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Reporting rates from cod tagging studies in NAFO Divisions 2J3KL and Subdivision 3Ps

Taux de déclaration obtenus à partir des expériences de marquage de la morue dans les divisions 2J3KL et la sous-division 3Ps de l'OPANO

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ABSTRACT

Estimates of tag reporting rates are necessary to infer fishery exploitation rates from the fraction of tags returned from tagging experiments. Changes in reporting rates can have considerable influence on estimates of exploitation rates. Some evidence was presented in the 2007 assessment of northern cod that suggested reporting rates had changed. This motivated us to examine in more detail the methods used to provide estimates of reporting rates.

We estimate reporting rates using the proportion of low-reward tags returned from low and high-reward releases. We use the common Binomial logistic regression model to estimate reporting rates. This approach yielded infeasible estimates in some regions and years, wide confidence intervals, and large between-year variability in some regions. We also considered another model in which year-effects in log reporting rates were modelled as random error terms. This mixed-effects logistic regression model did not produce infeasible estimates, gave narrower confidence intervals, and little between-year variability in reporting rates for most regions. Estimates suggest a decreasing trend in single tag reporting rates from 3KL, from 70-92% in 1997-2005 to 62% in 2006-07, and in 3Ps from 70-81% in 1997-2005 to 65-67% in 2006-07.

RÉSUMÉ

Les estimations des taux de déclaration des individus marqués sont utilisées pour calculer par inférence les taux d'exploitation à partir de la fraction des marques retournées dans le cadre d'expériences de marquage. Nous savons que des changements dans les taux de déclaration peuvent avoir une incidence considérable sur les estimations des taux d'exploitation. Or, selon certaines informations présentées dans l'évaluation de la morue du Nord de 2007, les taux de déclaration auraient changé. Cette situation nous a amené à examiner plus en détail les méthodes employées pour établir les estimations des taux de déclaration.

Pour estimer les taux de déclaration, nous calculons la fraction des marques faiblement primées qui sont retournées par rapport aux remises à l'eau d'individus avec marques soit fortement soit faiblement primées. Nous utilisons le modèle courant de régression logistique binomiale pour estimer les taux de déclaration. Avec cette approche, nous avons obtenu des estimations non plausibles pour certaines régions et certaines années, de larges intervalles de confiance et de grandes variations inter-années dans certaines régions. Nous avons également examiné un autre modèle dans lequel les effets-années associés aux taux de déclaration dans les journaux de bord ont été modélisés en tant que termes d'erreur aléatoire. Ce modèle de régression logistique à effets mixtes n'a pas produit d'estimations non plausibles et a donné des intervalles de confiance plus étroits et peu de variations inter-années dans les taux de déclaration de la plupart des régions. Les estimations laissent entrevoir une tendance à la baisse dans la déclaration des marques simples : dans 3KL, le taux de déclaration estimé a chuté de 70-92 % entre 1997 et 2005 à 62 % entre 2006 et 2007; dans 3Ps, il est passé de 70-81% entre 1997 et 2005 à 65-67 % entre 2006 et 2007.

INTRODUCTION

In the 2007 assessment of northern (NAFO Div. 2J3KL) cod, Brattey and Healey (2007) noted a substantial drop in tag reporting rates from tagging studies during 2006 in inshore areas of 3KL. This change in reporting rates had considerable influence on the estimates of exploitation rates. This motivated us to examine in more detail the methods used to provide estimates of reporting rates. The results are reported in this document.

We use the high-reward method to estimate reporting rates. Our approach is similar to that described in Cadigan and Brattey (2006). A difference is that we only examine tag-returns from fish initially tagged with a single low or high-reward tag. This greatly simplifies the estimation procedure. Returns from double-tagged fish are not used. Since 2000, we have not used double tagging and only 15% of recaptured tags in our data are from double-tagged fish. These can be ignored without much loss in estimation efficiency.

We use the common Binomial logistic regression model to estimate reporting rates, based on the proportion of low-reward tags returned from low and high-reward releases. Reporting rates are estimated spatially for eight geographic regions around the coast of Newfoundland, and for 10-11 years depending on the region. This leads to a large number of reporting rate parameters to estimate, which causes problems such as infeasible estimates in some regions and years, wide confidence intervals, and large between-year variability in some regions, especially those will less data.

Combining regions and years to simplify the model is a useful strategy to improve estimates. This was a major focus of Cadigan and Brattey (2006). However, an alternative and potentially simpler approach is to consider year-effects in log reporting rates as random error terms. This can be implemented in a mixed-effects logistic regression model, with fixed 'parameters' and random 'effects'. This type of model has many fewer parameters to estimate, and may provide more reliable estimates of reporting rates. In this paper we also consider this approach.

MATERIALS AND METHODS

Tagging experiments were conducted on cod during 1997-2007 in NAFO Subdiv. 3Ps and Div. 3KL. Most cod for tagging were captured with hand-lines equipped with feathered hooks. Only cod >45 cm in fork length and in excellent condition were used for tagging. Fish were tagged with one or two 6.3 cm t-bar anchor tags (Floy Tag Co., Seattle, Washington) inserted at the base of the first dorsal fin. The tagging experiments are described in more detail by Cadigan and Brattey (2006).

A reward scheme was used to encourage those participating in the fishery to return cod tags and recapture information. The reward for returning a standard tag was $10 Can. Cod were tagged with one standard yellow ($10 reward), two standard yellow ($20 reward for returning both tags), or one high-reward pink tag ($100 reward). During initial experiments, tags were applied in the sequence one pink tag, nine single yellow tags, one pink tag, nine double yellow tags. This ensured that fish with different tag types were thoroughly mixed. Tags had the value of the reward printed on them, as well as a unique serial number and a return address. The reward scheme was advertised widely. All individuals who returned tags were sent a standard letter describing the date, size, and location where the fish was tagged along with a request to confirm recapture information as well as provide any further recapture details.

Information on tag loss was obtained from double-tagged fish. However, since 2000 double tagging has been used rarely because sufficient information about tag loss was available from earlier experiments.

Reporting rates are estimated using the high-reward method, in which return rates of low-reward tags are compared to the return-rates of high-reward tags. It is assumed that all high-reward tags found on captured fish are returned. It is important with this approach to insure that other factors affecting tag return-rates are controlled or accounted for when estimating reporting rates. The factors we control for are

1. number released in experiment *x*,
2. length (*l*),
3. location (*h*), and
4. time of capture (*t* in weeks).

Factors 2-4 are important because fishery exploitation rates vary by length, region, and time; hence, these factors also influence the rate of tag-returns.

We refer to the release of a batch of tagged fish over a 1-3 week period at a specific site as an experiment (*x*). We analyze tag-returns from 144 experiments conducted during 1997-2007. These were experiments which, in addition to single low reward tags, at least some high reward tags were used. If only single low or high reward tags were used in an experiment and for a length class, then subsequent recaptures do not provide information about reporting rates (Cadigan and Brattey (2006). We pooled lengths into 3 cm classes to increase the number of tags that could be used to estimate reporting rates, and because we do not feel that selectivity varies much within 3 cm length classes. We analyze tag-returns in weekly time intervals (*t*). Release and capture locations are categorized into regions, described in Table 1 (Appendix 1).

To infer reporting rates, the number of low-reward tags is compared to the number of high-reward tags, relative to the numbers released, within the above factor combinations. More specifically, let N_{Sxl} denote the number of length/single low-reward tagged fish released in experiment *x*, and let N_{Hxl} denote the corresponding number of high-reward tagged fish released. Let R_{Sxlht} and R_{Hxlht} denote the number of low and high-reward tags returned in region *h* and time *t*. It is reasonable to assume that reporting rates, denoted as λ_{hy}, are constant within a region *h* and year *y*. Some regions and years have few returns and we pool in these cases. This is described in the next section.

FIXED-EFFECTS LOGISTIC REGRESSION MODEL

Based on arguments similar to those in C&B, we assume that the statistical distribution of R_{Sxlht} conditional on the sum $R_{xlht} = R_{Sxlht} + R_{Hxlht}$ is Binomial, with probability

$$p_{xlht} = \frac{\lambda_{hy} N_{Sxl}}{\lambda_{hy} N_{Sxl} + N_{Hxl}}, \quad t \in y,$$

where R_{xlht} is the Binomial "sample size". In their discussion, C&B noted that

$$\log\left(\frac{p_{xlht}}{1-p_{xlht}}\right)=\log(\lambda_{hy})+\log\left(\frac{N_{Sxl}}{N_{Hxl}}\right),$$

and $\log\{p/(1-p)\}$ is the standard canonical link in a Generalized Linear Model (GLIM) for Binomial random variables, commonly referred to as a Logistic Regression Model (LRM). Hence, log reporting rates can be estimated as main effects in an LRM, with $\log\{N_{Sxl}/N_{Hxl}\}$ incorporated as an offset variable.

An advantage of the LRM approach is that it involves a well-known model in which much theory is available for estimation and statistical inference. We can use common statistical software, with more flexible modelling capabilities, than the approach in Cadigan and Brattey (2006). In this paper we use PROC GENMOD in SAS, which is much faster and easier to use than the more general optimization software used by Cadigan and Brattey (2006).

It is easier to examine the statistical significance of year-effects in reporting rates by estimating a regional reporting rate (λ_h) and region*year interactions (γ); that is, $\log(\lambda_{hy})=\log(\lambda_h)+\gamma_{hy}$. PROC GENMOD constrains $\gamma_{hy}=0$ for *y* = *2007* (or more generally the last year) so that γ and λ are identified. Confidence intervals for γ can be examined to see which year-effects are significantly different from the reference value of 0. If no year-effects are significant then all confidence intervals for γ_{hy}'s should cover 0.

A disadvantage of the LRM approach is that it does not use reporting rate information from the returns of single tags from double tagged fish, or from double-tag returns. However, we show in the next section that the number of such returns has diminished since 2000, and the amount of information lost does not seem large. In addition, we can use the odds-ratio in Cadigan and Brattey (2006) to derive double-tag reporting rates from single-tag reporting rates that we estimate here using LRM, so the information in double-tag returns can still be used to some extent. Another disadvantage of the LRM approach, perhaps more serious is that it is not possible to use boundary constraints in SAS PROC GENMOD, which can lead to infeasible reporting-rate estimates.

Another problem with the LRM approach is model selection. Estimating reporting rates by year and by coarse spatial regions involves a large number of parameters. Many of the year-region model "cells" have little data which also complicates estimation. Cadigan and Brattey (2006) dealt with sparse data problems by pooling cells, and we also use this approach. However, deciding which cells to pool is tedious and to some extent subjective. Also, large between-cell changes in reporting rates can still occur.

MIXED-EFFECTS LOGISTIC REGRESSION MODEL

The time-series of reporting-rate data may now be long enough to implement a mixed-effects model in which annual reporting rates for a region are decomposed into a main effect and a random year effect; that is, $\log(\lambda_{hy})=\log(\lambda_h)+\delta_{hy}$, where δ_{hy} is a random variable with mean zero, and variance σ^2. Essentially, the year*region interactions in the LRM are treated as random effects. It is common to assume

$\delta_{hy} \sim N(0, \sigma^2)$. As a first step we assume the δ_{hy}'s are independent over time, although alternative approaches involving auto-correlation clearly seem sensible to investigate.

The combination of fixed and random "parameters" or effects produces a mixed-effects model. Such models are common extensions to a LRM, which is another advantage of the LRM approach. It would be difficult to implement a mixed-effects version of the C&B model. Mixed-effects models potentially provide a useful way to deal with sparse data because the predicted random effects in log reporting rates will tend to be close to zero unless the data substantially indicate otherwise. This is a type of shrinkage estimation procedure.

Generalized linear mixed models have become an increasingly important method for fisheries research in recent years (Xiao et. al. 2004). We used the new SAS/STAT PROC GLIMMIX software for estimation. PROC GLIMMIX software fits generalized linear mixed models (GLMM's) based on linearizations. A Taylor's series expansion is used to approximate the GLMM as a linear mixed model. The advantage of the linearization is that only the variance parameters have to be estimated numerically because closed form expressions exist for estimates of the regression parameters. The default estimation method in PROC GLIMMIX software for models containing random effects is a technique known as restricted pseudo-likelihood estimation. Random effects are incorporated as best linear unbiased predictors (BLUPs) in the approximated linear model. Maximum likelihood estimates of variance parameters (e.g. σ^2) tend to be biased for small sample sizes (Lin and Breslow 1996). Therefore, we used the restricted pseudo-likelihood method in PROC GLIMMIX, which may provide less biased estimation of random effect variance parameters. The BLUPs of the δ_{hy}'s can be added to the estimates of λ_h to estimate/predict the annual reporting rates, λ_{hy}'s.

There is less motivation to consider region effects as random, at least at the regional scale we consider. This is because the number of regions is small and constant over time. We used the same basic strategy as Cadigan and Brattey (2006) to decide which regions to combine when estimating reporting rates.

RESULTS

DATA OVERVIEW

The number of fish tagged in the 144 experiments during 1997-2007 ranged from 5 to 3828, with an average of 719. The length of fish tagged ranged from 41 cm to 125 cm, with an average of 66 cm, although only 10% of releases were smaller than 47 cm, and 10% were larger than 89 cm. The average time-at-liberty was 75 weeks, with 10% and 90% quantiles of 8 and 164 weeks, respectively. A cross-tabulation of total releases each year is shown in Table 2 (Appendix 1). Only 7 fish have been double-tagged since 2000. During 1997-2000, 23% of fish were double tagged, but during 1997-2007 this number was reduced to 10%.

A summary of recapture data is presented in Table 3. The last year double tagging was used was 2000, and since 2004 there have been few returns of these tags. Based on all tagging in 1997-2007, about 15% of returned tags have come from double tagged cod.

Note that the directed inshore cod fishery in 2J3KL was closed during 2003-05 which reduced the numbers of tag returns considerably in those years.

FIXED-EFFECTS LOGISTIC REGRESSION MODEL

In some years and regions there were insufficient data to estimate reporting rates. In most regions there were few tag-returns in 1997 when the program had just started, so we pooled data for 1997-98 for all regions. We also pooled data for: 2003-05 in 3K_IN (20 returns in total), 2003-06 in 3L_INS (28), 2003-04 in 3Pn_4R (18), and 2005-06 in 3Pn_4R (19). Combined reporting rates were estimated for these pooled 'cells'.

The output from PROC GENMOD is given in Appendix 2. The estimated year-effects are also plotted in Fig. 1. Year-effects were not significant in 3K_IN, 3L_INS, OFF_SH, and 3PN_4R, which were the areas with the least amount of data. There was evidence of a decreasing trend in 3L_INN and 3Ps_BB, and more recently in 3Ps_PB and 3Ps_FB. The year-effects can be added to the log region-effects, and the results exponentiated to produce annual estimates of reporting rates. Alternatively, the region*year effects can be estimated directly, which is an easy way we used to also get confidence intervals for reporting rates. These estimates are shown in Table 4 (Appendix 1) and plotted in Fig. 2. Some large infeasible estimates are not plotted, but are tabulated. Confidence intervals are wide for some regions, indicating considerable uncertainty about reporting rates. There is also large between-year variability in some regions, especially those will less data. The estimate for 3L_INN in 2007 is 46% (Table 4) which is significantly lower than average for the series (Fig. 2).

The between-year variability in reporting rates seems large in some years, and some estimates are infeasible (Fig. 2; Table 4). The estimates may be fitting to noise in the data. Cadigan and Brattey (2006) addressed this problem by pooling 'cells'; however, this is tedious and somewhat subjective, and large between-cell changes in reporting rates can still occur. Random year-effects (YE) is another approach.

MIXED-EFFECTS LOGISTIC REGRESSION MODEL

The year-effect estimates are plotted in Fig. 3. The 95% confidence intervals are Wald-type, based on ± Z × standard errors, where Z is the 97.5 percentile of a Normal distribution. The year-effects have much less variability than the fixed-effects LRM results (Fig. 1). The widths of confidence intervals between regions are more similar in Fig. 3 than in Fig. 1. This is presumably because the year-effects variance was assumed to be the same in each region. The standard errors are considered further in the **DISCUSSION**. The estimate of the year-effects variance is $\hat{\sigma}^2 = 0.014$, with a standard error of 0.011.

All but one of the confidence intervals for log year-effects covered zero, which may suggest that the year-effects are not significant; however, this interpretation may not be correct (see **DISCUSSION**). The variability of the year-effects appears to be greater in 3L_INN and 3Ps_PB.

The year-effect predictions can be added to the estimates of the fixed log region-effects to produce annual estimates of reporting rates. These are shown in Fig. 4 and Table 5. The region-effect estimates are shown in Table 6. There are no infeasible estimates, and confidence intervals are narrower than those from the fixed-effects LRM. There is little between-year variability in most regions, especially those will less data. This is consistent with Cadigan and Brattey (2006), who pooled most years. However, there is evidence of a decreasing trend in 3L_INN, and more recently in 3Ps_PB and 3Ps_FB.

The year-over-year trends are similar between 3K_IN and 3L_INN, notably the increases in 1999 and 2001, and the 2005-06 declines.

Cadigan and Brattey (2006) grouped 3K_IN, 3L_INN, and 3L_INS into one region, which we call 3KL. They also grouped 3Ps_PB and 3Ps_FB into a region we call 3Ps_IN, and they grouped OFF_SH and 3Ps_BB into one region, which we still call OFF_SH. Similarities between year-effects for 3K_IN and 3L_INN, between year-effects for 3Ps_PB and 3Ps_FB, and the lower reporting rates in OFF_SH and 3Ps_BB (Table 6), provide motivation for this grouping, in addition to the contiguity of the regions. Hence, this grouping still seems reasonable.

The PROC GLIMMIX output using this further grouping is given in Appendix 3. Reporting rate estimates are presented in Table 7a, and plotted in Fig. 5. The year-effects variance estimate (0.022) was larger than for the previous formulation; hence, the reporting rate estimates are closer to the fixed-effects LRM results (not shown). This is why, for example, the estimates in 2006-2007 for 3KL and 3Ps_IN are lower than those in Table 5.

Reporting rates for fish caught with two tags can be inferred from the results in Table 7a using the odds-ratio method described in Cadigan and Brattey (2006). These estimates are presented in Table 7b.

DISCUSSION AND CONCLUSIONS

We propose that the estimates in Table 7a are the best ones to use in the tagging exploitation rate model for the 2008 assessment of Northern cod.

We also investigated estimating the year-effect variability, σ^2, separately for each region. These estimates varied considerably between regions, and convergence of the iterative estimation algorithm was a problem. There are only 10 years of data per region, and this may be too low for reliable estimation of σ^2. When a common σ^2 is estimated for all regions, there is much more data available to estimate σ^2.

The value of σ^2 has a substantial impact on the reporting rate estimates. When σ^2 is small, then the predicted year-effects are small and consequently annual differences in reporting rates are small. Conversely, when σ^2 is larger then the estimates of reporting rates are more similar to the fixed-effects results. The value of σ^2 also has a large impact of the standard errors for reporting rates. It would be useful to assess these issues in a simulation study to examine the efficacy of the mixed-model approach.

The estimate of the variance of the year effects may be sensitive to the 2001 data for 3L_INN. This is an anomalous observation. However, such anomalies would tend to result in an over-estimate of the year-effect variability, and this will lead to results more similar to the fixed-effect LRM which should be unbiased, although highly variable especially for regions with low numbers of returns.

An advantage of linearization-based methods is that they use a relatively simple form of the linearized model that typically can be fit based on only the mean and variance in the linearized form. Models for which the marginal distribution of the data is difficult, or impossible, to compute can be fit with linearization-based approaches. The marginal distribution of the data is based on integrating out the random effects from the joint distribution of the data and random effects. The linearization approach is well-suited for models with either correlated errors, large number of random effects, crossed random effects, and/or multiple types of subjects. Disadvantages of this approach are the absence of a true likelihood function for the overall optimization process and potentially biased estimates of the covariance parameters, especially for binary data.

It also seems reasonable that the year-effects in reporting rates are autocorrelated. One of the strengths of the linearization approach for estimation provided in PROC GLIMMIX is that complicated correlation structures can be investigated which could result in improved estimates of reporting rates, especially if they are changing smoothly over time. This is also a useful area for future research.

There are subtle differences in how we should interpret standard errors and confidence intervals for the fixed and mixed-effects models. For example, we arbitrarily multiplied returns by 100 and re-estimated the LRM and found, as expected, that the standard errors decreased 10 fold. In the mixed-model the estimate of σ^2 increased almost 10-fold, but the standard errors for reporting rates decreased much less. Estimates changed as well, in a direction more similar to the fixed-effects estimates, presumably because of the increase in σ^2 which results in less "shrinkage" of the reporting rates. The mixed-model standard errors are more complicated to interpret, and they do not necessarily decrease the way we normally expect as sample sizes increase. It would be desirable to better understand the statistical properties of the mixed-model estimators.

PROC GLIMMIX software provides marginal and conditional residuals, on the data or link scale. Conditional residuals are based on BLUPs of the random effects and estimates of the fixed effects parameters. Although Cadigan and Brattey (2006) examined residuals extensively, it is advisable in the future to again examine residuals to assess the model goodness-of-fit.

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APPENDIX 1

Table 1. Regions used to estimate reporting rates.

Region	NAFO unit area
3K_IN	3Kd, 3Kh, 3Ki
3L_INN	3La, 3Lb
3L_INS	3Lf, 3Lj, 3Lq
3Ps_PB	3Psc
3Ps_FB	3Psb
3Ps_BB	3Psa, 3Psd
OFF_SH	3Pse-3Psh, all of 3N and 3O
3PN_4RS	3Pn, 4Ra-4Rd, 4Sv-4Sw

Table 2. Annual number of fish tagged with low and high reward tags.

Release	Reward			
Year	1 Low	2 Low's	High	Total
1997	4753	3012	923	8688
1998	4065	3993	1970	10028
1999	12063	1799	1673	15535
2000	9305	1961	334	11600
2001	11979	1	1356	13336
2002	12777	2	1702	14481
2003	9414	2	1640	11056
2004	2200	1	445	2646
2005	2039	1	276	2316
2006	5077	0	1415	6492
2007	5944	0	1379	7323
Total	79616	10772	13113	103501

Table 3. Annual number of tag returned in 2000-07.

Release Year	Recapture Year	single low-reward tag	1 front tag from double	1 back tag from double	2 tags back from double	single high-reward tag	Total
2000	2000	653	10	21	154	18	856
2000	2001	690	13	38	116	9	866
2000	2002	303	11	16	40	7	377
2000	2003	120	3	13	18	1	155
2000	2004	40	2	1	2	0	45
2000	2005	21	0	2	2	0	25
2000	2006	11	1	2	1	0	15
2000	2007	3	0	0	1	0	4
2001	2001	1192	0	0	0	100	1292
2001	2002	818	0	0	0	80	898
2001	2003	314	0	0	0	26	340
2001	2004	78	0	0	0	5	83
2001	2005	55	0	0	0	7	62
2001	2006	37	0	0	0	7	44
2001	2007	16	0	0	0	1	17
2002	2002	901	0	1	0	108	1010
2002	2003	857	0	0	0	107	964
2002	2004	300	0	0	0	28	328
2002	2005	136	0	0	0	17	153
2002	2006	62	0	0	0	6	68
2002	2007	20	0	0	0	5	25
2003	2003	558	0	0	0	137	695
2003	2004	549	0	0	0	137	686
2003	2005	369	0	0	0	78	447
2003	2006	148	0	0	0	41	189
2003	2007	41	0	0	0	12	53
2004	2005	58	0	0	0	22	80
2004	2006	31	0	0	0	10	41
2004	2007	17	0	0	0	4	21
2005	2005	11	0	0	0	2	13
2005	2006	57	0	0	0	15	72
2005	2007	31	0	0	0	6	37
2006	2006	151	0	0	0	84	235
2006	2007	77	0	0	0	40	117
2007	2007	182	0	0	0	59	241
total (1996-2007)		13307	269	540	2060	2358	18534

Table 4. Reporting rate estimates from the fixed-effects LRM. Pooled cells are shaded. Infeasible estimates are show in red.

Region	Single tag reporting rates										
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
3K_IN	0.72		0.82	0.71	1.18	0.75	0.71			0.57	0.74
3L_INN	0.63		0.85	0.60	1.22	0.73	0.77	0.56	0.58	0.52	0.46
3L_INS	0.66		0.87	1.65	0.70	0.89	0.77				0.46
OFF_SH	0.91		0.67	0.84	0.92	1.06	0.33	0.64	0.52	0.79	0.73
3Ps_PB	0.68		0.74	0.92	0.84	0.88	0.89	0.85	0.79	0.58	0.52
3Ps_FB	0.74		0.64	0.86	0.96	0.74	0.75	0.70	1.11	0.35	0.42
3Ps_BB	0.69		0.74	0.29	1.91	0.96	0.36	0.61	0.20	0.33	0.51
3PN_4R	0.24		0.45	0.76	0.98	0.85	0.44		0.89		0.99

Table 5. Reporting rate estimates from the preliminary mixed-effects LRM.

Region	Single tag reporting rates										
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
3K_IN		0.74	0.78	0.74	0.78	0.74	0.75	0.75	0.74	0.68	0.74
3L_INN	0.72	0.71	0.76	0.69	0.88	0.73	0.74	0.70	0.71	0.66	0.64
3L_INS	0.79	0.77	0.80	0.83	0.77	0.80	0.79	0.79	0.79	0.79	0.77
OFF_SH	0.69	0.69	0.68	0.70	0.70	0.71	0.65	0.68	0.65	0.69	0.69
3Ps_PB	0.76	0.72	0.75	0.87	0.81	0.83	0.85	0.83	0.79	0.72	0.75
3Ps_FB	0.72	0.72	0.70	0.74	0.75	0.72	0.73	0.71	0.75	0.68	0.68
3Ps_BB		0.58	0.59	0.56	0.63	0.59	0.57	0.58	0.56	0.57	0.56
3PN_4R		0.62	0.64	0.66	0.68	0.67	0.65	0.65	0.67	0.65	0.67

Table 6. Estimated region effects (i.e. fixed-effects) from the preliminary mixed-effects LRM. Regions to be pooled are color coded.

Log Region Effects			
Region	Estimate	Std.Err	Z-value
3K_IN	-0.296	0.1042	-2.84
3L_INN	-0.3293	0.07241	-4.55
3L_INS	-0.2356	0.1434	-1.64
3Ps_FB	-0.3307	0.08913	-3.71
3Ps_PB	-0.2382	0.05117	-4.65
3Ps_BB	-0.5447	0.1514	-3.6
OFF_SH	-0.3783	0.1211	-3.12
3PN_4R	-0.4213	0.1754	-2.4

Table 7a. Single-tag reporting rate estimates from the final mixed-effects LRM.

	Single tag reporting rates										
Region	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
3KL	0.73	0.70	0.80	0.72	0.92	0.74	0.75	0.71	0.70	0.62	0.62
3Ps_IN	0.74	0.70	0.73	0.88	0.82	0.81	0.84	0.81	0.80	0.65	0.67
OFF_SH	0.65	0.66	0.66	0.64	0.74	0.70	0.58	0.64	0.59	0.64	0.61
3PN_4R		0.61	0.63	0.66	0.69	0.67	0.64	0.65	0.68	0.64	0.67

Table 7b. Double-tag reporting rate estimates.

	Double tag reporting rates										
Region	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
3KL	0.82	0.80	0.87	0.81	0.95	0.83	0.83	0.81	0.80	0.74	0.74
3Ps_IN	0.83	0.80	0.82	0.92	0.89	0.88	0.90	0.88	0.87	0.76	0.77
OFF_SH	0.76	0.77	0.77	0.76	0.83	0.80	0.70	0.75	0.71	0.75	0.73
3PN_4R		0.73	0.75	0.77	0.79	0.78	0.75	0.76	0.79	0.75	0.78

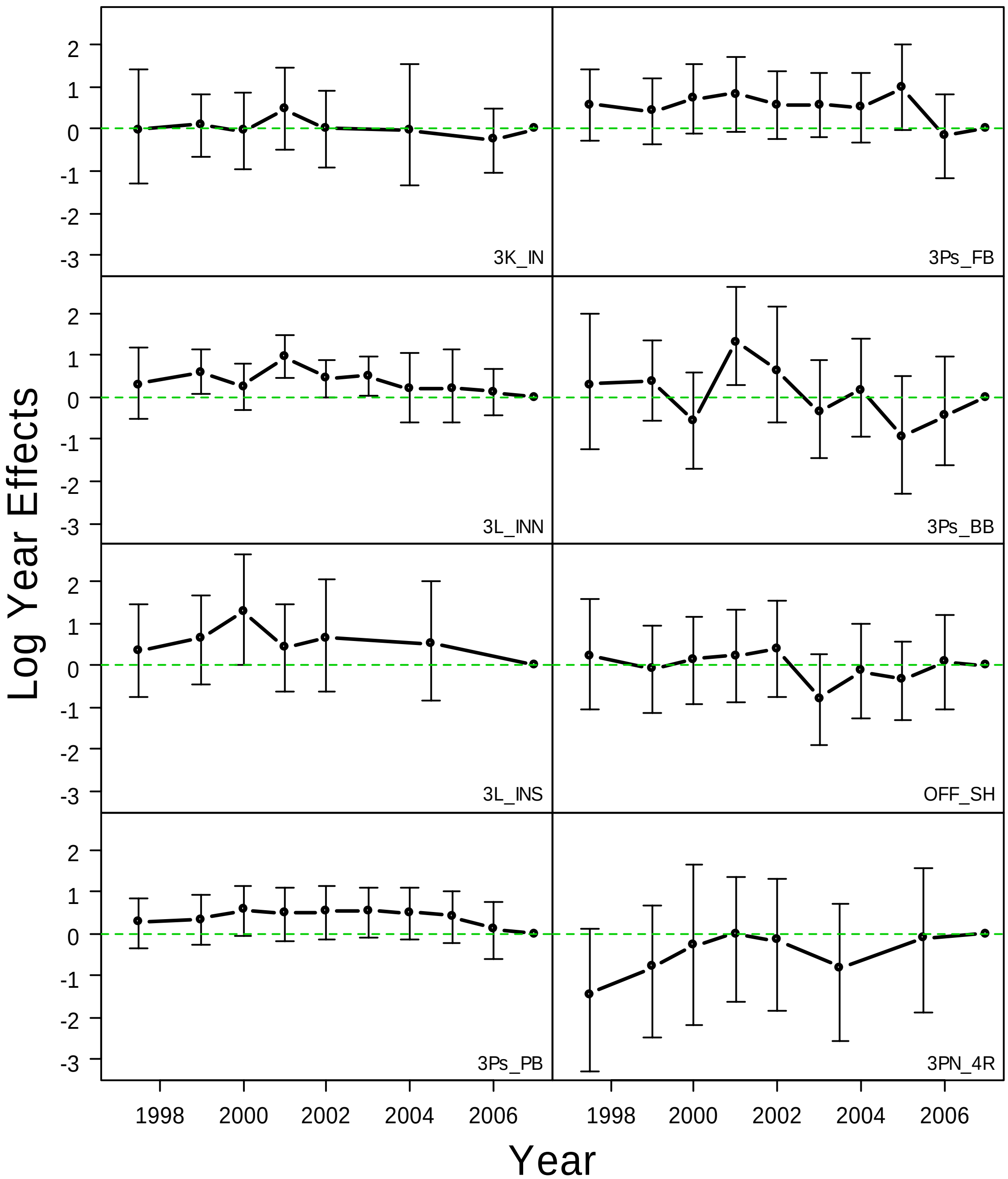

Figure 1. Estimates of log year-effects (γ_{hy}) from the fixed-effects LRM, with 95% profile likelihood confidence intervals (vertical segments). Pooled estimates are plotted versus the average of the years that were pooled. A dashed horizontal line at zero is shown for reference.

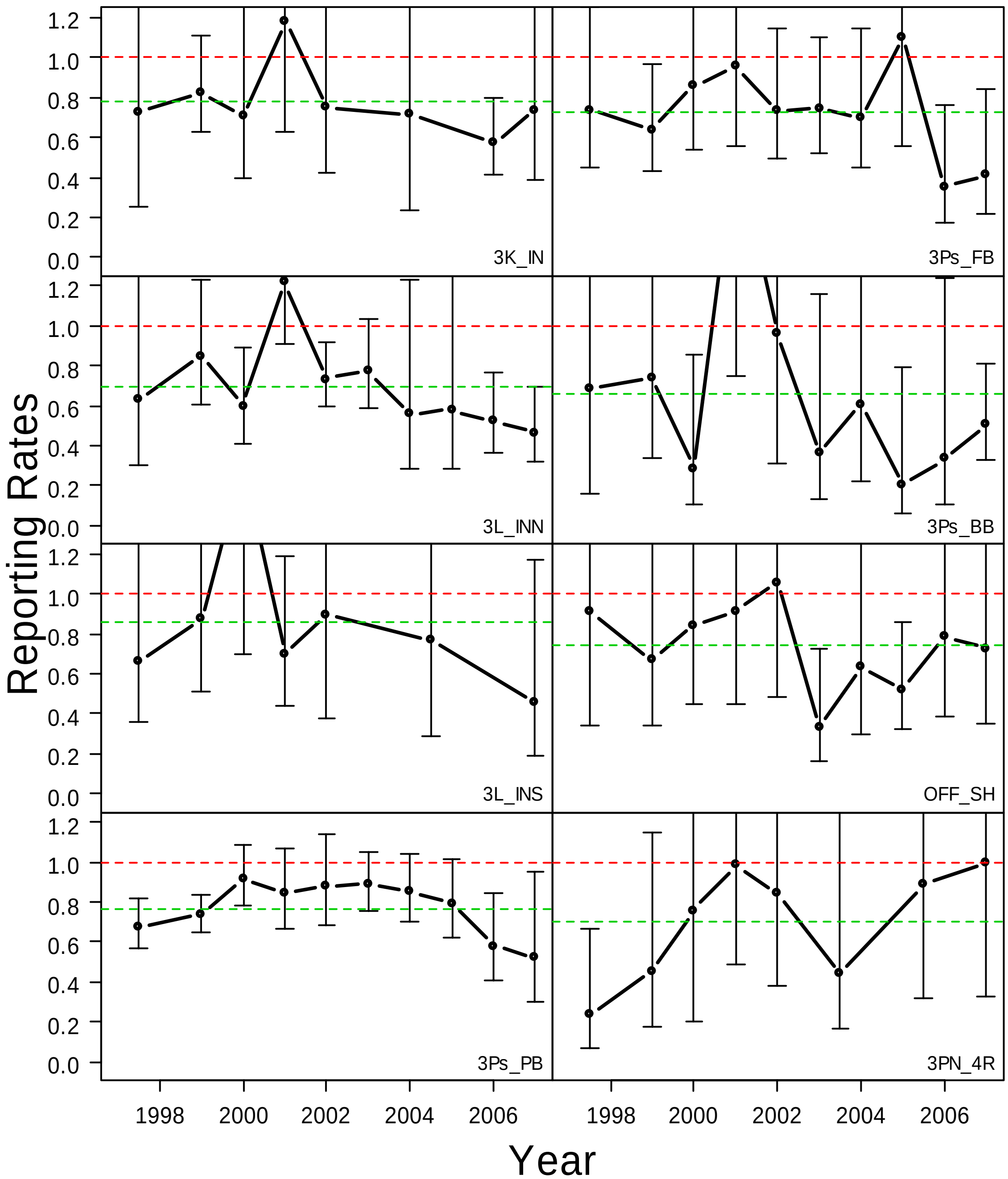

Figure 2. Estimates of reporting rates from the fixed-effects LRM, with 95% profile likelihood confidence intervals (vertical segments). Infeasible results >1.2 are not shown. Pooled estimates are plotted versus the average of the years that were pooled. A red dashed horizontal line at one is shown for reference. The average of the series is shown as a green dashed line.

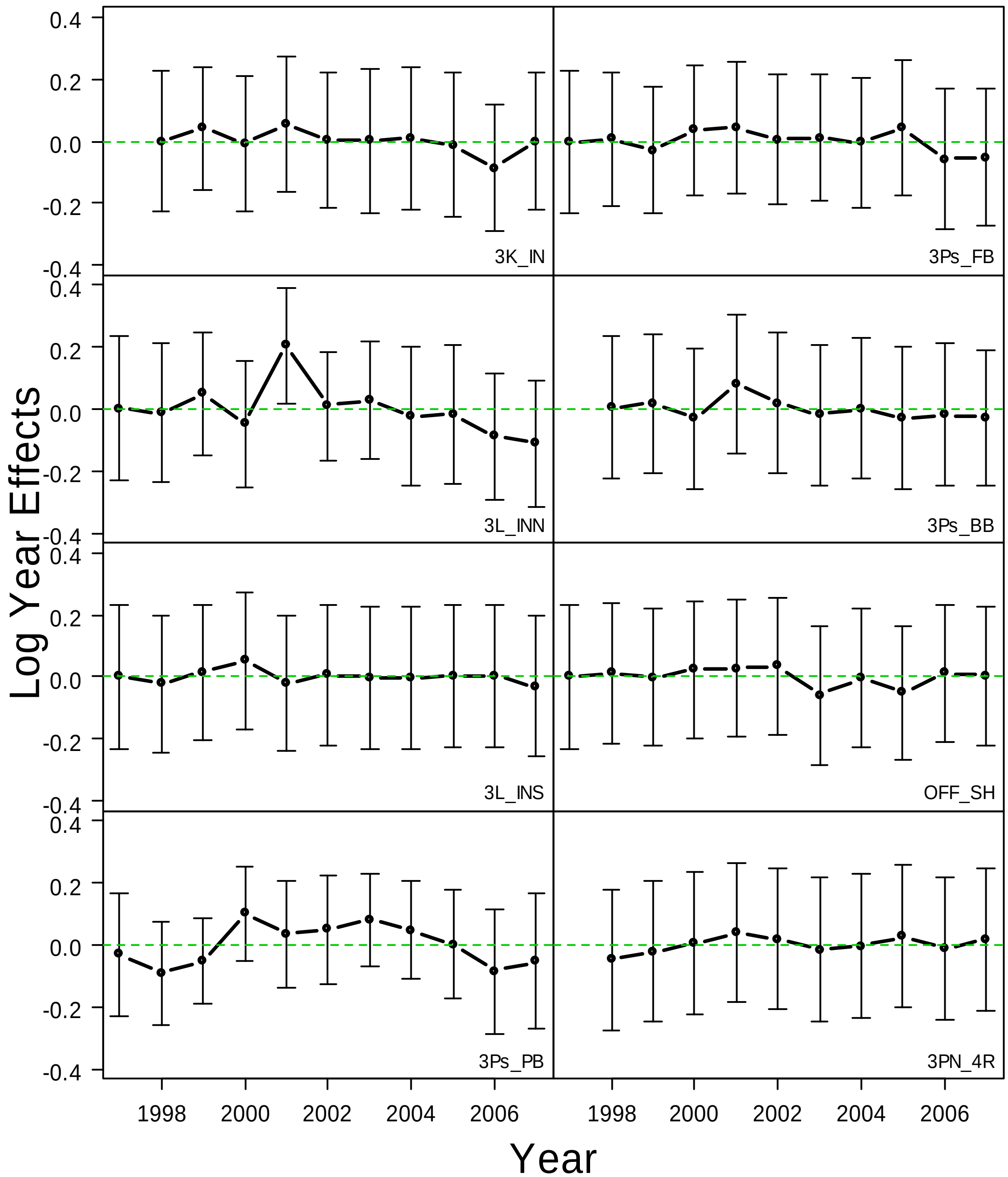

Figure 3. Estimates of log year-effects (δ_{hy}) from the preliminary mixed-effects LRM, with 95% confidence intervals (vertical segments). A dashed horizontal line at zero is shown for reference.

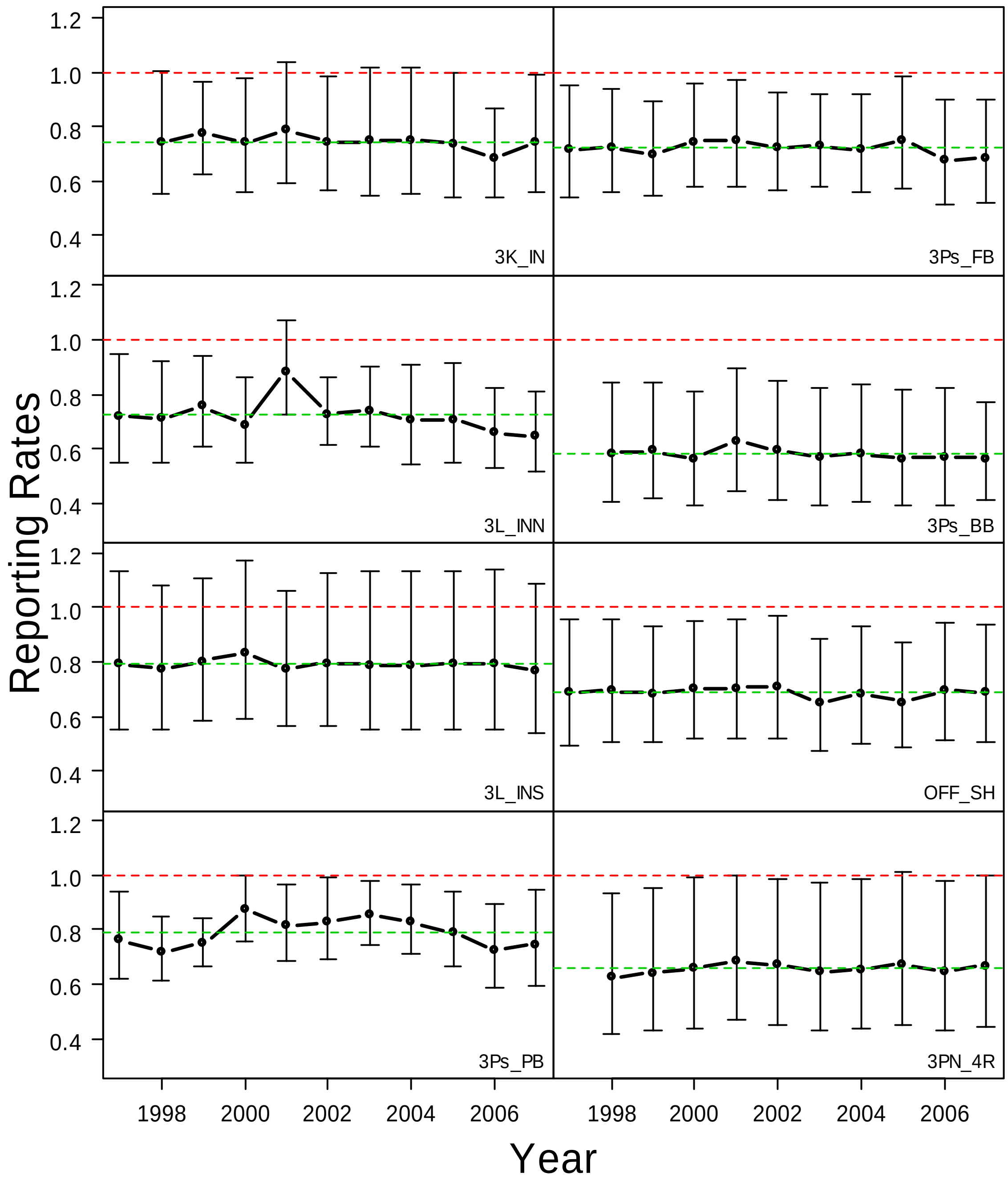

Figure 4. Estimates of reporting rates from the preliminary mixed-effects LRM, with 95% confidence intervals (vertical segments). A red dashed horizontal line at one is shown for reference. The average of the series is shown as a dashed green line.

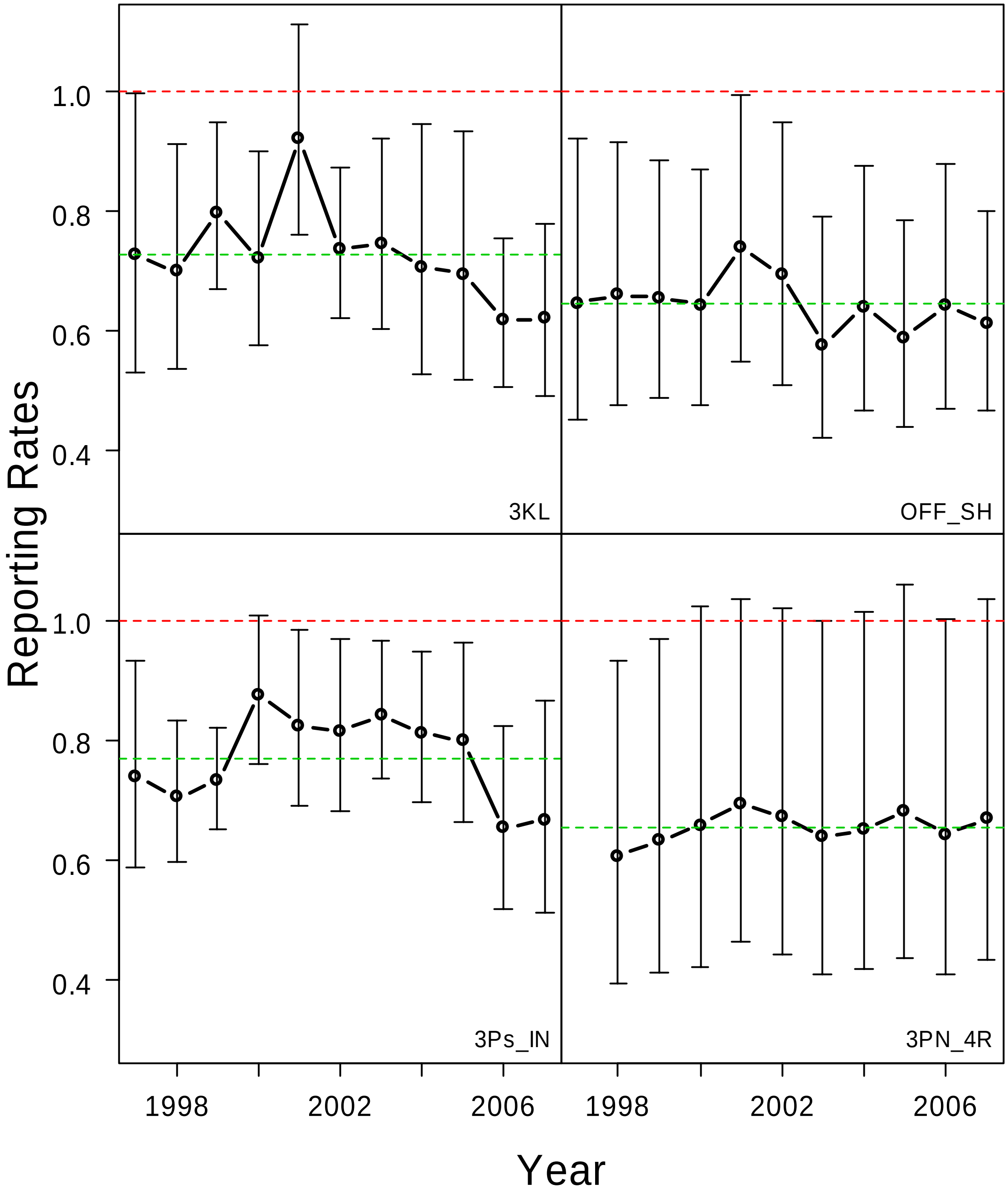

Figure 5. Estimates of reporting rates from the final mixed-effects LRM, with 95% confidence intervals (vertical segments). A red dashed horizontal line at one is shown for reference. The average of the series is shown as a dashed green line.

APPENDIX 2

The GENMOD Procedure

Model Information

Data Set	WORK.D2
Distribution	Binomial
Link Function	Logit
Response Variable (Events)	y
Response Variable (Trials)	N
Offset Variable	z

Number of Observations Read	10044
Number of Observations Used	10044
Number of Events	12149
Number of Trials	14506

Class Level Information

Class	Levels	Values
region	8	3K_IN 3L_INN 3L_INS 3PN_4R 3Ps_BB 3Ps_FB 3Ps_PB OFF_SH
rclass	14	1998- 1999 2000 2001 2002 2003 2003-4 2003-5 2003-6 2004 2005 2005-6 2006 2007

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	9971	8639.1958	0.8664
Scaled Deviance	9971	8639.1958	0.8664
Pearson Chi-Square	9971	9664.4341	0.9693
Scaled Pearson X2	9971	9664.4341	0.9693
Log Likelihood		-5567.4855	

Algorithm converged.

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Likelihood Ratio 95% Confidence Limits	
Intercept			0	0.0000	0.0000	0.0000	0.0000
region	3K_IN		1	-0.3019	0.3425	-0.9467	0.4088
region	3L_INN		1	-0.7673	0.1983	-1.1504	-0.3707
region	3L_INS		1	-0.7795	0.4562	-1.6516	0.1620
region	3PN_4R		1	-0.0071	0.6324	-1.1110	1.4566
region	3Ps_BB		1	-0.6762	0.2259	-1.1029	-0.2139
region	3Ps_FB		1	-0.8773	0.3467	-1.5372	-0.1668
region	3Ps_PB		1	-0.6540	0.2898	-1.1935	-0.0493
region	OFF_SH		1	-0.3196	0.3983	-1.0499	0.5322
region*rclass	3K_IN	1998-	1	-0.0214	0.6765	-1.2963	1.4081

Analysis Of Parameter Estimates

Parameter			Chi-Square	Pr > ChiSq
Intercept			.	.
region	3K_IN		0.78	0.3782
region	3L_INN		14.96	0.0001
region	3L_INS		2.92	0.0875
region	3PN_4R		0.00	0.9911
region	3Ps_BB		8.96	0.0028
region	3Ps_FB		6.40	0.0114
region	3Ps_PB		5.09	0.0240
region	OFF_SH		0.64	0.4223
region*rclass	3K_IN	1998-	0.00	0.9748

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The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Likelihood Ratio 95% Confidence Limits	
region*rclass	3K_IN	1999	1	0.1094	0.3727	-0.6533	0.8189
region*rclass	3K_IN	2000	1	-0.0452	0.4620	-0.9582	0.8666
region*rclass	3K_IN	2001	1	0.4679	0.4920	-0.4894	1.4592
region*rclass	3K_IN	2002	1	0.0147	0.4612	-0.8959	0.9261
region*rclass	3K_IN	2003-5	1	-0.0351	0.7211	-1.3572	1.5535
region*rclass	3K_IN	2006	1	-0.2576	0.3809	-1.0351	0.4686
region*rclass	3K_IN	2007	0	0.0000	0.0000	0.0000	0.0000
region*rclass	3L_INN	1998-	1	0.3081	0.4343	-0.5223	1.1935
region*rclass	3L_INN	1999	1	0.6045	0.2686	0.0791	1.1342
region*rclass	3L_INN	2000	1	0.2517	0.2793	-0.2931	0.8044
region*rclass	3L_INN	2001	1	0.9664	0.2535	0.4692	1.4651
region*rclass	3L_INN	2002	1	0.4584	0.2272	0.0084	0.9006
region*rclass	3L_INN	2003	1	0.5076	0.2448	0.0257	0.9870
region*rclass	3L_INN	2004	1	0.1871	0.4197	-0.6010	1.0598
region*rclass	3L_INN	2005	1	0.2200	0.4411	-0.6054	1.1425
region*rclass	3L_INN	2006	1	0.1159	0.2743	-0.4221	0.6548
region*rclass	3L_INN	2007	0	0.0000	0.0000	0.0000	0.0000
region*rclass	3L_INS	1998-	1	0.3668	0.5584	-0.7530	1.4540
region*rclass	3L_INS	1999	1	0.6451	0.5357	-0.4336	1.6853
region*rclass	3L_INS	2000	1	1.2803	0.6659	-0.0023	2.6477
region*rclass	3L_INS	2001	1	0.4250	0.5230	-0.6306	1.4397
region*rclass	3L_INS	2002	1	0.6672	0.6664	-0.6165	2.0353
region*rclass	3L_INS	2003-6	1	0.5175	0.7152	-0.8449	2.0108
region*rclass	3L_INS	2007	0	0.0000	0.0000	0.0000	0.0000
region*rclass	3PN_4R	1998-	1	-1.4379	0.8444	-3.2564	0.1119
region*rclass	3PN_4R	1999	1	-0.7888	0.7863	-2.4833	0.6724
region*rclass	3PN_4R	2000	1	-0.2683	0.9469	-2.1945	1.6361
region*rclass	3PN_4R	2001	1	-0.0086	0.7373	-1.6187	1.3587
region*rclass	3PN_4R	2002	1	-0.1601	0.7694	-1.8161	1.2883
region*rclass	3PN_4R	2003-4	1	-0.8124	0.8109	-2.5351	0.7281
region*rclass	3PN_4R	2005-6	1	-0.1116	0.8501	-1.8795	1.5608
region*rclass	3PN_4R	2007	0	0.0000	0.0000	0.0000	0.0000
region*rclass	3Ps_BB	1998-	1	0.3004	0.7837	-1.2150	1.9656
region*rclass	3Ps_BB	1999	1	0.3792	0.4820	-0.5423	1.3668
region*rclass	3Ps_BB	2000	1	-0.5788	0.5729	-1.6856	0.5950
region*rclass	3Ps_BB	2001	1	1.3240	0.5802	0.2779	2.6076
region*rclass	3Ps_BB	2002	1	0.6377	0.6780	-0.5800	2.1643
region*rclass	3Ps_BB	2003	1	-0.3441	0.5925	-1.4687	0.8969
region*rclass	3Ps_BB	2004	1	0.1804	0.5855	-0.9224	1.4127
region*rclass	3Ps_BB	2005	1	-0.9344	0.6937	-2.2819	0.5093
region*rclass	3Ps_BB	2006	1	-0.4241	0.6440	-1.6297	0.9523
region*rclass	3Ps_BB	2007	0	0.0000	0.0000	0.0000	0.0000
region*rclass	3Ps_FB	1998-	1	0.5736	0.4338	-0.2919	1.4172
region*rclass	3Ps_FB	1999	1	0.4306	0.4034	-0.3813	1.2086
region*rclass	3Ps_FB	2000	1	0.7262	0.4233	-0.1192	1.5491
region*rclass	3Ps_FB	2001	1	0.8315	0.4526	-0.0623	1.7229
region*rclass	3Ps_FB	2002	1	0.5713	0.4085	-0.2476	1.3629
region*rclass	3Ps_FB	2003	1	0.5876	0.3951	-0.2076	1.3506
region*rclass	3Ps_FB	2004	1	0.5207	0.4200	-0.3173	1.3386
region*rclass	3Ps_FB	2005	1	0.9777	0.5143	-0.0136	2.0225
region*rclass	3Ps_FB	2006	1	-0.1708	0.5048	-1.1565	0.8372
region*rclass	3Ps_FB	2007	0	0.0000	0.0000	0.0000	0.0000
region*rclass	3Ps_PB	1998-	1	0.2661	0.3041	-0.3632	0.8365
region*rclass	3Ps_PB	1999	1	0.3464	0.2975	-0.2714	0.9025
region*rclass	3Ps_PB	2000	1	0.5690	0.3023	-0.0571	1.1355
region*rclass	3Ps_PB	2001	1	0.4831	0.3135	-0.1622	1.0742
region*rclass	3Ps_PB	2002	1	0.5245	0.3171	-0.1268	1.1238
region*rclass	3Ps_PB	2003	1	0.5355	0.3018	-0.0897	1.1011
region*rclass	3Ps_PB	2004	1	0.4961	0.3063	-0.1369	1.0714
region*rclass	3Ps_PB	2005	1	0.4193	0.3155	-0.2295	1.0149
region*rclass	3Ps_PB	2006	1	0.1096	0.3437	-0.5875	0.7673
region*rclass	3Ps_PB	2007	0	0.0000	0.0000	0.0000	0.0000
region*rclass	OFF_SH	1998-	1	0.2253	0.6653	-1.0681	1.5819
region*rclass	OFF_SH	1999	1	-0.0805	0.5287	-1.1507	0.9411
region*rclass	OFF_SH	2000	1	0.1498	0.5228	-0.9065	1.1643
region*rclass	OFF_SH	2001	1	0.2323	0.5522	-0.8697	1.3204
region*rclass	OFF_SH	2002	1	0.3760	0.5823	-0.7725	1.5418
region*rclass	OFF_SH	2003	1	-0.7778	0.5500	-1.8876	0.2868
region*rclass	OFF_SH	2004	1	-0.1303	0.5646	-1.2579	0.9792

Analysis Of Parameter Estimates

Parameter			Chi-Square	Pr > ChiSq
region*rclass	3K_IN	1999	0.09	0.7692
region*rclass	3K_IN	2000	0.01	0.9220
region*rclass	3K_IN	2001	0.90	0.3416
region*rclass	3K_IN	2002	0.00	0.9745
region*rclass	3K_IN	2003-5	0.00	0.9612
region*rclass	3K_IN	2006	0.46	0.4989
region*rclass	3K_IN	2007	.	.
region*rclass	3L_INN	1998-	0.50	0.4780
region*rclass	3L_INN	1999	5.06	0.0244
region*rclass	3L_INN	2000	0.81	0.3676
region*rclass	3L_INN	2001	14.53	0.0001
region*rclass	3L_INN	2002	4.07	0.0436
region*rclass	3L_INN	2003	4.30	0.0381
region*rclass	3L_INN	2004	0.20	0.6558
region*rclass	3L_INN	2005	0.25	0.6179
region*rclass	3L_INN	2006	0.18	0.6725
region*rclass	3L_INN	2007	.	.
region*rclass	3L_INS	1998-	0.43	0.5113
region*rclass	3L_INS	1999	1.45	0.2285
region*rclass	3L_INS	2000	3.70	0.0545
region*rclass	3L_INS	2001	0.66	0.4165
region*rclass	3L_INS	2002	1.00	0.3167
region*rclass	3L_INS	2003-6	0.52	0.4693
region*rclass	3L_INS	2007	.	.
region*rclass	3PN_4R	1998-	2.90	0.0886
region*rclass	3PN_4R	1999	1.01	0.3158
region*rclass	3PN_4R	2000	0.08	0.7769
region*rclass	3PN_4R	2001	0.00	0.9906
region*rclass	3PN_4R	2002	0.04	0.8352
region*rclass	3PN_4R	2003-4	1.00	0.3164
region*rclass	3PN_4R	2005-6	0.02	0.8955
region*rclass	3PN_4R	2007	.	.
region*rclass	3Ps_BB	1998-	0.15	0.7015
region*rclass	3Ps_BB	1999	0.62	0.4315
region*rclass	3Ps_BB	2000	1.02	0.3123
region*rclass	3Ps_BB	2001	5.21	0.0225
region*rclass	3Ps_BB	2002	0.88	0.3470
region*rclass	3Ps_BB	2003	0.34	0.5614
region*rclass	3Ps_BB	2004	0.09	0.7579
region*rclass	3Ps_BB	2005	1.81	0.1780
region*rclass	3Ps_BB	2006	0.43	0.5102
region*rclass	3Ps_BB	2007	.	.
region*rclass	3Ps_FB	1998-	1.75	0.1861
region*rclass	3Ps_FB	1999	1.14	0.2858
region*rclass	3Ps_FB	2000	2.94	0.0863
region*rclass	3Ps_FB	2001	3.37	0.0662
region*rclass	3Ps_FB	2002	1.96	0.1620
region*rclass	3Ps_FB	2003	2.21	0.1369
region*rclass	3Ps_FB	2004	1.54	0.2150
region*rclass	3Ps_FB	2005	3.61	0.0573
region*rclass	3Ps_FB	2006	0.11	0.7352
region*rclass	3Ps_FB	2007	.	.
region*rclass	3Ps_PB	1998-	0.77	0.3816
region*rclass	3Ps_PB	1999	1.36	0.2442
region*rclass	3Ps_PB	2000	3.54	0.0598
region*rclass	3Ps_PB	2001	2.38	0.1233
region*rclass	3Ps_PB	2002	2.74	0.0981
region*rclass	3Ps_PB	2003	3.15	0.0760
region*rclass	3Ps_PB	2004	2.62	0.1053
region*rclass	3Ps_PB	2005	1.77	0.1839
region*rclass	3Ps_PB	2006	0.10	0.7498
region*rclass	3Ps_PB	2007	.	.
region*rclass	OFF_SH	1998-	0.11	0.7348
region*rclass	OFF_SH	1999	0.02	0.8791
region*rclass	OFF_SH	2000	0.08	0.7745
region*rclass	OFF_SH	2001	0.18	0.6740
region*rclass	OFF_SH	2002	0.42	0.5185
region*rclass	OFF_SH	2003	2.00	0.1573
region*rclass	OFF_SH	2004	0.05	0.8174

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Likelihood Ratio 95% Confidence Limits	
region*rclass	OFF_SH	2005	1	-0.3368	0.4689	-1.3054	0.5510
region*rclass	OFF_SH	2006	1	0.0812	0.5590	-1.0284	1.1916
region*rclass	OFF_SH	2007	0	0.0000	0.0000	0.0000	0.0000
Scale			0	1.0000	0.0000	1.0000	1.0000

Analysis Of Parameter Estimates

Parameter			Chi-Square	Pr > ChiSq
region*rclass	OFF_SH	2005	0.52	0.4726
region*rclass	OFF_SH	2006	0.02	0.8845
region*rclass	OFF_SH	2007	.	.
Scale				

NOTE: The scale parameter was held fixed.

APPENDIX 3

The GLIMMIX Procedure

Model Information

Data Set	WORK.D2
Response Variable (Events)	y
Response Variable (Trials)	N
Response Distribution	Binomial
Link Function	Logit
Variance Function	Default
Offset Variable	z
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
region	4	3KL 3PN_4R 3Ps_IN OFF_SH
yeart	11	1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

Number of Observations Read	10044
Number of Observations Used	10044
Number of Events	12149
Number of Trials	14506

Dimensions

G-side Cov. Parameters	1
Columns in X	4
Columns in Z	43
Subjects (Blocks in V)	1
Max Obs per Subject	10044

Parameter Search

CovP1	Objective Function
0.05000	40754.293504

Optimization Information

Optimization Technique	Newton-Raphson
Parameters in Optimization	1
Lower Boundaries (User)	1
Lower Boundaries (User)	1
Lower Boundaries	1
Upper Boundaries	1
Fixed Effects	Profiled
Starting From	Data

Iteration History

Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	29	45549.066003	0.80442757	2.166206

Iteration History

Parm1	Gradient1
0.01640	2.1662

The GLIMMIX Procedure

Iteration History

Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
1	0	3	48545.568436	0.27182481	0.002936

Iteration History

Parm1	Gradient1
0.02156	-0.00294

Iteration History

Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
2	0	2	48999.996267	0.01965953	0.000042

Iteration History

Parm1	Gradient1
0.02198	-0.00004

Iteration History

Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
3	0	1	49011.962112	0.00019989	0.00001

Iteration History

Parm1	Gradient1
0.02199	-0.00001

Iteration History

Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
4	0	1	49011.98766	0.00000065	1.06E-10

Iteration History

Parm1	Gradient1
0.02199	-106E-12

Iteration History

Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
5	0	0	49011.987612	0.00000000	8.103E-7

Iteration History

Parm1	Gradient1
0.02199	-8.1E-7

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics

-2 Res Log Pseudo-Likelihood	49011.99
Generalized Chi-Square	9679.65
Gener. Chi-Square / DF	0.96

The GLIMMIX Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error
region*yeart	0.02199	0.01362

Solutions for Fixed Effects

Effect	region	Estimate	Standard Error	DF	t Value	Pr > |t|
region	3KL	-0.3247	0.06919	39	-4.69	<.0001
region	3PN_4R	-0.4243	0.1785	39	-2.38	0.0225
region	3Ps_IN	-0.2662	0.05671	39	-4.69	<.0001
region	OFF_SH	-0.4391	0.1022	39	-4.30	0.0001

Type III Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
region	4	39	17.04	<.0001

Solution for Random Effects

Effect	region	yeart	Estimate	Std Err Pred	DF	t Value	Pr > |t|
region*yeart	3KL	1997	0.006875	0.1458	10001	0.05	0.9624
region*yeart	3KL	1998	-0.03246	0.1276	10001	-0.25	0.7992
region*yeart	3KL	1999	0.1004	0.09702	10001	1.03	0.3010
region*yeart	3KL	2000	-0.00305	0.1128	10001	-0.03	0.9784
region*yeart	3KL	2001	0.2421	0.1015	10001	2.39	0.0171
region*yeart	3KL	2002	0.01863	0.09614	10001	0.19	0.8463
region*yeart	3KL	2003	0.03341	0.1084	10001	0.31	0.7579
region*yeart	3KL	2004	-0.02145	0.1366	10001	-0.16	0.8753
region*yeart	3KL	2005	-0.03737	0.1375	10001	-0.27	0.7858
region*yeart	3KL	2006	-0.1549	0.1043	10001	-1.49	0.1375
region*yeart	3KL	2007	-0.1521	0.1146	10001	-1.33	0.1845
region*yeart	3PN_4R	1998	-0.07499	0.1431	10001	-0.52	0.6003
region*yeart	3PN_4R	1999	-0.03352	0.1425	10001	-0.24	0.8140
region*yeart	3PN_4R	2000	0.006468	0.1452	10001	0.04	0.9645
region*yeart	3PN_4R	2001	0.05872	0.1391	10001	0.42	0.6730
region*yeart	3PN_4R	2002	0.02777	0.1411	10001	0.20	0.8440
region*yeart	3PN_4R	2003	-0.02440	0.1461	10001	-0.17	0.8674
region*yeart	3PN_4R	2004	-0.00601	0.1454	10001	-0.04	0.9670

Solution for Random Effects

Effect	region	yeart	Alpha	Lower	Upper
region*yeart	3KL	1997	0.05	-0.2789	0.2927
region*yeart	3KL	1998	0.05	-0.2827	0.2177
region*yeart	3KL	1999	0.05	-0.08983	0.2905
region*yeart	3KL	2000	0.05	-0.2241	0.2180
region*yeart	3KL	2001	0.05	0.04312	0.4410
region*yeart	3KL	2002	0.05	-0.1698	0.2071
region*yeart	3KL	2003	0.05	-0.1790	0.2458
region*yeart	3KL	2004	0.05	-0.2892	0.2464
region*yeart	3KL	2005	0.05	-0.3069	0.2322
region*yeart	3KL	2006	0.05	-0.3594	0.04953
region*yeart	3KL	2007	0.05	-0.3767	0.07252
region*yeart	3PN_4R	1998	0.05	-0.3555	0.2055
region*yeart	3PN_4R	1999	0.05	-0.3128	0.2457
region*yeart	3PN_4R	2000	0.05	-0.2781	0.2910
region*yeart	3PN_4R	2001	0.05	-0.2140	0.3314
region*yeart	3PN_4R	2002	0.05	-0.2488	0.3044
region*yeart	3PN_4R	2003	0.05	-0.3108	0.2620
region*yeart	3PN_4R	2004	0.05	-0.2910	0.2790

The GLIMMIX Procedure

Solution for Random Effects

Std Err

Effect	region	yeart	Estimate	Pred	DF	t Value	Pr > |t|
region*yeart	3PN_4R	2005	0.04060	0.1453	10001	0.28	0.7799
region*yeart	3PN_4R	2006	-0.01919	0.1459	10001	-0.13	0.8954
region*yeart	3PN_4R	2007	0.02456	0.1438	10001	0.17	0.8644
region*yeart	3Ps_IN	1997	-0.03444	0.1157	10001	-0.30	0.7660
region*yeart	3Ps_IN	1998	-0.08377	0.09202	10001	-0.91	0.3627
region*yeart	3Ps_IN	1999	-0.04593	0.07564	10001	-0.61	0.5437
region*yeart	3Ps_IN	2000	0.1344	0.08300	10001	1.62	0.1054
region*yeart	3Ps_IN	2001	0.07359	0.09528	10001	0.77	0.4399
region*yeart	3Ps_IN	2002	0.05974	0.09522	10001	0.63	0.5304
region*yeart	3Ps_IN	2003	0.09537	0.08133	10001	1.17	0.2410
region*yeart	3Ps_IN	2004	0.05834	0.08771	10001	0.67	0.5060
region*yeart	3Ps_IN	2005	0.04159	0.09839	10001	0.42	0.6725
region*yeart	3Ps_IN	2006	-0.1596	0.1157	10001	-1.38	0.1678
region*yeart	3Ps_IN	2007	-0.1393	0.1274	10001	-1.09	0.2744
region*yeart	OFF_SH	1997	0.003078	0.1481	10001	0.02	0.9834
region*yeart	OFF_SH	1998	0.02490	0.1403	10001	0.18	0.8591
region*yeart	OFF_SH	1999	0.01896	0.1318	10001	0.14	0.8856
region*yeart	OFF_SH	2000	-0.00141	0.1333	10001	-0.01	0.9916
region*yeart	OFF_SH	2001	0.1369	0.1318	10001	1.04	0.2990
region*yeart	OFF_SH	2002	0.07658	0.1357	10001	0.56	0.5724
region*yeart	OFF_SH	2003	-0.1093	0.1370	10001	-0.80	0.4251
region*yeart	OFF_SH	2004	-0.00471	0.1359	10001	-0.03	0.9724
region*yeart	OFF_SH	2005	-0.09077	0.1295	10001	-0.70	0.4833
region*yeart	OFF_SH	2006	-0.00308	0.1362	10001	-0.02	0.9820
region*yeart	OFF_SH	2007	-0.05120	0.1247	10001	-0.41	0.6815

Solution for Random Effects

Effect	region	yeart	Alpha	Lower	Upper
region*yeart	3PN_4R	2005	0.05	-0.2441	0.3253
region*yeart	3PN_4R	2006	0.05	-0.3053	0.2669
region*yeart	3PN_4R	2007	0.05	-0.2573	0.3065
region*yeart	3Ps_IN	1997	0.05	-0.2613	0.1924
region*yeart	3Ps_IN	1998	0.05	-0.2642	0.09661
region*yeart	3Ps_IN	1999	0.05	-0.1942	0.1023
region*yeart	3Ps_IN	2000	0.05	-0.02830	0.2971
region*yeart	3Ps_IN	2001	0.05	-0.1132	0.2604
region*yeart	3Ps_IN	2002	0.05	-0.1269	0.2464
region*yeart	3Ps_IN	2003	0.05	-0.06406	0.2548
region*yeart	3Ps_IN	2004	0.05	-0.1136	0.2303
region*yeart	3Ps_IN	2005	0.05	-0.1513	0.2345
region*yeart	3Ps_IN	2006	0.05	-0.3864	0.06718
region*yeart	3Ps_IN	2007	0.05	-0.3891	0.1105
region*yeart	OFF_SH	1997	0.05	-0.2872	0.2934
region*yeart	OFF_SH	1998	0.05	-0.2501	0.2999
region*yeart	OFF_SH	1999	0.05	-0.2394	0.2773
region*yeart	OFF_SH	2000	0.05	-0.2626	0.2598
region*yeart	OFF_SH	2001	0.05	-0.1215	0.3953
region*yeart	OFF_SH	2002	0.05	-0.1893	0.3425
region*yeart	OFF_SH	2003	0.05	-0.3778	0.1593
region*yeart	OFF_SH	2004	0.05	-0.2712	0.2617
region*yeart	OFF_SH	2005	0.05	-0.3446	0.1630
region*yeart	OFF_SH	2006	0.05	-0.2701	0.2639
region*yeart	OFF_SH	2007	0.05	-0.2957	0.1933