NOAA FISHERIES

Alaska Fisheries Science Center

Preliminary assessment of Pacific cod in the Eastern Bering Sea

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Responses to Team/SSC comments

SSC comments in general (1 of 2)

- SSC1 (10/15 minutes): *"The Team Procedures document clarifies that the … naming convention should focus on tracking the modeling configurations used for a particular stock assessment…. Of the options presented in the Joint Plan Teams minutes, the SSC agrees that Option 4 has several advantages and recommends that this Option be advanced next year."* As in last year's final assessment, Option 4a was used to number models
- SSC2 (12/15 minutes): *"The SSC reminds the authors and PTs to follow the model numbering scheme adopted at the December 2014 meeting*." This comment was assumed to be an error

SSC comments in general (2 of 2)

- SSC3 (12/15 minutes): *"Many assessments are currently exploring ways to improve model performance by re-weighting historic survey data. The SSC encourages the authors and PTs to refer to the forthcoming CAPAM data-weighting workshop report."* Results described by Punt (in press) were used to choose a data-weighting method for Model 16.5
- SSC4 (12/15 minutes): *"The SSC recommends that assessment authors work with AFSC's survey program scientist to develop some objective criteria to inform the best approaches for calculating Q with respect to information provided by previous survey trawl performance studies…."* The recent paper by Weinberg et al. (2016) is an example of the suggested collaboration

SSC comments on EBS Pacific cod (1 of 4)

- SSC5 (12/15 minutes, similar comment in 6/16 minutes): *"The SSC was encouraged by the author's explanation that dome-shaped selectivity may, in part, be explained by the possibility that some of older fish may be residing in the northern Bering Sea (NBS) at the time of the survey…. The SSC encourages the author to further examine Pacific cod catches from trawl surveys conducted triennially by the National Marine Fisheries Service (NMFS) (1976-1991) and by the Alaska Department of Fish & Game…."* The JTS recommended postponing this examination until 2017, when another survey of the NBS is scheduled

SSC comments on EBS Pacific cod (2 of 4)

- SSC6 (12/15 minutes): *"The SSC noted that the iteratively tuned, time-varying parameters in the model have not been updated since 2009…. The SSC looks forward to a new paper on this issue that the author is preparing."* The paper is in revision following initial journal review
- 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."* Retrospective analyses are presented for all models

SSC comments on EBS Pacific cod (3 of 4)

- 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."* This comment will be addressed in the final assessment
- SSC9 (6/16 minutes): *"The SSC accepts the JTS recommendations for models to bring forward in the 2016 assessment…."* Done
- SSC10 (6/16 minutes): *"The SSC agrees with CIE recommendations to use all reasonable data sources that are available…. The use of 'extra SD' in the proposed models for both regions is a reasonable approach to deal with this issue."* Done

SSC comments on EBS Pacific cod (4 of 4)

- SSC11 (6/16 minutes): *"The SSC encourages the use of empirical weight-at-age data in some of the model variants, but notes that this requires precise aging data."* Empirical weight-at-age data are used in Models 16.1, 16.4, and 16.5; some issues involved in generating these data are discussed
- 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."* Barring any changes in this request (note that there have been no changes in the accepted model since 2011), this will be included in the final assessment

Data

Data used in one or more models

- Data not used last year shown in italics

Source	Type	Years
Fishery	Catch biomass	1977-2015
Fishery	Catch size composition	1977-2015
Fishery	Catch per unit effort	1991-2015
Fishery	*Empirical weight at age*	*2008-2011*
EBS shelf bottom trawl survey	Relative abundance	1982-2015
EBS shelf bottom trawl survey	Size composition	1982-2015
EBS shelf bottom trawl survey	Age composition	1994-2014
EBS shelf bottom trawl survey	Mean size at age	1994-2014
EBS shelf bottom trawl survey	*Empirical weight at age*	*1998-2014*
IPHC longline survey	*Relative abundance*	*1997-2014*
IPHC longline survey	*Size composition*	*2008-2009, 2011-2015*
NMFS longline survey	*Relative abundance*	*1997-2015 (odd years only)*
NMFS longline survey	*Size composition*	*1997-2015 (odd years only)*

Possible issues with empirical weight at age

- No smoothing was applied to the estimates, even though they exhibit a fair amount of variability
- Age data exist for only 17 of the 34 years in the survey time series and only 4 of the 39 years in the fishery time series
- The fishery age data come primarily from the longline fishery, and may not be representative of the overall fishery
- Because the trawl survey takes place in summer, beginning-of-year population weights at age were calculated by averaging mid-year weight(age,year) and mid-year weight(age–1,year–1), implying that weight at age changes linearly within each one-year interval

Model structures

Requested models (1 of 3)

- Model 11.5: Final model from 2015 (same as the final models from 2011-2014)
- Model 16.1: Like Model 15.6, but simplified as follows:
  - Weight abundance indices more heavily than sizecomps
  - Use the simplest selectivity form that gives a reasonable fit
  - Do not allow survey selectivity to vary with time
  - Do not allow survey catchability to vary with time
  - Force trawl survey selectivity to be asymptotic
  - Do not allow strange selectivity patterns
  - Use empirical weight at age

Requested models (2 of 3)

- Model 16.2: Like Model 15.6, but including the IPHC longline survey data and other features, specifically:
  - Do not allow strange selectivity patterns
  - Estimate catchability of new surveys internally with non-restrictive priors
  - Include additional data sets to increase confidence in model results
  - Include IPHC longline survey, with ‘extra SD’
- Model 16.3: Like Model 16.2 above, but including the NMFS longline survey instead of the IPHC longline survey

Requested models (3 of 3)

- Model 16.4: Like Models 16.2 and 16.3 above, but including both the IPHC and NMFS longline survey data and two features not included in either Model 16.2 or 16.3, specifically:
  - Start including fishery agecomp data
  - Use empirical weight at age
- Model 16.5: Like Model 16.4 above, but including two features not included in Model 16.4, specifically:
  - Use either Francis or harmonic mean weighting
  - Explore age-specific M (e.g., using Lorenzen function)

Index "weight" relative to sizecomp "weight"

- Determined by comparing spawning biomass from 3 models:
  A. specified set of "emphasis" (λ) values, with each $\lambda \geq 1.0$;
  B. index $\lambda = 0.01$ while each λ for the sizecomp data was left at the value specified in model A; and
  C. sizecomp $\lambda = 0.01$ while each λ for the index data was left at the value specified in model A
- The abundance data in model A were determined to receive greater weight than the sizecomp data in that model if the absolute value of the proportional change in spawning biomass between models B and A exceeded the analogous value between models C and A

“Reasonable fit” to compositional data

- Avoid confounding with input multinomial sample size
  - That is, do not conclude that a simple functional form gives a reasonable fit by increasing the input N values
- Weighted coefficients of determination (R^2), computed on both the raw and logit scales, were used to measure goodness of fit
  - Annual weight = N(year)/sum(N(year))
- Fit is reasonable if and only if $R^2 \geq 0.99$ on the raw scale *and* $R^2 \geq 0.70$ on the logit scale
- Once reasonable fit obtained, try simpler functional forms

Index of selectivity "strangeness"

- An index of "strangeness" was defined, which varied directly with the number of changes in the signs of first differences, particularly if those first differences were large, and particularly if sign changes in occurred at early ages
- Index attains a minimum of 0 when selectivity varies monotonically and a maximum of 1 if selectivity alternates between values of 0 and 1 at all pairs of adjacent ages
- A time series of selectivity at age was determined to be "strange" if the average index exceeded a value of 0.05
- If a model produced a "strange" pattern, the SDs of the priors for the selectivity parameters and the SDs of any selectivity **dev** vectors were decreased proportionally relative to the values estimated for Model 15.6 in last year's assessment

New approach to "jittering" initial values

- An attempt was made to standardize the bounds within which individual parameters were "jittered"
- Bounds for each parameter in the model were adjusted to match the 99.9% confidence interval
- Jitter rate (equal to half the standard deviation of the logit-scale distribution from which "jittered" parameter values are drawn) was set at 1.0 for all models
- Standardizing the jittering process in this manner may not explore parameter space as thoroughly as previous approach
  - However, it should make the jitter rate more interpretable, and show the extent to which the identified minimum (local or otherwise) is well behaved

Model 11.5: main features

- Age- and time-invariant M, estimated outside the model
- All length-at-age parameters, including σs, estimated internally
- Ageing bias parameters estimated internally
- Gear-and-season-specific catch and selectivity for the fisheries
- Double normal selectivity for the fisheries and survey
- Length-based selectivity for the fisheries
- Age-based selectivity for the survey
- Fishery selectivity estimated for “blocks” of years
- Survey selectivity constant, except *dev*s for *ascending_width*
- Sizecomps used in all years, including years with agecomps
- Survey Q fixed at 0.77

Model 11.5: iterative tuning

- The standard deviations of the two **dev** vectors in Model 11.5 (log of age 0 recruitment and the survey *ascending_width* parameter, both additive) were estimated iteratively during the 2009 assessment by setting σ=stdev(**dev**)
- Survey catchability (Q) was estimated iteratively during the 2009 assessment by tuning Q so that average product of Q and selectivity across the 60-81 cm size range matched the point estimate of 0.47 given by Nichol et al. (2007)
- When the standard deviations were re-estimated by same method in preliminary 2011 assessment, Joint Plan Team determined the method to be "pathological" and "suspect"
- Per request of the Joint Plan Team, the above quantities have been held constant in Model 11.5 at the 2009 values

Main differences: Models 15.6 and 11.5

- Each year consisted of a single season instead of five
- 1 fishery was defined instead of 9 season $\times$ gear fisheries
- 20 age groups were estimated in the initial vector (vs. 3)
- The natural mortality rate was estimated internally
- The base value of Q was estimated internally
- Q was allowed to vary annually
- Selectivity for fishery and survey were allowed to vary annually
- Random walk w.r.t. age selectivity for both fishery and survey
  - Selectivity at ages 9+ constrained to equal selectivity at age 8 for both fishery and survey
- Tuning procedures (see next slide)

Model 15.6: iterative tuning

- Iterative tuning of time-varying catchability
  - SS treats each annual deviation in ln(Q) as a true parameter, with its own prior (not a "dev")
  - A single σ was assumed for all such prior distributions
  - The procedure involved iteratively adjusting σ until the SDNR for survey abundance equaled unity
- For composition data, arithmetic mean input N was set equal to min(300, harmonic mean effective N)
- Iterative tuning of selectivity and recruitment σs followed method of Thompson (2015)
  - If gradient was large, another **dev** vector was turned off (oldest first)

Results

Big picture

- Female spawning biomass (t), relative to $B_{100\%}$:

Quantity	Model 11.5			Model 16.1			Model 16.2		
	Value	SD	CV	Value	SD	CV	Value	SD	CV
FSB 2016	457,341	30,739	0.07	414,941	40,176	0.10	399,149	67,976	0.17
Bratio 2016	0.61	0.03	0.06	0.57	0.06	0.10	0.46	0.07	0.15

Quantity	Model 16.3			Model 16.4			Model 16.5		
	Value	SD	CV	Value	SD	CV	Value	SD	CV
FSB 2016	196,753	25,016	0.13	154,877	15,482	0.10	133,142	12,167	0.09
Bratio 2016	0.21	0.03	0.14	0.14	0.02	0.12	0.09	0.01	0.11

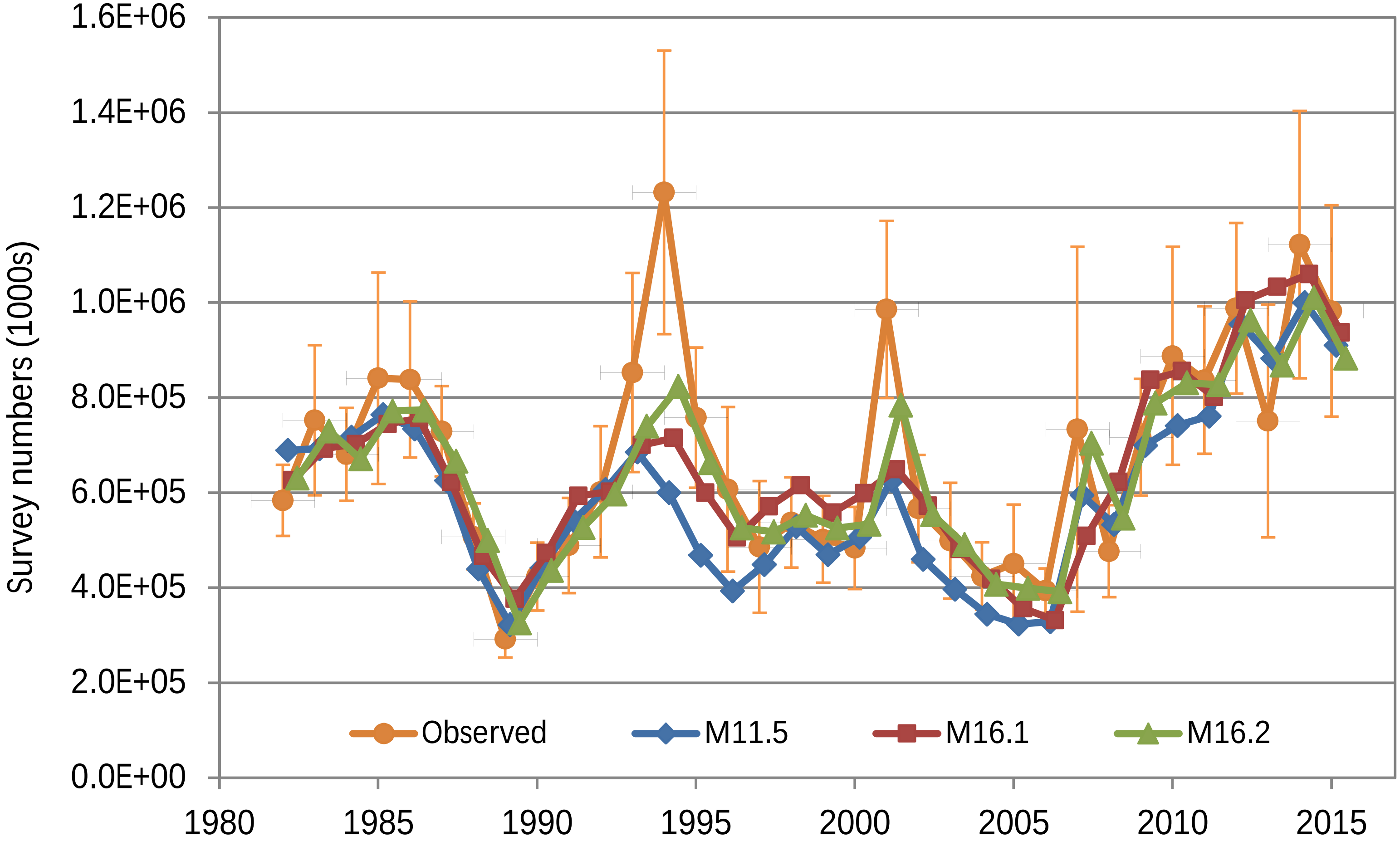
Objective function values

Obj. function component	Aggregated data components					
	M11.5	M16.1	M16.2	M16.3	M16.4	M16.5
Catch	0.00	0.00	0.00	0.00	0.00	0.00
Equilibrium catch	0.01	0.00	0.00	0.00	0.01	0.03
Survey abundance index	-6.87	-20.68	-65.07	-68.95	-72.68	-63.49
Size composition	5235.34	1332.77	1203.53	1359.81	1595.14	2144.84
Age composition	145.88	230.60	87.74	67.26	111.19	72.49
Recruitment	22.19	4.55	-4.05	-0.40	5.28	44.64
Priors	0.00	0.00	158.73	304.00	480.69	784.12
"Softbounds"	0.03	0.01	0.00	0.00	0.00	0.00
Deviations	20.31	0.00	96.61	55.82	59.85	118.88
"F ballpark"	0.00	n/a	n/a	n/a	n/a	n/a
Total	5416.88	1547.24	1477.49	1717.55	2179.47	3101.51

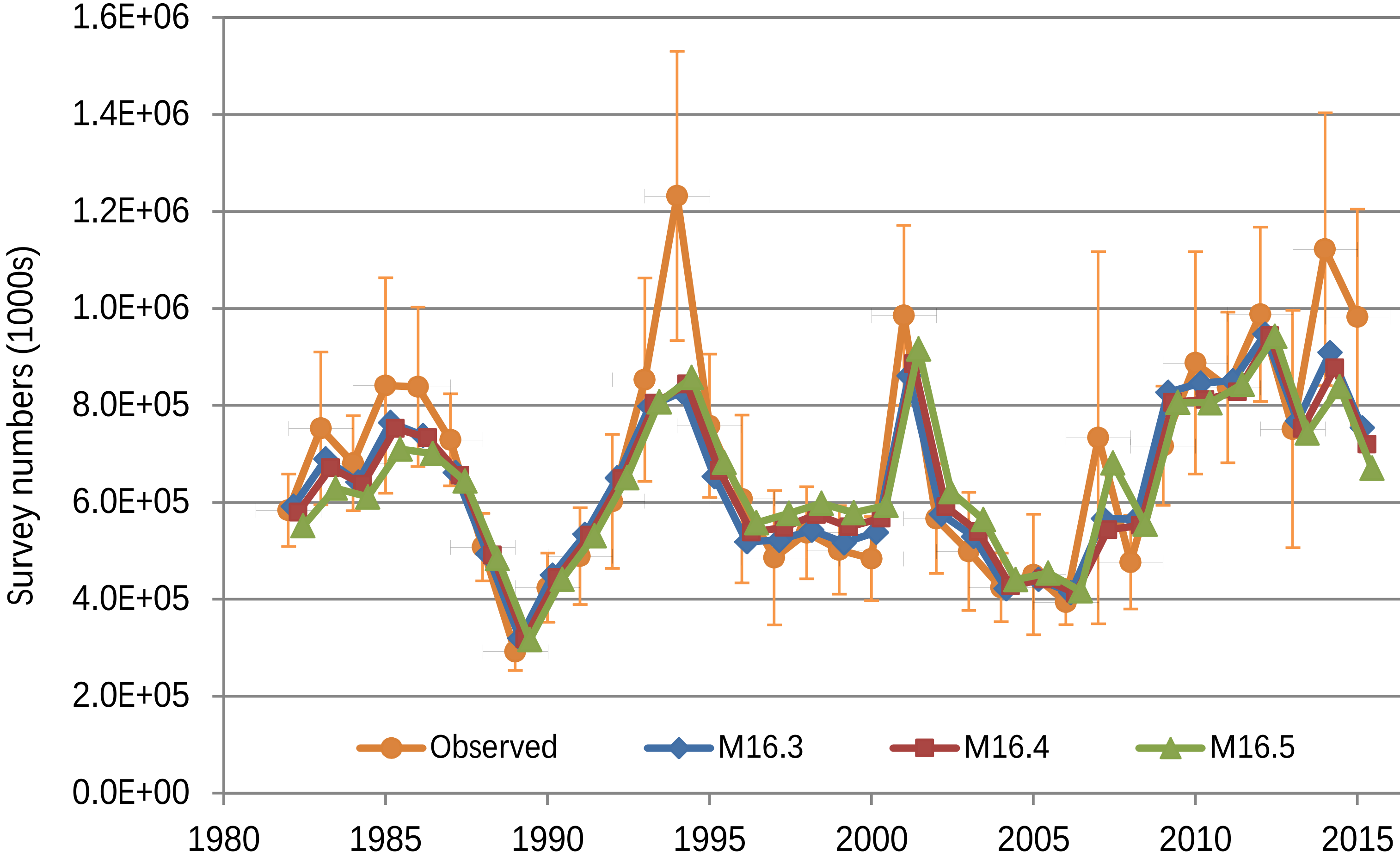
Goodness of fit: survey indices

Model	Survey	σave	RMSE	MNR	SDNR	Corr.
11.5	Trawl	0.11	0.22	0.95	1.80	0.78
16.1	Trawl	0.11	0.19	0.07	1.82	0.78
16.2	Trawl	0.11	0.11	0.09	1.00	0.93
16.3	Trawl	0.11	0.13	0.10	1.10	0.91
16.4	Trawl	0.11	0.14	0.10	1.17	0.90
16.5	Trawl	0.11	0.15	0.07	1.36	0.88
16.2	IPHC LL	0.43	0.56	-0.05	1.07	-0.12
16.4	IPHC LL	0.42	0.55	-0.06	1.08	-0.14
16.5	IPHC LL	0.46	0.58	-0.05	1.07	-0.14
16.3	NMFS LL	0.18	0.19	-0.22	0.99	0.70
16.4	NMFS LL	0.17	0.16	-0.19	0.96	0.77
16.5	NMFS LL	0.17	0.15	-0.14	0.93	0.82

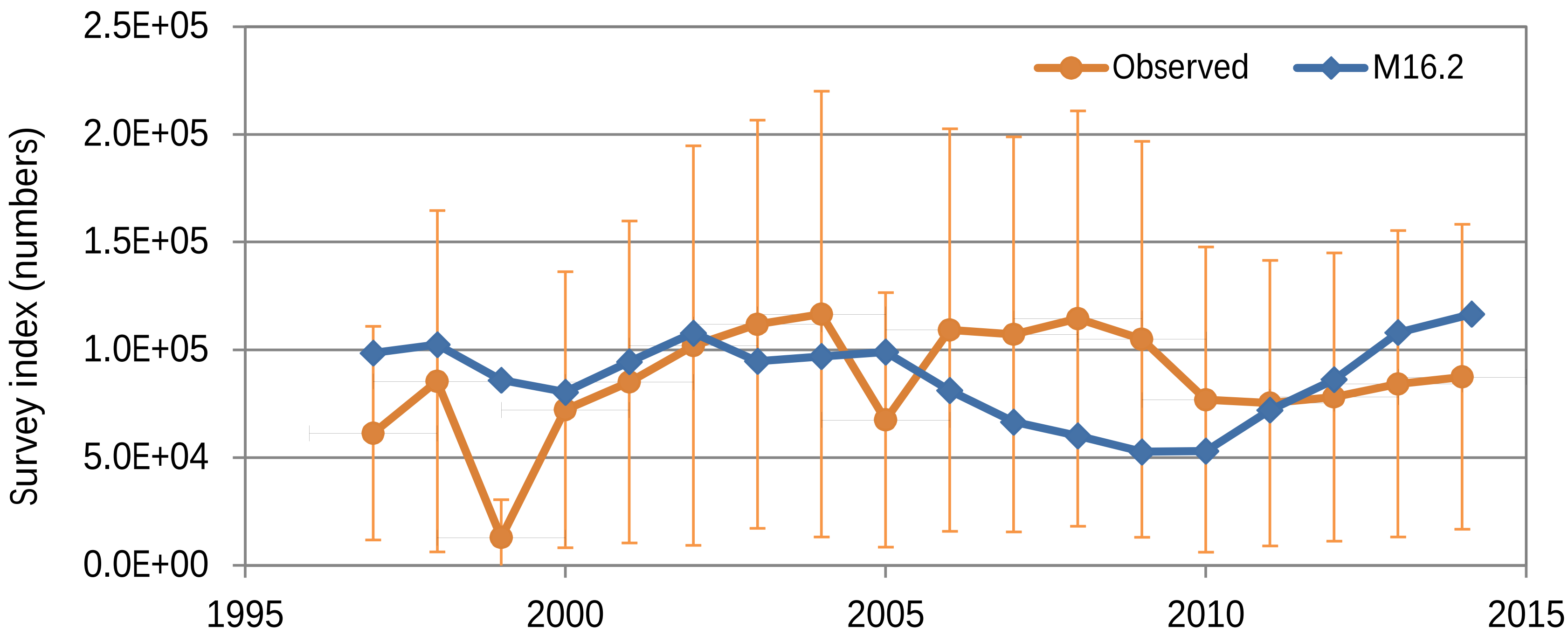
Fit to trawl survey index (Models 11.5-16.2)



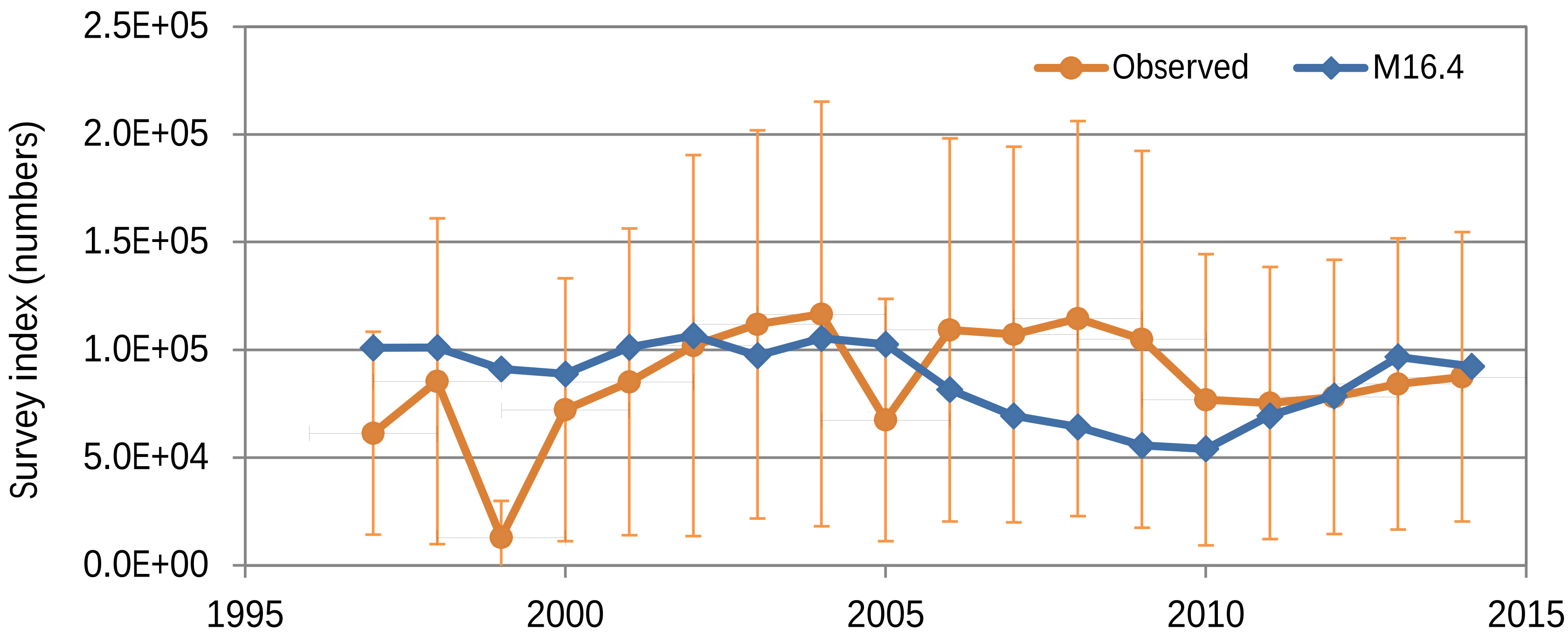
Fit to trawl survey index (Models 16.3-16.5)



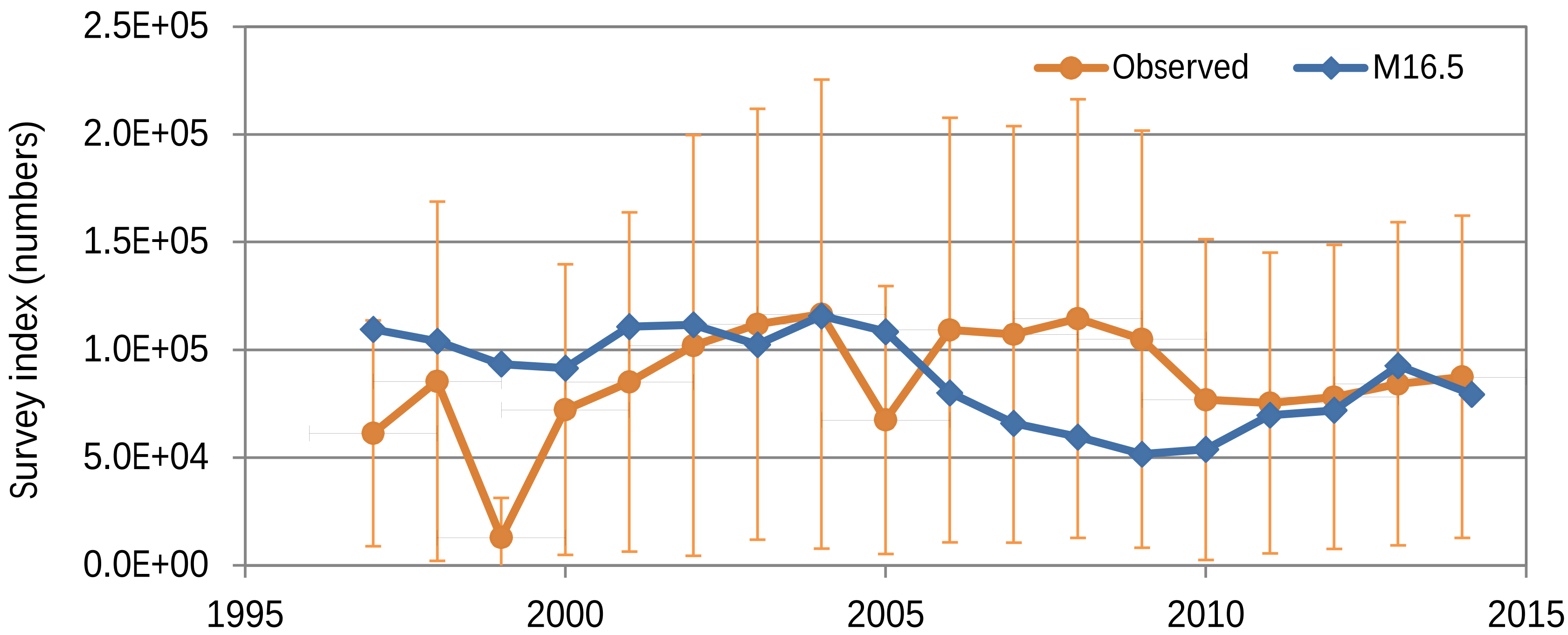
Fit to IPHC LL survey index (Model 16.2)



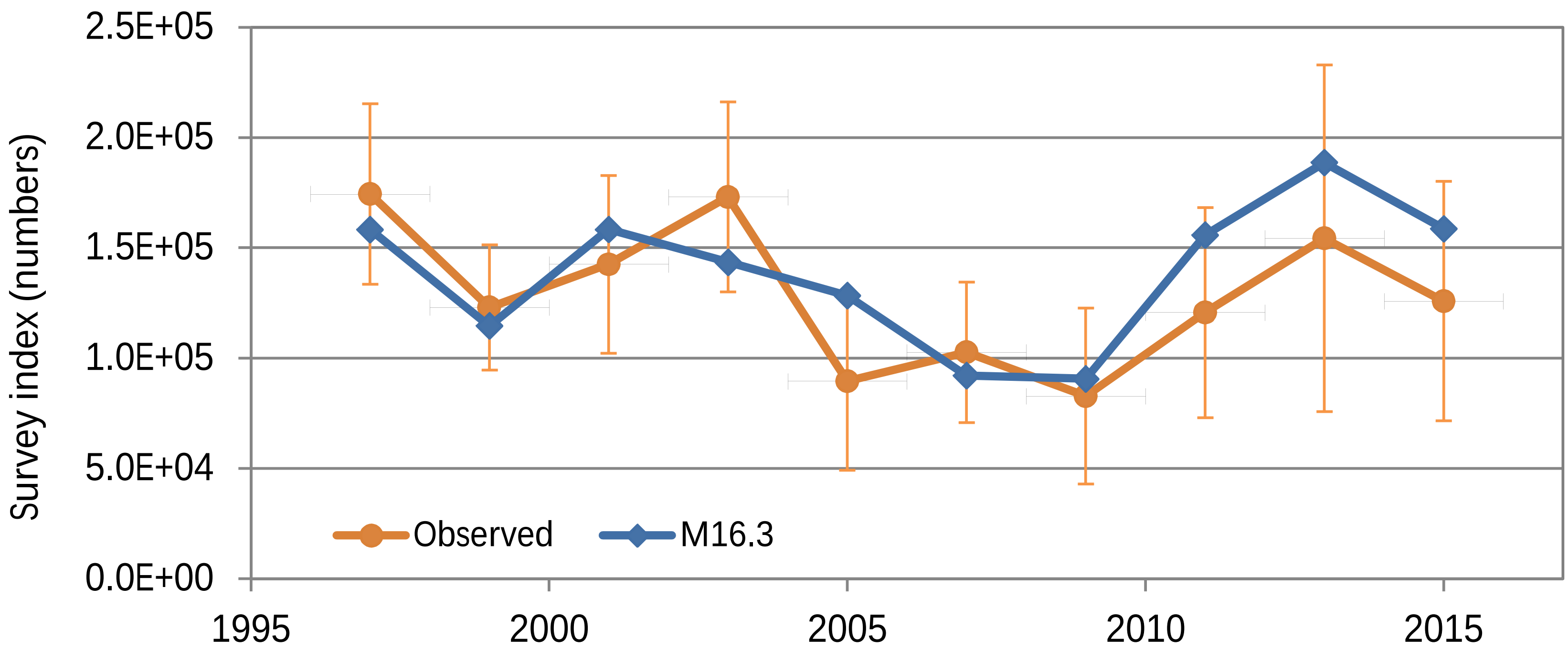
Fit to IPHC LL survey index (Model 16.4)



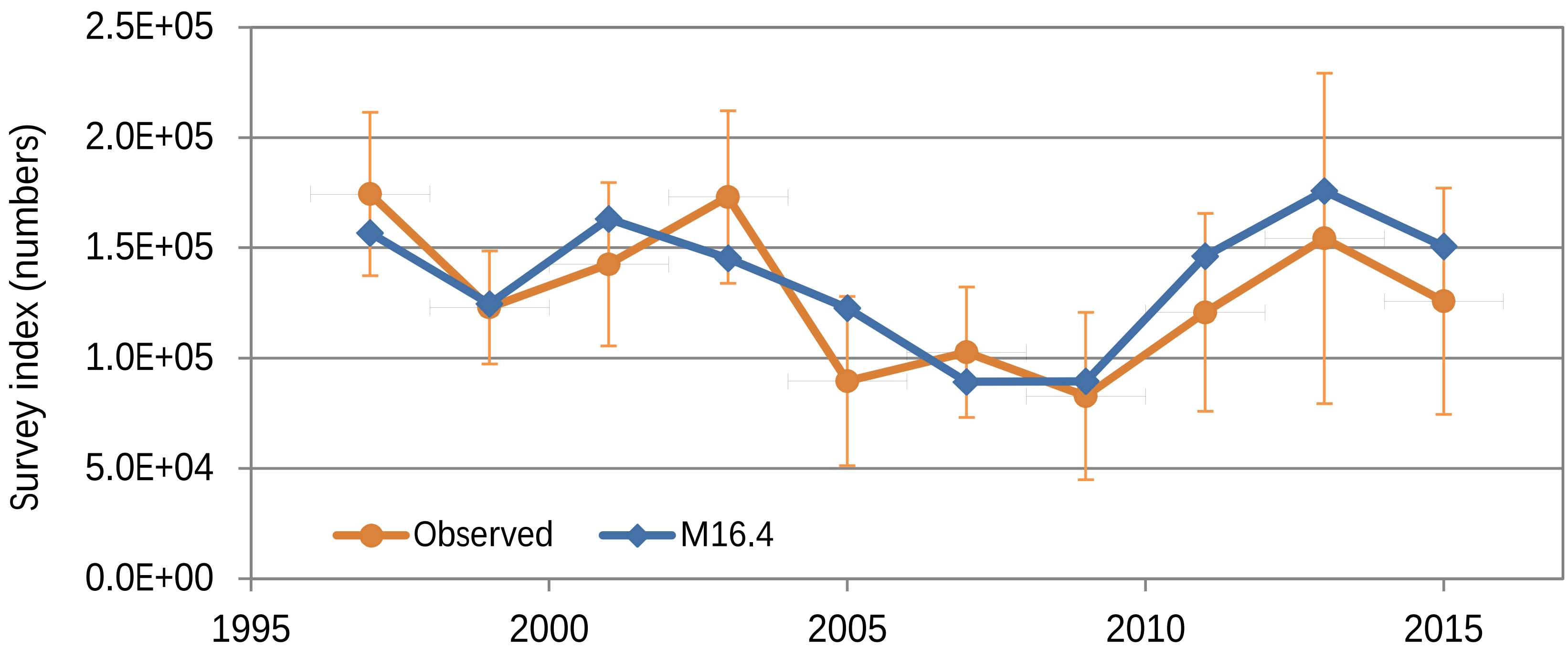
Fit to IPHC LL survey index (Model 16.5)



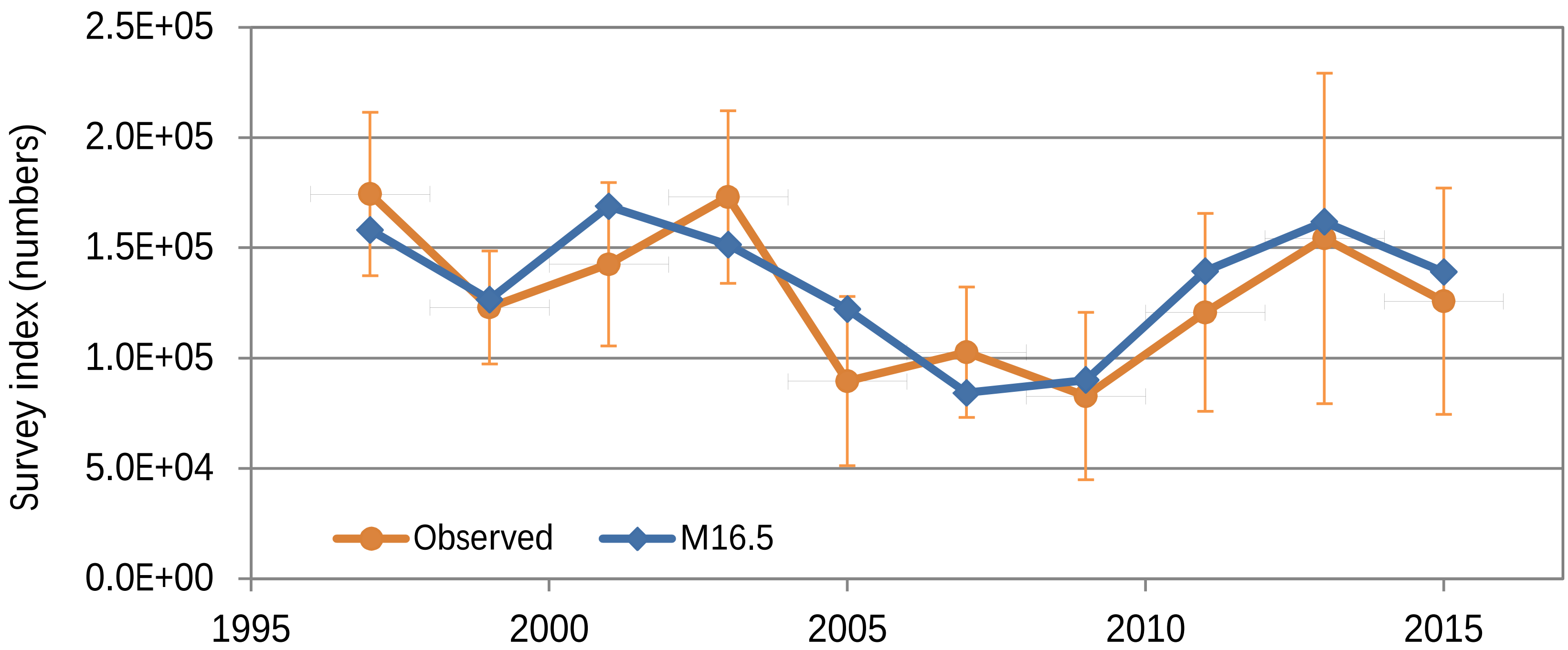
Fit to NMFS LL survey index (Model 16.3)



Fit to NMFS LL survey index (Model 16.4)



Fit to NMFS LL survey index (Model 16.5)



Goodness of fit: size composition

Model	Fleet	Nrec	A(Ninp)	A(Neff)/A(Ninp)	H(Neff)/A(Ninp)
11.5	Jan-Apr trawl fish.	68	314	2.92	1.53
11.5	May-Jul trawl fish.	35	62	7.26	3.32
11.5	Aug-Dec trawl fish.	38	44	6.00	3.24
11.5	Jan-Apr longline fish.	72	476	3.99	1.18
11.5	May-Jul longline fish.	35	252	5.16	3.00
11.5	Aug-Dec longline fish.	67	673	3.09	0.89
11.5	Jan-Apr pot fish.	40	129	9.71	3.37
11.5	May-Jul pot fish.	17	129	7.72	1.72
11.5	Aug-Dec pot fish.	40	84	7.25	2.75
16.1	Fishery	39	300	5.61	1.86
16.2	Fishery	39	300	10.31	2.35
16.3	Fishery	39	300	14.34	2.17
16.4	Fishery	39	300	11.25	1.91
16.5	Fishery	39	603	5.87	1.00
11.5	Trawl survey	34	286	1.66	1.03
16.1	Trawl survey	34	300	1.57	1.01
16.2	Trawl survey	34	300	1.88	1.15
16.3	Trawl survey	34	300	2.01	1.17
16.4	Trawl survey	34	300	1.97	1.14
16.5	Trawl survey	34	321	1.75	1.00
16.2	IPHC longline survey	7	300	2.41	2.03
16.4	IPHC longline survey	7	300	2.58	2.16
16.5	IPHC longline survey	7	1094	1.13	1.00
16.3	NMFS longline survey	10	300	1.93	1.31
16.4	NMFS longline survey	10	300	1.80	1.28
16.5	NMFS longline survey	10	456	1.31	1.00

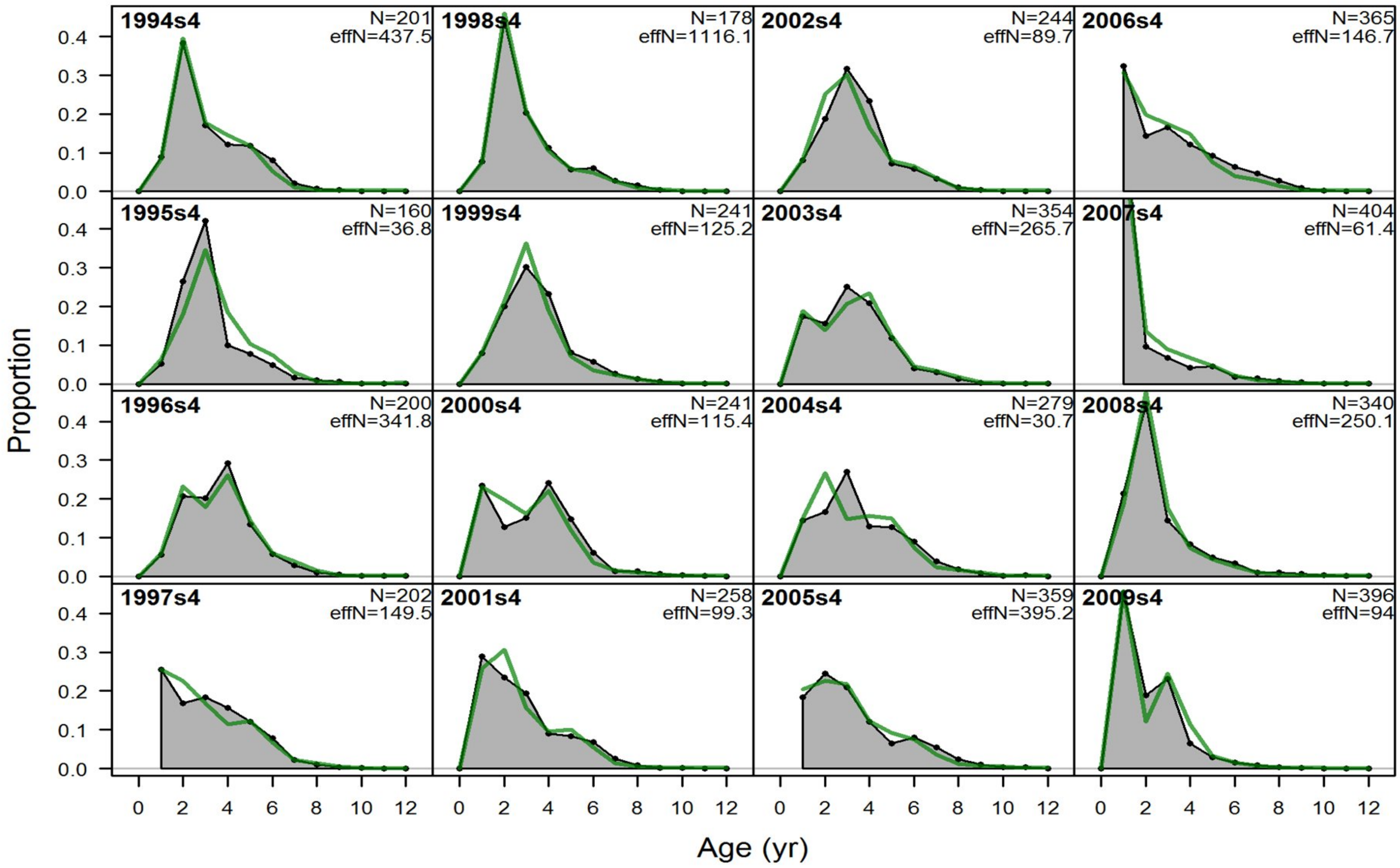
Goodness of fit: survey age composition

	Model 11.5		Model 16.1		Model 16.2		Model 16.3		Model 16.4		Model 16.5	
Year	In. N	Eff. N	In. N	Eff. N	In. N	Eff. N	In. N	Eff. N	In. N	Eff. N	In. N	Eff. N
1994	201	437	201	209	99	211	99	210	99	155	60	186
1995	160	37	160	29	79	39	79	47	79	62	48	44
1996	200	342	200	69	98	156	98	240	98	198	60	103
1997	202	149	202	47	99	226	99	279	99	175	61	147
1998	178	1116	178	89	88	160	88	1913	88	1346	53	800
1999	241	125	241	59	119	79	119	111	119	76	72	83
2000	241	115	241	60	119	84	119	55	119	48	72	44
2001	258	99	258	37	127	73	127	85	127	79	77	89
2002	244	90	244	40	120	52	120	77	120	62	73	57
2003	354	266	354	797	174	1699	174	613	174	792	106	1212
2004	279	31	279	35	137	38	137	47	137	43	84	44
2005	359	395	359	184	177	388	177	379	177	360	108	319
2006	365	147	365	54	180	98	180	177	180	130	110	85
2007	404	61	404	11	199	34	199	477	199	270	121	107
2008	340	250	340	137	167	375	167	278	167	379	102	107
2009	396	94	396	168	195	214	195	303	195	500	119	210
2010	363	94	363	210	179	218	179	190	179	190	109	124
2011	352	151	352	121	173	99	173	92	173	120	106	46
2012	365	98	365	82	180	79	180	97	180	107	110	59
2013	398	122	398	141	196	107	196	116	196	95	119	85
2014	399	483	399	285	196	417	196	392	196	355	120	369
Mean	300	224	300	136	148	231	148	294	148	264	90	206
Harm.		109		58		95		128		119		90
Ratio1		0.75		0.45		1.56		1.99		1.79		2.29
Ratio2		0.36		0.19		0.64		0.87		0.81		1.00

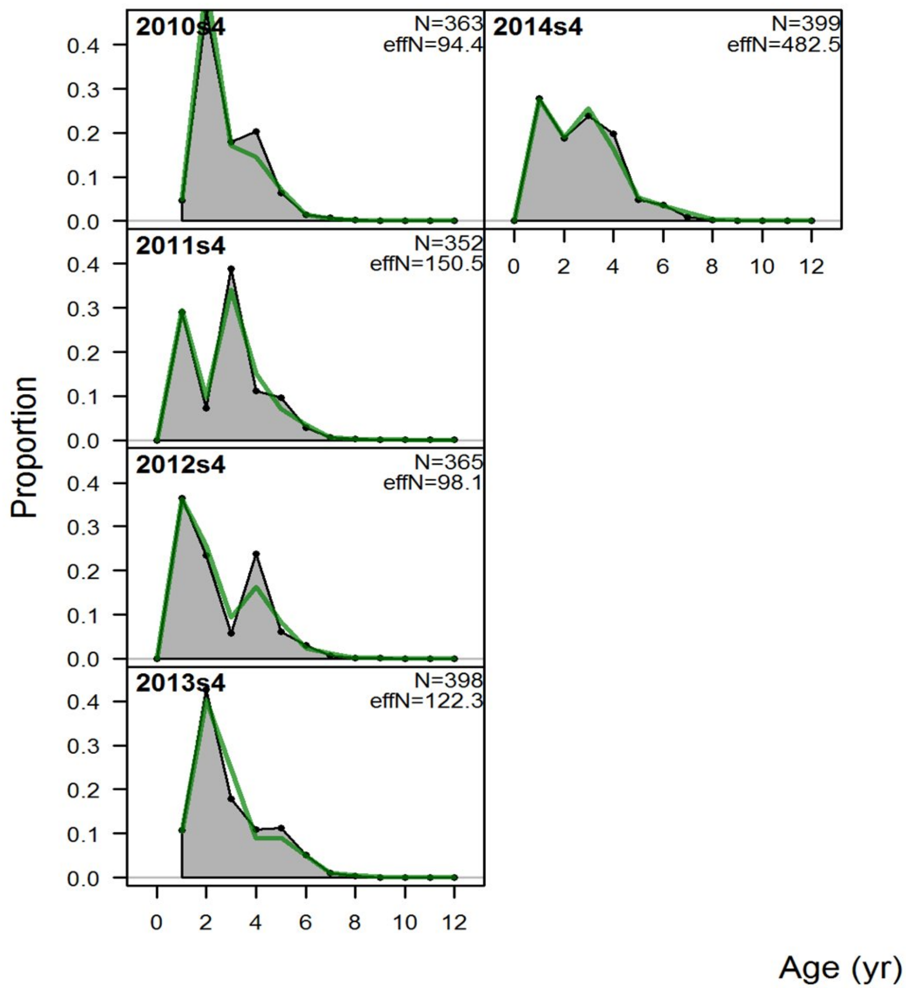
Goodness of fit: fishery age composition

Year	Model 16.4		Model 16.5	
	In. N	Eff. N	In. N	Eff. N
2008	130	75	32	59
2009	127	44	31	25
2010	111	71	27	31
2011	222	79	54	41
Mean	148	67	36	39
Harm.		64		35
Ratio1		0.46		1.08
Ratio2		0.43		0.98

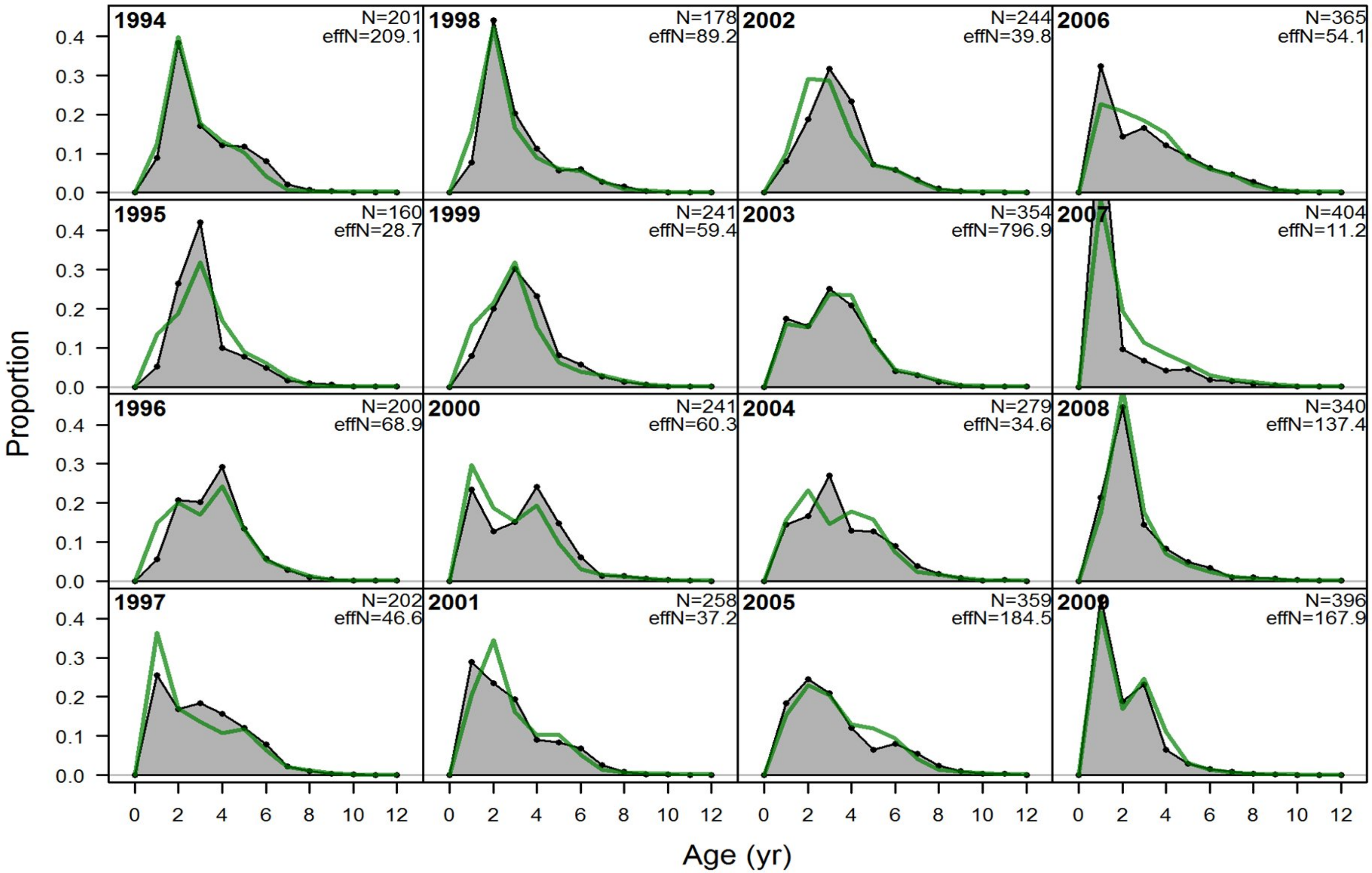
Fit to survey agecomps (Model 11.5, 1 of 2)



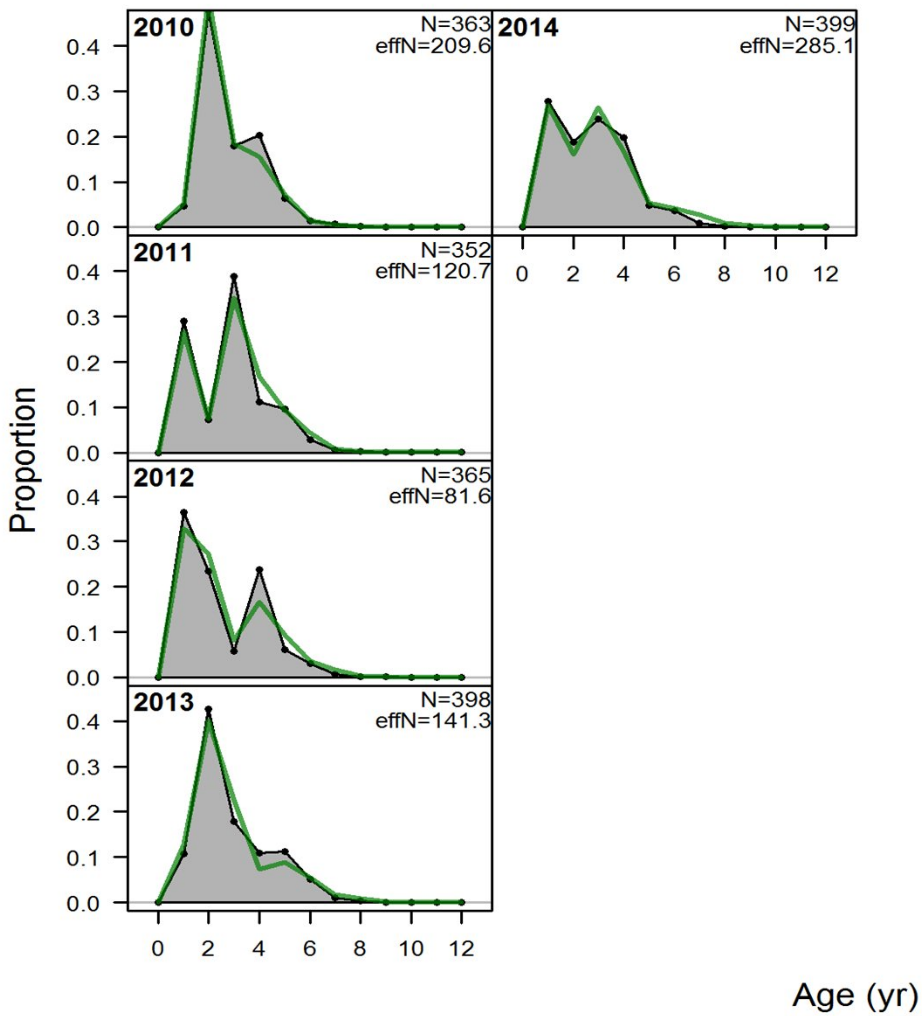
Fit to survey agecomps (Model 11.5, 2 of 2)



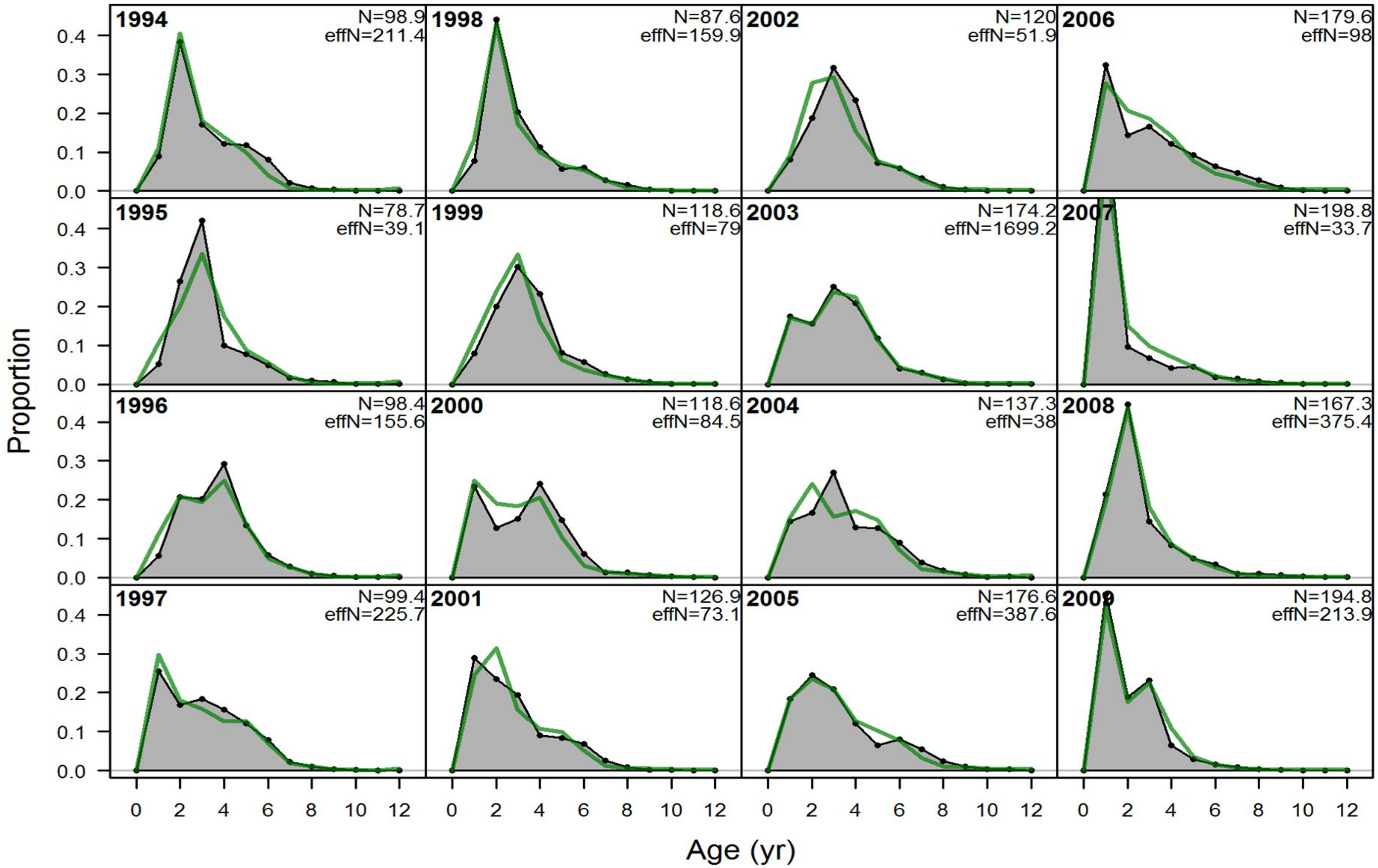
Fit to survey agecomps (Model 16.1, 1 of 2)



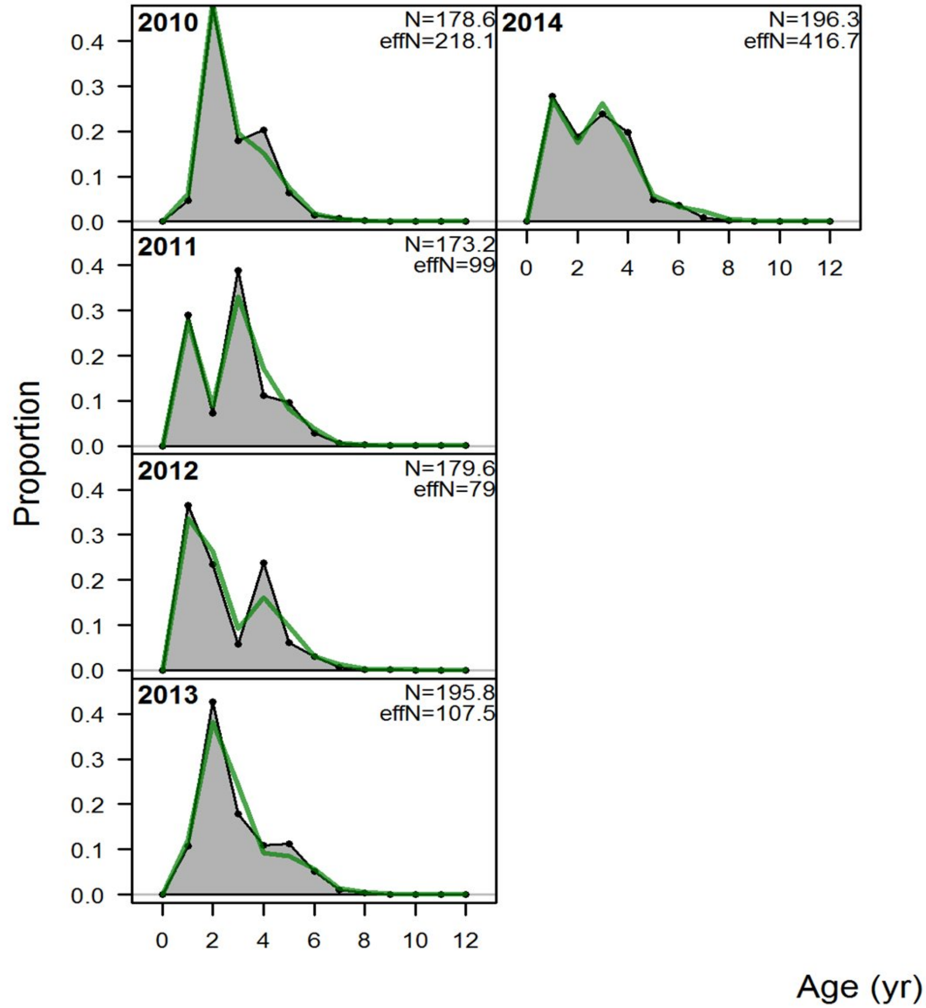
Fit to survey agecomps (Model 16.1, 2 of 2)



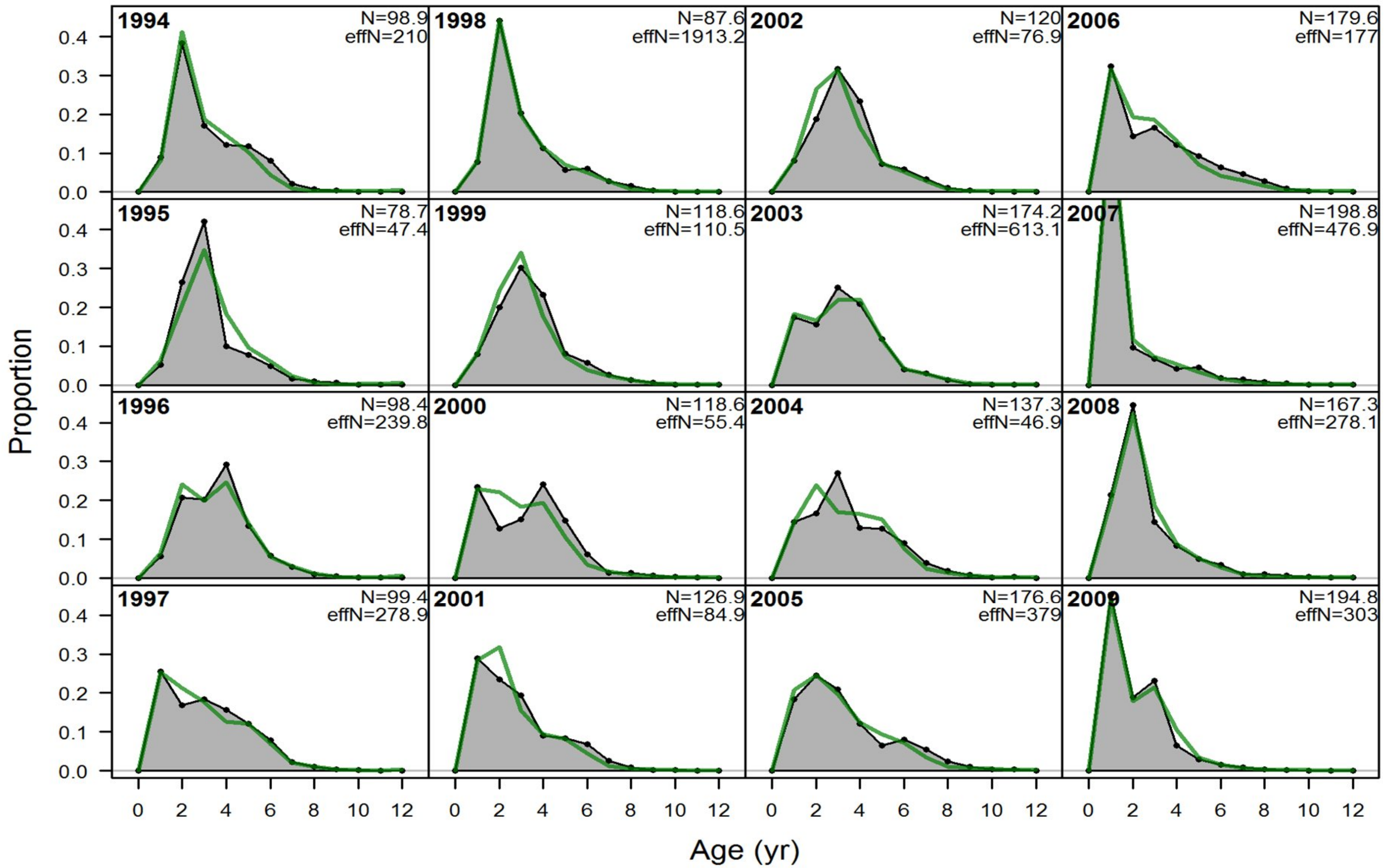
Fit to survey agecomps (Model 16.2, 1 of 2)



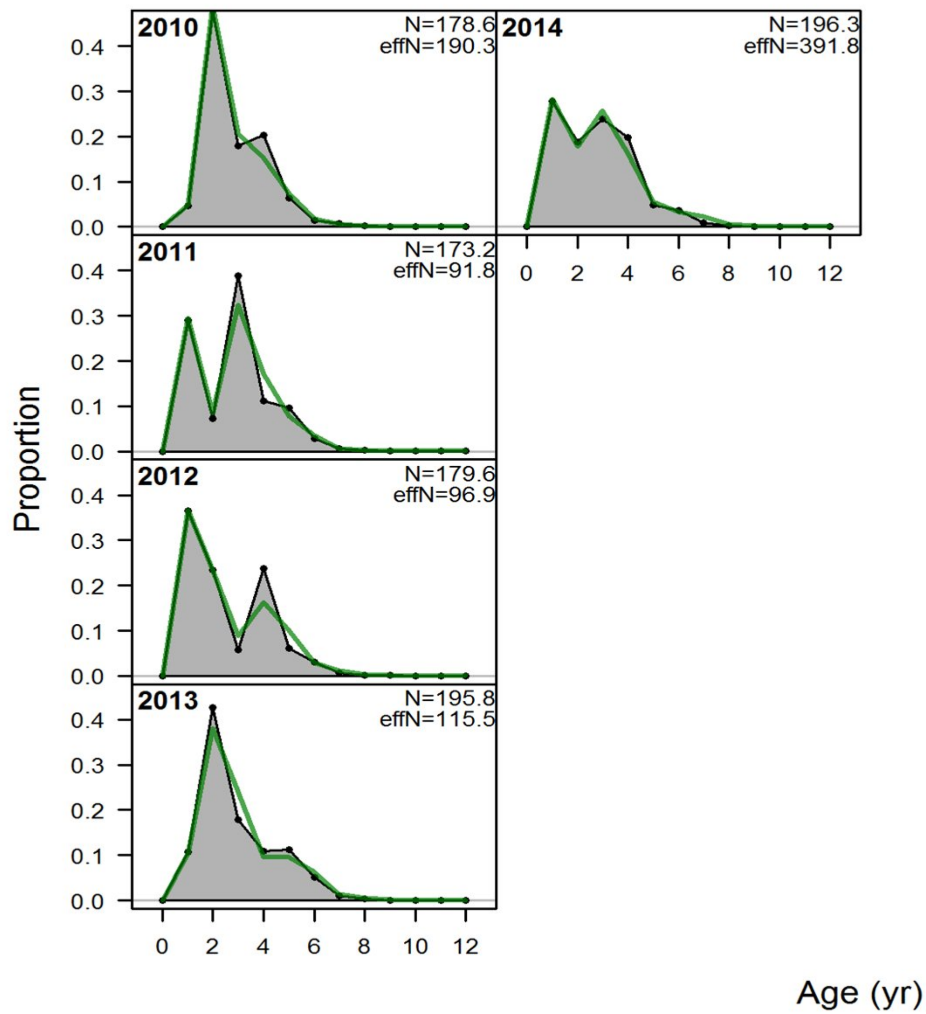
Fit to survey agecomps (Model 16.2, 2 of 2)



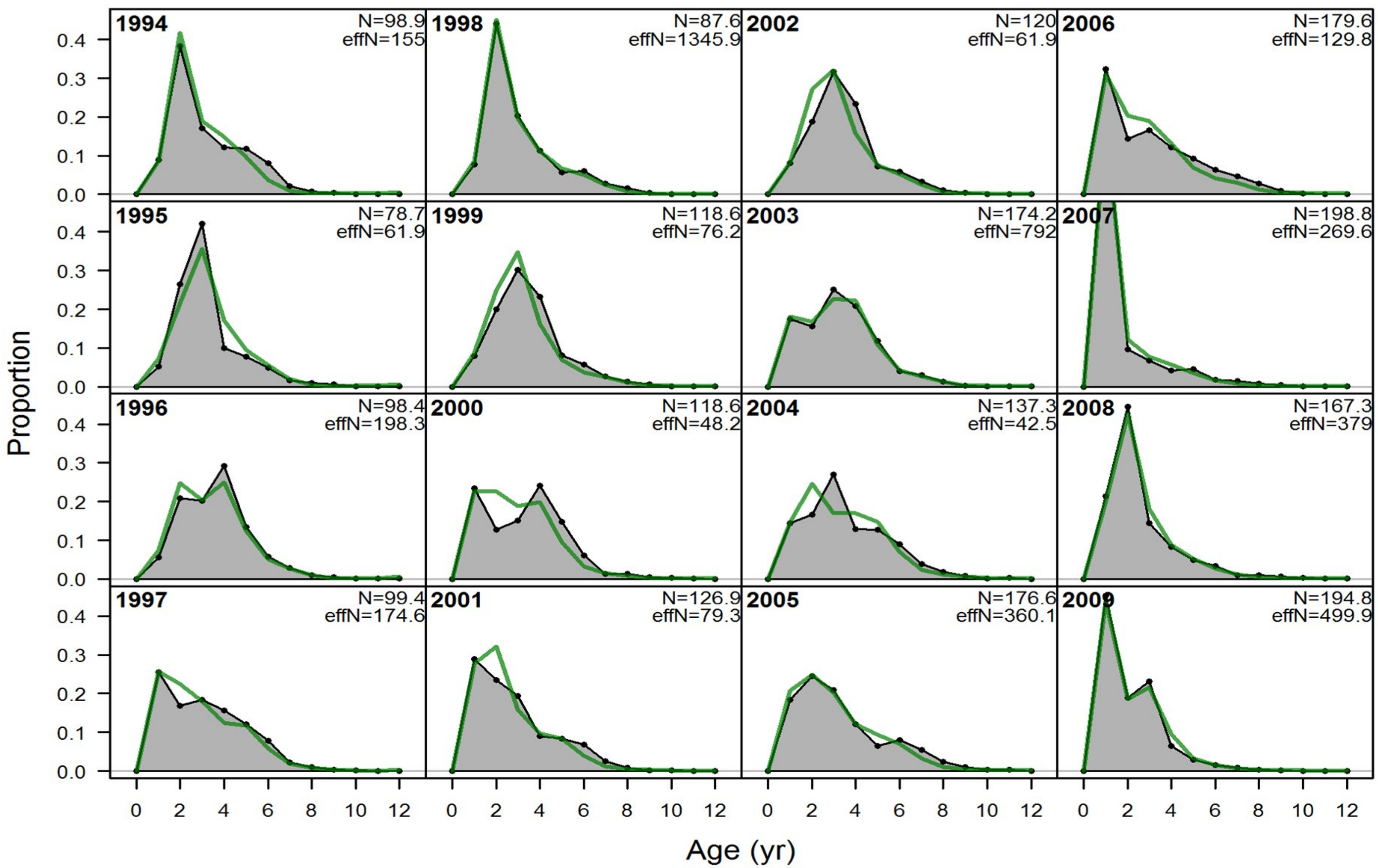
Fit to survey agecomps (Model 16.3, 1 of 2)



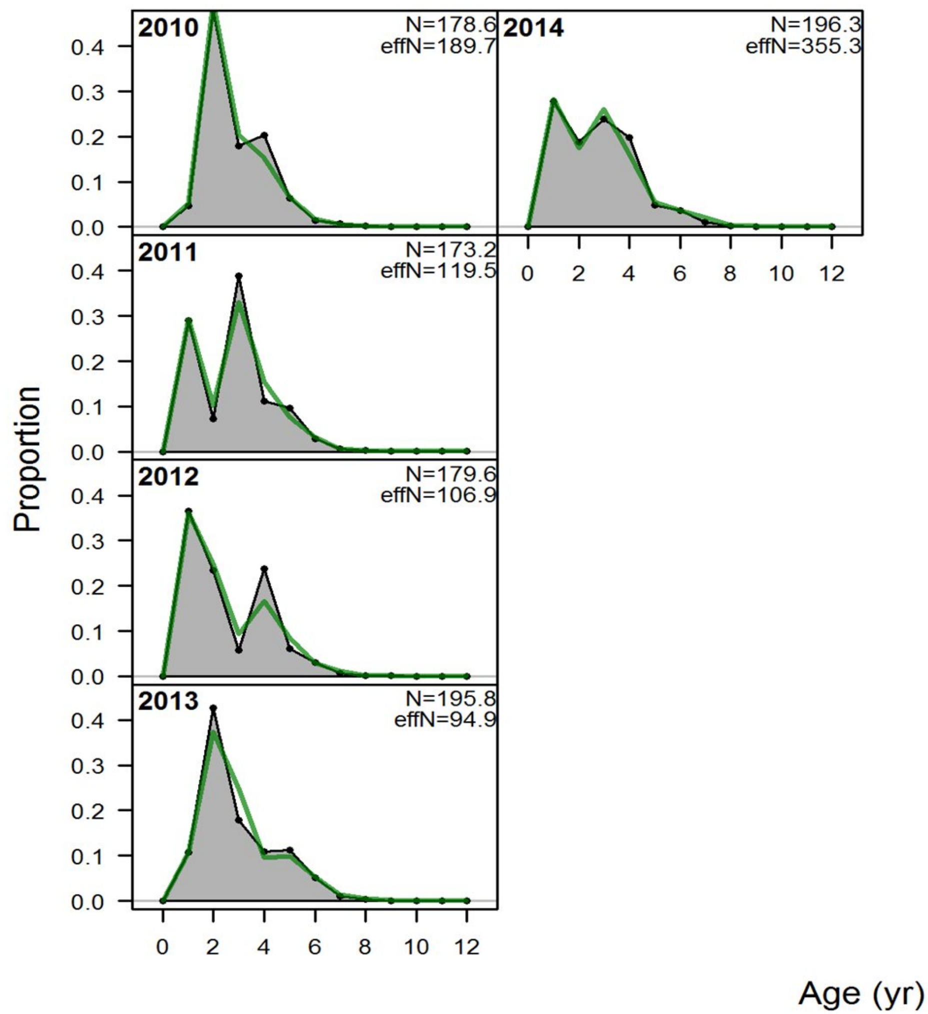
Fit to survey agecomps (Model 16.3, 2 of 2)



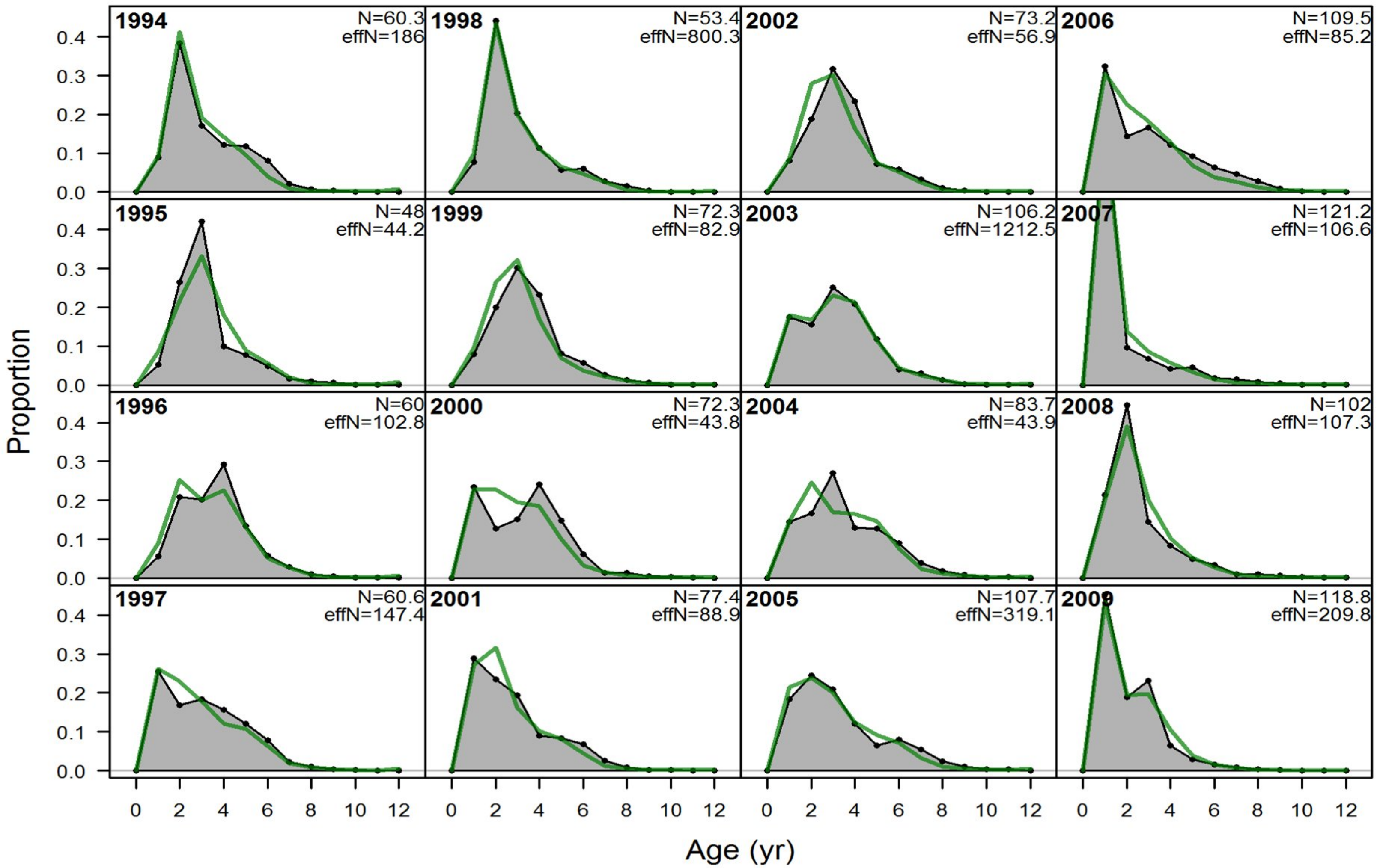
Fit to survey agecomps (Model 16.4, 1 of 2)



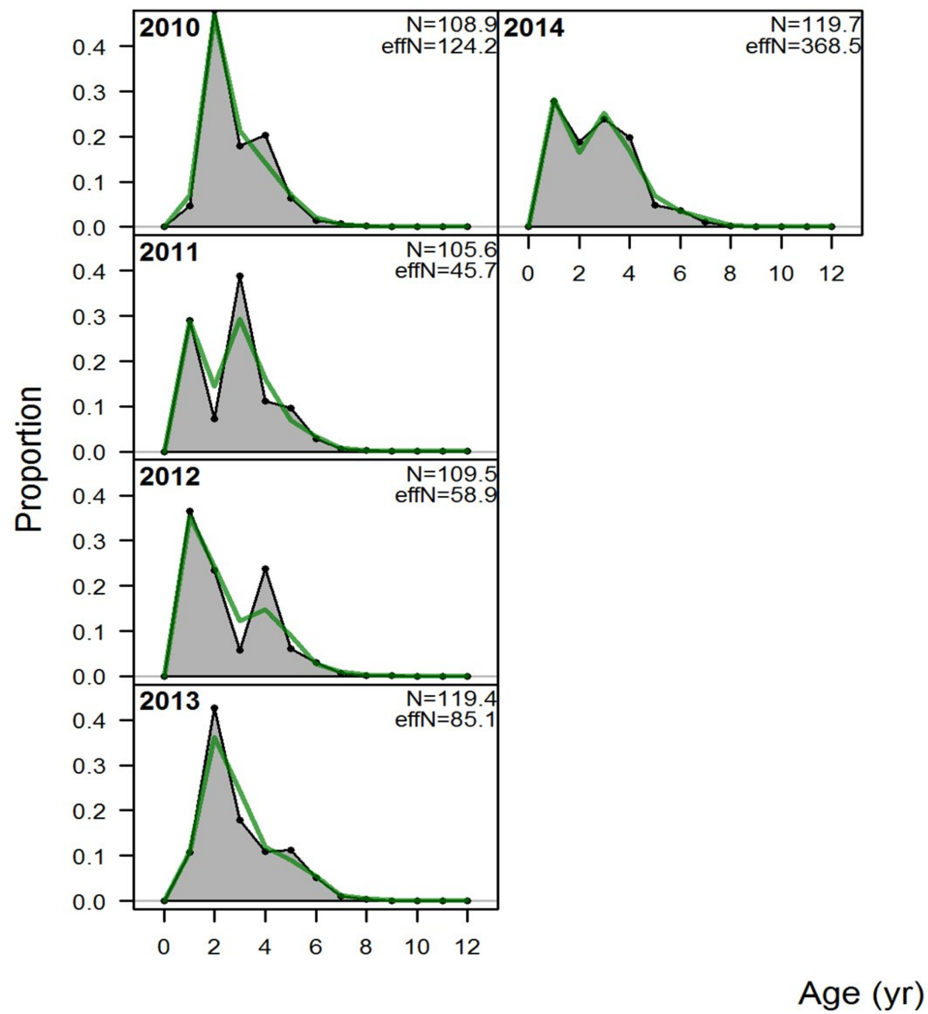
Fit to survey agecomps (Model 16.4, 2 of 2)



Fit to survey agecomps (Model 16.5, 1 of 2)

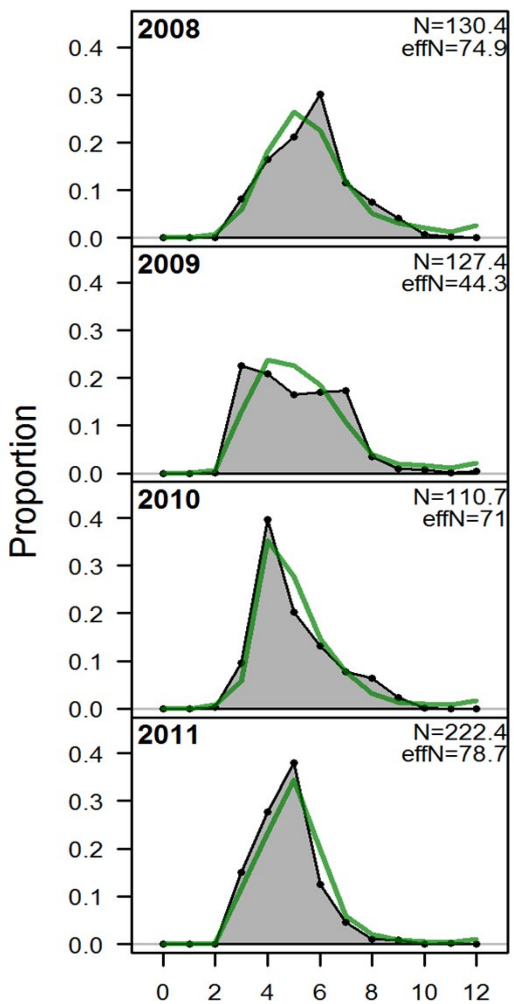


Fit to survey agecomps (Model 16.5, 2 of 2)

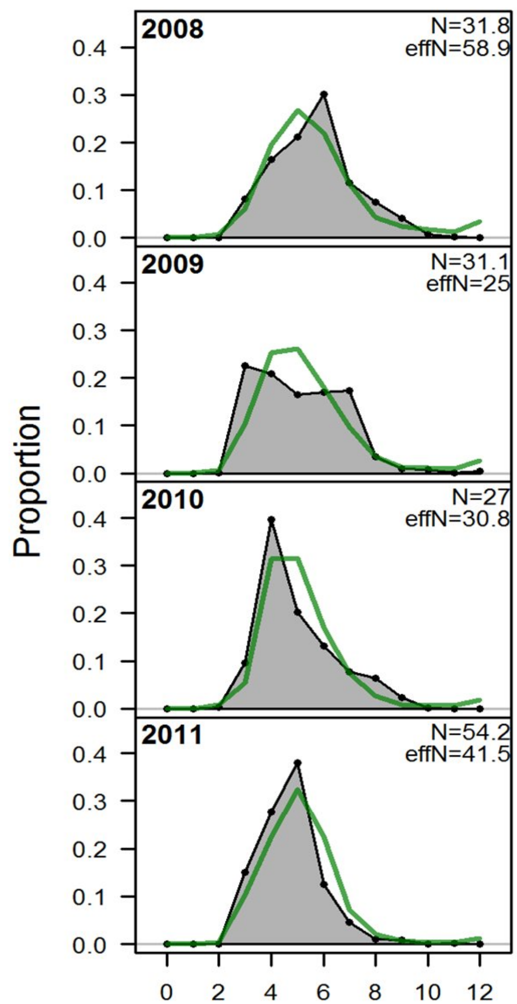


Fit to fishery agecomps (Models 16.4 and 16.5)

Model 16.4



Model 16.5



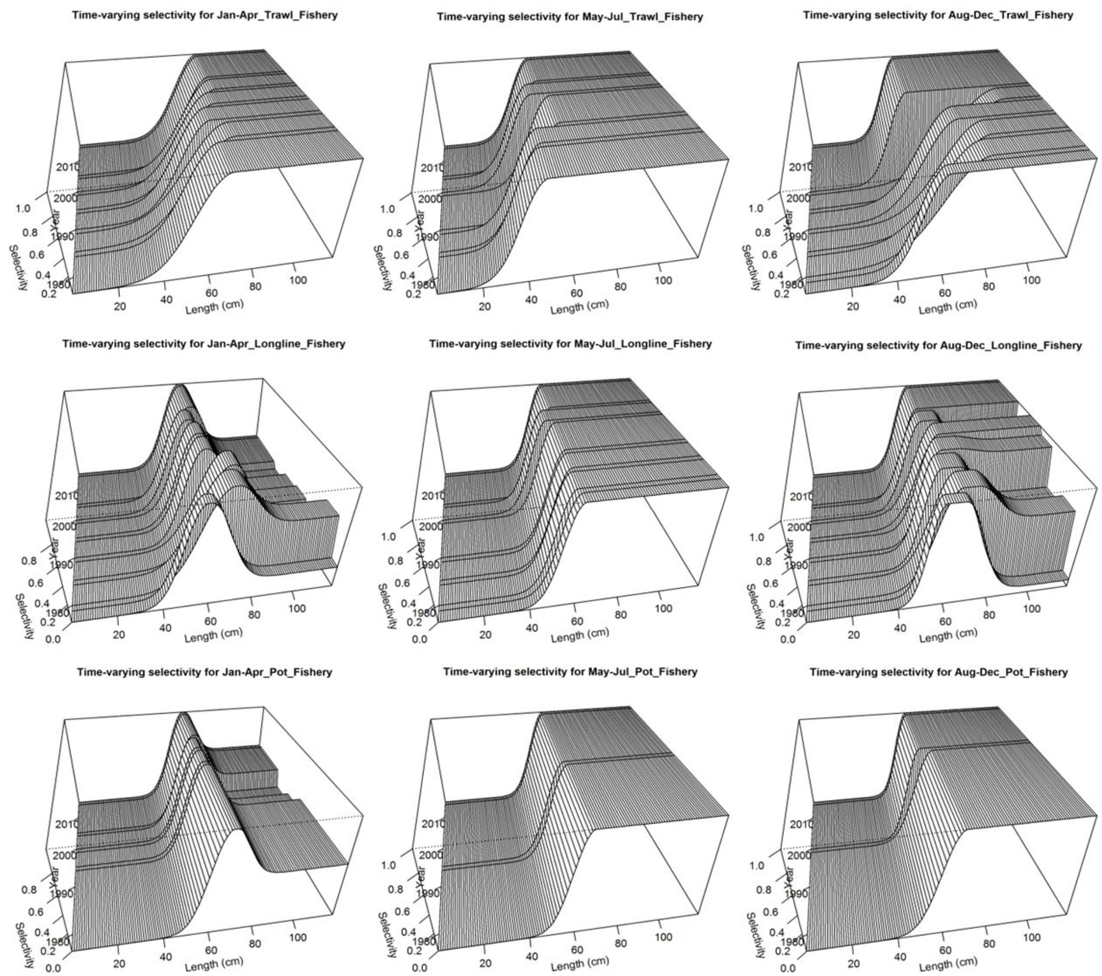
Key parameters (Table 2.1.8, p. 27)

Parameter	Model 11.5 Est.	Model 11.5 SD	Model 16.1 Est.	Model 16.1 SD	Model 16.2 Est.	Model 16.2 SD	Model 16.3 Est.	Model 16.3 SD	Model 16.4 Est.	Model 16.4 SD	Model 16.5 Est.	Model 16.5 SD
Natural mortality	0.340	_	0.373	0.012	0.300	0.020	0.230	0.015	0.216	0.013	0.194	0.010
Length at age 1 (cm)	14.244	0.104	16.323	0.086	16.397	0.087	16.392	0.087	16.420	0.088	16.465	0.086
Asymptotic length (cm)	92.513	0.493	98.211	1.848	97.879	1.343	95.326	1.335	98.524	1.242	98.169	0.847
Brody growth coefficient	0.240	0.002	0.199	0.012	0.214	0.010	0.229	0.011	0.209	0.009	0.222	0.007
Richards growth coefficient			1.058	0.049	0.985	0.044	0.961	0.043	1.031	0.039	0.986	0.032
SD of length at age 1 (cm)	3.537	0.066	3.375	0.057	3.489	0.057	3.508	0.057	3.566	0.058	3.619	0.055
SD of length at age 20 (cm)	9.776	0.152	9.863	0.279	7.688	0.228	7.293	0.211	6.959	0.200	6.651	0.147
Ageing bias at age 1 (years)	0.333	0.013	0.320	0.013	0.287	0.025	0.285	0.027	0.295	0.026	0.277	0.032
Ageing bias at age 20 (years)	0.354	0.148	0.340	0.159	0.703	0.254	0.753	0.264	0.281	0.235	0.910	0.306
ln(mean post-1976 recruitment)	13.196	0.019	13.580	0.104	12.949	0.167	12.328	0.107	12.458	0.093	13.563	0.145
Sigma_R	0.570	_	0.644	0.068	0.603	_	0.603	_	0.603	_	0.603	_
ln(pre-1977 recruitment offset)	-1.151	0.130	-1.071	0.228	-0.559	0.172	-0.616	0.137	-0.699	0.126	-0.718	0.096
Initial F (Jan-Apr trawl fishery)	0.657	0.140										
Initial F (fishery)			0.126	0.045	0.080	0.020	0.087	0.020	0.082	0.016	0.069	0.012
"Extra SD" for NMFS LL survey					0.335	0.079			0.000	_	0.000	_
"Extra SD" for IPHC LL survey							0.011	0.041	0.316	0.076	0.355	0.082
Base ln(Q) for trawl survey	-0.261	_	-0.441	0.063	0.049	0.108	0.458	0.074	0.295	0.065	0.464	0.046
Base ln(Q) for NMFS LL survey					-0.002	0.170			0.068	0.066	0.354	0.057
Base ln(Q) for IPHC LL survey							0.324	0.081	0.324	0.158	0.562	0.141

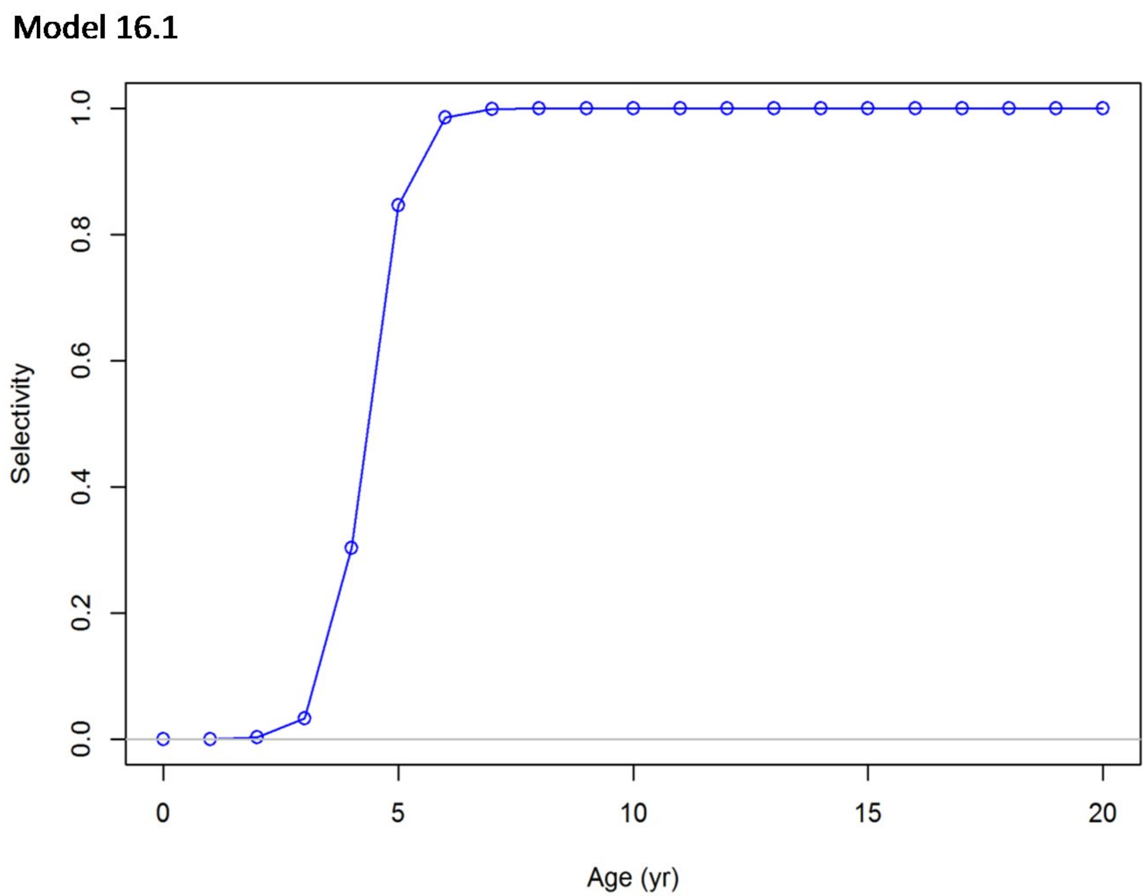
- Trawl survey catchability:

Model 11.5		Model 16.1		Model 16.2		Model 16.3		Model 16.4		Model 16.5	
Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
0.770	n/a	0.643	0.063	1.050	0.108	1.581	0.075	1.343	0.065	1.590	0.046

Fishery selectivity (Model 11.5)

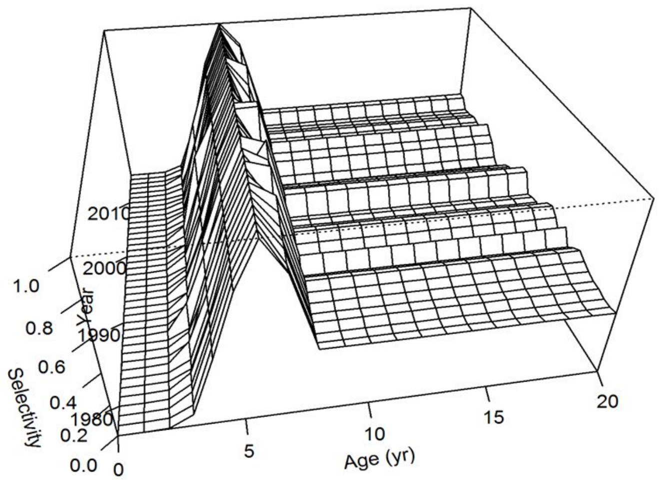


Fishery selectivity (Model 16.1)

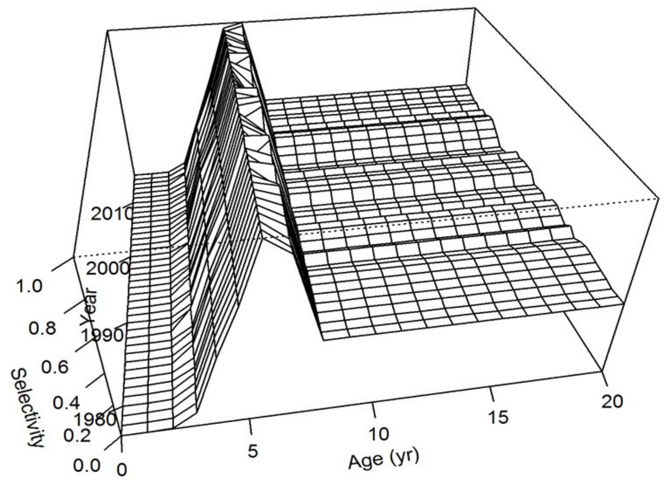


Fishery selectivity (Models 16.2-16.5)

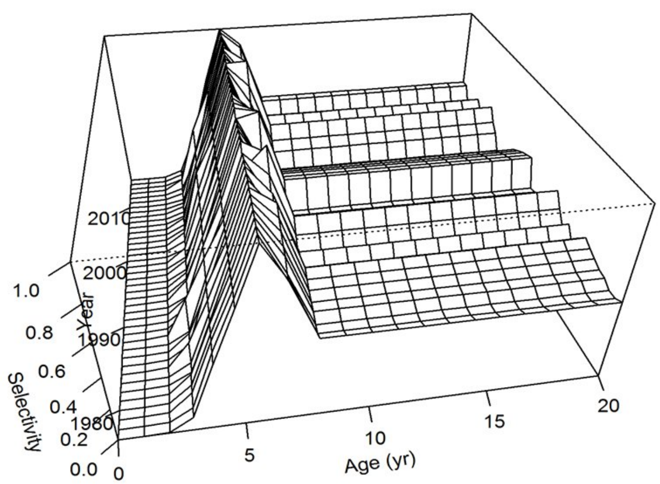
Model 16.2



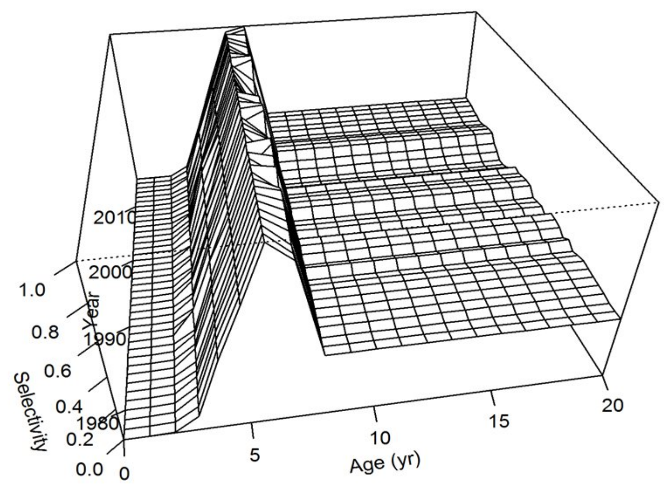
Model 16.4



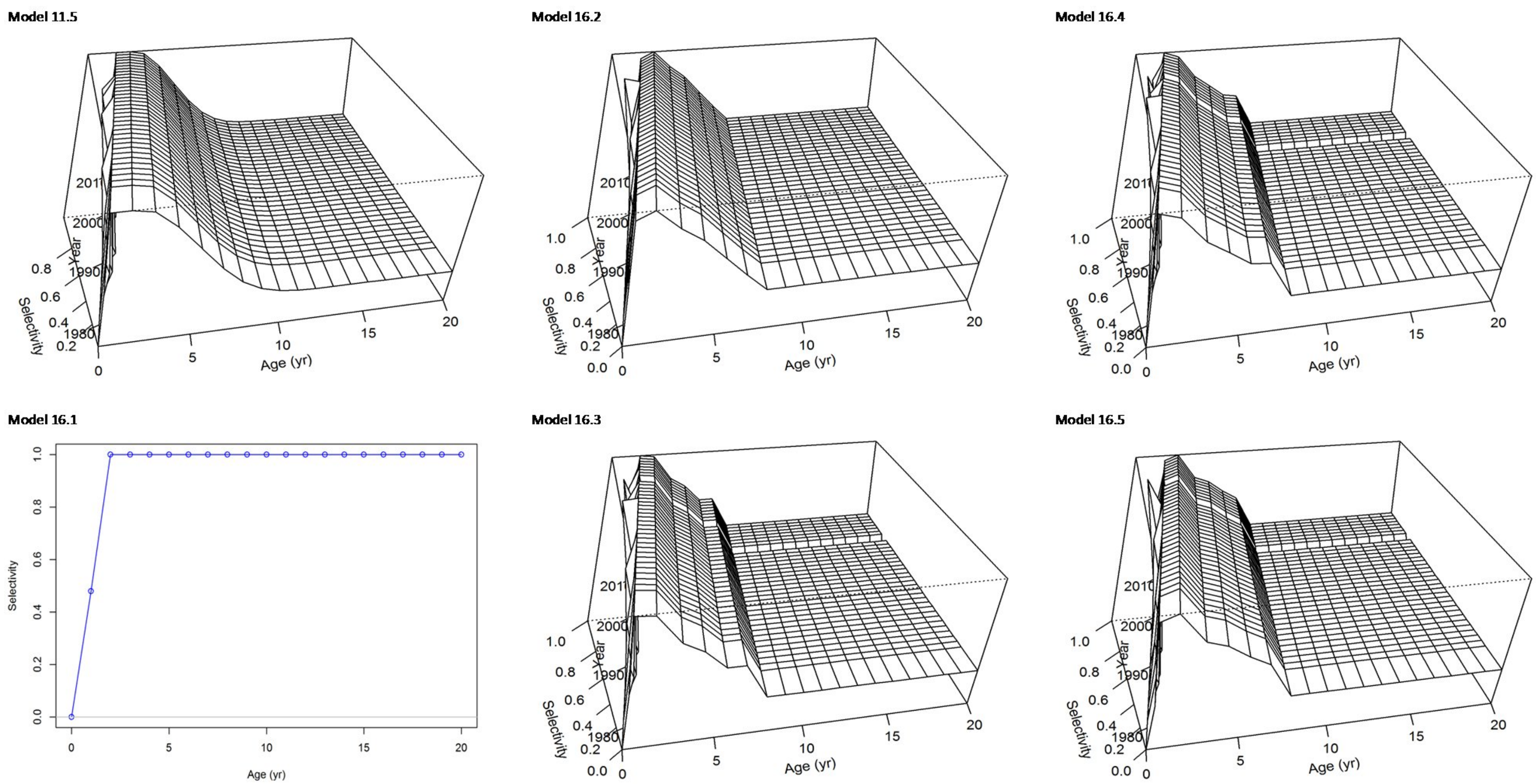
Model 16.3



Model 16.5

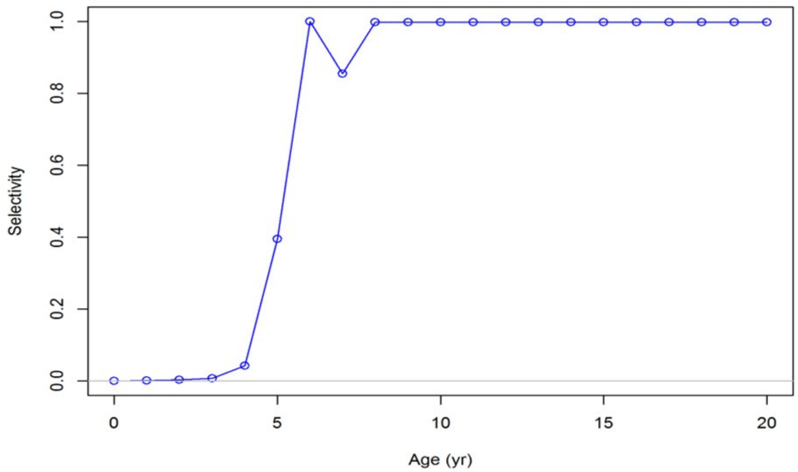


Trawl survey selectivity

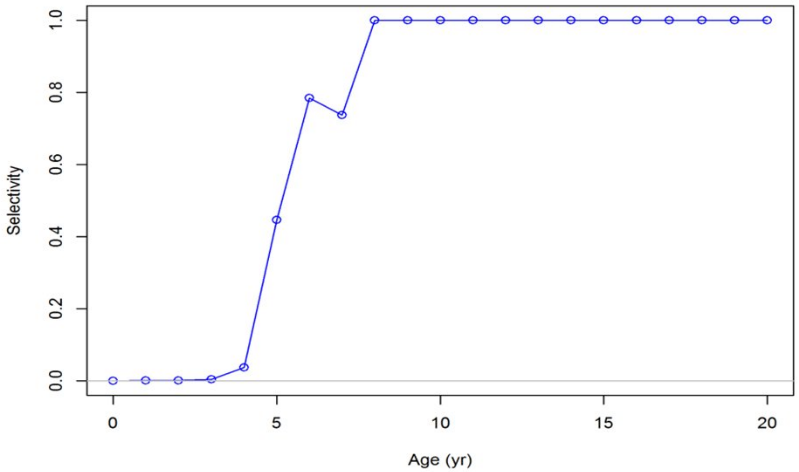


IPHC LL survey selectivity

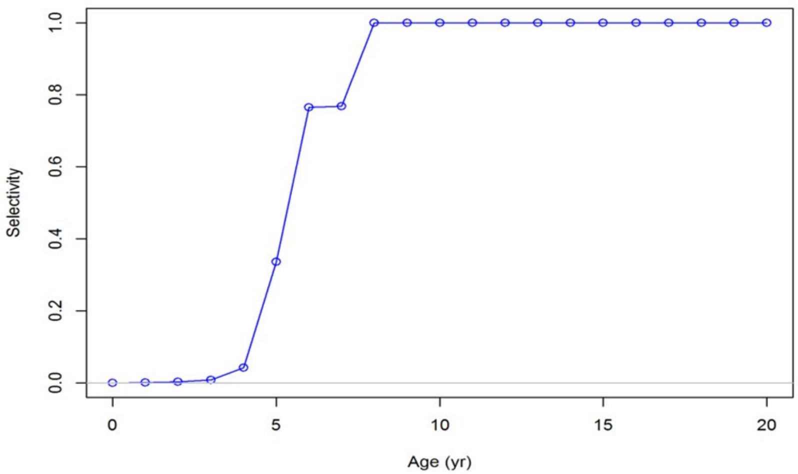
Model 16.2



Model 16.5

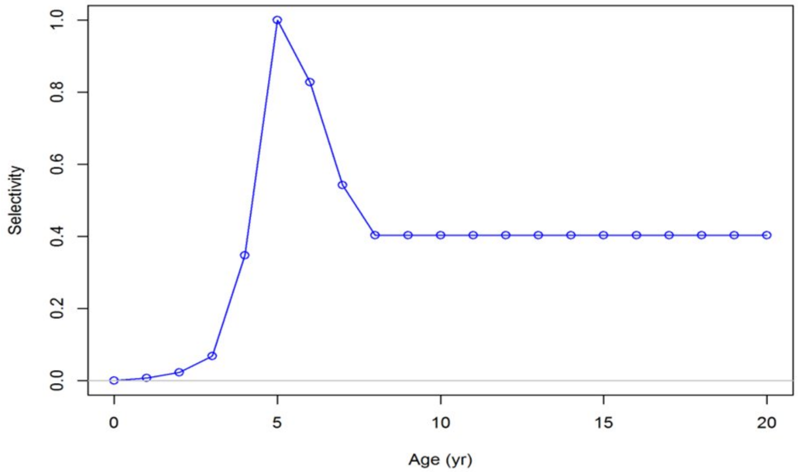


Model 16.4

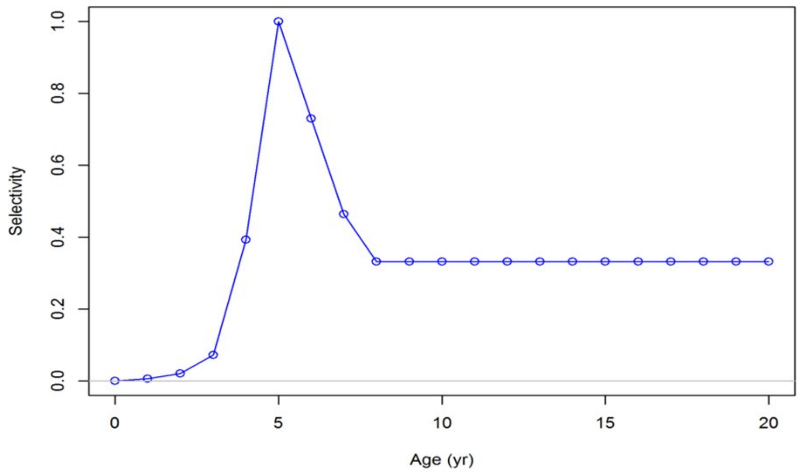


NMFS LL survey selectivity

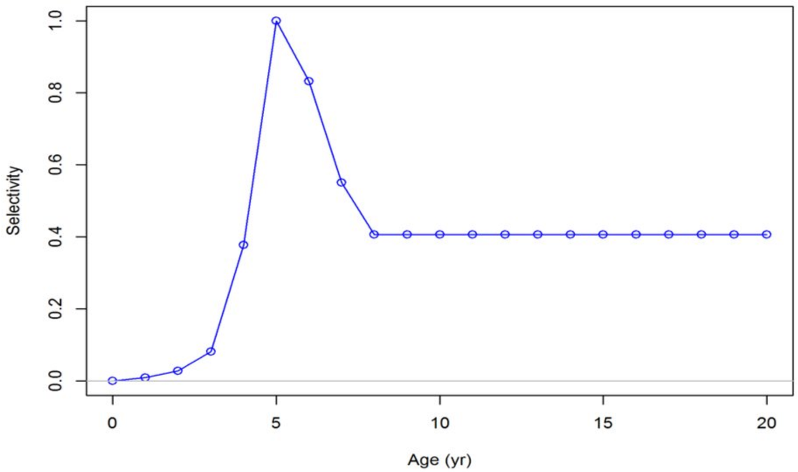
Model 16.3



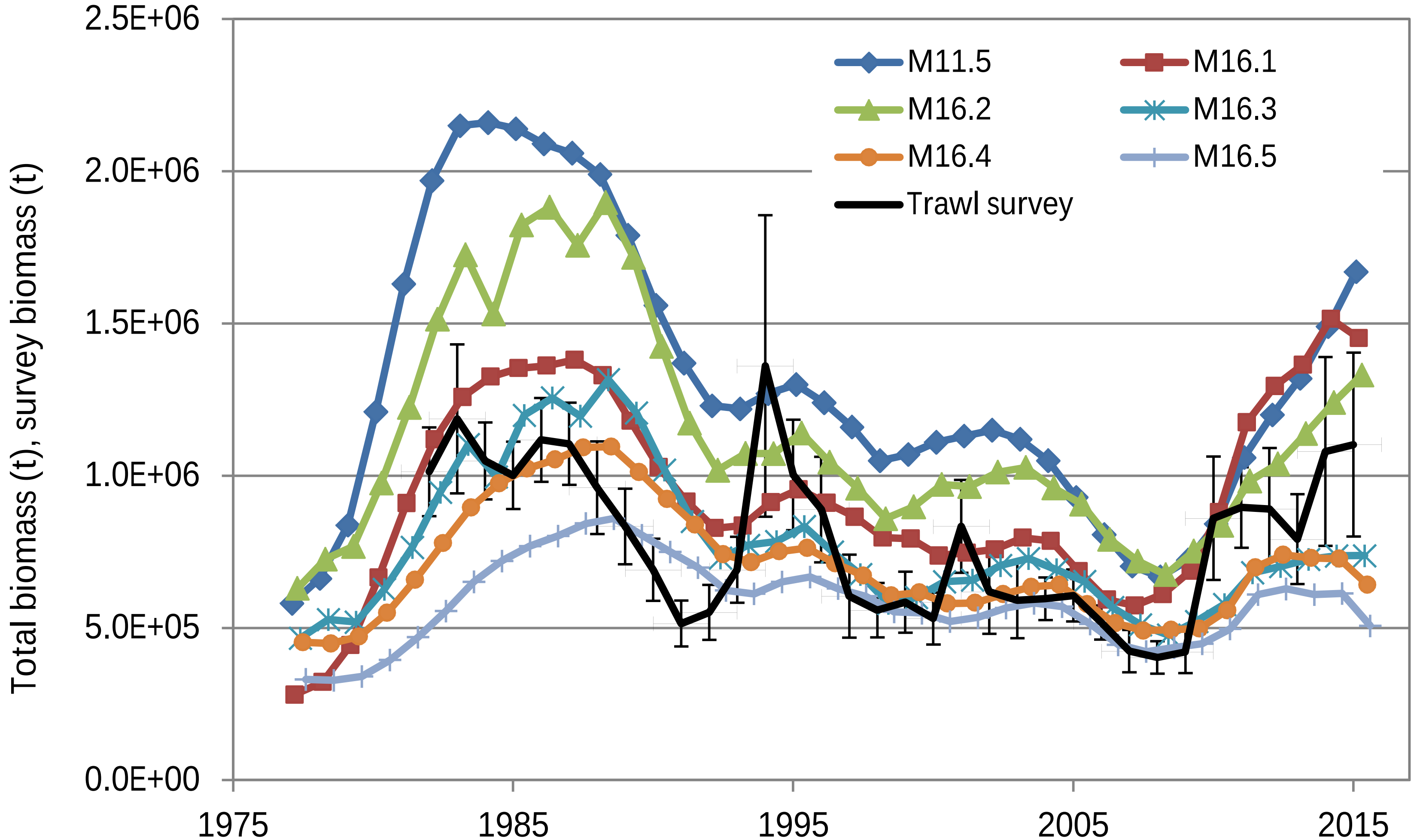
Model 16.5



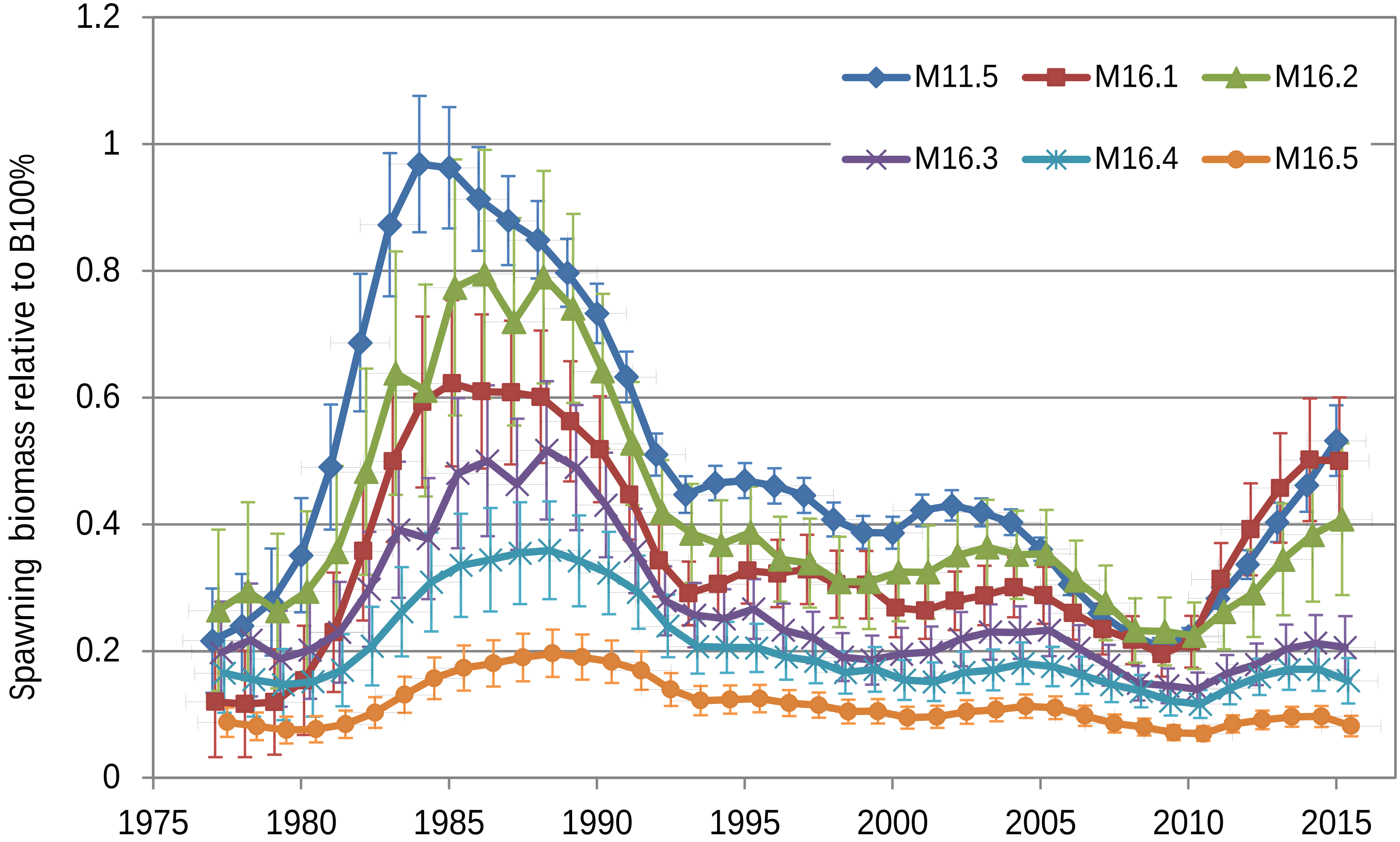
Model 16.4



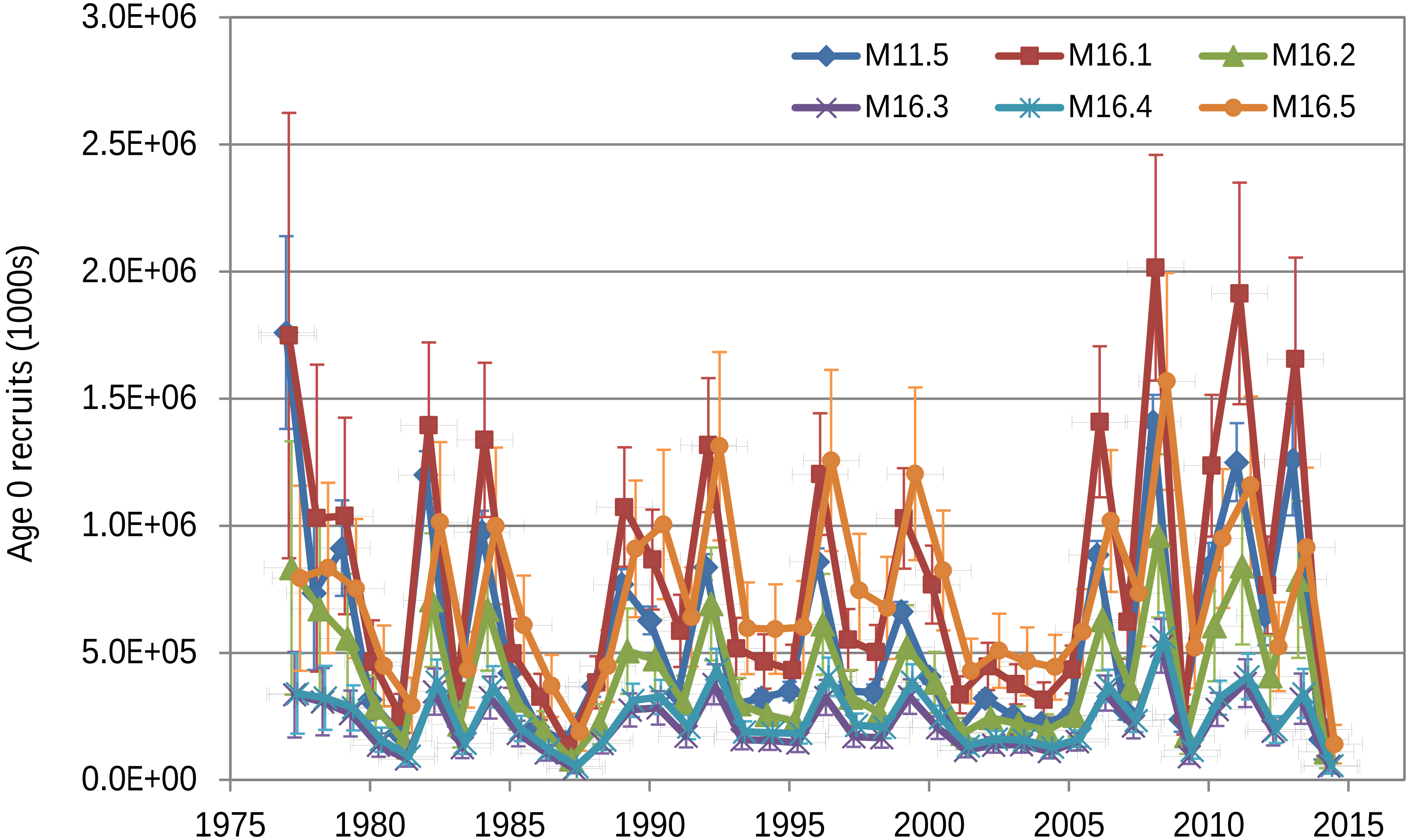
Total biomass time series



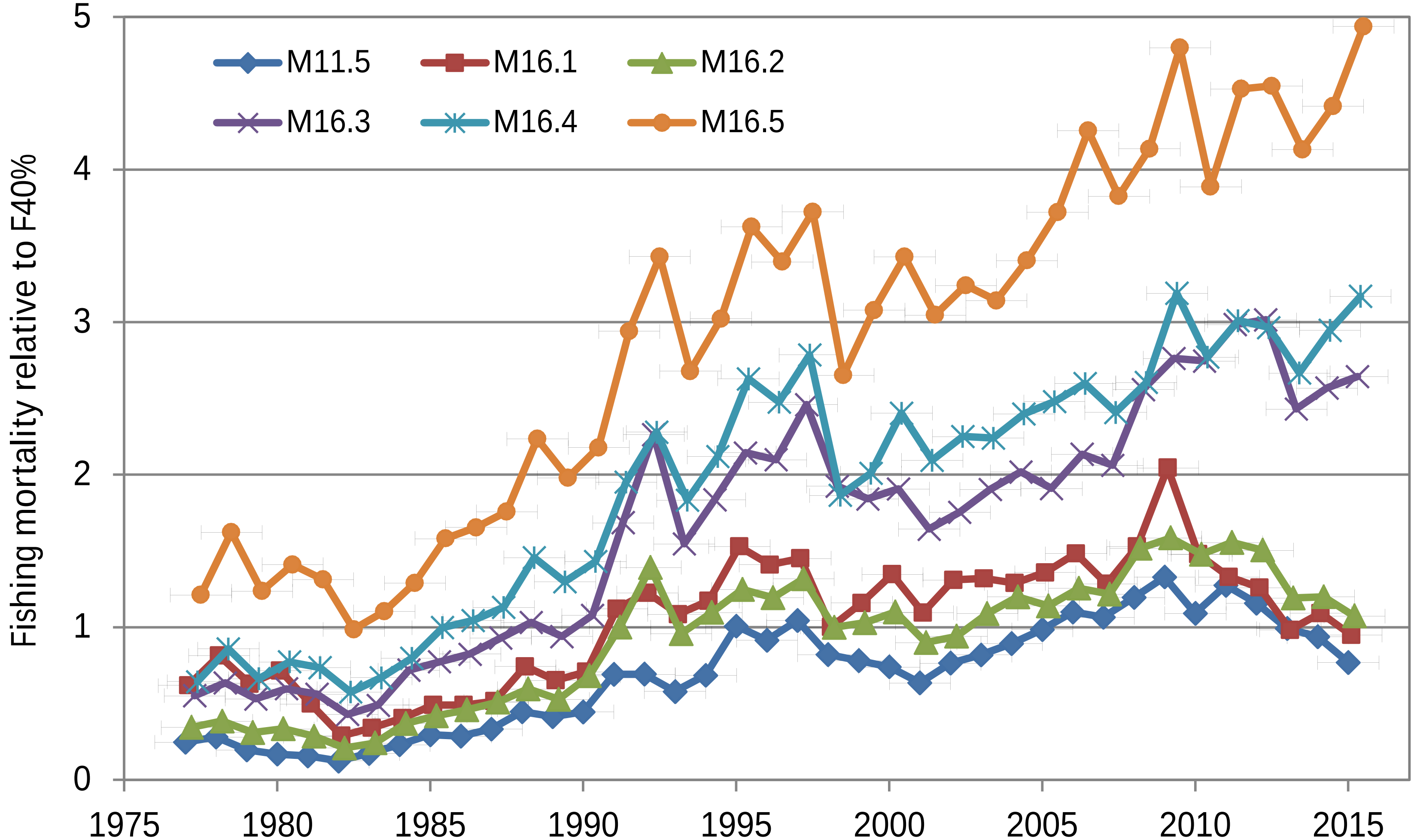
Relative spawning biomass time series



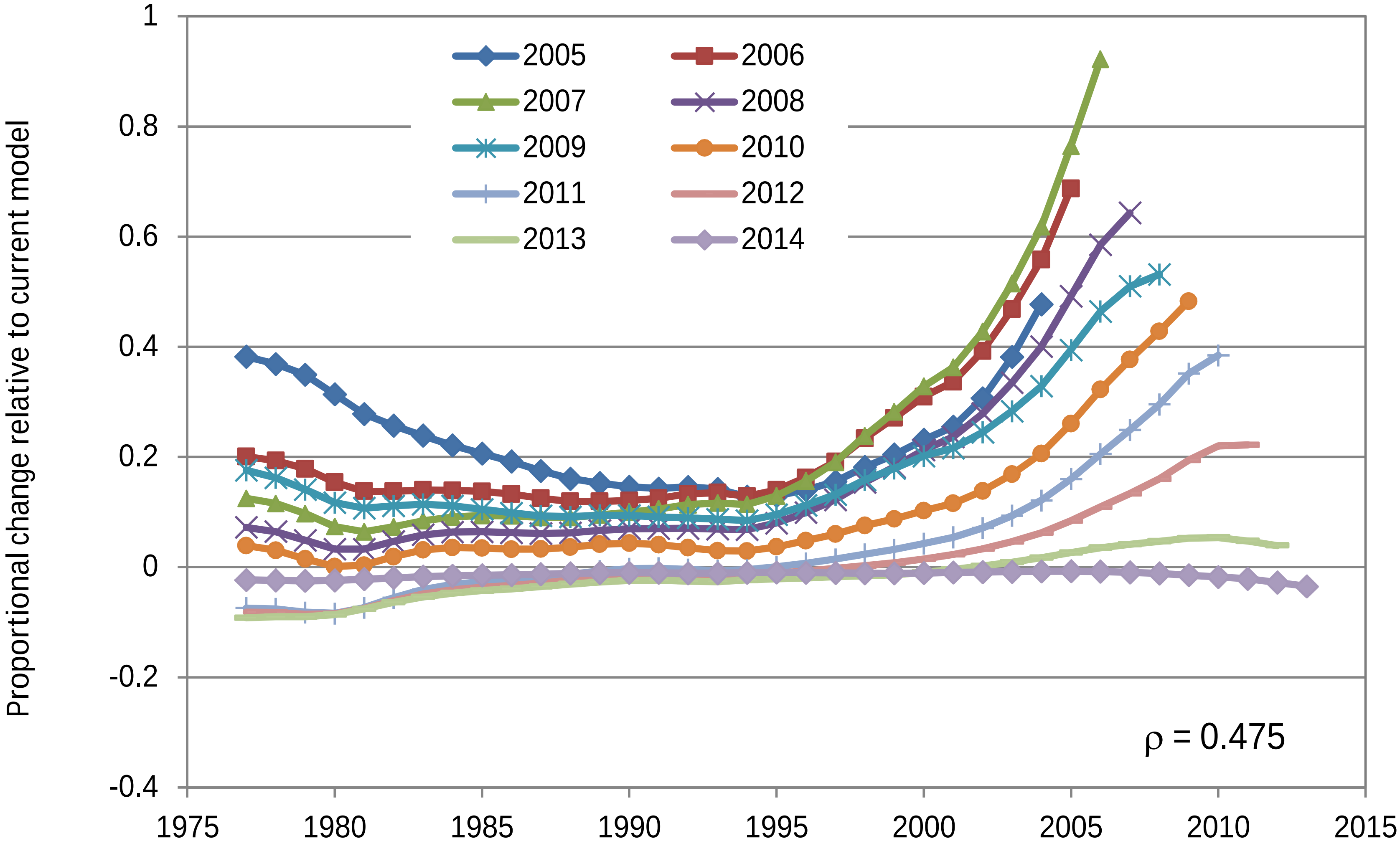
Recruitment time series



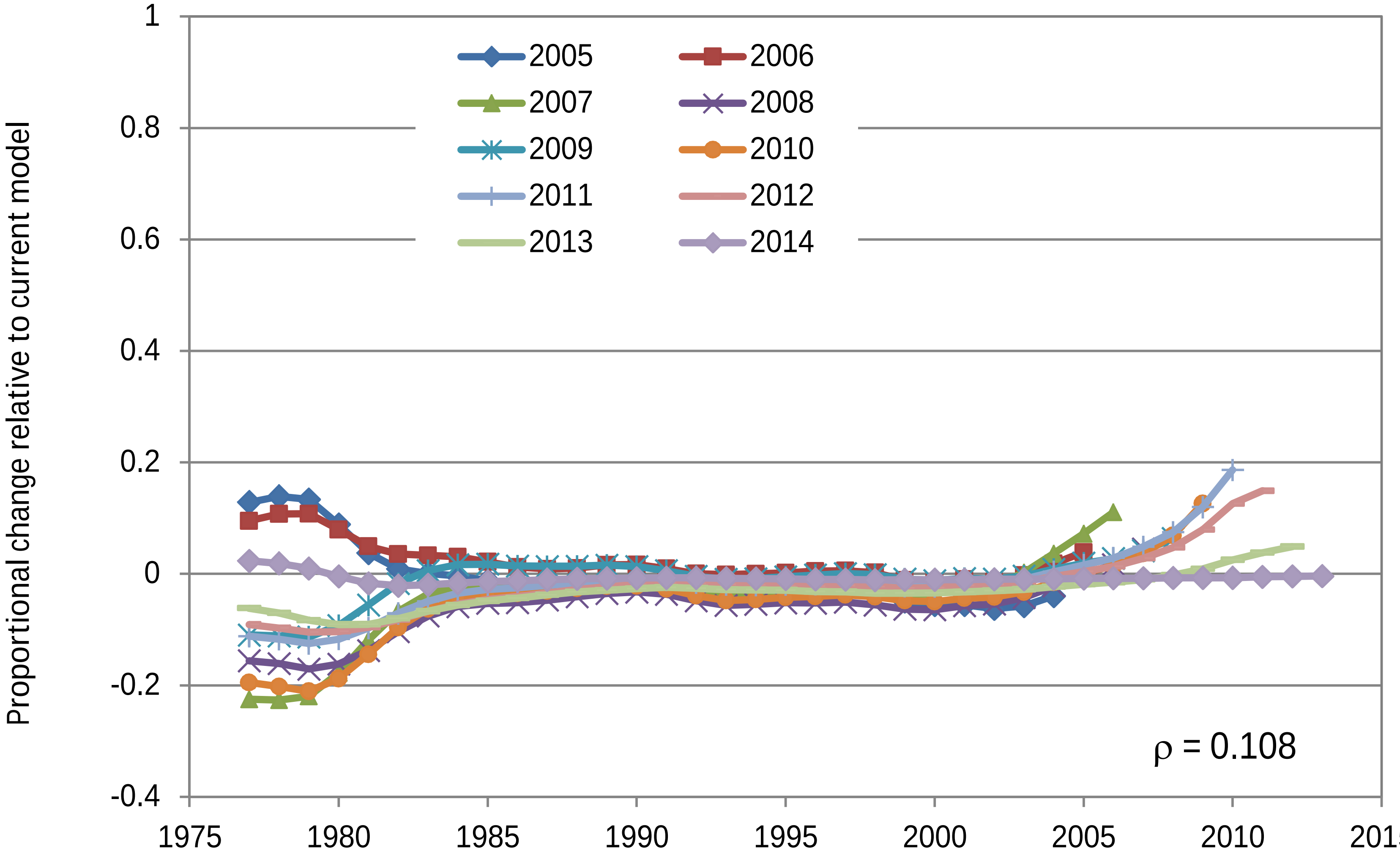
Relative fishing mortality time series



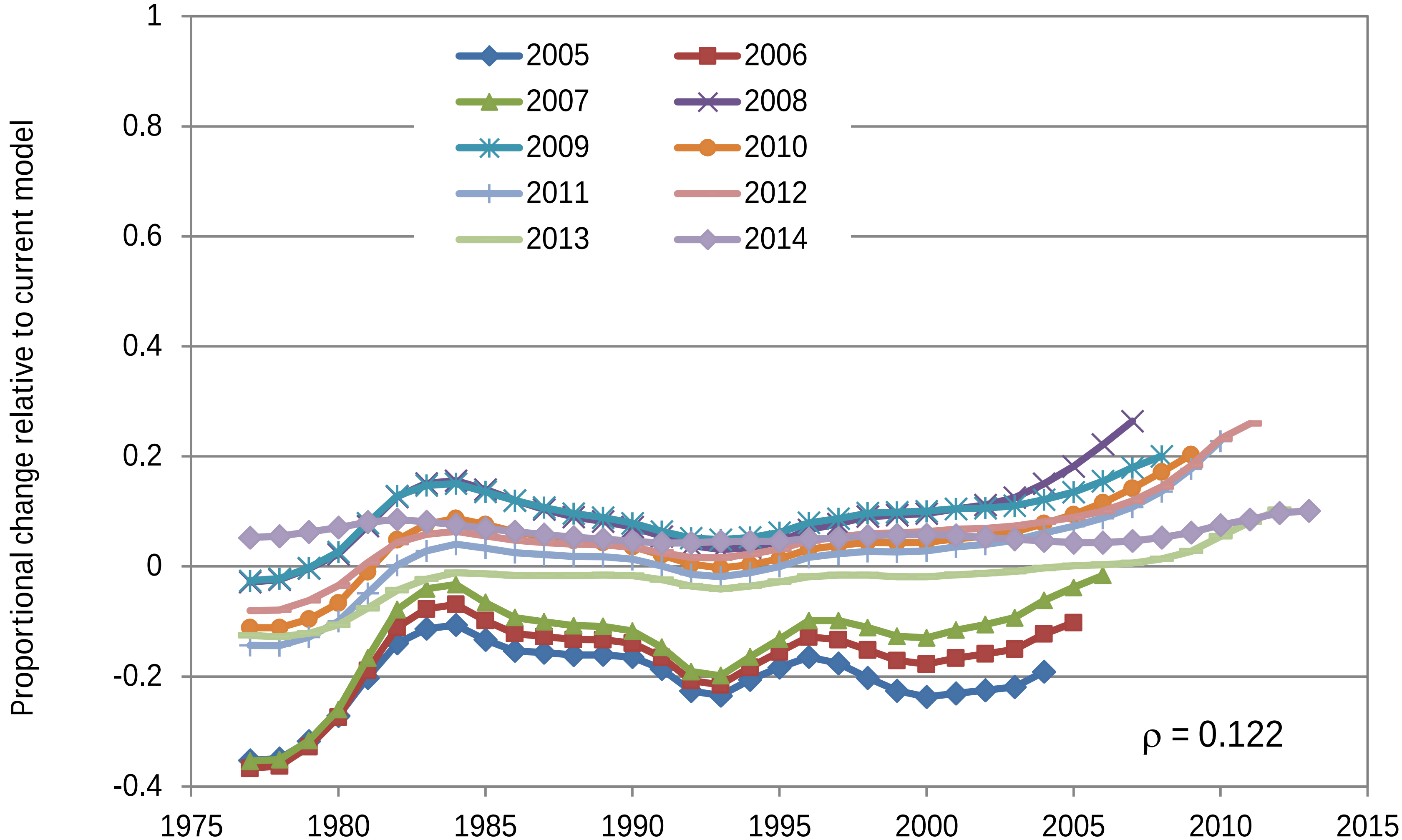
Spawning biomass retrospective (Model 11.5)



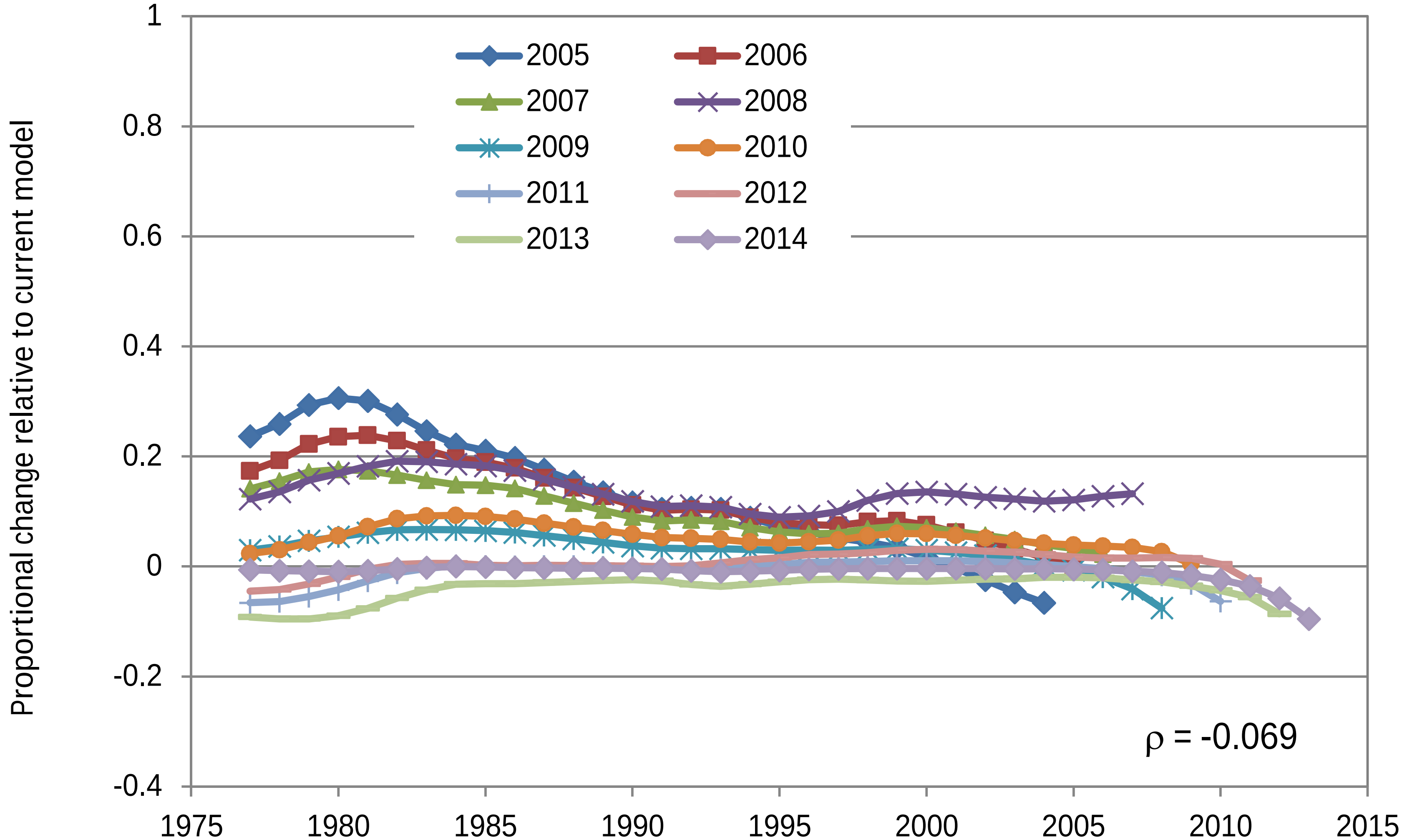
Spawning biomass retrospective (Model 16.1)



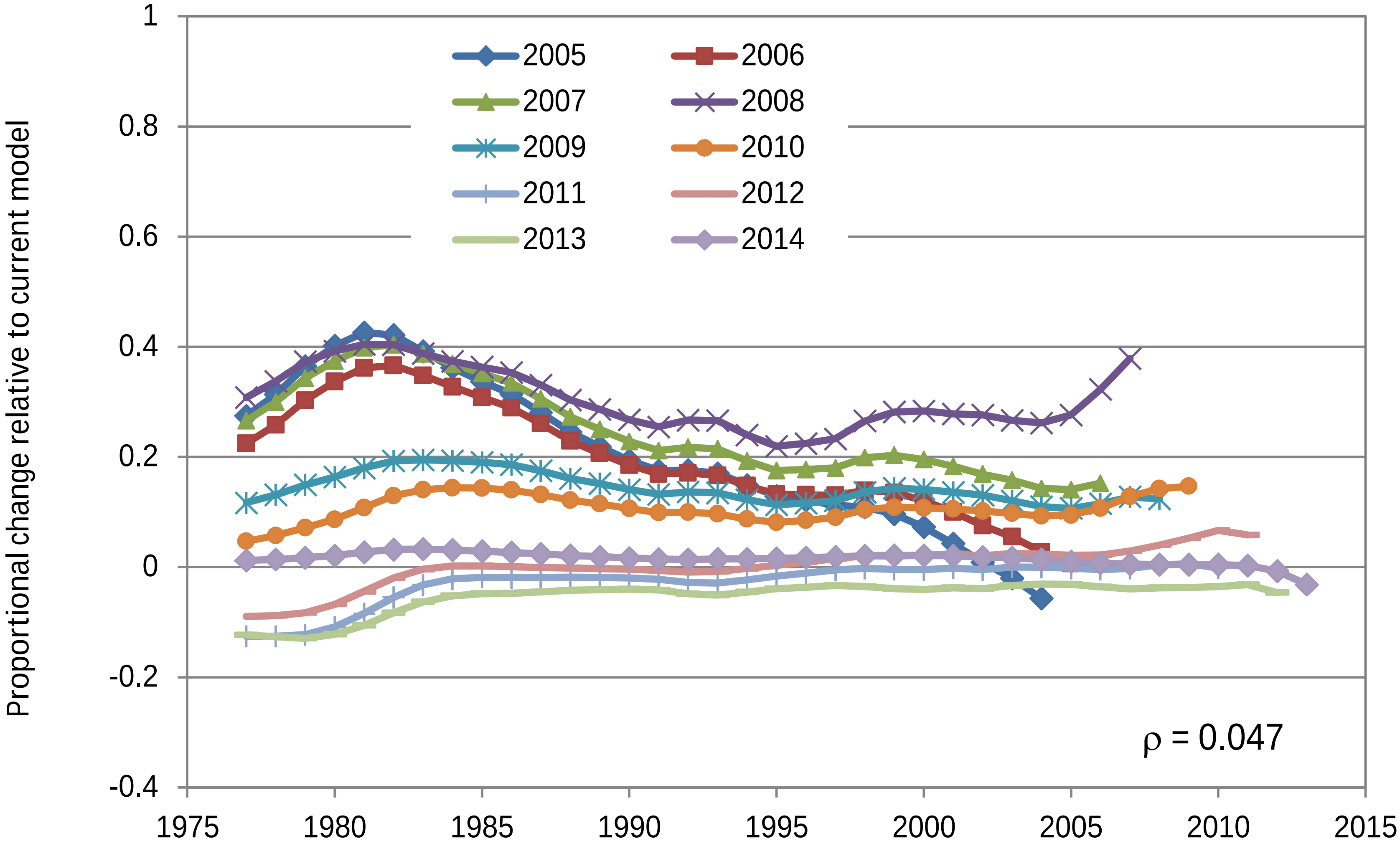
Spawning biomass retrospective (Model 16.2)



Spawning biomass retrospective (Model 16.3)



Spawning biomass retrospective (Model 16.4)



Spawning biomass retrospective (Model 16.5)