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Standardized Abundance Indices for Blue Marlin (*Makaira nigricans*) in Pacific Ocean from Analyses of Catch and Fishing Effort from Offshore and Distance Water Longline Vessels of Japan[1]

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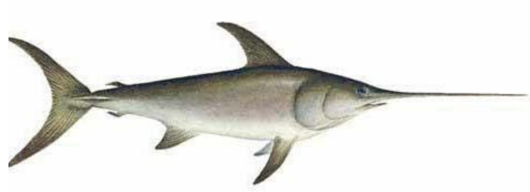

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Standardized abundance indices for blue marlin (*Makaira nigricans*) in Pacific Ocean from analyses of catch and fishing effort from offshore and distance water longline vessels of Japan

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Summary

Blue marlin are highly migratory with movement patterns that vary by sex and age. Their feeding habitat preference is for yellow-fin and albacore tuna, the principal species sought by the longline fisheries that capture blue marlin. As a result, it is to be expected that hooking efficiency, or selectivity, of hooks set to capture the target species will be different than that observed for blue marlin, which are not directly targeted, taken by these hooks.

Two methods were applied to obtain standardized catch-per-unit-effort (CPUE) estimates from the fishing effort (hooks) and catch (number of fish) of blue marlin taken by the longline fisheries of Japan. The first method, which incorporated a Δ-distribution model and a generalized linear model (Δ-GLM), was applied to data from two time periods (1975 to 1993; 1994 to 2010); and the second, a deterministic habitat-based standardization model (HBS), was applied to data from the period 1994 to 2011.

Diagnostics from the Δ-GLM indicated poor fit of the binomial model (the 0/1, presence/absence) component, while performance of the second component (fit to positive catch data) was satisfactory. Results of the Δ-GLM showed a slight increasing trend in the 1975 to 1993 period, which was followed by a slight decrease in the 1994 to 2010 period. Standard deviations of CPUE were obtained using bootstrap analysis.

The HBS model was used for the previous assessments (2001 and 2003) of blue marlin in the Pacific, however unlike the fishing effort data used in those analyses, detailed data on gear configuration by operation (set) was available for use in this assessment. The HBS model includes a component gear model that provides an estimate of the fishing depth of hooks on a

longline based on lengths of the various components of a longline, e.g. lengths of branch or float lines. There were over 4,000 gear configurations present in the operational data.

A comparison of estimated depth of hooks obtained from the gear model used in this HBS to the estimates from HBS that were used in the previous assessments found that depths estimated using operational data were deeper for the shallowest hooks on the longline, and shallower for the deepest. The blue marlin habitat distribution was estimated using the temperature of the mixed-layer and the depths of isotherms at temperatures of one to eight degrees less than the mixed-layer temperature. The trends in standardized and in nominal catch-per-unit effort were presented.

Given the data available, the most reliable standardization of the longline data of Japan is by the Δ-GLM for the 1975 to 1993 period and by HBS for the 1994 to 2011 period.

Introduction

Catches of blue marlin are a major part of the total catch made by Japanese offshore and distant-water longline vessels, which target primarily tunas and swordfish but whose catch includes blue shark (*Prionace glauca*) and striped marlin (*Kajikia audax* Philippi, 1887).

The detailed data available from the records of the Japan Fishing Agency (JFA) for longline fisheries of Japan offer a variety of key inputs for stock assessments of pelagic fishes, including blue marlin (Kleiber et. al.; 2003). A principal requirement for an assessment is an index of relative abundance. Fishery independent indices are not available for pan-ocean species, such as blue marlin, so models using data on catch and fishing effort are used to obtain indices of standardized catch-per-unit-effort (CPUE), which are then assumed to be proportional to population abundance.

Developing standardized CPUE abundance indices for blue marlin based on data from longline fisheries of Japan has been determined problematic by the Billfish Working Group of the International Commission for the Conservation of Atlantic Tuna (ICCAT) (e.g., ICCAT; 2004). The ICCAT working group found that the application of the traditional GLM approach to the historical data of the longline fisheries of Japan resulted in underestimates of current stock levels (Yokawa, 2004; Yokawa and Saito, 2004; Goodyear, 2006; Goodyear et. al., 2006; Ortiz, 2006).

Previous stock assessments of blue marlin in the Pacific Ocean (Hinton 2001, Kleiber et al., 2003) were conducted using different population dynamics models (Hinton, 2001: delay-difference; Kleiber et al., 2003: MultiFAN CL) but the same standardized CPUE developed using habitat-based standardization (HBS: Hinton and Nakano, 1996). This standardization assumed a single gear configuration for the longline fishery, which was necessary due to lack of information on gear configuration for individual operations of longline gear. However, this assumption may be unrealistic when applied to an entire fleet (Yokawa and Takeuchi, 2003).

We have applied two modeling approaches catch and effort data from longline fisheries of Japan to obtain standardized CPUE. In the first we applied a Δ-distribution model combined with a generalized linear model (Δ-GLM: Stefánsson, 1991 and 1996; Lo et al., 1992) to data from the periods 1975 to 1993 and 1994 to 2010. Data from years prior to 1975 were not included due to lack of data on total catch of blue marlin resulting from misidentification of black (*M. indica*) and blue marlin in earlier years (Kimoto and Yokawa, 2012)

In 1994 the JFA introduced a new logbook reporting system for Japanese offshore and distant-water longline vessels that requested, among other things, the submission of detailed gear configuration data for each operation of the longline. Such data are believed to be quite important (Goodyear et al. 2003) to performance of HBS models. With such data now available from the JFA logbook system, we applied a deterministic HBS model to obtain standardized CPUE for the period 1994 to 2011.

Materials and Methods

The operational catch and effort data used in these analyses was obtained from the Japanese offshore and distant longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries, Japan.

Data included in standardizations was restricted to that from operations occurring between 30°S and 30°N in order to minimize the occurrence of data from fisheries targeting albacore tuna (*Thunnus alalunga*), which resulted in a reduction of operational data that accounted for about 0.1 percent of the total catch of blue marlin reported in those data.

The current logbook reporting system for longline vessels of Japan was started by the JFA in 1994. This system asks skippers to report detailed information on gear configuration for each operation of the gear, including such as the length of branch lines, the length of the mainline between branch lines, and length of float lines. Although the logbook system was introduced in 1994, the collection of these detailed data was not immediately implemented due to the rather long cruises (more than two years) made by the distant water longline vessels. Thus, detailed data began to be recorded for the most part in about 1997.

Habitat based standardization

Japanese commercial longline operational fishing effort data for the 1994 to 2011 period was standardized using habitat-based standardization (HBS: Hinton and Nakano, 1996). Data were restricted to operations with between 3 and 34 hooks-per-basket.

The HBS standardization uses models of fishing effort distribution (gear model), blue marlin distribution (habitat-preference model), and habitat distribution (habitat model)

1. Gear model: The operational data contains measures of the length of branch lines, length of line mainline between breach lines, and length of float lines. These measures were used to estimate the fishing depths of hooks using the catenary curve model of Suzuki et al. (1977), which estimates fishing depth at 85 percent of the theoretical depth obtained from the catenary model. There were over 4,000 gear configurations observed in the operational data.

Since the collection of detailed gear configuration for each operation realistically was not implemented until about 1997 and it was not fully realized until 1998, estimates of gear configuration parameters for the period prior to 1998 were made using data from the 1994 to 1998 period. This was possible because gear configurations of vessels licensed by individual prefectures and from ports therein function similarly to code groups that operate in the same areas targeting the same species using similar gear configurations. As well, data indicate that there is little between-year change in gear configurations within these groups, though there are changes over longer time periods.

Estimated gear configuration parameters were developed using the average parameter values by large area (north of 20°N, 0° to 20°N, 0° to 20°S, and south of 20°S), hooks-per-basket category (3 to 5, 6 to 9, 10 to 14, 15 to 17, and 18 to 25), calendar quarter, and material of mainline (nylon and other). There were some few infrequently observed gear configurations that were not included in estimation procedures. The data from sets identified as targeting swordfish and from shallow sets conducted in the tropical ocean were also excluded from the analysis.

2. Habitat-preference model: The vertical distribution of marlins has been related to the difference [ΔT] between the temperature of the mixed layer [the temperature to which a fish is acclimated] and the temperature of its immediate surroundings [the temperature at depths below the mixed layer] (Brill et al., 1993). This vertical distribution was described by the amount of time spent in waters with temperatures lower than the temperature of the mixed layer. Hinton and Nakano (1996) used the ΔT approach to develop a habitat-preference model for blue marlin (Fig. 1) using data from archival tags.

The ΔT model places blue marlin in the mixed layer 76 percent of the time, and in waters within 1° C of the mixed layer temperature 14 percent of the time. The possibility that temperature-based models may not correspond well with feeding behavior or strikes on bait has been noted (Goodyear, 2003). It has been demonstrated that for some species that there is a positive correlation of body size and maximum depth excursions (e.g. sharks: Sepulveda et al. 2004) and that the location of feeding events may not correspond well with time in an area (Bestley et al. 2008).

In the case of marlins, however, the archival tag data shows intolerance to temperatures differences of greater than 1° C less than the mixed-layer temperature, and the eyes of marlins are highly specialized for feeding in the mixed layer and for compensating for rapid changes in light levels as would be experienced in pursuit of prey to depth (Fritches et al., 2003a; Fritches et al., 2003b). These physiological adaptions of the eye tend to suggest that there is a positive relationship between the time-temperature distribution in the ΔT model and the feeding depths of marlin.

3. Habitat Model: The depth and temperature of the mixed layer and of the depths of isotherms at temperatures of 1°C to 6°C less than the temperature of the mixed layer at a resolution of 1° latitude by 1° longitude (1x1) were determined using modeled data for mixed-layer depth[1] and temperature-at-depth[2].

Temperature-at-depth (TAD) was available at a resolution of 1.0° latitude by 1.875° longitude. Data for 1x1 areas was estimated by assigning TAD observations occurring within a 1x1 area to that area; and for 1x1 areas without observations, TAD was estimated by averaging the values at depth from immediately adjacent areas at the same latitude.

Mixed-layer depth (MLD) data was available at a resolution of 0.33° latitude by 1.0° longitude. The MLD for a 1x1 area was estimated as the average of the three MLD observations within the area. Temperature of the mixed layer was estimated as the average of TAD observations in a 1x1 area from depths shallower than the depth of the mixed layer. Depths of isotherms at temperatures of 1°C to 6°C below the temperature of the mixed layer were estimated by interpolation of temperature at depth data within the area.

Δ-distribution model with a generalized linear model (Δ-GLM) model

The operational data for the period 1975 to 2010 was analyzed with a Δ-GLM model (Stefánsson, 1991 and 1996; Lo et al., 1992). The parameters included catch in numbers, number of hooks by set, and number of hooks-per-basket (HPB) for operations with 3 < HPB < 21. The data were further restricted to those from vessels operating from the Fukushima, Miyagi, and Iwate Prefectures. These vessels were responsible for about 70 percent of the total catch of blue marlin in the operational data.

The model was fitted to data from an early period, 1975 to 1993, and a later period, 1994 to 2010, due to significant and sudden changes in gear type and HPB configurations (Kanaiwa and Yokawa, 2009) and to limitations in computer resources needed to solve a full model over the 1975 to 2010 period. The significant shift in basic parameters of the fishery caused significant problems with the GLM-based, and on

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[1] iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP/.EMC/.CMB/.GODAS/.monthly/.ocean_mixed_layer_bot/ (accessed 3 Jan 2013).

[2] http://iridl.ldeo.columbia.edu/SOURCES/.CMA/.BCC/.GODAS/.temp (accessed 3 Jan 2013).

review of preliminary results and our recommendation, the ISC Billfish Working Group decided that the time series should be split as noted.

Both forward and backward step-wise methods with AIC criterion were applied for all models to determine optimal fits, and all initial models were adopted. The GLM-tree method (Ichinokawa and Brodziak, 2010) was used to obtain optimal area stratification to standardize CPUE with fishery data after 1994 in the 2nd model. The 4th level split on area (i.e. 5 areas: Fig. 2) was used, because the 5th level split resulted in areas that were too small to contain sufficient sample data (Fig. 3: area 1) for analyses. The standard deviations for each year were estimated using bootstrap analysis with 100 resamples.

The acronyms and model parameters were defined as follows. Names in capital letters indicate categorical variables (factors):

1. Existence: a binary variable indicating the presence (1) or absence (0) of blue marlin in the catch of a single operation;
2. Latitude (Lat) and longitude (Lon);
3. HPB: the number of hooks on the mainline between each float;
4. CPUE: 1000 × [catch of blue marlin] / [total number of hooks on the mainline]
5. Poly(…): a polynomial equation of order 2
6. Report: the number of fishing days in a report period / the number of days in the period;
7. SEASON: calendar quarter with values 0 = Jan-Mar, 1 = Apr-Jun, 2 = Jul-Sep, and 3 = Oct-Dec;
8. YEAR
9. PREF: geographical region in Japan, e.g. 24 = Fukushima, 23 = Miyagi, and 22: = Iwate.
10. AREA: geographical area (this factor was used only in the Gaussian component of the later period model).

Fitted Δ-GLM models

1. Early period (1975 to 1993)
   a. Binomial model: Existence ~ Intercept + YEAR × (poly[HPB] + SEASON
      + poly[Lat] × poly[Lon]) + Binomial error term
   b. Gaussian model: ln(CPUE) ~ Intercept + YEAR × (poly[HPB] + PREF + Report
      + poly[Lat] × poly[Lon] + SEASON × poly[Lat]) + Gaussian error term
2. Later period (1994 to 2010)
   a. Binomial model: Existence ~ Intercept + (YEAR + poly[HPB] + SEASON + PREF

$+ \text{poly[Lat]} \times \text{poly[Lon]})^2 + \text{Binomial error term}$

b. Gaussian model: ln(CPUE) ~ Intercept + YEAR × (poly[HPB] + SEASON + PREF + Report + AREA) + Gaussian error term

Results and Discussion

Habitat based standardization

The expected fishing depth of hooks estimated in the gear model were compared to those of the gear model of Hinton and Nakano (1996), which was used in previous assessments of blue marlin (Hinton 2001, Kleiber et al., 2003). Hinton and Nakano (1996) lacked operational gear configuration data and therefore assumed a single gear configuration based on Suzuki et al. (1977). Comparisons of hook-depth distributions obtained herein to their model was made by first estimating the depth of hooks for all observed gear configurations, and then computing the weighted-average depth of individual hooks within hook-per-basket strata, where weights were the number of operations by gear configuration. The table below provides an example of the differences in the hook depths from the Hinton and Nakano (1996) model and from the gear model incorporating operational data. The estimated fishing depth of hooks in sets with 17 hooks-per-basket in the 2013 model were significantly different at all hook positions than those of the 1996 model. The increased depth of the shallowest hooks in the set; those in positions 1, 2, 16, and 17; would tend to move hooks out of the mixed layer, while the shallower hook depths for hooks at positions between 3 and 15 would be expected to have little impact on effective effort estimates for these hooks, because these hooks are generally fishing at depths and temperatures which blue marlin rarely frequent.

Representative comparison of the estimated depth (m) of individual hooks for longline gear configured with 17 hooks-per-basket for the gear model of Hinton and Nakano (1996) and for the model used herein (the 2013 model) based on operational data.

Hook numbers	1 & 17	2 & 16	3 & 15	4 & 14	5 & 13	6 & 12	7 & 11	8 & 10	9
1996 model	97	144	189	234	275	314	346	369	377
2013 model	112	150	185	218	248	274	293	306	310
Difference	15	6	-4	-16	-27	-40	-53	-63	-67

The nominal and standardized CPUE of blue marlin by Japanese longline vessels are shown in Fig. 4. A catenary angle of 72° was assumed for all sets, regardless of mainline material. A sensitivity to this assumption was provided by comparison to standardizations using angles of 64° and 85° (Bigelow et al., 2006) (Fig. 5), which showed that there was little change in standardized CPUE trends across these angles.

GLM analysis

The time series of standardized CPUE are shown in Figs. 7 and 9 and in Table 2. They were generated by multiplying the standardized positive catch ratio (left panel, Figs. 6 and 8) by the standardized CPUE for positive catches (right panel, Figs. 6 and 8). All diagnostics and estimated values are provided in the Appendix. CPUE shows a slightly increasing trend in the earlier period (1975 to 1993) and a decreasing trend in the later period (1994 to 2010). These results were robust to selection of various combinations of explanatory factors selected from preliminary results.

In the first step, there was a two modal residual distribution and evidence of over dispersion ([early residual deviance] / DF = 1.061; [later residual deviance] / DF = 1.150: Tables A-5 and A-7). This suggests that the explanatory factors included in this analysis were not optimal, which may result from that fact that a zero catch of blue marlin may be result from failure to record a catch or discards, as well as from failure to catch a blue marlin. Limitations in computer resources prevented analysis of models of more memory or computationally demanding models. The model provided was the best available of those which we were able to fit. In the second step, there were no diagnostic indicators of lack of model fit. The trends of standardized CPUE which include only positive catch are similar to those obtained from the full model (Figs. 6 and 8 right)

Conclusions

In general models obtaining standardized catch-per-unit-effort using data from longline fisheries of Japan, including GLM and HBS models, has been considered problematic (Ortiz, 2006; Yokawa, 2004; Goodyear et. al., 2003), and no solutions to identified difficulties has yet been identified. The previous assessments of Pacific blue marlin (Hinton, 2001; Kleiber et al., 2003) were conducted using CPUE standardized using HBS. In the present study, detailed gear configuration data was used to address problems arising from lack of such data (Goodyear, 2003).. The HBS also addressed the problem of significant changes in gear configuration on a wide-spread basis across the longline fleet of Japan. Thus, at present, the use of the standardized CPUE obtained from the Δ-GLM model for the early (1975 to 1993) period, and that obtained from HBS for the later (1994 to 2011), is expected to provide the best available combination of indices for input to the analysis of status and trends of blue marlin in the Pacific Ocean. It is suggested that additional studies directed to increase the reliability of standardized catch rate indices be undertaken, including in collaborations among members of the working group.

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Table 1. Standardized catch rate (CPUE) and the median absolute deviation[3] (MAD) for blue marlin estimated using habitat based standardization (HBS).

Year	CPUE	MAD
1994	4.296	0.034
1995	5.040	0.041
1996	2.664	0.025
1997	3.959	0.037
1998	3.619	0.034
1999	2.883	0.031
2000	3.104	0.039
2001	2.702	0.030
2002	2.556	0.029
2003	3.033	0.035
2004	3.560	0.040
2005	3.300	0.040
2006	3.375	0.046
2007	3.027	0.039
2008	3.037	0.040
2009	3.691	0.078
2010	3.602	0.043
2011	2.972	0.041

[3] MAD estimated using bootstrap

Table 2-1. Nominal (Nom) and standardized catch rate (CPUE) for 1975 to 1993 estimated using Δ-GLM. Binomial: Bin; Gaussian: GD; SD(…): standard deviation.

Year	Nom	Bin	sd(Bin)	GD	sd(GD)	CPUE	sd(CPUE)
1975	0.316	0.478	0.006	-0.362	0.01	0.333	0.005
1976	0.338	0.469	0.007	-0.353	0.01	0.329	0.006
1977	0.312	0.378	0.006	-0.425	0.01	0.247	0.005
1978	0.318	0.551	0.006	-0.322	0.011	0.399	0.007
1979	0.356	0.604	0.004	-0.281	0.01	0.456	0.006
1980	0.378	0.573	0.004	-0.202	0.01	0.468	0.006
1981	0.389	0.703	0.005	-0.249	0.009	0.548	0.006
1982	0.43	0.671	0.004	-0.206	0.01	0.546	0.006
1983	0.397	0.599	0.006	-0.312	0.012	0.439	0.008
1984	0.58	0.768	0.004	-0.098	0.01	0.697	0.009
1985	0.388	0.65	0.005	-0.311	0.01	0.476	0.006
1986	0.455	0.673	0.005	-0.314	0.01	0.492	0.006
1987	0.403	0.668	0.005	-0.326	0.009	0.482	0.005
1988	0.411	0.613	0.005	-0.289	0.01	0.459	0.006
1989	0.439	0.669	0.005	-0.34	0.009	0.476	0.006
1990	0.579	0.63	0.004	-0.309	0.009	0.463	0.005
1991	0.486	0.626	0.004	-0.346	0.012	0.443	0.006
1992	0.378	0.635	0.006	-0.337	0.008	0.454	0.006
1993	0.477	0.701	0.003	-0.212	0.008	0.567	0.006

Table 2-2. Nominal (Nom) and standardized catch rate (CPUE) for 1994 to 2010 estimated using Δ-GLM. Binomial: Bin; Gaussian: GD; SD(…): standard deviation.

Year	Nom	Bin	sd(Bin)	GD	sd(GD)	CPUE	sd(CPUE)
1994	0.496	0.432	0.005	-0.279	0.008	0.327	0.006
1995	0.517	0.464	0.006	-0.154	0.007	0.398	0.008
1996	0.318	0.375	0.007	-0.512	0.012	0.225	0.005
1997	0.441	0.414	0.006	-0.355	0.012	0.290	0.008
1998	0.422	0.414	0.006	-0.325	0.011	0.299	0.007
1999	0.342	0.401	0.008	-0.412	0.011	0.266	0.006
2000	0.444	0.410	0.007	-0.372	0.010	0.283	0.006
2001	0.337	0.378	0.007	-0.480	0.011	0.234	0.006
2002	0.318	0.389	0.008	-0.452	0.014	0.248	0.007
2003	0.336	0.389	0.008	-0.436	0.010	0.251	0.007
2004	0.406	0.380	0.009	-0.487	0.013	0.234	0.007
2005	0.351	0.395	0.011	-0.413	0.011	0.261	0.009
2006	0.266	0.368	0.015	-0.541	0.009	0.214	0.009
2007	0.323	0.363	0.016	-0.557	0.014	0.208	0.010
2008	0.283	0.351	0.017	-0.591	0.017	0.195	0.011
2009	0.286	0.346	0.015	-0.633	0.014	0.184	0.009
2010	0.272	0.368	0.020	-0.546	0.015	0.213	0.012

Figure 1. Estimated proportion of the blue marlin population at water temperatures relative to the temperature of the mixed layer.

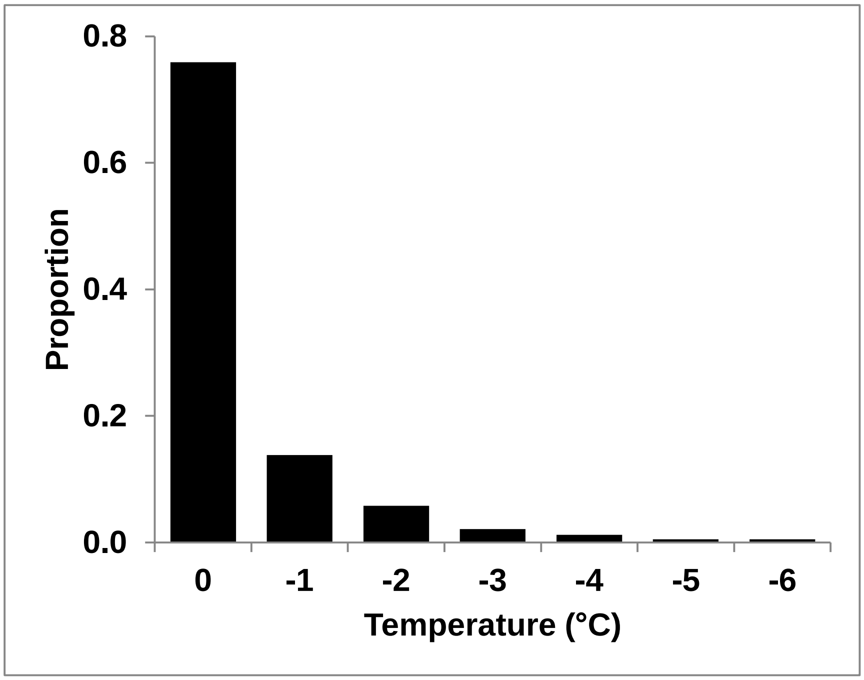


Figure 2. Target area and area definitions for the Gaussian component of the Δ-GLM for the 1994 to 2010 period.

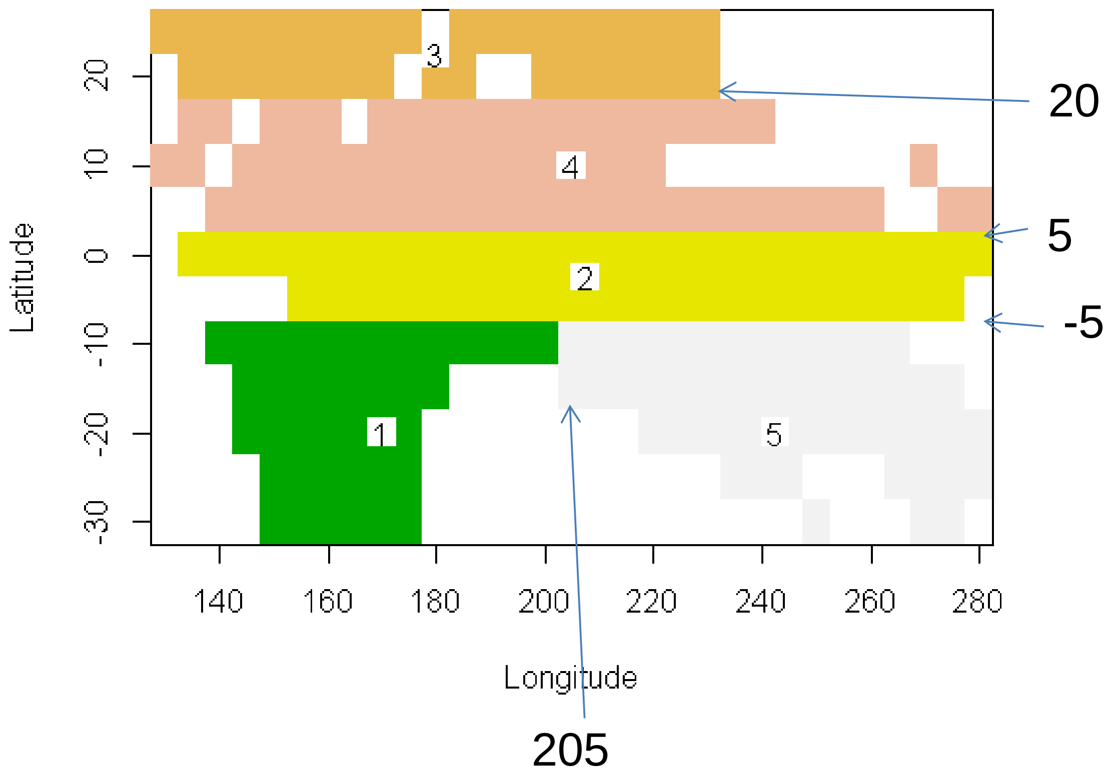


Figure 3. Area definitions obtained using the 5th level split showing the resulting small geographical areas that lacked sufficient number of operations to reliably estimate CPUE.

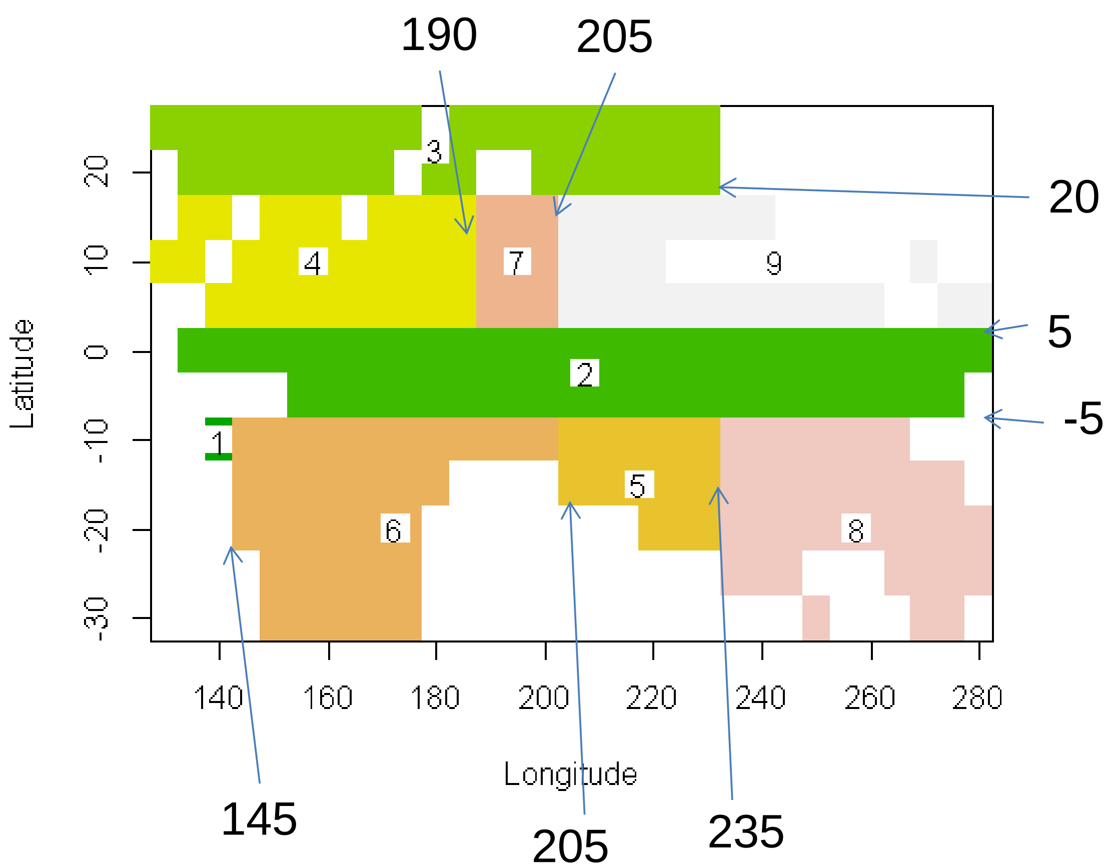


Figure 4. Nominal (CPUNE) and standardized (CPUSE by HBS) catch rates (fish per 1000 hooks) of blue marlin taken by Japanese longline vessels in the Pacific Ocean during the period 1994 to 2011.

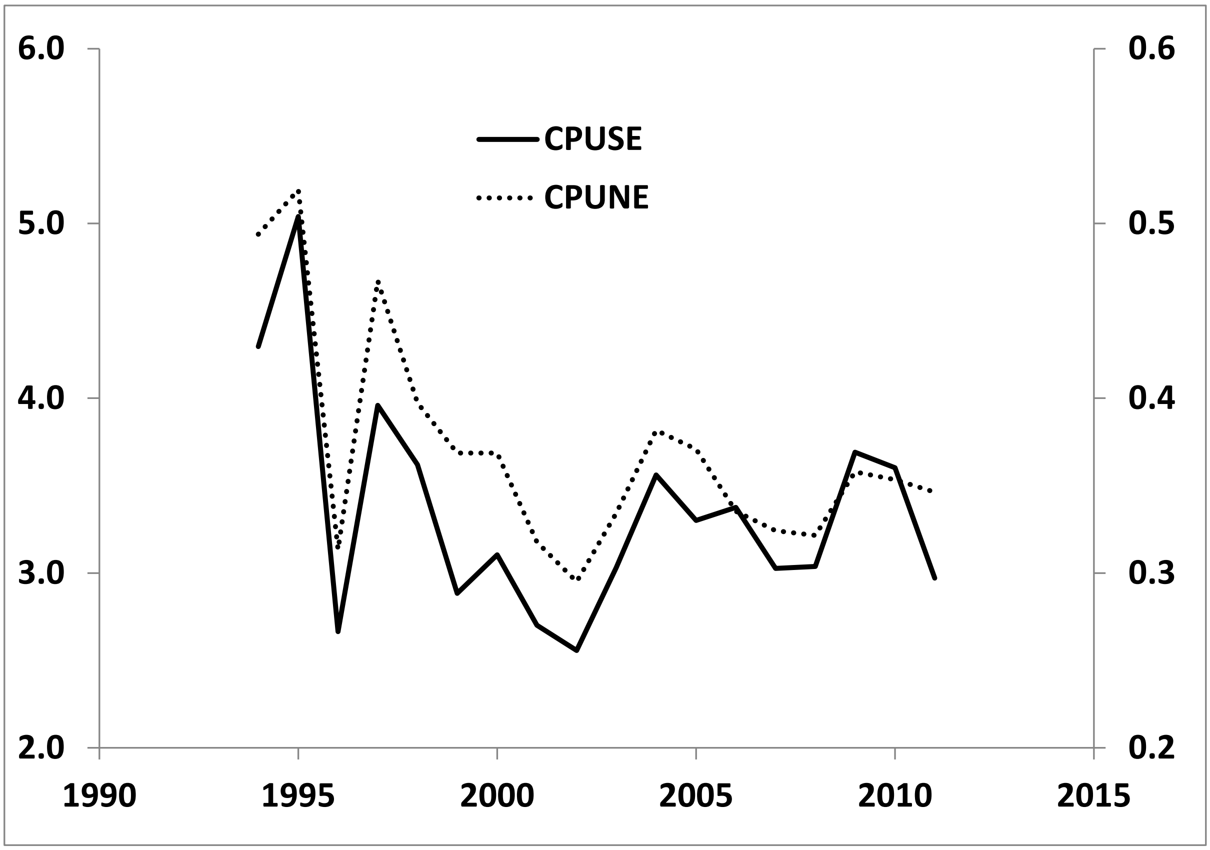


Figure 5. A comparison of CPUE series obtained using HBS with catenary angles of 72° (Fig. 4, red), 64° (green), and 85° (purple).

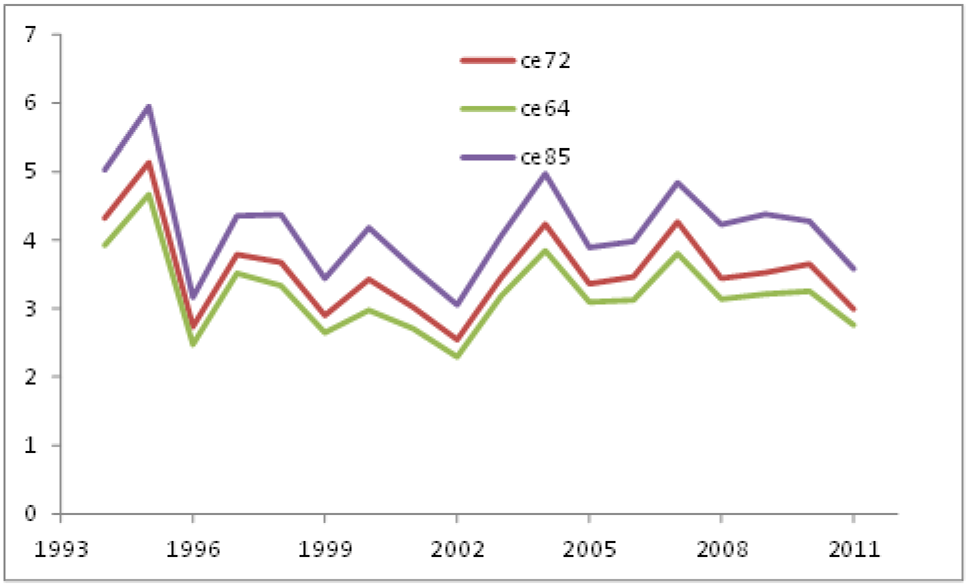


Figure 6. Annual predicted values of the positive catch ratio and the standardized catch rate from Δ-GLM (pcpue) for 1975 to 1993.

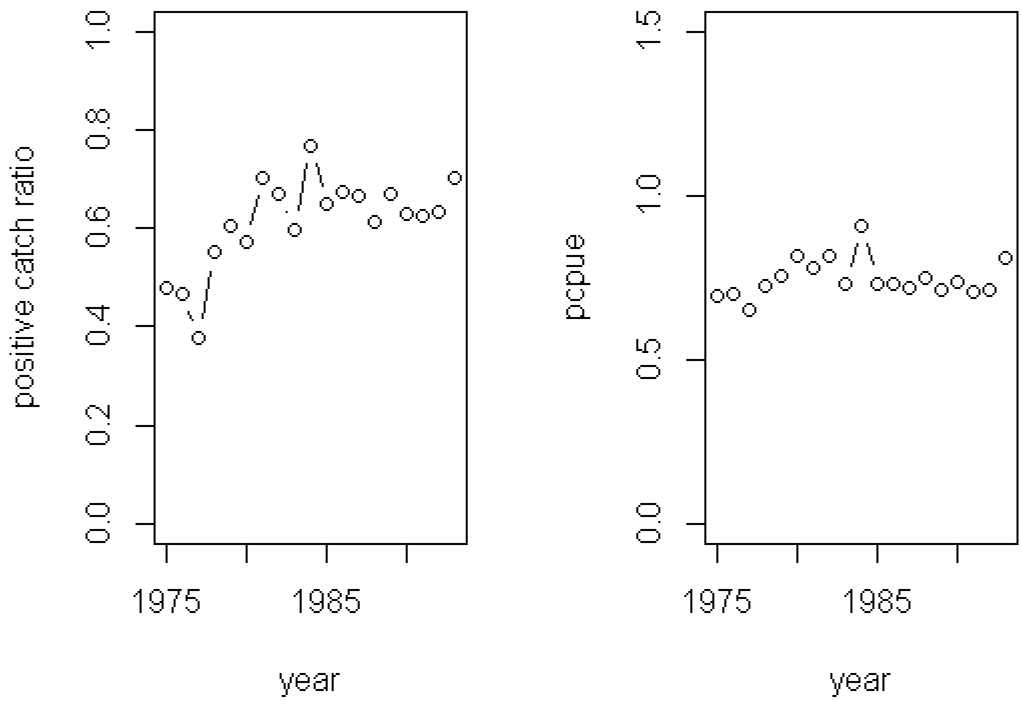


Figure 7. Annual nominal (open circles) and standardized (solid line) catch rates from the Δ-GLM model for the period 1975 to 1993.

Figure 8. Annual predicted values of the positive catch ratio and the standardized catch rate from Δ-GLM (pcpue) for 1994 to 2010.

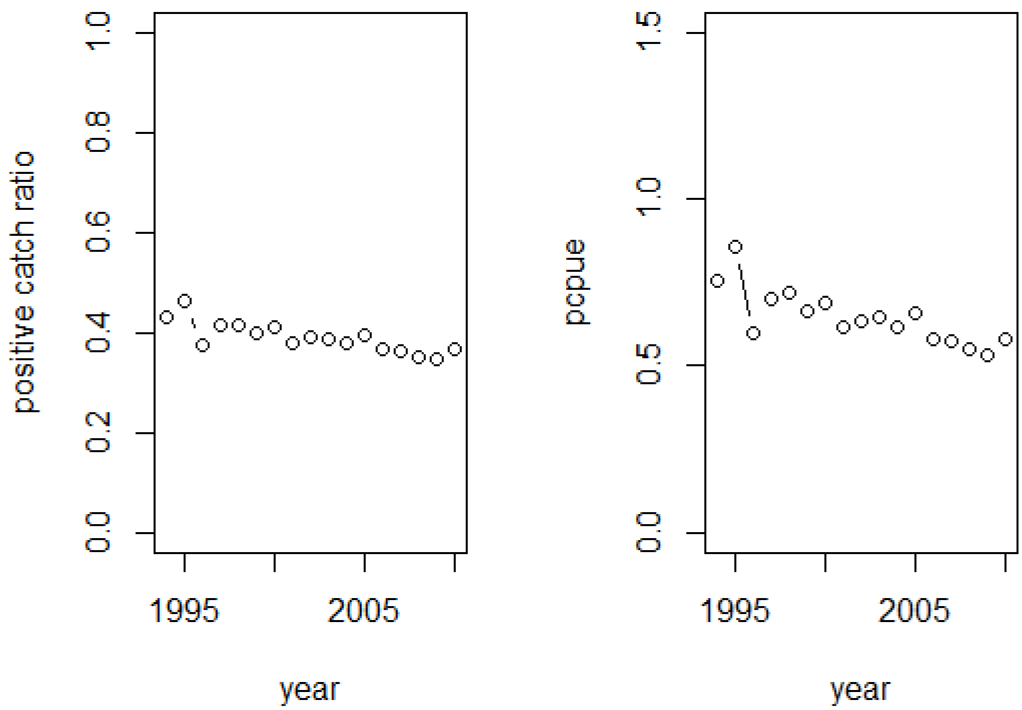
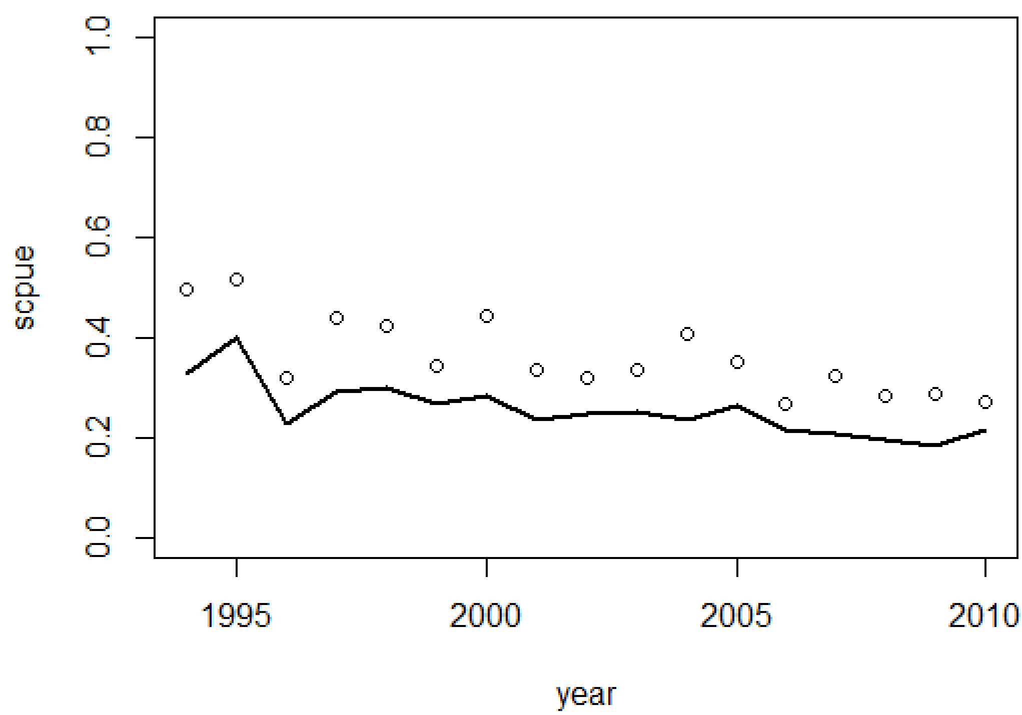


Figure 9. Annual nominal (open circles) and standardized (solid line) catch rates from the Δ-GLM model for the period 1994 to 2010.



APPENDIX: Model Diagnostics and Predicted Values

List of Appendix Figures and Tables

Figure A-1. Diagnostics for the Binomial component of the Δ-GLM model for 1975 to 1993.

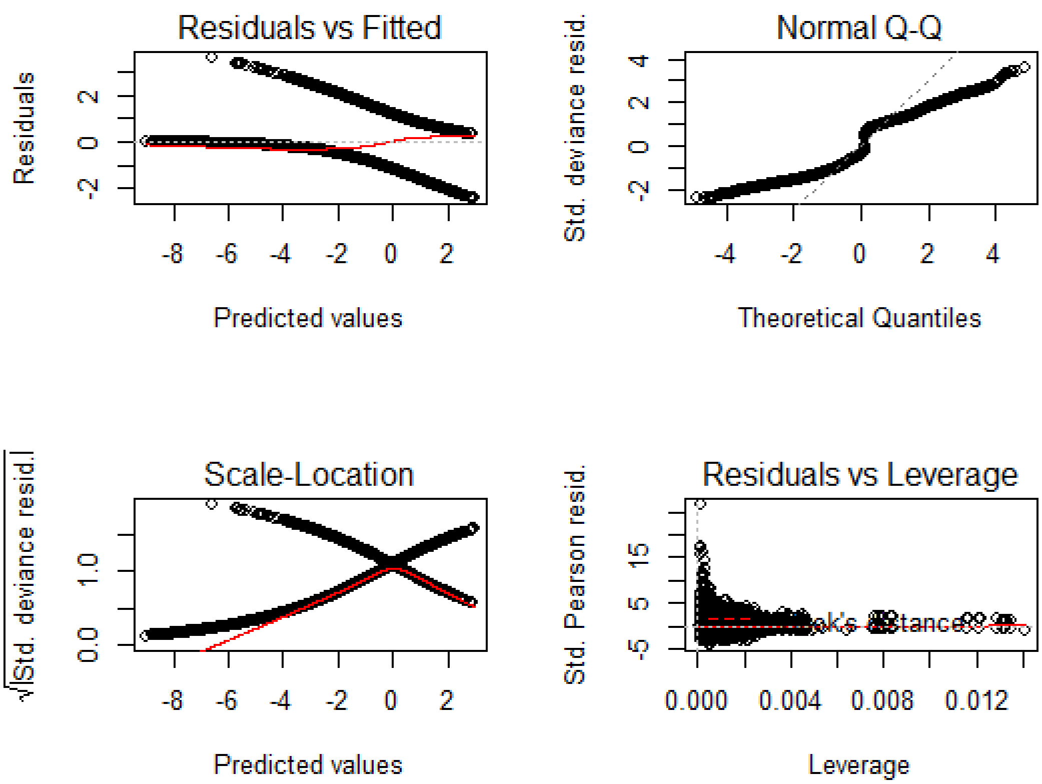


Figure A-2 Yearly residual patterns for the Binomial component of the Δ-GLM model for 1975 to 1993.

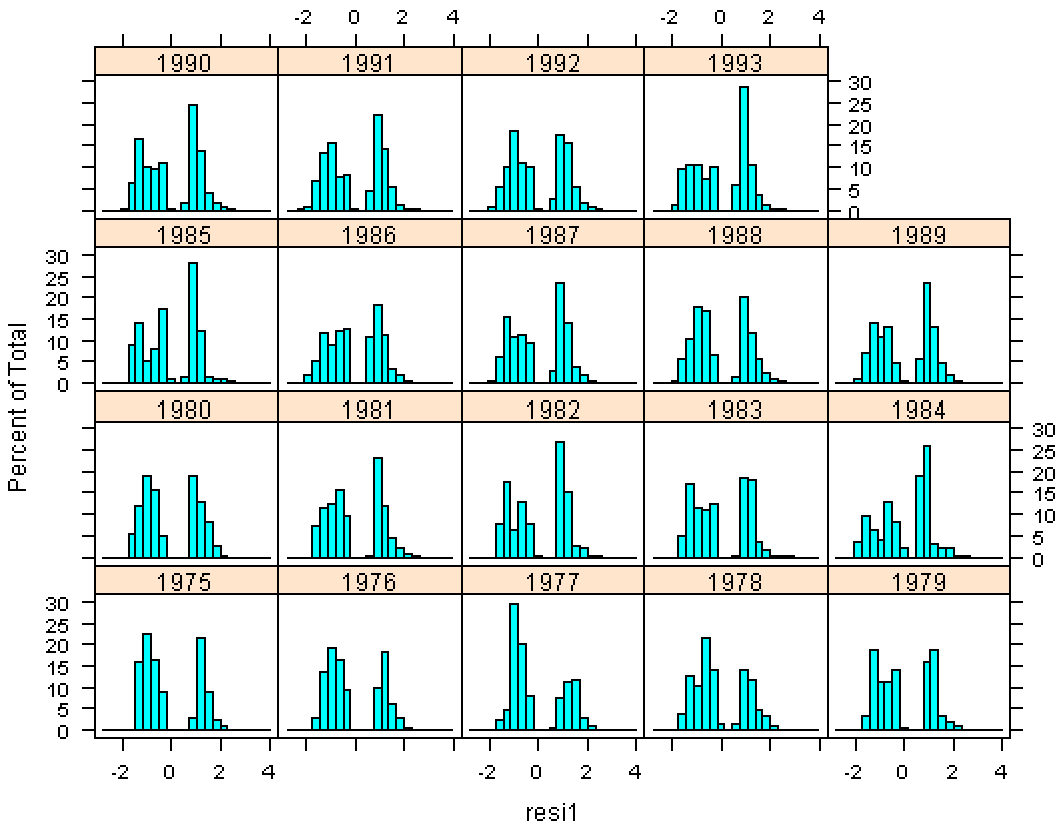


Figure A-3. Seasonal residual patterns for the Binomial component of the Δ-GLM model for 1975 to 1993. Seasons: 0 = Jan-Mar; 1 = Apr-Jun; 2 = Jul-Sep; 3 = Oct-Dec.

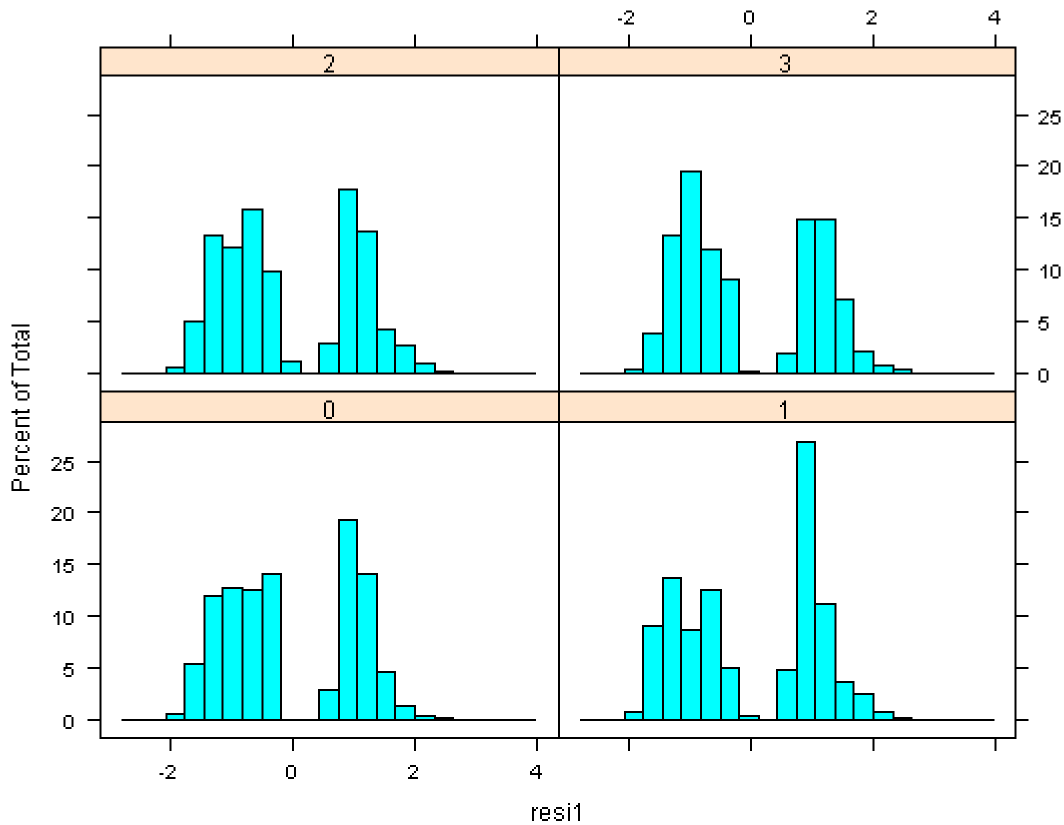


Figure A-4. Residual patterns for prefectures (PREF) for the Binomial component of the Δ-GLM model for 1975 to 1993. Iwate = 22; Miyagi = 23; Fukushima = 24.

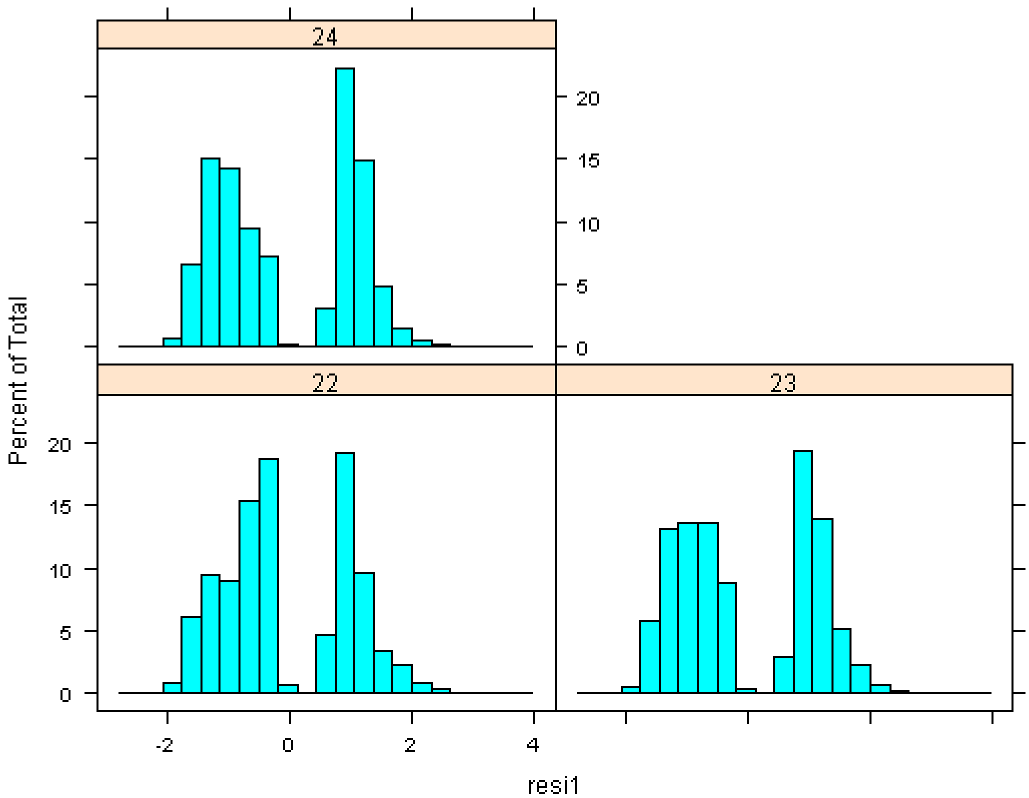


Figure A-5. Annual trends of CPUE (response) by season and prefecture from the Δ-GLM for the period 1975 to 1993. Prefectures: Iwate = 22; Miyagi = 23; Fukushima = 24. Seasons: 0 = Jan-Mar; 1 = Apr-Jun; 2 = Jul-Sep; 3 = Oct-Dec.

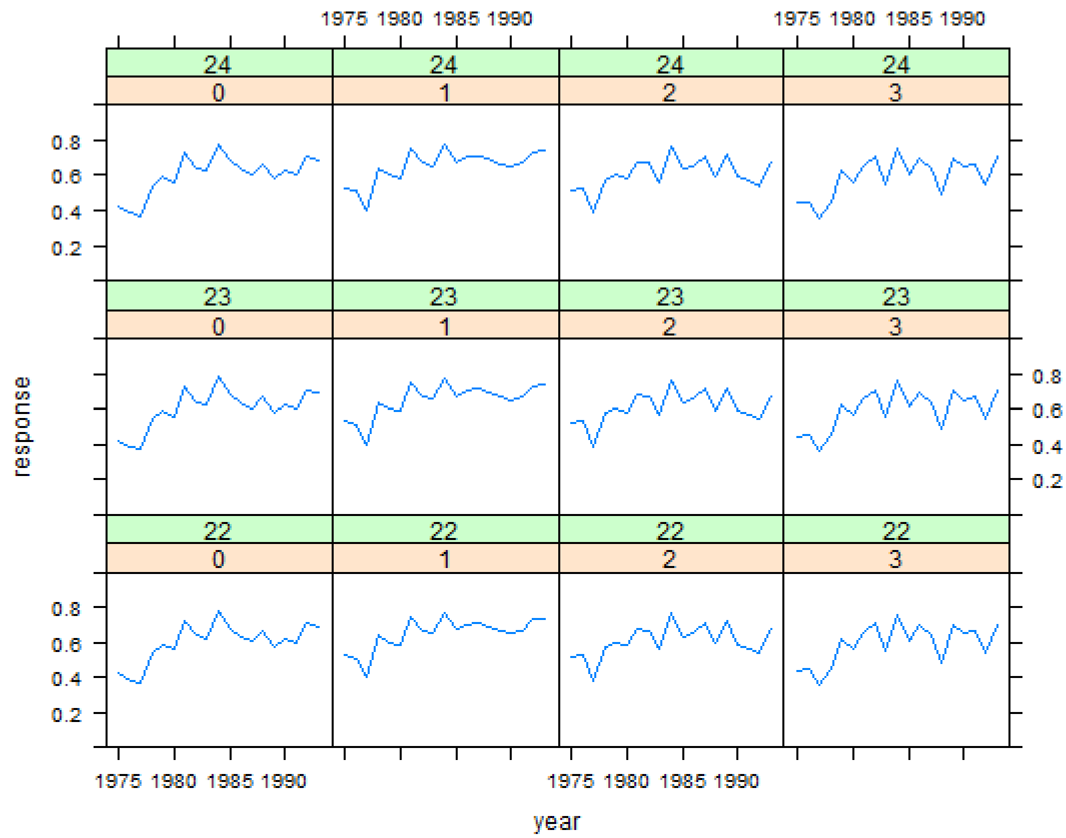


Figure A-6. Diagnostics for Gaussian component of the Δ-GLM model for 1975 to 1993. There were 190 observations (less than 0.06%) with residuals greater than 3.5.

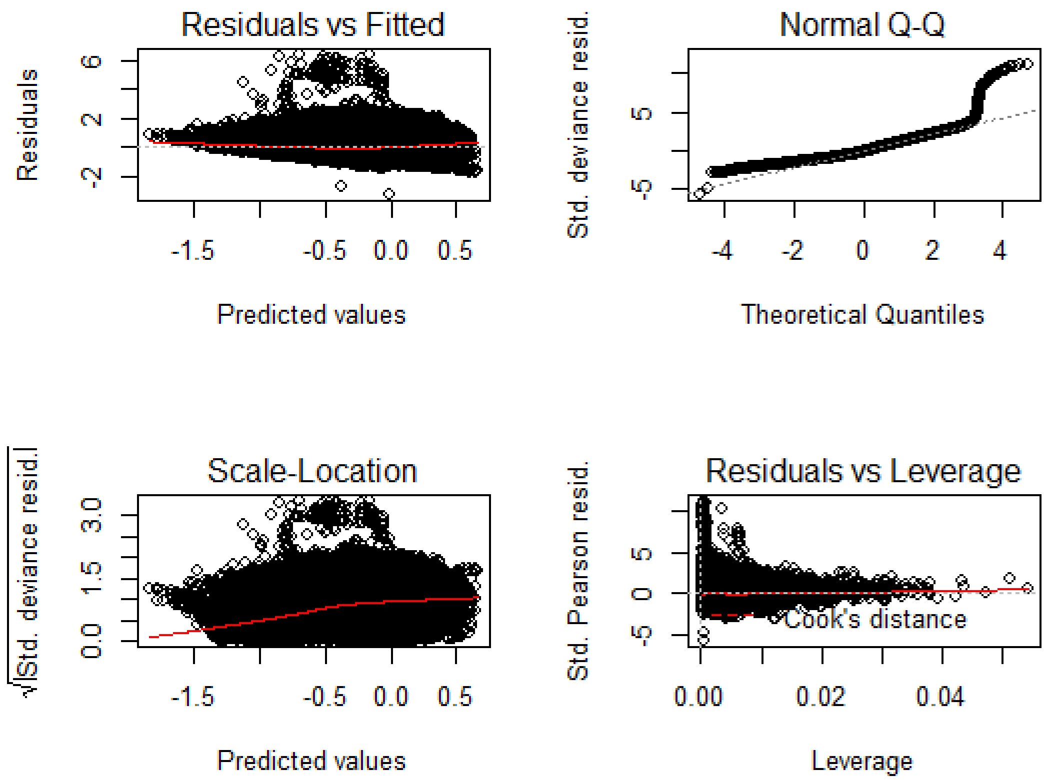


Figure A-7. Residual patterns for Year from the Gaussian component of the Δ-GLM model for 1975 to 1993.

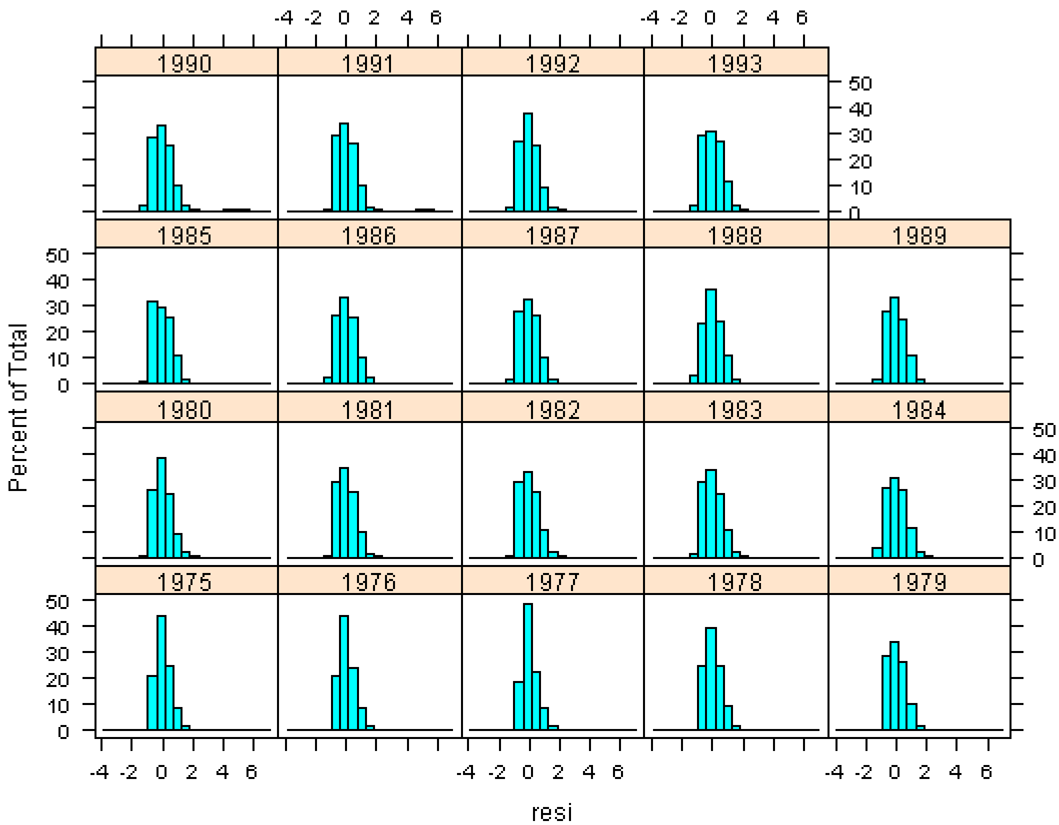


Figure A-8. Residual patterns for season from the Gaussian component of the Δ-GLM model for 1975 to 1993. Seasons: 0 = Jan-Mar; 1 = Apr-Jun; 2 = Jul-Sep; 3 = Oct-Dec.

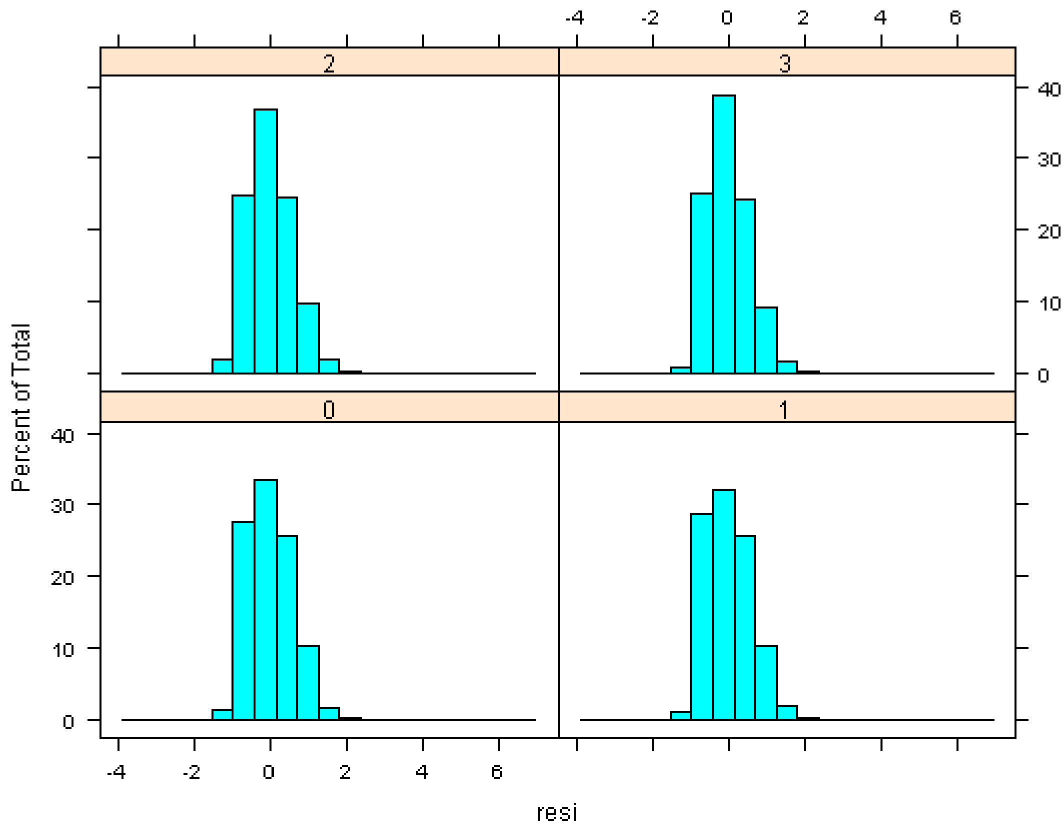


Figure A-9. Residual patterns for prefectures (PREF) for the Gaussian component of the Δ-GLM model for 1975 to 1993. Iwate = 22; Miyagi = 23; Fukushima = 24.

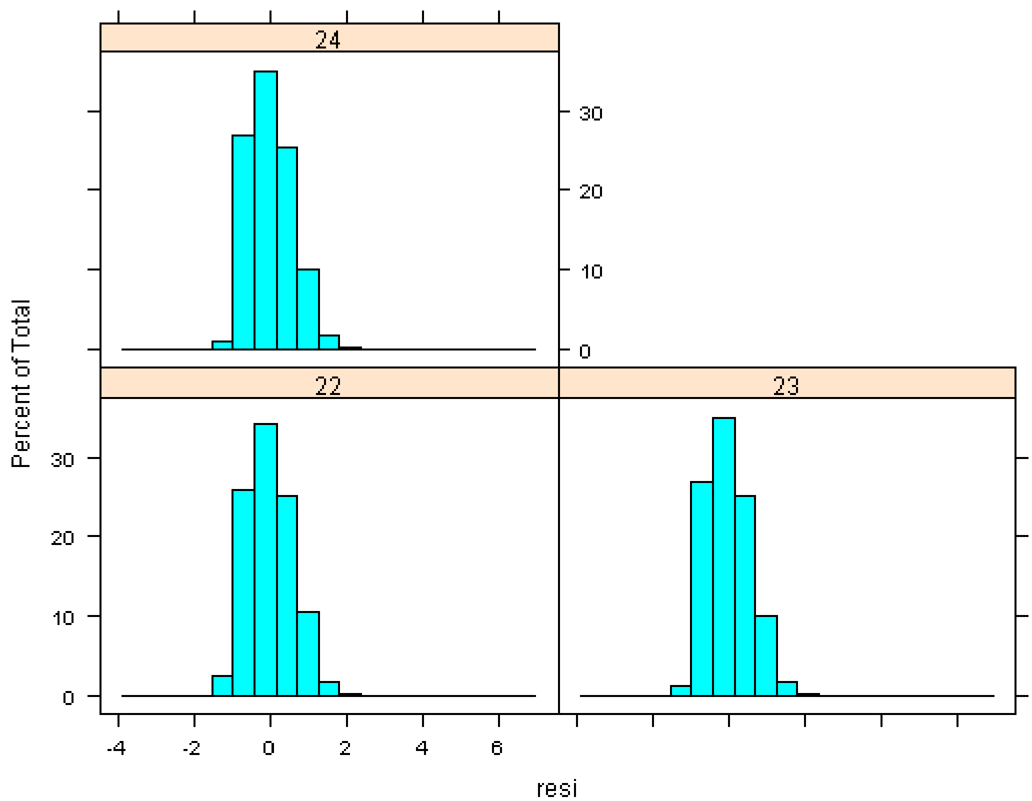


Figure A-10. Annual trends of the Gaussian component of the Δ-GLM by season for the period 1975 to 1993. Seasons: 0 = Jan-Mar; 1 = Apr-Jun; 2 = Jul-Sep; 3 = Oct-Dec.

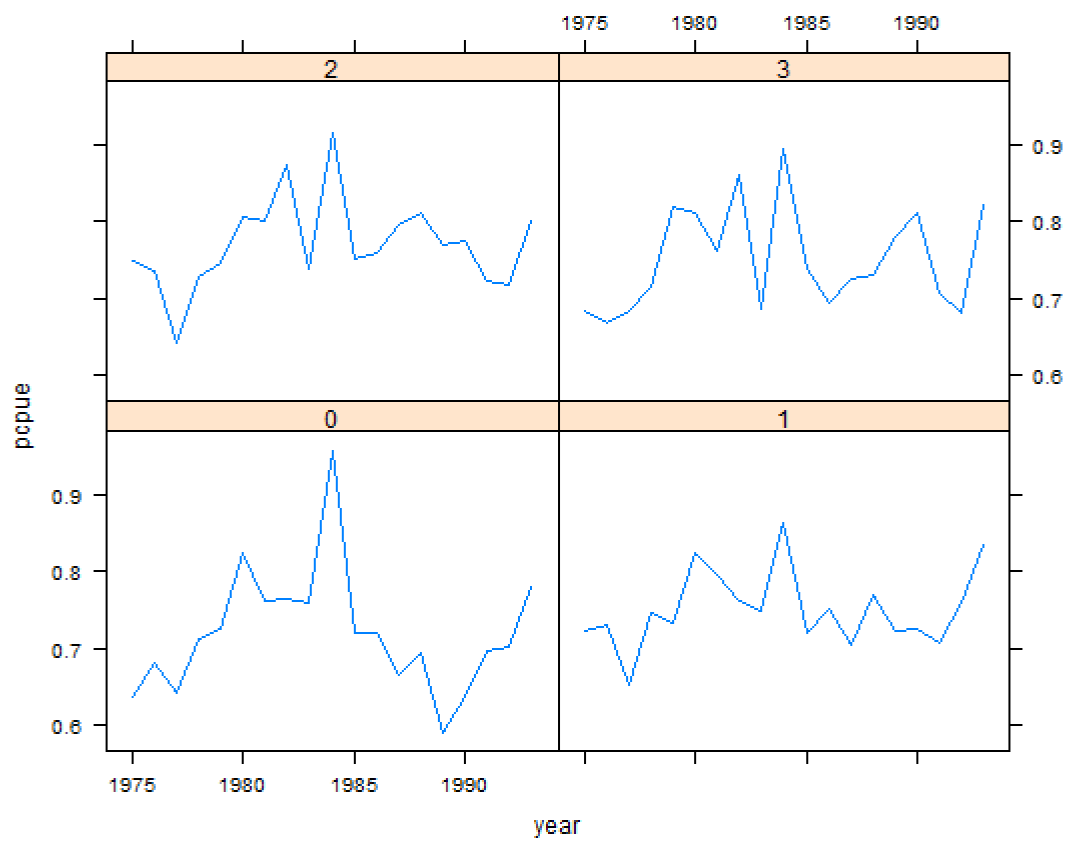


Figure A-11. Annual trends of the Gaussian component of the Δ-GLM by prefecture for the period 1975 to 1993. Prefectures: Iwate = 22; Miyagi = 23; Fukushima = 24.

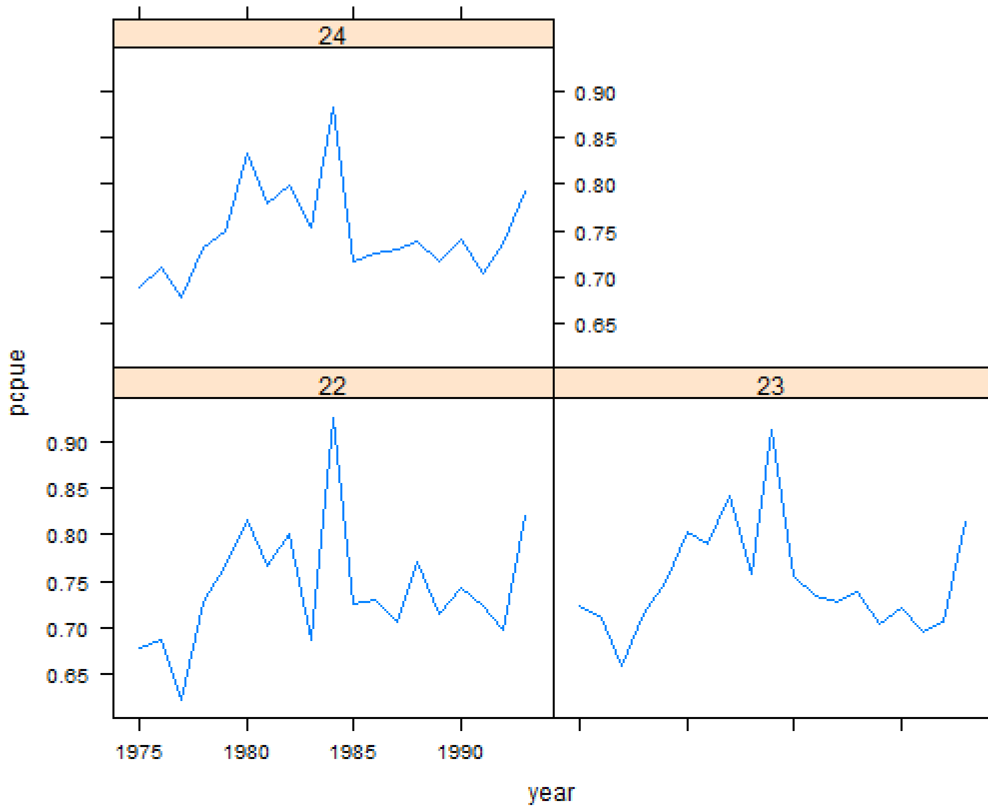


Figure A-12. Estimated effects for HPB for the Binomial (left panel) and Gaussian (right panel) components of the Δ-GLM model for the period 1975 to 1993.

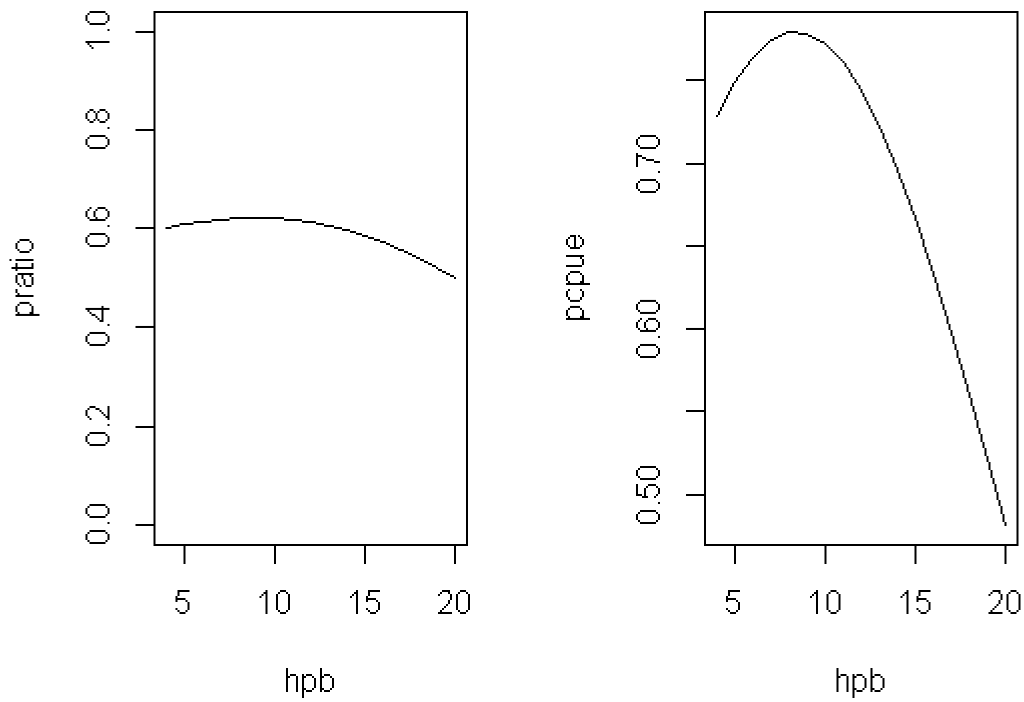


Figure A-13. Estimated effects for latitude for the Binomial (left panel) and Gaussian (right panel) components of the Δ-GLM model for the period 1975 to 1993.

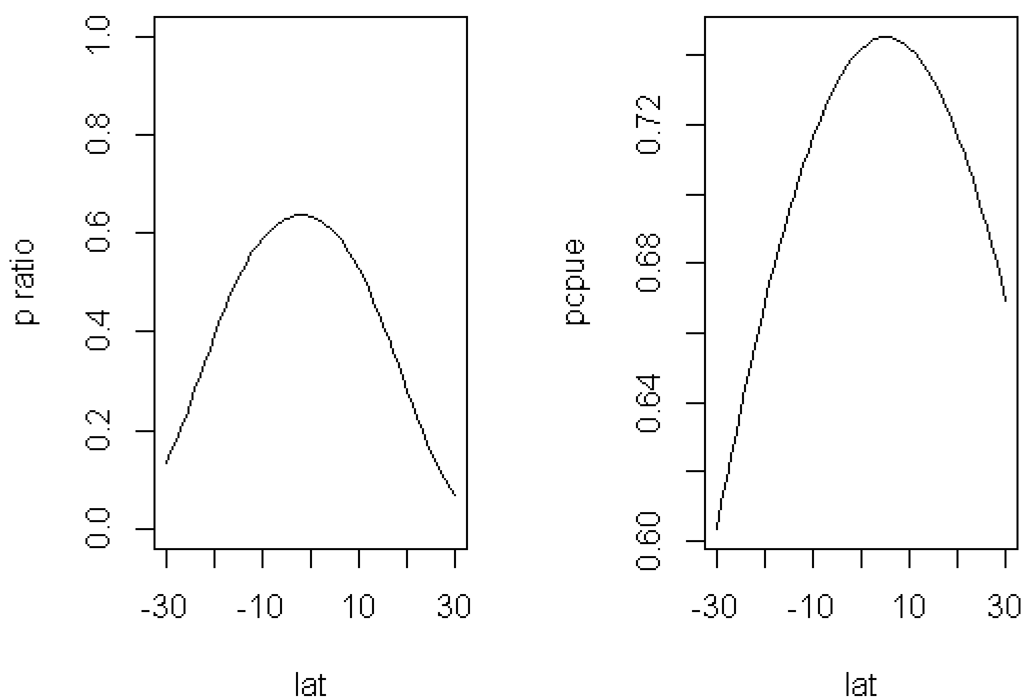
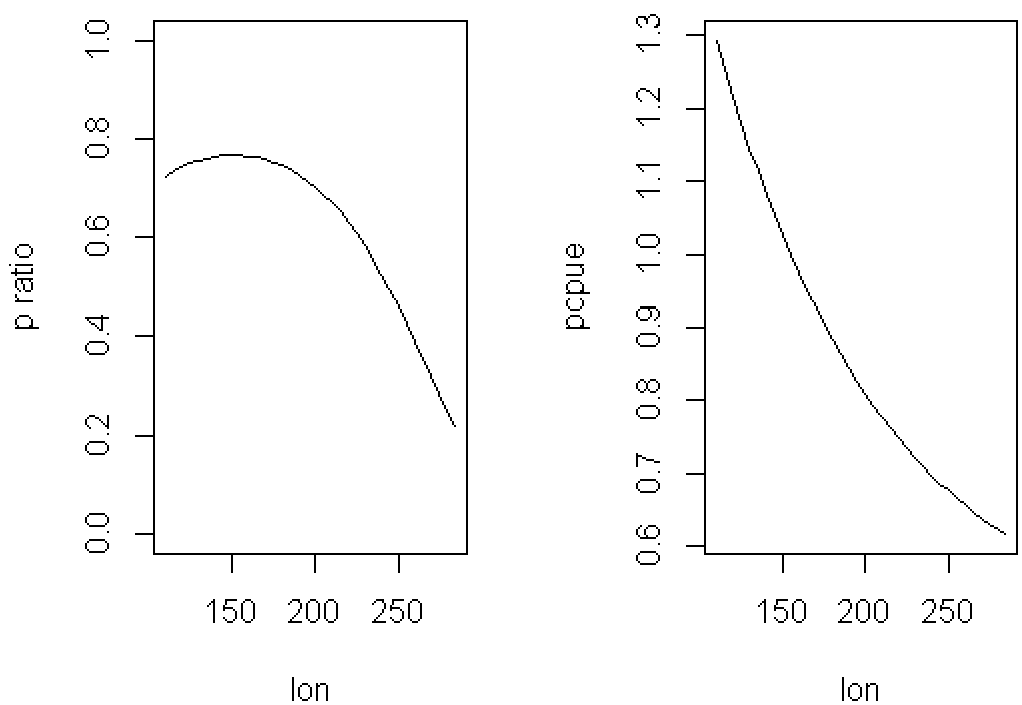


Figure A-14. Estimated effects for longitude for the Binomial (left panel) and Gaussian (right panel) components of the Δ-GLM model for the period 1975 to 1993.



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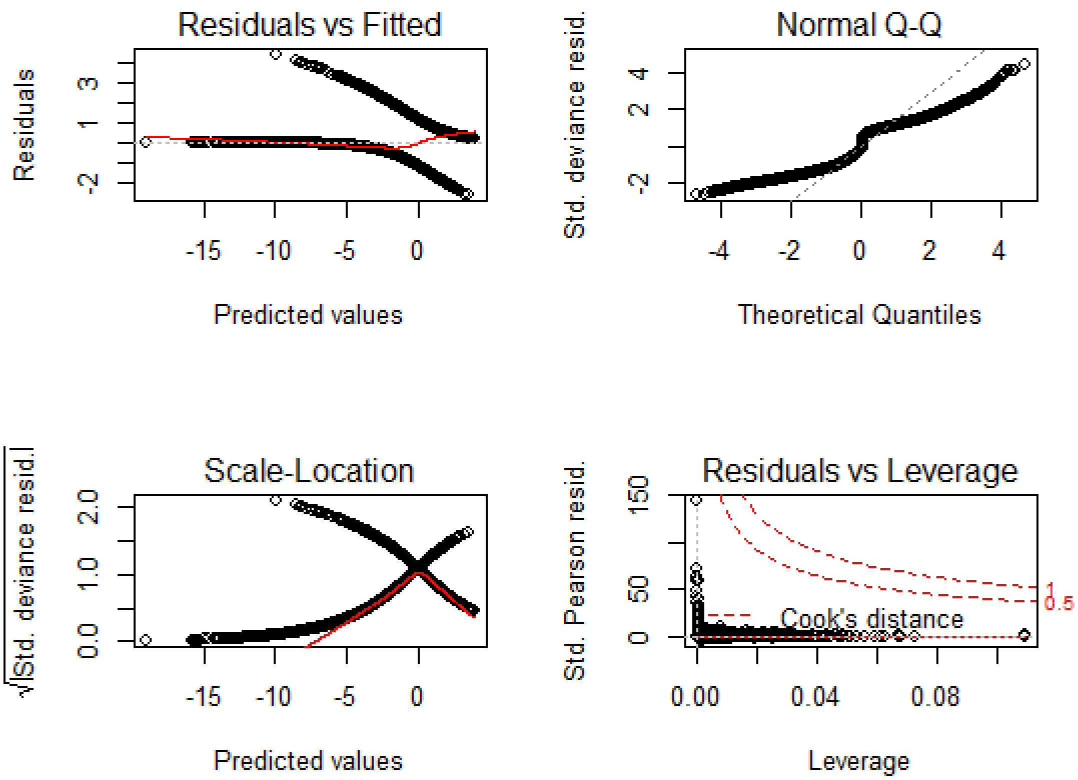


Figure A-16. Residual patterns for Year for the Binomial component of the Δ-GLM model for 1994 to 2010.

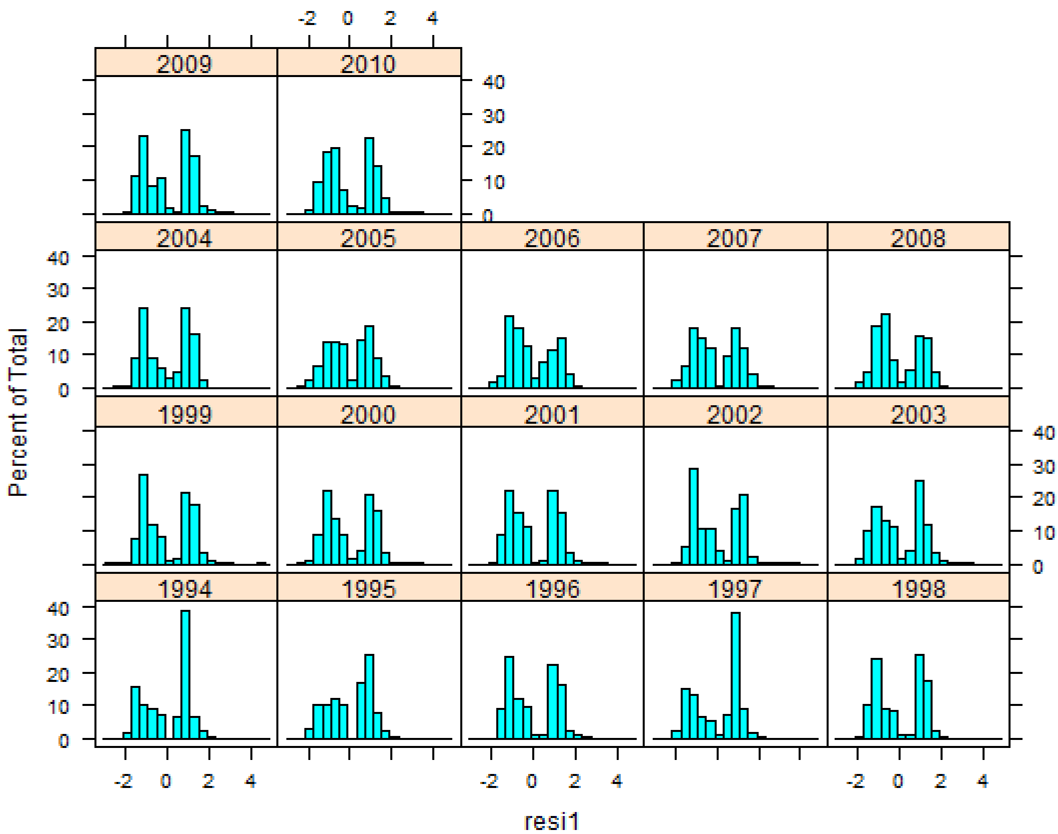


Figure A-17. Seasonal residual patterns for the Binomial component of the Δ-GLM model for 1994 to 2010. Seasons: 0 = Jan-Mar; 1 = Apr-Jun; 2 = Jul-Sep; 3 = Oct-Dec.

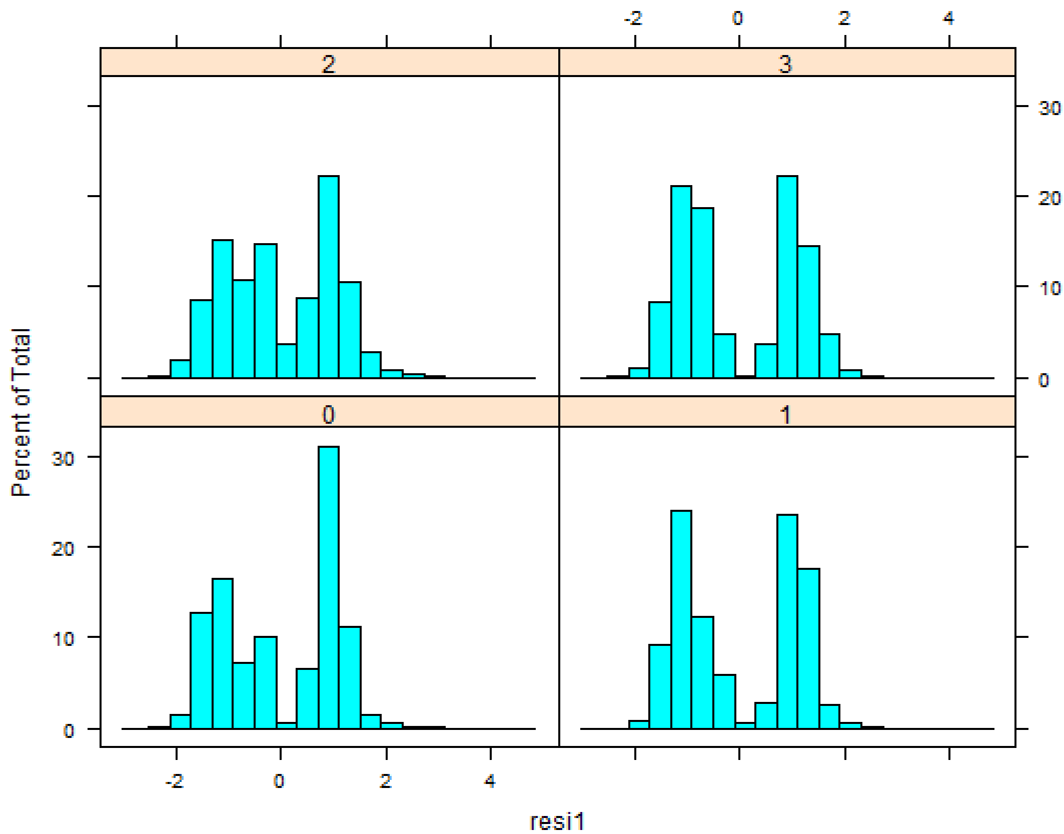


Figure A-18. Residual patterns for prefectures (PREF) for the Binomial component of the Δ-GLM model for 1994 to 2010. Iwate = 22; Miyagi = 23; Fukushima = 24.

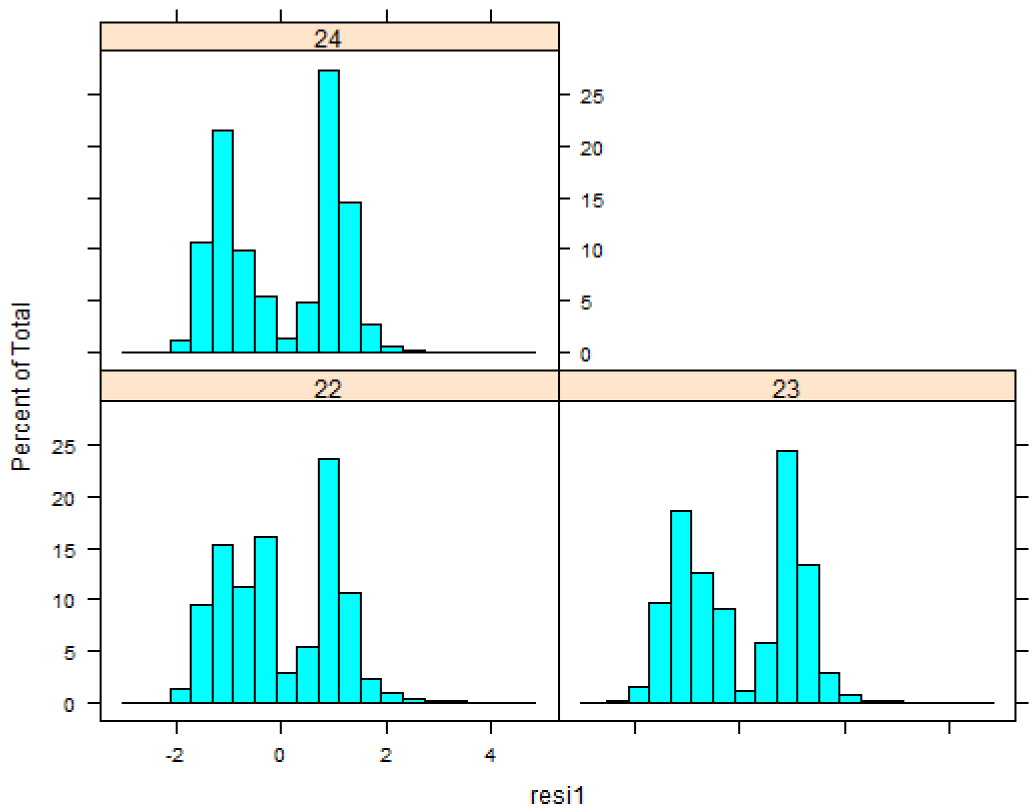
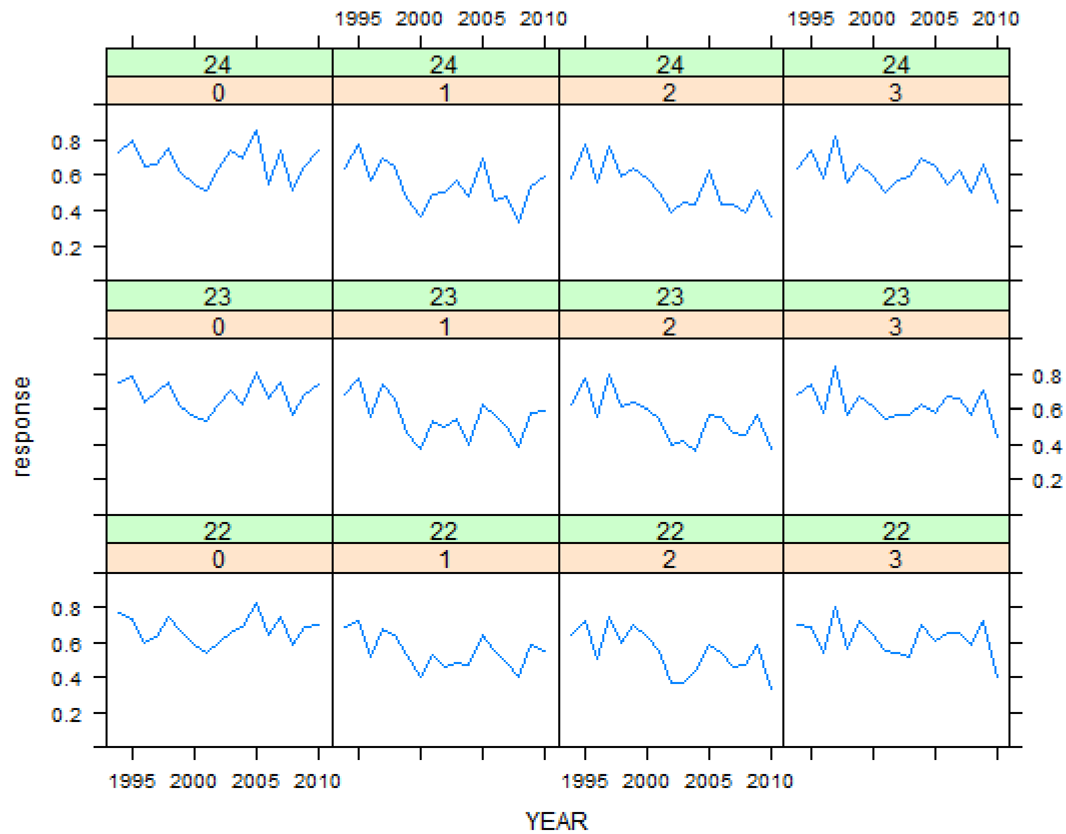


Figure A-19. Annual trends of CPUE (response) by season and prefecture from the Δ-GLM for the period 1975 to 1993. Prefectures: Iwate = 22; Miyagi = 23; Fukushima = 24. Seasons: 0 = Jan-Mar; 1 = Apr-Jun; 2 = Jul-Sep; 3 = Oct-Dec.



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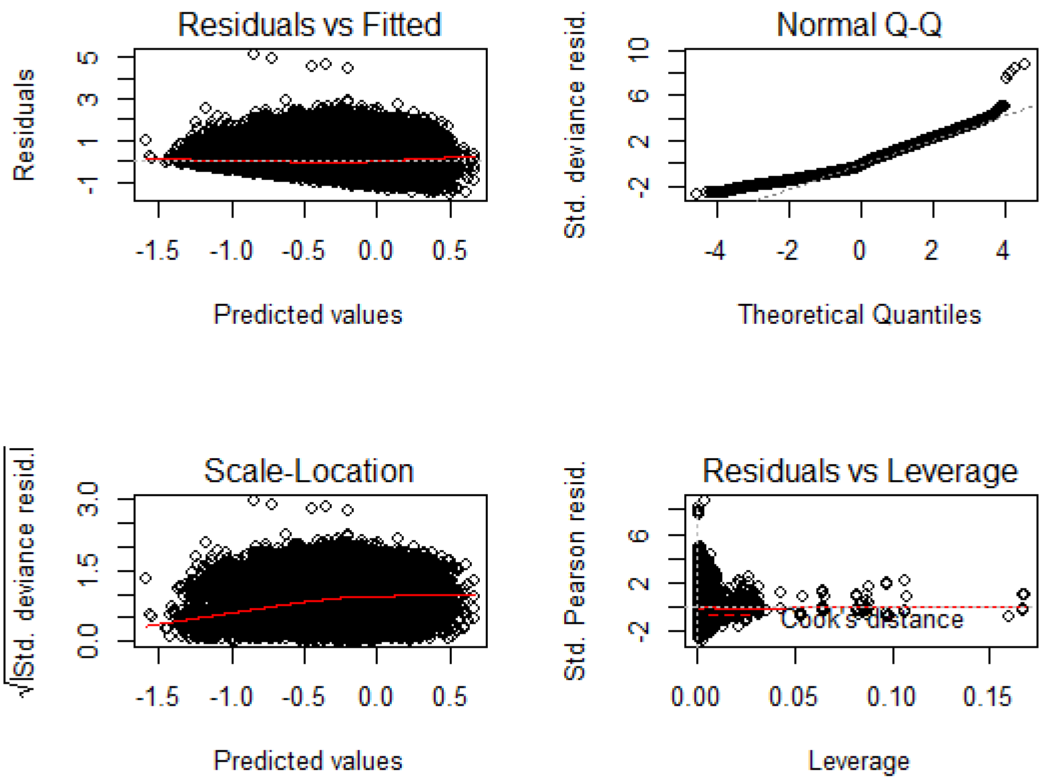

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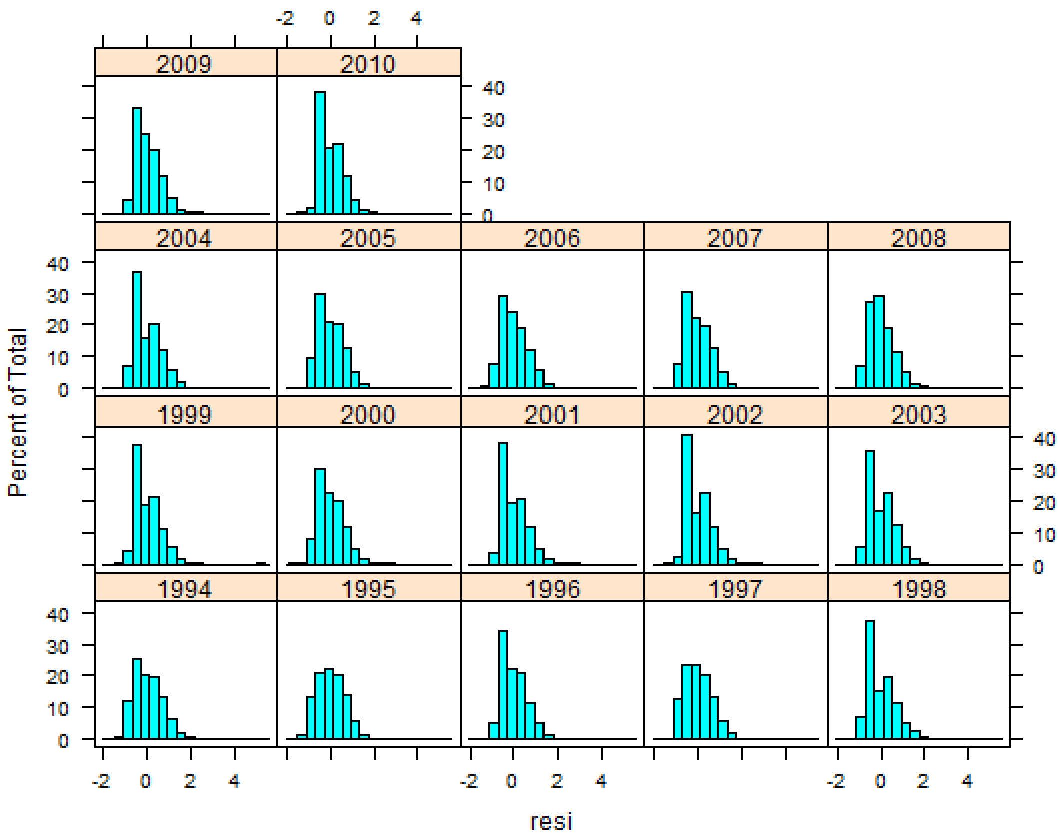

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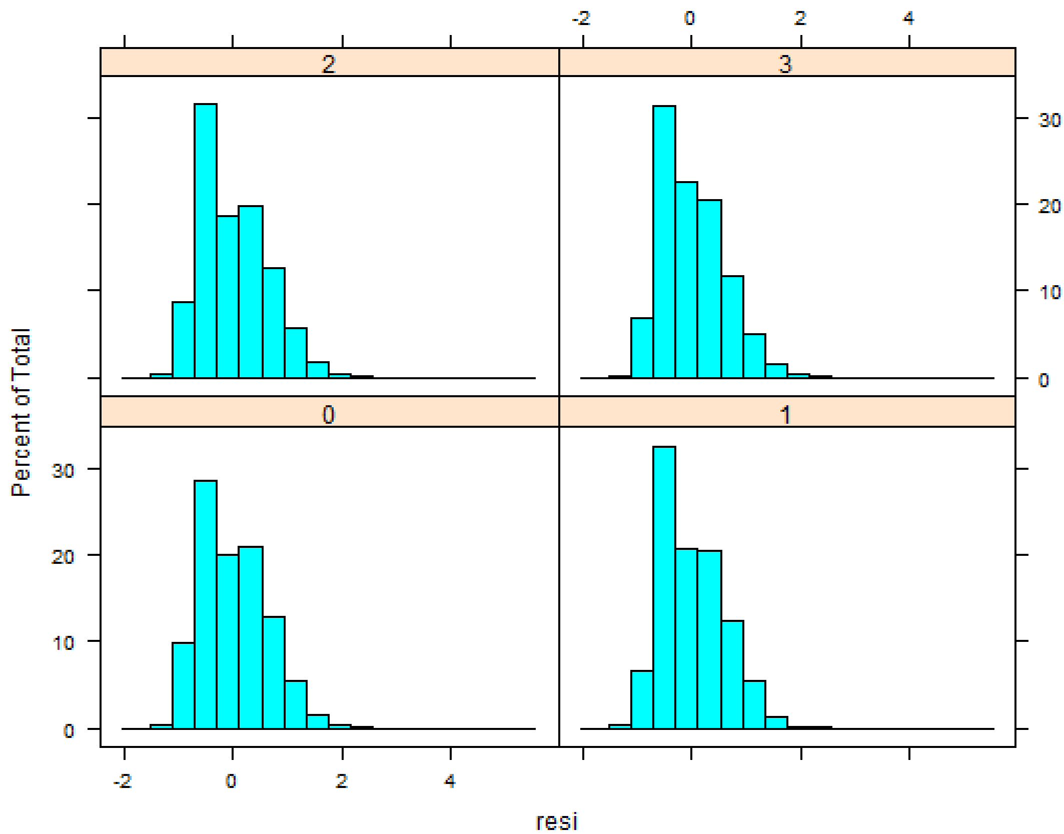


Figure A-23. Residual patterns for prefectures (PREF) for the Gaussian component of the Δ-GLM model for 1994 to 2010. Iwate = 22; Miyagi = 23; Fukushima = 24.

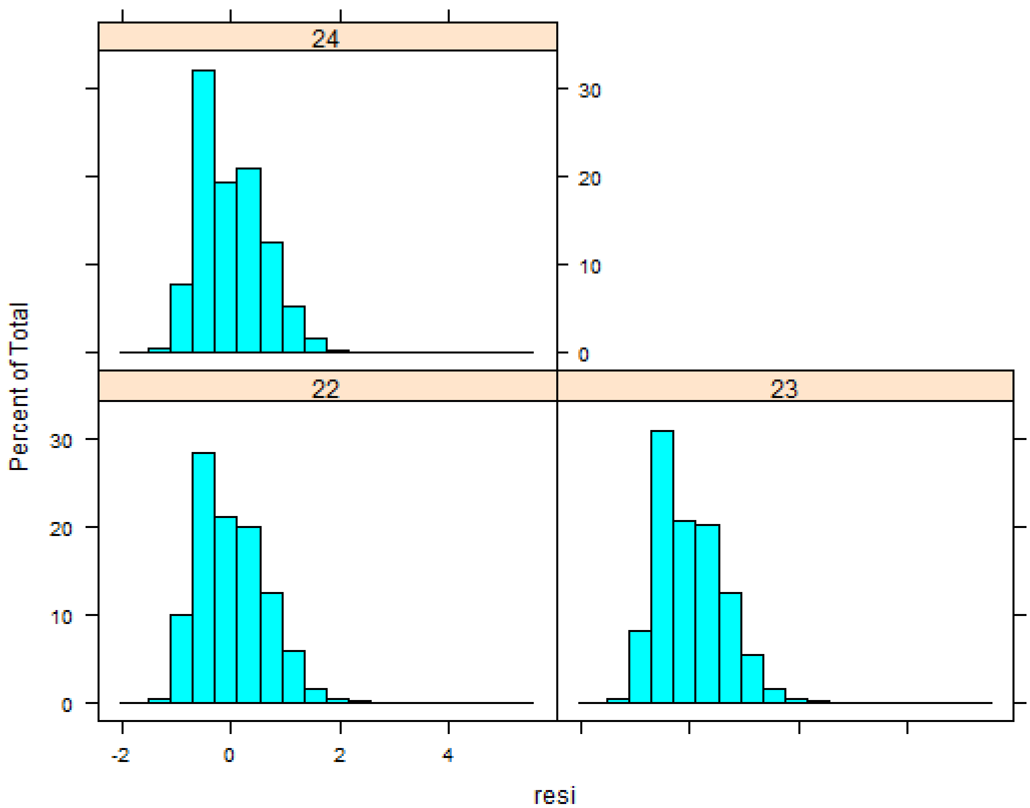
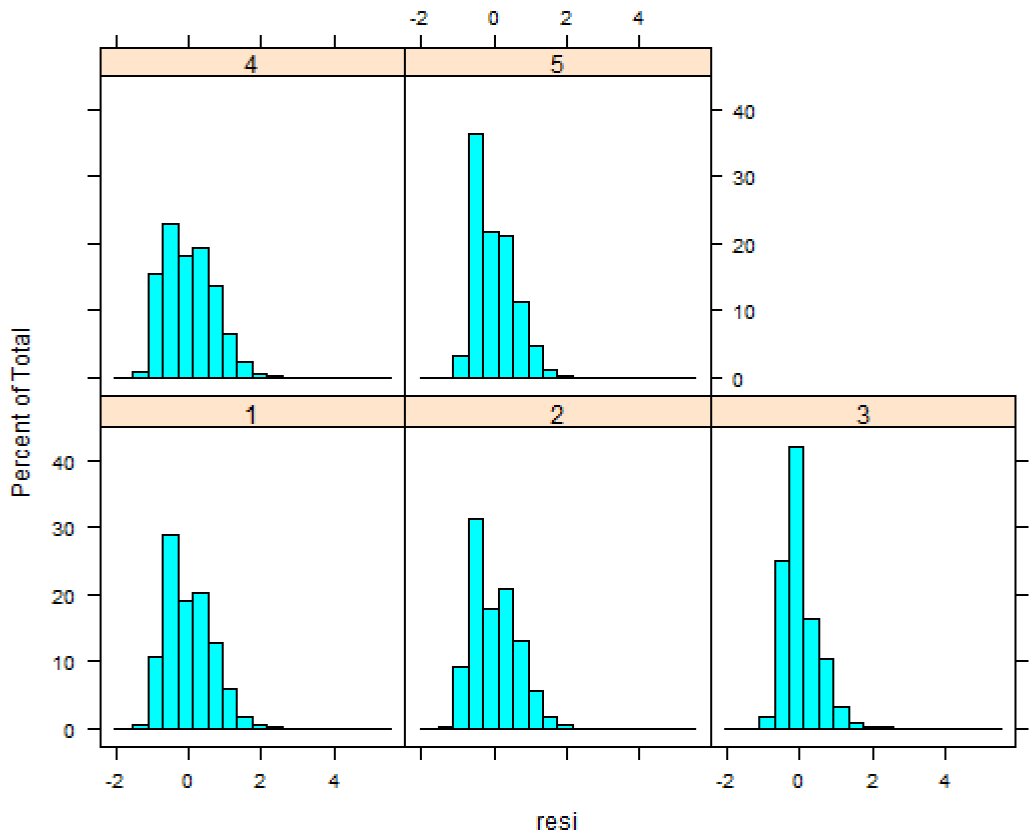


Figure A-24. Residuals for areas (see Figure 2) for the Gaussian component of the Δ-GLM model for 1994 to 2010.



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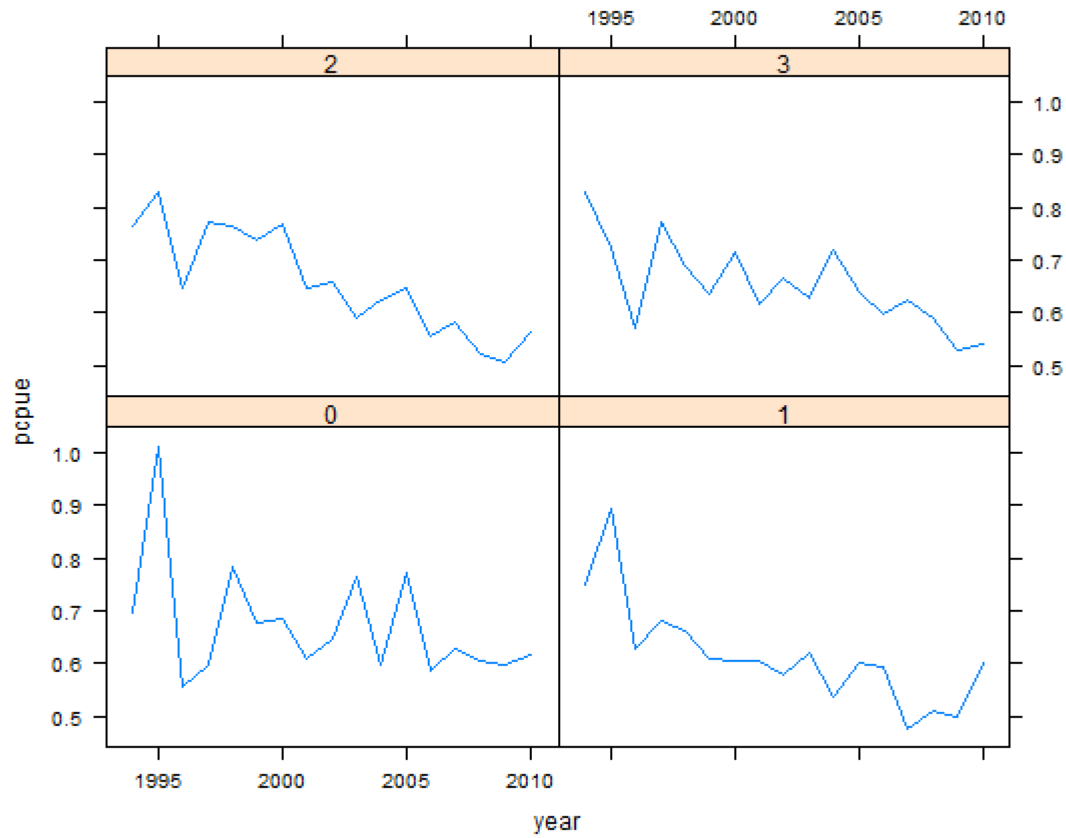
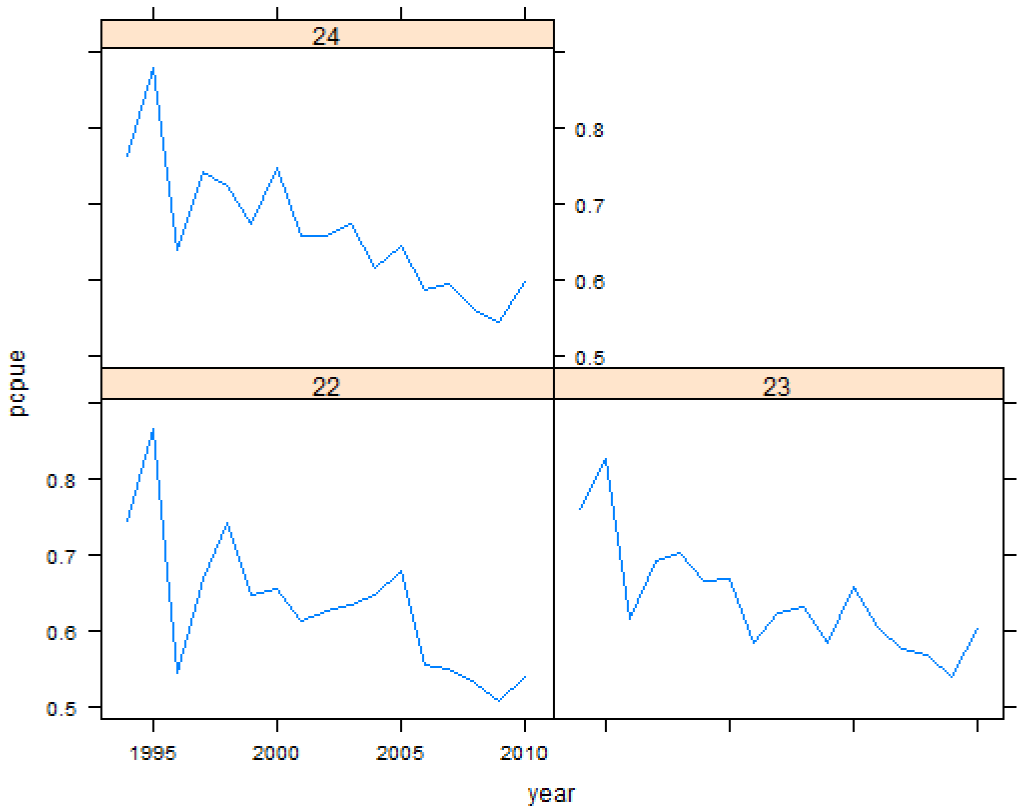


Figure A-26. Annual trends of the Gaussian component of the Δ-GLM by prefecture for the period 1994 to 2010. Prefectures: Iwate = 22; Miyagi = 23; Fukushima = 24.



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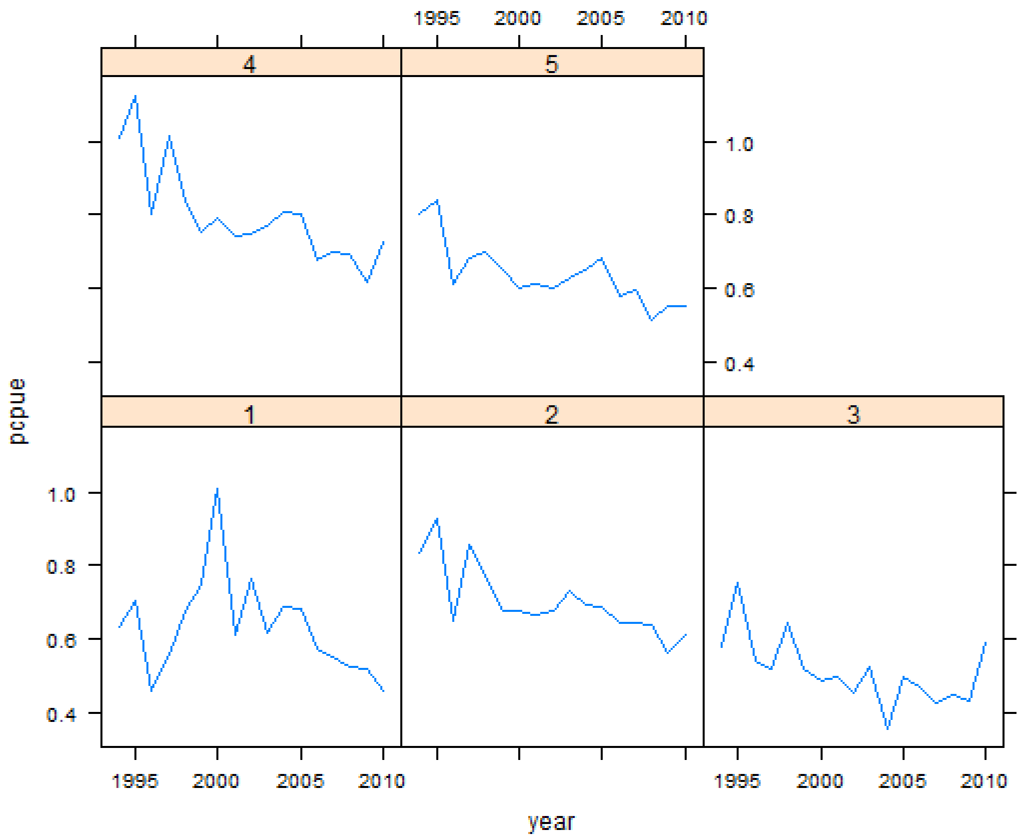

Figure A-28. Estimated effects for HPB for the Binomial (left panel) and Gaussian (right panel) components of the Δ-GLM model for the period 1994-2010.

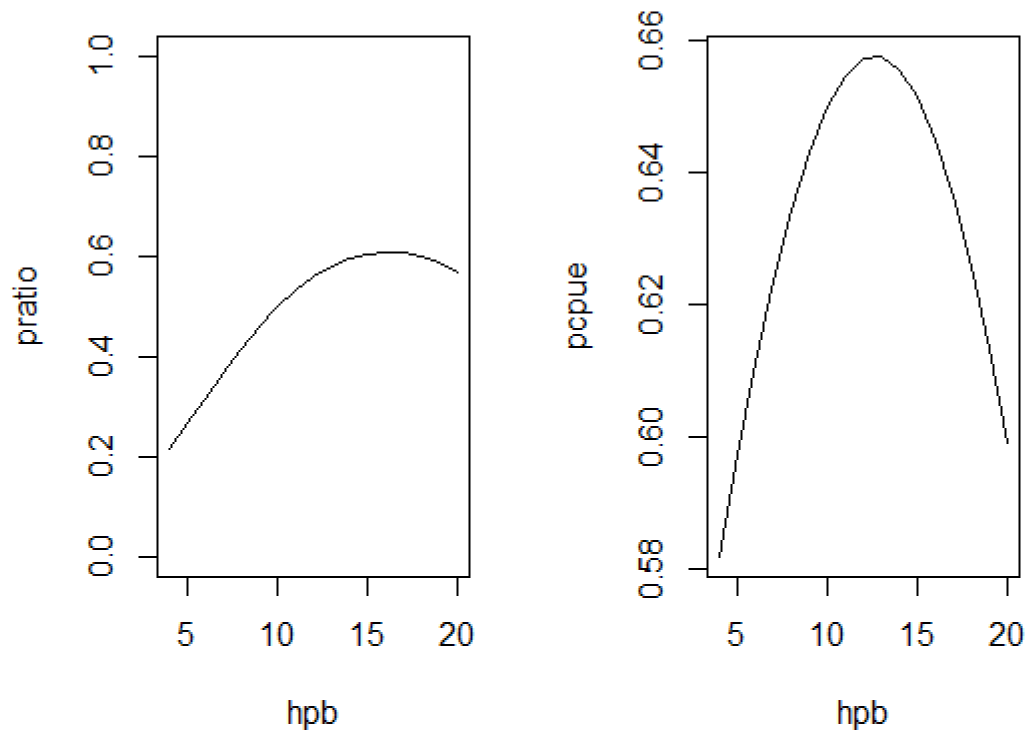

Figure A-29. Estimated effects for latitude (lat) and longitude (lon) for the Binomial component of the Δ-GLM model for the period 1994 to 2010.

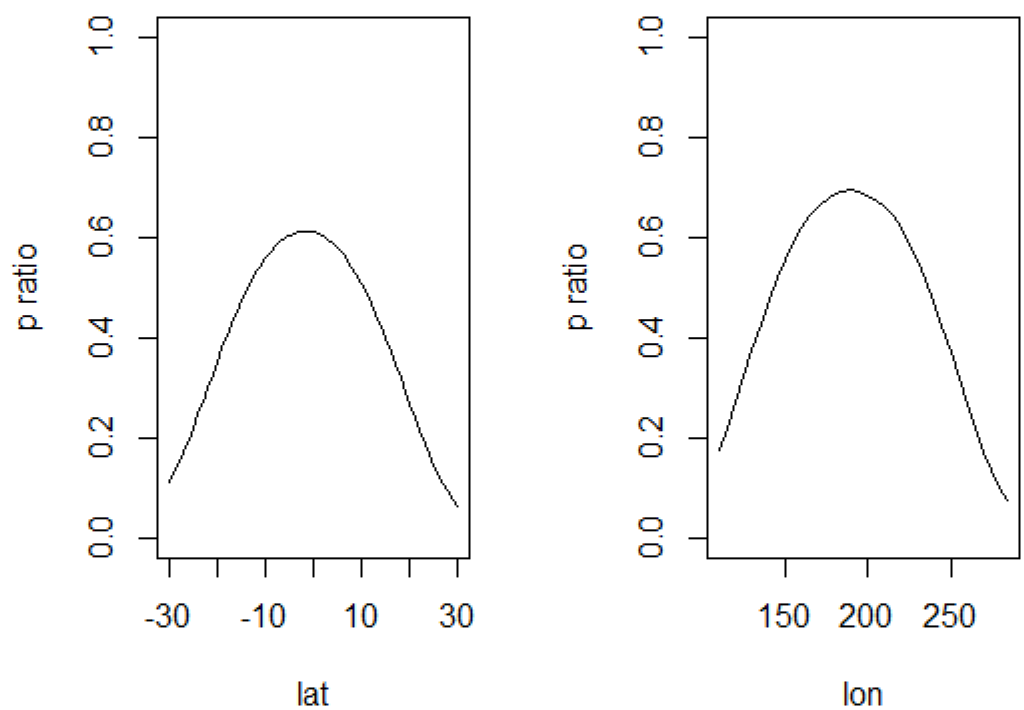

Table A-1. Deviance and residuals for the Binomial component of the Δ-GLM model for the period 1975 to 1993.

	Df	Deviance	Dev. / Df	Resid. Df	Resid. Dev
NULL				838895	1151150
as.factor(YEAR)	18	7334.0	407.4	838877.0	1143817
poly(lat, 2)	2	106972.0	53486.0	838875.0	1036845
poly(lon, 2)	2	41820.0	20910.0	838873.0	995025
poly(hpb, 2)	2	9.0	4.5	838871.0	995016
as.factor(SEASON)	3	1127.0	375.7	838868.0	993889
poly(lat, 2):poly(lon, 2)	4	3569.0	892.3	838864.0	990320
as.factor(YEAR):poly(lat, 2)	36	5475.0	152.1	838828.0	984845
as.factor(YEAR):poly(lon, 2)	36	3705.0	102.9	838792.0	981140
as.factor(YEAR):poly(hpb, 2)	36	1049.0	29.1	838756.0	980091
as.factor(YEAR):as.factor(SEASON)	54	4240.0	78.5	838702.0	975851
as.factor(YEAR):poly(lat, 2):poly(lon,2)	72	3658.0	50.8	838630.0	972193

Table A-2. Deviance and residuals for Gaussian component of the Δ-GLM model for the period 1975 to 1993.

	Df	Deviance	Dev. / Df	Resid. Df	Resid. Dev
NULL				369745	150575
factor(YEAR)	18	1178.8	65.5	369727.0	149396
poly(hpb, 2)	2	990.8	495.4	369725.0	148406
factor(SEASON)	3	542.5	180.8	369722.0	147863
poly(lat, 2)	2	4458.3	2229.2	369720.0	143405
report2	1	17661.1	17661.1	369719.0	125744
factor(pref)	2	26.5	13.3	369717.0	125717
poly(lon, 2)	2	1231.7	615.9	369715.0	124485
factor(SEASON):poly(lat, 2)	6	446.7	74.5	369709.0	124039
poly(lat, 2):poly(lon, 2)	4	249.9	62.5	369705.0	123789
factor(YEAR):poly(hpb, 2)	36	365.4	10.2	369669.0	123423
factor(YEAR):factor(SEASON)	54	446.9	8.3	369615.0	122976
factor(YEAR):poly(lat, 2)	36	541.8	15.1	369579.0	122435
factor(YEAR):report2	18	389.5	21.6	369561.0	122045
factor(YEAR):factor(pref)	36	91.9	2.6	369525.0	121953
factor(YEAR):poly(lon, 2)	36	382.6	10.6	369489.0	121571
factor(YEAR):factor(SEASON):poly(lat, 2)	108	466.0	4.3	369381.0	121105
factor(YEAR):poly(lat, 2):poly(lon, 2)	72	367.5	5.1	369309.0	120737

Table A-3. Deviance and residuals for the Binomial component of the Δ-GLM model for the period 1994 to 2010.

	Df	Deviance	Dev. / Df	Resid. Df	Resid. Dev
NULL				334546	463033
as.factor(YEAR)	16	3803	237.7	334530	459229
poly(lat, 2)	2	32546	16273.0	334528	426683
poly(lon, 2)	2	19447	9723.5	334526	407236
poly(hpb, 2)	2	198	99.0	334524	407038
as.factor(SEASON)	3	720	240.0	334521	406318
as.factor(pref)	2	42	21.0	334519	406275
as.factor(YEAR):poly(lat, 2)	32	1162	36.3	334487	405113
as.factor(YEAR):poly(lon, 2)	32	3099	96.8	334455	402014
as.factor(YEAR):poly(hpb, 2)	32	799	25.0	334423	401215
as.factor(YEAR):as.factor(SEASON)	48	3137	65.4	334375	398078
as.factor(YEAR):as.factor(pref)	32	568	17.8	334343	397510
poly(lat, 2):poly(lon, 2)	4	1050	262.5	334339	396460
poly(lat, 2):poly(hpb, 2)	4	1112	278.0	334335	395349
poly(lat, 2):as.factor(SEASON)	6	6485	1080.8	334329	388864
poly(lat, 2):as.factor(pref)	4	115	28.8	334325	388748
poly(lon, 2):poly(hpb, 2)	4	614	153.5	334321	388134
poly(lon, 2):as.factor(SEASON)	6	848	141.3	334315	387286
poly(lon, 2):as.factor(pref)	4	985	246.3	334311	386300
poly(hpb, 2):as.factor(SEASON)	6	37	6.2	334305	386264
poly(hpb, 2):as.factor(pref)	4	73	18.3	334301	386190
as.factor(SEASON):as.factor(pref)	6	29	4.8	334295	386161
as.factor(YEAR):poly(lat, 2):poly(lon, 2)	64	1878	29.3	334231	384283
poly(lat, 2):poly(lon, 2):poly(hpb, 2)	8	440	55.0	334223	383843
poly(lat, 2):poly(lon, 2):as.factor(SEASON)	12	858	71.5	334211	382985
poly(lat, 2):poly(lon, 2):as.factor(pref)	8	166	20.8	334203	382819

Table A-4. Deviance and residuals for the Gaussian component of the Δ-GLM model for the period 1994 to 2010.

	Df	Deviance	Dev. / Df	Resid. Df	Resid. Dev
NULL				159364	67070
as.factor(YEAR)	16	2493.1	155.8	159348	64577
poly(hpb, 2)	2	903.1	451.6	159346	63674
as.factor(SEASON)	3	195.4	65.1	159343	63479
as.factor(pref)	2	57.1	28.6	159341	63422
report2	1	4430.9	4430.9	159340	58991
as.factor(area4)	4	1585.4	396.4	159336	57405
as.factor(YEAR):poly(hpb, 2)	32	216.5	6.8	159304	57189
as.factor(YEAR):as.factor(SEASON)	48	983.6	20.5	159256	56205
as.factor(YEAR):as.factor(pref)	32	103.5	3.2	159224	56102
as.factor(YEAR):report2	16	160.3	10.0	159208	55942
as.factor(YEAR):as.factor(area4)	64	532.7	8.3	159144	55409

Table A-5. Estimated coefficients for the Binomial component of the Δ-GLM model for the period 1975 to 1993.

	Estimate	Std. Error	z value	P (>|z|)	Sig.
(Intercept)	-1.2	0.1	-22.9	0.0	***
as.factor(YEAR)1976	0.2	0.1	2.7	0.0	**
as.factor(YEAR)1977	0.7	0.1	12.0	0.0	***
as.factor(YEAR)1978	0.8	0.1	13.2	0.0	***
as.factor(YEAR)1979	0.7	0.1	11.7	0.0	***
as.factor(YEAR)1980	0.7	0.1	12.6	0.0	***
as.factor(YEAR)1981	0.6	0.1	11.1	0.0	***
as.factor(YEAR)1982	0.6	0.1	9.7	0.0	***
as.factor(YEAR)1983	1.0	0.1	18.3	0.0	***
as.factor(YEAR)1984	1.3	0.1	21.7	0.0	***
as.factor(YEAR)1985	1.1	0.1	17.1	0.0	***
as.factor(YEAR)1986	1.1	0.1	18.7	0.0	***
as.factor(YEAR)1987	0.8	0.1	14.2	0.0	***
as.factor(YEAR)1988	1.1	0.1	19.0	0.0	***
as.factor(YEAR)1989	0.8	0.1	13.7	0.0	***
as.factor(YEAR)1990	1.0	0.1	17.0	0.0	***
as.factor(YEAR)1991	1.3	0.1	21.5	0.0	***
as.factor(YEAR)1992	1.6	0.1	25.2	0.0	***
as.factor(YEAR)1993	1.4	0.1	21.9	0.0	***
poly(lat, 2)1	-431.4	30.9	-14.0	0.0	***
poly(lat, 2)2	-679.1	27.7	-24.6	0.0	***
poly(lon, 2)1	-375.4	24.6	-15.3	0.0	***
poly(lon, 2)2	-217.1	18.1	-12.0	0.0	***
poly(hpb, 2)1	-163.7	29.6	-5.5	0.0	***
poly(hpb, 2)2	-127.0	23.6	-5.4	0.0	***
as.factor(SEASON)1	0.4	0.0	11.8	0.0	***
as.factor(SEASON)2	0.4	0.0	10.3	0.0	***
as.factor(SEASON)3	0.1	0.0	1.9	0.1	.
poly(lat, 2)1:poly(lon, 2)1	-93830	30170	-3.1	0.0	**
poly(lat, 2)2:poly(lon, 2)1	-204000	23730	-8.6	0.0	***
poly(lat, 2)1:poly(lon, 2)2	153500	19980	7.7	0.0	***
poly(lat, 2)2:poly(lon, 2)2	-222200	19570	-11.4	0.0	***
as.factor(YEAR)1976:poly(lat, 2)1	53.6	38.3	1.4	0.2	
as.factor(YEAR)1977:poly(lat, 2)1	210.5	41.3	5.1	0.0	***
as.factor(YEAR)1978:poly(lat, 2)1	183.9	40.1	4.6	0.0	***
as.factor(YEAR)1979:poly(lat, 2)1	264.3	39.5	6.7	0.0	***
as.factor(YEAR)1980:poly(lat, 2)1	157.1	37.1	4.2	0.0	***
as.factor(YEAR)1981:poly(lat, 2)1	-71.1	37.8	-1.9	0.1	.
as.factor(YEAR)1982:poly(lat, 2)1	-275.5	40.5	-6.8	0.0	***
as.factor(YEAR)1983:poly(lat, 2)1	-202.7	37.4	-5.4	0.0	***
as.factor(YEAR)1984:poly(lat, 2)1	-277.5	39.5	-7.0	0.0	***
as.factor(YEAR)1985:poly(lat, 2)1	-30.7	46.0	-0.7	0.5	
as.factor(YEAR)1986:poly(lat, 2)1	-192.6	36.3	-5.3	0.0	***
as.factor(YEAR)1987:poly(lat, 2)1	-183.1	38.0	-4.8	0.0	***
as.factor(YEAR)1988:poly(lat, 2)1	-1.9	36.9	-0.1	1.0	
as.factor(YEAR)1989:poly(lat, 2)1	211.4	35.9	5.9	0.0	***
as.factor(YEAR)1990:poly(lat, 2)1	155.3	39.8	3.9	0.0	***

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	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)1991:poly(lat, 2)1	90.9	39.0	2.3	0.0	*
as.factor(YEAR)1992:poly(lat, 2)1	89.7	37.6	2.4	0.0	*
as.factor(YEAR)1993:poly(lat, 2)1	181.0	38.0	4.8	0.0	***
as.factor(YEAR)1976:poly(lat, 2)2	342.3	33.5	10.2	0.0	***
as.factor(YEAR)1977:poly(lat, 2)2	523.1	35.6	14.7	0.0	***
as.factor(YEAR)1978:poly(lat, 2)2	266.2	35.8	7.4	0.0	***
as.factor(YEAR)1979:poly(lat, 2)2	17.3	37.7	0.5	0.6	
as.factor(YEAR)1980:poly(lat, 2)2	128.8	36.1	3.6	0.0	***
as.factor(YEAR)1981:poly(lat, 2)2	-257.6	36.3	-7.1	0.0	***
as.factor(YEAR)1982:poly(lat, 2)2	-291.3	38.4	-7.6	0.0	***
as.factor(YEAR)1983:poly(lat, 2)2	72.7	35.5	2.1	0.0	*
as.factor(YEAR)1984:poly(lat, 2)2	-316.2	38.5	-8.2	0.0	***
as.factor(YEAR)1985:poly(lat, 2)2	49.8	43.8	1.1	0.3	
as.factor(YEAR)1986:poly(lat, 2)2	-302.4	34.7	-8.7	0.0	***
as.factor(YEAR)1987:poly(lat, 2)2	-237.8	36.1	-6.6	0.0	***
as.factor(YEAR)1988:poly(lat, 2)2	-129.7	35.7	-3.6	0.0	***
as.factor(YEAR)1989:poly(lat, 2)2	-71.1	34.7	-2.0	0.0	*
as.factor(YEAR)1990:poly(lat, 2)2	-306.9	38.0	-8.1	0.0	***
as.factor(YEAR)1991:poly(lat, 2)2	-224.9	36.9	-6.1	0.0	***
as.factor(YEAR)1992:poly(lat, 2)2	-198.8	36.7	-5.4	0.0	***
as.factor(YEAR)1993:poly(lat, 2)2	-121.6	37.0	-3.3	0.0	***
as.factor(YEAR)1976:poly(lon, 2)1	17.4	30.6	0.6	0.6	
as.factor(YEAR)1977:poly(lon, 2)1	41.9	33.5	1.2	0.2	
as.factor(YEAR)1978:poly(lon, 2)1	9.1	32.6	0.3	0.8	
as.factor(YEAR)1979:poly(lon, 2)1	105.6	33.6	3.1	0.0	**
as.factor(YEAR)1980:poly(lon, 2)1	-77.7	30.4	-2.6	0.0	*
as.factor(YEAR)1981:poly(lon, 2)1	-92.7	30.3	-3.1	0.0	**
as.factor(YEAR)1982:poly(lon, 2)1	-69.1	32.0	-2.2	0.0	*
as.factor(YEAR)1983:poly(lon, 2)1	208.9	29.4	7.1	0.0	***
as.factor(YEAR)1984:poly(lon, 2)1	-83.1	31.9	-2.6	0.0	**
as.factor(YEAR)1985:poly(lon, 2)1	18.9	37.4	0.5	0.6	
as.factor(YEAR)1986:poly(lon, 2)1	-454.7	31.9	-14.3	0.0	***
as.factor(YEAR)1987:poly(lon, 2)1	-82.2	31.7	-2.6	0.0	**
as.factor(YEAR)1988:poly(lon, 2)1	-229.5	30.5	-7.5	0.0	***
as.factor(YEAR)1989:poly(lon, 2)1	-321.6	33.5	-9.6	0.0	***
as.factor(YEAR)1990:poly(lon, 2)1	-84.0	33.3	-2.5	0.0	*
as.factor(YEAR)1991:poly(lon, 2)1	-275.5	36.5	-7.5	0.0	***
as.factor(YEAR)1992:poly(lon, 2)1	94.6	34.9	2.7	0.0	**
as.factor(YEAR)1993:poly(lon, 2)1	-0.6	32.8	0.0	1.0	
as.factor(YEAR)1976:poly(lon, 2)2	92.0	24.1	3.8	0.0	***
as.factor(YEAR)1977:poly(lon, 2)2	264.4	24.7	10.7	0.0	***
as.factor(YEAR)1978:poly(lon, 2)2	-23.1	24.2	-1.0	0.3	
as.factor(YEAR)1979:poly(lon, 2)2	-43.0	25.9	-1.7	0.1	.
as.factor(YEAR)1980:poly(lon, 2)2	-0.2	23.6	0.0	1.0	
as.factor(YEAR)1981:poly(lon, 2)2	-120.9	23.6	-5.1	0.0	***
as.factor(YEAR)1982:poly(lon, 2)2	-64.4	25.3	-2.5	0.0	*
as.factor(YEAR)1983:poly(lon, 2)2	177.7	24.1	7.4	0.0	***
as.factor(YEAR)1984:poly(lon, 2)2	-132.0	25.0	-5.3	0.0	***
as.factor(YEAR)1985:poly(lon, 2)2	78.1	26.9	2.9	0.0	**
as.factor(YEAR)1986:poly(lon, 2)2	132.4	25.6	5.2	0.0	***
as.factor(YEAR)1987:poly(lon, 2)2	97.2	25.1	3.9	0.0	***

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)1988:poly(lon, 2)2	2.3	23.2	0.1	0.9	
as.factor(YEAR)1989:poly(lon, 2)2	81.0	27.3	3.0	0.0	**
as.factor(YEAR)1990:poly(lon, 2)2	330.0	26.0	12.7	0.0	***
as.factor(YEAR)1991:poly(lon, 2)2	67.0	27.2	2.5	0.0	*
as.factor(YEAR)1992:poly(lon, 2)2	289.7	26.4	11.0	0.0	***
as.factor(YEAR)1993:poly(lon, 2)2	97.6	26.2	3.7	0.0	***
as.factor(YEAR)1976:poly(hpb, 2)1	36.1	40.7	0.9	0.4	
as.factor(YEAR)1977:poly(hpb, 2)1	186.6	34.7	5.4	0.0	***
as.factor(YEAR)1978:poly(hpb, 2)1	106.7	37.9	2.8	0.0	**
as.factor(YEAR)1979:poly(hpb, 2)1	156.1	34.7	4.5	0.0	***
as.factor(YEAR)1980:poly(hpb, 2)1	200.2	33.7	5.9	0.0	***
as.factor(YEAR)1981:poly(hpb, 2)1	138.4	33.3	4.2	0.0	***
as.factor(YEAR)1982:poly(hpb, 2)1	192.3	33.4	5.8	0.0	***
as.factor(YEAR)1983:poly(hpb, 2)1	333.7	34.8	9.6	0.0	***
as.factor(YEAR)1984:poly(hpb, 2)1	168.1	35.1	4.8	0.0	***
as.factor(YEAR)1985:poly(hpb, 2)1	282.4	37.0	7.6	0.0	***
as.factor(YEAR)1986:poly(hpb, 2)1	167.8	35.4	4.7	0.0	***
as.factor(YEAR)1987:poly(hpb, 2)1	208.3	36.2	5.7	0.0	***
as.factor(YEAR)1988:poly(hpb, 2)1	181.8	35.9	5.1	0.0	***
as.factor(YEAR)1989:poly(hpb, 2)1	293.0	35.2	8.3	0.0	***
as.factor(YEAR)1990:poly(hpb, 2)1	187.3	36.7	5.1	0.0	***
as.factor(YEAR)1991:poly(hpb, 2)1	-70.7	37.0	-1.9	0.1	.
as.factor(YEAR)1992:poly(hpb, 2)1	67.8	42.2	1.6	0.1	
as.factor(YEAR)1993:poly(hpb, 2)1	32.1	43.0	0.7	0.5	
as.factor(YEAR)1976:poly(hpb, 2)2	-34.6	33.3	-1.0	0.3	
as.factor(YEAR)1977:poly(hpb, 2)2	72.1	27.9	2.6	0.0	**
as.factor(YEAR)1978:poly(hpb, 2)2	115.6	33.1	3.5	0.0	***
as.factor(YEAR)1979:poly(hpb, 2)2	111.6	30.2	3.7	0.0	***
as.factor(YEAR)1980:poly(hpb, 2)2	103.7	30.1	3.4	0.0	***
as.factor(YEAR)1981:poly(hpb, 2)2	44.8	30.0	1.5	0.1	
as.factor(YEAR)1982:poly(hpb, 2)2	135.5	26.9	5.0	0.0	***
as.factor(YEAR)1983:poly(hpb, 2)2	141.0	29.3	4.8	0.0	***
as.factor(YEAR)1984:poly(hpb, 2)2	222.0	28.4	7.8	0.0	***
as.factor(YEAR)1985:poly(hpb, 2)2	22.4	28.3	0.8	0.4	
as.factor(YEAR)1986:poly(hpb, 2)2	207.3	26.6	7.8	0.0	***
as.factor(YEAR)1987:poly(hpb, 2)2	79.5	26.5	3.0	0.0	**
as.factor(YEAR)1988:poly(hpb, 2)2	82.0	26.7	3.1	0.0	**
as.factor(YEAR)1989:poly(hpb, 2)2	92.7	27.3	3.4	0.0	***
as.factor(YEAR)1990:poly(hpb, 2)2	9.9	26.0	0.4	0.7	
as.factor(YEAR)1991:poly(hpb, 2)2	197.7	25.7	7.7	0.0	***
as.factor(YEAR)1992:poly(hpb, 2)2	100.9	26.6	3.8	0.0	***
as.factor(YEAR)1993:poly(hpb, 2)2	57.0	26.3	2.2	0.0	*
as.factor(YEAR)1976:as.factor(SEASON)1	0.1	0.0	1.7	0.1	.
as.factor(YEAR)1977:as.factor(SEASON)1	-0.3	0.0	-6.0	0.0	***
as.factor(YEAR)1978:as.factor(SEASON)1	0.0	0.0	-0.5	0.6	
as.factor(YEAR)1979:as.factor(SEASON)1	-0.4	0.0	-8.0	0.0	***
as.factor(YEAR)1980:as.factor(SEASON)1	-0.3	0.0	-7.0	0.0	***
as.factor(YEAR)1981:as.factor(SEASON)1	-0.3	0.0	-7.1	0.0	***
as.factor(YEAR)1982:as.factor(SEASON)1	-0.3	0.0	-6.0	0.0	***
as.factor(YEAR)1983:as.factor(SEASON)1	-0.3	0.0	-6.3	0.0	***
as.factor(YEAR)1984:as.factor(SEASON)1	-0.5	0.0	-10.0	0.0	***

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)1985:as.factor(SEASON)1	-0.5	0.0	-9.7	0.0	***
as.factor(YEAR)1986:as.factor(SEASON)1	-0.1	0.0	-2.1	0.0	*
as.factor(YEAR)1987:as.factor(SEASON)1	0.0	0.0	0.9	0.4	
as.factor(YEAR)1988:as.factor(SEASON)1	-0.3	0.0	-6.7	0.0	***
as.factor(YEAR)1989:as.factor(SEASON)1	-0.1	0.0	-1.2	0.2	
as.factor(YEAR)1990:as.factor(SEASON)1	-0.3	0.0	-6.6	0.0	***
as.factor(YEAR)1991:as.factor(SEASON)1	-0.1	0.0	-2.7	0.0	**
as.factor(YEAR)1992:as.factor(SEASON)1	-0.3	0.0	-6.5	0.0	***
as.factor(YEAR)1993:as.factor(SEASON)1	-0.2	0.0	-3.8	0.0	***
as.factor(YEAR)1976:as.factor(SEASON)2	0.2	0.1	4.0	0.0	***
as.factor(YEAR)1977:as.factor(SEASON)2	-0.3	0.0	-6.2	0.0	***
as.factor(YEAR)1978:as.factor(SEASON)2	-0.2	0.0	-5.0	0.0	***
as.factor(YEAR)1979:as.factor(SEASON)2	-0.3	0.0	-6.8	0.0	***
as.factor(YEAR)1980:as.factor(SEASON)2	-0.3	0.0	-6.2	0.0	***
as.factor(YEAR)1981:as.factor(SEASON)2	-0.6	0.0	-13.3	0.0	***
as.factor(YEAR)1982:as.factor(SEASON)2	-0.2	0.0	-4.9	0.0	***
as.factor(YEAR)1983:as.factor(SEASON)2	-0.6	0.0	-12.9	0.0	***
as.factor(YEAR)1984:as.factor(SEASON)2	-0.5	0.1	-9.4	0.0	***
as.factor(YEAR)1985:as.factor(SEASON)2	-0.6	0.0	-11.7	0.0	***
as.factor(YEAR)1986:as.factor(SEASON)2	-0.3	0.0	-5.8	0.0	***
as.factor(YEAR)1987:as.factor(SEASON)2	0.1	0.0	1.9	0.1	.
as.factor(YEAR)1988:as.factor(SEASON)2	-0.7	0.0	-14.9	0.0	***
as.factor(YEAR)1989:as.factor(SEASON)2	0.3	0.0	5.2	0.0	***
as.factor(YEAR)1990:as.factor(SEASON)2	-0.5	0.0	-10.8	0.0	***
as.factor(YEAR)1991:as.factor(SEASON)2	-0.5	0.0	-10.5	0.0	***
as.factor(YEAR)1992:as.factor(SEASON)2	-1.1	0.0	-22.9	0.0	***
as.factor(YEAR)1993:as.factor(SEASON)2	-0.5	0.0	-9.2	0.0	***
as.factor(YEAR)1976:as.factor(SEASON)3	0.2	0.1	3.7	0.0	***
as.factor(YEAR)1977:as.factor(SEASON)3	-0.1	0.0	-2.4	0.0	*
as.factor(YEAR)1978:as.factor(SEASON)3	-0.4	0.0	-8.9	0.0	***
as.factor(YEAR)1979:as.factor(SEASON)3	0.1	0.0	1.4	0.2	
as.factor(YEAR)1980:as.factor(SEASON)3	-0.1	0.0	-1.2	0.2	
as.factor(YEAR)1981:as.factor(SEASON)3	-0.4	0.0	-8.7	0.0	***
as.factor(YEAR)1982:as.factor(SEASON)3	0.2	0.0	5.0	0.0	***
as.factor(YEAR)1983:as.factor(SEASON)3	-0.4	0.1	-7.4	0.0	***
as.factor(YEAR)1984:as.factor(SEASON)3	-0.2	0.0	-3.9	0.0	***
as.factor(YEAR)1985:as.factor(SEASON)3	-0.4	0.1	-7.5	0.0	***
as.factor(YEAR)1986:as.factor(SEASON)3	0.2	0.0	4.3	0.0	***
as.factor(YEAR)1987:as.factor(SEASON)3	0.1	0.0	1.6	0.1	
as.factor(YEAR)1988:as.factor(SEASON)3	-0.8	0.0	-17.1	0.0	***
as.factor(YEAR)1989:as.factor(SEASON)3	0.5	0.0	9.9	0.0	***
as.factor(YEAR)1990:as.factor(SEASON)3	0.0	0.0	1.0	0.3	
as.factor(YEAR)1991:as.factor(SEASON)3	0.2	0.0	4.2	0.0	***
as.factor(YEAR)1992:as.factor(SEASON)3	-0.8	0.0	-15.8	0.0	***
as.factor(YEAR)1993:as.factor(SEASON)3	0.0	0.0	-0.1	1.0	
as.factor(YEAR)1976:poly(lat, 2)1:poly(lon, 2)[1]	139000	37150	3.7	0.0	***
as.factor(YEAR)1977:poly(lat, 2)1:poly(lon, 2)1	535400	40890	13.1	0.0	***
as.factor(YEAR)1978:poly(lat, 2)1:poly(lon, 2)1	491300	40020	12.3	0.0	***
as.factor(YEAR)1979:poly(lat, 2)1:poly(lon, 2)1	512400	39760	12.9	0.0	***
as.factor(YEAR)1980:poly(lat, 2)1:poly(lon, 2)1	261700	36410	7.2	0.0	***
as.factor(YEAR)1981:poly(lat, 2)1:poly(lon, 2)1	36670	36830	1.0	0.3	

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)1982:poly(lat, 2)1:poly(lon, 2)1	-56130	38670	-1.5	0.1	
as.factor(YEAR)1983:poly(lat, 2)1:poly(lon, 2)1	318500	35530	9.0	0.0	***
as.factor(YEAR)1984:poly(lat, 2)1:poly(lon, 2)1	134500	37840	3.6	0.0	***
as.factor(YEAR)1985:poly(lat, 2)1:poly(lon, 2)1	399100	46330	8.6	0.0	***
as.factor(YEAR)1986:poly(lat, 2)1:poly(lon, 2)1	259600	35680	7.3	0.0	***
as.factor(YEAR)1987:poly(lat, 2)1:poly(lon, 2)1	186200	35210	5.3	0.0	***
as.factor(YEAR)1988:poly(lat, 2)1:poly(lon, 2)1	155100	34600	4.5	0.0	***
as.factor(YEAR)1989:poly(lat, 2)1:poly(lon, 2)1	328100	35660	9.2	0.0	***
as.factor(YEAR)1990:poly(lat, 2)1:poly(lon, 2)1	314100	39500	8.0	0.0	***
as.factor(YEAR)1991:poly(lat, 2)1:poly(lon, 2)1	346500	39420	8.8	0.0	***
as.factor(YEAR)1992:poly(lat, 2)1:poly(lon, 2)1	548700	40920	13.4	0.0	***
as.factor(YEAR)1993:poly(lat, 2)1:poly(lon, 2)1	435500	39250	11.1	0.0	***
as.factor(YEAR)1976:poly(lat, 2)2:poly(lon, 2)1	417900	29180	14.3	0.0	***
as.factor(YEAR)1977:poly(lat, 2)2:poly(lon, 2)1	460400	31730	14.5	0.0	***
as.factor(YEAR)1978:poly(lat, 2)2:poly(lon, 2)1	427500	31180	13.7	0.0	***
as.factor(YEAR)1979:poly(lat, 2)2:poly(lon, 2)1	240700	34360	7.0	0.0	***
as.factor(YEAR)1980:poly(lat, 2)2:poly(lon, 2)1	331000	30450	10.9	0.0	***
as.factor(YEAR)1981:poly(lat, 2)2:poly(lon, 2)1	138600	29830	4.6	0.0	***
as.factor(YEAR)1982:poly(lat, 2)2:poly(lon, 2)1	-13370	31510	-0.4	0.7	
as.factor(YEAR)1983:poly(lat, 2)2:poly(lon, 2)1	310500	28280	11.0	0.0	***
as.factor(YEAR)1984:poly(lat, 2)2:poly(lon, 2)1	82110	31590	2.6	0.0	**
as.factor(YEAR)1985:poly(lat, 2)2:poly(lon, 2)1	313700	37640	8.3	0.0	***
as.factor(YEAR)1986:poly(lat, 2)2:poly(lon, 2)1	379200	29600	12.8	0.0	***
as.factor(YEAR)1987:poly(lat, 2)2:poly(lon, 2)1	228600	28750	8.0	0.0	***
as.factor(YEAR)1988:poly(lat, 2)2:poly(lon, 2)1	240200	28670	8.4	0.0	***
as.factor(YEAR)1989:poly(lat, 2)2:poly(lon, 2)1	238100	30820	7.7	0.0	***
as.factor(YEAR)1990:poly(lat, 2)2:poly(lon, 2)1	253000	31990	7.9	0.0	***
as.factor(YEAR)1991:poly(lat, 2)2:poly(lon, 2)1	337800	32290	10.5	0.0	***
as.factor(YEAR)1992:poly(lat, 2)2:poly(lon, 2)1	413500	32070	12.9	0.0	***
as.factor(YEAR)1993:poly(lat, 2)2:poly(lon, 2)1	483500	31840	15.2	0.0	***
as.factor(YEAR)1976:poly(lat, 2)1:poly(lon, 2)2	76410	25770	3.0	0.0	**
as.factor(YEAR)1977:poly(lat, 2)1:poly(lon, 2)2	215700	28080	7.7	0.0	***
as.factor(YEAR)1978:poly(lat, 2)1:poly(lon, 2)2	298900	27390	10.9	0.0	***
as.factor(YEAR)1979:poly(lat, 2)1:poly(lon, 2)2	309000	26790	11.5	0.0	***
as.factor(YEAR)1980:poly(lat, 2)1:poly(lon, 2)2	52150	25240	2.1	0.0	*
as.factor(YEAR)1981:poly(lat, 2)1:poly(lon, 2)2	-95380	25510	-3.7	0.0	***
as.factor(YEAR)1982:poly(lat, 2)1:poly(lon, 2)2	-142500	26970	-5.3	0.0	***
as.factor(YEAR)1983:poly(lat, 2)1:poly(lon, 2)2	130300	26000	5.0	0.0	***
as.factor(YEAR)1984:poly(lat, 2)1:poly(lon, 2)2	80950	26480	3.1	0.0	**
as.factor(YEAR)1985:poly(lat, 2)1:poly(lon, 2)2	201200	29610	6.8	0.0	***
as.factor(YEAR)1986:poly(lat, 2)1:poly(lon, 2)2	74850	25040	3.0	0.0	**
as.factor(YEAR)1987:poly(lat, 2)1:poly(lon, 2)2	32260	24530	1.3	0.2	
as.factor(YEAR)1988:poly(lat, 2)1:poly(lon, 2)2	-93000	24520	-3.8	0.0	***
as.factor(YEAR)1989:poly(lat, 2)1:poly(lon, 2)2	126300	26290	4.8	0.0	***
as.factor(YEAR)1990:poly(lat, 2)1:poly(lon, 2)2	12920	27430	0.5	0.6	
as.factor(YEAR)1991:poly(lat, 2)1:poly(lon, 2)2	33120	26780	1.2	0.2	
as.factor(YEAR)1992:poly(lat, 2)1:poly(lon, 2)2	162400	28260	5.7	0.0	***
as.factor(YEAR)1993:poly(lat, 2)1:poly(lon, 2)2	213000	28270	7.5	0.0	***
as.factor(YEAR)1976:poly(lat, 2)2:poly(lon, 2)2	104900	25900	4.1	0.0	***
as.factor(YEAR)1977:poly(lat, 2)2:poly(lon, 2)2	112100	26030	4.3	0.0	***
as.factor(YEAR)1978:poly(lat, 2)2:poly(lon, 2)2	222600	25020	8.9	0.0	***

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)1979:poly(lat, 2)2:poly(lon, 2)2	219000	28160	7.8	0.0	***
as.factor(YEAR)1980:poly(lat, 2)2:poly(lon, 2)2	259300	25490	10.2	0.0	***
as.factor(YEAR)1981:poly(lat, 2)2:poly(lon, 2)2	422600	24750	17.1	0.0	***
as.factor(YEAR)1982:poly(lat, 2)2:poly(lon, 2)2	144200	26540	5.4	0.0	***
as.factor(YEAR)1983:poly(lat, 2)2:poly(lon, 2)2	305900	24740	12.4	0.0	***
as.factor(YEAR)1984:poly(lat, 2)2:poly(lon, 2)2	74260	26490	2.8	0.0	**
as.factor(YEAR)1985:poly(lat, 2)2:poly(lon, 2)2	128000	27490	4.7	0.0	***
as.factor(YEAR)1986:poly(lat, 2)2:poly(lon, 2)2	207100	25440	8.1	0.0	***
as.factor(YEAR)1987:poly(lat, 2)2:poly(lon, 2)2	273300	24680	11.1	0.0	***
as.factor(YEAR)1988:poly(lat, 2)2:poly(lon, 2)2	265400	24320	10.9	0.0	***
as.factor(YEAR)1989:poly(lat, 2)2:poly(lon, 2)2	193200	27100	7.1	0.0	***
as.factor(YEAR)1990:poly(lat, 2)2:poly(lon, 2)2	308800	25730	12.0	0.0	***
as.factor(YEAR)1991:poly(lat, 2)2:poly(lon, 2)2	244600	25540	9.6	0.0	***
as.factor(YEAR)1992:poly(lat, 2)2:poly(lon, 2)2	428200	24590	17.4	0.0	***
as.factor(YEAR)1993:poly(lat, 2)2:poly(lon, 2)2	410900	24870	16.5	0.0	***

Significance levels: 0 = ‘***’; < 0.001 = ‘**’ ; < 0.01 = ‘*’; < 0.05 = ‘.’; < 0.1 = ‘ ’

Dispersion parameter for binomial family taken to be 1

Null deviance: 1151150 on 838895 degrees of freedom

Residual deviance: 972193 on 838630 degrees of freedom 1.061

AIC: 972725

Number of Fisher Scoring iterations: 6

Table A-6. Estimated coefficients for the Gaussian component of the Δ-GLM model for the period 1975 to 1993.

	Estimate	Std. Error	z value	P(>|z|)	Sig.
(Intercept)	0.4	0.1	6.3	0.0	***
as.factor(YEAR)1995	-0.2	0.1	-3.4	0.0	***
as.factor(YEAR)1996	-1.0	0.1	-12.9	0.0	***
as.factor(YEAR)1997	-1.3	0.1	-14.2	0.0	***
as.factor(YEAR)1998	-0.3	0.1	-3.5	0.0	***
as.factor(YEAR)1999	-0.5	0.1	-5.0	0.0	***
as.factor(YEAR)2000	-0.9	0.1	-10.0	0.0	***
as.factor(YEAR)2001	-0.8	0.1	-9.6	0.0	***
as.factor(YEAR)2002	-0.8	0.1	-8.6	0.0	***
as.factor(YEAR)2003	-0.9	0.1	-9.7	0.0	***
as.factor(YEAR)2004	-0.5	0.1	-4.6	0.0	***
as.factor(YEAR)2005	-0.1	0.1	-1.4	0.2	
as.factor(YEAR)2006	-1.4	0.1	-12.7	0.0	***
as.factor(YEAR)2007	-1.4	0.1	-10.7	0.0	***
as.factor(YEAR)2008	-1.6	0.1	-12.4	0.0	***
as.factor(YEAR)2009	-1.7	0.1	-12.7	0.0	***
as.factor(YEAR)2010	-0.5	0.1	-4.5	0.0	***
poly(lat,2)1	-521.2	23.3	-22.4	0.0	***
poly(lat,2)2	-341.6	28.8	-11.9	0.0	***
poly(lon,2)1	-352.4	17.7	-19.9	0.0	***
poly(lon,2)2	-379.5	18.0	-21.1	0.0	***
poly(hpb,2)1	157.5	21.6	7.3	0.0	***
poly(hpb,2)2	-23.9	18.6	-1.3	0.2	
as.factor(SEASON)1	0.0	0.1	-0.3	0.8	
as.factor(SEASON)2	-0.2	0.1	-4.2	0.0	***
as.factor(SEASON)3	-0.1	0.1	-1.8	0.1	.
as.factor(pref)23	0.1	0.1	1.7	0.1	.
as.factor(pref)24	-0.1	0.1	-1.5	0.1	
as.factor(YEAR)1995:poly(lat,2)1	52.5	17.1	3.1	0.0	**
as.factor(YEAR)1996:poly(lat,2)1	-23.2	21.3	-1.1	0.3	
as.factor(YEAR)1997:poly(lat,2)1	-55.8	20.9	-2.7	0.0	**
as.factor(YEAR)1998:poly(lat,2)1	-116.6	19.2	-6.1	0.0	***
as.factor(YEAR)1999:poly(lat,2)1	-48.7	22.9	-2.1	0.0	*
as.factor(YEAR)2000:poly(lat,2)1	-29.4	26.9	-1.1	0.3	
as.factor(YEAR)2001:poly(lat,2)1	24.3	23.7	1.0	0.3	
as.factor(YEAR)2002:poly(lat,2)1	114.1	30.4	3.8	0.0	***
as.factor(YEAR)2003:poly(lat,2)1	-113.6	26.6	-4.3	0.0	***
as.factor(YEAR)2004:poly(lat,2)1	-42.7	45.2	-0.9	0.3	
as.factor(YEAR)2005:poly(lat,2)1	-200.2	34.2	-5.8	0.0	***
as.factor(YEAR)2006:poly(lat,2)1	-85.8	36.7	-2.3	0.0	*
as.factor(YEAR)2007:poly(lat,2)1	-505.0	55.5	-9.1	0.0	***
as.factor(YEAR)2008:poly(lat,2)1	-340.0	54.3	-6.3	0.0	***
as.factor(YEAR)2009:poly(lat,2)1	-507.1	61.1	-8.3	0.0	***
as.factor(YEAR)2010:poly(lat,2)1	128.6	49.1	2.6	0.0	**
as.factor(YEAR)1995:poly(lat,2)2	179.8	22.7	7.9	0.0	***
as.factor(YEAR)1996:poly(lat,2)2	78.9	27.0	2.9	0.0	**
as.factor(YEAR)1997:poly(lat,2)2	-245.7	27.3	-9.0	0.0	***
as.factor(YEAR)1998:poly(lat,2)2	35.8	25.6	1.4	0.2	
as.factor(YEAR)1999:poly(lat,2)2	-210.2	28.8	-7.3	0.0	***
as.factor(YEAR)2000:poly(lat,2)2	-0.8	30.0	0.0	1.0	
as.factor(YEAR)2001:poly(lat,2)2	90.4	30.8	2.9	0.0	**
as.factor(YEAR)2002:poly(lat,2)2	-19.8	35.0	-0.6	0.6	
as.factor(YEAR)2003:poly(lat,2)2	-336.8	32.8	-10.3	0.0	***

	Estimate	Std. Error	z value	P(>|z|)	Sig.
as.factor(YEAR)2004:poly(lat,2)2	-257.2	59.7	-4.3	0.0	***
as.factor(YEAR)2005:poly(lat,2)2	-112.5	37.3	-3.0	0.0	**
as.factor(YEAR)2006:poly(lat,2)2	-209.6	39.1	-5.4	0.0	***
as.factor(YEAR)2007:poly(lat,2)2	-448.5	60.8	-7.4	0.0	***
as.factor(YEAR)2008:poly(lat,2)2	-260.5	62.5	-4.2	0.0	***
as.factor(YEAR)2009:poly(lat,2)2	-326.9	74.2	-4.4	0.0	***
as.factor(YEAR)2010:poly(lat,2)2	-130.9	56.8	-2.3	0.0	*
as.factor(YEAR)1995:poly(lon,2)1	54.0	14.0	3.9	0.0	***
as.factor(YEAR)1996:poly(lon,2)1	-53.7	17.1	-3.1	0.0	**
as.factor(YEAR)1997:poly(lon,2)1	84.5	17.7	4.8	0.0	***
as.factor(YEAR)1998:poly(lon,2)1	35.2	16.7	2.1	0.0	*
as.factor(YEAR)1999:poly(lon,2)1	-99.3	22.2	-4.5	0.0	***
as.factor(YEAR)2000:poly(lon,2)1	-134.3	22.6	-6.0	0.0	***
as.factor(YEAR)2001:poly(lon,2)1	-86.8	20.4	-4.2	0.0	***
as.factor(YEAR)2002:poly(lon,2)1	-87.5	23.9	-3.7	0.0	***
as.factor(YEAR)2003:poly(lon,2)1	-267.4	22.1	-12.1	0.0	***
as.factor(YEAR)2004:poly(lon,2)1	-327.6	29.5	-11.1	0.0	***
as.factor(YEAR)2005:poly(lon,2)1	-412.4	27.5	-15.0	0.0	***
as.factor(YEAR)2006:poly(lon,2)1	-346.2	28.7	-12.0	0.0	***
as.factor(YEAR)2007:poly(lon,2)1	-640.2	40.6	-15.8	0.0	***
as.factor(YEAR)2008:poly(lon,2)1	-586.8	40.3	-14.6	0.0	***
as.factor(YEAR)2009:poly(lon,2)1	-483.5	50.4	-9.6	0.0	***
as.factor(YEAR)2010:poly(lon,2)1	-68.1	48.5	-1.4	0.2	
as.factor(YEAR)1995:poly(lon,2)2	-118.2	12.8	-9.2	0.0	***
as.factor(YEAR)1996:poly(lon,2)2	-60.2	16.7	-3.6	0.0	***
as.factor(YEAR)1997:poly(lon,2)2	-53.2	17.7	-3.0	0.0	**
as.factor(YEAR)1998:poly(lon,2)2	68.9	14.8	4.6	0.0	***
as.factor(YEAR)1999:poly(lon,2)2	178.9	22.4	8.0	0.0	***
as.factor(YEAR)2000:poly(lon,2)2	138.9	22.4	6.2	0.0	***
as.factor(YEAR)2001:poly(lon,2)2	103.8	18.9	5.5	0.0	***
as.factor(YEAR)2002:poly(lon,2)2	240.9	22.9	10.5	0.0	***
as.factor(YEAR)2003:poly(lon,2)2	39.3	21.3	1.8	0.1	.
as.factor(YEAR)2004:poly(lon,2)2	280.4	36.8	7.6	0.0	***
as.factor(YEAR)2005:poly(lon,2)2	78.9	34.0	2.3	0.0	*
as.factor(YEAR)2006:poly(lon,2)2	72.1	32.3	2.2	0.0	*
as.factor(YEAR)2007:poly(lon,2)2	-6.0	37.7	-0.2	0.9	
as.factor(YEAR)2008:poly(lon,2)2	-51.7	40.1	-1.3	0.2	
as.factor(YEAR)2009:poly(lon,2)2	-98.0	47.5	-2.1	0.0	*
as.factor(YEAR)2010:poly(lon,2)2	172.2	46.6	3.7	0.0	***
as.factor(YEAR)1995:poly(hpb,2)1	-32.2	17.1	-1.9	0.1	.
as.factor(YEAR)1996:poly(hpb,2)1	-32.1	20.2	-1.6	0.1	
as.factor(YEAR)1997:poly(hpb,2)1	-68.9	20.5	-3.4	0.0	***
as.factor(YEAR)1998:poly(hpb,2)1	-26.6	21.0	-1.3	0.2	
as.factor(YEAR)1999:poly(hpb,2)1	-226.7	25.6	-8.8	0.0	***
as.factor(YEAR)2000:poly(hpb,2)1	-71.0	30.0	-2.4	0.0	*
as.factor(YEAR)2001:poly(hpb,2)1	-6.3	32.2	-0.2	0.8	
as.factor(YEAR)2002:poly(hpb,2)1	16.8	39.8	0.4	0.7	
as.factor(YEAR)2003:poly(hpb,2)1	-35.5	39.2	-0.9	0.4	
as.factor(YEAR)2004:poly(hpb,2)1	40.7	51.1	0.8	0.4	
as.factor(YEAR)2005:poly(hpb,2)1	-175.0	53.4	-3.3	0.0	**
as.factor(YEAR)2006:poly(hpb,2)1	-6.2	51.7	-0.1	0.9	
as.factor(YEAR)2007:poly(hpb,2)1	89.0	49.8	1.8	0.1	.
as.factor(YEAR)2008:poly(hpb,2)1	44.4	49.3	0.9	0.4	
as.factor(YEAR)2009:poly(hpb,2)1	120.8	46.9	2.6	0.0	**
as.factor(YEAR)2010:poly(hpb,2)1	-56.5	52.6	-1.1	0.3	
as.factor(YEAR)1995:poly(hpb,2)2	-61.5	13.8	-4.5	0.0	***
as.factor(YEAR)1996:poly(hpb,2)2	-120.7	15.9	-7.6	0.0	***

	Estimate	Std. Error	z value	P(>|z|)	Sig.
as.factor(YEAR)1997:poly(hpb,2)2	-104.3	16.0	-6.5	0.0	***
as.factor(YEAR)1998:poly(hpb,2)2	-3.0	16.2	-0.2	0.9	
as.factor(YEAR)1999:poly(hpb,2)2	58.5	19.0	3.1	0.0	**
as.factor(YEAR)2000:poly(hpb,2)2	-68.1	22.3	-3.1	0.0	**
as.factor(YEAR)2001:poly(hpb,2)2	-33.6	21.4	-1.6	0.1	
as.factor(YEAR)2002:poly(hpb,2)2	-77.8	25.6	-3.0	0.0	**
as.factor(YEAR)2003:poly(hpb,2)2	-21.9	24.9	-0.9	0.4	
as.factor(YEAR)2004:poly(hpb,2)2	-89.6	35.3	-2.5	0.0	*
as.factor(YEAR)2005:poly(hpb,2)2	-168.0	36.2	-4.6	0.0	***
as.factor(YEAR)2006:poly(hpb,2)2	2.9	30.9	0.1	0.9	
as.factor(YEAR)2007:poly(hpb,2)2	-165.4	30.4	-5.4	0.0	***
as.factor(YEAR)2008:poly(hpb,2)2	-51.1	29.9	-1.7	0.1	.
as.factor(YEAR)2009:poly(hpb,2)2	-69.6	28.2	-2.5	0.0	*
as.factor(YEAR)2010:poly(hpb,2)2	-93.0	30.9	-3.0	0.0	**
as.factor(YEAR)1995:as.factor(SEASON)1	0.2	0.0	4.9	0.0	***
as.factor(YEAR)1996:as.factor(SEASON)1	0.2	0.1	2.9	0.0	**
as.factor(YEAR)1997:as.factor(SEASON)1	0.5	0.1	9.0	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)1	-0.1	0.1	-1.0	0.3	
as.factor(YEAR)1999:as.factor(SEASON)1	-0.3	0.1	-5.5	0.0	***
as.factor(YEAR)2000:as.factor(SEASON)1	-0.4	0.1	-6.5	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)1	0.3	0.1	4.5	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)1	-0.1	0.1	-1.6	0.1	
as.factor(YEAR)2003:as.factor(SEASON)1	-0.3	0.1	-4.3	0.0	***
as.factor(YEAR)2004:as.factor(SEASON)1	-0.4	0.1	-6.5	0.0	***
as.factor(YEAR)2005:as.factor(SEASON)1	-0.4	0.1	-5.6	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)1	0.2	0.1	2.3	0.0	*
as.factor(YEAR)2007:as.factor(SEASON)1	-0.4	0.1	-5.5	0.0	***
as.factor(YEAR)2008:as.factor(SEASON)1	-0.1	0.1	-1.6	0.1	
as.factor(YEAR)2009:as.factor(SEASON)1	0.2	0.1	2.1	0.0	*
as.factor(YEAR)2010:as.factor(SEASON)1	0.1	0.1	1.7	0.1	.
as.factor(YEAR)1995:as.factor(SEASON)2	0.3	0.1	5.7	0.0	***
as.factor(YEAR)1996:as.factor(SEASON)2	0.5	0.1	8.6	0.0	***
as.factor(YEAR)1997:as.factor(SEASON)2	0.9	0.1	16.0	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)2	0.1	0.1	1.7	0.1	.
as.factor(YEAR)1999:as.factor(SEASON)2	0.4	0.1	6.1	0.0	***
as.factor(YEAR)2000:as.factor(SEASON)2	0.6	0.1	9.7	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)2	0.4	0.1	6.9	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)2	-0.2	0.1	-3.9	0.0	***
as.factor(YEAR)2003:as.factor(SEASON)2	-0.3	0.1	-5.0	0.0	***
as.factor(YEAR)2004:as.factor(SEASON)2	-0.3	0.1	-4.7	0.0	***
as.factor(YEAR)2005:as.factor(SEASON)2	-0.4	0.1	-5.2	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)2	0.3	0.1	3.9	0.0	***
as.factor(YEAR)2007:as.factor(SEASON)2	-0.3	0.1	-3.6	0.0	***
as.factor(YEAR)2008:as.factor(SEASON)2	0.5	0.1	6.2	0.0	***
as.factor(YEAR)2009:as.factor(SEASON)2	0.6	0.1	7.0	0.0	***
as.factor(YEAR)2010:as.factor(SEASON)2	-0.3	0.1	-4.2	0.0	***
as.factor(YEAR)1995:as.factor(SEASON)3	0.0	0.1	-0.6	0.6	
as.factor(YEAR)1996:as.factor(SEASON)3	0.3	0.1	5.1	0.0	***
as.factor(YEAR)1997:as.factor(SEASON)3	1.1	0.1	18.2	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)3	-0.3	0.1	-5.7	0.0	***
as.factor(YEAR)1999:as.factor(SEASON)3	0.4	0.1	6.1	0.0	***
as.factor(YEAR)2000:as.factor(SEASON)3	0.5	0.1	7.9	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)3	0.2	0.1	4.1	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)3	0.2	0.1	3.2	0.0	**
as.factor(YEAR)2003:as.factor(SEASON)3	0.0	0.1	0.2	0.8	
as.factor(YEAR)2004:as.factor(SEASON)3	0.5	0.1	6.6	0.0	***
as.factor(YEAR)2005:as.factor(SEASON)3	-0.5	0.1	-6.7	0.0	***

	Estimate	Std. Error	z value	P(>|z|)	Sig.
as.factor(YEAR)2006:as.factor(SEASON)3	0.6	0.1	7.0	0.0	***
as.factor(YEAR)2007:as.factor(SEASON)3	0.2	0.1	1.8	0.1	.
as.factor(YEAR)2008:as.factor(SEASON)3	0.6	0.1	6.9	0.0	***
as.factor(YEAR)2009:as.factor(SEASON)3	0.8	0.1	9.3	0.0	***
as.factor(YEAR)2010:as.factor(SEASON)3	-0.5	0.1	-5.8	0.0	***
as.factor(YEAR)1995:as.factor(pref)23	0.3	0.1	5.3	0.0	***
as.factor(YEAR)1996:as.factor(pref)23	0.2	0.1	2.5	0.0	*
as.factor(YEAR)1997:as.factor(pref)23	0.4	0.1	4.5	0.0	***
as.factor(YEAR)1998:as.factor(pref)23	0.1	0.1	0.8	0.4	
as.factor(YEAR)1999:as.factor(pref)23	-0.1	0.1	-1.7	0.1	.
as.factor(YEAR)2000:as.factor(pref)23	-0.1	0.1	-1.3	0.2	
as.factor(YEAR)2001:as.factor(pref)23	0.0	0.1	0.4	0.7	
as.factor(YEAR)2002:as.factor(pref)23	0.1	0.1	1.7	0.1	.
as.factor(YEAR)2003:as.factor(pref)23	0.2	0.1	2.6	0.0	**
as.factor(YEAR)2004:as.factor(pref)23	-0.3	0.1	-3.9	0.0	***
as.factor(YEAR)2005:as.factor(pref)23	-0.1	0.1	-0.9	0.4	
as.factor(YEAR)2006:as.factor(pref)23	0.1	0.1	1.0	0.3	
as.factor(YEAR)2007:as.factor(pref)23	-0.1	0.1	-0.7	0.5	
as.factor(YEAR)2008:as.factor(pref)23	-0.2	0.1	-2.2	0.0	*
as.factor(YEAR)2009:as.factor(pref)23	-0.2	0.1	-2.1	0.0	*
as.factor(YEAR)2010:as.factor(pref)23	0.0	0.1	-0.2	0.8	
as.factor(YEAR)1995:as.factor(pref)24	0.4	0.1	5.4	0.0	***
as.factor(YEAR)1996:as.factor(pref)24	0.3	0.1	3.7	0.0	***
as.factor(YEAR)1997:as.factor(pref)24	0.2	0.1	2.3	0.0	*
as.factor(YEAR)1998:as.factor(pref)24	0.1	0.1	0.9	0.4	
as.factor(YEAR)1999:as.factor(pref)24	-0.1	0.1	-0.9	0.3	
as.factor(YEAR)2000:as.factor(pref)24	0.0	0.1	-0.3	0.7	
as.factor(YEAR)2001:as.factor(pref)24	-0.1	0.1	-1.0	0.3	
as.factor(YEAR)2002:as.factor(pref)24	0.2	0.1	2.6	0.0	**
as.factor(YEAR)2003:as.factor(pref)24	0.4	0.1	4.4	0.0	***
as.factor(YEAR)2004:as.factor(pref)24	0.1	0.1	1.5	0.1	
as.factor(YEAR)2005:as.factor(pref)24	0.4	0.1	4.0	0.0	***
as.factor(YEAR)2006:as.factor(pref)24	-0.2	0.1	-2.1	0.0	*
as.factor(YEAR)2007:as.factor(pref)24	0.1	0.1	0.6	0.5	
as.factor(YEAR)2008:as.factor(pref)24	-0.4	0.1	-3.9	0.0	***
as.factor(YEAR)2009:as.factor(pref)24	-0.2	0.1	-2.5	0.0	*
as.factor(YEAR)2010:as.factor(pref)24	0.0	0.1	-0.3	0.8	
poly(lat,2)1:poly(lon,2)1	-83060	13760	-6.0	0.0	***
poly(lat,2)2:poly(lon,2)1	-75260	14340	-5.2	0.0	***
poly(lat,2)1:poly(lon,2)2	-92890	12820	-7.2	0.0	***
poly(lat,2)2:poly(lon,2)2	23290	11540	2.0	0.0	*
poly(lat,2)1:poly(hpb,2)1	20870	4896	4.3	0.0	***
poly(lat,2)2:poly(hpb,2)1	64600	5109	12.6	0.0	***
poly(lat,2)1:poly(hpb,2)2	34430	4241	8.1	0.0	***
poly(lat,2)2:poly(hpb,2)2	8471	4765	1.8	0.1	.
poly(lat,2)1:as.factor(SEASON)1	479.5	18.0	26.7	0.0	***
poly(lat,2)2:as.factor(SEASON)1	241.1	25.3	9.5	0.0	***
poly(lat,2)1:as.factor(SEASON)2	861.9	16.5	52.2	0.0	***
poly(lat,2)2:as.factor(SEASON)2	-20.6	20.7	-1.0	0.3	
poly(lat,2)1:as.factor(SEASON)3	553.7	16.4	33.8	0.0	***
poly(lat,2)2:as.factor(SEASON)3	-7.2	19.1	-0.4	0.7	
poly(lat,2)1:as.factor(pref)23	-16.1	16.4	-1.0	0.3	
poly(lat,2)2:as.factor(pref)23	48.2	20.0	2.4	0.0	*
poly(lat,2)1:as.factor(pref)24	-11.8	21.7	-0.5	0.6	
poly(lat,2)2:as.factor(pref)24	71.0	25.3	2.8	0.0	**
poly(lon,2)1:poly(hpb,2)1	40550	4290	9.5	0.0	***
poly(lon,2)2:poly(hpb,2)1	-38630	3906	-9.9	0.0	***

	Estimate	Std. Error	z value	P(>|z|)	Sig.
poly(lon,2)1:poly(hpb,2)2	-2075	3508	-0.6	0.6	
poly(lon,2)2:poly(hpb,2)2	19950	3185	6.3	0.0	***
poly(lon,2)1:as.factor(SEASON)1	172.7	12.8	13.5	0.0	***
poly(lon,2)2:as.factor(SEASON)1	95.5	11.2	8.6	0.0	***
poly(lon,2)1:as.factor(SEASON)2	81.4	13.1	6.2	0.0	***
poly(lon,2)2:as.factor(SEASON)2	221.5	12.1	18.3	0.0	***
poly(lon,2)1:as.factor(SEASON)3	155.3	12.7	12.2	0.0	***
poly(lon,2)2:as.factor(SEASON)3	166.6	12.6	13.3	0.0	***
poly(lon,2)1:as.factor(pref)23	-60.7	12.8	-4.8	0.0	***
poly(lon,2)2:as.factor(pref)23	-30.3	13.5	-2.3	0.0	*
poly(lon,2)1:as.factor(pref)24	162.9	16.3	10.0	0.0	***
poly(lon,2)2:as.factor(pref)24	-174.7	17.1	-10.2	0.0	***
poly(hpb,2)1:as.factor(SEASON)1	54.2	14.1	3.9	0.0	***
poly(hpb,2)2:as.factor(SEASON)1	-65.3	10.1	-6.5	0.0	***
poly(hpb,2)1:as.factor(SEASON)2	85.7	17.5	4.9	0.0	***
poly(hpb,2)2:as.factor(SEASON)2	-63.3	13.0	-4.9	0.0	***
poly(hpb,2)1:as.factor(SEASON)3	-6.3	19.1	-0.3	0.7	
poly(hpb,2)2:as.factor(SEASON)3	4.0	13.9	0.3	0.8	
poly(hpb,2)1:as.factor(pref)23	-7.6	17.0	-0.4	0.7	
poly(hpb,2)2:as.factor(pref)23	48.1	13.4	3.6	0.0	***
poly(hpb,2)1:as.factor(pref)24	-27.6	22.0	-1.3	0.2	
poly(hpb,2)2:as.factor(pref)24	135.2	16.8	8.1	0.0	***
as.factor(SEASON)1:as.factor(pref)23	0.0	0.0	0.2	0.9	
as.factor(SEASON)2:as.factor(pref)23	0.0	0.0	-0.1	0.9	
as.factor(SEASON)3:as.factor(pref)23	0.0	0.0	-0.5	0.6	
as.factor(SEASON)1:as.factor(pref)24	0.0	0.0	-0.7	0.5	
as.factor(SEASON)2:as.factor(pref)24	-0.1	0.0	-1.6	0.1	
as.factor(SEASON)3:as.factor(pref)24	-0.1	0.0	-1.4	0.2	
as.factor(YEAR)1995:poly(lat,2)1:poly(lon,2)1	41220	10170	4.1	0.0	***
as.factor(YEAR)1996:poly(lat,2)1:poly(lon,2)1	-44330	12650	-3.5	0.0	***
as.factor(YEAR)1997:poly(lat,2)1:poly(lon,2)1	-45830	12850	-3.6	0.0	***
as.factor(YEAR)1998:poly(lat,2)1:poly(lon,2)1	3595	12080	0.3	0.8	
as.factor(YEAR)1999:poly(lat,2)1:poly(lon,2)1	20770	15390	1.4	0.2	
as.factor(YEAR)2000:poly(lat,2)1:poly(lon,2)1	45050	17840	2.5	0.0	*
as.factor(YEAR)2001:poly(lat,2)1:poly(lon,2)1	73730	16630	4.4	0.0	***
as.factor(YEAR)2002:poly(lat,2)1:poly(lon,2)1	84030	20750	4.0	0.0	***
as.factor(YEAR)2003:poly(lat,2)1:poly(lon,2)1	-47980	18500	-2.6	0.0	**
as.factor(YEAR)2004:poly(lat,2)1:poly(lon,2)1	5959	21370	0.3	0.8	
as.factor(YEAR)2005:poly(lat,2)1:poly(lon,2)1	-82090	19630	-4.2	0.0	***
as.factor(YEAR)2006:poly(lat,2)1:poly(lon,2)1	-127900	22150	-5.8	0.0	***
as.factor(YEAR)2007:poly(lat,2)1:poly(lon,2)1	-262800	30850	-8.5	0.0	***
as.factor(YEAR)2008:poly(lat,2)1:poly(lon,2)1	-271200	30870	-8.8	0.0	***
as.factor(YEAR)2009:poly(lat,2)1:poly(lon,2)1	-249500	38590	-6.5	0.0	***
as.factor(YEAR)2010:poly(lat,2)1:poly(lon,2)1	35950	38030	0.9	0.3	
as.factor(YEAR)1995:poly(lat,2)2:poly(lon,2)1	53410	10430	5.1	0.0	***
as.factor(YEAR)1996:poly(lat,2)2:poly(lon,2)1	-39100	13430	-2.9	0.0	**
as.factor(YEAR)1997:poly(lat,2)2:poly(lon,2)1	-139400	13360	-10.4	0.0	***
as.factor(YEAR)1998:poly(lat,2)2:poly(lon,2)1	-139.2	12650	0.0	1.0	
as.factor(YEAR)1999:poly(lat,2)2:poly(lon,2)1	-11950	17850	-0.7	0.5	
as.factor(YEAR)2000:poly(lat,2)2:poly(lon,2)1	131400	17000	7.7	0.0	***
as.factor(YEAR)2001:poly(lat,2)2:poly(lon,2)1	106700	17140	6.2	0.0	***
as.factor(YEAR)2002:poly(lat,2)2:poly(lon,2)1	164900	20180	8.2	0.0	***
as.factor(YEAR)2003:poly(lat,2)2:poly(lon,2)1	17110	18950	0.9	0.4	
as.factor(YEAR)2004:poly(lat,2)2:poly(lon,2)1	-76500	30480	-2.5	0.0	*
as.factor(YEAR)2005:poly(lat,2)2:poly(lon,2)1	157600	20000	7.9	0.0	***
as.factor(YEAR)2006:poly(lat,2)2:poly(lon,2)1	200600	22430	8.9	0.0	***
as.factor(YEAR)2007:poly(lat,2)2:poly(lon,2)1	-163500	33840	-4.8	0.0	***

	Estimate	Std. Error	z value	P(>|z|)	Sig.
as.factor(YEAR)2008:poly(lat,2)2:poly(lon,2)1	-3522	30240	-0.1	0.9	
as.factor(YEAR)2009:poly(lat,2)2:poly(lon,2)1	-124100	41440	-3.0	0.0	**
as.factor(YEAR)2010:poly(lat,2)2:poly(lon,2)1	199500	29930	6.7	0.0	***
as.factor(YEAR)1995:poly(lat,2)1:poly(lon,2)2	56070	9399	6.0	0.0	***
as.factor(YEAR)1996:poly(lat,2)1:poly(lon,2)2	3883	11760	0.3	0.7	
as.factor(YEAR)1997:poly(lat,2)1:poly(lon,2)2	-26440	11790	-2.2	0.0	*
as.factor(YEAR)1998:poly(lat,2)1:poly(lon,2)2	53000	10750	4.9	0.0	***
as.factor(YEAR)1999:poly(lat,2)1:poly(lon,2)2	49260	14230	3.5	0.0	***
as.factor(YEAR)2000:poly(lat,2)1:poly(lon,2)2	93510	15730	5.9	0.0	***
as.factor(YEAR)2001:poly(lat,2)1:poly(lon,2)2	116700	14520	8.0	0.0	***
as.factor(YEAR)2002:poly(lat,2)1:poly(lon,2)2	168800	20290	8.3	0.0	***
as.factor(YEAR)2003:poly(lat,2)1:poly(lon,2)2	-9035	16870	-0.5	0.6	
as.factor(YEAR)2004:poly(lat,2)1:poly(lon,2)2	73100	29980	2.4	0.0	*
as.factor(YEAR)2005:poly(lat,2)1:poly(lon,2)2	85520	20520	4.2	0.0	***
as.factor(YEAR)2006:poly(lat,2)1:poly(lon,2)2	49090	21180	2.3	0.0	*
as.factor(YEAR)2007:poly(lat,2)1:poly(lon,2)2	-32150	26800	-1.2	0.2	
as.factor(YEAR)2008:poly(lat,2)1:poly(lon,2)2	-71340	28620	-2.5	0.0	*
as.factor(YEAR)2009:poly(lat,2)1:poly(lon,2)2	-30060	36710	-0.8	0.4	
as.factor(YEAR)2010:poly(lat,2)1:poly(lon,2)2	175800	35820	4.9	0.0	***
as.factor(YEAR)1995:poly(lat,2)2:poly(lon,2)2	29290	8129	3.6	0.0	***
as.factor(YEAR)1996:poly(lat,2)2:poly(lon,2)2	-51600	11060	-4.7	0.0	***
as.factor(YEAR)1997:poly(lat,2)2:poly(lon,2)2	4951	11120	0.4	0.7	
as.factor(YEAR)1998:poly(lat,2)2:poly(lon,2)2	-13100	9865	-1.3	0.2	
as.factor(YEAR)1999:poly(lat,2)2:poly(lon,2)2	-69150	15120	-4.6	0.0	***
as.factor(YEAR)2000:poly(lat,2)2:poly(lon,2)2	-12270	13800	-0.9	0.4	
as.factor(YEAR)2001:poly(lat,2)2:poly(lon,2)2	16190	12570	1.3	0.2	
as.factor(YEAR)2002:poly(lat,2)2:poly(lon,2)2	39240	15650	2.5	0.0	*
as.factor(YEAR)2003:poly(lat,2)2:poly(lon,2)2	41600	14710	2.8	0.0	**
as.factor(YEAR)2004:poly(lat,2)2:poly(lon,2)2	-143300	31210	-4.6	0.0	***
as.factor(YEAR)2005:poly(lat,2)2:poly(lon,2)2	-49740	17540	-2.8	0.0	**
as.factor(YEAR)2006:poly(lat,2)2:poly(lon,2)2	-4083	18040	-0.2	0.8	
as.factor(YEAR)2007:poly(lat,2)2:poly(lon,2)2	-138100	25950	-5.3	0.0	***
as.factor(YEAR)2008:poly(lat,2)2:poly(lon,2)2	-56260	21460	-2.6	0.0	**
as.factor(YEAR)2009:poly(lat,2)2:poly(lon,2)2	-78000	32800	-2.4	0.0	*
as.factor(YEAR)2010:poly(lat,2)2:poly(lon,2)2	28210	22670	1.2	0.2	
poly(lat,2)1:poly(lon,2)1:poly(hpb,2)1	10750000	2112000	5.1	0.0	***
poly(lat,2)2:poly(lon,2)1:poly(hpb,2)1	-13970000	2069000	-6.8	0.0	***
poly(lat,2)1:poly(lon,2)2:poly(hpb,2)1	-598100	2124000	-0.3	0.8	
poly(lat,2)2:poly(lon,2)2:poly(hpb,2)1	4984000	1782000	2.8	0.0	**
poly(lat,2)1:poly(lon,2)1:poly(hpb,2)2	13000000	1979000	6.6	0.0	***
poly(lat,2)2:poly(lon,2)1:poly(hpb,2)2	-167400	1849000	-0.1	0.9	
poly(lat,2)1:poly(lon,2)2:poly(hpb,2)2	-114600	1817000	-0.1	0.9	
poly(lat,2)2:poly(lon,2)2:poly(hpb,2)2	7030000	1486000	4.7	0.0	***
poly(lat,2)1:poly(lon,2)1:as.factor(SEASON)1	867.8	10340	0.1	0.9	
poly(lat,2)2:poly(lon,2)1:as.factor(SEASON)1	29640	10870	2.7	0.0	**
poly(lat,2)1:poly(lon,2)2:as.factor(SEASON)1	-4748	8528	-0.6	0.6	
poly(lat,2)2:poly(lon,2)2:as.factor(SEASON)1	20370	7591	2.7	0.0	**
poly(lat,2)1:poly(lon,2)1:as.factor(SEASON)2	89990	10680	8.4	0.0	***
poly(lat,2)2:poly(lon,2)1:as.factor(SEASON)2	2140	11050	0.2	0.8	
poly(lat,2)1:poly(lon,2)2:as.factor(SEASON)2	8129	9366	0.9	0.4	
poly(lat,2)2:poly(lon,2)2:as.factor(SEASON)2	54250	8921	6.1	0.0	***
poly(lat,2)1:poly(lon,2)1:as.factor(SEASON)3	141500	9612	14.7	0.0	***
poly(lat,2)2:poly(lon,2)1:as.factor(SEASON)3	49990	9848	5.1	0.0	***
poly(lat,2)1:poly(lon,2)2:as.factor(SEASON)3	-9617	9335	-1.0	0.3	
poly(lat,2)2:poly(lon,2)2:as.factor(SEASON)3	68030	8963	7.6	0.0	***
poly(lat,2)1:poly(lon,2)1:as.factor(pref)23	-2803	9866	-0.3	0.8	
poly(lat,2)2:poly(lon,2)1:as.factor(pref)23	-22350	10240	-2.2	0.0	*

	Estimate	Std. Error	z value	P(>|z|)	Sig.
poly(lat,2)1:poly(lon,2)2:as.factor(pref)23	41060	9183	4.5	0.0	***
poly(lat,2)2:poly(lon,2)2:as.factor(pref)23	-66310	8607	-7.7	0.0	***
poly(lat,2)1:poly(lon,2)1:as.factor(pref)24	-9203	12700	-0.7	0.5	
poly(lat,2)2:poly(lon,2)1:as.factor(pref)24	-76380	12870	-5.9	0.0	***
poly(lat,2)1:poly(lon,2)2:as.factor(pref)24	-9894	12810	-0.8	0.4	
poly(lat,2)2:poly(lon,2)2:as.factor(pref)24	-83780	11480	-7.3	0.0	***

Significance levels: 0='***'; <0.001='**'; <0.01='*'; <0.05='.'; <0.1=''

Dispersion parameter for binomial family taken to be 1.

Null deviance: 463033 on 334546 degrees of freedom

Residual deviance: 384194 on 334203 degrees of freedom 1.150

AIC: 384882

Number of Fisher Scoring iterations: 7

Table A-7. Estimated coefficients for the Binomial component of the Δ-GLM model for the period 1994 to 2010.

	Estimate	Std. Error	z value	P(>|z|)	Sig.
(Intercept)	0.4	0.1	6.3	0.0	***
as.factor(YEAR)1995	-0.2	0.1	-3.4	0.0	***
as.factor(YEAR)1996	-1.0	0.1	-12.9	0.0	***
as.factor(YEAR)1997	-1.3	0.1	-14.2	0.0	***
as.factor(YEAR)1998	-0.3	0.1	-3.5	0.0	***
as.factor(YEAR)1999	-0.5	0.1	-5.0	0.0	***
as.factor(YEAR)2000	-0.9	0.1	-10.0	0.0	***
as.factor(YEAR)2001	-0.8	0.1	-9.6	0.0	***
as.factor(YEAR)2002	-0.8	0.1	-8.6	0.0	***
as.factor(YEAR)2003	-0.9	0.1	-9.7	0.0	***
as.factor(YEAR)2004	-0.5	0.1	-4.6	0.0	***
as.factor(YEAR)2005	-0.1	0.1	-1.4	0.2	
as.factor(YEAR)2006	-1.4	0.1	-12.7	0.0	***
as.factor(YEAR)2007	-1.4	0.1	-10.7	0.0	***
as.factor(YEAR)2008	-1.6	0.1	-12.4	0.0	***
as.factor(YEAR)2009	-1.7	0.1	-12.7	0.0	***
as.factor(YEAR)2010	-0.5	0.1	-4.5	0.0	***
poly(lat, 2)1	-521.2	23.3	-22.4	0.0	***
poly(lat, 2)2	-341.6	28.8	-11.9	0.0	***
poly(lon, 2)1	-352.4	17.7	-19.9	0.0	***
poly(lon, 2)2	-379.5	18.0	-21.1	0.0	***
poly(hpb, 2)1	157.5	21.6	7.3	0.0	***
poly(hpb, 2)2	-23.9	18.6	-1.3	0.2	
as.factor(SEASON)1	0.0	0.1	-0.3	0.8	
as.factor(SEASON)2	-0.2	0.1	-4.2	0.0	***
as.factor(SEASON)3	-0.1	0.1	-1.8	0.1	.
as.factor(pref)23	0.1	0.1	1.7	0.1	.
as.factor(pref)24	-0.1	0.1	-1.5	0.1	
as.factor(YEAR)1995:poly(lat, 2)1	52.5	17.1	3.1	0.0	**
as.factor(YEAR)1996:poly(lat, 2)1	-23.2	21.3	-1.1	0.3	
as.factor(YEAR)1997:poly(lat, 2)1	-55.8	20.9	-2.7	0.0	**
as.factor(YEAR)1998:poly(lat, 2)1	-116.6	19.2	-6.1	0.0	***
as.factor(YEAR)1999:poly(lat, 2)1	-48.7	22.9	-2.1	0.0	*
as.factor(YEAR)2000:poly(lat, 2)1	-29.4	26.9	-1.1	0.3	
as.factor(YEAR)2001:poly(lat, 2)1	24.3	23.7	1.0	0.3	
as.factor(YEAR)2002:poly(lat, 2)1	114.1	30.4	3.8	0.0	***
as.factor(YEAR)2003:poly(lat, 2)1	-113.6	26.6	-4.3	0.0	***
as.factor(YEAR)2004:poly(lat, 2)1	-42.7	45.2	-0.9	0.3	
as.factor(YEAR)2005:poly(lat, 2)1	-200.2	34.2	-5.8	0.0	***
as.factor(YEAR)2006:poly(lat, 2)1	-85.8	36.7	-2.3	0.0	*
as.factor(YEAR)2007:poly(lat, 2)1	-505.0	55.5	-9.1	0.0	***
as.factor(YEAR)2008:poly(lat, 2)1	-340.0	54.3	-6.3	0.0	***
as.factor(YEAR)2009:poly(lat, 2)1	-507.1	61.1	-8.3	0.0	***
as.factor(YEAR)2010:poly(lat, 2)1	128.6	49.1	2.6	0.0	**

as.factor(YEAR)1995:poly(lat, 2)2	179.8	22.7	7.9	0.0	***
as.factor(YEAR)1996:poly(lat, 2)2	78.9	27.0	2.9	0.0	**
as.factor(YEAR)1997:poly(lat, 2)2	-245.7	27.3	-9.0	0.0	***
as.factor(YEAR)1998:poly(lat, 2)2	35.8	25.6	1.4	0.2	
as.factor(YEAR)1999:poly(lat, 2)2	-210.2	28.8	-7.3	0.0	***
as.factor(YEAR)2000:poly(lat, 2)2	-0.8	30.0	0.0	1.0	
as.factor(YEAR)2001:poly(lat, 2)2	90.4	30.8	2.9	0.0	**
as.factor(YEAR)2002:poly(lat, 2)2	-19.8	35.0	-0.6	0.6	
as.factor(YEAR)2003:poly(lat, 2)2	-336.8	32.8	-10.3	0.0	***
as.factor(YEAR)2004:poly(lat, 2)2	-257.2	59.7	-4.3	0.0	***
as.factor(YEAR)2005:poly(lat, 2)2	-112.5	37.3	-3.0	0.0	**
as.factor(YEAR)2006:poly(lat, 2)2	-209.6	39.1	-5.4	0.0	***
as.factor(YEAR)2007:poly(lat, 2)2	-448.5	60.8	-7.4	0.0	***
as.factor(YEAR)2008:poly(lat, 2)2	-260.5	62.5	-4.2	0.0	***
as.factor(YEAR)2009:poly(lat, 2)2	-326.9	74.2	-4.4	0.0	***
as.factor(YEAR)2010:poly(lat, 2)2	-130.9	56.8	-2.3	0.0	*
as.factor(YEAR)1995:poly(lon, 2)1	54.0	14.0	3.9	0.0	***
as.factor(YEAR)1996:poly(lon, 2)1	-53.7	17.1	-3.1	0.0	**
as.factor(YEAR)1997:poly(lon, 2)1	84.5	17.7	4.8	0.0	***
as.factor(YEAR)1998:poly(lon, 2)1	35.2	16.7	2.1	0.0	*
as.factor(YEAR)1999:poly(lon, 2)1	-99.3	22.2	-4.5	0.0	***
as.factor(YEAR)2000:poly(lon, 2)1	-134.3	22.6	-6.0	0.0	***
as.factor(YEAR)2001:poly(lon, 2)1	-86.8	20.4	-4.2	0.0	***
as.factor(YEAR)2002:poly(lon, 2)1	-87.5	23.9	-3.7	0.0	***
as.factor(YEAR)2003:poly(lon, 2)1	-267.4	22.1	-12.1	0.0	***
as.factor(YEAR)2004:poly(lon, 2)1	-327.6	29.5	-11.1	0.0	***
as.factor(YEAR)2005:poly(lon, 2)1	-412.4	27.5	-15.0	0.0	***
as.factor(YEAR)2006:poly(lon, 2)1	-346.2	28.7	-12.0	0.0	***
as.factor(YEAR)2007:poly(lon, 2)1	-640.2	40.6	-15.8	0.0	***
as.factor(YEAR)2008:poly(lon, 2)1	-586.8	40.3	-14.6	0.0	***
as.factor(YEAR)2009:poly(lon, 2)1	-483.5	50.4	-9.6	0.0	***
as.factor(YEAR)2010:poly(lon, 2)1	-68.1	48.5	-1.4	0.2	
as.factor(YEAR)1995:poly(lon, 2)2	-118.2	12.8	-9.2	0.0	***
as.factor(YEAR)1996:poly(lon, 2)2	-60.2	16.7	-3.6	0.0	***
as.factor(YEAR)1997:poly(lon, 2)2	-53.2	17.7	-3.0	0.0	**
as.factor(YEAR)1998:poly(lon, 2)2	68.9	14.8	4.6	0.0	***
as.factor(YEAR)1999:poly(lon, 2)2	178.9	22.4	8.0	0.0	***
as.factor(YEAR)2000:poly(lon, 2)2	138.9	22.4	6.2	0.0	***
as.factor(YEAR)2001:poly(lon, 2)2	103.8	18.9	5.5	0.0	***
as.factor(YEAR)2002:poly(lon, 2)2	240.9	22.9	10.5	0.0	***
as.factor(YEAR)2003:poly(lon, 2)2	39.3	21.3	1.8	0.1	.
as.factor(YEAR)2004:poly(lon, 2)2	280.4	36.8	7.6	0.0	***
as.factor(YEAR)2005:poly(lon, 2)2	78.9	34.0	2.3	0.0	*
as.factor(YEAR)2006:poly(lon, 2)2	72.1	32.3	2.2	0.0	*
as.factor(YEAR)2007:poly(lon, 2)2	-6.0	37.7	-0.2	0.9	
as.factor(YEAR)2008:poly(lon, 2)2	-51.7	40.1	-1.3	0.2	
as.factor(YEAR)2009:poly(lon, 2)2	-98.0	47.5	-2.1	0.0	*
as.factor(YEAR)2010:poly(lon, 2)2	172.2	46.6	3.7	0.0	***
as.factor(YEAR)1995:poly(hpb, 2)1	-32.2	17.1	-1.9	0.1	.
as.factor(YEAR)1996:poly(hpb, 2)1	-32.1	20.2	-1.6	0.1	

as.factor(YEAR)1997:poly(hpb, 2)1	-68.9	20.5	-3.4	0.0	***
as.factor(YEAR)1998:poly(hpb, 2)1	-26.6	21.0	-1.3	0.2	
as.factor(YEAR)1999:poly(hpb, 2)1	-226.7	25.6	-8.8	0.0	***
as.factor(YEAR)2000:poly(hpb, 2)1	-71.0	30.0	-2.4	0.0	*
as.factor(YEAR)2001:poly(hpb, 2)1	-6.3	32.2	-0.2	0.8	
as.factor(YEAR)2002:poly(hpb, 2)1	16.8	39.8	0.4	0.7	
as.factor(YEAR)2003:poly(hpb, 2)1	-35.5	39.2	-0.9	0.4	
as.factor(YEAR)2004:poly(hpb, 2)1	40.7	51.1	0.8	0.4	
as.factor(YEAR)2005:poly(hpb, 2)1	-175.0	53.4	-3.3	0.0	**
as.factor(YEAR)2006:poly(hpb, 2)1	-6.2	51.7	-0.1	0.9	
as.factor(YEAR)2007:poly(hpb, 2)1	89.0	49.8	1.8	0.1	.
as.factor(YEAR)2008:poly(hpb, 2)1	44.4	49.3	0.9	0.4	
as.factor(YEAR)2009:poly(hpb, 2)1	120.8	46.9	2.6	0.0	**
as.factor(YEAR)2010:poly(hpb, 2)1	-56.5	52.6	-1.1	0.3	
as.factor(YEAR)1995:poly(hpb, 2)2	-61.5	13.8	-4.5	0.0	***
as.factor(YEAR)1996:poly(hpb, 2)2	-120.7	15.9	-7.6	0.0	***
as.factor(YEAR)1997:poly(hpb, 2)2	-104.3	16.0	-6.5	0.0	***
as.factor(YEAR)1998:poly(hpb, 2)2	-3.0	16.2	-0.2	0.9	
as.factor(YEAR)1999:poly(hpb, 2)2	58.5	19.0	3.1	0.0	**
as.factor(YEAR)2000:poly(hpb, 2)2	-68.1	22.3	-3.1	0.0	**
as.factor(YEAR)2001:poly(hpb, 2)2	-33.6	21.4	-1.6	0.1	
as.factor(YEAR)2002:poly(hpb, 2)2	-77.8	25.6	-3.0	0.0	**
as.factor(YEAR)2003:poly(hpb, 2)2	-21.9	24.9	-0.9	0.4	
as.factor(YEAR)2004:poly(hpb, 2)2	-89.6	35.3	-2.5	0.0	*
as.factor(YEAR)2005:poly(hpb, 2)2	-168.0	36.2	-4.6	0.0	***
as.factor(YEAR)2006:poly(hpb, 2)2	2.9	30.9	0.1	0.9	
as.factor(YEAR)2007:poly(hpb, 2)2	-165.4	30.4	-5.4	0.0	***
as.factor(YEAR)2008:poly(hpb, 2)2	-51.1	29.9	-1.7	0.1	.
as.factor(YEAR)2009:poly(hpb, 2)2	-69.6	28.2	-2.5	0.0	*
as.factor(YEAR)2010:poly(hpb, 2)2	-93.0	30.9	-3.0	0.0	**
as.factor(YEAR)1995:as.factor(SEASON)1	0.2	0.0	4.9	0.0	***
as.factor(YEAR)1996:as.factor(SEASON)1	0.2	0.1	2.9	0.0	**
as.factor(YEAR)1997:as.factor(SEASON)1	0.5	0.1	9.0	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)1	-0.1	0.1	-1.0	0.3	
as.factor(YEAR)1999:as.factor(SEASON)1	-0.3	0.1	-5.5	0.0	***
as.factor(YEAR)2000:as.factor(SEASON)1	-0.4	0.1	-6.5	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)1	0.3	0.1	4.5	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)1	-0.1	0.1	-1.6	0.1	
as.factor(YEAR)2003:as.factor(SEASON)1	-0.3	0.1	-4.3	0.0	***
as.factor(YEAR)2004:as.factor(SEASON)1	-0.4	0.1	-6.5	0.0	***
as.factor(YEAR)2005:as.factor(SEASON)1	-0.4	0.1	-5.6	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)1	0.2	0.1	2.3	0.0	*
as.factor(YEAR)2007:as.factor(SEASON)1	-0.4	0.1	-5.5	0.0	***
as.factor(YEAR)2008:as.factor(SEASON)1	-0.1	0.1	-1.6	0.1	
as.factor(YEAR)2009:as.factor(SEASON)1	0.2	0.1	2.1	0.0	*
as.factor(YEAR)2010:as.factor(SEASON)1	0.1	0.1	1.7	0.1	.
as.factor(YEAR)1995:as.factor(SEASON)2	0.3	0.1	5.7	0.0	***
as.factor(YEAR)1996:as.factor(SEASON)2	0.5	0.1	8.6	0.0	***
as.factor(YEAR)1997:as.factor(SEASON)2	0.9	0.1	16.0	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)2	0.1	0.1	1.7	0.1	.

as.factor(YEAR)1999:as.factor(SEASON)2	0.4	0.1	6.1	0.0	***
as.factor(YEAR)2000:as.factor(SEASON)2	0.6	0.1	9.7	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)2	0.4	0.1	6.9	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)2	-0.2	0.1	-3.9	0.0	***
as.factor(YEAR)2003:as.factor(SEASON)2	-0.3	0.1	-5.0	0.0	***
as.factor(YEAR)2004:as.factor(SEASON)2	-0.3	0.1	-4.7	0.0	***
as.factor(YEAR)2005:as.factor(SEASON)2	-0.4	0.1	-5.2	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)2	0.3	0.1	3.9	0.0	***
as.factor(YEAR)2007:as.factor(SEASON)2	-0.3	0.1	-3.6	0.0	***
as.factor(YEAR)2008:as.factor(SEASON)2	0.5	0.1	6.2	0.0	***
as.factor(YEAR)2009:as.factor(SEASON)2	0.6	0.1	7.0	0.0	***
as.factor(YEAR)2010:as.factor(SEASON)2	-0.3	0.1	-4.2	0.0	***
as.factor(YEAR)1995:as.factor(SEASON)3	0.0	0.1	-0.6	0.6	
as.factor(YEAR)1996:as.factor(SEASON)3	0.3	0.1	5.1	0.0	***
as.factor(YEAR)1997:as.factor(SEASON)3	1.1	0.1	18.2	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)3	-0.3	0.1	-5.7	0.0	***
as.factor(YEAR)1999:as.factor(SEASON)3	0.4	0.1	6.1	0.0	***
as.factor(YEAR)2000:as.factor(SEASON)3	0.5	0.1	7.9	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)3	0.2	0.1	4.1	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)3	0.2	0.1	3.2	0.0	**
as.factor(YEAR)2003:as.factor(SEASON)3	0.0	0.1	0.2	0.8	
as.factor(YEAR)2004:as.factor(SEASON)3	0.5	0.1	6.6	0.0	***
as.factor(YEAR)2005:as.factor(SEASON)3	-0.5	0.1	-6.7	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)3	0.6	0.1	7.0	0.0	***
as.factor(YEAR)2007:as.factor(SEASON)3	0.2	0.1	1.8	0.1	.
as.factor(YEAR)2008:as.factor(SEASON)3	0.6	0.1	6.9	0.0	***
as.factor(YEAR)2009:as.factor(SEASON)3	0.8	0.1	9.3	0.0	***
as.factor(YEAR)2010:as.factor(SEASON)3	-0.5	0.1	-5.8	0.0	***
as.factor(YEAR)1995:as.factor(pref)23	0.3	0.1	5.3	0.0	***
as.factor(YEAR)1996:as.factor(pref)23	0.2	0.1	2.5	0.0	*
as.factor(YEAR)1997:as.factor(pref)23	0.4	0.1	4.5	0.0	***
as.factor(YEAR)1998:as.factor(pref)23	0.1	0.1	0.8	0.4	
as.factor(YEAR)1999:as.factor(pref)23	-0.1	0.1	-1.7	0.1	.
as.factor(YEAR)2000:as.factor(pref)23	-0.1	0.1	-1.3	0.2	
as.factor(YEAR)2001:as.factor(pref)23	0.0	0.1	0.4	0.7	
as.factor(YEAR)2002:as.factor(pref)23	0.1	0.1	1.7	0.1	.
as.factor(YEAR)2003:as.factor(pref)23	0.2	0.1	2.6	0.0	**
as.factor(YEAR)2004:as.factor(pref)23	-0.3	0.1	-3.9	0.0	***
as.factor(YEAR)2005:as.factor(pref)23	-0.1	0.1	-0.9	0.4	
as.factor(YEAR)2006:as.factor(pref)23	0.1	0.1	1.0	0.3	
as.factor(YEAR)2007:as.factor(pref)23	-0.1	0.1	-0.7	0.5	
as.factor(YEAR)2008:as.factor(pref)23	-0.2	0.1	-2.2	0.0	*
as.factor(YEAR)2009:as.factor(pref)23	-0.2	0.1	-2.1	0.0	*
as.factor(YEAR)2010:as.factor(pref)23	0.0	0.1	-0.2	0.8	
as.factor(YEAR)1995:as.factor(pref)24	0.4	0.1	5.4	0.0	***
as.factor(YEAR)1996:as.factor(pref)24	0.3	0.1	3.7	0.0	***
as.factor(YEAR)1997:as.factor(pref)24	0.2	0.1	2.3	0.0	*
as.factor(YEAR)1998:as.factor(pref)24	0.1	0.1	0.9	0.4	
as.factor(YEAR)1999:as.factor(pref)24	-0.1	0.1	-0.9	0.3	
as.factor(YEAR)2000:as.factor(pref)24	0.0	0.1	-0.3	0.7	

as.factor(YEAR)2001:as.factor(pref)24	-0.1	0.1	-1.0	0.3	
as.factor(YEAR)2002:as.factor(pref)24	0.2	0.1	2.6	0.0	**
as.factor(YEAR)2003:as.factor(pref)24	0.4	0.1	4.4	0.0	***
as.factor(YEAR)2004:as.factor(pref)24	0.1	0.1	1.5	0.1	
as.factor(YEAR)2005:as.factor(pref)24	0.4	0.1	4.0	0.0	***
as.factor(YEAR)2006:as.factor(pref)24	-0.2	0.1	-2.1	0.0	*
as.factor(YEAR)2007:as.factor(pref)24	0.1	0.1	0.6	0.5	
as.factor(YEAR)2008:as.factor(pref)24	-0.4	0.1	-3.9	0.0	***
as.factor(YEAR)2009:as.factor(pref)24	-0.2	0.1	-2.5	0.0	*
as.factor(YEAR)2010:as.factor(pref)24	0.0	0.1	-0.3	0.8	
poly(lat, 2)1:poly(lon, 2)1	-83060	13760	-6.0	0.0	***
poly(lat, 2)2:poly(lon, 2)1	-75260	14340	-5.2	0.0	***
poly(lat, 2)1:poly(lon, 2)2	-92890	12820	-7.2	0.0	***
poly(lat, 2)2:poly(lon, 2)2	23290	11540	2.0	0.0	*
poly(lat, 2)1:poly(hpb, 2)1	20870	4896	4.3	0.0	***
poly(lat, 2)2:poly(hpb, 2)1	64600	5109	12.6	0.0	***
poly(lat, 2)1:poly(hpb, 2)2	34430	4241	8.1	0.0	***
poly(lat, 2)2:poly(hpb, 2)2	8471	4765	1.8	0.1	.
poly(lat, 2)1:as.factor(SEASON)1	479.5	18.0	26.7	0.0	***
poly(lat, 2)2:as.factor(SEASON)1	241.1	25.3	9.5	0.0	***
poly(lat, 2)1:as.factor(SEASON)2	861.9	16.5	52.2	0.0	***
poly(lat, 2)2:as.factor(SEASON)2	-20.6	20.7	-1.0	0.3	
poly(lat, 2)1:as.factor(SEASON)3	553.7	16.4	33.8	0.0	***
poly(lat, 2)2:as.factor(SEASON)3	-7.2	19.1	-0.4	0.7	
poly(lat, 2)1:as.factor(pref)23	-16.1	16.4	-1.0	0.3	
poly(lat, 2)2:as.factor(pref)23	48.2	20.0	2.4	0.0	*
poly(lat, 2)1:as.factor(pref)24	-11.8	21.7	-0.5	0.6	
poly(lat, 2)2:as.factor(pref)24	71.0	25.3	2.8	0.0	**
poly(lon, 2)1:poly(hpb, 2)1	40550	4290	9.5	0.0	***
poly(lon, 2)2:poly(hpb, 2)1	-38630	3906	-9.9	0.0	***
poly(lon, 2)1:poly(hpb, 2)2	-2075	3508	-0.6	0.6	
poly(lon, 2)2:poly(hpb, 2)2	19950	3185	6.3	0.0	***
poly(lon, 2)1:as.factor(SEASON)1	172.7	12.8	13.5	0.0	***
poly(lon, 2)2:as.factor(SEASON)1	95.5	11.2	8.6	0.0	***
poly(lon, 2)1:as.factor(SEASON)2	81.4	13.1	6.2	0.0	***
poly(lon, 2)2:as.factor(SEASON)2	221.5	12.1	18.3	0.0	***
poly(lon, 2)1:as.factor(SEASON)3	155.3	12.7	12.2	0.0	***
poly(lon, 2)2:as.factor(SEASON)3	166.6	12.6	13.3	0.0	***
poly(lon, 2)1:as.factor(pref)23	-60.7	12.8	-4.8	0.0	***
poly(lon, 2)2:as.factor(pref)23	-30.3	13.5	-2.3	0.0	*
poly(lon, 2)1:as.factor(pref)24	162.9	16.3	10.0	0.0	***
poly(lon, 2)2:as.factor(pref)24	-174.7	17.1	-10.2	0.0	***
poly(hpb, 2)1:as.factor(SEASON)1	54.2	14.1	3.9	0.0	***
poly(hpb, 2)2:as.factor(SEASON)1	-65.3	10.1	-6.5	0.0	***
poly(hpb, 2)1:as.factor(SEASON)2	85.7	17.5	4.9	0.0	***
poly(hpb, 2)2:as.factor(SEASON)2	-63.3	13.0	-4.9	0.0	***
poly(hpb, 2)1:as.factor(SEASON)3	-6.3	19.1	-0.3	0.7	
poly(hpb, 2)2:as.factor(SEASON)3	4.0	13.9	0.3	0.8	
poly(hpb, 2)1:as.factor(pref)23	-7.6	17.0	-0.4	0.7	
poly(hpb, 2)2:as.factor(pref)23	48.1	13.4	3.6	0.0	***

poly(hpb, 2)1:as.factor(pref)24	-27.6	22.0	-1.3	0.2	
poly(hpb, 2)2:as.factor(pref)24	135.2	16.8	8.1	0.0	***
as.factor(SEASON)1:as.factor(pref)23	0.0	0.0	0.2	0.9	
as.factor(SEASON)2:as.factor(pref)23	0.0	0.0	-0.1	0.9	
as.factor(SEASON)3:as.factor(pref)23	0.0	0.0	-0.5	0.6	
as.factor(SEASON)1:as.factor(pref)24	0.0	0.0	-0.7	0.5	
as.factor(SEASON)2:as.factor(pref)24	-0.1	0.0	-1.6	0.1	
as.factor(SEASON)3:as.factor(pref)24	-0.1	0.0	-1.4	0.2	
as.factor(YEAR)1995:poly(lat, 2)1:poly(lon, 2)1	41220	10170	4.1	0.0	***
as.factor(YEAR)1996:poly(lat, 2)1:poly(lon, 2)1	-44330	12650	-3.5	0.0	***
as.factor(YEAR)1997:poly(lat, 2)1:poly(lon, 2)1	-45830	12850	-3.6	0.0	***
as.factor(YEAR)1998:poly(lat, 2)1:poly(lon, 2)1	3595	12080	0.3	0.8	
as.factor(YEAR)1999:poly(lat, 2)1:poly(lon, 2)1	20770	15390	1.4	0.2	
as.factor(YEAR)2000:poly(lat, 2)1:poly(lon, 2)1	45050	17840	2.5	0.0	*
as.factor(YEAR)2001:poly(lat, 2)1:poly(lon, 2)1	73730	16630	4.4	0.0	***
as.factor(YEAR)2002:poly(lat, 2)1:poly(lon, 2)1	84030	20750	4.0	0.0	***
as.factor(YEAR)2003:poly(lat, 2)1:poly(lon, 2)1	-47980	18500	-2.6	0.0	**
as.factor(YEAR)2004:poly(lat, 2)1:poly(lon, 2)1	5959	21370	0.3	0.8	
as.factor(YEAR)2005:poly(lat, 2)1:poly(lon, 2)1	-82090	19630	-4.2	0.0	***
as.factor(YEAR)2006:poly(lat, 2)1:poly(lon, 2)1	-127900	22150	-5.8	0.0	***
as.factor(YEAR)2007:poly(lat, 2)1:poly(lon, 2)1	-262800	30850	-8.5	0.0	***
as.factor(YEAR)2008:poly(lat, 2)1:poly(lon, 2)1	-271200	30870	-8.8	0.0	***
as.factor(YEAR)2009:poly(lat, 2)1:poly(lon, 2)1	-249500	38590	-6.5	0.0	***
as.factor(YEAR)2010:poly(lat, 2)1:poly(lon, 2)1	35950	38030	0.9	0.3	
as.factor(YEAR)1995:poly(lat, 2)2:poly(lon, 2)1	53410	10430	5.1	0.0	***
as.factor(YEAR)1996:poly(lat, 2)2:poly(lon, 2)1	-39100	13430	-2.9	0.0	**
as.factor(YEAR)1997:poly(lat, 2)2:poly(lon, 2)1	-139400	13360	-10.4	0.0	***
as.factor(YEAR)1998:poly(lat, 2)2:poly(lon, 2)1	-139.2	12650	0.0	1.0	
as.factor(YEAR)1999:poly(lat, 2)2:poly(lon, 2)1	-11950	17850	-0.7	0.5	
as.factor(YEAR)2000:poly(lat, 2)2:poly(lon, 2)1	131400	17000	7.7	0.0	***
as.factor(YEAR)2001:poly(lat, 2)2:poly(lon, 2)1	106700	17140	6.2	0.0	***
as.factor(YEAR)2002:poly(lat, 2)2:poly(lon, 2)1	164900	20180	8.2	0.0	***
as.factor(YEAR)2003:poly(lat, 2)2:poly(lon, 2)1	17110	18950	0.9	0.4	
as.factor(YEAR)2004:poly(lat, 2)2:poly(lon, 2)1	-76500	30480	-2.5	0	*
as.factor(YEAR)2005:poly(lat, 2)2:poly(lon, 2)1	157600	20000	7.9	0	***
as.factor(YEAR)2006:poly(lat, 2)2:poly(lon, 2)1	200600	22430	8.9	0	***
as.factor(YEAR)2007:poly(lat, 2)2:poly(lon, 2)1	-163500	33840	-4.8	0	***
as.factor(YEAR)2008:poly(lat, 2)2:poly(lon, 2)1	-3522	30240	-0.1	0.9	
as.factor(YEAR)2009:poly(lat, 2)2:poly(lon, 2)1	-124100	41440	-3	0	**
as.factor(YEAR)2010:poly(lat, 2)2:poly(lon, 2)1	199500	29930	6.7	0	***
as.factor(YEAR)1995:poly(lat, 2)1:poly(lon, 2)2	56070	9399	6	0	***
as.factor(YEAR)1996:poly(lat, 2)1:poly(lon, 2)2	3883	11760	0.3	0.7	
as.factor(YEAR)1997:poly(lat, 2)1:poly(lon, 2)2	-26440	11790	-2.2	0	*
as.factor(YEAR)1998:poly(lat, 2)1:poly(lon, 2)2	53000	10750	4.9	0	***
as.factor(YEAR)1999:poly(lat, 2)1:poly(lon, 2)2	49260	14230	3.5	0	***
as.factor(YEAR)2000:poly(lat, 2)1:poly(lon, 2)2	93510	15730	5.9	0	***
as.factor(YEAR)2001:poly(lat, 2)1:poly(lon, 2)2	116700	14520	8	0	***
as.factor(YEAR)2002:poly(lat, 2)1:poly(lon, 2)2	168800	20290	8.3	0	***
as.factor(YEAR)2003:poly(lat, 2)1:poly(lon, 2)2	-9035	16870	-0.5	0.6	
as.factor(YEAR)2004:poly(lat, 2)1:poly(lon, 2)2	73100	29980	2.4	0	*

as.factor(YEAR)2005:poly(lat, 2)1:poly(lon, 2)2	85520	20520	4.2	0	***
as.factor(YEAR)2006:poly(lat, 2)1:poly(lon, 2)2	49090	21180	2.3	0	*
as.factor(YEAR)2007:poly(lat, 2)1:poly(lon, 2)2	-32150	26800	-1.2	0.2	
as.factor(YEAR)2008:poly(lat, 2)1:poly(lon, 2)2	-71340	28620	-2.5	0	*
as.factor(YEAR)2009:poly(lat, 2)1:poly(lon, 2)2	-30060	36710	-0.8	0.4	
as.factor(YEAR)2010:poly(lat, 2)1:poly(lon, 2)2	175800	35820	4.9	0	***
as.factor(YEAR)1995:poly(lat, 2)2:poly(lon, 2)2	29290	8129	3.6	0	***
as.factor(YEAR)1996:poly(lat, 2)2:poly(lon, 2)2	-51600	11060	-4.7	0	***
as.factor(YEAR)1997:poly(lat, 2)2:poly(lon, 2)2	4951	11120	0.4	0.7	
as.factor(YEAR)1998:poly(lat, 2)2:poly(lon, 2)2	-13100	9865	-1.3	0.2	
as.factor(YEAR)1999:poly(lat, 2)2:poly(lon, 2)2	-69150	15120	-4.6	0	***
as.factor(YEAR)2000:poly(lat, 2)2:poly(lon, 2)2	-12270	13800	-0.9	0.4	
as.factor(YEAR)2001:poly(lat, 2)2:poly(lon, 2)2	16190	12570	1.3	0.2	
as.factor(YEAR)2002:poly(lat, 2)2:poly(lon, 2)2	39240	15650	2.5	0	*
as.factor(YEAR)2003:poly(lat, 2)2:poly(lon, 2)2	41600	14710	2.8	0	**
as.factor(YEAR)2004:poly(lat, 2)2:poly(lon, 2)2	-143300	31210	-4.6	0	***
as.factor(YEAR)2005:poly(lat, 2)2:poly(lon, 2)2	-49740	17540	-2.8	0	**
as.factor(YEAR)2006:poly(lat, 2)2:poly(lon, 2)2	-4083	18040	-0.2	0.8	
as.factor(YEAR)2007:poly(lat, 2)2:poly(lon, 2)2	-138100	25950	-5.3	0	***
as.factor(YEAR)2008:poly(lat, 2)2:poly(lon, 2)2	-56260	21460	-2.6	0	**
as.factor(YEAR)2009:poly(lat, 2)2:poly(lon, 2)2	-78000	32800	-2.4	0	*
as.factor(YEAR)2010:poly(lat, 2)2:poly(lon, 2)2	28210	22670	1.2	0.2	
poly(lat, 2)1:poly(lon, 2)1:poly(hpb, 2)1	10750000	2112000	5.1	0	***
poly(lat, 2)2:poly(lon, 2)1:poly(hpb, 2)1	-13970000	2069000	-6.8	0	***
poly(lat, 2)1:poly(lon, 2)2:poly(hpb, 2)1	-598100	2124000	-0.3	0.8	
poly(lat, 2)2:poly(lon, 2)2:poly(hpb, 2)1	4984000	1782000	2.8	0	**
poly(lat, 2)1:poly(lon, 2)1:poly(hpb, 2)2	13000000	1979000	6.6	0	***
poly(lat, 2)2:poly(lon, 2)1:poly(hpb, 2)2	-167400	1849000	-0.1	0.9	
poly(lat, 2)1:poly(lon, 2)2:poly(hpb, 2)2	-114600	1817000	-0.1	0.9	
poly(lat, 2)2:poly(lon, 2)2:poly(hpb, 2)2	7030000	1486000	4.7	0	***
poly(lat, 2)1:poly(lon, 2)1:as.factor(SEASON)1	867.8	10340	0.1	0.9	
poly(lat, 2)2:poly(lon, 2)1:as.factor(SEASON)1	29640	10870	2.7	0	**
poly(lat, 2)1:poly(lon, 2)2:as.factor(SEASON)1	-4748	8528	-0.6	0.6	
poly(lat, 2)2:poly(lon, 2)2:as.factor(SEASON)1	20370	7591	2.7	0	**
poly(lat, 2)1:poly(lon, 2)1:as.factor(SEASON)2	89990	10680	8.4	0	***
poly(lat, 2)2:poly(lon, 2)1:as.factor(SEASON)2	2140	11050	0.2	0.8	
poly(lat, 2)1:poly(lon, 2)2:as.factor(SEASON)2	8129	9366	0.9	0.4	
poly(lat, 2)2:poly(lon, 2)2:as.factor(SEASON)2	54250	8921	6.1	0	***
poly(lat, 2)1:poly(lon, 2)1:as.factor(SEASON)3	141500	9612	14.7	0	***
poly(lat, 2)2:poly(lon, 2)1:as.factor(SEASON)3	49990	9848	5.1	0	***
poly(lat, 2)1:poly(lon, 2)2:as.factor(SEASON)3	-9617	9335	-1	0.3	
poly(lat, 2)2:poly(lon, 2)2:as.factor(SEASON)3	68030	8963	7.6	0	***
poly(lat, 2)1:poly(lon, 2)1:as.factor(pref)23	-2803	9866	-0.3	0.8	
poly(lat, 2)2:poly(lon, 2)1:as.factor(pref)23	-22350	10240	-2.2	0	*
poly(lat, 2)1:poly(lon, 2)2:as.factor(pref)23	41060	9183	4.5	0	***
poly(lat, 2)2:poly(lon, 2)2:as.factor(pref)23	-66310	8607	-7.7	0	***
poly(lat, 2)1:poly(lon, 2)1:as.factor(pref)24	-9203	12700	-0.7	0.5	
poly(lat, 2)2:poly(lon, 2)1:as.factor(pref)24	-76380	12870	-5.9	0	***
poly(lat, 2)1:poly(lon, 2)2:as.factor(pref)24	-9894	12810	-0.8	0.4	
poly(lat, 2)2:poly(lon, 2)2:as.factor(pref)24	-83780	11480	-7.3	0	***

Significance levels: 0 = ‘***’; <0.001 = ‘**’; <0.01 = ‘*’; <0.05 = ‘.’; <0.1 = ‘’

Dispersion parameter for binomial family taken to be 1.

Null deviance: 463033 on 334546 degrees of freedom

Residual deviance: 384194 on 334203 degrees of freedom 1.150

AIC: 384882

Number of Fisher Scoring iterations: 7

Table A-8. Estimated coefficients for the Gaussian component of the Δ-GLM model for the period 1994 to 2010.

	Estimate	Std. Error	z value	P (>|z|)	Sig.
(Intercept)	1.3	0.0	49.4	0.0	***
as.factor(YEAR)1995	0.4	0.0	9.7	0.0	***
as.factor(YEAR)1996	0.2	0.0	4.0	0.0	***
as.factor(YEAR)1997	0.0	0.0	0.4	0.7	
as.factor(YEAR)1998	0.5	0.0	13.3	0.0	***
as.factor(YEAR)1999	0.5	0.1	9.4	0.0	***
as.factor(YEAR)2000	0.7	0.0	16.8	0.0	***
as.factor(YEAR)2001	0.3	0.1	5.8	0.0	***
as.factor(YEAR)2002	0.6	0.0	13.0	0.0	***
as.factor(YEAR)2003	0.7	0.0	16.0	0.0	***
as.factor(YEAR)2004	0.7	0.0	15.2	0.0	***
as.factor(YEAR)2005	0.7	0.0	14.7	0.0	***
as.factor(YEAR)2006	0.2	0.1	3.9	0.0	***
as.factor(YEAR)2007	0.3	0.1	5.3	0.0	***
as.factor(YEAR)2008	0.4	0.1	5.6	0.0	***
as.factor(YEAR)2009	0.3	0.1	5.5	0.0	***
as.factor(YEAR)2010	0.1	0.1	1.7	0.1	.
poly(hpb,2)1	0.3	1.7	0.2	0.9	
poly(hpb,2)2	3.8	1.4	2.6	0.0	**
as.factor(SEASON)1	0.1	0.0	6.6	0.0	***
as.factor(SEASON)2	0.1	0.0	8.0	0.0	***
as.factor(SEASON)3	0.2	0.0	14.2	0.0	***
as.factor(pref)23	0.0	0.0	1.6	0.1	.
as.factor(pref)24	0.0	0.0	1.7	0.1	.
report2	1.0	0.0	46.1	0.0	***
as.factor(area4)2	0.3	0.0	15.7	0.0	***
as.factor(area4)3	0.1	0.0	3.2	0.0	**
as.factor(area4)4	0.5	0.0	26.6	0.0	***
as.factor(area4)5	0.2	0.0	13.7	0.0	***
as.factor(YEAR)1995:poly(hpb,2)1	22.3	2.5	8.8	0.0	***
as.factor(YEAR)1996:poly(hpb,2)1	4.6	3.2	1.4	0.2	
as.factor(YEAR)1997:poly(hpb,2)1	1.8	3.1	0.6	0.6	
as.factor(YEAR)1998:poly(hpb,2)1	9.3	3.2	2.9	0.0	**
as.factor(YEAR)1999:poly(hpb,2)1	8.9	3.5	2.6	0.0	*
as.factor(YEAR)2000:poly(hpb,2)1	20.8	4.1	5.1	0.0	***
as.factor(YEAR)2001:poly(hpb,2)1	25.8	5.2	5.0	0.0	***
as.factor(YEAR)2002:poly(hpb,2)1	5.2	6.5	0.8	0.4	
as.factor(YEAR)2003:poly(hpb,2)1	0.3	6.4	0.0	1.0	
as.factor(YEAR)2004:poly(hpb,2)1	18.7	6.7	2.8	0.0	**
as.factor(YEAR)2005:poly(hpb,2)1	1.9	6.8	0.3	0.8	
as.factor(YEAR)2006:poly(hpb,2)1	4.8	9.3	0.5	0.6	
as.factor(YEAR)2007:poly(hpb,2)1	1.0	8.0	0.1	0.9	
as.factor(YEAR)2008:poly(hpb,2)1	4.3	8.2	0.5	0.6	
as.factor(YEAR)2009:poly(hpb,2)1	8.3	9.8	0.8	0.4	
as.factor(YEAR)2010:poly(hpb,2)1	13.1	9.1	1.4	0.1	
as.factor(YEAR)1995:poly(hpb,2)2	4.0	2.1	1.9	0.1	.
as.factor(YEAR)1996:poly(hpb,2)2	8.1	3.0	2.7	0.0	**

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)1997:poly(hpb,2)2	6.1	2.7	2.2	0.0	*
as.factor(YEAR)1998:poly(hpb,2)2	8.2	2.8	2.9	0.0	**
as.factor(YEAR)1999:poly(hpb,2)2	10.9	3.0	3.6	0.0	***
as.factor(YEAR)2000:poly(hpb,2)2	13.6	3.7	3.6	0.0	***
as.factor(YEAR)2001:poly(hpb,2)2	3.9	4.6	0.8	0.4	
as.factor(YEAR)2002:poly(hpb,2)2	17.7	5.7	3.1	0.0	**
as.factor(YEAR)2003:poly(hpb,2)2	8.8	5.6	1.6	0.1	
as.factor(YEAR)2004:poly(hpb,2)2	24.0	7.4	3.2	0.0	**
as.factor(YEAR)2005:poly(hpb,2)2	6.0	6.1	1.0	0.3	
as.factor(YEAR)2006:poly(hpb,2)2	5.7	7.4	0.8	0.4	
as.factor(YEAR)2007:poly(hpb,2)2	3.8	6.8	0.6	0.6	
as.factor(YEAR)2008:poly(hpb,2)2	10.1	6.0	1.7	0.1	.
as.factor(YEAR)2009:poly(hpb,2)2	1.4	6.8	0.2	0.8	
as.factor(YEAR)2010:poly(hpb,2)2	1.4	5.9	0.2	0.8	
as.factor(YEAR)1995:as.factor(SEASON)1	0.2	0.0	12.4	0.0	***
as.factor(YEAR)1996:as.factor(SEASON)1	0.1	0.0	2.8	0.0	**
as.factor(YEAR)1997:as.factor(SEASON)1	0.1	0.0	3.3	0.0	**
as.factor(YEAR)1998:as.factor(SEASON)1	0.2	0.0	13.4	0.0	***
as.factor(YEAR)1999:as.factor(SEASON)1	0.2	0.0	7.9	0.0	***
as.factor(YEAR)2000:as.factor(SEASON)1	0.2	0.0	8.3	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)1	0.1	0.0	3.7	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)1	0.2	0.0	8.3	0.0	***
as.factor(YEAR)2003:as.factor(SEASON)1	0.3	0.0	14.1	0.0	***
as.factor(YEAR)2004:as.factor(SEASON)1	0.2	0.0	7.7	0.0	***
as.factor(YEAR)2005:as.factor(SEASON)1	0.3	0.0	12.6	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)1	0.1	0.0	2.2	0.0	*
as.factor(YEAR)2007:as.factor(SEASON)1	0.3	0.0	12.8	0.0	***
as.factor(YEAR)2008:as.factor(SEASON)1	0.2	0.0	8.2	0.0	***
as.factor(YEAR)2009:as.factor(SEASON)1	0.3	0.0	7.8	0.0	***
as.factor(YEAR)2010:as.factor(SEASON)1	0.1	0.0	3.6	0.0	***
as.factor(YEAR)1995:as.factor(SEASON)2	0.3	0.0	17.7	0.0	***
as.factor(YEAR)1996:as.factor(SEASON)2	0.1	0.0	3.0	0.0	**
as.factor(YEAR)1997:as.factor(SEASON)2	0.2	0.0	8.5	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)2	0.1	0.0	6.7	0.0	***
as.factor(YEAR)1999:as.factor(SEASON)2	0.0	0.0	0.3	0.8	
as.factor(YEAR)2000:as.factor(SEASON)2	0.0	0.0	0.9	0.4	
as.factor(YEAR)2001:as.factor(SEASON)2	0.0	0.0	1.6	0.1	
as.factor(YEAR)2002:as.factor(SEASON)2	0.1	0.0	3.3	0.0	***
as.factor(YEAR)2003:as.factor(SEASON)2	0.4	0.0	16.4	0.0	***
as.factor(YEAR)2004:as.factor(SEASON)2	0.1	0.0	2.3	0.0	*
as.factor(YEAR)2005:as.factor(SEASON)2	0.3	0.0	10.6	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)2	0.2	0.0	5.1	0.0	***
as.factor(YEAR)2007:as.factor(SEASON)2	0.2	0.0	5.9	0.0	***
as.factor(YEAR)2008:as.factor(SEASON)2	0.2	0.0	7.8	0.0	***
as.factor(YEAR)2009:as.factor(SEASON)2	0.3	0.0	8.7	0.0	***
as.factor(YEAR)2010:as.factor(SEASON)2	0.2	0.0	6.1	0.0	***
as.factor(YEAR)1995:as.factor(SEASON)3	0.5	0.0	28.5	0.0	***
as.factor(YEAR)1996:as.factor(SEASON)3	0.1	0.0	7.3	0.0	***
as.factor(YEAR)1997:as.factor(SEASON)3	0.1	0.0	4.3	0.0	***
as.factor(YEAR)1998:as.factor(SEASON)3	0.3	0.0	15.5	0.0	***
as.factor(YEAR)1999:as.factor(SEASON)3	0.2	0.0	10.5	0.0	***

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)2000:as.factor(SEASON)3	0.1	0.0	5.7	0.0	***
as.factor(YEAR)2001:as.factor(SEASON)3	0.2	0.0	7.2	0.0	***
as.factor(YEAR)2002:as.factor(SEASON)3	0.1	0.0	6.5	0.0	***
as.factor(YEAR)2003:as.factor(SEASON)3	0.4	0.0	17.9	0.0	***
as.factor(YEAR)2004:as.factor(SEASON)3	0.0	0.0	0.3	0.8	
as.factor(YEAR)2005:as.factor(SEASON)3	0.4	0.0	13.4	0.0	***
as.factor(YEAR)2006:as.factor(SEASON)3	0.2	0.0	5.4	0.0	***
as.factor(YEAR)2007:as.factor(SEASON)3	0.2	0.0	5.8	0.0	***
as.factor(YEAR)2008:as.factor(SEASON)3	0.2	0.0	6.1	0.0	***
as.factor(YEAR)2009:as.factor(SEASON)3	0.3	0.0	9.9	0.0	***
as.factor(YEAR)2010:as.factor(SEASON)3	0.3	0.0	10.2	0.0	***
as.factor(YEAR)1995:as.factor(pref)23	0.1	0.0	3.1	0.0	**
as.factor(YEAR)1996:as.factor(pref)23	0.1	0.0	3.6	0.0	***
as.factor(YEAR)1997:as.factor(pref)23	0.0	0.0	0.5	0.6	
as.factor(YEAR)1998:as.factor(pref)23	0.1	0.0	3.1	0.0	**
as.factor(YEAR)1999:as.factor(pref)23	0.0	0.0	0.1	0.9	
as.factor(YEAR)2000:as.factor(pref)23	0.0	0.0	0.1	0.9	
as.factor(YEAR)2001:as.factor(pref)23	0.1	0.0	2.7	0.0	**
as.factor(YEAR)2002:as.factor(pref)23	0.0	0.0	1.0	0.3	
as.factor(YEAR)2003:as.factor(pref)23	0.0	0.0	1.1	0.3	
as.factor(YEAR)2004:as.factor(pref)23	0.1	0.0	5.3	0.0	***
as.factor(YEAR)2005:as.factor(pref)23	0.1	0.0	2.0	0.0	*
as.factor(YEAR)2006:as.factor(pref)23	0.1	0.0	2.0	0.0	*
as.factor(YEAR)2007:as.factor(pref)23	0.0	0.0	0.8	0.4	
as.factor(YEAR)2008:as.factor(pref)23	0.0	0.0	1.5	0.1	
as.factor(YEAR)2009:as.factor(pref)23	0.0	0.0	1.3	0.2	
as.factor(YEAR)2010:as.factor(pref)23	0.1	0.0	3.3	0.0	***
as.factor(YEAR)1995:as.factor(pref)24	0.0	0.0	0.4	0.7	
as.factor(YEAR)1996:as.factor(pref)24	0.1	0.0	4.6	0.0	***
as.factor(YEAR)1997:as.factor(pref)24	0.1	0.0	2.6	0.0	*
as.factor(YEAR)1998:as.factor(pref)24	0.1	0.0	1.9	0.1	.
as.factor(YEAR)1999:as.factor(pref)24	0.0	0.0	0.5	0.6	
as.factor(YEAR)2000:as.factor(pref)24	0.1	0.0	3.5	0.0	***
as.factor(YEAR)2001:as.factor(pref)24	0.0	0.0	1.4	0.2	
as.factor(YEAR)2002:as.factor(pref)24	0.0	0.0	0.7	0.5	
as.factor(YEAR)2003:as.factor(pref)24	0.0	0.0	1.1	0.3	
as.factor(YEAR)2004:as.factor(pref)24	0.1	0.0	2.8	0.0	**
as.factor(YEAR)2005:as.factor(pref)24	0.1	0.0	2.5	0.0	*
as.factor(YEAR)2006:as.factor(pref)24	0.0	0.0	0.9	0.4	
as.factor(YEAR)2007:as.factor(pref)24	0.1	0.0	1.5	0.1	
as.factor(YEAR)2008:as.factor(pref)24	0.0	0.0	0.6	0.5	
as.factor(YEAR)2009:as.factor(pref)24	0.0	0.0	1.3	0.2	
as.factor(YEAR)2010:as.factor(pref)24	0.1	0.0	2.4	0.0	*
as.factor(YEAR)1995:report2	0.0	0.0	0.1	0.9	
as.factor(YEAR)1996:report2	0.2	0.0	4.1	0.0	***
as.factor(YEAR)1997:report2	0.4	0.0	9.4	0.0	***
as.factor(YEAR)1998:report2	0.3	0.0	7.4	0.0	***
as.factor(YEAR)1999:report2	0.2	0.1	4.3	0.0	***
as.factor(YEAR)2000:report2	0.0	0.0	0.9	0.4	
as.factor(YEAR)2001:report2	0.2	0.0	4.7	0.0	***
as.factor(YEAR)2002:report2	0.3	0.1	6.7	0.0	***

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)2003:report2	0.6	0.0	13.1	0.0	***
as.factor(YEAR)2004:report2	0.6	0.1	10.3	0.0	***
as.factor(YEAR)2005:report2	0.4	0.1	7.8	0.0	***
as.factor(YEAR)2006:report2	0.0	0.1	0.2	0.9	
as.factor(YEAR)2007:report2	0.2	0.1	3.1	0.0	**
as.factor(YEAR)2008:report2	0.3	0.1	4.6	0.0	***
as.factor(YEAR)2009:report2	0.4	0.1	5.3	0.0	***
as.factor(YEAR)2010:report2	0.4	0.1	5.7	0.0	***
as.factor(YEAR)1995:as.factor(area4)2	0.0	0.0	0.2	0.9	
as.factor(YEAR)1996:as.factor(area4)2	0.1	0.0	2.7	0.0	**
as.factor(YEAR)1997:as.factor(area4)2	0.2	0.0	4.6	0.0	***
as.factor(YEAR)1998:as.factor(area4)2	0.1	0.0	5.0	0.0	***
as.factor(YEAR)1999:as.factor(area4)2	0.4	0.0	7.5	0.0	***
as.factor(YEAR)2000:as.factor(area4)2	0.7	0.0	21.9	0.0	***
as.factor(YEAR)2001:as.factor(area4)2	0.2	0.0	4.9	0.0	***
as.factor(YEAR)2002:as.factor(area4)2	0.4	0.0	11.5	0.0	***
as.factor(YEAR)2003:as.factor(area4)2	0.1	0.0	3.8	0.0	***
as.factor(YEAR)2004:as.factor(area4)2	0.3	0.0	7.6	0.0	***
as.factor(YEAR)2005:as.factor(area4)2	0.3	0.0	8.0	0.0	***
as.factor(YEAR)2006:as.factor(area4)2	0.2	0.0	4.7	0.0	***
as.factor(YEAR)2007:as.factor(area4)2	0.1	0.0	3.7	0.0	***
as.factor(YEAR)2008:as.factor(area4)2	0.1	0.0	2.0	0.0	*
as.factor(YEAR)2009:as.factor(area4)2	0.2	0.0	5.2	0.0	***
as.factor(YEAR)2010:as.factor(area4)2	0.0	0.0	0.1	0.9	
as.factor(YEAR)1995:as.factor(area4)3	0.2	0.0	4.3	0.0	***
as.factor(YEAR)1996:as.factor(area4)3	0.3	0.1	5.1	0.0	***
as.factor(YEAR)1997:as.factor(area4)3	0.0	0.1	0.5	0.6	
as.factor(YEAR)1998:as.factor(area4)3	0.0	0.0	0.9	0.3	
as.factor(YEAR)1999:as.factor(area4)3	0.3	0.1	4.8	0.0	***
as.factor(YEAR)2000:as.factor(area4)3	0.6	0.1	11.5	0.0	***
as.factor(YEAR)2001:as.factor(area4)3	0.1	0.1	1.8	0.1	.
as.factor(YEAR)2002:as.factor(area4)3	0.4	0.1	6.8	0.0	***
as.factor(YEAR)2003:as.factor(area4)3	0.1	0.1	1.3	0.2	
as.factor(YEAR)2004:as.factor(area4)3	0.6	0.1	5.2	0.0	***
as.factor(YEAR)2005:as.factor(area4)3	0.2	0.1	3.9	0.0	***
as.factor(YEAR)2006:as.factor(area4)3	0.1	0.1	1.7	0.1	.
as.factor(YEAR)2007:as.factor(area4)3	0.2	0.1	1.9	0.1	.
as.factor(YEAR)2008:as.factor(area4)3	0.1	0.1	0.7	0.5	
as.factor(YEAR)2009:as.factor(area4)3	0.1	0.1	0.9	0.4	
as.factor(YEAR)2010:as.factor(area4)3	0.3	0.1	3.7	0.0	***
as.factor(YEAR)1995:as.factor(area4)4	0.0	0.0	0.0	1.0	
as.factor(YEAR)1996:as.factor(area4)4	0.1	0.0	3.2	0.0	**
as.factor(YEAR)1997:as.factor(area4)4	0.1	0.0	3.7	0.0	***
as.factor(YEAR)1998:as.factor(area4)4	0.2	0.0	8.7	0.0	***
as.factor(YEAR)1999:as.factor(area4)4	0.5	0.0	9.4	0.0	***
as.factor(YEAR)2000:as.factor(area4)4	0.7	0.0	21.9	0.0	***
as.factor(YEAR)2001:as.factor(area4)4	0.3	0.0	6.7	0.0	***
as.factor(YEAR)2002:as.factor(area4)4	0.5	0.0	13.3	0.0	***
as.factor(YEAR)2003:as.factor(area4)4	0.2	0.0	8.2	0.0	***
as.factor(YEAR)2004:as.factor(area4)4	0.3	0.0	8.7	0.0	***
as.factor(YEAR)2005:as.factor(area4)4	0.3	0.0	8.0	0.0	***

	Estimate	Std. Error	z value	P (>|z|)	Sig.
as.factor(YEAR)2006:as.factor(area4)4	0.3	0.0	8.2	0.0	***
as.factor(YEAR)2007:as.factor(area4)4	0.2	0.0	6.2	0.0	***
as.factor(YEAR)2008:as.factor(area4)4	0.2	0.0	5.0	0.0	***
as.factor(YEAR)2009:as.factor(area4)4	0.3	0.0	6.7	0.0	***
as.factor(YEAR)2010:as.factor(area4)4	0.0	0.0	0.2	0.9	
as.factor(YEAR)1995:as.factor(area4)5	0.1	0.0	2.5	0.0	*
as.factor(YEAR)1996:as.factor(area4)5	0.1	0.0	1.8	0.1	.
as.factor(YEAR)1997:as.factor(area4)5	0.0	0.0	0.8	0.4	
as.factor(YEAR)1998:as.factor(area4)5	0.2	0.0	7.3	0.0	***
as.factor(YEAR)1999:as.factor(area4)5	0.4	0.0	7.7	0.0	***
as.factor(YEAR)2000:as.factor(area4)5	0.8	0.0	22.5	0.0	***
as.factor(YEAR)2001:as.factor(area4)5	0.2	0.0	5.9	0.0	***
as.factor(YEAR)2002:as.factor(area4)5	0.5	0.0	13.5	0.0	***
as.factor(YEAR)2003:as.factor(area4)5	0.2	0.0	7.5	0.0	***
as.factor(YEAR)2004:as.factor(area4)5	0.3	0.0	8.4	0.0	***
as.factor(YEAR)2005:as.factor(area4)5	0.2	0.0	6.6	0.0	***
as.factor(YEAR)2006:as.factor(area4)5	0.2	0.0	5.9	0.0	***
as.factor(YEAR)2007:as.factor(area4)5	0.2	0.0	4.3	0.0	***
as.factor(YEAR)2008:as.factor(area4)5	0.3	0.0	6.2	0.0	***
as.factor(YEAR)2009:as.factor(area4)5	0.2	0.0	4.4	0.0	***
as.factor(YEAR)2010:as.factor(area4)5	0.1	0.0	1.7	0.1	.

Significance levels: 0 = ‘***’; <0.001 = ‘**’; <0.01 = ‘*’; <0.05 = ‘.’; <0.1 = ‘’

Dispersion parameter for binomial family taken to be 1.

Null deviance: 67070 on 159364 degrees of freedom

Residual deviance: 55409 on 159144 degrees of freedom 0.348

AIC: 284340

Number of Fisher Scoring iterations: 2