Standardized Catch Per Unit Effort Indices for Bottomfish Management Unit Species of Guam, 1982–2023

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Executive Summary

This technical memo documents the standardized catch per unit effort (CPUE) of the bottomfish management unit species (BMUS) of Guam based on the Guam Department of Agriculture, Division of Aquatic and Wildlife Resources boat-based creel survey. CPUE indices for 1982–2023 are presented for 11 of the 13 Guam BMUS: *Aphareus rutilans*, *Caranx ignobilis*, *C. lugubris*, *Etelis coruscans*, *Lethrinus rubrioperculatus*, *Lutjanus kasmira*, *Pristipomoides auricilla*, *P. filamentosus*, *P. flavipinnis*, *P. zonatus*, and *Variola louti*. There were insufficient data to produce standardized CPUE indices for the remaining two BMUS, *E. carbunculus* and *P. sieboldii*. We followed the delta-type modeling approach that assumed the overall expected catch per boat-based survey interview of a given BMUS is the product of two independent processes: the probability of occurrence (the presence/absence process) and the CPUE given the species occurred in the interview (the positive process). Each process was modeled with a mixed-effect general additive model and included covariates for area, time of year, and vessel. Additional covariates that could affect catch independently of changes in stock abundance were also explored using forward stepwise model selection, including time of day, type of day, charter status, bottomfishing type, total fishing effort, wind speed and direction, and moon phase. The selected models explained between 21% and 68% of deviance in the data and most often included bottomfishing type and total fishing effort. The CPUE indices presented in this technical memo all show high interannual variability and wide confidence intervals, which may be due partially to overall small sample sizes and high observation error of the Guam boat-based creel survey. However, these indices represent continued improvement in CPUE standardization approaches for the assessment of BMUS of Guam and may be used in the upcoming single-species benchmark stock assessments.

Introduction

The Bottomfish Management Unit Species (BMUS) of Guam include 13 species of snappers, jacks, and a grouper that are managed in federal waters by the Western Pacific Regional Fishery Management Council (WPRFMC) under the Fishery Ecosystem Plan (FEP) for the Mariana Archipelago (FEP; WPRFMC, 2009). This working paper is one of four documents prepared ahead of an external review which was conducted in July 2024 as part of the Western Pacific Stock Assessment Review (WPSAR). Its purpose is to review data that will be used in benchmark stock assessments of Guam BMUS. Previous stock assessments of the BMUS have been conducted on the aggregate multi-species complex, most recently in the 2019 benchmark stock assessment (Langseth et al., 2019), which was updated in 2024 (Bohaboy & Matthews, 2024). For the upcoming BMUS benchmark assessment, single-species assessments will be considered, which greatly increases the amount and complexity of data and modeling analyses to present and review. This report documents the standardized catch per unit effort (CPUE) indices for each of the BMUS of Guam, and is accompanied by reports on species-specific catch, length, and life history data.

Methods

Catch Data

The Guam Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR) has conducted a boat-based creel survey (BBS) since 1982. The survey uses a stratified design to estimate total catch from boat fishing across Guam and is fully documented in Jasper et al. (2016) and summarized in Matthews & Bohaboy (2024). The BBS includes fisher interviews for which DAWR staff visit the main landing points of Guam and speak with fishers to collect trip-level information, including fishing effort (hours fished, number and types of fishing gear, number of fishers/people on board, and whether the trip was chartered), locations fished (Figure 1), and catch. Catch information includes total catch per species in numbers and weight (which may sometimes be estimated) and may also include individual fish length or weight observations.

We downloaded 1982–2023 BBS interview records from the Guam SQL-server Datawarehouse curated by the Western Pacific Fisheries Information Network (WPacFIN) on 1 May 2024. We only used interviews with reported fishing method of bottomfishing and minimally filtered the interview set to remove incomplete records and records containing values suggestive of a possible data entry or sampling error, leaving 6,062 total interviews. CPUE was calculated as catch per trip; trip duration and fishing intensity, recorded as hours fished and number of fishers or gears, were investigated within the standardization models as possible covariates.

In the BBS, catch is occasionally recorded using common name groups or families. There are nine such groupings that may contain BMUS: shallow bottomfish, assorted bottomfish, deep bottomfish, Lethrinidae, deep snappers, Carangidae, Lutjanidae, Serranidae, and shallow snappers. When estimating total catch from the BBS, the unidentified catch within these groups was allocated into presumptive component species following the approach detailed in Matthews & Bohaboy (2024). However, for producing the standardized CPUE index, unidentified catch from groups was not allocated to presumptive species at the interview level because doing so would inflate the occurrence of each species by adding a small amount of catch to each interview that recorded groups that could include the species. For example, in 1985, there were 36 interviews that recorded *L. kasmira* and 37 interviews that recorded shallow bottomfish, but did not identify *L. kasmira*. The species composition of the shallow bottomfish encountered in these 37 interviews is unknown but, based on DAWR catch identification practices, could include *L. kasmira* as well as 39 other species of jacks, emperors, snappers, butterfishes, scorpaenids, and small groupers. Allocating 2% of recorded catch of shallow bottomfish in every interview to *L. kasmira* (the proportion of shallow bottomfish recorded in 1985 presumed to be *L. kasmira*, by weight) would double the number of interviews positive for *L. kasmira* in 1985. It would also likely introduce false occurrences to the set of interviews used for the CPUE standardization. Similarly, assuming no species-level decomposition of shallow bottomfish would be classifying these 37 interviews as negative for *L. kasmira*, which would also introduce bias into the data set. We chose instead to exclude these 37 interviews used for the *L. kasmira* CPUE index. When preparing the interview sets for the CPUE standardization of each individual BMUS, we excluded those containing unidentified groups that could include the particular BMUS (Table 1).

The 2019 benchmark and 2024 update stock assessments used a standardized CPUE index for aggregate BMUS. As a result, allocating unidentified group catch into presumed BMUS introduced less positive bias to the occurrence data because, in aggregate, the 13 BMUS were well represented in unidentified groups.

Table 1. Species groups that indicated the exclusion of an interview from data set used in the catch per unit effort (CPUE) standardization analysis for each bottomfish management unit species (BMUS) in Guam.

BMUS	Unidentified groups								
	Assorted bottomfish	Shallow bottomfish	Deep bottomfish	Shallow snappers	Deep snappers	Carangidae	Lethrinidae	Lutjanidae	Serranidae
A. rutilans	x		x		x			x	
C. ignobilis	x	x				x			
C. lugubris	x	x				x			
E. carbunculus	x		x		x			x	
E. coruscans	x		x		x			x	
P. auricilla	x		x		x			x	
P. filamentosus	x		x		x			x	
P. flavipinnis	x		x		x			x	
P. sieboldii	x		x		x			x	
P. zonatus	x		x		x			x	
L. rubrioperculatus	x	x					x		
L. kasmira	x	x						x	
V. louti	x	x							x

Modeling Approach

CPUE standardization was performed on each BMUS individually. The proportion of interviews where a given BMUS was not caught (absence) ranged from 0.73 for the most commonly encountered BMUS, *L. rubrioperculatus*, to 0.99 for the most rarely recorded BMUS, *P. sieboldii*. Because there were high numbers of zero-catch (absence) observations in the data and the units of CPUE were continuous values of weight per trip, we used a delta-type modeling approach in the CPUE standardization. The approach assumed the overall expected CPUE of a given BMUS is the product of two independent processes: the probability of occurrence (the presence/absence process) and the catch weight per trip, given the species occurred in the interview (the positive process).

The probability that a given BMUS was present in the interview, *p*, was modeled as a function of a set of independent covariates (X_p) and parameters (θ_p, see Covariates and Model Selection) and was assumed to follow a binomial error distribution using a logit link function (eq. 1).

$$p = \frac{e^{f(X_p,\theta_p)}}{1 + e^{f(X_p,\theta_p)}} \qquad \text{eq. 1}$$

The positive process modeled the natural logarithm of the CPUE in kg per trip, following a gaussian error distribution and used an identity link. Hence, the CPUE given a non-zero catch (*c*) was modeled as a function of a set of independent covariates (X_c) and parameters (θ_c, see Covariates and Model Selection) (eq. 2).

$$c = e^{f(X_c \theta_c)} \qquad \text{eq. 2}$$

The functional form of the covariates for each process, $f(X_p,\theta_p)$ and $f(X_c,\theta_c)$, was a general additive model (GAM), fit using the gam() function in R package ‘mgcv’ (Wood, 2019). For BMUS and processes with sufficient interviews, vessel identification was added as a random intercept term after covariate selection was complete. Covariates were included in the models as categorical, linear, or smooth terms using cyclic cubic regression splines. Cyclic cubic regression splines were penalized to ensure model effects for minimum and maximum values matched, e.g., 0 and 1 for moon phase, 0 and 366 for time of year, and 0 and 360 for wind direction. The dimension of the basis (e.g., maximum number of knots) for all smooth terms was from 6–8.

Covariates and Model Selection

We compiled time series of data for variables that we expected to affect catch independently of changes in stock abundance. All covariate data were either taken from BBS interview records or publicly available data sources. Year, time of year, and area were included a priori in all standardization models and were not subject to selection. Time of year was modeled in the GAMs as a cyclic cubic regression spline, with a value ranging from 1 (i.e., January 1) to 365 or 366 (i.e., December 31 in normal or leap years, respectively). Bottomfishing interviews included 36 unique offshore area codes (Figure 1), ranging in detail from specific location (e.g., 11 Mile Bank, Area 14 offshore of Agana) to relatively undefined fishing locations such as quadrants (e.g., "Southwest") and cardinal directions from Guam (e.g., "North"). We included area as a categorical variable by grouping offshore area codes into five larger areas: the northern banks (45 Degree and Rota), the southern banks (11 Mile, Galvez, Baby, Santa Rosa, and White Tuna), the eastern side of Guam (offshore area codes 31, 32, 50–52), the northwestern side of Guam (offshore area codes 10–16), and the southwestern side of Guam (offshore area codes 69, 71–73). Conversations with fishers and preliminary data analyses suggested catch rates and fishing behaviors vary considerably between the banks and nearshore areas of Guam; hence, we had to exclude 456 interviews that were recorded only in the northeast or southwest quadrants (offshore area codes 30 and 70) because it is unknown whether these trips were conducted on the banks or nearshore areas. The cardinal directions of north, west, and south were also ambiguous because they could include banks or nearshore areas, so interviews recorded for offshore area codes 20, 40, 60, and 80 (N = 218 interviews) were also excluded. We included a random interaction between year and area when there were sufficient interviews to allow model fitting to accommodate possible differences in CPUE trends over time among areas.

We explored time of day as a categorical variable in the models with levels corresponding to quarters of the day (midnight until 6 am, 6 am until noon, noon until 6 pm, 6 pm until midnight). Type of day was explored in the CPUE standardization as a categorical variable with two values: weekday (Monday through Friday, excluding holidays) and weekend (Saturdays, Sundays, and holidays as determined within the BBS sampling protocol). Charter status (e.g., whether a fishing trip was for-hire, meaning the fishers on board would have been paying the boat owner/operator to be taken fishing) was evaluated as a two-level variable (yes/no). Charter fishing trips were previously excluded from the CPUE standardization of Guam BMUS during the 2019 benchmark stock assessment (Langseth et al., 2019). However, we chose to retain all charter trips in the data set and instead evaluate charter status within the standardization models because the number of interviews positive for individual BMUS, particularly the less common species, is far less than for all BMUS considered in aggregate. Therefore, by excluding charter trips, there would have been too few interviews to estimate CPUE for some BMUS in some years. We also considered the amount of effort per fishing trip which can be recorded in the BBS interview data as the length of time (hours) spent fishing, the number of fishers that were fishing, and the number of gears fished (although not clearly defined, a fishing line, regardless of the number of hooks per line, is considered a single gear).

Fishers may target different species of bottomfish by varying fishing practices such as where, when, and how they fish. For the 2019 benchmark stock assessment, bottomfishing interviews were filtered to exclude trips by fishers (identified by vessel) that did not have any history of catching BMUS or groups potentially containing BMUS. We instead chose to retain all bottomfishing interviews and account for the targeting behavior of fishers by the type of bottomfishing that was reported (shallow, deep, or mixed). There are no quantitative depth ranges established for these identifications, instead they roughly correspond to the types of bottomfishes a fisher may be targeting. For example, many fishers indicate when they are 'shallow' bottomfishing, they catch *C. ignobilis, C. lugubris*, *L. rubrioperculatus*, *L. kasmira*, and *V. louti*, whereas they often catch *A. rutilans*, and *Etelis* and *Pristipomoides* spp. while deep bottomfishing (Iwane et al., 2023). Interviews recorded as mixed within the BBS data describe fishing trips where the fishers engaged in both types of fishing; this was considered a third level of the type of bottomfishing variable.

The environmental variables we selected that may affect catchability of BMUS were moon phase, wind speed, and wind direction, which were all indicated by Guam fishers as important factors affecting bottomfishing (Iwane et al., 2023). Moon phase was assigned for each interview using the R package 'lunar' (Lazaridis, 2015) providing values between 0 and 1 which represent the beginning and end of the moon cycle (new moon), 0.25 represents the first quarter, 0.5 the full moon, and 0.75 the last quarter. Moon phase was considered as a cyclic cubic regression spline, penalized to ensure model effects for 0 and 1 were equivalent. Daily average wind speed (miles per hour; mph) and wind direction (origination of wind, degrees from north) for 1982–2023 were downloaded from the publicly available data set at visualcrossing.com, which was produced by combining multiple nearby meteorological monitoring stations to create the entire time series (Visual Crossing Corporation, 2024). Wind speed was considered as a linear term and wind direction was considered as a cyclic cubic regression spline, penalized to ensure model effects for 0 and 360 degrees were equivalent.

For BMUS and processes with sufficient interviews to allow for model minimization, vessel identification was added after covariate selection as a random effect to account for differences in fishers' skill which would be expected to vary over time in the CPUE standardization data set as more or less skilled fishers are represented in BBS interviews. BBS interviews include vessel identification information in terms of the boat registration number, name, or description. Of the covariates investigated in these analyses, vessel identification was the most computationally demanding for model fitting and most frequently missing information in BBS interviews, so it was considered last after all other covariates were added to the models. There were 1,515 unique vessel names recorded in bottomfishing interviews; however, after interviews attributed to ambiguous identifiers such as “white boat” and “unknown#” were eliminated and assumed duplicate values were standardized (e.g., “25,” “025,” “0025” were assumed to represent the same vessel/fisher), there were 1,450 unique vessels remaining in the data set.

Models were selected using a forward-stepwise approach. All perspective covariates were evaluated at each step. Models containing each candidate covariate were compared to the previous step using a chi-squared likelihood ratio test (Ott & Longnecker, 2001). The model with the lowest Akaike information criterion (AIC) value and a significant likelihood ratio chi-squared test statistic at alpha = 0.05 was retained at each step. Addition of covariates to each model continued only if the percent deviance explained relative to the intercept only (null) model was at least 1% greater than the percent deviance explained by the previous simplest model.

Table 2. Summary of covariates considered in the CPUE standardization of Guam BMUS.

Covariate name	Type of variable	Description in model: number of levels or range.	Included in model?	Notes / source
Year	categorical	42 (each year 1982–2023)	a priori	Recorded in interview.
Area	categorical	5 (E_banks, E_nearshore, NW, SW_banks, SW_nearshore)	a priori	Based on DAWR BBS offshore survey codes (Figure 1).
Year*area interaction	random interaction	42*5 year*area interactions, modeled as *iid* normal.	data permitting	
Time of year	cyclic cubic regression spline	2–365 (day of year)	a priori	Penalized to ensure modeled values of 0 and 366 were equal.
Vessel	random intercept	1,450 unique vessels, modeled as *iid* normal.	data permitting	
Time of day	categorical	4 (by quarter 0000–0600, 0600–1200, 1200–1800, 1800–0000)	if selected	Based on recorded time of interview.
Type of day	categorical	2 (weekday, weekend/holiday)	if selected	Recorded in interview.
Charter status	categorical	2 (charter, non-charter)	if selected	Recorded in interview.
Type of fishing	categorical	3 (deep, shallow, mixed)	if selected	Recorded in interview as "depth".
Hours fished per trip	linear	1–24	if selected	Recorded in interview.
Number of fishers per trip	categorical	6 (1, 2, 3, 4, 5, or 6+)	if selected	Recorded in interview.
Number of gears per trip	categorical	4 (1, 2, 3, or 4+)	if selected	Recorded in interview.
Moon phase	cyclic cubic regression spline	0–1 (new moon: 0 and 1, first quarter: 0.25, full moon: 0.5, last quarter: 0.75)	if selected	Determined by date using R package 'lunar' (Lazaridis, 2015). Penalized to ensure modeled values of 0 and 1 were equal.
Wind speed	linear	5.1–49.4 miles per hour (mph)	if selected	Daily average wind speed compiled from meteorological stations in Guam (Visual Crossing Corporation, 2024).
Wind direction	cyclic cubic regression spline	0.6–357.5 degrees from north	if selected	Daily average wind direction compiled from meteorological stations in Guam (Visual Crossing Corporation, 2024). Penalized to ensure modeled values of 0 and 360 were equal.

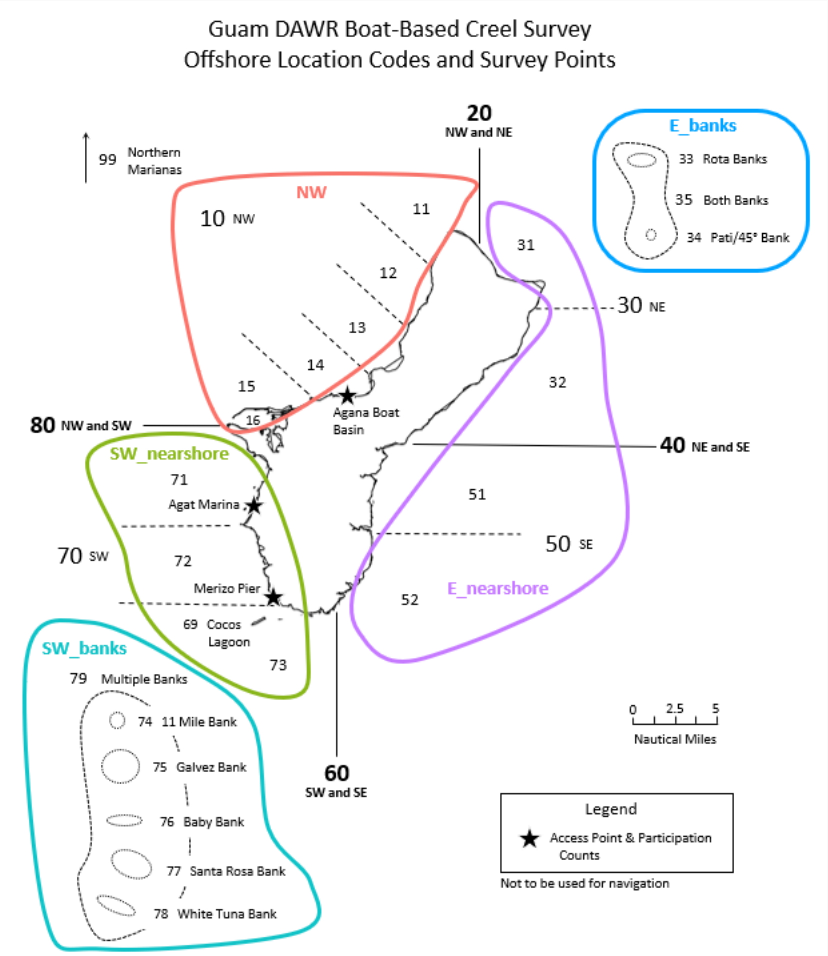

Figure 1. Guam Department of Agriculture and Wildlife Resources (DAWR) boat-based creel aurvey offshore location codes, grouped into 5 larger areas: the east/northeast banks (E_banks), the northwestern quadrant of Guam (NW), the southwestern nearshore areas (SW_nearshore), the south / southwestern banks (SW_banks), and the eastern nearshore areas (E_nearshore).

Index Generation

The probability of presence (*p*) and expected CPUE given positive catch (*c*), together with estimated 95% confidence intervals ($p \pm 1.96se_p$ and $c \pm 1.96se_c$) within the logit and natural log scales, were calculated from the selected models for all combinations of year (*y* from 1982 to 2023), month (*m* from 1 to *j*=12 months), area (*a* from 1 to k, where *k*=5 areas for all BMUS except *k*=3 for *Caranx ignobilis*), and for each BMUS (Walters, 2003). Values were backtransformed to the response scale using the inverse logit for the presence/absence process and exponentiating for the positive process (multiplied by $e^{0.5MSE}$ to account for bias correction where *MSE* is the mean squared error of the positive process; Brodziak & Walsh, 2013). An estimate of the square-root of the variance for each process (σ_p and σ_c), was calculated as the range of the backtransformed 95% confidence interval divided by 3.92. For each year, *y*, the expected probability of presence ($\bar{p}_y$) and CPUE given positive catch ($\bar{c}_y$) with associated estimates of variance ($\overline{\sigma^2}_{p,y}$ and $\overline{\sigma^2}_{c,y,}$) were calculated by averaging over *j* months and *k* areas:

$$\bar{p}_y = \sum_{m=1}^{j}\sum_{a=1}^{k}\frac{1}{j}p_m w_a p_{y,a} \qquad \text{eq. 3}$$

$$\overline{\sigma^2}_{p,y} = \sum_{m=1}^{j}\sum_{a=1}^{k}\frac{1}{j}\sigma^2{}_{p,y,m}w_a\sigma^2{}_{p,y,a} \qquad \text{eq. 4}$$

$$\bar{c}_y = \sum_{m=1}^{j}\sum_{a=1}^{k}\frac{1}{j}c_{y,m}w_a c_{y,a} \qquad \text{eq. 5}$$

$$\overline{\sigma^2}_{c,y} = \sum_{m=1}^{j}\sum_{a=1}^{k}\frac{1}{j}\sigma^2{}_{c,y,m}w_a\sigma^2{}_{c,y,a} \qquad \text{eq. 6}$$

This approach, sometimes referred to as “estimated marginal means” or “Walter’s large table” (Campbell, 2015), was used because the number of interviews for each area and time of year were not expected to be constant over the 42 years of the time series. In equations 3–6, areas were weighted by w_a , which was based on the relative amount of seafloor within either the 0–100 m or 100–400 m depth range (Figures 2–3), as indicated by the General Bathymetric Chart of the Oceans (GEBCO) 2023 global bathymetry 15 arc-second spatial resolution model (GEBCO Compilation Group, 2023). Either the 0–100 or 100–400 m depth range was used for each BMUS based on information provided by Guam fishers regarding where they catch each species (Iwane et al., 2023): 0–100 m was used for *Caranx* spp., *L. rubrioperculatus*, *L. kasmira*, and *V. louti*; 100–400 m was used for *A. rutilans*, *Etelis* spp., and *Pristipomoides* spp.

Months were calculated from time of year as the mid-point of each month for the purposes of index generation to reduce the size of the prediction grid (i.e., representing time of year by month in equations 3–6 resulted in *j*=12 levels within the prediction grid, instead of 365 or 366). For models that included random vessel effects, predictions were calculated assuming the central random effect of vessel, e.g., a vessel coefficient of zero, or the most typical fishing vessel. For all other covariates, median values across the data set were used for linear and smooth covariates, and mode values were used for categorical covariates.

Yearly mean probability of presence ($\bar{p}_y$) and expected CPUE given positive catch ($\bar{c}_y$), together with estimates of variance ($\overline{\sigma^2}_{p,y}$ and $\overline{\sigma^2}_{c,y}$), were combined following the approach of Goodman (1960) as described in Campbell (2015) to produce the final standardized CPUE indices ($CPUE_y$) in kg per trip and variance estimates ($\sigma^2_{cpue,y}$; equations 7 and 8).

$$CPUE_y = \bar{p}_y \times \bar{c}_y \qquad \text{eq. 7}$$

$$\sigma^2_{cpue,y} = \overline{\sigma^2_p} \times \overline{\sigma^2_c} + \overline{\sigma^2_p} \times \overline{c_y}^2 + \overline{\sigma^2_c} \times \overline{p_y}^2 \qquad \text{eq. 8}$$

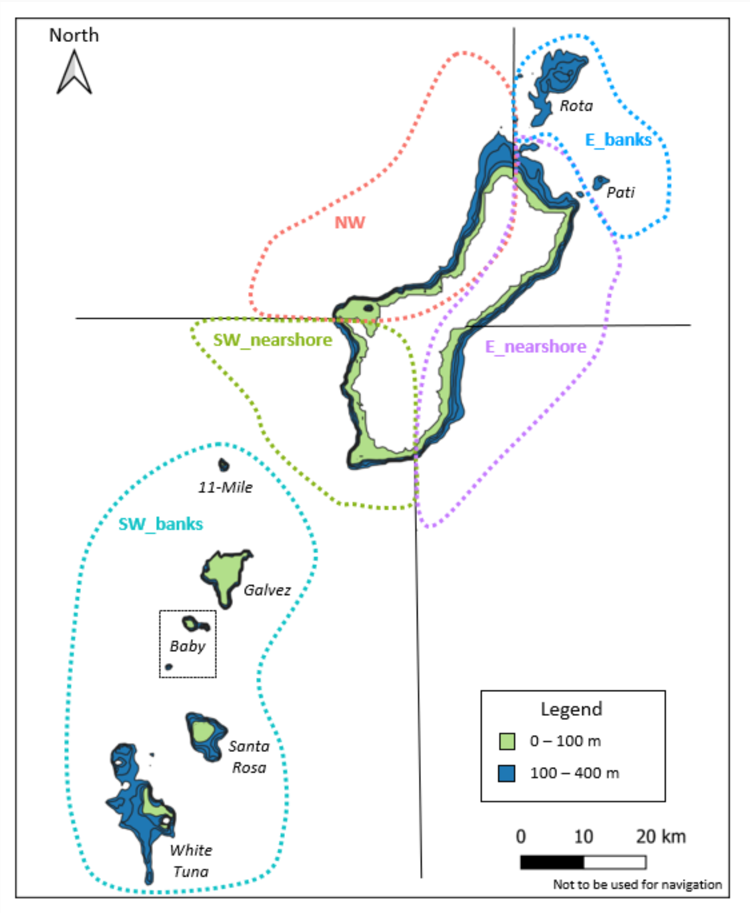

Figure 2. A map showing the relative amount of seafloor bottom, by 0–100 m and 100–400 m depth ranges for the five areas around Guam.

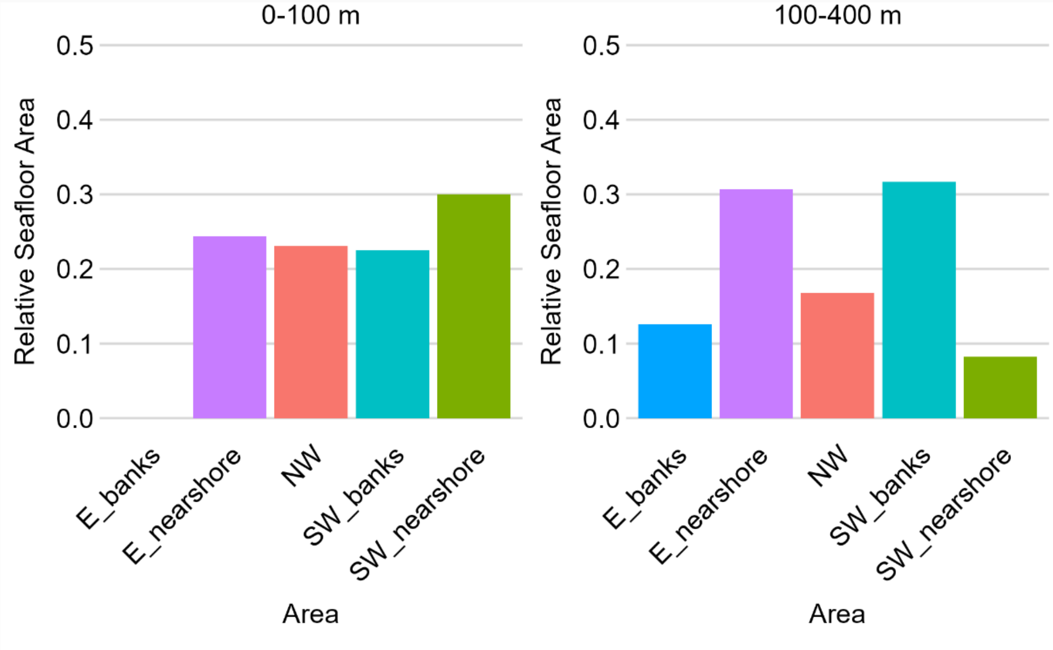

Figure 3. A barplot showing the proportion of seafloor area (w_a) for the five regions around Guam, by 0–100 m depth (left) and 100–400 m depth (right).

Model Diagnostics and Visualization

Residual distributions for each selected presence/absence and positive process model were examined to ensure model appropriateness. A predictive check was performed by simulating 50 data sets from each model (computed using R package ‘performance’; Ludecke, 2024) and visually comparing the density distributions of the simulations and the model input data.

We plotted the partial effects of each covariate within each model using the ggpredict() function from the R package ‘ggeffects’ (Ludecke et al., 2022). The partial effect is the effect of each level or value of the covariate on the response when all other variables in the model are held constant. For fixed-effect categorical covariates, the partial effects are proportional to the coefficient values for each level of the variable. We also plotted the number of BBS interviews for each level or value of the covariate by year to visualize variability or shifts in the number of observations (interviews) for a covariate over time. As described in the previous section, we accounted for any temporal variation in the number of interviews by area and time of year by including those variables in the calculated marginal means of the estimated CPUE indices. For all other covariates, we used influence plots following Bentley et al. (2012) to visualize the combined influence of the covariate effect and any trends or variability in the number of observations (interviews) for each level or values of the covariate over time. For a given covariate, this annual metric of relative influence can be summarized as the partial effects averaged over all observations within a year minus the partial effect averaged over all observations and years.

Results by BMUS

Aphareus rutilans

A. rutilans was moderately represented in the BBS, occurring in 6.1% of interviews over all years, ranging from 1–20 positive interviews per year (Figure 4). Data included five levels of area and year × area interaction for both the presence/absence and positive processes (Table 3). A random vessel effect was used for the presence/absence process only. The selected CPUE standardization models explained 31% and 41% of deviance in the data for the presence/absence and positive processes, respectively. Model residual diagnostics do not indicate any notable degree of overdispersion or heteroskedasticity (Figures 5–6), and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *A. rutilans*). CPUE was relatively higher on the east/northeast banks. Type of bottomfishing and trip duration had effects within the standardization models, suggesting species were more likely to be caught, and at higher catch rates during deep bottomfishing and longer duration fishing trips (Appendix, Supplemental Results for *A. rutilans*). Overall, there was no clear trend in the standardized CPUE of *A. rutilans* over time (Figure 7).

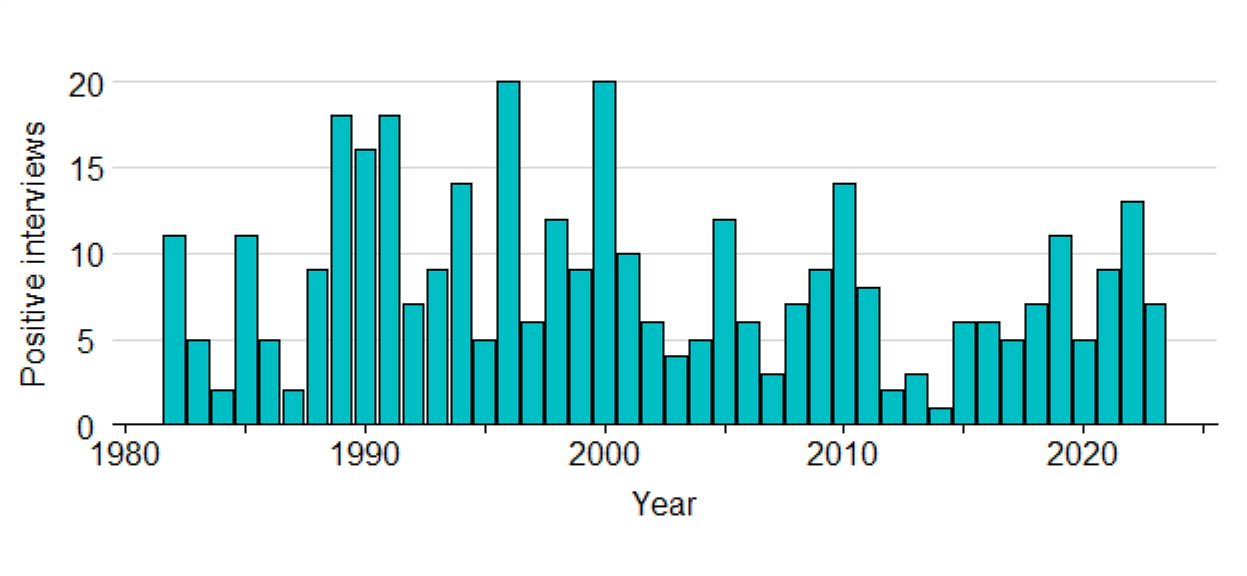

Figure 4. Number of bottomfishing interviews positive for *A. rutilans* by year. The nominal probability of occurrence for 1982–2023 was 0.0608.

Table 3. Selected models for the presence/absence and positive processes for *A. rutilans* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	**Formula**	**n**	**nparm**	**Dev. Expl.**
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	5039	1574	0.3068
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED	316	261	0.4121

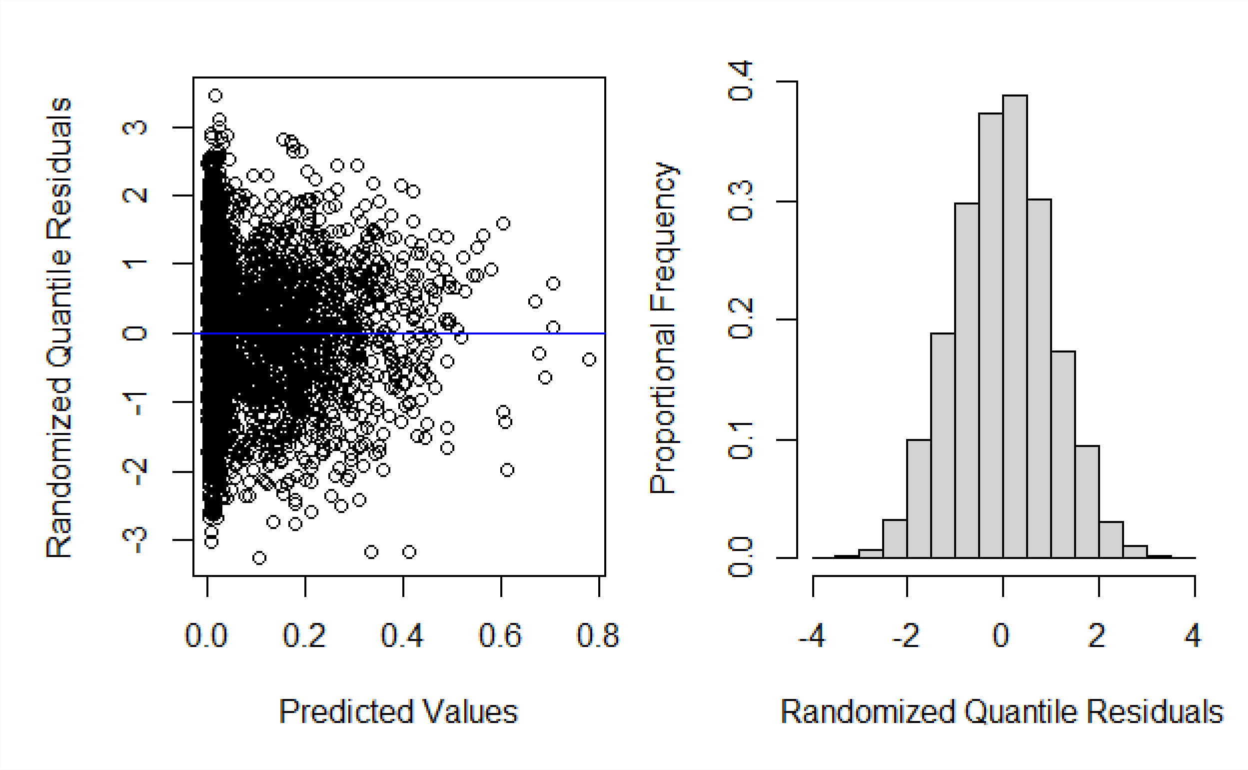

Figure 5. Residual distributions of the presence/absence process model selected for the *A. rutilans* CPUE standardization.

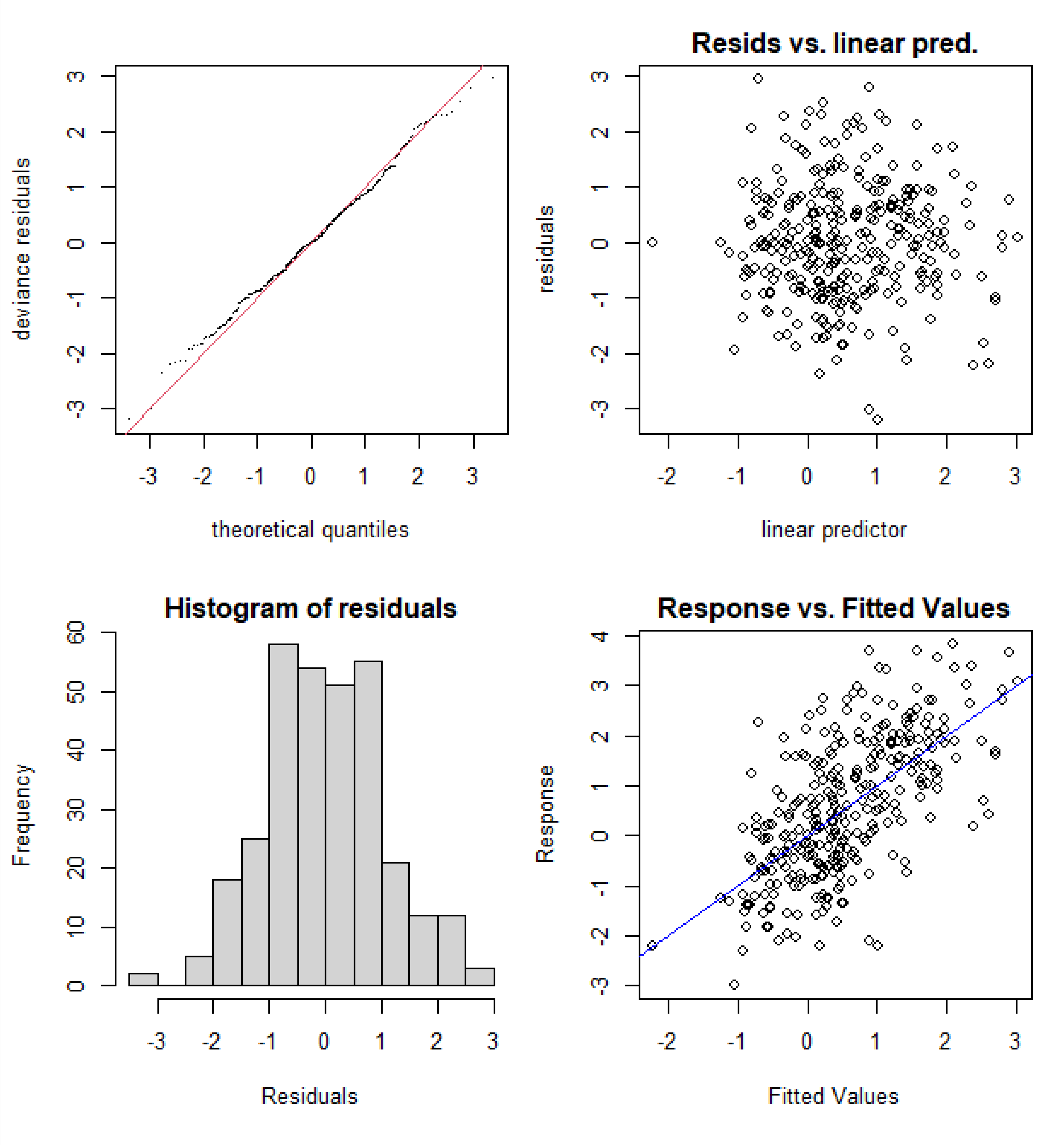

Figure 6. Residual distributions of the positive process model selected for the *A. rutilans* CPUE standardization.

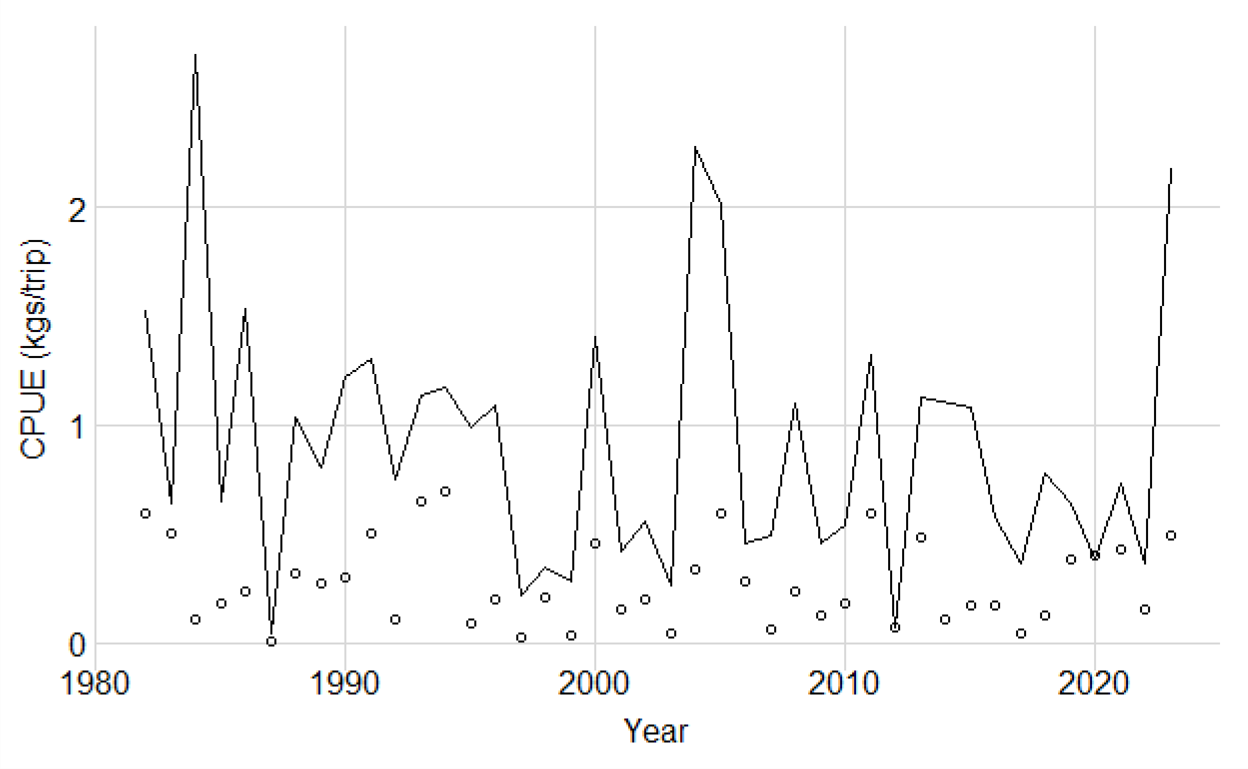

Figure 7. Standardized CPUE index (line) and nominal CPUE (points) of *A. rutilans*.

Caranx ignobilis

C. ignobilis was rarely encountered in the BBS, occurring in 1.6% of interviews over all years, and was not encountered in any interviews during 4 years of the time series (Figure 8). There were insufficient data to include a random vessel effect or a year × area interaction in either model (Table 4). The rarity of *C. ignobilis* in the BBS data necessitated reducing area to three levels, combining the banks and nearshore. Nearly all optional covariates were initially selected in the forward stepwise model selection for the *C. ignobilis* positive process model. To avoid excessive overparameterization, the positive process model was limited to just one optional covariate. Still, the positive process model was likely highly overparameterized, given the model contained 53 parameters and only 86 observations (positive interviews). The selected CPUE standardization models explained 9.7% and 59.7% of deviance in the data for the presence/absence and positive processes, respectively. The high amount of deviance explained by the positive process model was likely driven by overparameterization. Diagnostics (Figures 9–10) suggest model residuals are negatively skewed for the positive process. Overall, there was no clear trend in the standardized CPUE of *C. ignobilis* over time (Figure 11) and relative error (approximated as the standard deviation divided by the CPUE index) of the standardized CPUE index exceeded 100% in all years (Appendix, Supplemental Results for *C. ignobilis*).

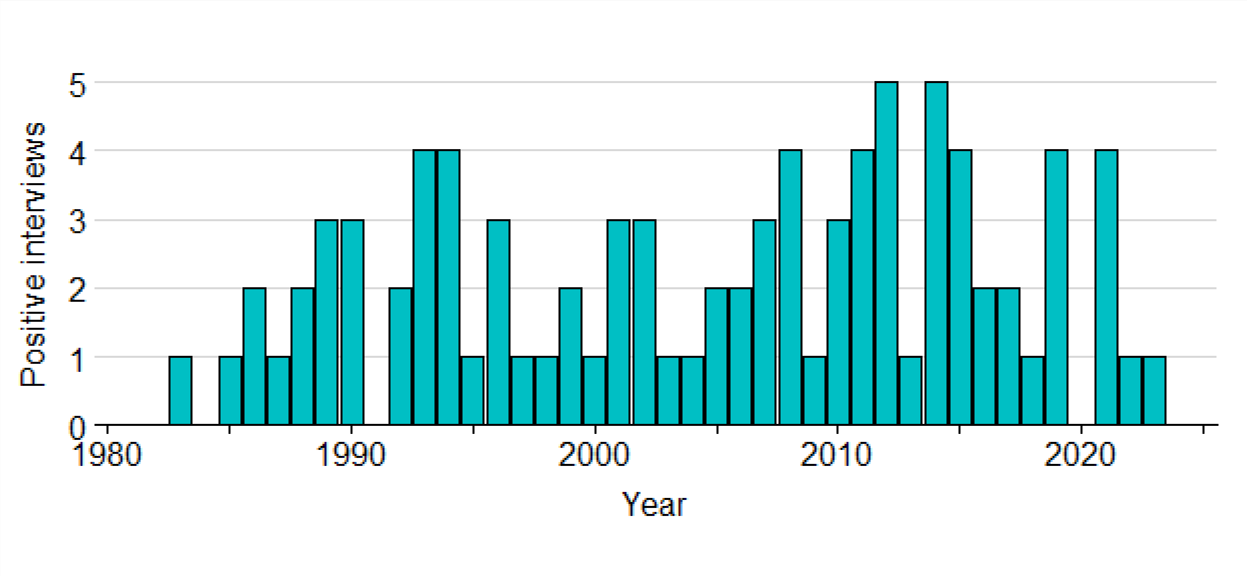

Figure 8. Number of bottomfishing interviews positive for *C. ignobilis* by year. The nominal probability of occurrence for 1982–2023 was 0.016.

Table 4. Selected models for the presence/absence and positive processes for *C. ignobilis* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	**Formula**	**n**	**nparm**	**Dev. Expl.**
Presence/ Absence	z ~ year_fac + AREA_D + s(yday, bs = "cc") + HOURS_FISHED + tod_quarter	4991	52	0.0974
Positive	log(catch_kgs) ~ year_fac + AREA_D + s(yday, bs = "cc") + num_fisher_fac	86	53	0.5973

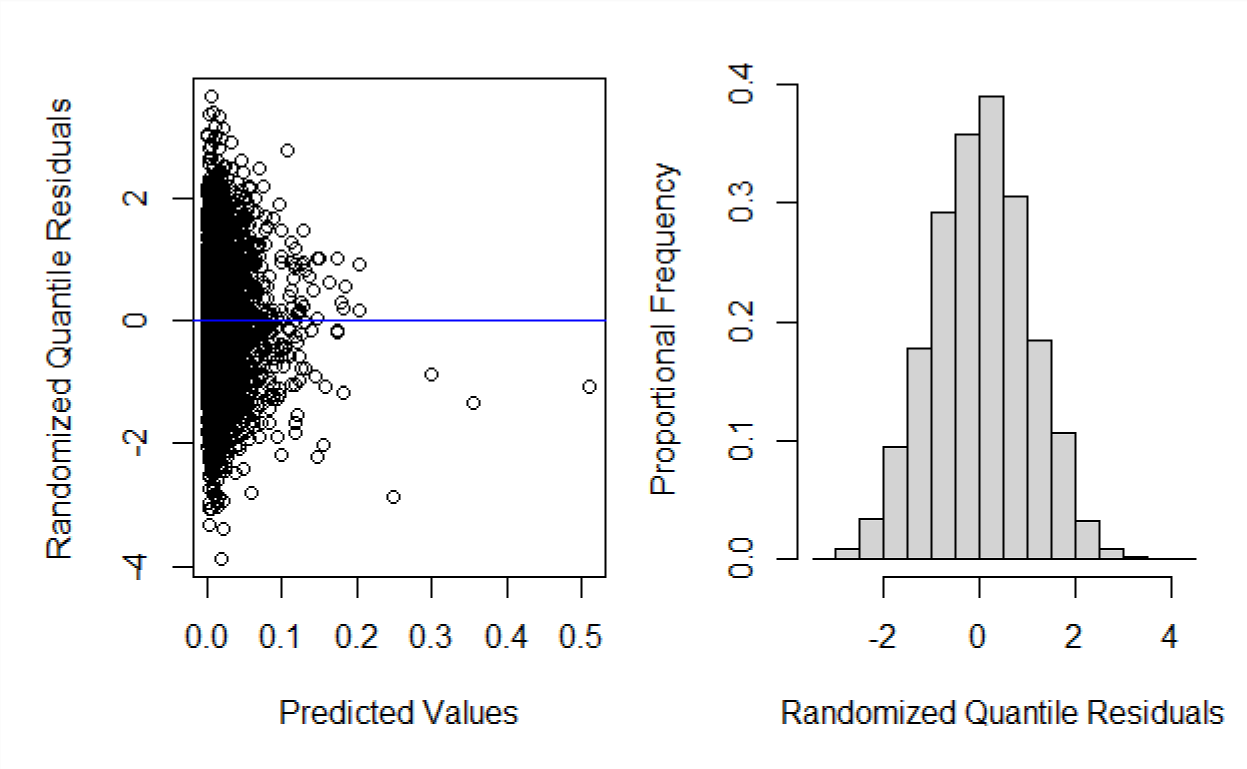

Figure 9. Residual distributions of the presence/absence process model selected for the *C. ignobilis* CPUE standardization.

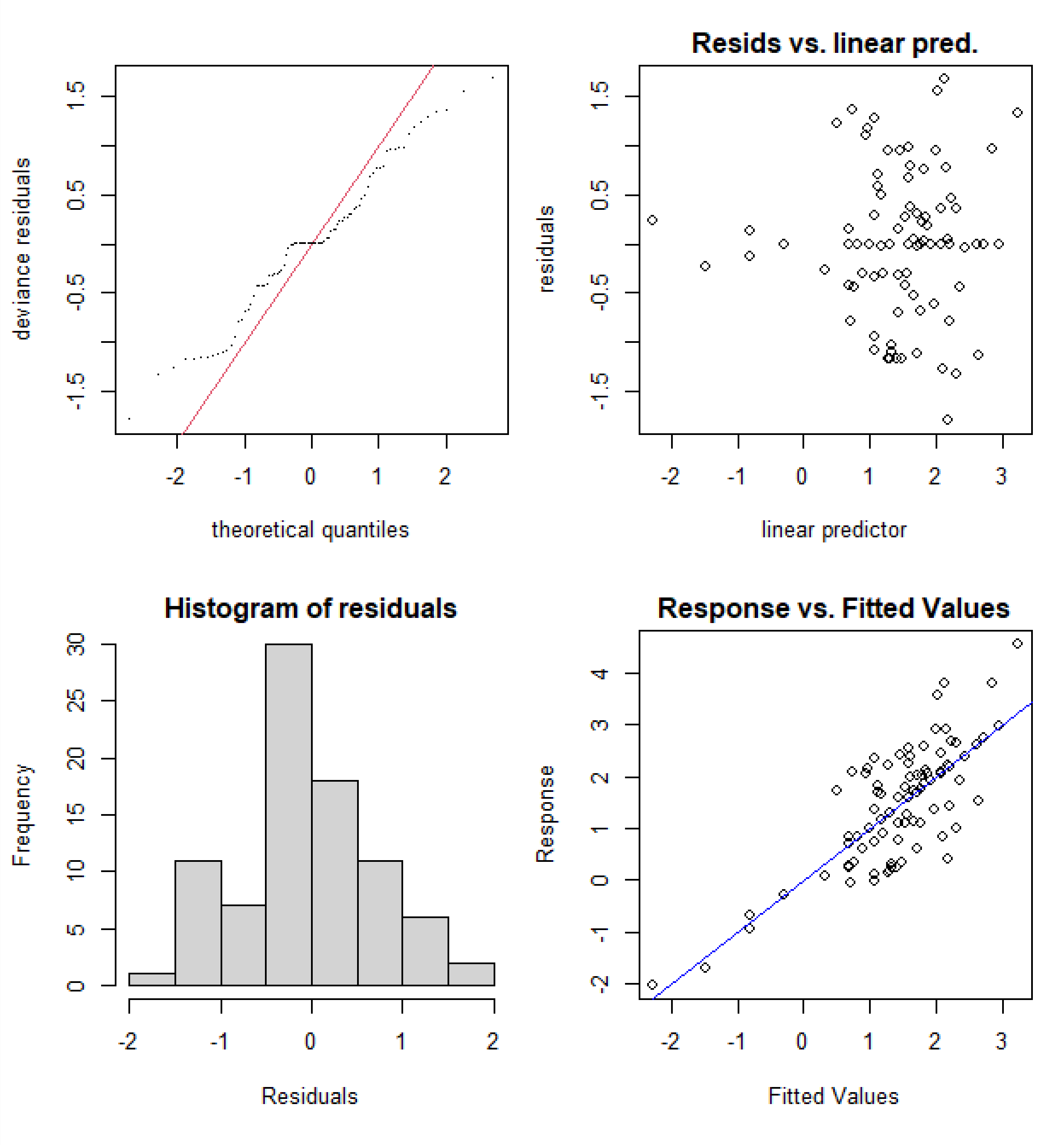

Figure 10. Residual distributions of the positive process model selected for the *C. ignobilis* CPUE standardization.

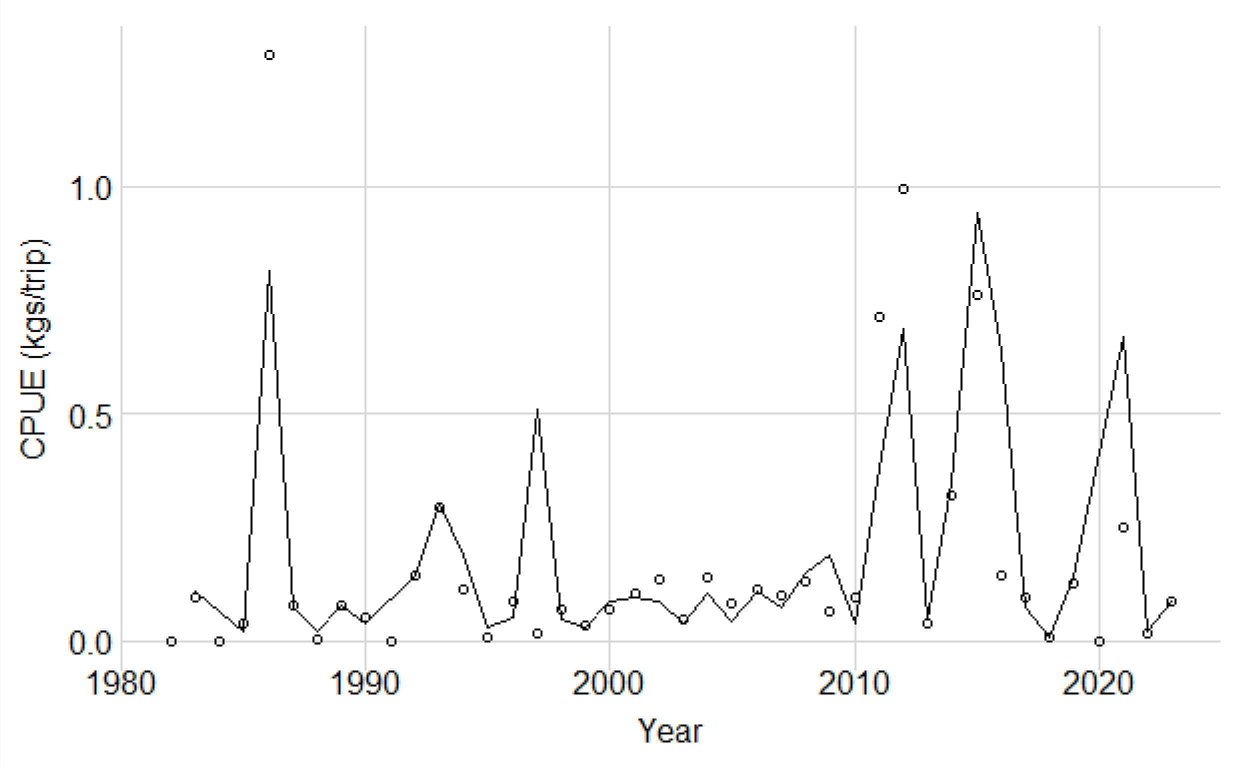

Figure 11. Standardized CPUE index (line) and nominal CPUE (points) of *C. ignobilis*.

Caranx lugubris

C. lugubris was rare in the BBS, occurring in 4.0% of interviews over all years, ranging from 0 interviews in 2023 to 15 interviews in 1998 (Figure 12). Area (as a five-level variable) and a random effect of vessel were included in both the presence/absence and positive processes (Table 5). However, there were insufficient data to include a year × area interaction in either model. The selected CPUE standardization models explained 28.9% and 68.0% of deviance in the data for the presence/absence and positive processes, respectively. The high amount of deviance explained by the positive process model was likely driven by overparameterization. Diagnostics (Figures 13–14) suggest model residuals are negatively skewed for the positive process. Overall, there was no clear trend in the standardized CPUE of *C. lugubris* over time (Figure 15) and relative error (approximated as the standard deviation divided by the CPUE index) of the standardized CPUE index exceeded 100% in all years (Appendix, Supplemental Results for *C. lugubris*).

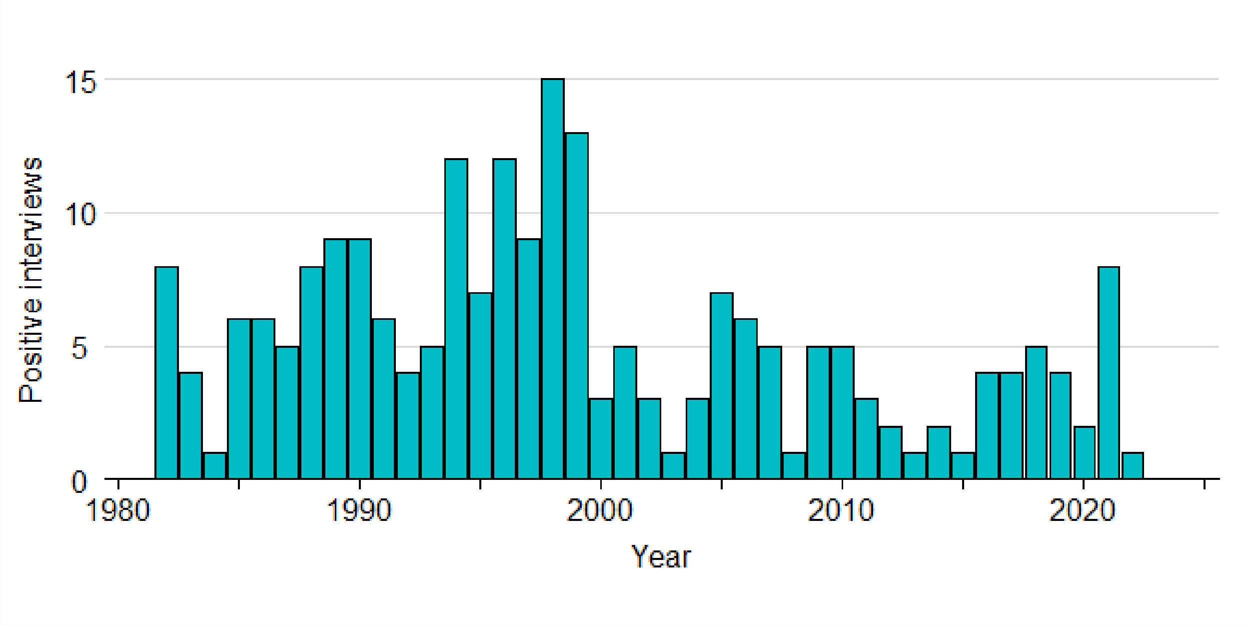

Figure 12. Number of bottomfishing interviews positive for *C. lugubris* by year. The nominal probability of occurrence for 1982–2023 was 0.0396.

Table 5. Selected models for the presence/absence and positive processes for *C. lugubris* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	**Formula**	**n**	**nparm**	**Dev. Expl.**
Presence/ Absence	z ~ year_fac + AREA_E + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	4533	1301	0.2889
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(yday, bs = "cc") + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	196	180	0.6803

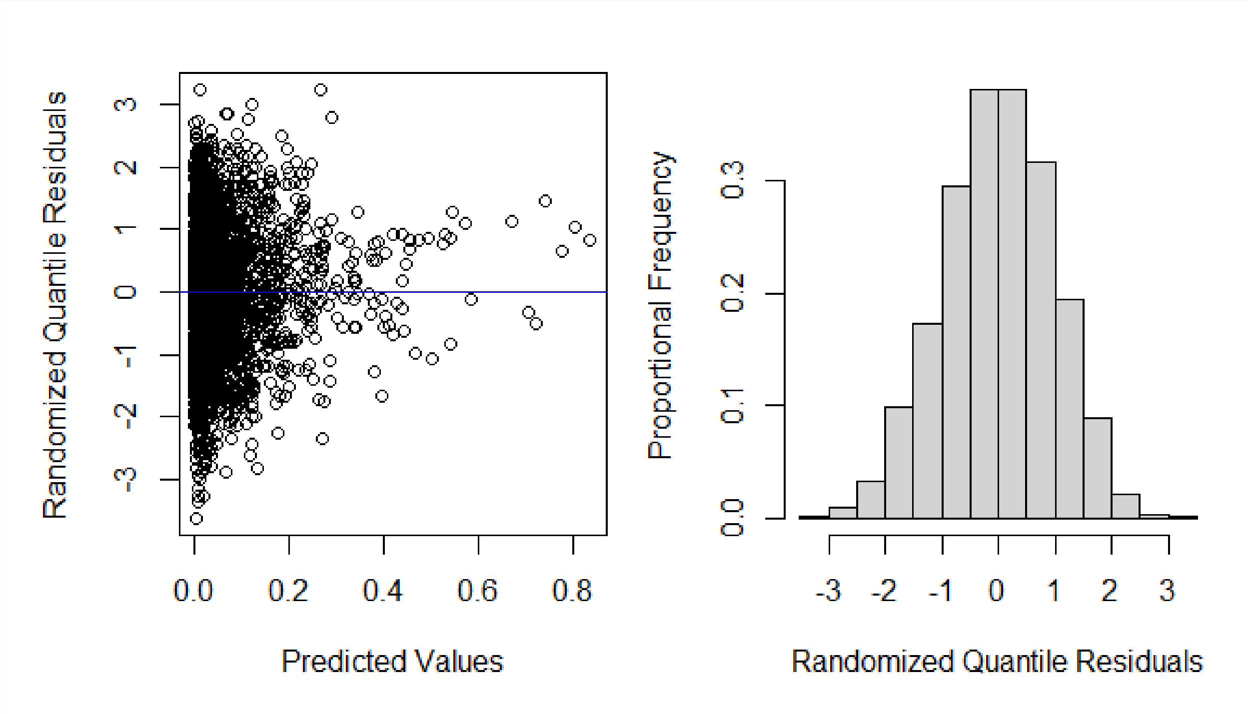

Figure 13. Residual distributions of the presence/absence process model selected for the *C. lugubris* CPUE standardization.

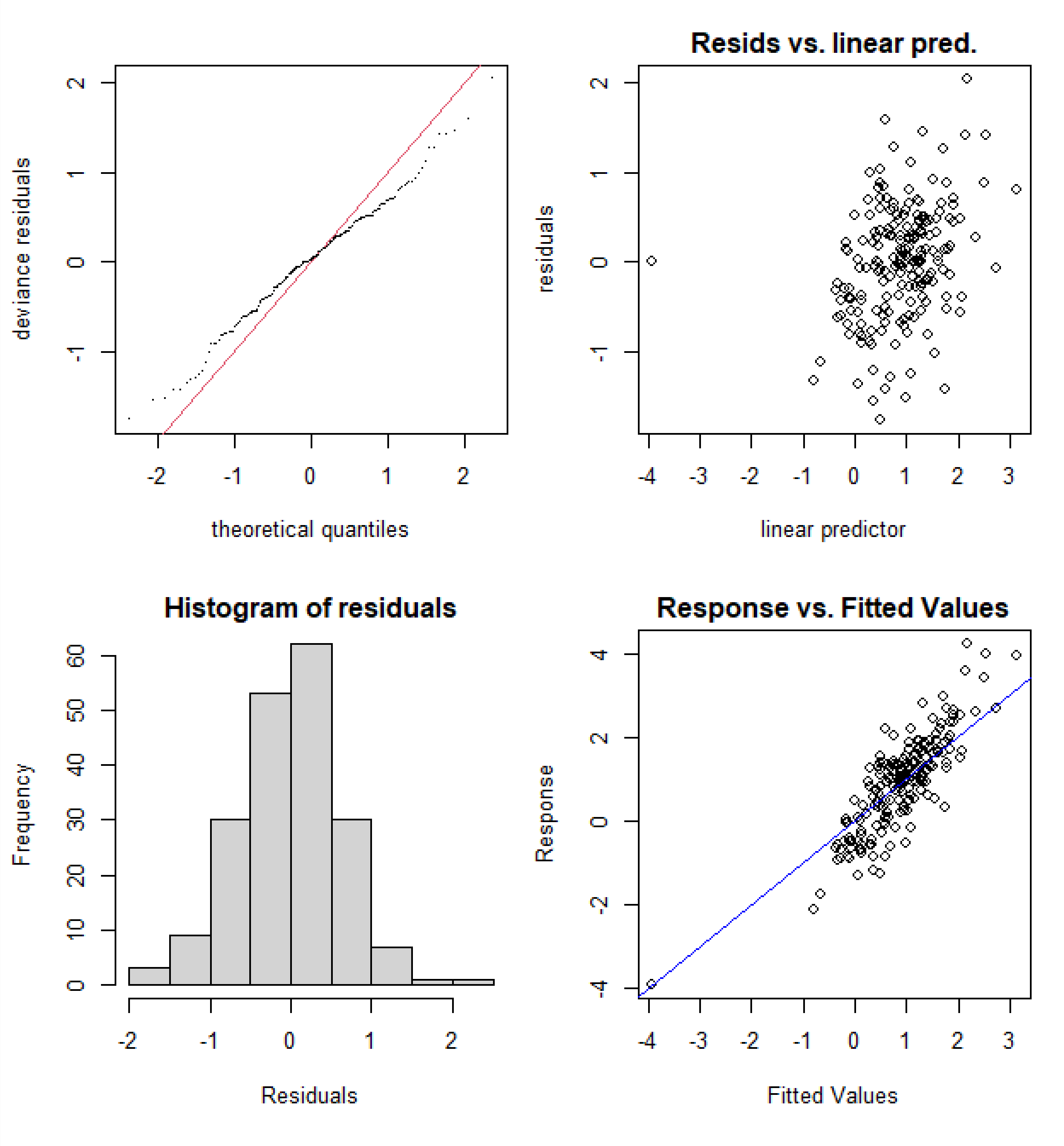

Figure 14. Residual distributions of the positive process model selected for the *C. lugubris* CPUE standardization.

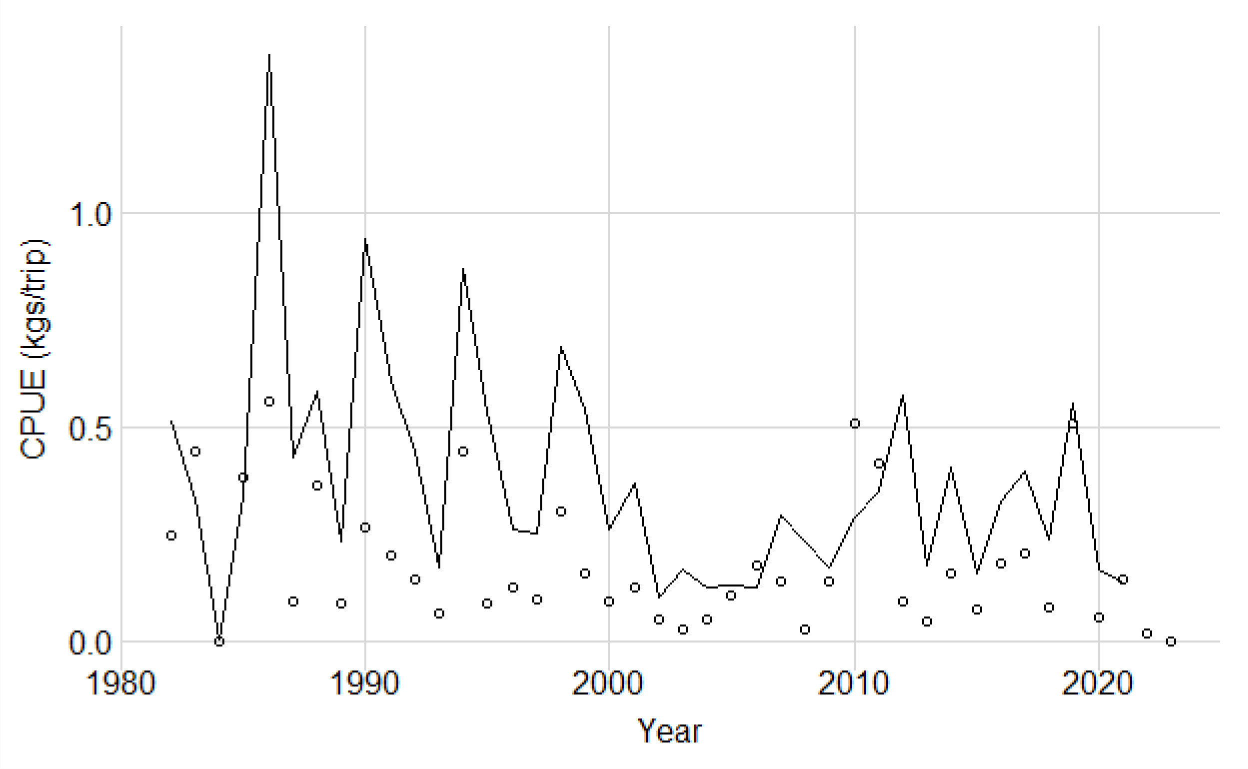

Figure 15. Standardized CPUE index (line) and nominal CPUE (points) of *C. lugubris*.

Etelis coruscans

E. coruscans was moderately represented in the BBS, occurring in 5.1% of interviews over all years; however, *E. coruscans* occurrence has been increasing. It was not observed in 1991 or 1997 but was recorded in 34 interviews in 2021 (Figure 16). There were sufficient data to include five levels of area and a random vessel effect for both the presence/absence and positive processes and a year × area interaction for the presence/absence process only (Table 6). The selected CPUE standardization models explained 55.8% and 51.1% of deviance in the data for the presence/absence and positive processes, respectively. Model residual diagnostics do not indicate any notable degree of overdispersion or heteroskedasticity (Figures 17–18), and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *E. coruscans*). The standardized CPUE of *E. coruscans* has increased and been notably higher since approximately 2000 (Figure 19). This generally positive trend is apparent from the nominal CPUE but is more pronounced according to the CPUE standardization. The influence plots (Appendix, Supplemental Results for *E. coruscans*) indicate some shifts in fisher behavior over time likely magnified the overall increasing trend in CPUE apparent in the nominal estimates.

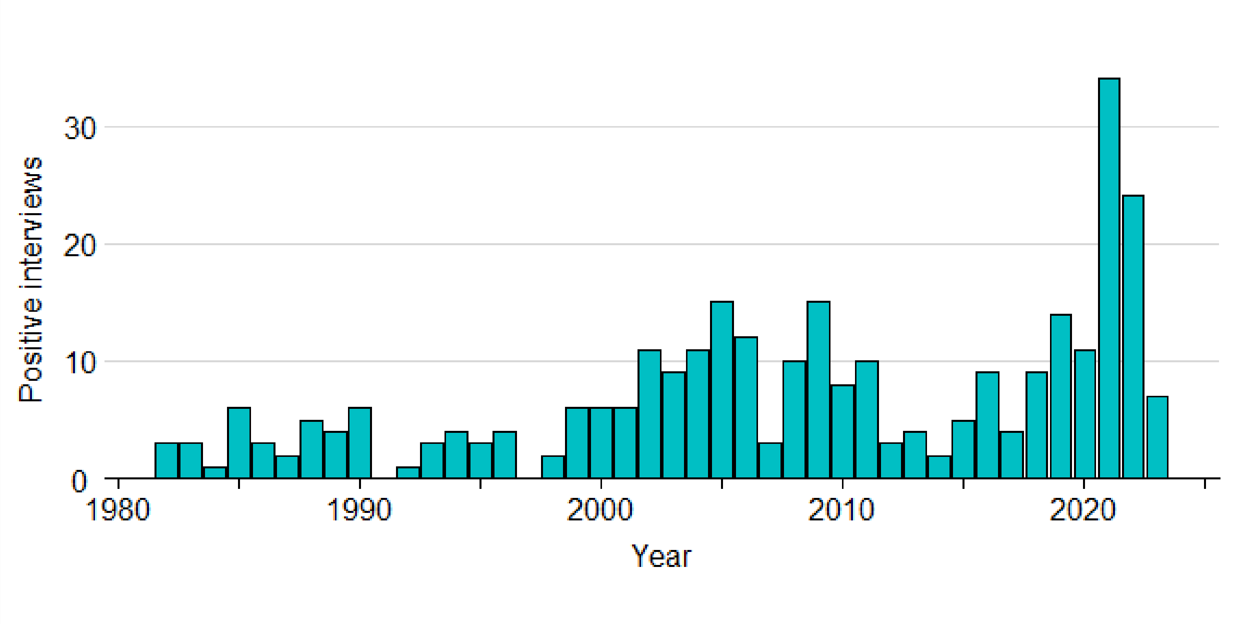

Figure 16. Number of bottomfishing interviews positive for *E. coruscans* by year. The nominal probability of occurrence for 1982–2023 was 0.0506.

Table 6. Selected models for the presence/absence and positive processes for *E. coruscans* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	Formula	n	nparm	Dev. Expl.
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + tod_quarter + s(VESSEL_ID_2, bs = "re")	4718	1536	0.5575
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(yday, bs = "cc") + s(moon, bs = "cc") + CHARTER_F + s(VESSEL_ID_2, bs = "re")	250	187	0.5107

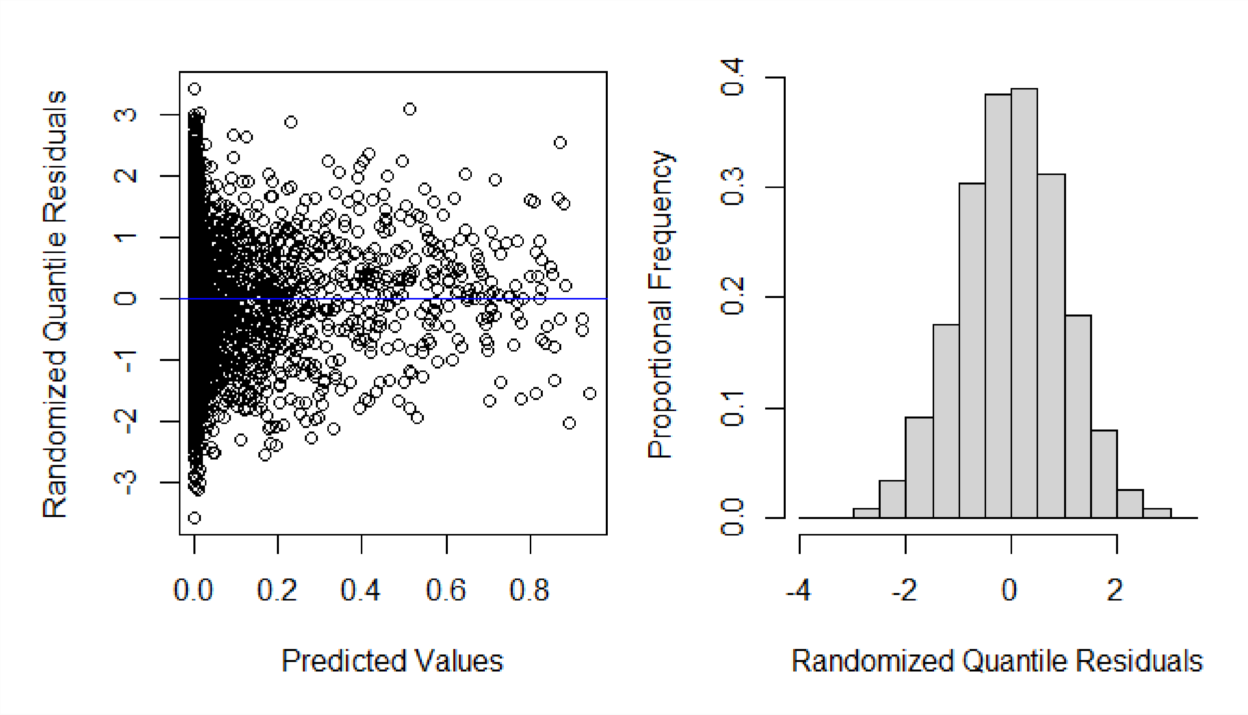

Figure 17. Residual distributions of the presence/absence process model selected for the *E. coruscans* CPUE standardization.

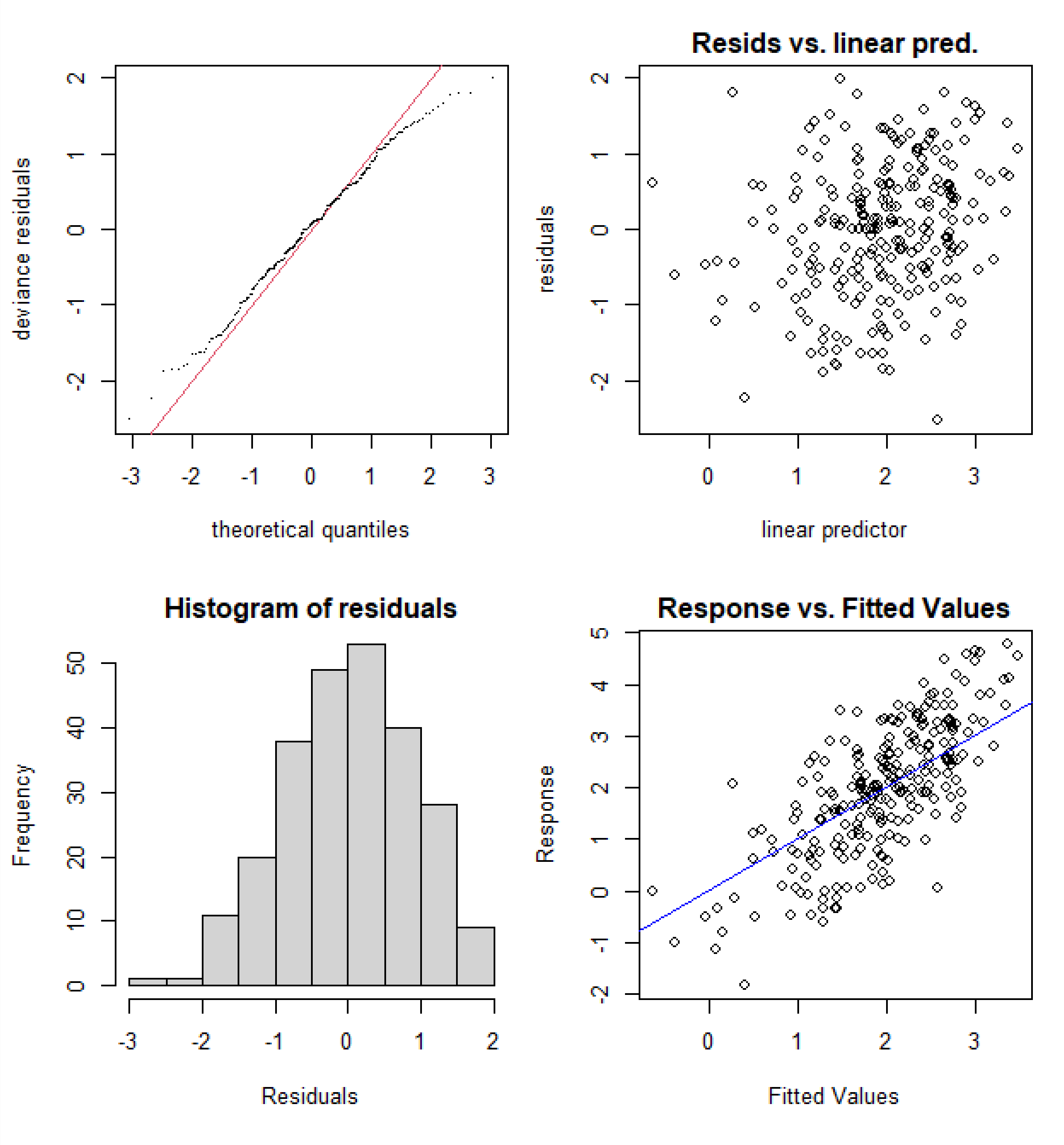

Figure 18. Residual distributions of the positive process model selected for the *E. coruscans* CPUE standardization.

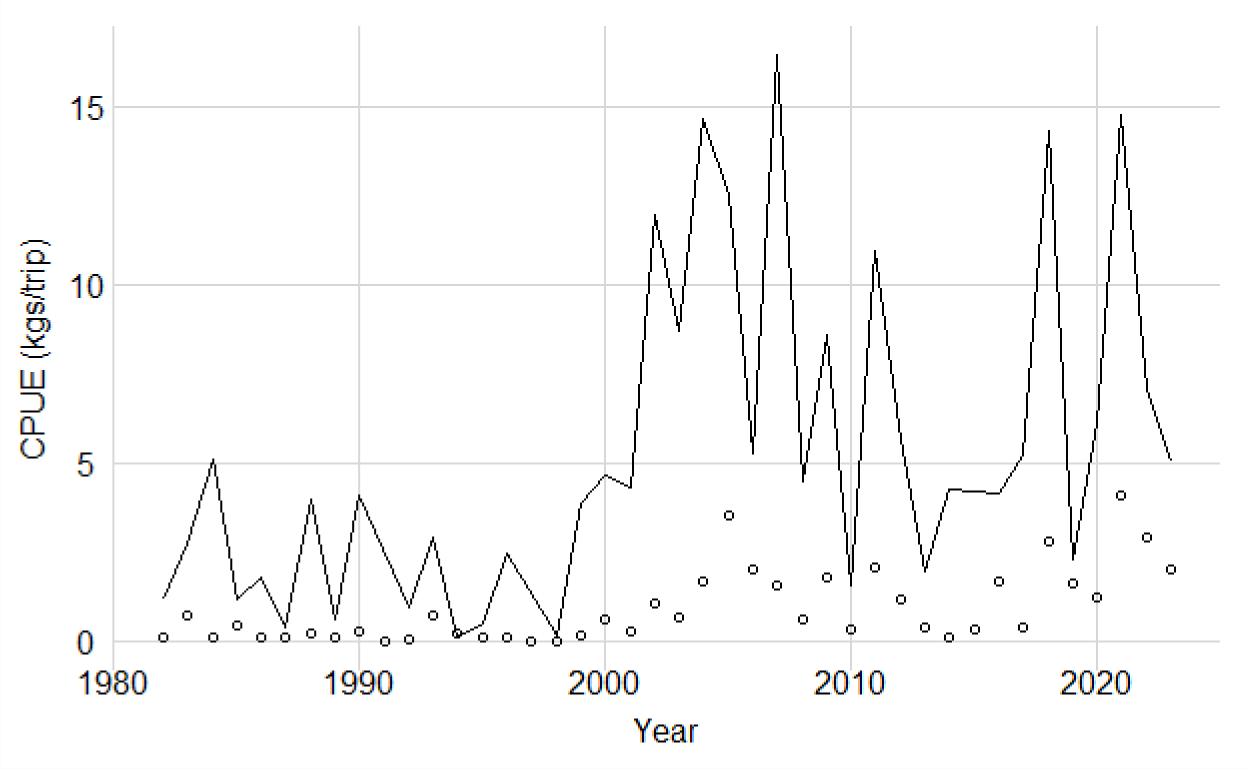

Figure 19. Standardized CPUE index (line) and nominal CPUE (points) of *E. coruscans*.

Etelis carbunculus

E. carbunculus is very similar in appearance to *E. boweni*, which was only recently identified and described (Andrews et al., 2021) and is not listed as a BMUS in the Fishery Ecosystem Plan (FEP) for the Mariana Archipelago. Accounts provided by fishers, Guam Department of Agriculture and Wildlife Resources (DAWR) staff, and NOAA Fisheries scientists confirm *E. boweni* is present in Guam (Dahl et al., 2024; Iwane et al., 2023) and has likely been previously misidentified as *E. carbunculus* within the BBS data. Because of the high difficulty of differentiating these two species, the relative occurrences of *E. boweni* and *E. carbunculus* in Guam are unknown and it is possible that the apparent catch rates of *E. carbunculus* over the BBS time series are heavily influenced by *E. boweni*. In summary, we do not have sufficient data to provide CPUE time series for *E. carbunculus*. In addition, it would be unreasonable to aggregate *E. boweni* and *E. carbunculus* within a CPUE index or assessment because *E. boweni* grows much larger than *E. carbunculus* (Andrews et al., 2021); hence, the growth and population dynamics of these two *Etelis* species are likely very dissimilar.

Lethrinus rubrioperculatus

L. rubrioperculatus was the most frequently encountered BMUS in the BBS data, occurring in 27.1% of interviews over all years, ranging from 4–97 positive interviews per year (Figure 20). There were sufficient data to include five levels of area, a year × area interaction, and a random vessel effect for both the presence/absence and positive processes (Table 7).The selected CPUE standardization models explained 34.7% and 37.5% of deviance in the data for the presence/absence and positive processes, respectively. Model residual diagnostics do not indicate any notable degree of overdispersion or heteroskedasticity (Figures 21–22), and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *L. rubrioperculatus*). The probability of occurrence and CPUE when present were highest in the Southwest Banks and East Nearshore regions, and lowest in the Southwest Nearshore Region. The random vessel effect within the presence/absence process model was also interesting because relatively more effective *L. rubrioperculatus* encountering vessels were well-represented in the BBS data set between 1985 and 1995, but less so in the later years. Type of bottomfishing had a prominent effect on the probability of presence, suggesting *L. rubrioperculatus* were relatively unlikely to be caught on shallow bottomfishing trips (Appendix, Supplemental Results for *L. rubrioperculatus*). Overall, there was an apparent decreasing trend in the standardized CPUE of *L. rubrioperculatus* over time (Figure 23).

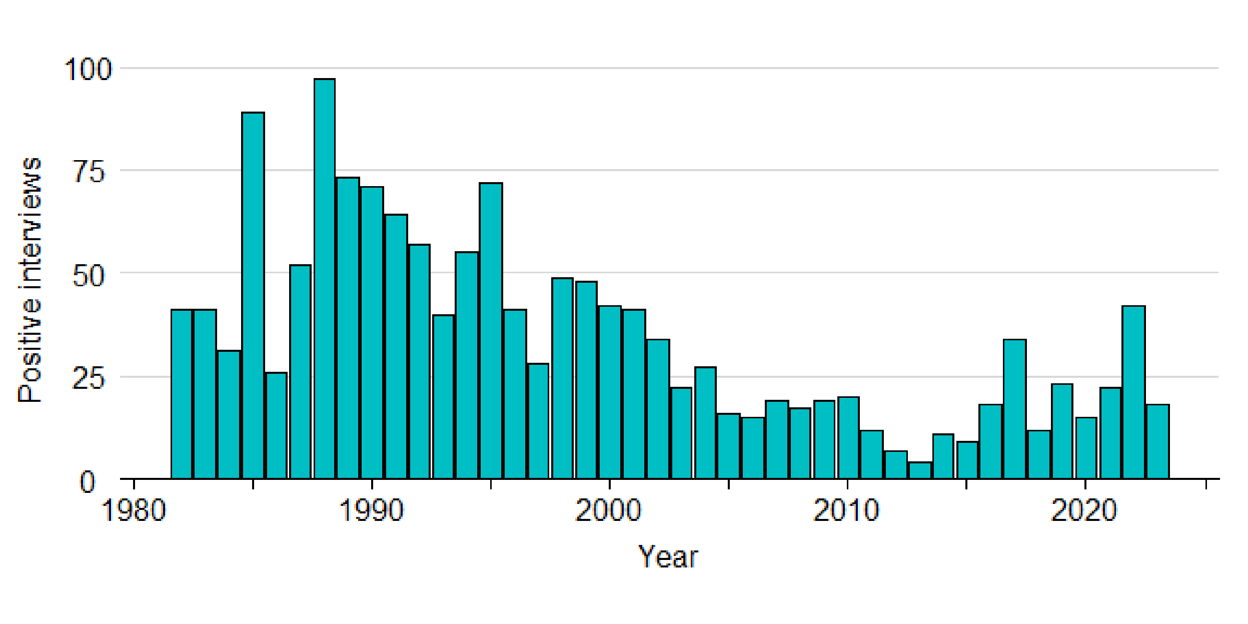

Figure 20. Number of bottomfishing interviews positive for *L. rubrioperculatus* by year. The nominal probability of occurrence for 1982–2023 was 0.2713.

Table 7. Selected models for the presence/absence and positive processes for *L. rubrioperculatus* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	**Formula**	**n**	**nparm**	**Dev. Expl.**
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4661	1553	0.3471
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	1321	823	0.3754

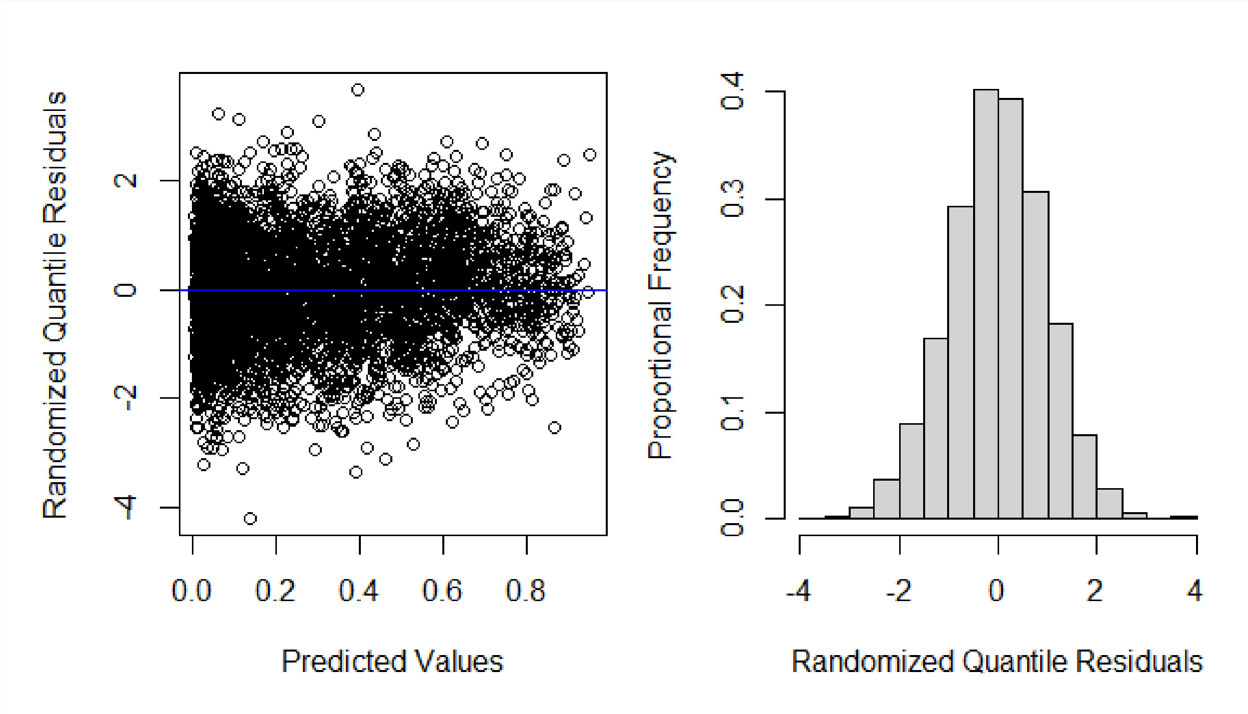

Figure 21. Residual distributions of the presence/absence process model selected for the *L. rubrioperculatus* CPUE standardization.

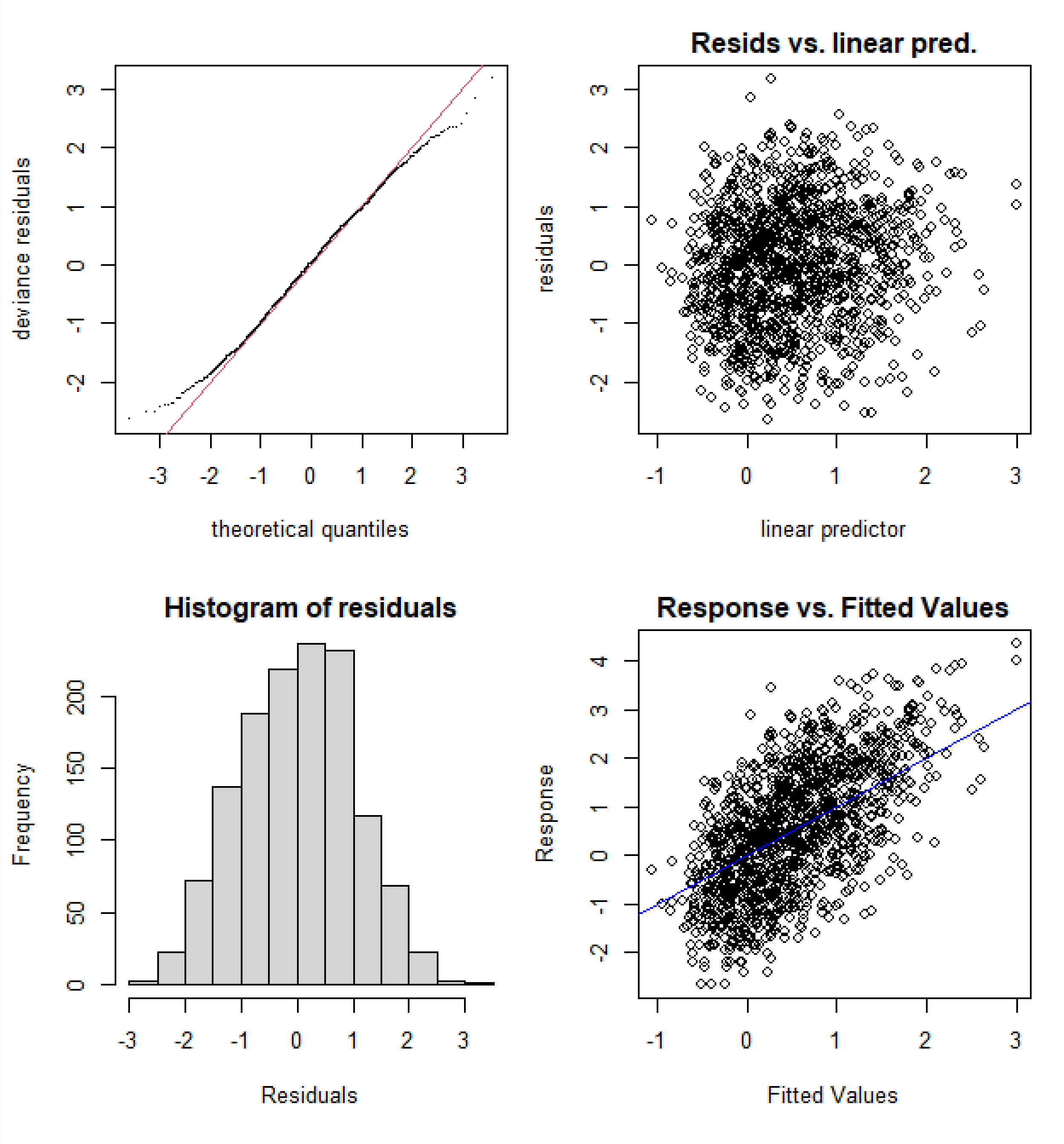

Figure 22. Residual distributions of the positive process model selected for the *L. rubrioperculatus* CPUE standardization.

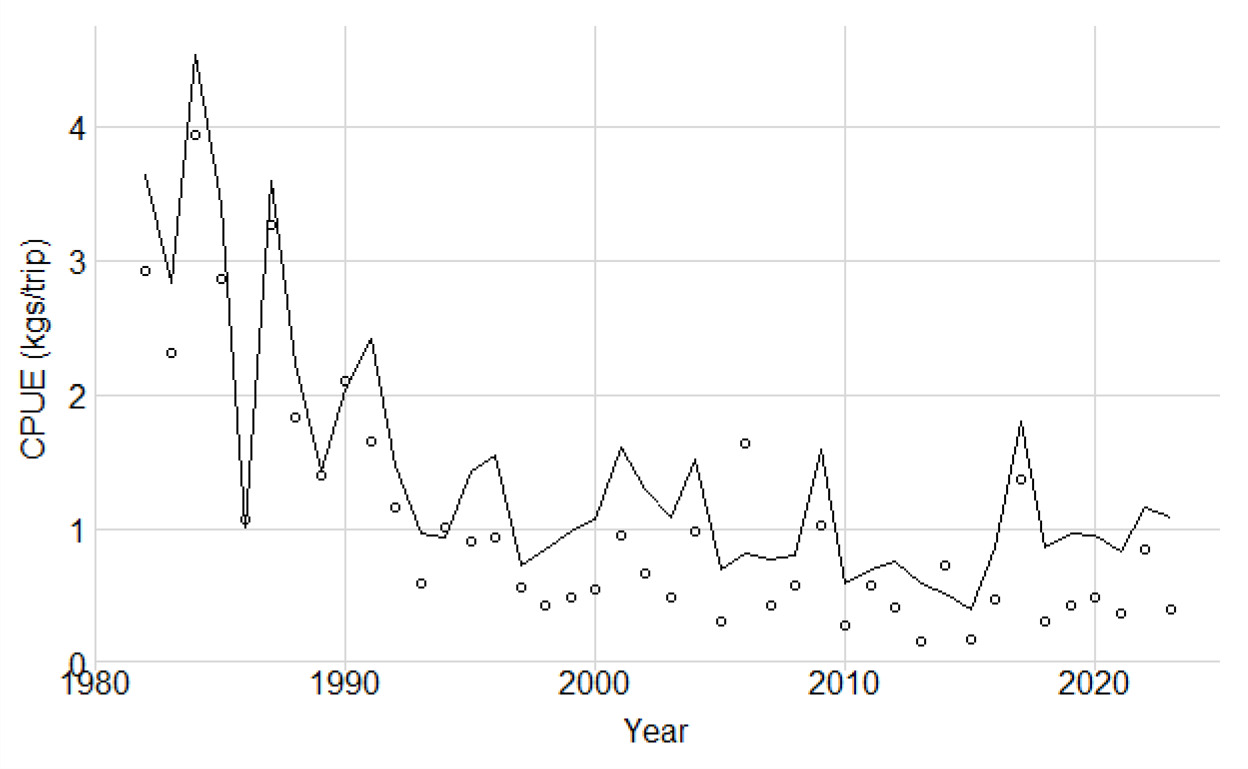

Figure 23. Standardized CPUE index (line) and nominal CPUE (points) of *L. rubrioperculatus*.

Lutjanus kasmira

L. kasmira was the second most frequently encountered BMUS in the BBS data, occurring in 14.3% of interviews over all years, ranging from 4–44 positive interviews per year (Figure 24). There were sufficient data to include five levels of area, a year × area interaction, and a random vessel effect for both the presence/absence and positive processes (Table 8).The selected CPUE standardization models explained 20.6% and 45.9% of deviance in the data for the presence/absence and positive processes, respectively. Model residual diagnostics do not indicate any notable degree of overdispersion or heteroskedasticity (Figures 25–26), and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *L. kasmira*). *L. kasmira* were unlikely to be encountered while deep bottomfishing and, similar to *L. rubrioperculatus*, the random vessel effect in the model suggests more specialized vessels were represented in the data during the earlier part of the time series. (Appendix, Supplemental Results for *L. kasmira*). The standardized CPUE of *L. kasmira* shows somewhat decadal periods of increase and decrease, and there are no overall trends in the time series (Figure 27).

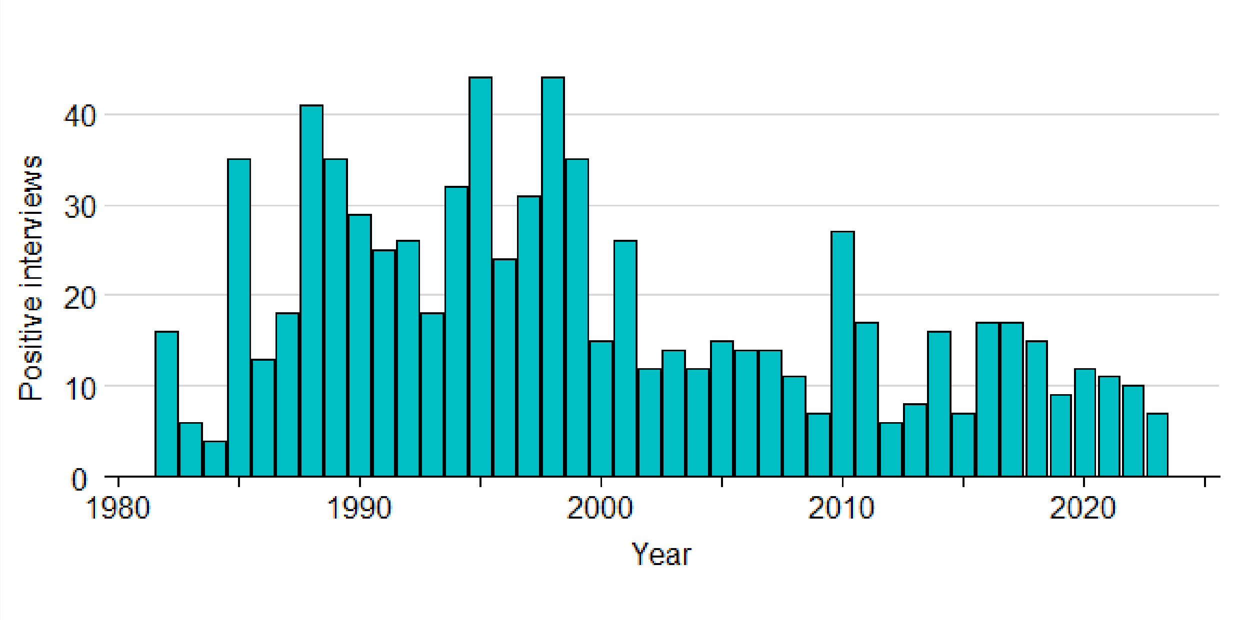

Figure 24. Number of bottomfishing interviews positive for *L. kasmira* by year. The nominal probability of occurrence for 1982–2023 was 0.1429.

Table 8. Selected models for the presence/absence and positive processes of *L. kasmira* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	**Formula**	**n**	**nparm**	**Dev. Expl.**
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	4785	1568	0.2056
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + tod_quarter + CHARTER_F + s(VESSEL_ID_2, bs = "re")	703	642	0.4591

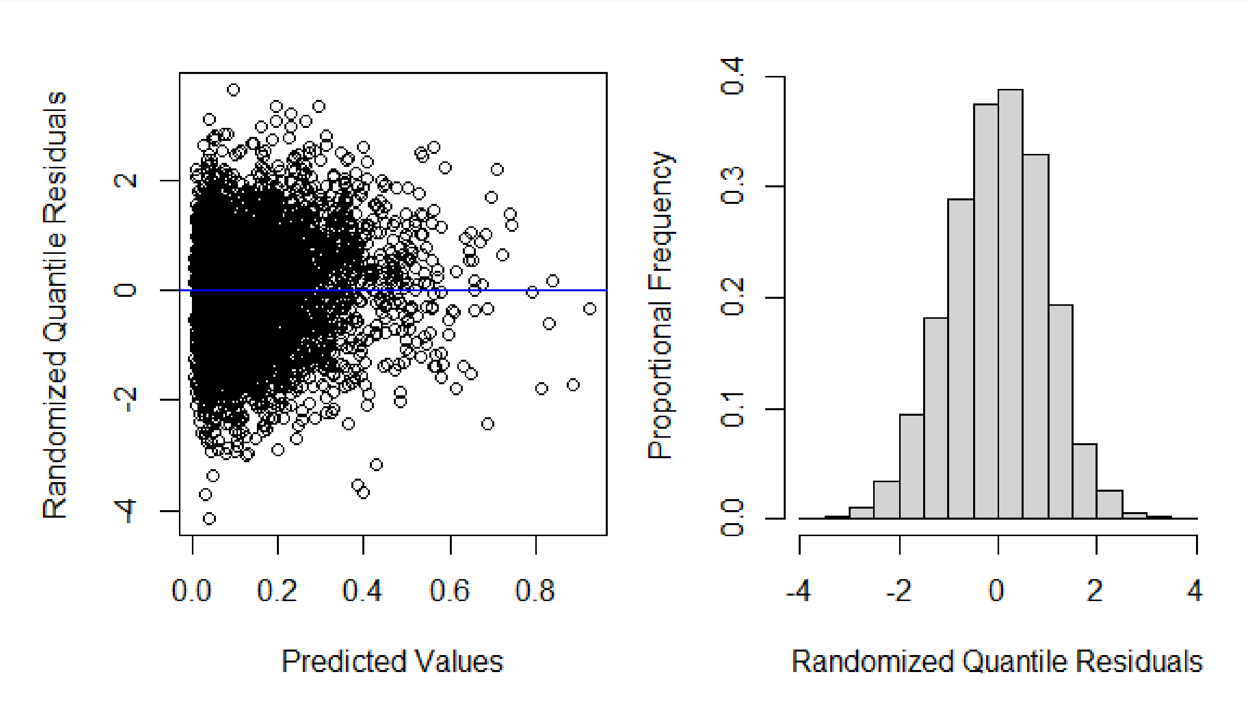

Figure 25. Residual distributions of the presence/absence process model selected for the *L. kasmira* CPUE standardization.

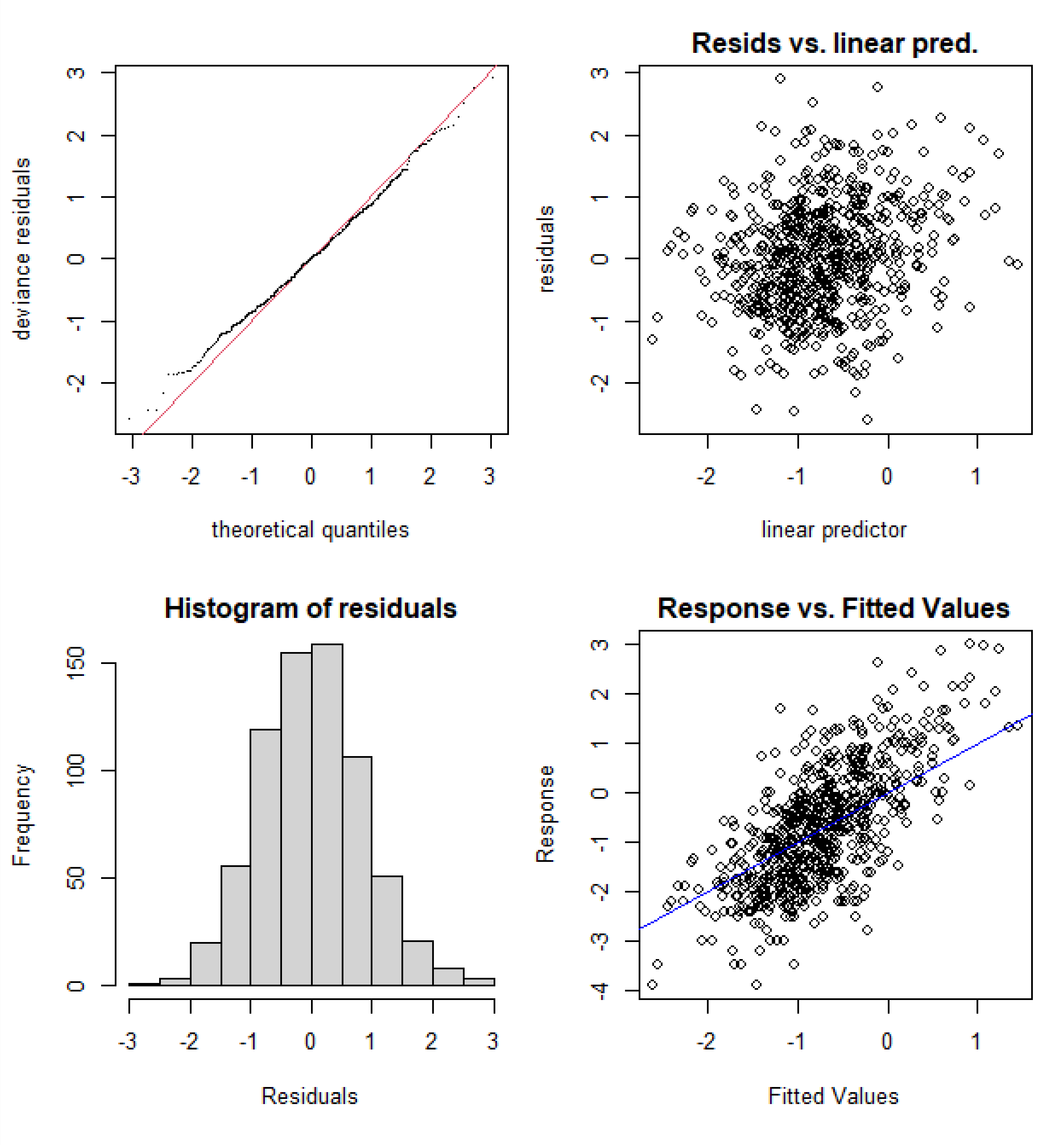

Figure 26. Residual distributions of the positive process model selected for the *L. kasmira* CPUE standardization.

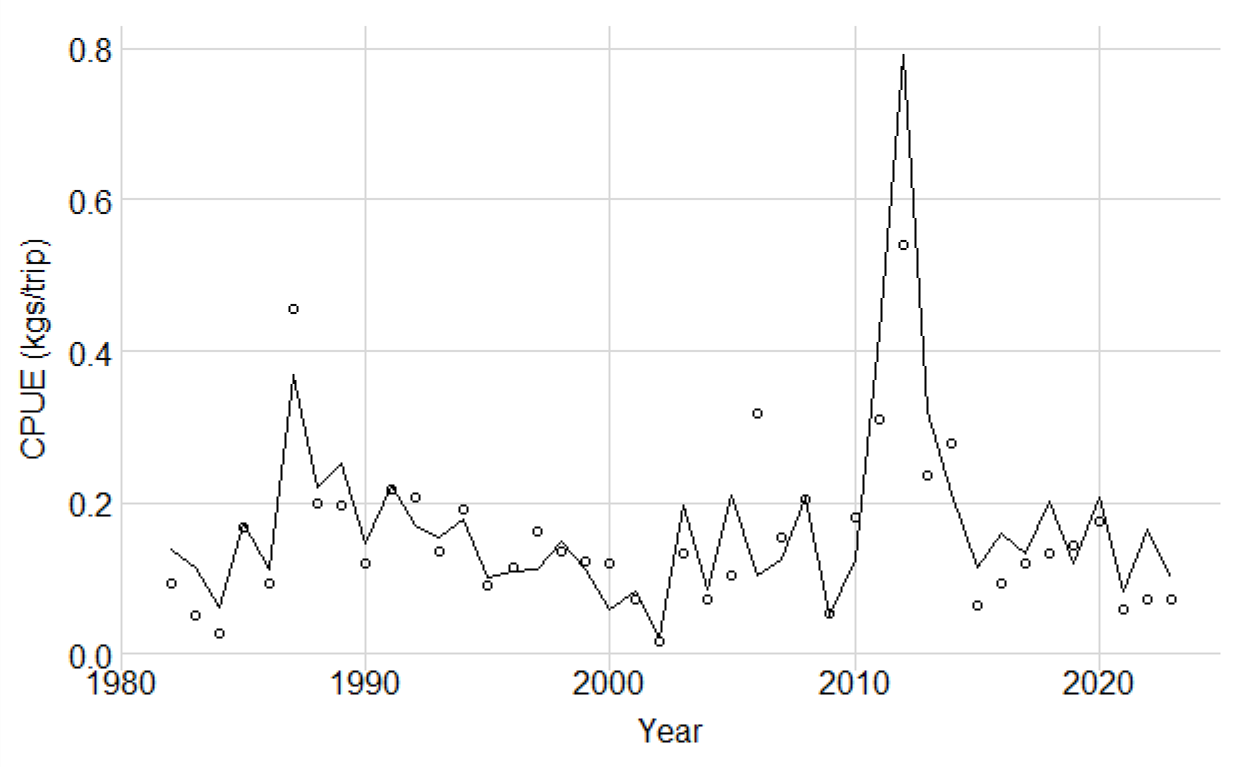

Figure 27. Standardized CPUE index (line) and nominal CPUE (points) of *L. kasmira*.

Pristipomoides auricilla

P. auricilla was relatively well-represented in the BBS, occurring in 12.8% of interviews over all years, ranging from 4–48 positive interviews per year (Figure 28). There were sufficient data to include five levels of area, a year × area interaction, and a random vessel effect for both the presence/absence and positive processes (Table 9). The selected CPUE standardization models explained 58.9% and 52.5% of deviance in the data for the presence/absence and positive processes, respectively. Diagnostics suggest model residuals are slightly negatively skewed for the positive process (Figures 29–30), but otherwise there was no notable degree of overdispersion or heteroskedasticity, and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *P. auricilla*). Bottomfishing type and trip duration were both retained in the selected models. *P. auricilla* was more likely to be encountered and was characterized by higher catch per trip for deep bottomfishing and longer duration trips (Appendix, Supplemental Results for *P. auricilla*). The standardized CPUE index shows a general decrease, albeit with high inter-annual variability, between 1990 and 2020, and a pronounced spike in 2021–2023 (Figure 31).

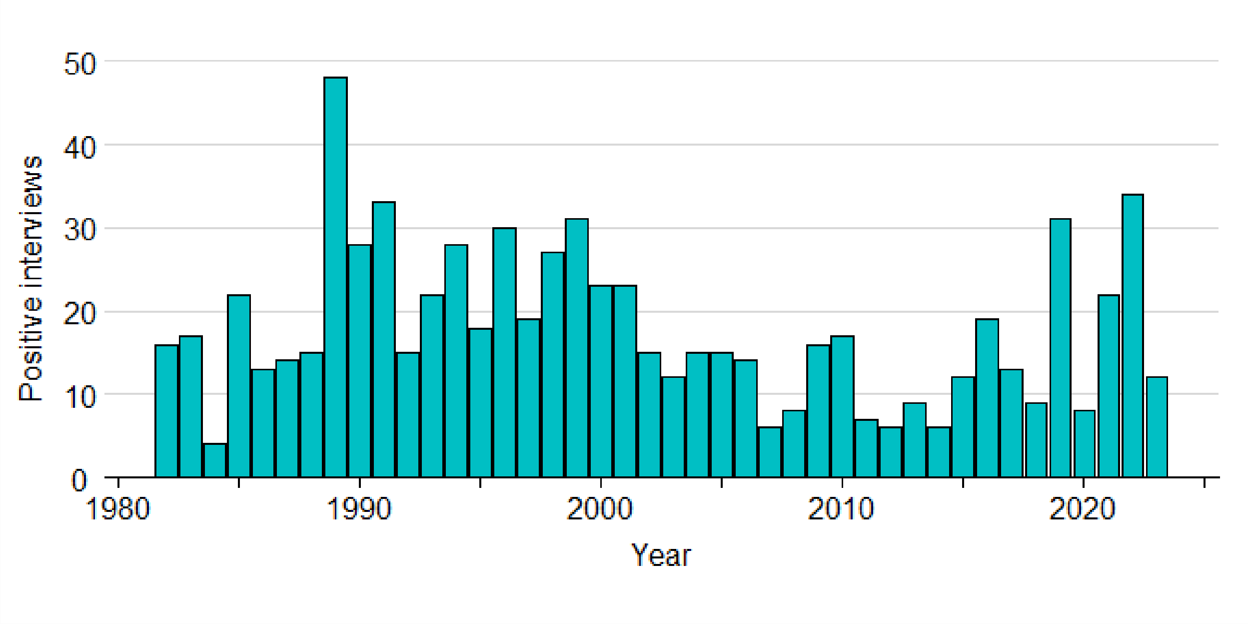

Figure 28. Number of bottomfishing interviews positive for *P. auricilla* by year. The nominal probability of occurrence for 1982–2023 was 0.1277.

Table 9. Selected models for the presence/absence and positive processes for *P. auricilla* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	**Formula**	**n**	**nparm**	**Dev. Expl.**
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	5083	1589	0.5887
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + DEPTH + num_gear_fac + num_fisher_fac + s(VESSEL_ID_2, bs = "re")	644	548	0.5254

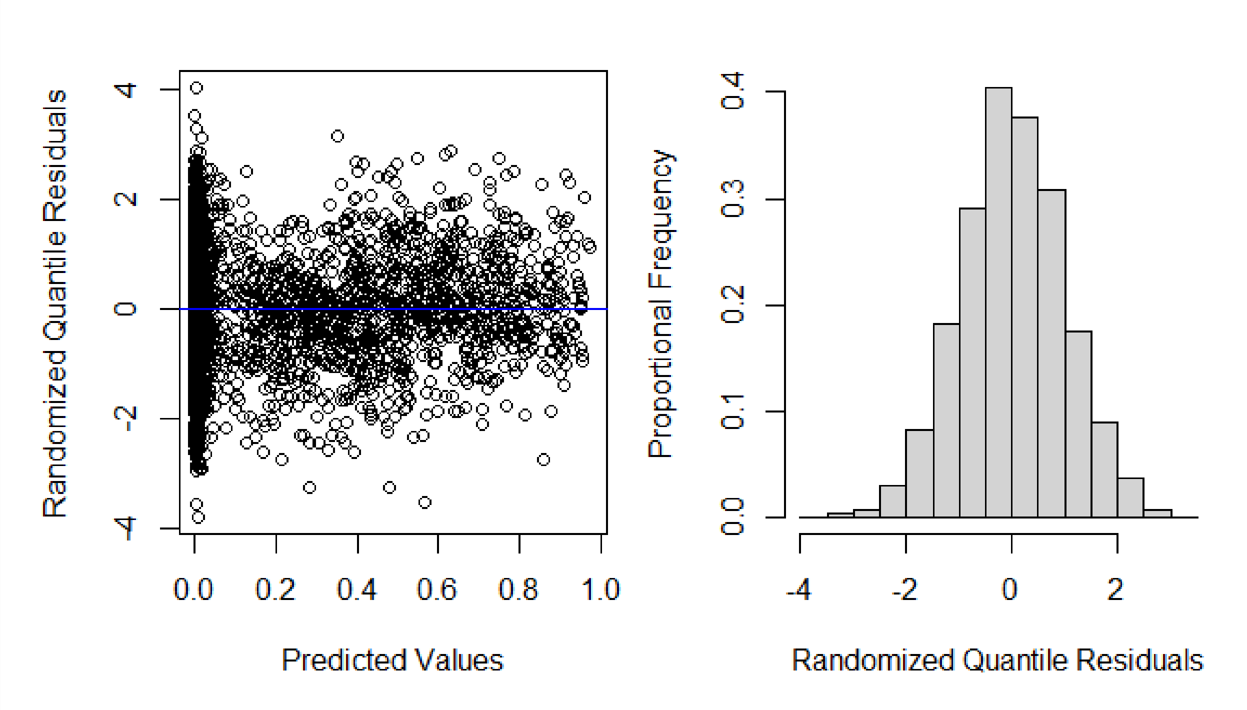

Figure 29. Residual distributions of the presence/absence process model selected for the *P. auricilla* CPUE standardization.

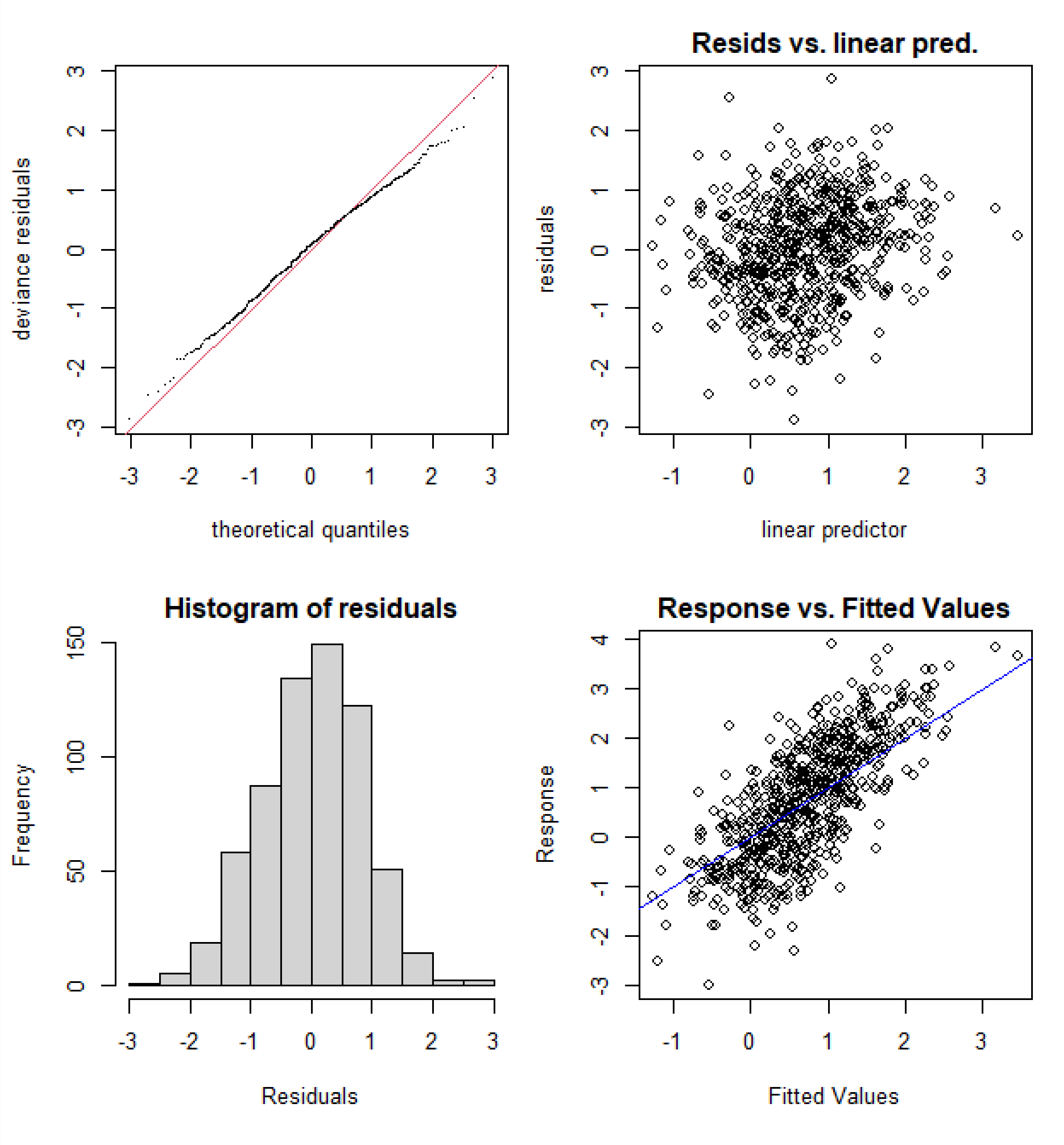

Figure 30. Residual distributions of the positive process model selected for the *P. auricilla* CPUE standardization.

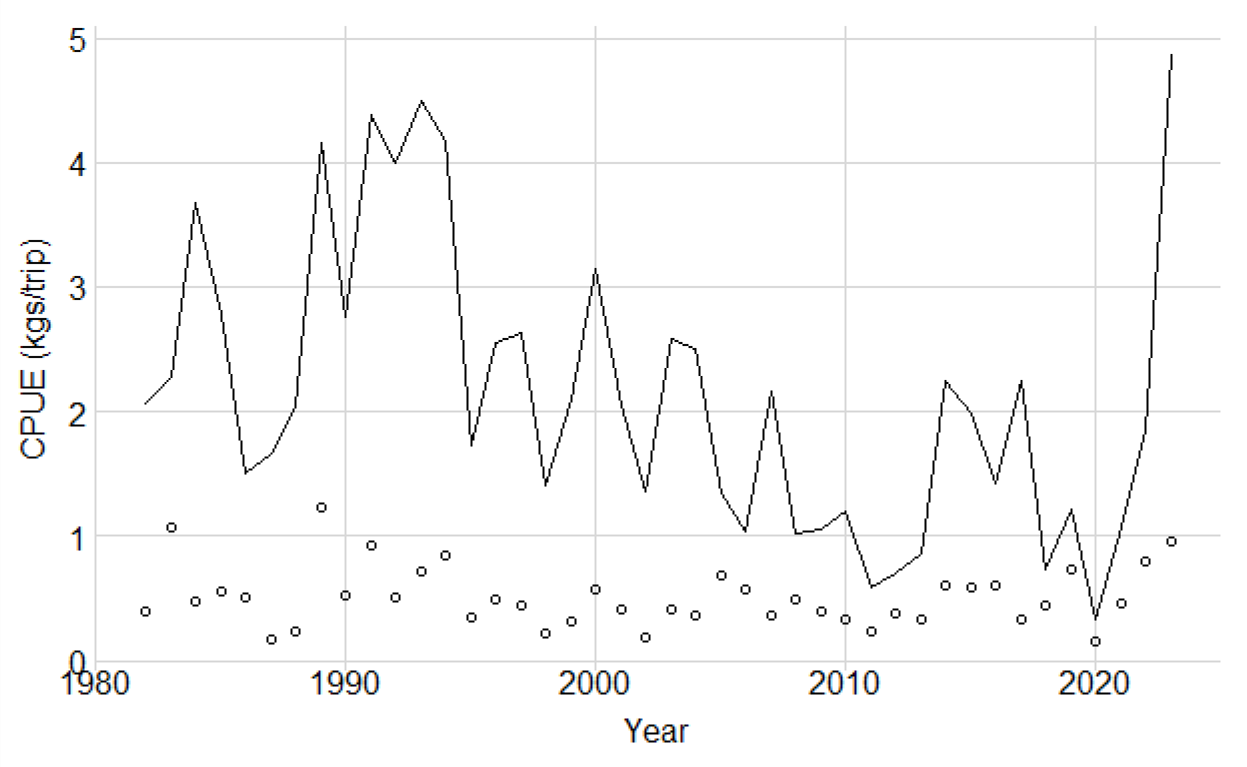

Figure 31. Standardized CPUE index (line) and nominal CPUE (points) of *P. auricilla*.

Pristipomoides filamentosus

P. filamentosus was rarely encountered in the BBS, occurring in 3.1% of interviews over all years, ranging from 0–13 interviews per year (Figure 32). There were sufficient data to include area (as a five-level variable), a year × area interaction, and a random effect of vessel in the presence/absence process (Table 10). However, given the low overall occurrence of *P. filamentosus* in the data, the positive process model did not include a year × area interaction or a random effect of vessel. The selected CPUE standardization models explained 39.5% and 33.3% of deviance in the data for the presence/absence and positive processes, respectively. Diagnostics suggest model residuals were slightly negatively skewed for the positive process (Figures 33–34), but otherwise there was no notable degree of overdispersion or heteroskedasticity, and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *P. filamentosus*). CPUE was notably lowest in the Southwest Nearshore region. The models indicate *P. filamentosus* was more likely to be encountered and was characterized by higher catch for deep bottomfishing trips (Appendix, Supplemental Results for *P. filamentosus*). Overall, there was no clear trend in the standardized CPUE of *P. filamentosus* over time (Figure 35).

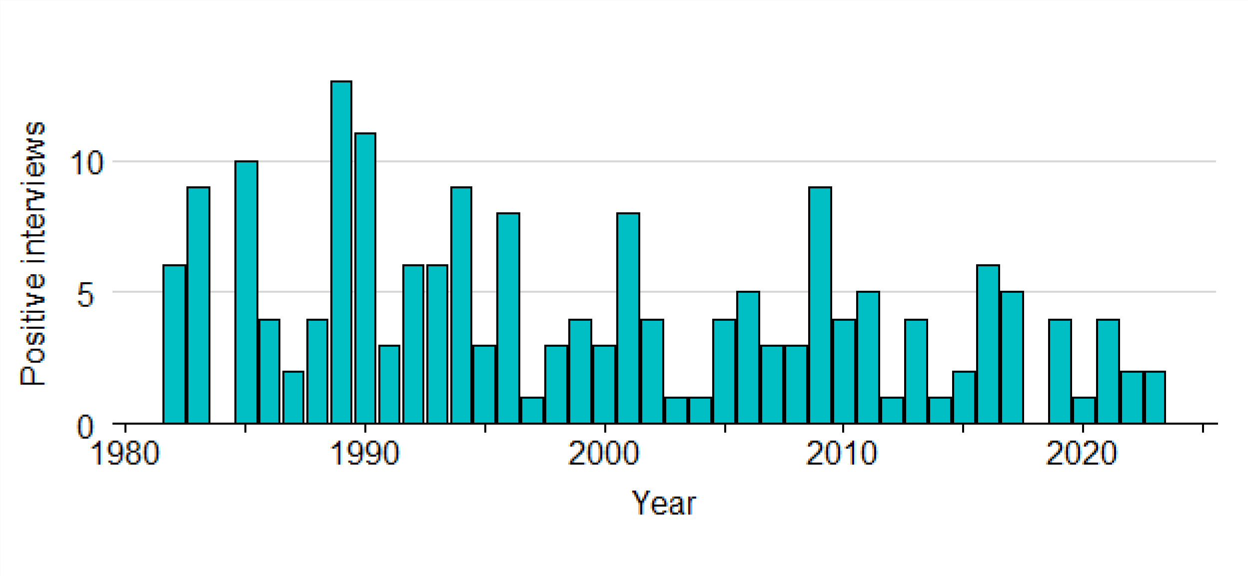

Figure 32. Number of bottomfishing interviews positive for *P. filamentosus* by year. The nominal probability of occurrence for 1982–2023 was 0.0312.

Table 10. Selected models for the presence/absence and positive processes for *P. filamentosus* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	**Formula**	**n**	**nparm**	**Dev. Expl.**
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4959	1555	0.3954
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(yday, bs = "cc") + HOURS_FISHED	169	53	0.3332

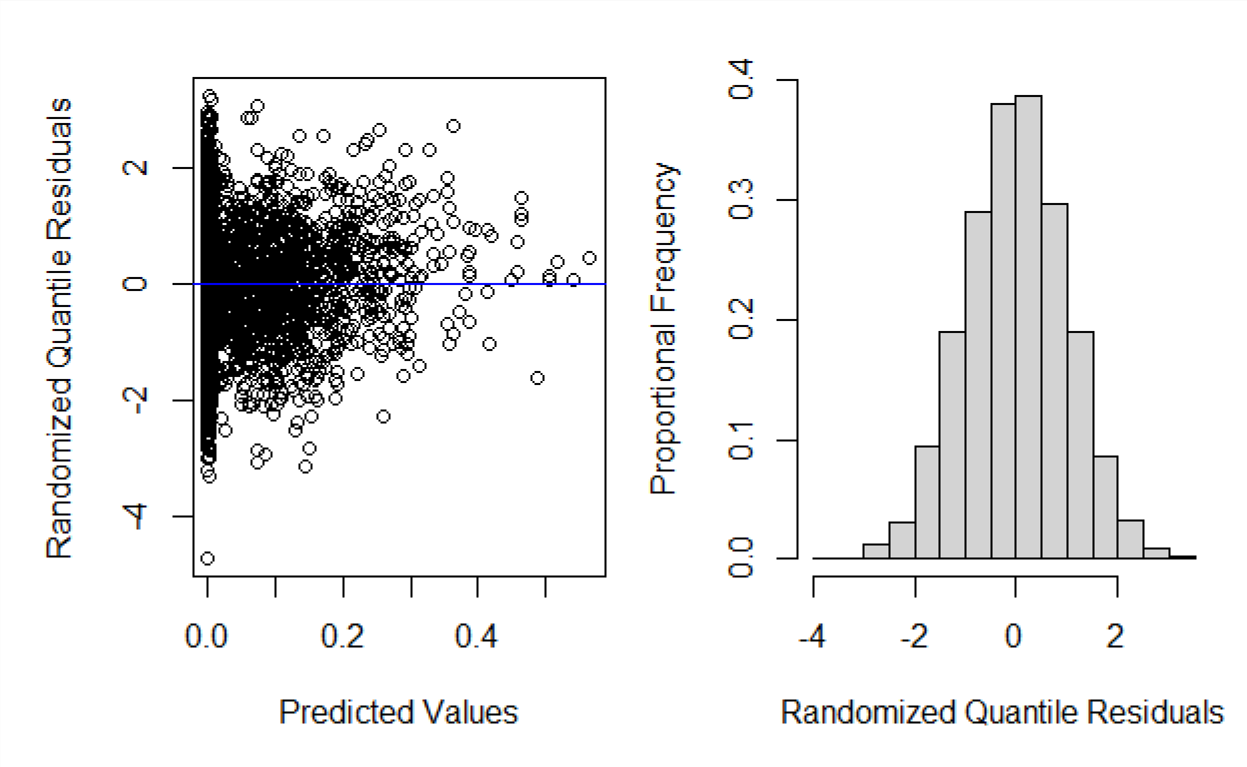

Figure 33. Residual distributions of the presence/absence process model selected for the *P. filamentosus* CPUE standardization.

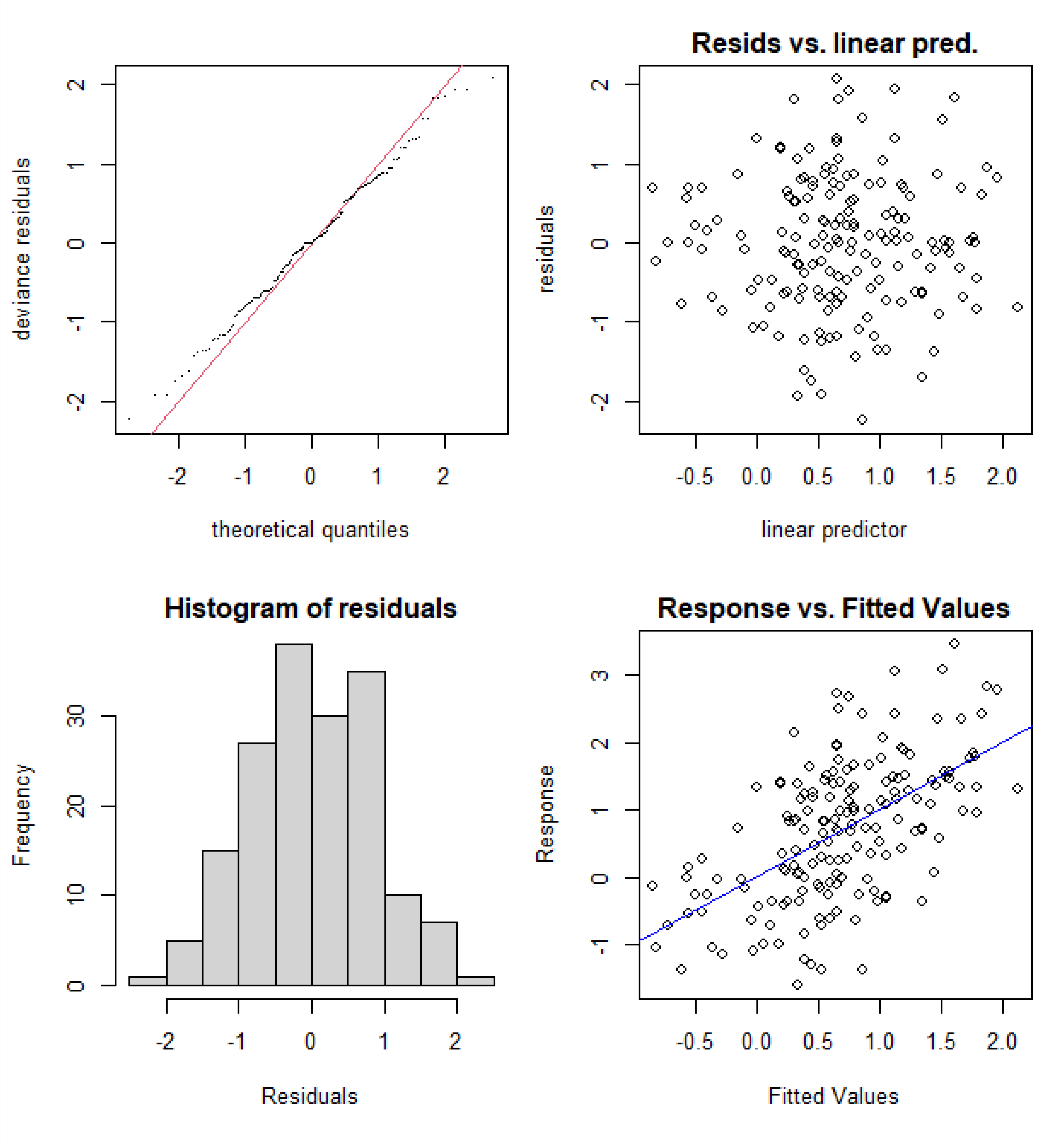

Figure 34. Residual distributions of the positive process model selected for the *P. filamentosus* CPUE standardization.

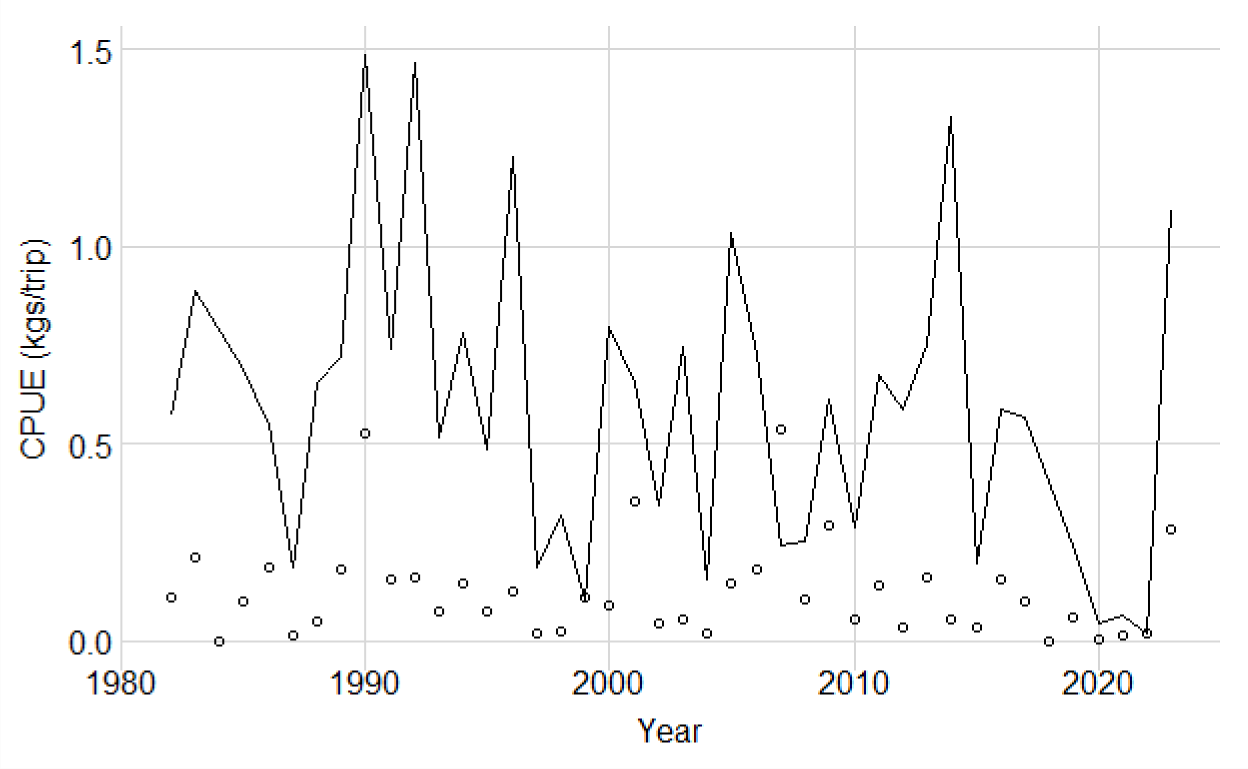

Figure 35. Standardized CPUE index (line) and nominal CPUE (points) of *P. filamentosus*.

Pristipomoides flavipinnis

P. flavipinnis was moderately represented in the BBS, occurring in 5.7% of interviews over all years, ranging from 2–19 positive interviews per year (Figure 36). There were sufficient data to include five levels of area, and a year × area interaction, for both the presence/absence and positive processes (Table 11). A random vessel effect was included for the presence/absence process only. The selected CPUE standardization models explained 38.2% and 33.5% of deviance in the data for the presence/absence and positive processes, respectively. Model residual diagnostics do not indicate any notable degree of overdispersion or heteroskedasticity (Figures 37–38), and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *P. flavipinnis*). CPUE was lowest in the Southwest Nearshore region. Type of bottomfishing had a noticeable effect within the presence/absence model: *P. flavipinnis* were unlikely to be encountered while shallow bottomfishing (Appendix, Supplemental Results for *P. flavipinnis*). Overall, there was an apparent decreasing trend in the standardized CPUE of *P. flavipinnis* over time, although with high interannual variability (Figure 39).

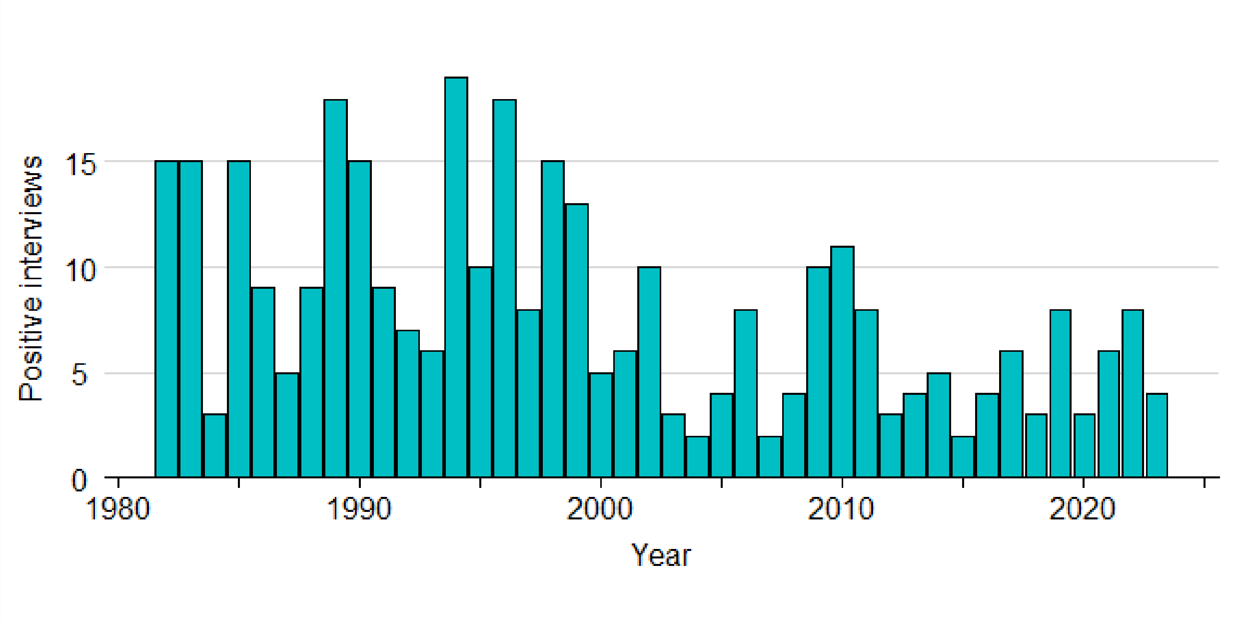

Figure 36. Number of bottomfishing interviews positive for *P. flavipinnis* by year. The nominal probability of occurrence for 1982–2023 was 0.0574.

Table 11. Selected models for the presence/absence and positive processes for *P. flavipinnis* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	Formula	n	nparm	Dev. Expl.
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4999	1573	0.3816
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + DEPTH + num_fisher_fac	287	264	0.3346

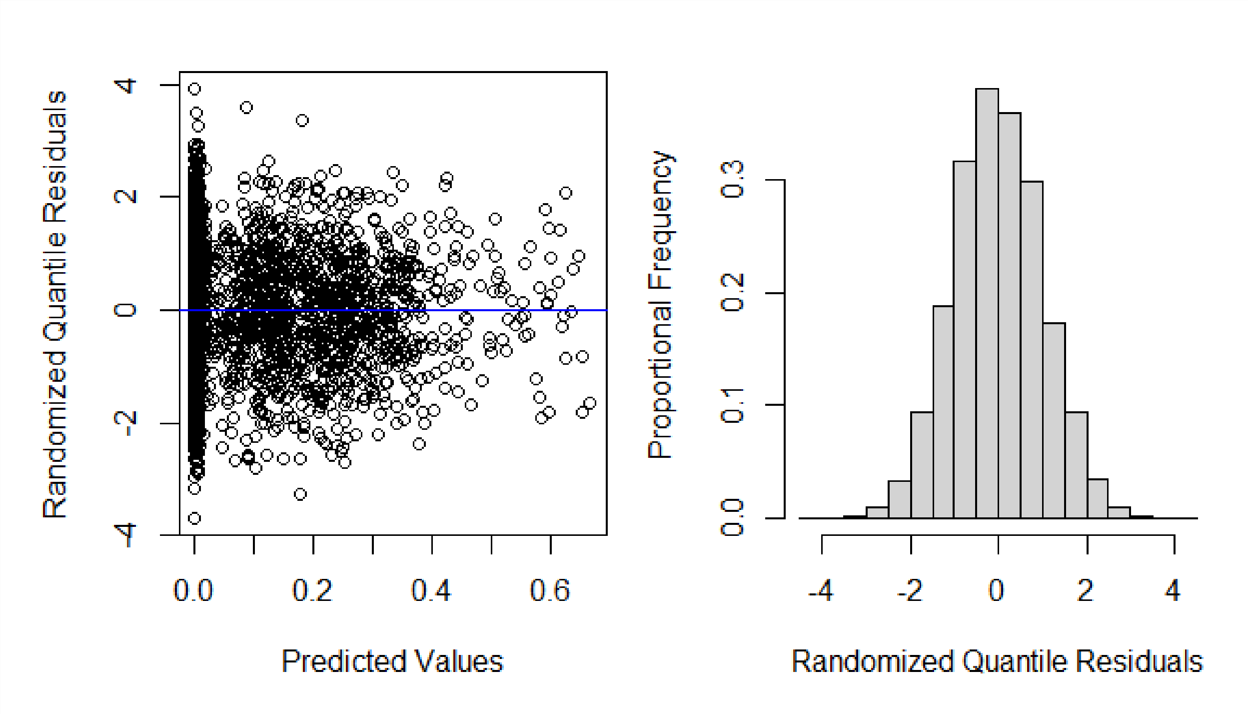

Figure 37. Residual distributions of the presence/absence process model selected for the *P. flavipinnis* CPUE standardization.

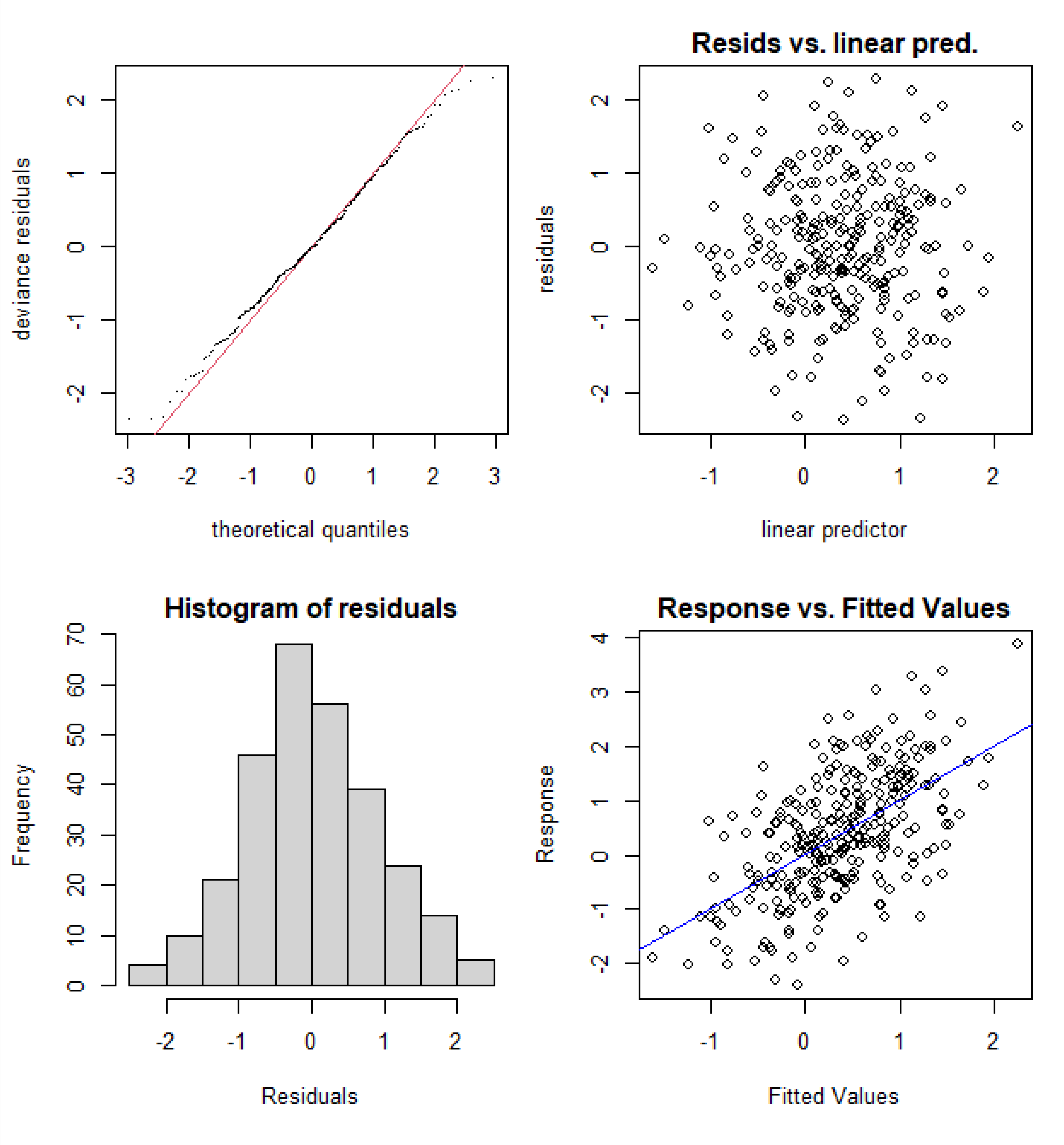

Figure 38. Residual distributions of the positive process model selected for the *P. flavipinnis* CPUE standardization.

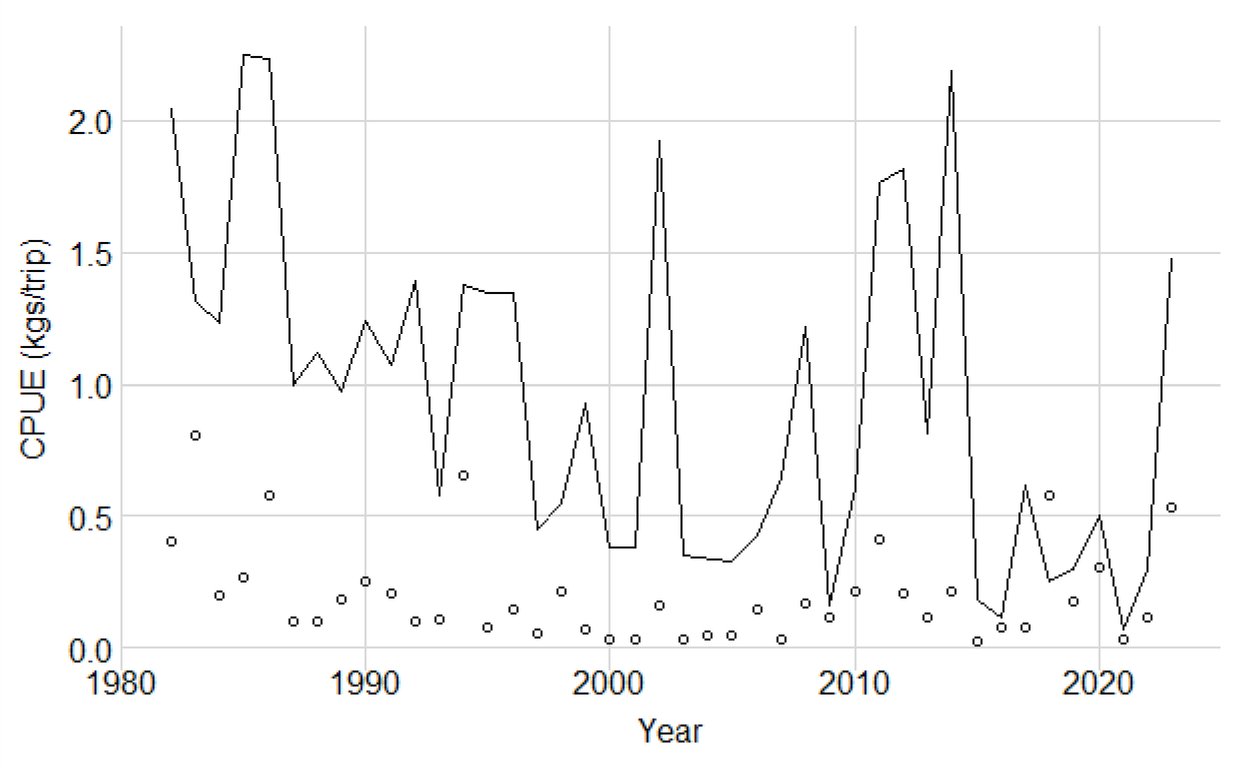

Figure 39. Standardized CPUE index (line) and nominal CPUE (points) of *P. flavipinnis*.

Pristipomoides sieboldii

P. sieboldii is rarely encountered in the BBS, with overall percent of positive interviews equal to 0.83. *P. sieboldii* was not observed at all in 19 years and was recorded in only one interview in 11 additional years (Figure 40). Although it is possible that some *P. sieboldii* were incorrectly identified as *P. filamentosus* (Iwane et al., 2023), the species is likely not commonly encountered by fishers in Guam. Regardless, there are insufficient observations in the BBS to produce a standardized CPUE index for *P. sieboldii*.

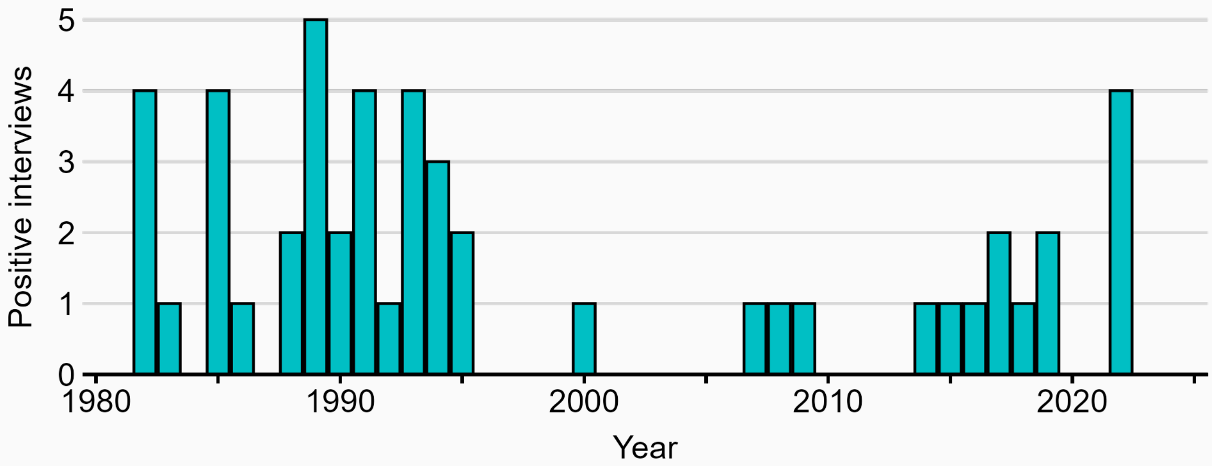

Figure 40. Number of bottomfishing interviews positive for *P. sieboldii* by year. The nominal probability of occurrence for 1982–2023 was 0.0083.

Pristipomoides zonatus

P. zonatus was relatively well-represented in the BBS, occurring in 11.4% of interviews over all years, ranging from 4–32 positive interviews per year (Figure 41). There were sufficient data to include five levels of area, a year × area interaction, and a random vessel effect for both the presence/absence and positive processes (Table 12). The selected CPUE standardization models explained 56.9% and 31.3% of deviance in the data for the presence/absence and positive processes, respectively. Model residual diagnostics do not indicate any notable degree of overdispersion or heteroskedasticity (Figures 42–43), and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *P. zonatus*). Type of bottomfishing had a noticeable effect within the presence/absence model: *P. zonatus* was unlikely to be encountered while shallow bottomfishing. *P. zonatus* was the only BMUS for which wind speed was selected in either model; it had a negative effect on catches. Also, in contrast to the *P. filamentosus* and *P. flavipinnis*, and to a lesser degree, *P. auricilla*, the CPUE of *P. zonatus* was not noticeably lower in the Southwest Nearshore Region (Appendix, Supplemental Results for *P. zonatus*). Overall, there was an apparent decreasing trend in the standardized CPUE of *P. zonatus* over time, although with high interannual variability (Figure 44).

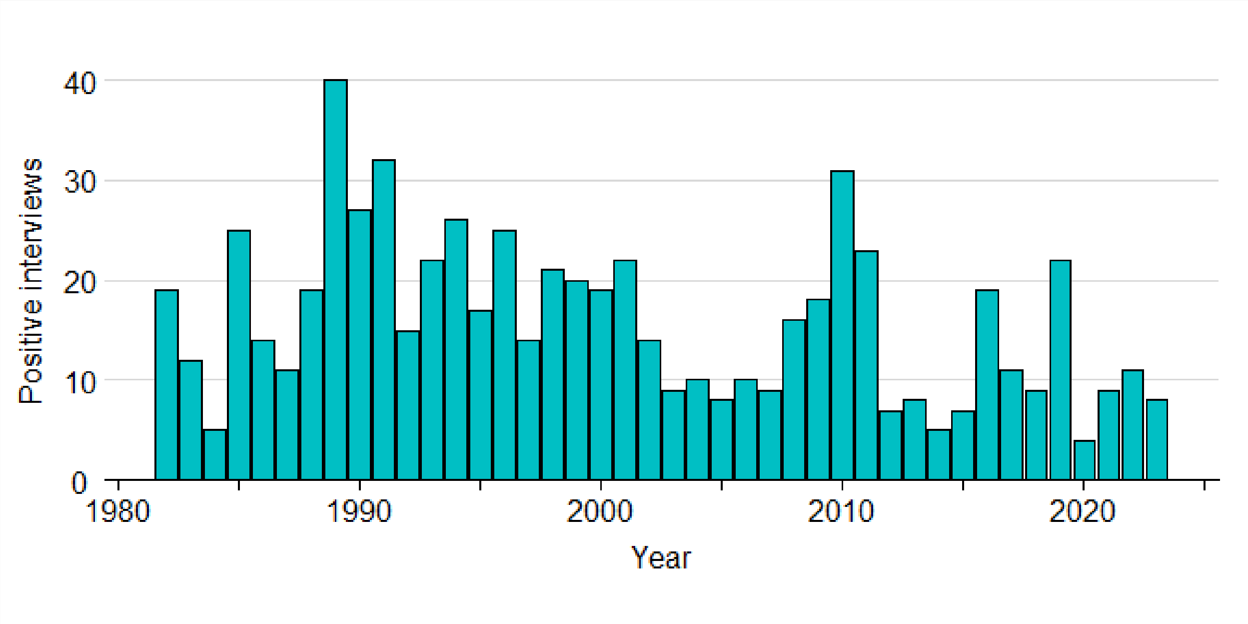

Figure 41. Number of bottomfishing interviews positive for *P. zonatus* by year. The nominal probability of occurrence for 1982–2023 was 0.1143.

Table 12. Selected models for the presence/absence and positive processes for *P. zonatus* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	Formula	n	nparm	Dev. Expl.
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	5083	1588	0.5692
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + DEPTH + vc_windspeed + s(VESSEL_ID_2, bs = "re")	582	513	0.3133

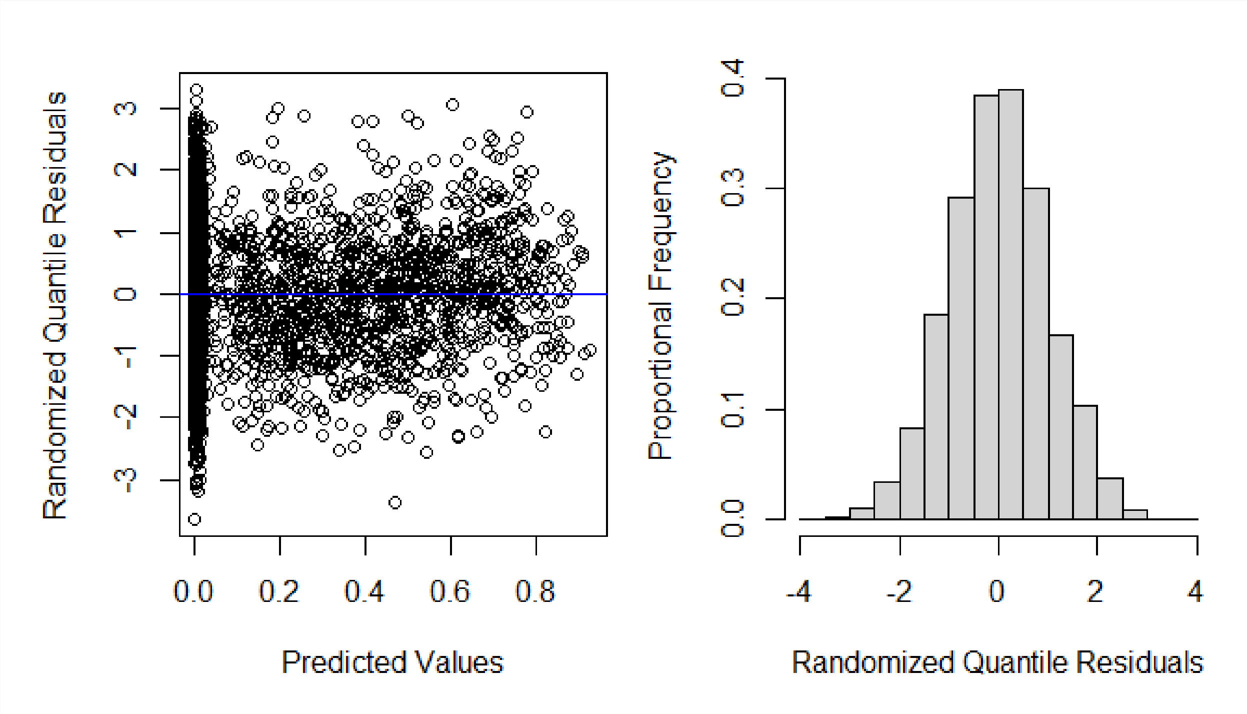

Figure 42. Residual distributions of the presence/absence process model selected for the *P. zonatus* CPUE standardization.

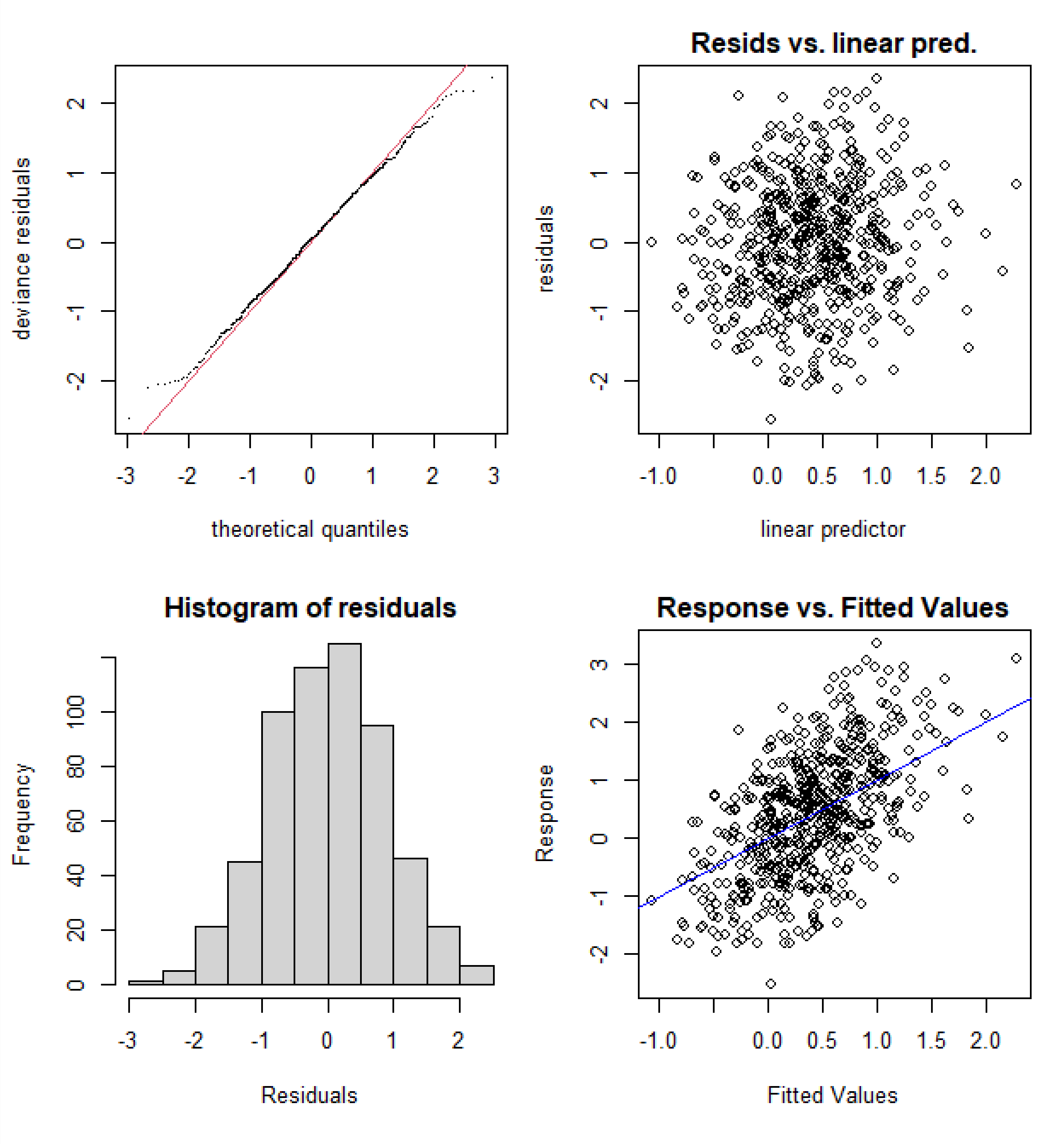

Figure 43. Residual distributions of the positive process model selected for the *P. zonatus* CPUE standardization.

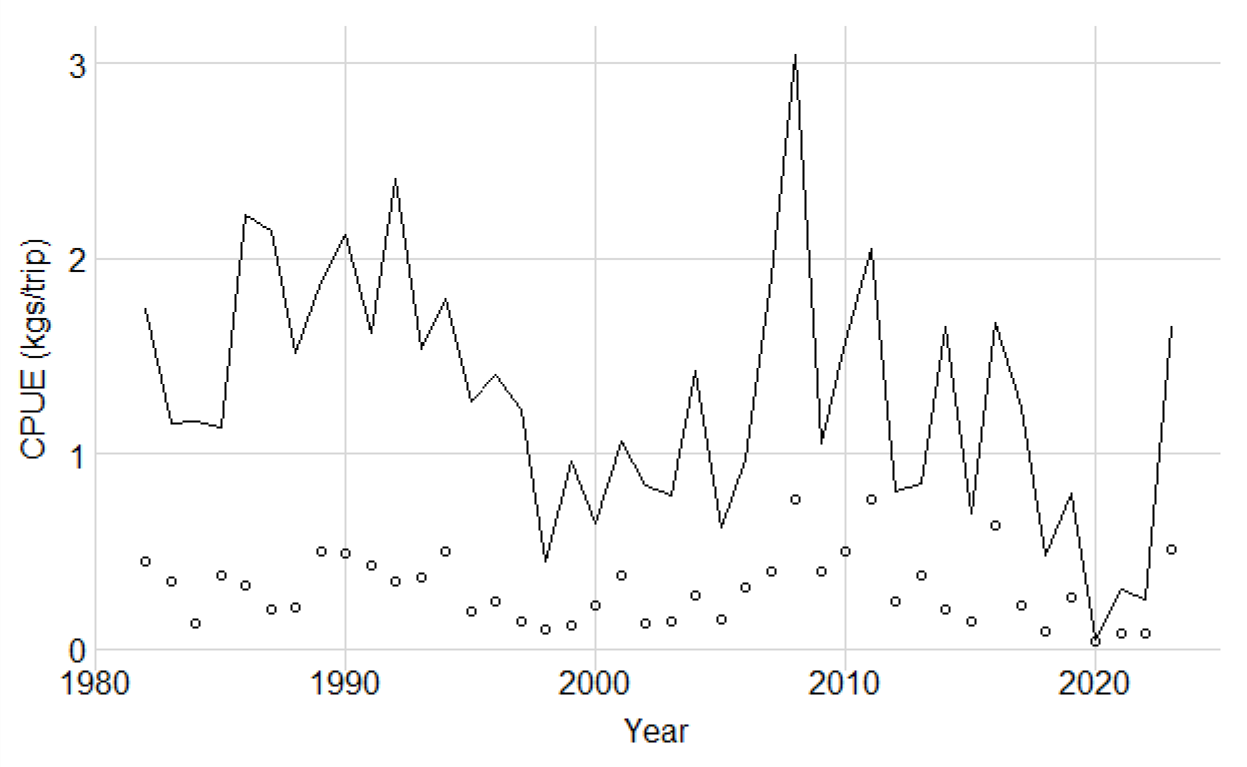

Figure 44. Standardized CPUE index (line) and nominal CPUE (points) of *P. zonatus*.

Variola louti

V. louti was moderately represented in the BBS, occurring in 10.5% of interviews over all years, ranging from 4–32 positive interviews per year (Figure 45). There were sufficient data to include five levels of area, and a year × area interaction, for both the presence/absence and positive processes (Table 13). A random vessel effect was included for the presence/absence process only. The selected CPUE standardization models explained 24.9% and 29.0% of deviance in the data for the presence/absence and positive processes, respectively. Model residual diagnostics do not indicate any notable degree of overdispersion or heteroskedasticity (Figures 46–47), and predictive checks indicate model error assumptions were appropriate (Appendix, Supplemental Results for *V. louti*). CPUE was highest in the Southwest Banks region and lowest in the Southwest Nearshore region (Appendix, Supplemental Results for *V. louti*). Overall, CPUE of *V. louti* is low in the BBS and there was no clear trend over time (Figure 48).

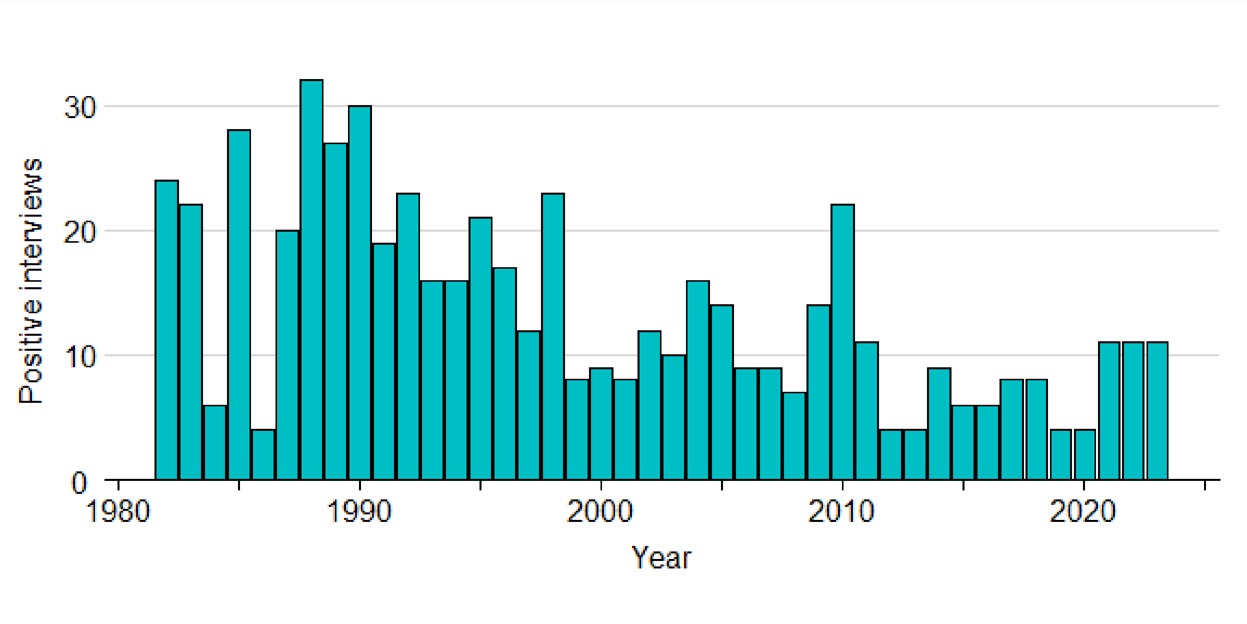

Figure 45. Number of bottomfishing interviews positive for *V. louti* by year. The nominal probability of occurrence for 1982–2023 was 0.1048.

Table 13. Selected models for the presence/absence and positive processes for *V. louti* with the number of interviews used in the model (n), the number of parameters in the model (nparm), and the deviance explained relative to the intercept only model (Dev. Expl.).

Process	Formula	n	nparm	Dev. Expl.
Presence/ Absence	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4717	1561	0.2486
Positive	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + tod_quarter + num_gear_fac	505	271	0.2894

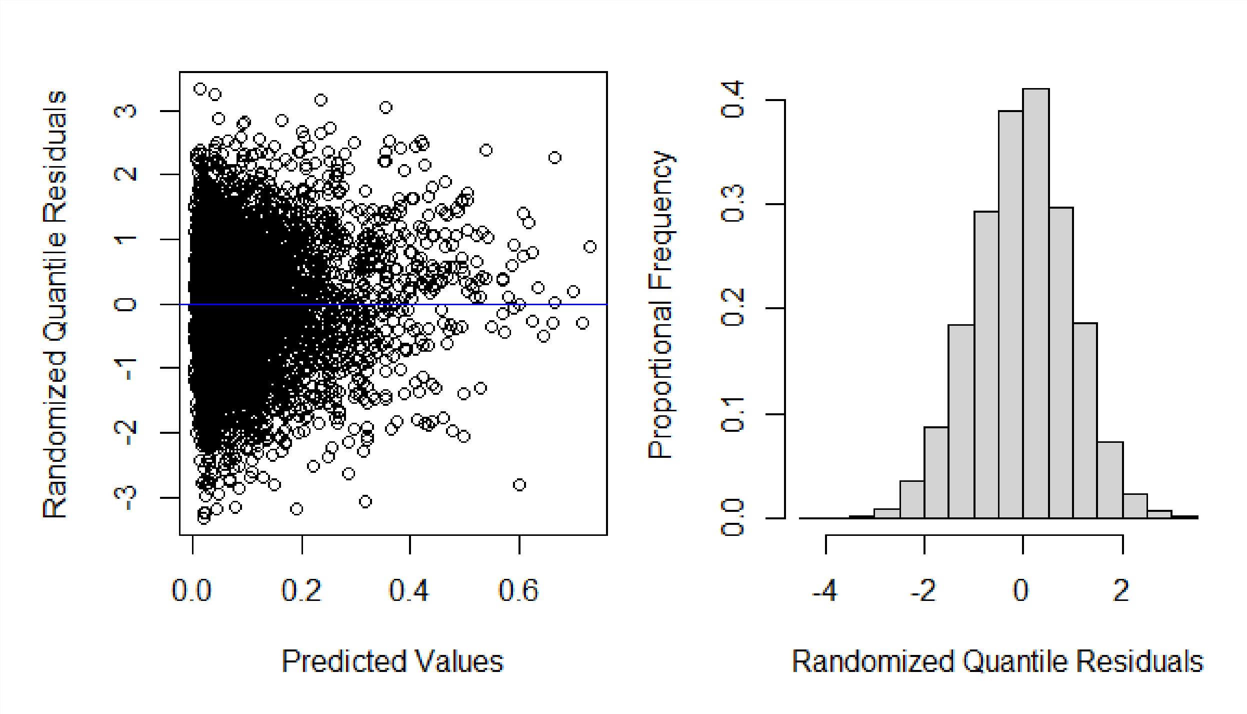

Figure 46. Residual distributions of the presence/absence process model selected for the *V. louti* CPUE standardization.

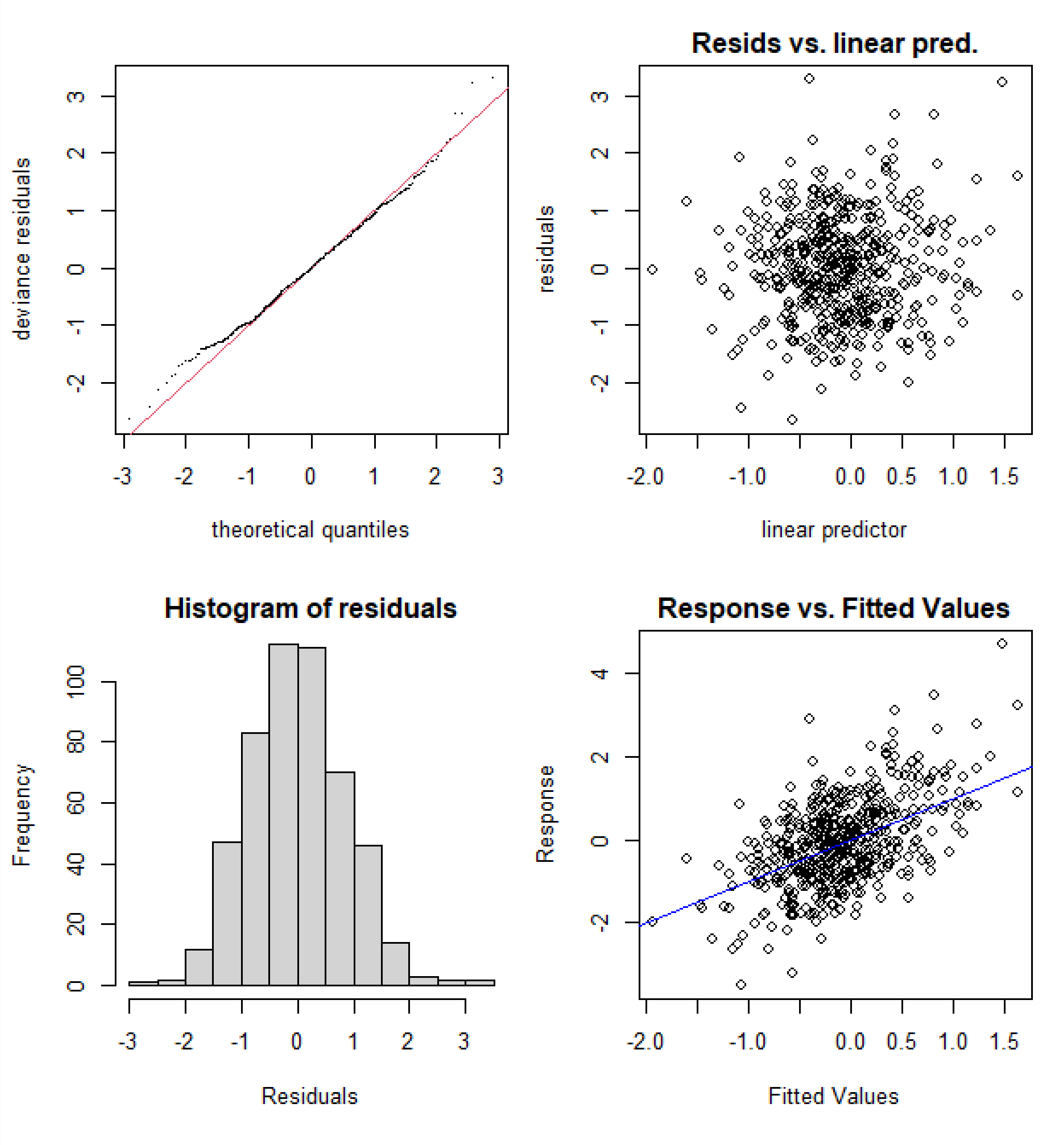

Figure 47. Residual distributions of the positive process model selected for the *V. louti* CPUE standardization.

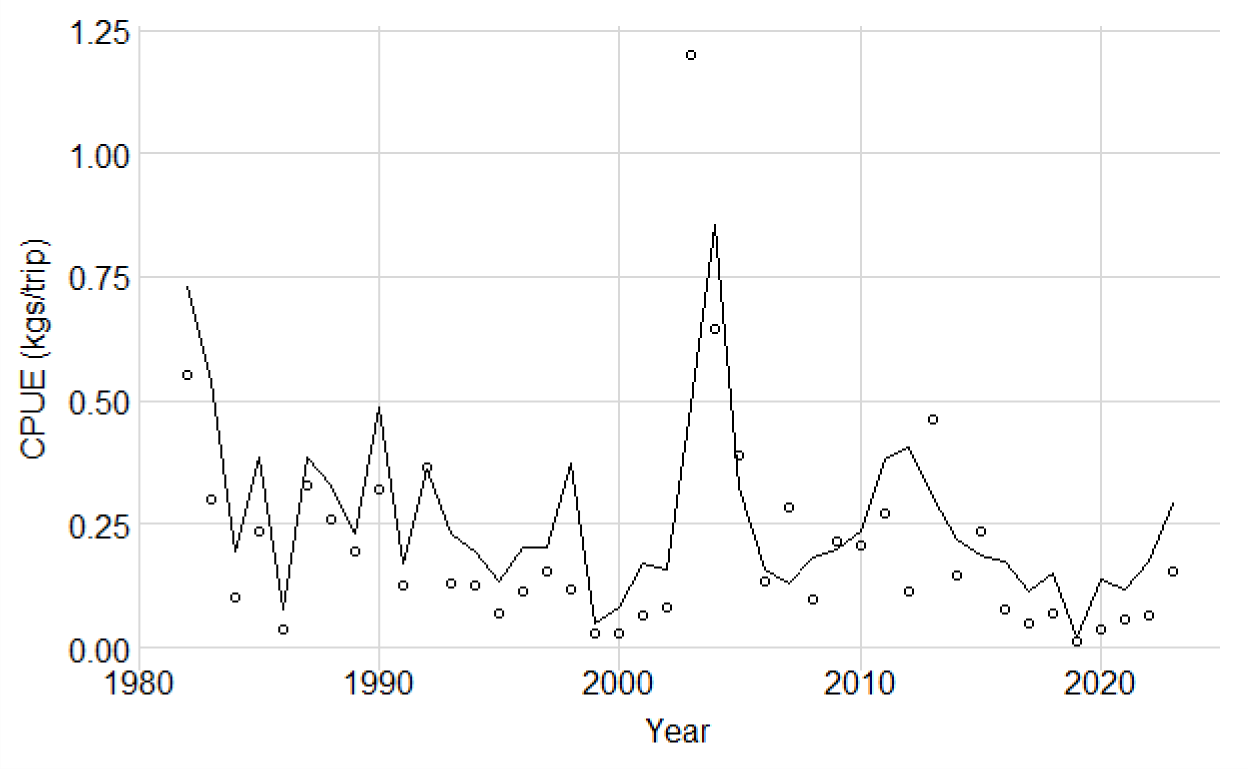

Figure 48. Standardized CPUE index (line) and nominal CPUE (points) of *V. louti*.

General Results and Discussion

We presented standardized CPUE indices for 11 of the 13 Guam BMUS. We did not attempt to provide a CPUE index for *E. carbunculus* because this species is not reliably identified in the Guam BBS. We also did not provide a CPUE index for *P. sieboldii* because it is rarely encountered by Guam bottomfishers and there are insufficient observations in the BBS to produce a standardized CPUE index.

The number of BBS interviews available for the CPUE standardization models varied among BMUS, especially for the positive process, ranging from 86 for the rarest BMUS in the BBS data, *C. ignobilis*, to 1,321 for the most common BMUS, *L. rubrioperculatus* (Table 14). The number of interviews in the presence/absence process models ranged from 4,533 to 5,083 and was variable among BMUS. Of the total 6,062 bottomfishing interviews in the data set, the interviews excluded for containing unidentified species groups varied by BMUS and interviews excluded for missing covariate information varied by the covariates within the model. The amount of deviance explained by each model ranged from 10% to 68%. Deviance was higher for models with less data, as expected.

Targeting (depth) was the first selected covariate in the presence/absence models for all BMUS except *C. ignobilis* (Table 14). The models suggest *A. rutilans*, *C. lugubris*, *E. coruscans*, *P. auricilla*, *P. filamentosus*, *P. flavipinnis*, and *P. zonatus* were less likely to be encountered in shallow bottomfishing trips than in deep or mixed bottomfishing trips. In contrast, *L. rubrioperculatus*, *L. kasmira*, and *V. louti* were more likely to be encountered in shallow bottomfishing trips. Targeting was included, but minimally influential, in the positive process models for *A. rutilans*, *P. auricilla*, *P. flavipinnis*, and *P. zonatus*. In these models, if encountered, the CPUE of each BMUS was marginally higher for deep relative to shallow or mixed bottomfishing trips. These general trends agree with the information from fishers that they effectively target different groups of BMUS by undertaking either shallow or deep bottomfishing.

Considered in isolation, the effect of targeting within the models suggests that the increase in deep relative to shallow bottomfishing interviews over the time series (Figure 27) has had a stabilizing effect on the year-only model estimated CPUE of species that are more likely to be encountered in deep bottomfishing (e.g., *P. auricilla*, Figure A64). The relatively heavy proportion of shallow bottomfishing trips in the data set during the early years (e.g., 1992, 1995, 1997, 1999) would have increased the year-only model estimated CPUE of those species more likely to be encountered in shallow waters during the early part of the time series and amplified declines in CPUE over time (e.g., L. rubrioperculatus; Figure A43).

It is important to remember within the final CPUE standardization models, no covariates operate in isolation, and partial effects of covariates that appear strong or unidirectional may be obscured by opposing effects of other covariates in the final CPUE index estimation.

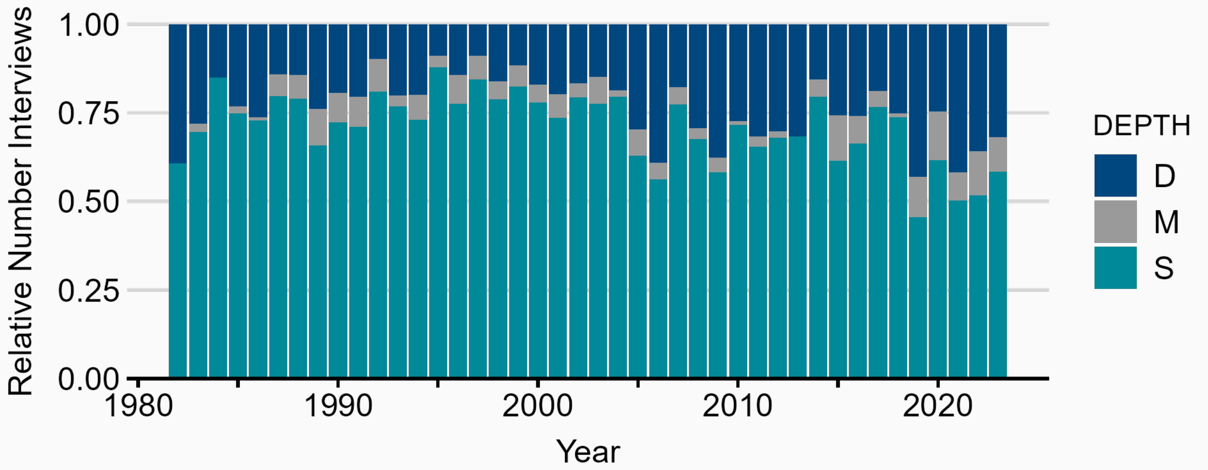

Figure 49. The relative number of interviews by bottomfishing type, 1982–2023. “D” is deep, “M” is mixed, and “S” is shallow.

Fishing effort per trip in the form of hours fished was selected in one or both processes for all BMUS. In the presence/absence models, the probability of encountering each BMUS increased as number of hours fished increased. For example, the presence/absence process model for *A. rutilans* included a relatively strong partial effect of effort on catch: a trip with 10 hours fished was twice as likely to encounter *A. rutilans* than a trip with 2 hours fished (Figure A4). It is important to note that hours fished was not included in the positive process models for either *C. ignobilis* or *E. coruscans*. This suggests if hours fished were included within the effort definition of the CPUE standardization (i.e., if CPUE were modeled in terms of catch per hour fished instead of catch per trip), then, variation in trip length between years would have unduly influenced modeled CPUE trends for these 2 BMUS. The other effort covariates, number of fishers and number of gears, were selected onl;y in the positive process models for *C. ignobilis*, *P. auricilla*, *P. flavipinnis*, and *V. louti*; they were selected last in each case. Similar to the hours fished effort metric, including either number of fishers or number of gears within the effort definition of the CPUE standardization (e.g., if CPUE were modeled in terms of catch per gear or catch per gear × hour fished instead of catch per trip) would have had a potentially spurious or obscuring effect on modeled CPUE for most of the BMUS.

A time of day covariate was not selected in the majority of models but was included in the presence/absence process models for *C. ignobilis* and *E. coruscans* and the positive process models for *L. kasmira*, *P. filamentosus*, and *V. louti*. The effect of time of day on *C. ignobilis* and *P. filamentosus* was very slight and could have been largely driven by small sample size. However, the influence of time of day on the standardization of the other BMUS revealed some interesting trends. For example, in the presence/absence process model for *E. coruscans*, the probability of occurrence in interviews reported between 1800 and 0600 was roughly twice that than during 0600 and 1800 (Appendix Figure A33). There is high interannual variability in the relative contribution of nighttime to daytime trips within the data set, and a general shift towards daytime trips in recent years. As a result, time of day has had a negative influence within the presence/absence process model for *E. coruscans*. Although of time of day was included in the positive processes for *L. kasmira* and *V. louti*, its influence, was relatively minor.

The type of day was not selected in any model. This was somewhat unexpected because there is a persistent perception that fishers who fish only on weekends and holidays would have different abilities to catch bottomfishes relative to fishers who fish during the week and are likely more dedicated or experienced bottomfishers. This may certainly be the case, but within the CPUE model selection, there may be insufficient data or this relationship is being captured in other model covariates such as vessel. Similarly, whether or not a fishing trip was a charter trip had an effect in only two models: the positive processes for *E. coruscans* and *L. kasmira*. In both instances, catch was slightly lower for charter trips than non-charter trips (Appendix Figures A37 and A59). The fishing community also indicated that charter fishing trips are conducted differently than non-charter trips, but within the CPUE standardization models presented here, it is possible that those differences are being captured in other model covariates such as area fished, depth, or hours fished.

Environmental factors were also surprisingly not selected for in most models. Wind direction was not retained in any models, while wind speed was retained in only the positive process model for *P. zonatus*. Fishers indicate that sea conditions, both on the fishing grounds and near the boat harbors, largely influence their decisions whether to go fishing. Within the interview data available in this analysis, however, whether a given BMUS is encountered and how much is caught is not influence by weather conditions when considered together with all the other covariates. Fishers suggested that in addition to affecting tidal currents, moon phase also affects the feeding behaviors and catchability of certain fish. In particular, there was a suggestion that the jacks, *C. ignobilis* and *C. lugubris*, would hunt more actively at night making them easier to catch as more moonlight would be available (Iwane et al., 2023). The relatively small sample size, especially for the positive process for these BMUS (86 and 196 interviews for *C.*

ignobilis and *C. lugubris*, respectively) may have prevented such a relationship from being apparent in the data. Further, it is expected that the amount of moonlight would only affect fish behavior at night so to properly account for it would require a moon phase × time of day interaction, for which there were not sufficient interview data. Moon phase was retained in one model: the positive process for *E. coruscans*, with fishers catching slightly more *E. coruscans* closer to the full moon (Figure A38). Interestingly, this is contrary to information from fishers which suggested too much moonlight causes *E. coruscans* to "go away" (Iwane et al., 2023); this would be associated with the opposite relationship in the model.

Unlike the covariates discussed thus far, area was included in all models without being subjected to selection. Both processes for all BMUS except *C. ignobilis* had sufficient data to use a five-level area variable in the models, which maintained a delineation between the offshore banks and nearer shore areas around Guam (Figure 1). There were very few interviews in which *C. ignobilis* was observed, so there were not enough data to fit models with five levels of area. Instead, both processes for the *C. ignobilis* models used a modified three-level area, where the banks and nearshore areas were combined (e.g., SW banks and SW nearshore were pooled to SW; E banks and E nearshore were pooled to E). The effect of area within the models was generally minor but most notable for *A. rutilans*, *E. coruscans*, *L. rubrioperculatus*, *P. filamentosus*, and *P. flavipinnis* where the southwest nearshore area had the lowest probabilities of occurrence and lowest catches (e.g., Figures A2, A7, A42, A46).

Including area as a fixed categorical effect allowed for scaling of the response among areas. However, we assumed the trends in response over time may differ among areas, so we added a year × area interaction term into all models, with the exception of instances where data were insufficient to fit the interaction term (the positive process models for *C. ignobilis*, *C. lugubris*, *E. coruscans*, and *P. filamentosus*). The year × area interaction terms were generally unnoticeable and not significant in most models, except for the presence/absence models for *E. coruscans*, *L. rubrioperculatus*, and *V. louti*, and the positive processes for *L. kasmira* and *P. auricilla*. It is important to note that because area was included in the final CPUE estimation of the marginal means by year, shifts in the number of interviews per area over the time series of the BBS (Bohaboy & Matthews, 2023) are not expected to influence trends in the estimated CPUE indices.

Time of year was also included in all models a priori but had relatively minor effects on either probability of occurrence or catch. The most noticeable trends were for *L. rubrioperculatus*, *P. auricilla*, and *P. zonatus*; they exhibited peaks in both probability of occurrence and catch during the summer months (July–September; e.g., Figures A42, A46, A94, A98). In contrast, *A. rutilans*, *L. kasmira*, and *P. flavipinnis* showed slightly higher probability of occurrence in the winter/spring (November–February; e.g., Figure A84).

We added a random intercept term for vessel to the selected models when there were enough data to do so. For the presence/absence process, only *C. ignobilis* had too few interviews to include a vessel term. For the positive process models, there were too many vessels relative to interviews to include a vessel term for *A. rutilans*, *C. ignobilis*, *P. filamentosus*, *P. flavipinnis*, or *V. louti*. In most instances, the amount of model deviance explained by the addition of the random vessel effect was relatively large, explaining an additional 10–30% of model deviance. For the majority of models that could include a random vessel effect, it is apparent that some vessels may "specialize" in certain BMUS (or multiple BMUS) and are more likely to encounter them or experience higher catches when they are encountered. In general, these specialized fishers may enter and leave the fishery at different times, often concurrently with less skilled or specialized fishers, hence the influence within the model is not strong or clearly directional. For instance, in the presence/absence models for *E. coruscans*, *P. filamentosus*, and *P. flavipinnis*, there is a small number of fishers who are more likely to catch these species, but these fishers have been participating in the fishery over the time series concurrently with many less experienced fishers so the overall influence within the model is small (Figures A34, A78, A86). The vessel effect is perhaps most influential for the relatively shallow BMUS (*L. rubrioperculatus* and *L. kasmira*, and to a lesser extent, *V. louti*) where between 1985 and 1995, there was a peak in interviews with vessels that were particularly likely to catch these species (Figures A44, A54, A107).

It is important to note that shifting compositions of fishing fleets over time can be challenging to account for in CPUE standardization models. Often, particularly for largescale industrialized fisheries, less effective fishers or fishing vessels might leave the fishery, especially if costs increase. It has been suggested by fishers that during the pandemic when restaurant demand for bottomfishes decreased, many Guam commercial bottomfish fishers fished less for deep BMUS, while those who were new to bottomfishing and perhaps had more free time due to pandemic lock-downs fished more for deep BMUS. The vessel effect influence values for 2020, 2021, and 2022 are negative relative to the time series average for most BMUS. This observation applies to both the "shallow" and "deep" BMUS, suggesting that during the pandemic, representation of newer or less skilled fishers increased in the interview data generally, not necessarily for only the deeper species.

Residual distributions for all presence/absence process models do not indicate any notable degree of overdispersion or heteroskedasticity. Predictive checks also indicated that the binomial error distribution is appropriate. The diagnostics of the positive process models suggest the assumptions of lognormal error structure are not unreasonable, but including *C. ignobilis*, *C. lugubris*, *E. coruscans*, *P. auricilla*, and *P. filamentosus* in some models negatively skewed model residuals slightly. Although not ideal, we believe the estimated variance of the final CPUE indices is sufficiently large to reasonably reflect any uncertainty this may confer within the modeled indices.

The 11 BMUS CPUE indices presented in this working paper all show high interannual variability. This may be due partially to overall small sample sizes or high observation error that is expected from a creel survey attempting to capture information on a fishery as large and diverse as all boat-based fishing in Guam. Guam bottomfishers report that BMUS catches spike in 2–7 year cycles (Iwane et al., 2023), and these observations are apparently captured within the CPUE indices. However, it is uncertain whether these short-term highs and lows in CPUE are reflective of underlying trends in abundance; they may be an artifact of some other variable affecting catchability of BMUS that has not been adequately addressed in these models.

We are confident the CPUE standardization approaches and indices presented in this working paper are appropriate for use in the next benchmark stock assessment of Guam BMUS. Although the generally small number of available interviews and uneven sample coverage over space and time introduce difficulty in the CPUE standardization process, we feel we have sufficiently captured the primary influences of catch rates that are independent of underlying abundance trends, particularly shifts in fishers' behavior over the time series regarding areas fished, trip length, and fishers skill.

The analyses presented here represent an improvement over the CPUE standardization used in the most recent benchmark stock assessment (Langseth et al., 2019). We addressed several suggestions made by members of the WPSAR panels and SSC, including:

(1) Account for shifts in overall BMUS species composition over time through the use of single species CPUE standardization models;
(2) Account for potential differences in CPUE trends between areas, particularly in the nearshore versus banks. Additionally, we grouped location definitions into larger regions and eliminated interviews with ambiguous location information from the data. We also considered a year × area interaction to account for potential differences in CPUE trajectories over time;
(3) Account for changes in the fishers participating in the fishery over time (i.e., fishers' skill) by including a random intercept term for vessel ID a priori;
(4) Account for targeting of species within the BMUS complex by using the reported bottomfishing method within the interview data, recognizing that Guam bottomfishers often target either shallow or deep bottomfishes;
(5) More accurately retain the zero catch interviews within the data because species groups are not being broken down to presumptive BMUS at the interview level;
(6) Retain charter fishing trips in the data and evaluate the effect for relevance, whereas previously, charter trips were excluded;

(7) Treat effort variables (hours fished, gears, fishers) as potential covariates in the model as opposed to in the definition of effort in the response, to allow for more flexibility.

Table 14. Summary of selected CPUE standardization models.

BMUS	Presence/Absence Process		Positive Process	
	Formula	n	Formula	n
A. rutilans	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	5039	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED	316
C. ignobilis	z ~ year_fac + AREA_D + s(yday, bs = "cc") + HOURS_FISHED + tod_quarter	4991	log(catch_kgs) ~ year_fac + AREA_D + s(yday, bs = "cc") + num_fisher_fac	86
C. lugubris	z ~ year_fac + AREA_E + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	4533	log(catch_kgs) ~ year_fac + AREA_E + s(yday, bs = "cc") + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	196
E. coruscans	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + tod_quarter + s(VESSEL_ID_2, bs = "re")	4718	log(catch_kgs) ~ year_fac + AREA_E + s(yday, bs = "cc") + s(moon, bs = "cc") + CHARTER_F + s(VESSEL_ID_2, bs = "re")	250
L. rubrioperculatus	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4661	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	1321
L. kasmira	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	4785	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + tod_quarter + CHARTER_F + s(VESSEL_ID_2, bs = "re")	703
P. auricilla	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + HOURS_FISHED + s(VESSEL_ID_2, bs = "re")	5083	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + DEPTH + num_gear_fac + num_fisher_fac + s(VESSEL_ID_2, bs = "re")	644
P. filamentosus	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4959	log(catch_kgs) ~ year_fac + AREA_E + s(yday, bs = "cc") + HOURS_FISHED	169

BMUS	Presence/Absence Process		Positive Process	
	Formula	n	Formula	n
P. flavipinnis	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4999	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + DEPTH + num_fisher_fac	287
P. zonatus	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	5083	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + DEPTH + vc_windspeed + s(VESSEL_ID_2, bs = "re")	582
V. louti	z ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + DEPTH + s(VESSEL_ID_2, bs = "re")	4717	log(catch_kgs) ~ year_fac + AREA_E + s(AREA_E, year_fac, bs = "re") + s(yday, bs = "cc") + HOURS_FISHED + tod_quarter + num_gear_fac	505

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Appendix: Supplemental Results

Aphareus rutilans

Presence/Absence Model

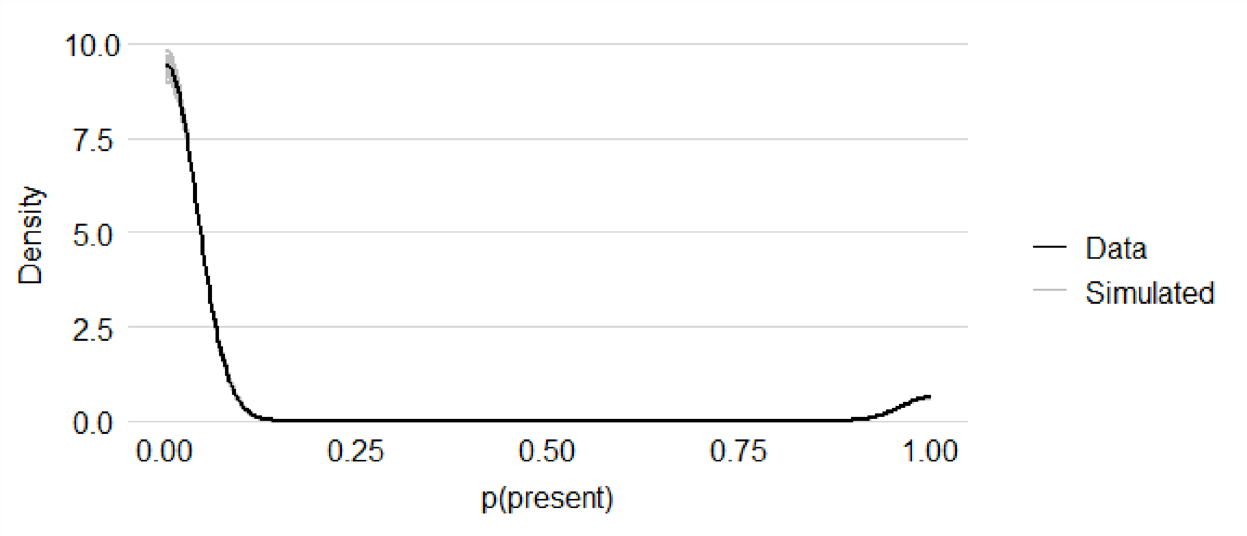

Figure A 1. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *A. rutilans* CPUE standardization.

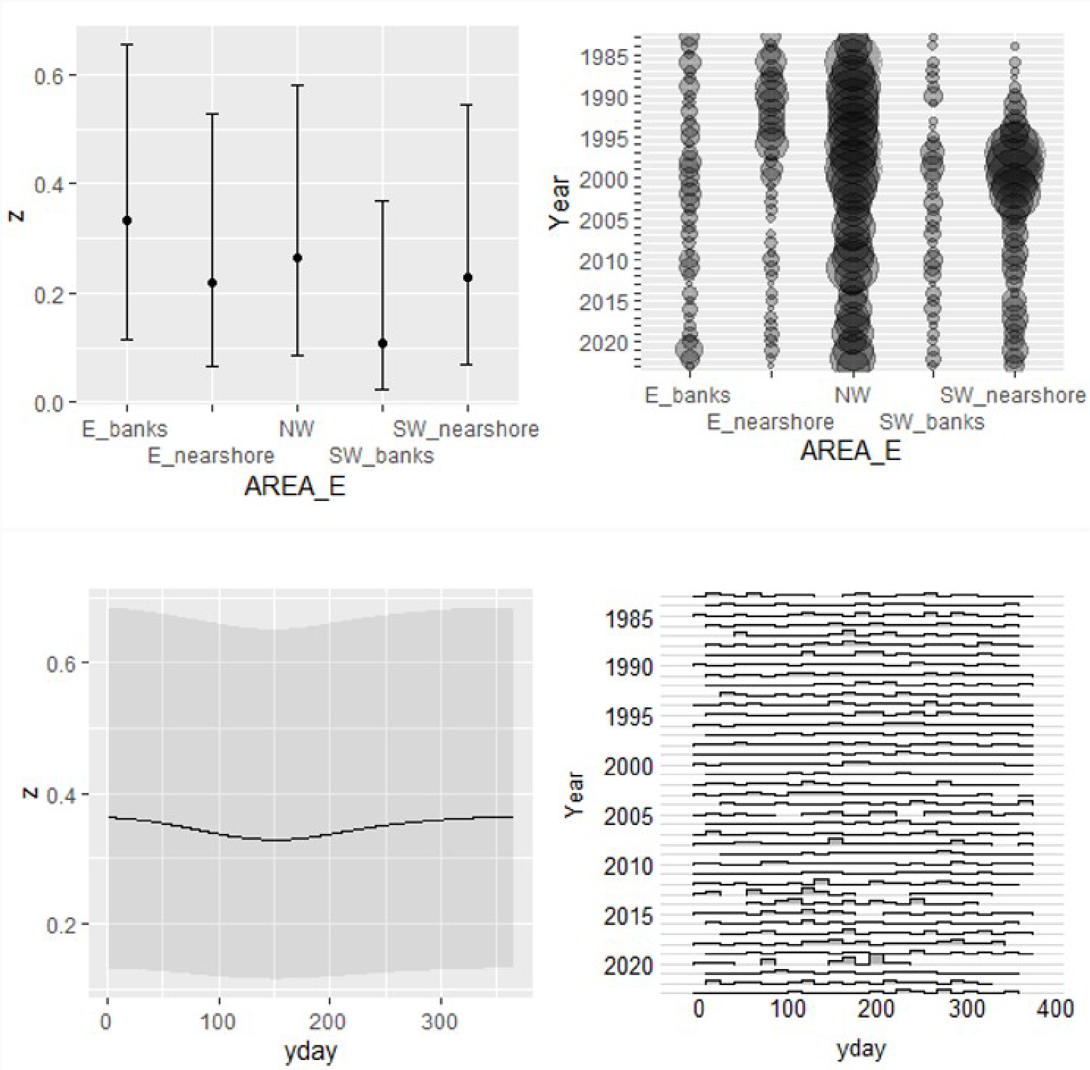

Figure A 2. Partial effects of area and time of year on probability of presence in the *A. rutilans* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

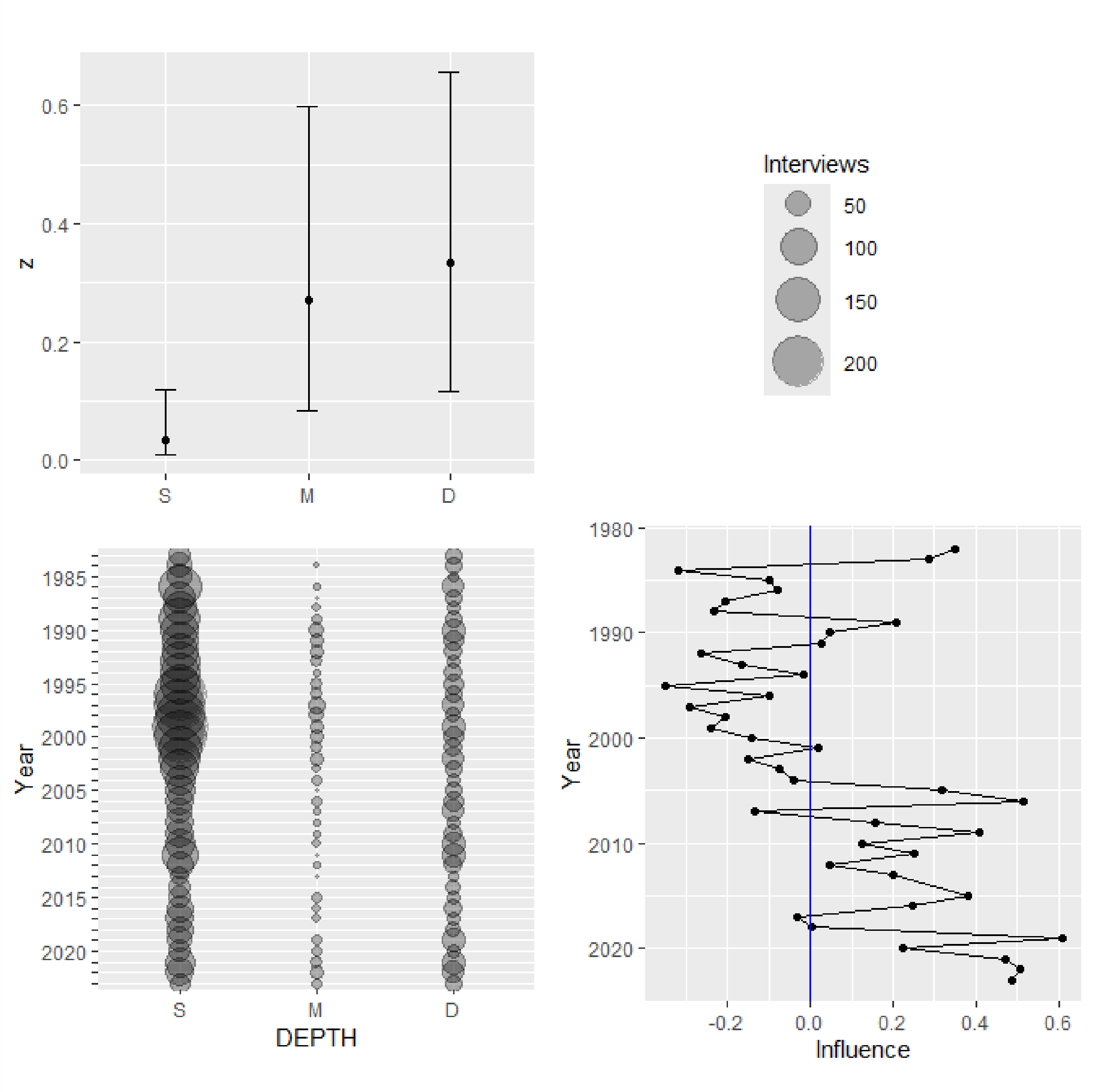

Figure A 3. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type ('depth') on probability of presence in the *A. rutilans* CPUE standardization.

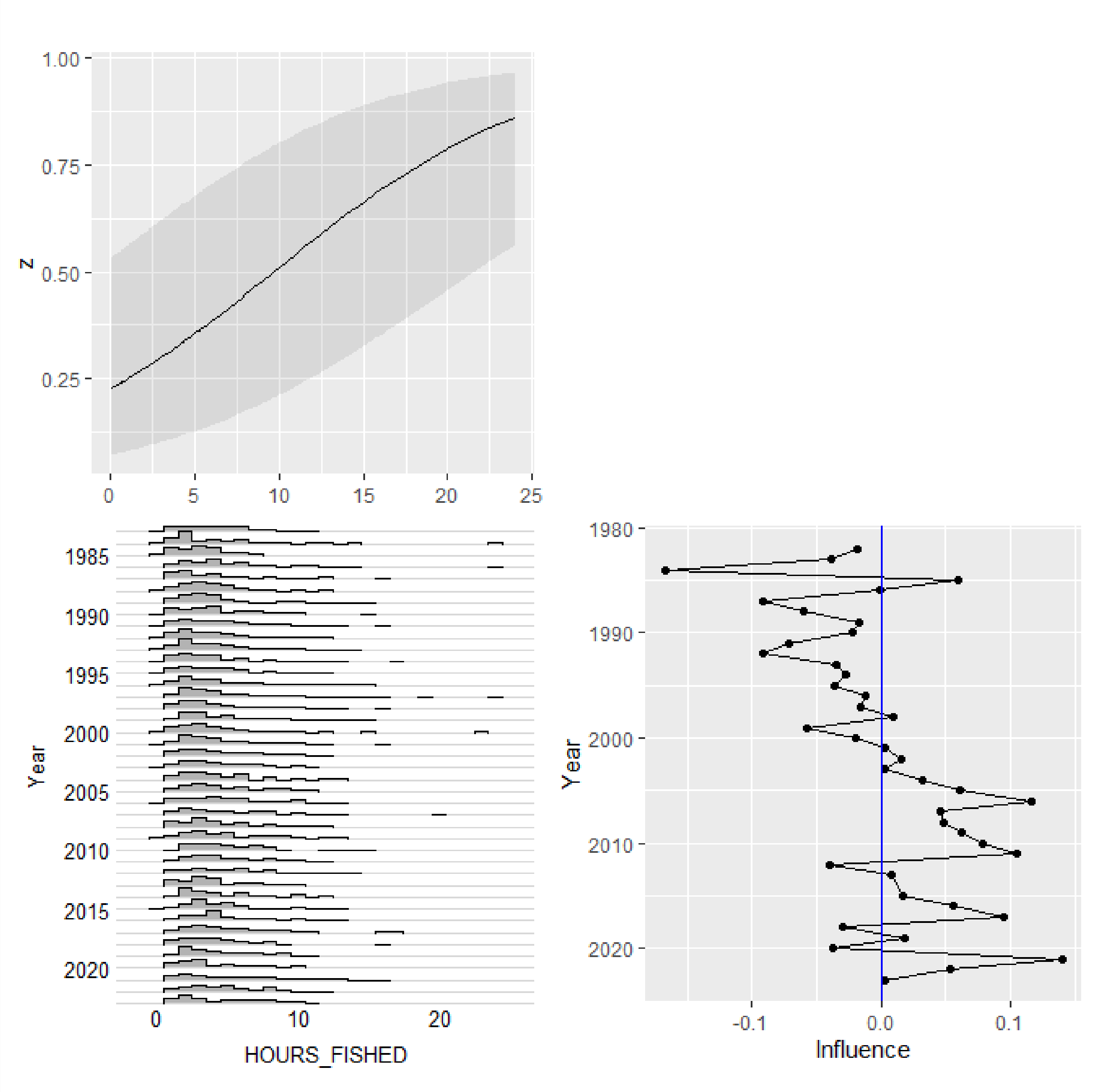

Figure A 4. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on probability of presence in the *A. rutilans* CPUE standardization.

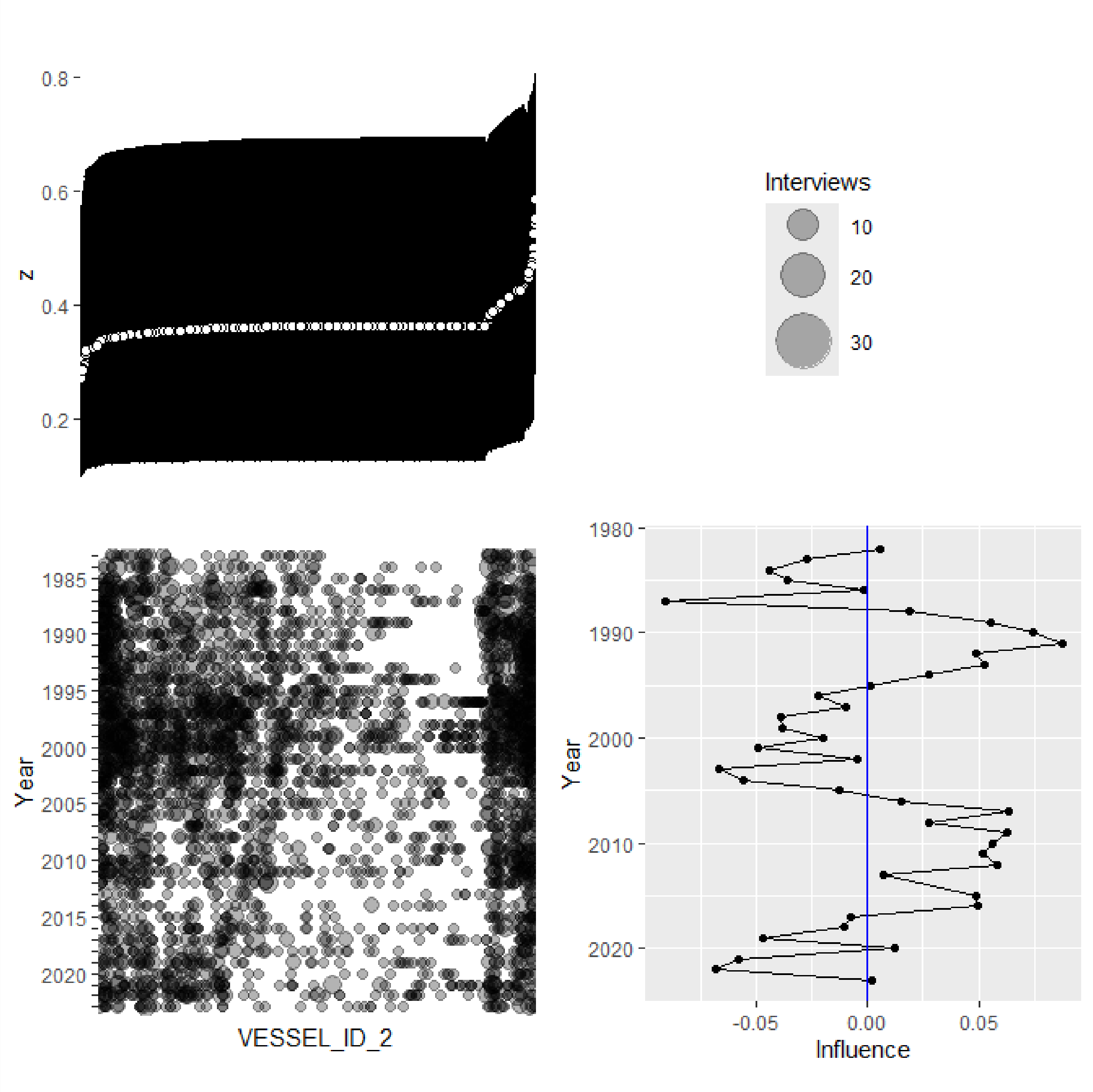

Figure A 5. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *A. rutilans* CPUE standardization.

Positive Process Model

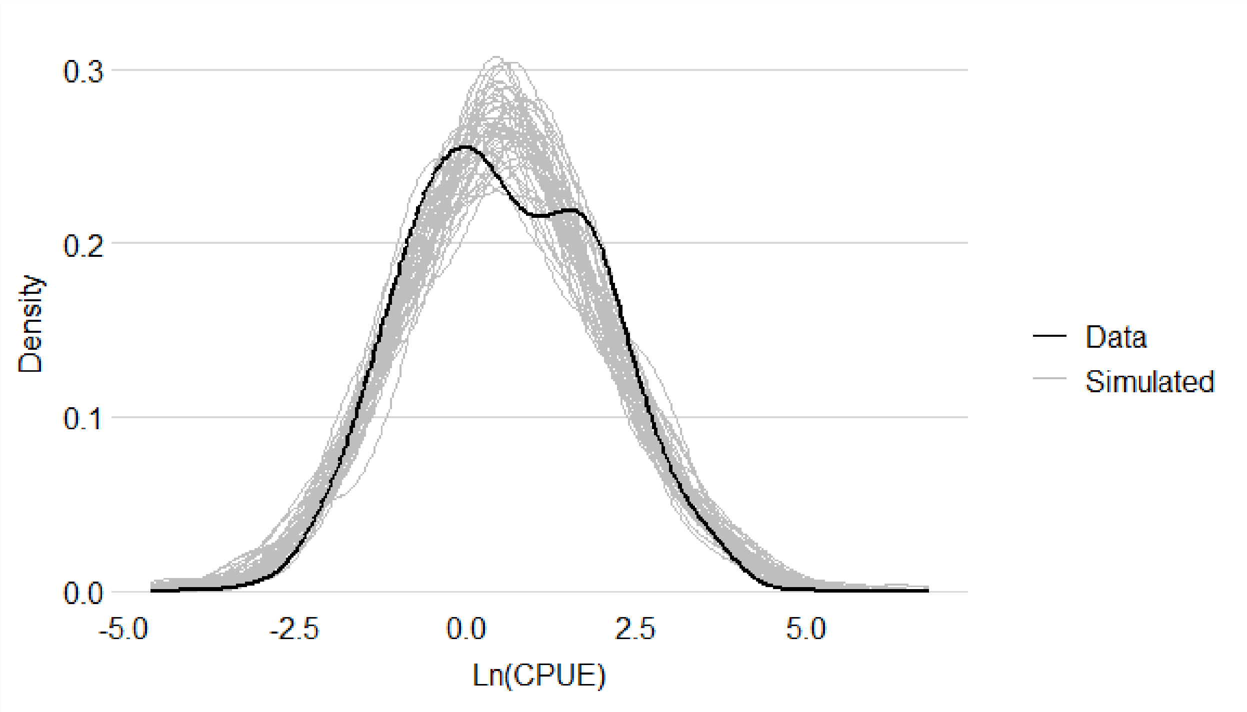

Figure A 6. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *A. rutilans* CPUE standardization.

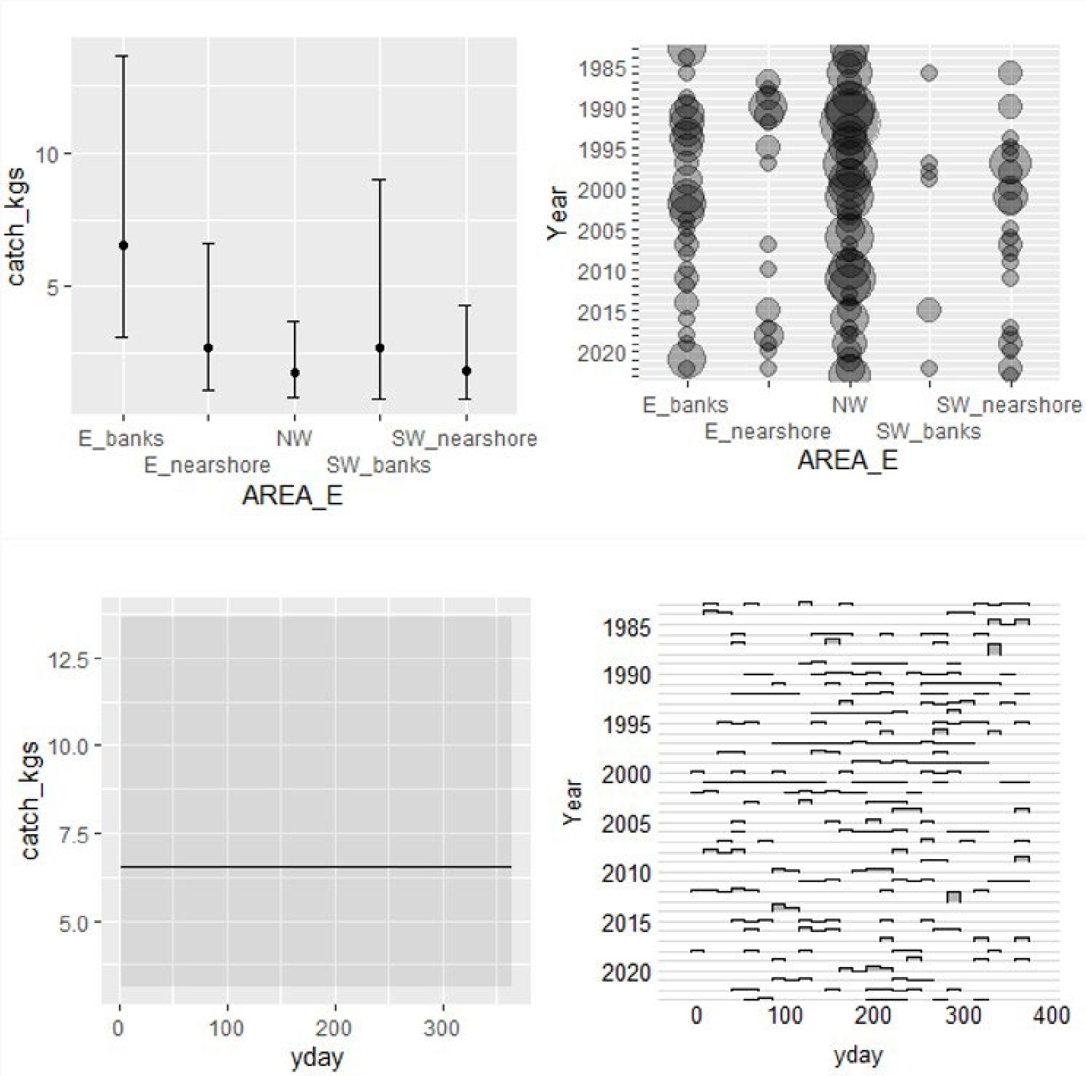

Figure A 7. Partial effects of area and time of year on CPUE (kg per trip) in the *A. rutilans* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

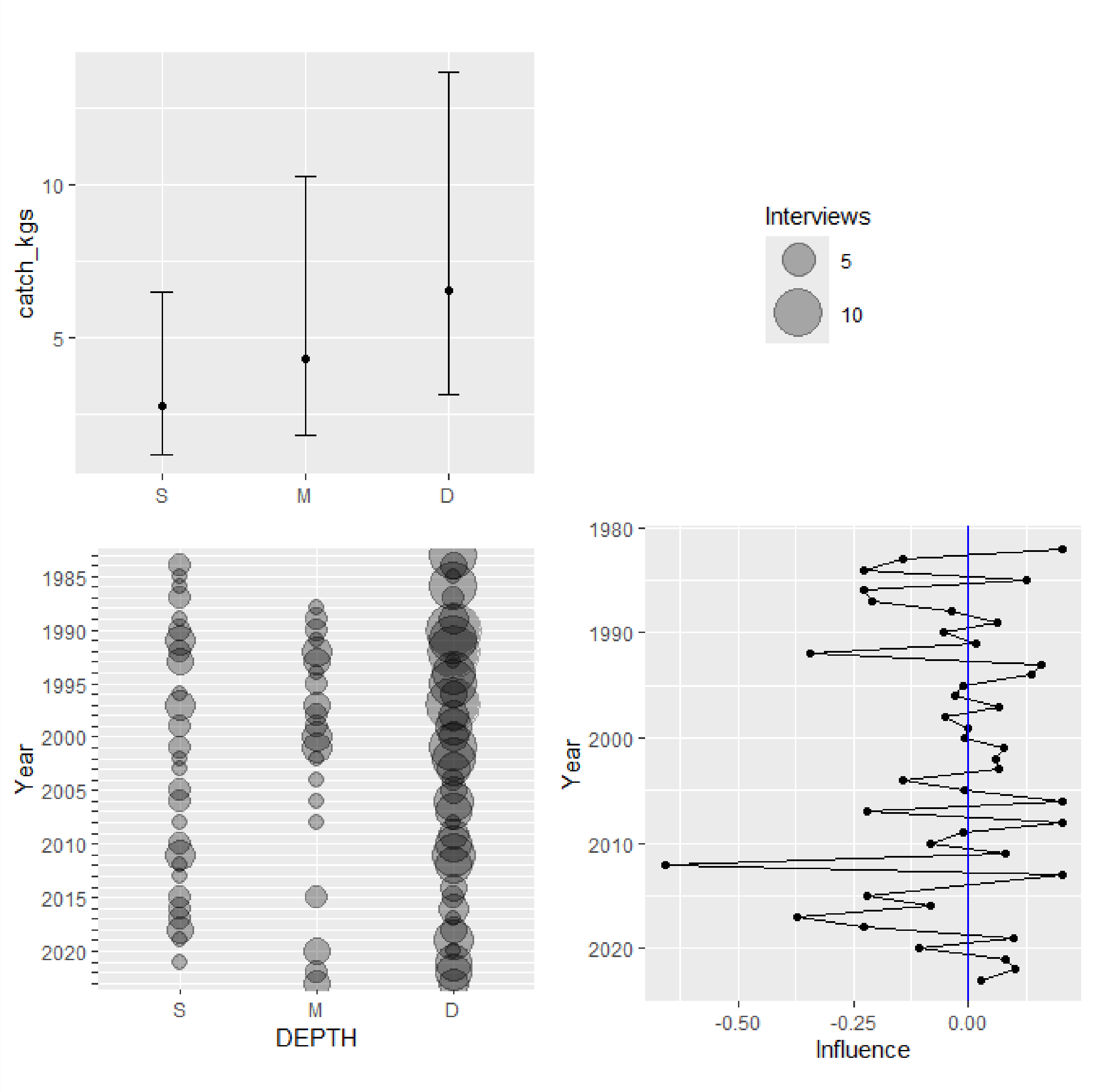

Figure A 8. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type ('depth') on CPUE (kg per trip) in the *A. rutilans* CPUE standardization.

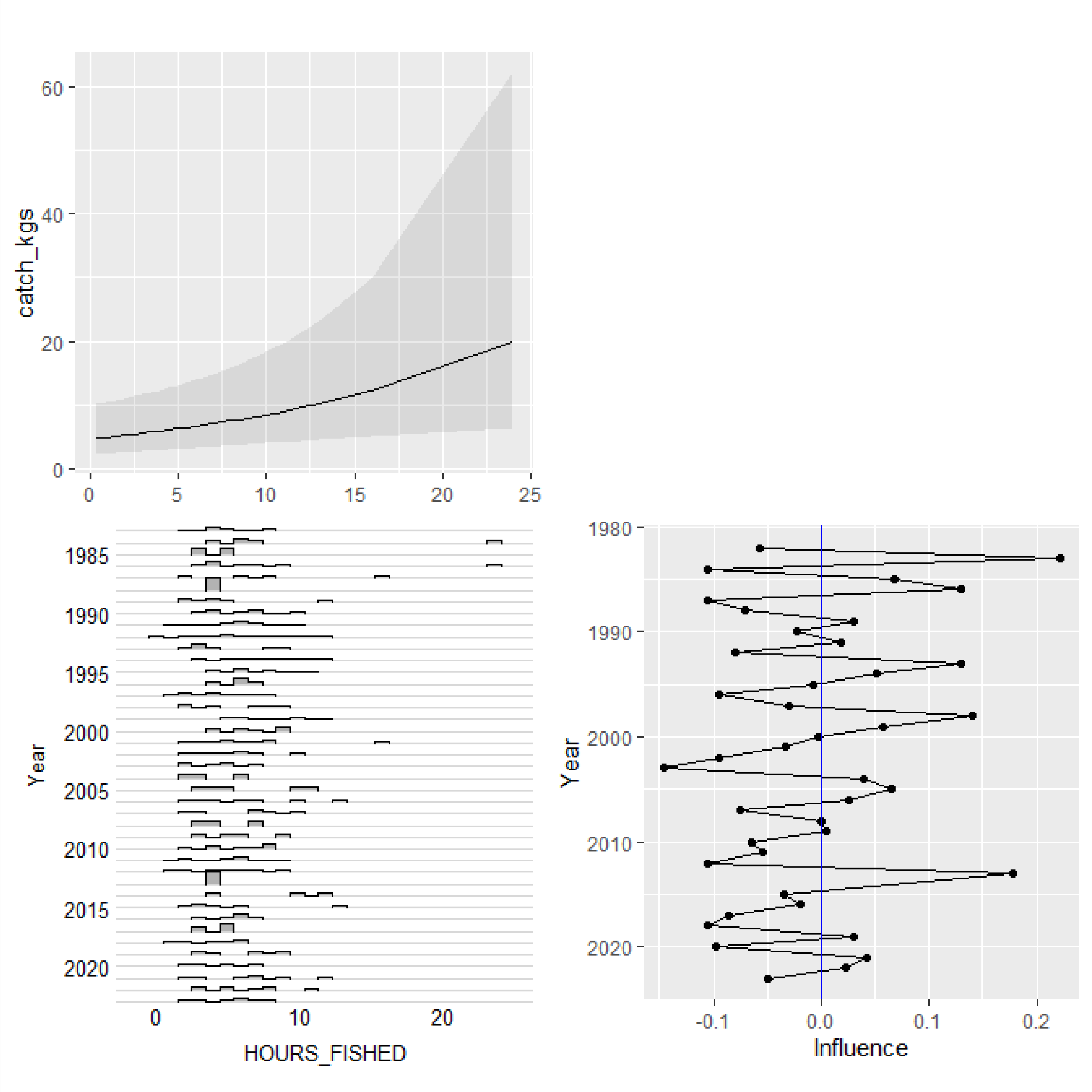

Figure A 9. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *A. rutilans* CPUE standardization.

Standardized CPUE Index

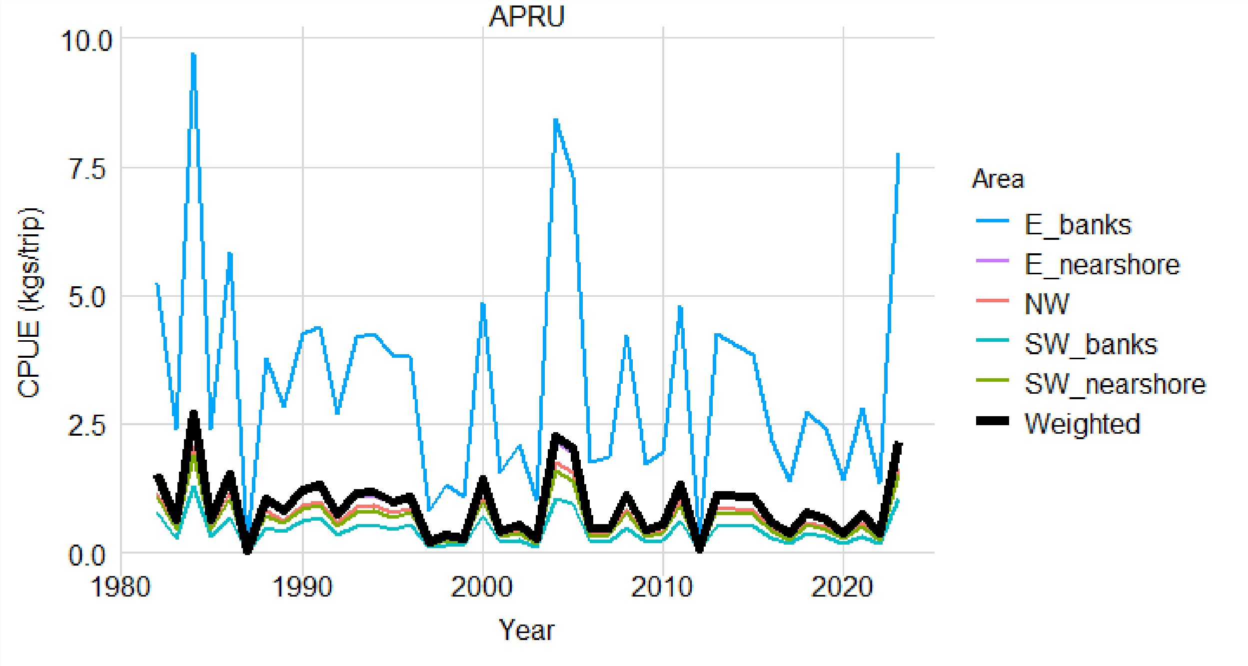

Figure A 10. Standardized CPUE index (kg per trip) of *A. rutilans* by area and weighted by habitat extent.

Table A 1. Standardized CPUE index (kg per trip) and standard deviation (sd) of *A. rutilans*.

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	1.53	1.19	1996	1.09	0.73	2010	0.54	0.44
1983	0.64	0.80	1997	0.21	0.25	2011	1.32	1.25
1984	2.70	5.05	1998	0.35	0.33	2012	0.07	0.36
1985	0.65	0.54	1999	0.28	0.29	2013	1.13	1.82
1986	1.53	2.15	2000	1.41	0.98	2014	---	---
1987	0.05	0.27	2001	0.42	0.37	2015	1.08	1.04
1988	1.04	1.00	2002	0.56	0.62	2016	0.58	0.63
1989	0.81	0.56	2003	0.27	0.43	2017	0.36	0.60
1990	1.22	0.86	2004	2.28	2.64	2018	0.78	0.75
1991	1.30	0.85	2005	2.01	1.75	2019	0.64	0.62
1992	0.75	0.73	2006	0.46	0.51	2020	0.38	0.51
1993	1.14	1.05	2007	0.49	0.80	2021	0.73	0.81
1994	1.18	0.95	2008	1.10	1.52	2022	0.36	0.34
1995	0.99	1.43	2009	0.46	0.45	2023	2.18	2.06

Caranx ignobilis

Presence/Absence Model

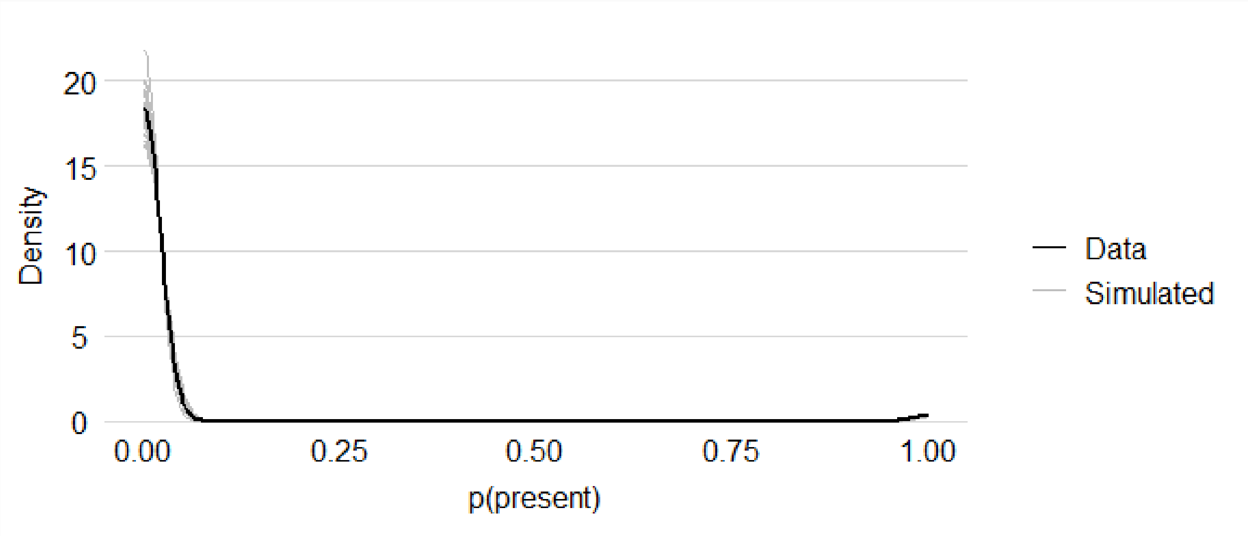

Figure A 11. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *C. ignobilis* CPUE standardization.

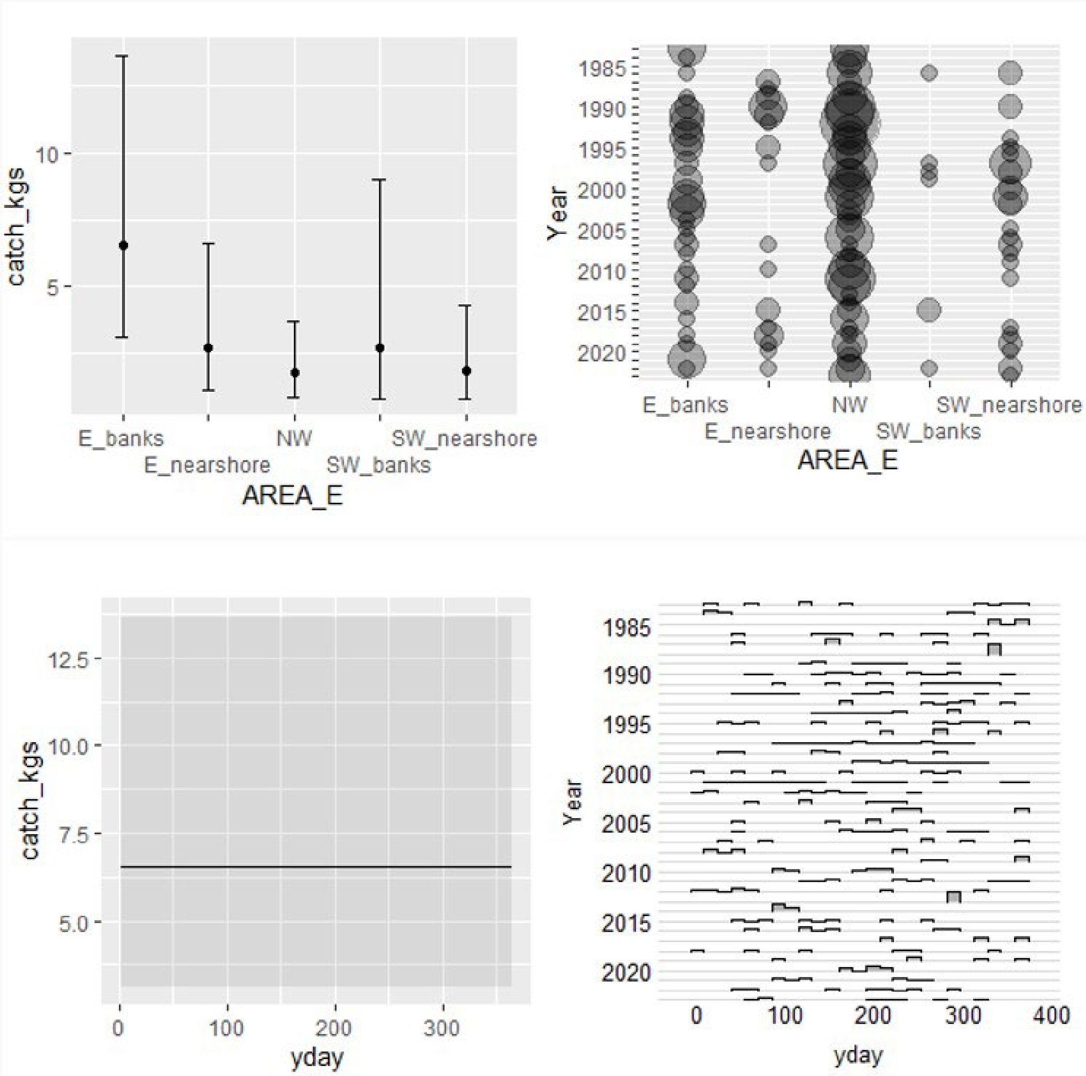

Figure A 12. Partial effects of area and time of year on probability of presence in the *C. ignobilis* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

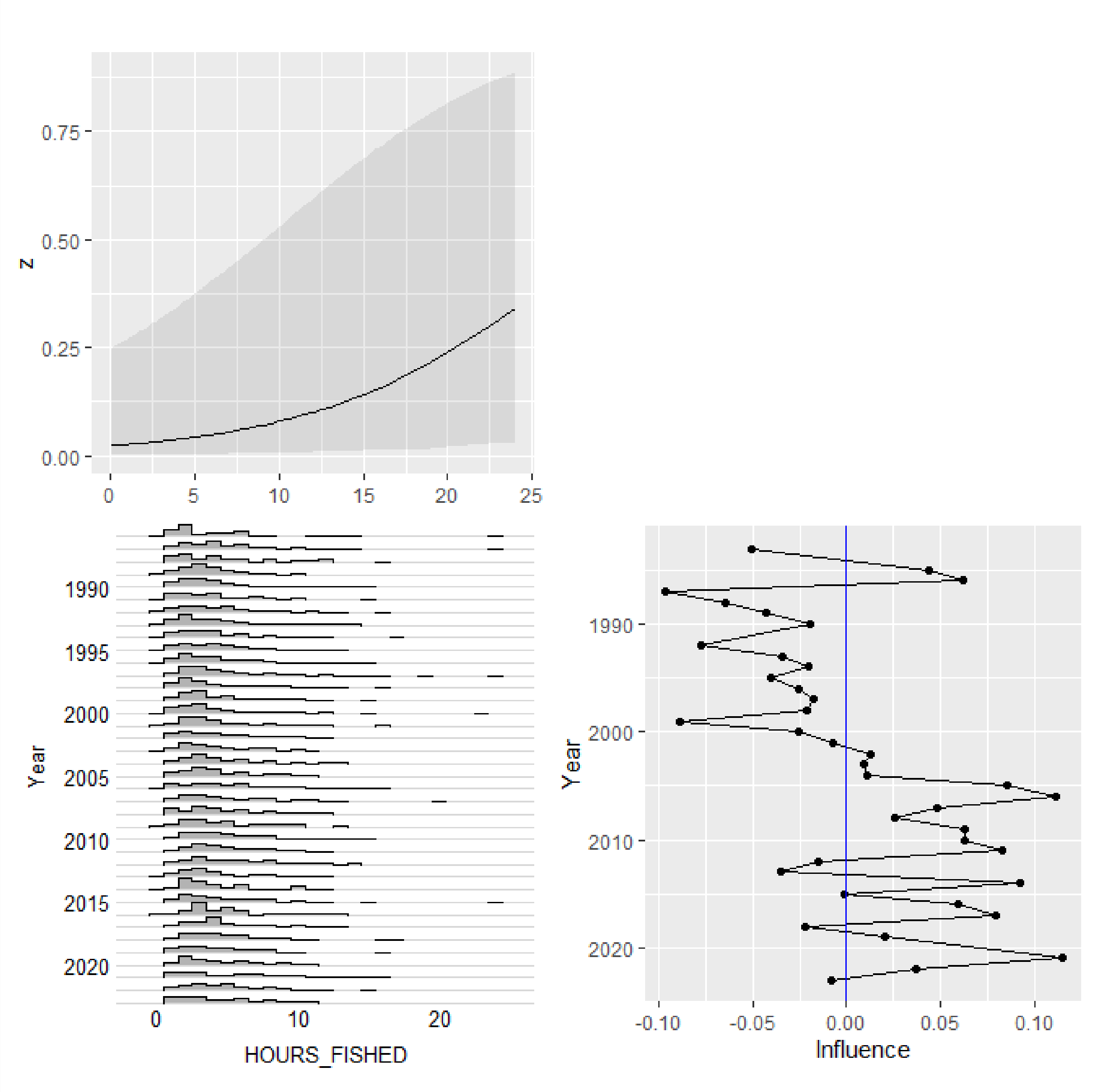

Figure A 13. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on probability of presence in the *C. ignobilis* CPUE standardization.

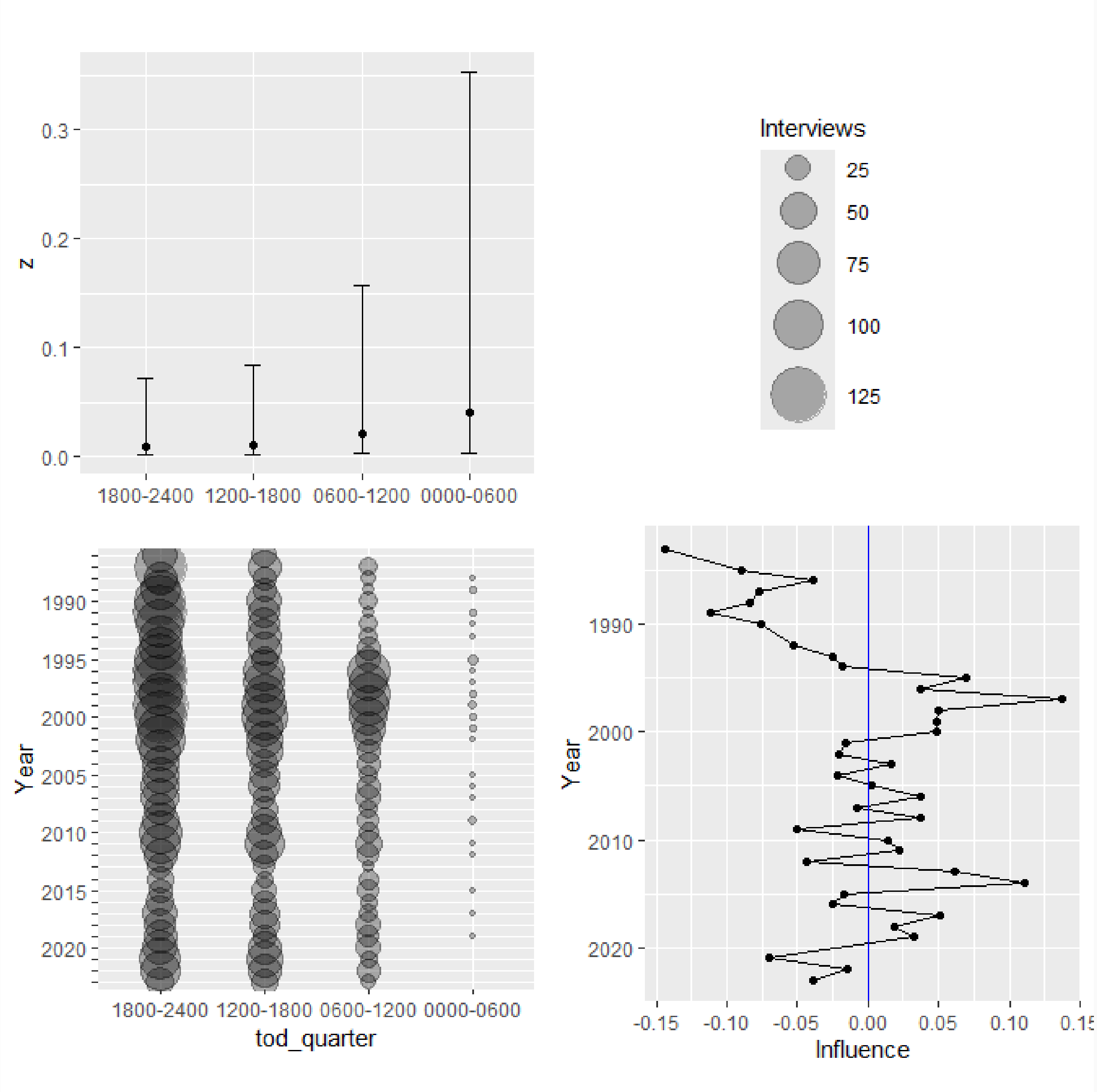

Figure A 14. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of time of day on probability of presence in the *C. ignobilis* CPUE standardization.

Positive Process Model

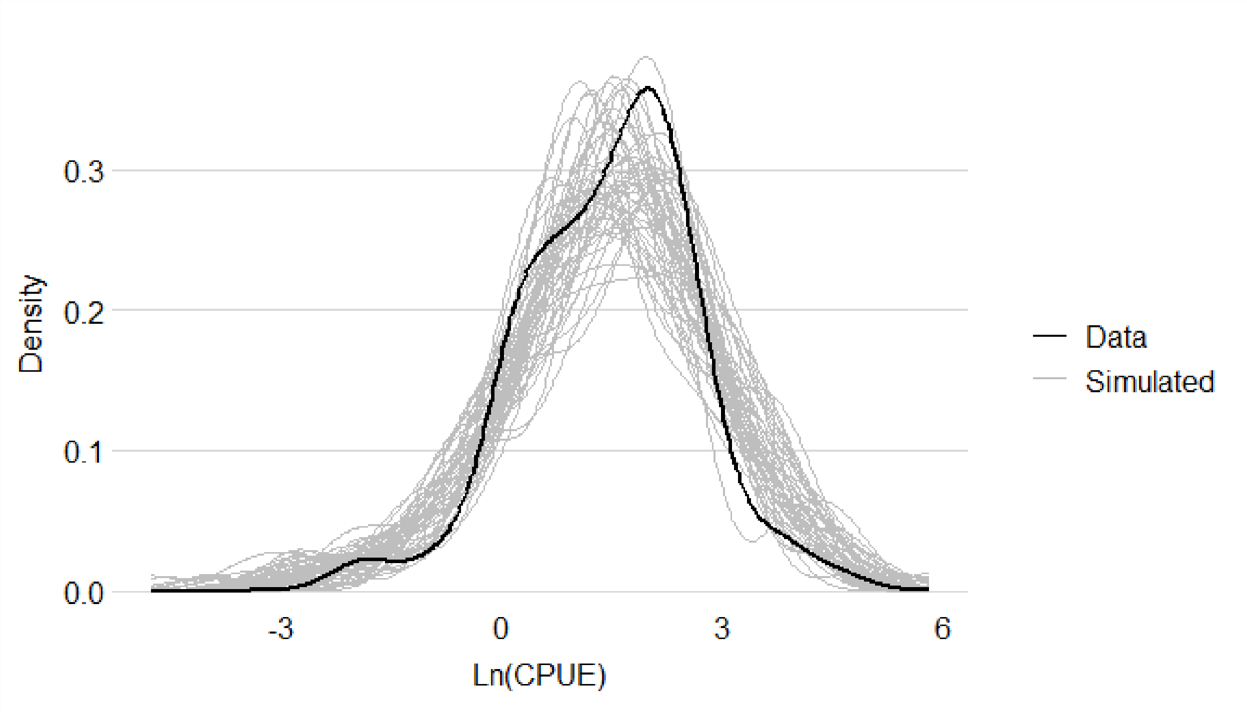

Figure A 15. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *C. ignobilis* CPUE standardization.

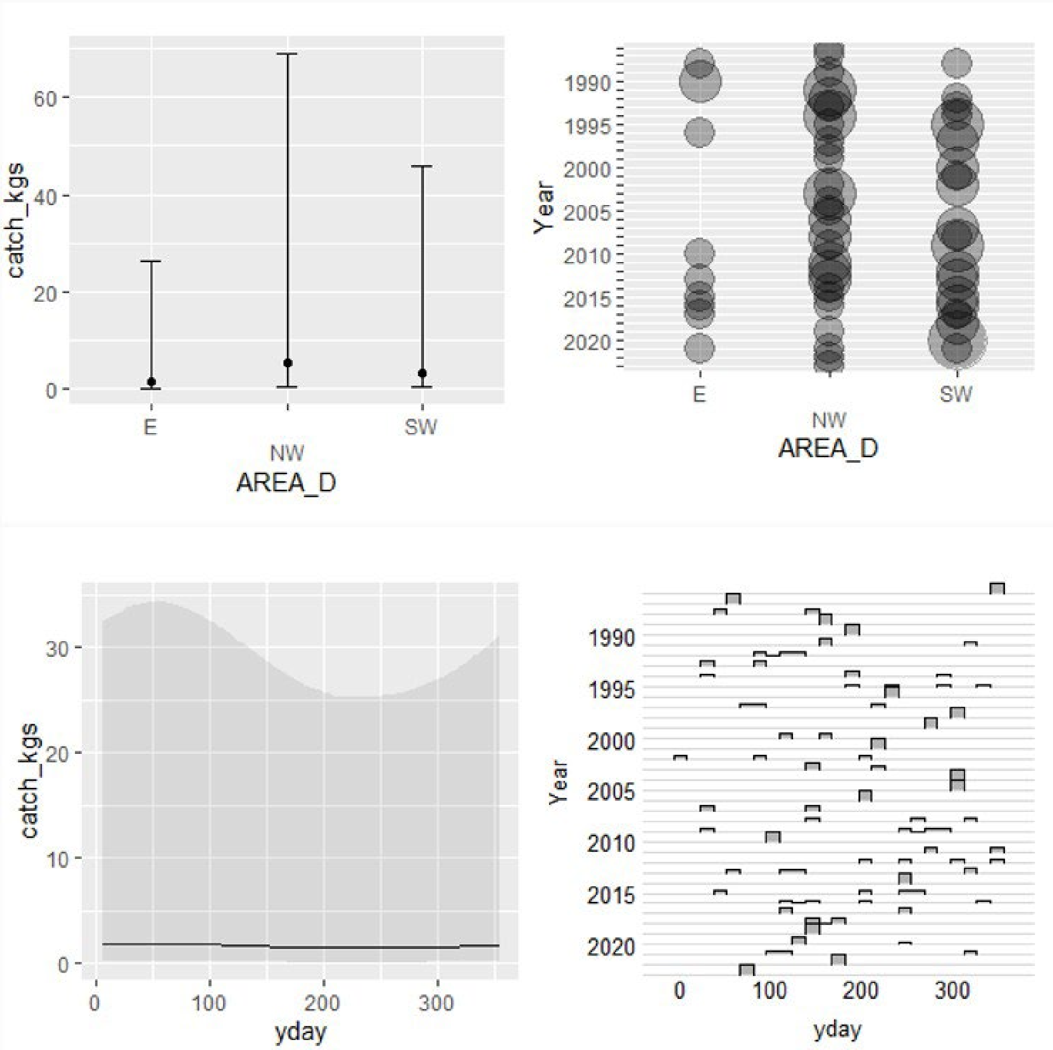

Figure A 16. Partial effects of area and time of year on CPUE (kg per trip) in the *C. ignobilis* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

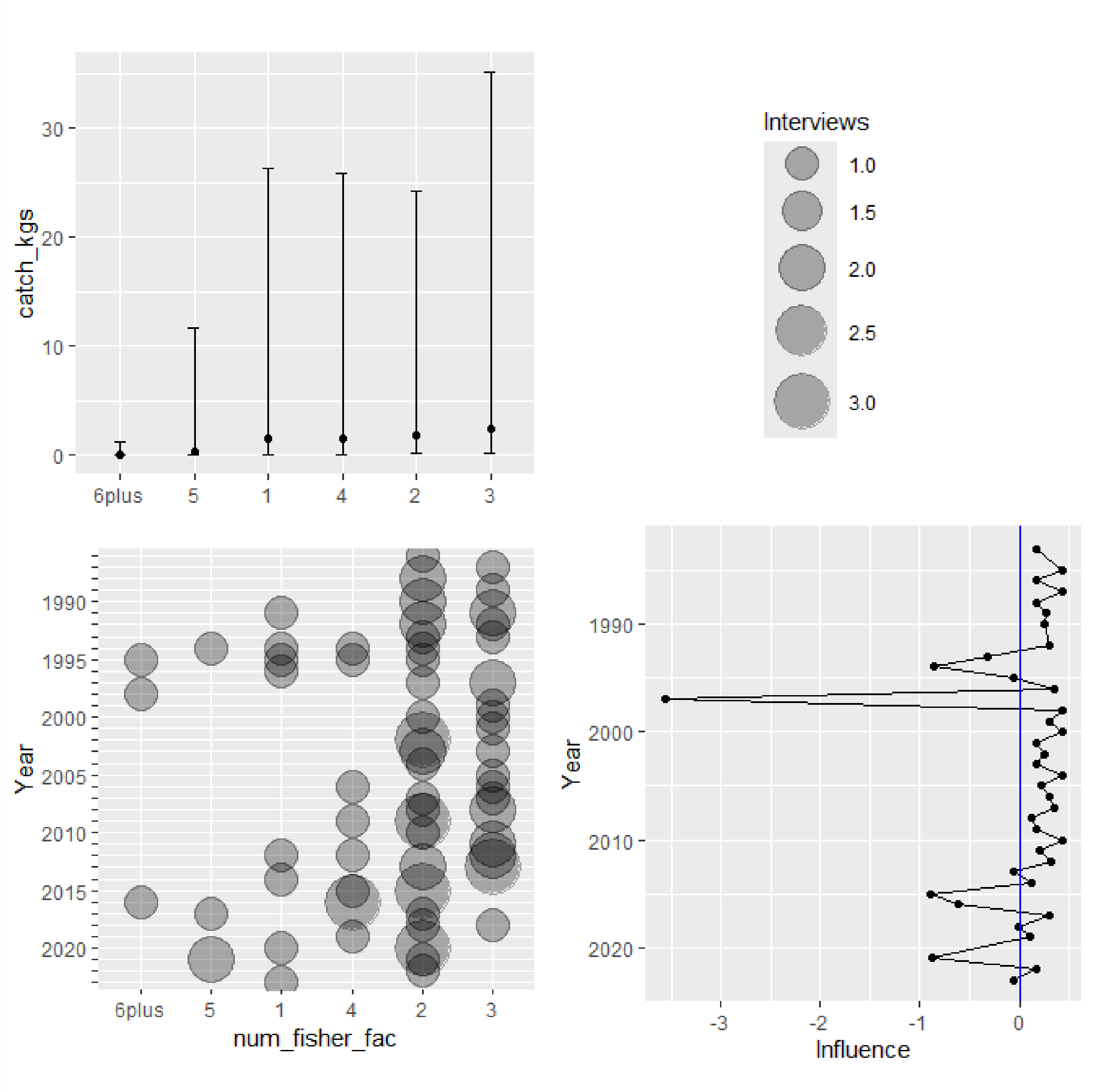

Figure A 17. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (number of fishers) on CPUE (kg per trip) in the *C. ignobilis* CPUE standardization.

Standardized CPUE Index

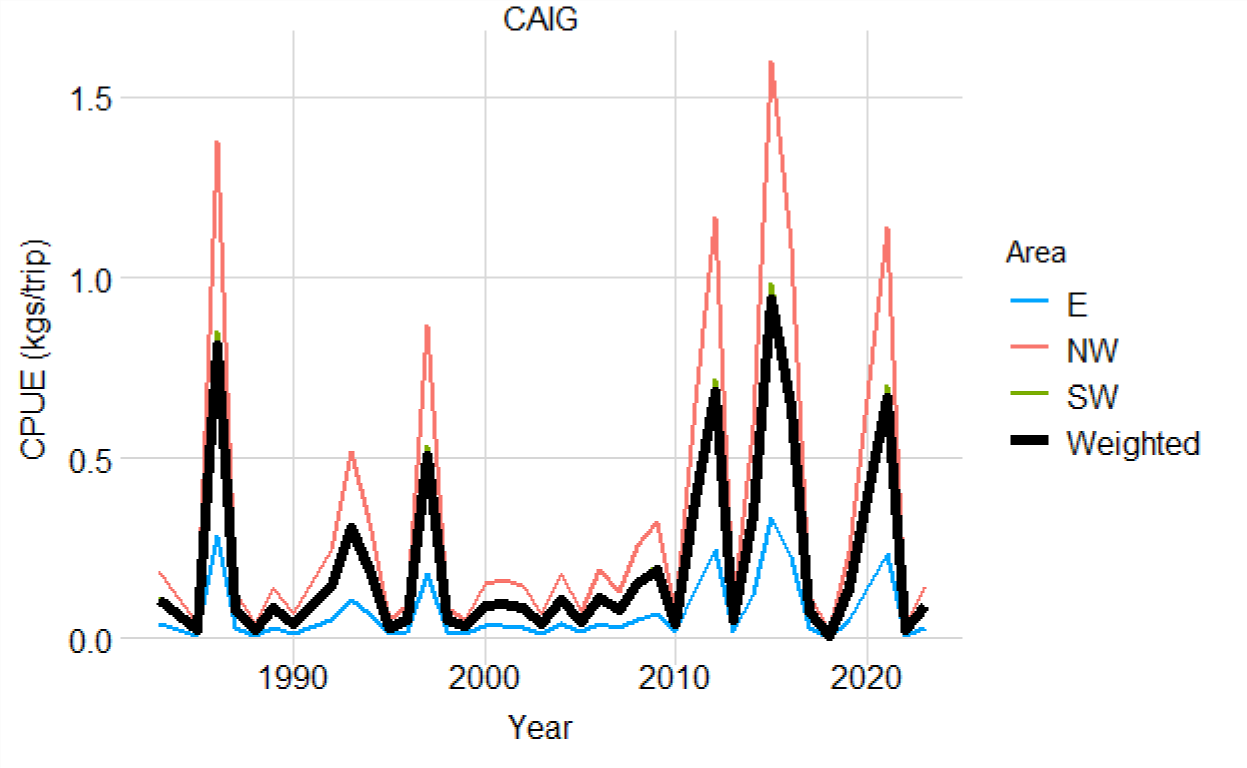

Figure A 18. Standardized CPUE index (kg per trip) of *C. ignobilis* by area and weighted by habitat extent.

Table A 2. Standardized CPUE index (kg per trip) and standard deviation (sd) of *C. ignobilis*.

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	--	--	1996	0.05	0.08	2010	0.04	0.10
1983	0.11	0.57	1997	0.51	6.01	2011	0.38	0.51
1984	--	--	1998	0.05	0.29	2012	0.69	0.71
1985	0.02	0.14	1999	0.03	0.07	2013	0.05	0.33
1986	0.81	1.76	2000	0.09	0.54	2014	0.35	0.42
1987	0.08	0.45	2001	0.10	0.13	2015	0.94	1.57
1988	0.02	0.06	2002	0.09	0.13	2016	0.64	1.77
1989	0.08	0.14	2003	0.04	0.20	2017	0.07	0.16
1990	0.04	0.06	2004	0.10	0.62	2018	0.01	0.06
1991	--	--	2005	0.04	0.11	2019	0.14	0.17
1992	0.15	0.31	2006	0.11	0.24	2020	--	--
1993	0.30	0.40	2007	0.08	0.12	2021	0.67	1.47
1994	0.19	0.26	2008	0.15	0.18	2022	0.02	0.11
1995	0.03	0.27	2009	0.19	1.21	2023	0.09	0.60

Caranx lugubris

Presence/Absence Model

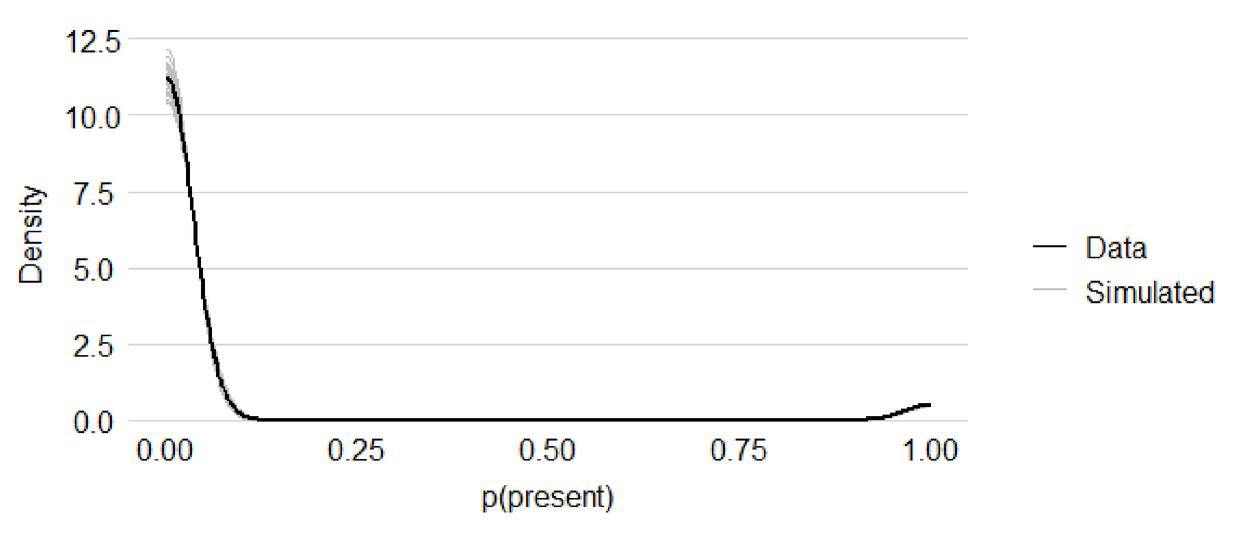

Figure A 19. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *C. lugubris* CPUE standardization.

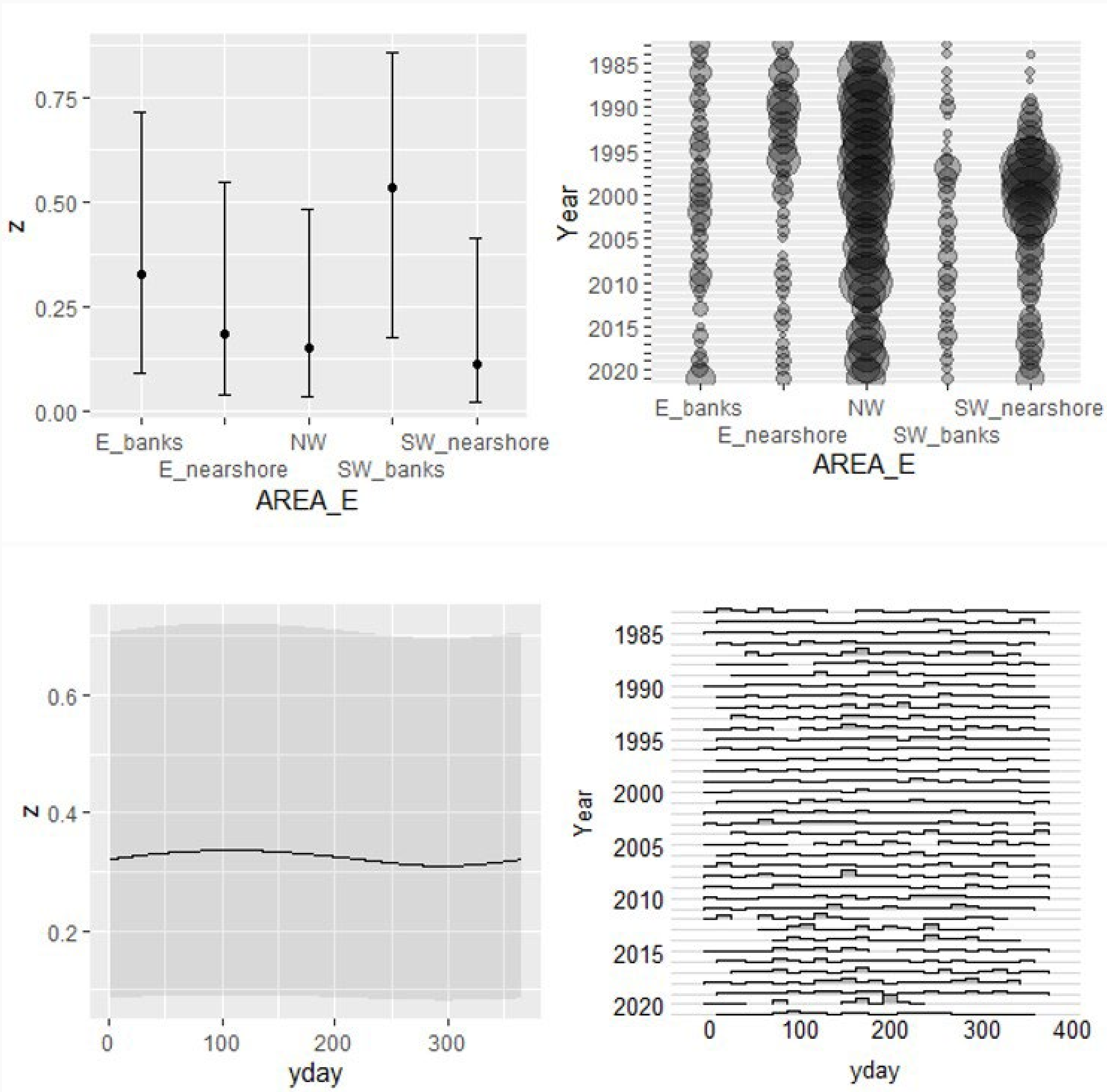

Figure A 20. Partial effects of area and time of year on probability of presence in the *C. lugubris* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

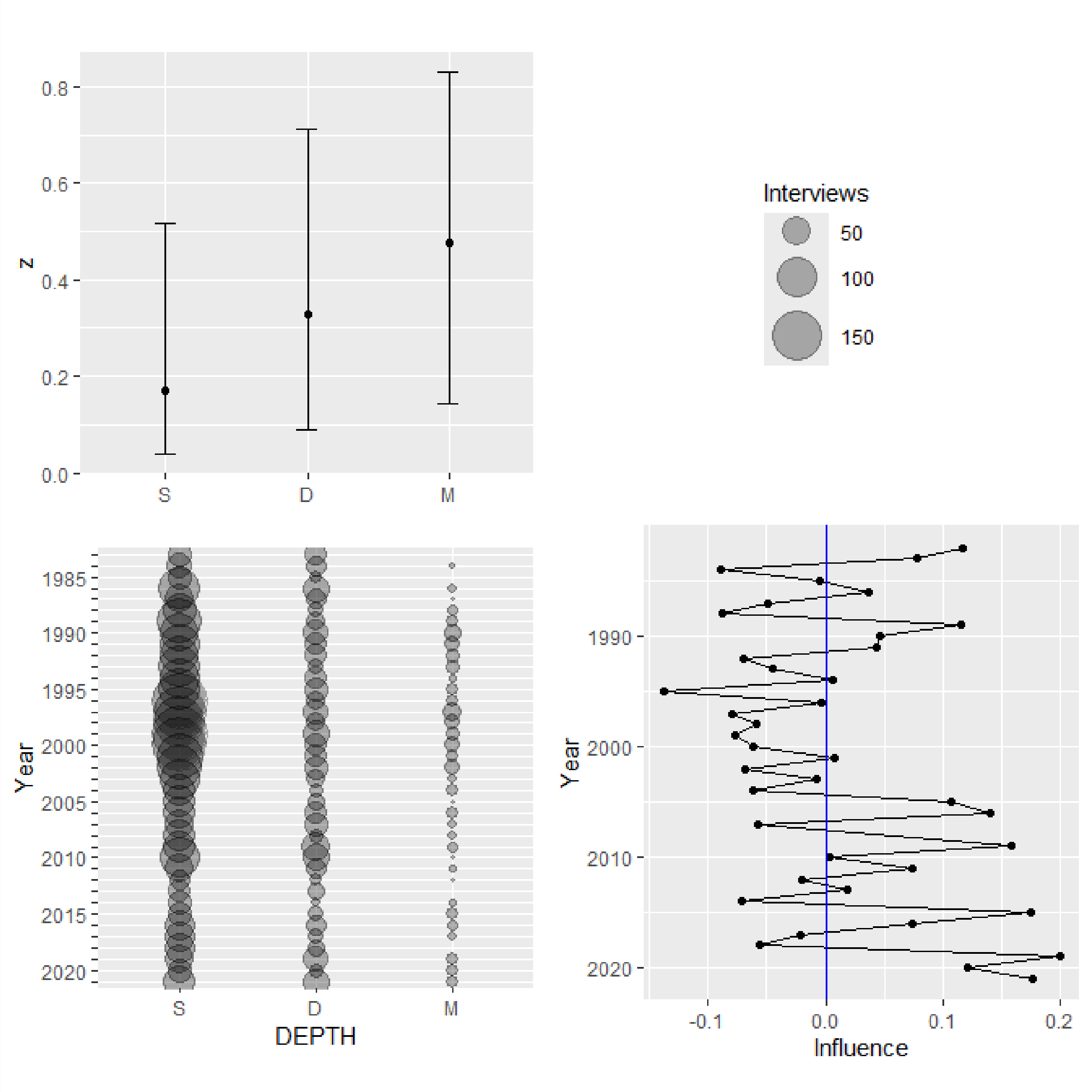

Figure A 21. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on probability of presence in the *C. lugubris* CPUE standardization.

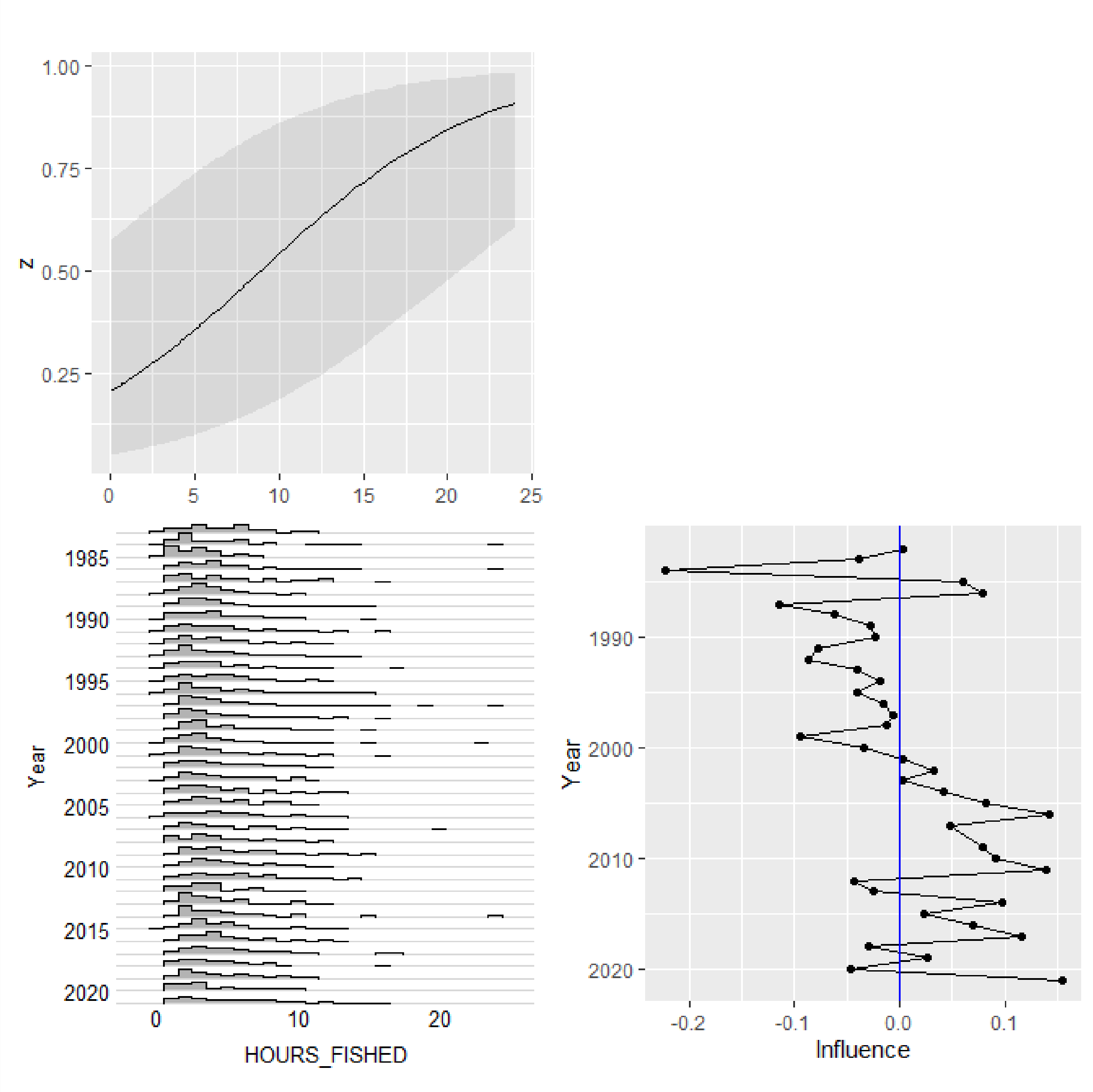

Figure A 22. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on probability of presence in the *C. lugubris* CPUE standardization.

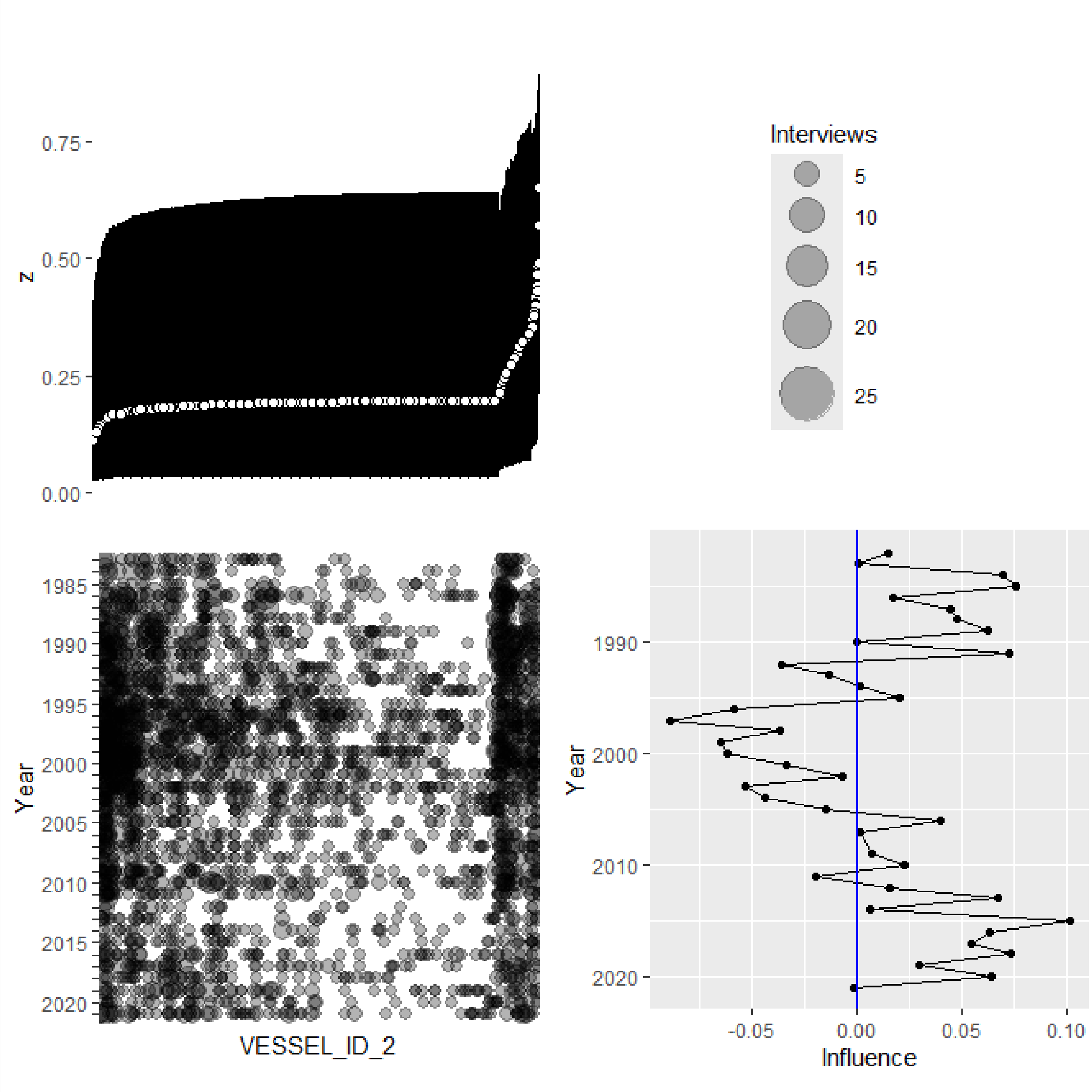

Figure A 23. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *C. lugubris* CPUE standardization.

Positive Process Model

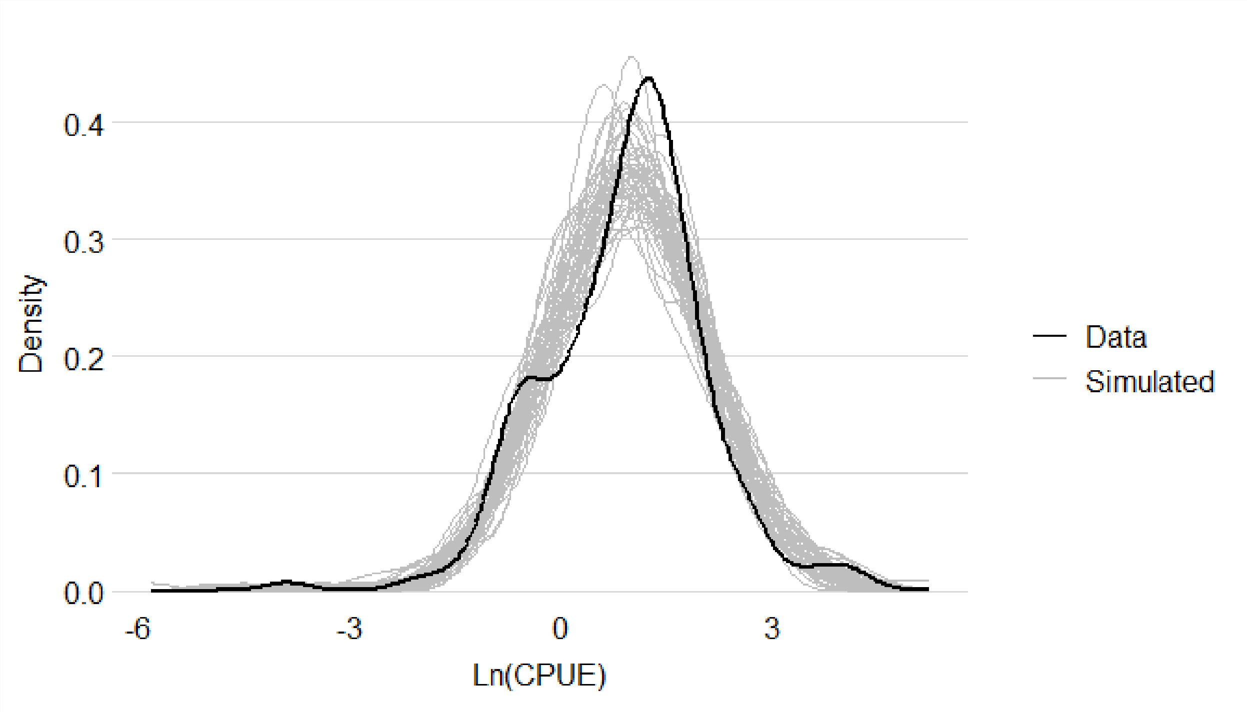

Figure A 24. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *C. lugubris* CPUE standardization.

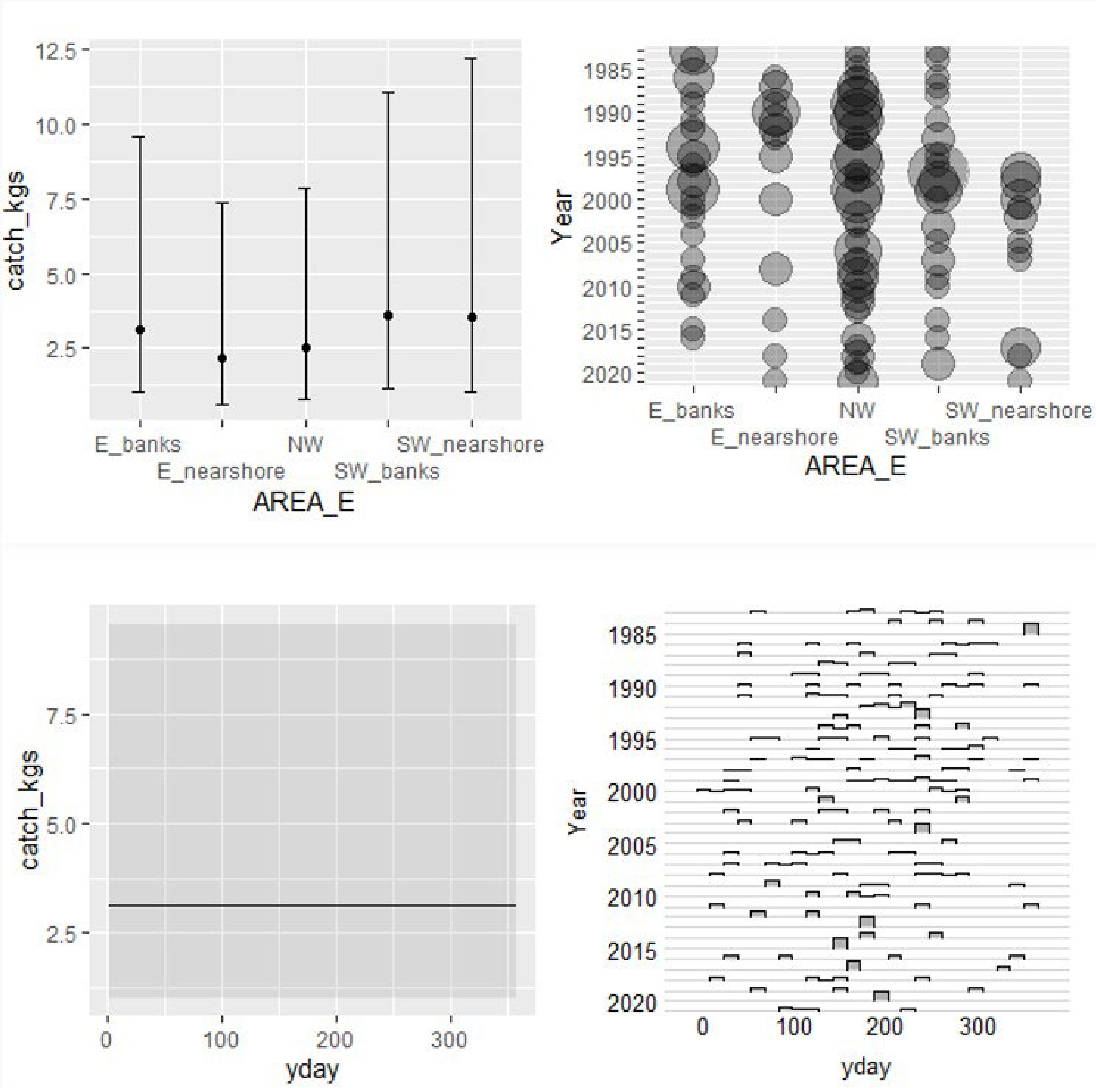

Figure A 25. Partial effects of area and time of year on CPUE (kg per trip) in the *C. lugubris* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

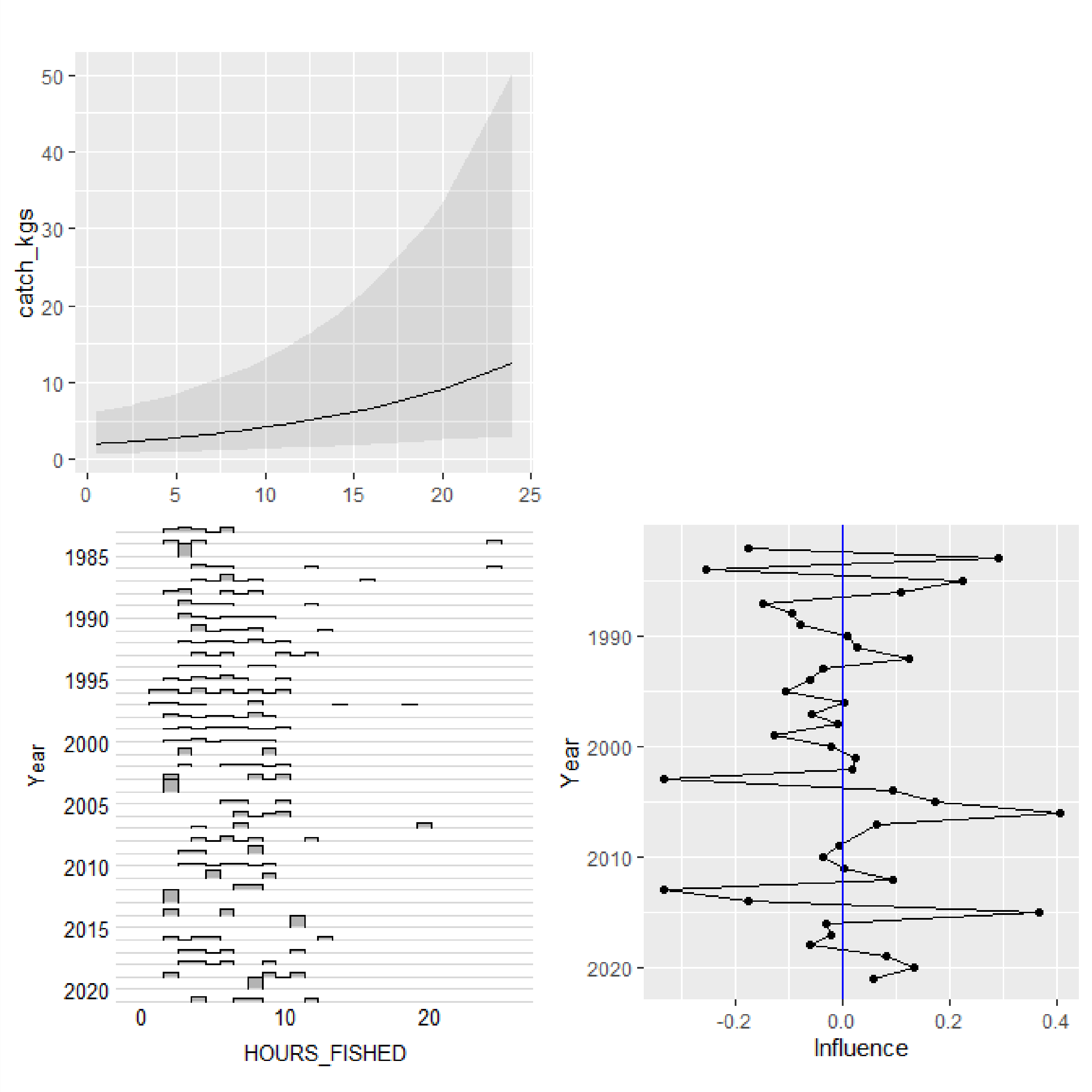

Figure A 26. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *C. lugubris* CPUE standardization.

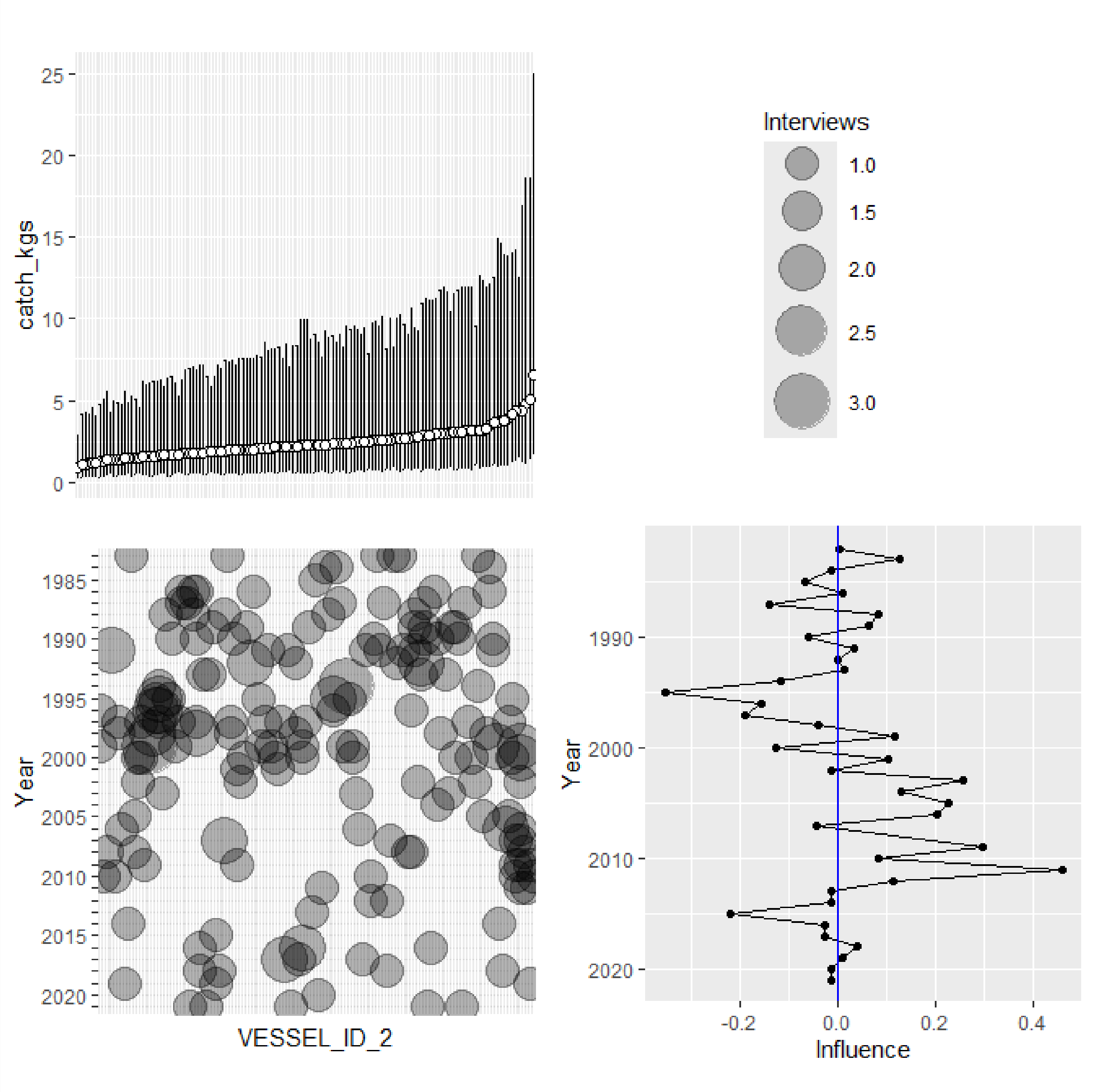

Figure A 27. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on CPUE (kg per trip) in the *C. lugubris* CPUE standardization.

Standardized CPUE Index

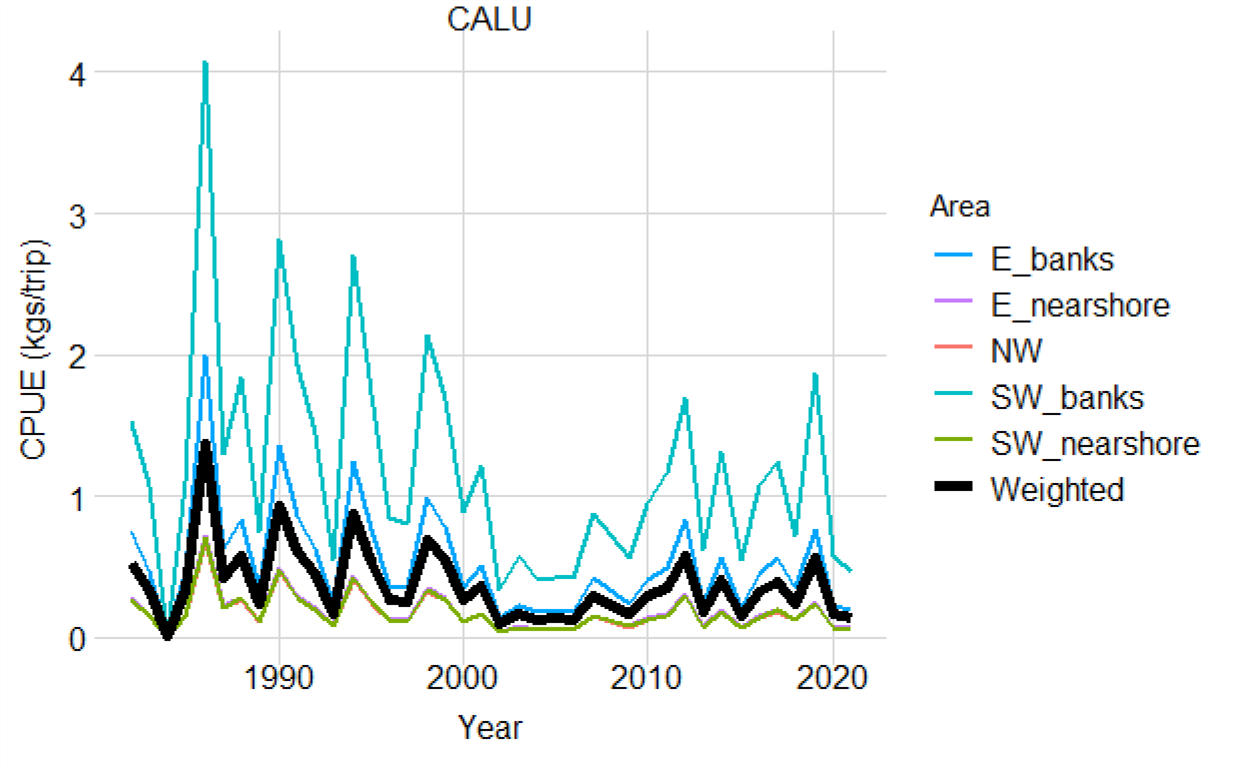

Figure A 28. Standardized CPUE index (kg per trip) of *C. lugubris* by area and weighted by habitat extent.

Table A 3. Standardized CPUE index (kg per trip) and standard deviation (sd) of *C. lugubris.*

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	0.51	0.77	1996	0.26	0.37	2010	0.29	0.51
1983	0.33	0.71	1997	0.25	0.36	2011	0.35	0.76
1984	0.00	0.02	1998	0.69	0.91	2012	0.57	1.27
1985	0.33	0.57	1999	0.54	0.71	2013	0.18	0.67
1986	1.36	2.02	2000	0.26	0.82	2014	0.40	1.11
1987	0.43	0.67	2001	0.37	0.64	2015	0.16	1.05
1988	0.58	0.87	2002	0.10	0.24	2016	0.33	0.62
1989	0.23	0.35	2003	0.17	0.97	2017	0.40	0.73
1990	0.94	1.28	2004	0.12	0.26	2018	0.24	0.39
1991	0.61	1.00	2005	0.13	0.22	2019	0.56	1.26
1992	0.44	0.84	2006	0.13	0.24	2020	0.17	1.07
1993	0.17	0.32	2007	0.29	0.46	2021	0.14	0.26
1994	0.87	1.21	2008	--	--	2022	--	--
1995	0.54	0.83	2009	0.17	0.30	2023	--	--

Etelis coruscans

Presence/Absence Model

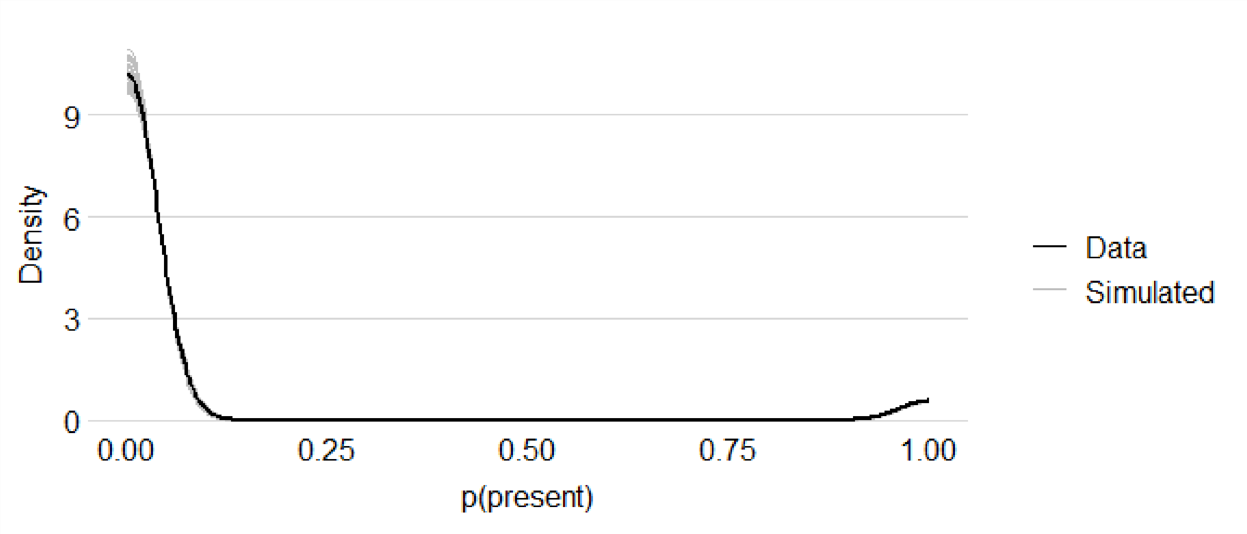

Figure A 29. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *E. coruscans* CPUE standardization.

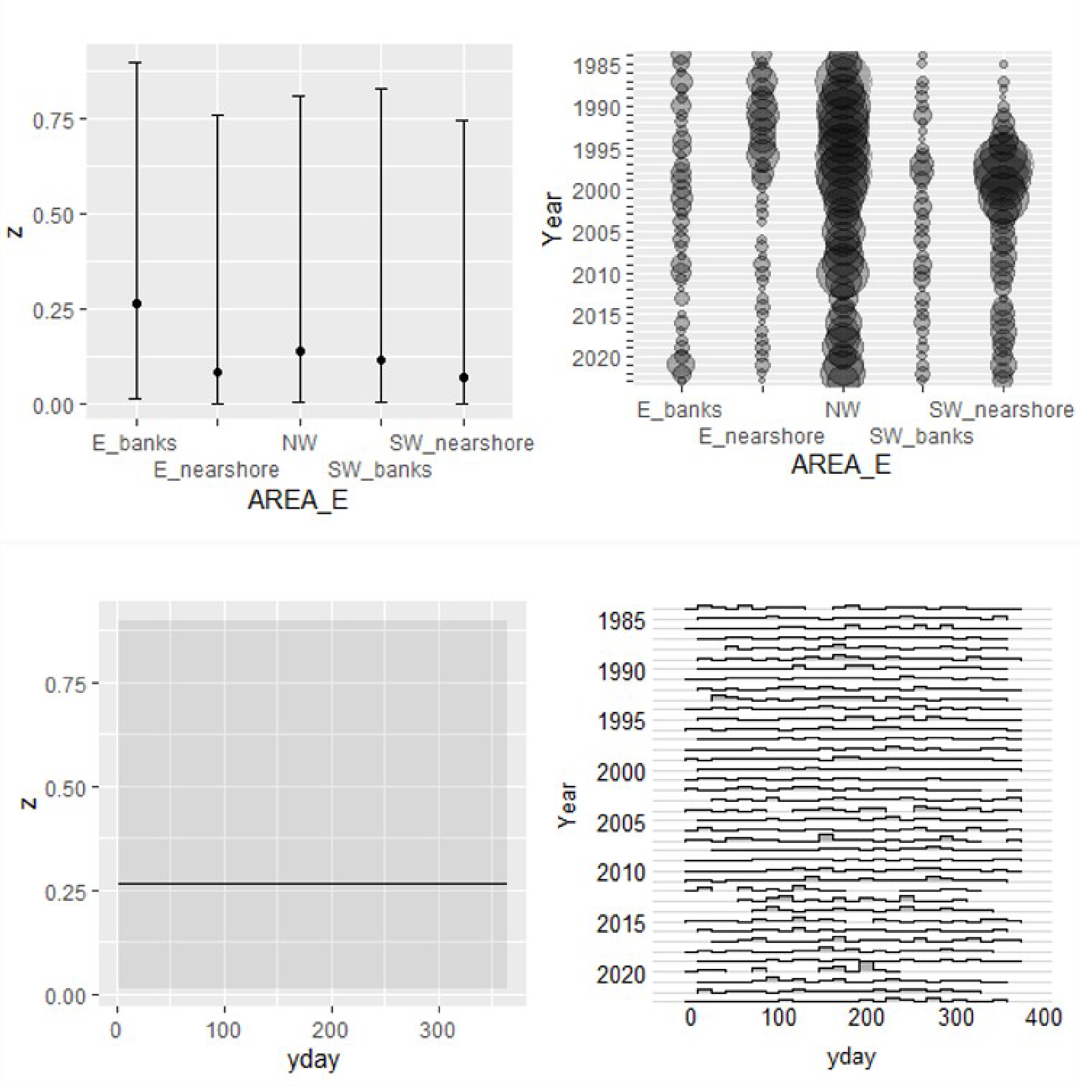

Figure A 30. Partial effects of area and time of year on probability of presence in the *E. coruscans* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

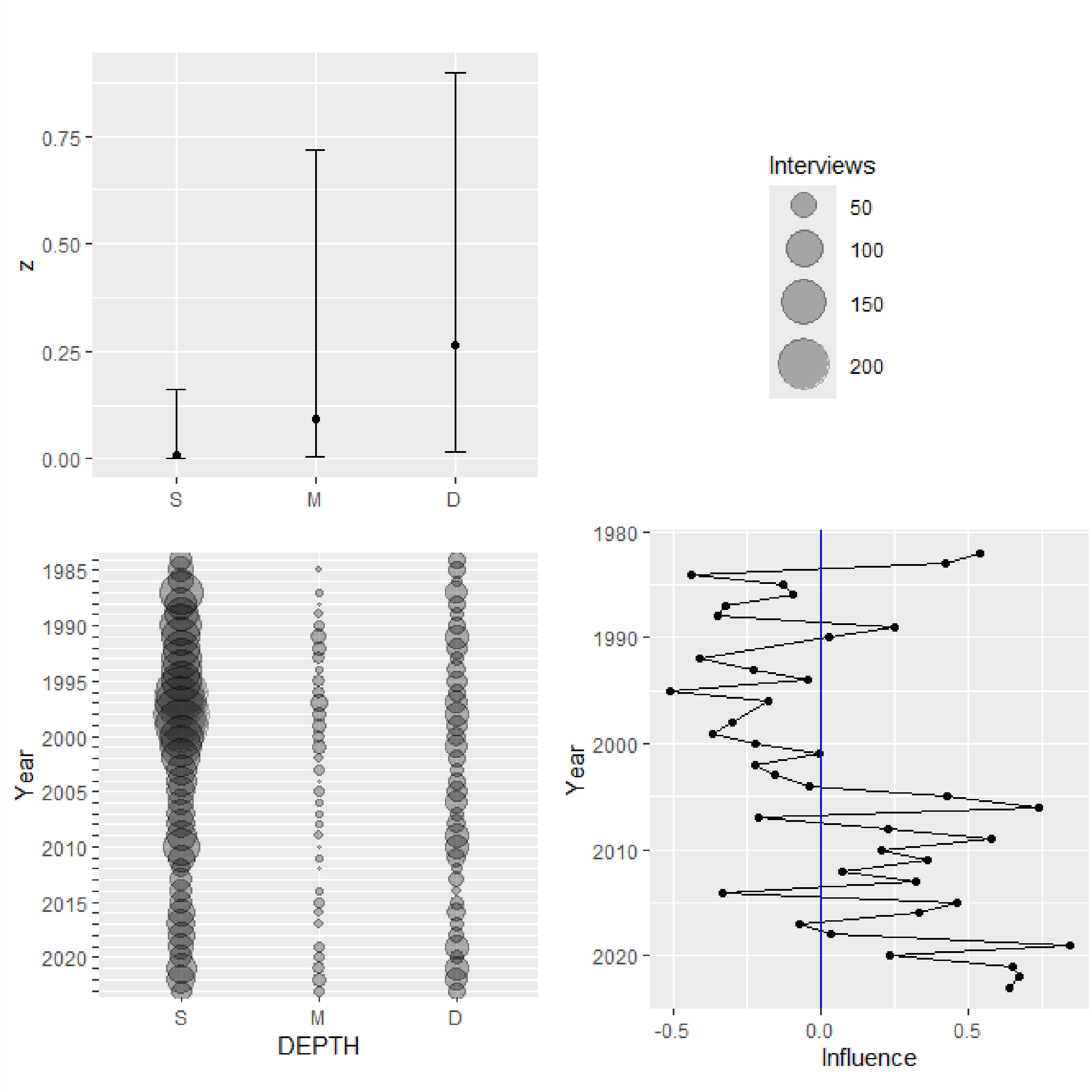

Figure A 31. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on probability of presence in the *E. coruscans* CPUE standardization.

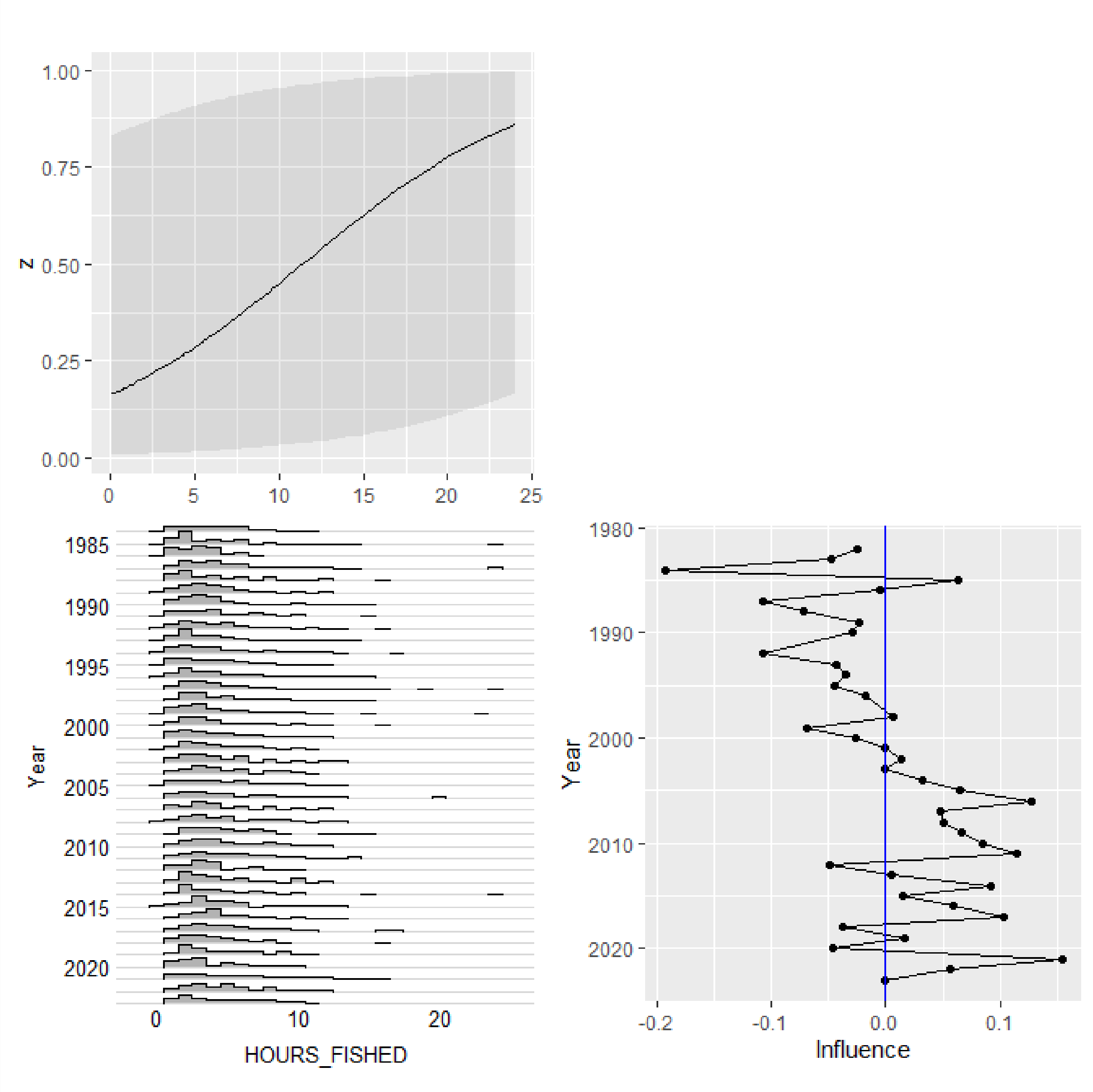

Figure A 32. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on probability of presence in the *E. coruscans* CPUE standardization.

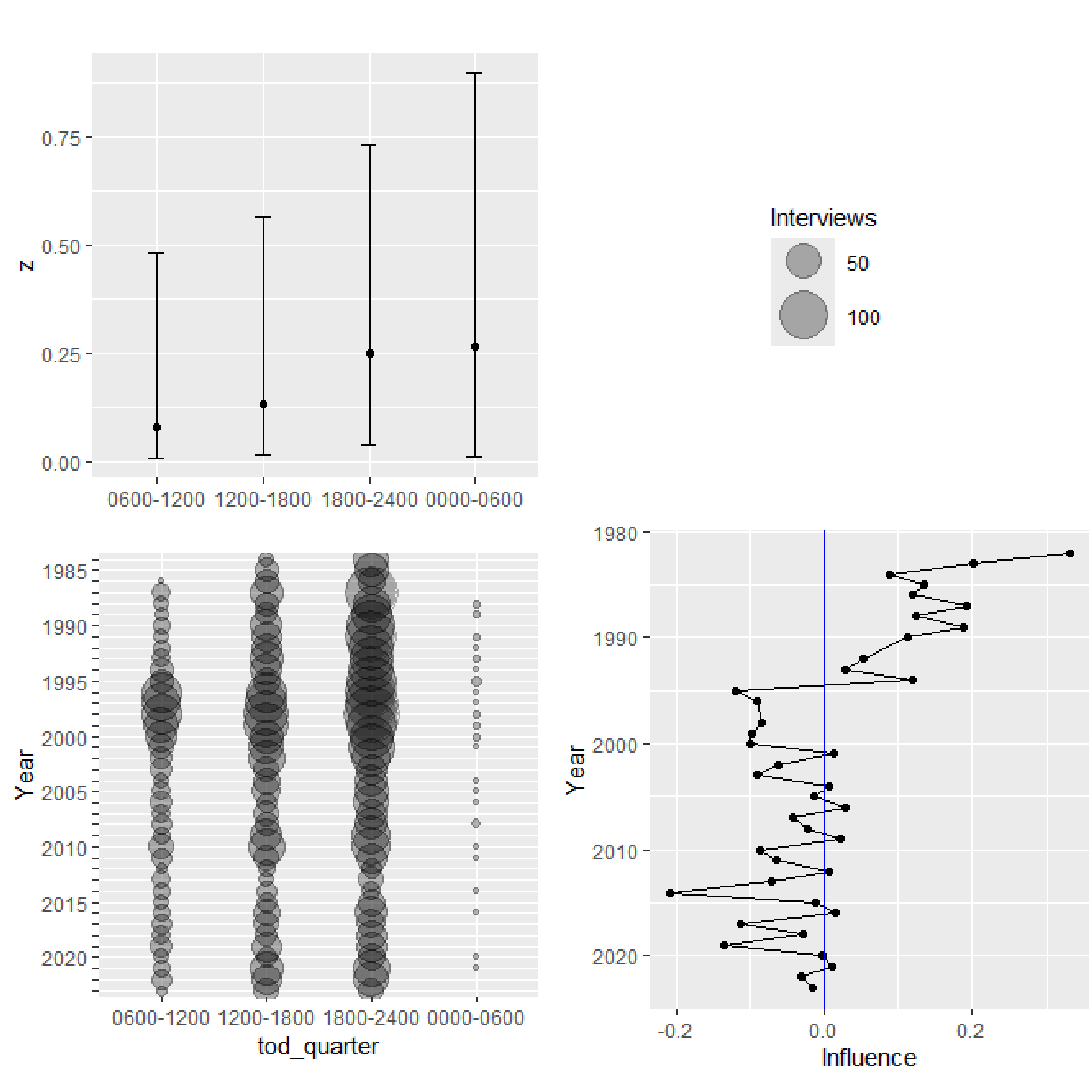

Figure A 33. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of time of day (quarter) on probability of presence in the *E. coruscans* CPUE standardization.

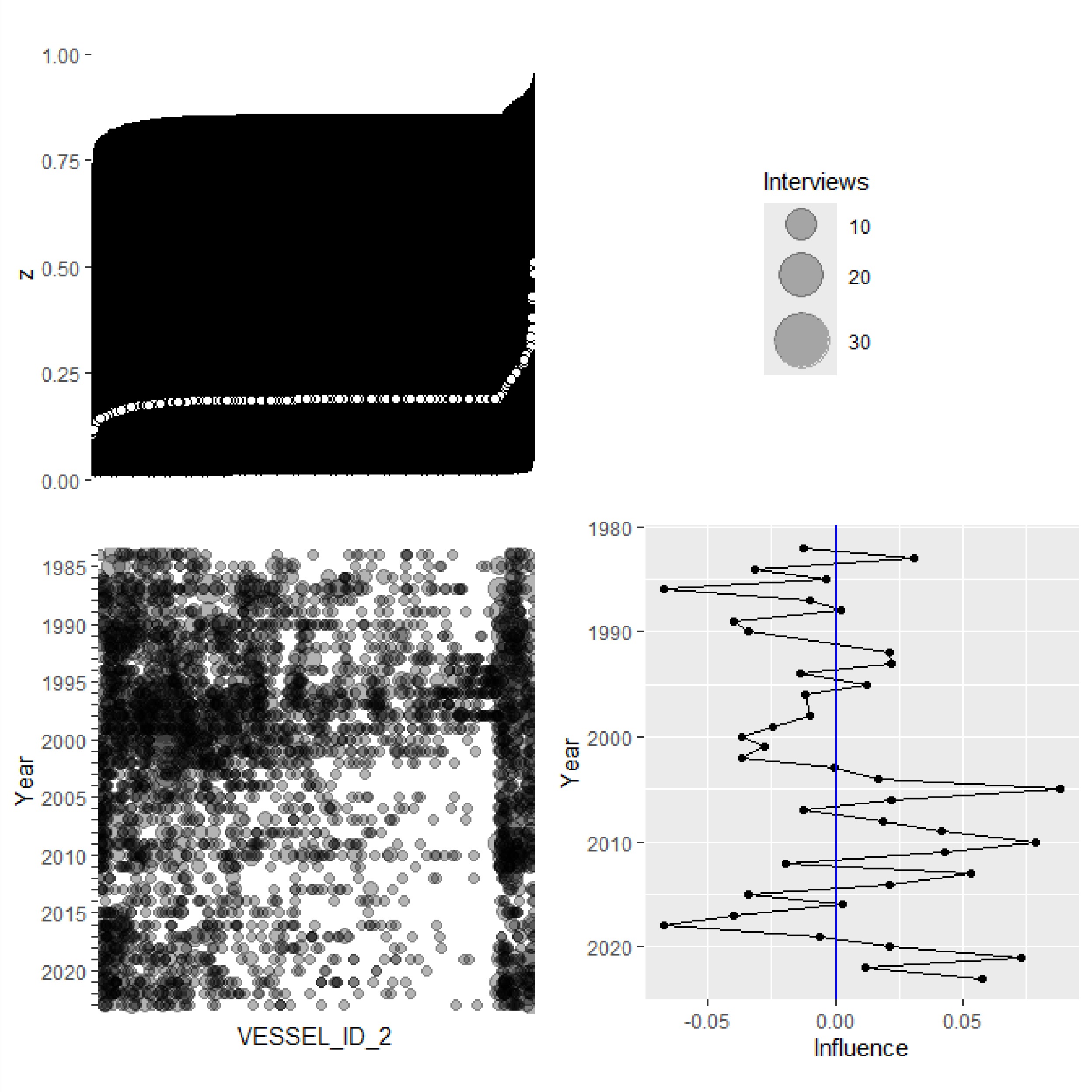

Figure A 34. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in *the E. coruscans* CPUE standardization.

Positive Process Model

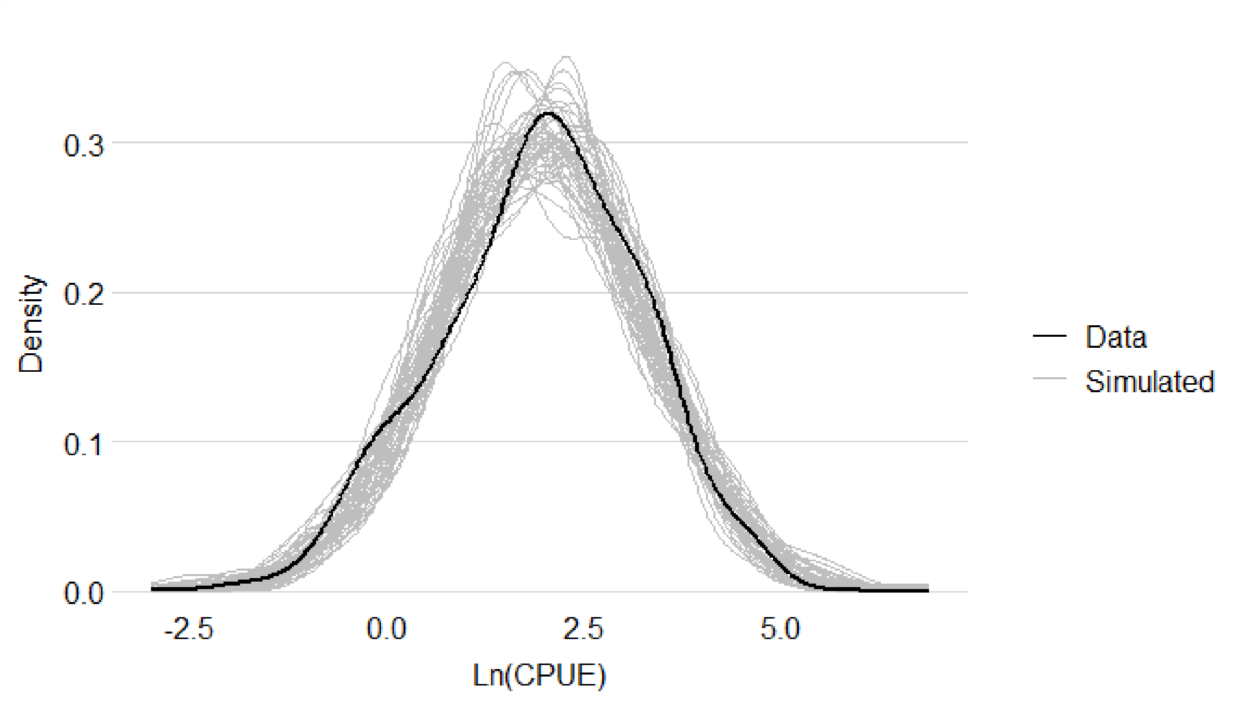

Figure A 35. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *E. coruscans* CPUE standardization.

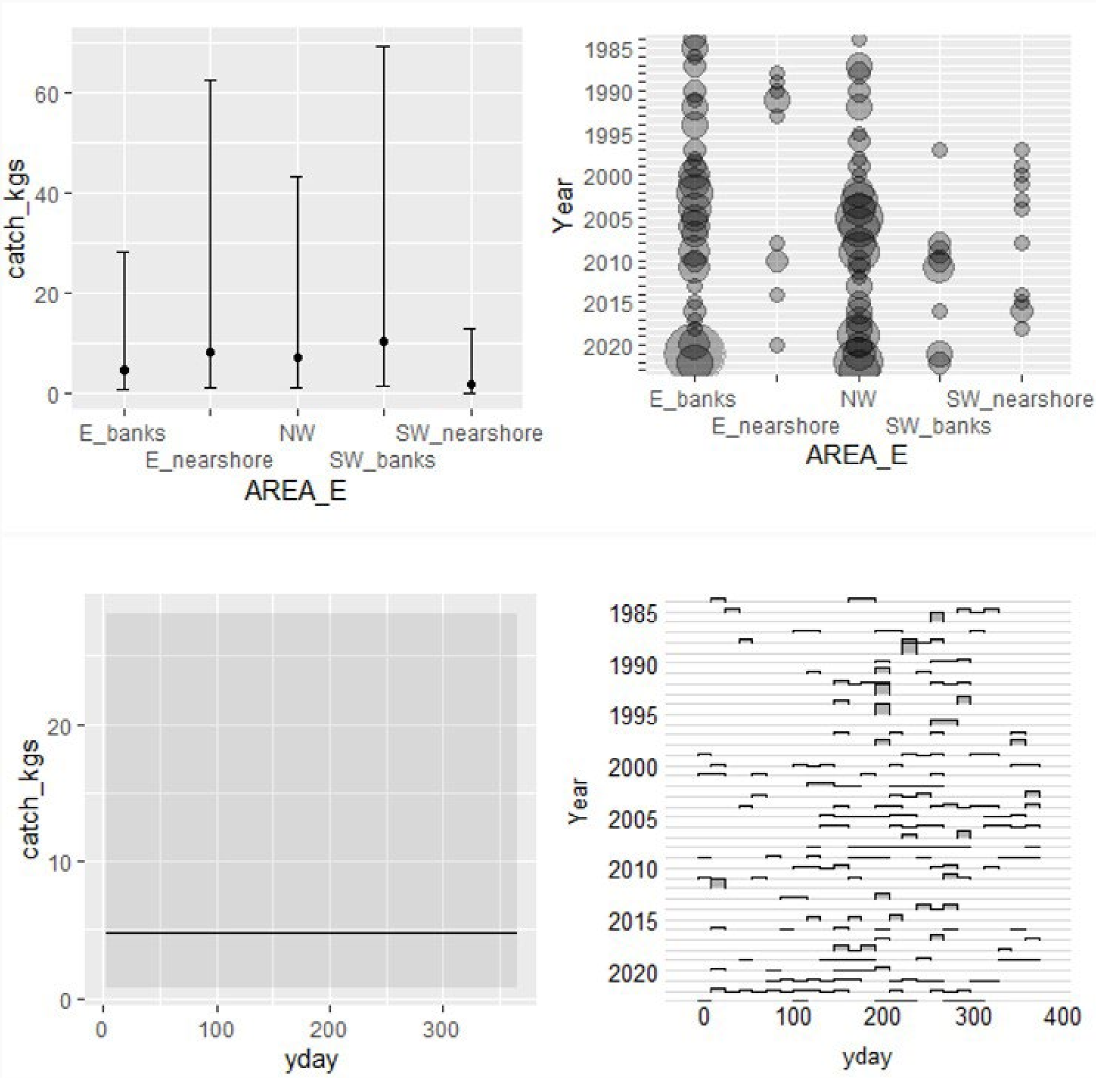

Figure A 36. Partial effects of area and time of year on CPUE (kg per trip) in the *E. coruscans* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

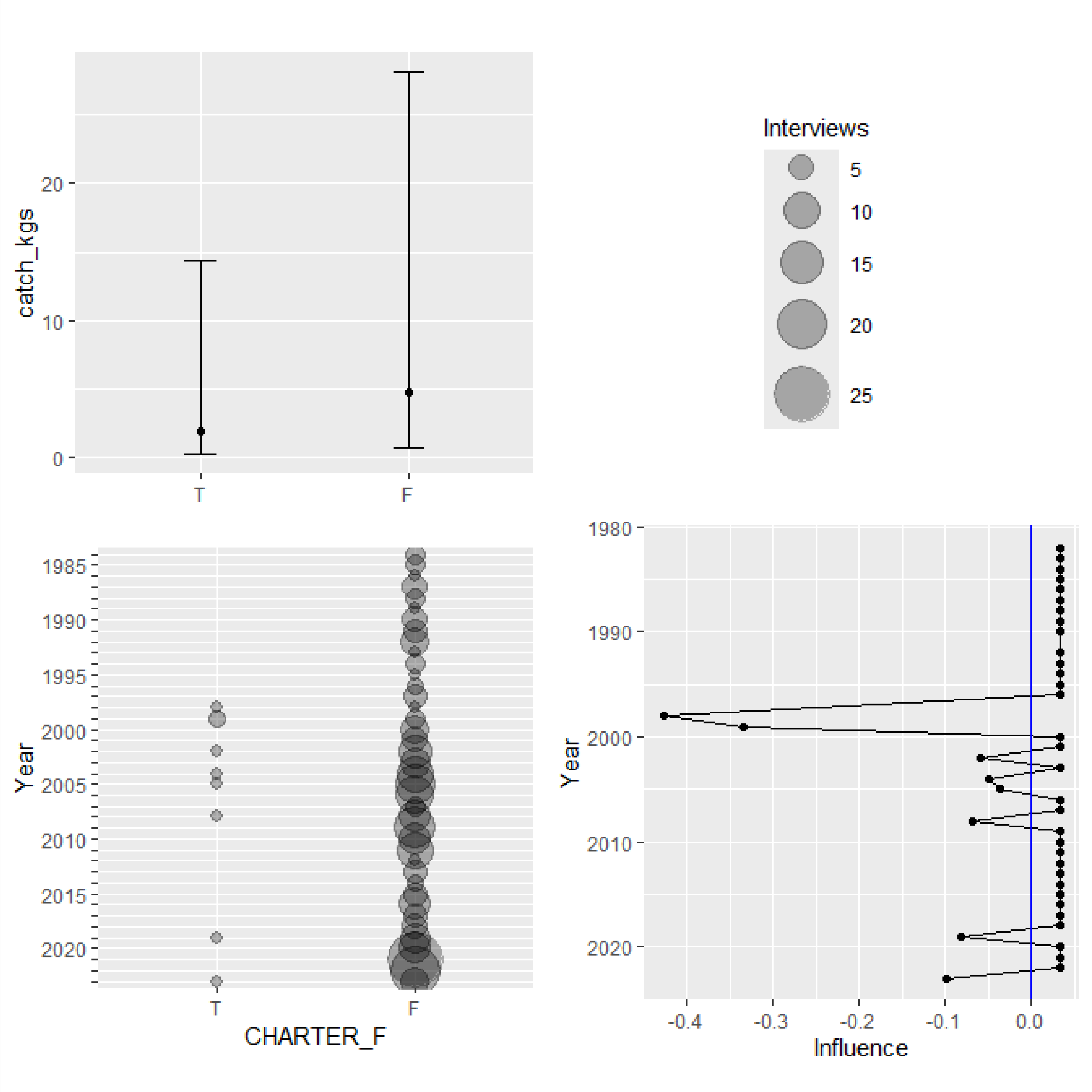

Figure A 37. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of charter status on CPUE (kg per trip) in the *E. coruscans* CPUE standardization.

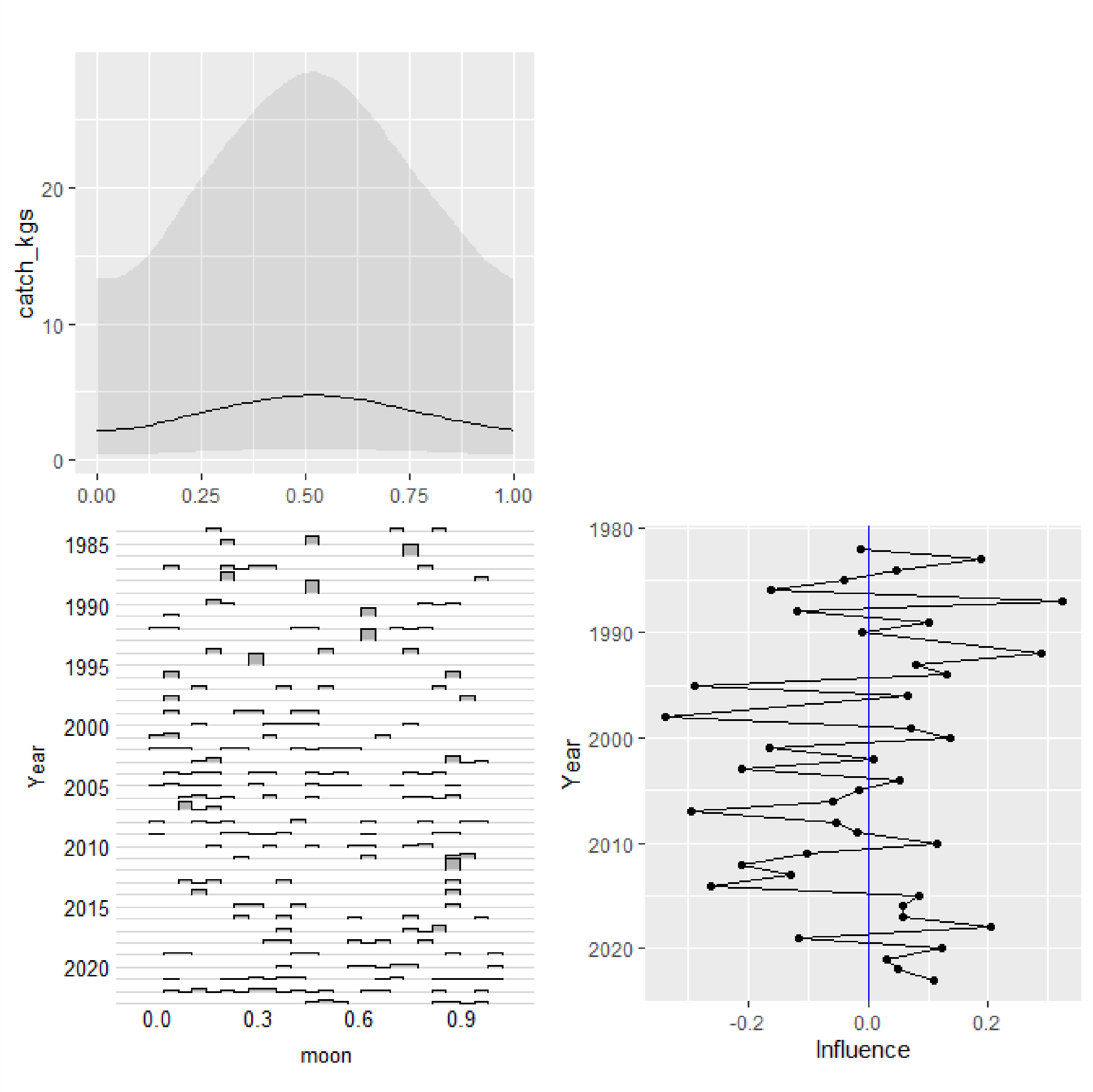

Figure A 38. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of moon phase on CPUE (kg per trip) in the *E. coruscans* CPUE standardization.

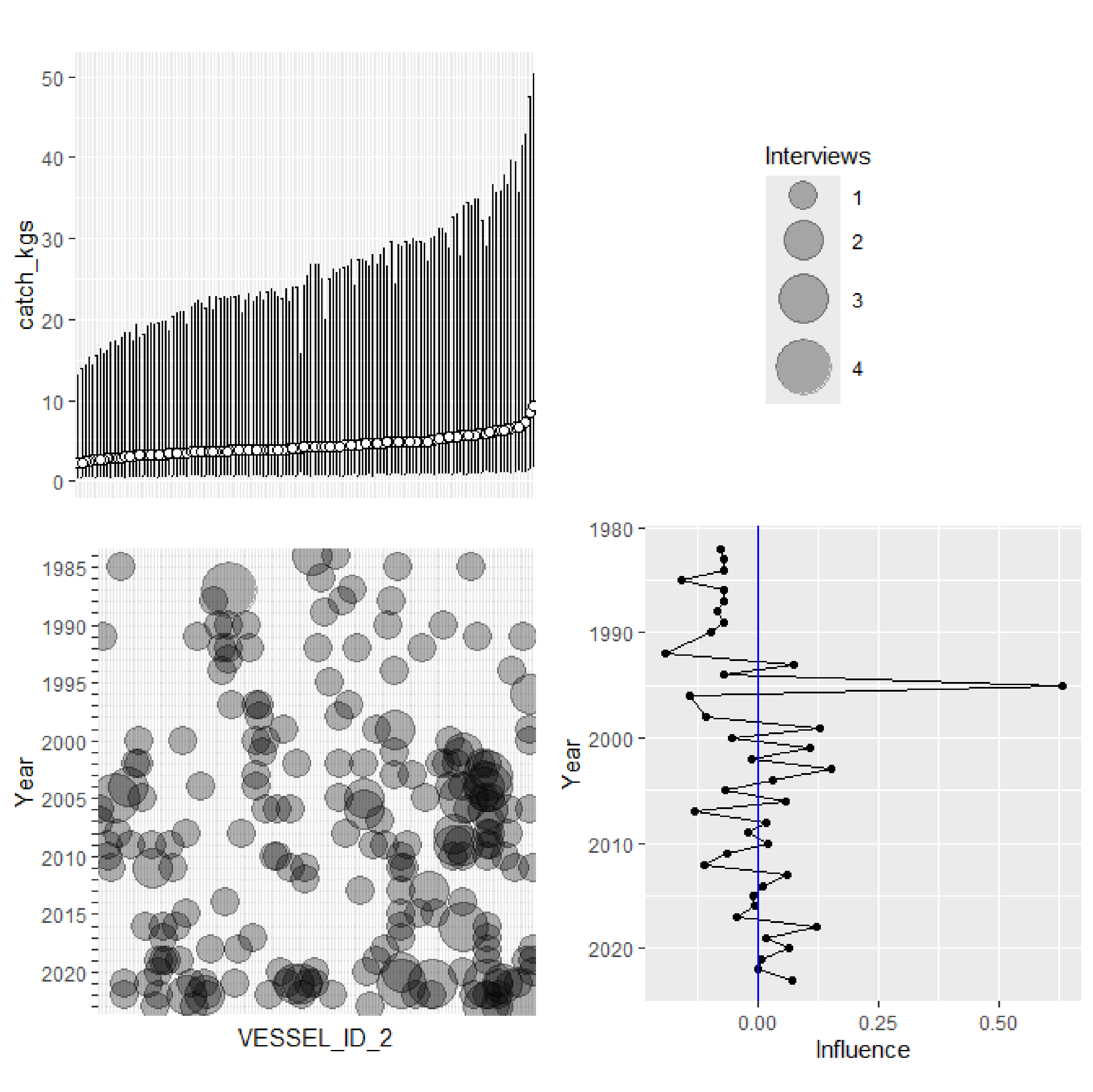

Figure A 39. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on CPUE (kg per trip) in the *E. coruscans* CPUE standardization.

Standardized CPUE Index

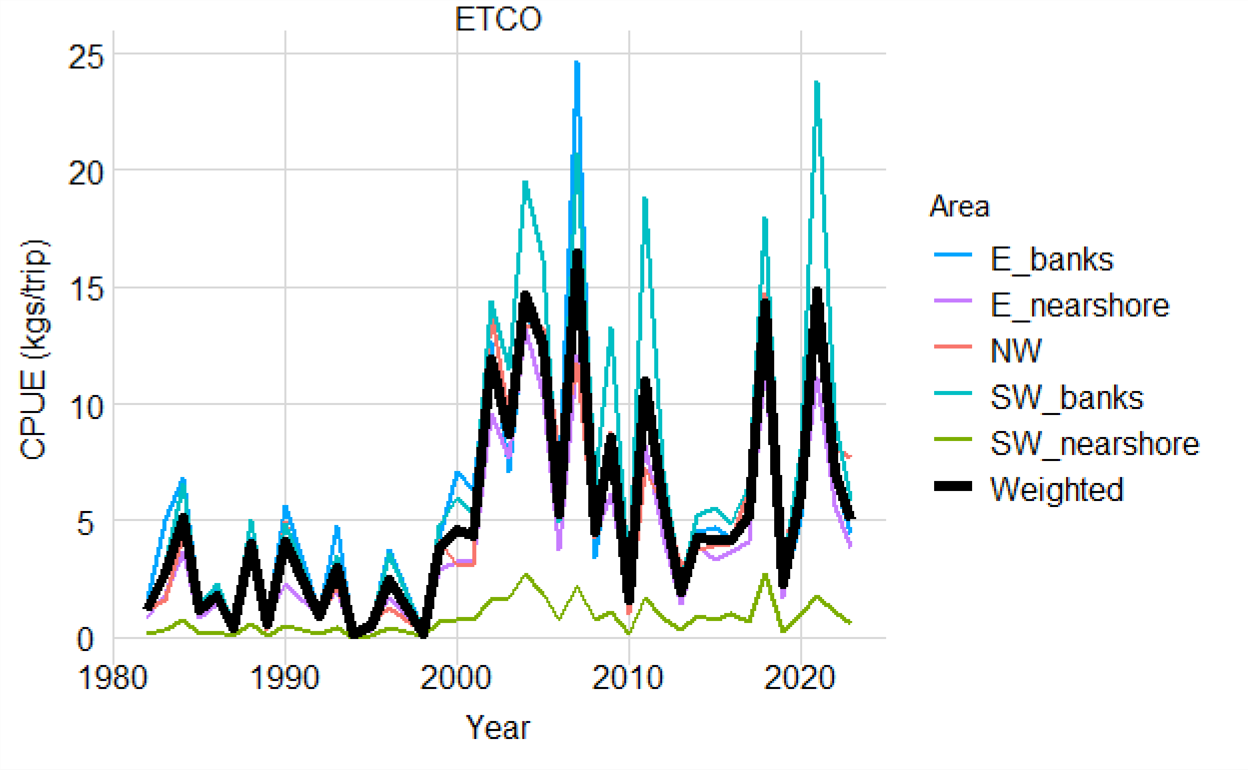

Figure A 40. Standardized CPUE index (kg per trip) of *E. coruscans* by area and weighted by habitat extent.

Table A 4. Standardized CPUE index (kg per trip) and standard deviation (sd) of *E. coruscans*.

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	1.17	3.99	1996	2.46	5.71	2010	1.59	2.54
1983	2.74	9.17	1997	--	--	2011	10.92	13.88
1984	5.10	28.20	1998	0.19	1.02	2012	5.68	35.61
1985	1.19	3.70	1999	3.85	8.68	2013	1.98	4.77
1986	1.81	4.40	2000	4.65	8.16	2014	4.29	10.89
1987	0.41	3.42	2001	4.30	10.80	2015	4.21	7.36
1988	3.98	7.49	2002	11.93	16.13	2016	4.17	6.30
1989	0.59	1.45	2003	8.68	11.97	2017	5.21	10.63
1990	4.10	7.47	2004	14.67	17.99	2018	14.30	23.31
1991	--	--	2005	12.50	17.51	2019	2.30	4.19
1992	0.93	7.33	2006	5.29	8.26	2020	6.13	8.01
1993	2.94	11.42	2007	16.42	40.34	2021	14.79	16.78
1994	0.11	0.95	2008	4.51	5.92	2022	7.09	8.18
1995	0.50	2.61	2009	8.58	11.51	2023	5.05	8.36

Lethrinus rubrioperculatus

Presence/Absence Model

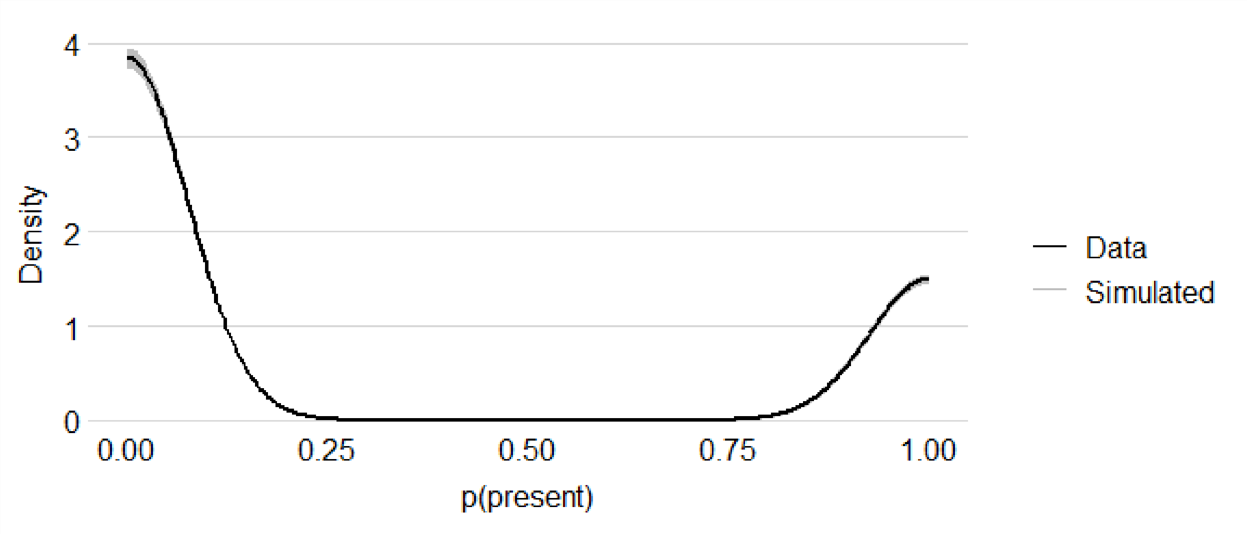

Figure A 41. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *L. rubrioperculatus* CPUE standardization.

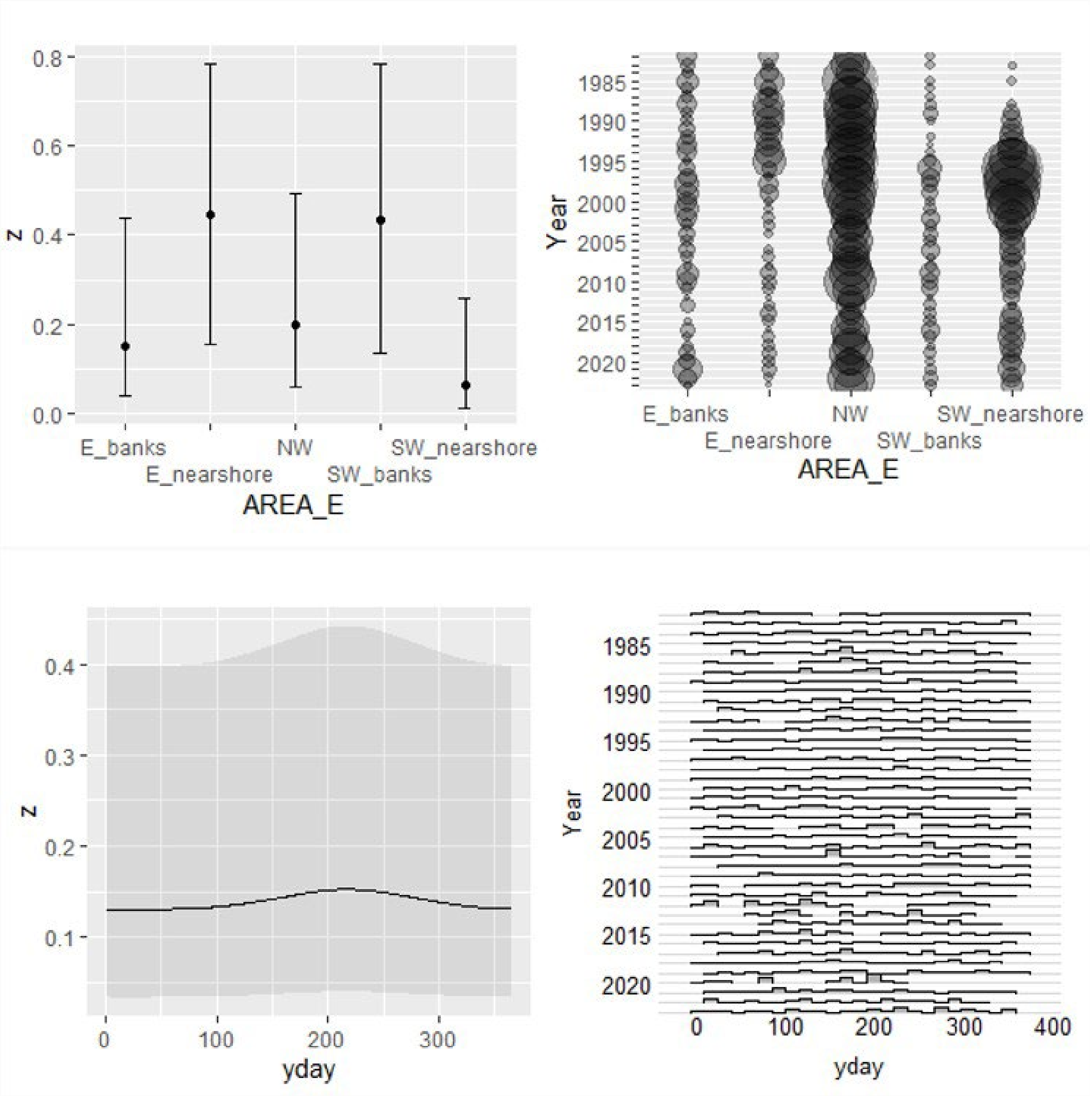

Figure A 42. Partial effects of area and time of year on probability of presence in the *L. rubrioperculatus* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

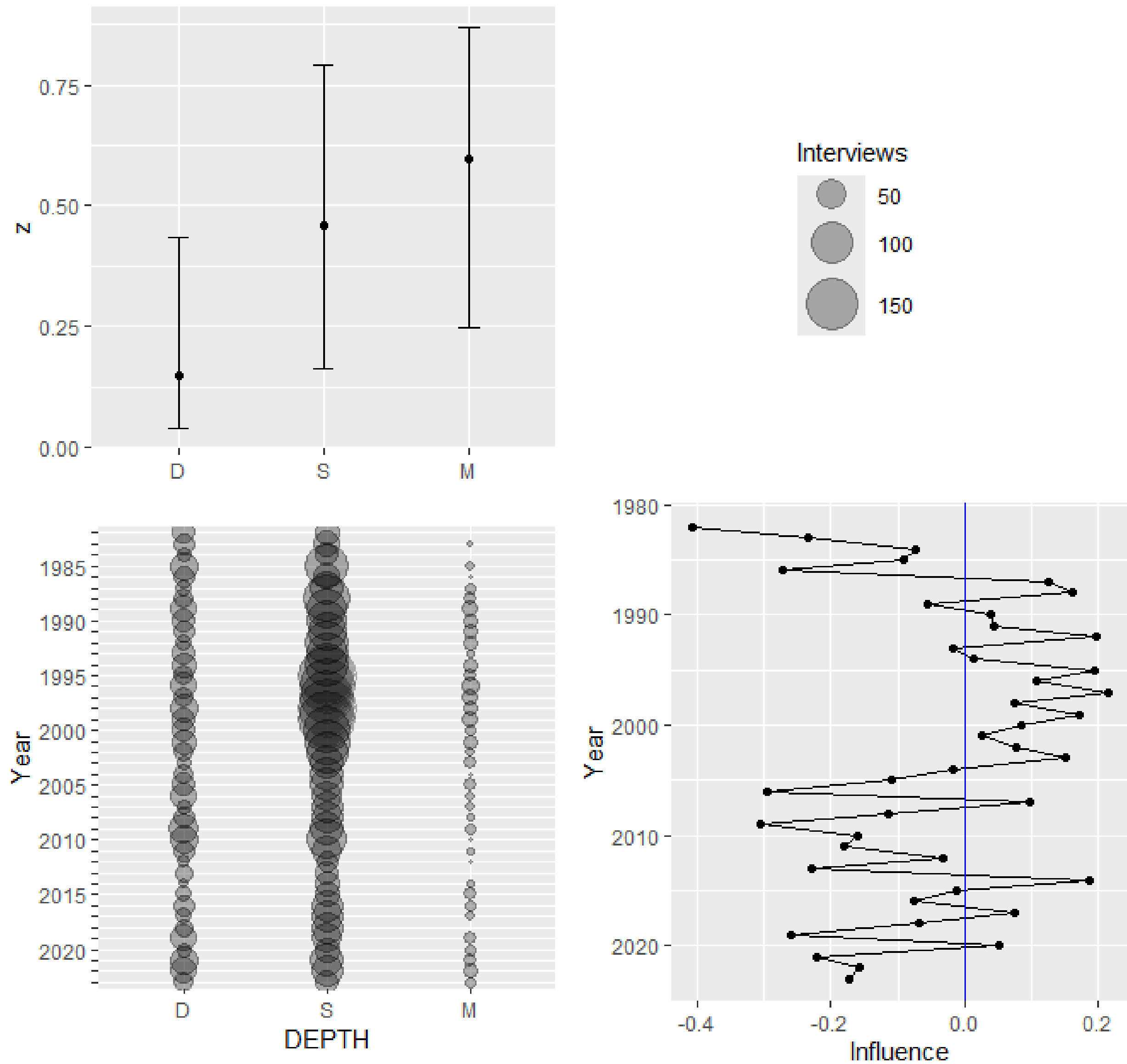

Figure A 43. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on probability of presence in the *L. rubrioperculatus* CPUE standardization.

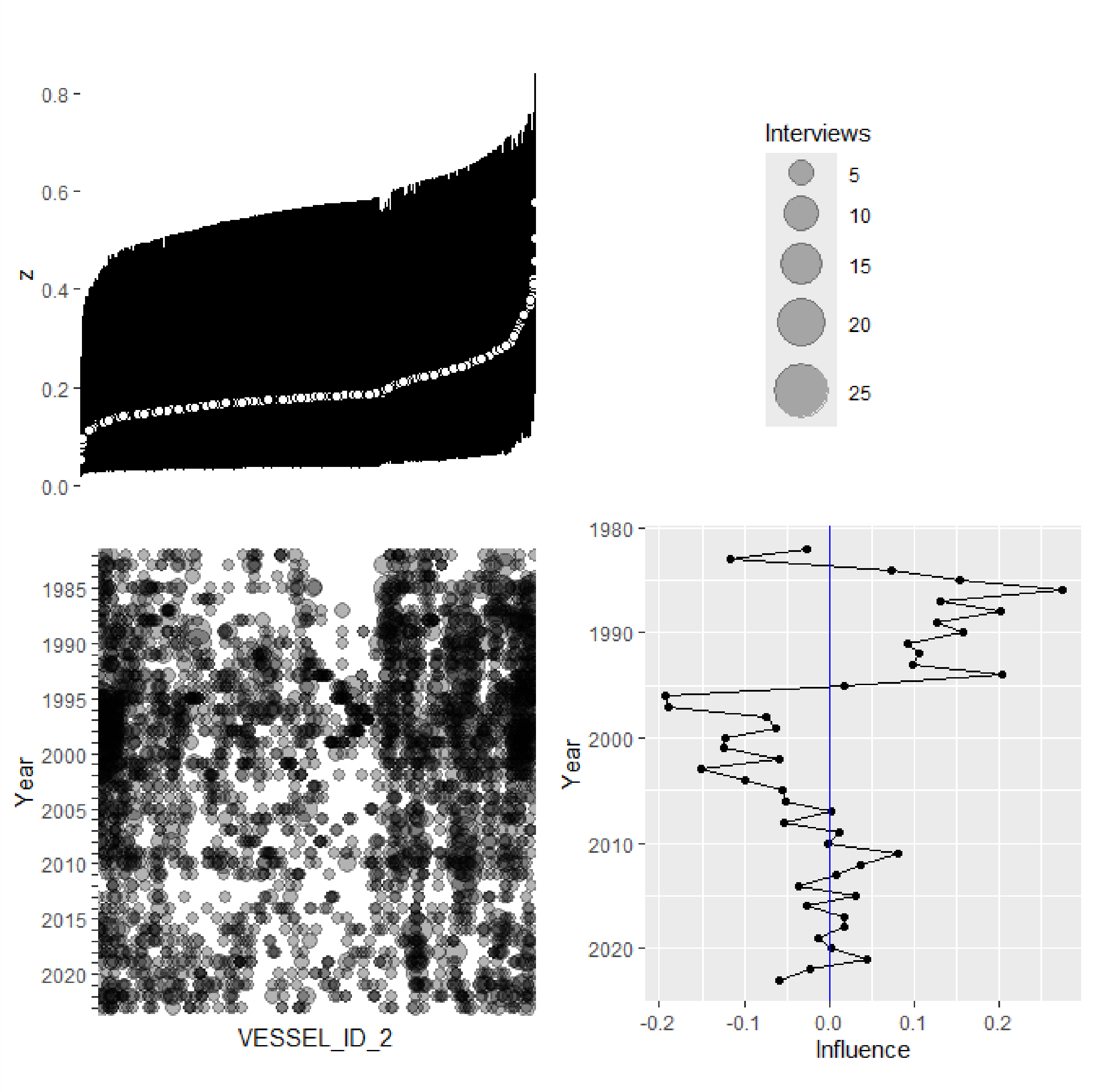

Figure A 44. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *L. rubrioperculatus* CPUE standardization.

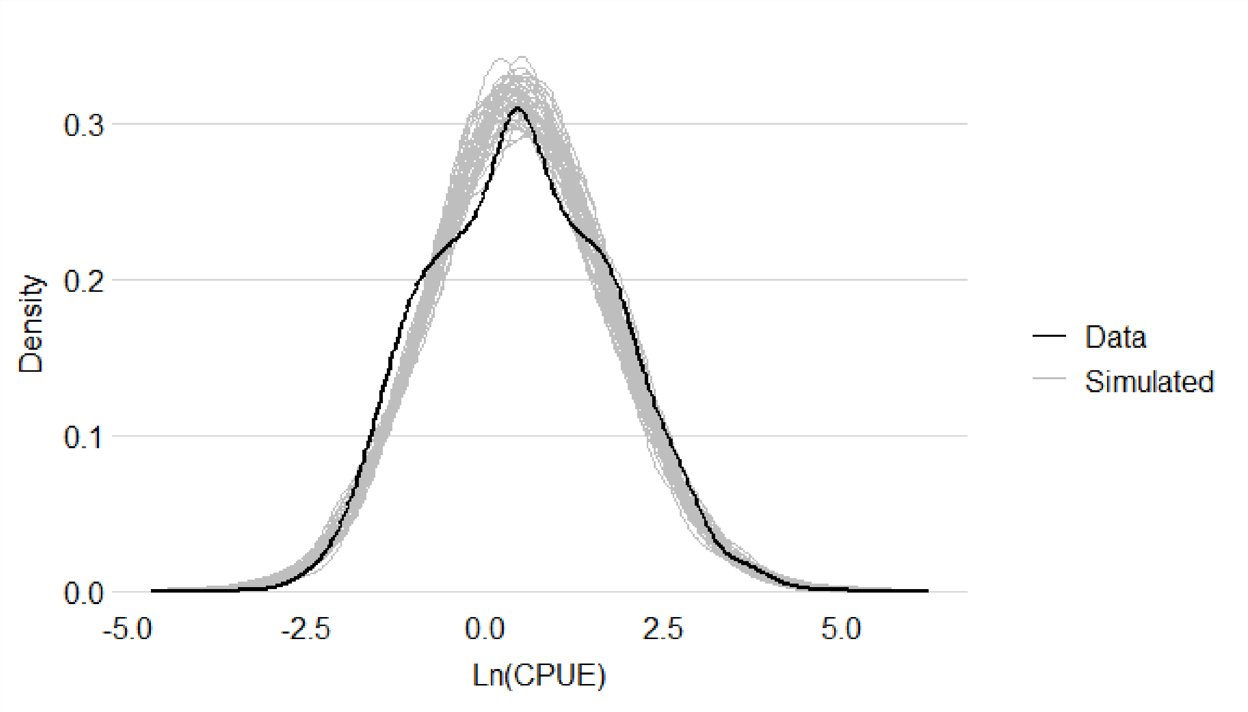

Figure A 45. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *L. rubrioperculatus* CPUE standardization.

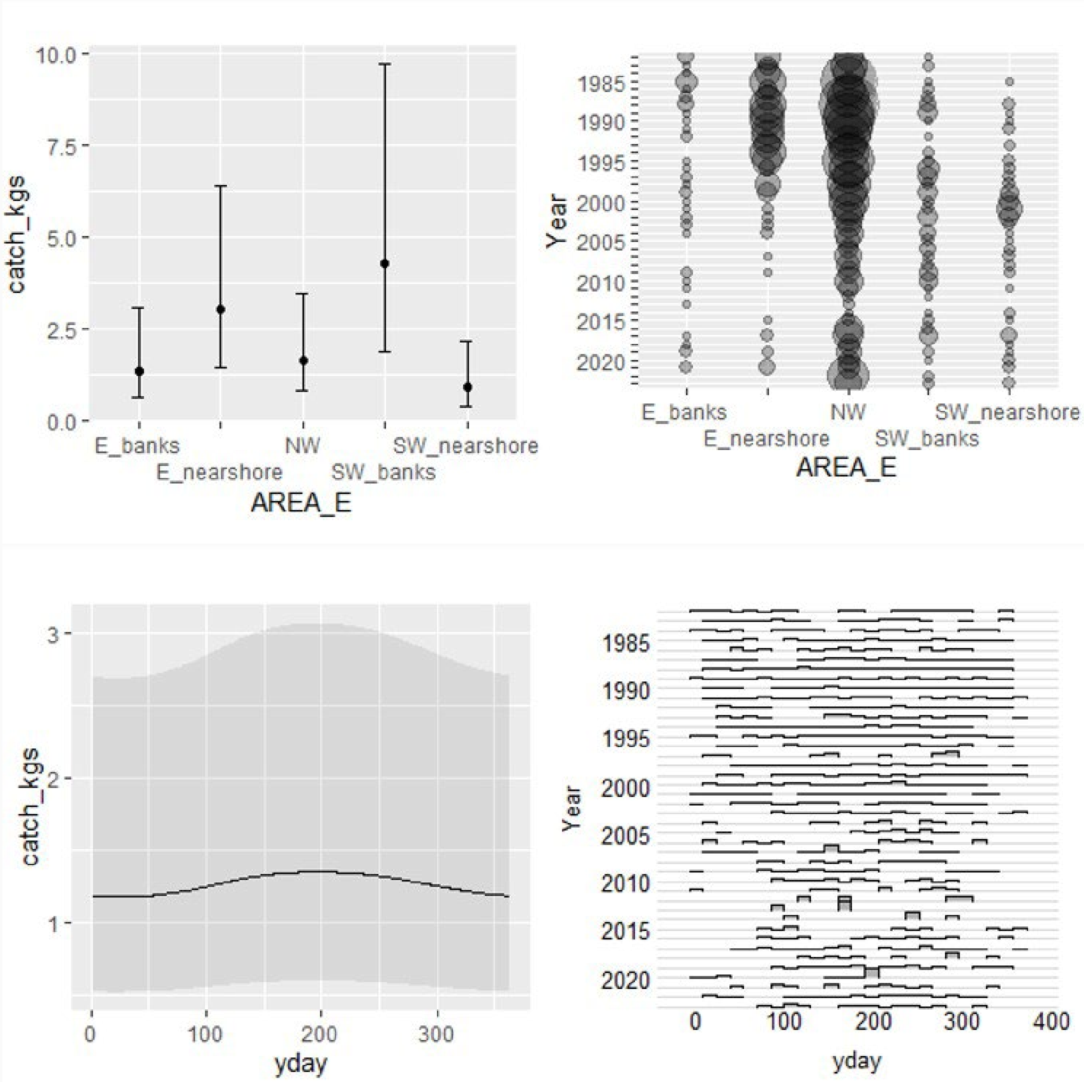

Figure A 46. Partial effects of area and time of year on CPUE (kg per trip) in the *L. rubrioperculatus* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

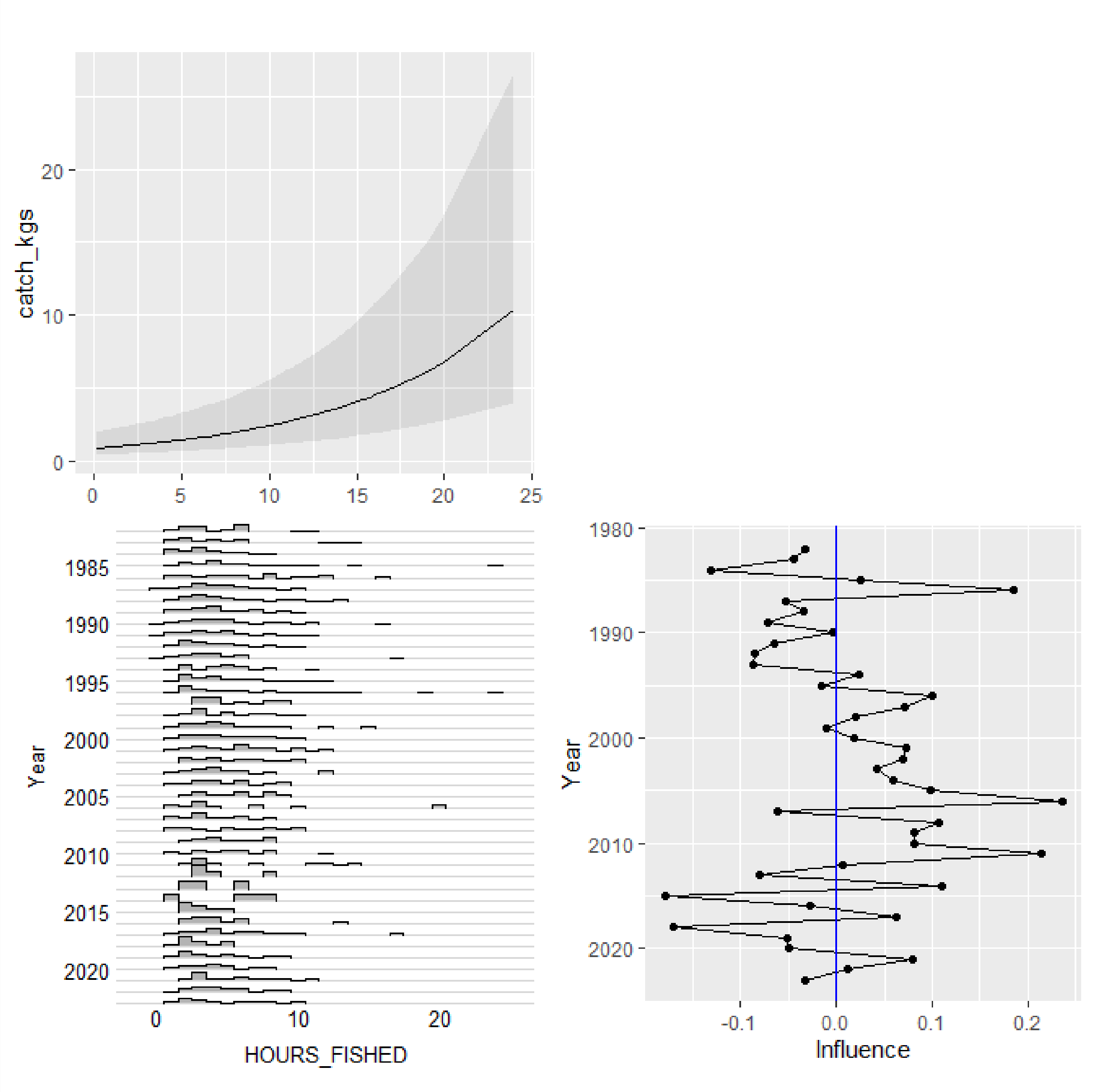

Figure A 47. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *L. rubrioperculatus* CPUE standardization.

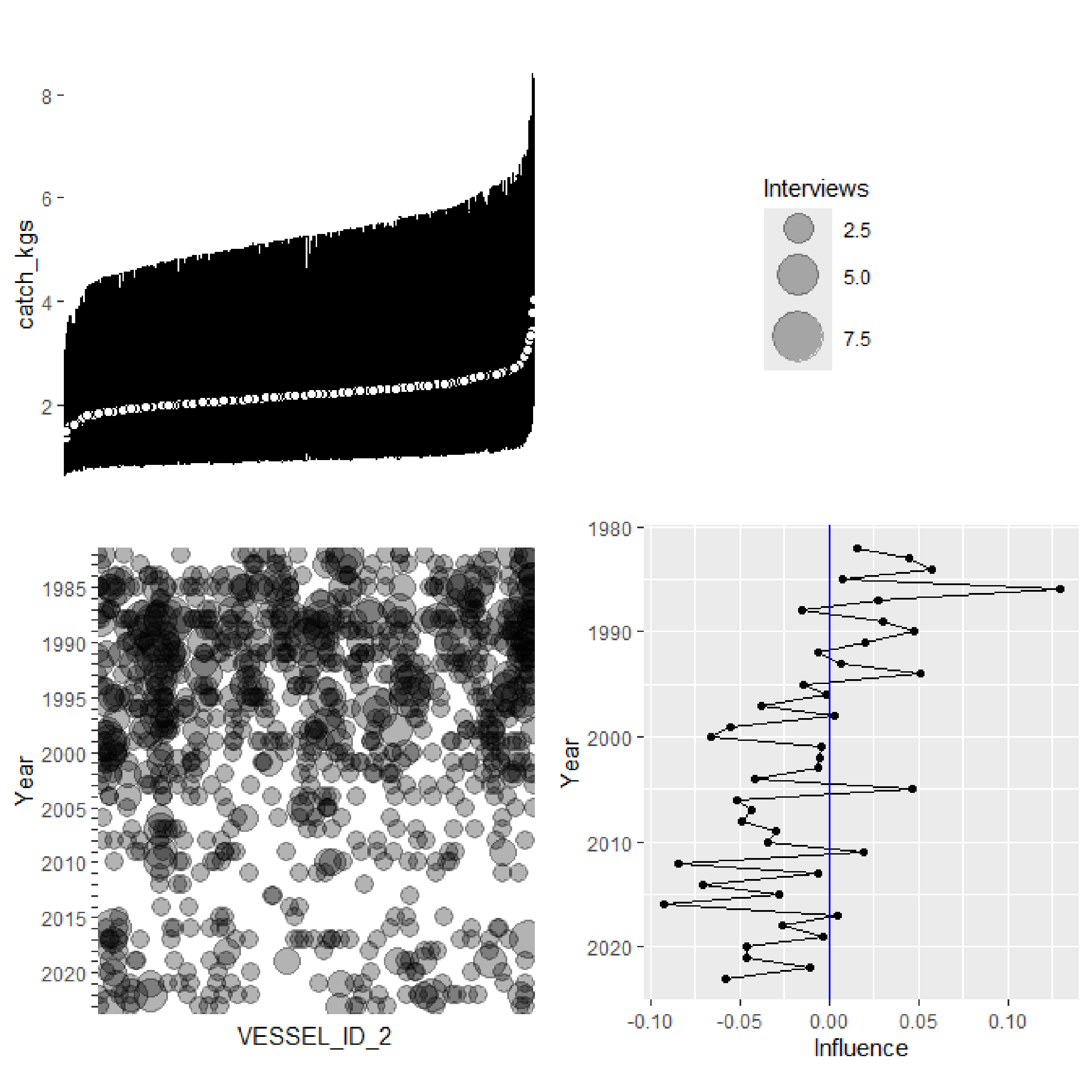

Figure A 48. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on CPUE (kg per trip) in the *L. rubrioperculatus* CPUE standardization.

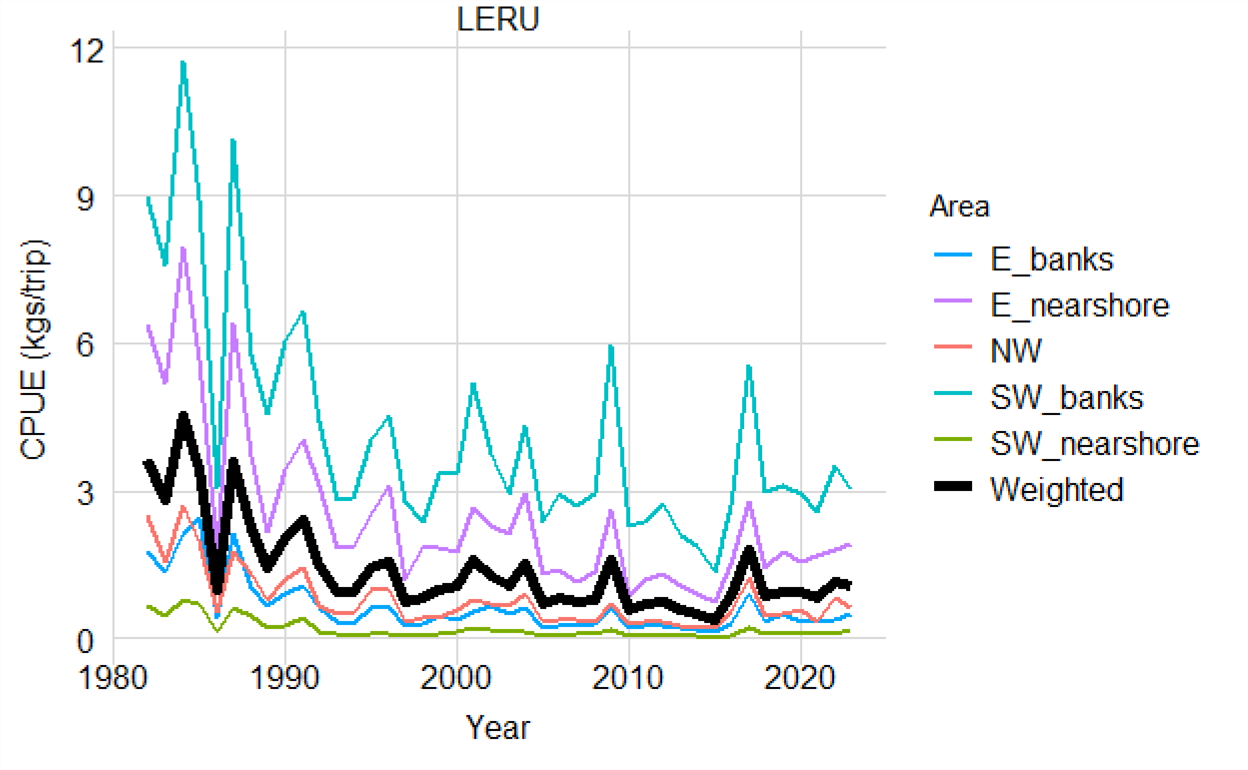

Figure A 49. Standardized CPUE index (kg per trip) of *L. rubrioperculatus* by area and weighted by habitat extent.

Table A 5. Standardized CPUE index (kg per trip) and standard deviation (sd) of *L. rubrioperculatus.*

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	3.64	2.05	1996	1.55	0.99	2010	0.59	0.47
1983	2.83	1.66	1997	0.73	0.54	2011	0.69	0.72
1984	4.53	2.59	1998	0.85	0.55	2012	0.75	0.95
1985	3.42	1.78	1999	0.97	0.61	2013	0.59	1.08
1986	1.01	0.63	2000	1.07	0.71	2014	0.52	0.77
1987	3.60	1.95	2001	1.61	0.99	2015	0.39	0.42
1988	2.24	1.12	2002	1.28	0.80	2016	0.86	0.68
1989	1.42	0.77	2003	1.09	0.80	2017	1.80	1.04
1990	2.04	1.13	2004	1.51	1.00	2018	0.86	0.84
1991	2.42	1.29	2005	0.70	0.62	2019	0.96	0.72
1992	1.48	0.86	2006	0.81	0.69	2020	0.95	0.80
1993	0.96	0.61	2007	0.76	0.56	2021	0.84	0.65
1994	0.94	0.57	2008	0.80	0.60	2022	1.15	0.81
1995	1.42	0.90	2009	1.59	1.22	2023	1.08	0.73

Lutjanus kasmira

Presence/Absence Model

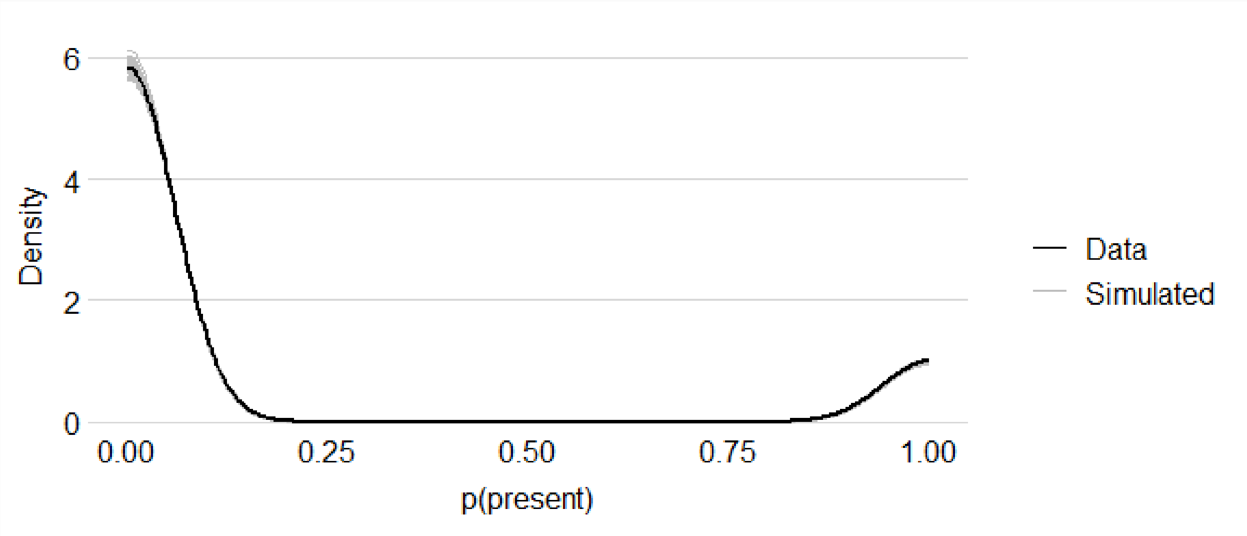

Figure A 50. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *L. kasmira* CPUE standardization.

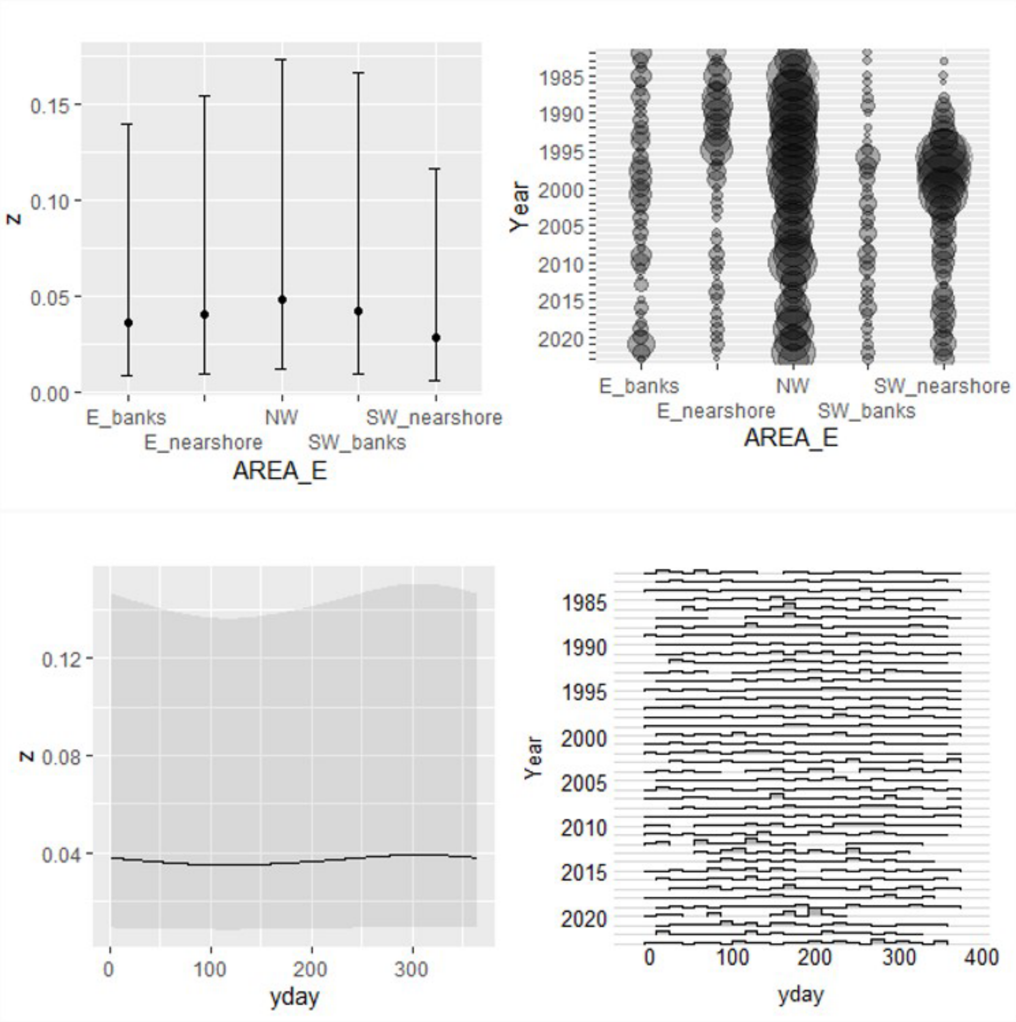

Figure A 51.Partial effects of area and time of year on probability of presence in the *L. kasmira* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

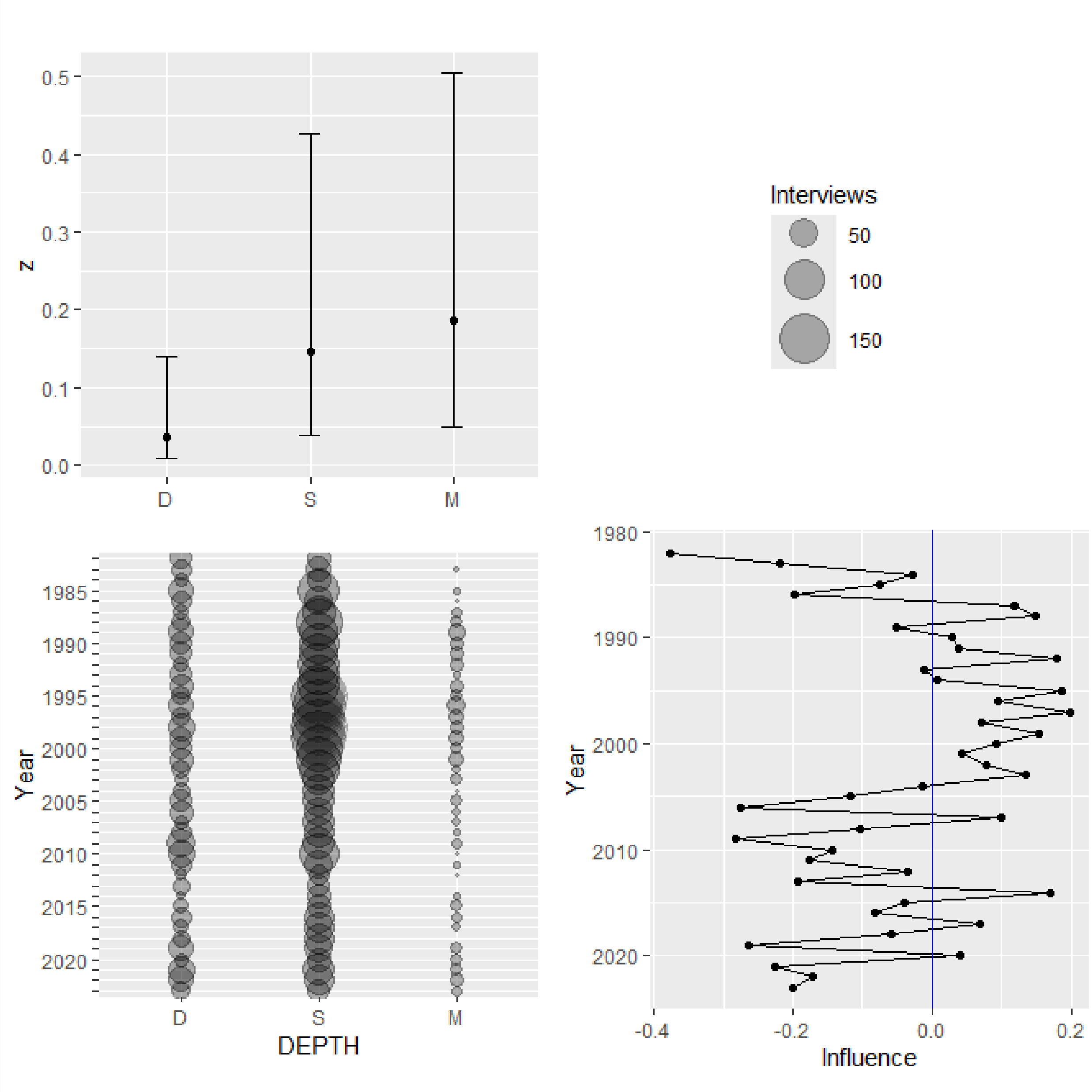

Figure A 52. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type ('depth') on probability of presence in the *L. kasmira* CPUE standardization.

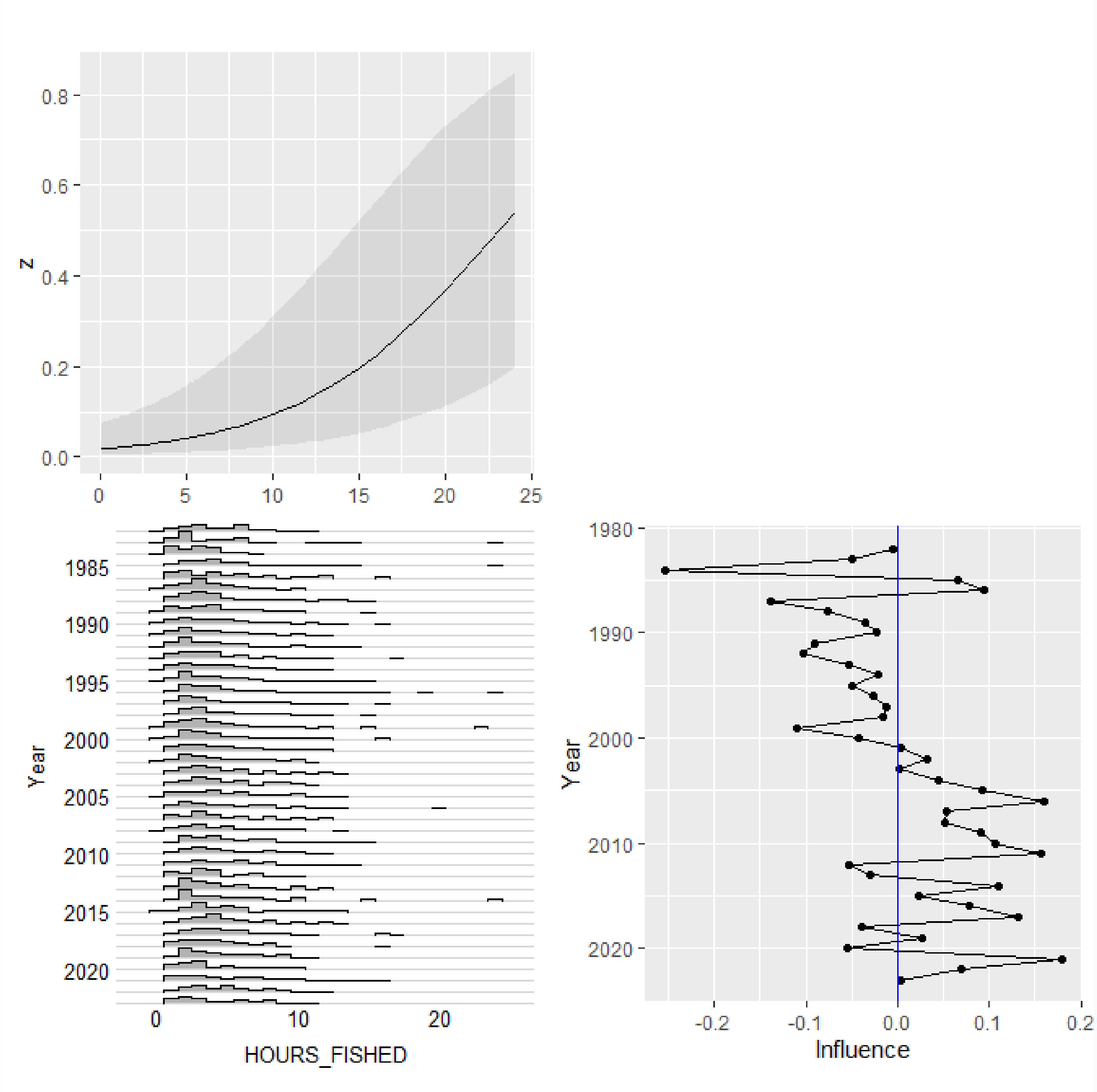

Figure A 53. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on probability of presence in the *L. kasmira* CPUE standardization.

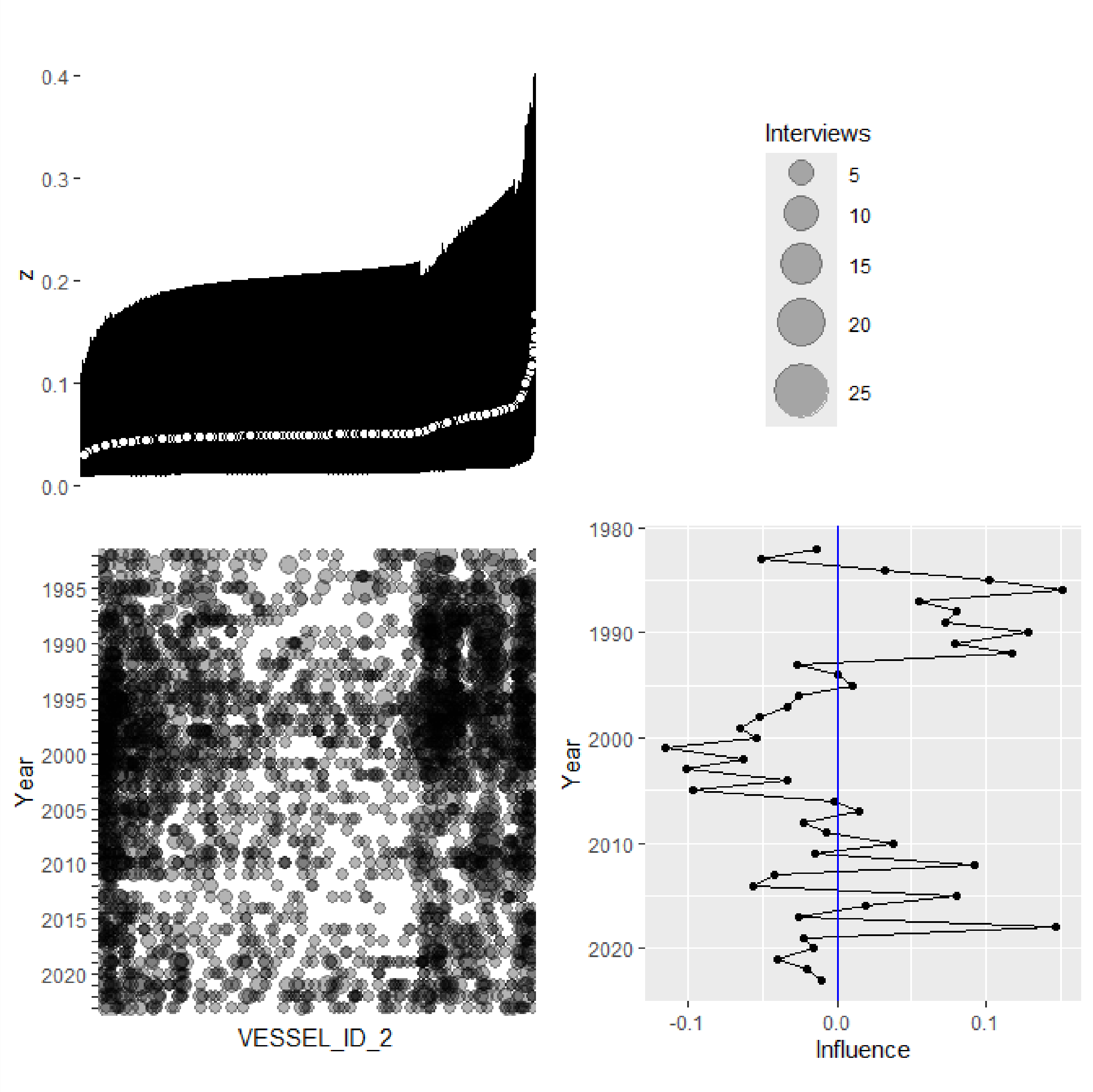

Figure A 54.Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *L. kasmira* CPUE standardization.

Positive Process Model

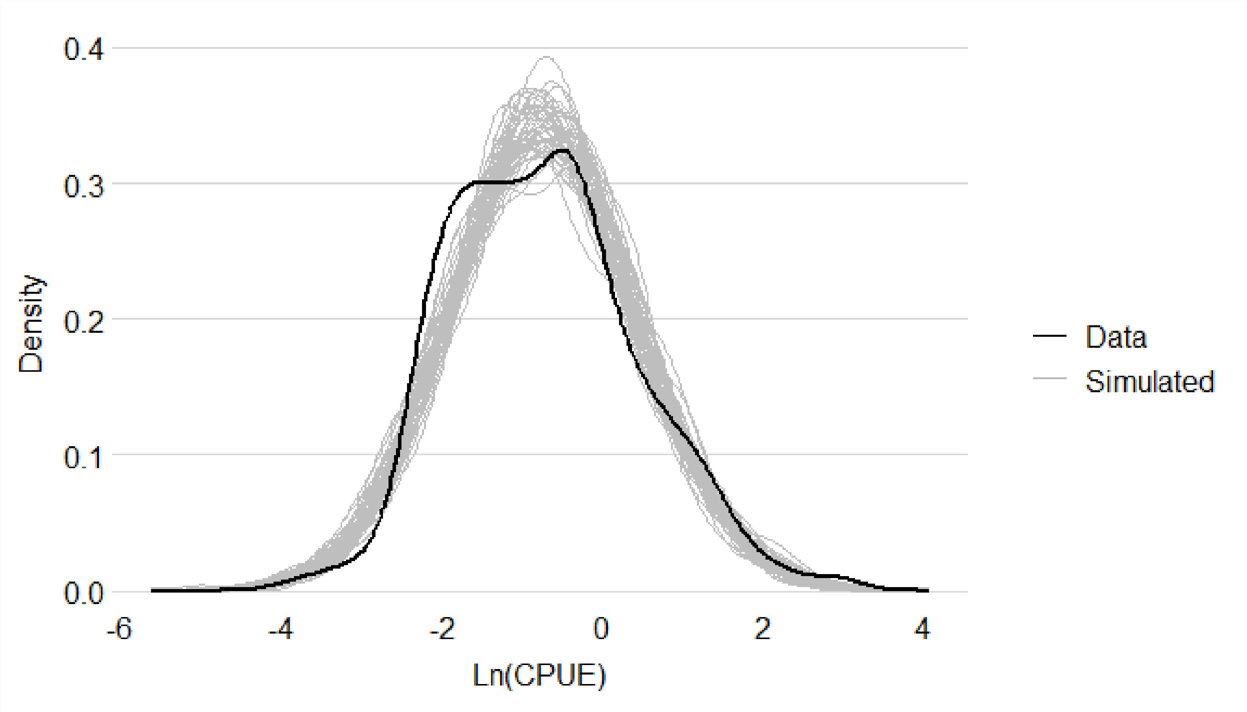

Figure A 55. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *L. kasmira* CPUE standardization.

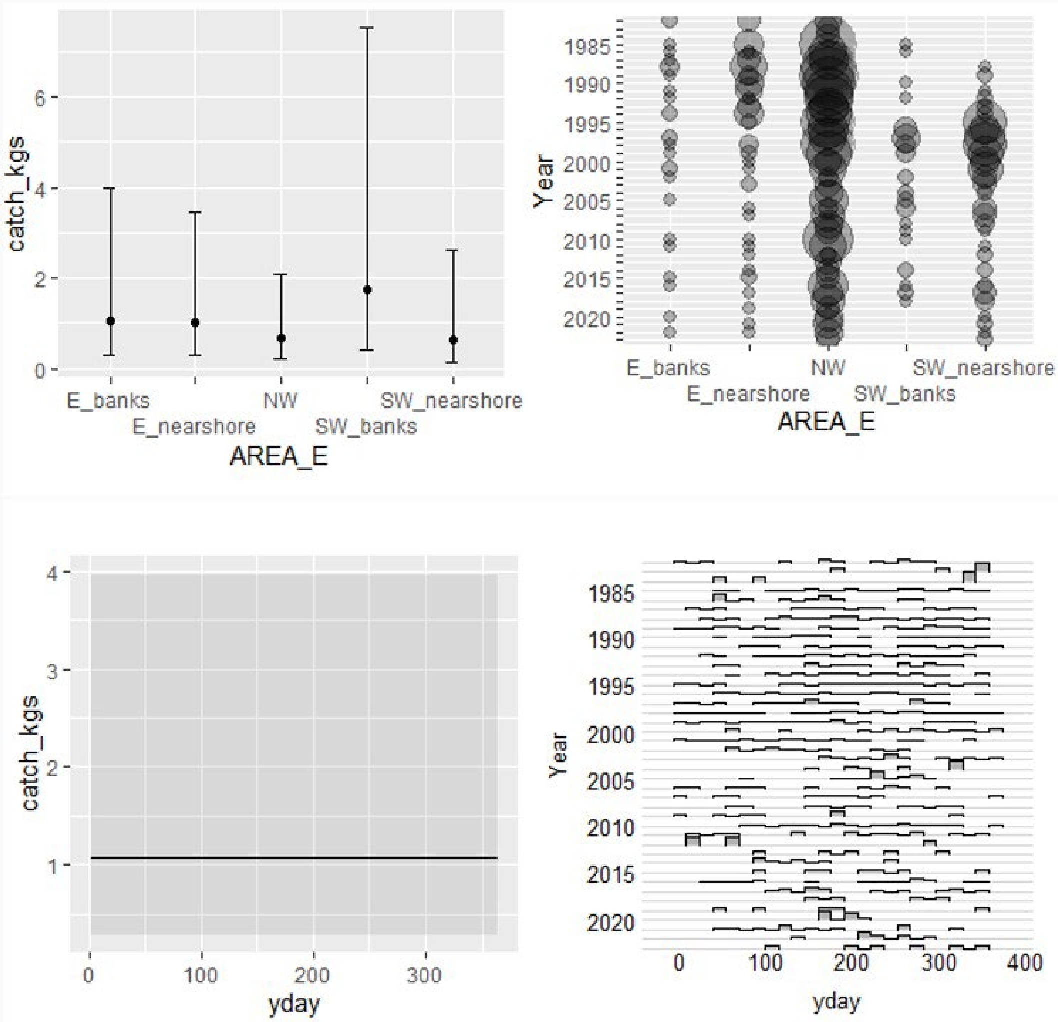

Figure A 56. Partial effects of area and time of year on CPUE (kg per trip) in the *L. kasmira* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

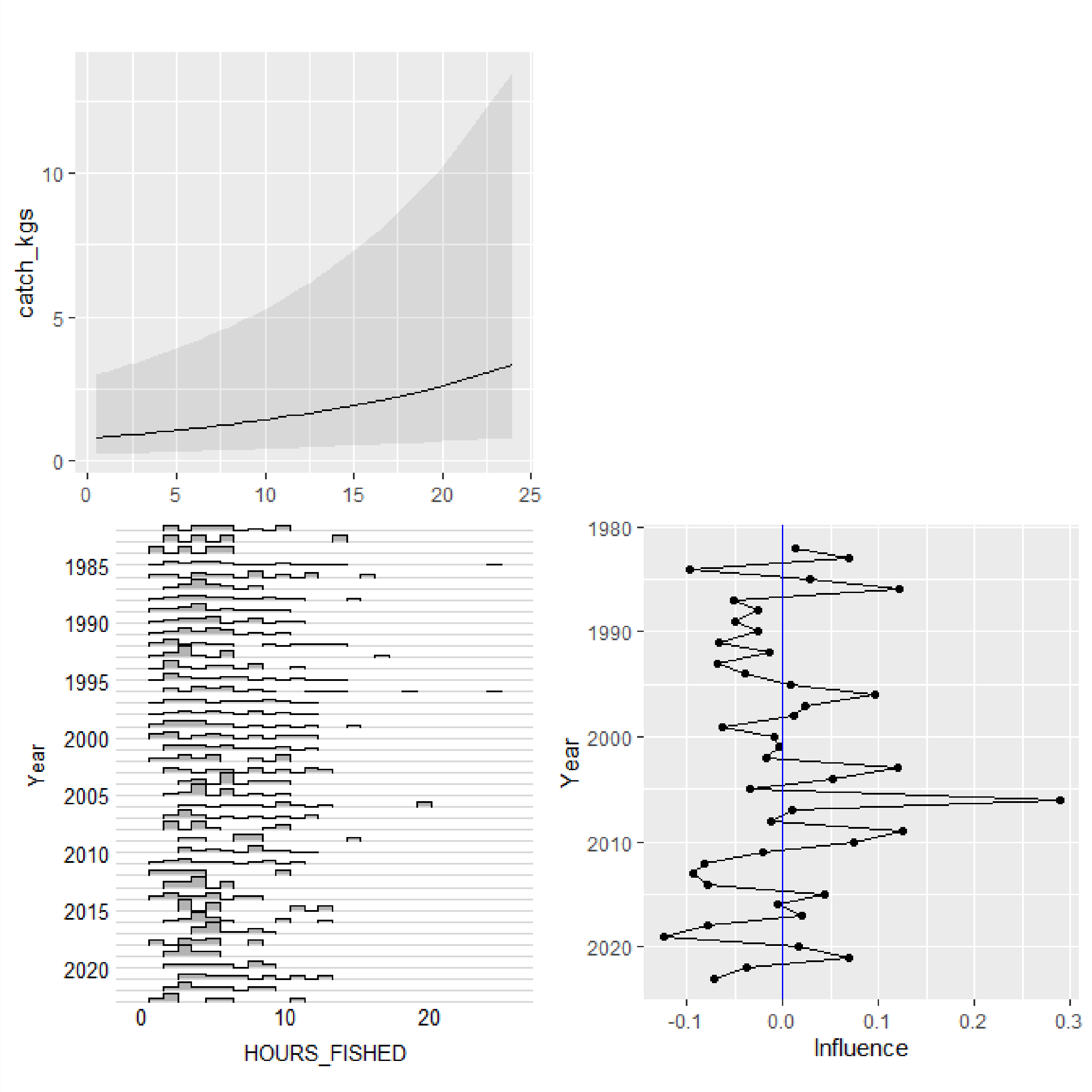

Figure A 57. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *L. kasmira* CPUE standardization.

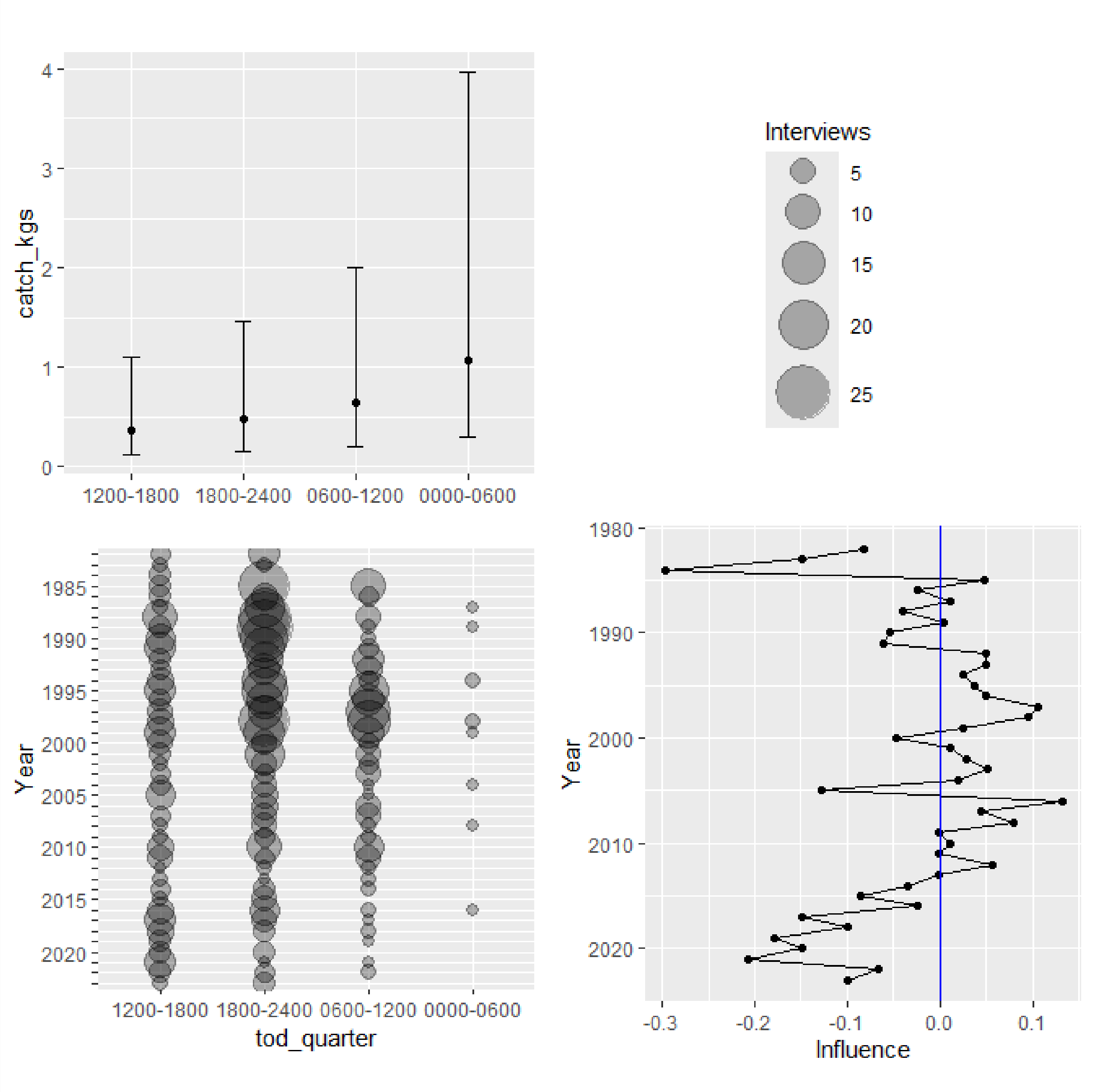

Figure A 58. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of time of day on CPUE (kg per trip) in the *L. kasmira* CPUE standardization.

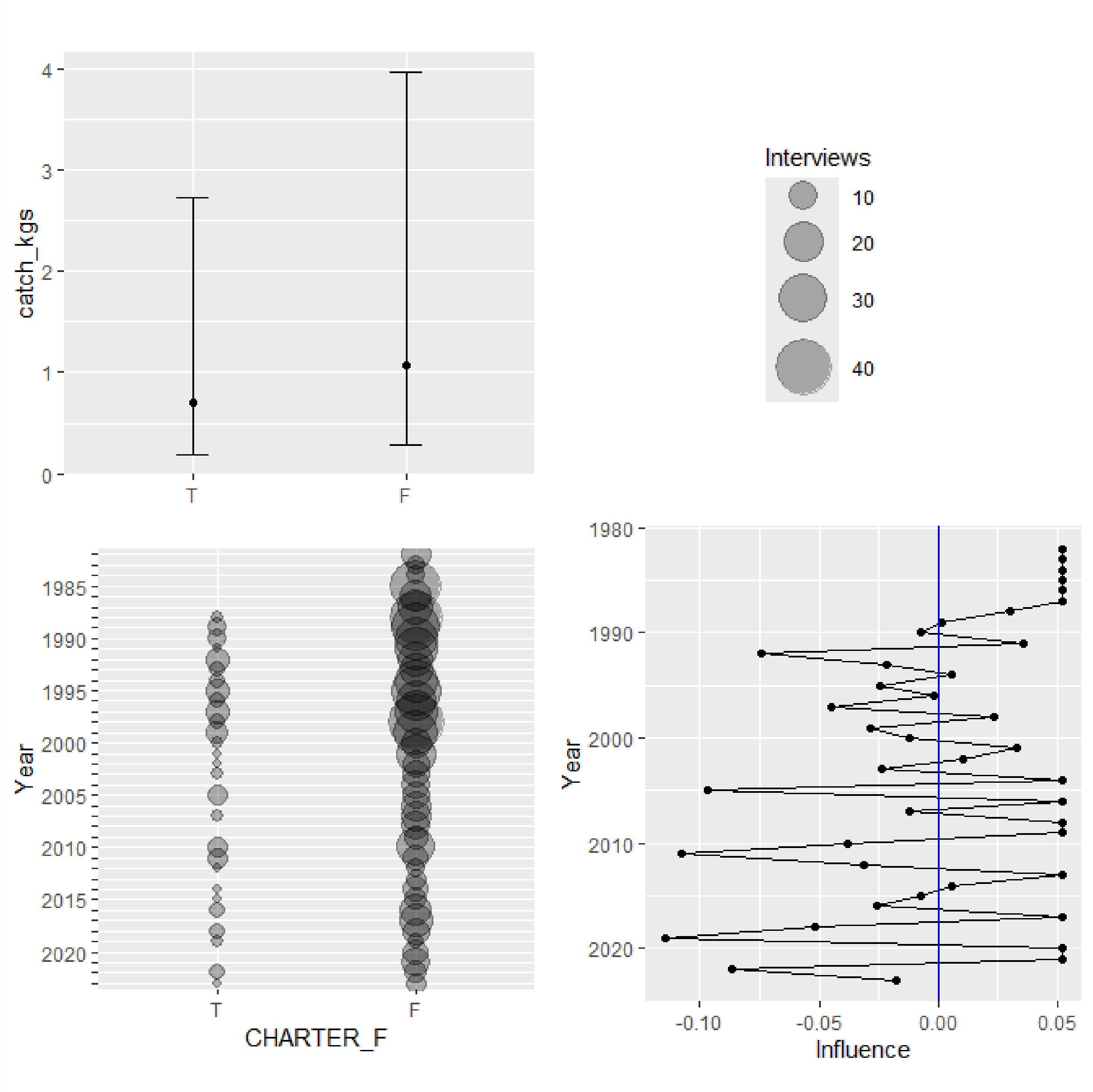

Figure A 59. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of charter status on CPUE (kg per trip) in the *L. kasmira* CPUE standardization.

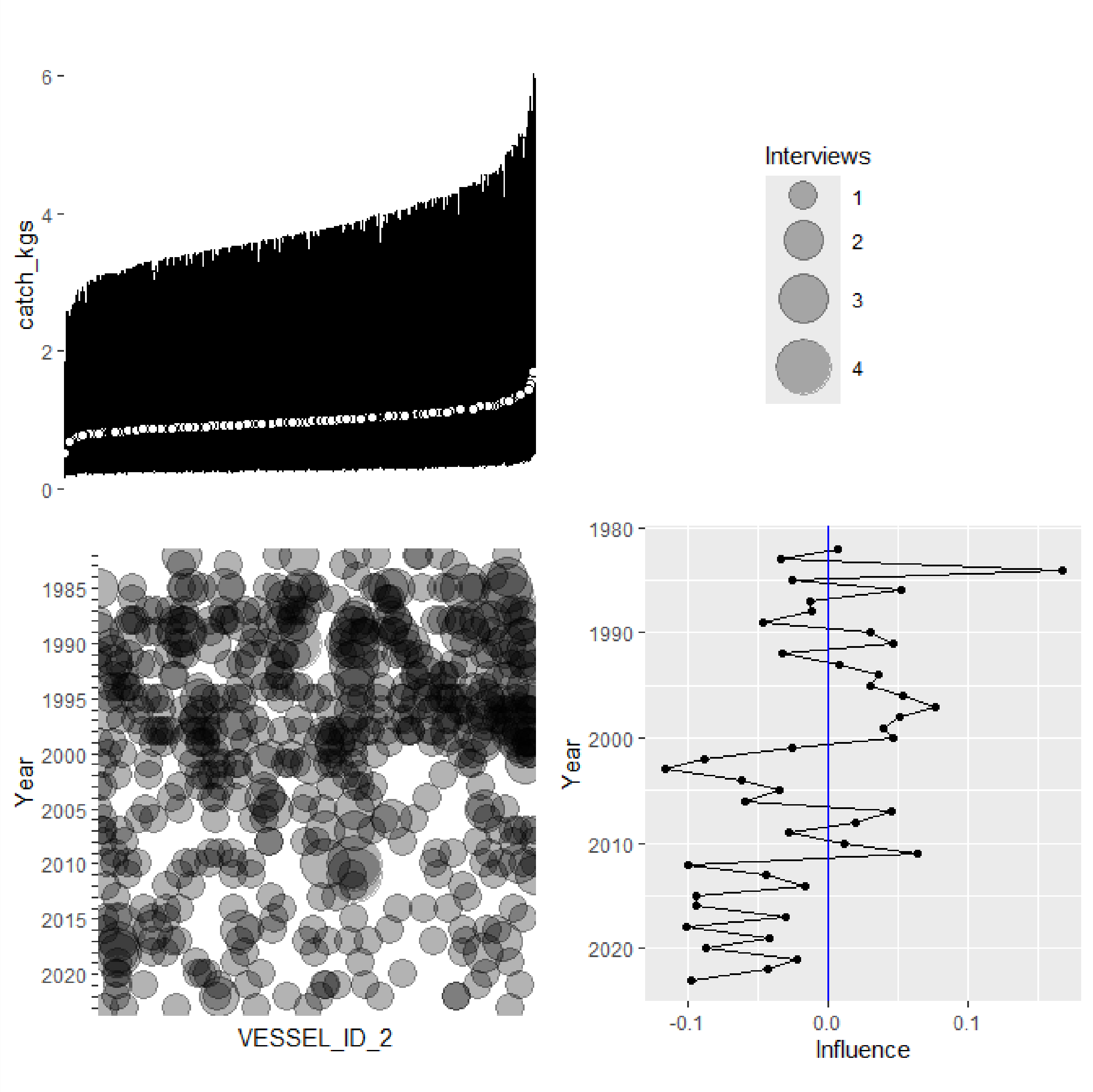

Figure A 60. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on CPUE (kg per trip) in the *L. kasmira* CPUE standardization.

Standardized CPUE Index

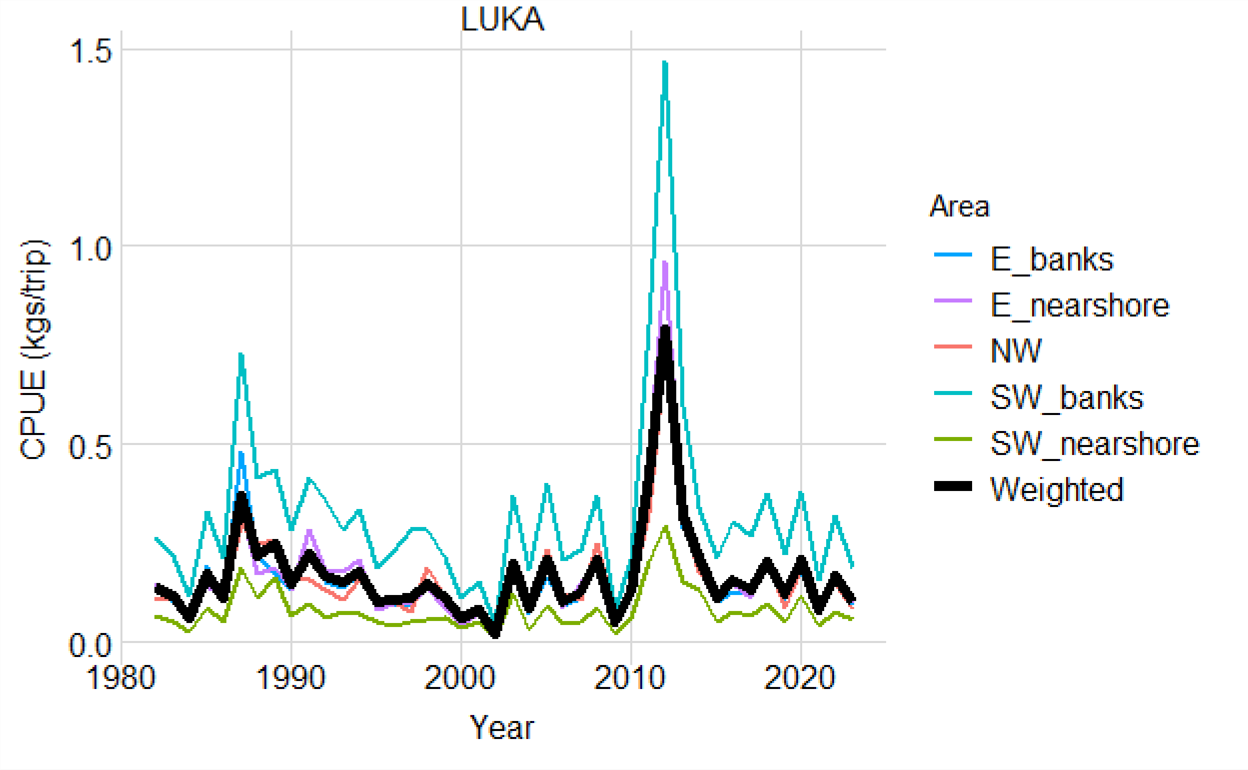

Figure A 61. Standardized CPUE index (kg per trip) of *L. kasmira* by area and weighted by habitat extent.

Table A 6. Standardized CPUE index (kg per trip) and standard deviation (sd) of *L. kasmira*.

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	0.14	0.14	1996	0.11	0.11	2010	0.13	0.13
1983	0.12	0.22	1997	0.11	0.10	2011	0.42	0.46
1984	0.06	0.12	1998	0.15	0.12	2012	0.79	1.01
1985	0.17	0.15	1999	0.11	0.10	2013	0.32	0.50
1986	0.11	0.12	2000	0.06	0.07	2014	0.21	0.21
1987	0.37	0.37	2001	0.08	0.08	2015	0.11	0.15
1988	0.22	0.19	2002	0.02	0.03	2016	0.16	0.16
1989	0.25	0.22	2003	0.20	0.21	2017	0.13	0.13
1990	0.15	0.13	2004	0.08	0.10	2018	0.20	0.21
1991	0.22	0.21	2005	0.21	0.22	2019	0.12	0.20
1992	0.17	0.17	2006	0.10	0.11	2020	0.21	0.25
1993	0.15	0.15	2007	0.13	0.13	2021	0.08	0.10
1994	0.18	0.16	2008	0.21	0.23	2022	0.17	0.21
1995	0.10	0.09	2009	0.05	0.07	2023	0.10	0.14

Pristipomoides auricilla

Presence/Absence Model

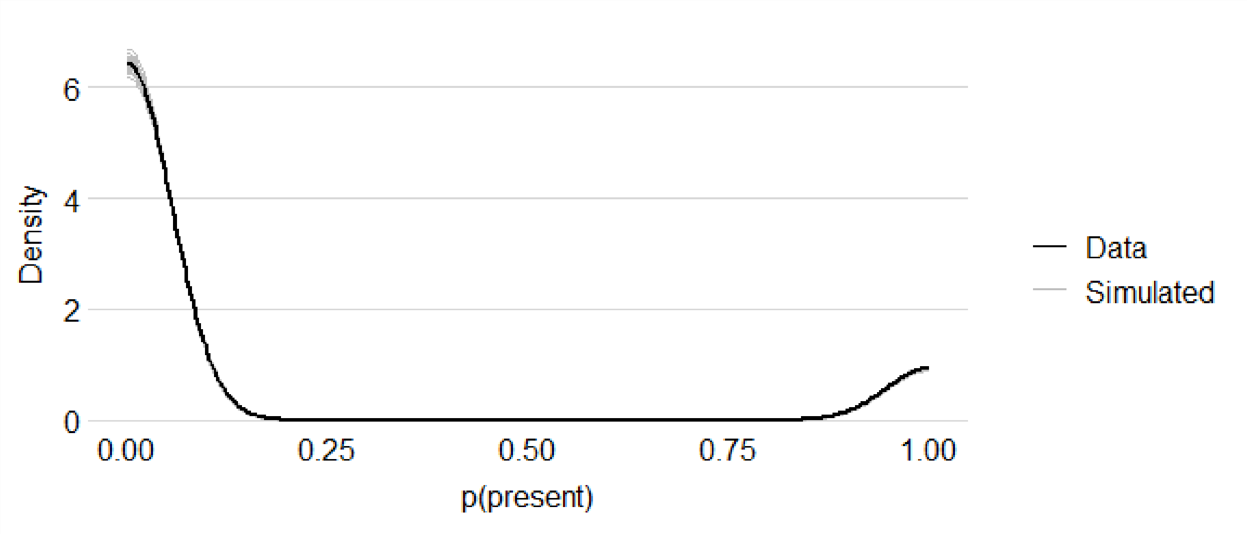

Figure A 62. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *P. auricilla* CPUE standardization.

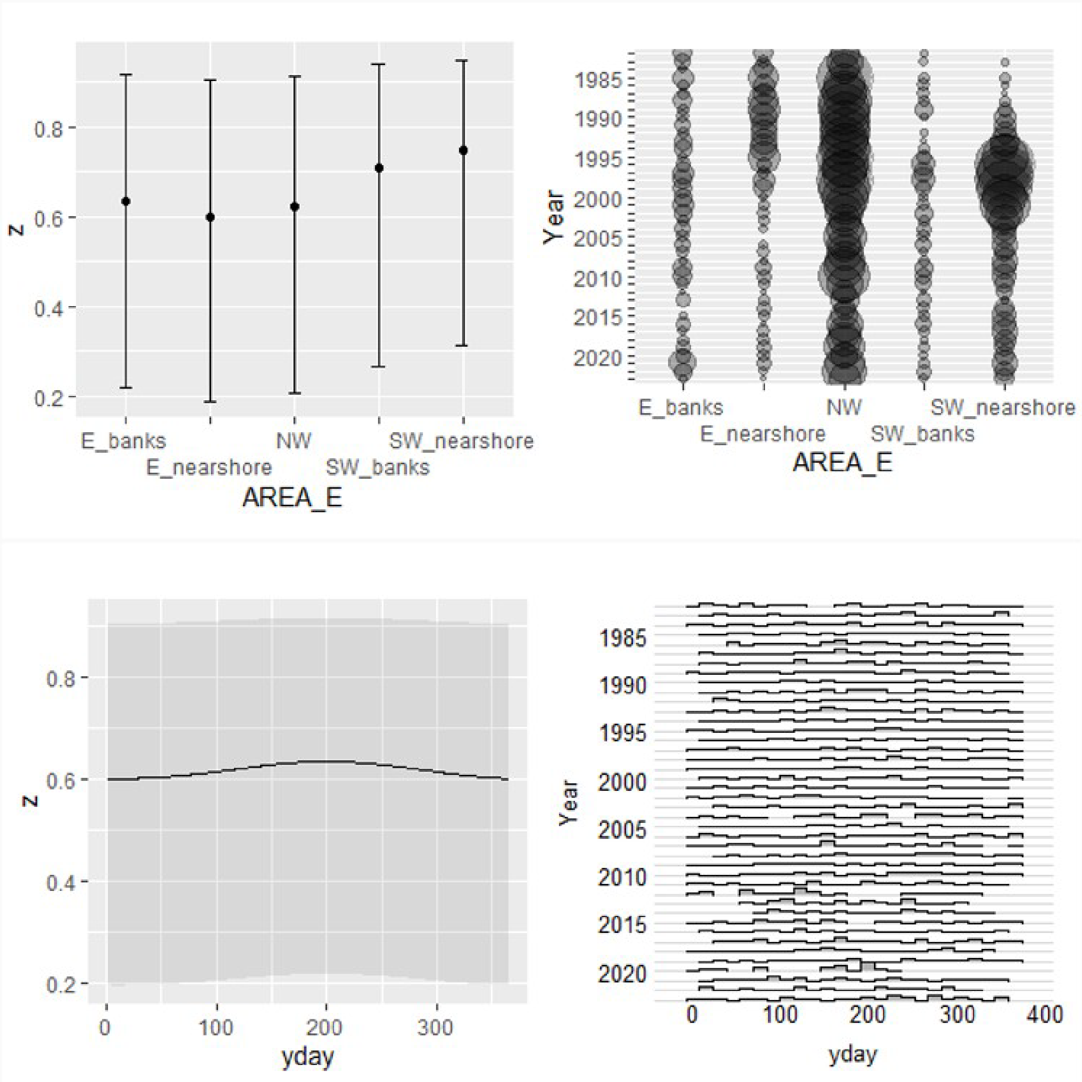

Figure A 63. Partial effects of area and time of year on probability of presence in the *P. auricilla* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

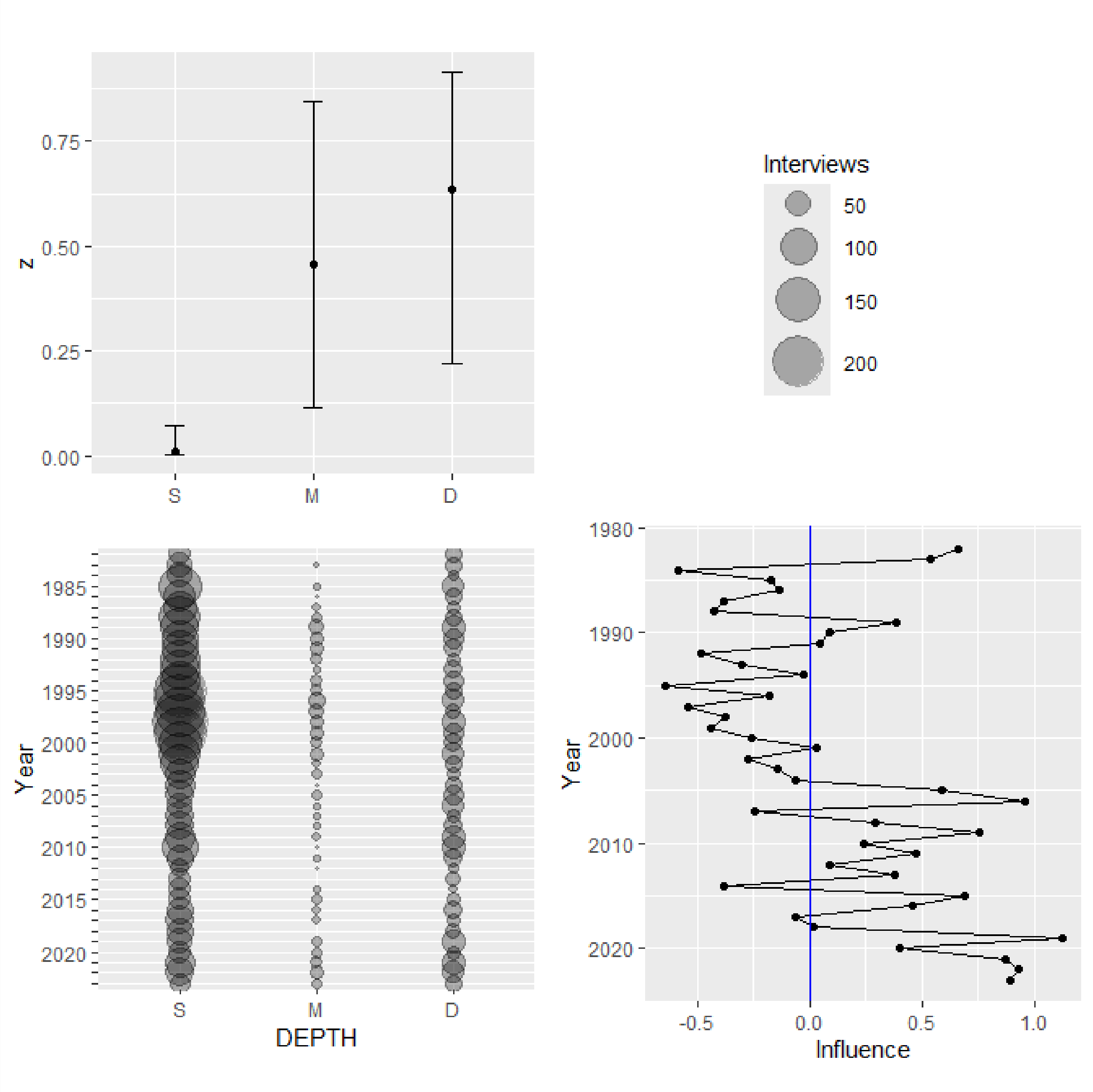

Figure A 64. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on probability of presence in the *P. auricilla* CPUE standardization.

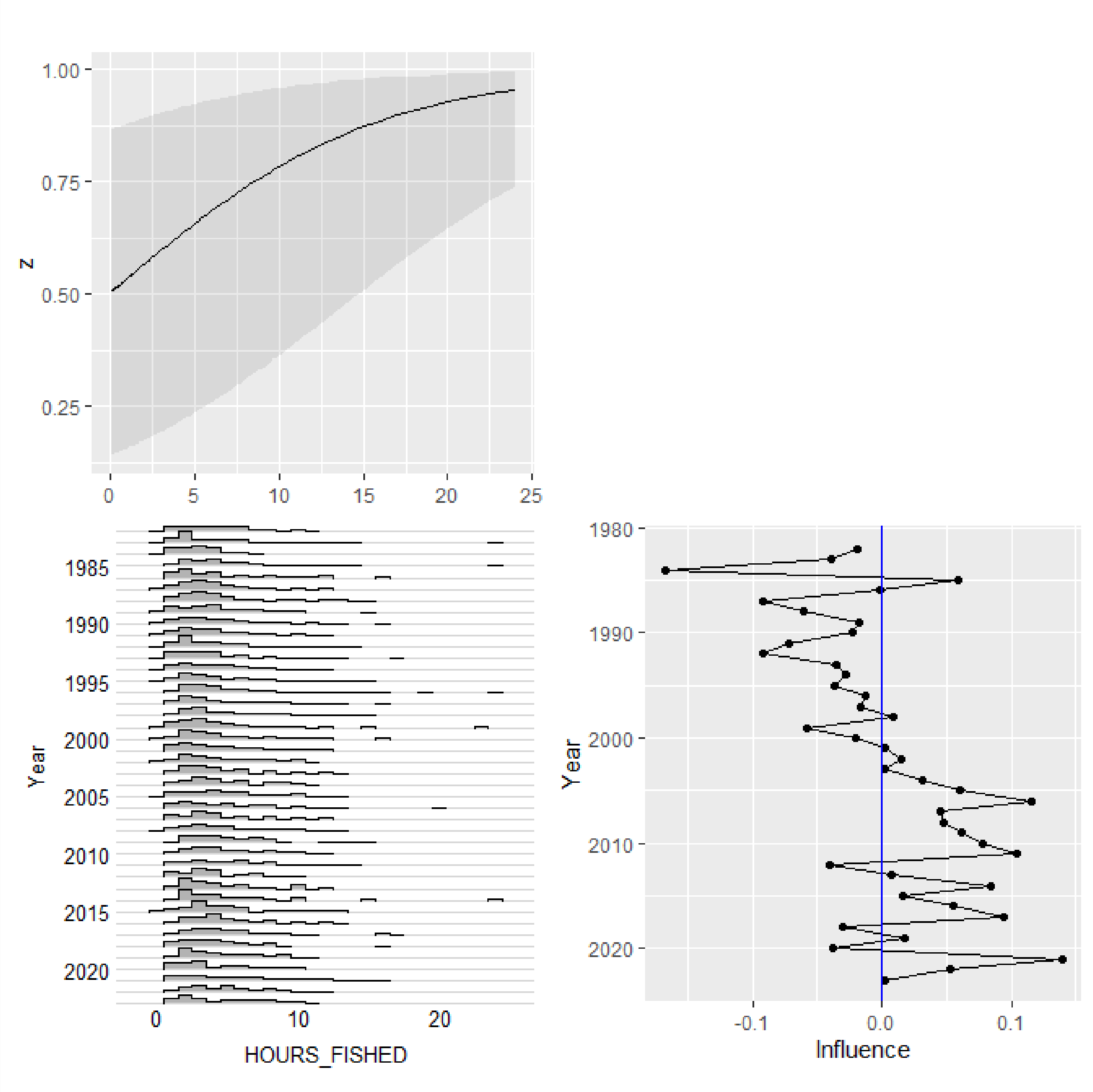

Figure A 65. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on probability of presence in the *P. auricilla* CPUE standardization.

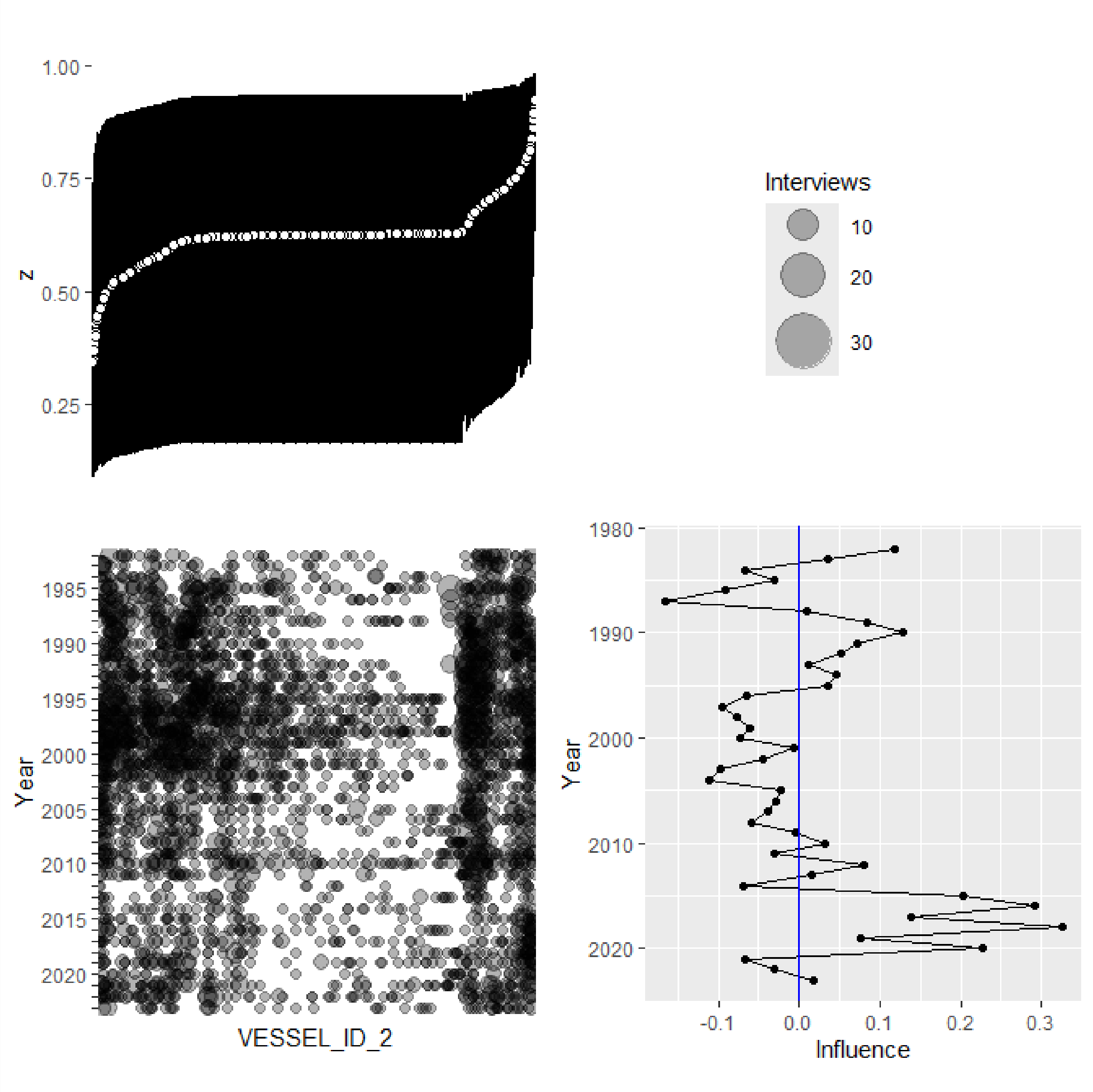

Figure A 66. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *P. auricilla* CPUE standardization.

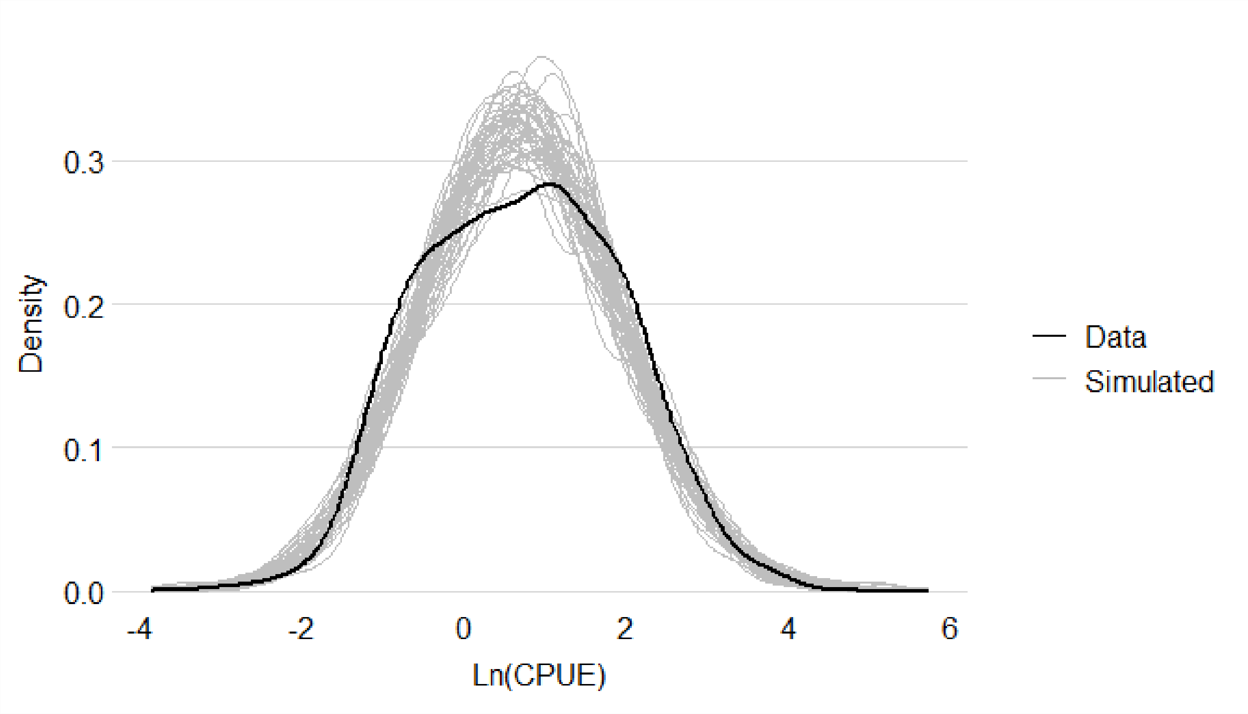

Figure A 67. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *P. auricilla* CPUE standardization.

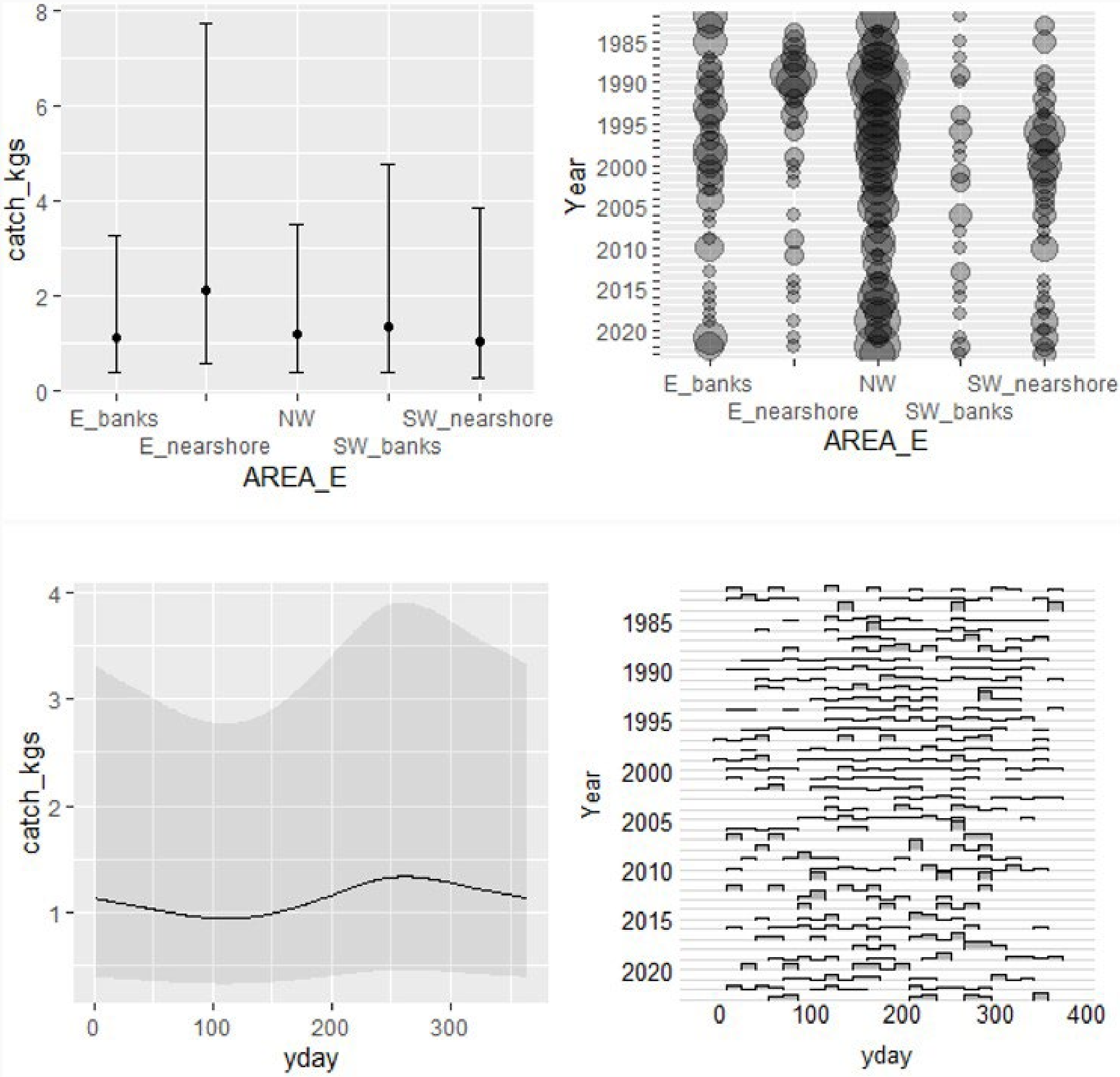

Figure A 68. Partial effects of area and time of year on CPUE (kg per trip) in the *P. auricilla* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

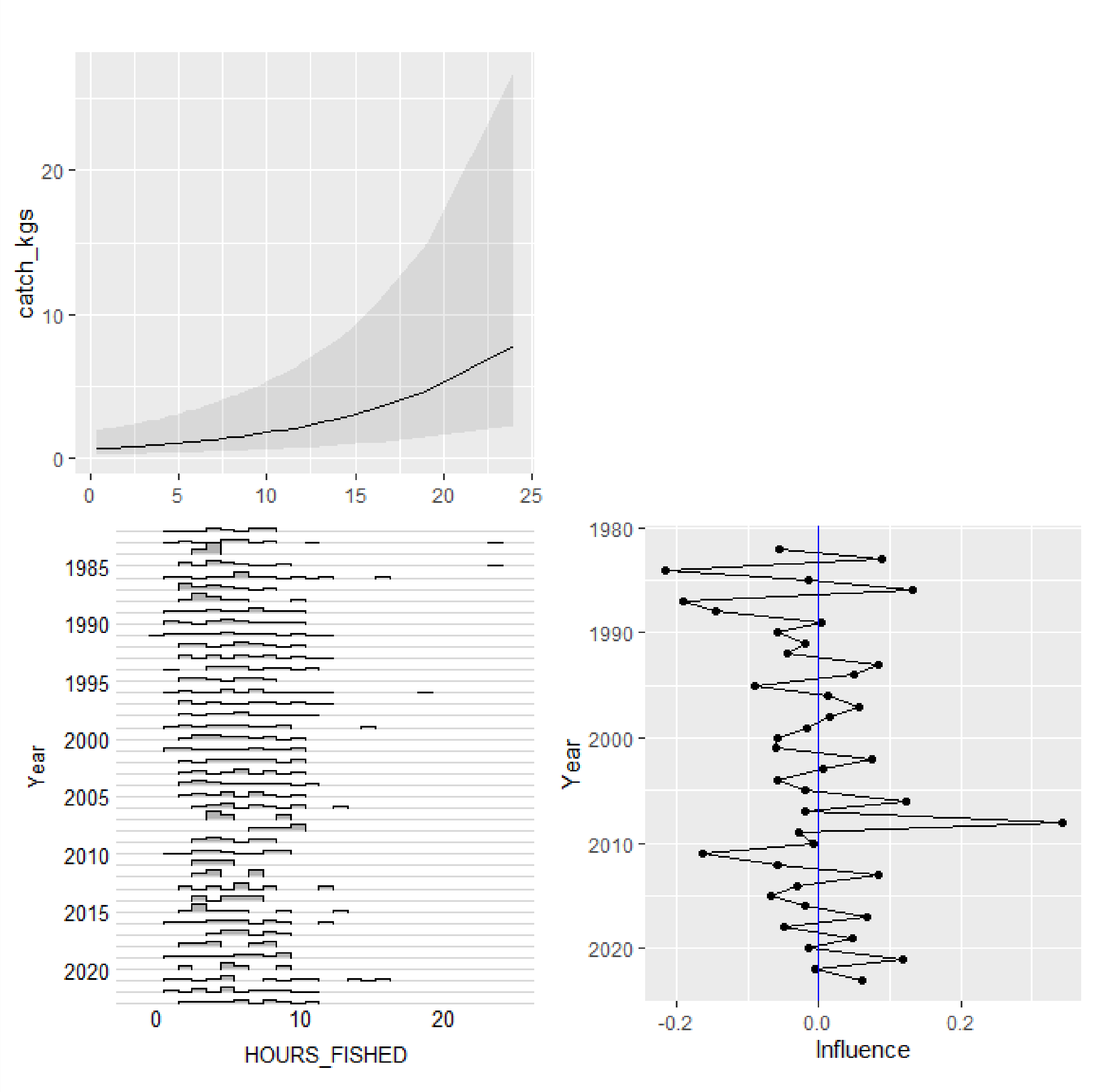

Figure A 69. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *P. auricilla* CPUE standardization.

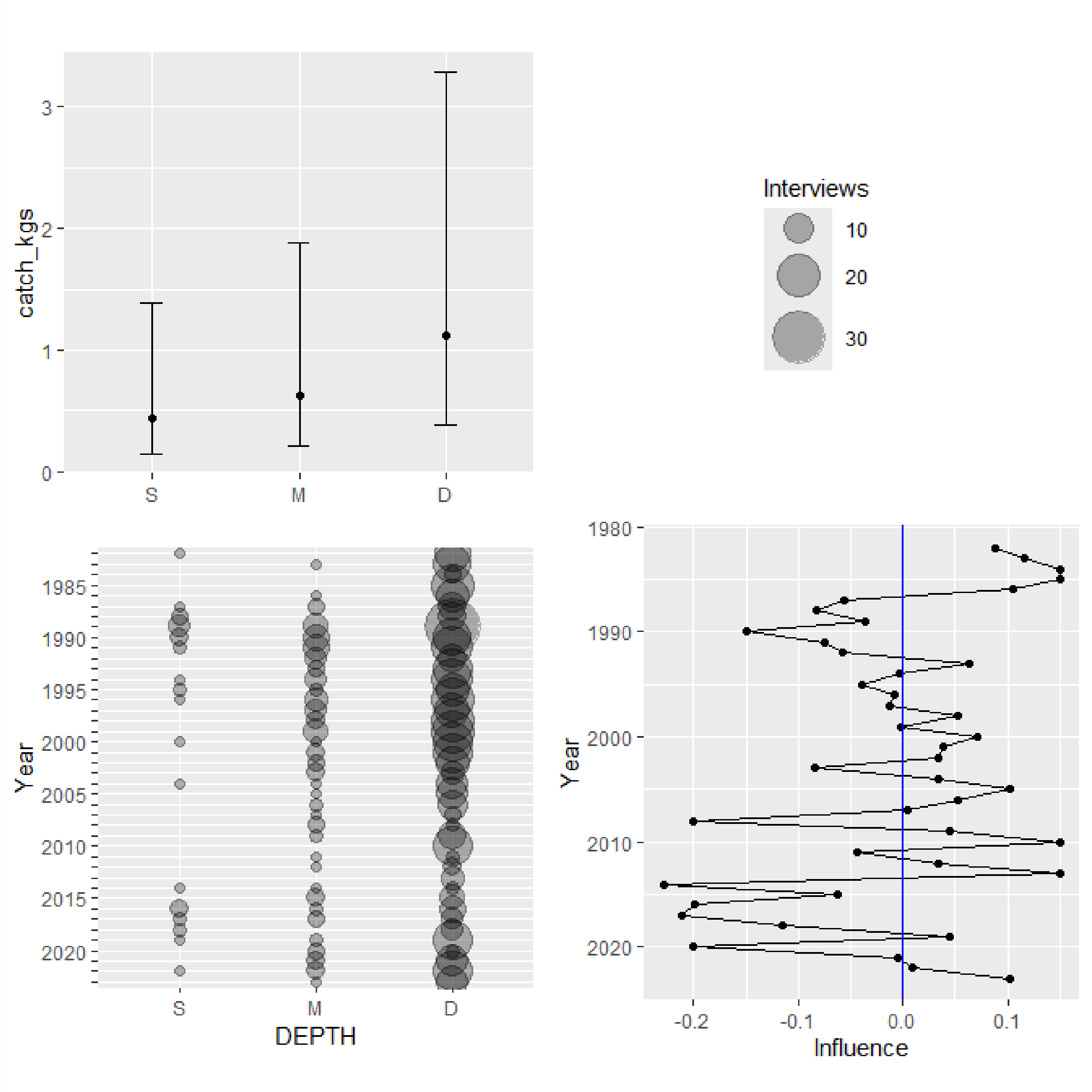

Figure A 70. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on CPUE (kg per trip) in the *P. auricilla* CPUE standardization.

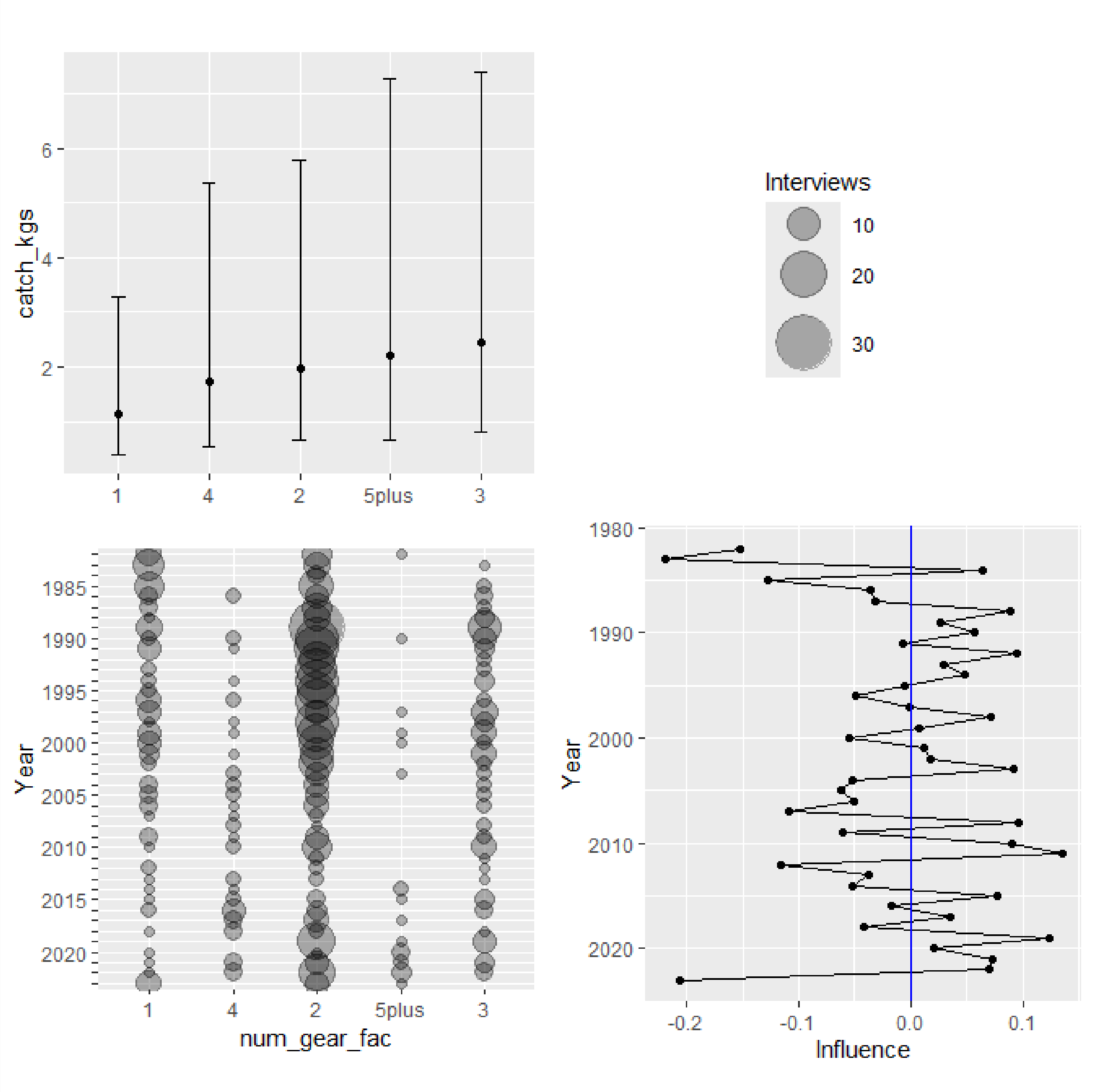

Figure A 71. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (number of gears) on CPUE (kg per trip) in the *P. auricilla* CPUE standardization.

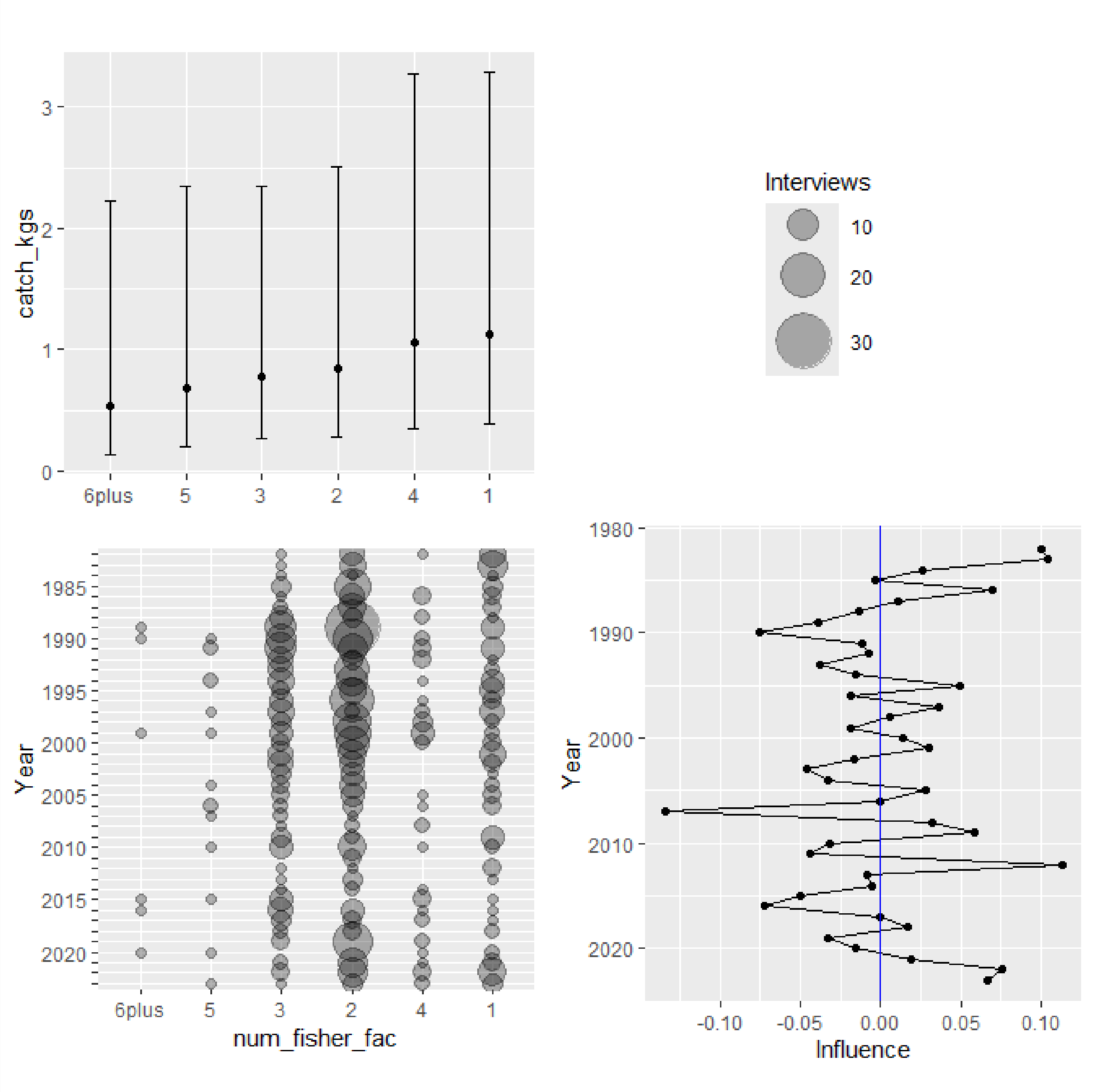

Figure A 72. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (number of fishers) on CPUE (kg per trip) in the *P. auricilla* CPUE standardization.

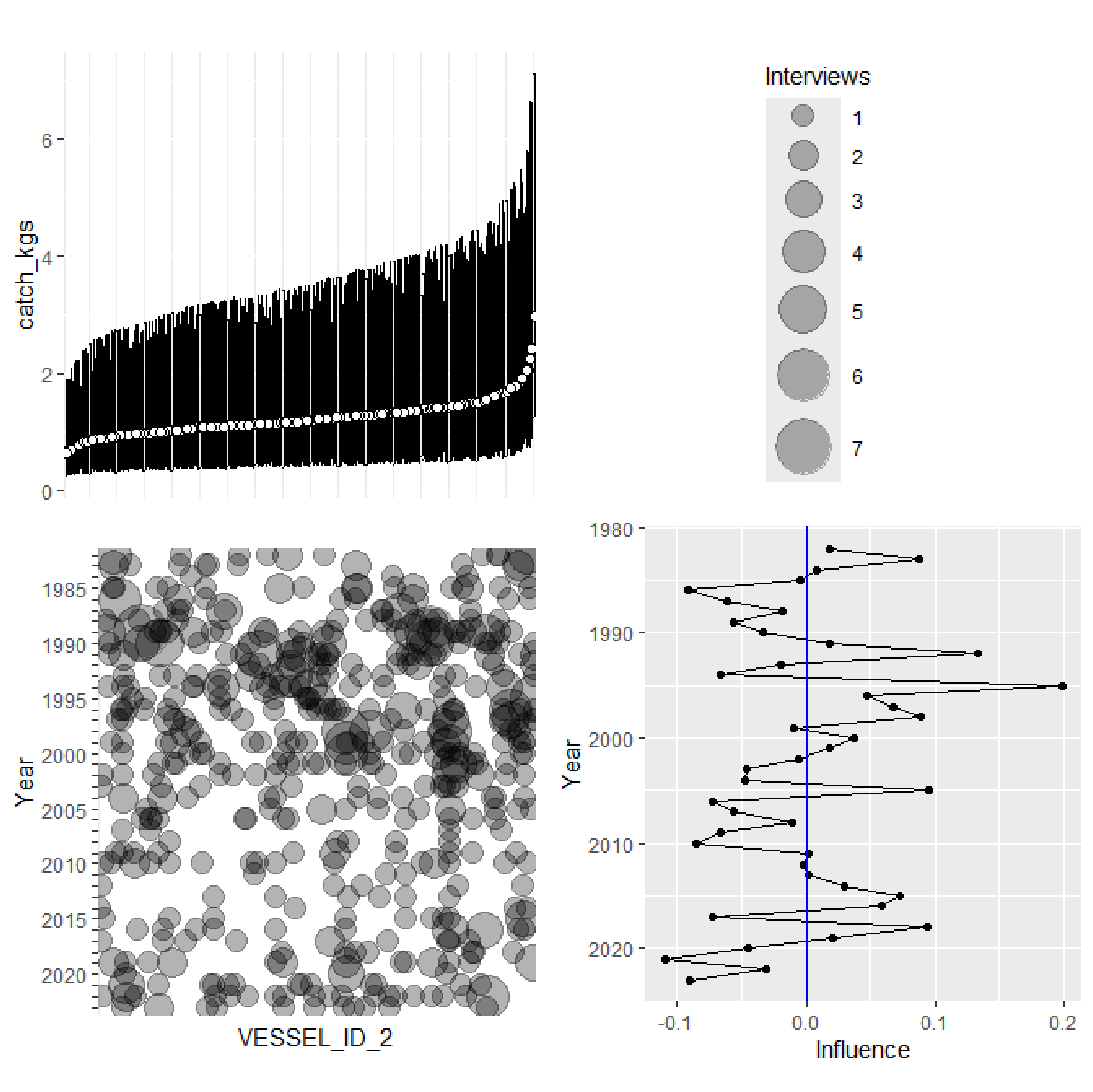

Figure A 73. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on CPUE (kg per trip) in the *P. auricilla* CPUE standardization.

Standardized CPUE Index

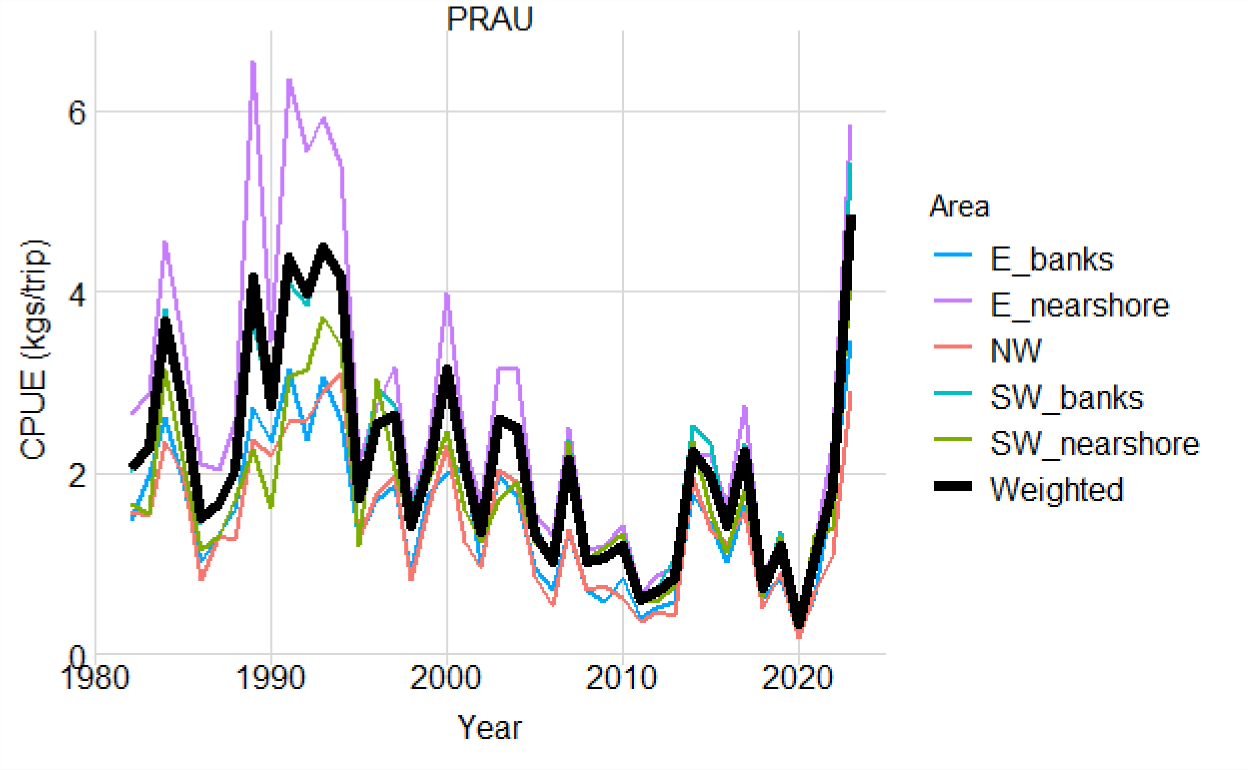

Figure A 74. Standardized CPUE index (kg per trip) of *P. auricilla* by area and weighted by habitat extent.

Table A 7. Standardized CPUE index (kg per trip) and standard deviation (sd) of *P. auricilla*.

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	2.07	1.81	1996	2.55	2.12	2010	1.20	1.20
1983	2.28	2.00	1997	2.63	2.47	2011	0.59	1.32
1984	3.67	5.09	1998	1.41	1.37	2012	0.69	0.85
1985	2.78	2.31	1999	2.09	1.66	2013	0.85	1.05
1986	1.50	1.37	2000	3.14	2.77	2014	2.24	2.80
1987	1.67	1.33	2001	2.06	1.83	2015	1.99	1.97
1988	2.04	1.83	2002	1.36	1.18	2016	1.42	1.45
1989	4.15	2.59	2003	2.58	2.53	2017	2.25	2.29
1990	2.75	2.00	2004	2.49	2.21	2018	0.74	0.95
1991	4.38	3.23	2005	1.34	1.54	2019	1.21	1.14
1992	3.99	3.41	2006	1.03	1.15	2020	0.33	0.57
1993	4.49	3.68	2007	2.16	3.17	2021	1.08	1.16
1994	4.17	3.19	2008	1.02	1.68	2022	1.85	1.56
1995	1.74	1.62	2009	1.06	1.34	2023	4.86	4.75

Pristipomoides filamentosus

Presence/Absence Model

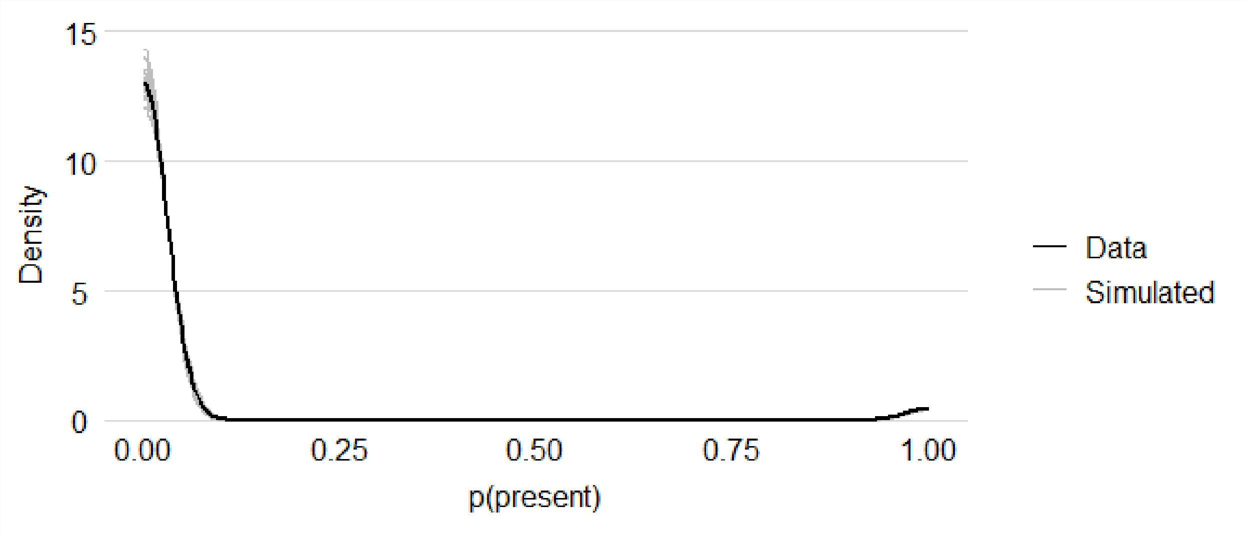

Figure A 75. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *P. filamentosus* CPUE standardization.

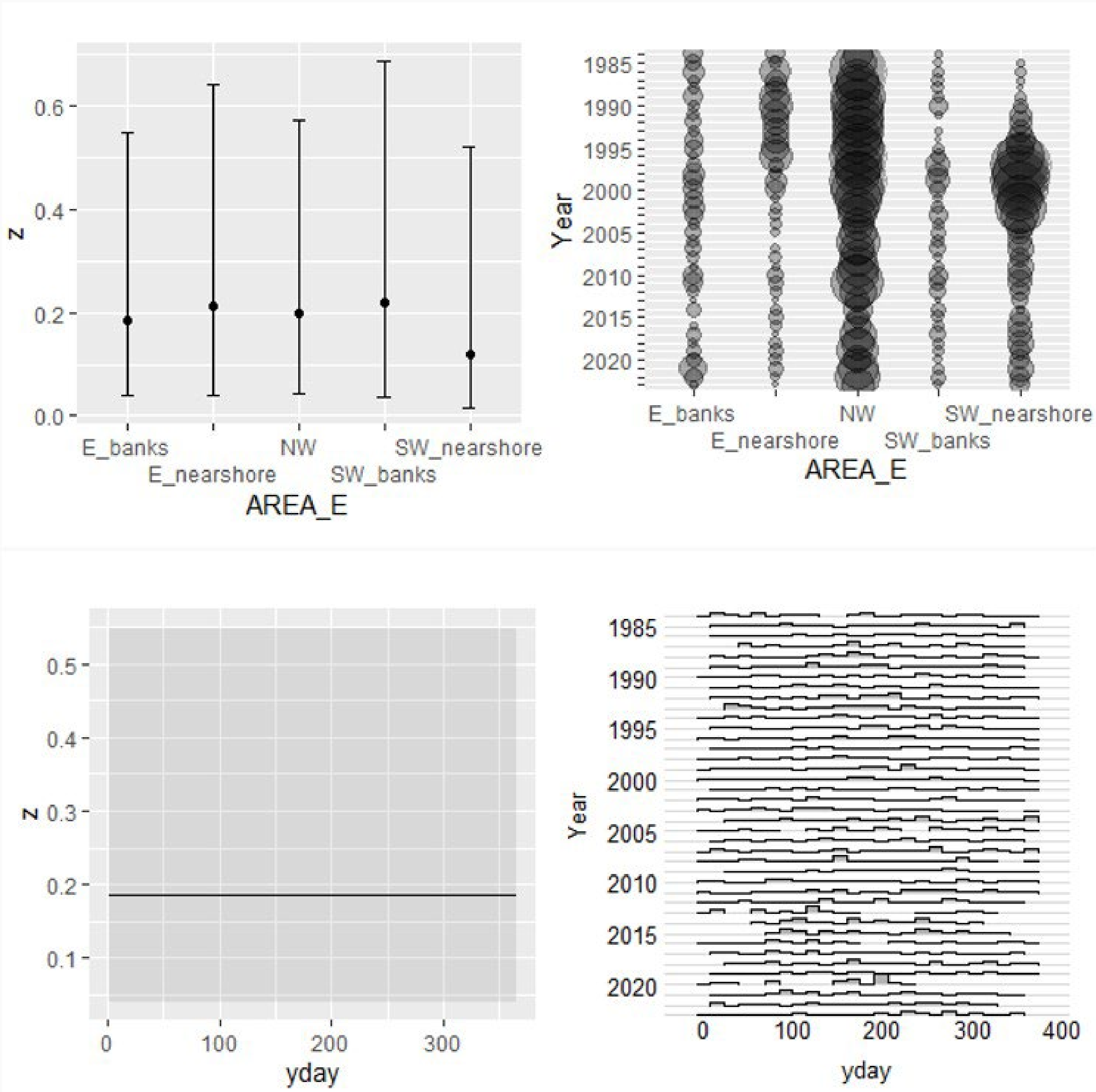

Figure A 76. Partial effects of area and time of year on probability of presence in the *P. filamentosus* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

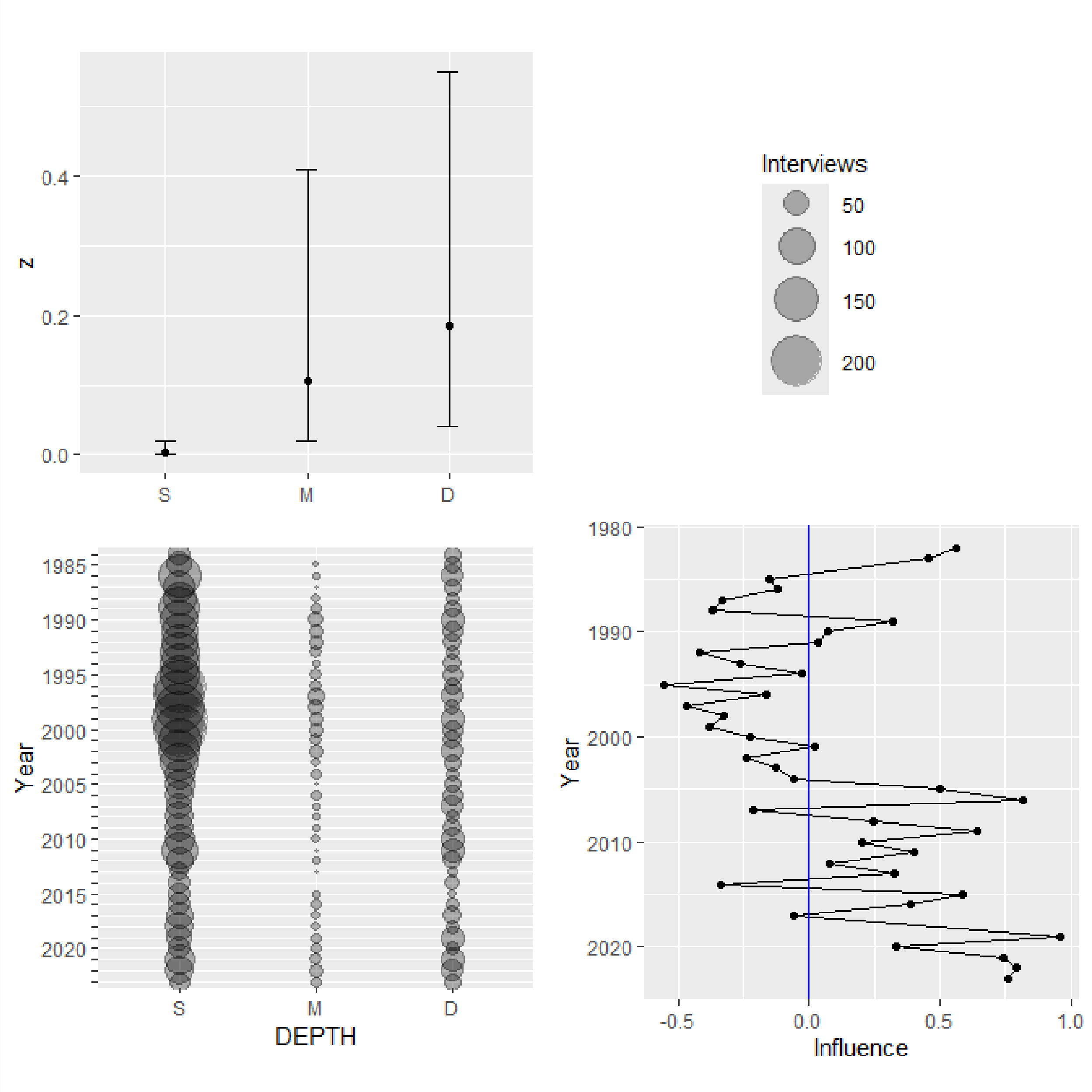

Figure A 77. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type ('depth') on probability of presence in the *P. filamentosus* CPUE standardization.

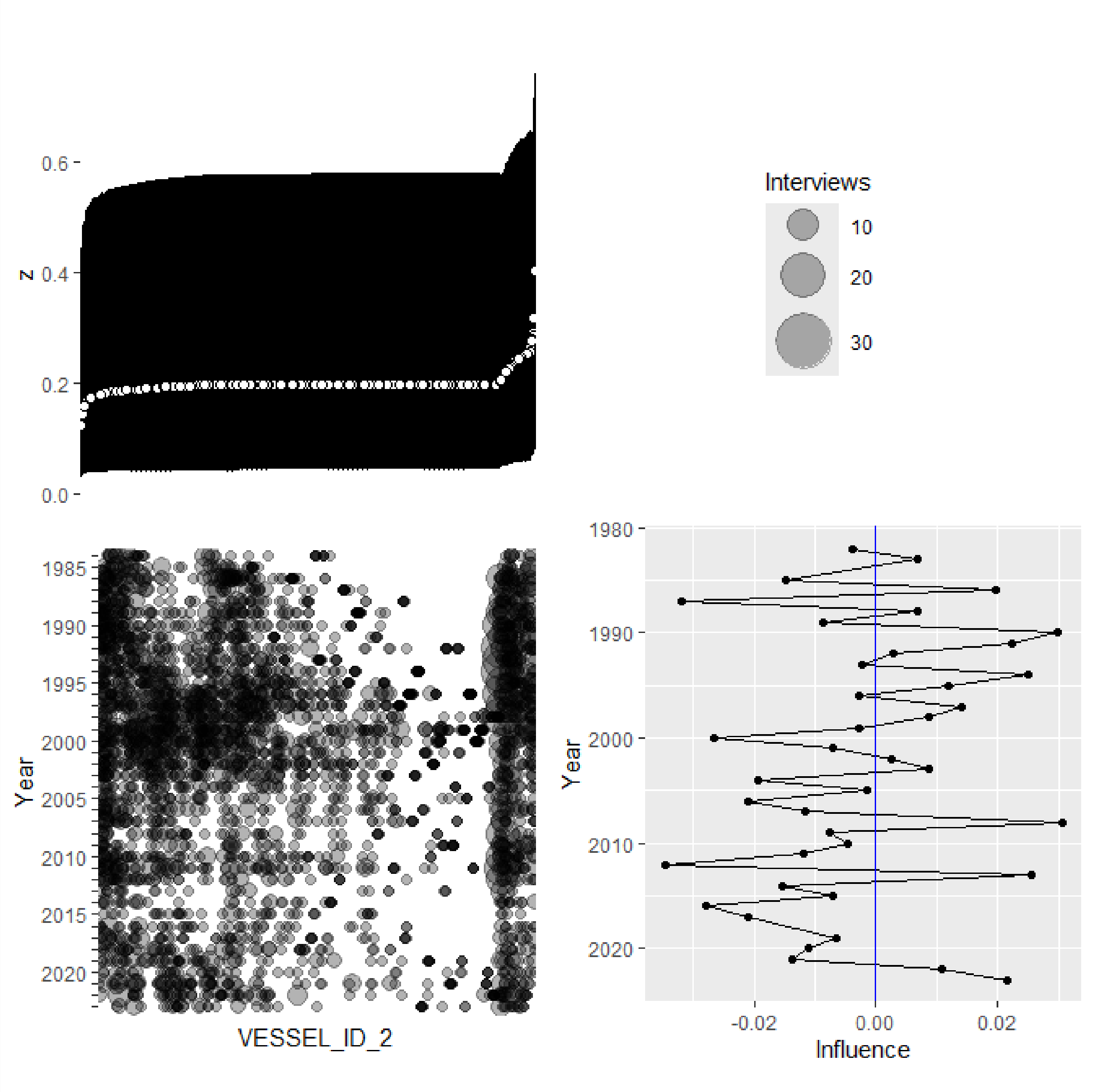

Figure A 78. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *P. filamentosus* CPUE standardization.

Positive Process Model

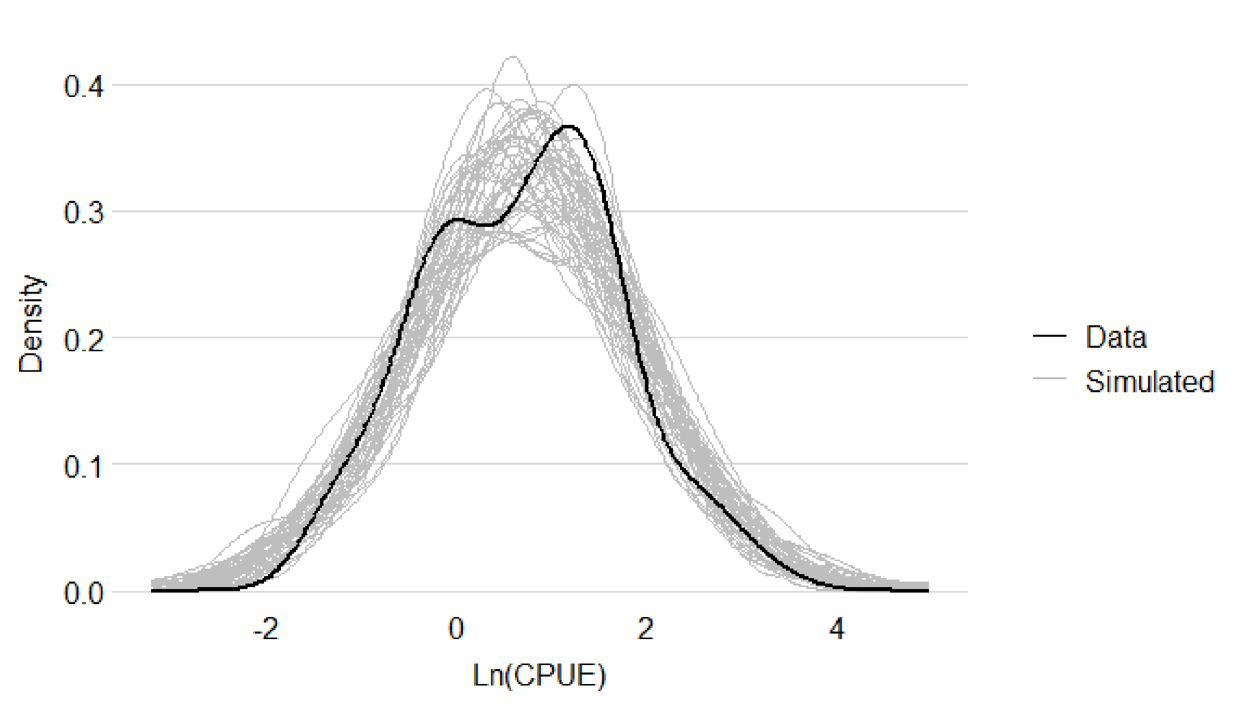

Figure A 79. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *P. filamentosus* CPUE standardization.

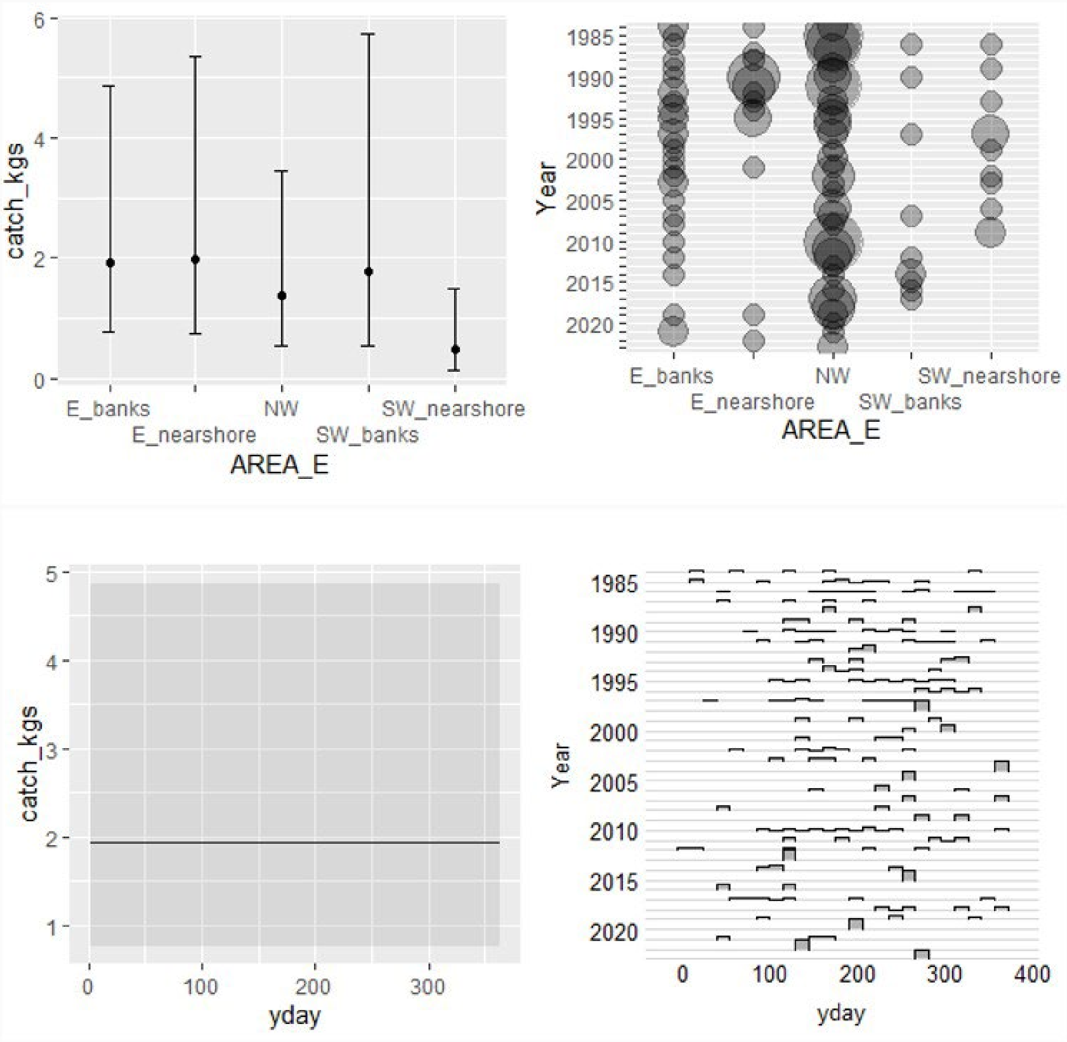

Figure A 80. Partial effects of area and time of year on CPUE (kg per trip) in the *P. filamentosus* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

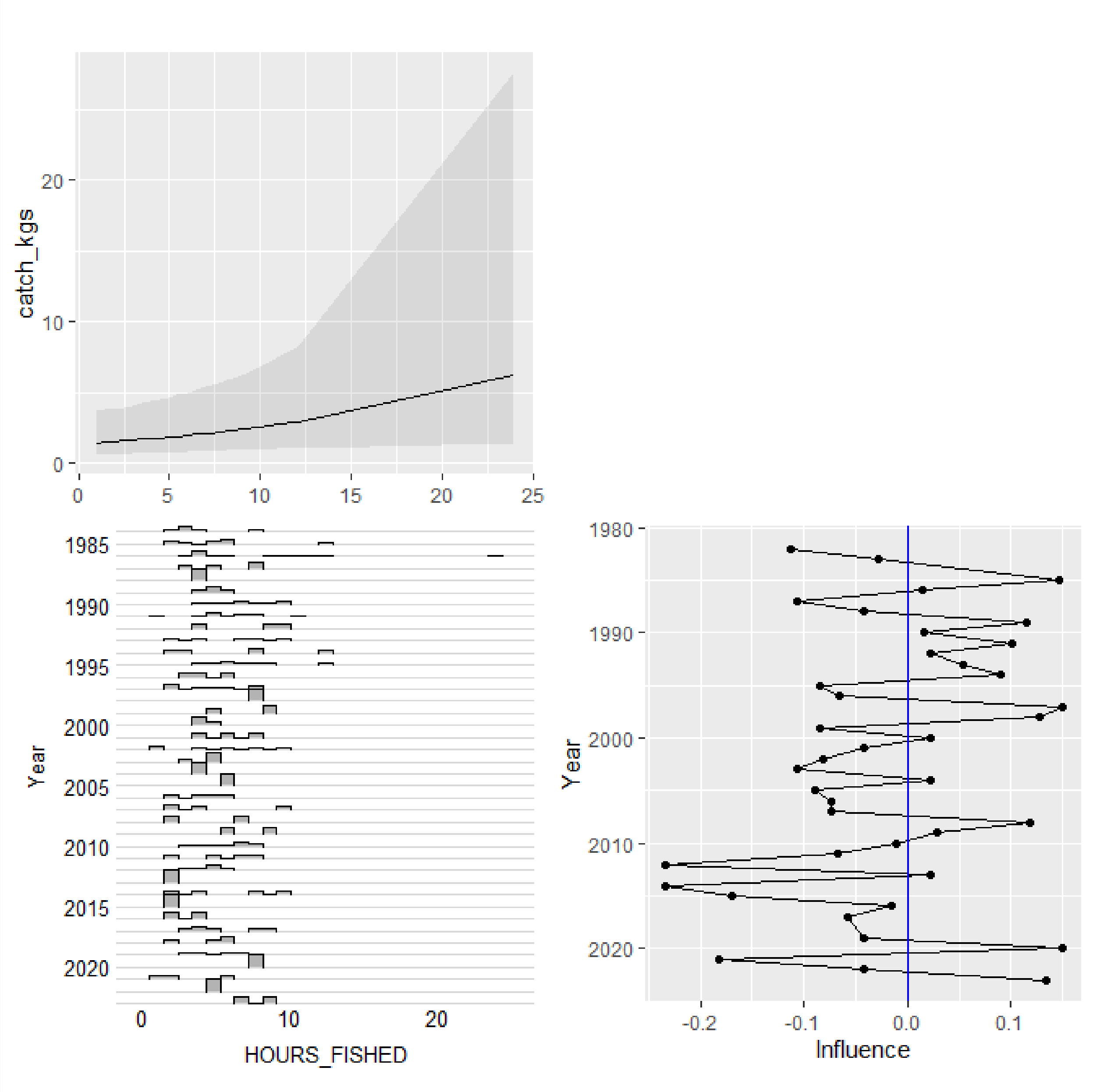

Figure A 81. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *P. filamentosus* CPUE standardization.

Standardized CPUE Index

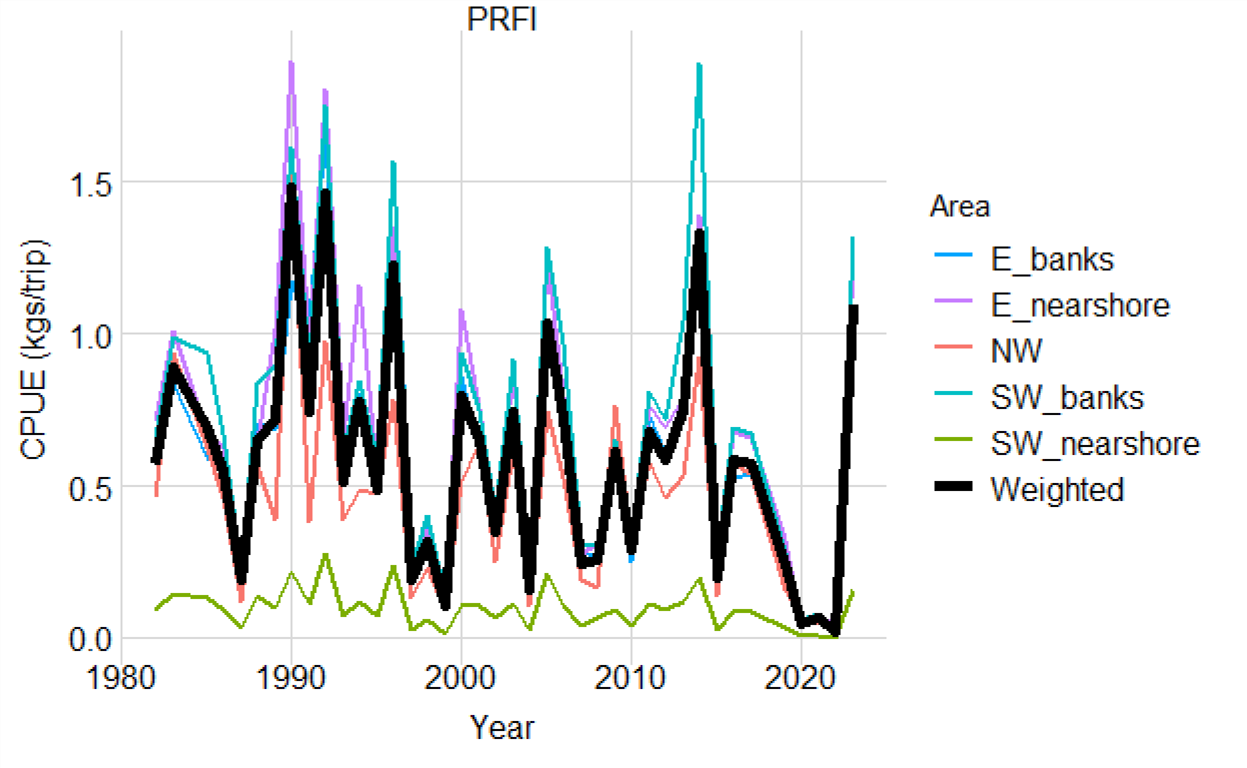

Figure A 82. Standardized CPUE index (kg per trip) of *P. filamentosus* by area and weighted by habitat extent.

Table A 8. Standardized CPUE index (kg per trip) and standard deviation (sd) of *P. filamentosus.*

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	0.57	0.60	1996	1.23	1.28	2010	0.29	0.46
1983	0.89	0.70	1997	0.19	1.08	2011	0.68	0.75
1984	---	---	1998	0.32	0.65	2012	0.59	2.14
1985	0.69	0.57	1999	0.11	0.20	2013	0.75	0.82
1986	0.55	0.69	2000	0.79	1.28	2014	1.33	4.21
1987	0.19	0.35	2001	0.65	0.77	2015	0.20	0.39
1988	0.65	0.84	2002	0.35	0.47	2016	0.59	0.60
1989	0.72	0.56	2003	0.74	3.63	2017	0.57	0.67
1990	1.48	1.17	2004	0.16	0.79	2018	---	---
1991	0.74	1.22	2005	1.03	1.52	2019	0.24	0.35
1992	1.46	1.40	2006	0.72	1.01	2020	0.05	0.22
1993	0.52	0.58	2007	0.25	0.47	2021	0.07	0.13
1994	0.78	0.70	2008	0.26	0.66	2022	0.02	0.13
1995	0.49	0.89	2009	0.62	0.62	2023	1.09	2.54

Pristipomoides flavipinnis

Presence/Absence Model

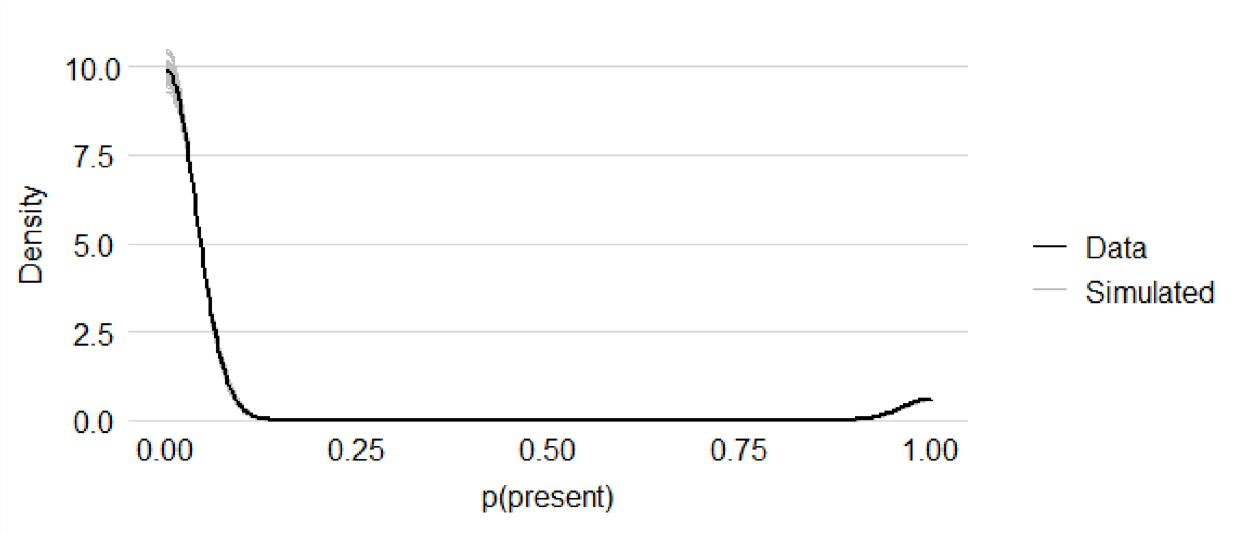

Figure A 83. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *P. flavipinnis* CPUE standardization.

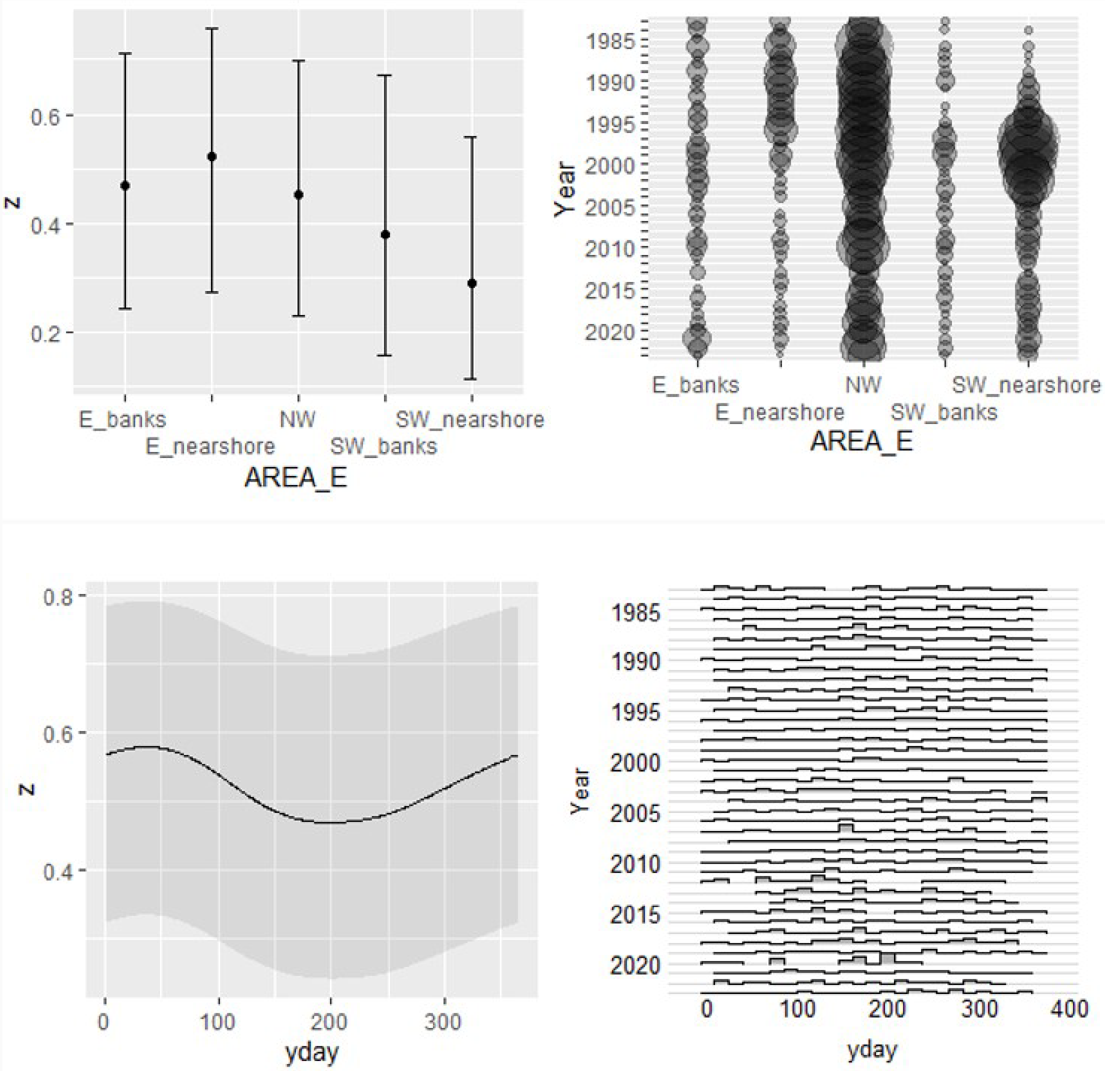

Figure A 84. Partial effects of area and time of year on probability of presence in the *P. flavipinnis* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

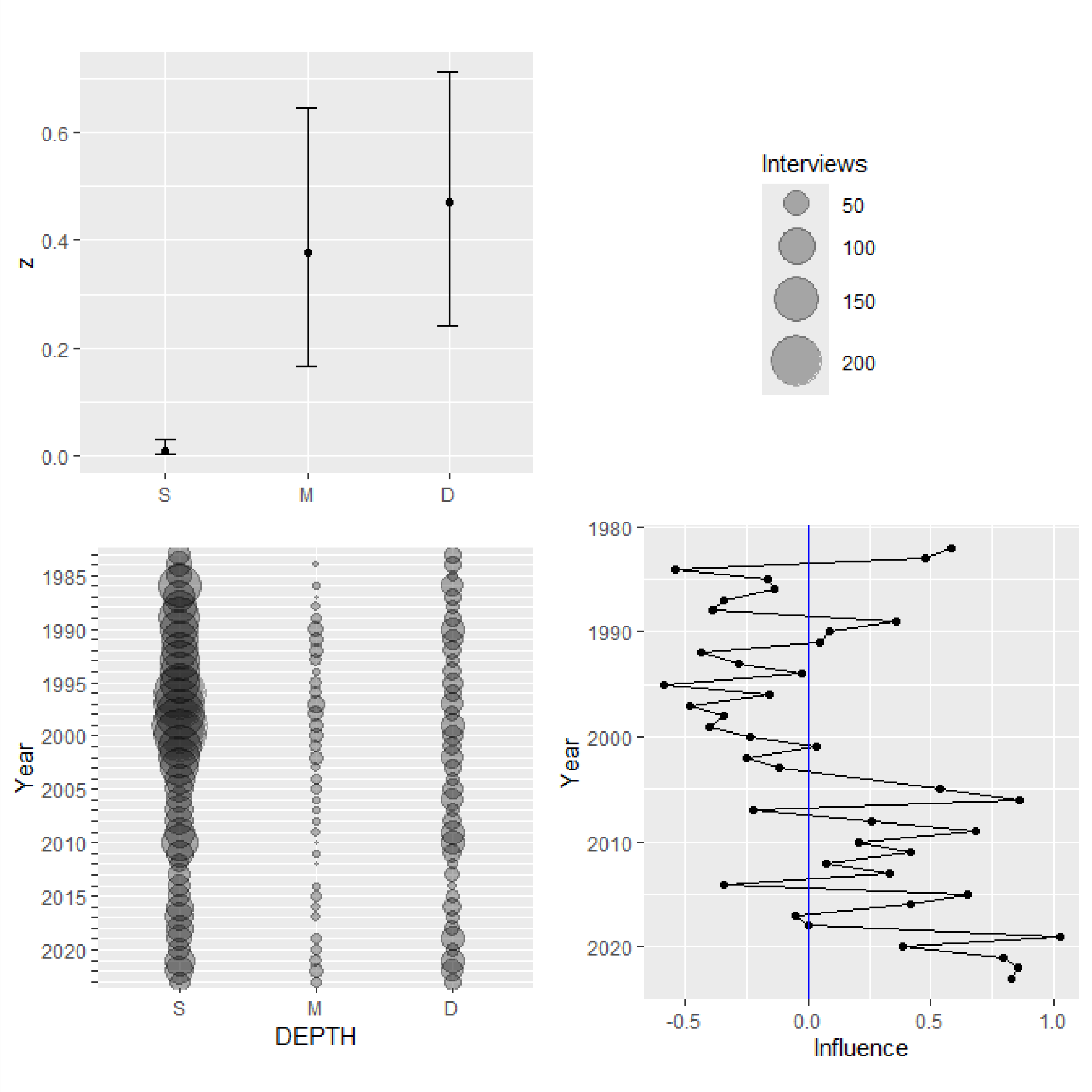

Figure A 85. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on probability of presence in the *P. flavipinnis* CPUE standardization.

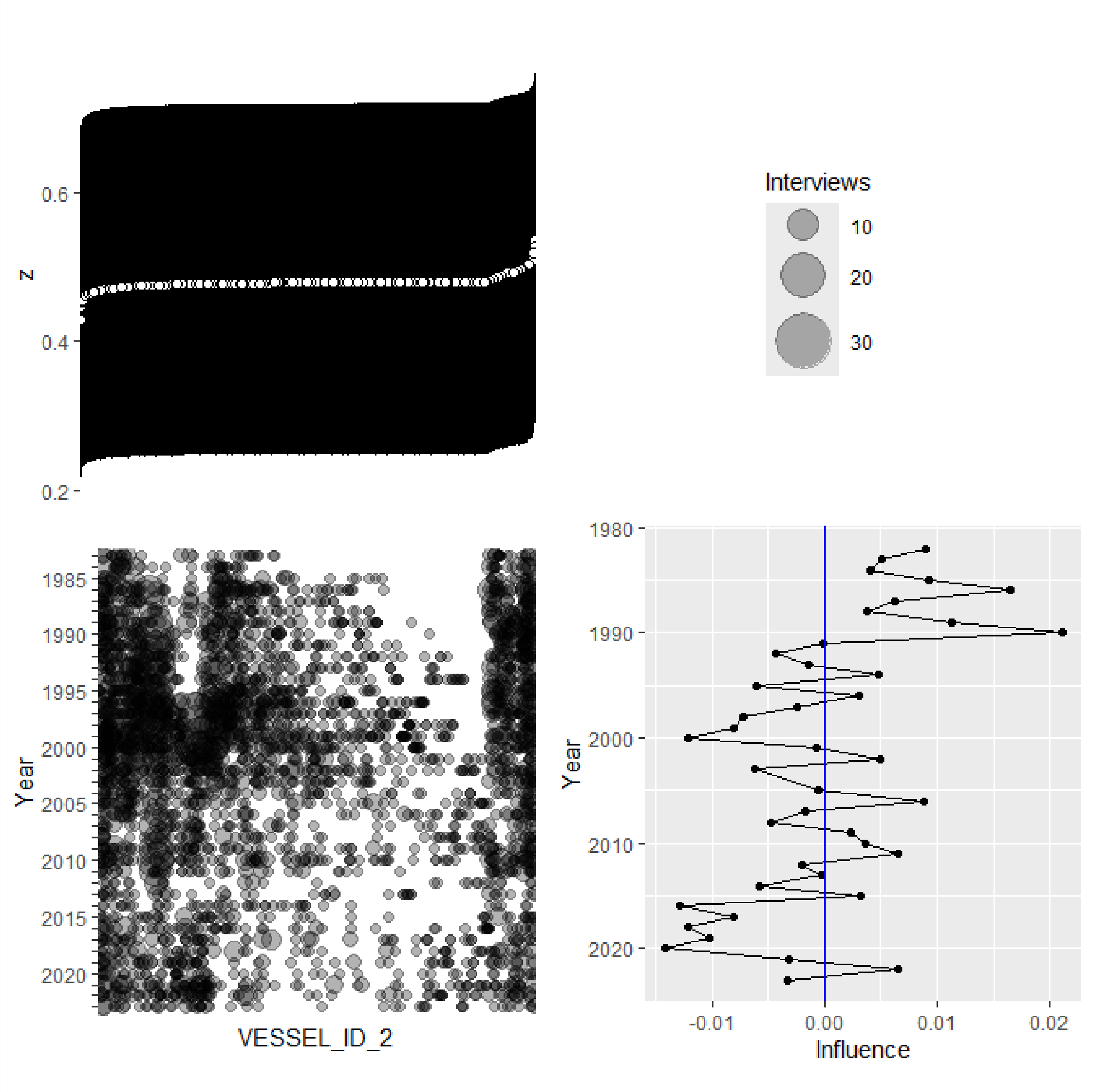

Figure A 86. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *P. flavipinnis* CPUE standardization.

Positive Process Model

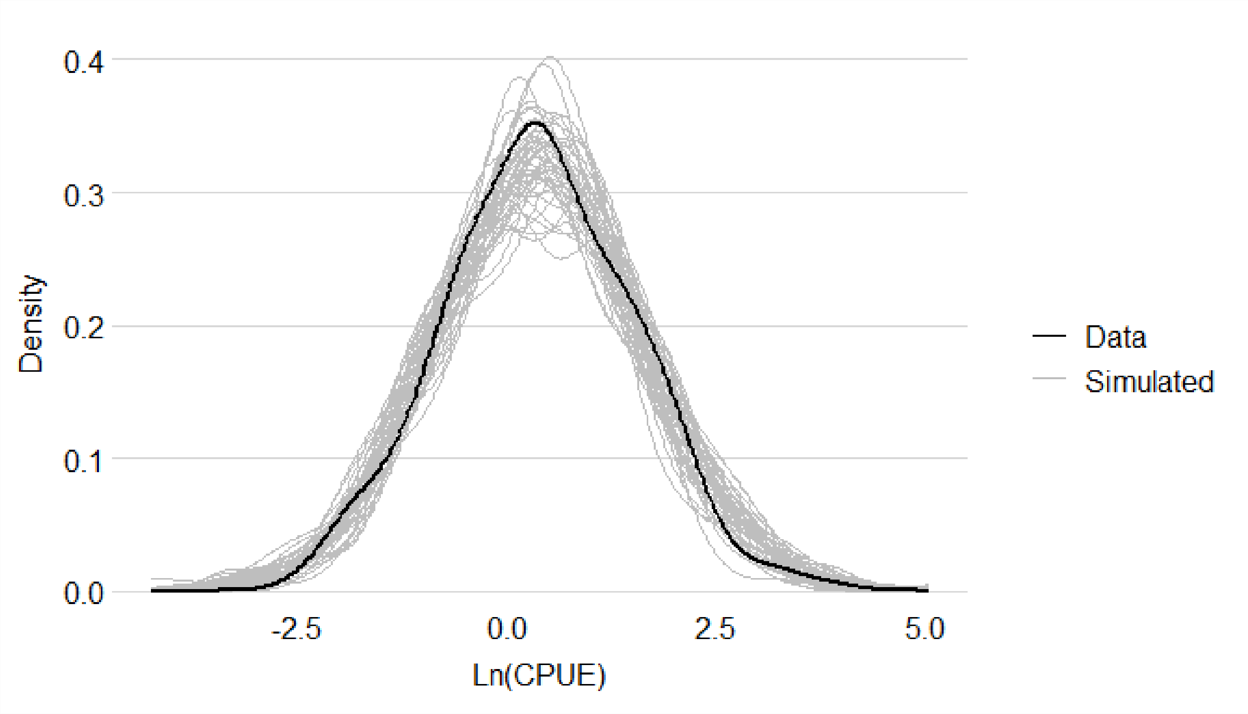

Figure A 87. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *P. flavipinnis* CPUE standardization.

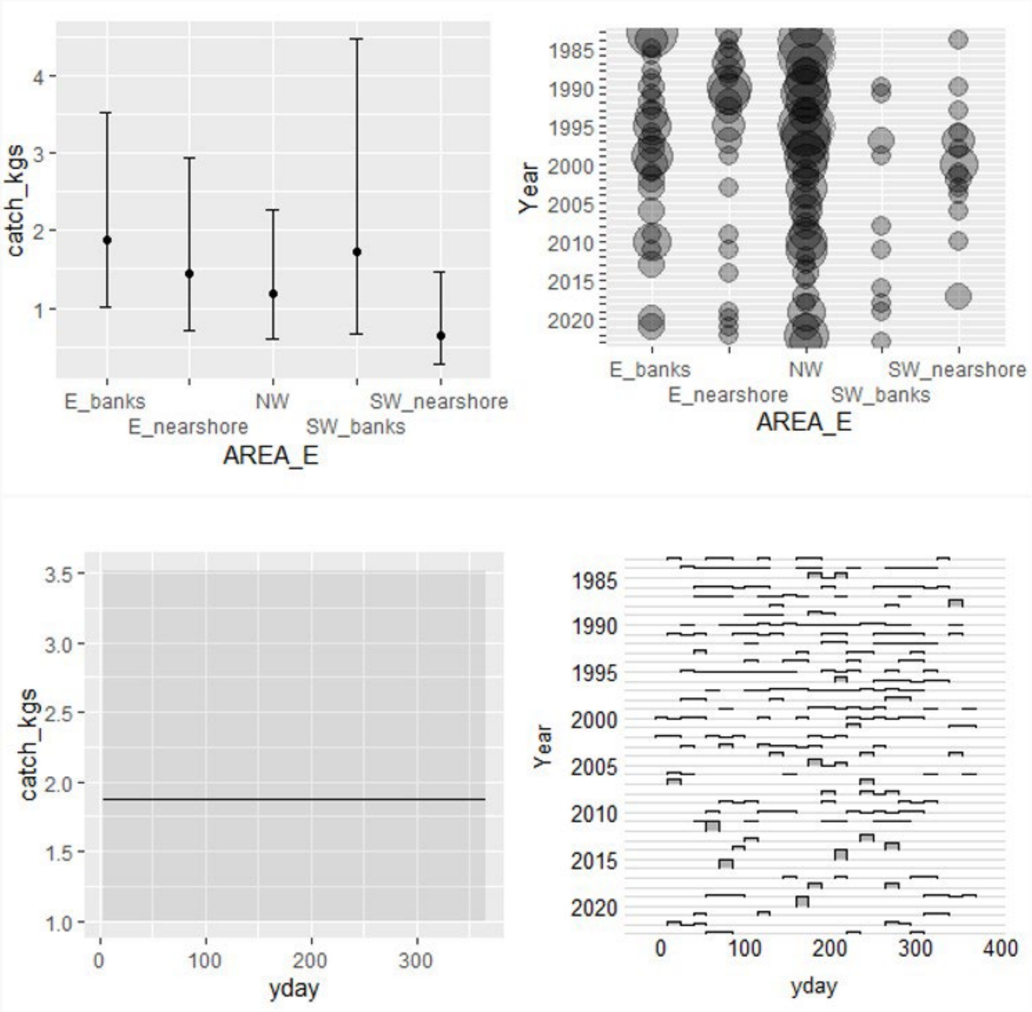

Figure A 88. Partial effects of area and time of year on CPUE (kg per trip) in the *P. flavipinnis* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

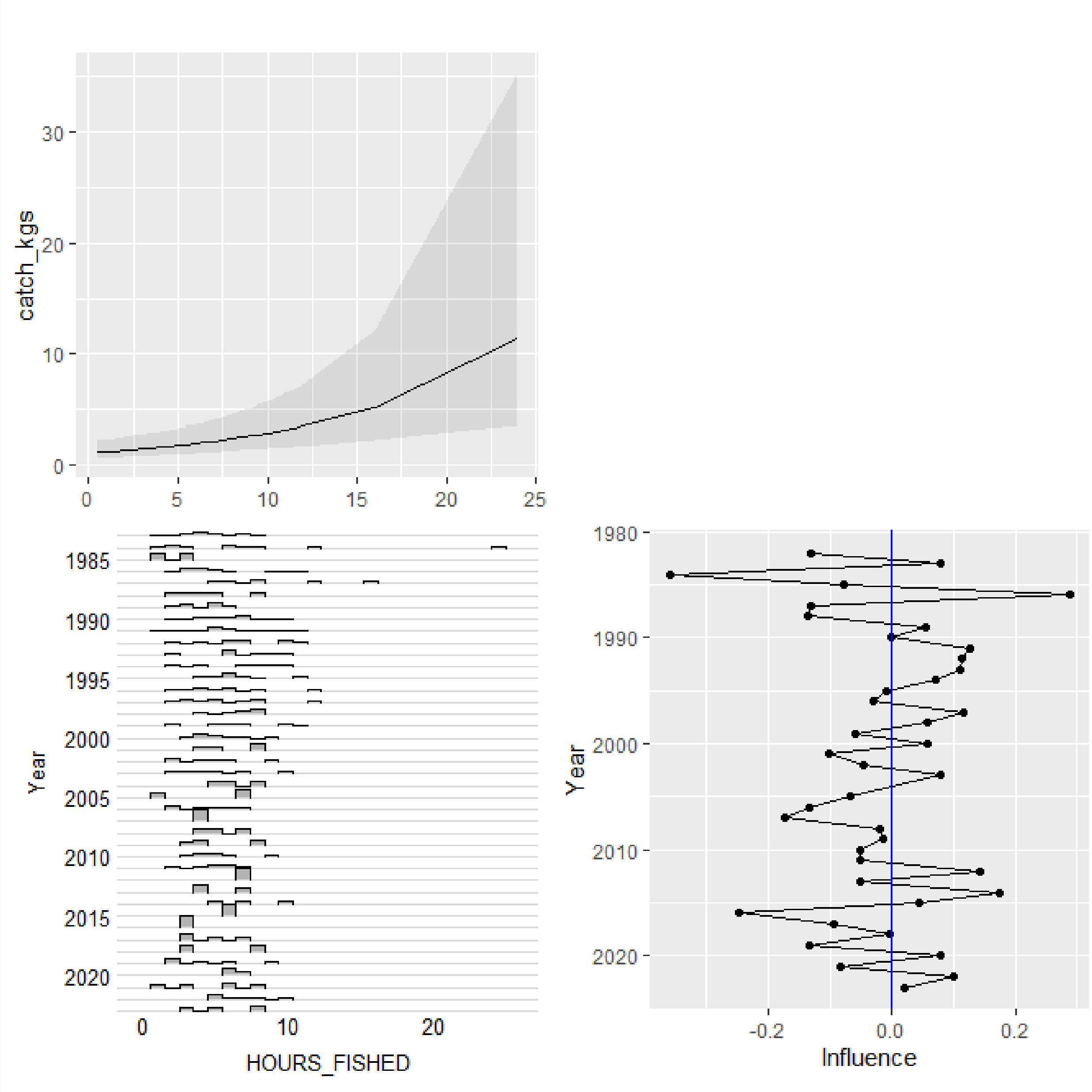

Figure A 89. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *P. flavipinnis* CPUE standardization.

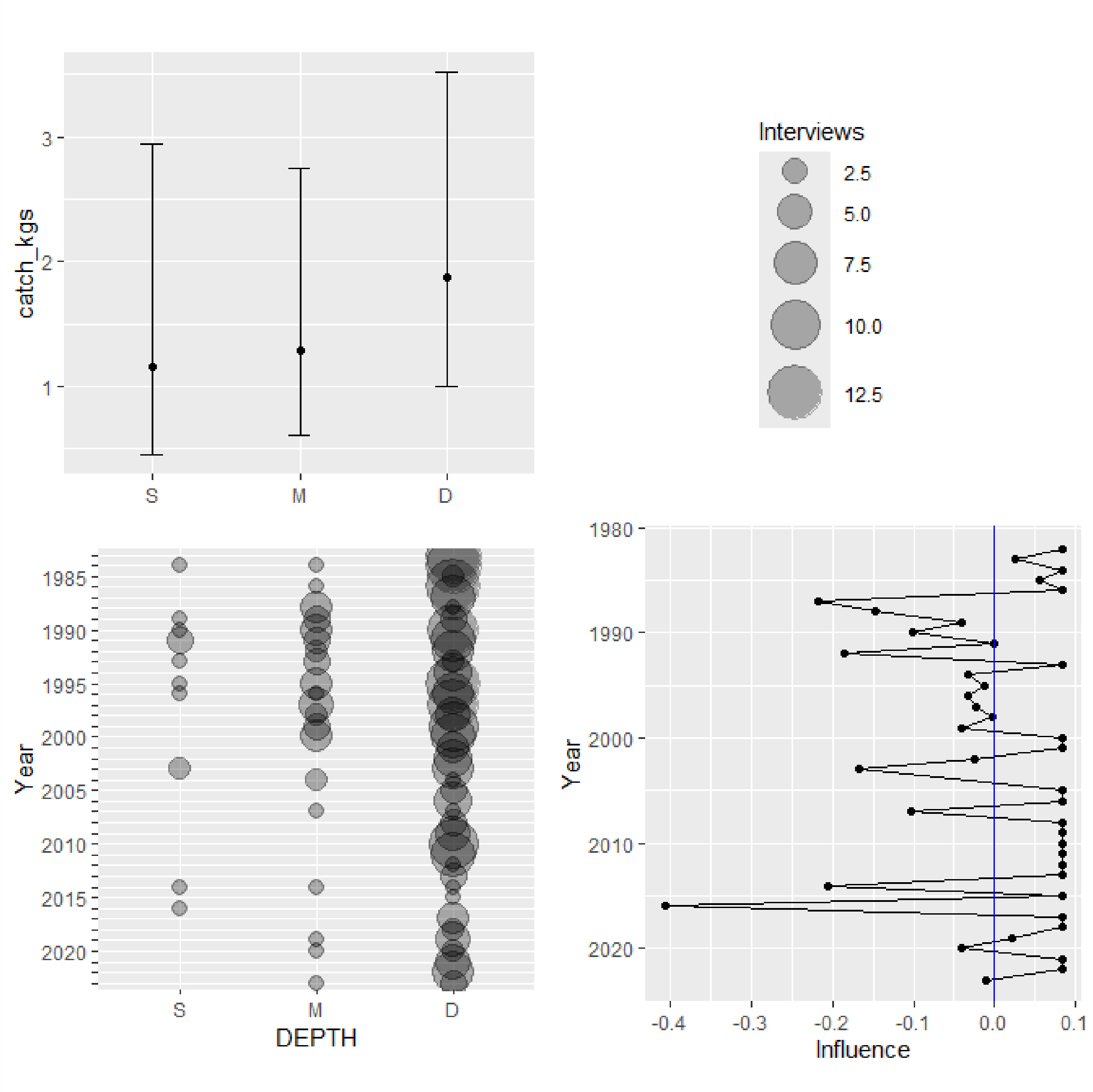

Figure A 90. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on CPUE (kg per trip) in the *P. flavipinnis* CPUE standardization.

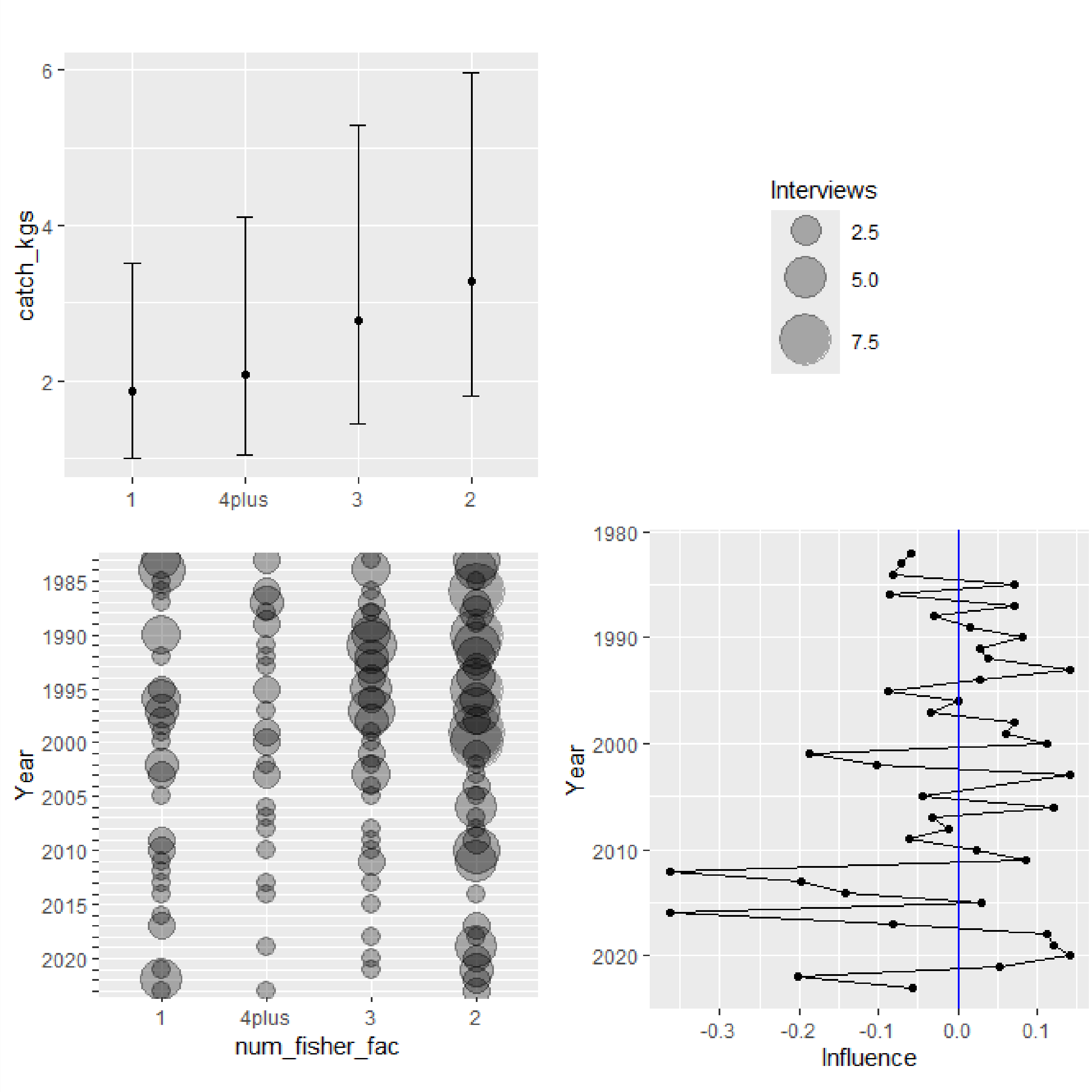

Figure A 91. Partial effects (top left), number of observations (bottom left), and relative influence 230 p(bottom right) of effort (number of fishers) on CPUE (kg per trip) in the *P. flavipinnis* CPUE standardization.

Standardized CPUE Index

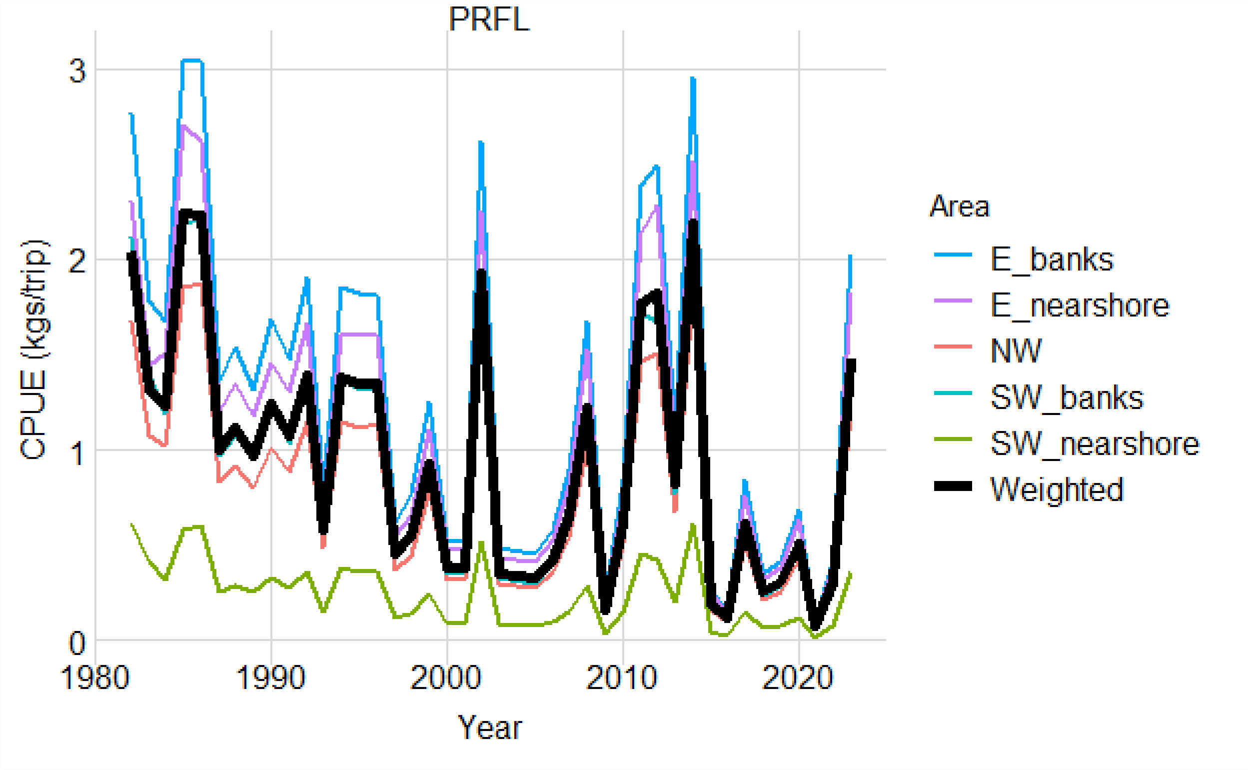

Figure A 92. Standardized CPUE index (kg per trip) of *P. flavipinnis* by area and weighted by habitat extent.

Table A 9. Standardized CPUE index (kg per trip) and standard deviation (sd) of *P. flavipinnis*.

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	2.04	1.05	1996	1.35	0.68	2010	0.61	0.39
1983	1.31	0.63	1997	0.45	0.33	2011	1.76	1.14
1984	1.23	1.77	1998	0.55	0.31	2012	1.82	6.18
1985	2.24	1.26	1999	0.93	0.54	2013	0.82	0.95
1986	2.23	1.49	2000	0.38	0.39	2014	2.18	2.24
1987	1.00	0.84	2001	0.38	0.32	2015	0.19	0.75
1988	1.12	0.82	2002	1.92	1.22	2016	0.11	0.54
1989	0.97	0.51	2003	0.35	0.42	2017	0.62	0.65
1990	1.24	0.66	2004	---	---	2018	0.25	0.40
1991	1.08	0.70	2005	0.33	0.43	2019	0.30	0.24
1992	1.39	1.07	2006	0.42	0.35	2020	0.50	0.59
1993	0.58	0.46	2007	0.65	1.08	2021	0.07	0.07
1994	1.38	0.68	2008	1.22	1.45	2022	0.30	0.24
1995	1.34	0.87	2009	0.16	0.15	2023	1.47	1.42

Pristipomoides zonatus

Presence/Absence Model

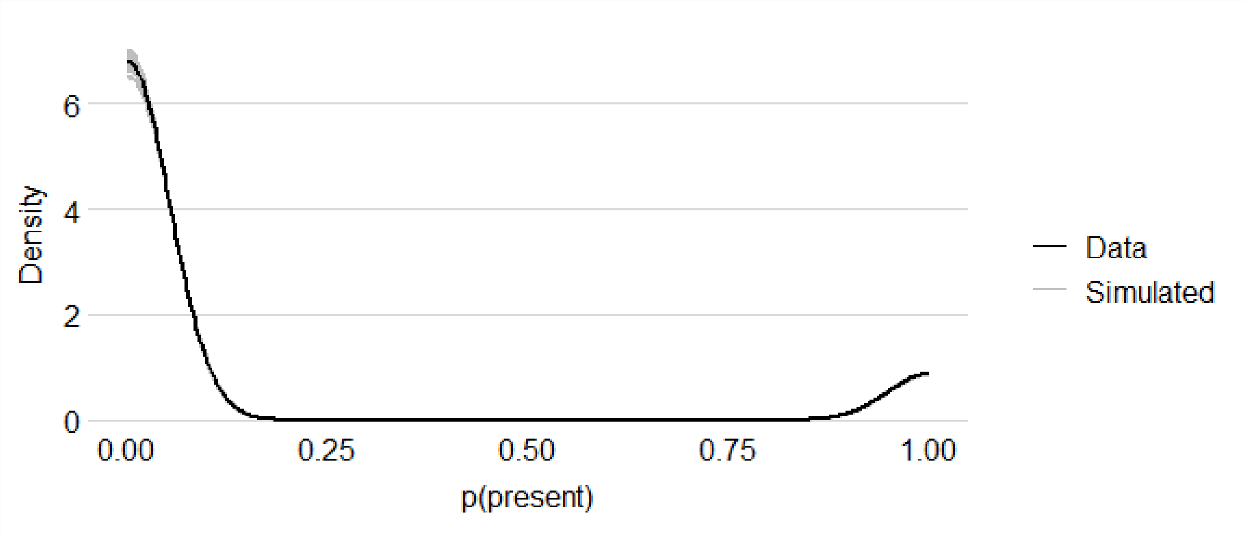

Figure A 93. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *P. zonatus* CPUE standardization.

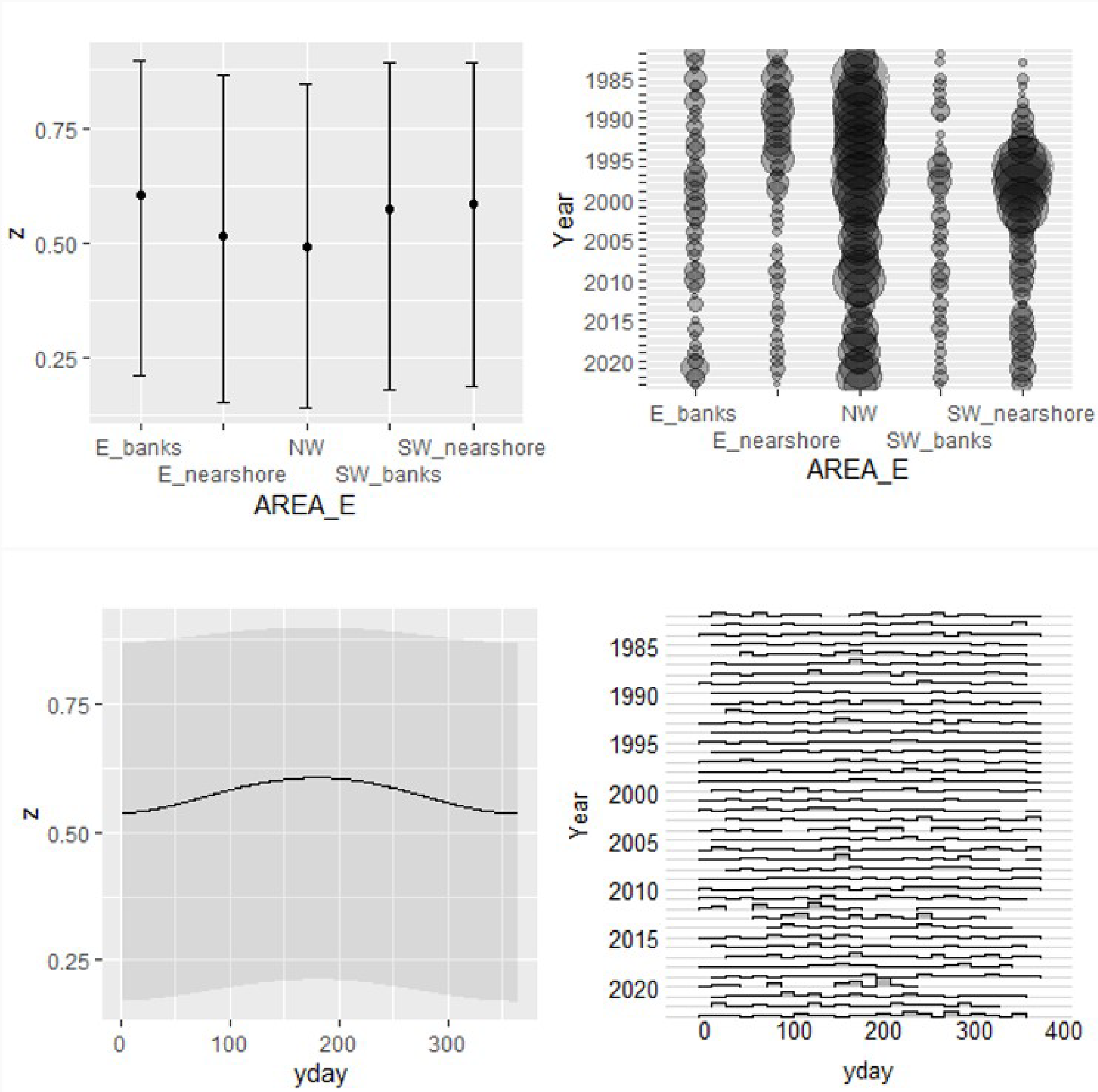

Figure A 94. Partial effects of area and time of year on probability of presence in the *P. zonatus* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

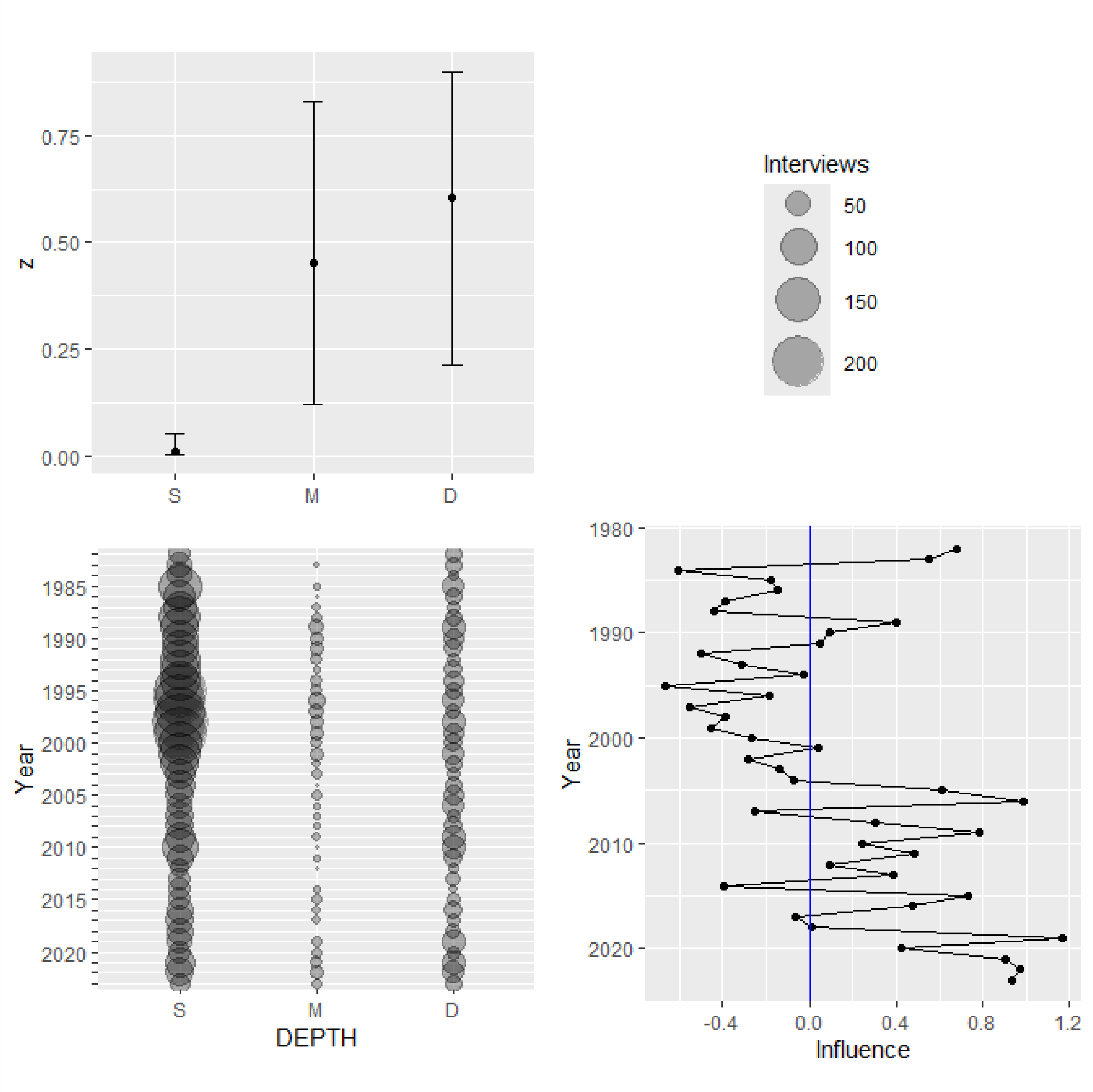

Figure A 95. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on probability of presence in the *P. zonatus* CPUE standardization.

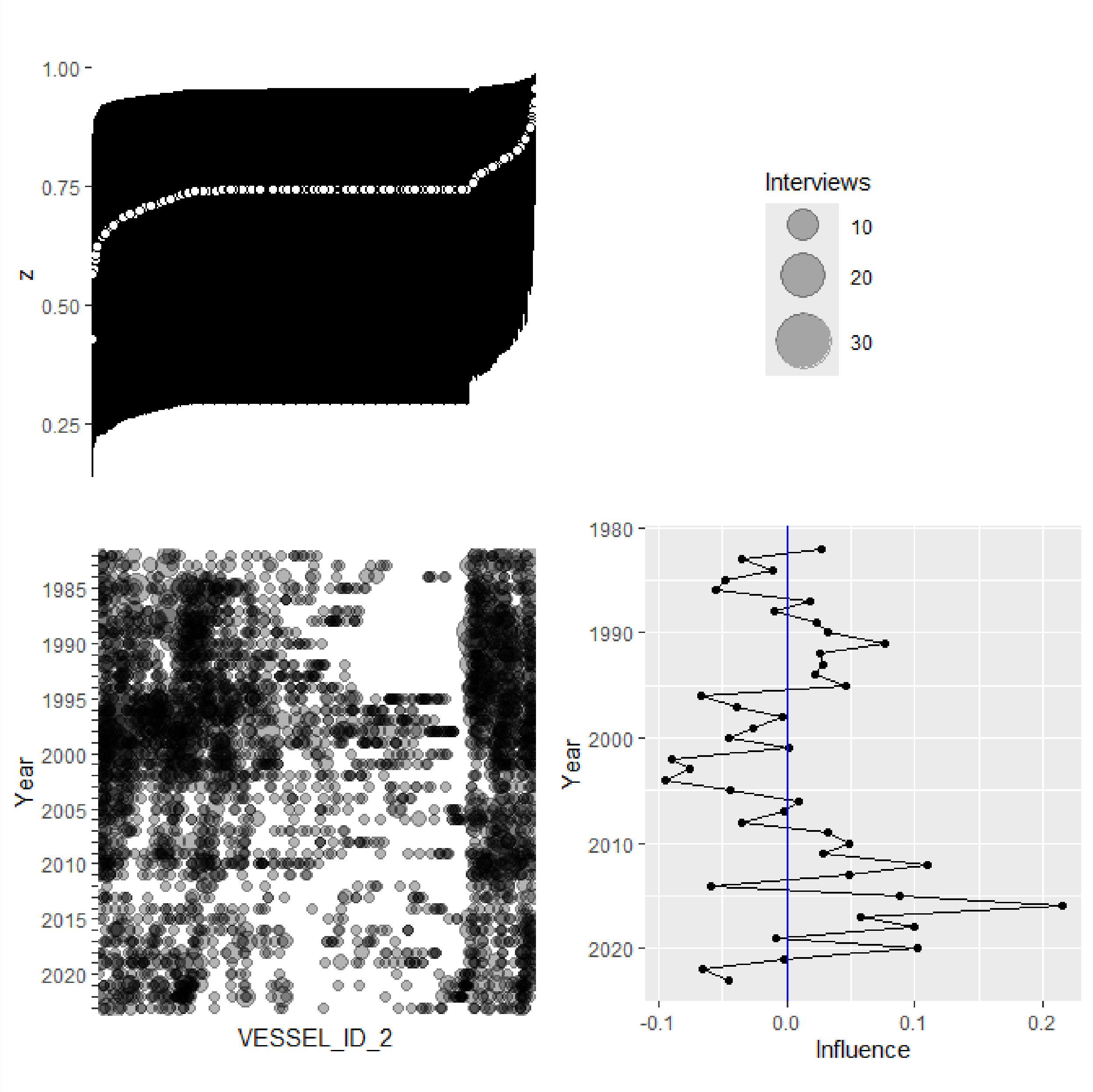

Figure A 96. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *P. zonatus* CPUE standardization.

Positive Process Model

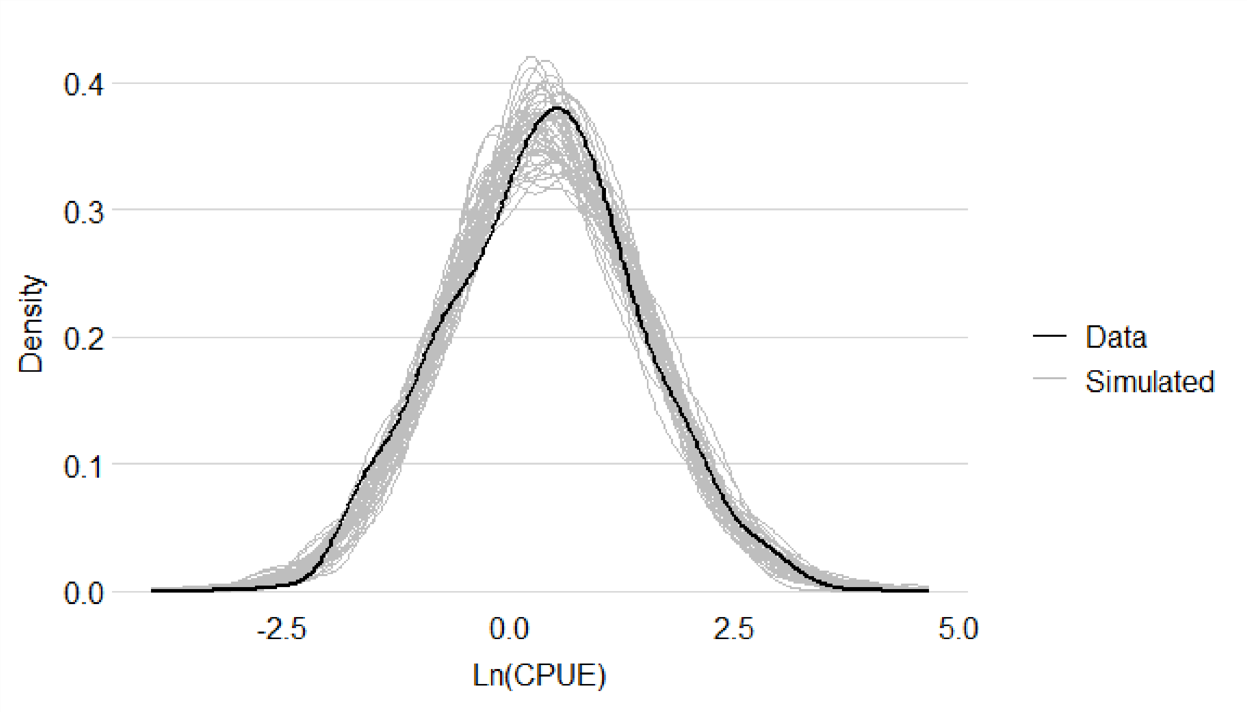

Figure A 97. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *P. zonatus* CPUE standardization.

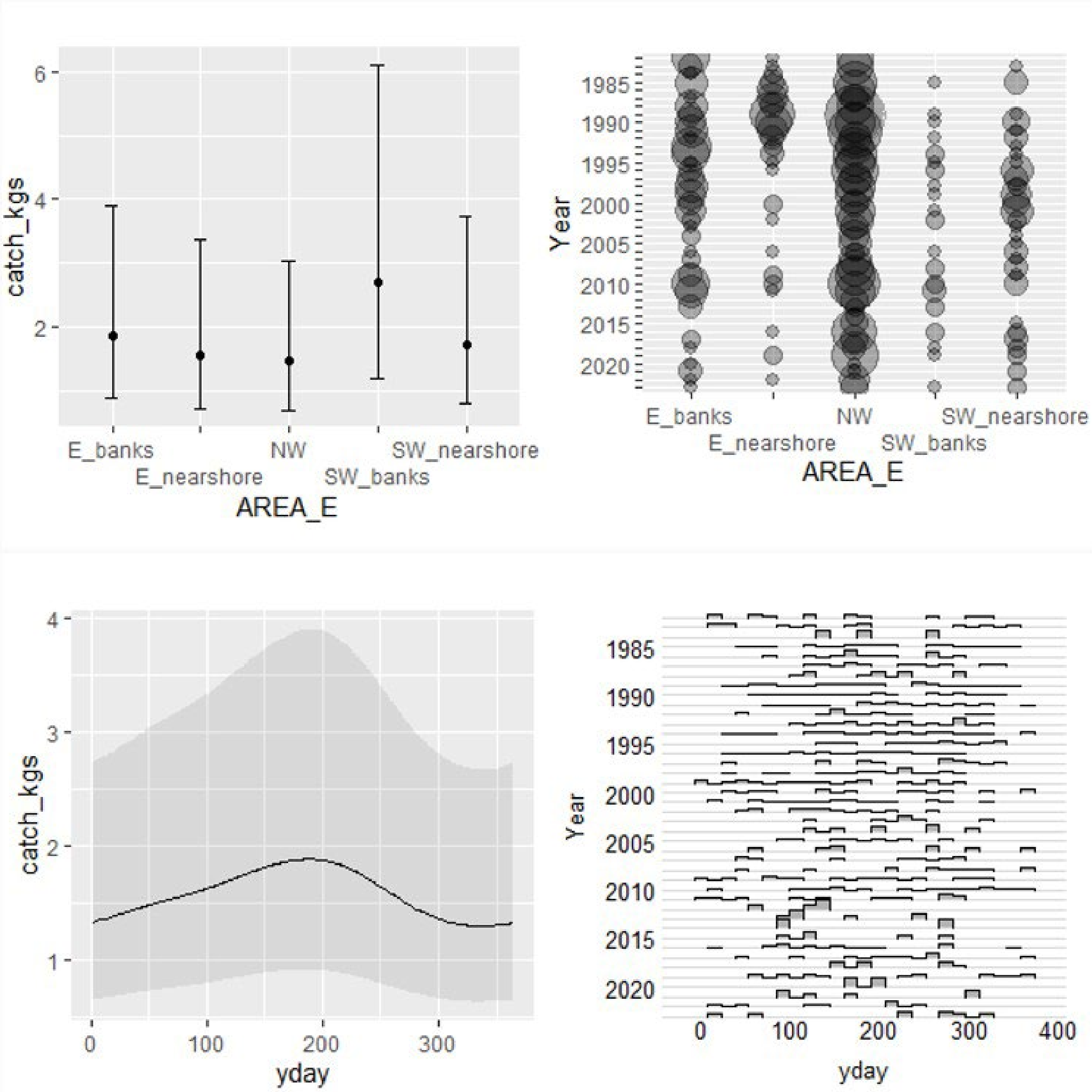

Figure A 98. Partial effects of area and time of year on CPUE (kg per trip) in the *P. zonatus* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right). Error bars and the shaded ribbon represent the 95% confidence intervals.

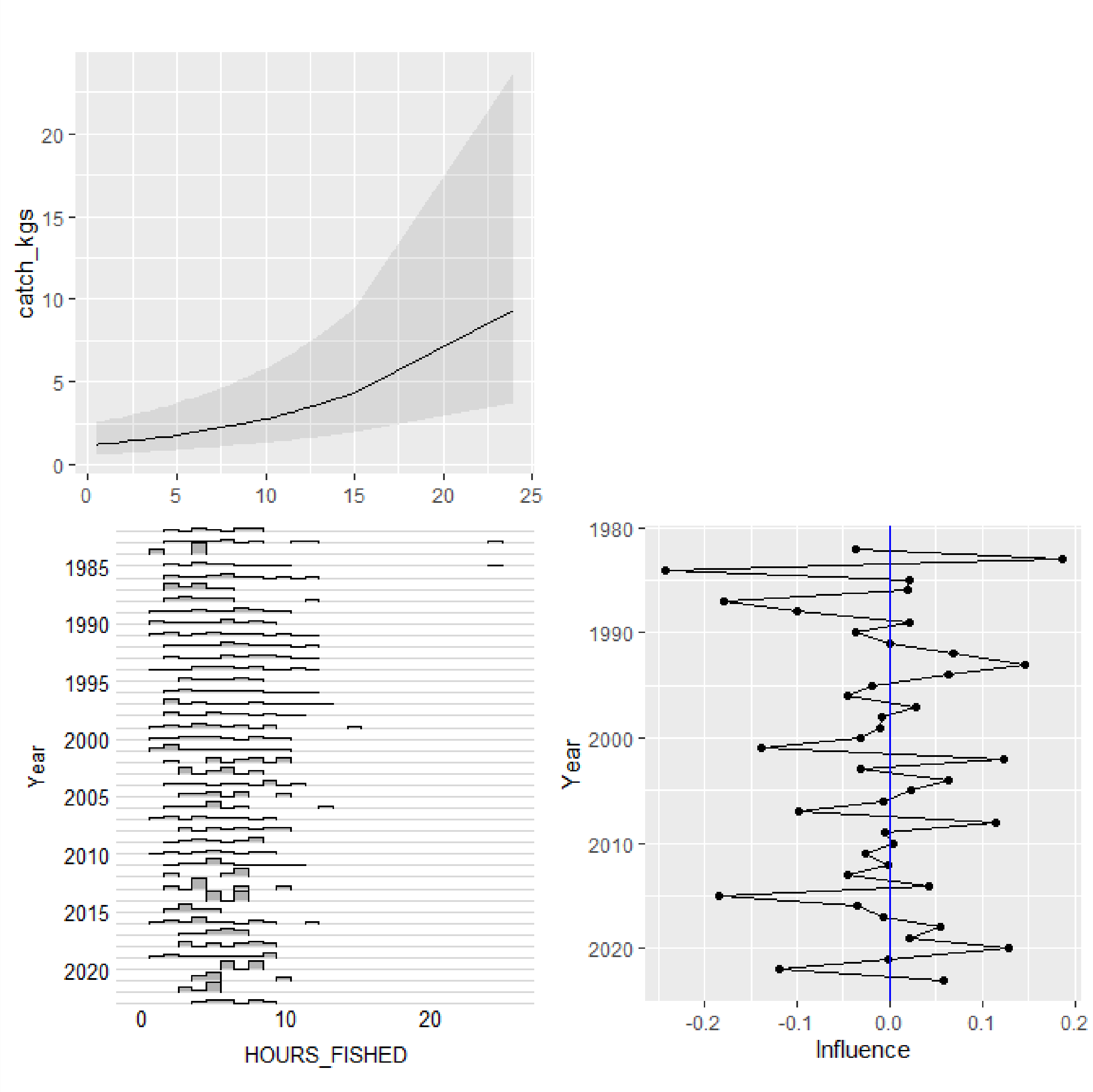

Figure A 99. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *P. zonatus* CPUE standardization.

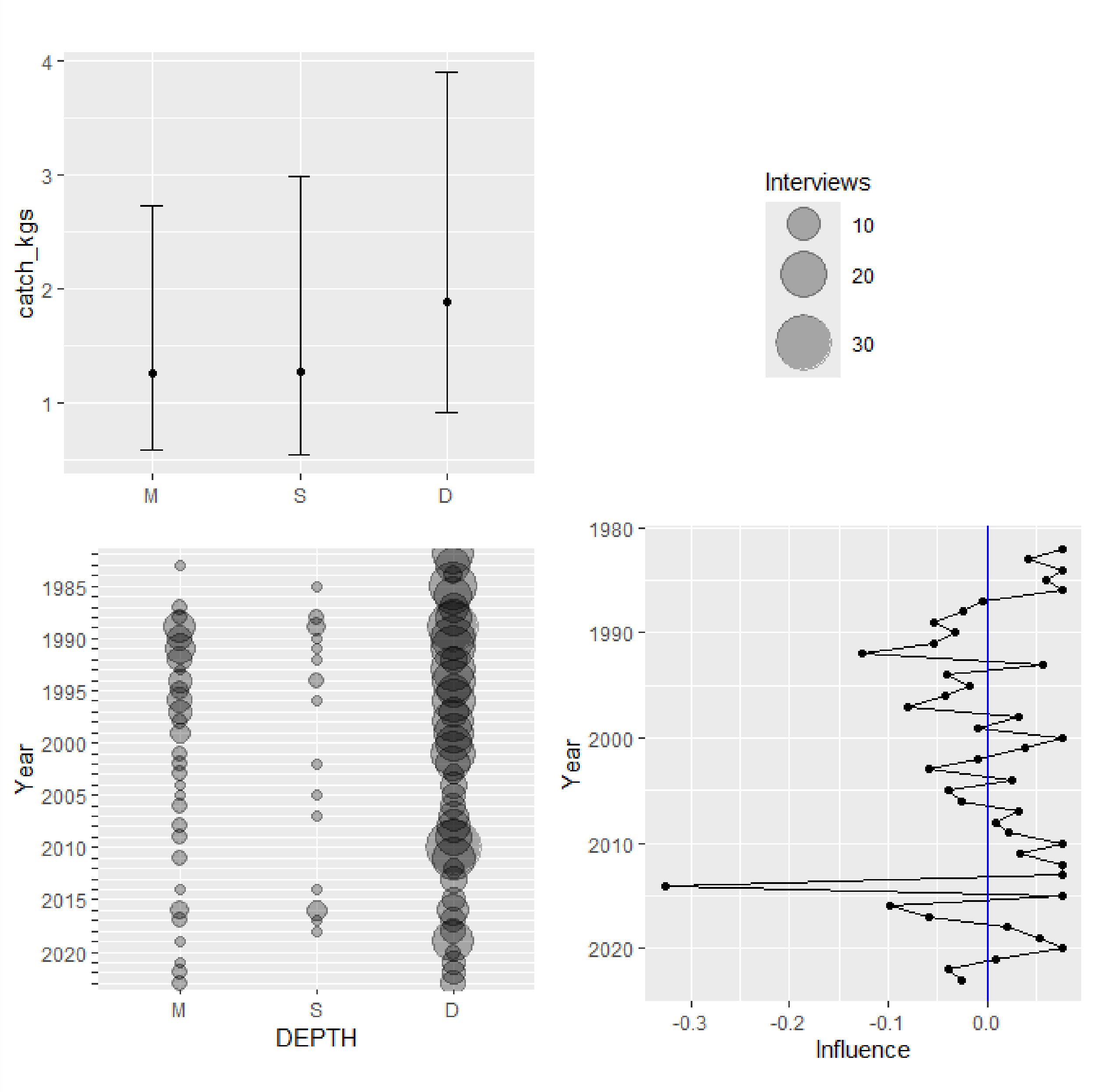

Figure A 100. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type ('depth') on CPUE (kg per trip) in the *P. zonatus* CPUE standardization.

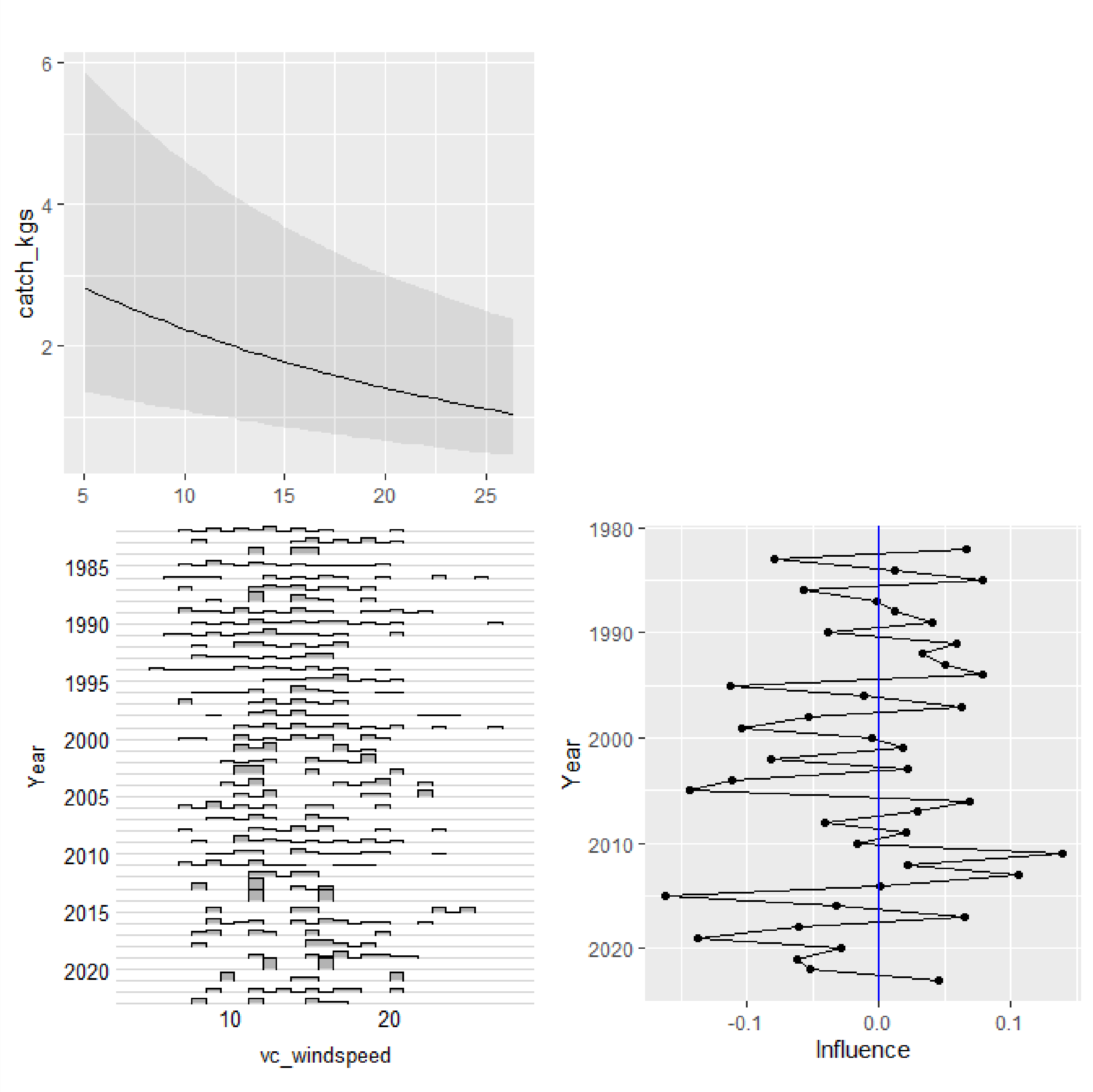

Figure A 101. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of wind speed on CPUE (kg per trip) in the *P. zonatus* CPUE standardization.

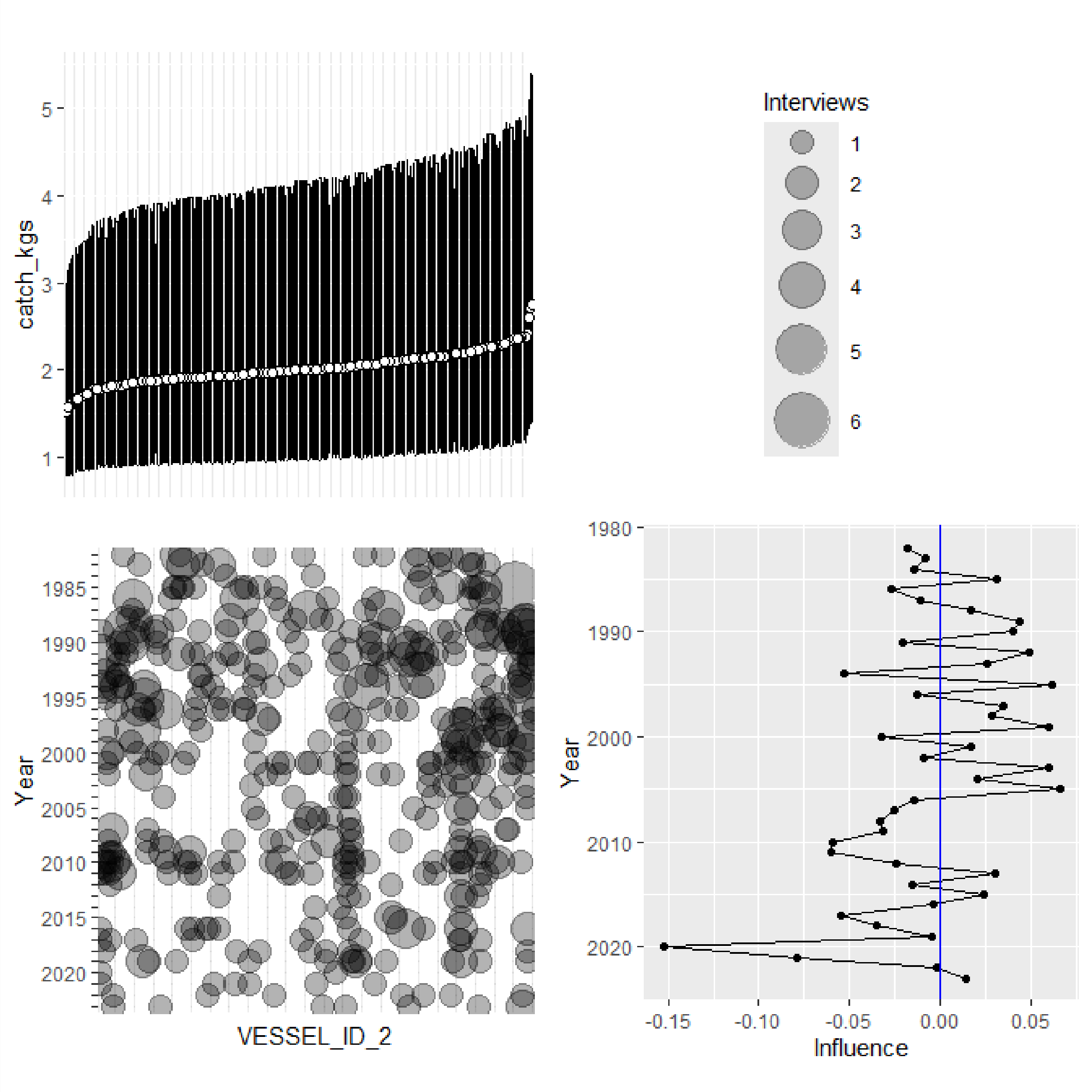

Figure A 102. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on CPUE (kg per trip) in the *P. zonatus* CPUE standardization.

Standardized CPUE Index

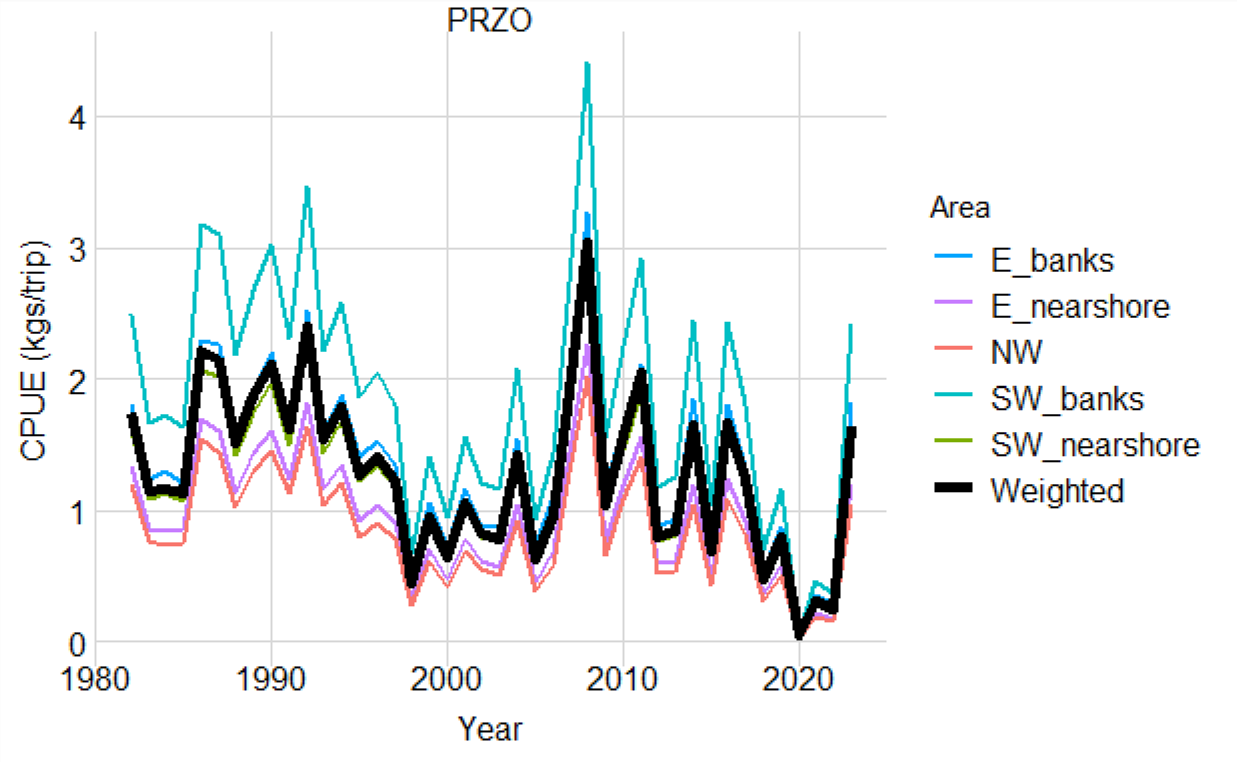

Figure A 103. Standardized CPUE index (kg per trip) of *P. zonatus* by area and weighted by habitat extent.

Table A 10. . Standardized CPUE index (kg per trip) and standard deviation (sd) of *P. zonatus*.

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	1.74	0.92	1996	1.40	0.85	2010	1.57	0.75
1983	1.15	0.73	1997	1.22	0.87	2011	2.05	1.02
1984	1.17	1.33	1998	0.44	0.36	2012	0.80	0.74
1985	1.14	0.62	1999	0.96	0.62	2013	0.85	0.68
1986	2.22	1.20	2000	0.65	0.48	2014	1.65	2.42
1987	2.14	1.35	2001	1.06	0.68	2015	0.69	0.79
1988	1.51	0.85	2002	0.83	0.51	2016	1.67	1.04
1989	1.88	0.86	2003	0.79	0.68	2017	1.24	0.84
1990	2.12	1.03	2004	1.42	1.06	2018	0.48	0.39
1991	1.62	0.76	2005	0.62	0.65	2019	0.80	0.53
1992	2.40	1.36	2006	0.97	0.98	2020	0.05	0.12
1993	1.54	0.82	2007	1.90	1.18	2021	0.31	0.43
1994	1.79	0.93	2008	3.04	1.88	2022	0.25	0.28
1995	1.26	0.93	2009	1.05	0.79	2023	1.64	1.31

Variola louti

Presence/Absence Model

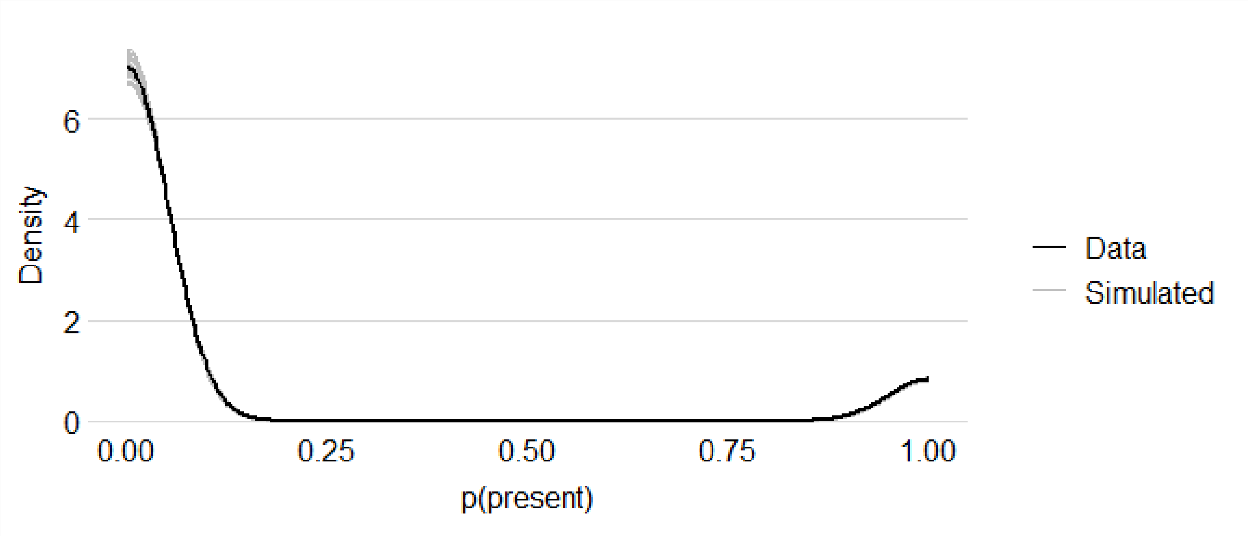

Figure A 104. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) presence/absence for the *V. louti* CPUE standardization.

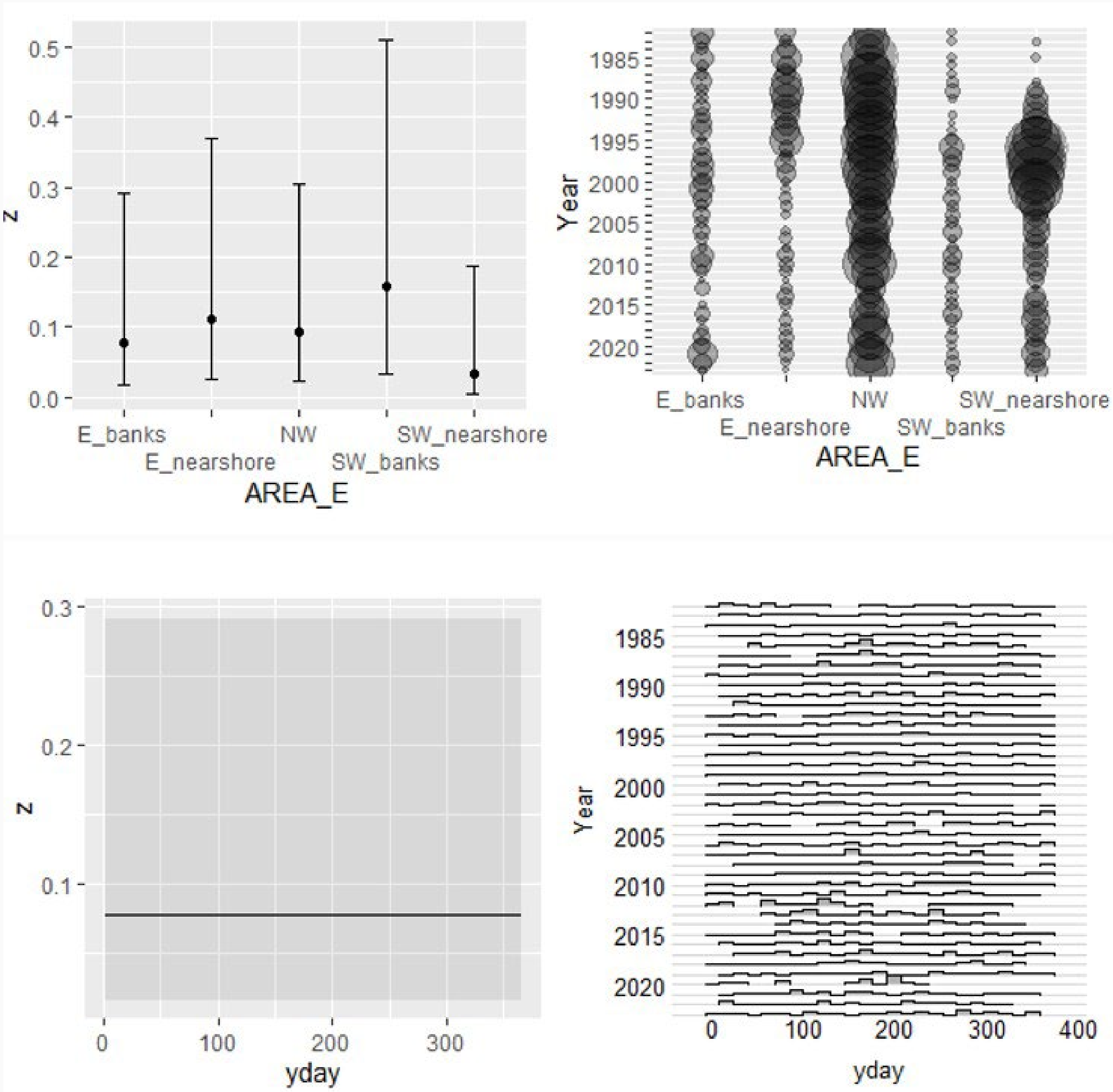

Figure A 105. Partial effects of area and time of year on probability of presence in the *V. louti* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

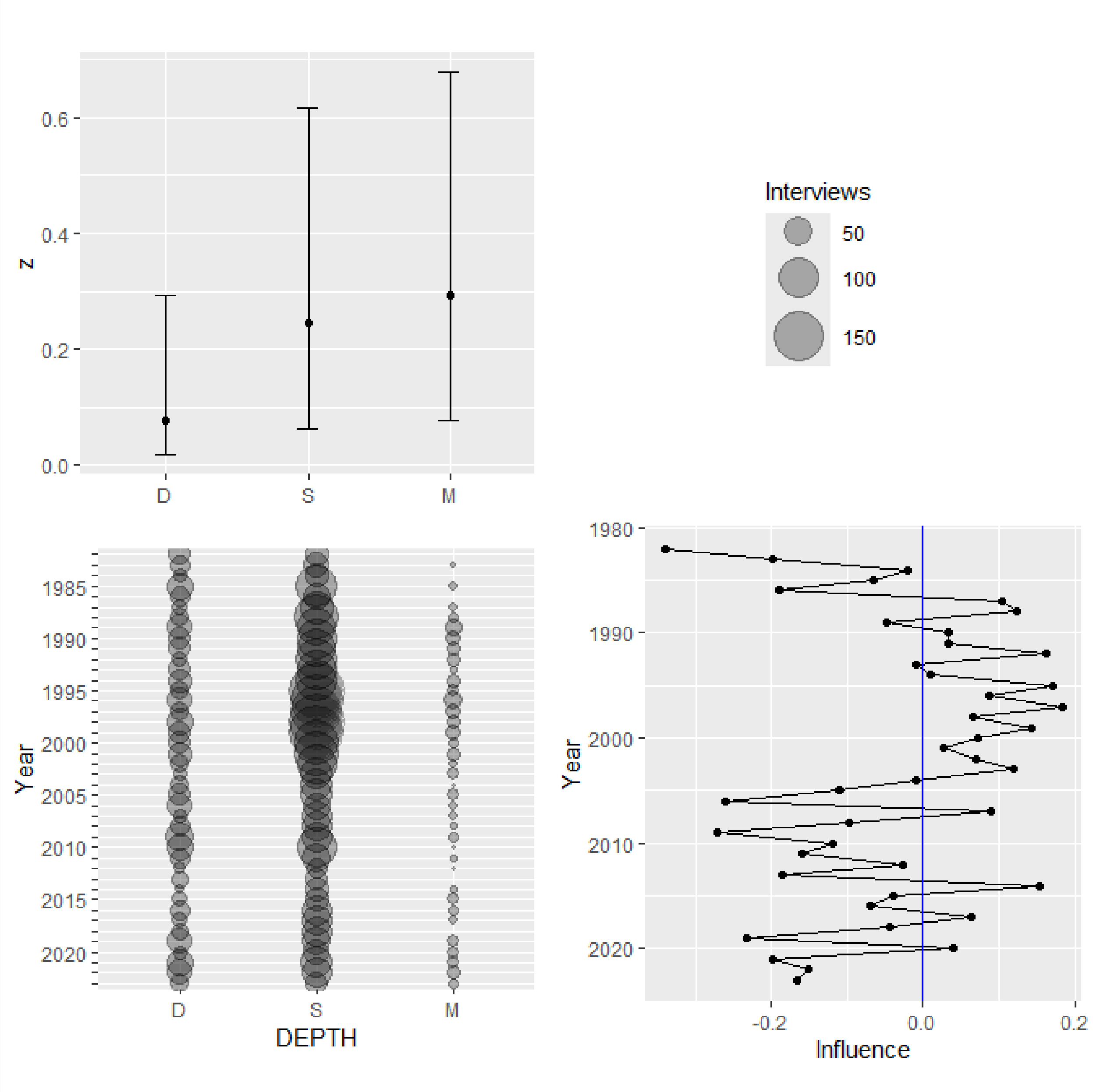

Figure A 106. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of fishing type (‘depth’) on probability of presence in the *V. louti* CPUE standardization.

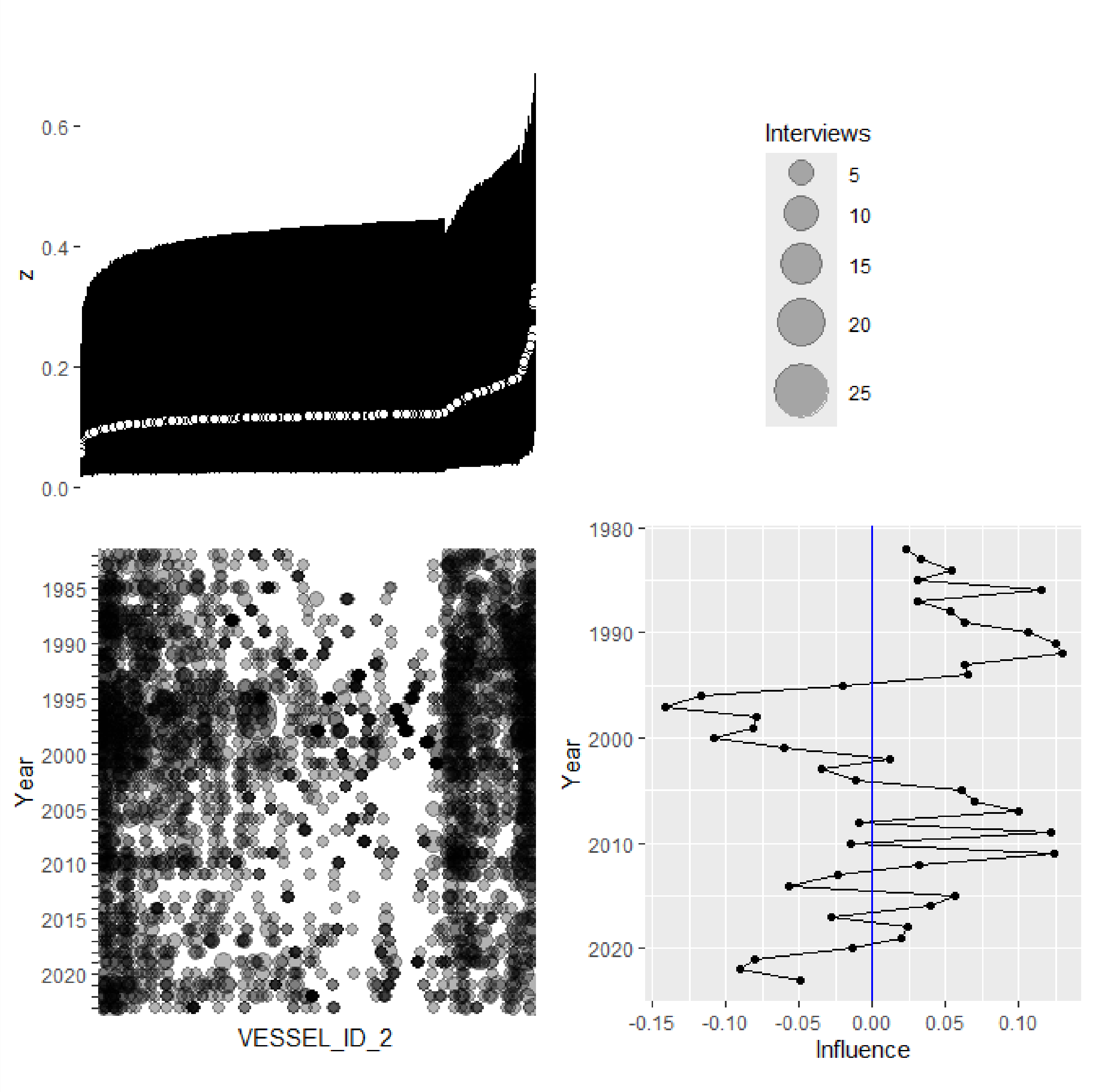

Figure A 107. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of vessel on probability of presence in the *V. louti* CPUE standardization.

Positive Process Model

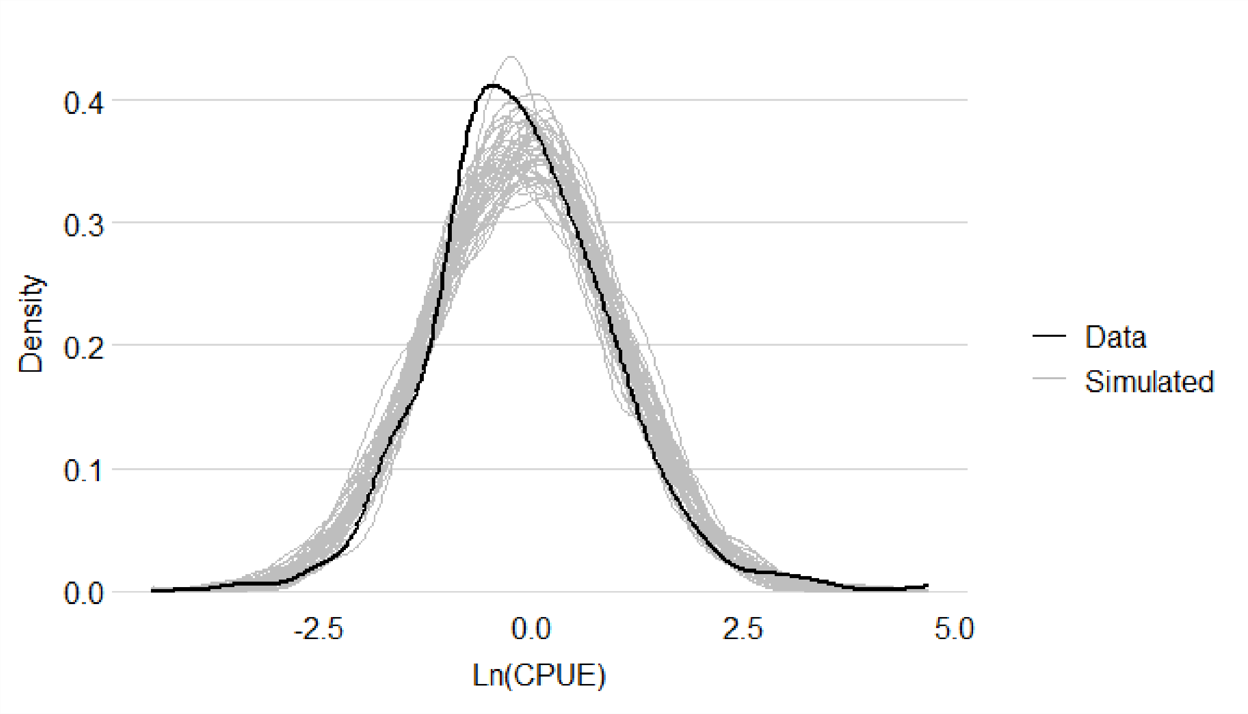

Figure A 108. Density distributions of observed (black) and model-simulated (gray; 50 simulations shown) Ln(CPUE) for the *V. louti* CPUE standardization.

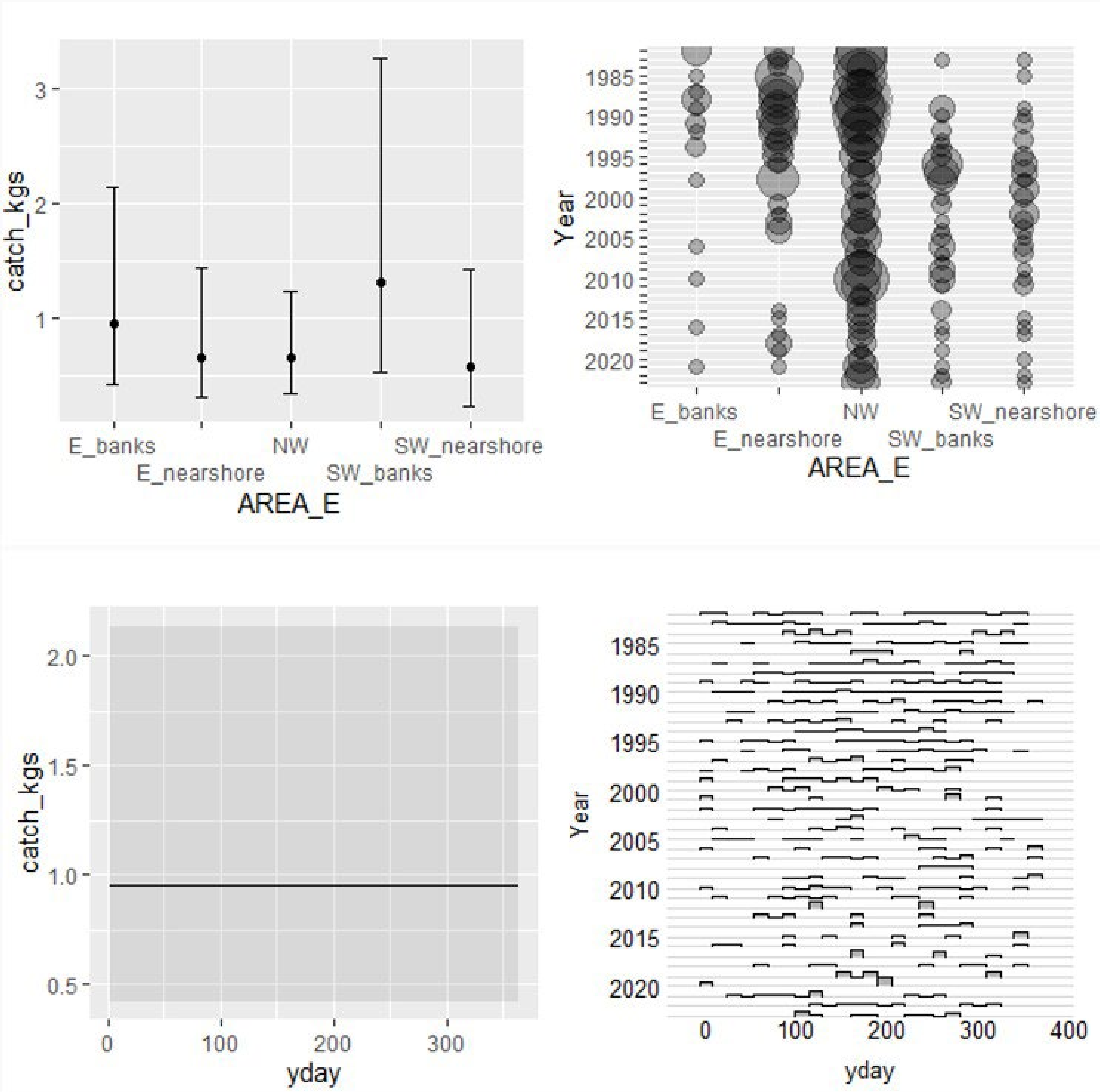

Figure A 109. Partial effects of area and time of year on CPUE (kg per trip) in the *V. louti* CPUE standardization (left) and relative number of interviews by area and time of year 1982–2023 (right).

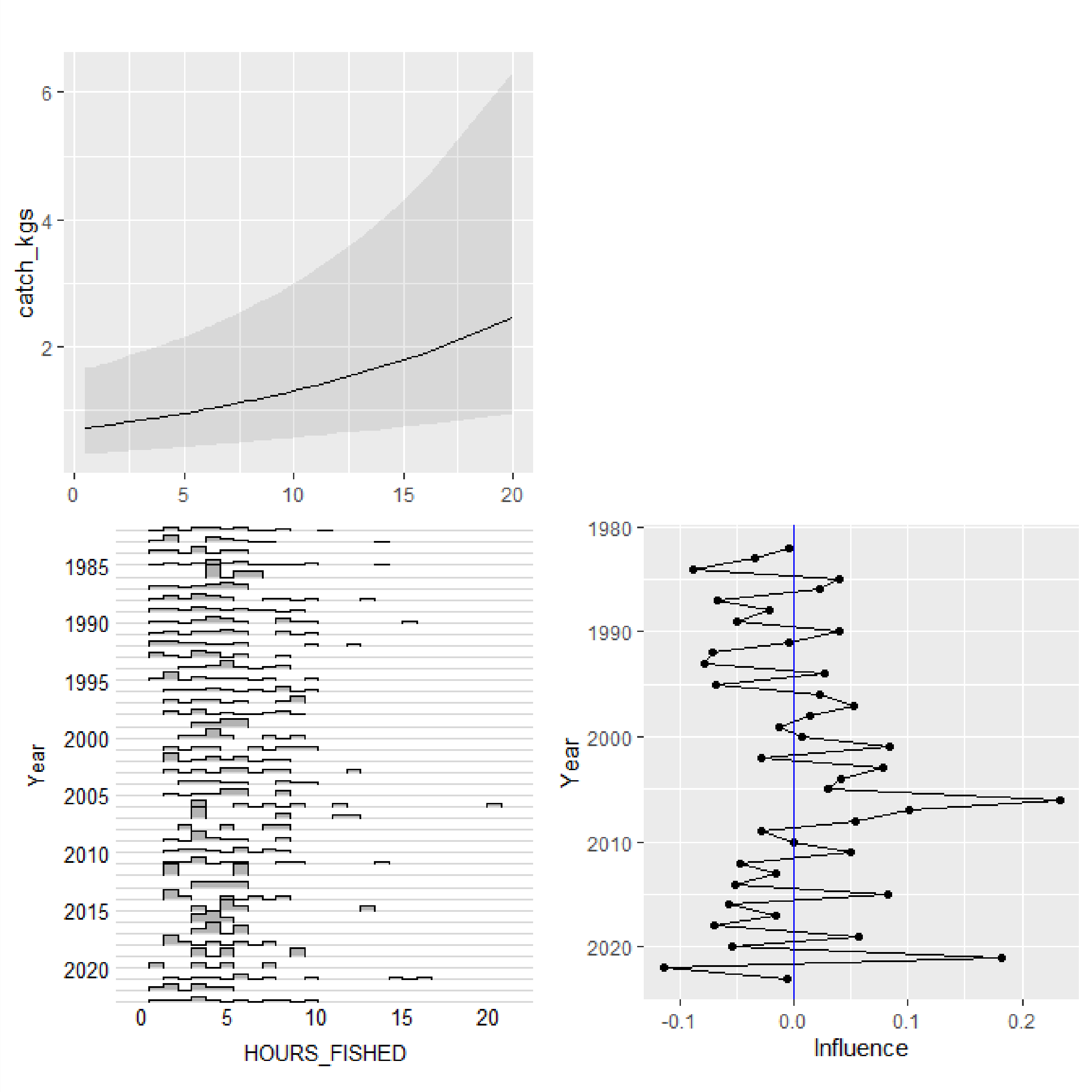

Figure A 110. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (hours fished) on CPUE (kg per trip) in the *V. louti* CPUE standardization.

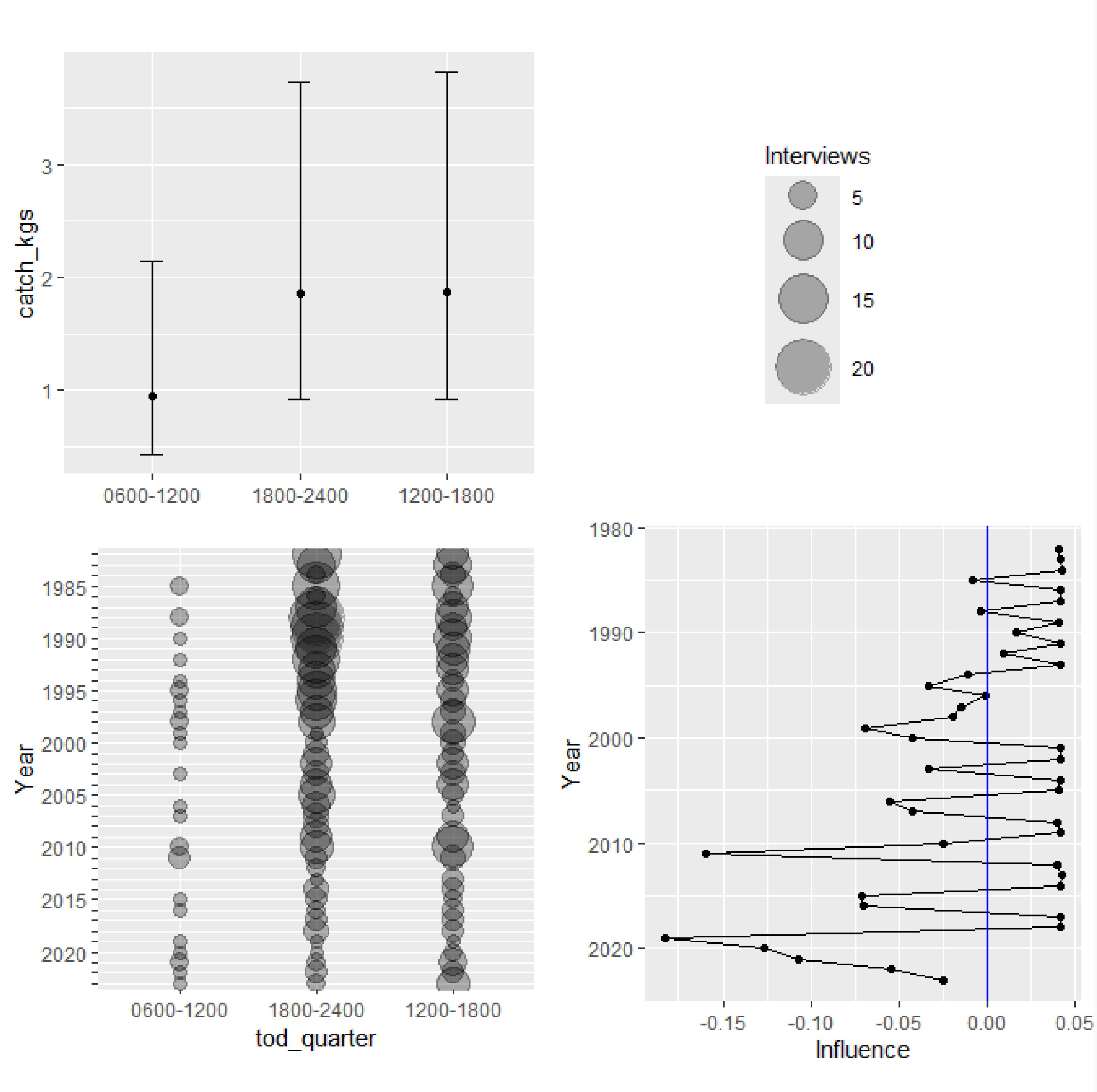

Figure A 111. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of time of day on CPUE (kg per trip) in the *V. louti* CPUE standardization.

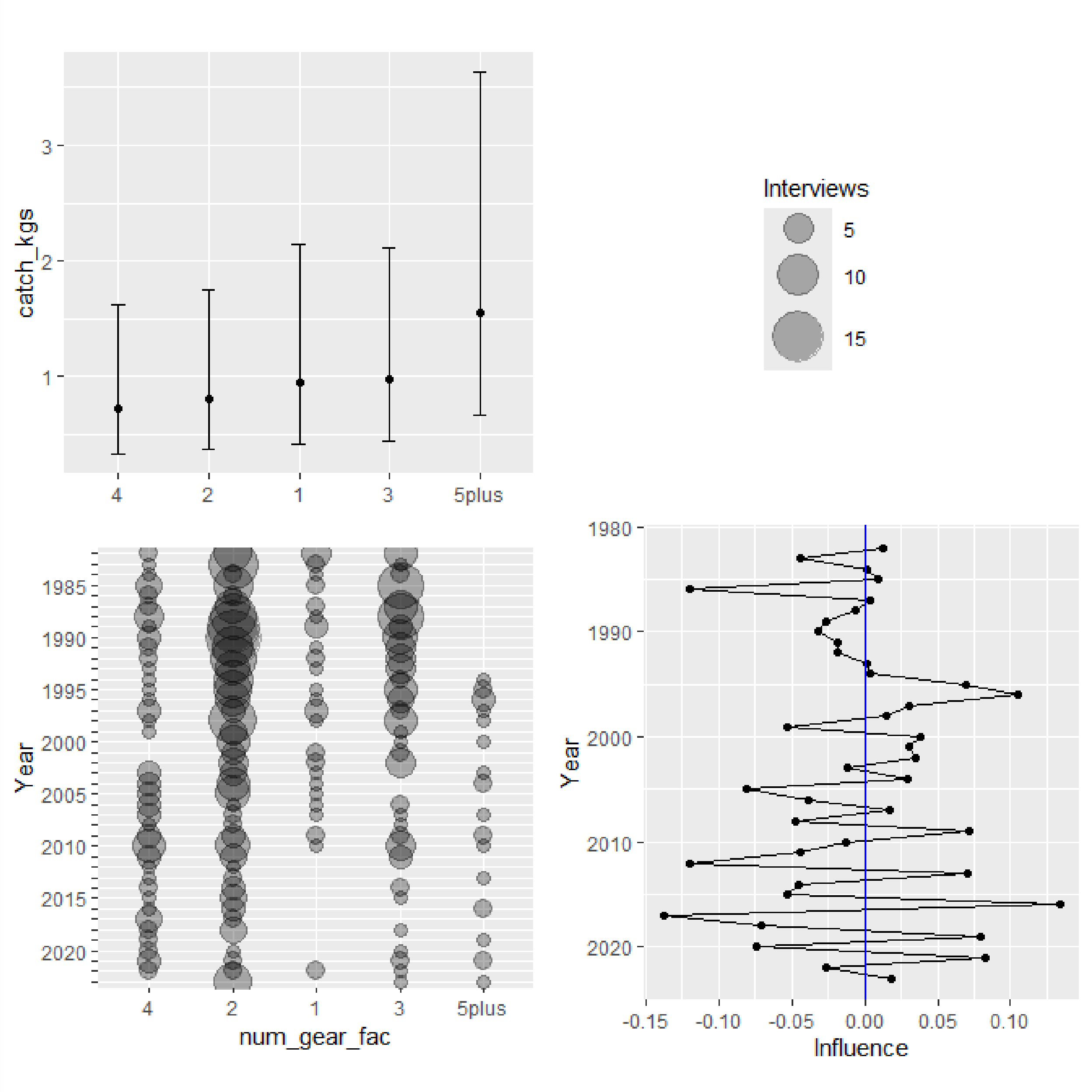

Figure A 112. Partial effects (top left), number of observations (bottom left), and relative influence (bottom right) of effort (number of gears) on CPUE (kg per trip) in the *V. louti* CPUE standardization.

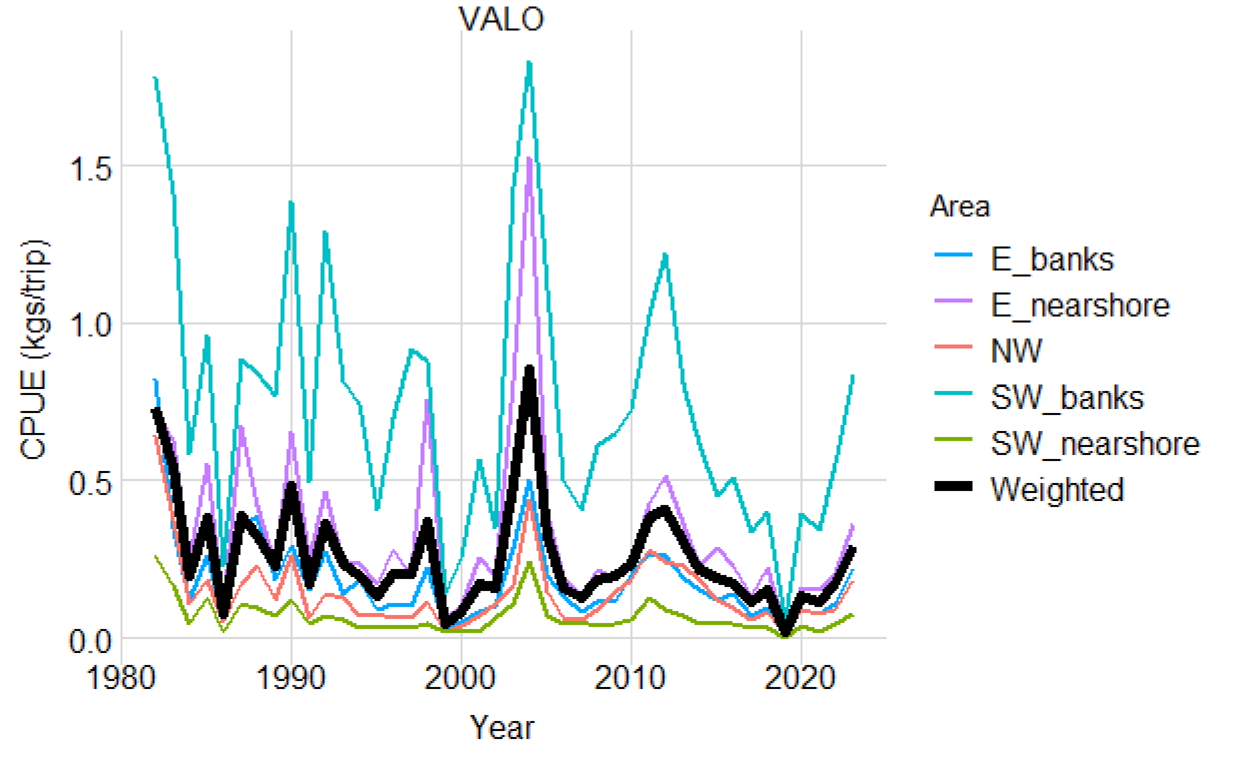

Figure A 113. Standardized CPUE index (kg per trip) of *V. louti* by area and weighted by habitat extent.

Table A 11. Standardized CPUE index (kg per trip) and standard deviation (sd) of *V. louti.*

Year	CPUE	sd	Year	CPUE	sd	Year	CPUE	sd
1982	0.73	0.45	1996	0.20	0.15	2010	0.24	0.19
1983	0.54	0.36	1997	0.20	0.18	2011	0.38	0.37
1984	0.20	0.23	1998	0.37	0.23	2012	0.41	0.85
1985	0.38	0.28	1999	0.05	0.07	2013	0.30	0.44
1986	0.08	0.13	2000	0.08	0.09	2014	0.22	0.20
1987	0.39	0.29	2001	0.17	0.17	2015	0.19	0.21
1988	0.33	0.26	2002	0.16	0.16	2016	0.17	0.21
1989	0.23	0.17	2003	0.49	0.42	2017	0.11	0.13
1990	0.49	0.32	2004	0.85	0.66	2018	0.15	0.15
1991	0.17	0.13	2005	0.32	0.29	2019	0.02	0.03
1992	0.36	0.26	2006	0.16	0.16	2020	0.14	0.20
1993	0.23	0.20	2007	0.13	0.13	2021	0.12	0.11
1994	0.20	0.17	2008	0.18	0.26	2022	0.17	0.20
1995	0.13	0.12	2009	0.20	0.19	2023	0.29	0.21