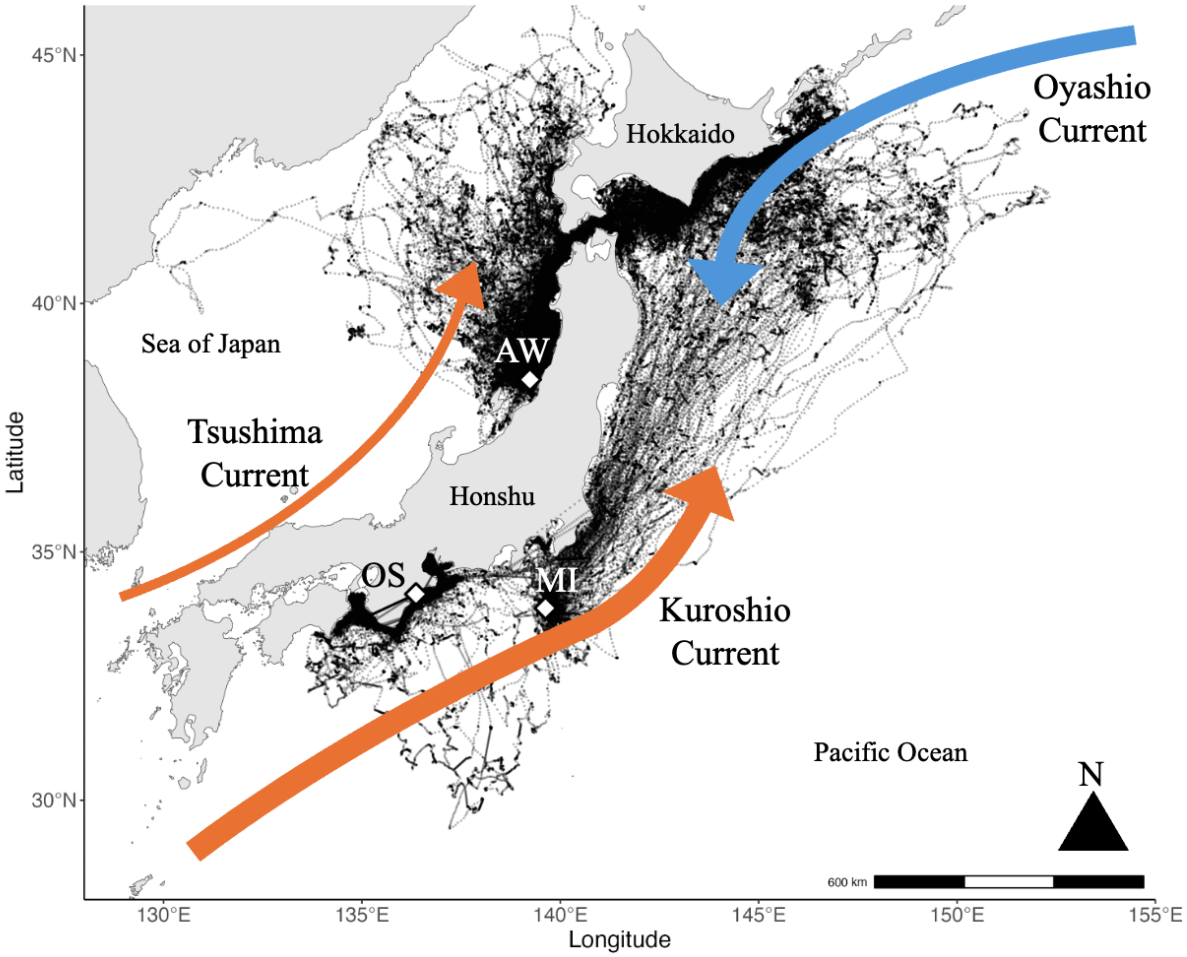
Figure S1. GPS locations and breeding colonies of tracked shearwaters in Japan.

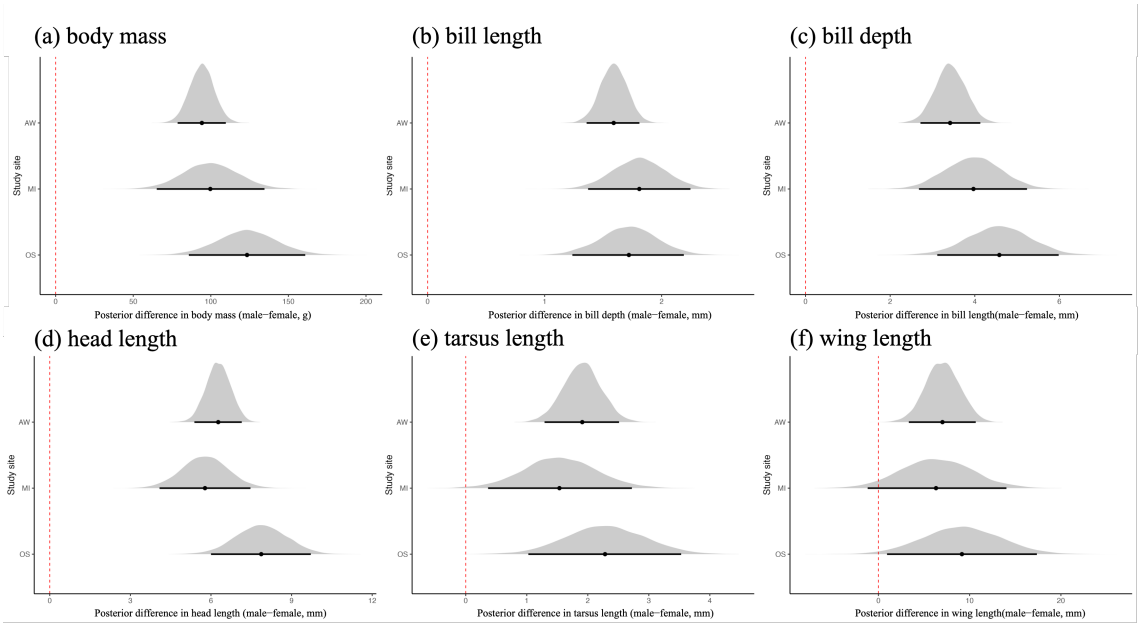


Parts of the Japanese archipelago and the breeding grounds of the shearwaters surveyed are shown. AW indicates Awashima Island, MI indicates Mikurajima Island, and OS indicates Oshima Island. Gray areas show land topography. Oceanographic features of the Sea of Japan and the northwestern Pacific are also shown. Orange arrows indicate warm currents, and blue arrows indicate cold currents.

Figure S2. Data recording periods for individual birds.

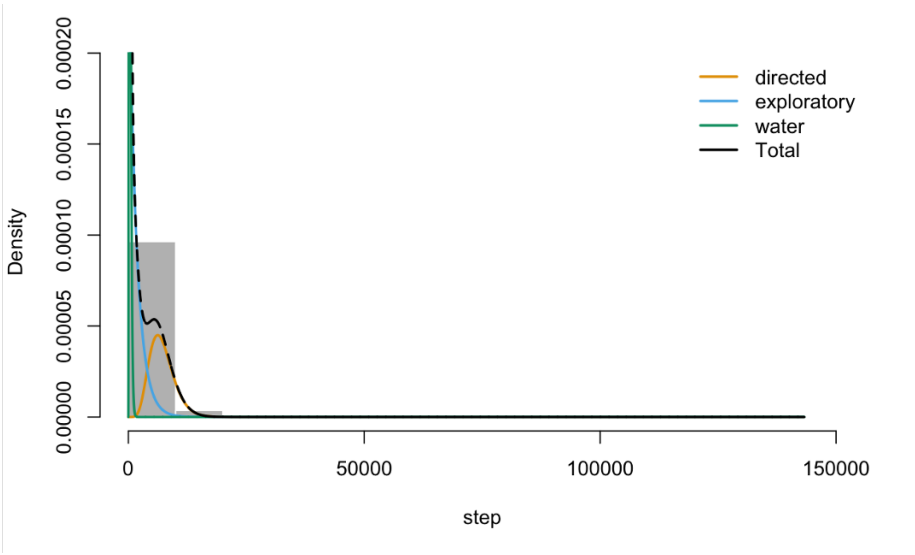
The chart shows the GPS data recording periods for each individual. The vertical axis shows individual IDs grouped by colony and year, and the horizontal axis represents calendar dates (month and day only, without year distinction). Red bars indicate females, and blue bars indicate males, representing the duration from the start to the end of data collection for each bird. AW, MI, and OS refer to Awashima Island, Mikurajima Island, and Oshima Island, respectively.

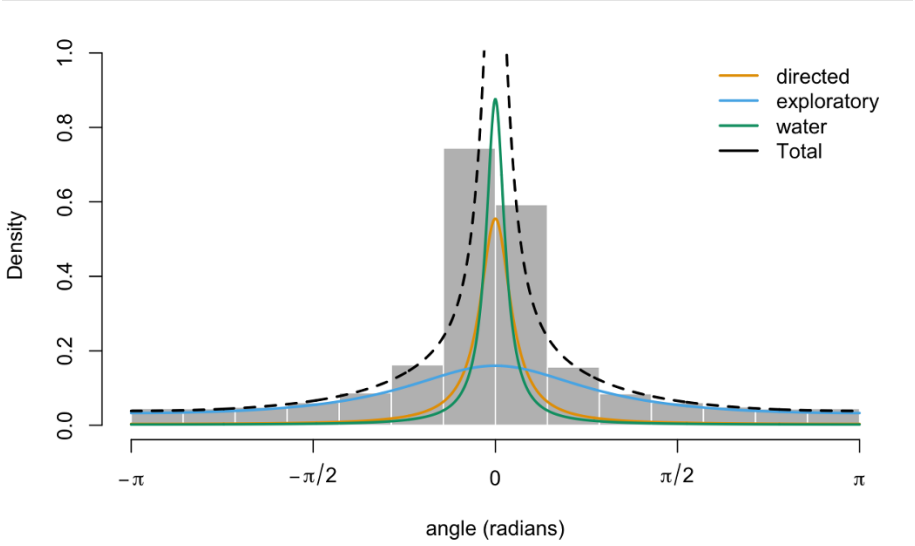
Figure S3. Posterior distributions of sex differences in morphological traits across study sites.



Each panel shows the posterior distribution of the difference between males and females (male − female) in a given morphological trait, estimated from hierarchical Bayesian models fitted separately for each trait. Expected values (epred) for each sex were obtained while marginalizing over random effects (re_formula = NA). Positive values indicate that males are larger than females, whereas negative values indicate the opposite. The vertical dashed red line denotes zero (no sex difference). Distributions represent posterior uncertainty in sex-specific differences for each study site.Panels:(a) body mass (g), (b) bill length (mm), (c) bill depth (mm), (d) head length (mm), (e) tarsus length (mm), (f) wing length (mm).

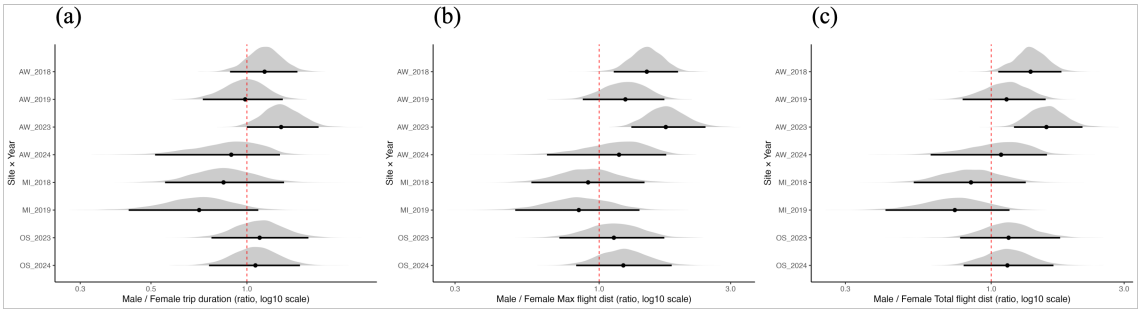
Figure S4. Distributions of step lengths and turning angles for foraging trips.





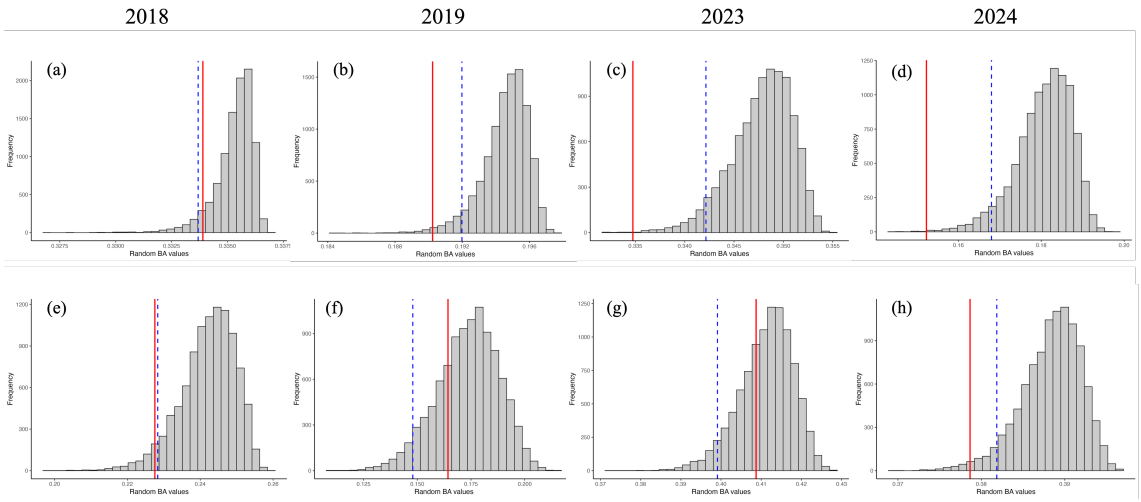
Colored solid lines represent the distributions of each behavioral state classified by the hidden Markov model (HMM).

Figure S5. Posterior distributions of male-to-female ratios for trip-level movement parameters across colony–year combinations.



Panels show the posterior distributions of the ratio between males and females (male/female) based on predicted values from hierarchical Bayesian models. Predicted trip metrics were obtained for each sex while averaging over random effects. The vertical dashed red line indicates a ratio of 1 (no sex difference). Values >1 reflect higher male values, whereas values <1 reflect higher female values. Distributions represent posterior uncertainty for each colony–year (Site × Year) combination. Panels; (a) Trip duration, (b) Maximum flight distance from the colony, (c) Total flight distance.

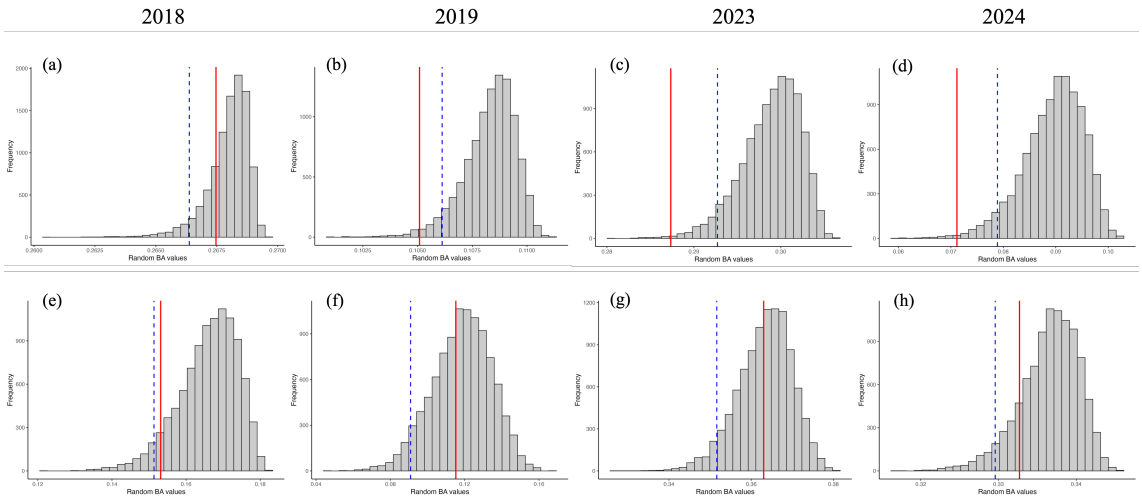
Figure S6. Opposite-sex spatial overlap and randomized BA distributions based on GPS points.



Mean Bhattacharyya's Affinity (BA) values between opposite-sex pairs based on all GPS points, and the distribution of BA values obtained from randomization for each breeding site and year. Each panel represents one site-year combination. Gray histograms show the distribution of BA values generated by randomly pairing male and female trips. The red line indicates the observed mean BA for actual male–female pairs. The blue dashed line represents the 95% lower bound of the randomized BA distribution. When the red line is to the left of the blue dashed line, the observed opposite-sex BA is significantly lower than expected by chance, indicating spatial segregation between sexes. Panels (a)–(d) show data

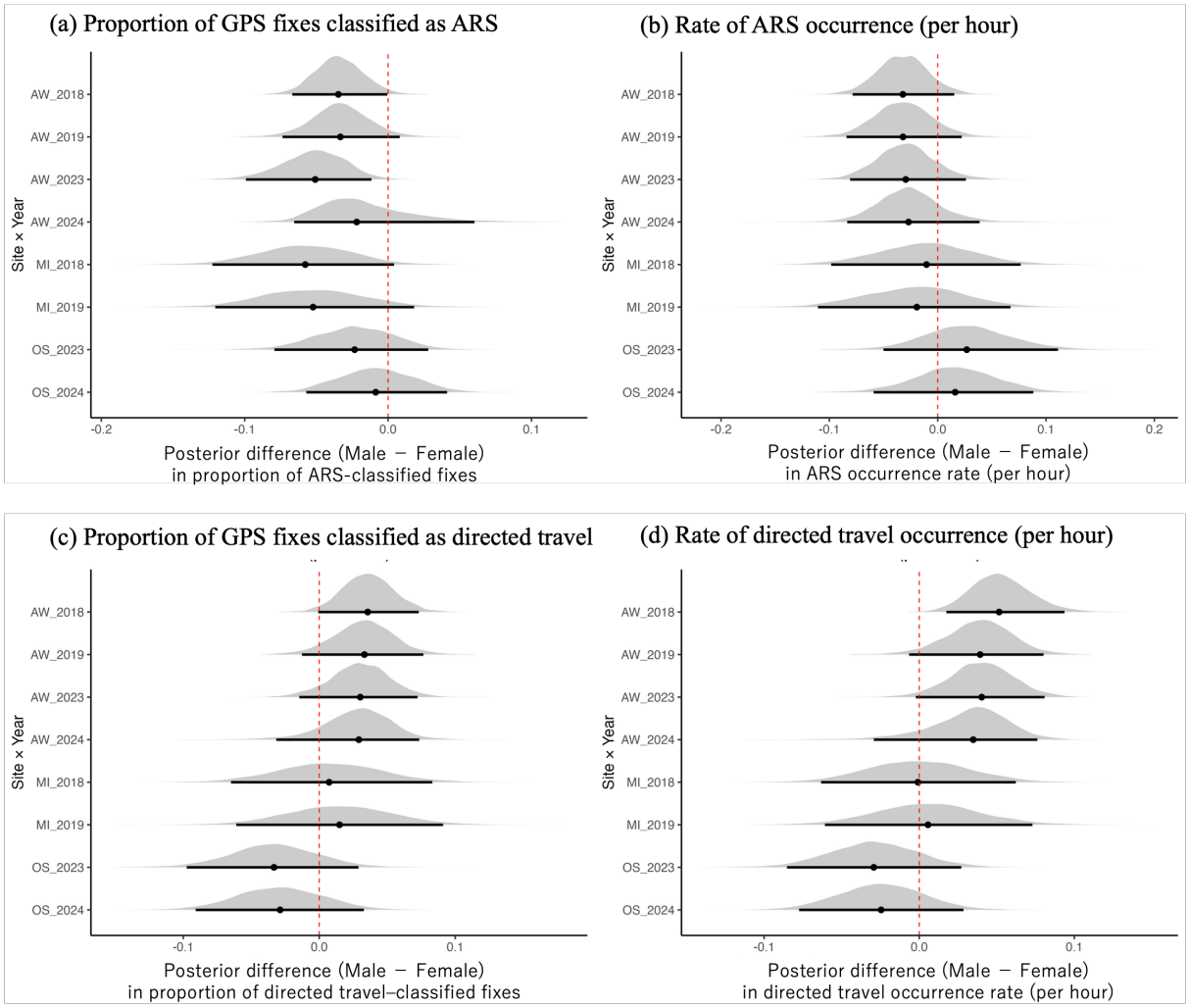
from Awashima Island, (e) and (f) from Mikurajima Island, and (g) and (h) from Oshima Island.

Figure S7. Opposite-sex spatial overlap and randomized BA distributions based on ARS points.



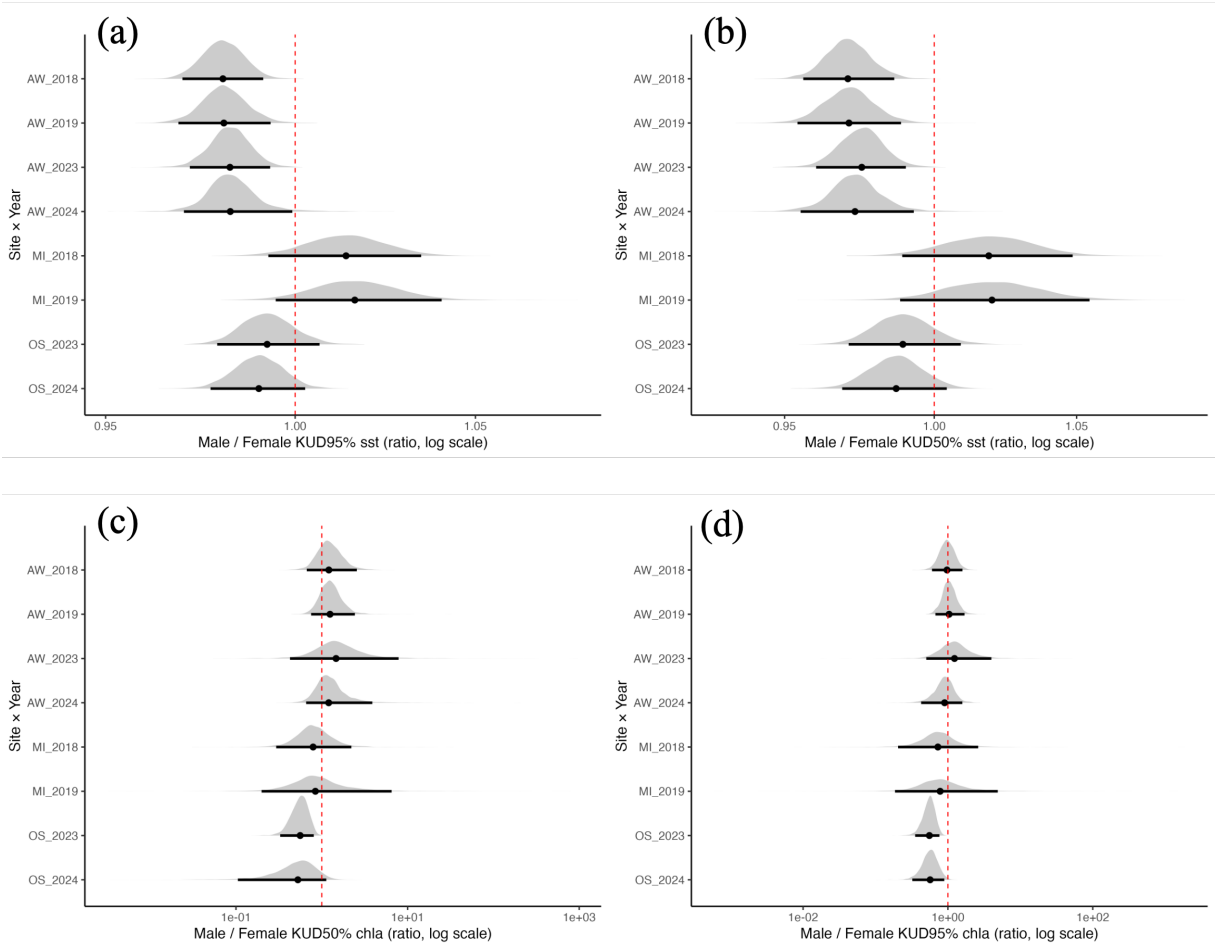
Mean Bhattacharyya's Affinity (BA) values between opposite-sex pairs based on ARS points, and the distribution of BA values obtained from randomization for each breeding site and year. Each panel represents one site-year combination. Gray histograms show the distribution of BA values generated by randomly pairing male and female trips. The red line indicates the observed mean BA for actual male–female pairs. The blue dashed line represents the 95% lower bound of the randomized BA distribution. When the red line falls to the left of the blue dashed line, it indicates that the observed opposite-sex BA is significantly lower than expected by chance—i.e., males and females exhibit significant spatial segregation. Panels (a)–(d) show data from Awashima Island, (e) and (f) from Mikurajima Island, and (g) and (h) from Oshima Island.

Figure S8. Posterior distributions of sex differences (male − female) in four fine-scale behavioral metrics.



(a) Proportion of GPS fixes classified as ARS, (b) Rate of ARS occurrence (per hour), (c) Proportion of GPS fixes classified as directed flight, and (d) Rate of directed flight occurrence (per hour). Values > 0 indicate higher male values. Across colonies and years, most distributions overlapped substantially with 0 (red dashed line), indicating weak or inconsistent sex differences.

Figure S9. Posterior distributions of sex ratios in environmental conditions across colonies and years.



Each panel shows the posterior distribution of the ratio between male and female expected environmental values (male/female), derived from hierarchical Bayesian models fitted separately for SST and chlorophyll-a. Ratios were computed from posterior expected values (epred) for each sex while marginalizing over random effects (re_formula = NA). The vertical dashed red line denotes a ratio of 1, indicating no sex difference. Values greater than 1 indicate higher environmental values associated with male UDs, whereas values less than 1 indicate higher values associated with female UDs. (a) Sea surface temperature (SST) for 95% UD. (b) SST for 50% UD. (c) Chlorophyll-a for 95% UD. (d) Chlorophyll-a for 50% UD. Distributions illustrate the uncertainty of sex-specific differences in environmental conditions experienced within trip-level UDs for each Site × Year category.