An exploration of GOA Pacific cod stock assessment models for 2012

Teresa A'mar

Resource Ecology and Fisheries Management Division
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE., Seattle, WA 98115

Introduction

This document represents an effort to respond to comments made the GOA Plan Team, the joint BSAI and GOA Plan Teams, and the SSC on the 2011 assessments of the Pacific cod (*Gadus macrocephalus*) stocks in the Gulf of Alaska (Thompson et al., 2011). In order to allow for exploration of a wide variety of modeling assumptions, this preliminary overview focuses on model development rather than application of the same model(s) to multiple data sets. Specifically, the Stock Synthesis model configurations presented here are applied to the data used in the 2011 GOA Pacific cod stock assessment.

Comments from the Plan Teams and SSC

Joint Plan Team Comments from the May 2012 Minutes

JPT1: "For the GOA, the Teams recommend that the preliminary assessment include the following two models, which are in addition to any models that the authors wish to propose: Model 1 is last year's final model, and Model 2 is last year's final model with re-tuned catchability."
Response: The initial results from these model configurations are included as Models 1 and 1Q ("Q" indicates the model was iteratively tuned so that mean catchability for 60-81 cm was 0.916).

JPT2: "For both the EBS and GOA, the Teams recommend that the authors attempt to explore the divergent ageing bias trends in the two regions and the impacts thereof."
Response: This issue will be addressed in the November SAFE document.

JPT3: "For both the EBS and GOA, the Teams recommend that the authors attempt to evaluate the biological basis for estimated patterns of seasonal weight at length."
Response: This issue will be addressed in the November SAFE document.

JPT4: "For both the EBS and GOA, the Teams recommend that the authors attempt to estimate catchability internally. This can be addressed as an option under Model 1 without developing and presenting a full set of results for an additional model (full results for the base case of Model 1 are requested, however)."
Response: The initial results from this model configuration are included as Model E.

JPT5: "For the GOA only, the Teams recommend that the authors reduce the number of parameters. This can be addressed as an option under Model 1 without developing and presenting a full set of results for an additional model (full results for the base case of Model 1 are requested, however)."
Response: Models B, BQ, C, CQ, and D have fewer estimated parameters than Models 1 and 1Q.

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JPT6: "Seven model evaluation criteria were proposed: 1) fitting the age composition data (unanimous CIE recommendation); 2) internal estimation of aging error bias (much more efficient); 3) correspondence between the model-estimated mean size-at-age and the empirical survey mean size-at-age of the first three modes of the average survey size composition; 4) correspondence of the product of survey catchability and survey selectivity (for the 61 to 80 cm size range) from the model and the value of 0.916 estimated by Nichol et al. (2007); 5) accounting for full variability in the observed length-at-age among individuals and years; 6) low temporal variability in survey selectivity and catchability; and 7) reasonable retrospective behavior. The Plan Team endorsed, and the SSC concurs, with these selection criteria, which are a distillation of past preferences and recommendations from the Plan Teams, CIE reviewers, the public, and the SSC. These criteria will be used when evaluating the results of model configurations."

Responses correspond to each of the JPT proposed model evaluation criteria listed above:

Criteria 1, The fits to the survey age composition data are presented for all models;

Criteria 2, All model configurations estimate ageing bias;

Criteria 3, Comparison of survey mean size-at-age with model-estimated survey mean size-at-age will be addressed in the November SAFE document;

Criteria 4, Calculated values for mean 27plus survey catchability for 60 – 81 cm for all model configurations are presented in Table 2;

Criteria 5, This issue will be addressed in the November SAFE document;

Criteria 6, Five model configurations were explored that have two time blocks defined for catchability and selectivity for the sub27 survey; one model configuration has two time blocks defined for selectivity for the 27plus survey as well, as the base model configurations have two time blocks defined for catchability of the 27plus survey (1984 – 1993 and 1996 – present) due to the switch from 30-minute to 15-minute tows in the survey design; and

Criteria 7, This issue will be addressed in the November SAFE document and when the Plan Team working group on retrospective analyses is completed.

SSC Comments from the June 2012 Minutes

SSC1: "As for the EBS, the SSC agrees with the choice of last year's final model (formerly Model 3, new model 1) as the baseline model for the Gulf of Alaska and a second model (model 2) that re-tunes catchability to match the empirical estimates from Nichol et al. (2007)."

Response: The initial results from these model configurations are included as Models 1 and 1Q.

Summary of the base model configuration

The base model configuration for 2012 is the 2011 Model 3 configuration. The software used to run all models was SS v3.24f as compiled on 03 August 2012 with ADMB v.11 (Last year's models used v3.22b, as compiled on 8/3/11).

Model evaluation

Model configurations for 2012

The following details attributes of the requested models:

Model 1:	2011 Model 3 (the base model)
Model 1Q:	Model 1 with mean catchability for the 27plus survey tuned iteratively to 0.916

These models include:

- Time-varying fishery selectivity-at-length for all gears and seasons;
- Two blocks for catchability for the 27plus survey, 1984 – 1993 and 1996 – 2011;

- Time-varying catchability for the Sub27 survey;
- Time-varying survey selectivity-at-age for the 27plus survey;
- Constant survey selectivity-at-age for the Sub27 survey; and
- Median recruitment before 1977 restricted to be less than the post-1976 median recruitment, as the pre-1977 recruitment deviation is restricted to be less than 0.0

On evaluation of these models it was suggested by Ian Stewart and Ian Taylor (NWFSC, pers. comm.) to change the Stock Synthesis option "comp_tail_compression" from 0.000001 (used previously) to -1, which turns this feature off and uses all of the age and length composition data. This feature, when implemented as last year, binned the values in the composition "tails" for both the observed and expected values. This change is applied in subsequent models beginning with:

Model A: Model 1 (the base model) with tail compression turned off
Model AQ: Model A with mean catchability for the 27plus survey tuned iteratively to 0.916

The four base models estimated very similar values for spawning biomass (Fig. 1), although the estimates of recruitment differ in recent years (Fig. 2), which is also seen in the fits to the 27plus and sub27 survey indices (Figs. 3 and 4). The fits to the survey length composition data for Models 1 (Figs. 5 and 7) and A (Figs. 6 and 8) also differ substantially, which shows the impact of tail compression and is likely the reason for differences in recent recruitment estimates.

The following considerations for proceeding with alternative models should consider (and for which feedback would be appreciated) include:

- The importance using the ADF&G nearshore trawl survey data as an additional index;
- The use of time-varying catchability coefficients for the sub27 survey;
- Fitting the age composition for the sub27 survey; and
- The use of time-varying selectivity for the 27plus survey.

Alternative model configurations evaluated included:

Model B: Model A with sub27 survey changed from time-varying Q and constant selectivity to two blocks for both Q and selectivity (split at 1996), and the initial value for the pre-1996 Q deviation for both the 27plus and sub27 surveys set to 0.0

Model BQ: Model B with mean catchability for the 27plus survey tuned iteratively to 0.916

Model C: Model B with the initial value for pre-1977 recruitment deviation changed to 0.0 and the upper bound increased to allow positive values

Model CQ: Model C with mean catchability for the 27plus survey tuned iteratively to 0.916

Model D: Model C with 27plus survey changed from 11 to 2 blocks for selectivity (split at 1996)

Model E: Model A with Q for the 27plus survey estimated, and the initial value for the pre-1996 Q deviation for both the 27plus and sub27 surveys set to 0.0 (See JPT4)

Model 1B: Model B with tail compression set to the value used in Model 1

Model 1C: Model C with tail compression set to the value used in Model 1

The changes for Q and selectivity for the sub27 survey characterizes the assumption that the data are representative of cohort strength, rather than survey variability. For comparison purposes only, the GOA Pacific cod length composition data from the ADF&G crab and groundfish nearshore trawl survey are presented. Small fish, 5 – 15 cm, which are assumed to be age-0, are sampled by the ADF&G survey and are prominently featured in the data in some years. The NMFS GOA bottom trawl survey samples fish less than 27 cm, which are assumed to be primarily age-1 fish. The results of a comparison of the proportions-at-length data from the ADF&G survey and the NMFS survey suggest that the relative numbers of assumed age-0 fish in the ADF&G survey in a given year are similar to the relative numbers of assumed age-1 fish in the NMFS survey the following year (Figs. 9 – 12). The change from time-varying to constant Q is featured in Models B, BQ, C, CQ, and D.

Similarly, the changes to selectivity for the 27plus survey characterize the assumption that the data are representative of the stock characteristics, rather than survey variability. These assumptions and model configurations will be investigated further. This feature is present in Model D.

To evaluate convergence, Models 1, 1Q, A, AQ, C, and CQ have been tested using the Stock Synthesis "jitter" functionality which generates random initial values based on parameter bounds and other properties. The jitter parameter was set to 0.1 and each model was run 50 times. If the jitter runs produced initial values which led to a lower value for the objection function, then these initial values were used as the starting point for another set of 50 jitter runs. To complement this work, the initial values of some deviation parameters were set to 0.0 to test convergence. Since deviation parameters are applied to other variables, setting the initial value to 0.0 represents the assumption that this deviation has no positive or negative impact on the variable. This was done for variables in Models B, BQ, C, CQ, D, and E.

Model configurations 1B and 1C were included as a comparison to Models 1 and 1Q, as these model configurations have tail compression turned on.

Results

The values for total likelihood for Models 1 and 1Q are lower than those for all new model configurations (Table 1), due to the change in the comp_tail_compression functionality. Model C has the lowest value of all new model configurations for both total likelihood and AIC; Model CQ has the lowest value for total likelihood and AIC of all new model configurations where the mean 27plus survey catchability has been tuned iteratively to 0.916.

The calculated values for the mean catchability for the 27plus survey for 60 – 81 cm ranged from values in the neighborhood of 0.916 for tuned model configurations to above 0.94 for the other model configurations (Table 2); the values for the pre-1996 Q deviation for the 27plus and sub27 surveys were in the neighborhood of 0.5 and -0.5, respectively, save for Model E, which estimated catchability for the 27plus survey. The (base) values for catchability for the sub27 survey ranged from a low of 0.07 to a high of 0.16.

The estimates of spawning biomass are similar across all new model configurations, save for Model E, which has consistently lower estimates due to estimating the catchability for the 27plus survey to be significantly higher than all other model configurations (Figs. 13 and 14). The estimates of age-0 recruits are similar across the new model configurations, with Model D having higher estimates in recent years and Model E having lower estimates in recent years (Figs. 15 and 16).

The estimates of the (log) survey indices are similar for the 27plus survey for Models 1, 1Q, A, AQ, B, BQ, C, and CQ, as these model configurations model this survey catchability and selectivity in the same manner (Figs. 17 and 18); Models D and E have different patterns due to estimating fewer selectivity

curves and catchability, respectively. The base models, Models 1, 1Q, A, and AQ, estimate catchability for each survey year for the sub27 survey, so the estimated values are close to the actual values, as these model configurations essentially track the numbers of age-1 fish seen in the survey (Figs. 19 and 20). Models B, BQ, C, CQ, and D estimated constant catchability for the periods 1984 – 1993 and 1996 – 2011, which results in less variability in the estimates.

Models 1, 1Q, 1B, and 1C have tail compression turned on. The estimates of spawning biomass are similar for all models (Fig. 21), although the estimates of age-0 recruitment differ in recent years (Fig. 22). The estimates of the survey indices are similar for the 27plus survey (Fig. 23), as these model configurations model this survey catchability and selectivity in the same manner. The sub27 survey estimates differ significantly (Fig. 24), as Models 1B and 1C estimate constant catchability for two periods rather than a separate catchability for each survey year.

The fits to the survey age composition data for all model configurations are shown in Figs. 25 – 48.

Tables

Table 1 – The likelihood components, number of parameters, and AIC values for the SS3 model configurations. Jitter convergence implies that the negative log likelihood total was lower (or as low) as any of the jittered runs.

Model	Total	Survey	Length comps	Age comps 27plus	Age comps sub27	Size at age	Recruit	Parameters	AIC	Jitter convergence?
1	3,842	4.34	3,116	80.67	16.61	645.73	-21.16	252	8,189	Yes
1Q	3,847	6.01	3,114	80.63	17.14	651.58	-22.37	252	8,199	Yes
A	3,990	1.73	3,217	89.25	46.69	657.67	-22.92	252	8,484	Yes
AQ	3,992	2.87	3,217	89.95	46.63	658.48	-22.84	252	8,489	Yes
B	3,952	14.12	3,175	91.22	36.59	656.63	-22.43	244	8,391	Yes
BQ	3,954	14.51	3,176	91.06	36.60	657.20	-22.33	244	8,395	Yes
C	3,951	13.14	3,177	91.61	36.65	654.93	-22.51	244	8,389	Yes
CQ	3,953	14.35	3,176	90.80	36.60	657.29	-22.35	244	8,394	Yes
D	4,094	-7.95	3,210	233.86	32.02	643.33	-16.61	207	8,603	Yes
E	3,959	-6.69	3,208	83.65	46.42	649.70	-21.63	253	8,425	Yes
1B	3,844	13.99	3,102	80.76	14.57	655.01	-22.46	244	8,176	Yes
1C	3,843	13.30	3,103	81.26	14.57	653.03	-22.52	244	8,174	Yes

Table 2 – Fixed and estimated catchability parameters for the 27plus and sub27 surveys (estimated values are in bold)

Model	Q for 27plus survey	Mean Q for 60-81 cm for 27plus survey (calc.)	Dev for Q for 27plus survey (1984-1993)	Q for sub27 survey	Min/max devs for Q for sub27 survey	Dev for Q for sub27 survey (1984-1993)
1	1.0400	0.9241	**0.5106**	**0.0749**	**-0.97 / 1.34**	-
1Q	1.0107	0.9159	**0.5387**	**0.0760**	**-1.01 / 1.31**	-
A	1.0400	0.9419	**0.4964**	**0.1318**	**-0.86 / 1.37**	-
AQ	1.0118	0.9168	**0.5288**	**0.1304**	**-0.85 / 1.35**	-
B	1.0400	0.9425	**0.5045**	**0.1164**	-	**-0.51**
BQ	1.0120	0.9154	**0.5250**	**0.1145**	-	**-0.49**
C	1.0400	0.9265	**0.4999**	**0.1144**	-	**-0.49**
CQ	1.0136	0.9165	**0.5231**	**0.1145**	-	**-0.49**
D	1.0400	0.9630	**0.5146**	**0.1077**	-	**-0.39**
E	**1.8817**	1.7314	**-0.0037**	**0.1592**	**-1.00 / 1.83**	-
1B	1.0400	0.9432	**0.5118**	**0.1156**	-	**-0.93**
1C	1.0400	0.9303	**0.5082**	**0.1140**	-	**-0.92**

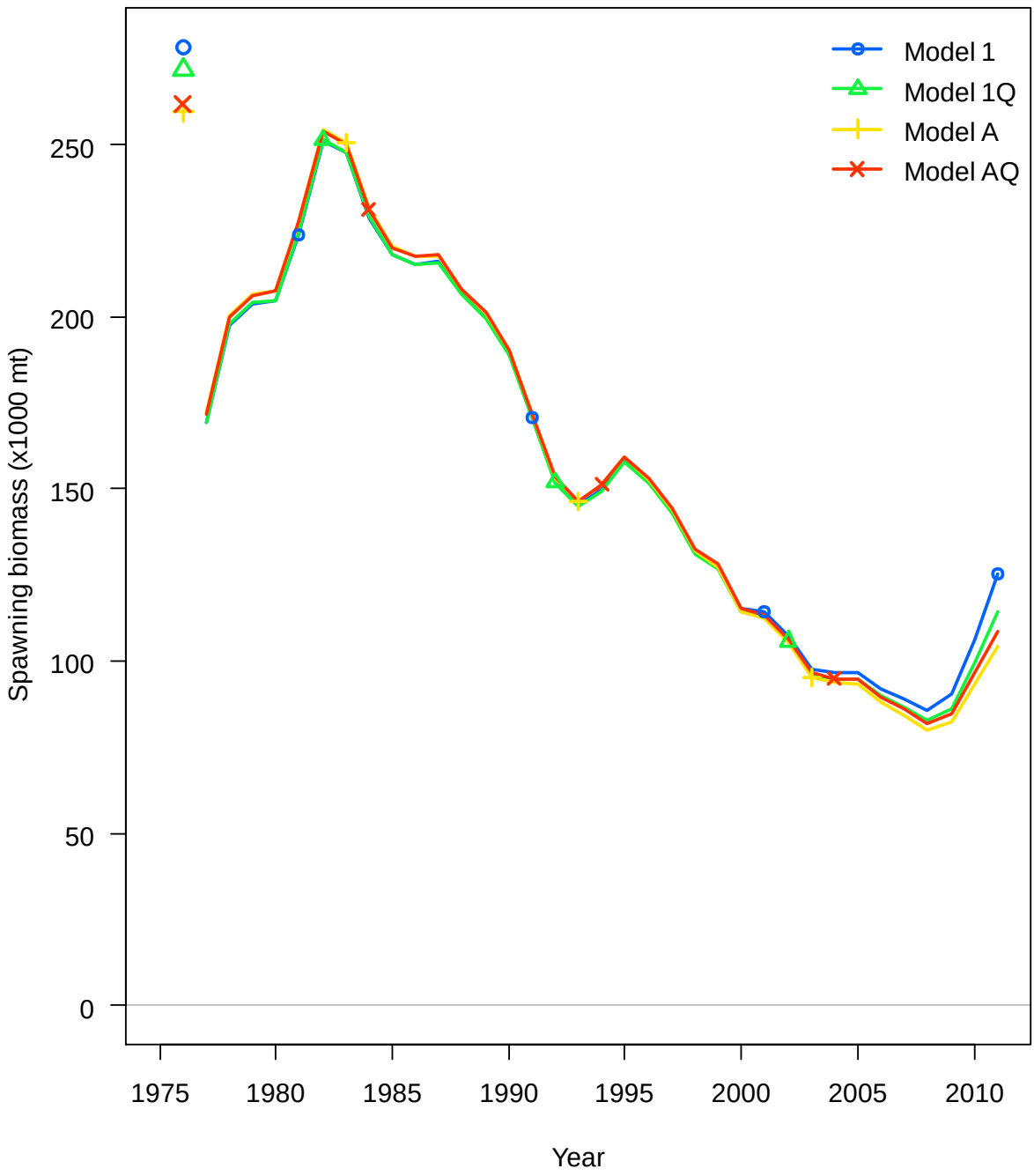

Figure 1 – Estimates of spawning biomass for Models 1, 1Q, A, and AQ

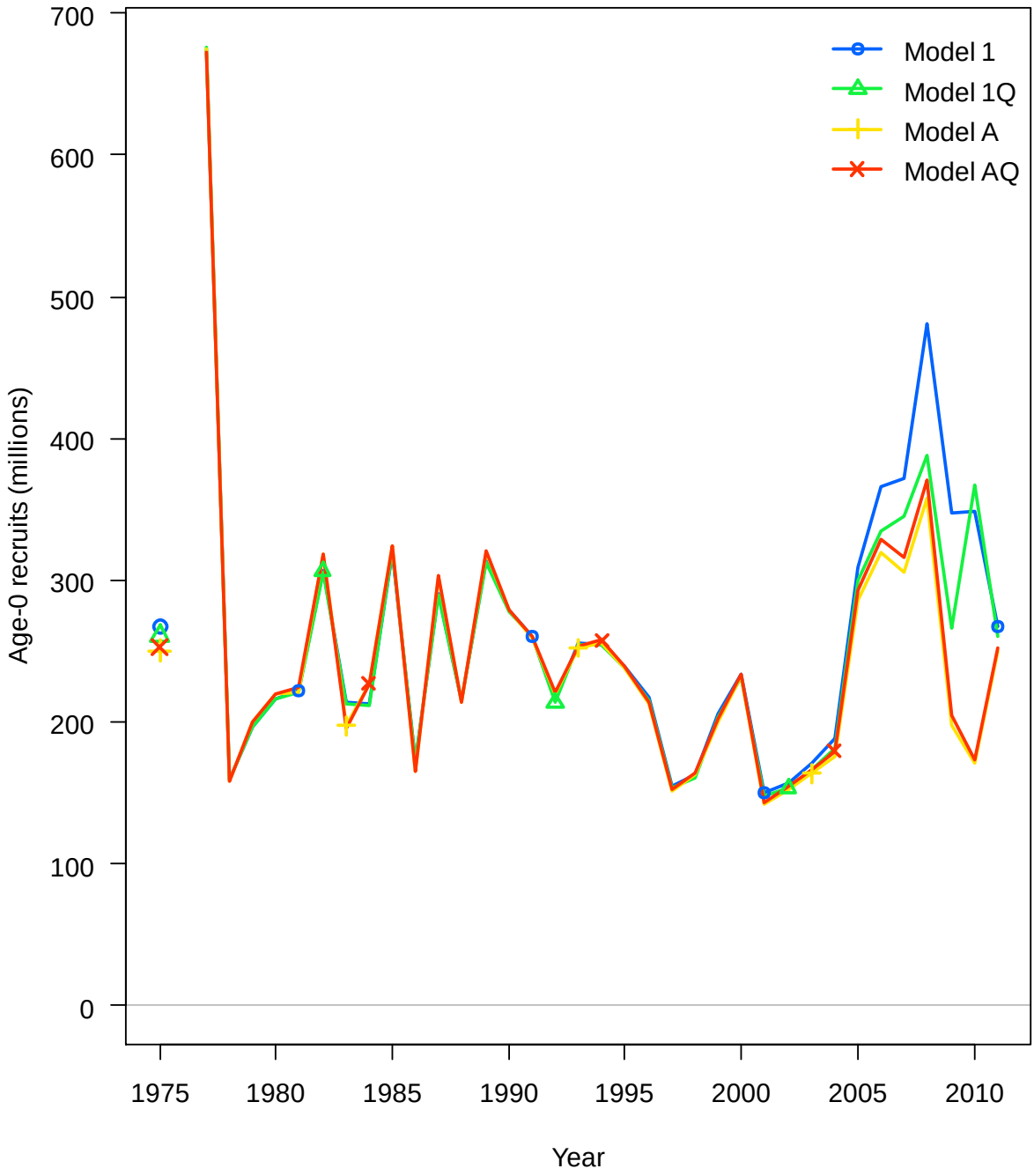

Figure 2 – Estimates of age-0 recruits Models 1, 1Q, A, and AQ

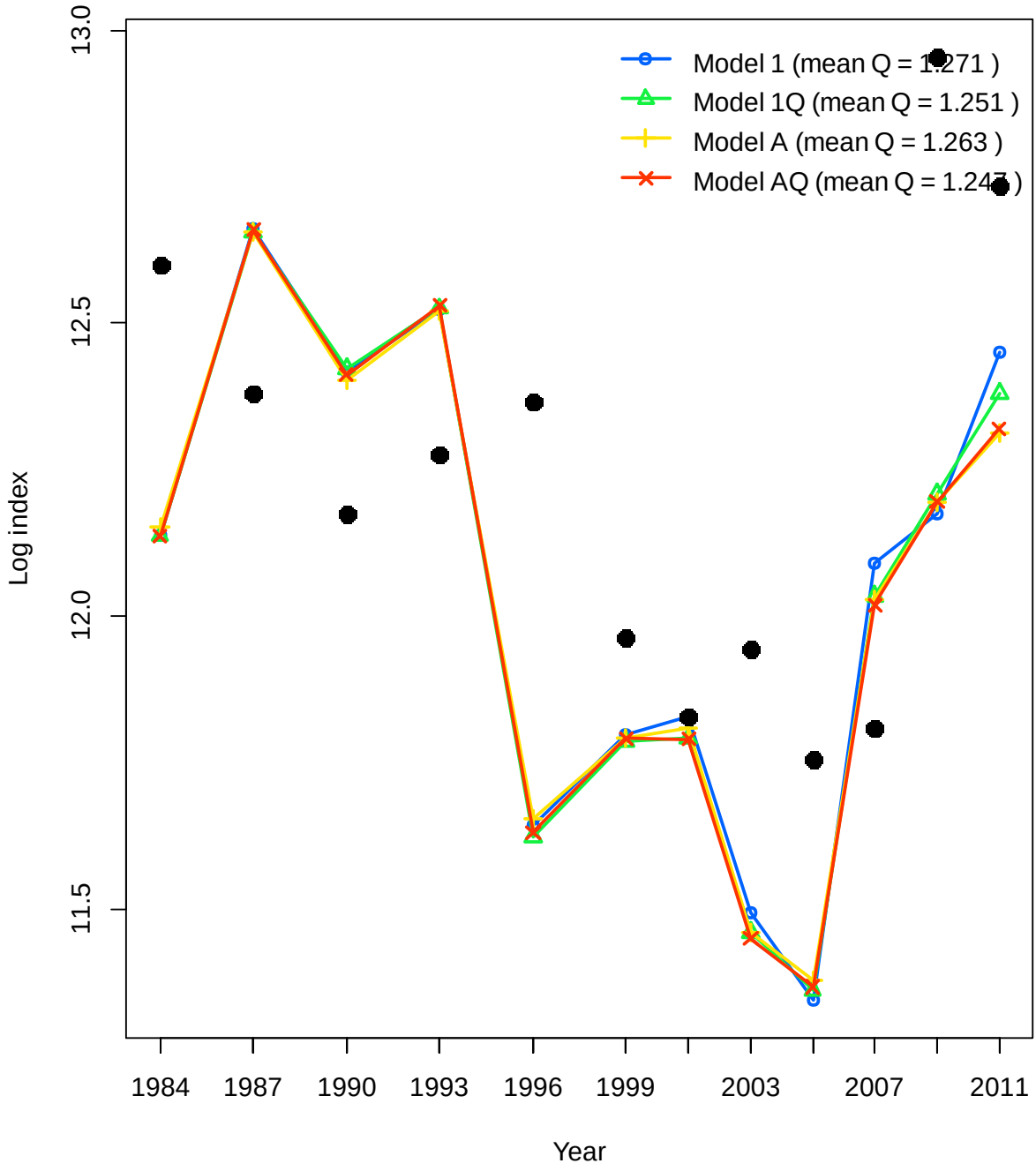

Figure 3 – Log survey estimates and model fits for the 27plus survey for Models 1, 1Q, A, and AQ

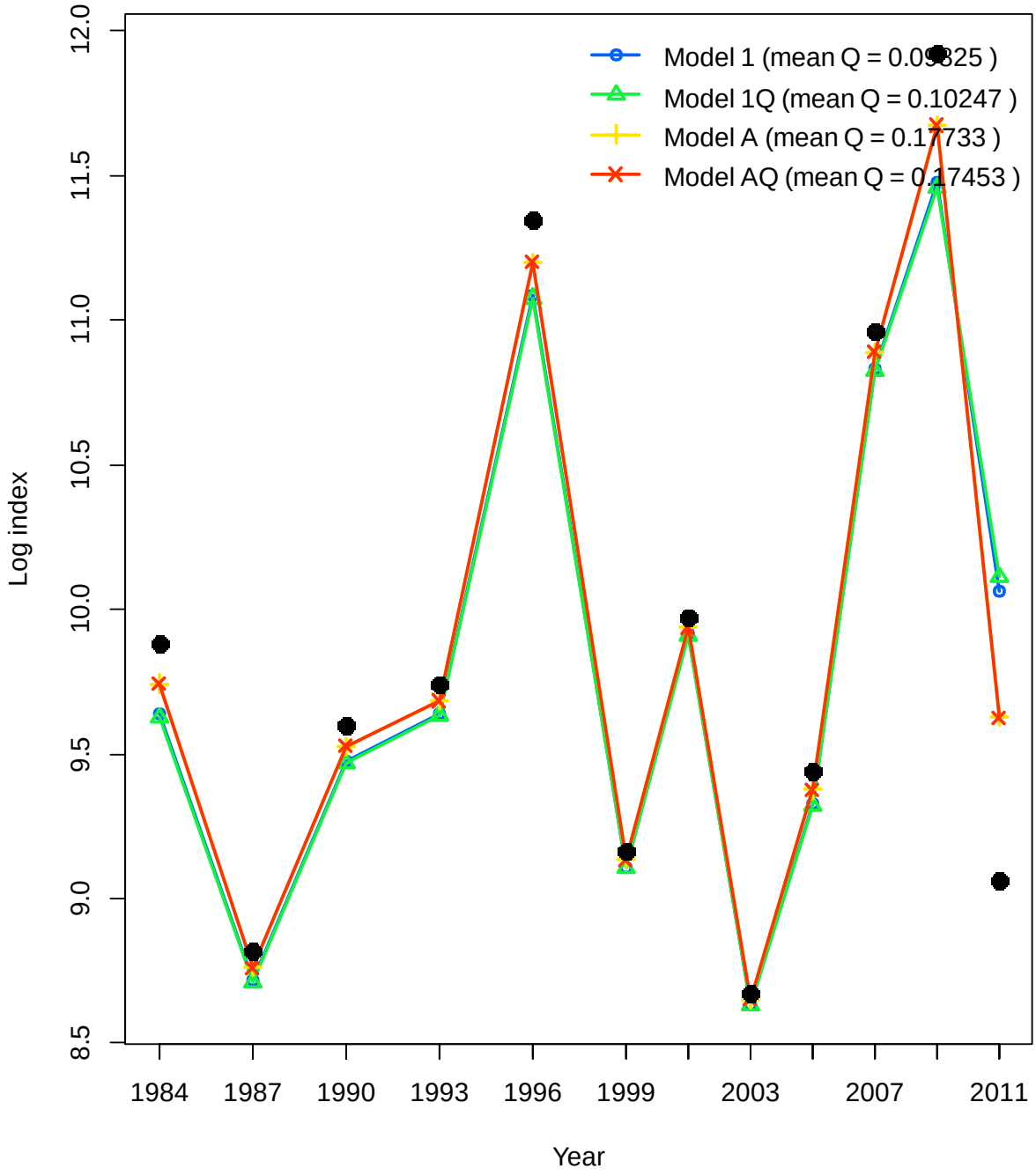

Figure 4 – Log survey estimates and model fits for the sub27 survey for Models 1, 1Q, A, and AQ

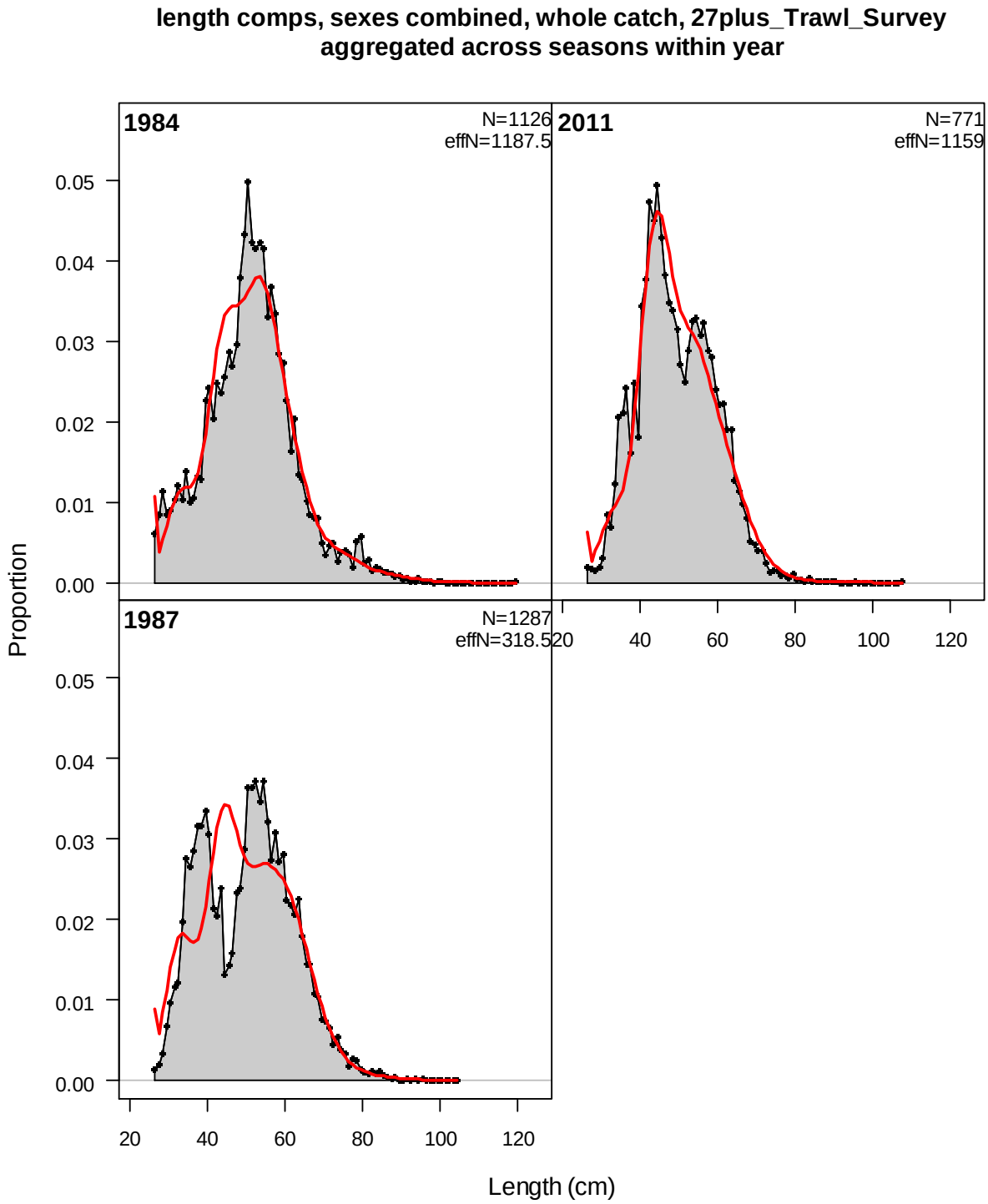

Figure 5 – Proportions-at-length for the 27plus survey for Model 1 (data in grey, model estimates in red)

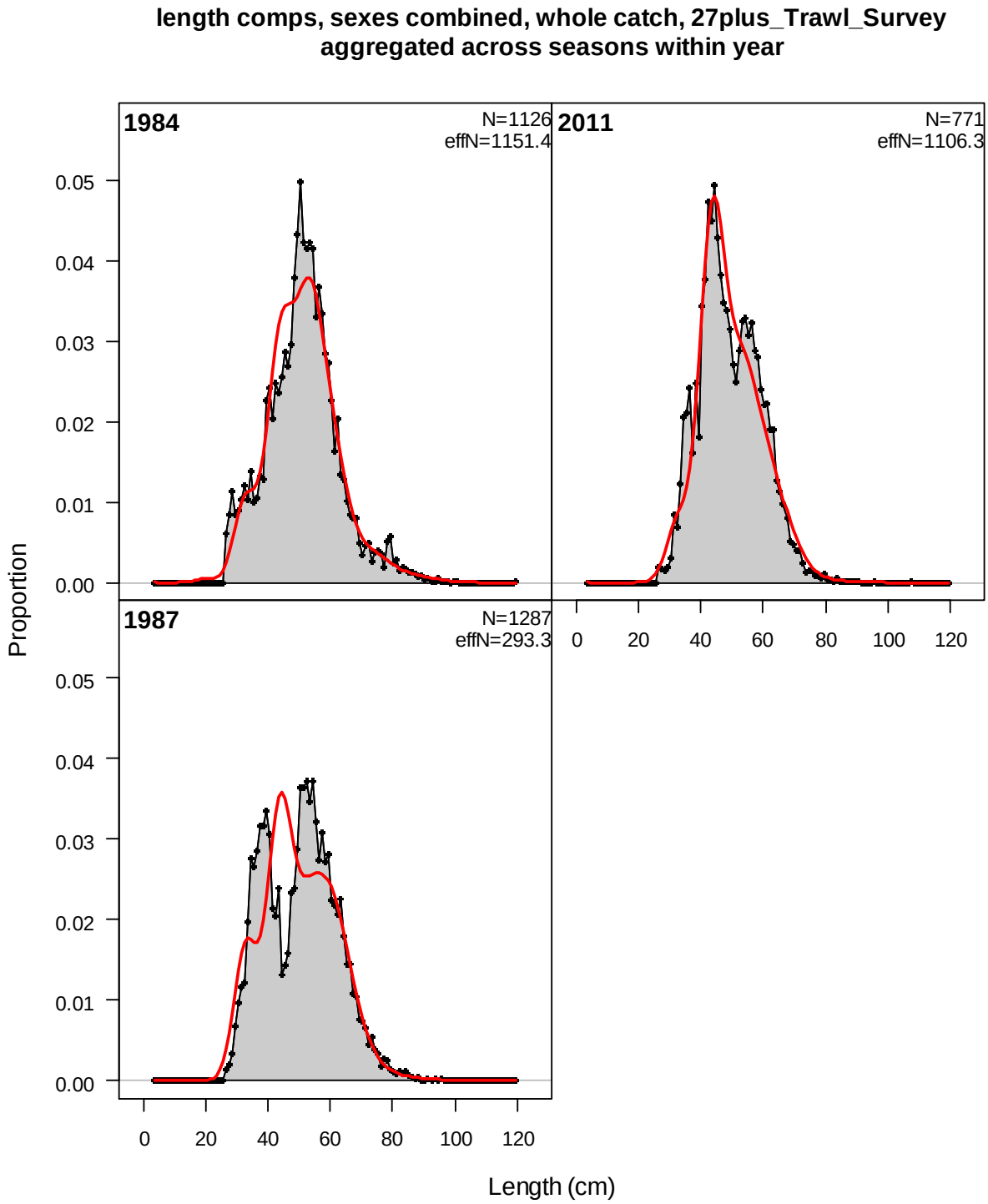

Figure 6 – Proportions-at-length for the 27plus survey for Model A (data in grey, model estimates in red)

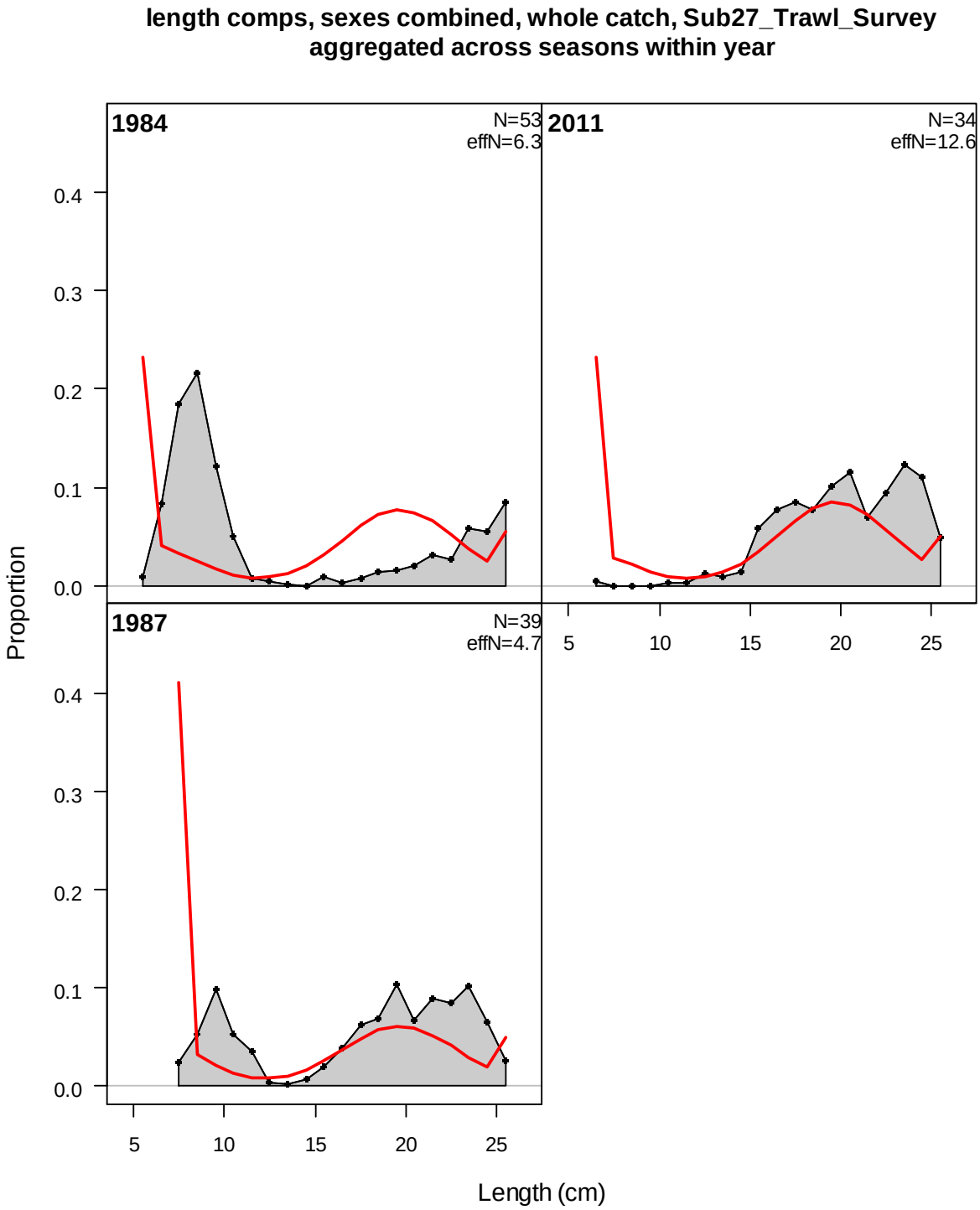

Figure 7 – Proportions-at-length for the sub27 survey for Model 1 (data in grey, model estimates in red)

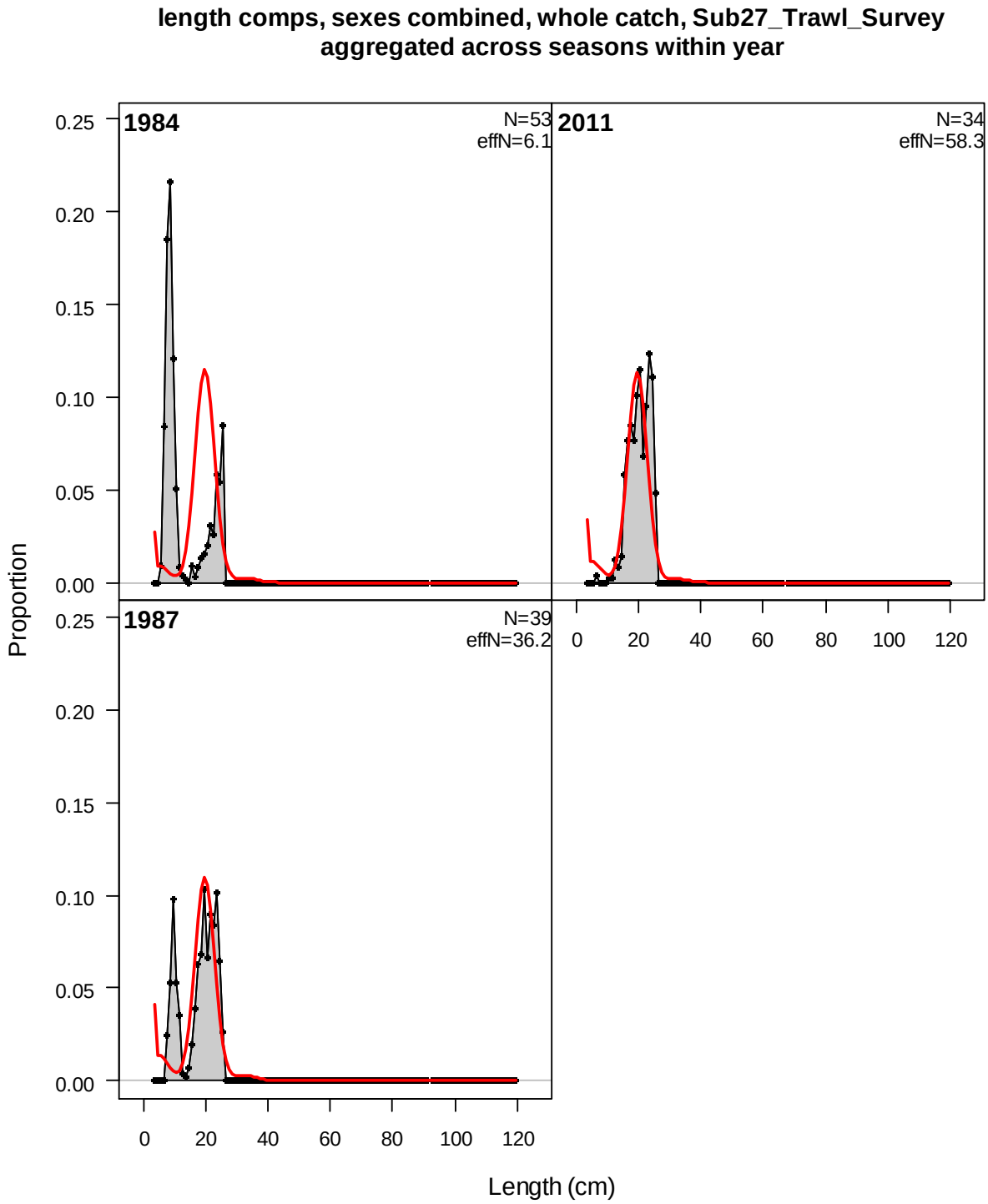

Figure 8 – Proportions-at-length for the sub27 survey for Model A (data in grey, model estimates in red)

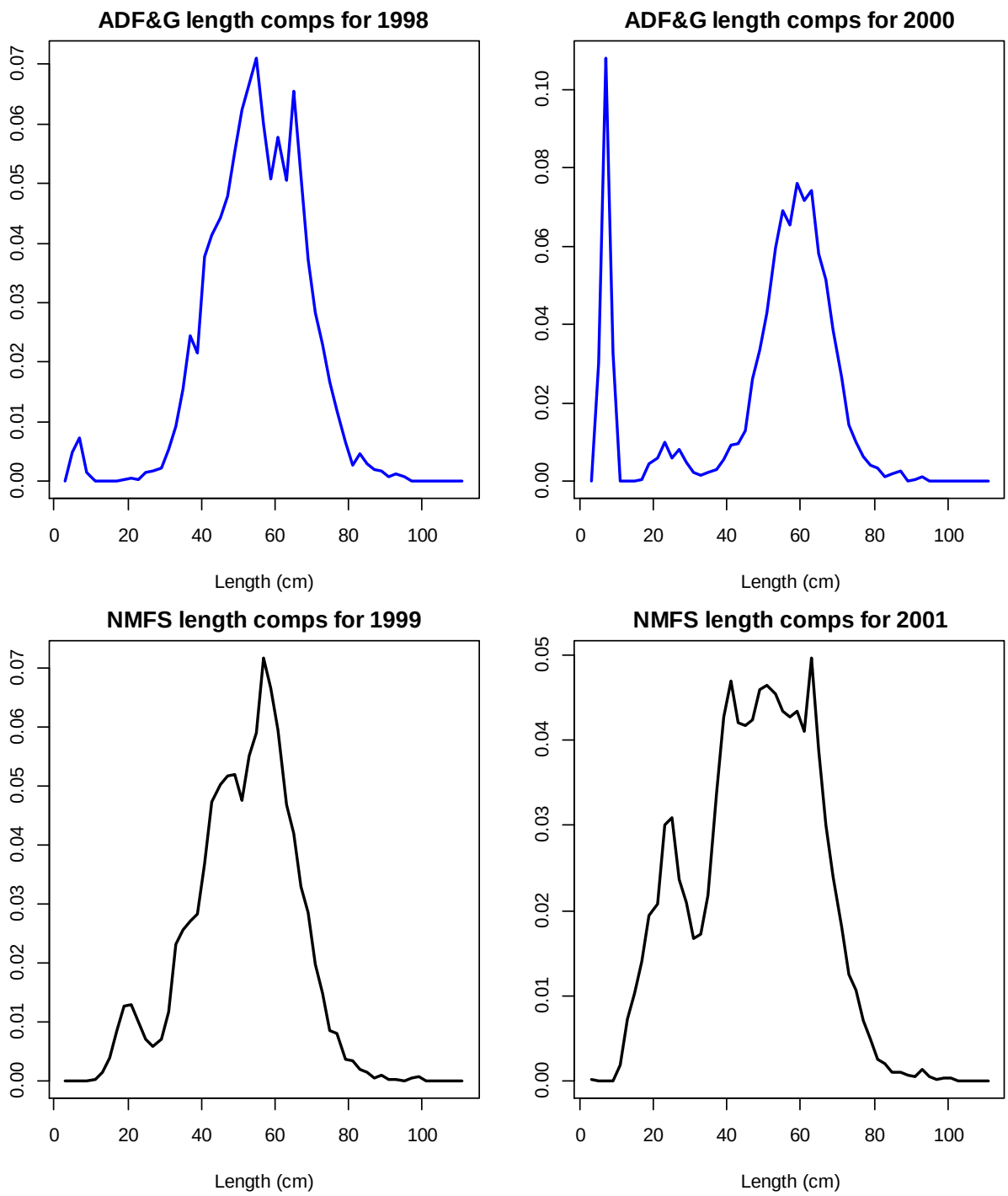

Figure 9 – Length composition data from the ADF&G survey for 1998 and 2000 (top row), length composition data from the NMFS GOA bottom trawl survey for 1999 and 2001 (bottom row)

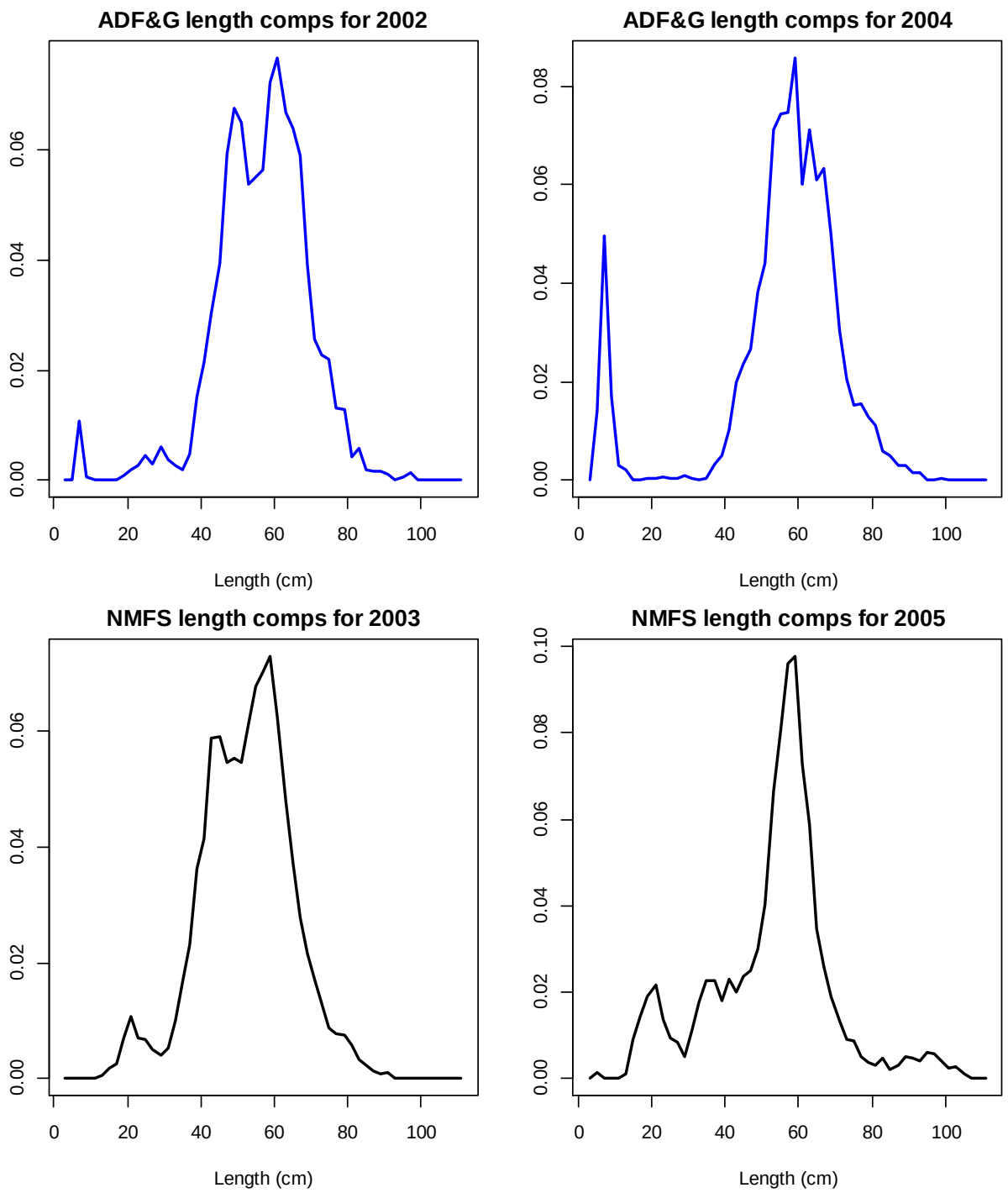

Figure 10 – Length composition data from the ADF&G survey for 2002 and 2004 (top row), length composition data from the NMFS GOA bottom trawl survey for 2003 and 2005 (bottom row)

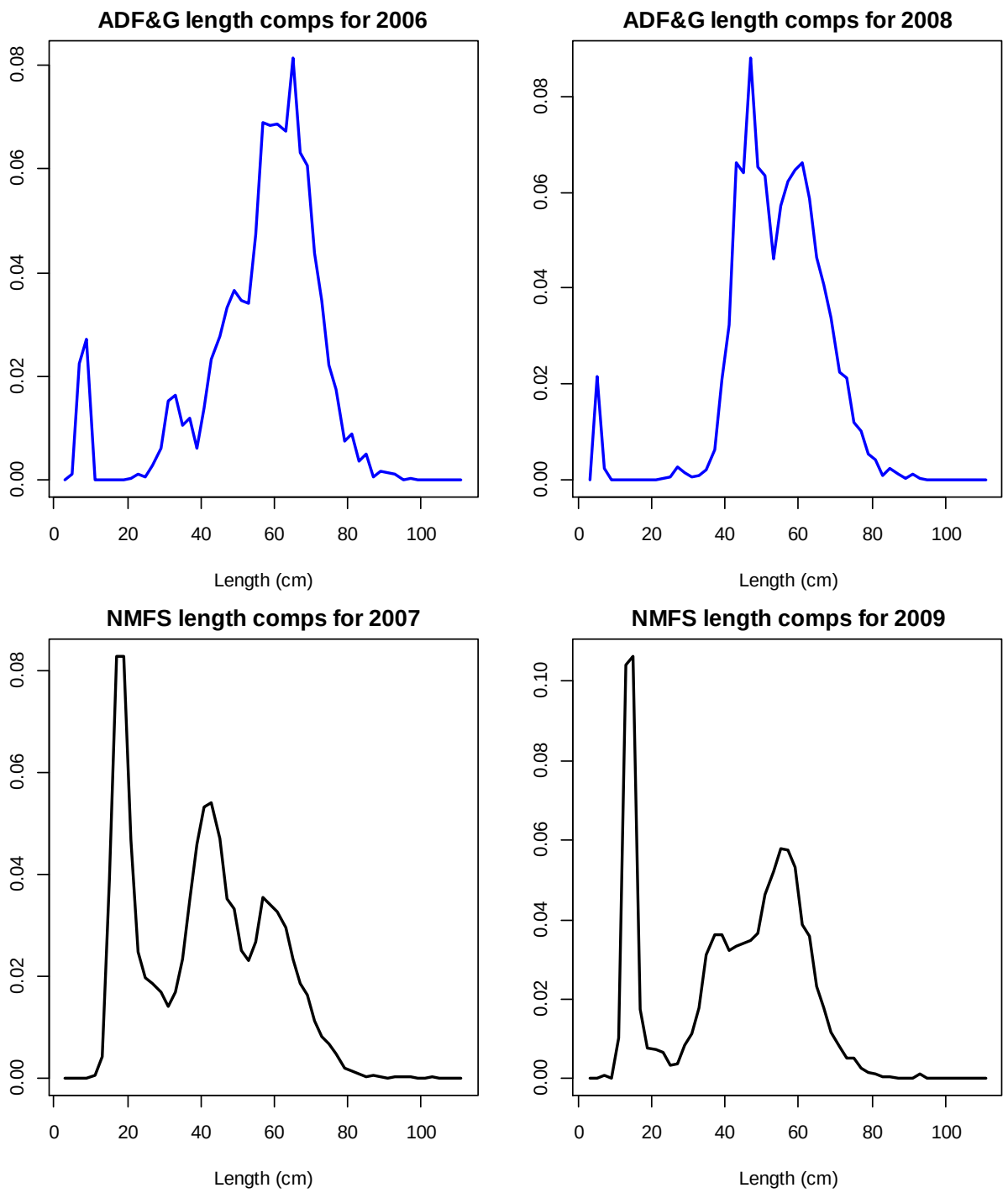

Figure 11 – Length composition data from the ADF&G survey for 2006 and 2008 (top row), length composition data from the NMFS GOA bottom trawl survey for 2007 and 2009 (bottom row)

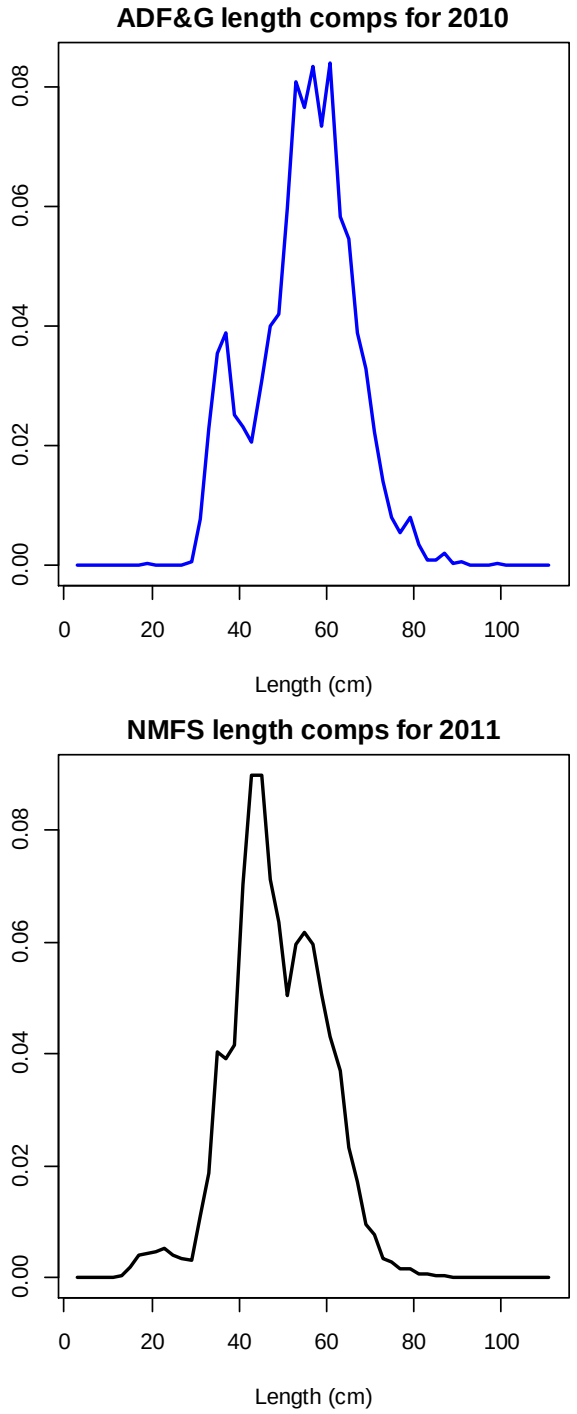

Figure 12 – Length composition data from the ADF&G survey for 2010 (top row), length composition data from the NMFS GOA bottom trawl survey for 2011 (bottom row)

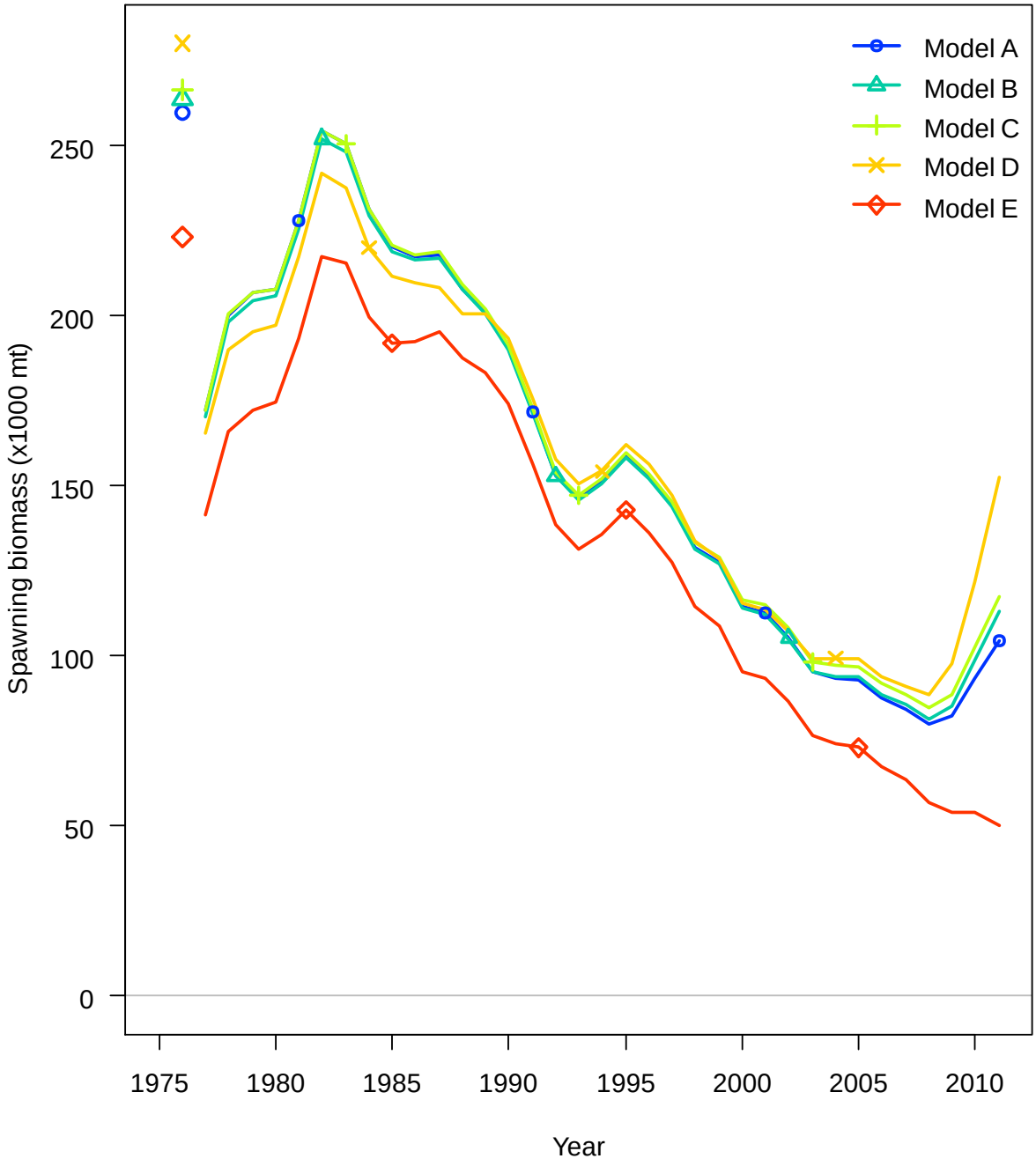

Figure 13 – Estimates of spawning biomass for Models A, B, C, D, and E

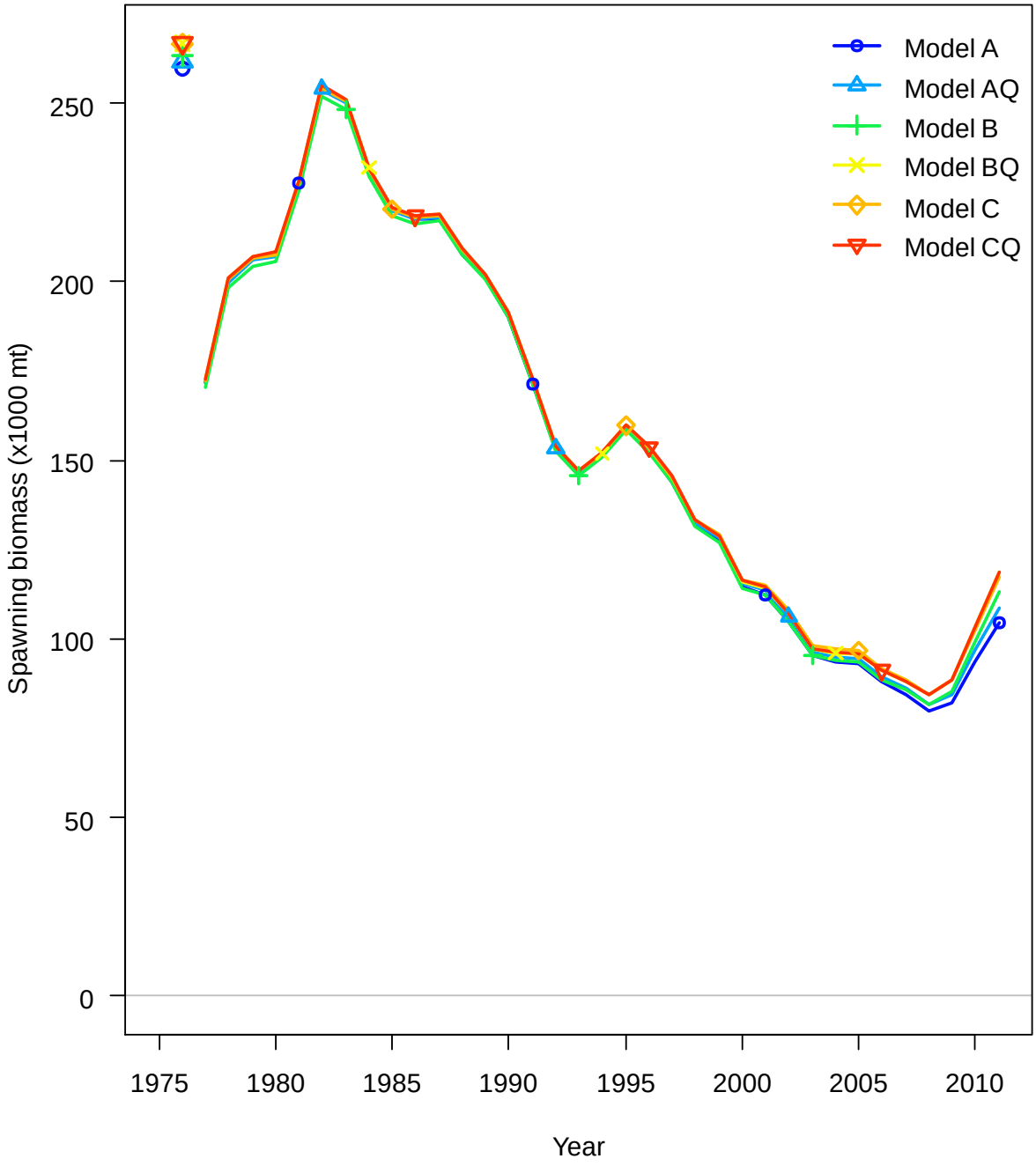

Figure 14 – Estimates of spawning biomass for Models A, AQ, B, BQ, C, and CQ

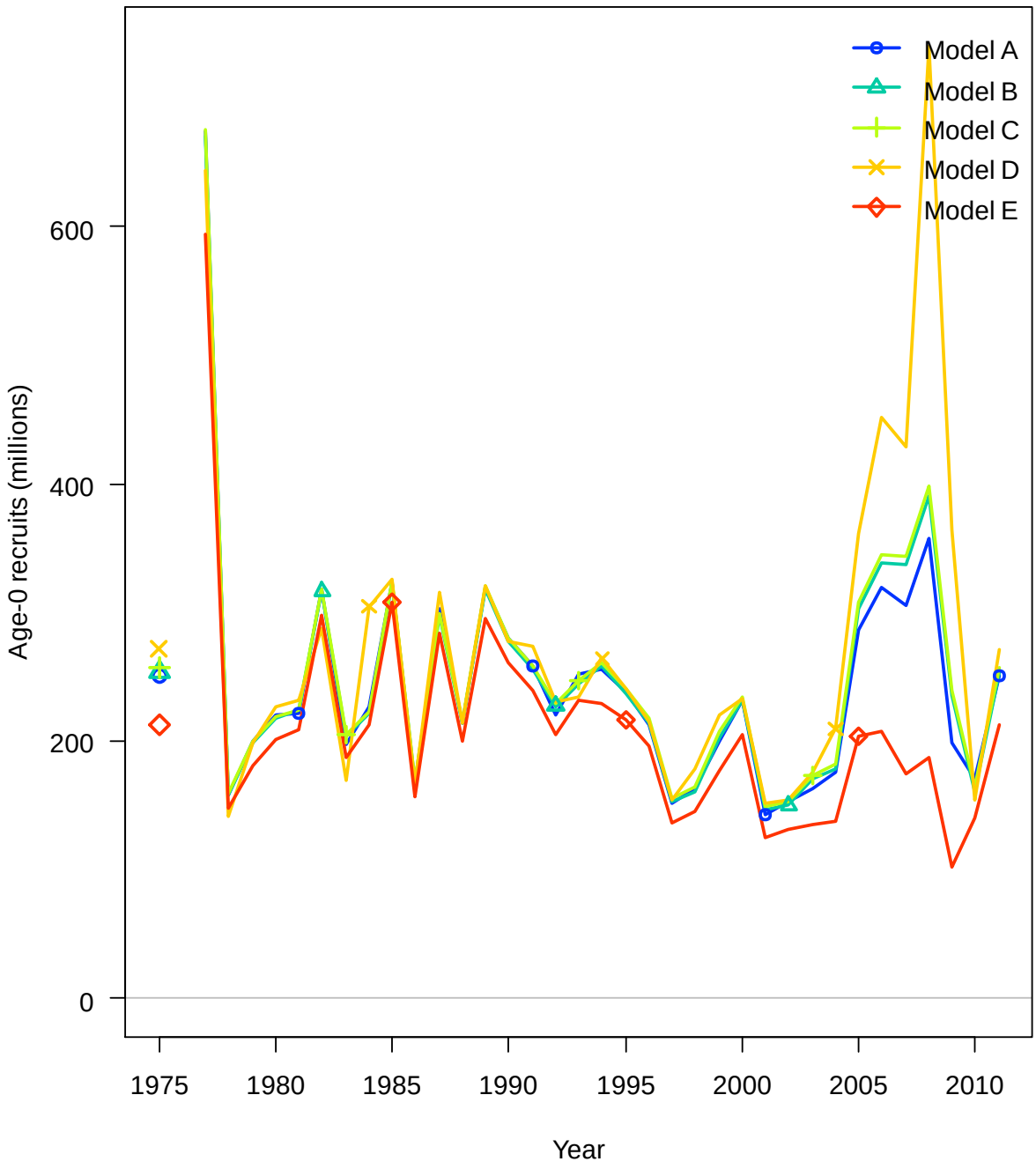

Figure 15 – Estimates of age-0 recruitment for Models A, B, C, D, and E

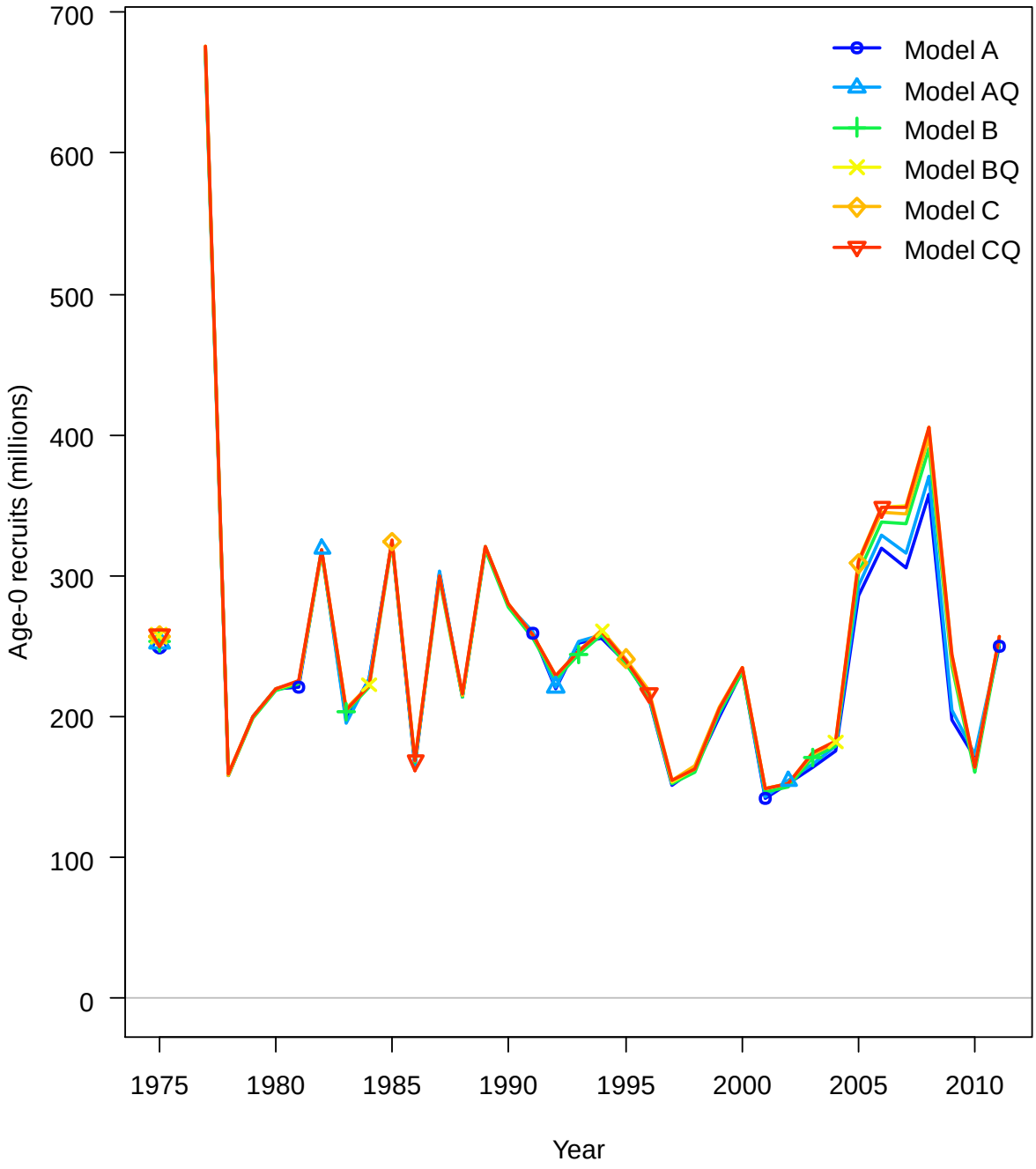

Figure 16 – Estimates of age-0 recruitment for Models A, AQ, B, BQ, C, and CQ

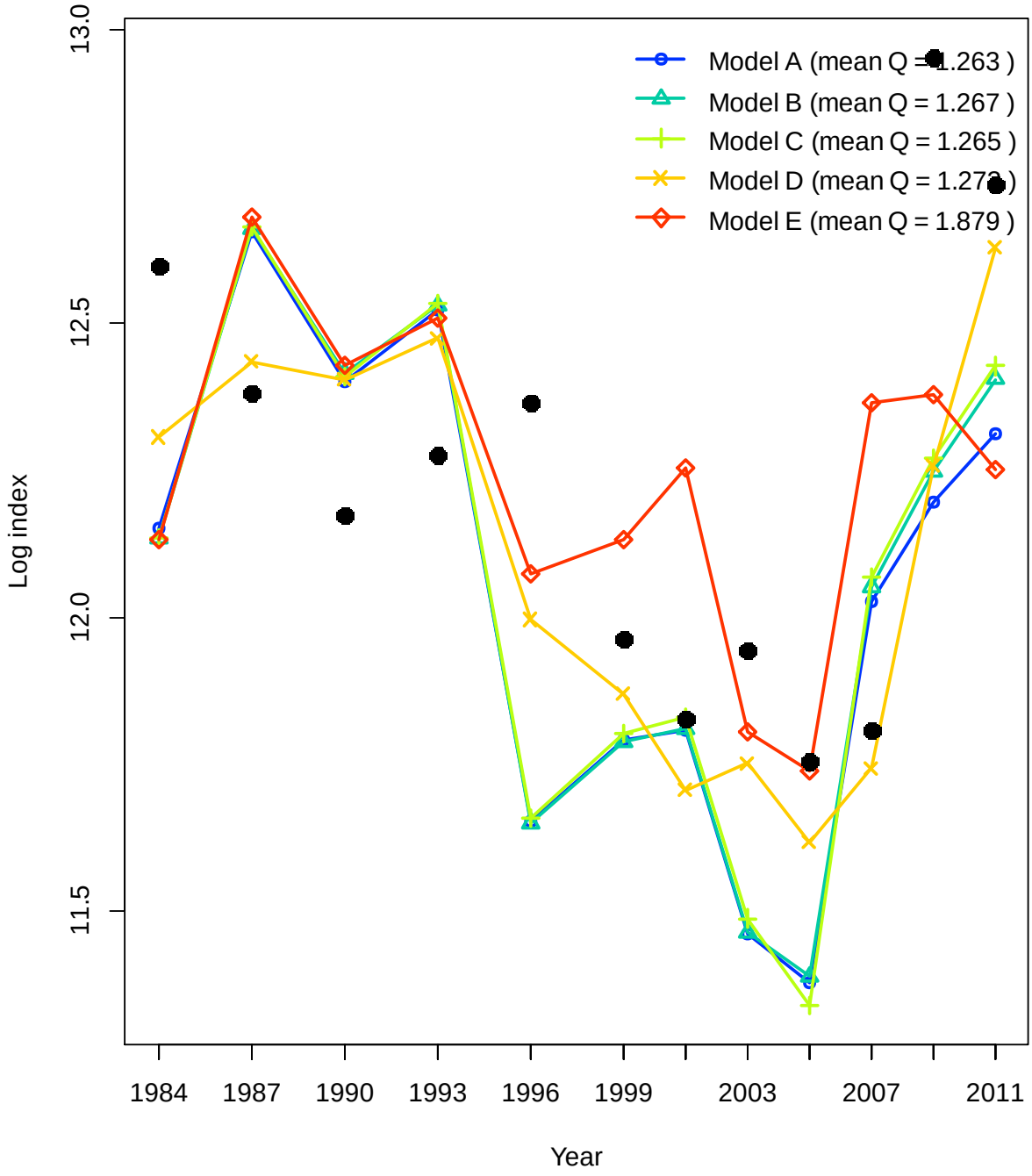

Figure 17 – Log survey estimates and model fits for the 27plus survey for Models A, B, C, D, and E

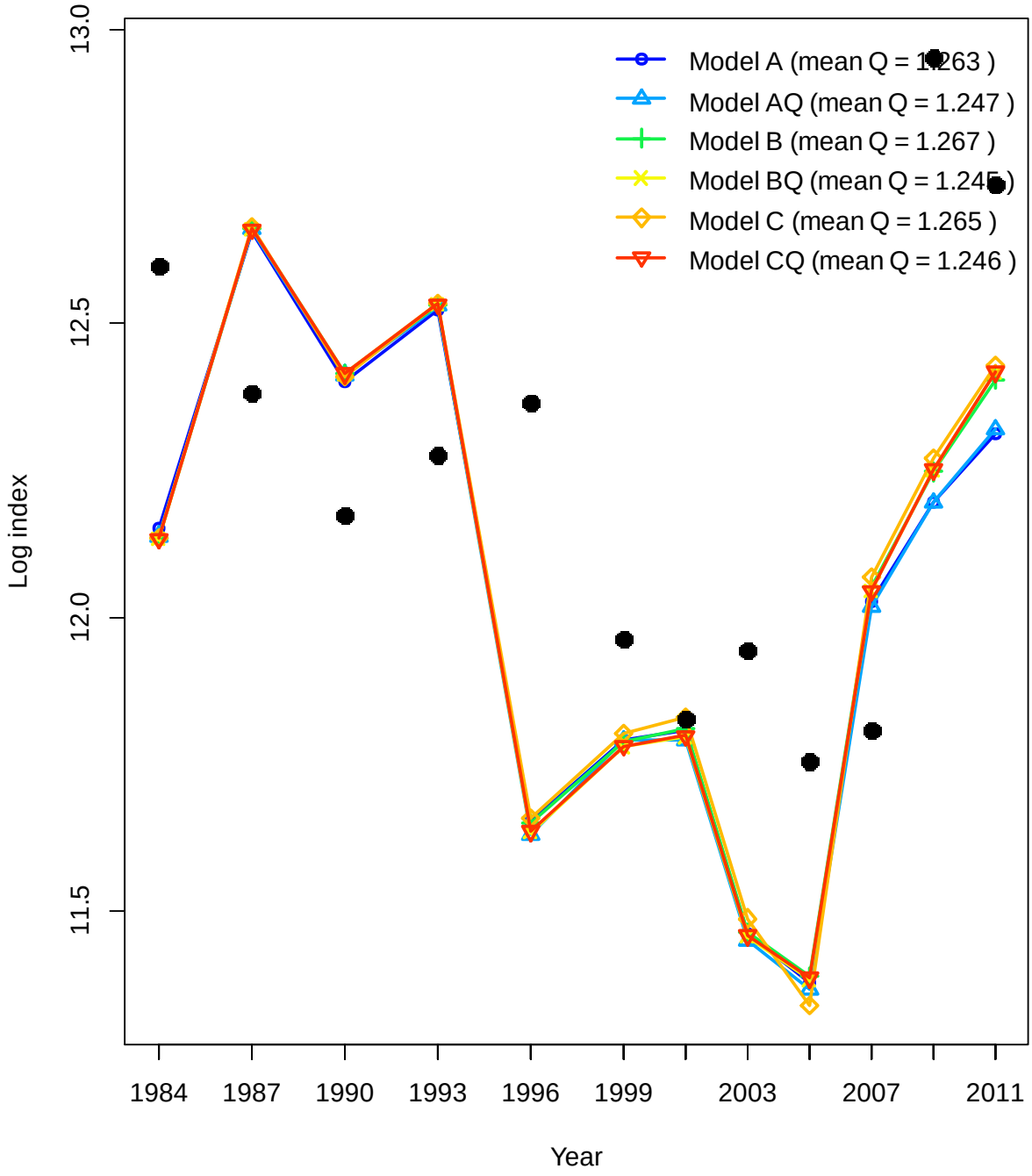

Figure 18 – Log survey estimates and model fits for the 27plus survey for Models A, AQ, B, BQ, C, and CQ

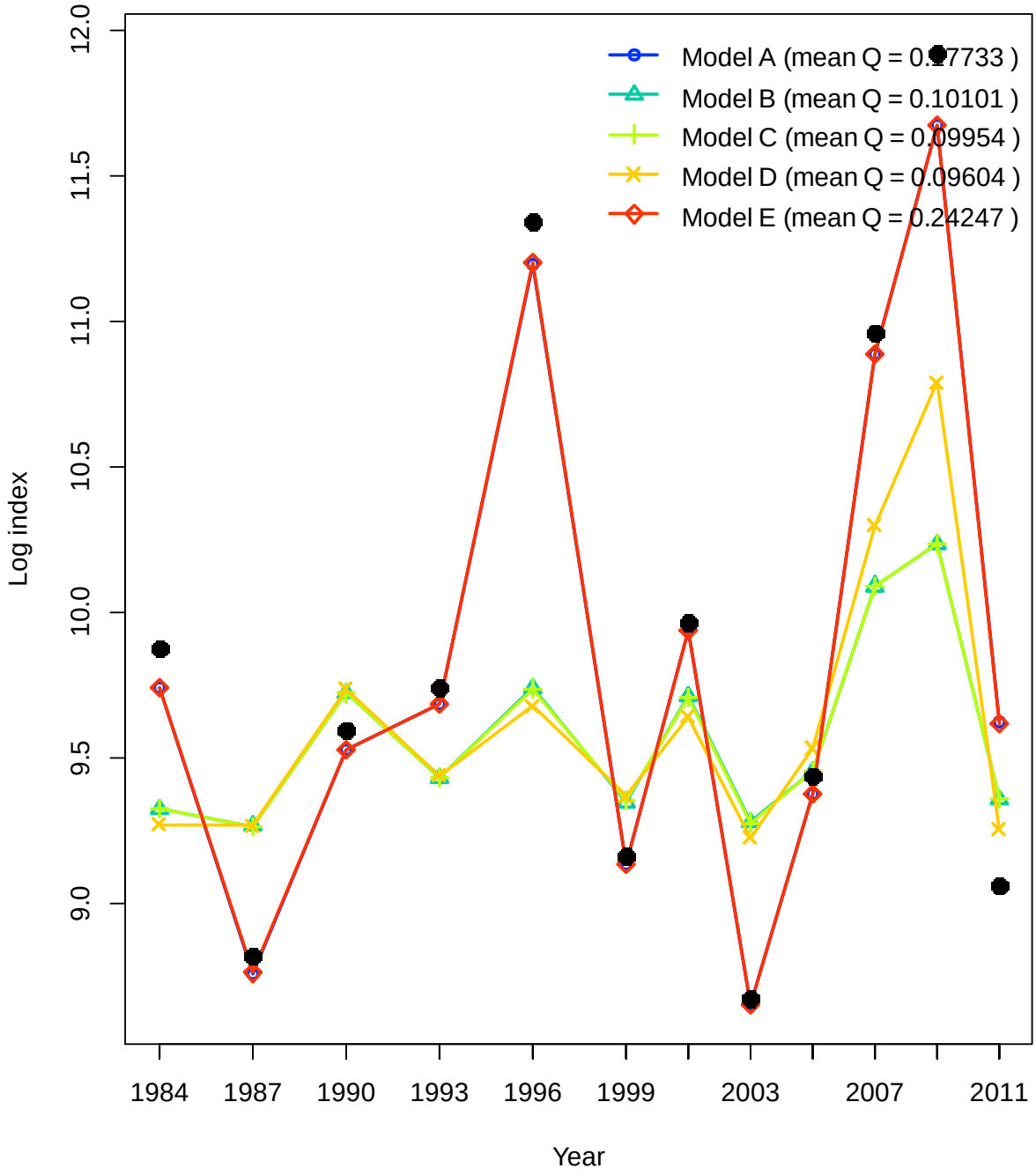

Figure 19 – Log survey estimates and model fits for the sub27 survey for Models A, B, C, D, and E

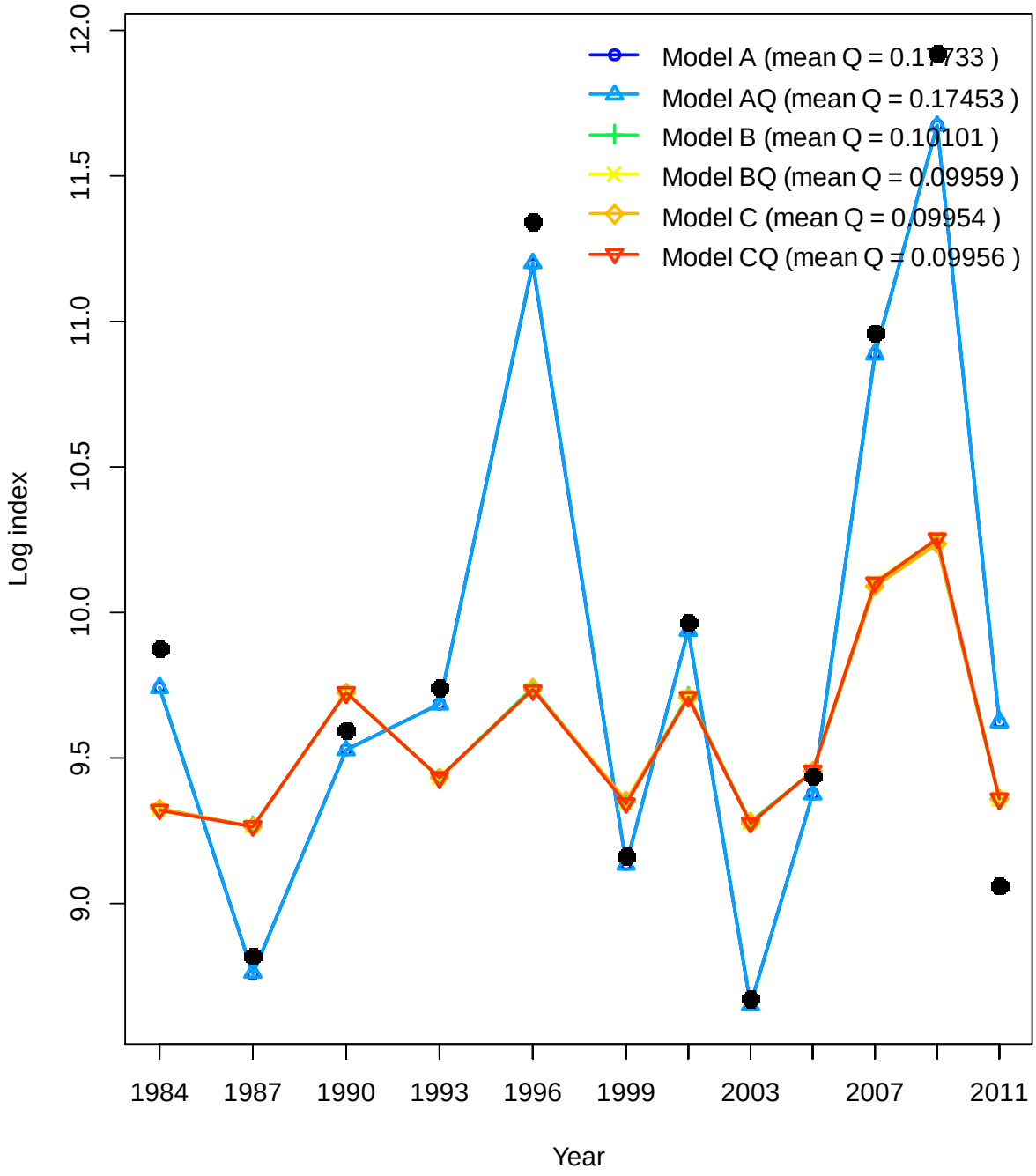

Figure 20 – Log survey estimates and model fits for the sub27 survey for Models A, AQ, B, BQ, C, and CQ

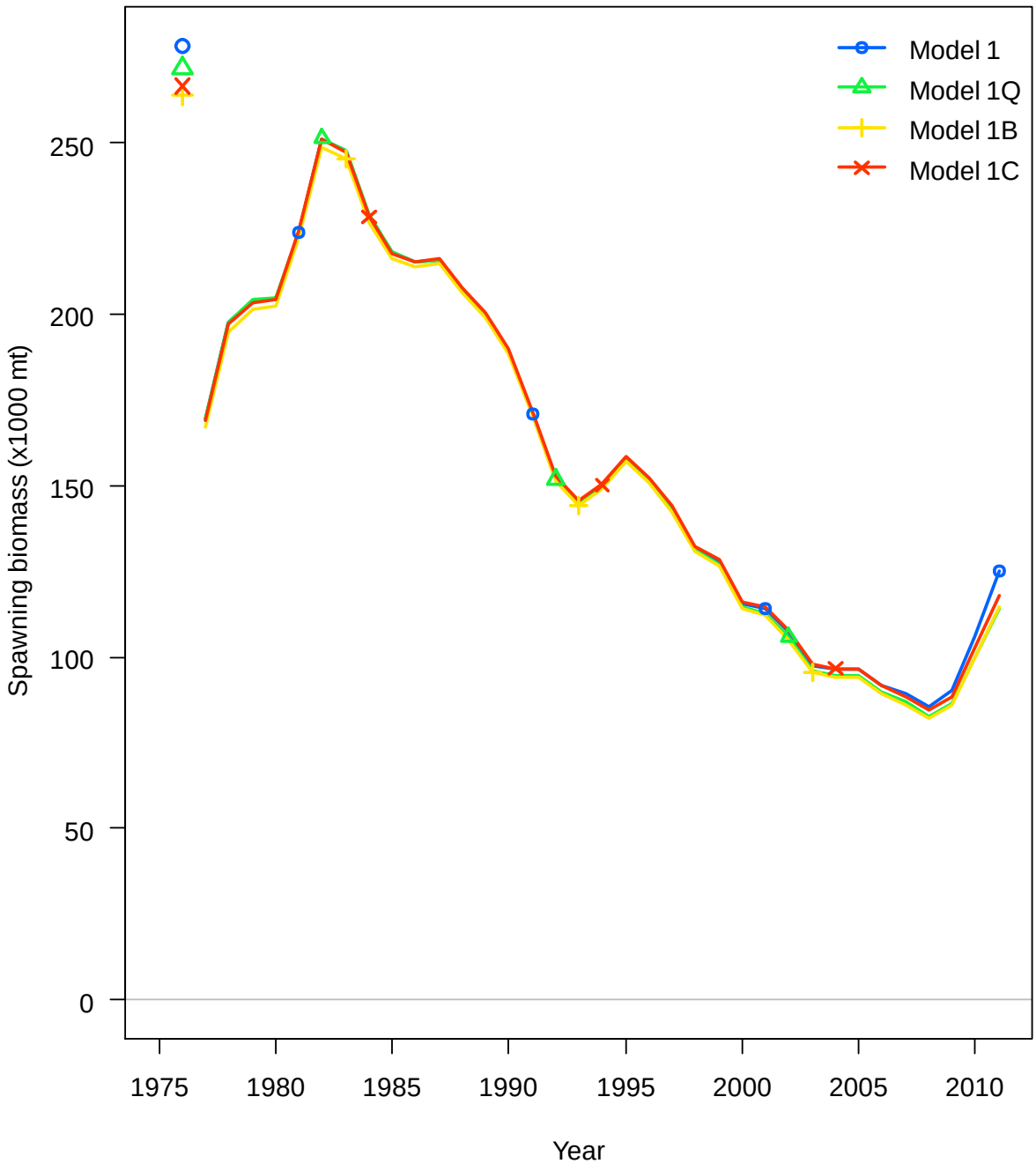

Figure 21 – Estimates of spawning biomass for Models 1, 1Q, 1B, and 1C

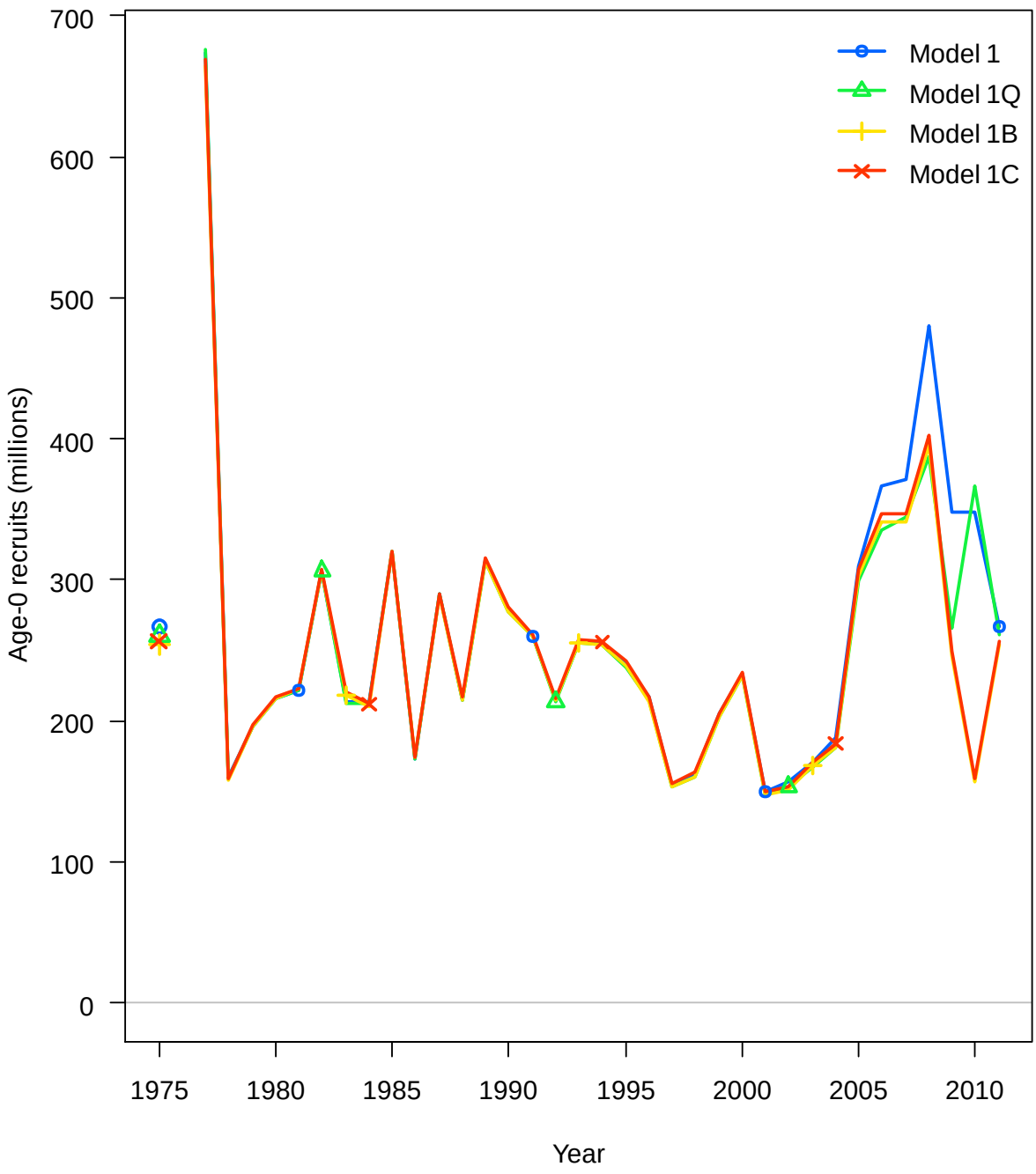

Figure 22 – Estimates of age-0 recruitment for Models 1, 1Q, 1B, and 1C

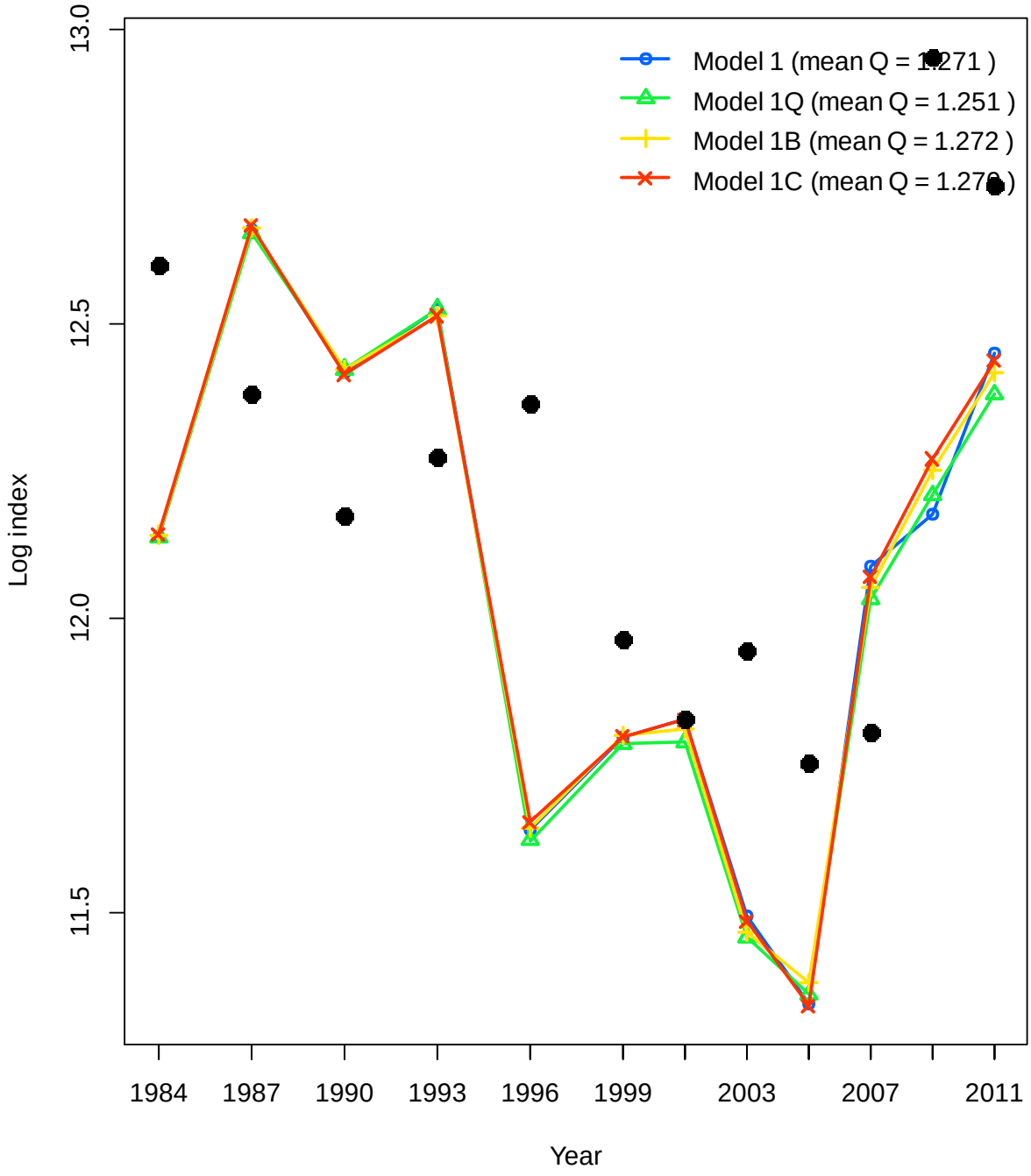

Figure 23 – Log survey estimates and model fits for the sub27 survey for Models 1, 1Q, 1B, and 1C

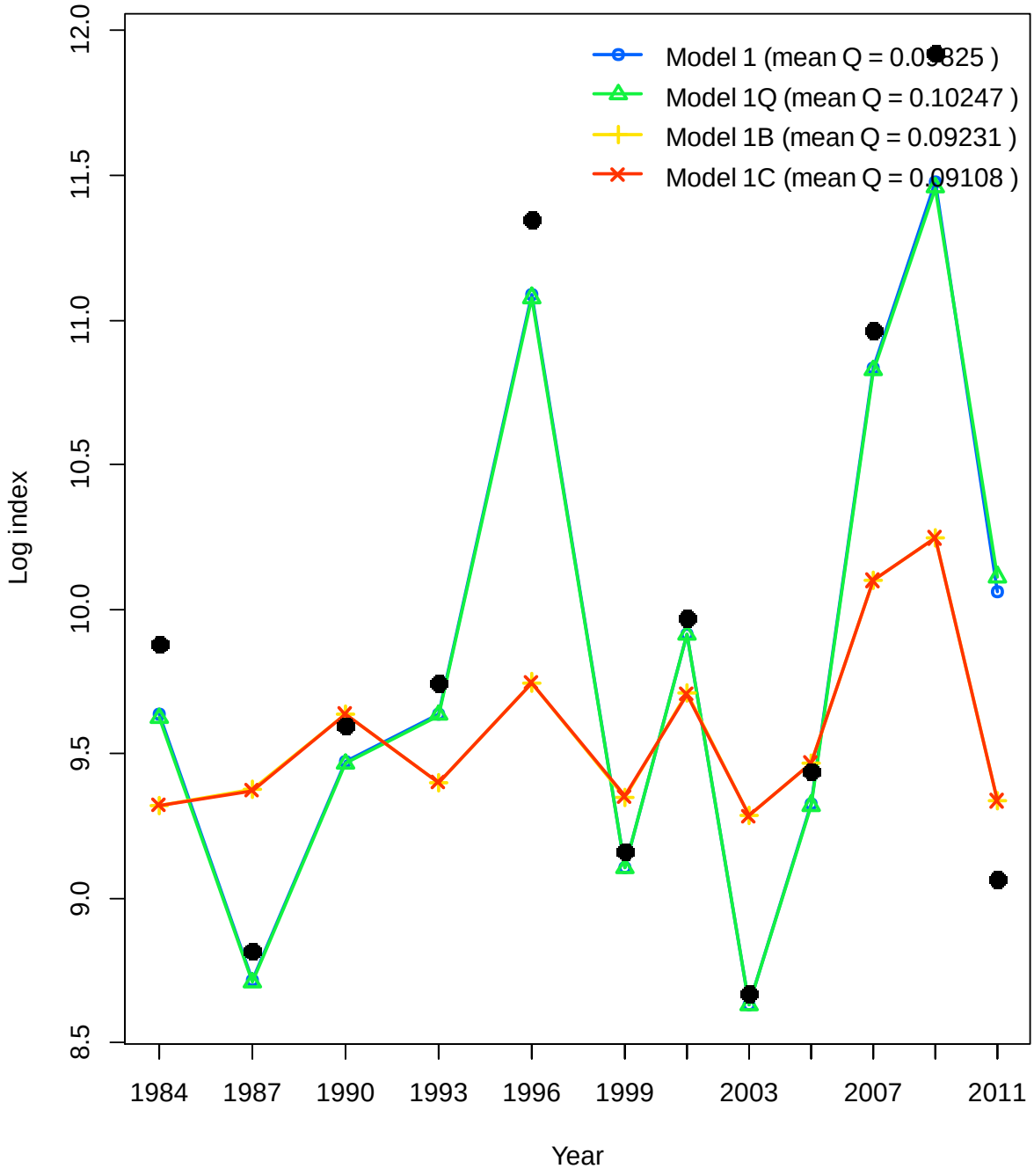

Figure 24 – Log survey estimates and model fits for the sub27 survey for Models 1, 1Q, 1B, and 1C

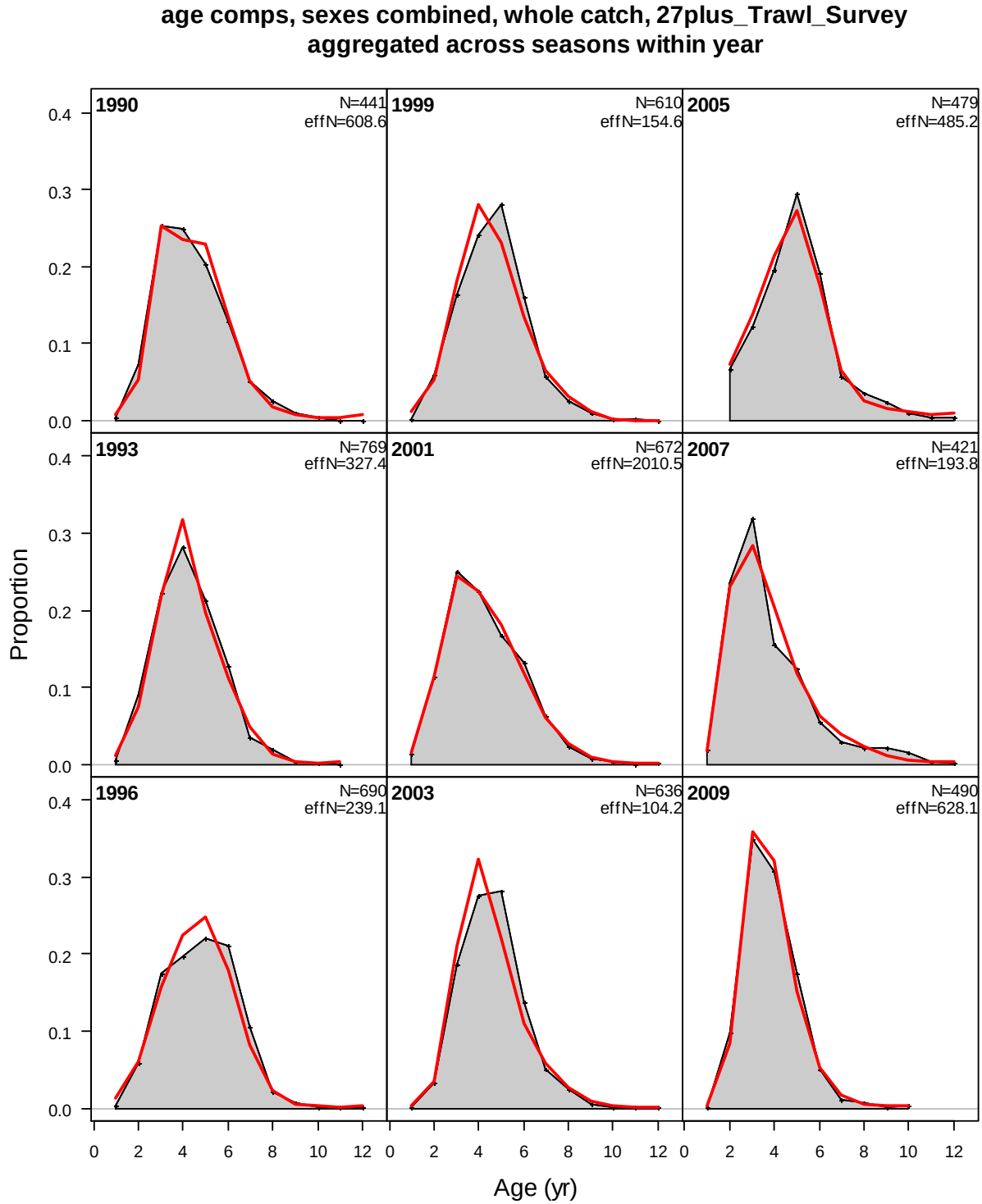

Figure 25 – Age composition data and model estimates for the 27plus survey for Model 1

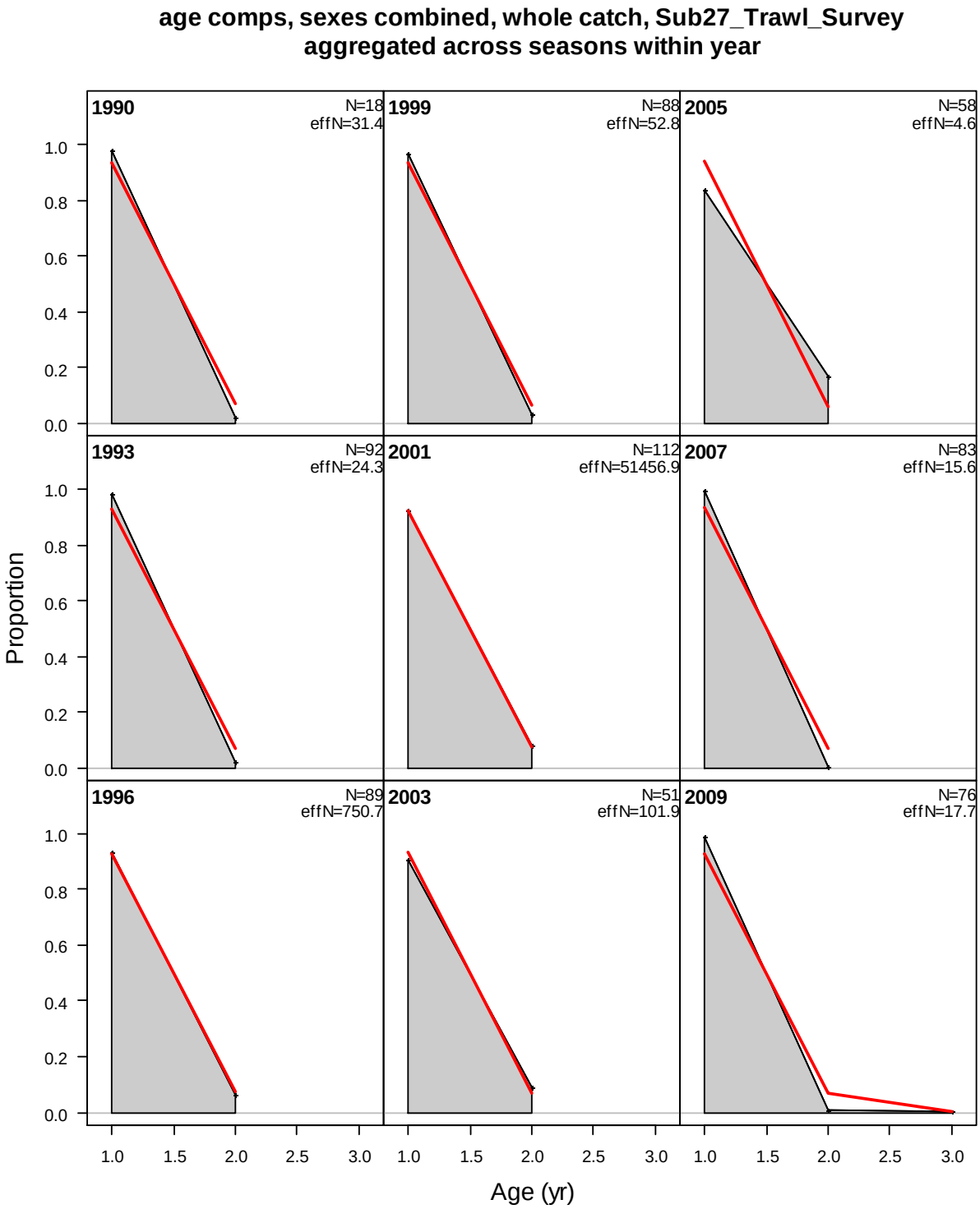

Figure 26 – Age composition data and model estimates for the sub27 survey for Model 1

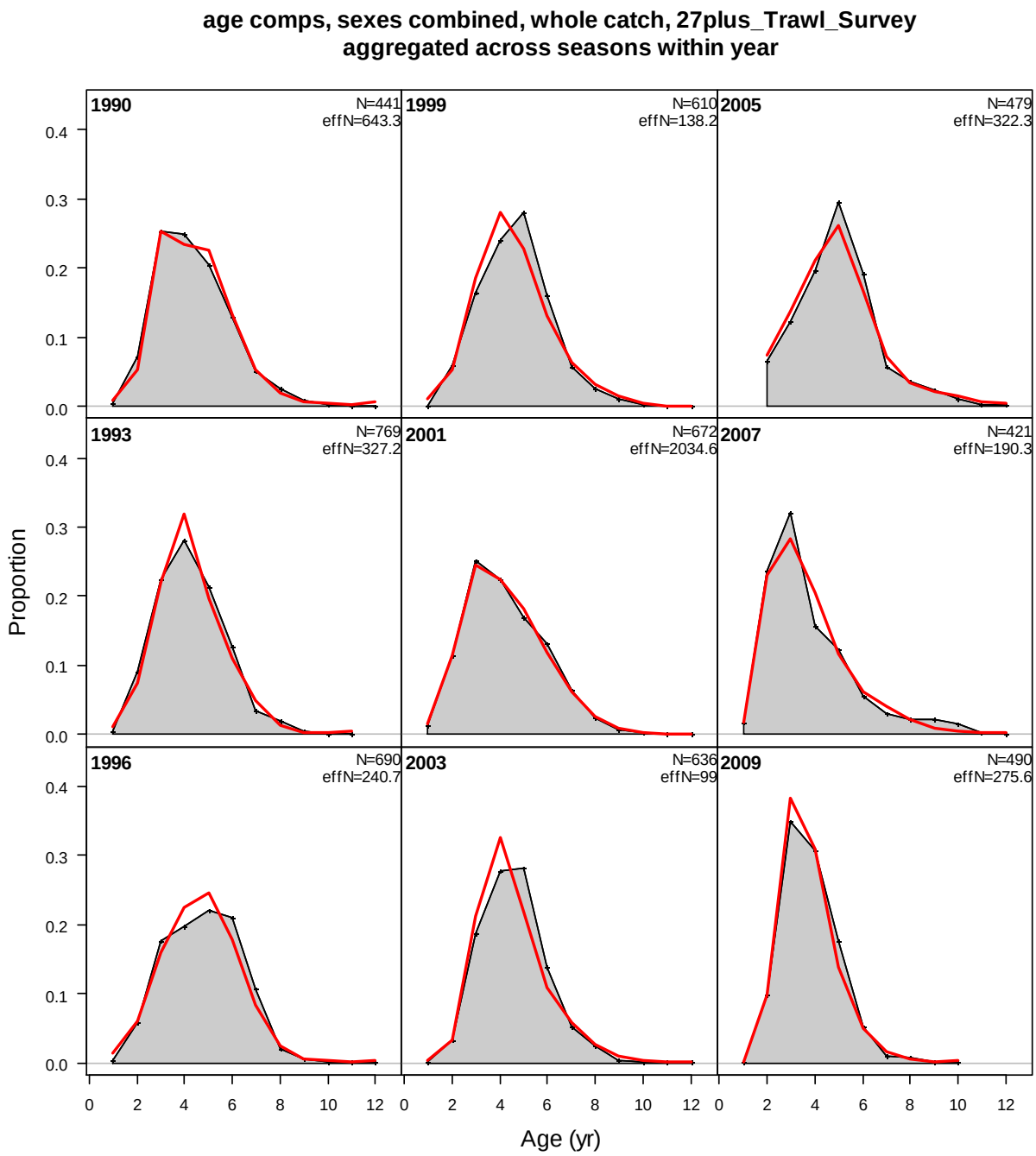

Figure 27 – Age composition data and model estimates for the 27plus survey for Model 1Q

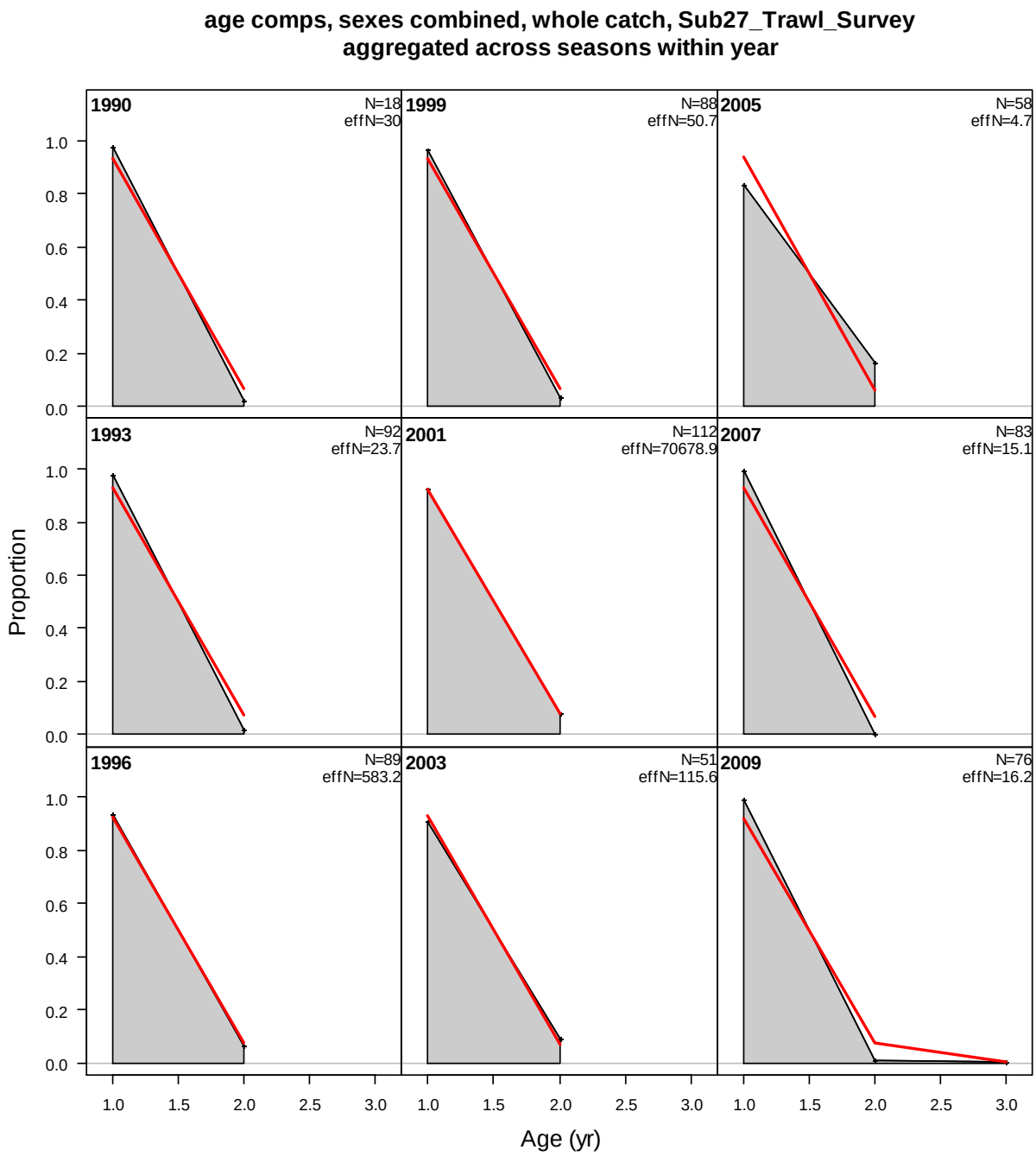

Figure 28 – Age composition data and model estimates for the sub27 survey for Model 1Q

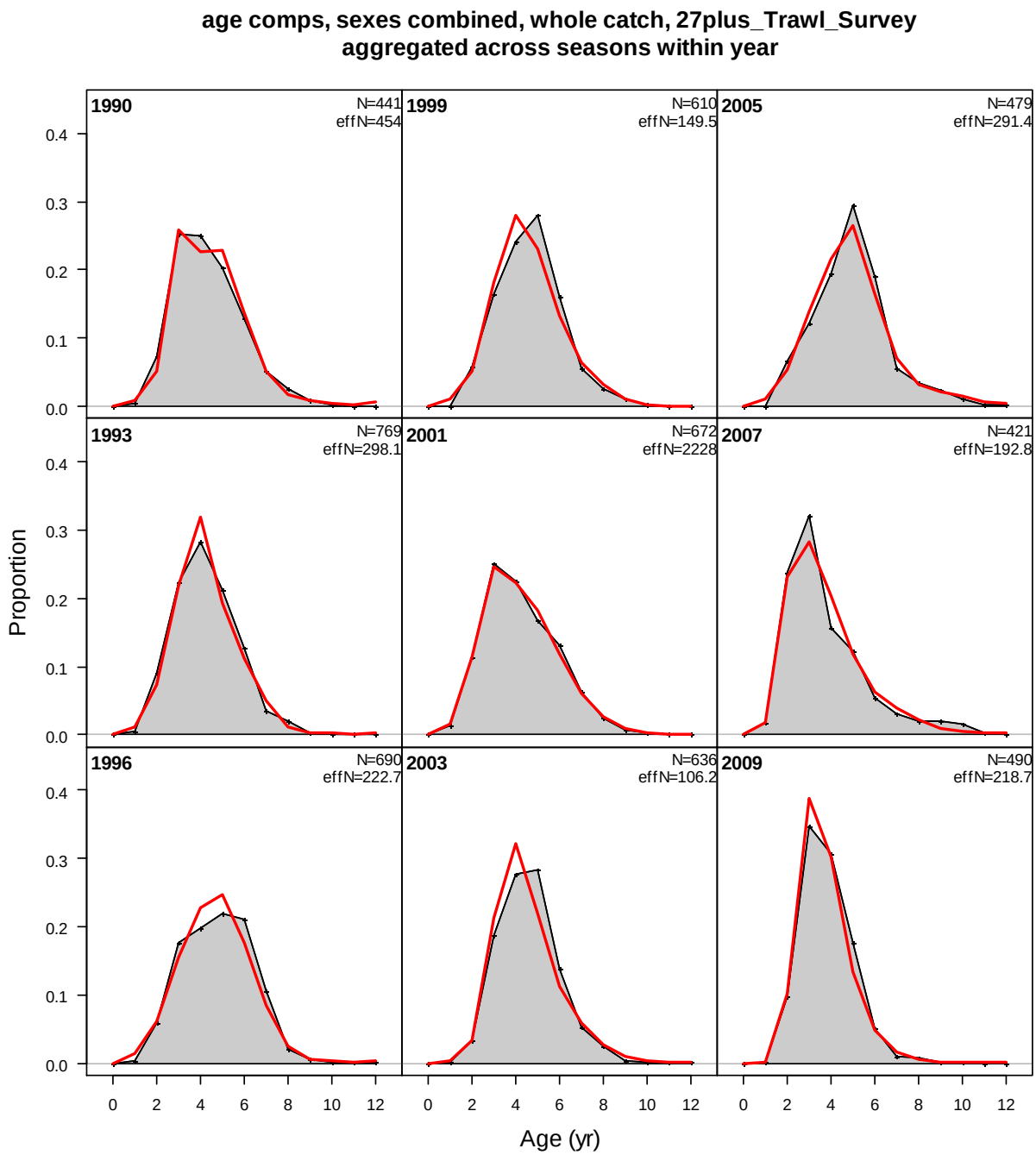

Figure 29 – Age composition data and model estimates for the 27plus survey for Model A

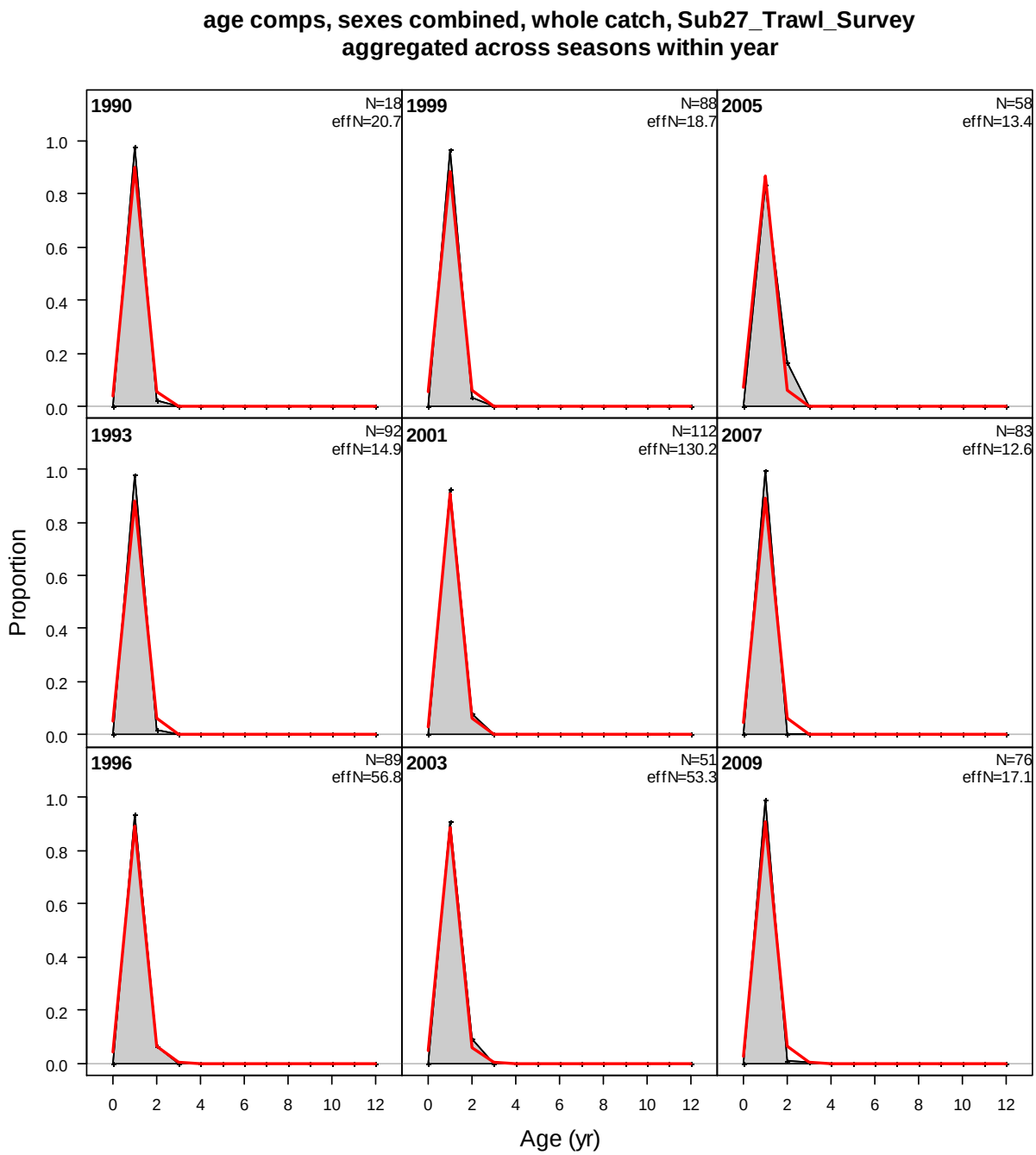

Figure 30 – Age composition data and model estimates for the sub27 survey for Model A

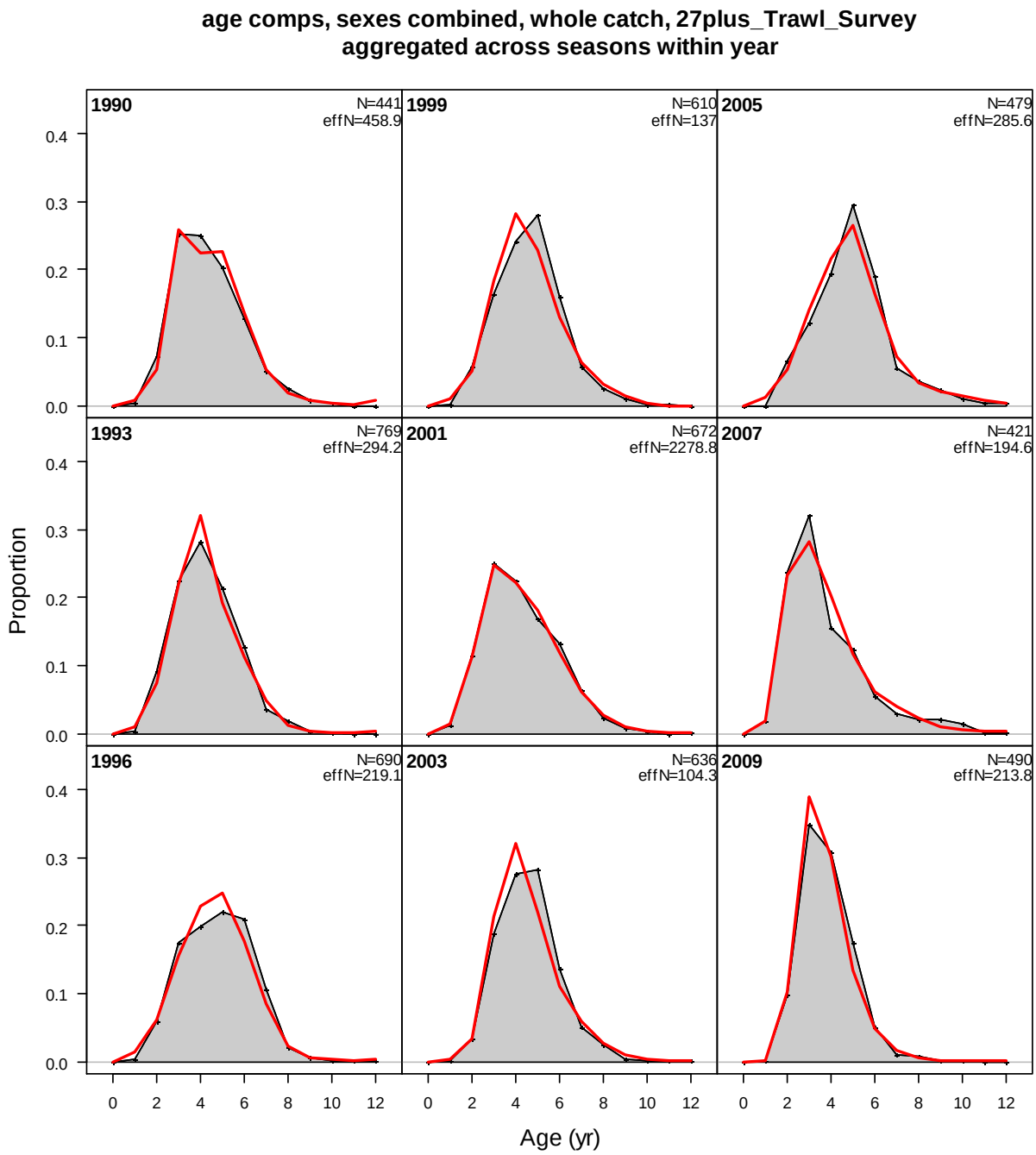

Figure 31 – Age composition data and model estimates for the 27plus survey for Model AQ

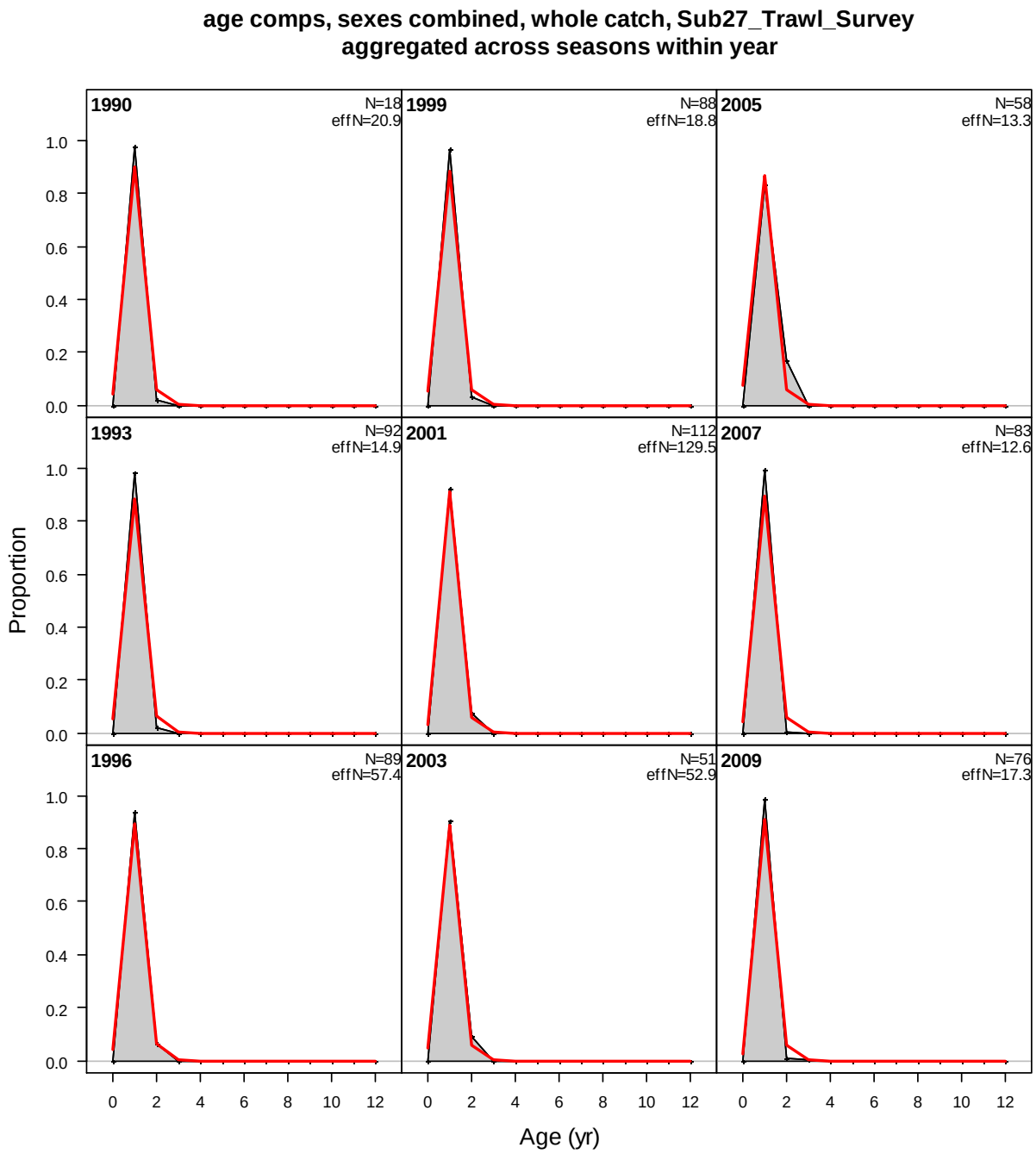

Figure 32 – Age composition data and model estimates for the sub27 survey for Model AQ

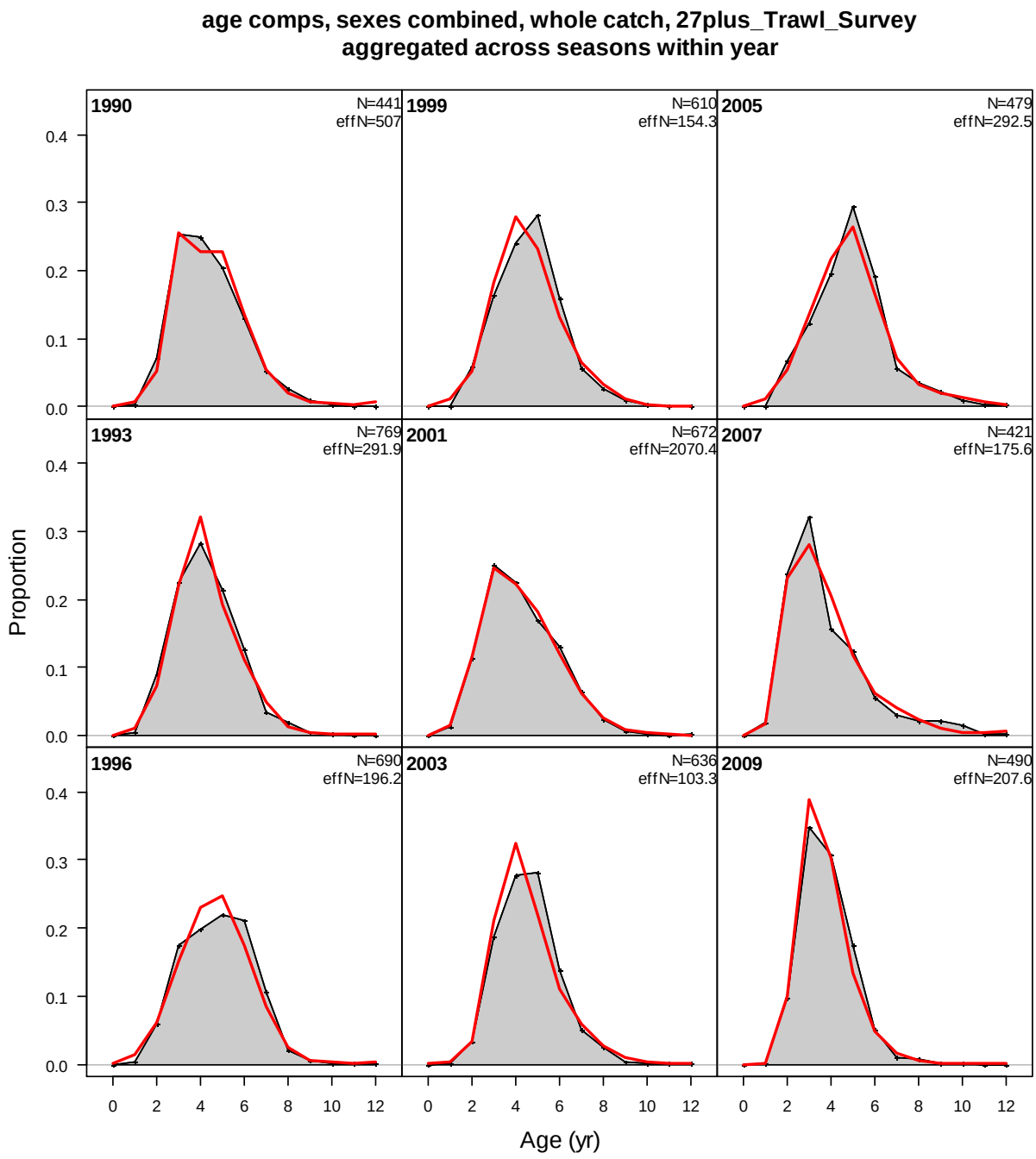

Figure 33 – Age composition data and model estimates for the 27plus survey for Model B

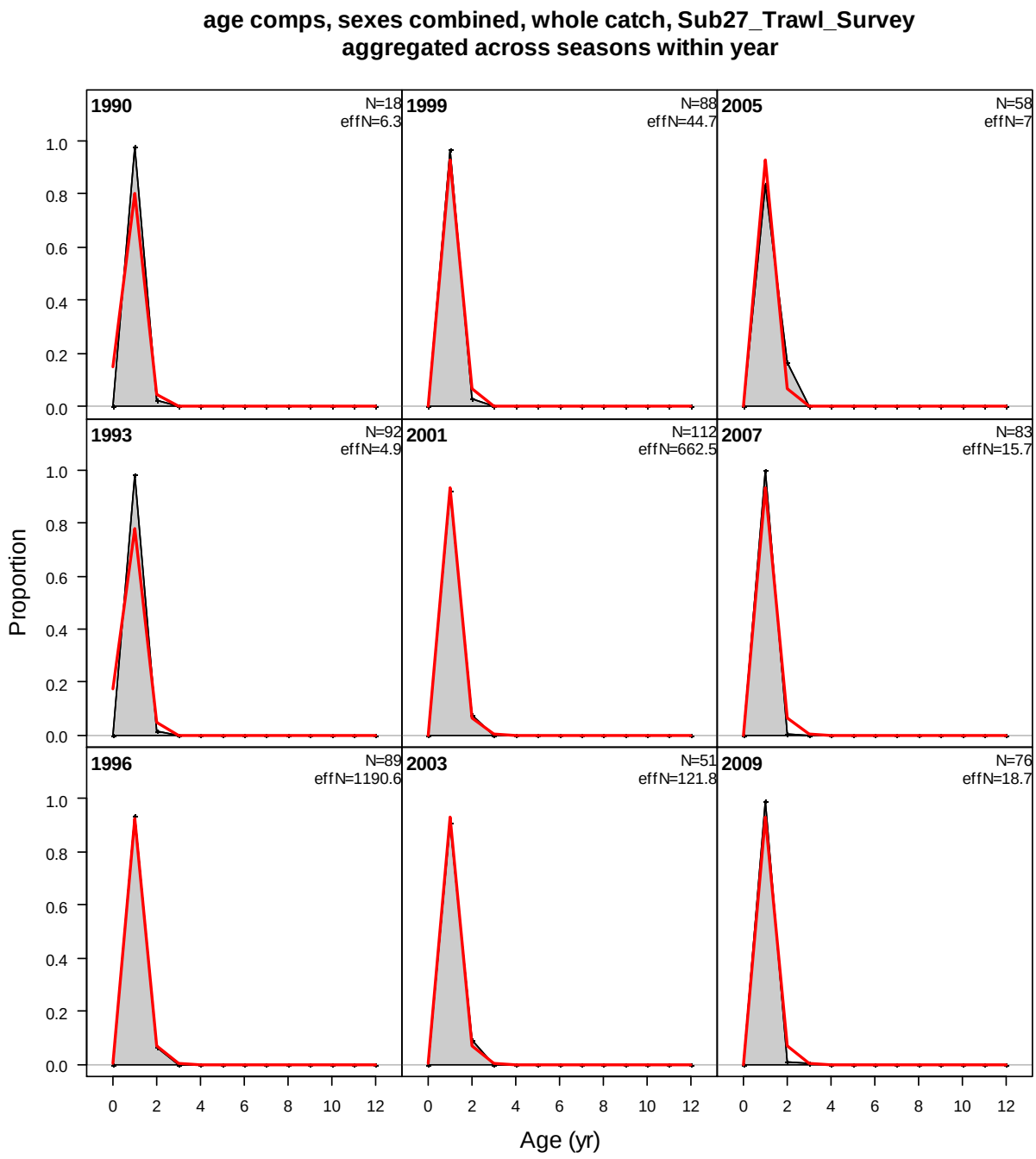

Figure 34 – Age composition data and model estimates for the sub27 survey for Model B

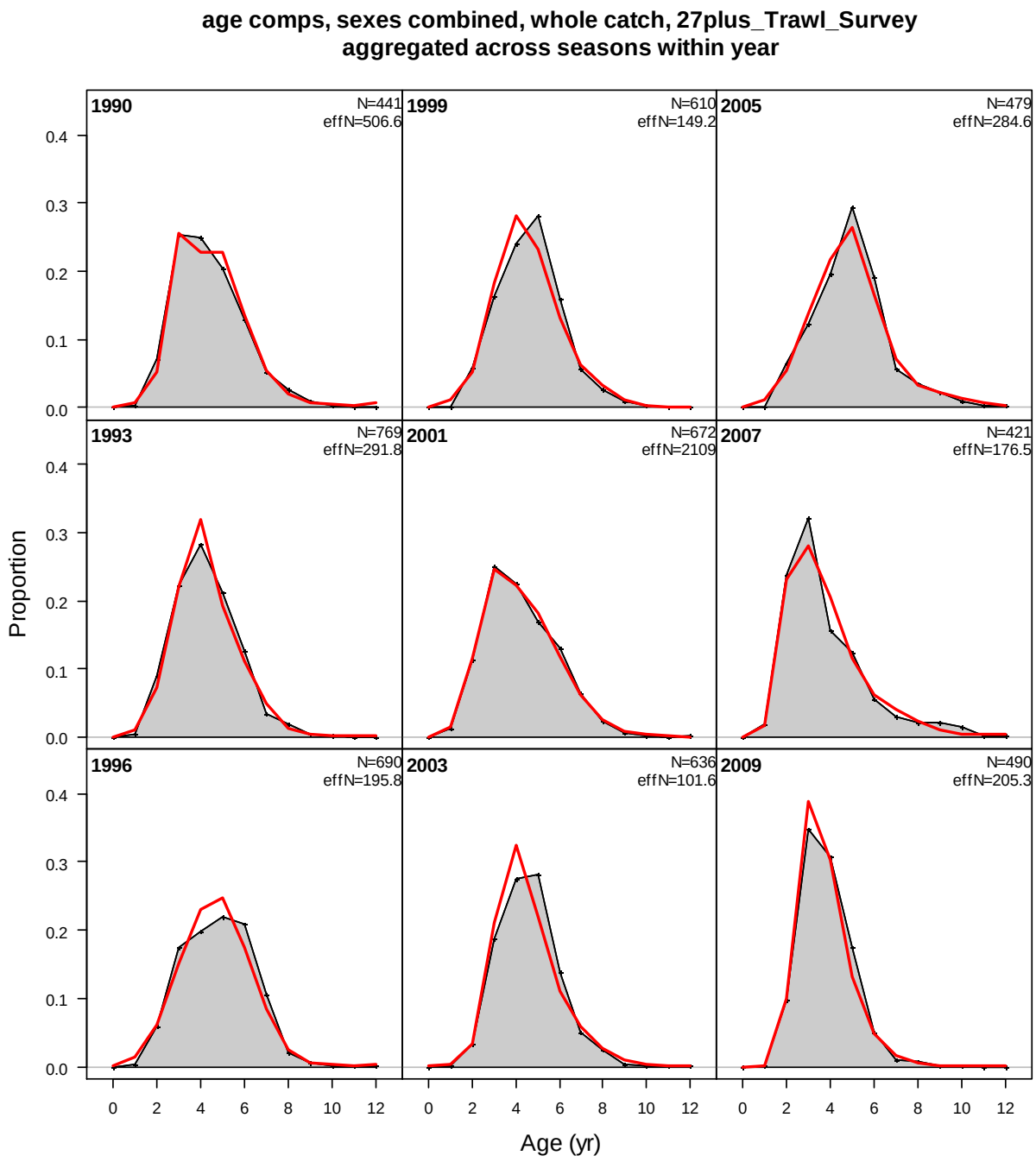

Figure 35 – Age composition data and model estimates for the 27plus survey for Model BQ

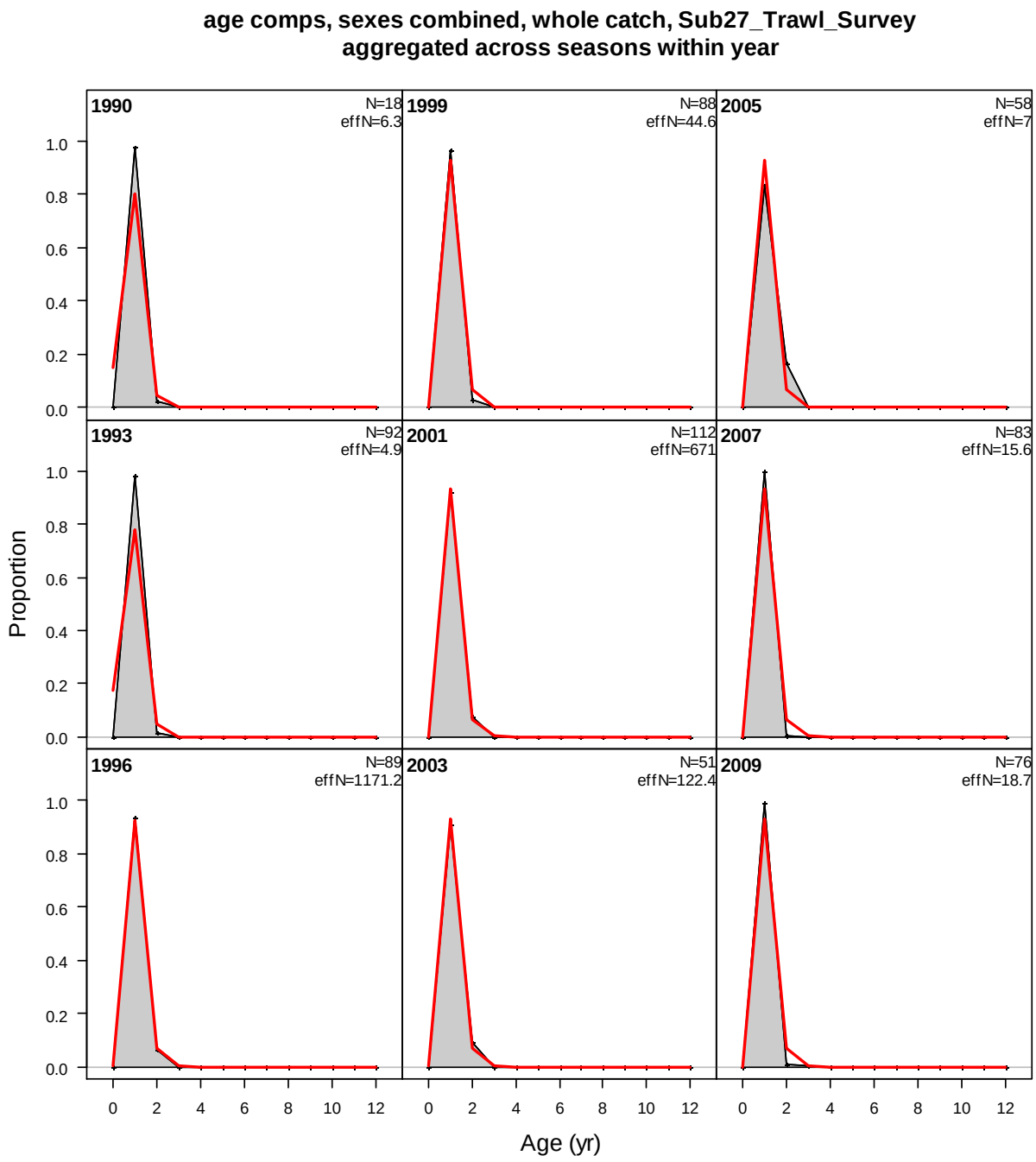

Figure 36 – Age composition data and model estimates for the sub27 survey for Model BQ

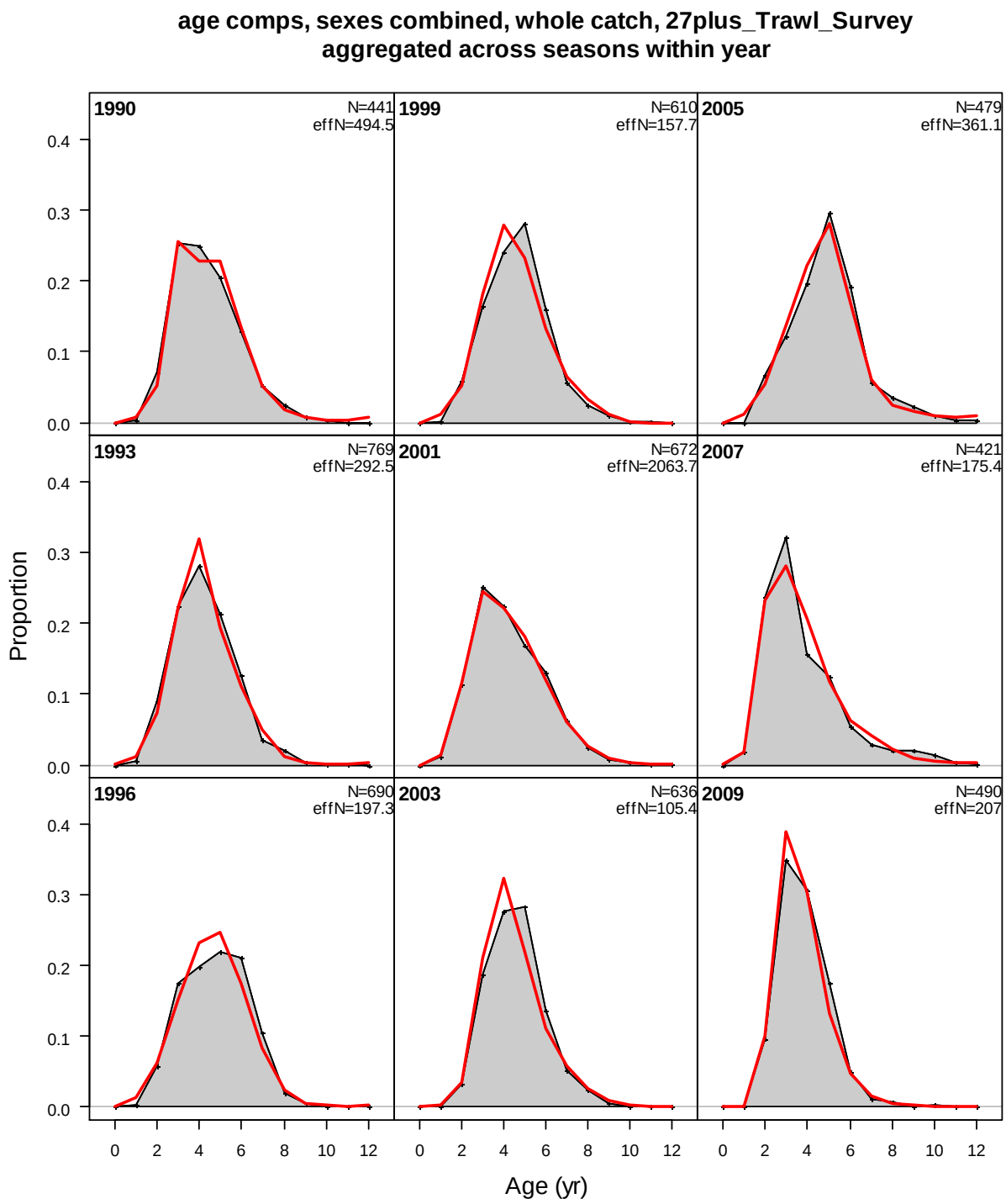

Figure 37 – Age composition data and model estimates for the 27plus survey for Model C

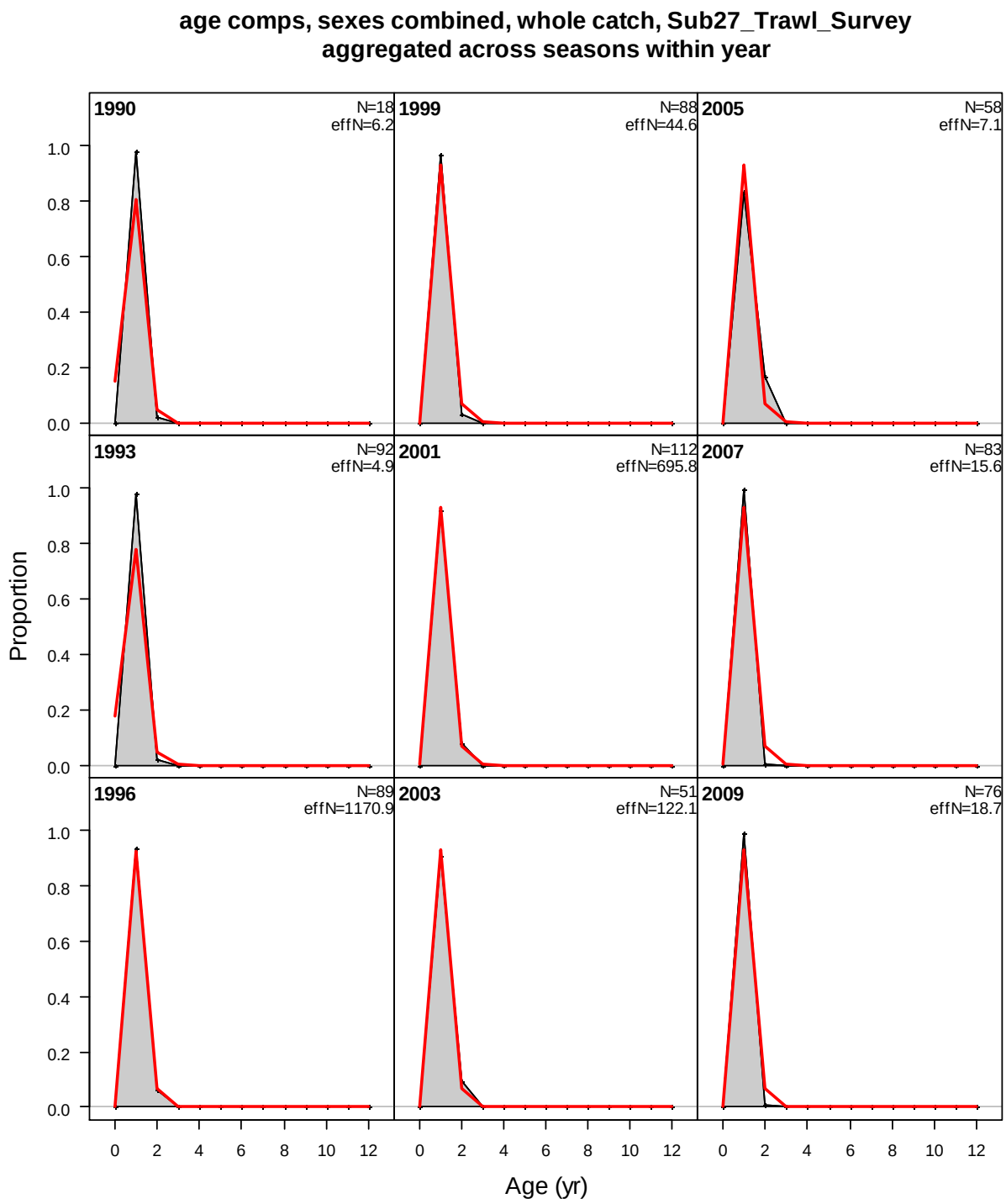

Figure 38 – Age composition data and model estimates for the sub27 survey for Model C

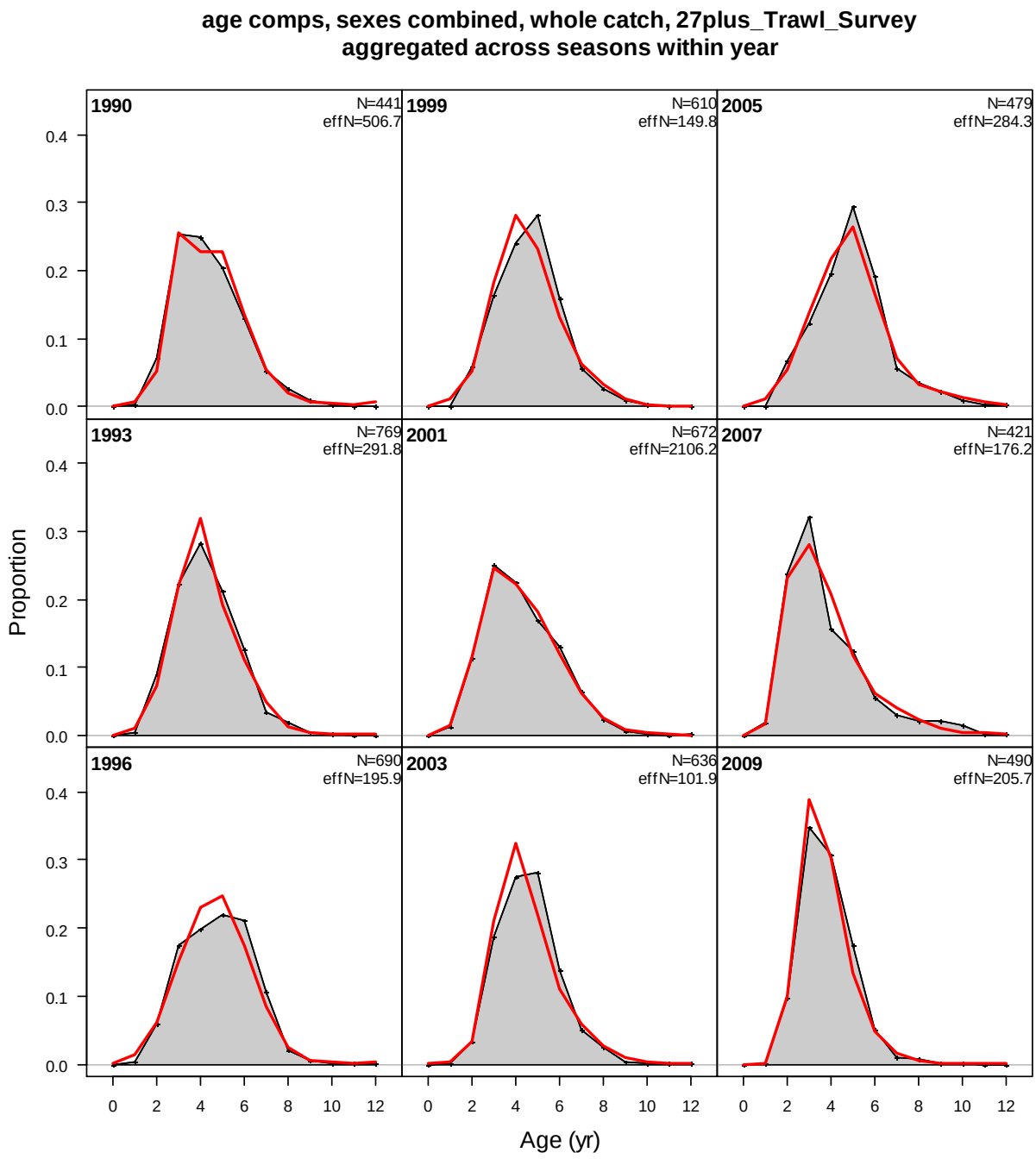

Figure 39 – Age composition data and model estimates for the 27plus survey for model CQ

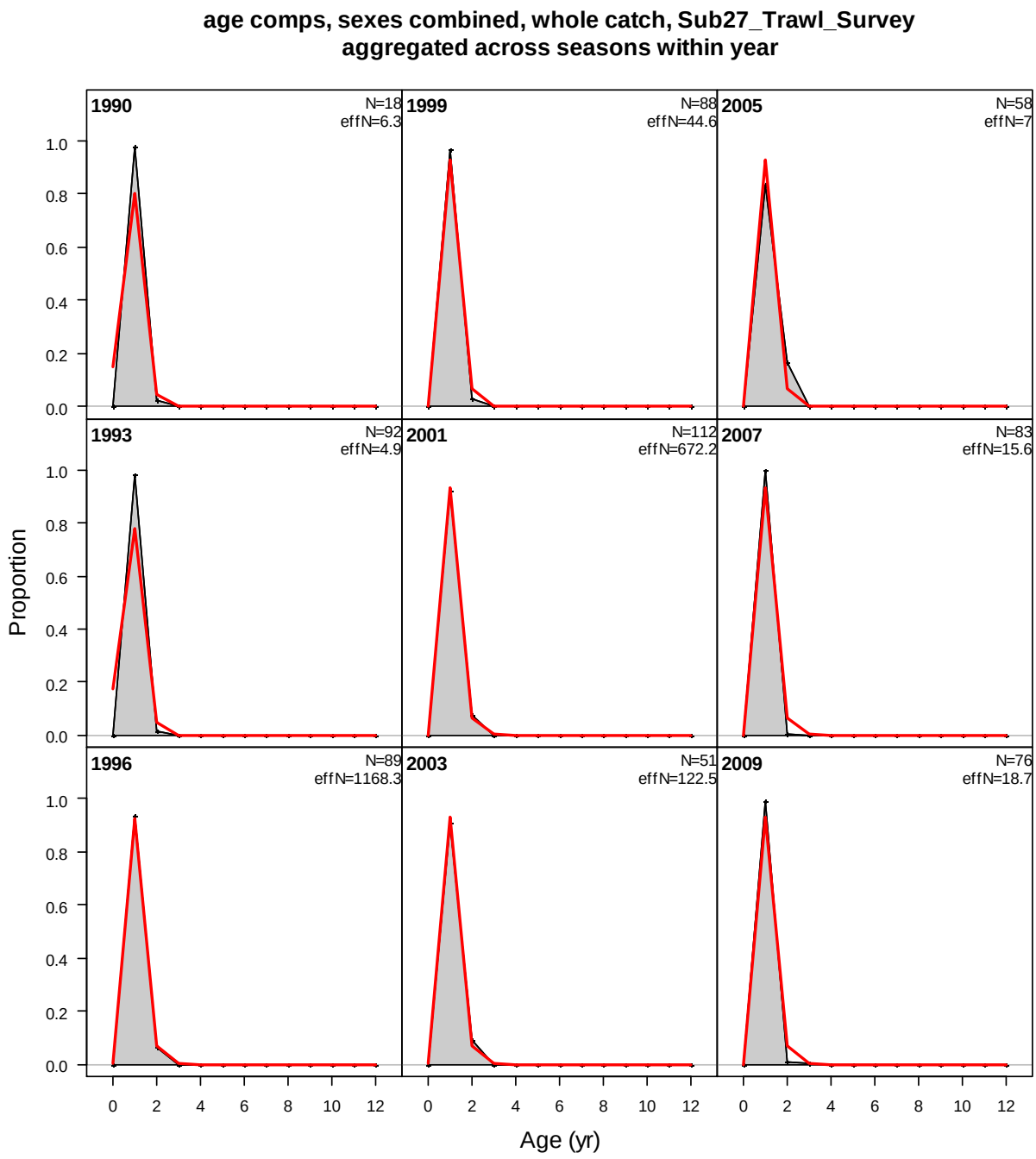

Figure 40 – Age composition data and model estimates for the sub27 survey for Model CQ

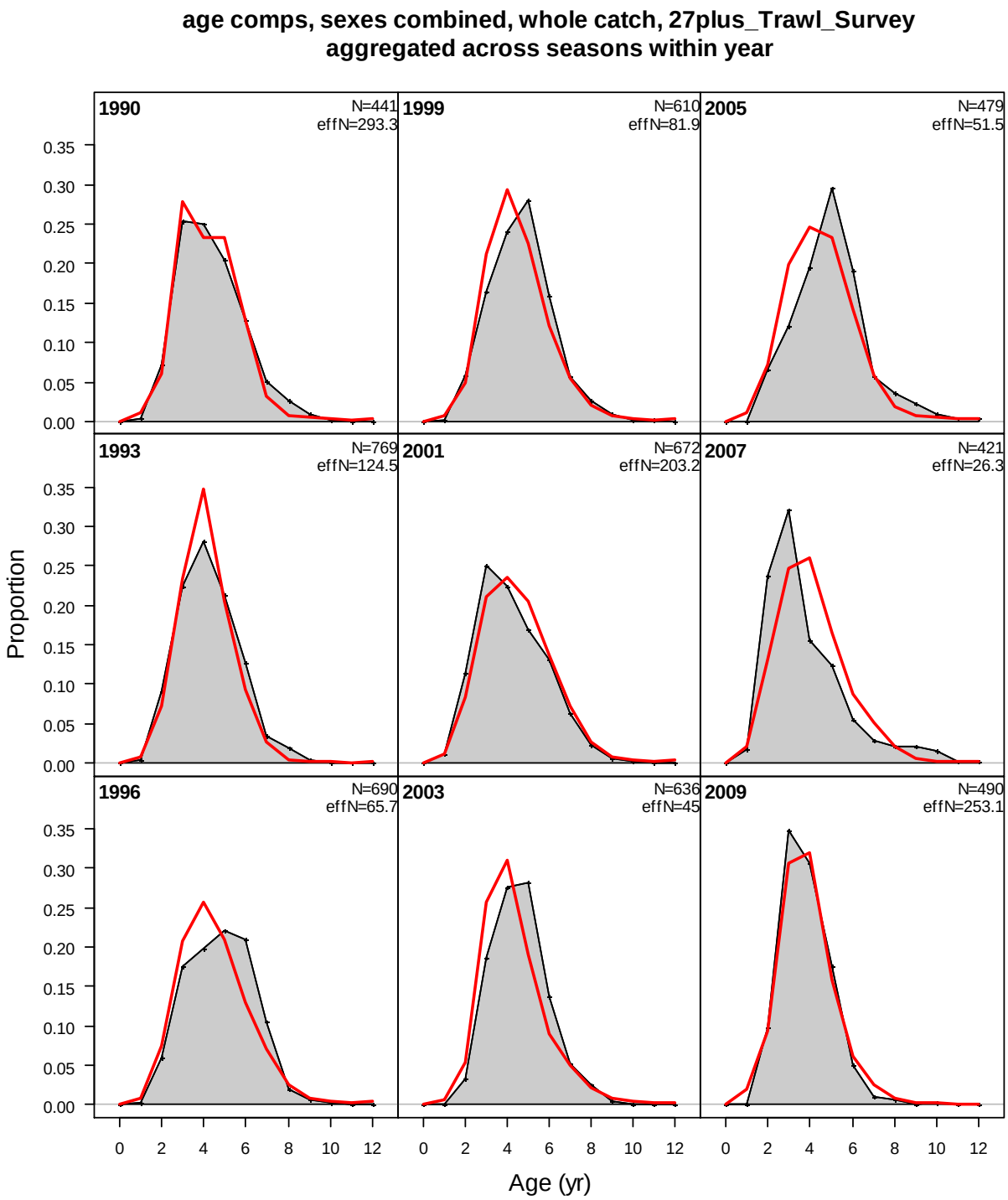

Figure 41 – Age composition data and model estimates for the 27plus survey for Model D

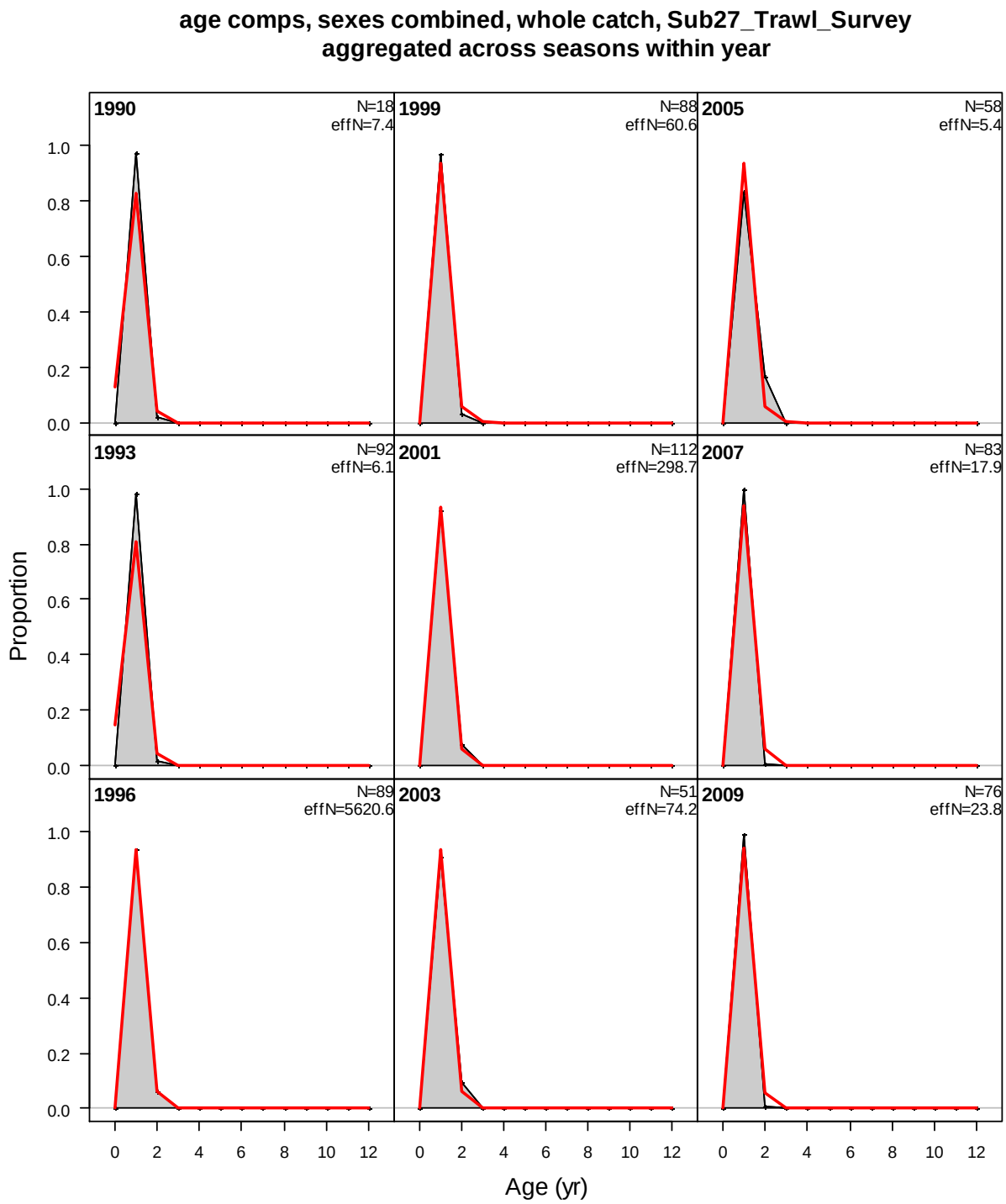

Figure 42 – Age composition data and model estimates for the sub27 survey for Model D

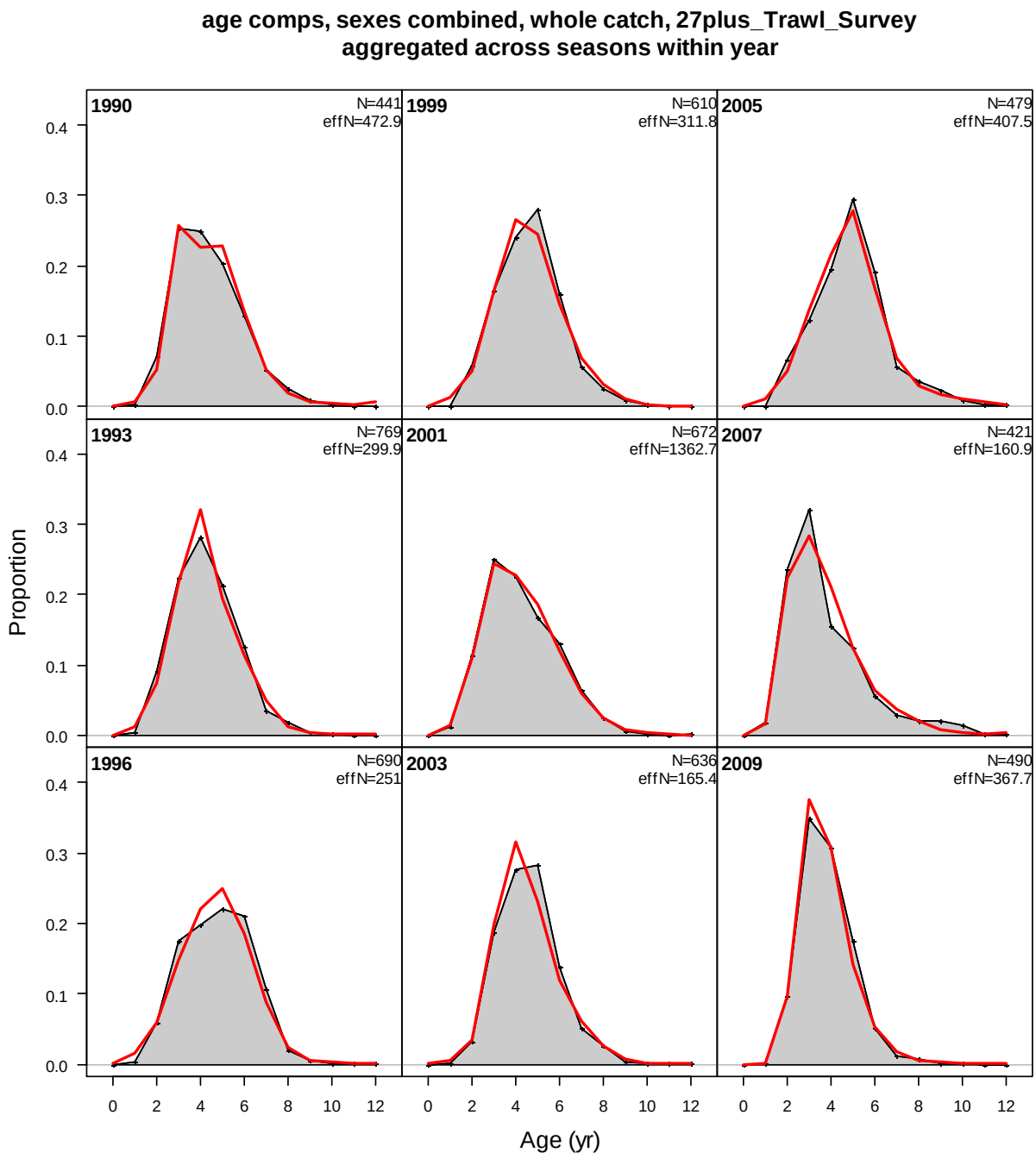

Figure 43 – Age composition data and model estimates for the 27plus survey for Model E

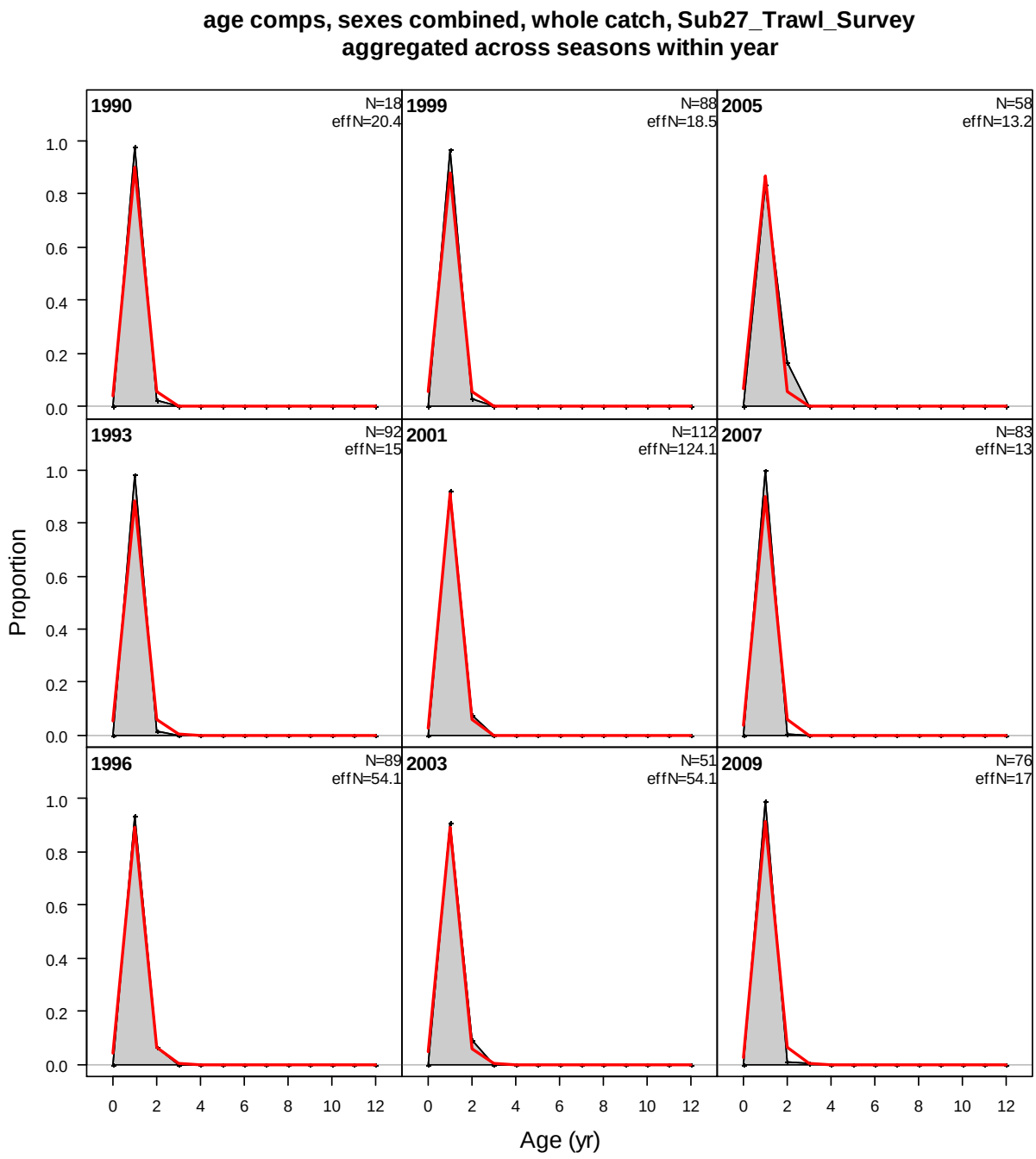

Figure 44 – Age composition data and model estimates for the sub27 survey for Model E

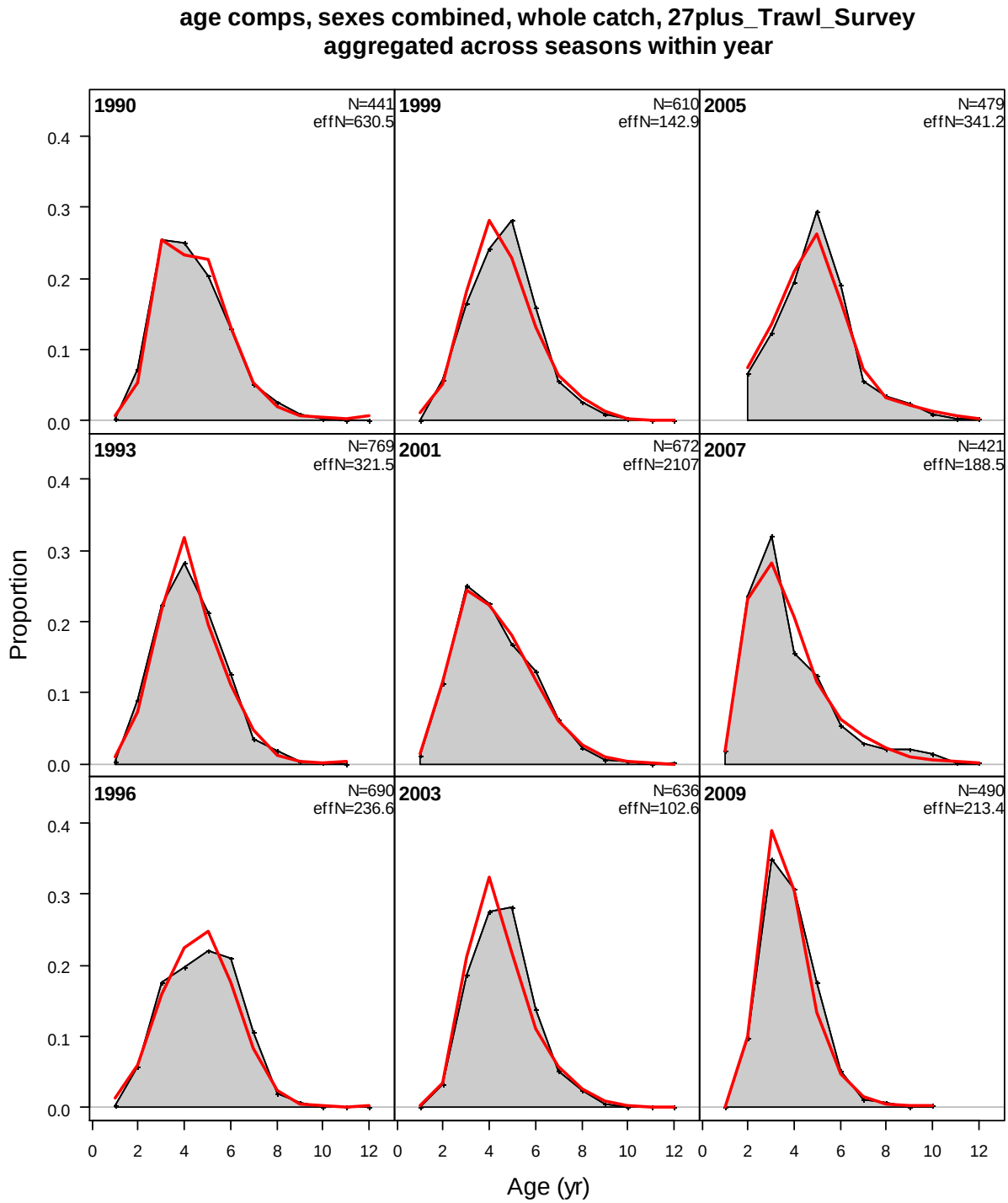

Figure 45 – Age composition data and model estimates for the 27plus survey for Model 1B

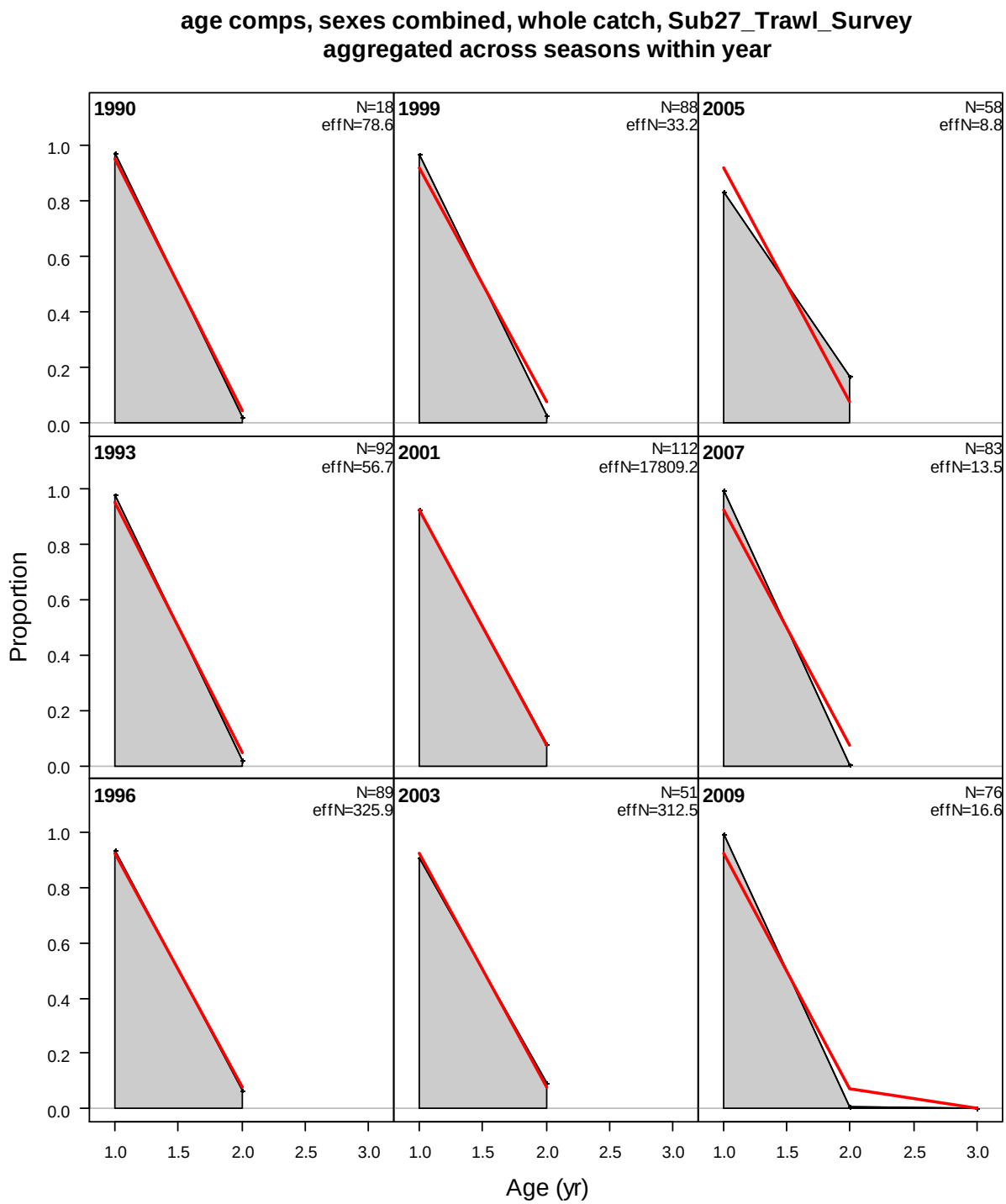

Figure 46 – Age composition data and model estimates for the sub27 survey for Model 1B

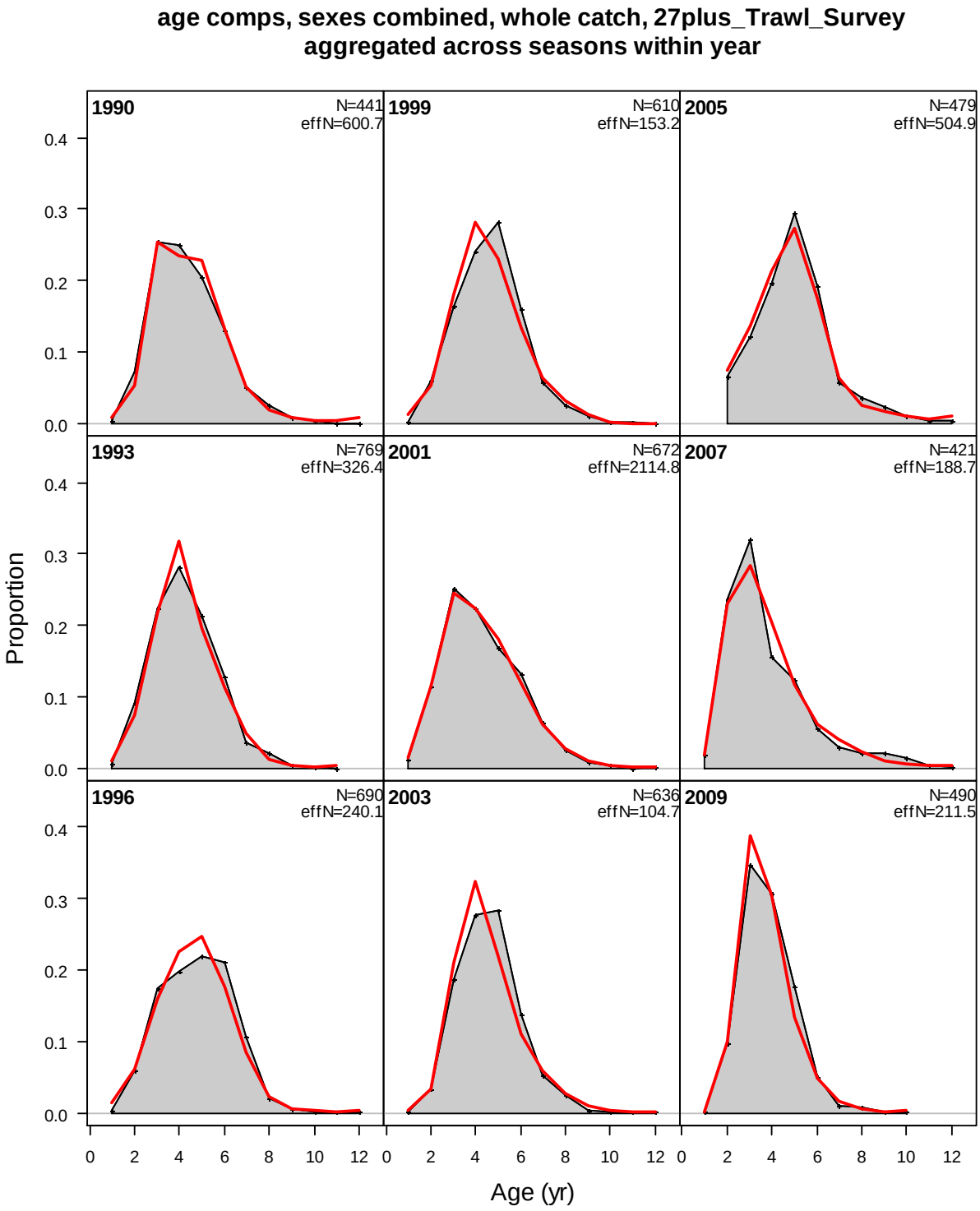

Figure 47 – Age composition data and model estimates for the 27plus survey for Model 1C

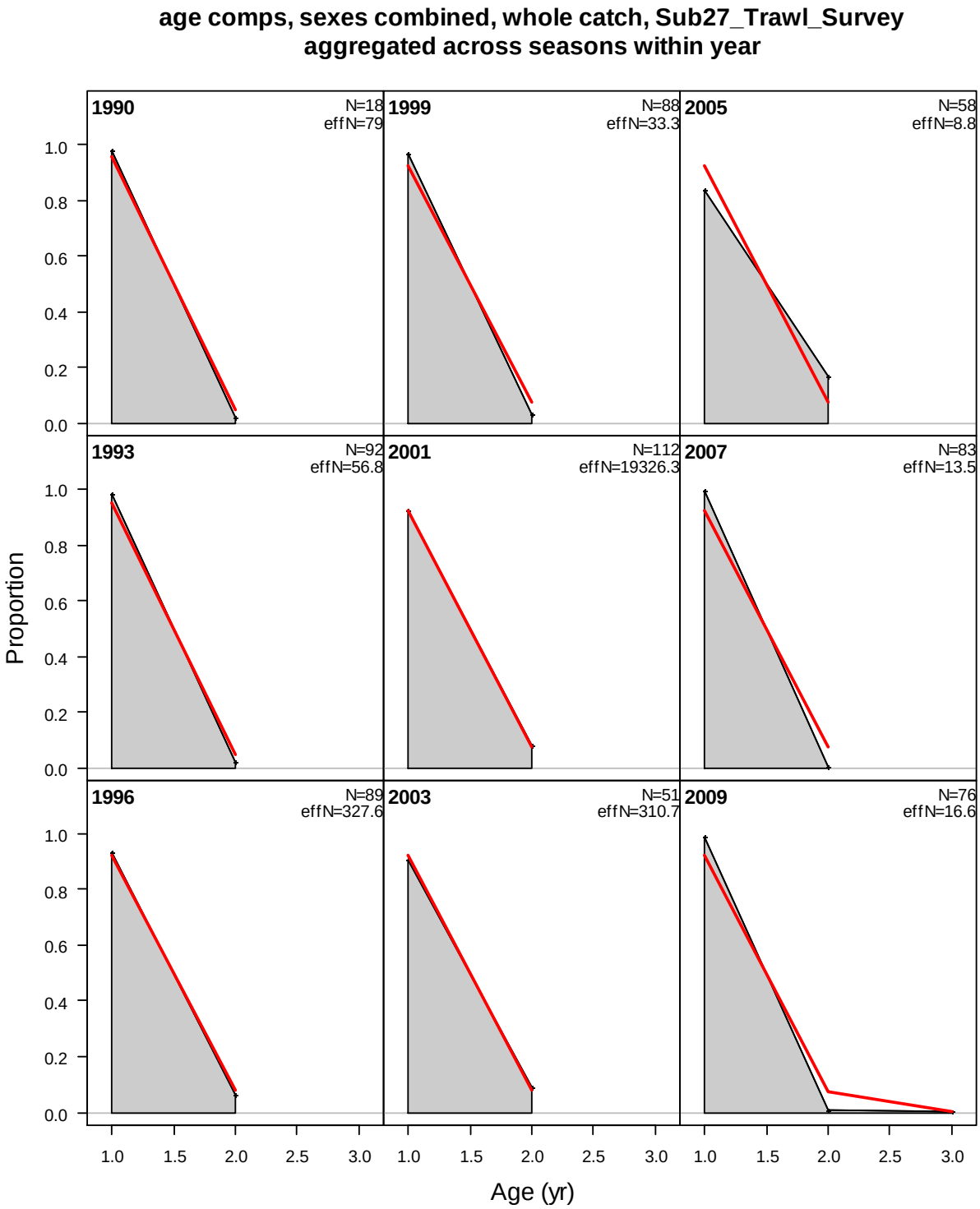

Figure 48 – Age composition data and model estimates for the sub27 survey for Model 1C