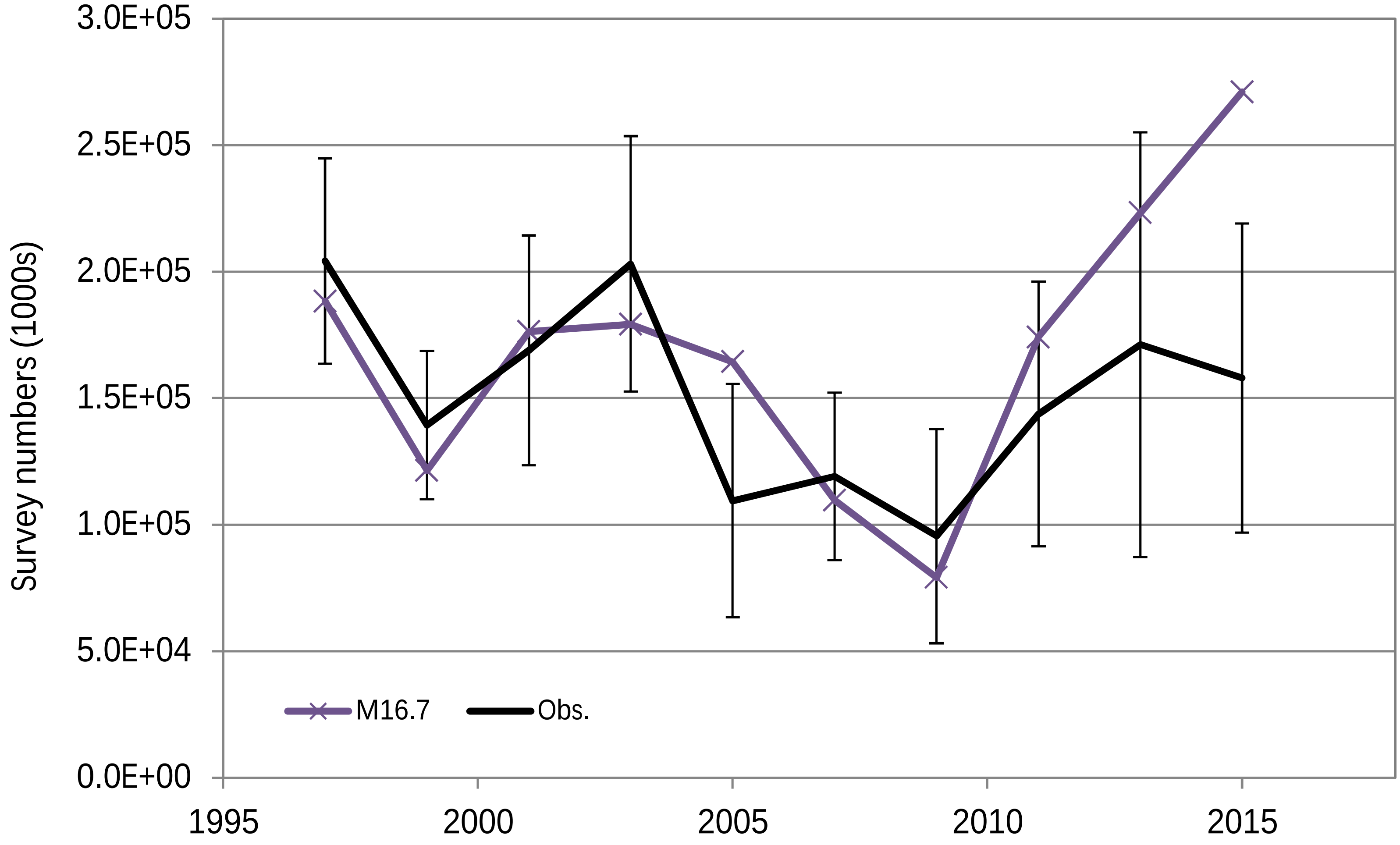
Component	M11.5	M16.1	M16.6	M16.7	M16.8	M16.9
Catch	0.00	0.00	0.00	0.00	0.00	0.00
Equilibrium catch	0.01	0.00	0.00	0.00	0.00	0.00
Survey abundance index	-3.95	-23.52	-25.21	-34.29	-41.36	-18.72
Size composition	5242.98	1378.92	1372.94	1636.85	1218.48	1187.99
Age composition	153.94	243.81	241.40	252.32	127.95	238.82
Recruitment	21.18	3.38	4.25	4.78	0.72	0.89
"Softbounds"	0.02	0.01	0.01	0.01	0.00	0.00
Deviations	20.71	0.00	0.00	0.00	0.00	0.01
"F ballpark"	0.00	n/a	n/a	n/a	n/a	n/a
TOTAL	5434.88	1602.60	1593.39	1859.67	1305.79	1408.97

Parameter type	M11.5	M16.1	M16.6	M16.7	M16.8	M16.9
True parameters:	115	18	18	21	17	18
Constrained *dev* s:	75	59	59	59	92	139
Total:	190	77	77	80	109	157

Fit to trawl survey abundance: figure



Fit to NMFS LL survey abundance: figure



Fit to fishery and survey CPUE: statistics

Model	Fleet	save	RMSE	MNR	SDNR	Corr.
11.5	Jan-Apr trawl fishery	0.08	0.48	0.57	4.02	0.17
11.5	May-Jul trawl fishery	0.25	0.42	-0.16	1.70	0.19
11.5	Aug-Dec trawl fishery	0.57	0.69	0.17	2.31	0.12
11.5	Jan-Apr longline fishery	0.08	0.39	0.23	4.68	-0.18
11.5	May-Jul longline fishery	0.20	0.29	0.35	2.61	0.46
11.5	Aug-Dec longline fishery	0.12	0.27	0.12	4.12	0.30
11.5	Jan-Apr pot fishery	0.12	0.35	0.18	2.05	0.23
11.5	May-Jul pot fishery	0.14	0.21	0.04	1.47	0.23
11.5	Aug-Dec pot fishery	0.32	0.39	0.01	2.06	0.14
11.5	Shelf trawl survey	0.11	0.23	1.04	1.82	0.78
16.1	Shelf trawl survey	0.11	0.19	0.07	1.79	0.79
16.6	Shelf trawl survey	0.11	0.19	0.10	1.76	0.79
16.7	Shelf trawl survey	0.11	0.18	0.11	1.76	0.80
16.8	Shelf trawl survey	0.11	0.16	0.11	1.47	0.85
16.9	Shelf trawl survey	0.11	0.20	0.08	1.86	0.78
16.7	NMFS longline survey	0.16	0.25	-0.27	1.42	0.60

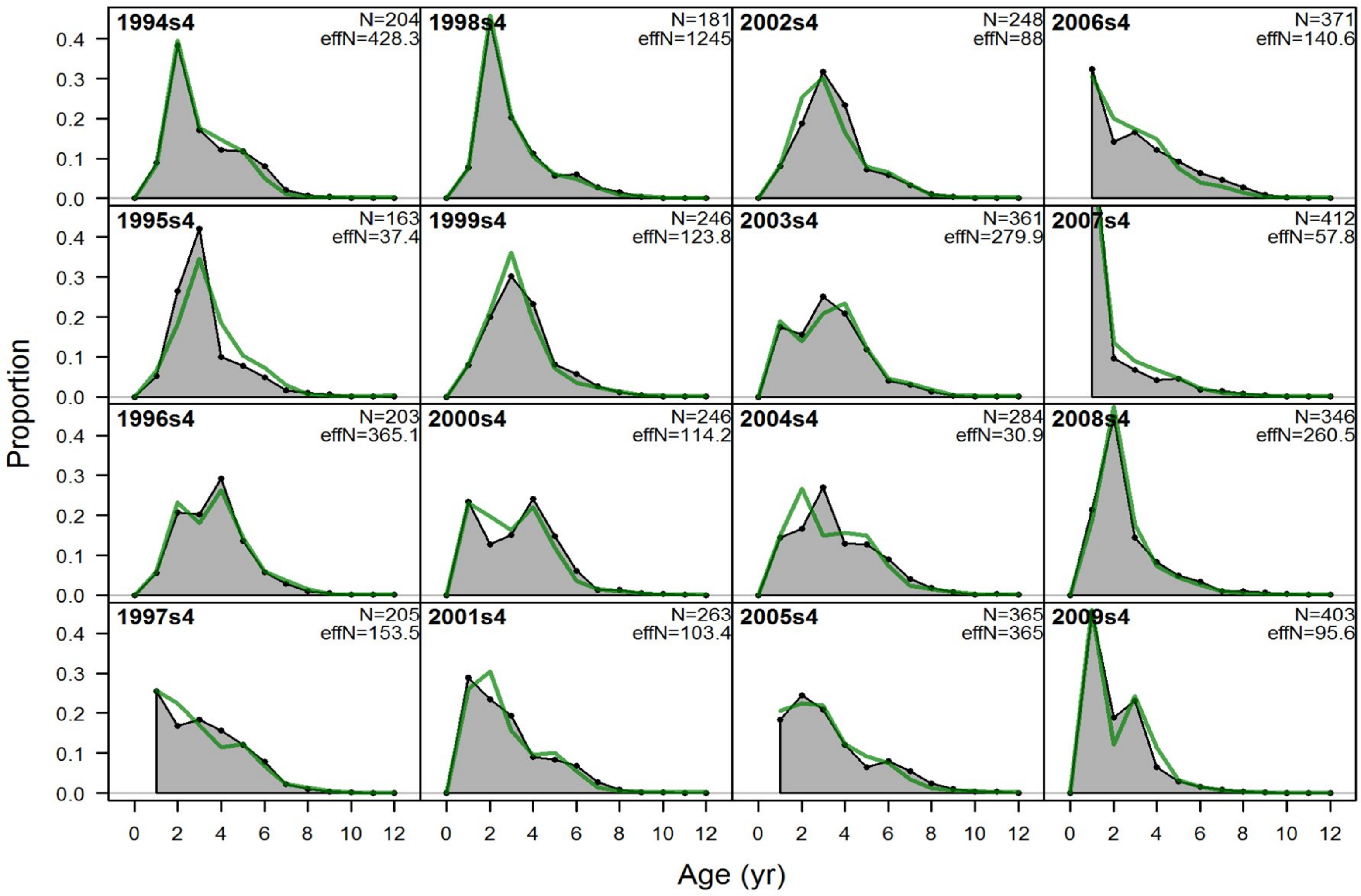
Fits to size composition data

				Ratios		
Model	Fleet	Nrec	A(Ninp)	A(Neff/Ninp)	A(Neff)/A(Ninp)	H(Neff)/A(Ninp)
11.5	Jan-Apr trawl fish.	70	312	4.97	3.02	1.71
11.5	May-Jul trawl fish.	36	61	9.24	7.49	3.34
11.5	Aug-Dec trawl fish.	39	43	12.67	6.07	3.36
11.5	Jan-Apr longl. fish.	74	474	8.36	3.99	1.20
11.5	May-Jul longl. fish.	36	261	9.35	5.00	2.91
11.5	Aug-Dec longl. fish.	69	674	6.34	3.11	0.91
11.5	Jan-Apr pot fish.	42	128	13.89	10.10	3.87
11.5	May-Jul pot fish.	17	128	17.97	7.81	1.86
11.5	Aug-Dec pot fish.	41	86	10.12	7.41	2.89
16.1	Fishery	40	300	8.68	5.83	1.88
16.6	Fishery	40	300	8.73	5.87	1.90
16.7	Fishery	40	300	10.25	8.47	1.89
16.8	Fishery	40	300	10.12	8.24	1.91
16.9	Fishery	40	300	16.43	8.82	3.48
11.5	Trawl survey	35	285	1.95	1.65	1.02
16.1	Trawl survey	35	300	1.82	1.56	1.00
16.6	Trawl survey	35	300	1.83	1.56	1.01
16.7	Trawl survey	35	300	1.84	1.57	1.00
16.8	Trawl survey	35	300	2.26	1.90	1.15
16.9	Trawl survey	35	300	1.87	1.59	1.03
16.7	NMFS LL survey	10	300	1.79	1.59	1.01

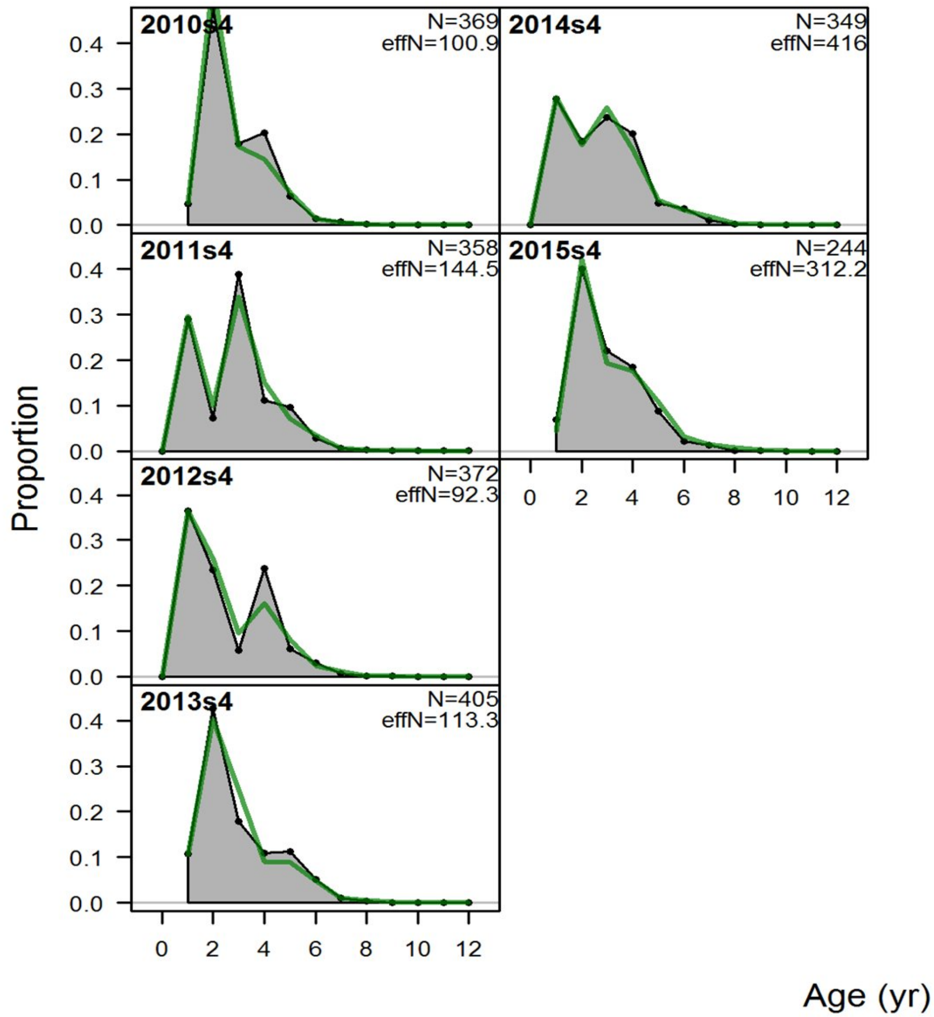
Fits to age composition data: statistics

Year	Input N	Effective N						Ratio					
		M11.5	M16.1	M16.6	M16.7	M16.8	M16.9	M11.5	M16.1	M16.6	M16.7	M16.8	M16.9
1994	204	428	186	209	233	237	163	2.10	0.91	0.49	1.26	1.13	0.70
1995	163	37	29	29	24	54	31	0.23	0.18	0.79	0.82	1.85	1.29
1996	203	365	68	79	60	598	83	1.80	0.34	0.22	0.87	7.55	1.39
1997	205	154	51	54	62	194	45	0.75	0.25	0.35	1.23	3.61	0.72
1998	181	1245	93	83	103	1229	97	6.88	0.51	0.07	1.11	14.77	0.94
1999	246	124	61	55	50	94	68	0.50	0.25	0.45	0.83	1.70	1.35
2000	246	114	62	53	42	60	82	0.46	0.25	0.46	0.67	1.15	1.96
2001	263	103	37	39	38	74	37	0.39	0.14	0.37	1.03	1.91	0.97
2002	248	88	40	38	39	96	40	0.35	0.16	0.43	0.98	2.53	1.04
2003	361	280	824	986	935	224	707	0.78	2.28	3.52	1.13	0.23	0.76
2004	284	31	34	34	34	50	35	0.11	0.12	1.11	0.97	1.46	1.04
2005	365	365	183	182	170	321	169	1.00	0.50	0.50	0.93	1.76	0.99
2006	371	141	51	52	57	404	55	0.38	0.14	0.37	1.11	7.82	0.97
2007	412	58	11	11	10	74	12	0.14	0.03	0.19	0.93	6.72	1.17
2008	346	261	135	136	153	838	127	0.75	0.39	0.52	1.13	6.18	0.83
2009	403	96	162	139	130	395	165	0.24	0.40	1.46	0.81	2.84	1.27
2010	369	101	210	260	241	171	285	0.27	0.57	2.57	1.15	0.66	1.18
2011	358	144	121	117	110	106	110	0.40	0.34	0.81	0.90	0.90	1.00
2012	372	92	76	78	69	97	91	0.25	0.20	0.85	0.91	1.24	1.32
2013	405	113	127	125	112	137	135	0.28	0.31	1.10	0.88	1.10	1.21
2014	349	416	290	311	370	323	259	1.19	0.83	0.75	1.27	1.04	0.70
2015	244	312	201	206	222	415	202	1.28	0.82	0.66	1.11	2.01	0.91
Mean	300	230	139	149	148	282	136	0.93	0.45	0.82	1.00	3.19	1.08
Harm.	277	112	59	59	56	132	62	0.38	0.19	0.40	0.98	1.33	1.01

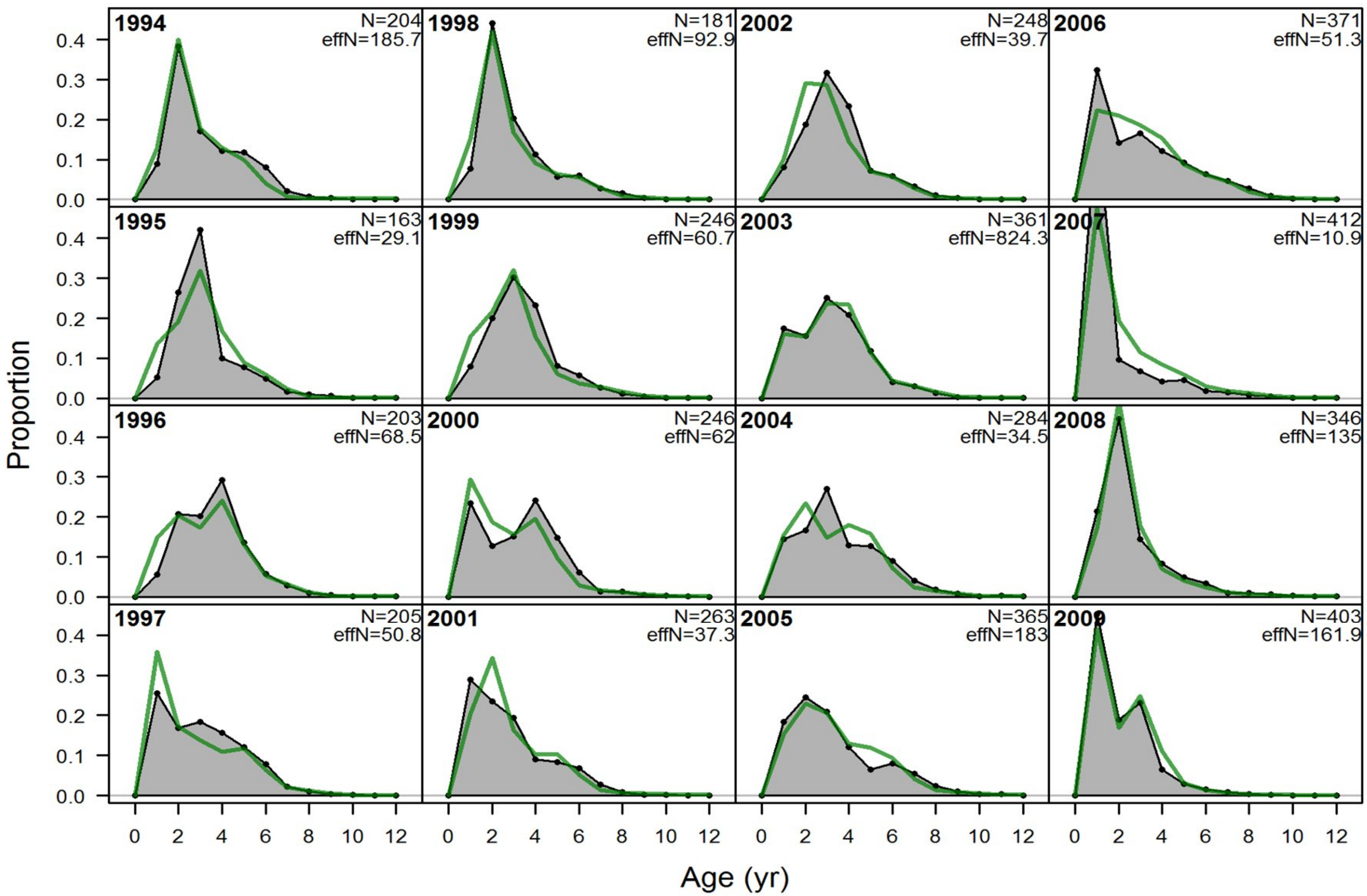
Fits to age composition data: M11.5 (1 of 2)



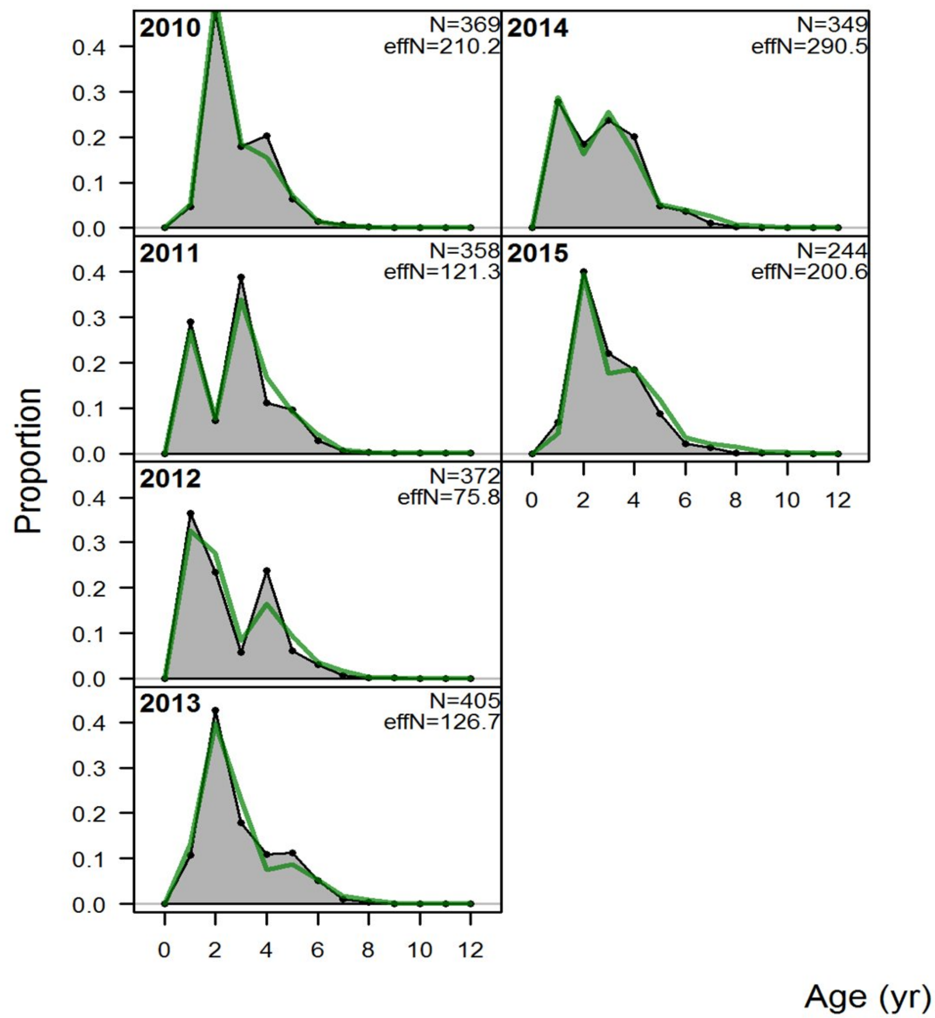
Fits to age composition data: M11.5 (2 of 2)



Fits to age composition data: M16.1 (1 of 2)



Fits to age composition data: M16.1 (2 of 2)



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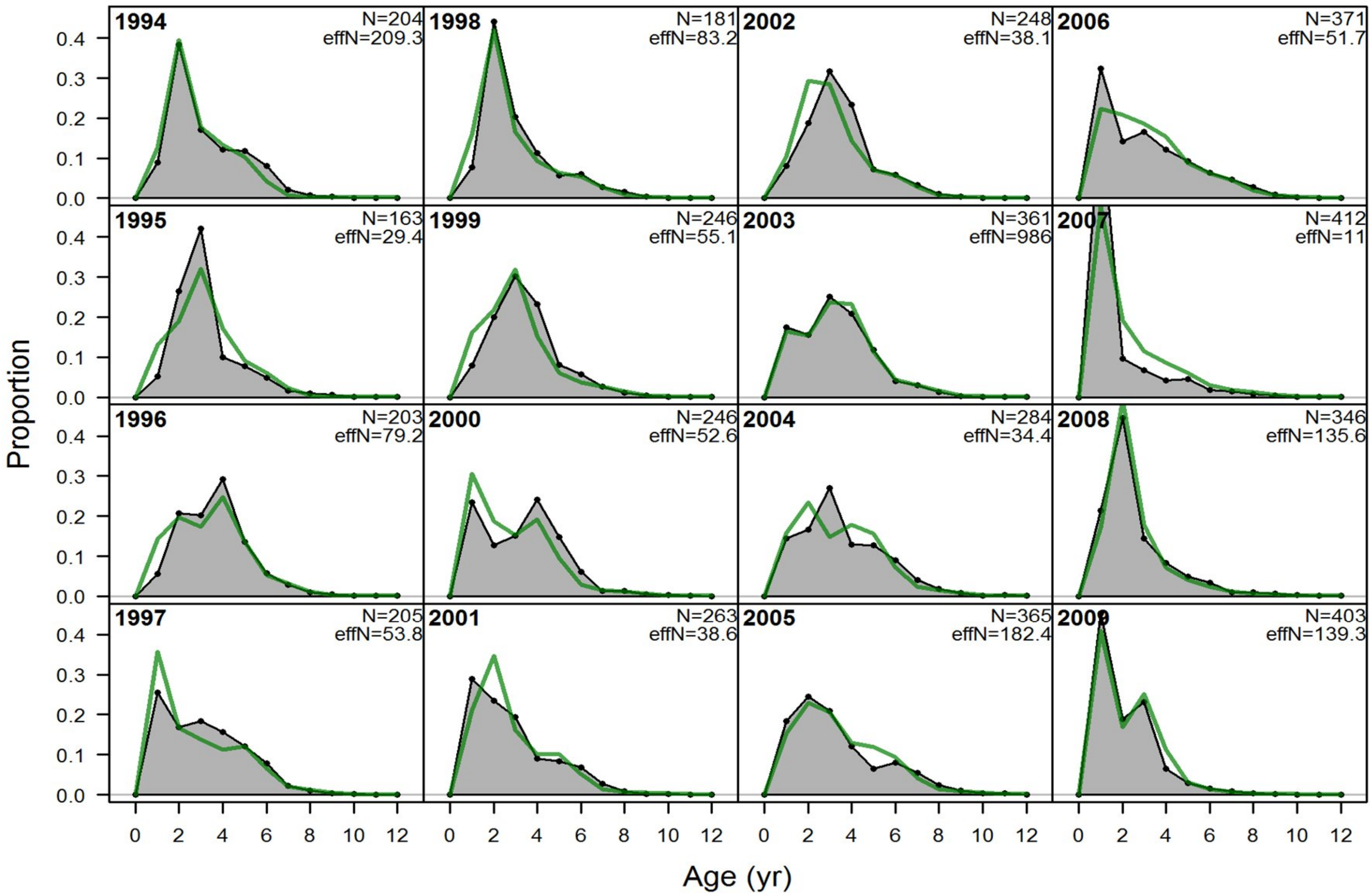
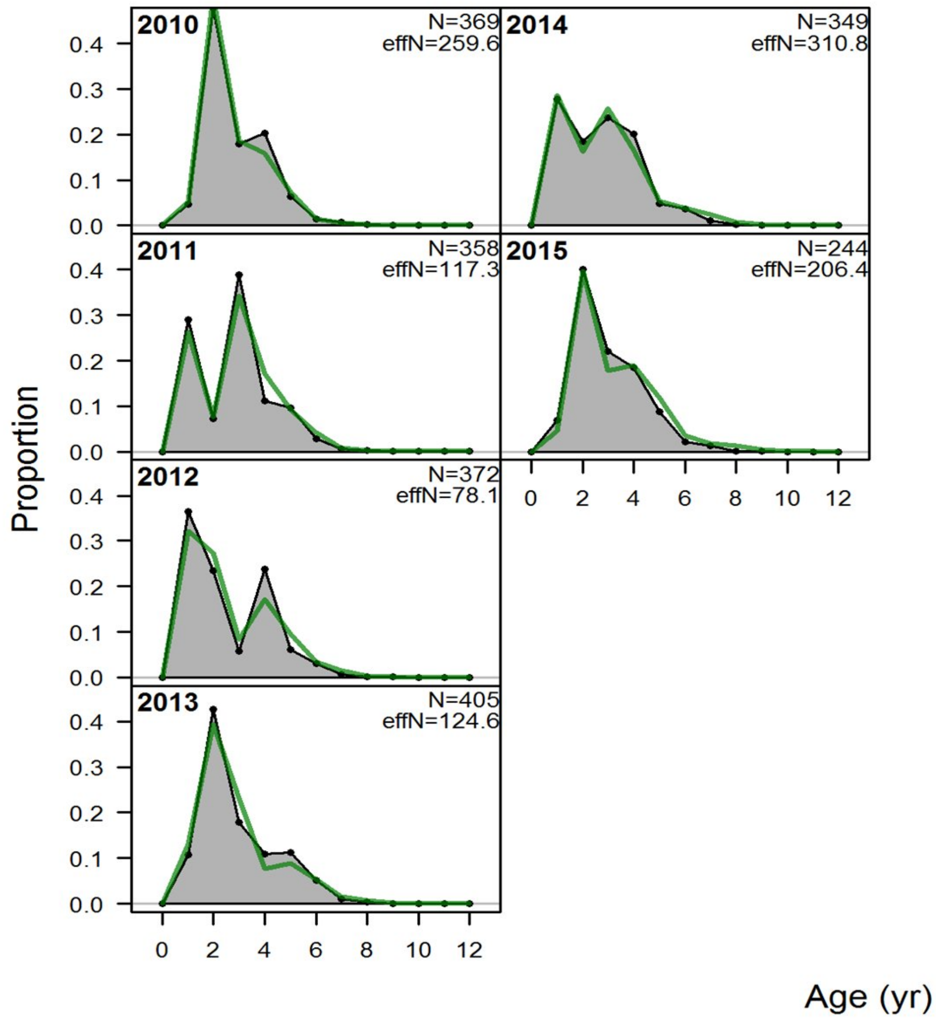


Fits to age composition data: M16.6 (2 of 2)



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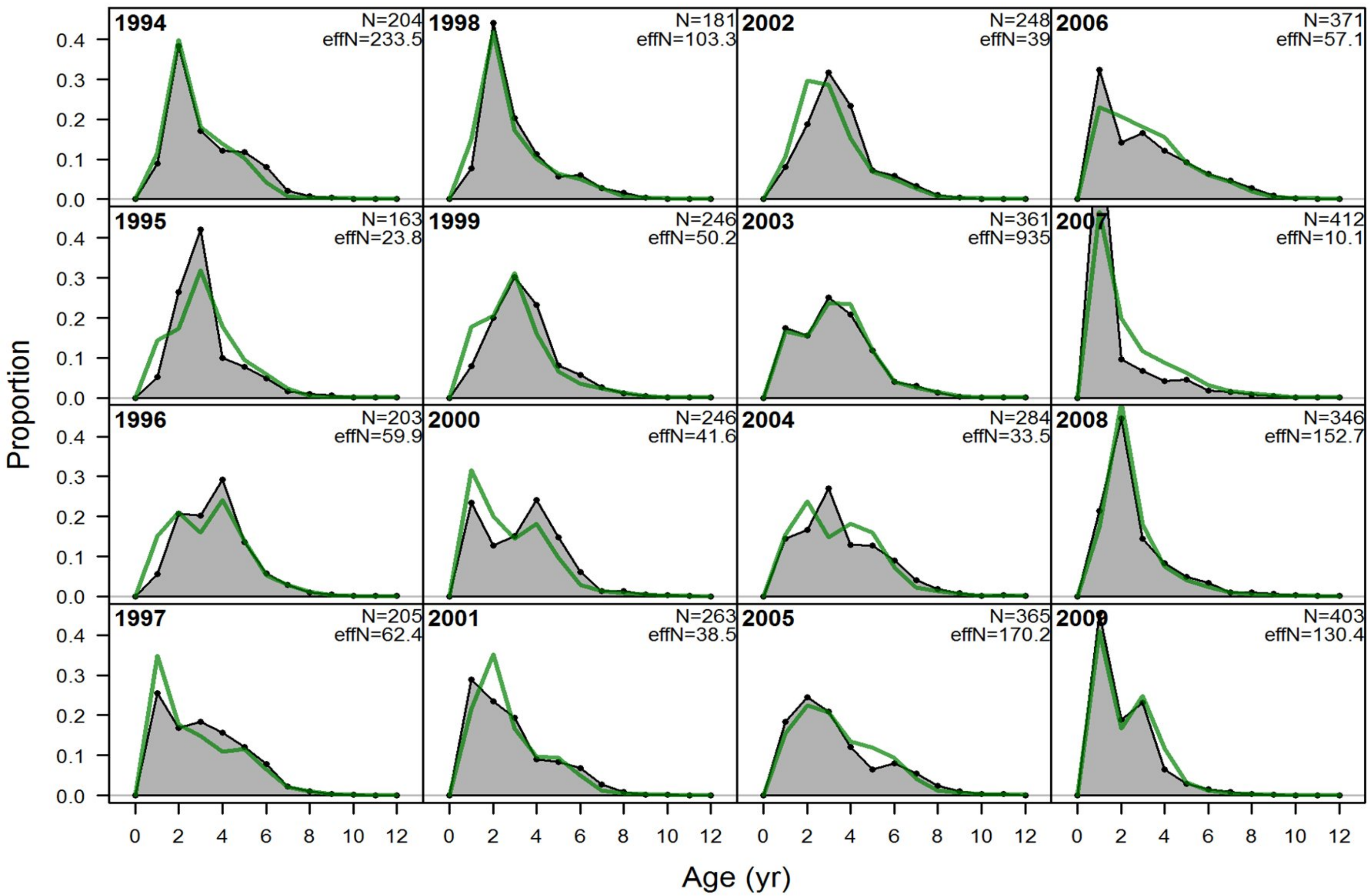
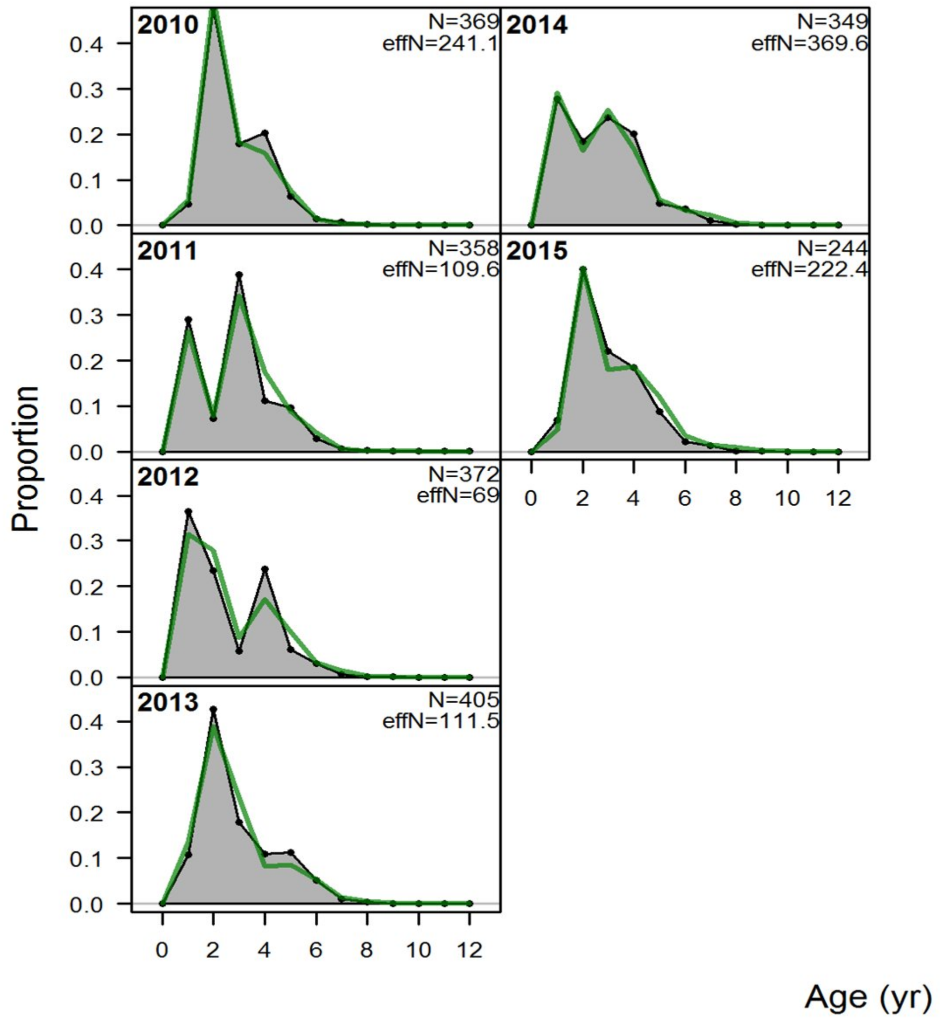
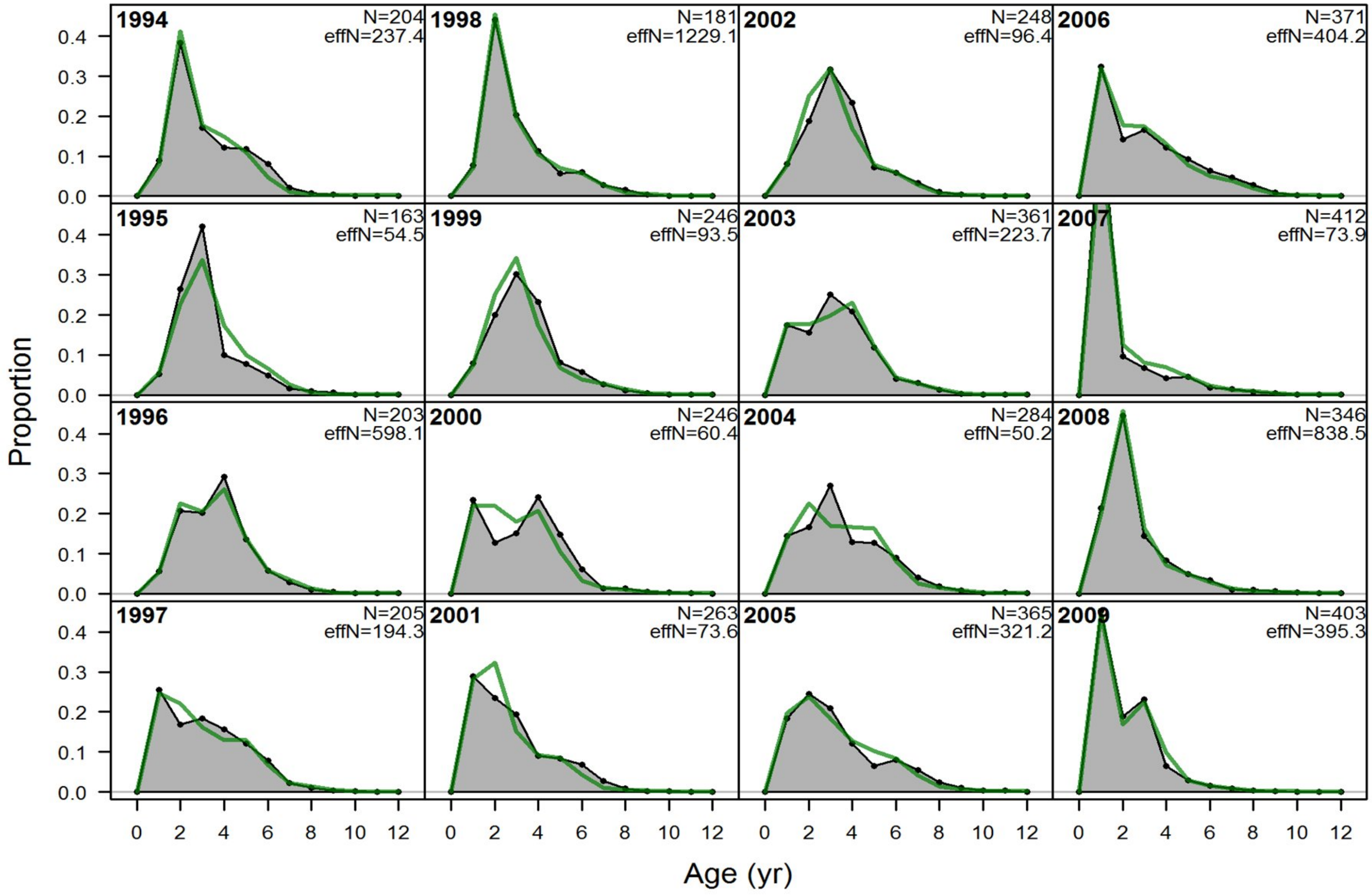


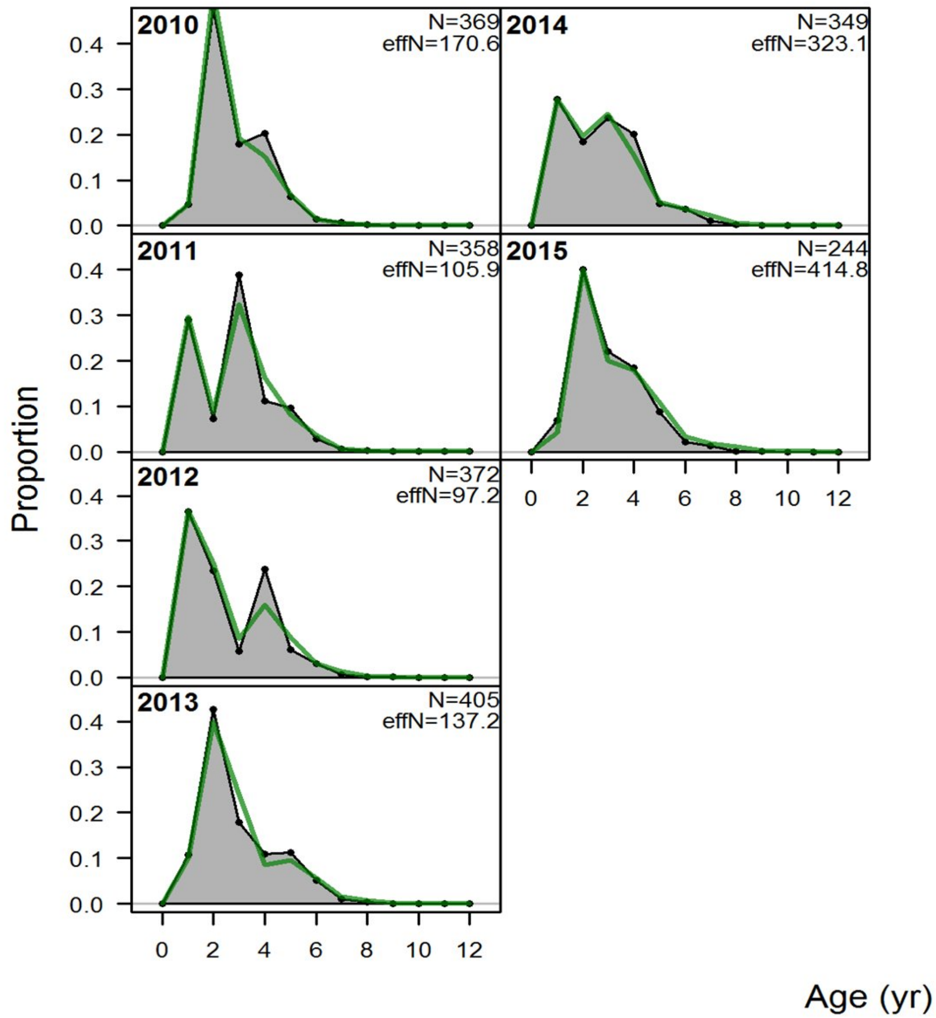
Fits to age composition data: M16.7 (2 of 2)



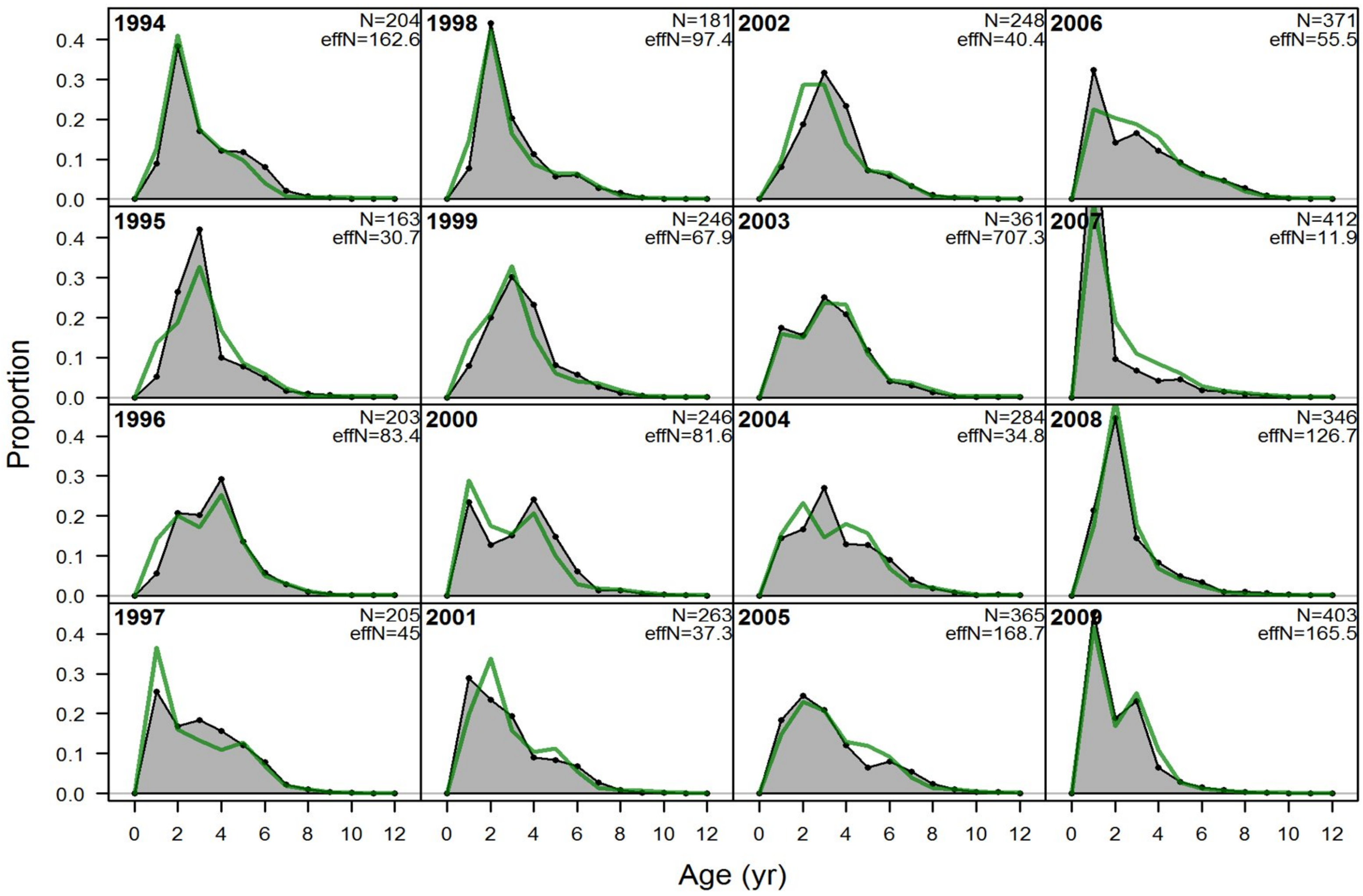
Fits to age composition data: M16.8 (1 of 2)



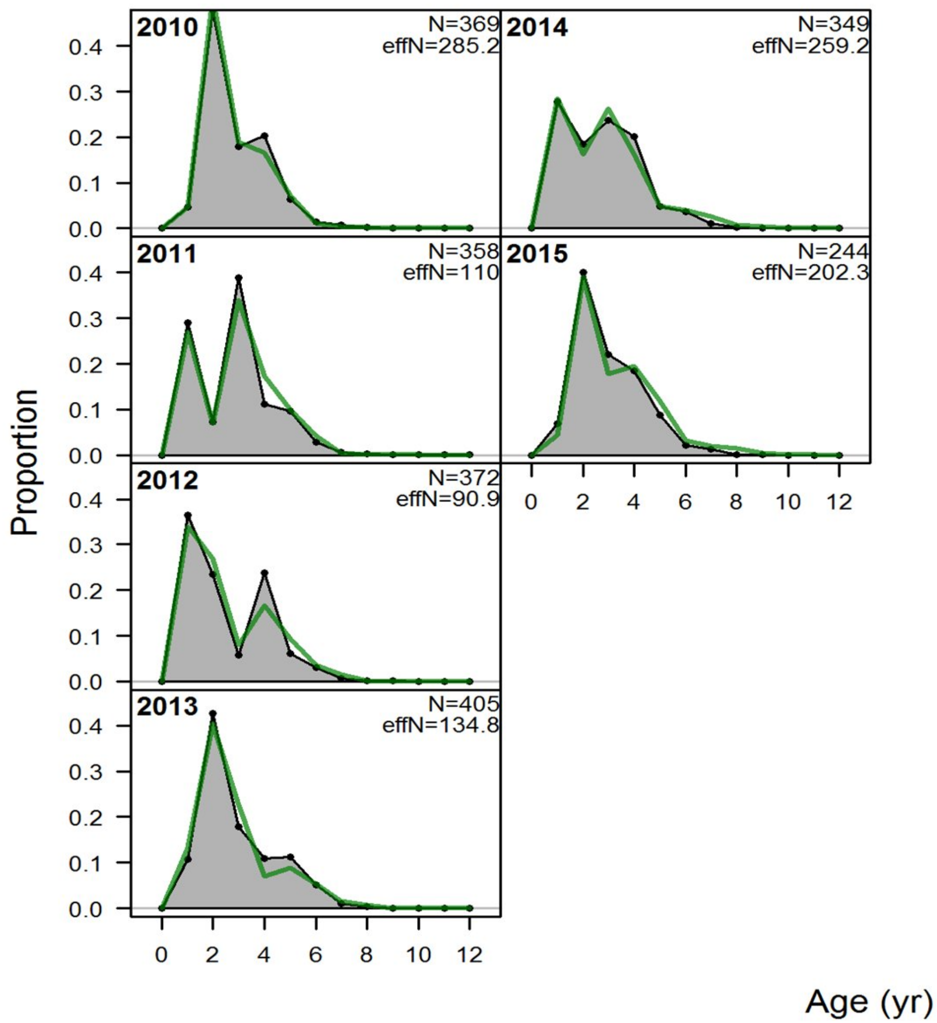
Fits to age composition data: M16.8 (2 of 2)



Fits to age composition data: M16.9 (1 of 2)



Fits to age composition data: M16.9 (2 of 2)



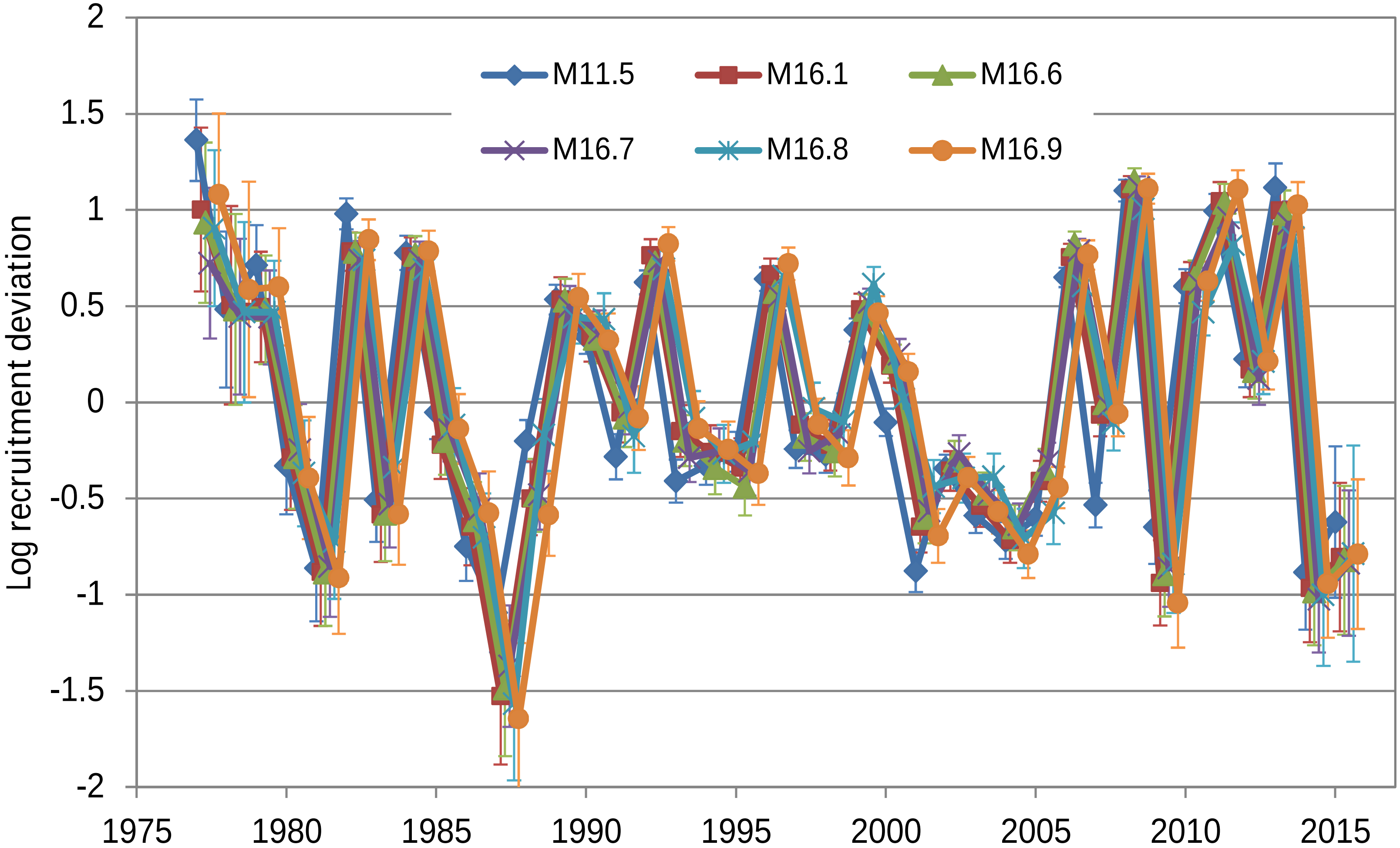
Main parameters

	Model 11.5		Model 16.1		Model 16.6		Model 16.7		Model 16.8		Model 16.9	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Natural mortality	0.340	_	0.378	0.012	0.363	0.013	0.344	0.012	0.375	0.012	0.376	0.012
Length at age 1 (cm)	14.352	0.106	16.399	0.088	16.401	0.088	16.449	0.088	16.360	0.088	16.381	0.088
Asymptotic length (cm)	92.747	0.494	98.412	1.826	99.387	1.901	101.132	1.814	100.396	1.984	97.914	1.778
Brody growth coefficient	0.239	0.002	0.200	0.012	0.197	0.012	0.200	0.011	0.195	0.012	0.195	0.012
Richards growth coefficient	n/a	n/a	1.054	0.048	1.050	0.048	1.014	0.043	1.050	0.048	1.077	0.050
SD of length at age 1 (cm)	3.605	0.067	3.424	0.058	3.425	0.058	3.479	0.057	3.422	0.058	3.403	0.058
SD of length at age 20 (cm)	9.616	0.154	9.663	0.275	9.717	0.282	8.851	0.219	9.551	0.296	9.984	0.289
Ageing bias at age 1 (years)	0.336	0.013	0.325	0.012	0.321	0.013	0.308	0.014	0.323	0.013	0.328	0.012
Ageing bias at age 20 (years)	0.322	0.145	0.323	0.153	0.351	0.154	0.527	0.154	0.351	0.160	0.313	0.150
ln(mean post-1976 recruitment)	13.171	0.019	13.620	0.104	13.220	0.104	13.011	0.094	13.555	0.094	13.593	0.103
s(recruitment)	0.570	_	0.631	0.066	0.638	0.066	0.638	0.066	0.602	0.065	0.610	0.061
ln(pre-1977 recruitment offset)	-1.137	0.130	-1.047	0.226	-1.099	0.216	-1.172	0.198	-1.098	0.220	-0.748	0.203
Initial F (Jan-Apr trawl fishery)	0.664	0.141	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Initial F (fishery)	n/a	n/a	0.127	0.045	0.155	0.056	0.188	0.071	0.149	0.056	0.073	0.021
ln(trawl survey catchability)	-0.261	_	-0.487	0.062	-0.133	0.065	0.033	0.056	-0.408	0.056	-0.496	0.061
ln(NMFS LL survey catchability)	n/a	n/a	n/a	n/a	n/a	n/a	0.410	0.071	n/a	n/a	n/a	n/a

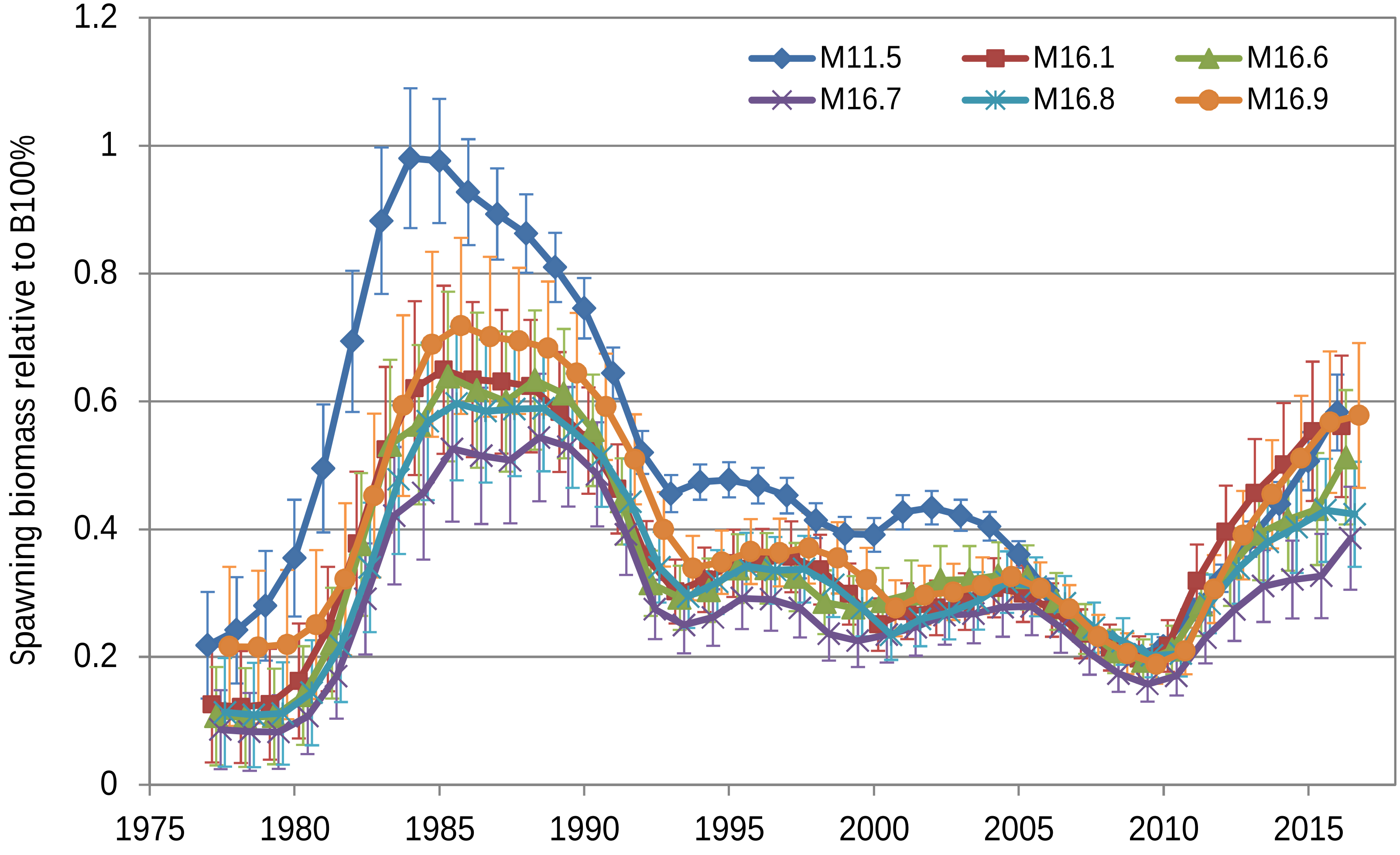
- Trawl survey catchability on the back-transformed scale:

Model 11.5		Model 16.1		Model 16.6		Model 16.7		Model 16.8		Model 16.9	
Est.	CV	Est.	CV	Est.	CV	Est.	CV	Est.	CV	Est.	CV
0.77	n/a	0.61	0.062	0.88	0.065	1.03	0.056	0.66	0.056	0.61	0.061

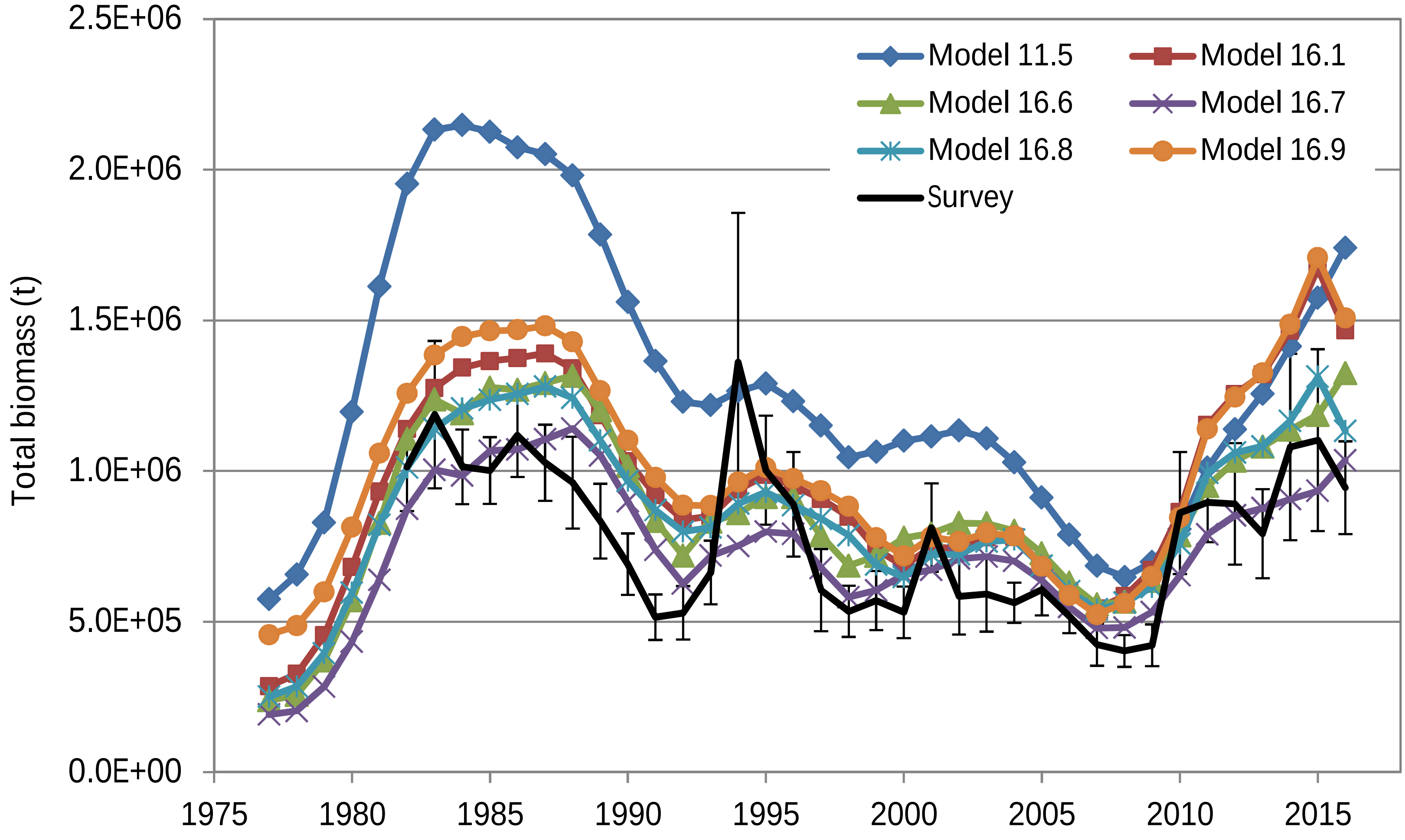
Log recruitment (age 0) deviations



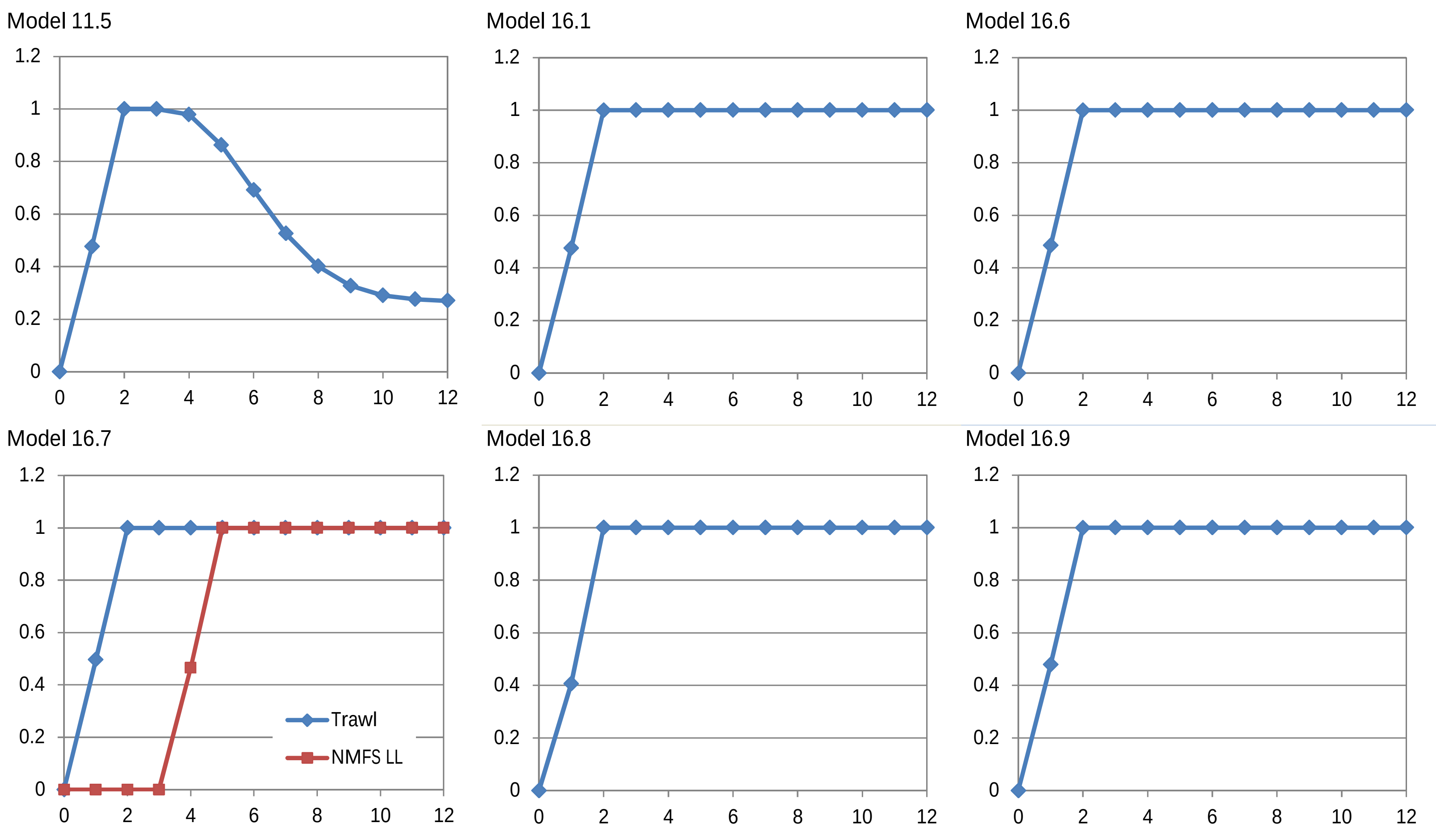
Spawning biomass relative to B100%



Total (age 0+) biomass, with survey

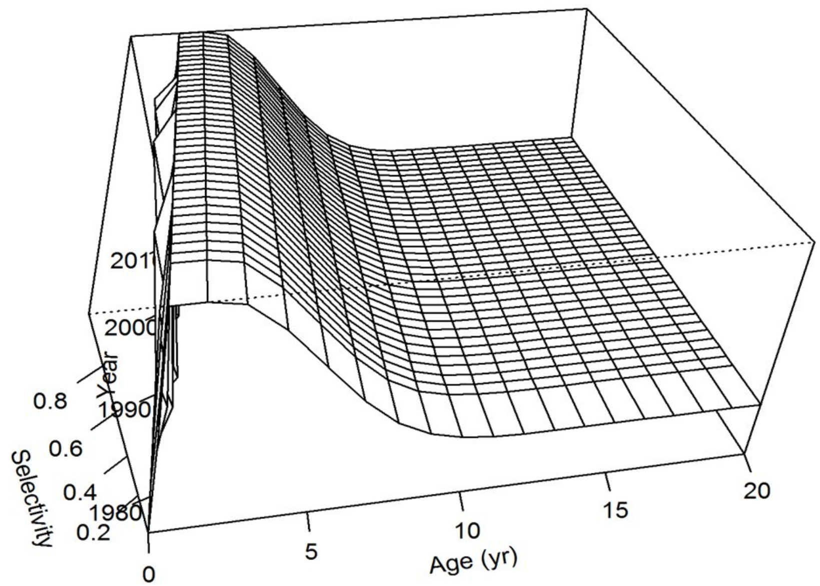


Survey selectivity (base case for M11.5, M16.8)

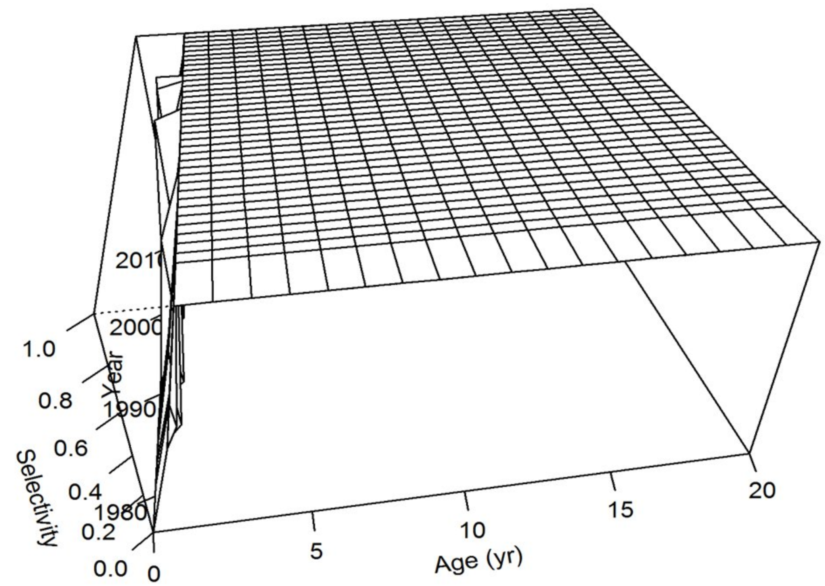


Survey selectivity: time-varying M11.5, M16.8

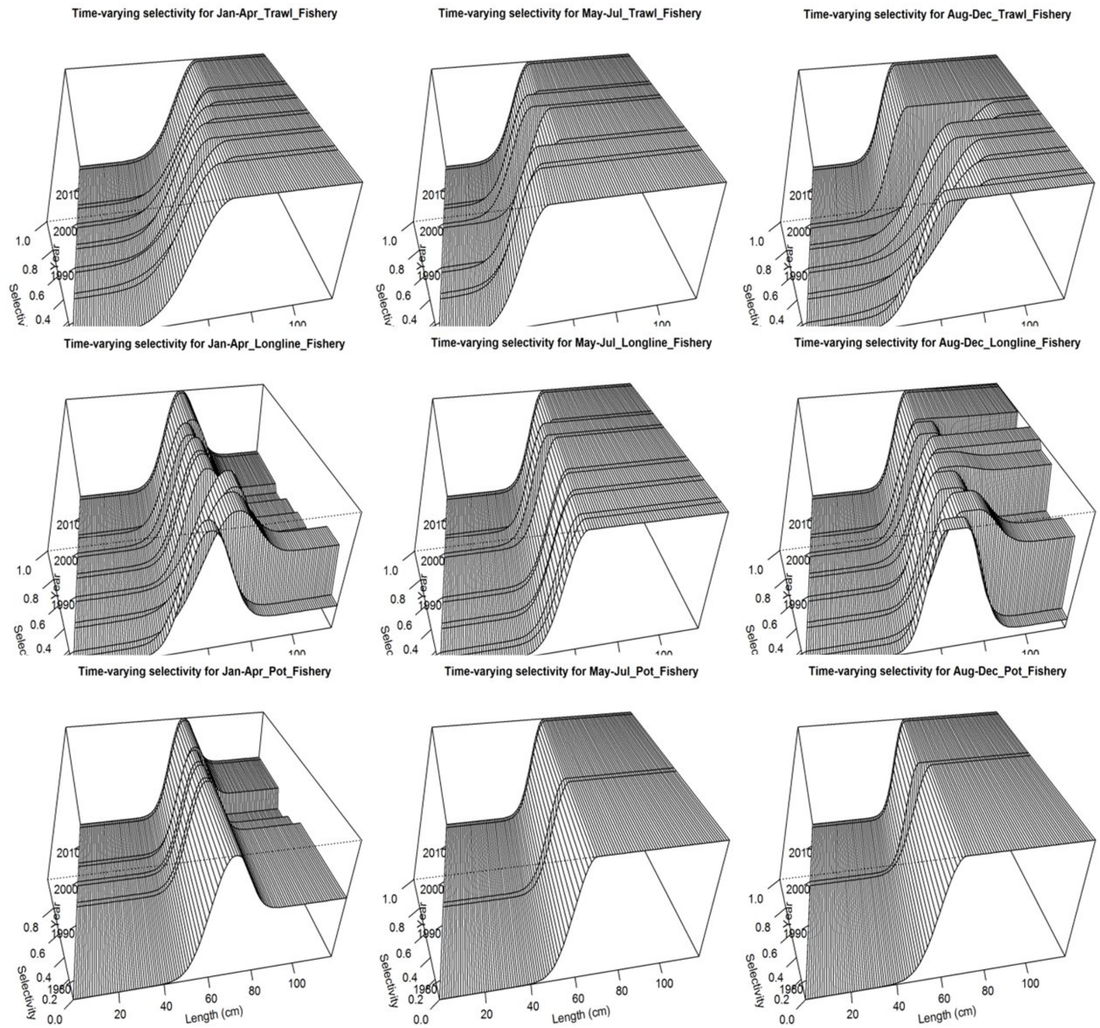
Model 11.5



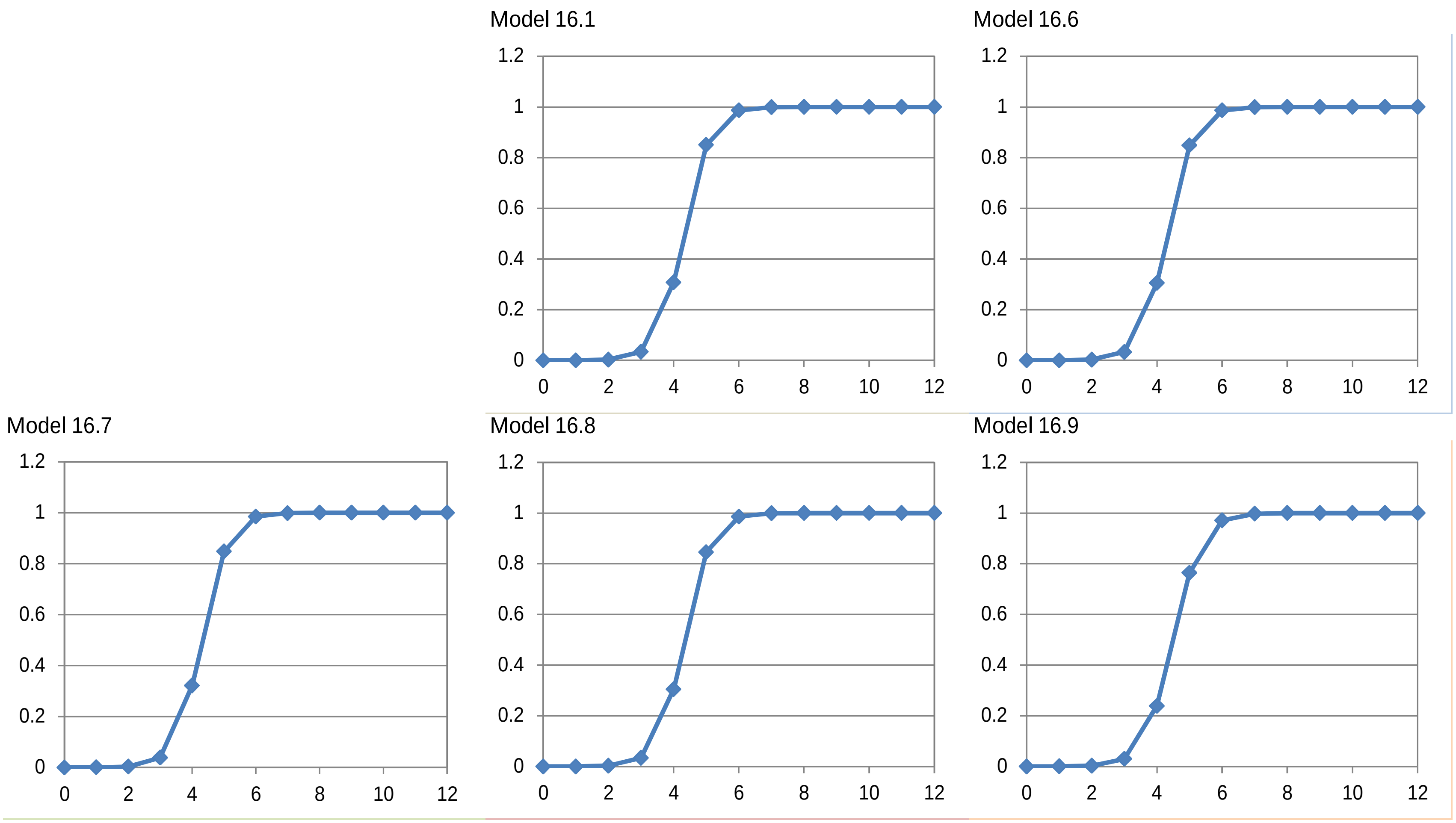
Model 16.8



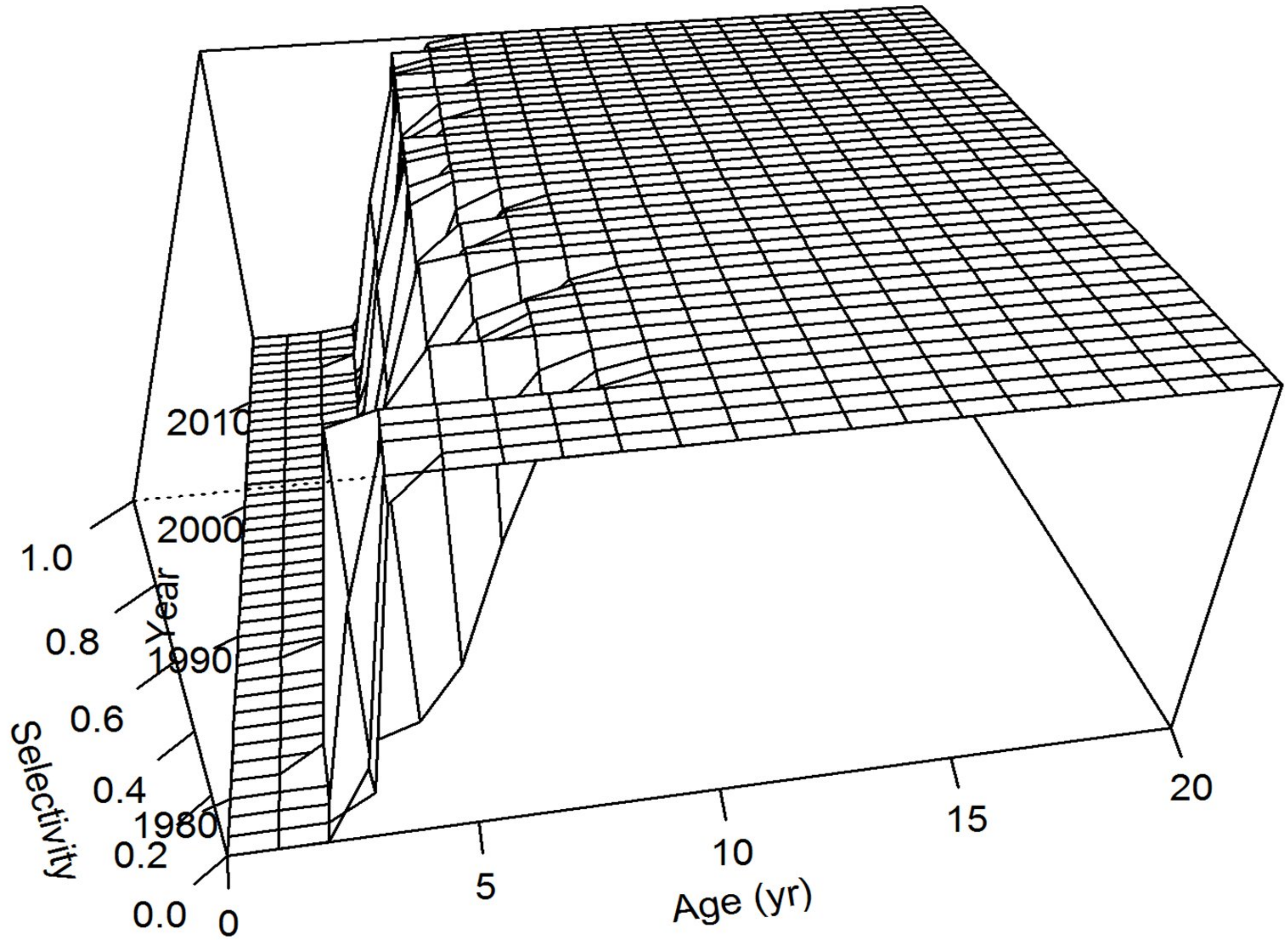
Fishery selectivity: Model 11.5



Fishery selectivity (base case for M16.9)



Fishery selectivity: time-varying M16.9



Management reference points

Quantity	M11.5	M16.1	M16.6	M16.7	M16.8	M16.9
B100%	788,000	668,000	620,000	609,000	631,000	681,000
B40%	315,000	267,000	248,000	243,000	252,000	272,000
B35%	276,000	234,000	217,000	213,000	221,000	238,000
B(2017)	440,000	380,000	327,000	242,000	267,000	393,000
B(2018)	462,000	393,000	337,000	266,000	281,000	403,000
B(2017)/B100%	0.56	0.57	0.53	0.40	0.42	0.58
B(2018)/B100%	0.59	0.59	0.54	0.44	0.45	0.59
F40%	0.28	0.29	0.31	0.29	0.29	0.32
F35%	0.34	0.36	0.38	0.35	0.35	0.38
maxFABC(2017)	0.28	0.29	0.31	0.29	0.29	0.32
maxFABC(2018)	0.28	0.29	0.31	0.29	0.29	0.32
maxABC(2017)	338,000	265,000	239,000	170,000	191,000	276,000
maxABC(2018)	325,000	280,000	255,000	192,000	207,000	302,000
FOFL(2017)	0.34	0.36	0.38	0.35	0.35	0.38
FOFL(2018)	0.34	0.36	0.38	0.35	0.35	0.38
OFL(2017)	396,000	314,000	284,000	200,000	226,000	327,000
OFL(2018)	381,000	331,000	302,000	228,000	244,000	357,000
Pr(maxABC(2017)>truOFL(2017))	0.01	0.08	0.08	0.08	0.08	0.09
Pr(maxABC(2018)>truOFL(2018))	0.03	0.10	0.10	0.08	0.10	0.10

Final model and projections

Retrospective considerations

- The SSC has recommended that retrospective performance be considered in the selection of a final model

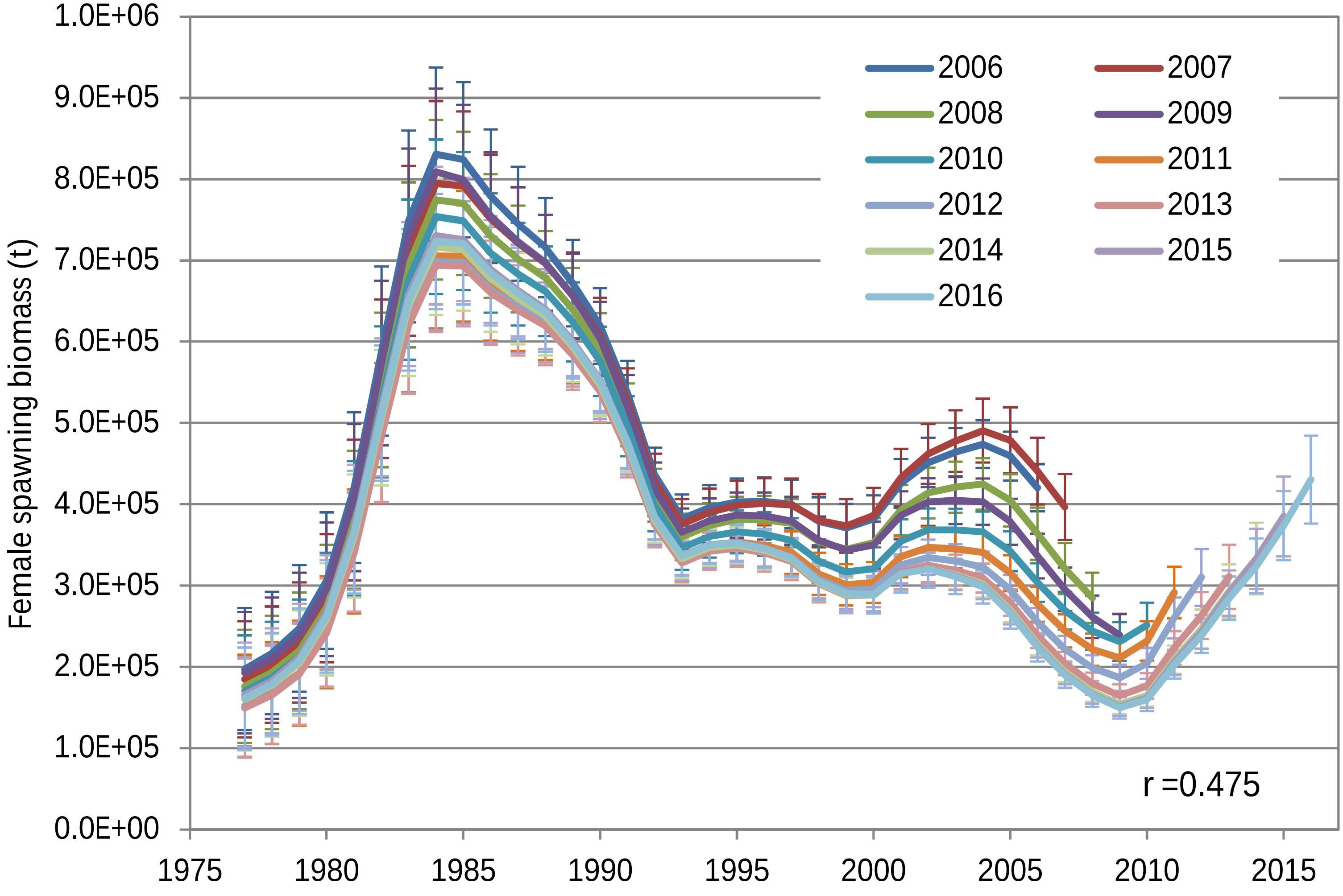
Model:	11.5	16.1	16.6	16.7	16.8	16.9
r :	0.475	0.194	0.147	0.144	0.094	0.250

- Interpolating the value of r that constitutes a "cause for concern" from Hurtado-Ferro et al. (2015):

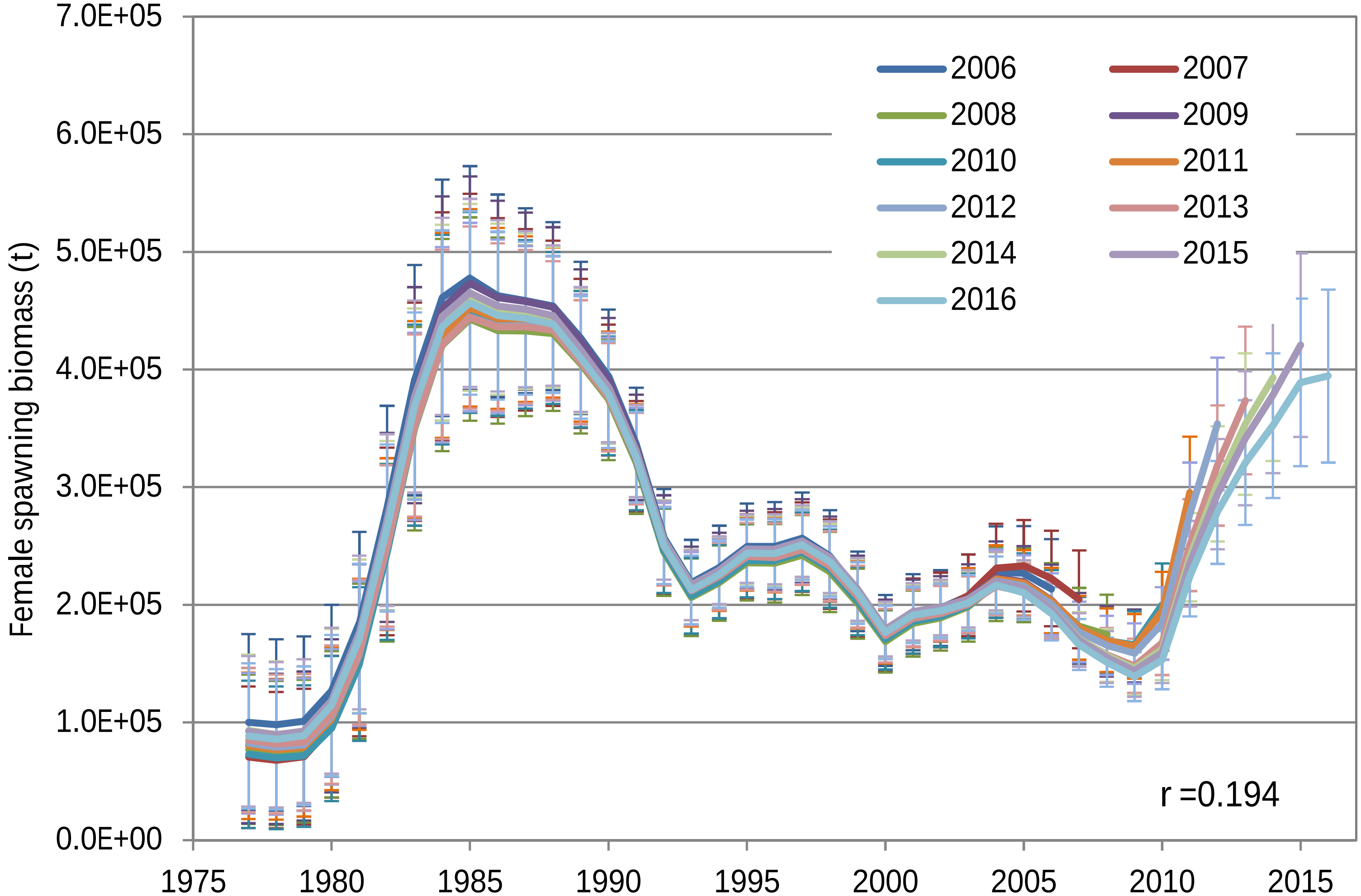
Model:	11.5	16.1	16.6	16.7	16.8	16.9
M :	0.340	0.378	0.363	0.344	0.375	0.376
r max:	0.270	0.289	0.282	0.272	0.288	0.288

- Model 11.5 is the only model where r exceeds r max

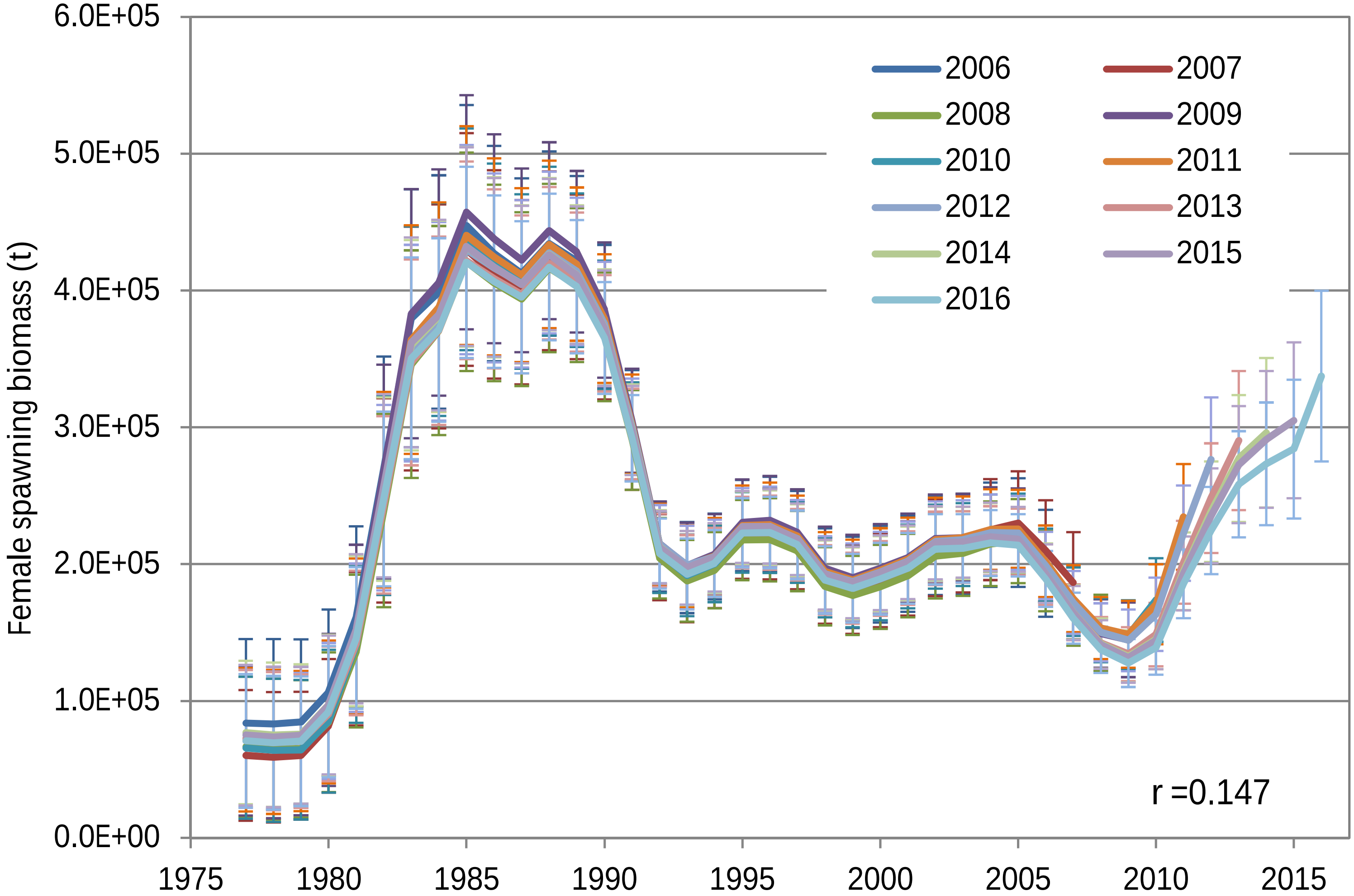
Retrospective analysis: Model 11.5



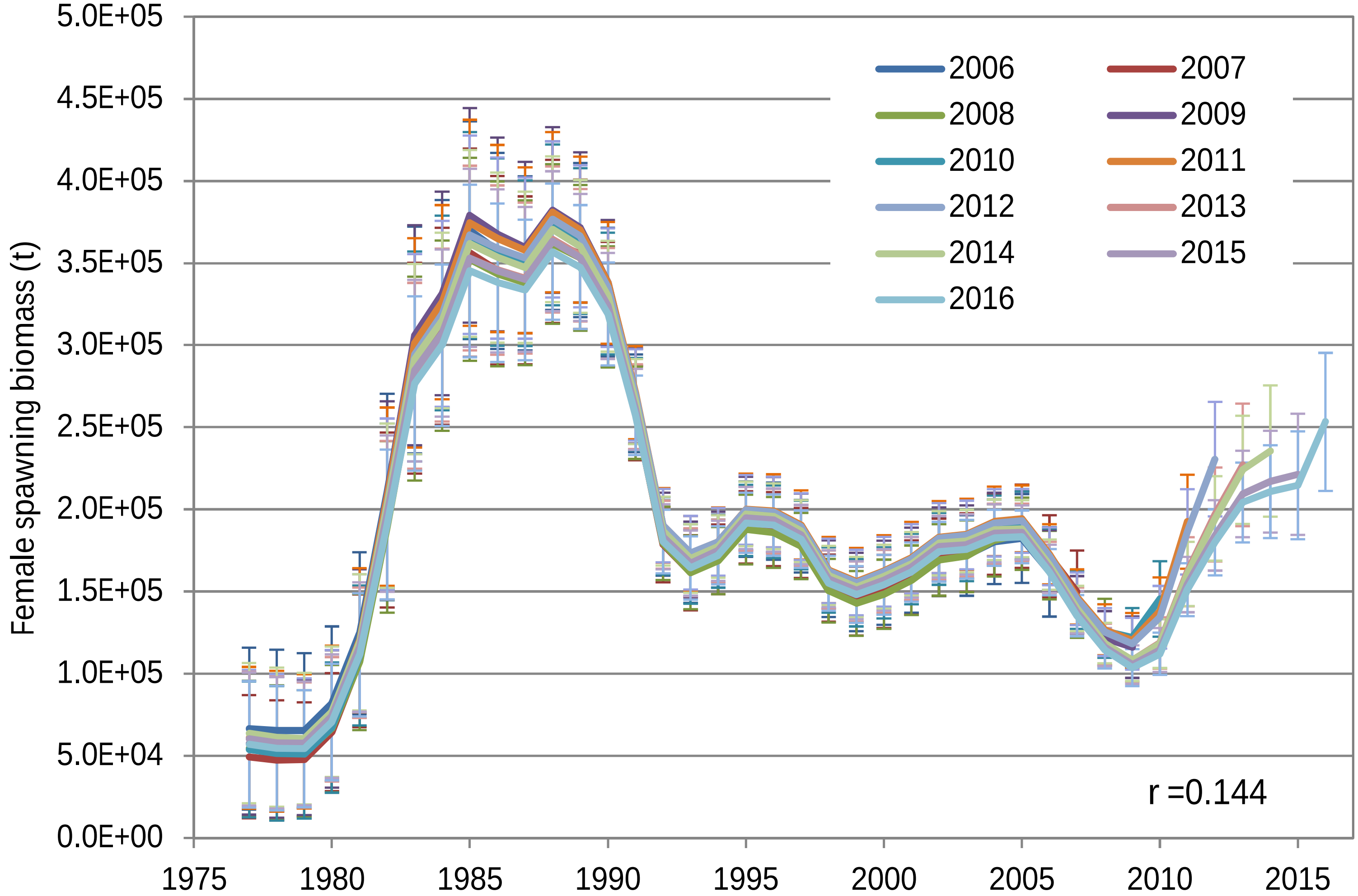
Retrospective analysis: Model 16.1



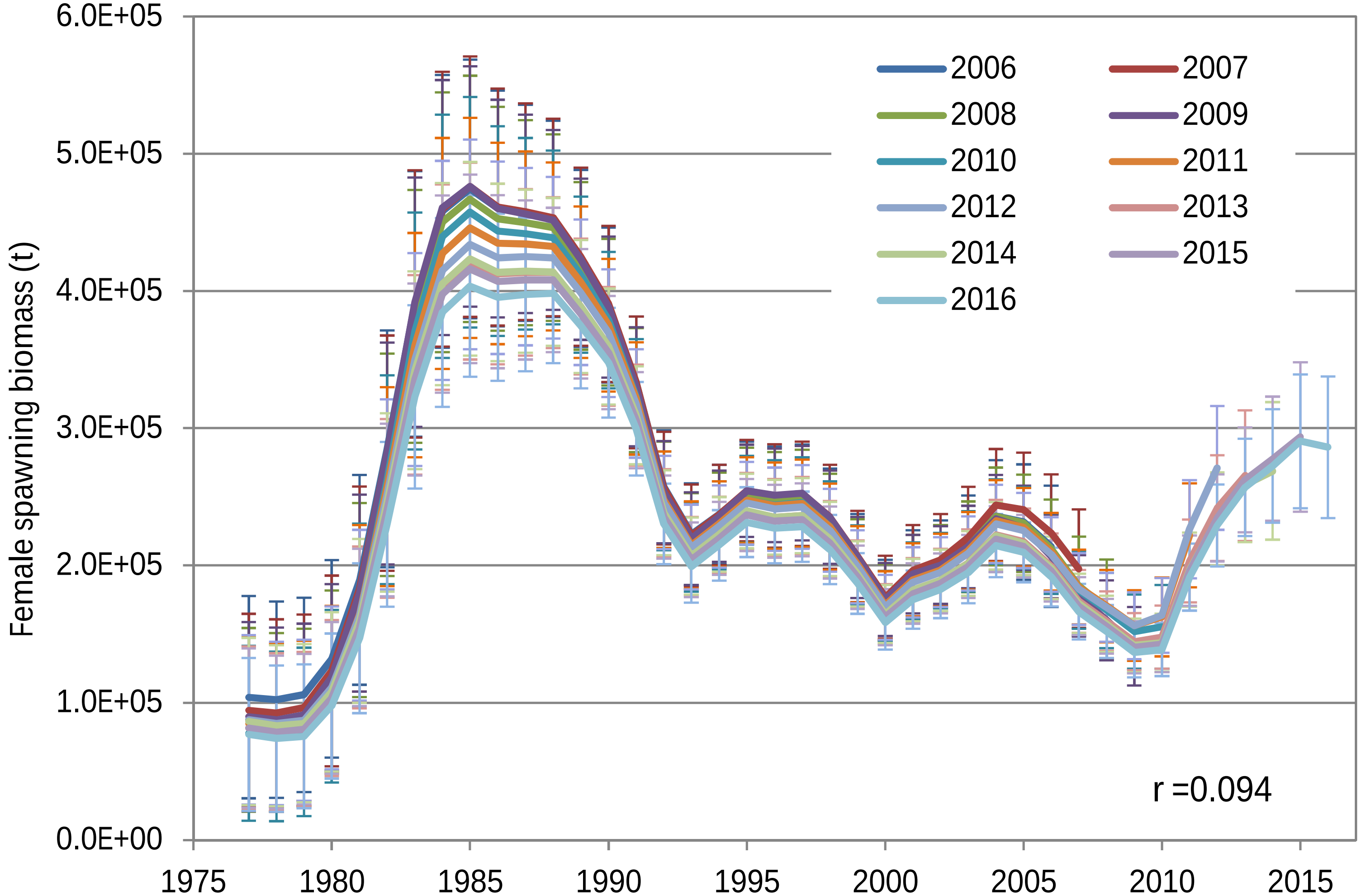
Retrospective analysis: Model 16.6



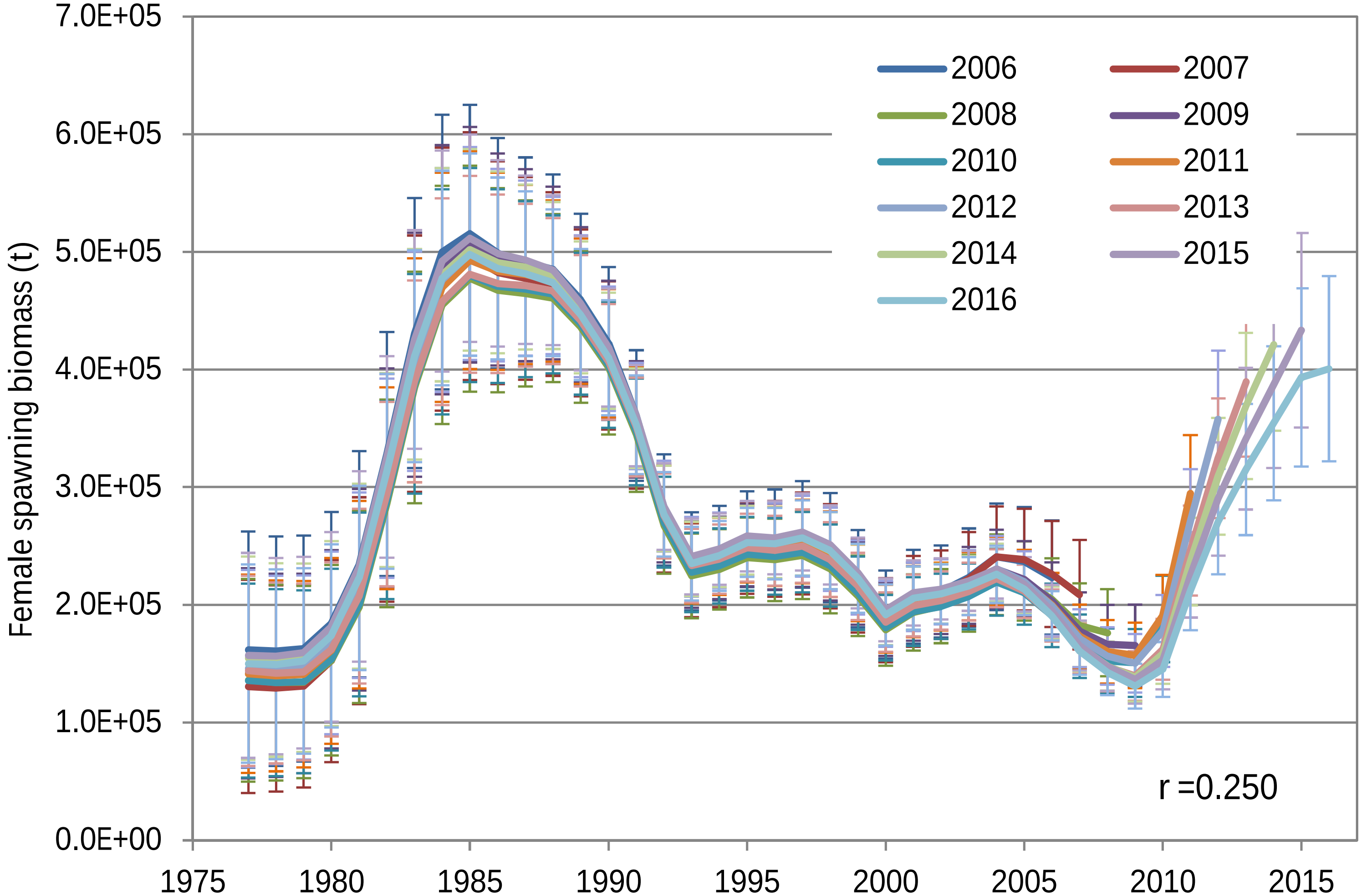
Retrospective analysis: Model 16.7



Retrospective analysis: Model 16.8



Retrospective analysis: Model 16.9



Other considerations (1 of 5)

- All models give good fits to the size composition data, but:
  - Only Models 16.7, 16.8, and 16.9 give good fits to the age composition data
  - None of the models gives a particularly good fit to the trawl survey abundance data
- Based on AIC:
  - Model 16.9 would be strongly preferred over Model 16.1
  - Model 16.8 would be strongly preferred over either Model 16.1 or Model 16.9
  - Other model comparisons not meaningful

Other considerations (2 of 5)

- Only Models 11.5 and 16.9 allow time-varying fishery selectivity
  - The various gear types likely have different selectivity schedules and the proportions of the catch taken by the various gear types has changed considerably over time
- Similarly, only Models 11.5 and 16.8 allow time-varying survey selectivity, and none of the models allow time-varying survey catchability
  - Lack of time-varying survey selectivity or catchability may be problematic, given that none of the models gives an acceptable fit to the trawl survey index

Other considerations (3 of 5)

- None of the models in the 16.x series allows for the possibility of dome-shaped survey selectivity, whereas the Team and SSC have recently supported allowing for this:
  - BPT (9/15): *“Dome-shaped survey selectivity seems inescapable”*
  - SSC (10/16): *“The SSC notes that, in spite of the concerns over dome-shaped selectivity in the survey, there are many potential mechanisms relating to the availability of larger fish to the survey gear that could result in these patterns, regardless of the efficiency of the trawl gear to capture large fish in its path”*

Other considerations (4 of 5)

- Models 16.1, 16.8, and 16.9 fix the time series of weight at age at externally estimated values
  - The other models use *internally* estimated length at age (time-invariant for all three models) and *externally* estimated weight at length (time-invariant in Model 11.5, time-varying in Models 16.6 and 16.7) to determine the time series of weight at age
- Advantage (assuming that the estimates are accurate):
  - This method integrates any changes in the length-at-age and weight-at-length relationships without having to estimate them inside the model
- Disadvantages: See next slide

Other considerations (5 of 5)

- Disadvantages (in the context of this assessment):
  - No smoothing was applied to the estimates, even though they exhibit a fair amount of variability, at least some of which seem implausible
    - For example, 10% of the within-cohort changes in weight from ages a to $a+1$ are negative
  - Age data exist for only 18 of the 35 years in the survey series and only 4 of the 39 years in the fishery series
  - Fishery age data come primarily from the longline fishery
  - Begin-year population weights at age were calculated by linear interpolation between mid-year surveys

Model averaging (1 of 4)

- In the context of the EBS Pacific cod assessment models, the SSC's first reference to use of model averaging came in December 2008:
  - *"Consider the strengths and weaknesses of model averaging as an alternative to model selection…."*
- At that time, the practice was to include, to the extent possible, every model that was requested by anyone
- One of the concerns expressed in the 2009 assessment was that the resulting set of models might be biased
- However, given that the set of models included in this assessment was the result of a formal, scientific vetting process, the concern about possible bias should be lessened

Model averaging (2 of 4)

- Individual members of the SSC have advocated a model averaging approach for this assessment at various times during the last few years, for example (comment SSC18):
  - *"We encourage the authors and Plan Teams to consider approaches such as multi-model inference…."*
- At its June meeting, the SSC also acknowledged potential difficulty in reconciling this approach with current procedures:
  - *"The time may be right for a workshop … on how to select and weight models for ensemble modeling and how to **use an ensemble approach with our current harvest control rules**"* (emphasis added)

Model averaging (3 of 4)

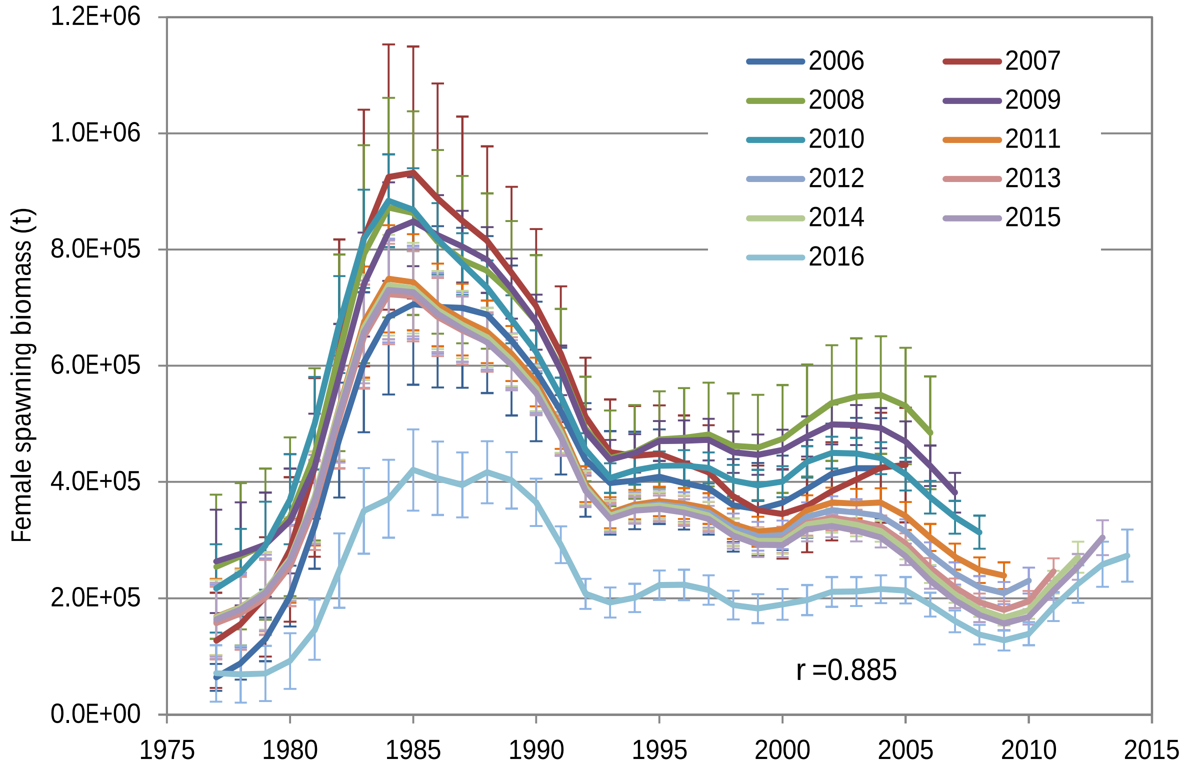
- As an appropriate method for using a full model averaging approach in the context of the current management framework has yet to be determined, a possible short-term compromise would be to choose the single model that gives a 2017 maximum permissible ABC closest to the average across all models
- This implies an equal weighting of models, which is a departure from traditional model averaging technique
- However, Stewart and Martell (2015) argued that equal weighting may prove to be a reasonable way forward for the time being, particularly if the models in the ensemble have been chosen carefully

Model averaging (4 of 4)

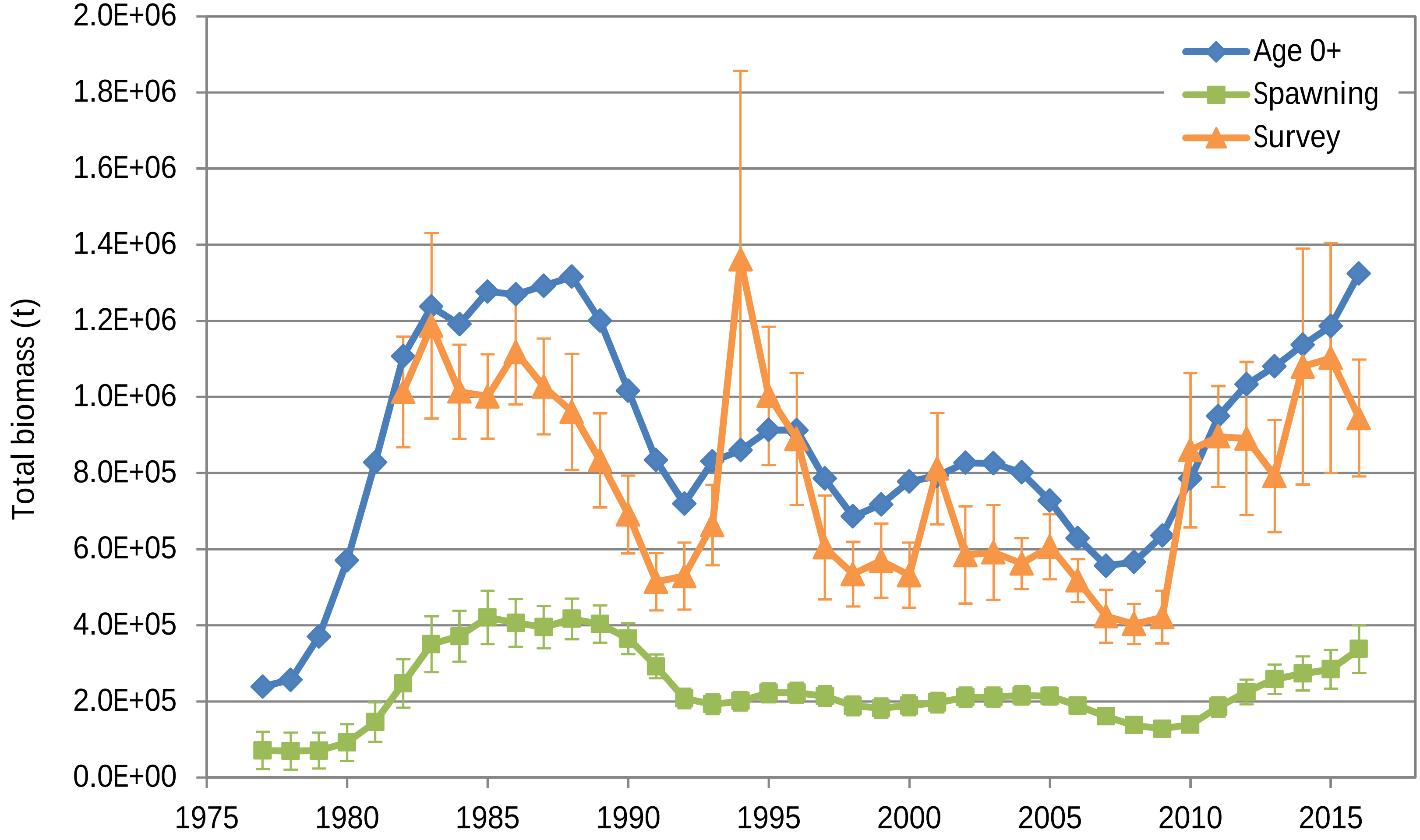
- The average 2017 maximum permissible ABC across all models is 246,500 t
  - If it is determined that Model 11.5 is no longer credible, the average across all models in the 16.x series is 228,200 t
- In either case, the single model whose 2017 maximum permissible ABC comes closest to the average is Model 16.6 (2017 maximum permissible ABC = 239,000 t)
- Given that each of the models has something to commend it but each also leaves something to be desired, and that a full model averaging approach does not seem possible at this time, Model 16.6 is recommended as this year's final model

Retrospective across assessments

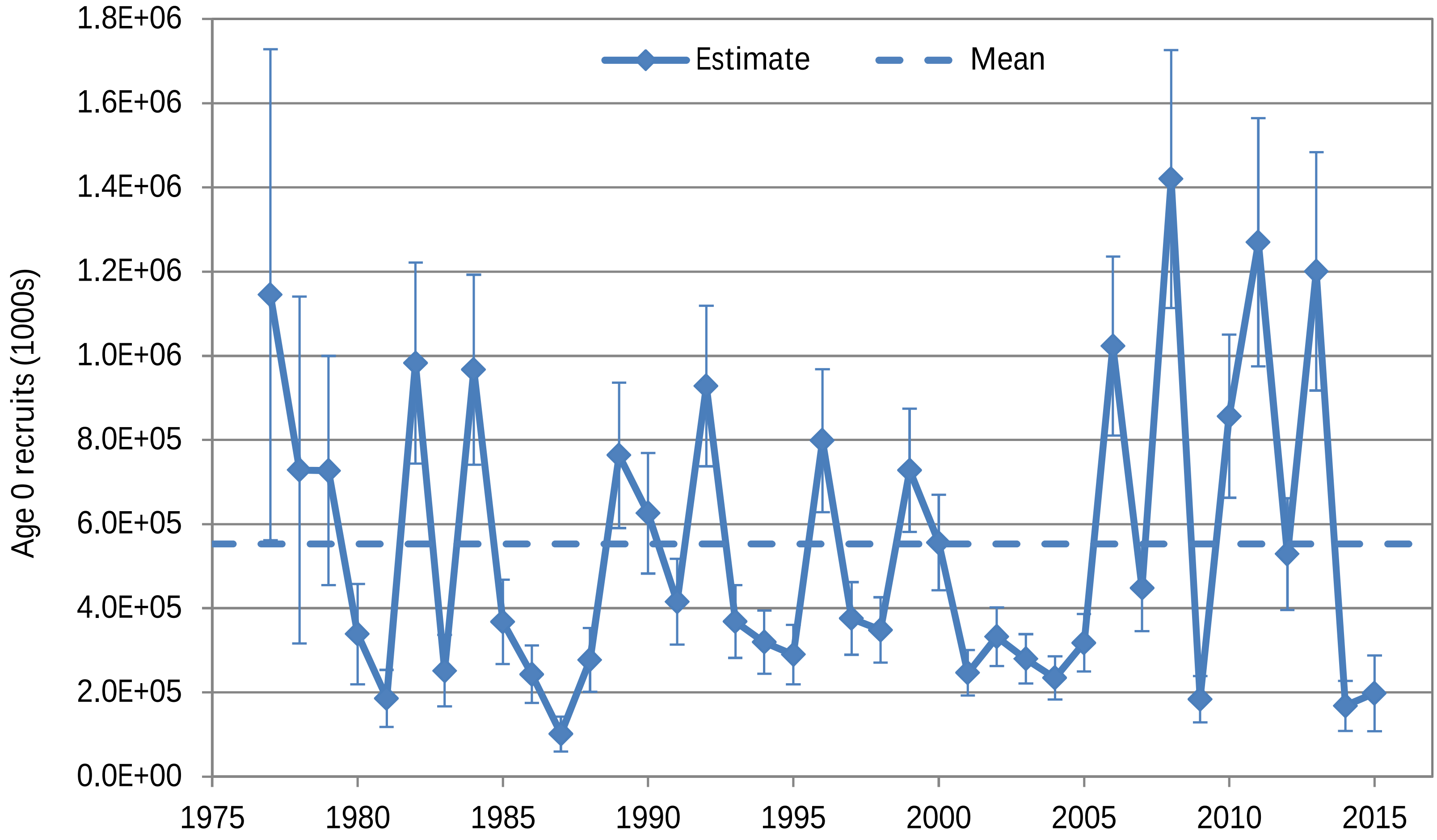
- Major model changes in 2007, 2008, 2010, 2011, 2016
- Minor model change in 2009



Biomass time series (Model 16.6)



Age 0 recruitment time series (Model 16.6)



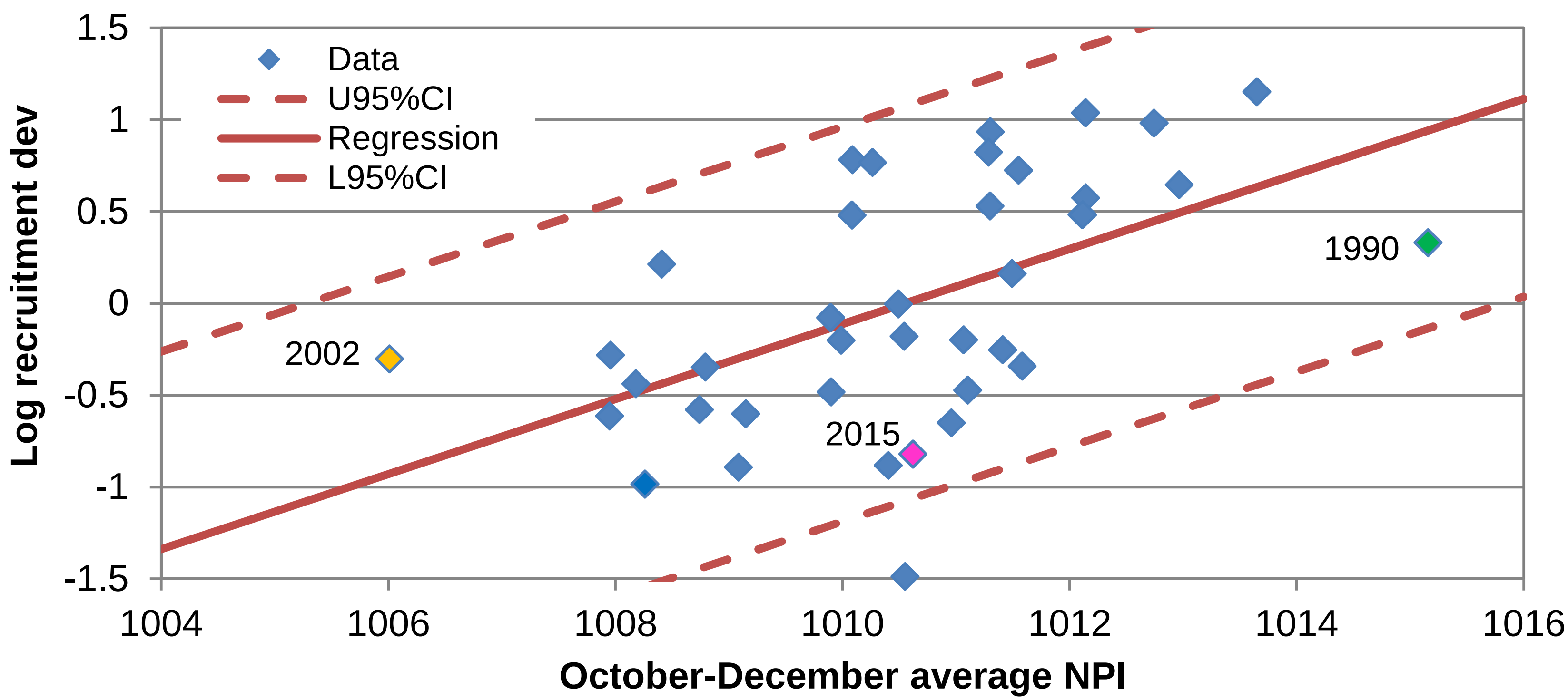
Summary of results

Quantity	As estimated or *specified last* year for: 2016	2017	As estimated or *recommended this* year for: 2017*	2018*
M (natural mortality rate)	0.34	0.34	0.36	0.36
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	1,830,000	1,780,000	1,260,000	1,110,000
Projected female spawning biomass (t)	466,000	530,000	327,000	340,000
$B_{100\%}$	806,000	806,000	620,000	620,000
$B_{40\%}$	323,000	323,000	248,000	248,000
$B_{35\%}$	282,000	282,000	217,000	217,000
F_{OFL}	0.35	0.35	0.38	0.38
$maxF_{ABC}$	0.3	0.3	0.31	0.31
F_{ABC}	0.22	0.22	0.31	0.31
OFL (t)	390,000	412,000	284,000	302,000
maxABC (t)	332,000	329,000	239,000	255,000
ABC (t)	255,000	255,000	239,000	255,000

Ecosystem considerations

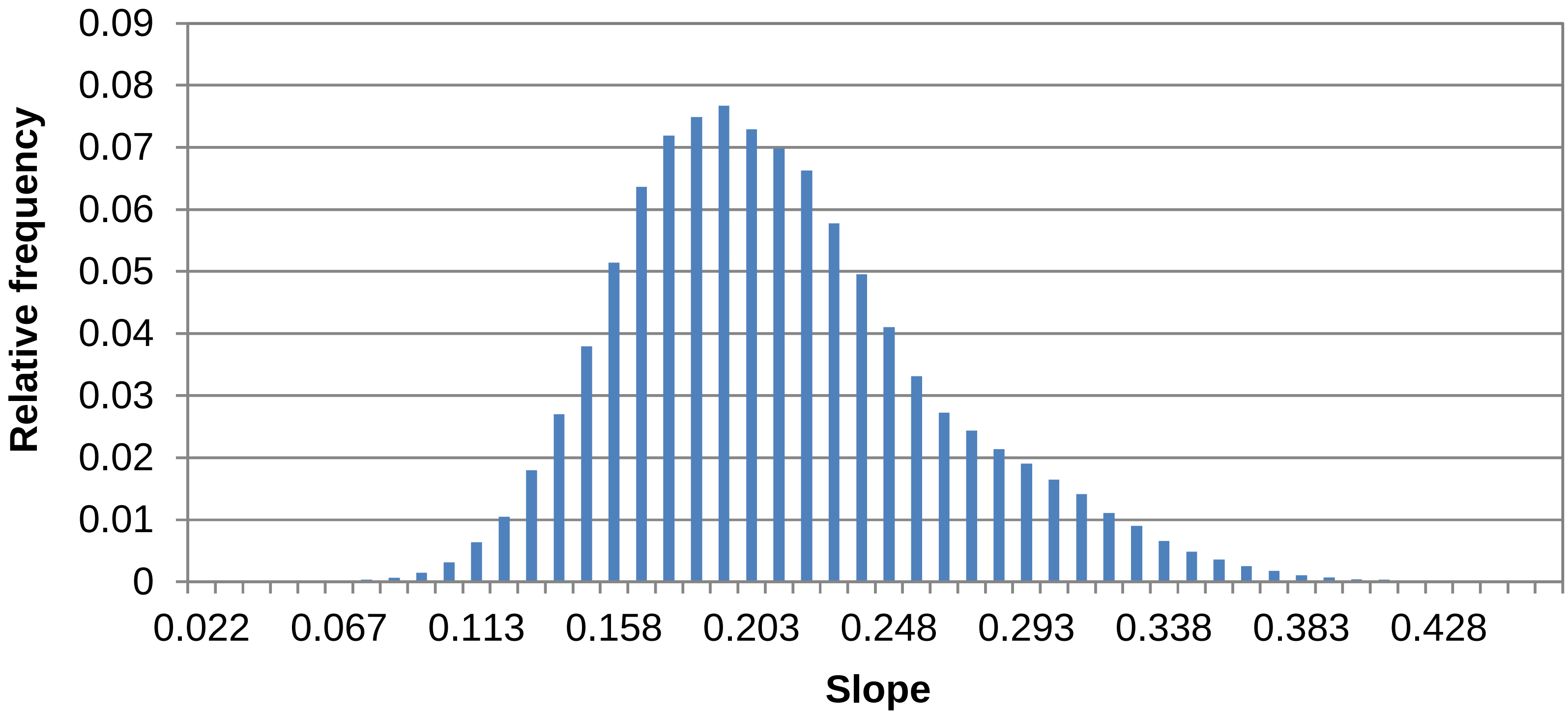
An environmental predictor of recruitment

- Recruitment varies directly with Oct-Dec average NPI
- Correlation = 0.55, R^2 = 0.30



Cross validation (50% random samples)

- RMSE from *test* sets: 0.68 without NPI, 0.59 with NPI
- Distribution of slope estimates from *training* sets



Impact of individual years on slope estimate

- 1990 and 2002 have strongest impact on slope, and both of those are in the negative direction