Local influence diagnostics for the retrospective problem in the Gulf of Maine - Georges Bank Herring VPA of 2005

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Abstract.

1 Introduction

A substantial retrospective problem exists in the VPA for Gulf of Main - Georges Bank Herring (GMGBH). In this paper we present local influence diagnostics for possible causes of the retrospective patterns. Retrospective estimates of total abundance for ages 2-10 (N_{2+}), average fishing mortality for ages 3-6 ($\bar{F}$), and VPA spawning stock biomass (SSB) are shown in Figure 1 in the **Appendix 1**. These results are obtained by retrospectively estimating the VPA using data for $1967, ..., t$ for $t = 1995, ..., 2005$, where t is the last year of catches and other fishery data used to estimate population size. The VPA structure we employ closely resembles that in Overholtz et al. (2004), and is described in **Section 2**.

Retrospective patterns like those in Figure 1 usually indicate a mis-specification of the VPA model (see Mohn, 1999). Most likely this involves a trend in some population process or population sampling process that is not accounted for in the VPA; however, a "year-effect" in the population or sampling process could also generate a retrospective pattern. Some retrospective patterns may be expected even in a correctly specified model because of the time series "filtering" nature of VPA's; however, the magnitude of the patterns in Figure 1 seem to large to be attributed to chance.

Mohn (1999) proposed the following statistic to measure the size of retrospective pattern, which we also use. Let $S_{y,t}$ be a stock size or fishing mortality rate estimate in year y based on data up to year $t \geq y$. The retrospective statistic is

$$\rho = \sum_{y=y_o}^{Y} \frac{S_{y,y} - S_{y,Y}}{S_{y,y}}, \tag{1}$$

where y_o and Y are the first and last years for which the retrospective pattern is assessed. In equation (1), $S_{y,Y}$ is the estimate of stock size in year y based on all catch and stock indices up to year Y. If the retrospective estimates for year y based on data only up to year y (i.e. $S_{y,y}$) fluctuate randomly about $S_{y,Y}$ then ρ will be approximately zero. The values of ρ for N_{2+}, $\bar{F}$, and SSB are shown in the upper left hand corners of each panel in Figure 1.

Mohn (1999) presented simulation results to explore the types of retrospective patterns that might arise from various VPA model mis-specifications. He also presented diagnostics to help discriminate between the possible sources of mis-specification that cause the retrospective problem. One type of diagnostic involved examining the magnitude of perturbations to model components required to remove the retrospective pattern. Cadigan and Farrell (2003, 2005) extended this approach using the local influence method to find perturbations to VPA inputs that have large effects on ρ.

The local influence method was first presented by Cook (1986) for likelihood analyses of statistical models, and has been generalized and applied to VPA by Cadigan and Farrell (2002). Cadigan and Farrell (2003, 2005) used the slope of the perturbation (influence) surface of ρ near the origin to find perturbations that removed or greatly reduced retrospective patterns as measured by ρ. This was done for perturbations to several VPA inputs, and the magnitudes of the perturbations required to remove the retrospective patterns were used to assess their plausibility. We consider four distinct perturbation schemes on fishery catches, natural mortality, survey catchability, and extrinsic estimation weights (case weights) in order to determine if the retrospective patterns in the GMGBH VPA are more likely caused by any of these components.

2 GMGBH VPA

We used the cohort model

$$N_{a,y} = \left(N_{a+1,y+1}e^{M/2} + C_{a,y}\right)e^{M/2}, \quad (2)$$

where

$N_{a,y}$ is the beginning of year stock numbers at age $a = 1, ..., 10$ in year $y = 1967, ..., 2005$,

$C_{a,y}$ is the commercial catch in year y (no plus group), and

$M = 0.2$ is the annual mortality rate.

The catches are presented in **Appendix 2**, along with other VPA output. Fishing mortalities at age 10 were set equal to the average F's at ages 7-9. Also, F's at ages 7-9 in 2005 were set equal to the average F at ages 4-6. This was an equal-weighted average, and other weighting schemes can have some impact on estimates. The cohort parameters (i.e. survivors) estimated were $N_{2,2005}, ..., N_{6,2005}$, with $N_{1,2005} = 2000$ fixed. The geometric mean of $N_{1,1993}, ..., N_{1,2005}$ was used to estimate $N_{1,2006}$.

Five sets (s) of survey stock biomass or abundance indices were used to estimate survivors (see Appendix 2):

1. Canadian larval (CAN_LRVL) biomass index for 1987-1995;

2. US larval (US_LRVL) biomass index for 1971-1994;
3. US fall survey (US_FALL) abundance index for ages 2-8 and years 1967-2005;
4. US spring survey (US_SPRG) abundance index for ages 2-8 and years 1968-2005;
5. US winter survey (US_WNTR) abundance index for ages 2-8 and years 1992-2005.

The Canadian RV index and acoustic indices were not used. In preliminary runs the fits to these indices were found to be poor so they were not included in the influence exercise to simplify it.

The abundance indices were assumed to be proportional to stock abundance; that is, $R_{s,a,y} \approx q_{s,a}N_{a,y}$, where $q_{s,a}$ is the unknown age-dependent catchability coefficient of the s'th index. The q's for ages 2 to 8 were estimated separately. Also, q's were estimated separately for

- US_LRVL. Period 1: 1971-1988, Period 2: 1989-1994;
- US_FALL. Period 1: 1967-1984, Period 2: 1985-2005;
- US_SPRG. Period 1: 1968-1984, Period 2: 1985-2005.

The total number of parameters (θ) to be estimated was 43 for the 38 q's and 5 $N_{a,2005}$'s. The fit function was

$$l(\theta) = \sum_{s,a,y} \left[\log(R_{s,a,y}) - \log(q_{s,a}) - \log\left\{N_{ay}(t_s)\right\}\right]^2, \tag{3}$$

where $\log\{N_{a,y}(t_s)\} = t_s \log(N_{a,y}) + (1-t_s)\log(N_{a+1,y+1})$ is a cohort approximation of abundance at time t_s (in fraction of the year) in which the survey occurred. Equation (3) is a log error sum of squares fit function with equal weight for all ages, years, and surveys. Any indices with zero values were not used.

Quantities derived from the VPA are total biomass ($B_{+,y} = \sum_{a=1}^{10} w_{a,y}N_{a,y}$) and VPA spawner biomass ($SSB = \sum_{a=2}^{10} p_{a,y}w_{a,y}N_{a,y}$), where $w_{a,y}$ is the beginning-of-year weight-at-age and $p_{a,y}$ is the maturity-at-age (see **Appendix 2**).

3 Results

3.1 VPA for GMGBH

Stock size estimates are presented in Figure 2. Recruitment ($N_{1,y}$) and total abundance ($N_{+,y} = \sum_{a=1}^{10} N_{a,y}$) are plotted in the top panel, and $B_{+,y}$ and SSB are plotted in the bottom panel. Some trends in average F's are shown in Figure 3. In recent year F's have been high on older ages. Partial recruitments (pr's; i.e. F's standardized to one each year) are shown in Figures 4 and 5. There has been a shift in the exploitation pattern towards older fish since 1990, although the pr in 2005 is an exception. The estimated survey catchabilities ($\times 10^3$) for the abundance indices are shown in Figure 6. The q's usually increase with age.

Summary fits to the survey indices are shown in Figure 7. The fits are poor overall. The trend in the CAN_LRVL index is opposite to that predicted by the VPA. Similarly, the recent trend in the US_SPRG index is opposite to that predicted by the VPA. The US_FALL and US_WNTR fits are poor since 1990. The VPA is fitted to age-disaggregated indices; however, these fits are no better than the results in Figure 7. Age-disaggregated residuals are shown in Figures 8 and 9. These residuals ($\log(r/\hat{r})$) are standardized by the root mean square error for all residuals, adjusted for the loss in degrees of freedom due to unknown catchabilities. These residual plots suggest that assumptions are mis-specified in the VPA. This is also evident in Figure 1.

Retrospective patterns in abundance at age estimates ($\hat{N}_{ay}$) are shown in Figure 10. The retrospective patterns are more pronounced at older ages. Retrospective patterns in the model predicted total survey indices ($R_y = \sum_a R_{ay}$) are shown in Figures 11-15. It is particularly clear in Figure 14 that the retrospective pattern is related to trends in the survey index which the VPA cannot explain. The reported catches and assumed M's are not enough to account for the decline in the survey indices. The problem could also involve a change in the survey catchabilities or (perhaps less likely) some other type of year effect.

We have shown residual and retrospective plots that suggest the GMGBH VPA is mis-specified; however, these graphics provide little insight about the source of the model mis-specification. In the next four sections we present diagnostics that can assist in identifying the source of the mis-specification.

3.2 Catch perturbations

In this section we present the direction of maximum slope for ρ, i.e. $d_{\max}$, based on catch perturbations ω:

$$C_{\omega,a,y} = C_{a,y} \times \omega_{a,y}. \tag{4}$$

We do this using ρ's for the retrospective patterns in N_{2+}, $\bar{F}$, and SSB. We also use the $d_{\max}$ perturbation of SSB to find a catch time series that results in reduced retrospective patterns. This is described as follows.

Let $\omega(h) = \mathbf{1} + hd_{\max}$ where $\mathbf{1}$ is a vector of ones. Let $\rho_\omega(h) = \rho\{\omega(h)\}$ denote the ρ value based on $\omega(h)$ perturbed catches, $C_{a,y}(h) = C_{a,y} \times \{1 + hd_{a,y}\}$ where $d_{a,y}$ is the element of the vector $d_{\max}$ that corresponds to $C_{a,y}$. If the influence surface in the direction of $d_{\max}$ is linear with slope $\dot{\rho}_{\max}$,

$$\rho_\omega(h) = \rho + \dot{\rho}_{\max} h,$$

then $\rho_\omega(h) = 0$ when $h = h_{\max} = -\rho/\dot{\rho}_{\max}$. In this case using $\omega(h_{\max})$ gives the smallest perturbations to catches that remove the retrospective pattern, as measured by ρ. When the influence graph has some nonlinearity, $\omega(h_{\max})$ may not completely remove the retrospective patterns. In this situation, a value close to $h_{\max}$ will usually be a better choice for h instead of $h_{\max}$.

The elements of the three $d_{\max}$'s are shown in Figure 16. They are similar for N_{2+} (panel a) and SSB (panel c). At the top of each panel we show $-h_{\max}^{-1} = \dot{\rho}_{\max}/\rho$ in percent. Values for $\dot{\rho}_{\max}$ can be derived from $h_{\max}$ and the respective ρ's shown in Figure 1. By construction the $\dot{\rho}_{\max}$'s are always positive, which indicates that perturbations in these directions will increase ρ. Hence, these results suggest that increasing reported catches after 1996, particularly at ages 7 and 8, and decreasing catches in 1985-1995 will result in relatively large reductions in retrospective patterns. The elements of $d_{\max}$ for $\bar{F}$ tend to be opposite in sign to those for N_{2+} and SSB, although not always. This is because the retrospective trends in $\bar{F}$ ($\rho = -23.1$) are the reverse of the trends in N_{2+} ($\rho = 5.34$) and SSB ($\rho = 6.11$). Changes to the catches in the direction of $d_{\max}$ in panel b of Figure 16 will increase ρ towards zero and reduce the retrospective pattern in $\bar{F}$.

If we change catches in the direction of $d_{\max}$ in Figure 16 (panel c) by $h_{\max} = -10.7$ then ρ should be near zero for this perturbation. After trial and error we found that $h = -5.4$ reduced ρ substantially (see Figure 17), from 6.11 to almost zero for SSB. The catch perturbations are shown in Figure 18. The change in many catches was more than ±50%, and some catches were changed more than ±100%. Differences between the total observed and perturbed catches are shown in Figure 19. The catch perturbations resulted in a poorer fit and retrospective patterns still exist. The age-specific patterns remained pronounced for some ages (compare Figures 10 and 20).

3.3 M perturbations

The M perturbations we considered were of the form

$$M_{\omega,a,y} = M \times \omega_{a,y},$$

where $\omega_o = 1$. These are multiplicative perturbations of M, which was set at 0.2.

The elements of the direction vectors are shown in Figure 21. They are broadly similar to the catch perturbation results in Figure 16 for N_{2+} and SSB. The results in Figure 21 suggest that an increase in M around 1995 will reduce the retrospective pattern. Recall that a negative slope implies that an increase in that M will decrease ρ towards zero. The results for SSB suggests that a perturbation in the direction shown in panel c of Figure 21 with h around $h_{\max} = -24.6$ will reduce ρ to near zero. After a few trials we chose $h = -12.7$. This difference is due to nonlinearity in the influence surface for large $|h|$.

The perturbed retrospective patterns are shown in Figure 22. They are reduced for N_{2+}, $\bar{F}$, and SSB compared to those in Figure 1, although substantial retrospective differences still occurred in 1991-1998. The perturbations based on $h = -12.7$ are shown in Figure 23. The perturbations are large; that is, many of them are greater than 50% in absolute value, and some perturbations are greater than 200%. The fit for the perturbed VPA improved slightly which was different than the catch perturbations which resulted in a poorer fit. Numbers-at-age retrospective plots are shown in Figure 24. They are arguably worse than the patterns from the catch perturbed VPA (see Figure 20).

3.4 Catchability perturbations

Another interesting perturbation scheme involves the survey catchabilities,

$$q_{\omega,s,a,y} = q_{s,a}\omega_{s,a,y}, \tag{5}$$

where $\omega_o = 1$. This involves perturbations to unknown model parameters. This perturbation scheme is useful for assessing if changes in survey catchability could account for the retrospective pattern.

We estimated the q_a's in (5) using the perturbed fit function,

$$\begin{aligned} l_\omega(\theta) &= \sum_{s,a,y} \left[\log(R_{s,a,y}) - \log(q_{\omega,s,a,y}) - \log\left\{N_{a,y}(t)\right\}\right]^2 \\ &= \sum_{s,a,y} \left[\log(R_{a,y}) - \log(\omega_{s,a,y}) - \log(q_{s,a}) - \log\left\{N_{a,y}(t)\right\}\right]^2. \end{aligned}$$

The perturbed catchabilities were estimated as $\hat{q}_{\omega,s,a,y} = \hat{q}_{s,a}\omega_{s,a,y}$. However, the $\omega_{s,a,y}$'s were fixed and obtained from the local influence diagnostics.

The elements of $d_{\max}$ for the three retrospective measures (ρ's) are shown in Figures 25-29. The "load" statistic reported at the top of each panel gives the sum of squares of the elements of $d_{\max}$ for each survey. These figures suggest that a change in catchability in 1994 for the US_FALL (Figure 27) and US_SPRG (Figure 28) surveys, and in 1996 for the US_WNTR (Figure 29) survey, can reduce the retrospective pattern. Catchability perturbations for the two larval survey have almost no effect (i.e. load near zero) on the retrospective patterns because they have almost no effect on the stock size estimates with the GMGBH VPA formulation.

We applied the $d_{\max}$ perturbation of SSB with $h = -7.6$. This reduced the ρ SSB statistic to near zero, although retrospective patterns still existed (see Figure 30). The perturbations are shown in Figures 31-35. On a relative scale these are individually smaller perturbations than those in Figure 23. Age specific retrospective patterns based on the q-perturbations are shown in Figure 36. These appear no better than the results for the other perturbation schemes (Figures 20 and 24) and Figure 10, although ρ is smaller at age 1. The q perturbations slightly improved the fit as well.

3.5 Case weight (CW) perturbations

This perturbation scheme involved changing the extrinsic weight (i.e. CW) each survey observation was given in estimation. The default or null value was one, except for indices with values of zero. Parameters were estimated using the perturbed fit function,

$$l_\omega(\theta) = \sum_{s,a,y} \omega_{s,a,y} \left[\log(R_{s,a,y}) - \log(q_{\omega,s,a,y}) - \log\left\{N_{a,y}(t)\right\}\right]^2.$$

This perturbation scheme is useful to detect if the retrospective pattern is caused by some anomalous indices.

The elements of $d_{\max}$ for the three retrospective measures (ρ's) are shown in Figures 37-41. The results are complex, but they do not suggest that changing the case weights for a small number of indices will substantially reduce the retrospective pattern. CW perturbations for the two larval survey have almost no effect (i.e. load near zero) on the retrospective patterns.

We applied the $d_{\max}$ perturbation of SSB with $h = -13.3$. This reduced the ρ SSB statistic to near zero, although retrospective patterns still existed (see Figure 42). The perturbations are shown in Figures 43-47. Age specific retrospective patterns based on the CW-perturbations are shown in Figure 48. They appear slightly improved compared to (Figures 20, 24, and 36) and Figure 10. The CW perturbations improved the fit as well.

4 Discussion Points

1. The input component that has the largest local slope is normally suggested as the more likely source of the retrospective problem, among the sources that are assessed. For GMGBH VPA this was catches, because the maximum slope for the change in SSB ρ caused by catch perturbations was 9.34% of ρ (see Figure 16). However, the percent slopes for catchability and case weight perturbations were almost as large, at 7.4% and 8.1% respectively. The local slope for M perturbations was substantially lower, at 4.1%, suggesting that larger changes to M are required to reduce the retrospective pattern.

2. However, none of the perturbation schemes were able to completely remove retrospective patterns, although it was possible to reduce ρ to zero. Age-specific patterns were usually not improved. A better choice of retrospective metric may improve the diagnostics; for example, it may be better to use $S_{y,Y}$ in the denominator terms in (1); that is,

$$\rho = \sum_{y=y_o}^{Y} \frac{S_{y,y} - S_{y,Y}}{S_{y,Y}}.$$

3. It might also be more informative to examine the F based diagnostics in more detail. They were somewhat different than the N_{2+} and SSB diagnostics.

4. The N_{2+} and SSB diagnostics for catch, M, and q perturbations all suggest that there was a change in some population process or population sampling process around 1995. Stock experts may have additional information about what may have changed in this period.

5. Additional information is required to resolve what is the source of the retrospective problem for this stock. This is typical.

6. The catchability perturbations suggest another change around 2004; however, we have observed in some simulated applications that the local influence diagnostics can be misleading in the last few years of a VPA, presumably because of the confounding effects of the unknown survivors.

7. Note that although some of the perturbations improved the model fit, the perturbations were not specified to improve fit. They were selected simply to reduce ρ to near zero.

8. Reducing ρ to zero involved large perturbations. The influence surfaces of the three ρ's over these scales of perturbations exhibited nonlinearity. Hence, it is possible that smaller perturbations exist that remove retrospective patterns than those based on $d_{\max}$.

9. Retrospective-corrected stock scenarios are shown in Figure 49. It is interesting that catch and M perturbations lead to somewhat different estimated stock trajectories, since they both play a very similar role in VPA by accounting for population deaths; however, an important difference in their roles involves the constraints on fishing mortalities at the oldest age A. These constraints are commonly used and often make an VPA more sensitive to errors in catches at age A than similar sized errors in M at that age.

10. Another conclusion we draw from Figure 49 is that a retrospective-corrected VPA may not produce lower estimates of stock size. This is contrary to the common perception that a retrospective problem implies that the VPA over-estimates current stock size.

11. The local influence approach is useful when the perturbation surface of ρ around a relevant neighborhood of the origin is fairly linear. In this case our approach finds the smallest (using the Euclidean norm) perturbations to some VPA inputs that remove the retrospective pattern. If these perturbations seem unrealistic then one can reasonably conclude that they are not the cause of the retrospective pattern. When the influence surface has substantial nonlinearity then second-order properties such as local curvature can be investigated, although we do not pursue this. We did not investigate this for GMGBH; however, Cadigan and Farrell (2005) found for two stocks that the influence surface of ρ was to be linear within a reasonable range of the origin.

5 References

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Cadigan, N. G., and Farrell, P. J. 2003. Local Influence Diagnostics for the Retrospective Problem in Sequential Population Analysis. DFO Canadian Science Advisory Secretariat Research Document 2003/057. http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2003/RES2003_057_E.pdf

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6 Appendix 1: Figures

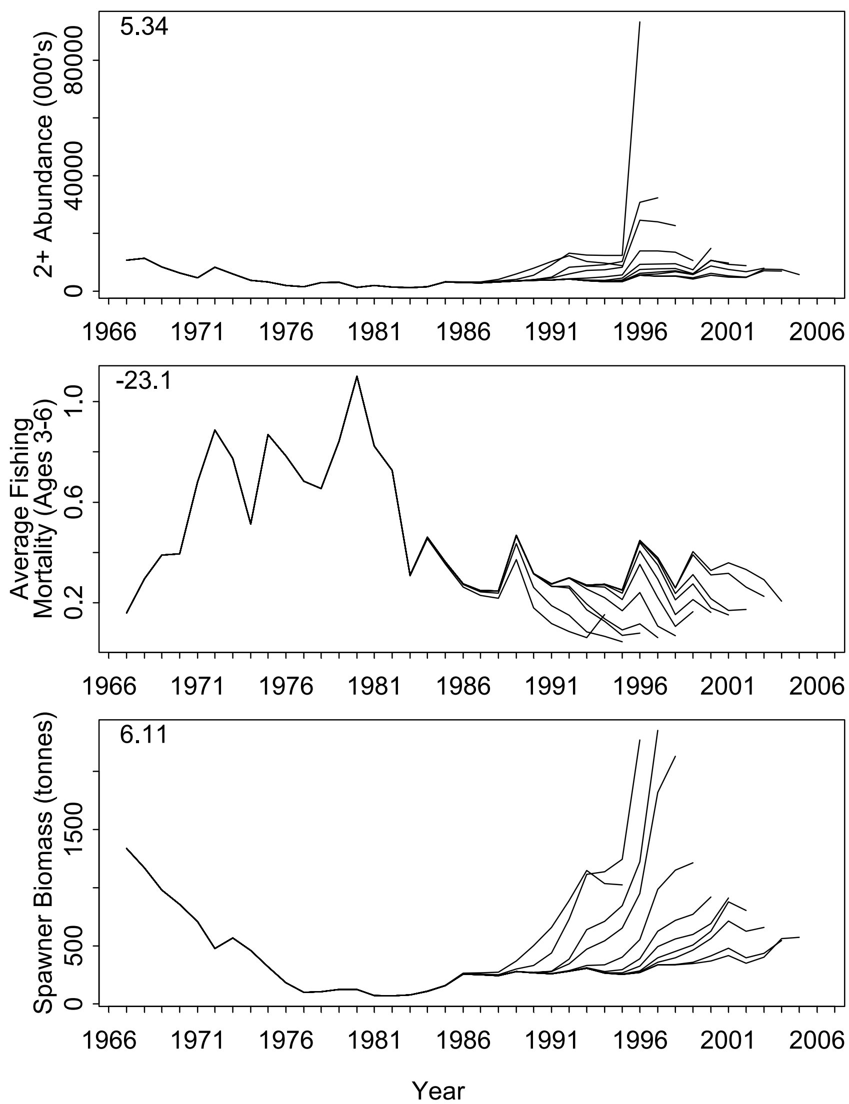

Figure 1: Retrospective estimates for GMGBH. The retrospective ρ statistic is shown in the top left-hand corner of each panel. Top panel: N_{2+}, middle panel: $\bar{F}$, bottom panel: SSB.

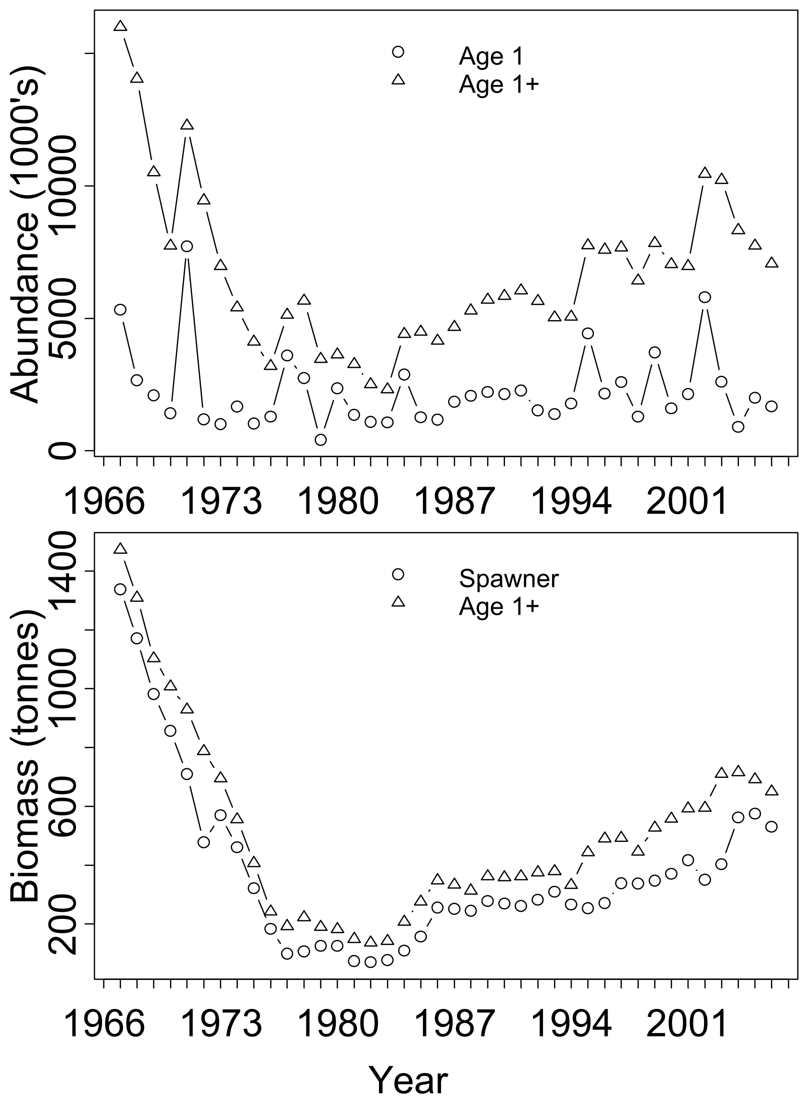

Figure 2: Estimates of recruitment and total abundance at ages 1-10 (top panel), and total biomass at ages 1-10 and spawner biomass (bottom panel).

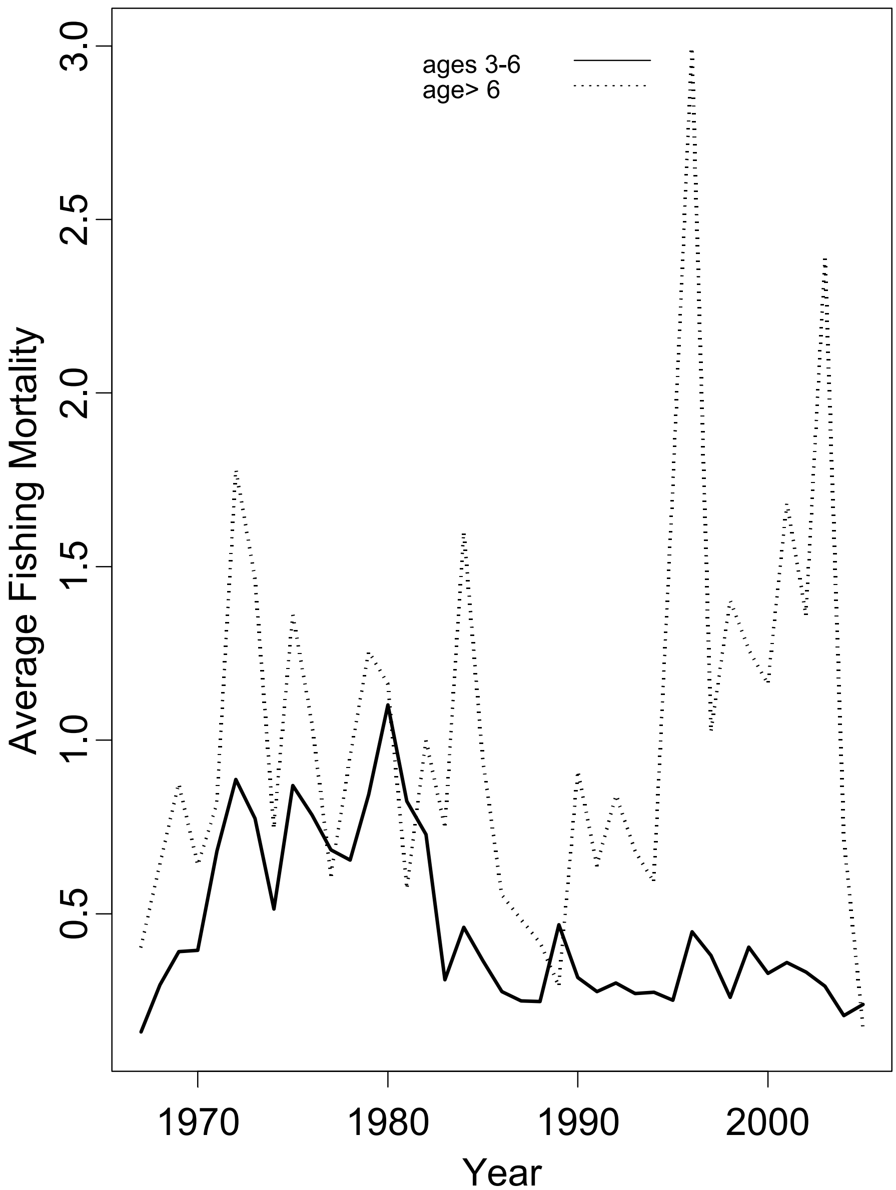

Figure 3: Average estimated fishing mortality for ages 3-6 and ages 7+.

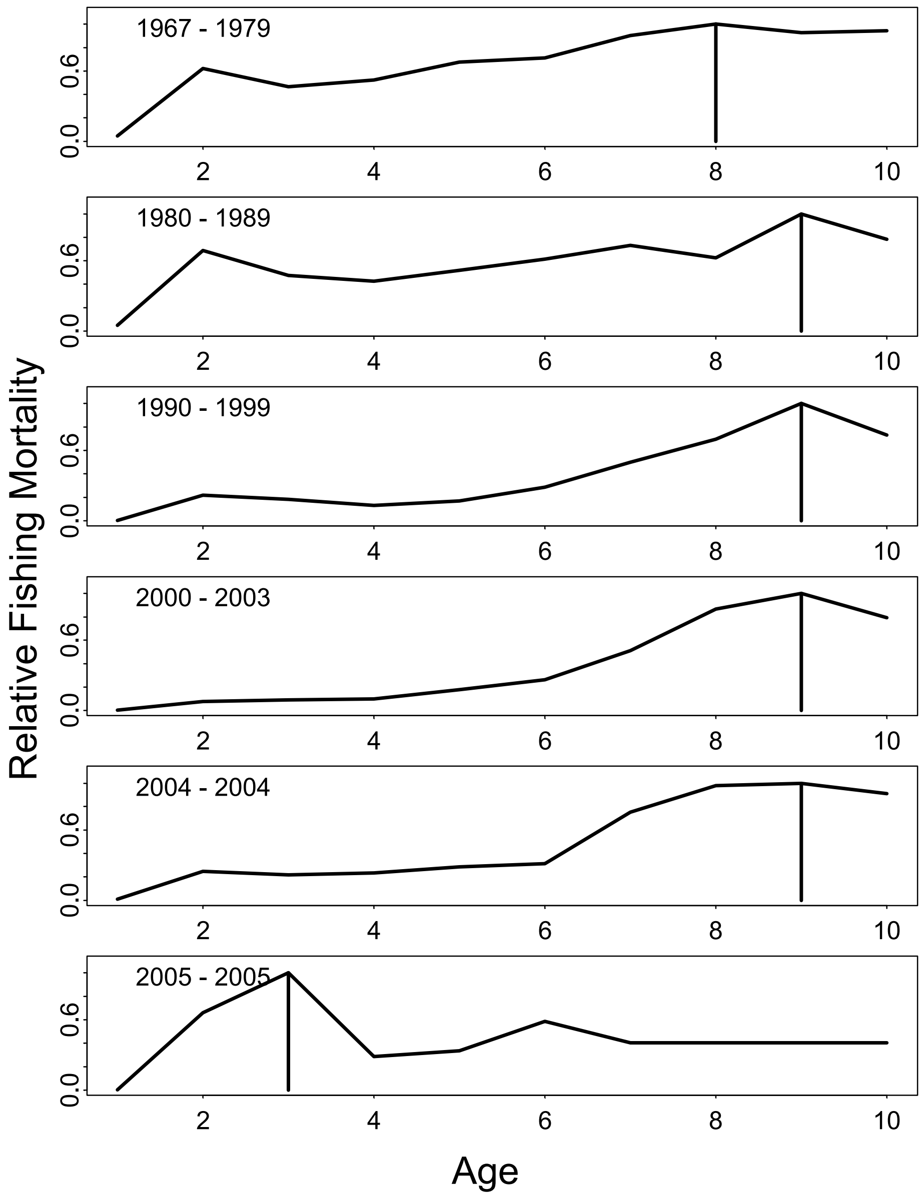

Figure 4: Average partial recruitment for selected time periods.

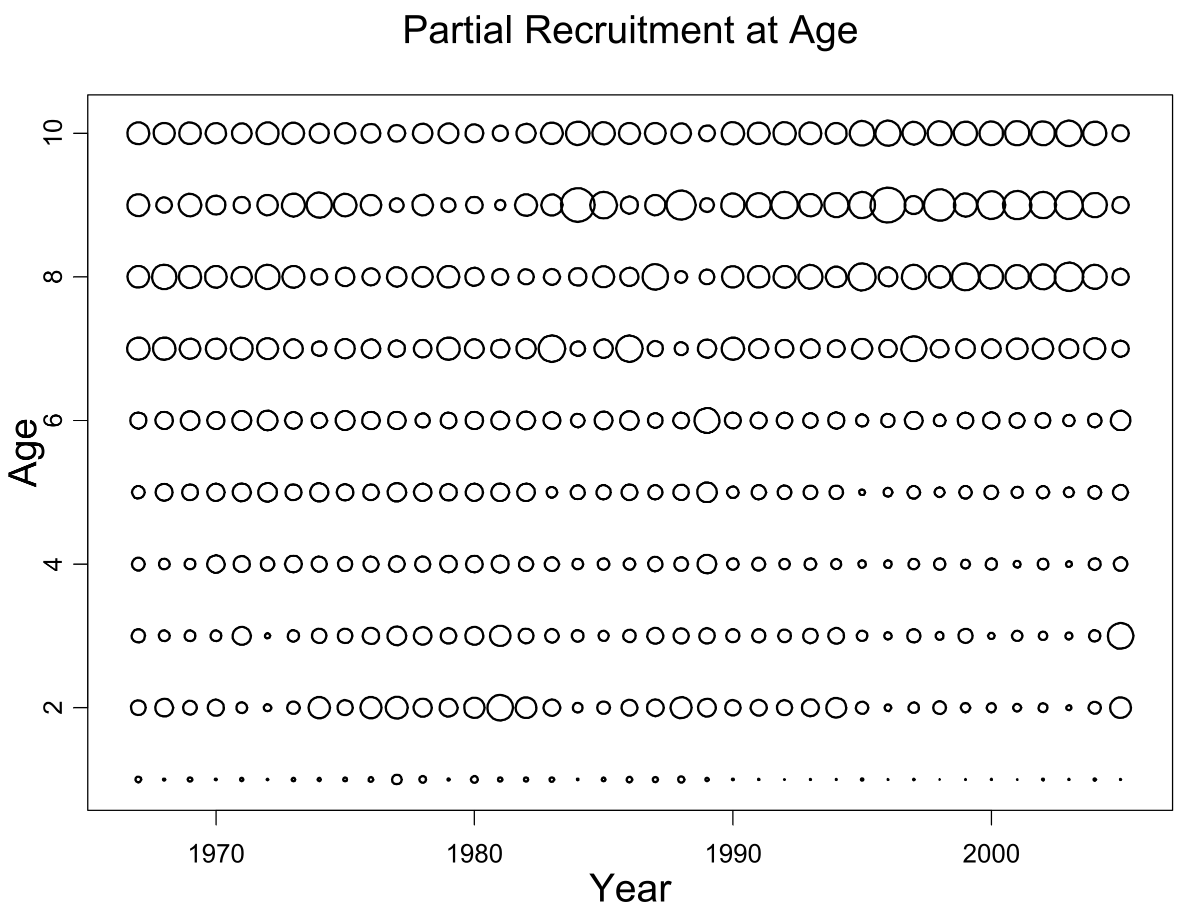

Figure 5: Annual partial recruitment. The area of a bubble is proportional to the partial recruitment.

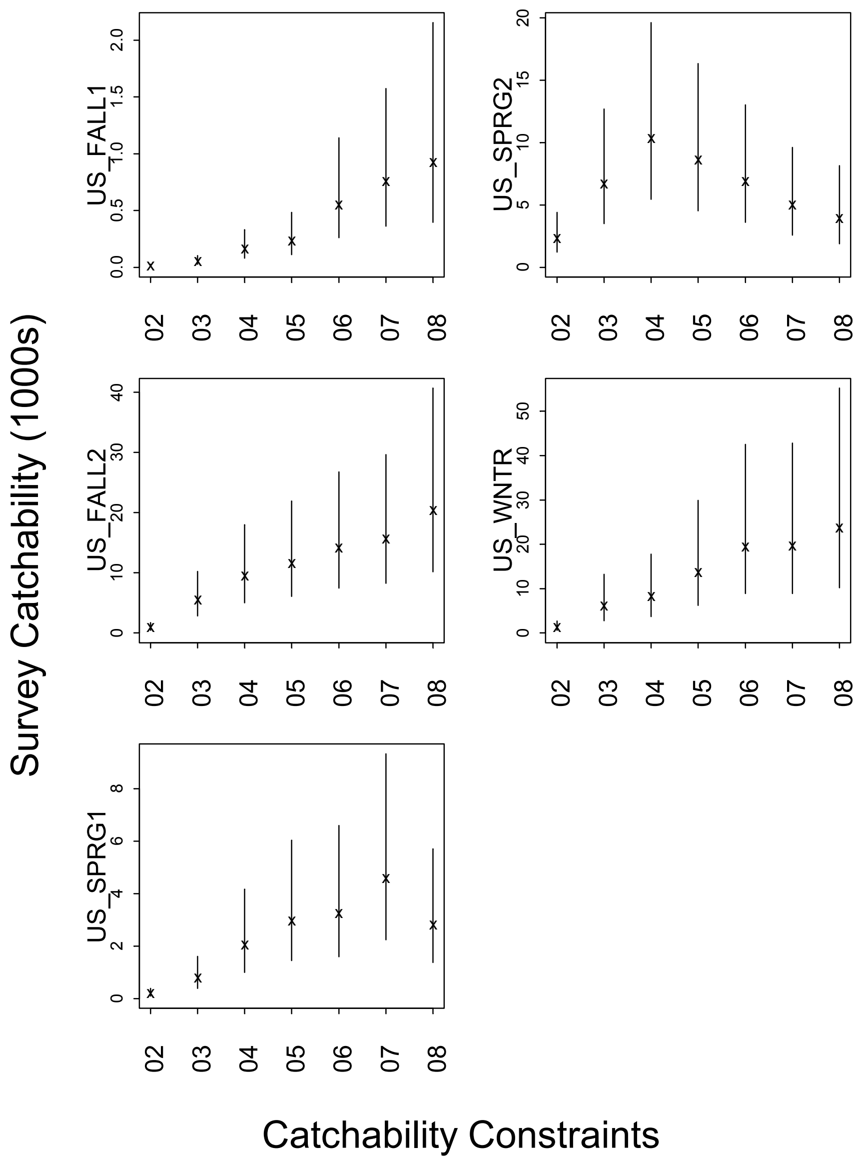

Figure 6: SPA survey catchability estimates ($q_{s,a}$'s). Vertical lines represent 95% confidence intervals.

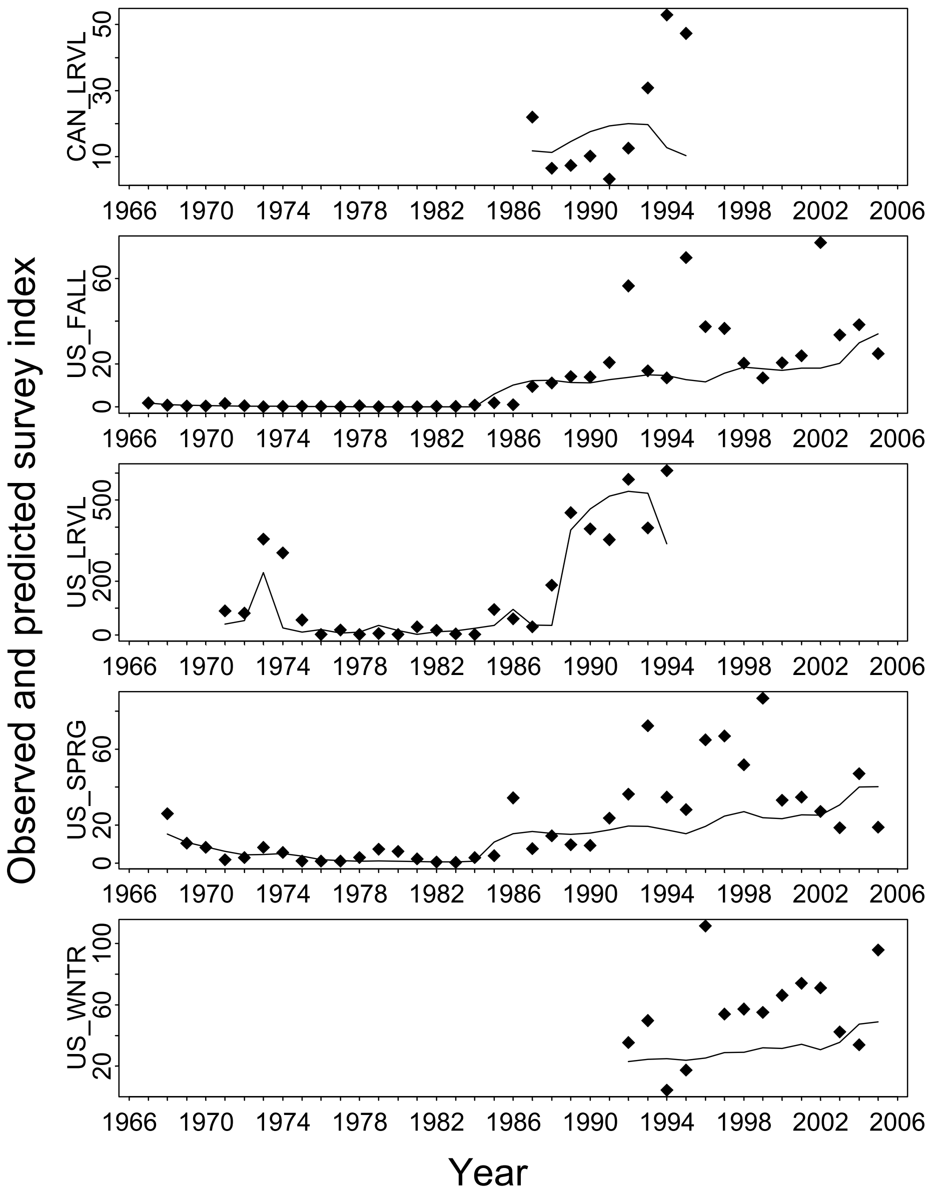

Figure 7: Age-aggregated observed (points) and SPA predicted (lines) survey indices.

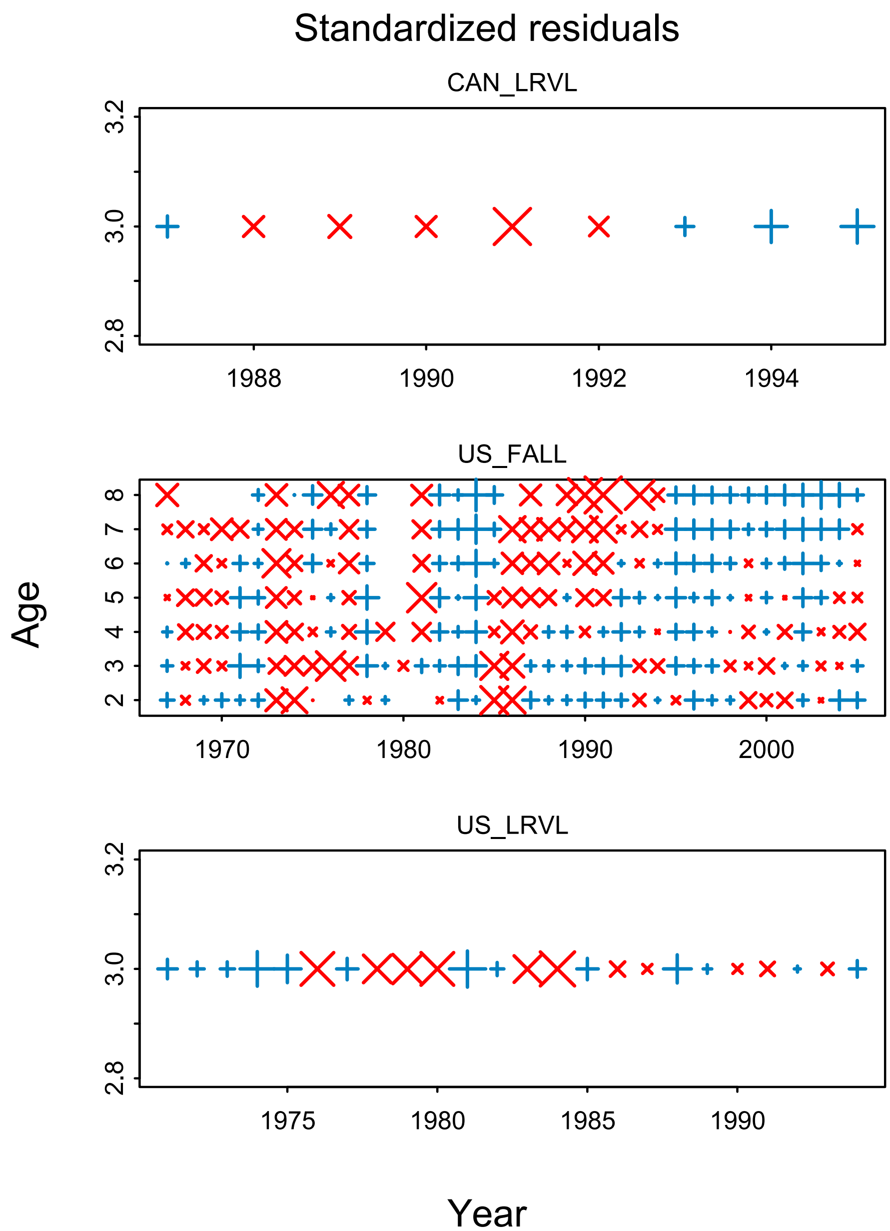

Figure 8: Standardized residuals versus age and year. The size of the plotting symbols is proportional to the absolute value of the residuals. A red × denotes a negative residual, and a blue + denotes a positive residual.

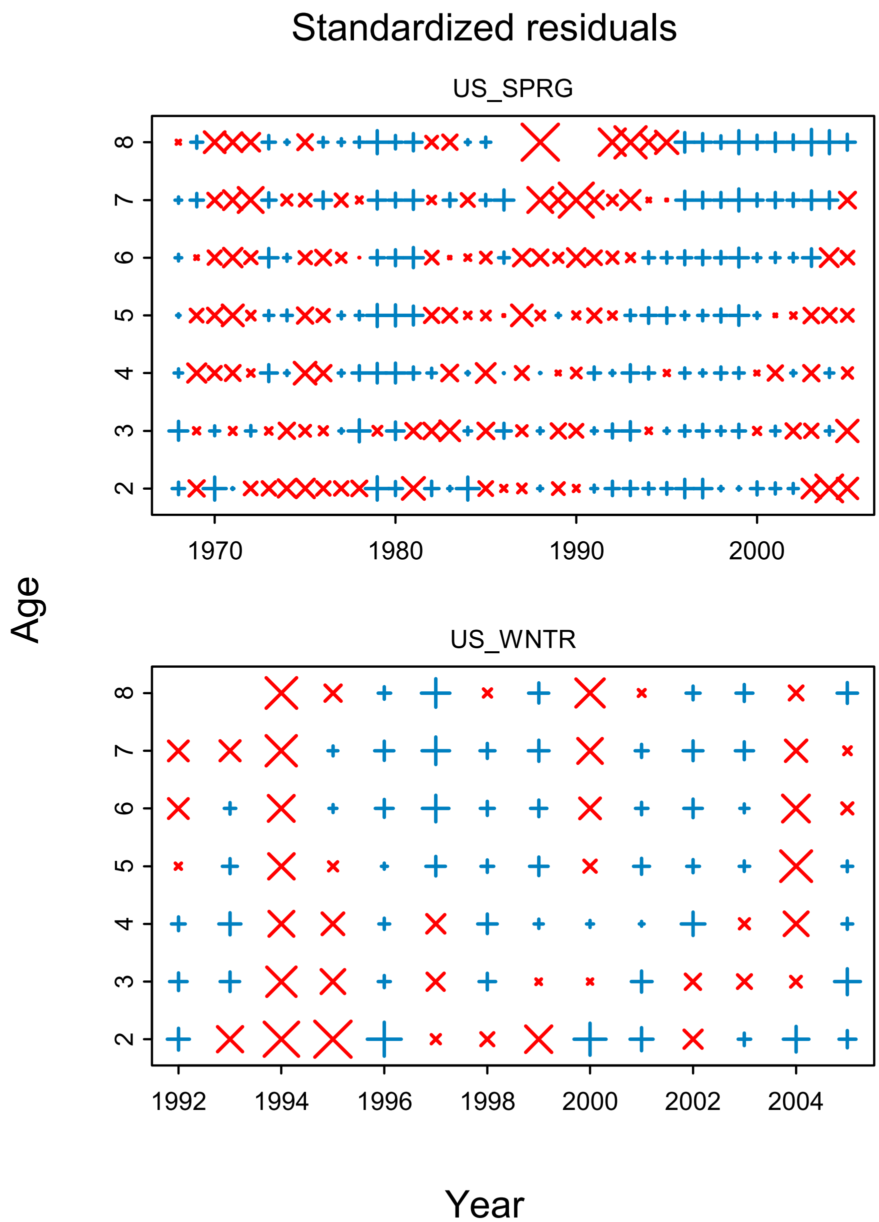

Figure 9: Standardized residuals versus age and year. The size of the plotting symbols is proportional to the absolute value of the residuals. A red × denotes a negative residual, and a blue + denotes a positive residual.

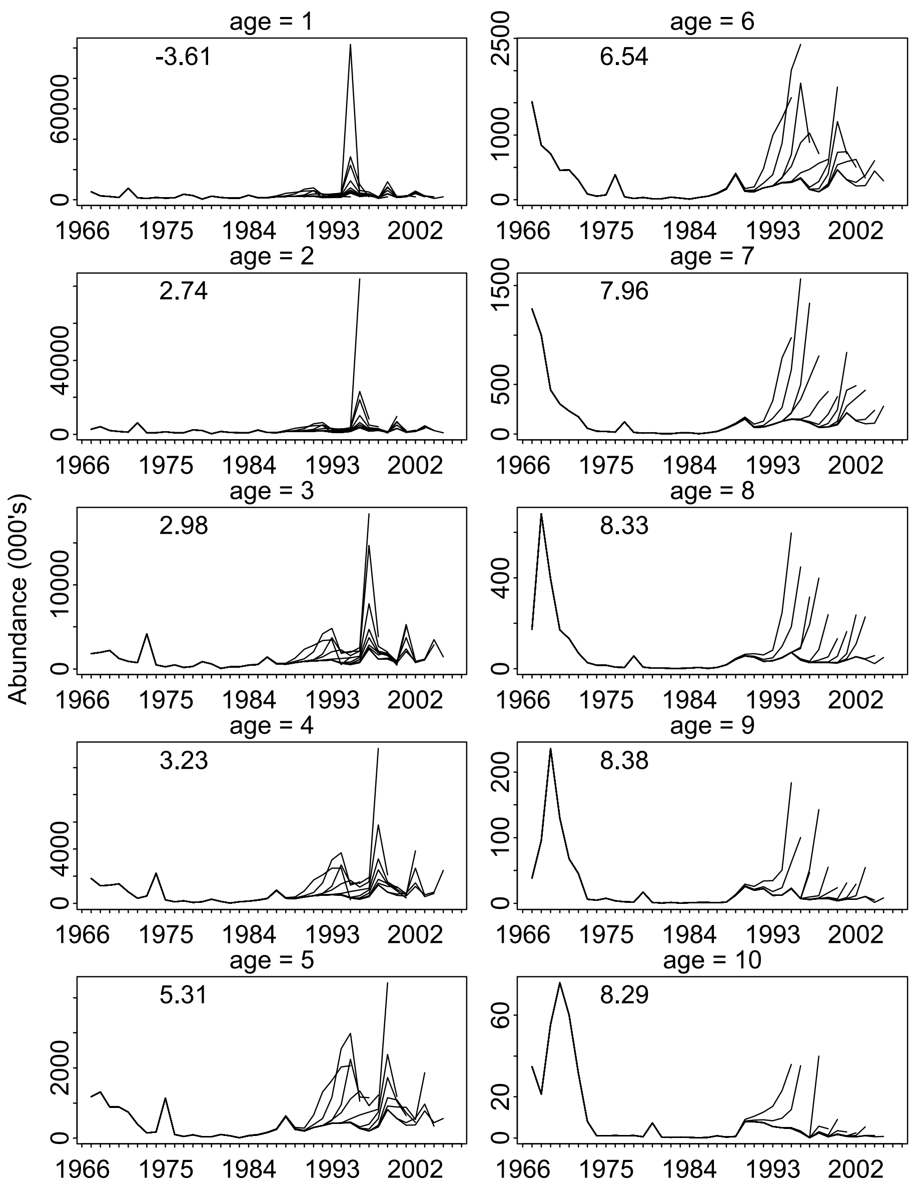

Figure 10: Retrospective plots of abundance-at-age estimates. The retrospective ρ statistic is shown in the top left-hand corner of each panel.

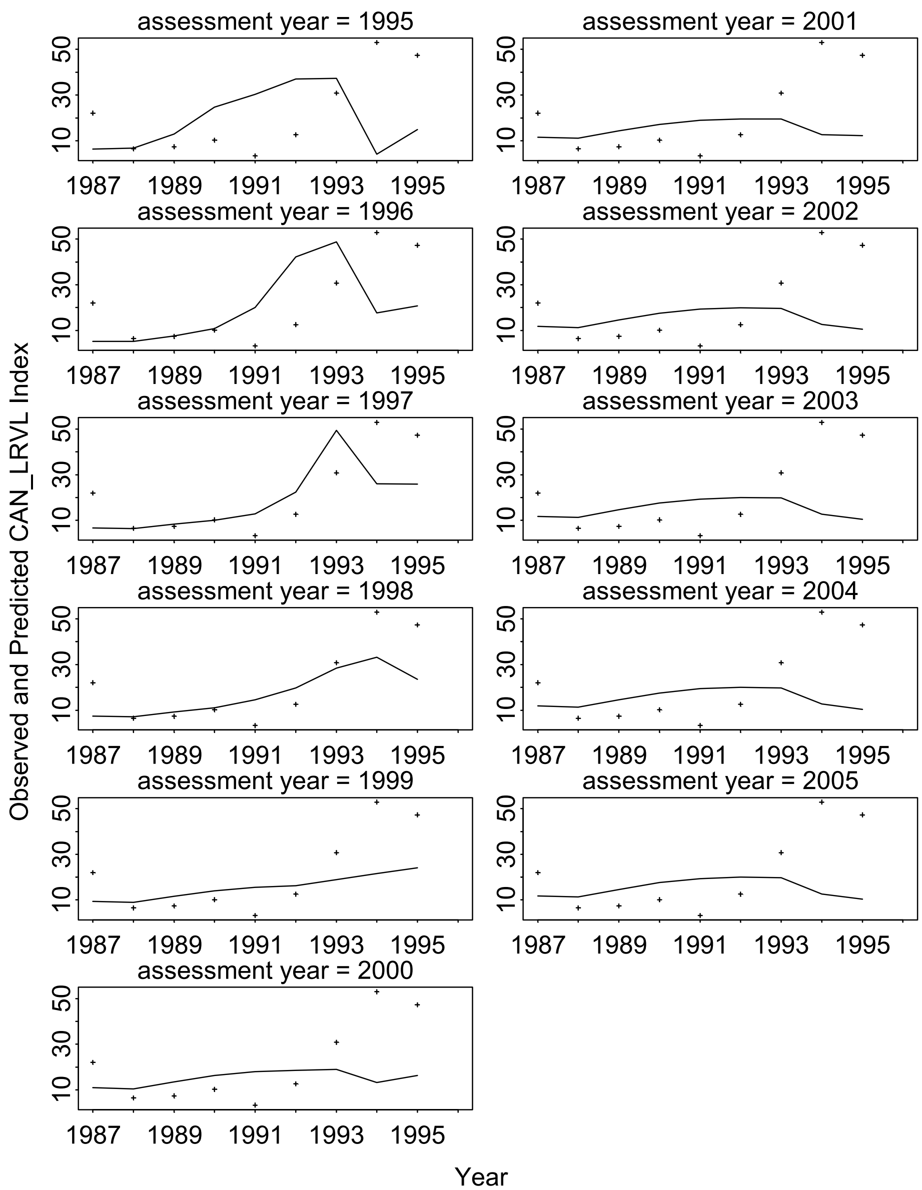

Figure 11: Observed and retrospective predicted age-aggregated Canadian larval biomass index.

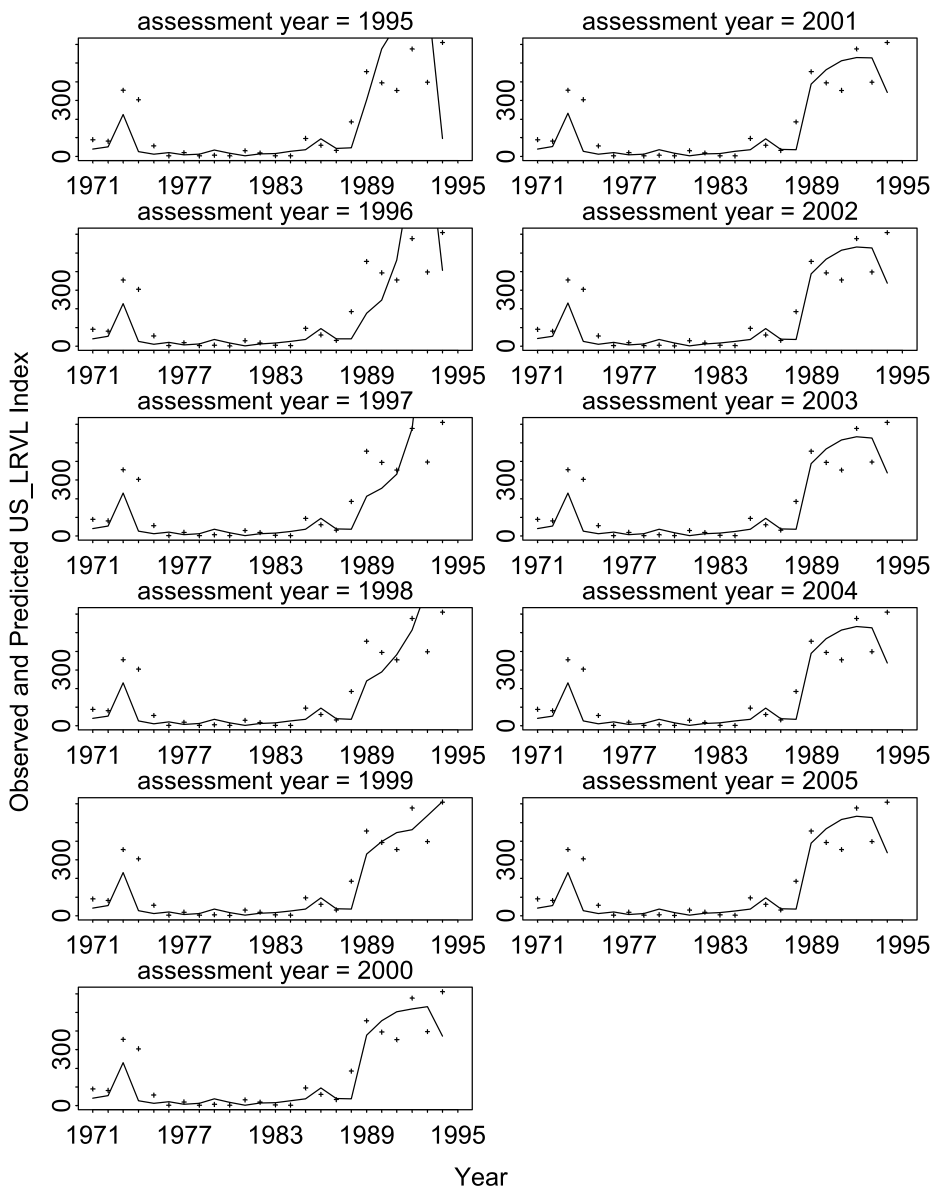

Figure 12: Observed and retrospective predicted age-aggregated US larval biomass index.

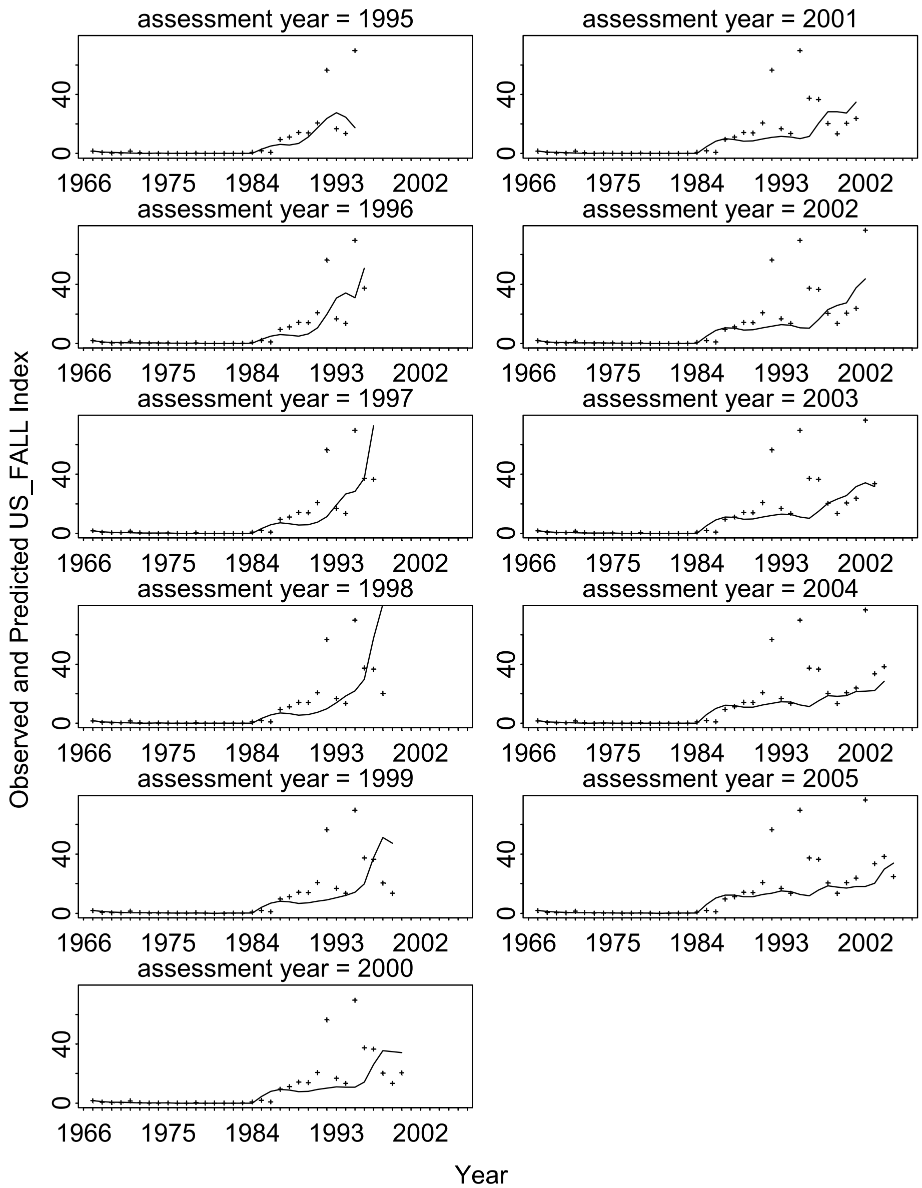

Figure 13: Observed and retrospective predicted age-aggregated US Fall abundance index.

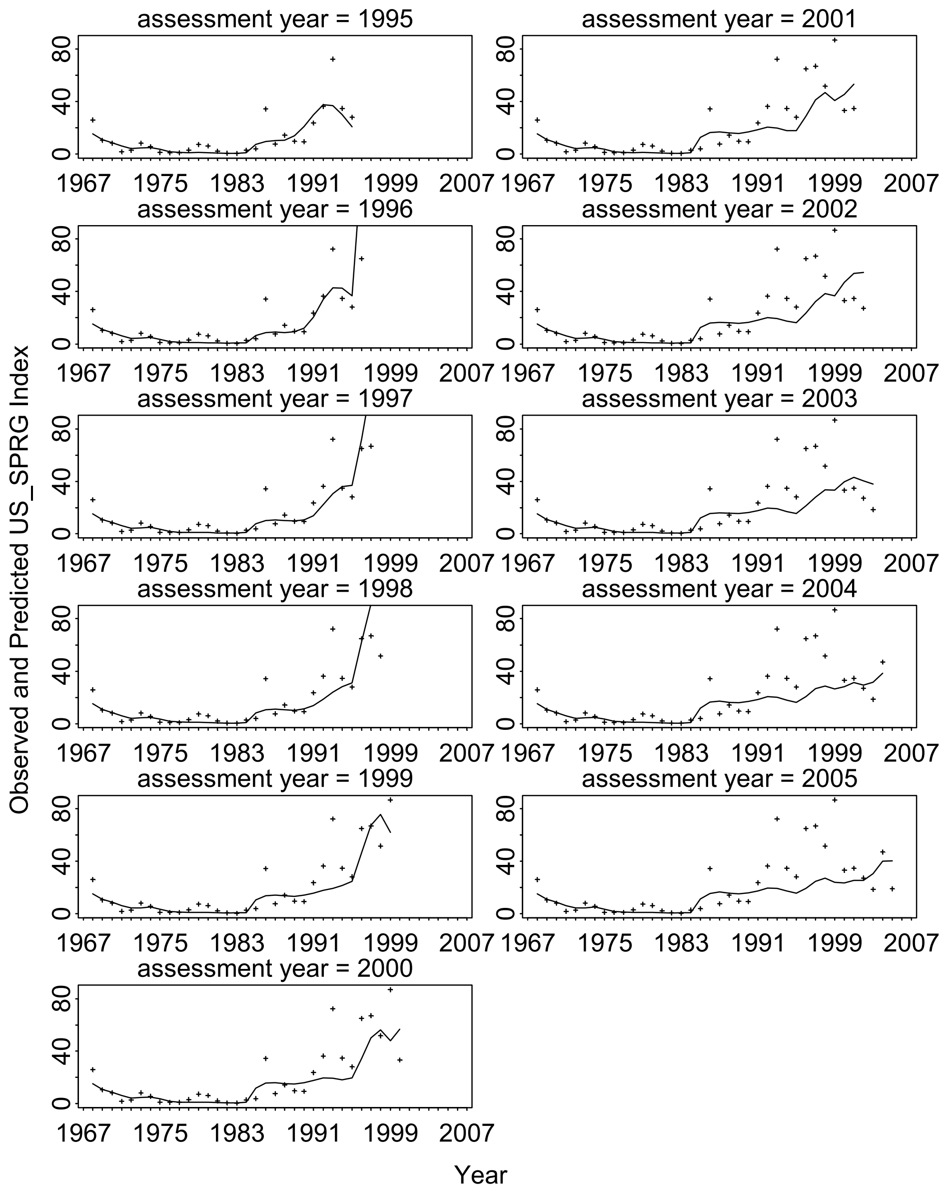

Figure 14: Observed and retrospective predicted age-aggregated US Spring abundance index.

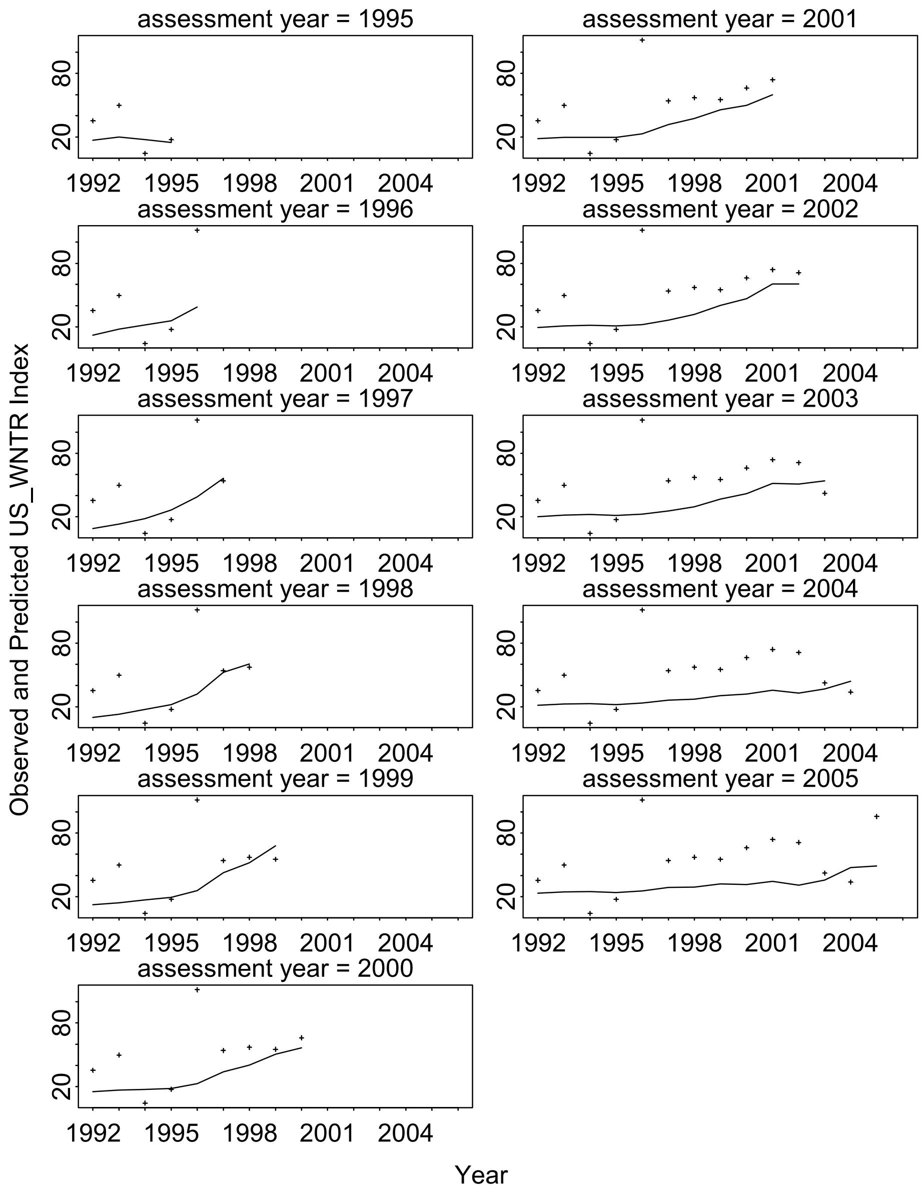

Figure 15: Observed and retrospective predicted age-aggregated US Winter abundance index.

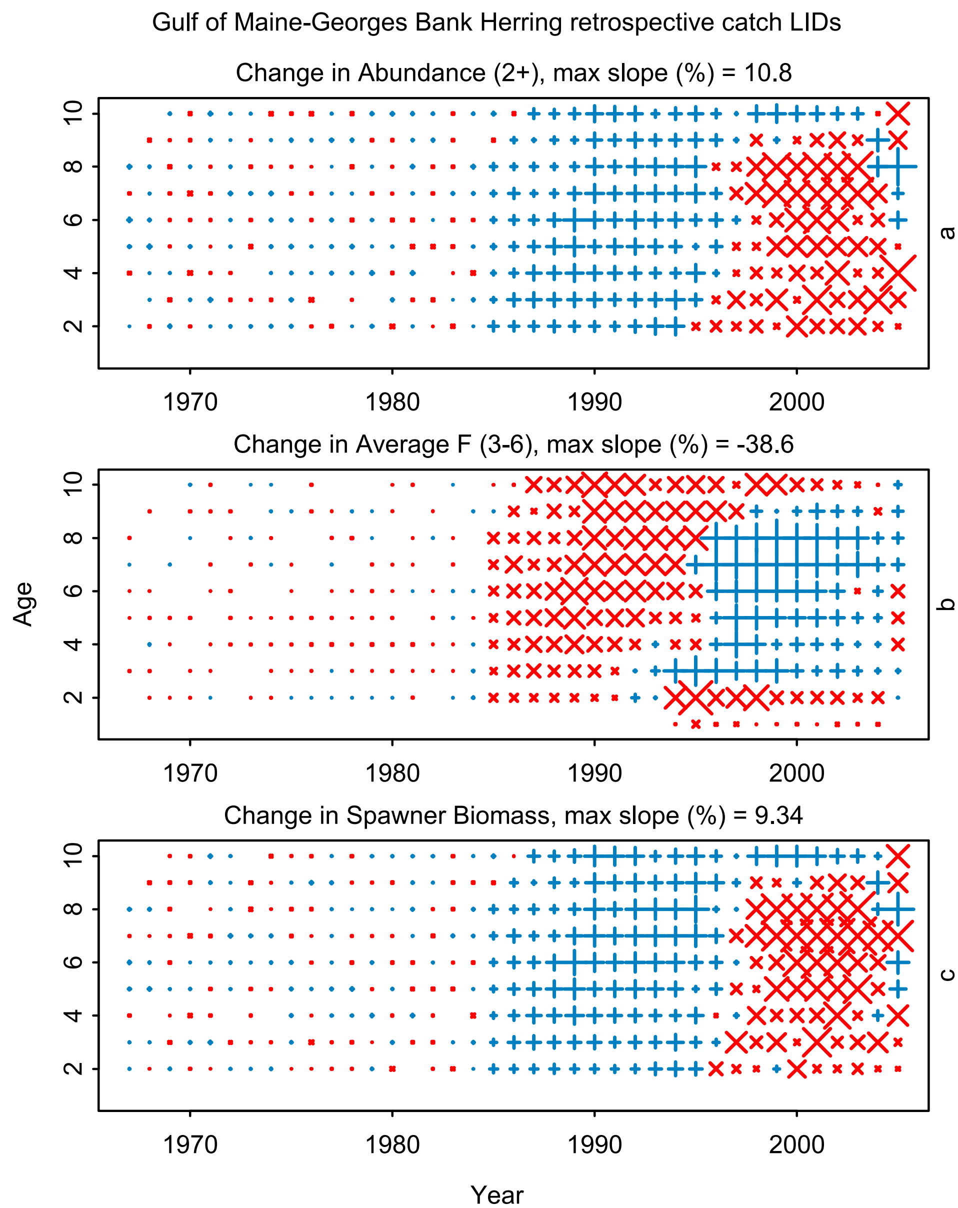

Figure 16: Catch local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

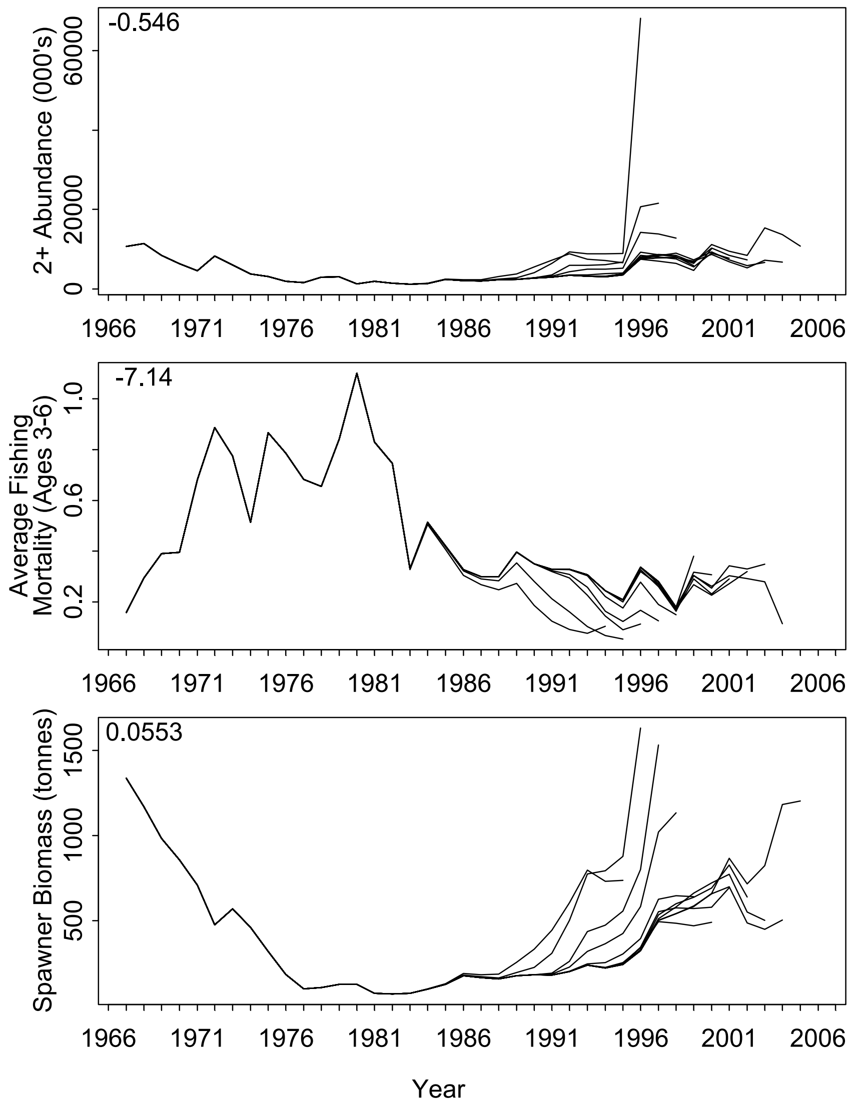

Figure 17: Retrospective estimates based on SSB $d_{\max}$ perturbed catches with $h = -5.4$. The value of ρ is shown in the top left-hand corner. Top panel: N_{2+}; middle panel: $\bar{F}$; bottom panel: SSB.

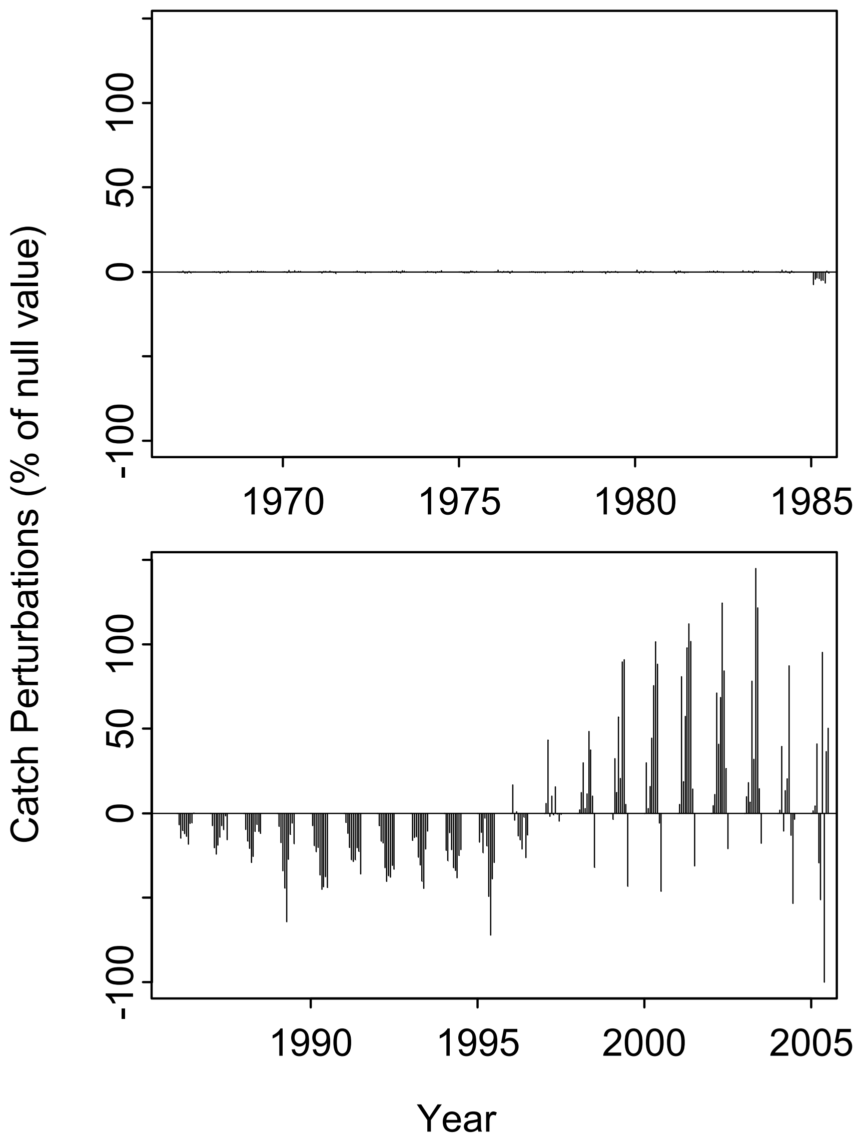

Figure 18: Catch perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to a catch. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 5.4$.

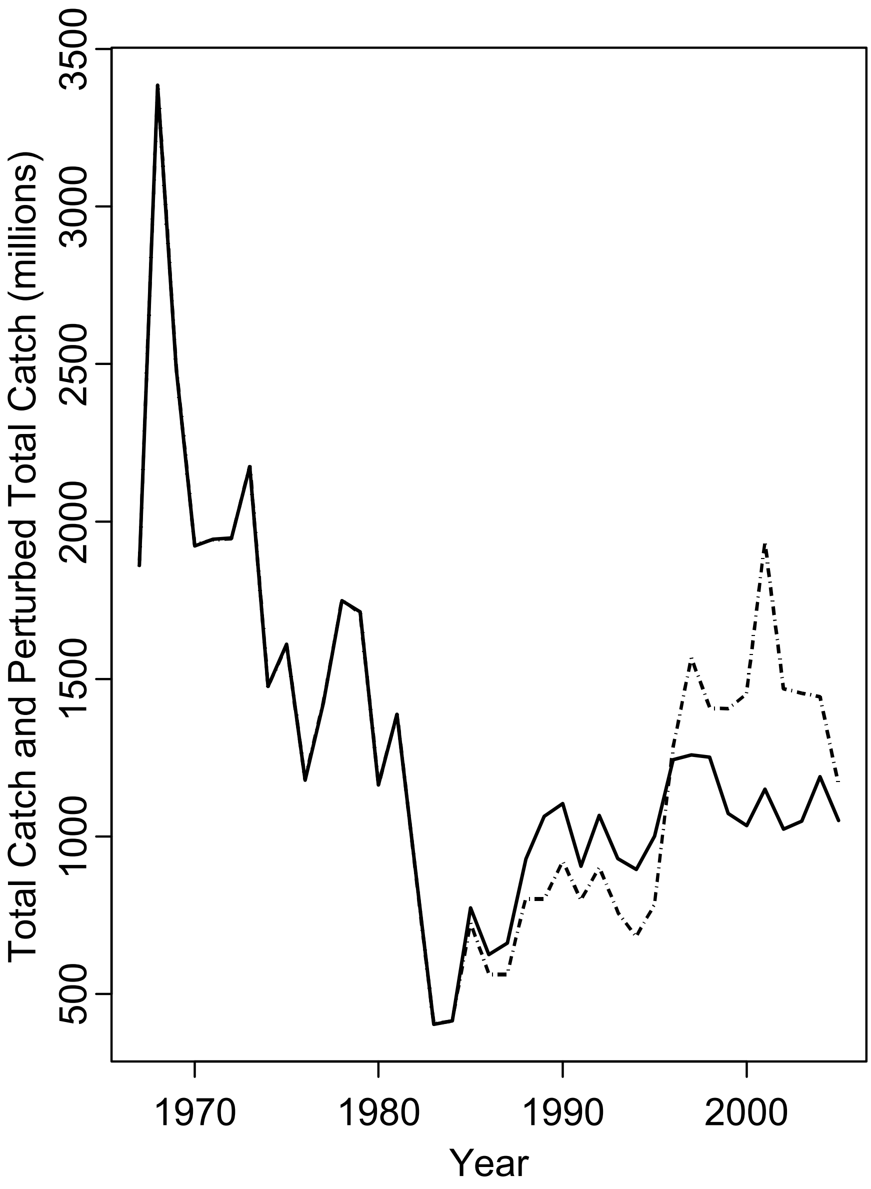

Figure 19: Total observed annual catch (solid line), and total perturbed annual catch (dashed line).

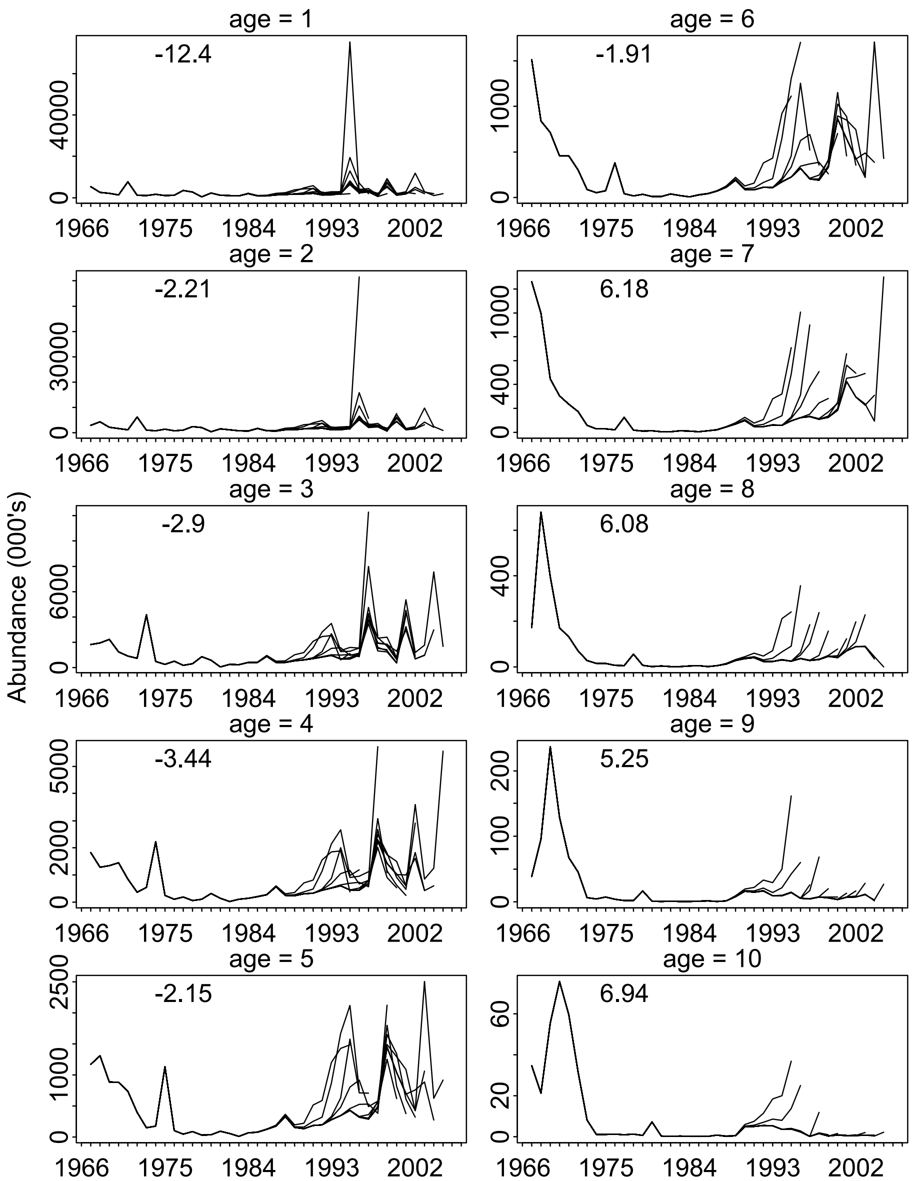

Figure 20: Retrospective plots of abundance-at-age estimates based on catches perturbed to reduce the SSB ρ statistic. The abundance ρ statistic is shown in the top left-hand corner of each panel.

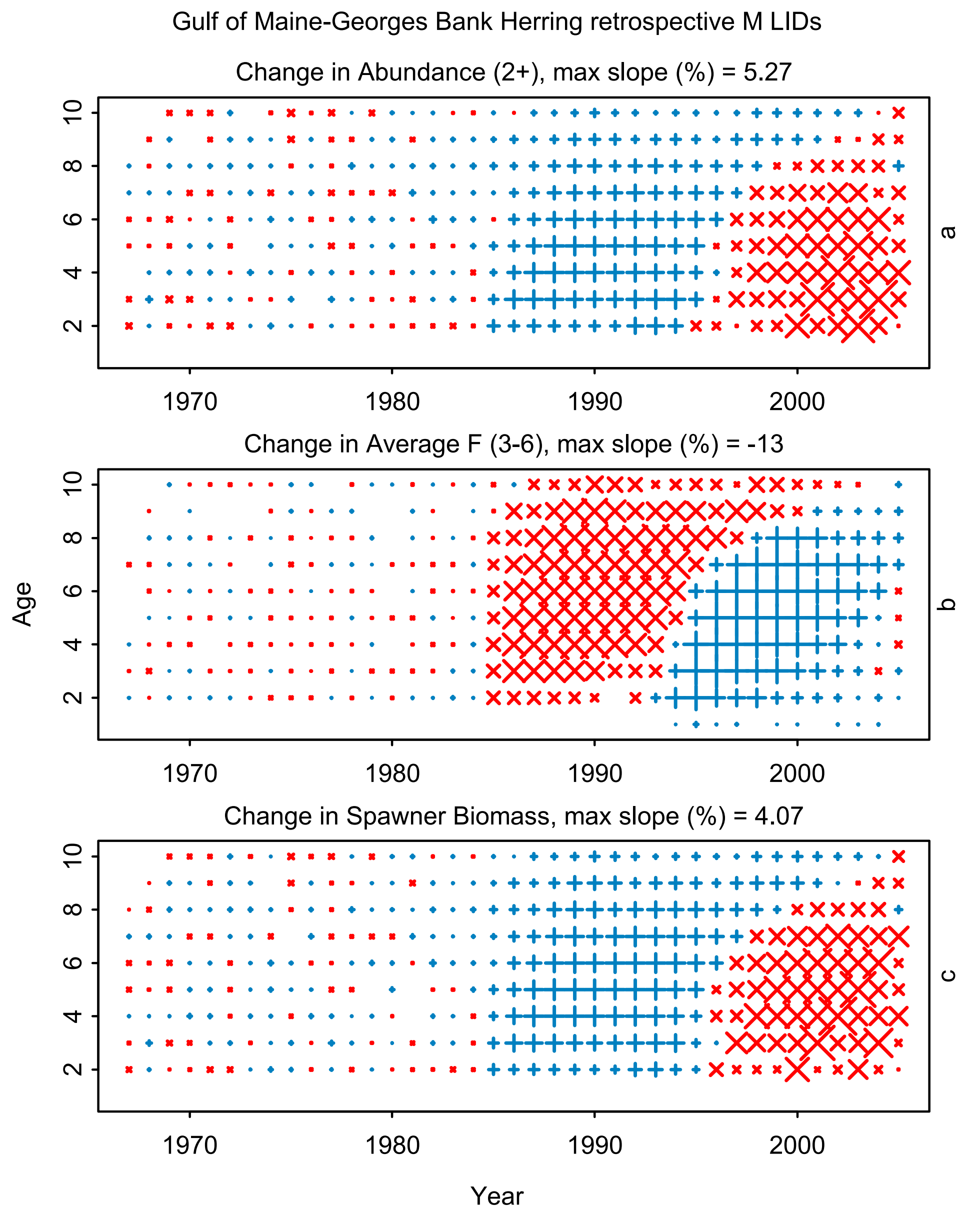

Figure 21: M local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

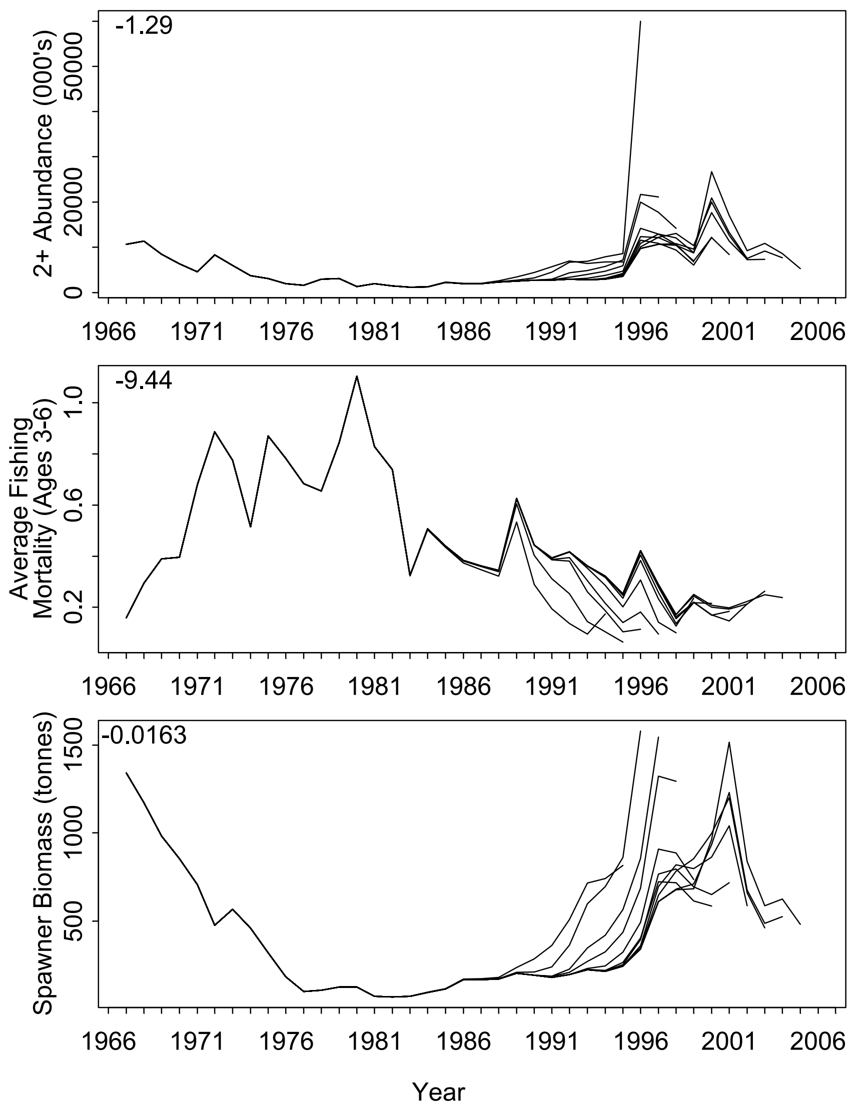

Figure 22: Retrospective estimates based on SSB $d_{\max}$ perturbed M's with $h = -12.7$. The value of ρ is shown in the top left-hand corner. Top panel: N_{2+}; middle panel: $\bar{F}$; bottom panel: SSB.

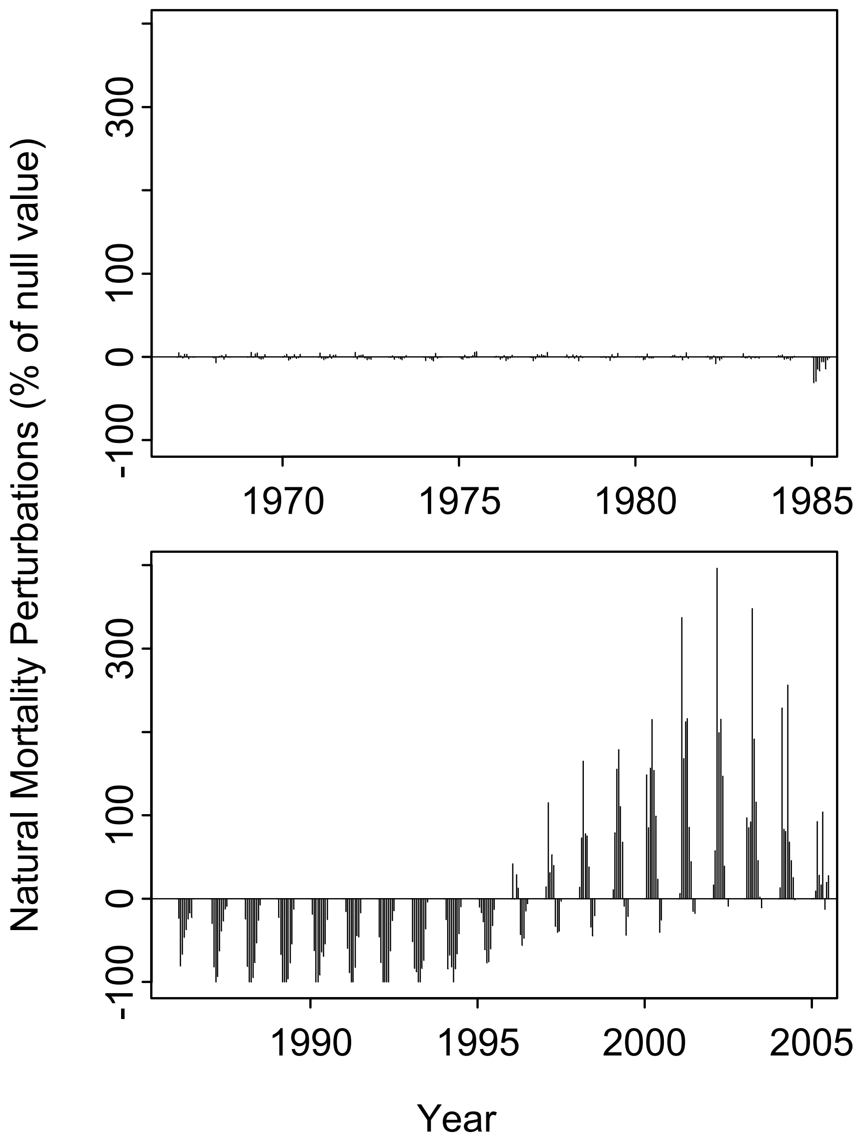

Figure 23: M perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to M for that age and year. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 12.7$.

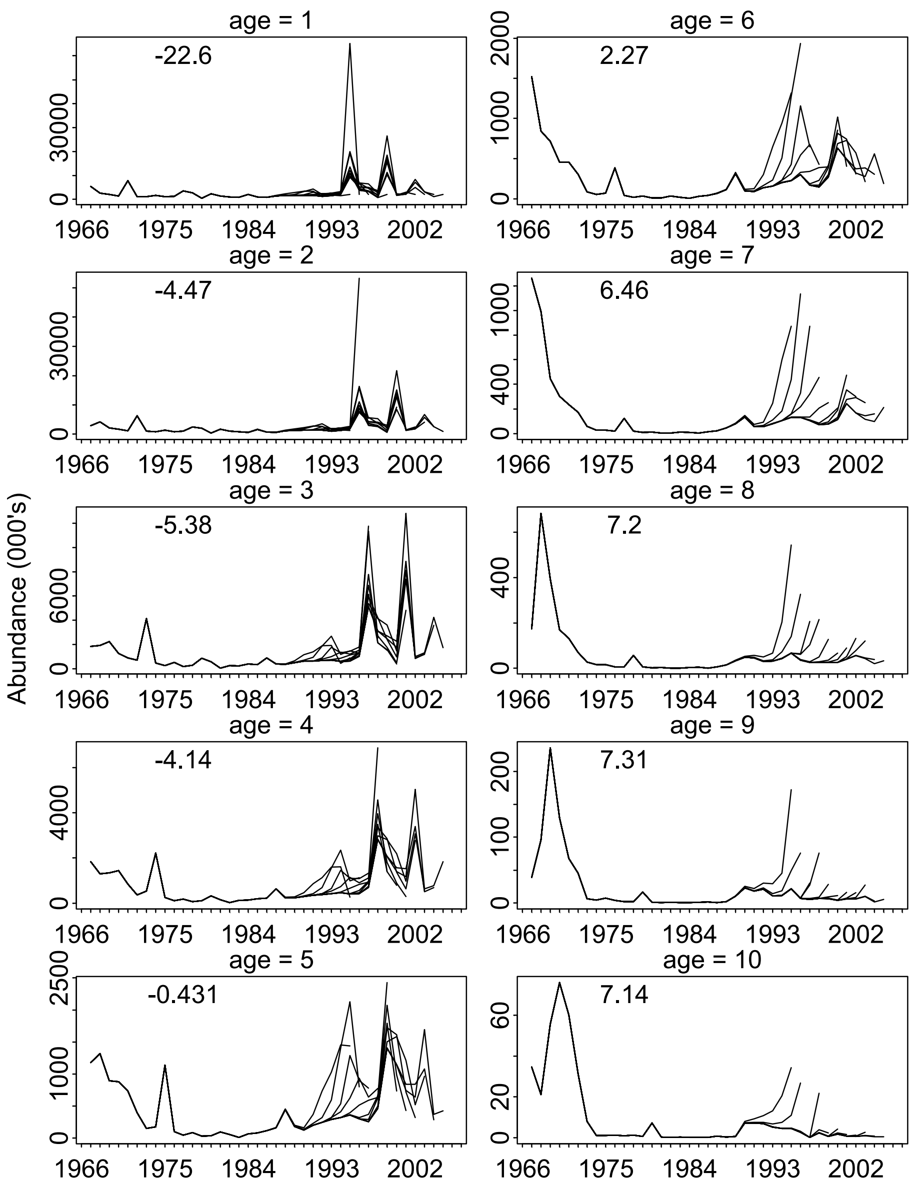

Figure 24: Retrospective plots of abundance-at-age estimates based on M's perturbed to reduce the SSB ρ statistic. The abundance ρ statistic is shown in the top left-hand corner of each panel.

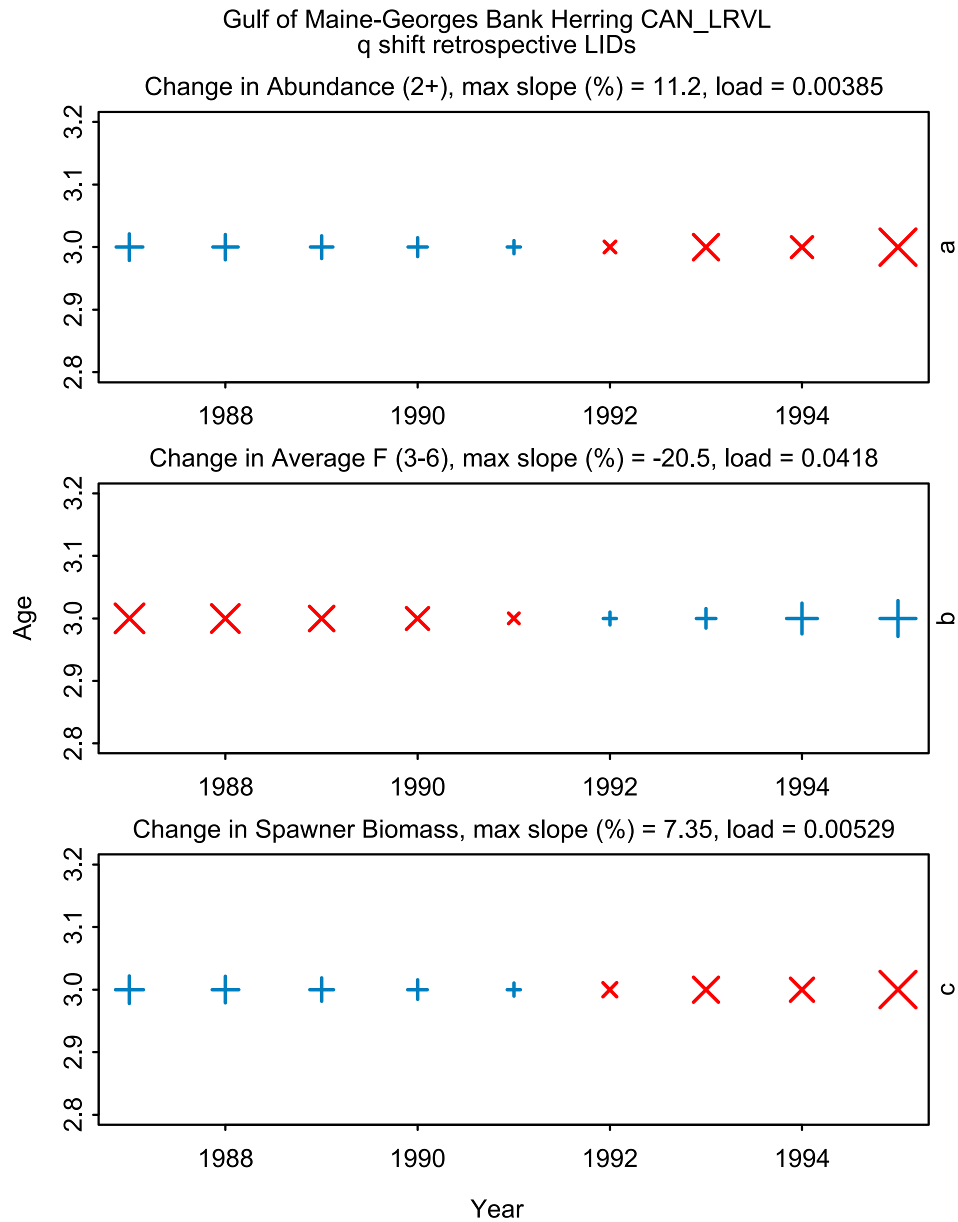

Figure 25: Canadian larval biomass index-catchability local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

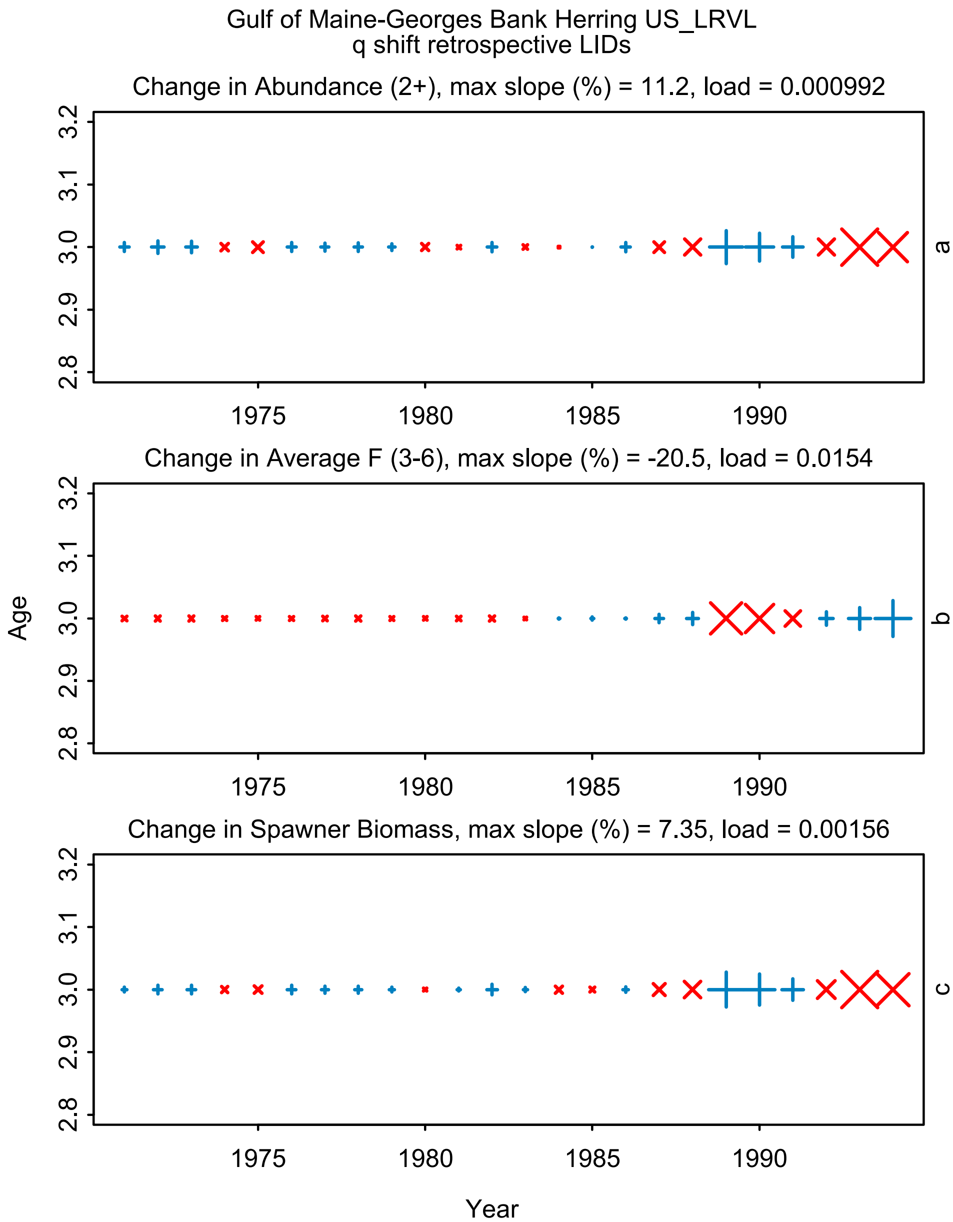

Figure 26: US larval biomass index-catchability local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

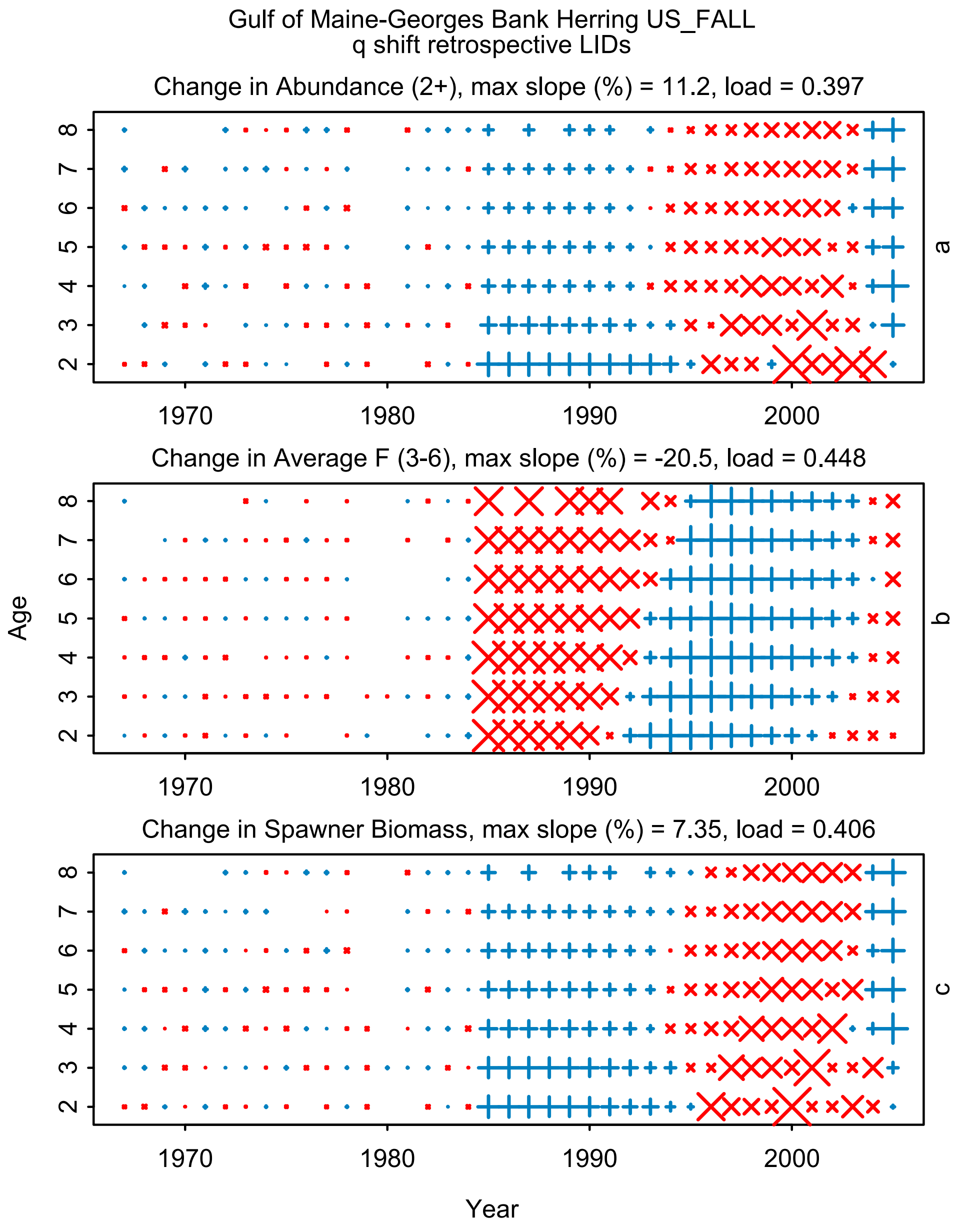

Figure 27: US fall survey-catchability local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

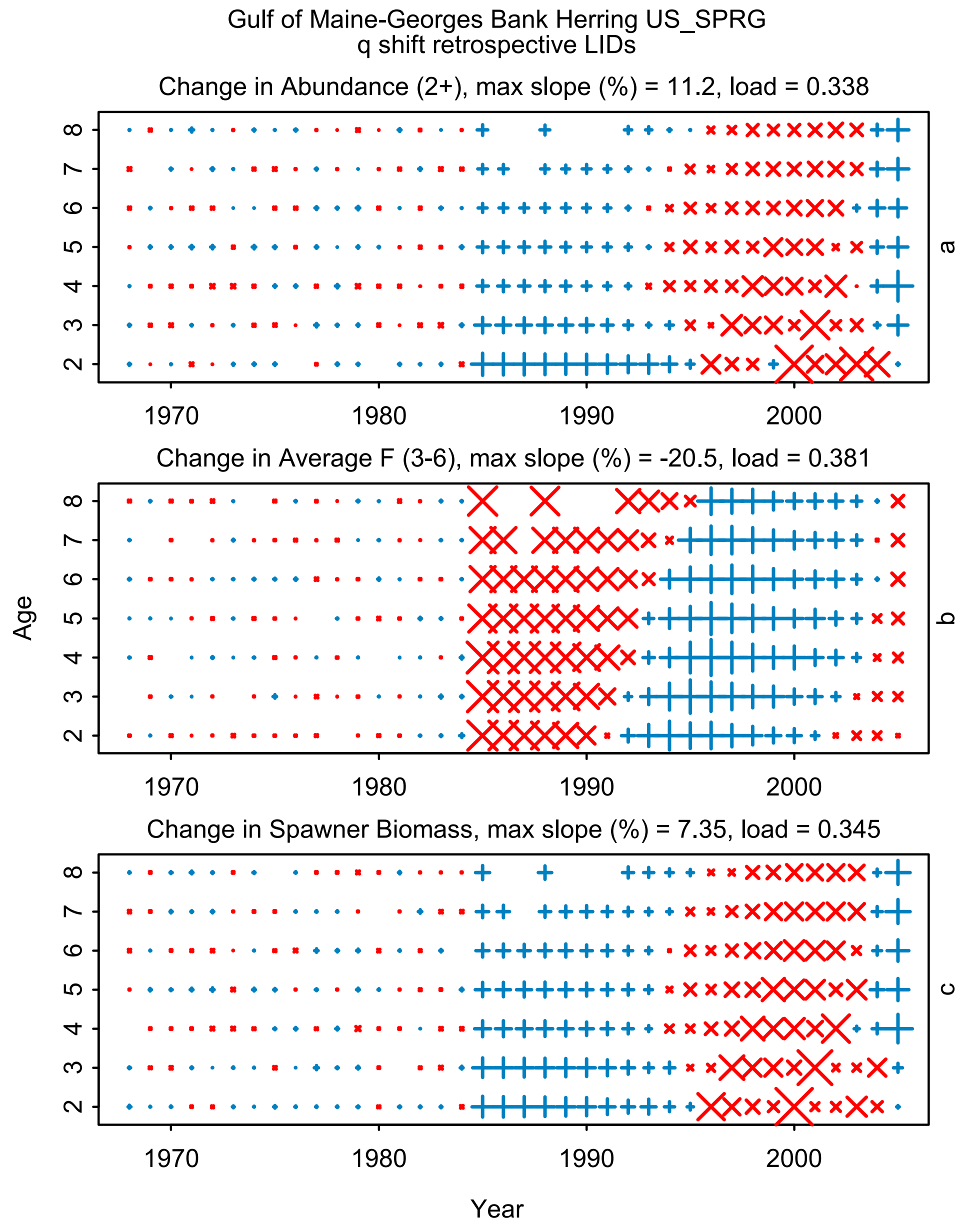

Figure 28: US spring survey-catchability local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

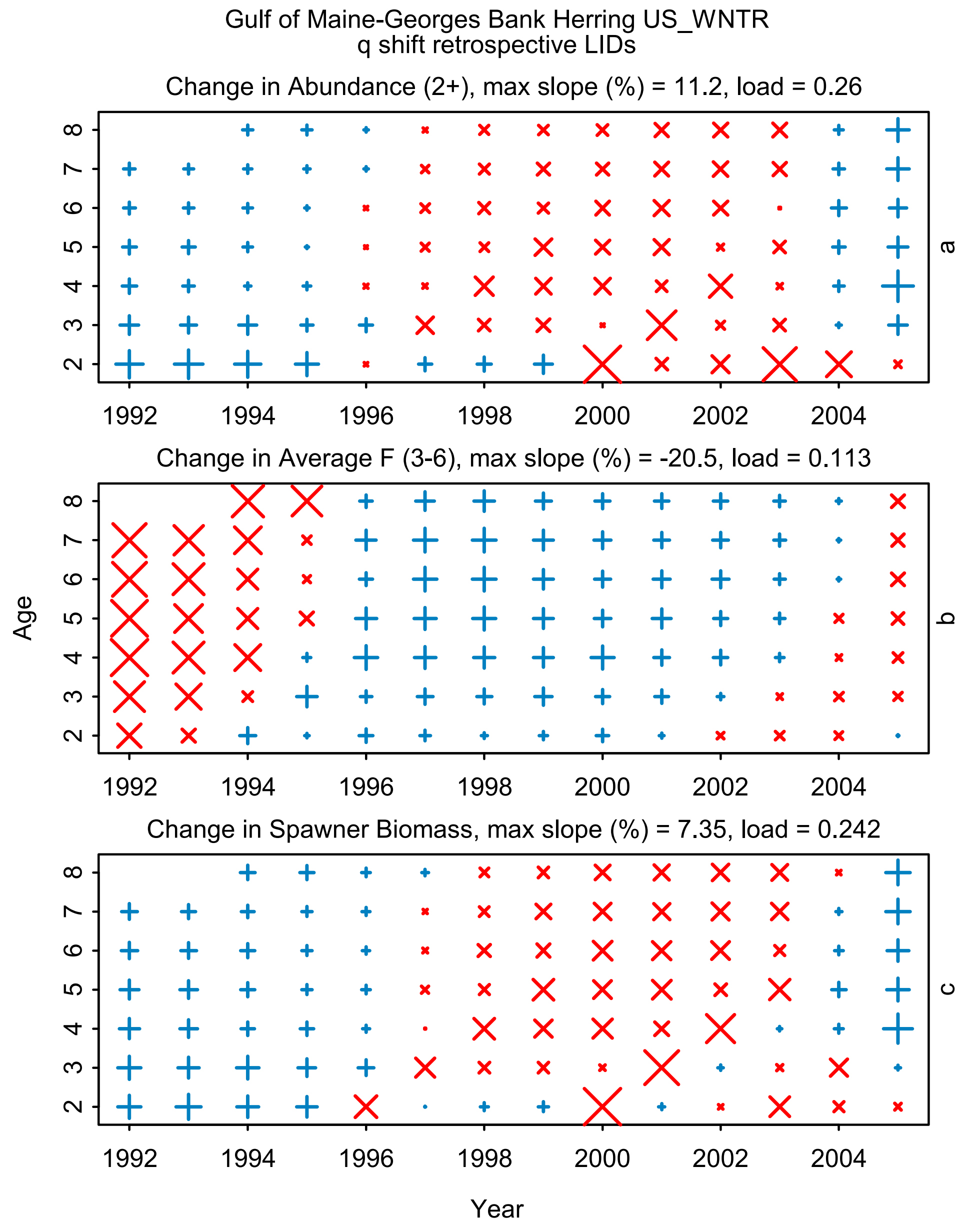

Figure 29: US wintersurvey-catchability local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

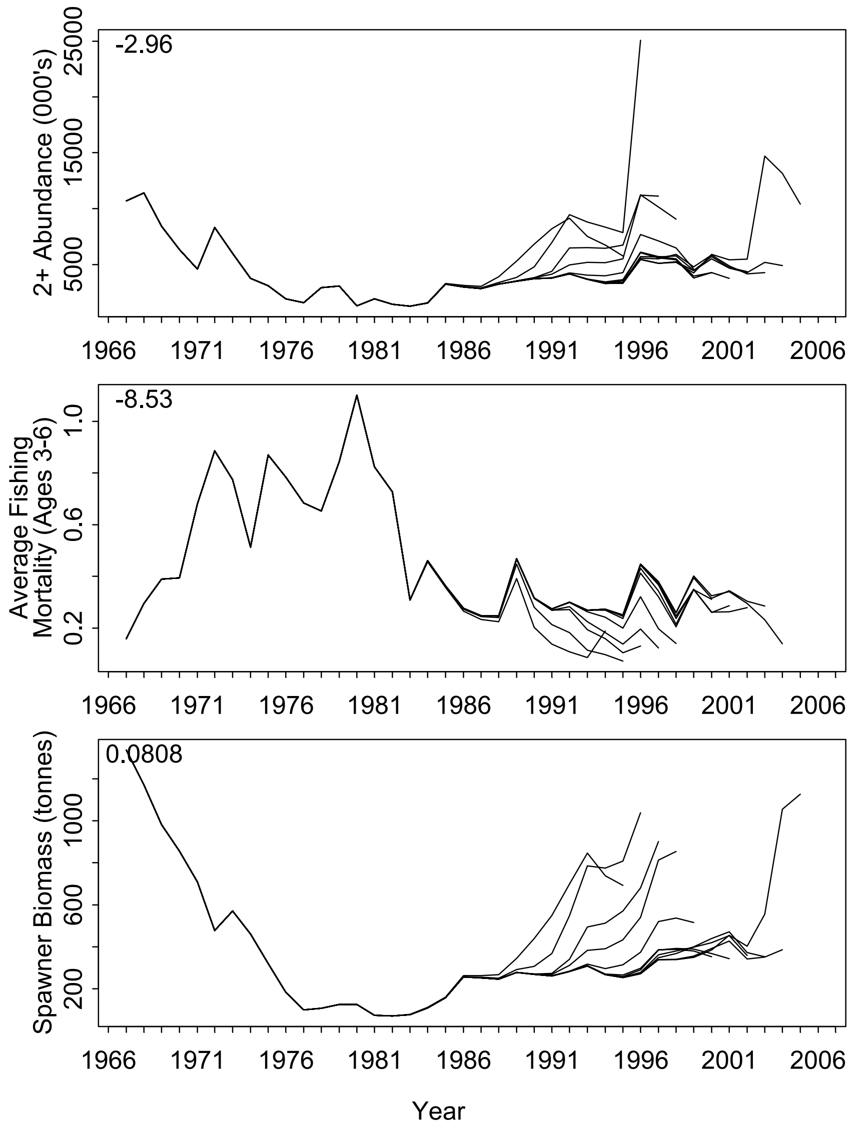

Figure 30: Retrospective estimates based on SSB $d_{\max}$ perturbed survey catchabilities with $h = -7.6$. The value of ρ is shown in the top left-hand corner. Top panel: N_{2+}; middle panel: $\bar{F}$; bottom panel: SSB.

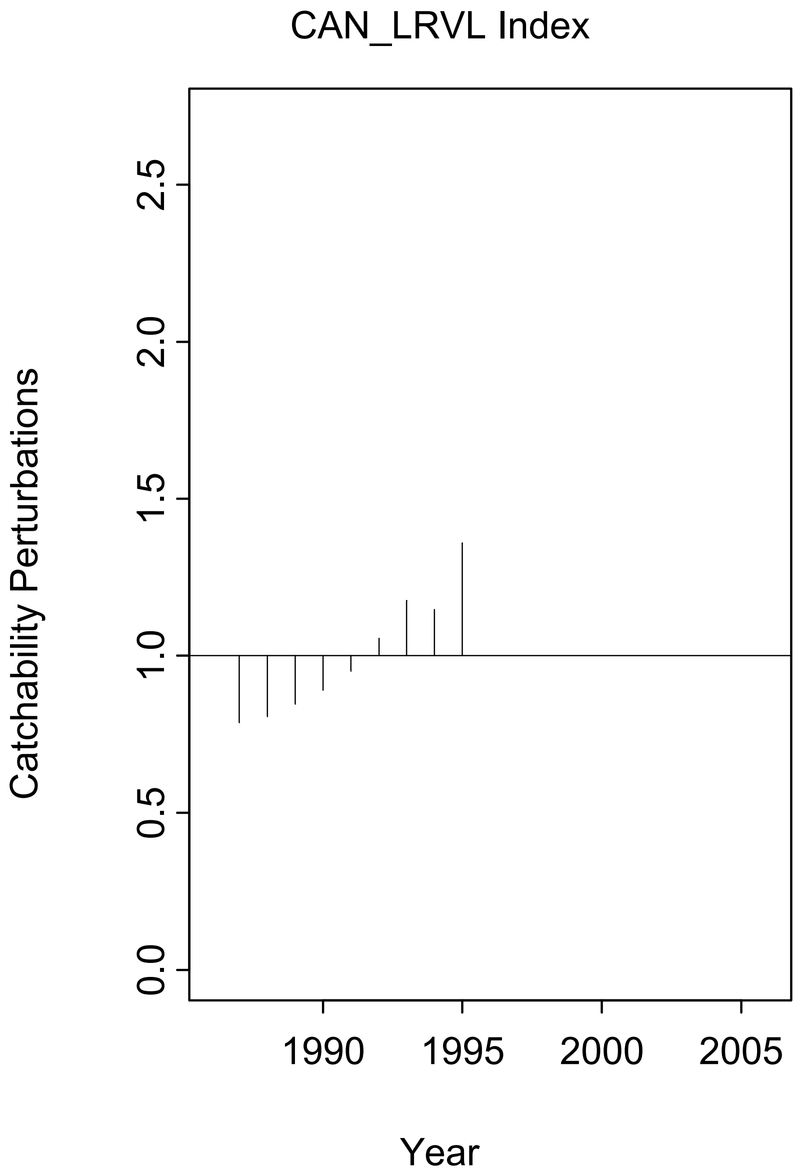

Figure 31: Canadian larval biomass index-catchability perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 7.6$.

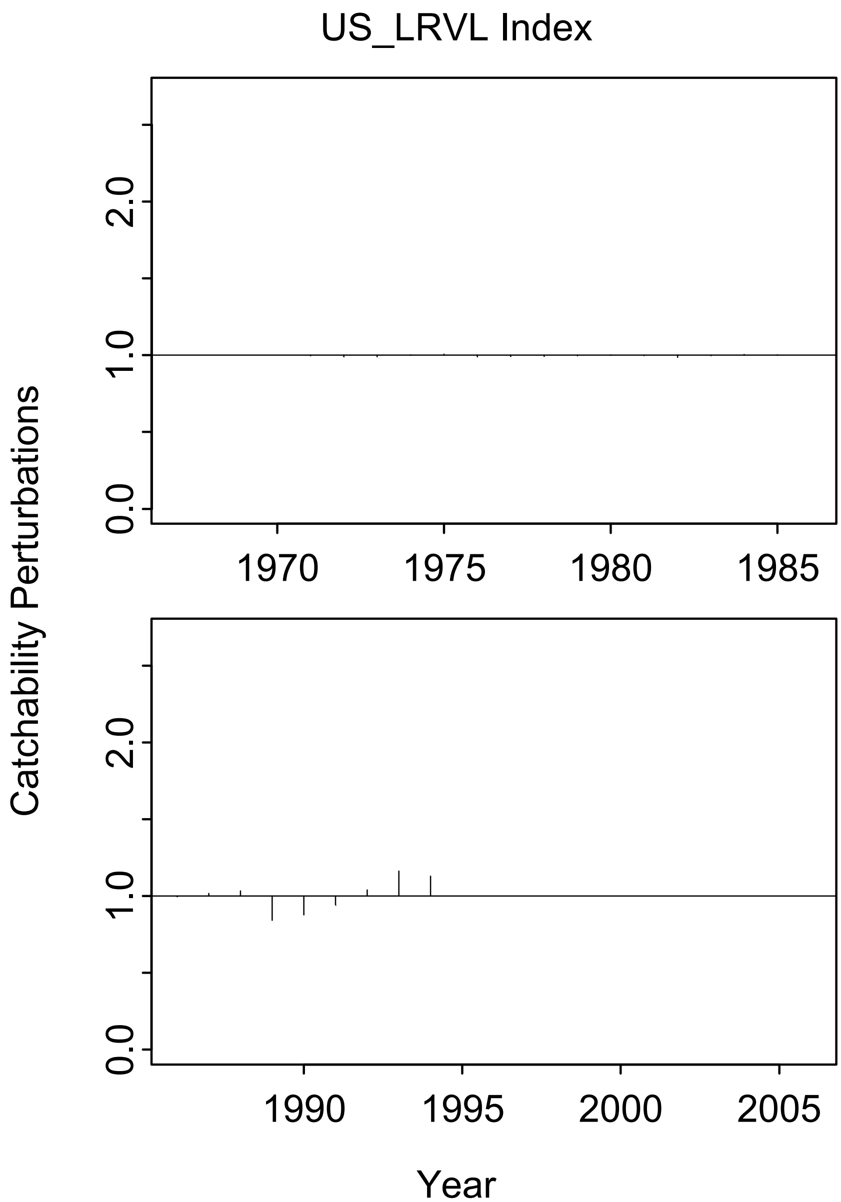

Figure 32: US larval biomass index-catchability perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 7.6$.

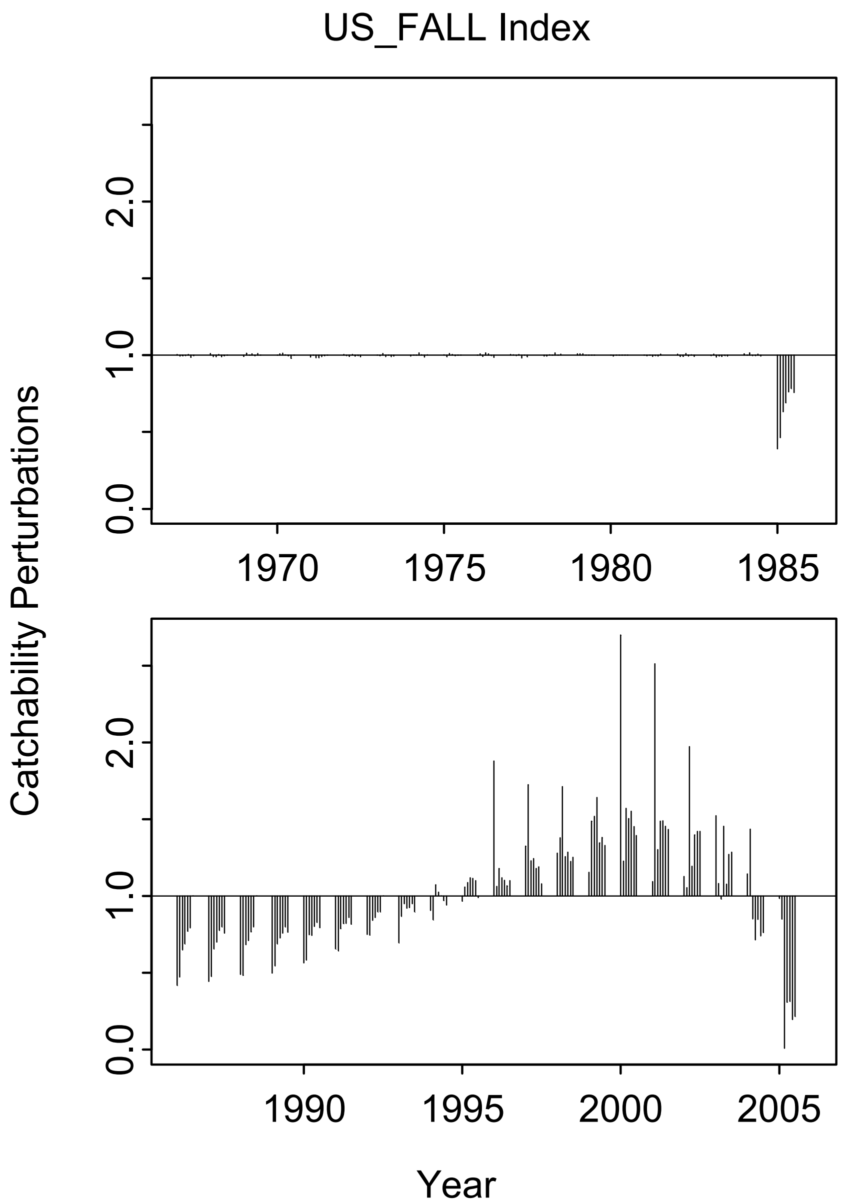

Figure 33: US fall survey-catchability perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 7.6$.

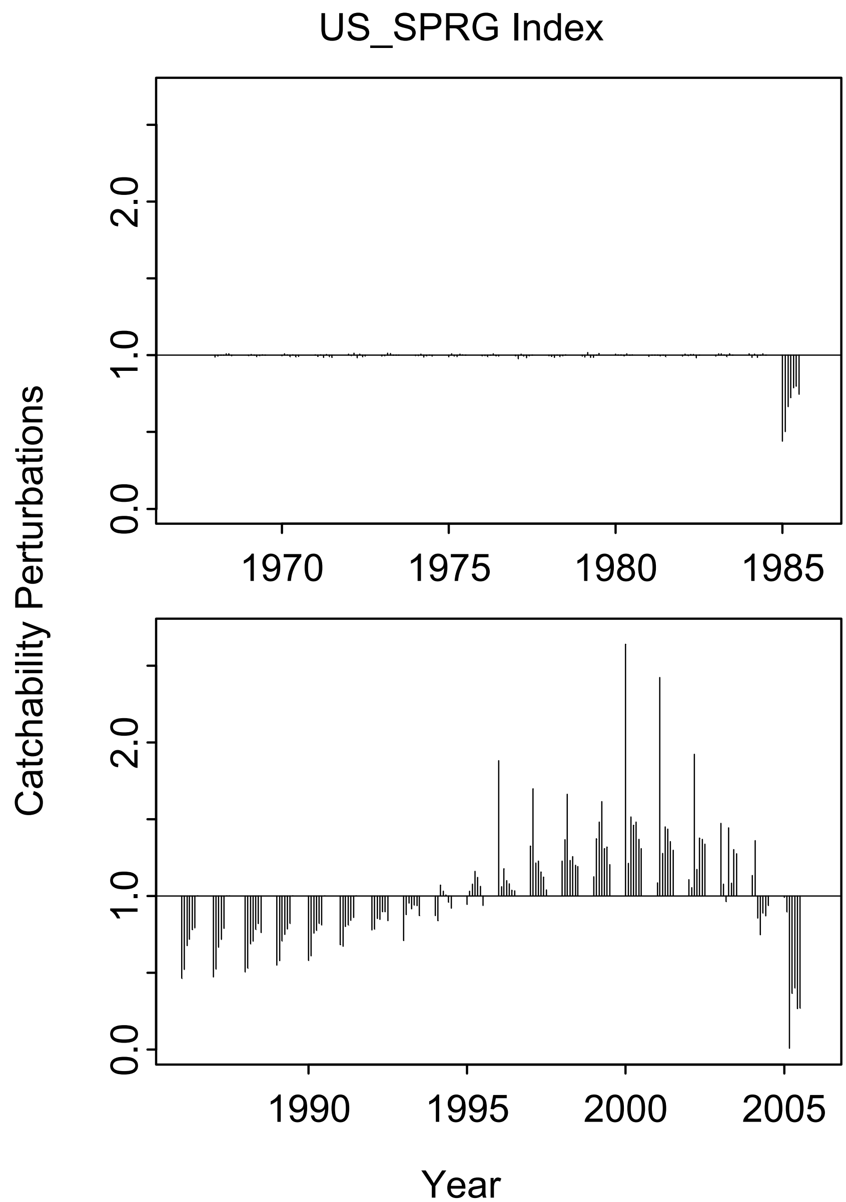

Figure 34: US spring survey-catchability perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 7.6$.

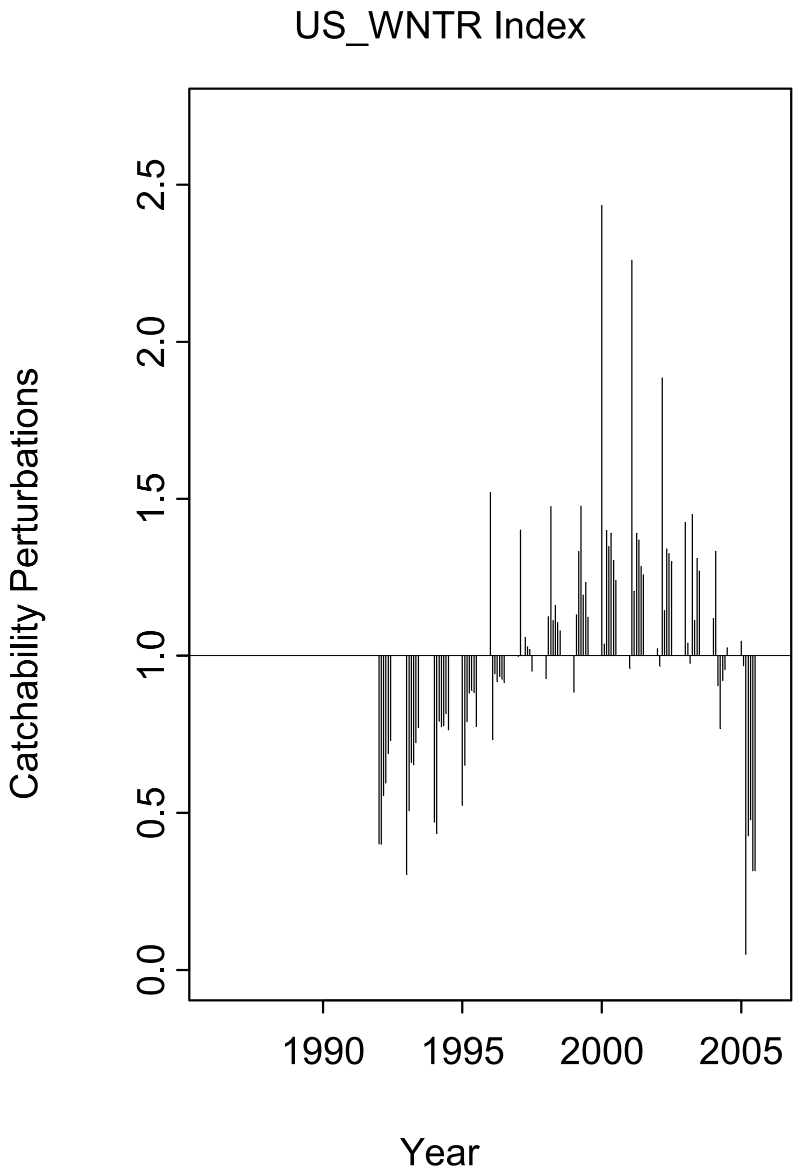

Figure 35: US winter survey-catchability perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 7.6$.

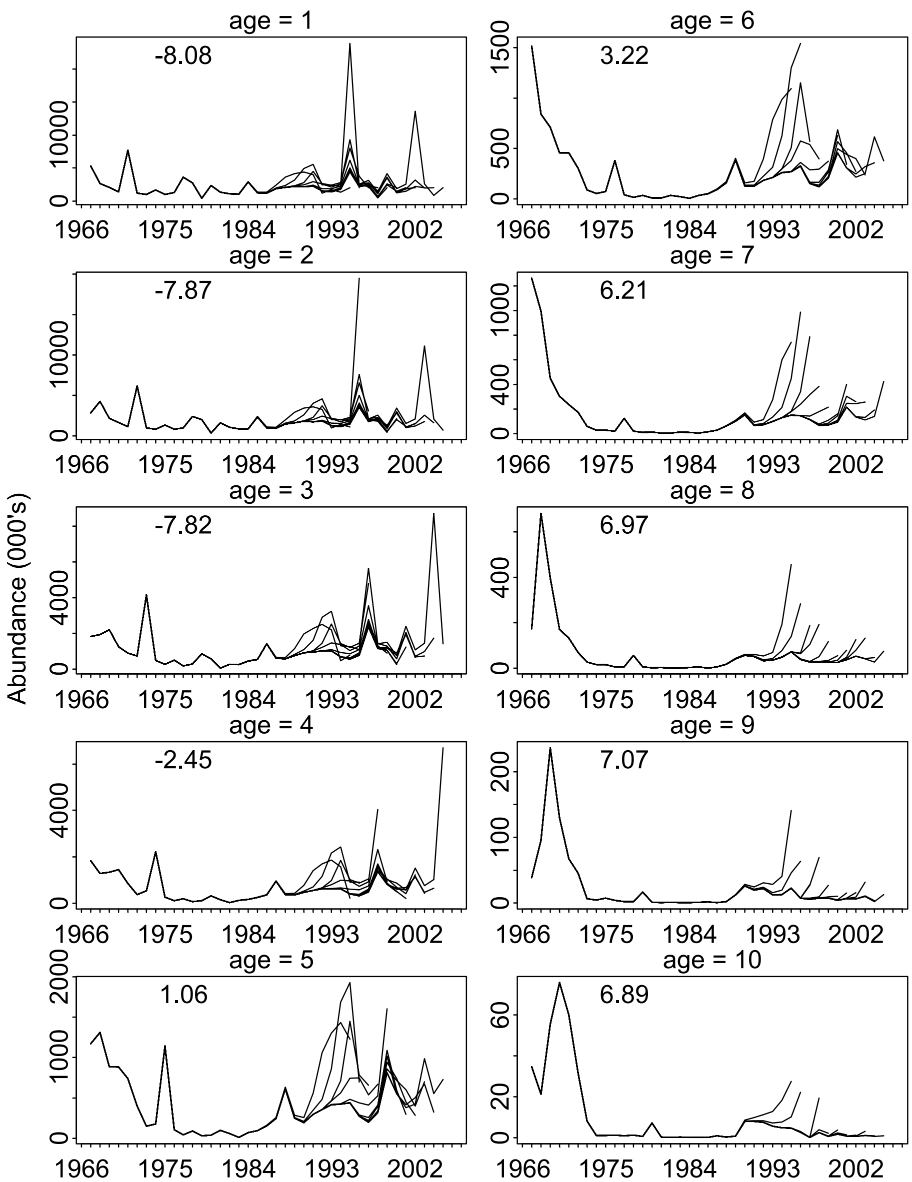

Figure 36: Retrospective plots of abundance-at-age estimates based on survey catchabilities perturbed to reduce the SSB ρ statistic. The abundance ρ statistic is shown in the top left-hand corner of each panel.

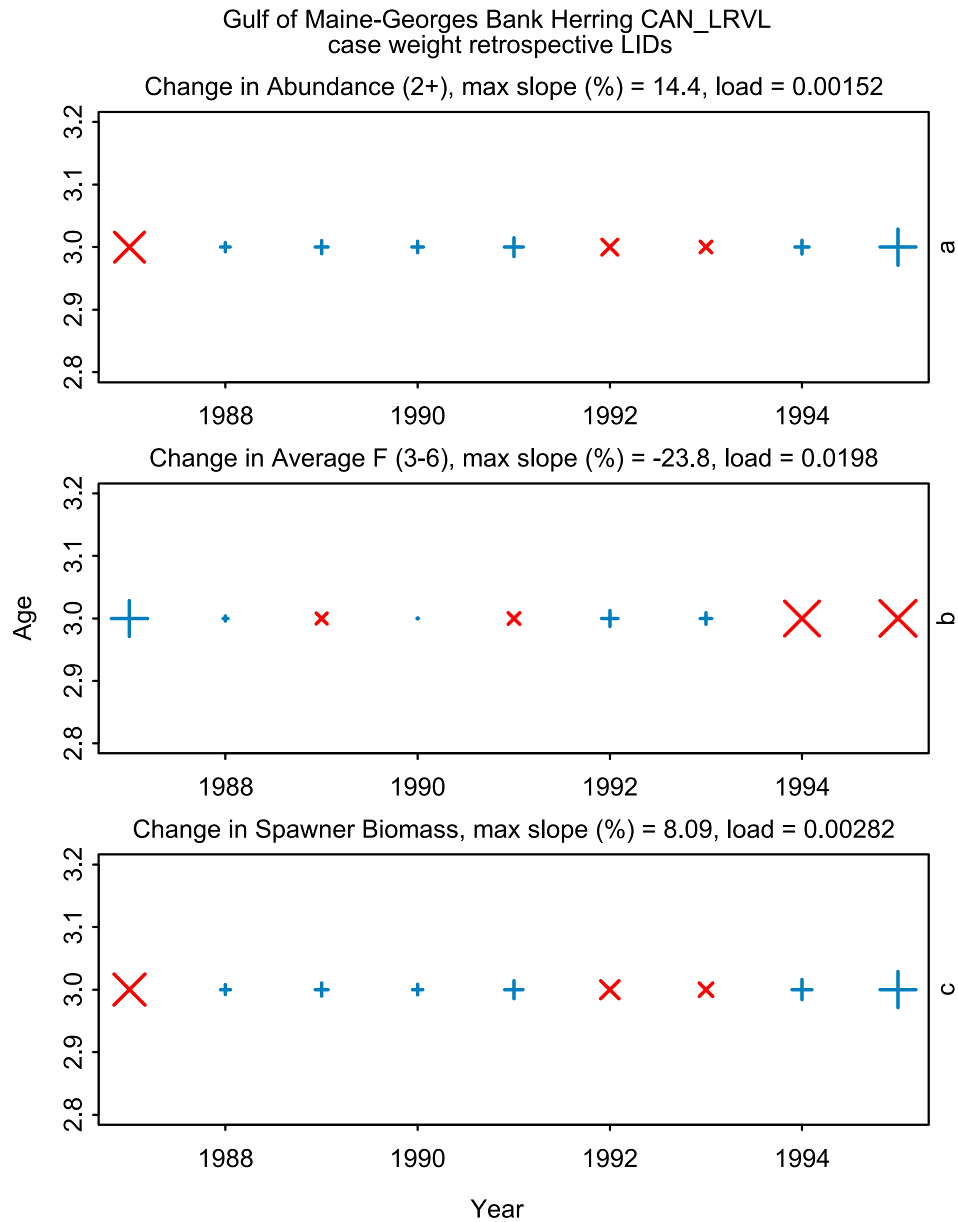

Figure 37: Canadian larval biomass index-case weight local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

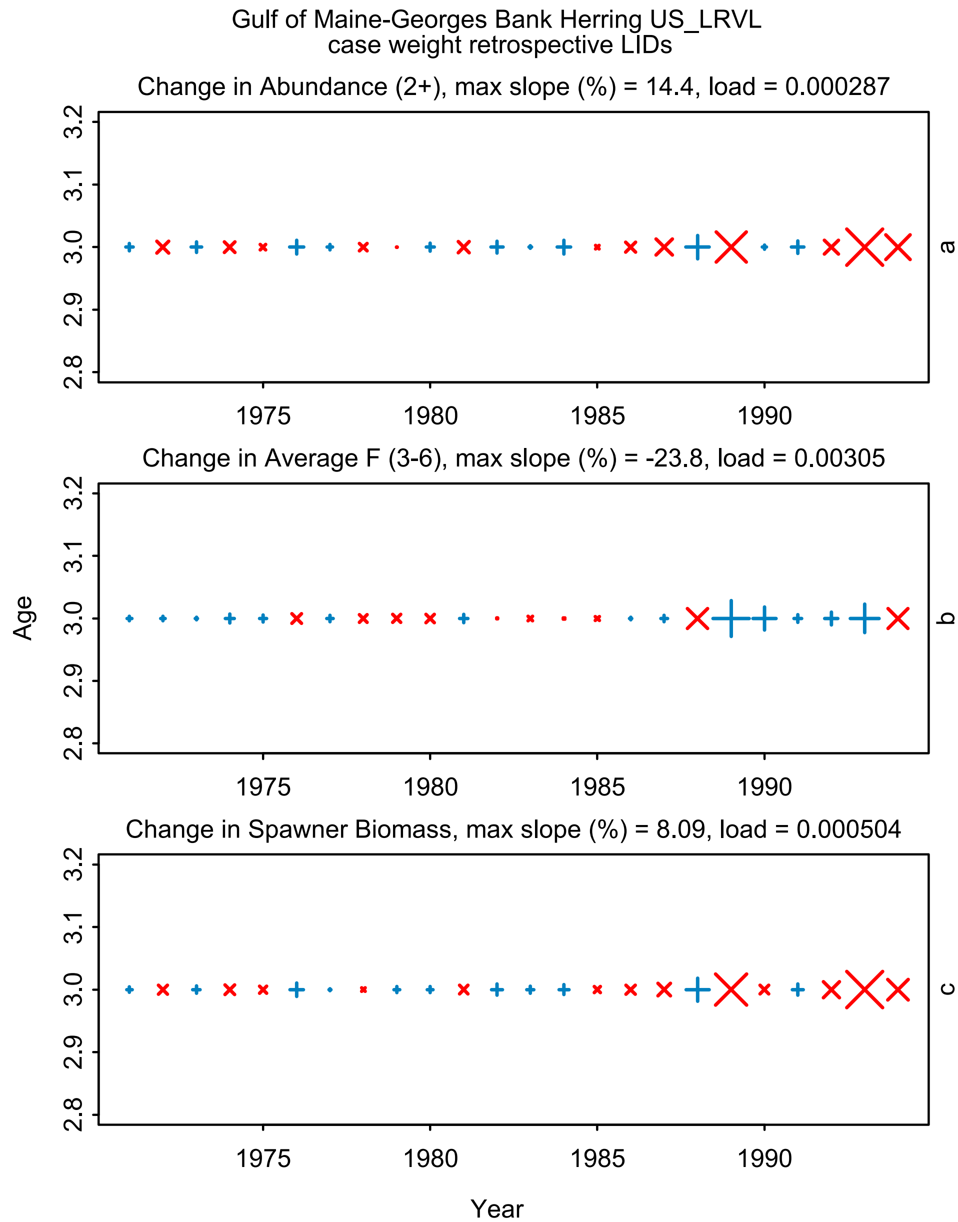

Figure 38: US larval biomass index-case weight local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

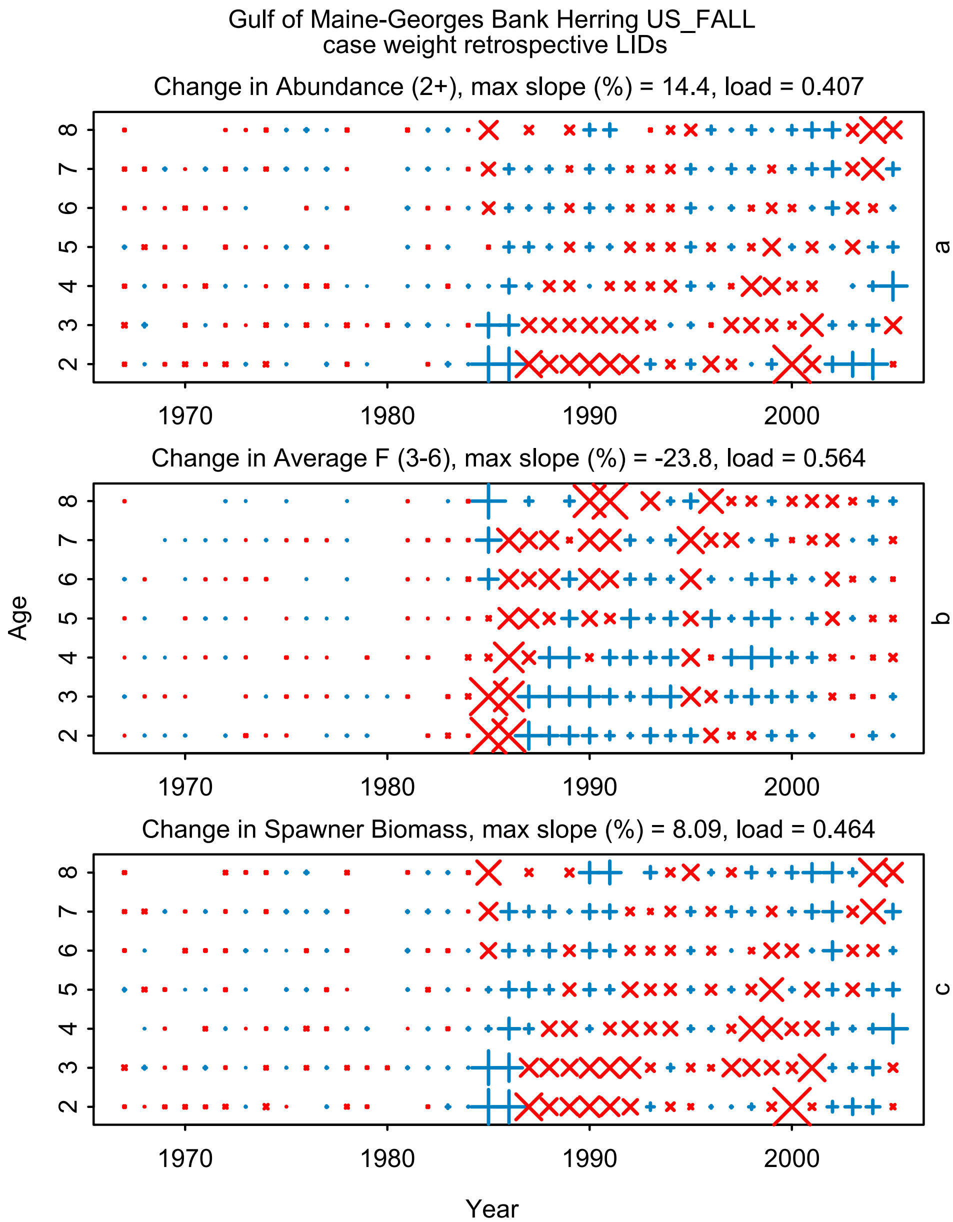

Figure 39: US fall survey-case weight local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

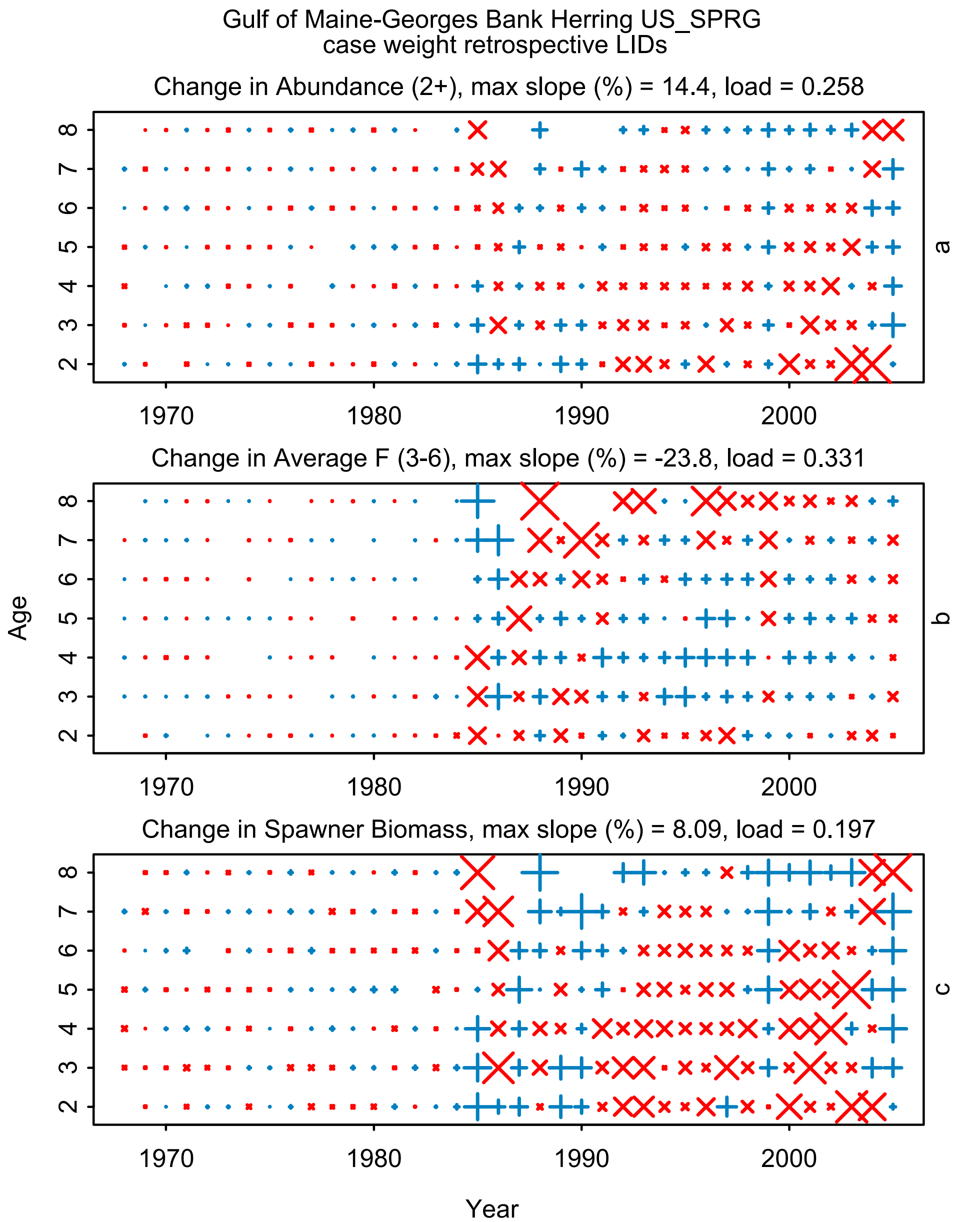

Figure 40: US spring survey-case weight local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

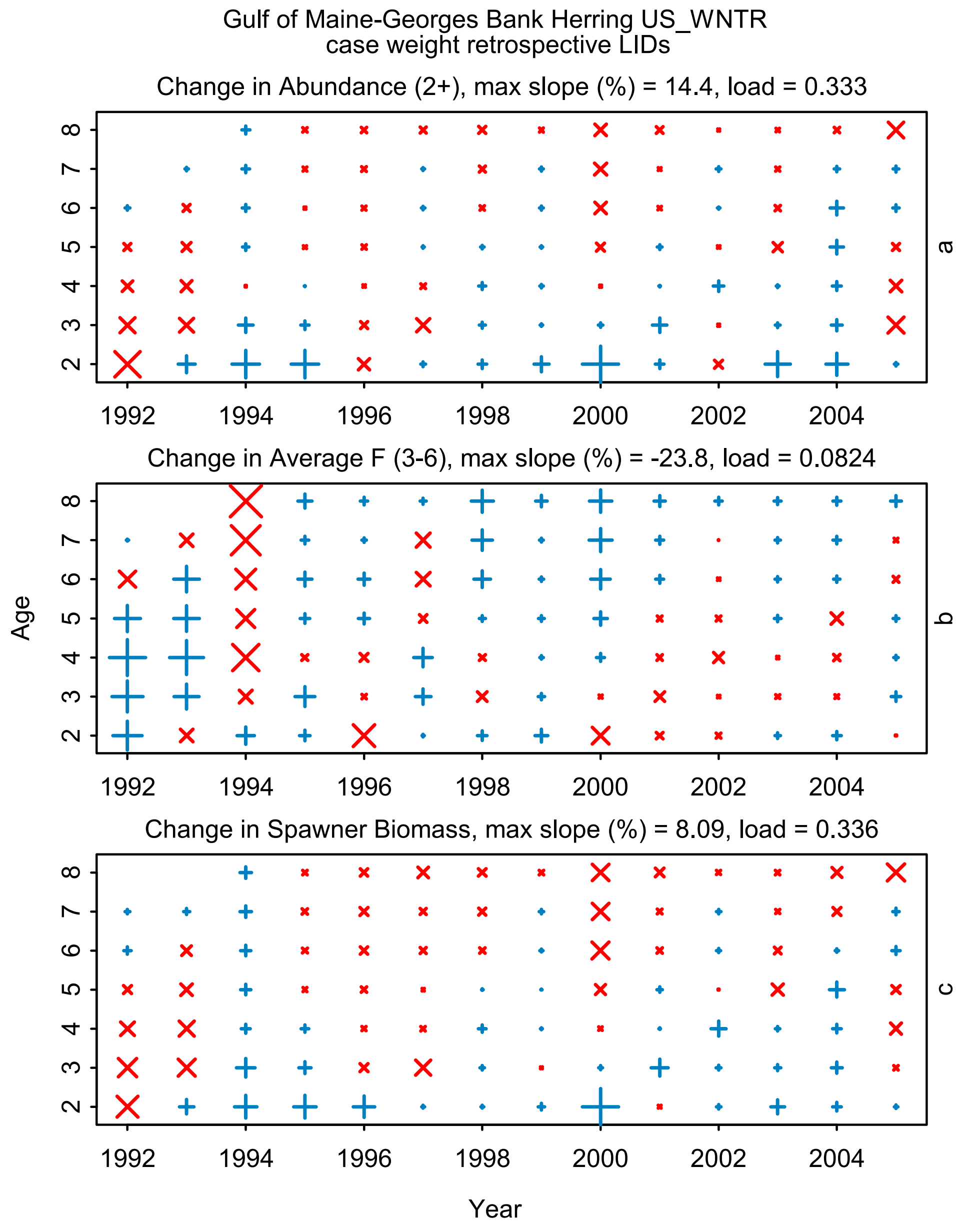

Figure 41: US wintersurvey-case weight local influence diagnostics (LID's) for ρ. Each panel shows the elements of $d_{\max}$. The size and type of the plotting symbols are proportional to the absolute value and sign of the elements, respectively. Negative is denoted by an $\times$. Panel a: N_{2+}; Panel b: $\bar{F}$; Panel c: SSB. At the top of each panel $\dot{\rho}_{\max}$ is shown in percent of the ρ values in Figure 1.

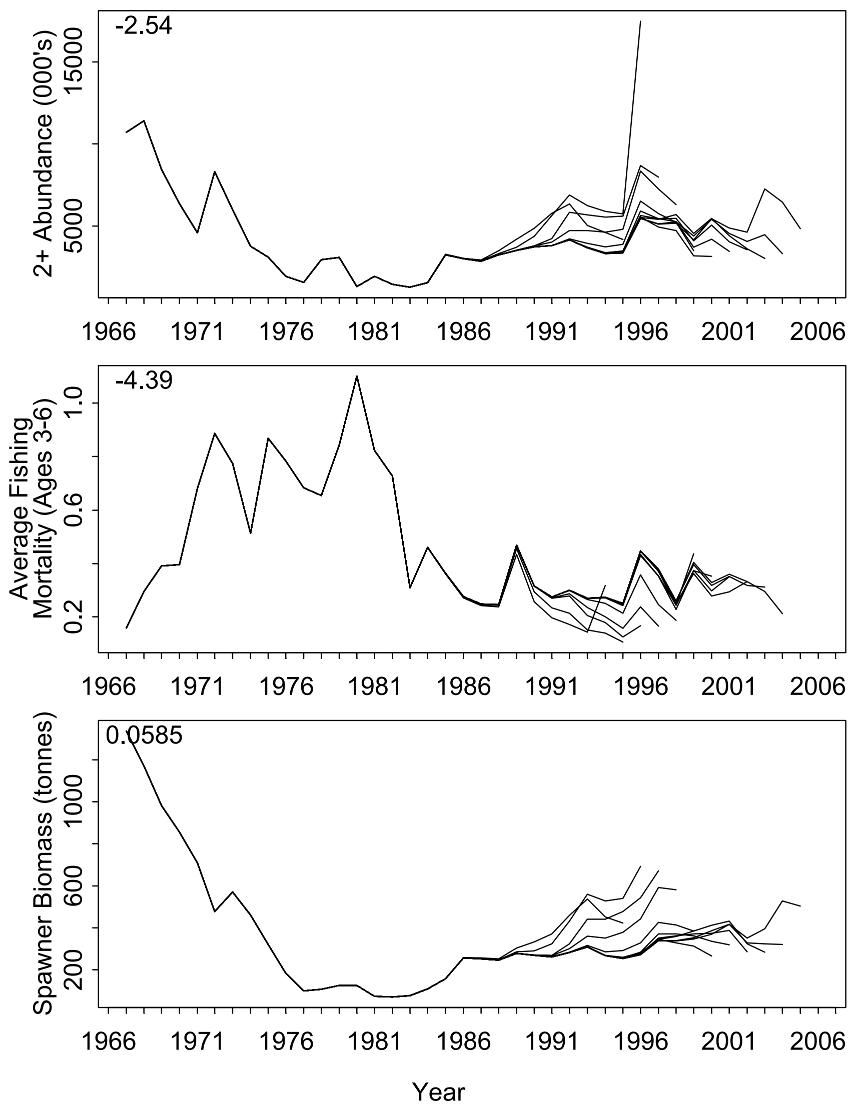

Figure 42: Retrospective estimates based on SSB $d_{\max}$ perturbed survey case weights with $h = -13.3$. The value of ρ is shown in the top left-hand corner. Top panel: N_{2+}; middle panel: $\bar{F}$; bottom panel: SSB.

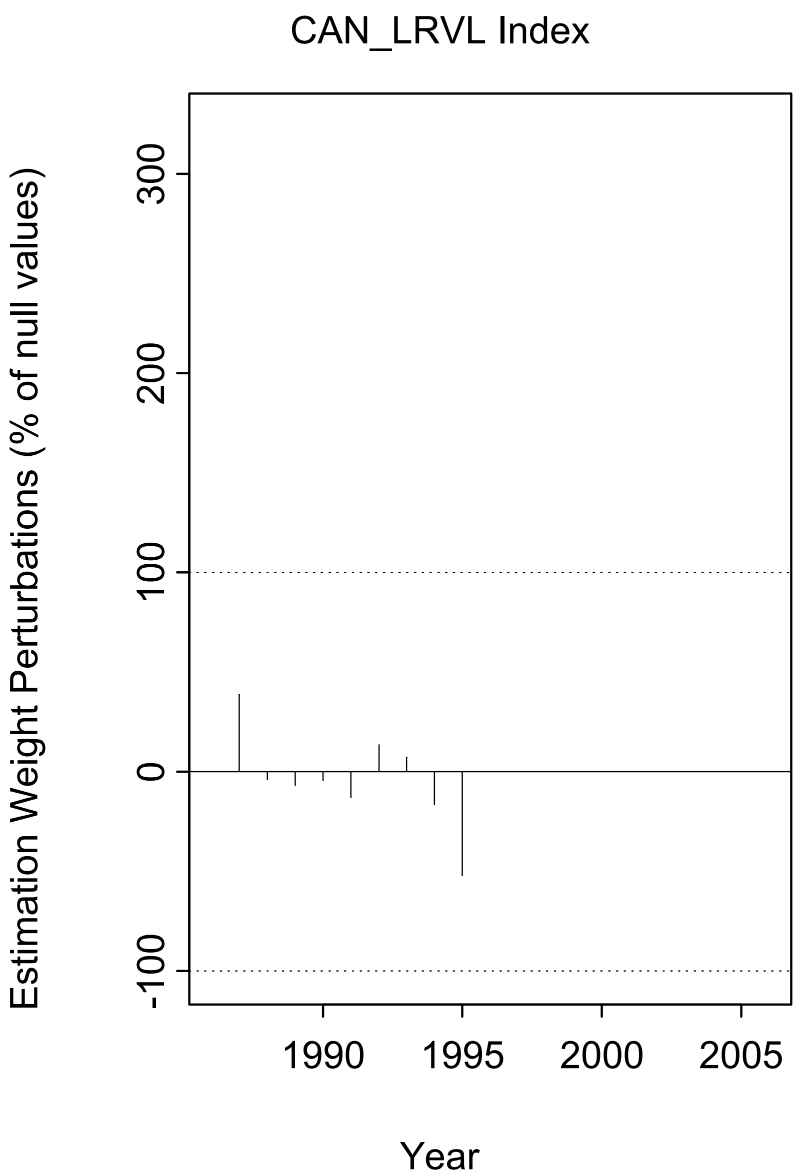

Figure 43: Canadian larval biomass index-case weight perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 13.3$.

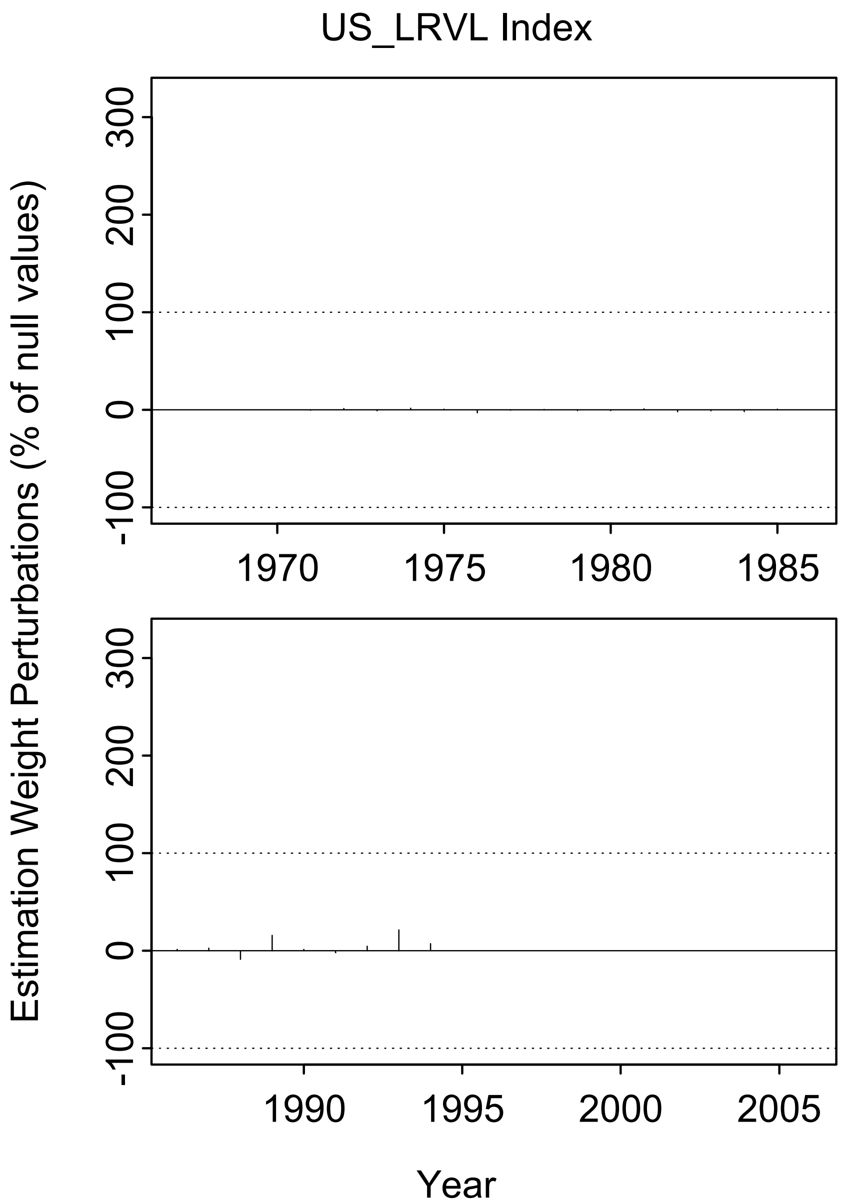

Figure 44: US larval biomass index-case weight perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 13.3$.

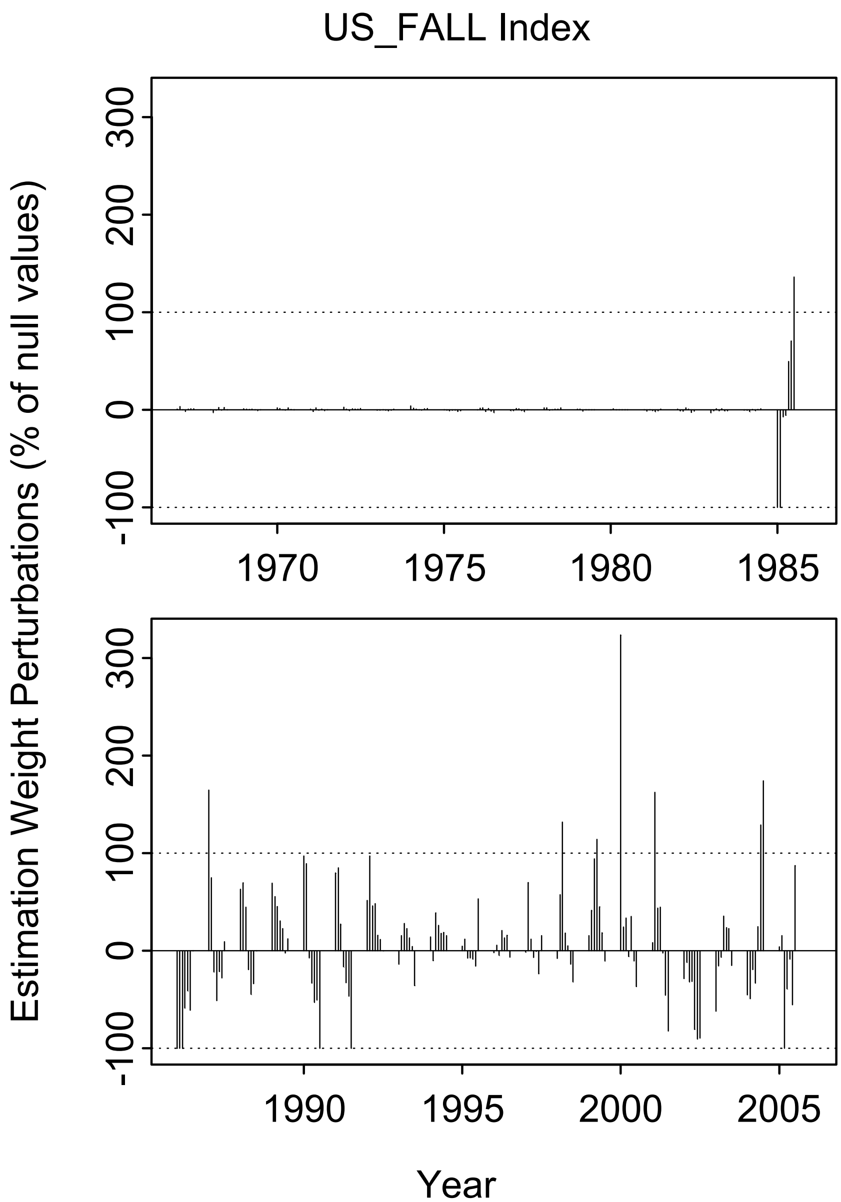

Figure 45: US fall survey-case weight perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 13.3$.

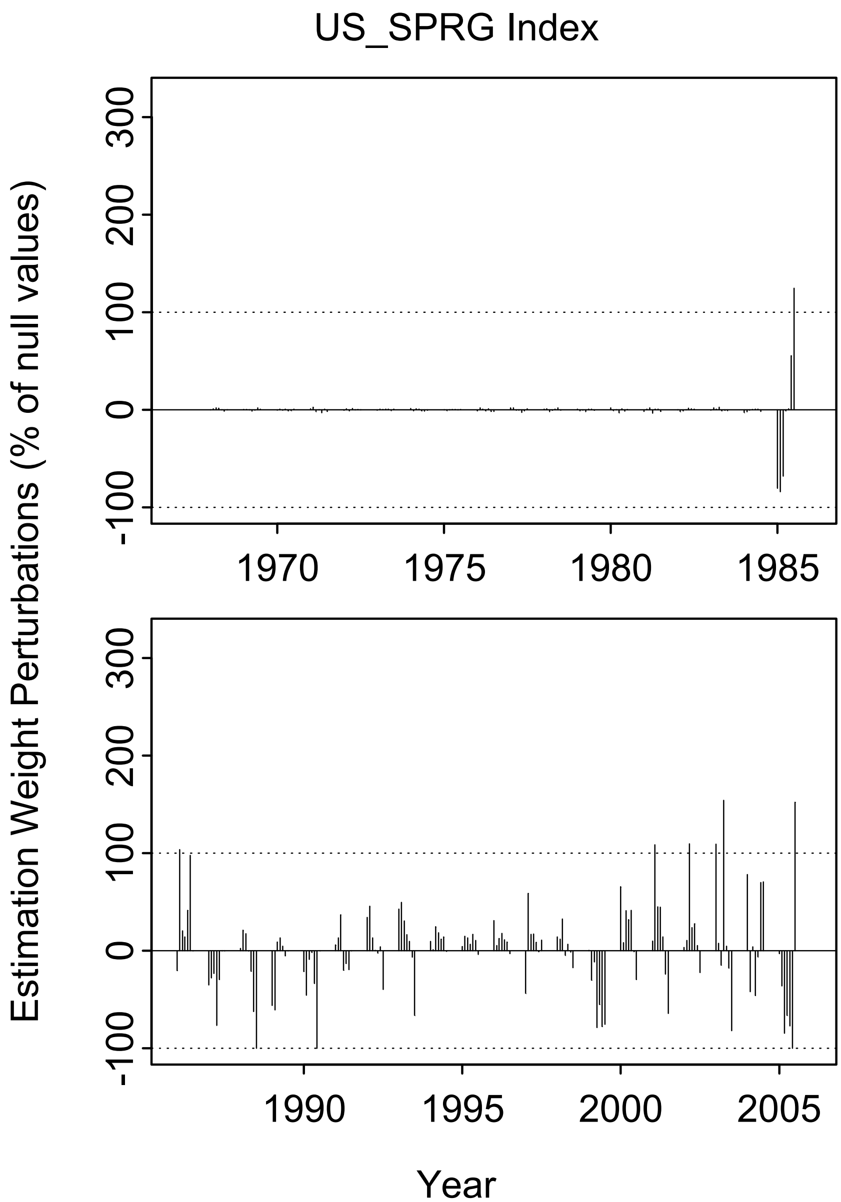

Figure 46: US spring survey-case weight perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 13.3$.

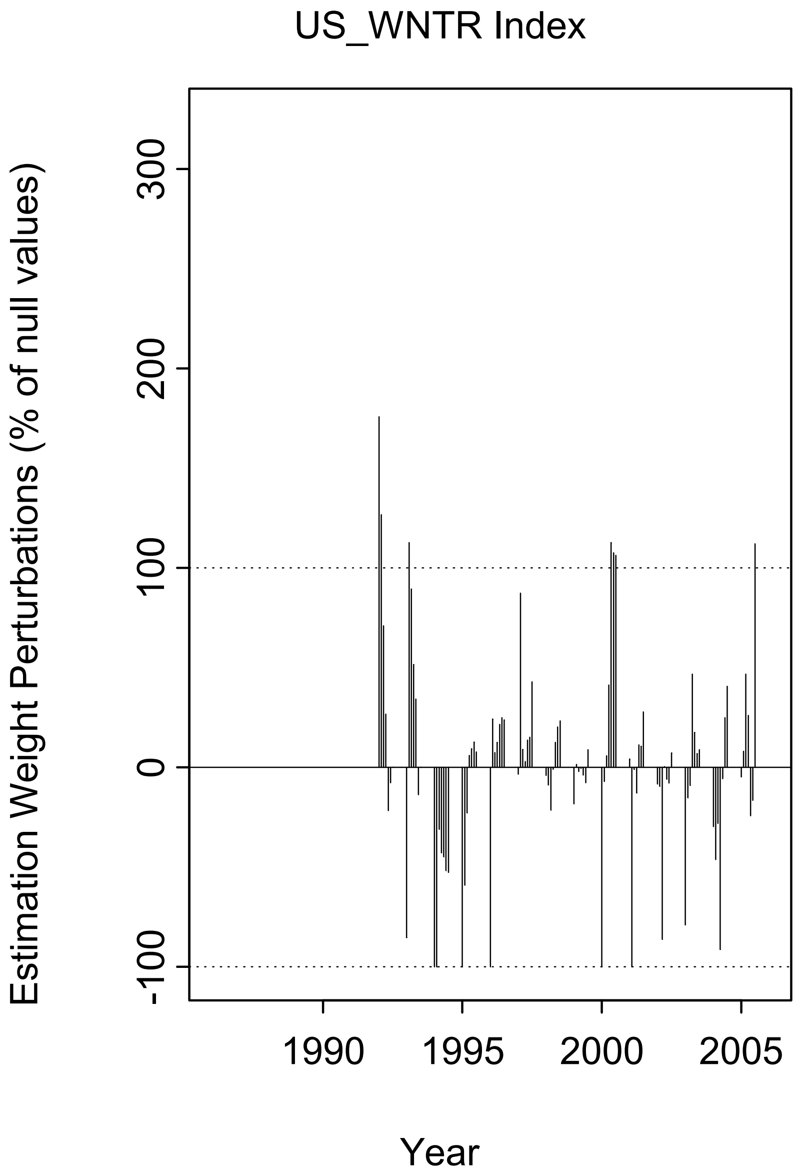

Figure 47: US winter survey-case weight perturbations to reduce the retrospective pattern in SSB. Each vertical line shows the perturbation to q. Perturbations are clustered by year and shown sequentially for ages 1-10. The values are $-h \times d_{\max}$ in percent with $h = 13.3$.

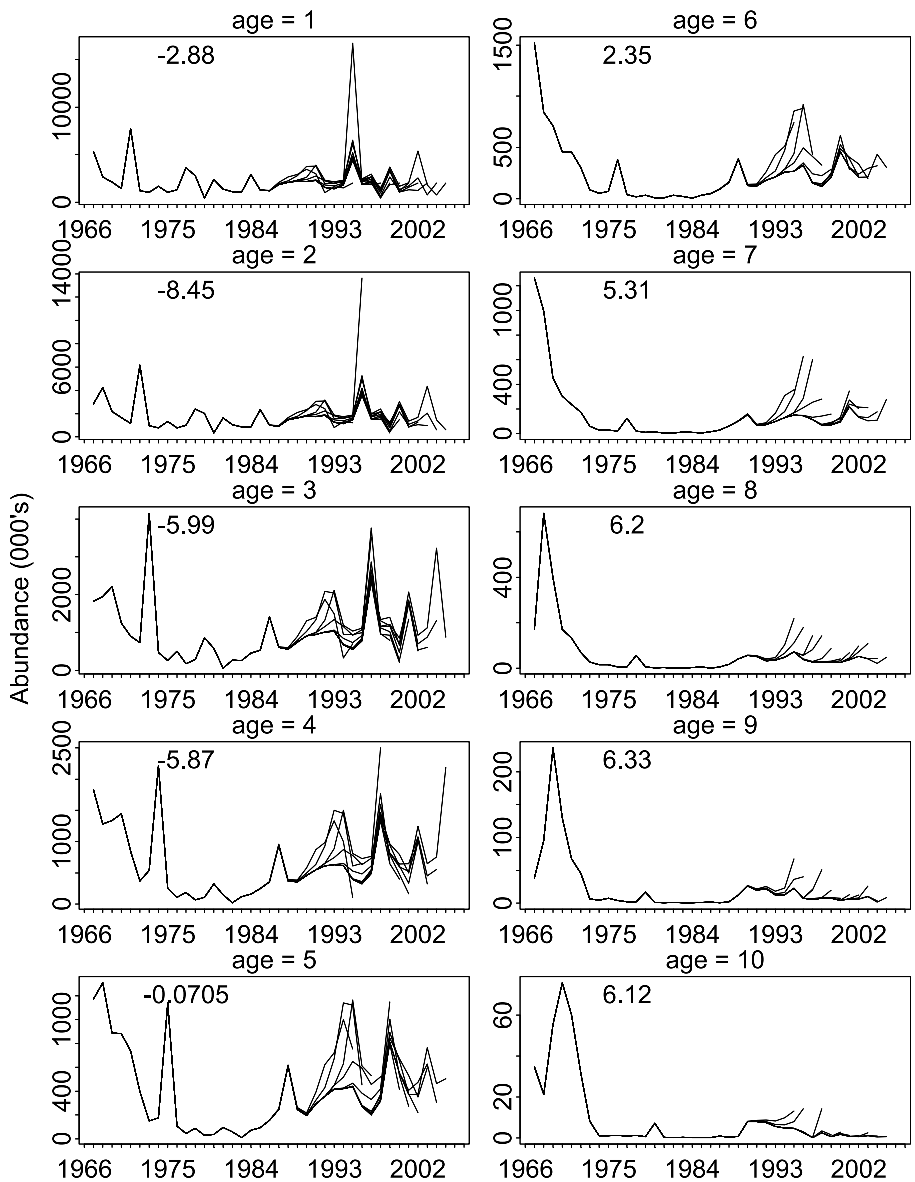

Figure 48: Retrospective plots of abundance-at-age estimates based on survey case weightd perturbed to reduce the SSB ρ statistic. The abundance ρ statistic is shown in the top left-hand corner of each panel.

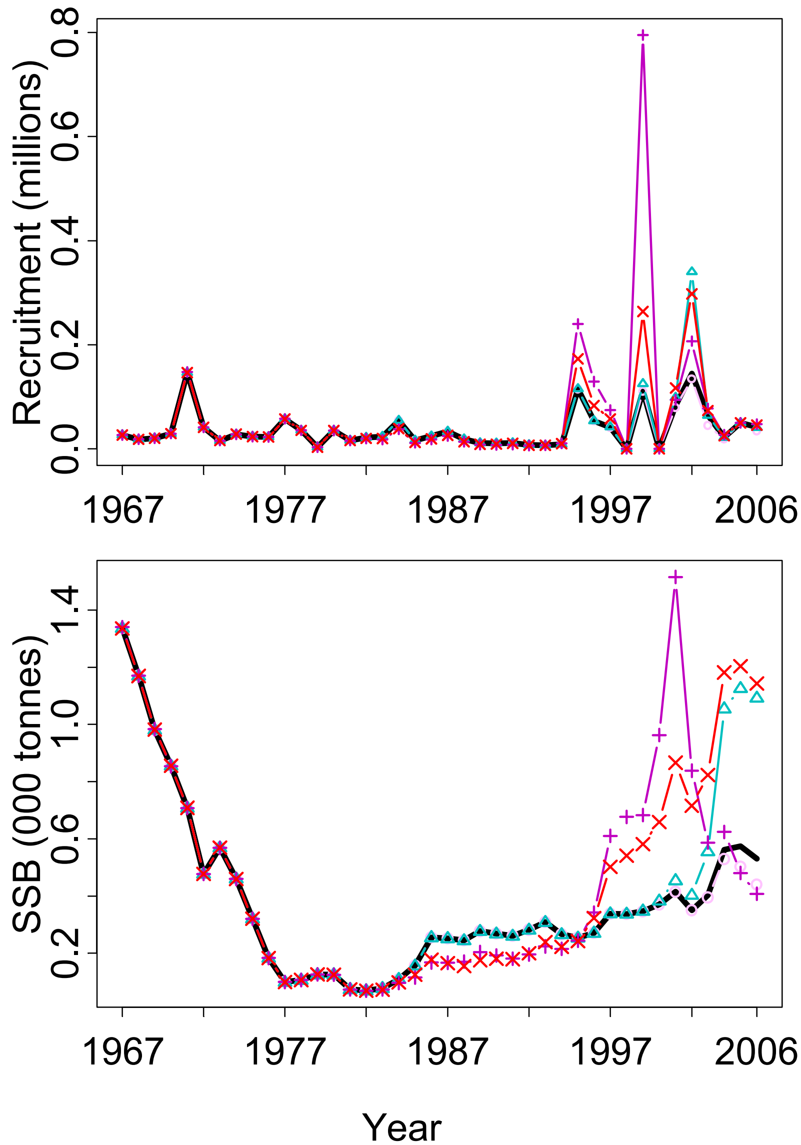

Figure 49: Comparison of recruitment estimates (top panel) and SSB's (bottom panel): unperturbed (heavy solid line), M-perturbed (+), catch perturbed (×), q-perturbed (△), and case-weights (∗).

7 Appendix 2: VPA output

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Optimization Start
Parameter Estimates

N	Parameter	Estimate	Gradient Objective Function	Lower Bound Constraint	Upper Bound Constraint
1	X1	8.517193	4.524340	5.204490	.
2	X2	8.517193	4.949673	6.217921	.
3	X3	8.517193	7.699188	5.642165	.
4	X4	8.006368	16.825864	4.311238	.
5	X5	7.600902	25.415012	4.172270	.

Value of Objective Function = 2329.8701193

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Dual Quasi-Newton Optimization

Minimum Iterations	0
Maximum Iterations	500
Maximum Function Calls	2500
ABSGCONV Gradient Criterion	0.00001
GCONV Gradient Criterion	1E-8
ABSFCONV Function Criterion	0
FCONV Function Criterion	2.220446E-16
FCONV2 Function Criterion	0
FSIZE Parameter	0
ABSXCONV Parameter Change Criterion	0
XCONV Parameter Change Criterion	0
XSIZE Parameter	0
ABSCONV Function Criterion	-1.34078E154
Line Search Method	2
Starting Alpha for Line Search	1
Line Search Precision LSPRECISION	0.4
DAMPSTEP Parameter for Line Search	.
MAXSTEP Parameter for Line Search	0
FD Derivatives: Accurate Digits in Obj.F	15.653559775
Singularity Tolerance (SINGULAR)	1E-8
Constraint Precision (LCEPS)	1E-8
Linearly Dependent Constraints (LCSING)	1E-8
Releasing Active Constraints (LCDEACT)	.

Dual Quasi-Newton Optimization

Dual Broyden - Fletcher - Goldfarb - Shanno Update (DBFGS)
Gradient Computed by Finite Differences

Parameter Estimates	5
Lower Bounds	5

Upper Bounds 0

Optimization Start

Active Constraints	0	Objective Function	2329.8701193
Max Abs Gradient Element	25.415012209		

Iter	Restarts	Function Calls	Active Constraints	Objective Function	Objective Function Change	Max Abs Gradient Element	Step Size	Slope of Search Direction
1	0	3	0	2286	43.5423	4.8156	0.436	-203.3
2	0	4	0	2283	3.5015	6.5495	1.000	-13.045
3	0	5	0	2280	2.4470	2.4899	1.000	-6.862
4	0	6	0	2280	0.4848	0.7609	1.000	-1.378
5	0	7	0	2280	0.0605	0.0937	1.000	-0.118
6	0	9	0	2280	0.000512	0.0856	1.000	-0.0029
7	0	10	0	2280	0.000402	0.0320	1.266	-0.0010
8	0	12	0	2280	0.000071	0.00156	0.976	-0.0001
9	0	14	0	2280	2.654E-7	0.000293	1.000	-651E-9

Optimization Results

Iterations	9	Function Calls	15
Gradient Calls	12	Active Constraints	0
Objective Function	2279.8331049	Max Abs Gradient Element	0.0002929462
Slope of Search Direction	-6.513601E-7		

GCONV convergence criterion satisfied.

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Optimization Results
Parameter Estimates

N	Parameter	Estimate	Gradient Objective Function
1	X1	6.598549	-0.000028114
2	X2	7.264649	-0.000236
3	X3	7.789923	0.000135
4	X4	6.312005	0.000209
5	X5	5.667179	-0.000293

Value of Objective Function = 2279.8331049

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Log Errors SPA for GOMGB Herring

Cohort model for years 1967 - 2005 , and ages 1 - 10

```
ALL          index for years 1967 to 2005 , and ages  2 to  8. Var =  Log Constant

-------------------------------------------------------------------------

Extended Deviance =  2279.8 , df =  600 , #Parms =    7

Penalty =    0.00

Var scale =  ALL           2.154

Quadratic Var   Beta Std. Err  95% L  95% U

.               .        .      .      .

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Age Survivors       CV    95% L    95% U

  1   2000.00      .        .        .
  2    734.03     0.73   174.48  3088.10
  3   1428.88     0.56   475.66  4292.39
  4   2416.13     0.46   990.30  5894.89
  5    551.15     0.42   240.99  1260.49
  6    289.22     0.36   142.36   587.57

Year Effect Constraint   Effect       CV    95% L    95% U

.                          1.00      .       1.00     1.00

F Constraint           Estimate     CV  95% L  95% U

Fratio                     1.000   .      .      .

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Q_CONST                    Estm (x1000)   SE   95% L   95% L

CAN_LRVL                        29.4156 0.49 11.0572 78.2548
US_FALL1_02                      0.0127 0.38  0.0059  0.0270
US_FALL1_03                      0.0520 0.35  0.0260  0.1039
US_FALL1_04                      0.1618 0.36  0.0794  0.3297
US_FALL1_05                      0.2330 0.37  0.1119  0.4854
US_FALL1_06                      0.5480 0.37  0.2631  1.1415
US_FALL1_07                      0.7550 0.37  0.3625  1.5728
```

US_FALL1_08	0.9234	0.42	0.3957	2.1548
US_FALL2_02	0.9103	0.32	0.4797	1.7272
US_FALL2_03	5.3899	0.32	2.8405	10.2273
US_FALL2_04	9.4677	0.32	4.9895	17.9650
US_FALL2_05	11.5412	0.32	6.0823	21.8996
US_FALL2_06	14.1151	0.32	7.4388	26.7836
US_FALL2_07	15.6076	0.32	8.2253	29.6156
US_FALL2_08	20.3559	0.35	10.1910	40.6595
US_LRVL1	93.5232	0.35	46.8216	186.807
US_LRVL2	782.925	0.60	236.203	2595.10
US_SPRG1_02	0.1913	0.36	0.0939	0.3898
US_SPRG1_03	0.7933	0.36	0.3893	1.6166
US_SPRG1_04	2.0479	0.36	1.0049	4.1734
US_SPRG1_05	2.9643	0.36	1.4546	6.0410
US_SPRG1_06	3.2433	0.36	1.5915	6.6096
US_SPRG1_07	4.5813	0.36	2.2480	9.3362
US_SPRG1_08	2.8013	0.36	1.3746	5.7088
US_SPRG2_02	2.3174	0.32	1.2213	4.3973
US_SPRG2_03	6.6801	0.32	3.5205	12.6756
US_SPRG2_04	10.3409	0.32	5.4497	19.6219
US_SPRG2_05	8.6067	0.32	4.5358	16.3313
US_SPRG2_06	6.8656	0.32	3.6182	13.0275
US_SPRG2_07	4.9795	0.33	2.5830	9.5992
US_SPRG2_08	3.9132	0.37	1.8786	8.1514
US_WNTR_02	1.2137	0.39	0.5539	2.6595
US_WNTR_03	6.0232	0.39	2.7487	13.1987
US_WNTR_04	8.1213	0.39	3.7061	17.7964
US_WNTR_05	13.6285	0.39	6.2193	29.8644
US_WNTR_06	19.4032	0.39	8.8546	42.5186
US_WNTR_07	19.5469	0.39	8.9202	42.8333
US_WNTR_08	23.6643	0.42	10.1412	55.2200

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Population Numbers at age

	1	2	3	4	5	6	7	8	9	10	1+
1967	5323	2841	1821	1829	1172	1517	1263	172	39	35	16012
1968	2657	4234	1942	1284	1309	842	997	682	96	21	14065
1969	2090	2161	2207	1340	888	712	447	396	236	56	10533
1970	1412	1646	1243	1447	885	455	303	170	130	76	7767
1971	7717	1151	900	846	739	456	235	132	68	60	12304
1972	1185	6178	731	366	396	303	173	69	45	32	9478
1973	1008	962	4152	540	150	87	59	27	7	8	7001
1974	1662	792	470	2222	176	53	29	15	5	1	5425
1975	1024	1329	260	252	1140	73	27	15	8	1	4129
1976	1290	797	504	106	105	381	18	6	4	1	3213
1977	3593	988	172	187	44	41	123	5	2	1	5157
1978	2748	2401	285	66	89	17	17	56	2	1	5682
1979	407	2006	860	108	30	34	8	6	17	1	3477
1980	2357	327	580	322	36	10	13	1	1	7	3654

1981	1357	1619	59	146	96	10	3	3	0	0	3293
1982	1090	1055	268	18	58	36	4	1	1	0	2530
1983	1071	844	258	119	8	20	12	1	0	0	2335
1984	2877	847	449	158	72	6	10	3	1	0	4423
1985	1264	2339	526	247	93	33	3	5	1	0	4510
1986	1179	1008	1406	354	156	51	15	1	2	0	4172
1987	1841	928	601	947	246	94	27	5	1	1	4692
1988	2070	1461	558	370	612	161	60	17	2	0	5312
1989	2212	1623	742	356	247	387	100	41	12	1	5721
1990	2142	1787	913	457	194	128	153	56	26	8	5864
1991	2269	1743	946	548	294	124	66	51	20	8	6068
1992	1527	1853	1009	611	356	181	72	33	22	7	5672
1993	1382	1250	1022	627	415	212	98	34	12	6	5058
1994	1780	1130	676	617	422	260	128	49	12	5	5077
1995	4424	1456	542	394	439	268	148	71	22	5	7769
1996	2158	3569	771	323	274	325	144	38	7	3	7612
1997	2595	1762	2361	486	200	153	111	28	6	0	7701
1998	1287	2114	1155	1357	317	119	68	26	7	2	6453
1999	3710	1053	1163	814	811	206	69	26	7	1	7860
2000	1602	3033	703	594	551	458	94	25	4	2	7066
2001	2139	1308	2081	526	370	305	215	37	6	1	6988
2002	5797	1750	896	1256	377	210	133	52	6	1	10478
2003	2602	4703	1186	619	774	216	102	41	10	1	10254
2004	904	2120	3501	809	442	441	109	22	2	0	8350
2005	2000	734	1429	2416	551	289	282	49	8	1	7760
2006	1676	1636	452	759	1747	390	184	194	34	6	7078

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Fishing Mortalities

	1	2	3	4	5	6	7	8	9	10
1967	0.029	0.180	0.149	0.135	0.131	0.219	0.416	0.388	0.400	0.402
1968	0.006	0.452	0.172	0.169	0.409	0.432	0.723	0.860	0.342	0.642
1969	0.039	0.353	0.222	0.215	0.469	0.655	0.767	0.918	0.937	0.874
1970	0.005	0.403	0.185	0.472	0.462	0.460	0.630	0.722	0.567	0.640
1971	0.022	0.254	0.701	0.559	0.690	0.771	1.019	0.869	0.564	0.817
1972	0.008	0.197	0.103	0.691	1.312	1.441	1.642	2.157	1.538	1.779
1973	0.042	0.516	0.425	0.921	0.835	0.914	1.139	1.564	1.696	1.466
1974	0.023	0.914	0.424	0.467	0.681	0.480	0.433	0.512	1.292	0.746
1975	0.050	0.770	0.695	0.677	0.895	1.210	1.247	1.144	1.692	1.361
1976	0.067	1.333	0.792	0.679	0.735	0.930	1.036	0.873	1.237	1.049
1977	0.203	1.044	0.765	0.540	0.745	0.684	0.590	0.825	0.417	0.610
1978	0.115	0.827	0.770	0.579	0.759	0.508	0.769	1.011	1.063	0.948
1979	0.018	1.041	0.783	0.893	0.893	0.803	1.635	1.494	0.636	1.255
1980	0.175	1.504	1.179	1.010	1.092	1.123	1.285	1.195	1.004	1.161
1981	0.052	1.600	1.017	0.724	0.778	0.777	0.820	0.629	0.264	0.571
1982	0.055	1.209	0.607	0.548	0.861	0.895	1.031	0.652	1.312	0.998
1983	0.034	0.431	0.292	0.311	0.181	0.453	1.121	0.406	0.710	0.745
1984	0.007	0.276	0.397	0.332	0.579	0.536	0.611	0.891	3.294	1.599
1985	0.027	0.309	0.195	0.259	0.392	0.607	0.650	0.842	1.330	0.941

1986	0.039	0.317	0.195	0.164	0.313	0.432	0.869	0.417	0.372	0.553
1987	0.031	0.310	0.285	0.237	0.225	0.245	0.263	0.725	0.460	0.483
1988	0.043	0.478	0.248	0.205	0.260	0.273	0.184	0.152	0.911	0.416
1989	0.014	0.376	0.284	0.409	0.453	0.727	0.389	0.257	0.225	0.291
1990	0.007	0.436	0.311	0.243	0.244	0.464	0.906	0.835	0.991	0.911
1991	0.003	0.347	0.237	0.230	0.282	0.351	0.493	0.631	0.787	0.637
1992	0.001	0.395	0.275	0.187	0.319	0.418	0.532	0.813	1.178	0.841
1993	0.001	0.415	0.306	0.197	0.269	0.307	0.498	0.821	0.721	0.680
1994	0.001	0.535	0.340	0.140	0.253	0.362	0.390	0.578	0.803	0.590
1995	0.015	0.436	0.318	0.162	0.100	0.422	1.148	2.101	1.944	1.731
1996	0.003	0.213	0.262	0.279	0.381	0.870	1.455	1.713	5.817	2.995
1997	0.005	0.222	0.354	0.227	0.316	0.620	1.239	1.158	0.673	1.023
1998	0.000	0.398	0.150	0.315	0.232	0.340	0.739	1.122	2.345	1.402
1999	0.001	0.204	0.471	0.190	0.372	0.580	0.831	1.707	1.238	1.259
2000	0.003	0.177	0.090	0.274	0.391	0.558	0.730	1.159	1.595	1.161
2001	0.001	0.179	0.305	0.134	0.367	0.631	1.209	1.590	2.248	1.682
2002	0.009	0.189	0.170	0.284	0.357	0.518	0.981	1.466	1.629	1.359
2003	0.005	0.095	0.183	0.136	0.362	0.486	1.329	2.998	2.836	2.388
2004	0.008	0.194	0.171	0.183	0.225	0.247	0.591	0.769	0.786	0.715
2005	0.001	0.285	0.432	0.124	0.145	0.254	0.174	0.174	0.174	0.174

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Commercial catch

	1	2	3	4	5	6	7	8	9	10
1967	136.6	424.1	228.6	208.8	130.5	270.3	389.4	50.18	11.55	10.39
1968	15.49	1392	277.2	180.6	397.2	266.9	464.7	356.1	25.11	9.100
1969	71.46	581.8	397.6	234.3	300.7	309.6	216.9	215.3	130.0	29.33
1970	5.990	494.4	190.0	492.9	296.2	151.8	128.1	79.17	50.75	32.41
1971	154.7	233.4	410.4	327.9	333.3	221.8	135.9	69.38	26.39	30.40
1972	8.250	1001	64.73	165.2	261.7	209.5	126.2	55.57	32.22	23.71
1973	37.42	351.2	1301	294.0	76.87	47.34	36.18	19.60	4.860	5.550
1974	34.62	429.3	146.9	750.4	78.65	18.41	9.110	5.590	3.080	0.470
1975	45.14	645.9	117.7	112.1	610.4	46.32	17.42	9.390	5.580	0.710
1976	75.38	531.3	249.3	47.34	49.39	208.9	10.40	3.350	2.550	0.670
1977	597.2	579.3	83.33	70.56	20.95	18.45	49.67	2.630	0.670	0.390
1978	269.8	1222	138.4	26.07	42.91	6.180	8.260	32.18	1.100	0.650
1979	6.560	1174	422.5	57.74	16.08	17.08	6.150	4.530	7.090	0.340
1980	343.2	230.1	363.2	185.1	21.77	6.160	8.210	0.850	0.680	4.490
1981	61.71	1169	34.36	68.10	46.89	4.860	1.360	1.200	0.070	0.140
1982	52.70	669.5	110.1	6.720	30.27	19.30	2.180	0.420	0.820	0.120
1983	32.81	267.5	59.10	28.90	1.250	6.620	7.360	0.330	0.190	0.130
1984	18.88	185.0	133.1	40.34	28.48	2.140	4.320	1.720	0.520	0.120
1985	30.20	562.8	84.32	51.07	27.17	13.55	1.180	2.390	0.720	0.010
1986	40.68	247.5	225.2	48.50	38.00	16.25	7.710	0.360	0.460	0.090
1987	50.99	223.8	134.8	180.5	44.86	18.43	5.690	2.350	0.210	0.320
1988	79.28	502.3	110.9	62.12	126.6	34.86	9.140	2.180	1.080	0.100
1989	27.07	460.2	166.0	108.1	81.34	180.7	29.27	8.390	2.200	0.150
1990	12.59	571.1	220.6	89.36	38.00	43.17	82.48	28.53	14.71	4.260
1991	5.540	461.8	180.4	101.7	65.30	33.27	23.29	21.45	9.750	3.350

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1992 0.800 546.8 219.6 94.22 88.11 56.04 26.74 16.64 13.81 3.790
1993 1.720 383.9 243.5 101.5 88.55 50.73 34.67 17.46 5.580 2.480
1994 1.970 423.5 176.1 72.71 85.28 71.41 37.33 19.32 6.200 1.930
1995 59.22 465.3 133.6 53.33 37.94 83.57 91.51 56.19 17.32 3.390
1996 5.790 619.7 160.6 71.14 78.69 170.9 99.88 28.55 6.390 2.250
1997 10.75 317.4 637.1 89.22 48.94 64.10 71.66 17.07 2.520 0.010
1998 0.440 628.3 145.9 331.3 59.47 31.11 31.94 16.13 5.790 1.620
1999 4.840 175.6 395.3 127.5 227.8 81.97 35.49 19.57 4.530 0.360
2000 3.920 445.1 54.68 128.7 161.4 177.2 44.18 15.39 2.830 1.040
2001 1.240 193.8 494.7 59.61 102.8 129.1 136.2 26.81 5.150 0.480
2002 47.45 272.9 126.6 281.1 102.4 76.80 75.15 36.48 4.520 0.370
2003 11.71 386.5 179.3 71.00 212.5 75.23 68.13 35.05 8.440 0.820
2004 6.650 339.0 497.7 122.6 80.60 87.28 43.97 10.77 0.820 0.220
2005 1.120 164.8 453.9 255.2 67.44 58.69 40.90 7.150 1.220 0.090
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Biomass at age

	1	2	3	4	5	6	7	8	9	10	1+
1967	27	82	142	216	190	390	347	59	11	10	1474
1968	19	106	115	182	254	181	244	177	26	6	1310
1969	21	84	174	68	224	192	143	117	64	16	1105
1970	30	104	132	242	186	109	92	53	40	22	1009
1971	147	56	104	152	173	149	69	38	22	20	931
1972	41	315	88	68	93	83	54	25	12	9	789
1973	16	52	448	92	35	22	17	9	2	2	696
1974	28	42	51	376	36	12	7	4	1	0	558
1975	24	68	25	43	219	17	7	4	2	0	409
1976	23	33	57	19	22	80	5	2	1	0	243
1977	57	42	18	30	8	9	28	1	1	0	195
1978	36	96	34	12	20	4	5	16	1	0	224
1979	3	64	77	21	8	10	2	2	6	0	192
1980	35	13	60	54	10	3	4	0	0	3	184
1981	16	73	7	28	22	3	1	1	0	0	151
1982	22	52	35	3	14	10	1	0	0	0	138
1983	24	46	36	26	2	6	4	0	0	0	144
1984	55	43	60	29	16	1	3	1	0	0	209
1985	16	115	73	45	19	8	1	1	0	0	278
1986	25	53	163	59	34	12	4	0	0	0	350
1987	33	41	56	134	44	20	6	1	0	0	336
1988	19	50	50	48	100	30	14	4	1	0	315
1989	11	75	75	48	41	76	24	10	3	0	363
1990	11	79	90	68	35	25	32	13	6	2	360
1991	11	92	82	73	49	24	14	11	5	2	364
1992	8	85	91	78	55	32	14	7	5	2	377
1993	7	55	98	83	66	39	21	8	3	2	381
1994	9	55	58	73	59	41	23	10	3	1	334
1995	115	82	53	48	61	42	25	14	5	1	446
1996	54	193	70	40	42	56	28	8	2	1	492
1997	42	100	208	60	30	26	21	6	1	0	493

1998	0	106	93	163	46	20	12	5	1	1	447
1999	111	61	99	93	112	33	12	5	2	0	529
2000	0	215	74	78	86	79	19	5	1	1	559
2001	83	75	207	70	57	52	40	8	2	0	594
2002	145	98	86	150	52	33	22	10	1	0	597
2003	65	277	106	82	115	36	19	8	2	0	711
2004	23	100	322	103	69	76	21	4	0	0	718
2005	50	35	121	294	80	49	52	10	2	0	693
2006	42	79	38	92	255	66	34	38	7	1	652

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Spawner Biomass at age

	1	2	3	4	5	6	7	8	9	10	1+
1967	0	17	122	200	186	386	345	59	11	10	1337
1968	0	22	99	169	249	179	243	177	26	6	1170
1969	0	17	150	63	220	191	142	117	64	16	981
1970	0	21	114	224	182	108	91	53	40	22	856
1971	0	12	89	141	170	148	69	38	22	20	709
1972	0	65	76	63	91	82	54	25	12	9	477
1973	0	11	387	85	34	22	17	9	2	2	569
1974	0	9	44	348	35	12	7	4	1	0	461
1975	0	14	21	39	215	17	7	4	2	0	321
1976	0	7	50	18	21	80	5	2	1	0	183
1977	0	9	15	28	8	9	28	1	1	0	99
1978	0	20	29	11	20	4	5	16	1	0	106
1979	0	13	66	20	8	10	2	2	6	0	125
1980	0	3	51	50	10	3	4	0	0	3	125
1981	0	15	6	26	22	3	1	1	0	0	73
1982	0	11	30	3	14	10	1	0	0	0	70
1983	0	10	31	24	2	6	4	0	0	0	77
1984	0	9	52	27	16	1	3	1	0	0	109
1985	0	24	63	41	18	7	1	1	0	0	156
1986	0	11	141	54	33	12	4	0	0	0	255
1987	0	8	48	124	43	20	6	1	0	0	251
1988	0	10	43	44	99	30	14	4	1	0	244
1989	0	15	65	45	41	75	23	10	3	0	277
1990	0	16	78	63	35	25	31	13	6	2	269
1991	0	19	71	67	48	24	14	11	5	2	261
1992	0	18	78	72	54	31	14	7	5	2	282
1993	0	11	85	77	64	38	20	8	3	2	309
1994	0	11	50	68	58	41	23	10	3	1	266
1995	0	17	45	45	60	41	25	14	5	1	253
1996	0	40	60	37	41	55	27	8	2	1	271
1997	0	21	179	56	29	26	20	6	1	0	338
1998	0	22	80	151	45	20	12	5	1	1	337
1999	0	13	85	86	110	33	12	5	2	0	346
2000	0	44	64	73	85	79	19	5	1	1	370
2001	0	15	179	65	56	51	39	8	2	0	416
2002	0	20	74	139	51	33	22	10	1	0	350

2003	0	57	92	76	113	36	19	8	2	0	403
2004	0	21	278	96	67	75	21	4	0	0	562
2005	0	7	104	272	79	48	52	10	2	0	574
2006	0	16	33	86	251	65	34	38	7	1	530

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Standardized CAN_LRVL Resdiuals; MSE= 0.48

	3
1987	0.42
1988	-0.38
1989	-0.46
1990	-0.37
1991	-1.21
1992	-0.32
1993	0.30
1994	0.97
1995	1.03

Unstandardized CAN_LRVL Resdiuals; MSE= 1.04

	3
1987	0.62
1988	-0.55
1989	-0.68
1990	-0.54
1991	-1.77
1992	-0.46
1993	0.44
1994	1.43
1995	1.52

CAN_LRVL Index

	3
1987	22.00
1988	6.50
1989	7.40
1990	10.20
1991	3.30
1992	12.60
1993	30.80
1994	52.90
1995	47.30

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Standardized US_FALL Resdiuals; MSE= 1.10

	2	3	4	5	6	7	8
1967	0.65	0.41	0.32	-0.05	0.01	-0.25	-1.52
1968	-0.23	-0.14	-0.69	-0.83	0.21	-0.76	0.00
1969	0.20	-0.55	-0.60	-0.77	-0.77	-0.28	0.00
1970	0.61	-0.24	-0.42	-0.45	-0.20	-1.46	0.00
1971	0.29	1.79	0.86	1.33	0.75	-0.87	0.00
1972	0.55	0.47	0.67	0.59	0.23	0.36	0.43
1973	-1.54	-0.74	-1.42	-1.33	-2.48	-1.29	-1.45
1974	-2.04	-1.20	-0.81	-0.51	-0.75	-0.71	0.00
1975	-0.00	-0.87	-0.19	-0.02	0.97	1.12	1.19
1976	0.00	-2.76	0.26	0.13	-0.12	0.42	-2.17
1977	0.21	-0.95	-0.57	-0.49	-1.22	-1.03	-1.31
1978	-0.13	1.54	1.83	1.92	0.67	0.87	1.02
1979	0.19	0.08	-1.01	0.00	0.00	0.00	0.00
1980	0.00	-0.30	0.00	0.00	0.00	0.00	0.00
1981	0.00	0.57	-1.06	-2.66	-0.85	-1.00	-1.29
1982	-0.12	0.41	0.95	1.13	0.69	0.84	1.37
1983	1.19	1.01	0.38	0.04	0.57	1.33	0.34
1984	0.16	1.45	1.50	1.95	2.30	2.70	3.38
1985	-2.53	-2.49	-0.33	-0.51	0.21	0.56	0.93
1986	-2.23	-1.73	-1.62	-1.26	-1.35	-2.12	0.00
1987	0.88	0.39	-0.50	-1.12	-0.98	-1.50	-1.37
1988	0.20	0.37	0.41	-0.68	-1.43	-1.63	0.00
1989	0.29	0.33	0.46	0.13	-0.12	-0.93	-1.27
1990	0.68	0.69	-0.31	-0.88	-1.68	-2.06	-3.70
1991	0.67	0.80	0.28	-0.66	-1.29	-2.21	-4.41
1992	0.53	1.32	0.93	0.90	0.10	-0.20	0.00
1993	-0.45	-0.48	0.32	0.43	-0.20	-0.73	-2.76
1994	0.09	-0.56	-0.05	0.06	0.17	-0.22	-0.55
1995	-0.20	0.96	0.79	1.22	1.52	1.53	0.86
1996	1.05	0.59	0.81	0.25	0.82	1.18	1.10
1997	0.33	0.53	0.25	0.69	0.93	1.31	0.87
1998	0.21	-0.34	-0.00	0.07	0.46	0.97	0.82
1999	-0.77	-0.15	-0.47	-0.07	-0.16	0.38	0.70
2000	-0.41	-0.74	0.07	0.38	0.28	0.62	0.93
2001	-0.72	0.10	-0.58	-0.02	0.51	1.07	1.35
2002	0.43	0.29	0.87	1.13	1.46	1.69	1.66
2003	-0.05	-0.22	-0.13	0.53	0.75	1.40	2.54
2004	1.23	-0.10	-0.41	-0.32	0.06	1.17	1.83
2005	0.77	0.42	-0.79	-0.25	-0.06	-0.29	0.47

Unstandardized US_FALL Resdiuals; MSE= 2.37

	2	3	4	5	6	7	8

1967	0.96	0.61	0.48	-0.08	0.01	-0.36	-2.23
1968	-0.34	-0.20	-1.02	-1.22	0.31	-1.12	0.00
1969	0.29	-0.81	-0.87	-1.12	-1.13	-0.41	0.00
1970	0.89	-0.35	-0.62	-0.66	-0.29	-2.15	0.00
1971	0.42	2.63	1.26	1.95	1.11	-1.27	0.00
1972	0.81	0.69	0.98	0.87	0.34	0.53	0.63
1973	-2.26	-1.09	-2.08	-1.95	-3.64	-1.89	-2.12
1974	-2.99	-1.76	-1.19	-0.74	-1.11	-1.05	0.00
1975	-0.00	-1.27	-0.27	-0.02	1.43	1.64	1.74
1976	0.00	-4.05	0.38	0.20	-0.17	0.61	-3.18
1977	0.31	-1.39	-0.83	-0.71	-1.79	-1.52	-1.92
1978	-0.19	2.26	2.68	2.81	0.98	1.28	1.49
1979	0.27	0.12	-1.48	0.00	0.00	0.00	0.00
1980	0.00	-0.44	0.00	0.00	0.00	0.00	0.00
1981	0.00	0.84	-1.56	-3.90	-1.24	-1.47	-1.89
1982	-0.17	0.61	1.40	1.66	1.01	1.23	2.01
1983	1.75	1.49	0.56	0.06	0.83	1.96	0.49
1984	0.24	2.13	2.20	2.86	3.37	3.97	4.97
1985	-3.71	-3.65	-0.48	-0.75	0.30	0.82	1.37
1986	-3.27	-2.54	-2.38	-1.85	-1.98	-3.11	0.00
1987	1.30	0.57	-0.73	-1.64	-1.44	-2.20	-2.01
1988	0.29	0.54	0.60	-1.00	-2.10	-2.39	0.00
1989	0.42	0.48	0.68	0.19	-0.18	-1.36	-1.87
1990	1.00	1.02	-0.45	-1.29	-2.46	-3.03	-5.43
1991	0.99	1.18	0.40	-0.97	-1.90	-3.25	-6.47
1992	0.78	1.94	1.37	1.32	0.15	-0.29	0.00
1993	-0.66	-0.70	0.46	0.63	-0.29	-1.07	-4.06
1994	0.13	-0.82	-0.07	0.08	0.25	-0.32	-0.80
1995	-0.29	1.41	1.16	1.79	2.23	2.25	1.26
1996	1.54	0.86	1.19	0.37	1.20	1.73	1.61
1997	0.48	0.77	0.37	1.02	1.37	1.92	1.28
1998	0.31	-0.49	-0.00	0.10	0.67	1.43	1.21
1999	-1.12	-0.23	-0.68	-0.11	-0.23	0.56	1.03
2000	-0.61	-1.08	0.10	0.56	0.41	0.91	1.36
2001	-1.06	0.14	-0.85	-0.04	0.75	1.57	1.98

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	2	3	4	5	6	7	8
2002	0.63	0.43	1.27	1.65	2.15	2.48	2.43
2003	-0.07	-0.32	-0.19	0.78	1.10	2.06	3.72
2004	1.81	-0.14	-0.60	-0.47	0.09	1.71	2.68
2005	1.12	0.62	-1.16	-0.37	-0.08	-0.43	0.69

US_FALL Index

	2	3	4	5	6	7	8
1967	0.07	0.13	0.36	0.19	0.59	0.40	0.01
1968	0.02	0.06	0.06	0.05	0.37	0.11	9999

1969	0.02	0.04	0.06	0.04	0.06	0.10	9999
1970	0.03	0.03	0.07	0.06	0.11	0.01	9999
1971	0.02	0.31	0.26	0.58	0.34	0.02	9999
1972	0.13	0.06	0.08	0.06	0.06	0.05	0.02
1973	0.00	0.04	0.00	0.00	0.00	0.00	0.00
1974	0.00	0.00	0.06	0.01	0.01	0.00	0.01
1975	0.01	0.00	0.02	0.10	0.05	0.03	0.03
1976	9999	0.00	0.01	0.01	0.07	0.01	0.00
1977	0.01	0.00	0.01	0.00	0.00	0.01	0.00
1978	0.01	0.06	0.08	0.16	0.01	0.02	0.08
1979	0.01	0.02	0.00	9999	9999	9999	9999
1980	9999	0.01	9999	9999	9999	9999	9999
1981	9999	0.00	0.00	0.00	0.00	0.00	0.00
1982	0.00	0.01	0.01	0.03	0.02	0.00	0.00
1983	0.04	0.04	0.02	0.00	0.01	0.02	0.00
1984	0.01	0.12	0.15	0.15	0.05	0.21	0.17
1985	0.03	0.05	0.99	0.31	0.32	0.05	0.16
1986	0.02	0.43	0.23	0.19	0.06	0.00	9999
1987	2.02	3.83	3.01	0.39	0.22	0.03	0.01
1988	1.02	3.56	4.54	1.77	0.19	0.06	9999
1989	1.40	4.32	4.02	2.01	2.11	0.25	0.09
1990	2.60	8.92	1.90	0.42	0.09	0.05	0.00
1991	2.70	11.55	5.44	0.86	0.17	0.02	0.00
1992	2.24	25.44	16.56	9.99	1.78	0.45	9999
1993	0.35	1.80	6.79	6.09	1.47	0.29	0.01
1994	0.63	1.03	4.11	3.63	2.97	0.89	0.23
1995	0.58	7.80	8.81	23.60	20.96	7.17	0.75
1996	10.81	6.72	6.75	2.83	6.27	3.21	0.80
1997	1.82	17.38	4.65	4.16	4.30	3.61	0.65
1998	1.60	2.84	8.36	2.82	2.10	2.02	0.60
1999	0.22	2.86	2.81	5.22	1.20	0.81	0.31
2000	1.10	1.01	4.19	6.79	5.18	1.69	0.64
2001	0.30	8.50	1.61	2.57	4.56	5.02	1.25
2002	2.16	5.46	28.44	14.31	13.97	9.30	3.04
2003	3.12	3.39	3.65	12.24	5.19	3.52	2.42
2004	8.49	12.02	3.06	2.25	4.71	4.87	2.95
2005	1.37	8.46	5.47	3.31	2.58	2.11	1.47

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Standardized US_LRVL Resdiuals; MSE= 0.89

	3
1971	0.55
1972	0.29
1973	0.29
1974	1.67
1975	1.07
1976	-1.53
1977	0.67
1978	-1.09

```
  1979 -1.21
  1980 -1.50
  1981  1.83
  1982  0.24
  1983 -1.00
  1984 -1.64
  1985  0.67
  1986 -0.31
  1987 -0.12
  1988  1.12
  1989  0.11
  1990 -0.12
  1991 -0.26
  1992  0.05
  1993 -0.19
  1994  0.40


Unstandardized US_LRVL      Resdiuals; MSE=   1.91


           3

  1971  0.81
  1972  0.43
  1973  0.43
  1974  2.45
  1975  1.58
  1976 -2.24
  1977  0.98
  1978 -1.60
  1979 -1.78
  1980 -2.21
  1981  2.69
  1982  0.35
  1983 -1.47
  1984 -2.41
  1985  0.99
  1986 -0.45
  1987 -0.18
  1988  1.64
  1989  0.16
  1990 -0.17
  1991 -0.38
  1992  0.08
  1993 -0.28
  1994  0.59


US_LRVL      Index


           3
```

1971	89.70
1972	81.40
1973	355.2
1974	304.5
1975	55.90
1976	2.20
1977	19.20
1978	2.40
1979	6.00
1980	1.90
1981	29.70
1982	18.20
1983	3.70
1984	2.30
1985	95.40
1986	60.40
1987	31.40
1988	184.9
1989	454.3

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	3
1990	394.1
1991	354.2
1992	577.1
1993	397.6
1994	610.0

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Standardized US_SPRG Resdiuals; MSE= 0.82

	2	3	4	5	6	7	8
1968	0.55	1.24	0.25	0.05	0.15	0.15	-0.06
1969	-0.75	-0.12	-1.09	-0.54	-0.05	0.63	0.50
1970	1.81	0.34	-0.60	-0.67	-0.56	-0.65	-1.46
1971	0.01	-0.16	-0.71	-1.45	-1.13	-1.16	-1.17
1972	-0.56	0.38	-0.16	-0.24	-0.49	-2.06	-1.07
1973	-0.57	-0.15	0.97	0.34	1.15	0.74	0.61
1974	-1.02	-0.76	0.10	0.41	0.17	-0.36	0.07
1975	-1.13	-0.37	-1.58	-0.77	-0.48	-0.47	-0.72
1976	-0.59	-0.22	-0.77	-0.51	-0.74	0.91	0.32
1977	-0.58	0.07	0.13	0.18	-0.28	-0.48	0.17
1978	-0.73	1.65	0.75	0.25	-0.00	-0.12	0.34
1979	1.89	-0.25	1.29	1.69	0.70	1.10	1.82
1980	0.70	1.02	1.38	1.48	0.86	0.67	0.65
1981	-1.59	-0.74	0.52	1.23	1.37	1.25	1.04
1982	0.71	-0.83	0.32	-0.68	-0.54	-0.19	-0.47
1983	0.07	-1.31	-0.83	-0.63	-0.02	0.57	-0.66

1984	1.77	0.19	0.05	-0.14	-0.11	-0.54	0.10
1985	-0.61	-0.83	-1.15	-0.24	-0.37	0.45	0.36
1986	-0.13	0.79	0.00	-0.01	0.42	1.36	0.00
1987	-0.26	-0.35	-0.57	-1.45	-0.96	0.00	0.00
1988	0.08	0.12	0.01	-0.24	-0.78	-2.06	-4.37
1989	-0.46	-0.66	-0.06	0.07	-0.29	-0.82	0.00
1990	-0.12	-0.55	-0.32	-0.17	-1.07	-3.90	0.00
1991	0.18	0.13	0.52	-0.58	-0.62	-1.07	0.00
1992	0.74	0.67	0.09	-0.18	-0.42	-0.31	-2.27
1993	0.73	1.15	1.00	0.40	-0.23	-1.24	-3.32
1994	0.47	-0.10	0.49	0.83	0.52	-0.04	-0.90
1995	0.51	0.12	-0.10	0.82	0.40	-0.01	-1.68
1996	1.16	0.42	0.37	0.22	0.66	1.14	1.31
1997	1.20	0.60	0.16	0.39	0.71	0.88	1.03
1998	0.07	0.28	0.55	0.60	0.54	0.78	0.58
1999	0.04	0.62	0.43	1.33	1.23	1.63	1.80
2000	0.59	-0.17	-0.06	0.13	0.24	0.52	0.69
2001	0.41	0.31	-0.66	-0.02	0.36	0.83	1.16
2002	0.33	-0.67	0.11	-0.11	0.24	0.59	0.70
2003	-1.15	-0.60	-0.75	-0.70	1.05	1.19	2.25
2004	-2.44	0.25	0.28	-0.63	-1.07	0.93	1.77
2005	-1.34	-1.52	-0.35	-0.45	-0.56	-0.84	0.89

Unstandardized US_SPRG Resdiuals; MSE= 1.77

	2	3	4	5	6	7	8
1968	0.81	1.82	0.36	0.07	0.21	0.22	-0.08
1969	-1.11	-0.17	-1.60	-0.80	-0.07	0.93	0.74
1970	2.65	0.50	-0.88	-0.98	-0.83	-0.95	-2.15
1971	0.02	-0.23	-1.04	-2.13	-1.65	-1.70	-1.72
1972	-0.82	0.56	-0.23	-0.35	-0.72	-3.03	-1.57
1973	-0.84	-0.22	1.42	0.50	1.68	1.09	0.89
1974	-1.49	-1.12	0.14	0.60	0.26	-0.53	0.10
1975	-1.65	-0.54	-2.32	-1.13	-0.71	-0.70	-1.06
1976	-0.87	-0.32	-1.13	-0.75	-1.09	1.33	0.47
1977	-0.86	0.10	0.19	0.26	-0.41	-0.70	0.24
1978	-1.07	2.42	1.10	0.37	-0.00	-0.18	0.51
1979	2.78	-0.36	1.89	2.47	1.03	1.62	2.67
1980	1.02	1.50	2.03	2.18	1.26	0.98	0.95
1981	-2.33	-1.09	0.76	1.80	2.02	1.84	1.52
1982	1.05	-1.21	0.47	-0.99	-0.79	-0.27	-0.69
1983	0.10	-1.92	-1.22	-0.93	-0.03	0.84	-0.97
1984	2.60	0.28	0.07	-0.20	-0.17	-0.79	0.14
1985	-0.89	-1.22	-1.69	-0.35	-0.54	0.66	0.52
1986	-0.19	1.16	0.01	-0.01	0.62	2.00	0.00
1987	-0.38	-0.51	-0.83	-2.12	-1.41	0.00	0.00
1988	0.12	0.18	0.01	-0.35	-1.14	-3.02	-6.42
1989	-0.68	-0.97	-0.09	0.10	-0.43	-1.20	0.00
1990	-0.17	-0.81	-0.46	-0.25	-1.57	-5.72	0.00
1991	0.26	0.18	0.76	-0.85	-0.90	-1.57	0.00

1992	1.09	0.98	0.13	-0.27	-0.61	-0.45	-3.33
1993	1.07	1.69	1.47	0.59	-0.34	-1.83	-4.87
1994	0.69	-0.15	0.73	1.22	0.76	-0.06	-1.32
1995	0.75	0.17	-0.14	1.20	0.59	-0.01	-2.47
1996	1.70	0.61	0.54	0.32	0.97	1.67	1.92
1997	1.76	0.88	0.23	0.57	1.04	1.30	1.50
1998	0.10	0.42	0.81	0.88	0.79	1.14	0.85
1999	0.06	0.91	0.63	1.96	1.80	2.39	2.64
2000	0.86	-0.25	-0.08	0.20	0.35	0.76	1.02
2001	0.60	0.45	-0.97	-0.03	0.52	1.22	1.71
2002	0.49	-0.98	0.16	-0.16	0.36	0.86	1.03
2003	-1.70	-0.88	-1.11	-1.03	1.55	1.74	3.30

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	2	3	4	5	6	7	8
2004	-3.58	0.37	0.41	-0.93	-1.57	1.36	2.60
2005	-1.97	-2.23	-0.52	-0.65	-0.82	-1.24	1.31

US_SPRG Index

	2	3	4	5	6	7	8
1968	1.54	8.70	3.44	3.57	2.89	4.50	1.35
1969	0.12	1.32	0.50	1.00	1.74	4.06	1.76
1970	3.85	1.48	1.04	0.83	0.55	0.43	0.04
1971	0.20	0.45	0.50	0.21	0.22	0.15	0.05
1972	0.47	0.94	0.48	0.57	0.32	0.02	0.02
1973	0.07	2.27	3.46	0.57	1.15	0.57	0.12
1974	0.03	0.10	4.44	0.76	0.19	0.07	0.04
1975	0.04	0.10	0.04	0.83	0.08	0.04	0.01
1976	0.04	0.23	0.06	0.12	0.31	0.23	0.02
1977	0.06	0.12	0.38	0.13	0.07	0.23	0.01
1978	0.12	1.99	0.33	0.30	0.05	0.05	0.19
1979	4.53	0.37	1.12	0.81	0.24	0.12	0.17
1980	0.11	1.46	3.71	0.68	0.08	0.11	0.01
1981	0.02	0.01	0.51	1.34	0.19	0.06	0.03
1982	0.40	0.05	0.05	0.05	0.04	0.01	0.00
1983	0.15	0.03	0.06	0.01	0.05	0.09	0.00
1984	1.93	0.41	0.30	0.14	0.01	0.02	0.01
1985	1.95	0.94	0.42	0.48	0.11	0.02	0.02
1986	1.69	27.17	3.37	1.17	0.56	0.41	9999
1987	1.30	2.13	3.83	0.23	0.14	9999	9999
1988	3.23	3.97	3.49	3.30	0.31	0.01	0.00
1989	1.66	1.66	2.89	1.99	1.37	0.13	9999
1990	2.97	2.38	2.67	1.16	0.16	0.00	9999
1991	4.58	6.81	10.91	0.96	0.30	0.06	9999
1992	11.00	15.99	6.50	2.05	0.58	0.19	0.00
1993	7.24	32.70	25.61	5.72	0.91	0.07	0.00
1994	4.35	3.38	12.11	11.00	3.31	0.52	0.04
1995	6.06	3.77	3.23	11.66	2.84	0.52	0.01

1996	40.91	8.48	5.06	2.80	4.48	2.52	0.64
1997	21.28	33.05	5.70	2.68	2.42	1.42	0.35
1998	4.68	10.74	27.77	5.88	1.58	0.83	0.17
1999	2.35	16.35	14.38	42.77	7.06	2.92	0.90
2000	15.11	3.42	5.03	4.97	3.67	0.80	0.19
2001	5.01	19.21	1.91	2.68	2.87	2.54	0.51
2002	5.99	2.05	13.44	2.40	1.72	1.17	0.38
2003	1.86	2.97	1.95	2.06	5.86	1.99	1.94
2004	0.12	30.92	11.45	1.35	0.56	1.73	0.91
2005	0.21	0.87	13.76	2.26	0.78	0.37	0.65

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Standardized US_WNTR Resdiuals; MSE= 0.61

	2	3	4	5	6	7	8
1992	0.84	0.53	0.34	-0.07	-0.65	-0.66	0.00
1993	-1.06	0.66	0.82	0.37	0.23	-0.67	0.00
1994	-1.93	-1.40	-1.00	-1.04	-1.10	-1.53	-1.57
1995	-2.17	-0.92	-0.80	-0.14	0.11	0.18	-0.45
1996	1.94	0.24	0.22	0.06	0.56	0.60	0.27
1997	-0.13	-0.48	-0.56	0.64	1.19	1.30	1.37
1998	-0.29	0.47	0.65	0.28	0.33	0.39	-0.11
1999	-1.14	-0.05	0.16	0.60	0.45	0.76	0.69
2000	1.75	-0.05	0.09	-0.24	-0.72	-1.01	-1.33
2001	0.90	0.76	0.04	0.43	0.27	0.28	-0.07
2002	-0.56	-0.38	0.94	0.28	0.58	0.67	0.33
2003	0.27	-0.30	-0.17	0.18	0.14	0.54	0.48
2004	1.10	-0.18	-0.93	-1.57	-1.20	-0.77	-0.31
2005	0.48	1.13	0.21	0.21	-0.20	-0.10	0.71

Unstandardized US_WNTR Resdiuals; MSE= 1.31

	2	3	4	5	6	7	8
1992	1.23	0.78	0.50	-0.10	-0.95	-0.97	0.00
1993	-1.56	0.97	1.21	0.55	0.34	-0.99	0.00
1994	-2.83	-2.06	-1.47	-1.53	-1.61	-2.24	-2.30
1995	-3.18	-1.36	-1.18	-0.20	0.16	0.26	-0.66
1996	2.85	0.35	0.32	0.09	0.82	0.89	0.39
1997	-0.19	-0.71	-0.83	0.94	1.75	1.90	2.00
1998	-0.42	0.69	0.95	0.41	0.49	0.58	-0.17
1999	-1.67	-0.08	0.23	0.87	0.67	1.12	1.01
2000	2.56	-0.07	0.13	-0.35	-1.05	-1.49	-1.95
2001	1.32	1.11	0.06	0.63	0.40	0.42	-0.10
2002	-0.83	-0.56	1.39	0.42	0.86	0.99	0.49
2003	0.40	-0.45	-0.25	0.27	0.21	0.80	0.71
2004	1.62	-0.27	-1.37	-2.30	-1.77	-1.12	-0.46
2005	0.70	1.65	0.30	0.30	-0.30	-0.15	1.04

US_WNTR Index

	2	3	4	5	6	7	8
1992	7.70	13.23	8.19	4.40	1.36	0.53	9999
1993	0.32	16.17	17.00	9.78	5.78	0.71	9999
1994	0.08	0.52	1.16	1.24	1.01	0.27	0.12
1995	0.07	0.84	0.99	4.89	6.09	3.77	0.87
1996	74.57	6.57	3.60	4.11	14.30	6.82	1.35
1997	1.76	6.98	1.72	6.99	17.12	14.62	4.83
1998	1.68	13.92	28.46	6.49	3.76	2.35	0.53
1999	0.24	6.48	8.34	26.47	7.78	4.17	1.71
2000	47.82	3.96	5.51	5.30	3.10	0.42	0.08
2001	5.97	38.02	4.56	9.46	8.83	6.37	0.79
2002	0.93	3.07	40.80	7.78	9.59	6.97	2.02
2003	8.53	4.58	3.91	13.80	5.16	4.44	1.96
2004	12.96	16.12	1.67	0.60	1.46	0.69	0.33
2005	1.80	45.02	26.56	10.16	4.16	4.77	3.32