Index of abundance for sablefish from NWFSC WCGBT Survey

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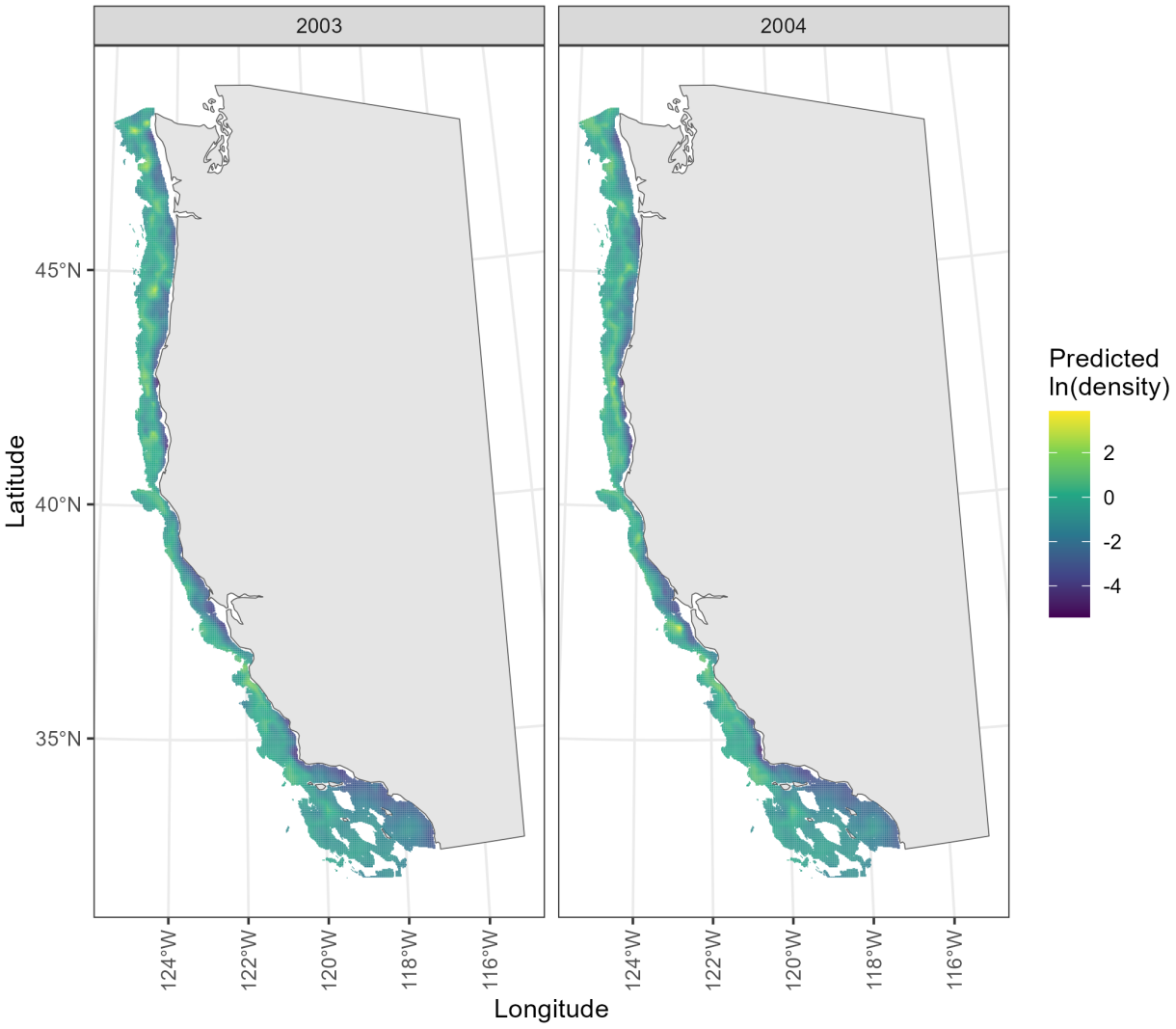
Survey indices of abundance

Geostatistical models of biomass density were fit to survey data using Template Model Builder (TMB) (Kristensen et al. 2016) via the R package Species Distribution Models with (`sdmTMB`) (Anderson et al. 2022). These models can account for latent spatial factors with a constant spatial Gaussian random field and spatiotemporal deviations to evolve as a random walk Guassian random field (Thorson et al. 2015). Tweedie, delta-binomial, delta-gamma, and mixture distributions, which allow for extreme catch events, were investigated. Results are only shown for the distribution that led to the best model diagnostics, e.g., similar distributions of theoretical normal quantiles and model quantiles, high precision, lack of extreme predictions that are incompatible with the life history, and low Akaike information criterion (AIC). Estimates of biomass from this best model were predicted using a grid based on available survey locations. Code to reproduce the analysis is available at https://github.com/pfmc-assessments/indexwc.

The model used a delta model with a gamma distribution for the catch-rate component. A logit-link was used for encounter probability and a log-link for positive catch rates. The response variable was catch (mt) with an offset of area (km^2) to account for differences in effort. Fixed effects were estimated for each year. The following additional covariates were included: pass. Vessel-year effects, which have traditionally been included in index standardization for this survey, were not included as the estimated variance for the random effect was close to zero. Vessel-year effects were more prominent when models did not include spatial effects and were included for each unique combination of vessel and year in the data to account for the random selection of commercial vessels used during sampling (Helser, Punt, and Methot 2004; Thorson and Ward 2014).

Spatial and spatiotemporal variation was included in the encounter probability and the positive catch rate model. Spatial variation was approximated using 500 knots, where more knots led to non-estimable standard errors because the positive encounters are too sparse to support the dense spatiotemporal structure.

Estimates of density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2004
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Latitude
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122°W
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118°W
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Longitude
Predicted
ln(density)
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-2
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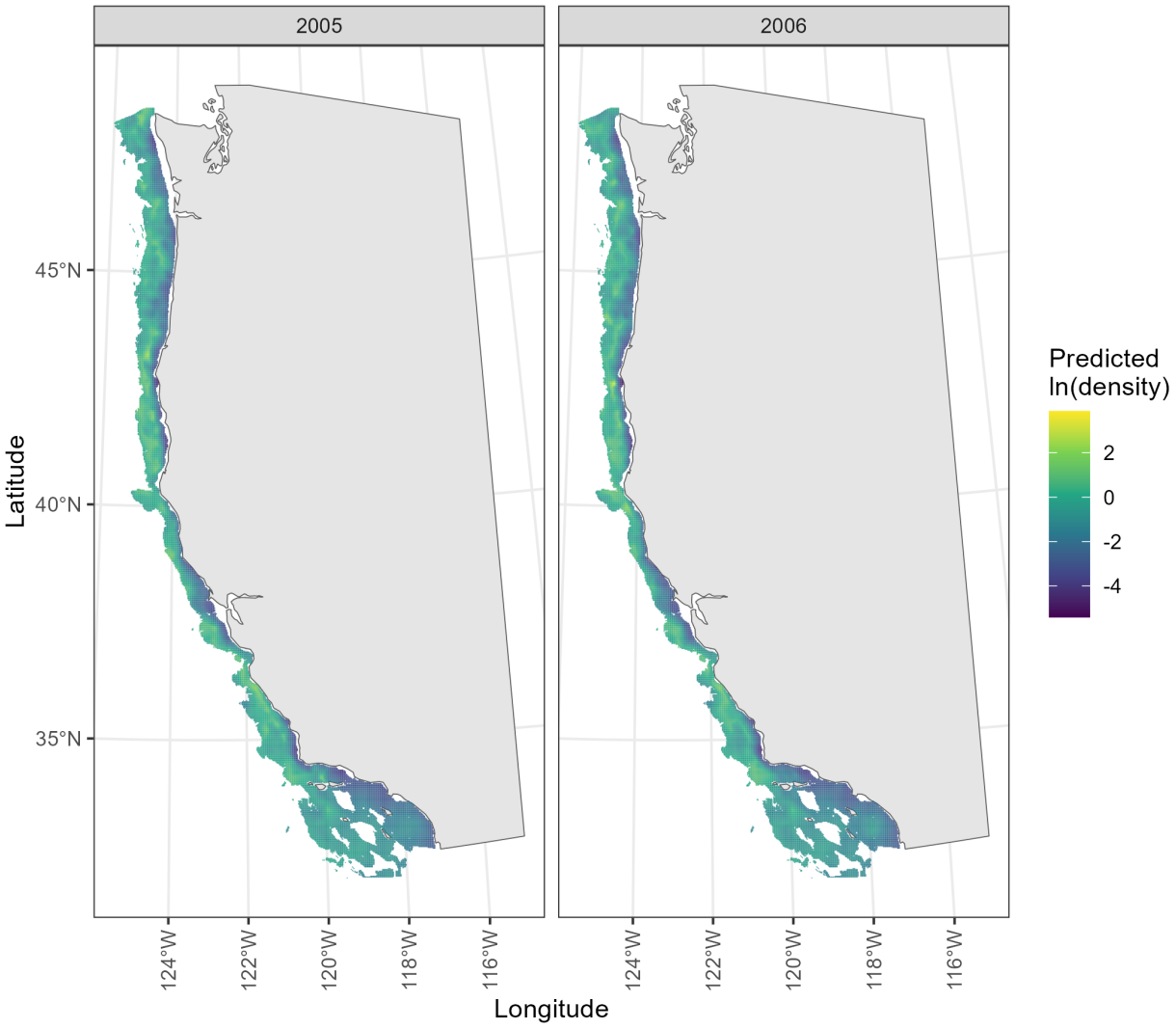
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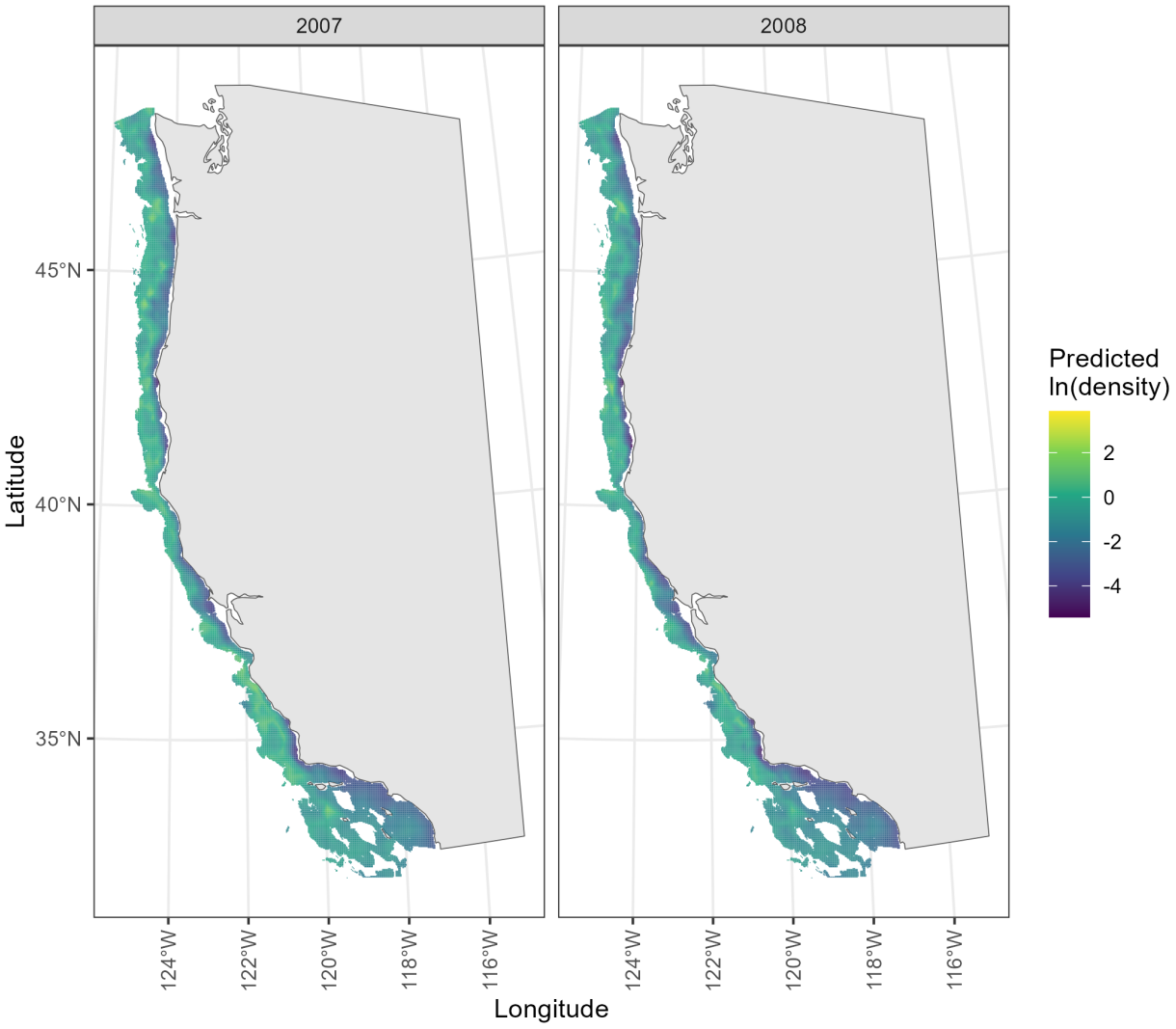
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Longitude
Predicted
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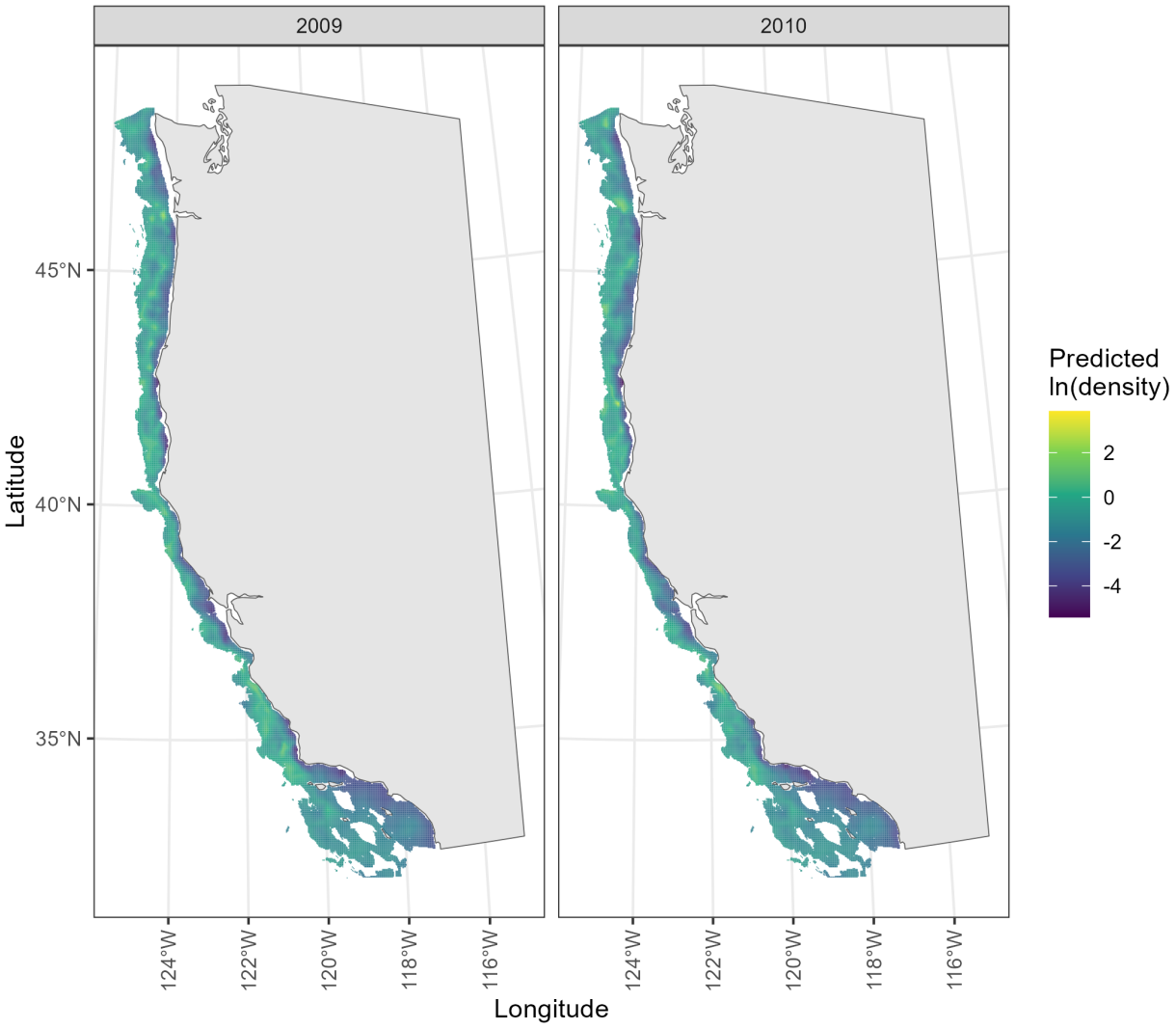
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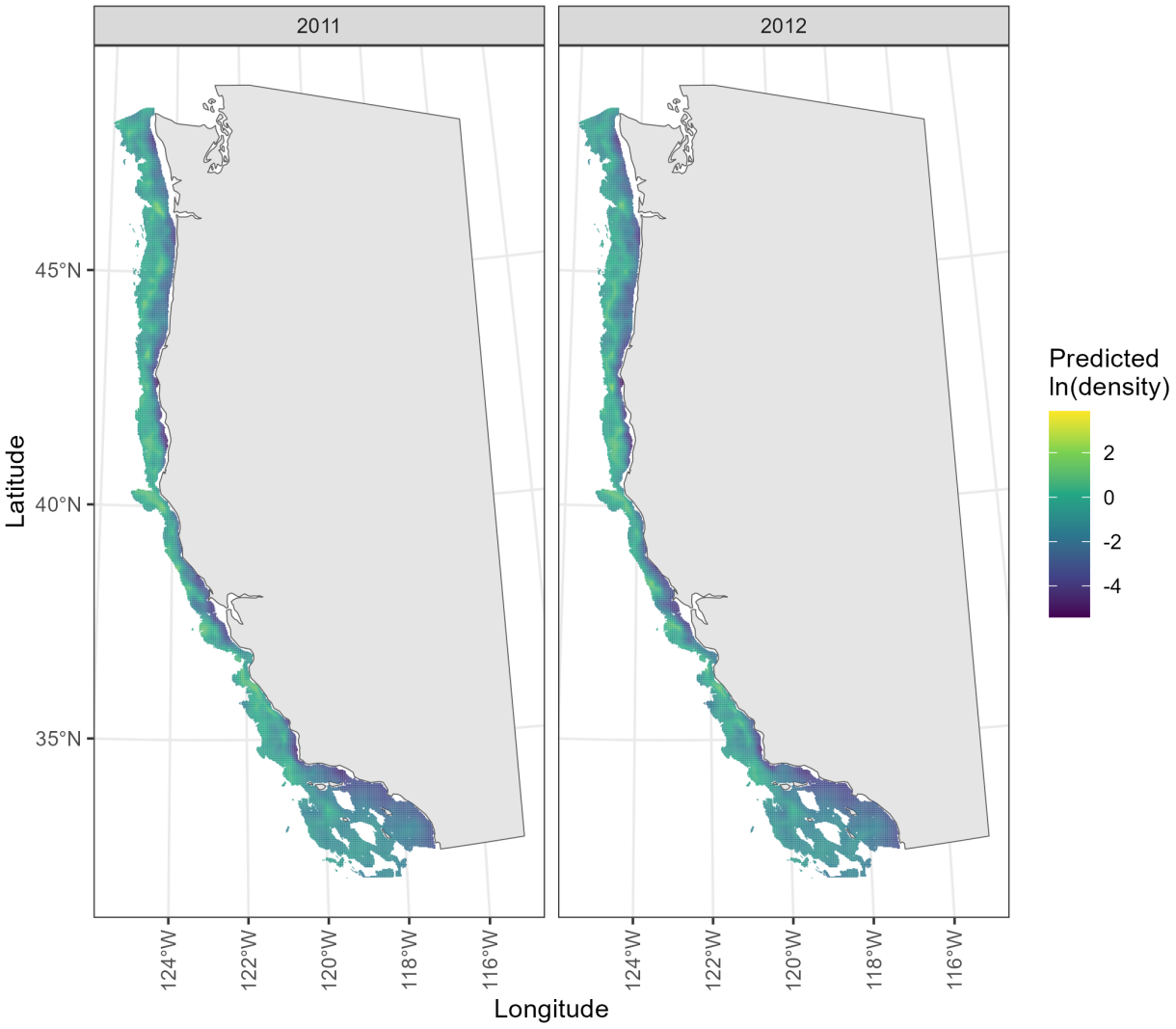
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Predicted
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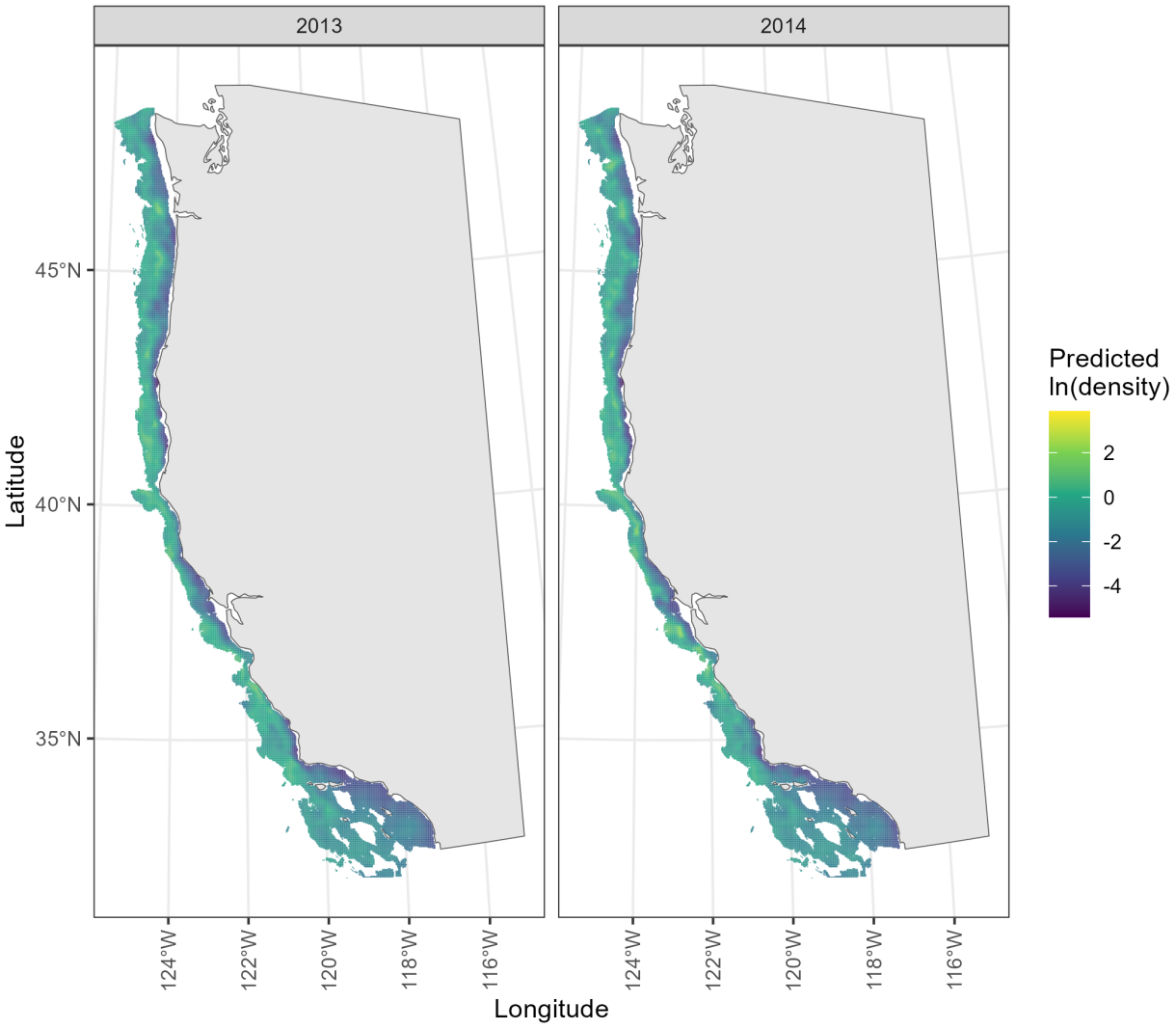
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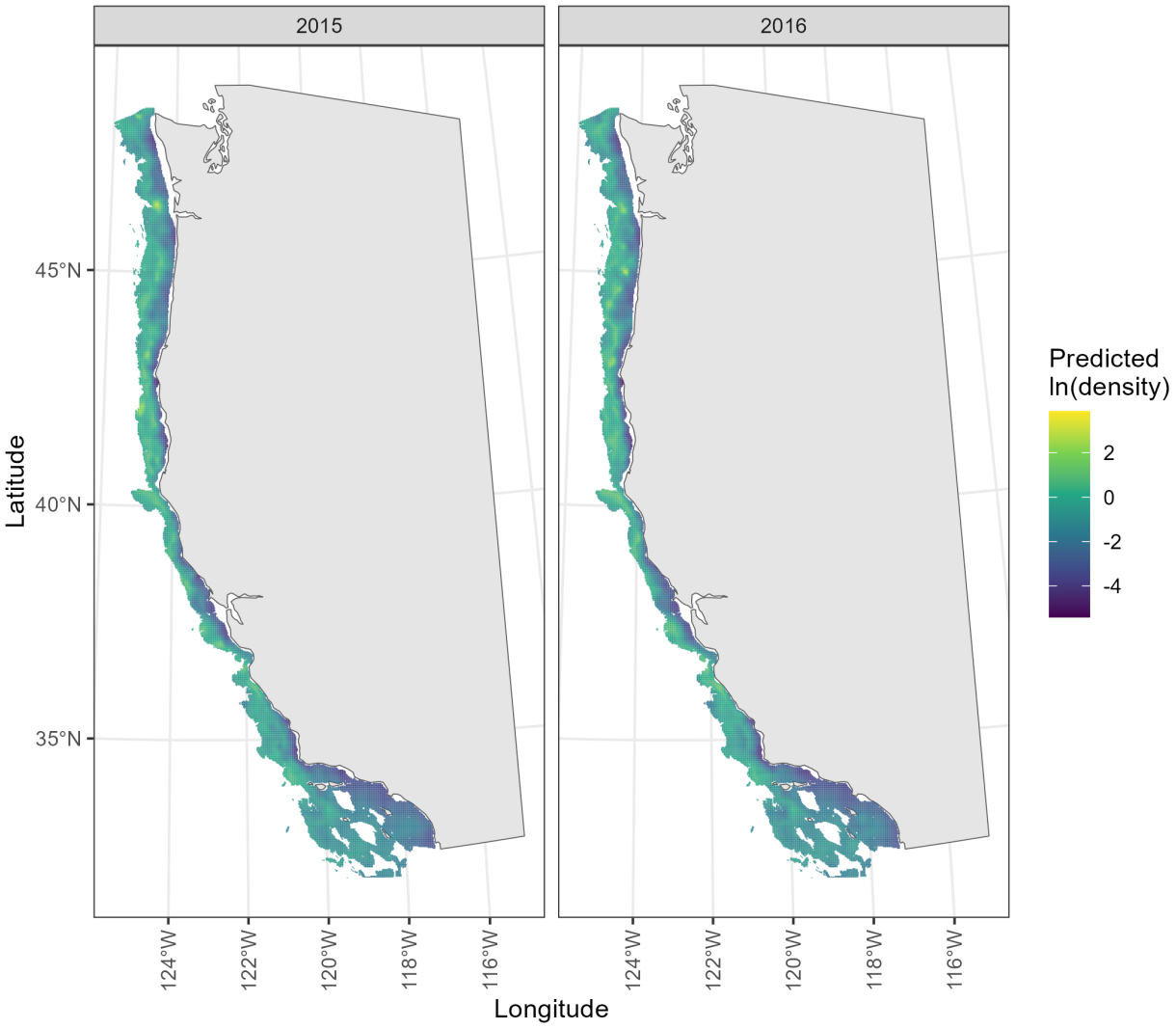
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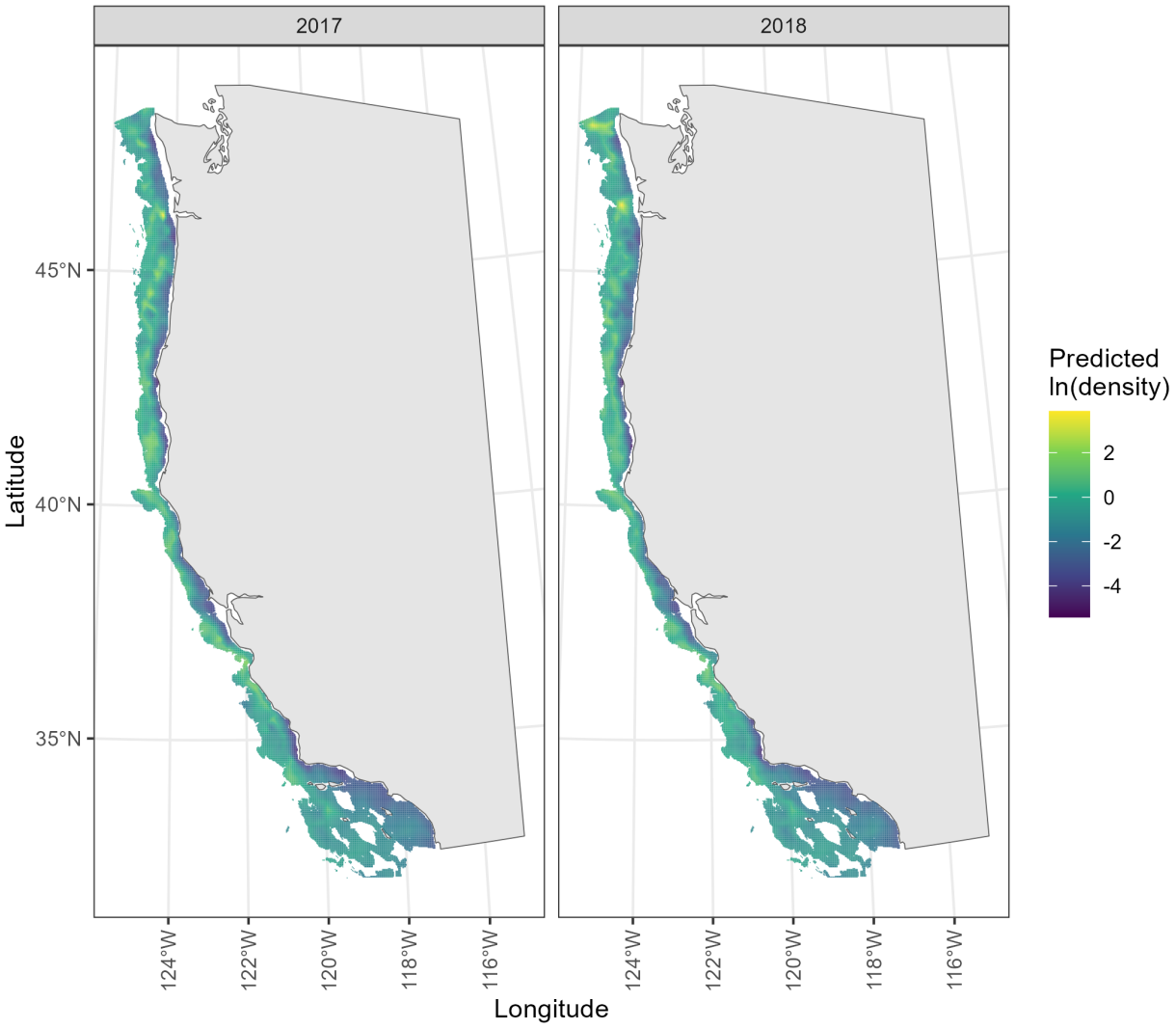
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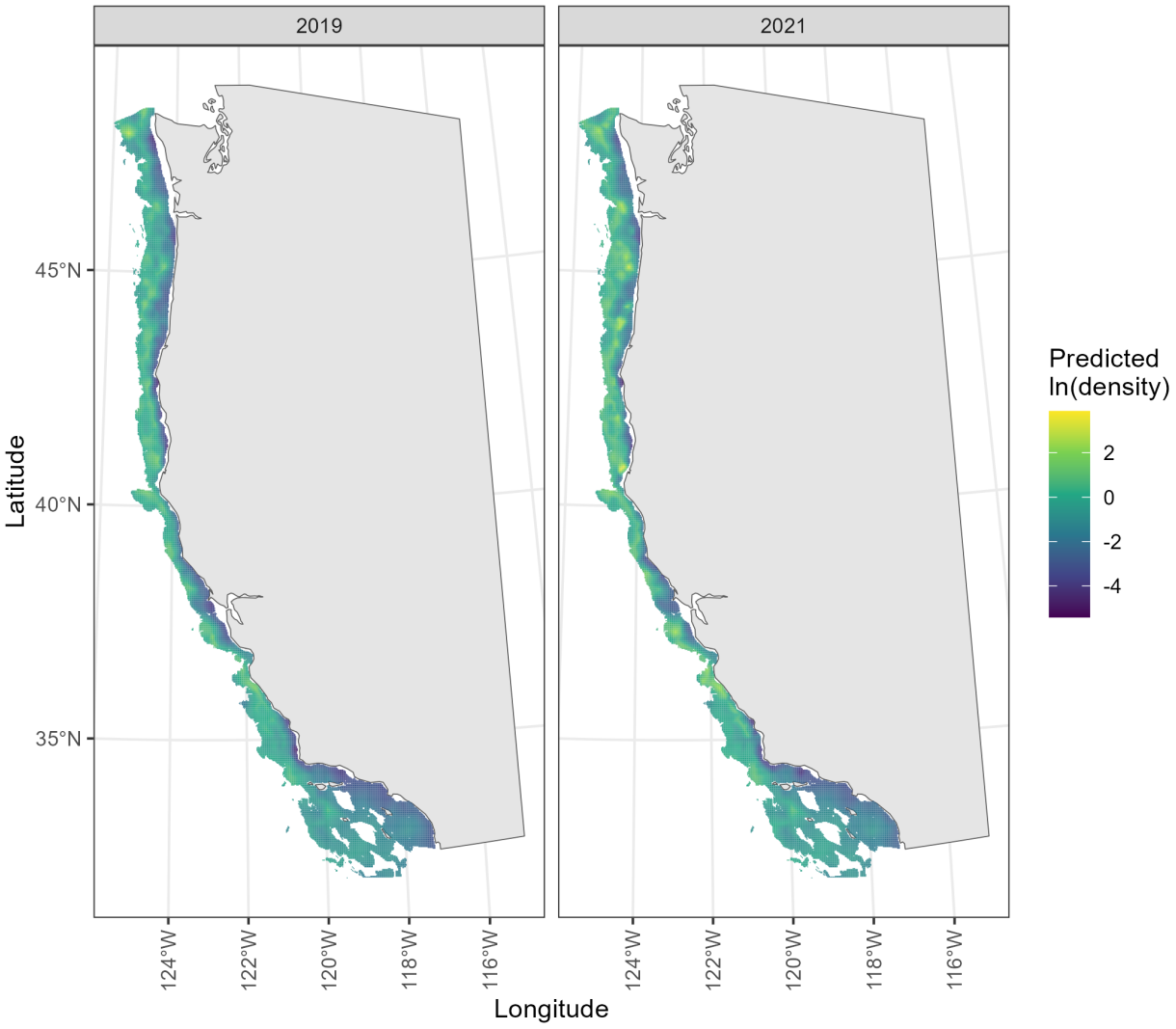
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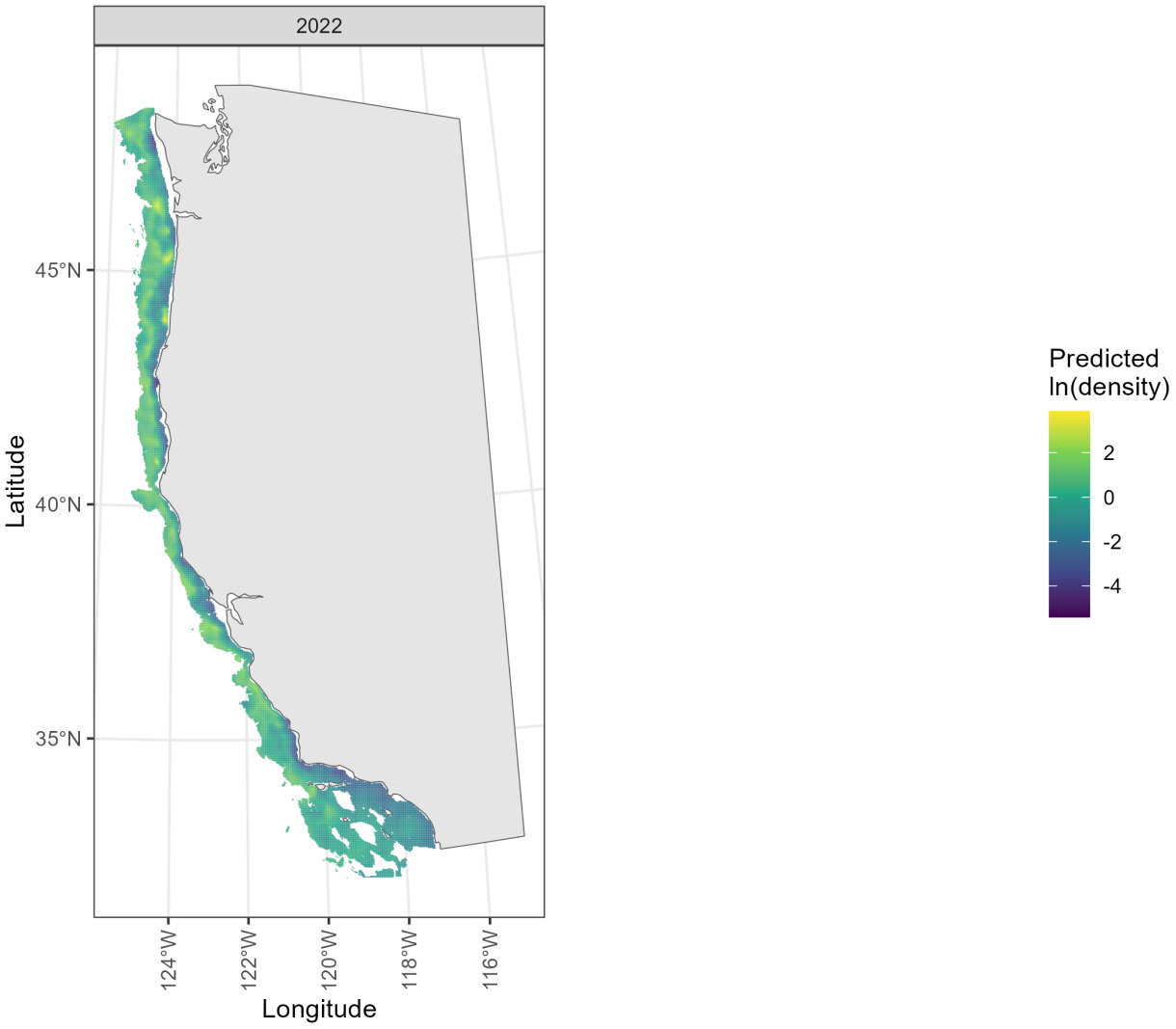
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Longitude
Predicted
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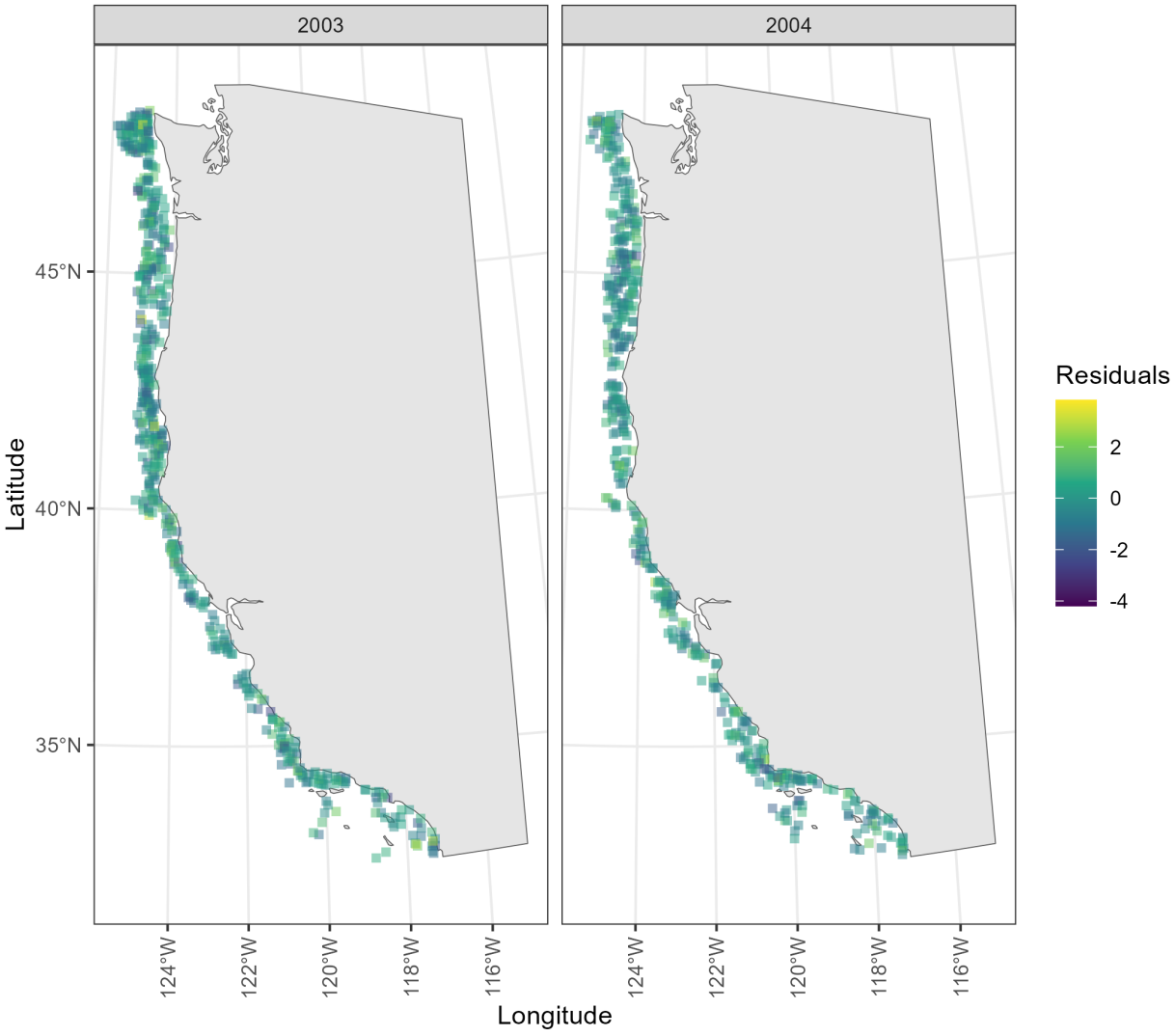
Residuals from the presence/absence model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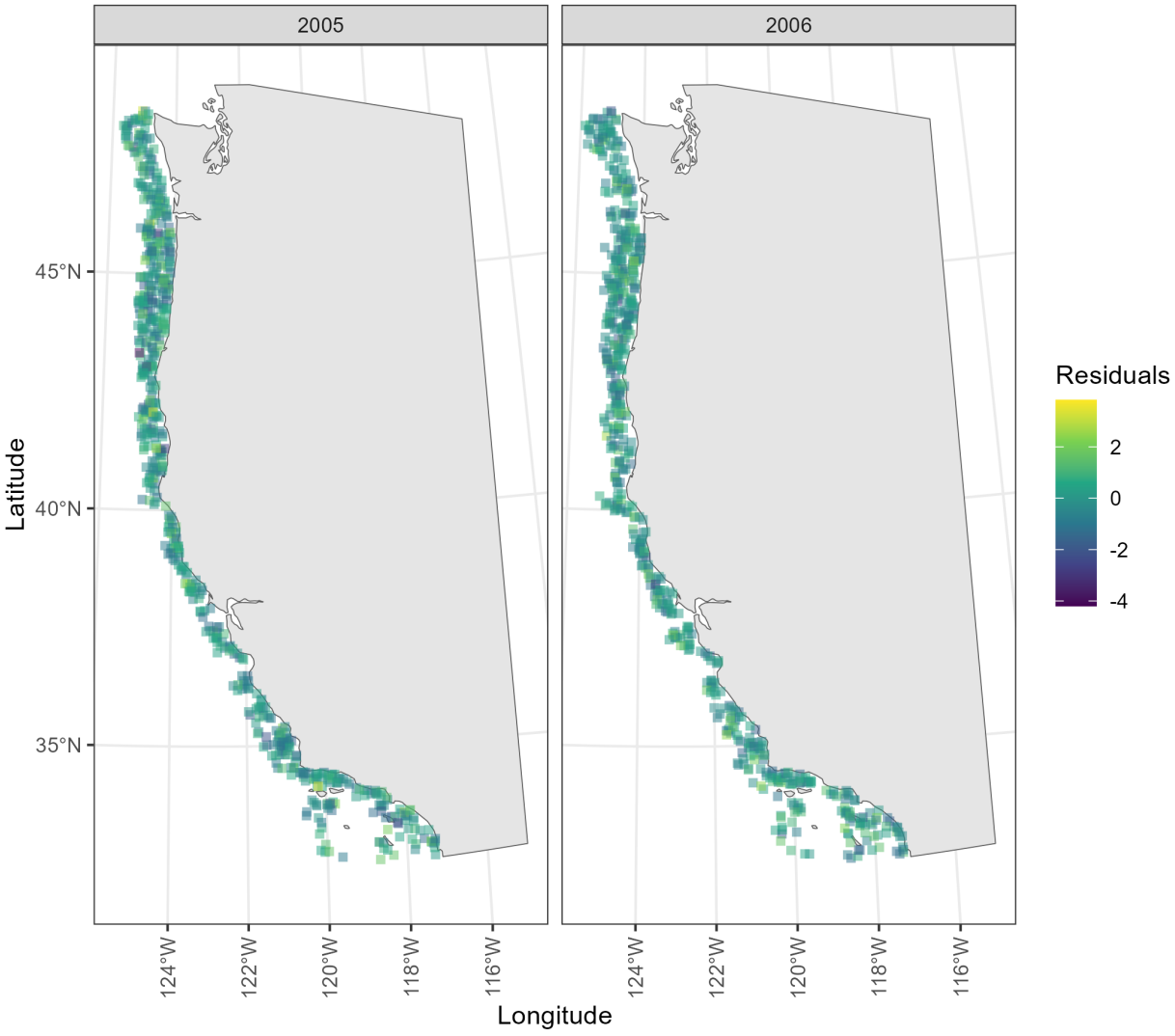
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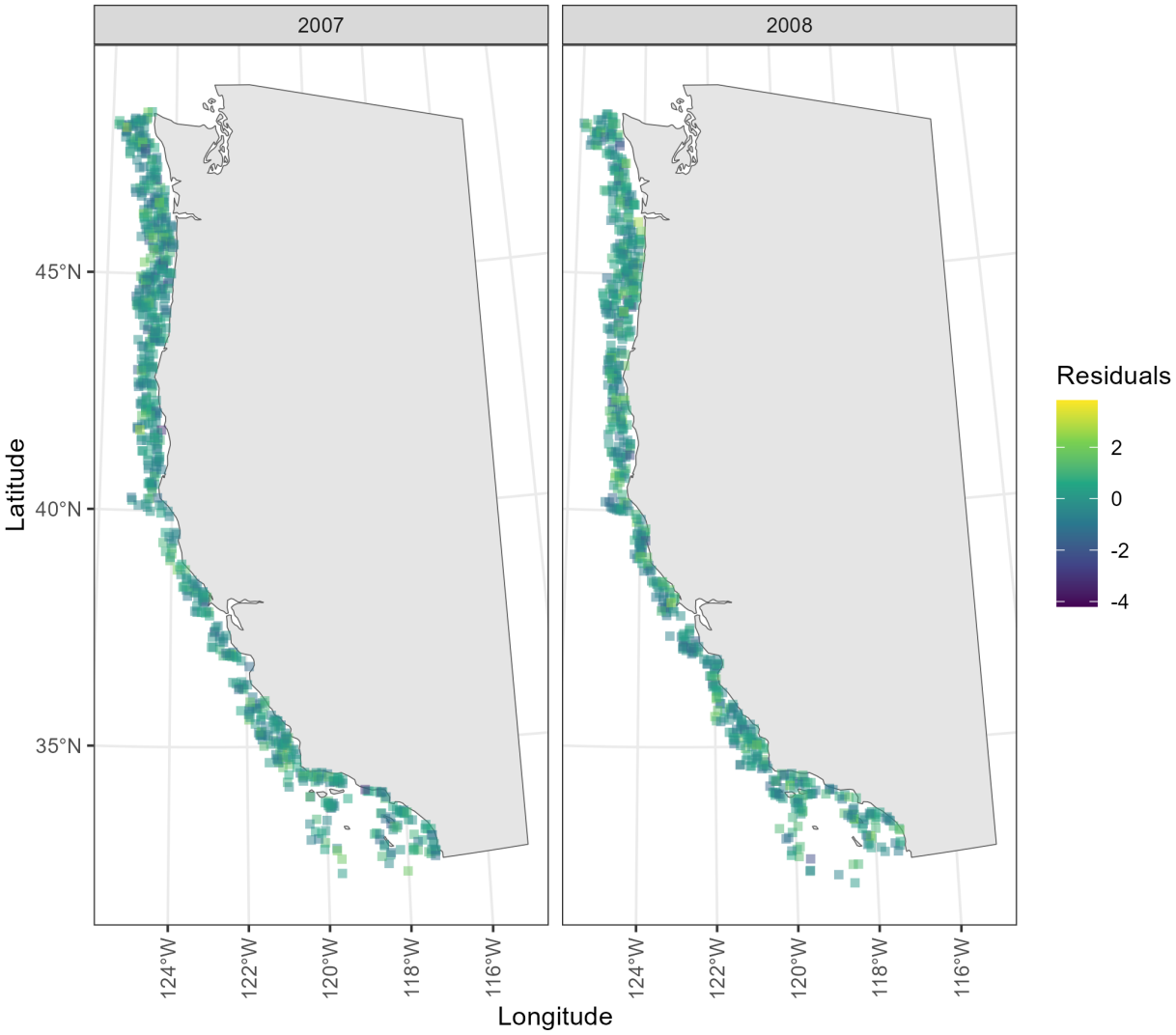
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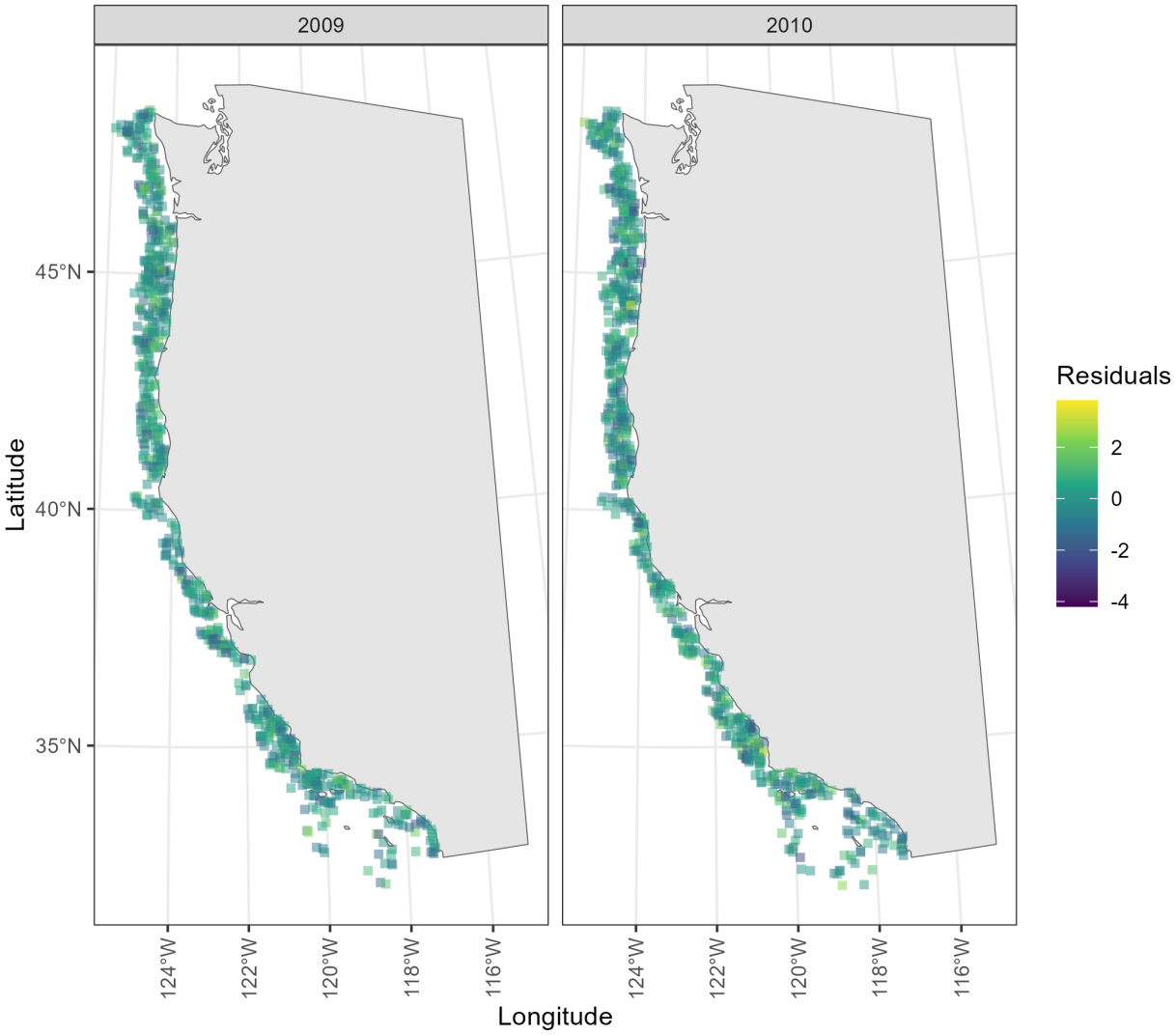
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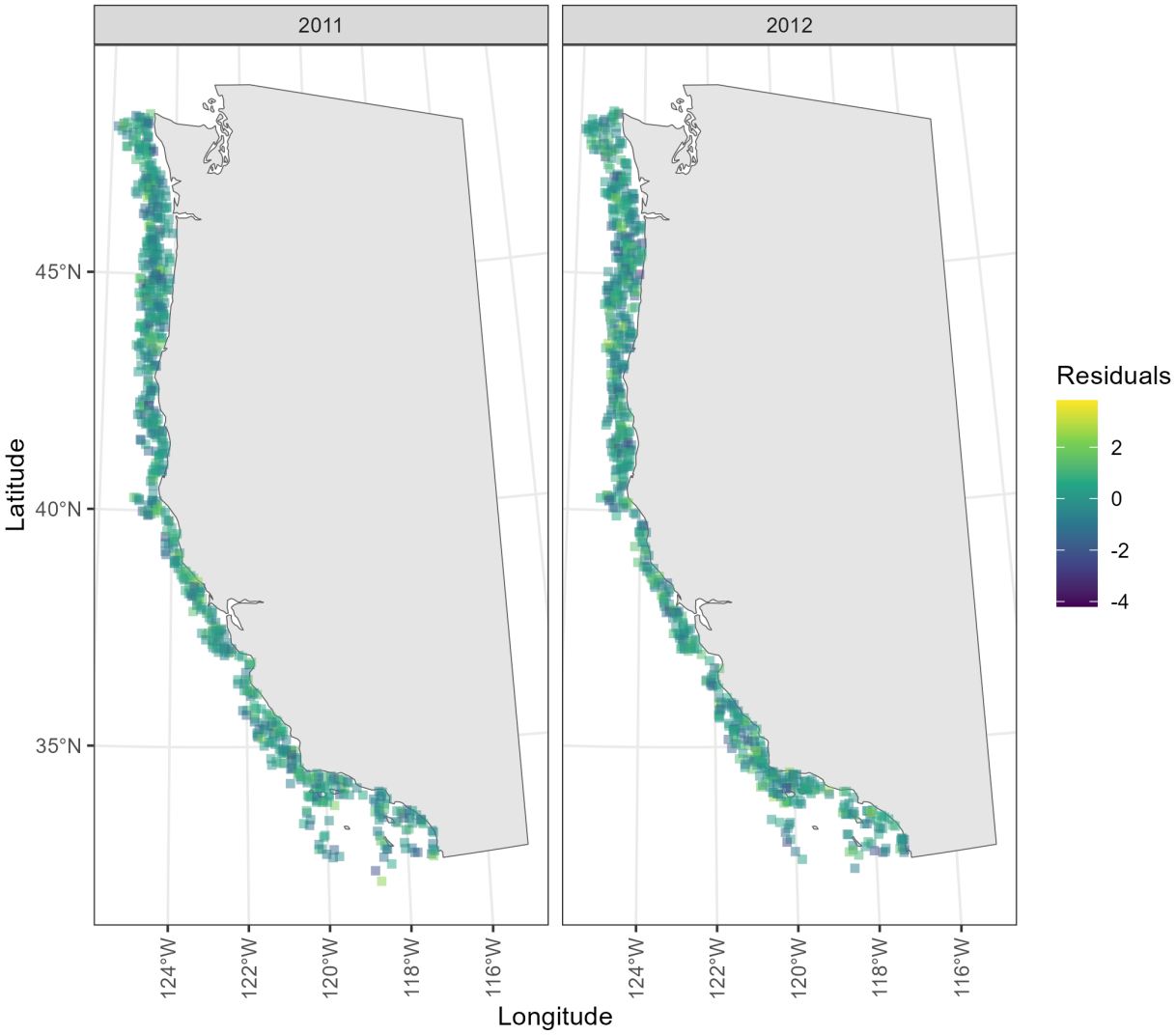
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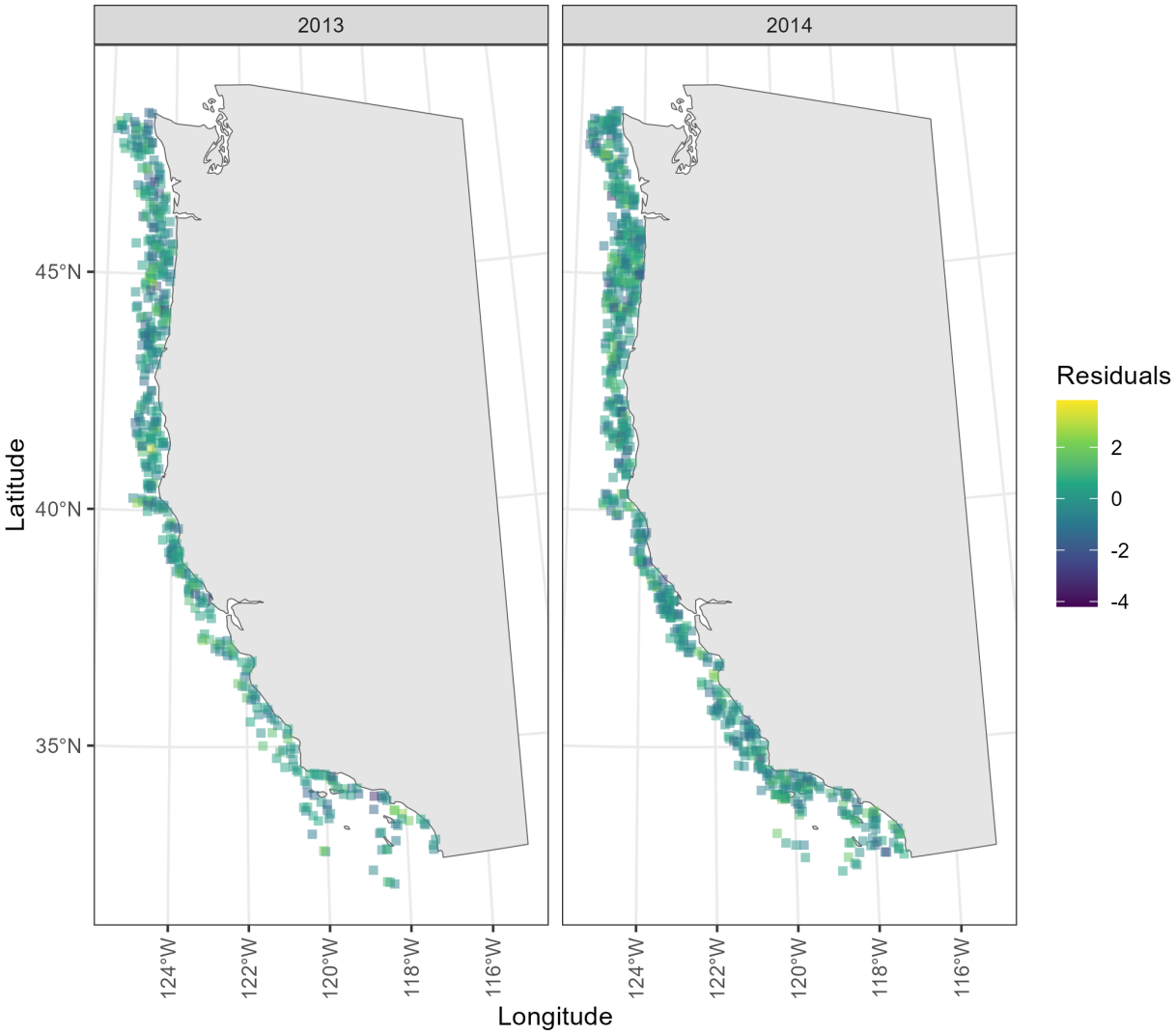
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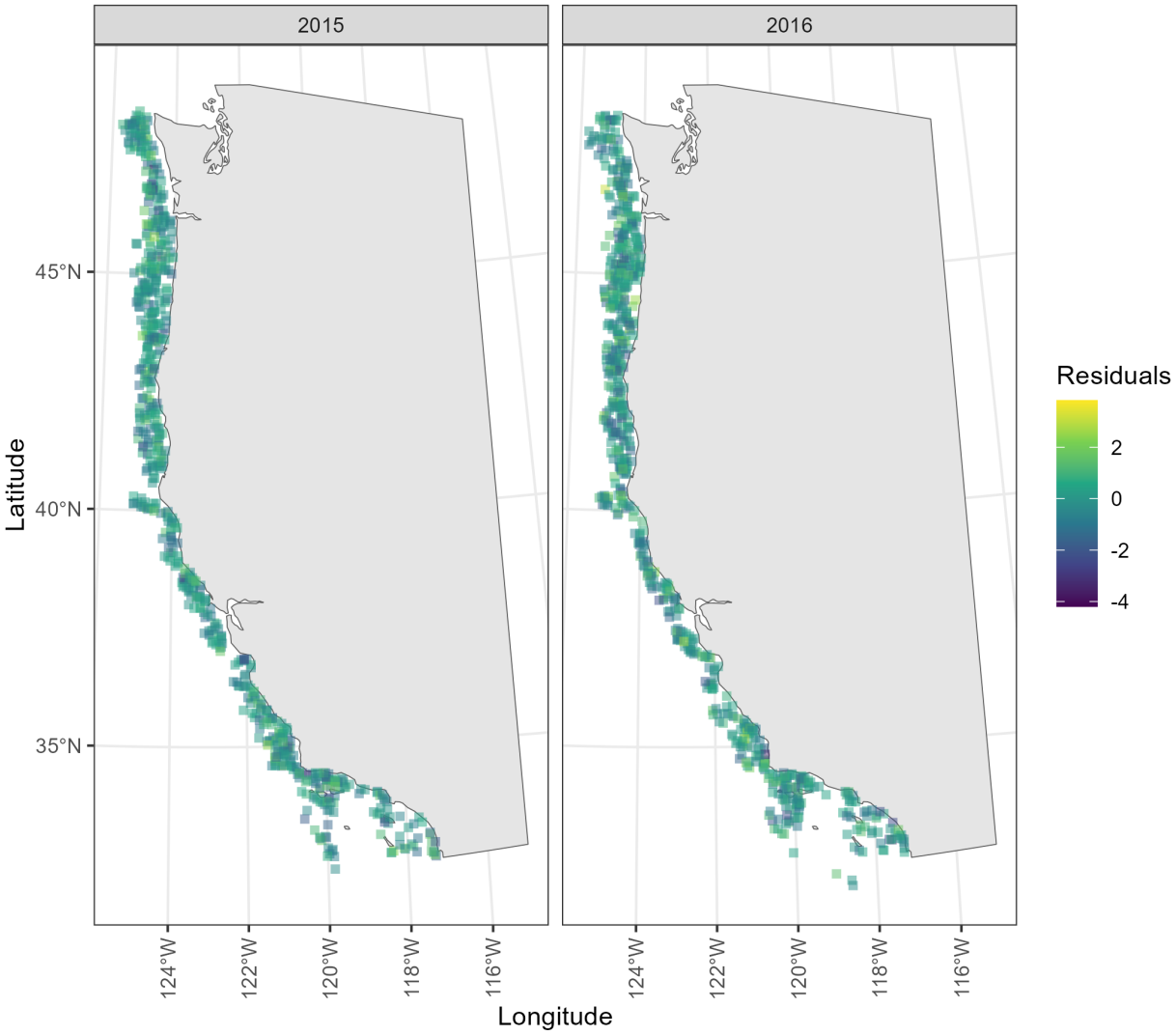
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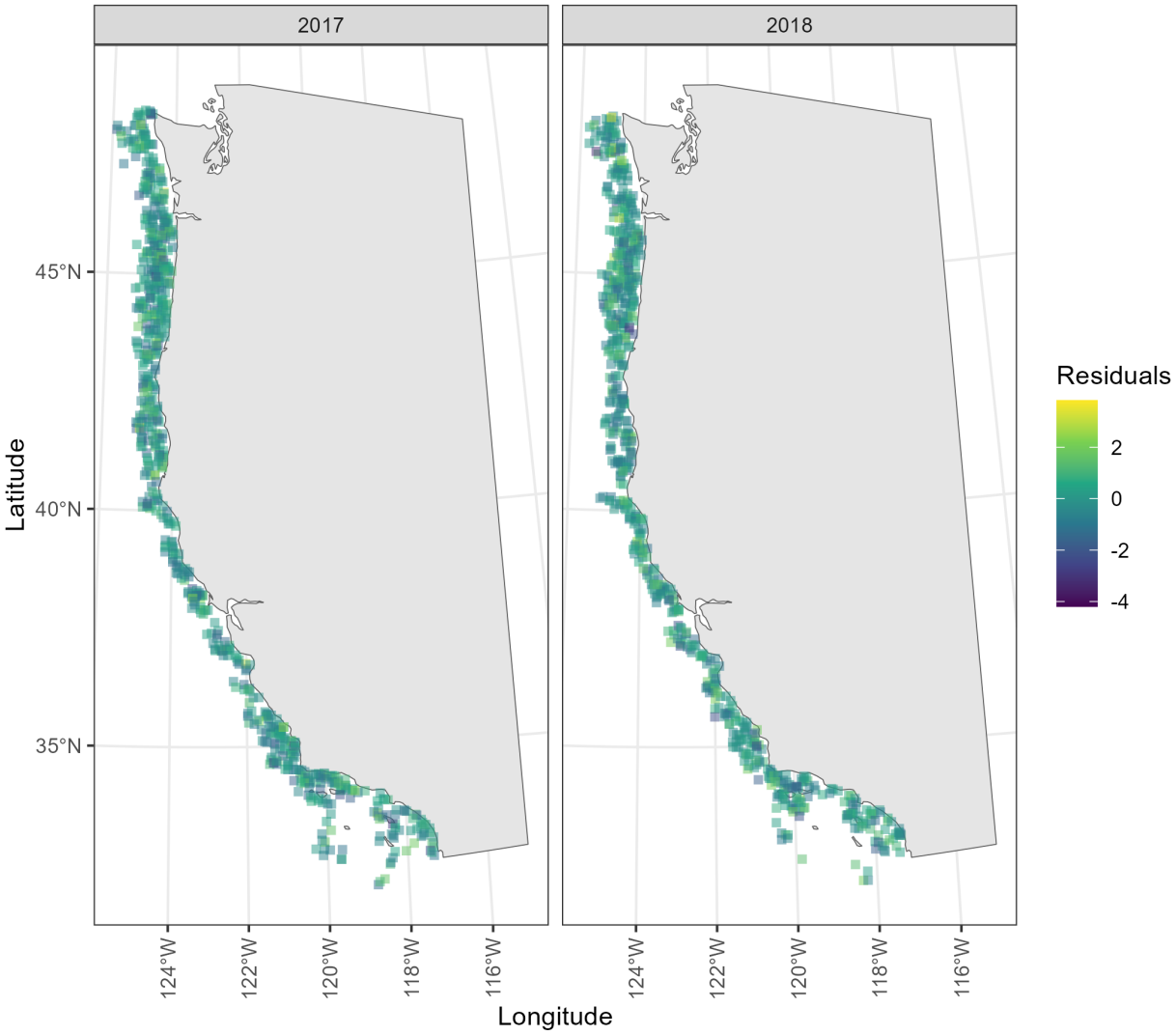
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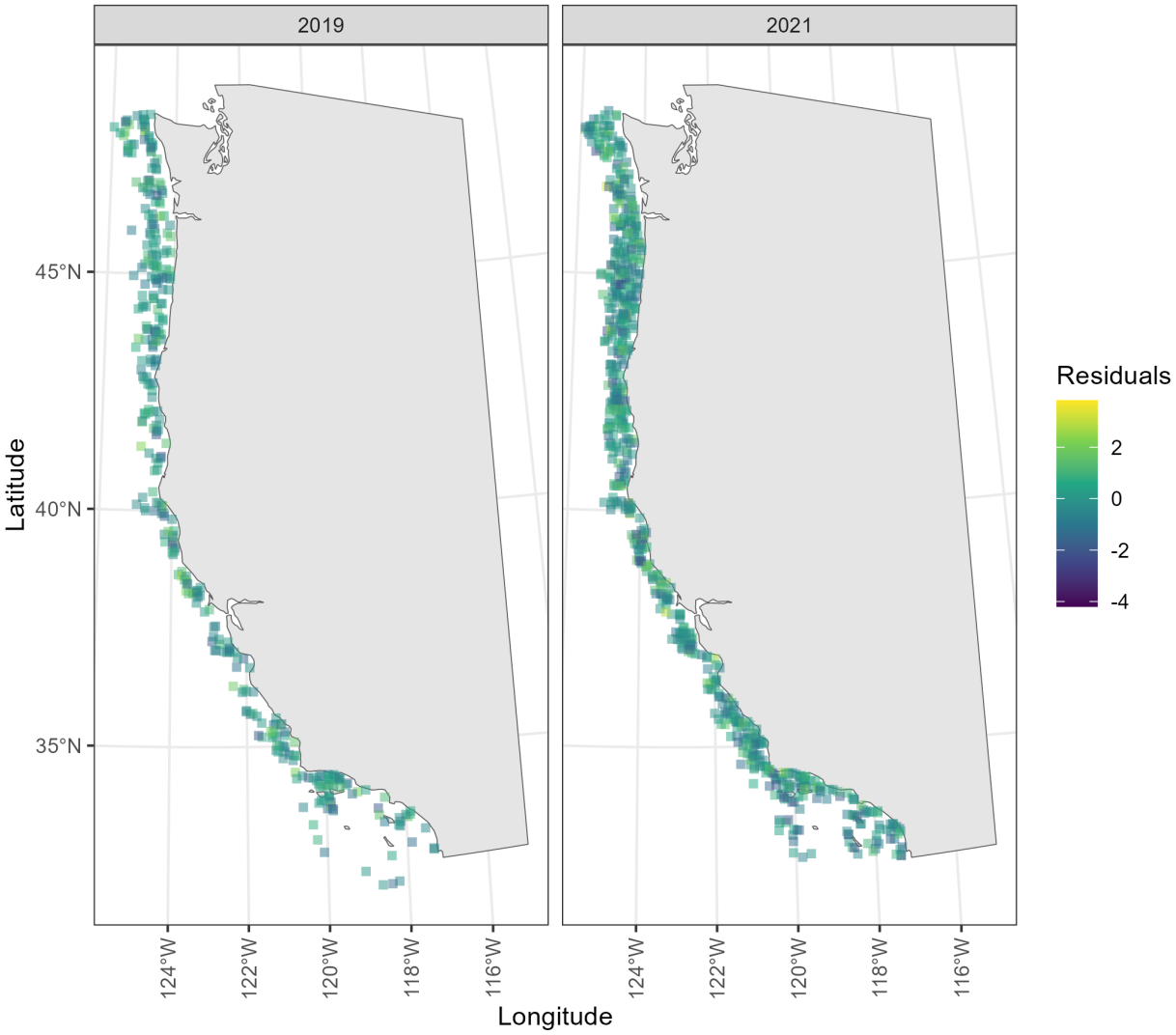
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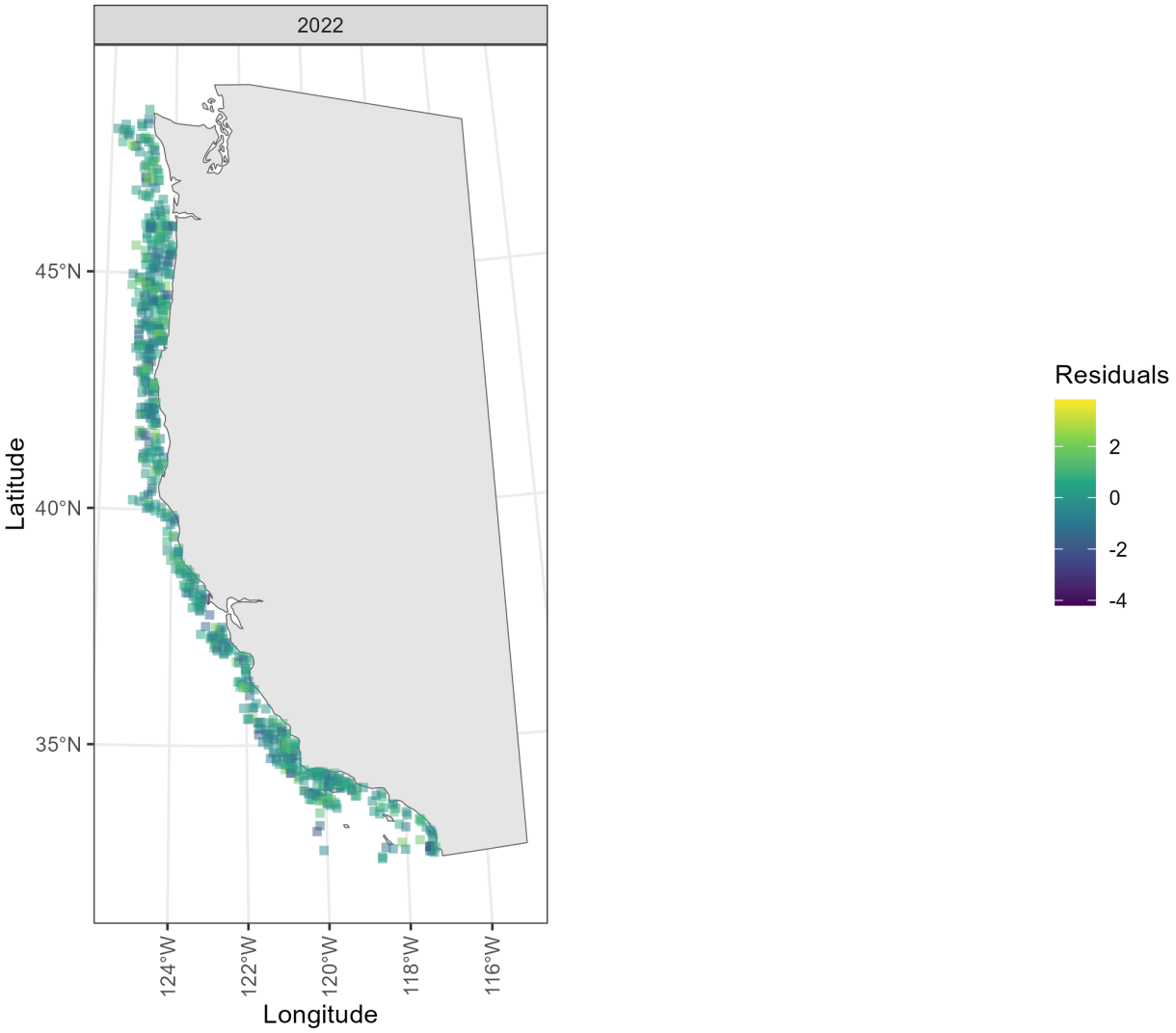
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Residuals
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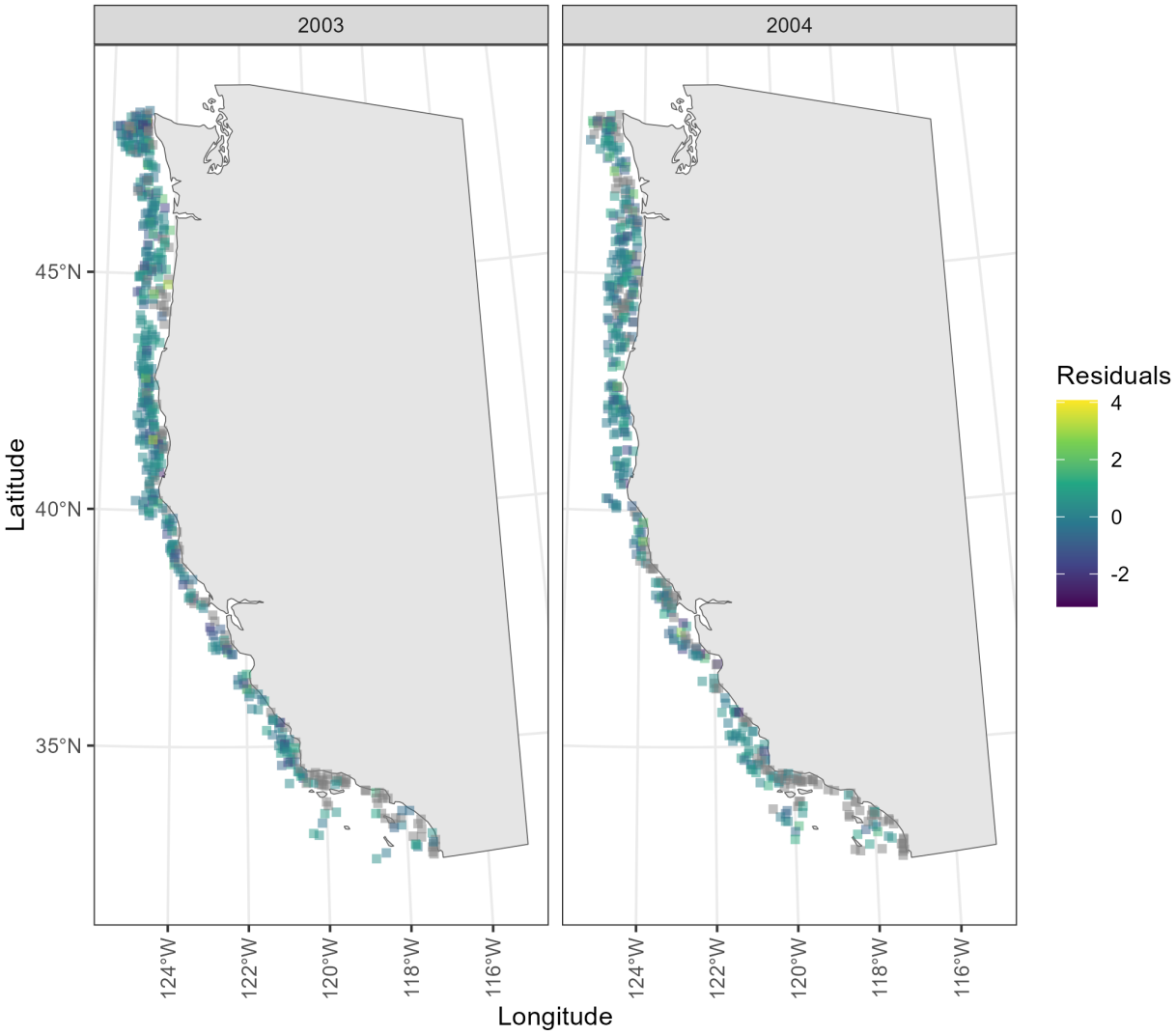
Residuals from the catch-rate model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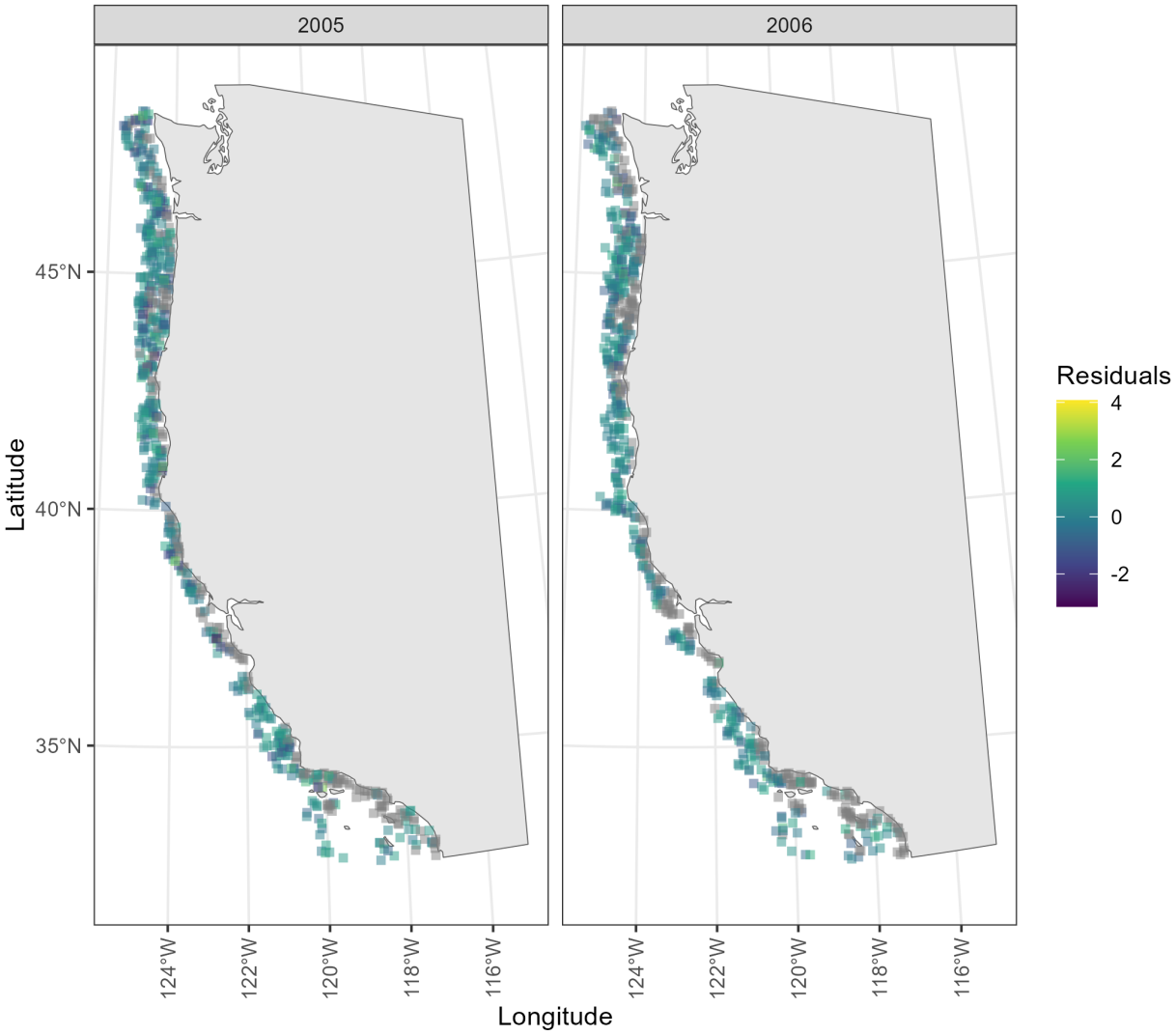
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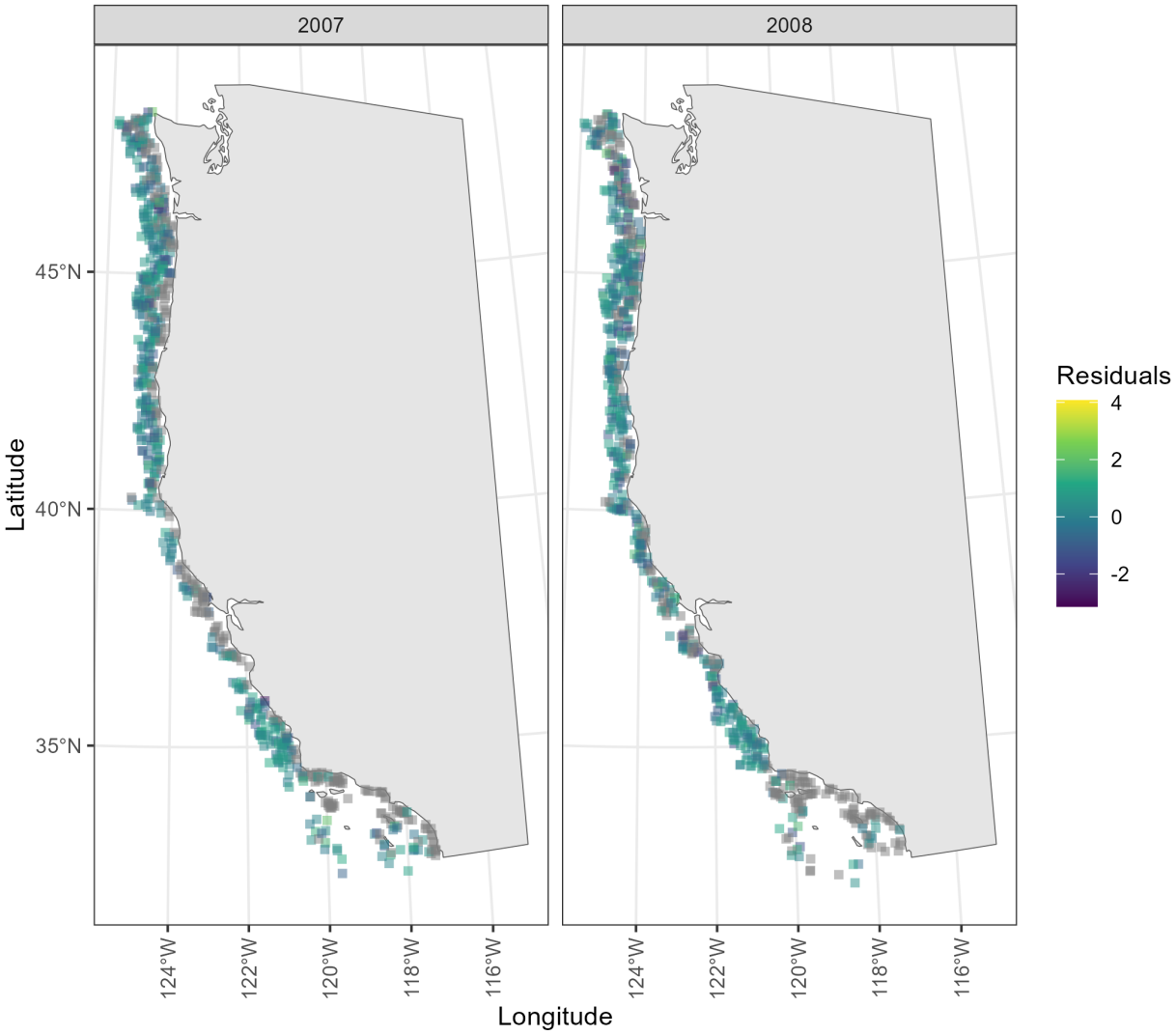
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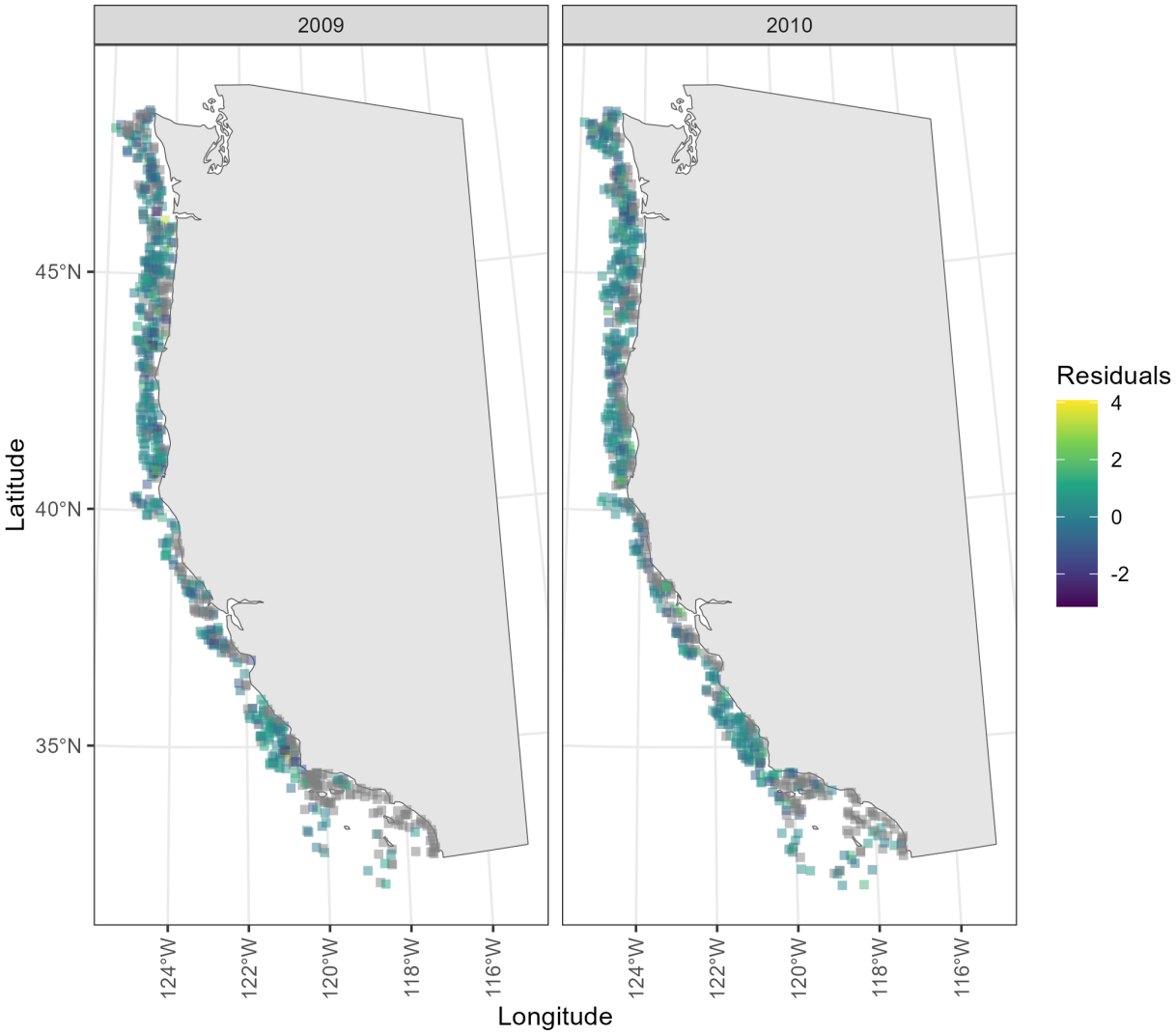
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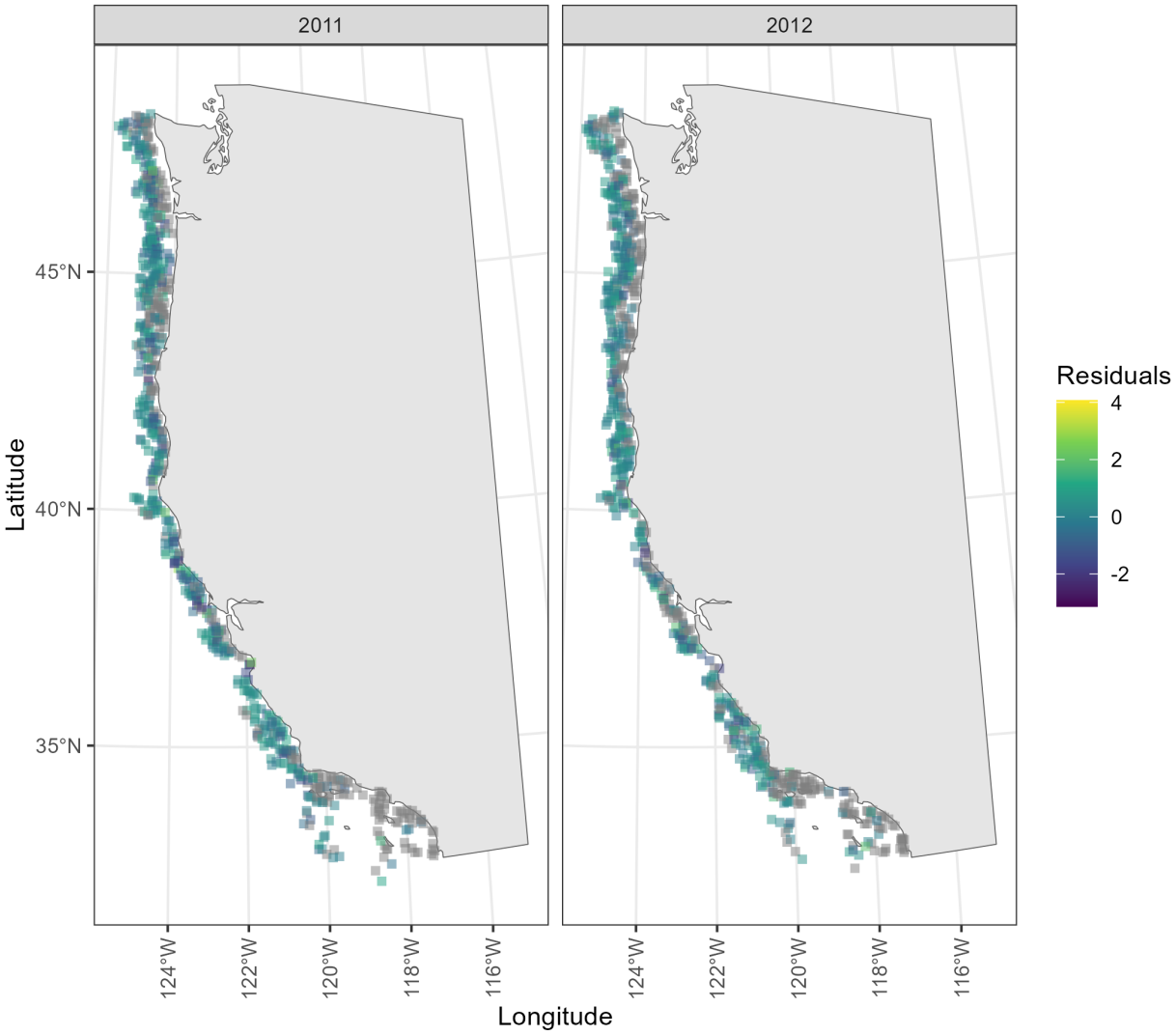
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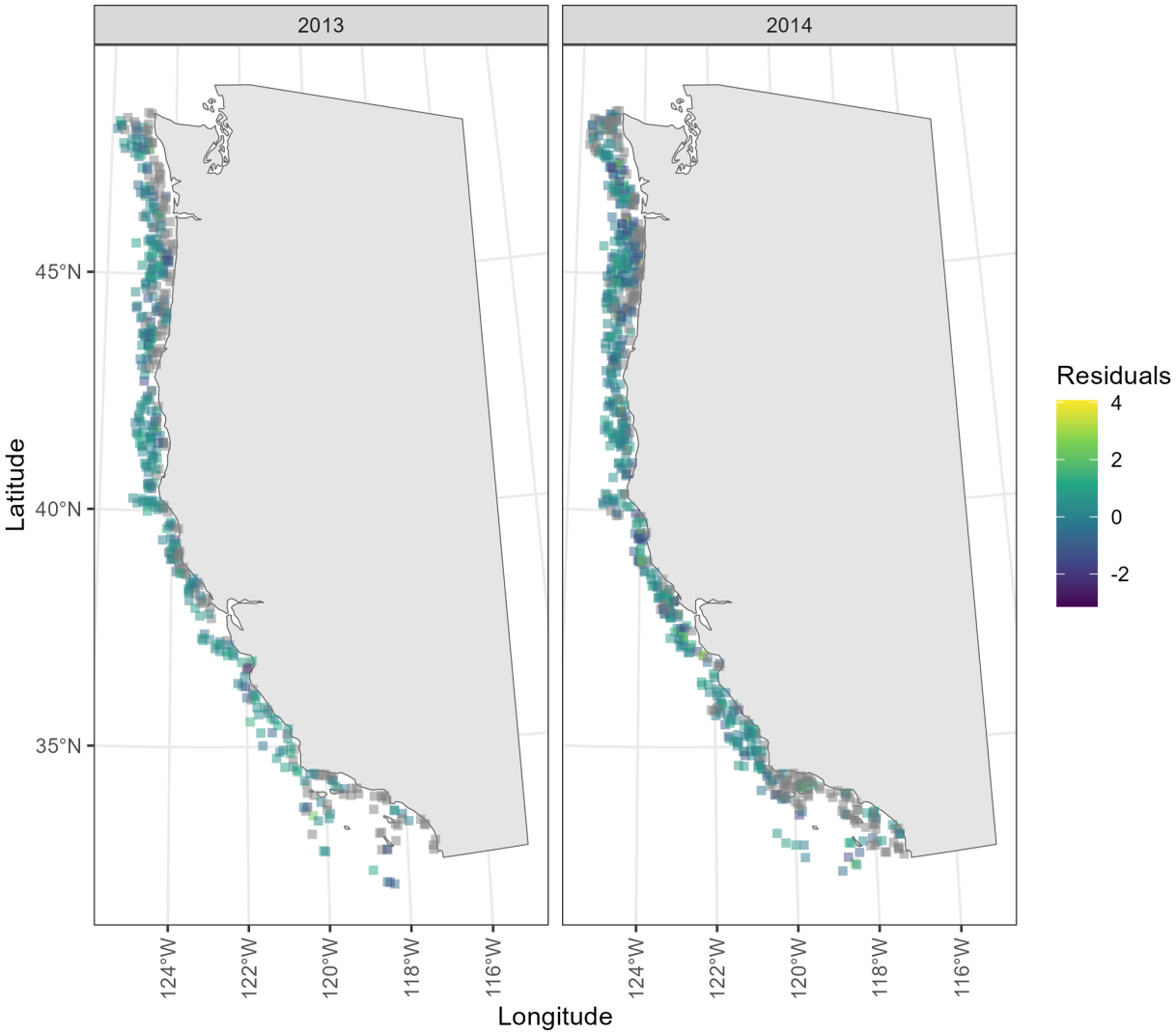
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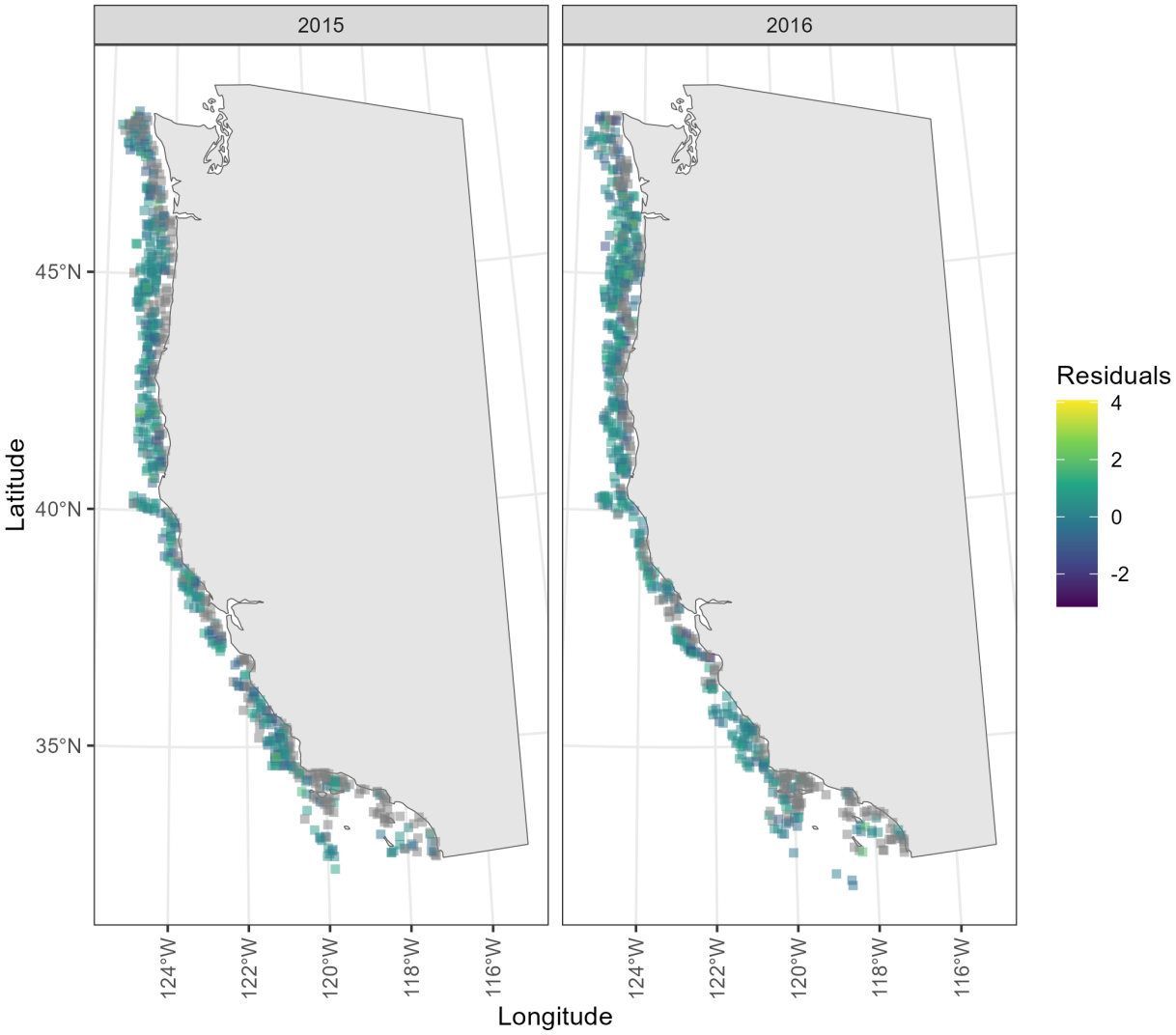
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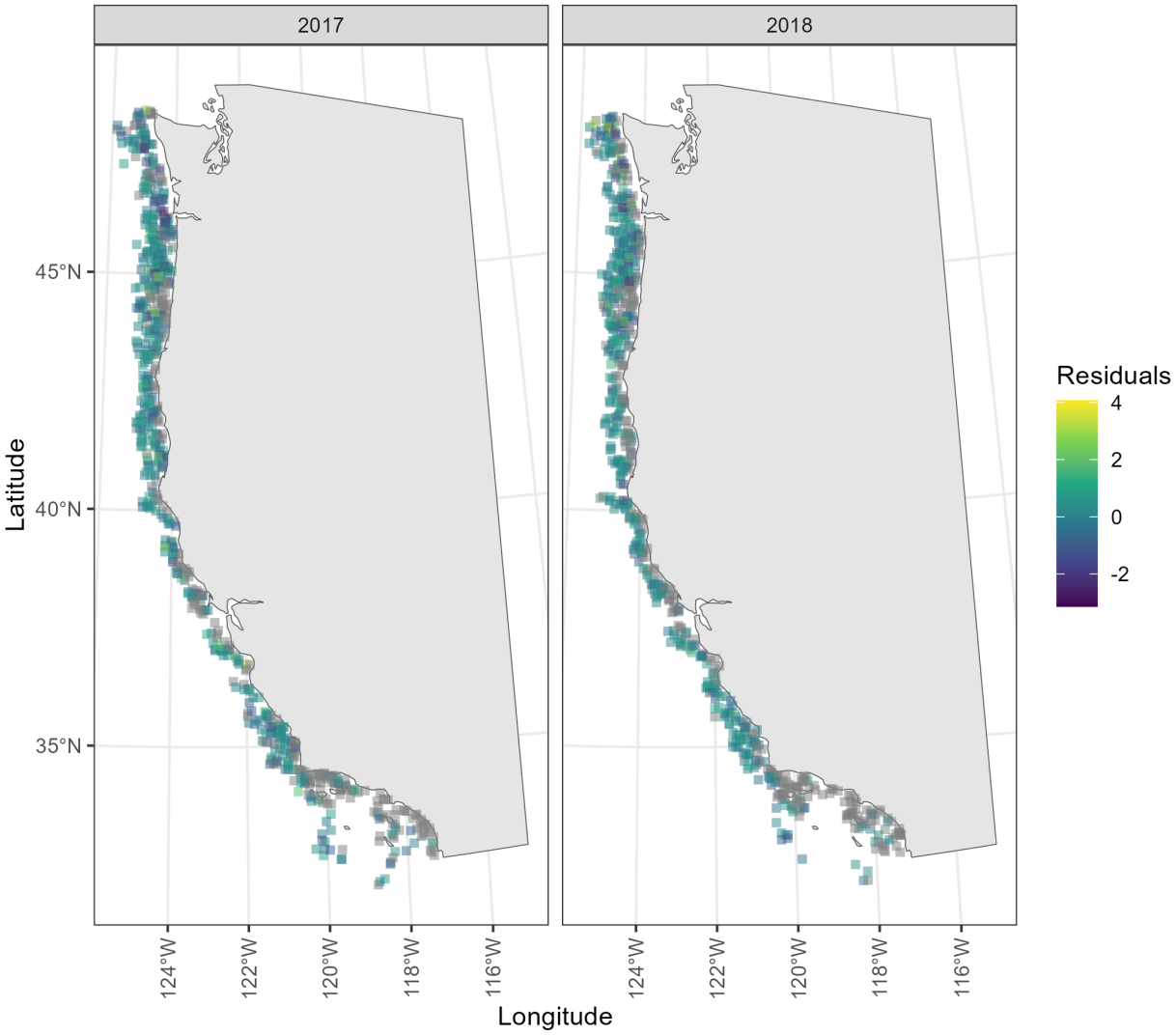
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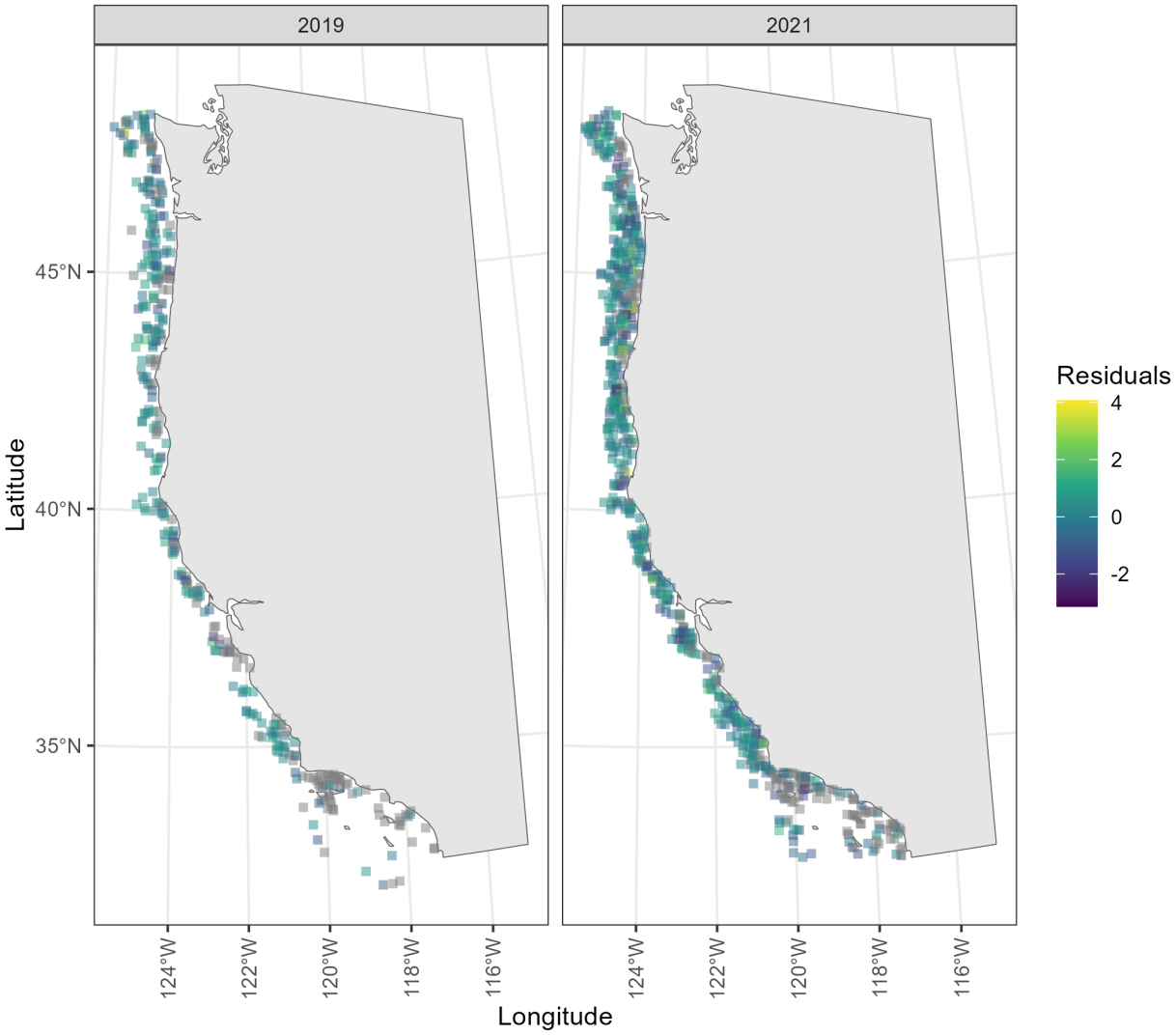
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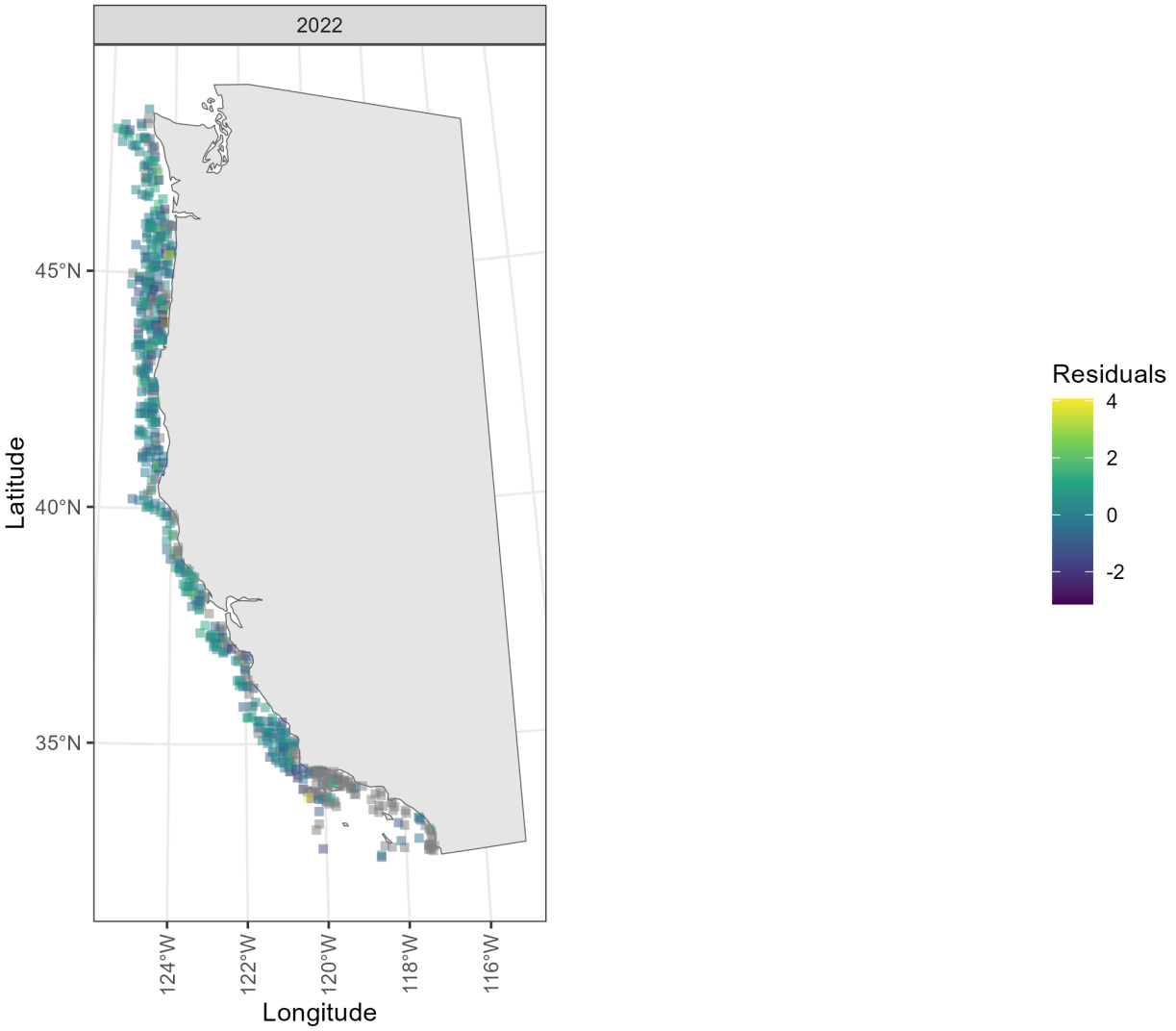

References

Anderson, Sean C., Eric J. Ward, and Philina A. English, and Lewis A. K. Barnett. 2022. "sdmTMB: An R Package for Fast, Flexible, and User-Friendly Generalized Linear Mixed Effects Models with Spatial and Spatiotemporal Random Fields." *bioRxiv* 2022.03.24.485545. https://doi.org/10.1101/2022.03.24.485545.

Helser, T. E., A. E. Punt, and R. D. Methot. 2004. "A Generalized Linear Mixed Model Analysis of a Multi-Vessel Fishery Resource Survey" 70: 251–64.

Kristensen, Kasper, A. Nielsen, Casper W Berg, H. J. Skaug, and B. M. Bell. 2016. "TMB: Automatic Differentiation and Laplace Approximation." *Journal of Statistical Software* 70: 1–21.

Thorson, James T., and Eric J. Ward. 2014. "Accounting for Vessel Effects When Standardizing Catch Rates from Cooperative Surveys." *Fisheries Research* 155 (July): 168–76. https://doi.org/10.1016/j.fishres.2014.02.036.

Thorson, J. T., A. O. Shelton, E. J. Ward, and H. J. Skaug. 2015. "Geostatistical Delta-Generalized Linear Mixed Models Improve Precision for Estimated Abundance Indices for West Coast Groundfishes." *ICES Journal of Marine Science* 72 (5): 1297–1310. https://doi.org/10.1093/icesjms/fsu243.