# Migratory connectivity analysis

**by EURING Migration Atlas**

*Larus fuscus* **(EURING code 05910)**

## 1.1 Connectivity between individuals

The analysis evaluated 5015 individuals (10030 encounters) filtered from a total of 352037 records in the EURING databank which were considered for the Atlas. The species shows a significant connectivity from pattern transference (Table 05910-1; Figure 05910-1).

**Table 05910-1.** Results from the migratory connectivity analysis. For each cluster, the degree of connectivity ($r_M$), its statistical significance (p-value) and 95% confidence interval limits are shown. When the p-value is less than or equal to 0.1, the degree of clustering structure (oasw) and the best number of clusters identified are reported.

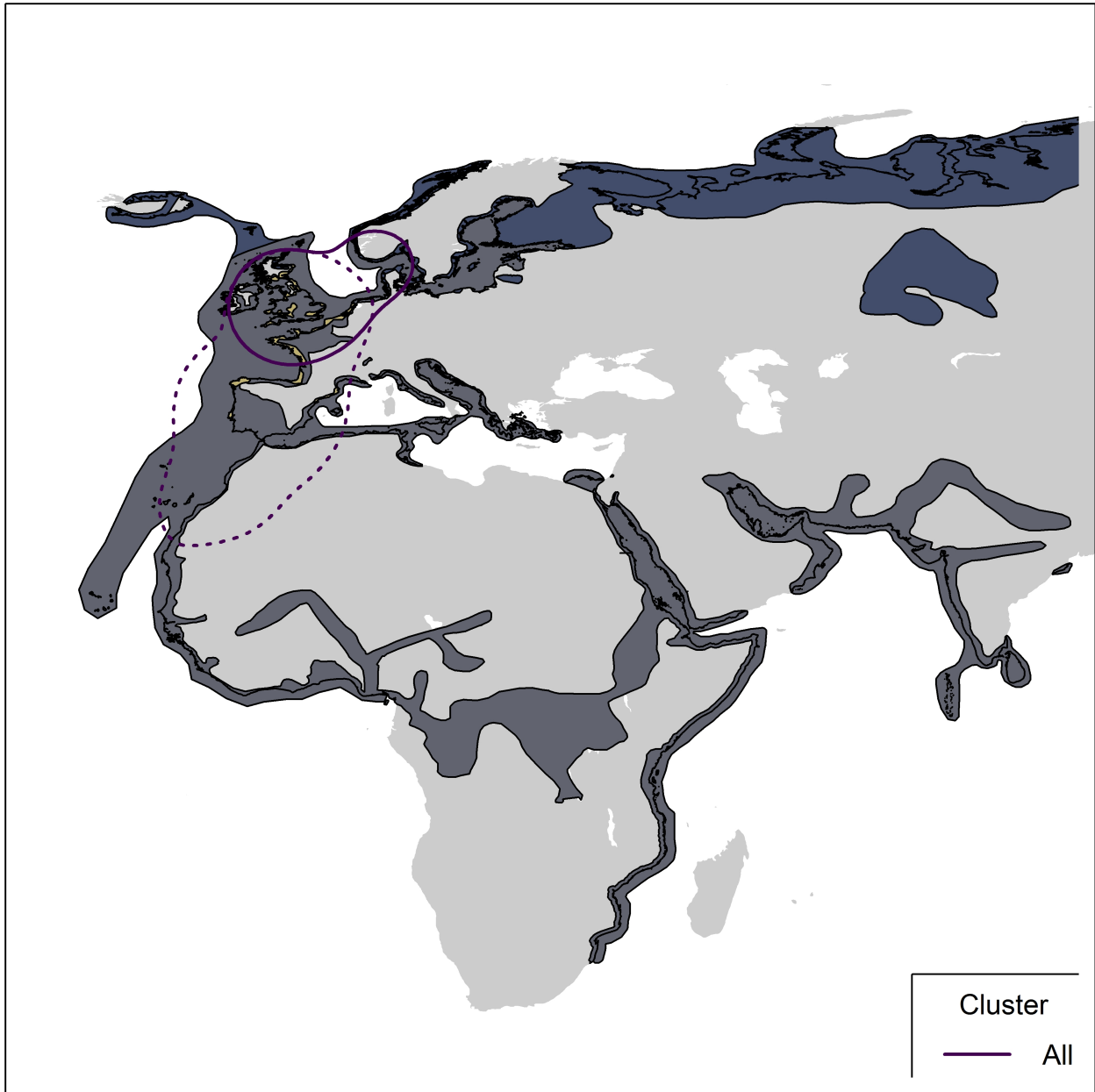| Cluster name | Level of clustering | N individuals | Migratory connectivity ($r_M$) | p-value | Lower 95% confidence limit | Upper 95% confidence limit | Best number of clusters | oasw |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 5015 | 0.264 | 0.001 | 0.226 | 0.301 | 2 | 0.482 |

**Figure 05910-1.** Map showing 95% kernel contours of of first-level clusters identified by the migratory connectivity analysis, if any, or 95% kernel contours of all encounters, in case of no clustering structure. Solid lines indicate the clusters in the breeding range, dotted lines those in the non-breeding range. Different contour colours correspond to different clusters, as reported in legend. The species distribution range is also shown (breeding range: blue; non-breeding range: dark grey; resident range: beige; from BirdLife International, 2019).

## 1.2 Sensitivity analysis

Results of power analysis and validation. Analyses at the species level were re-run on subsamples of individuals of decreasing size (100 repetitions per subsample size), according to simple random sampling of individuals (Figure 05910-2) and stratified sampling of individuals within the breeding range (Figure 05910-3) and the non breeding range (Figure 05910-4). For stratified sampling, we selected individuals with a

probability inversely proportional to the number of observation in each country. Figures below report the results of the procedure.
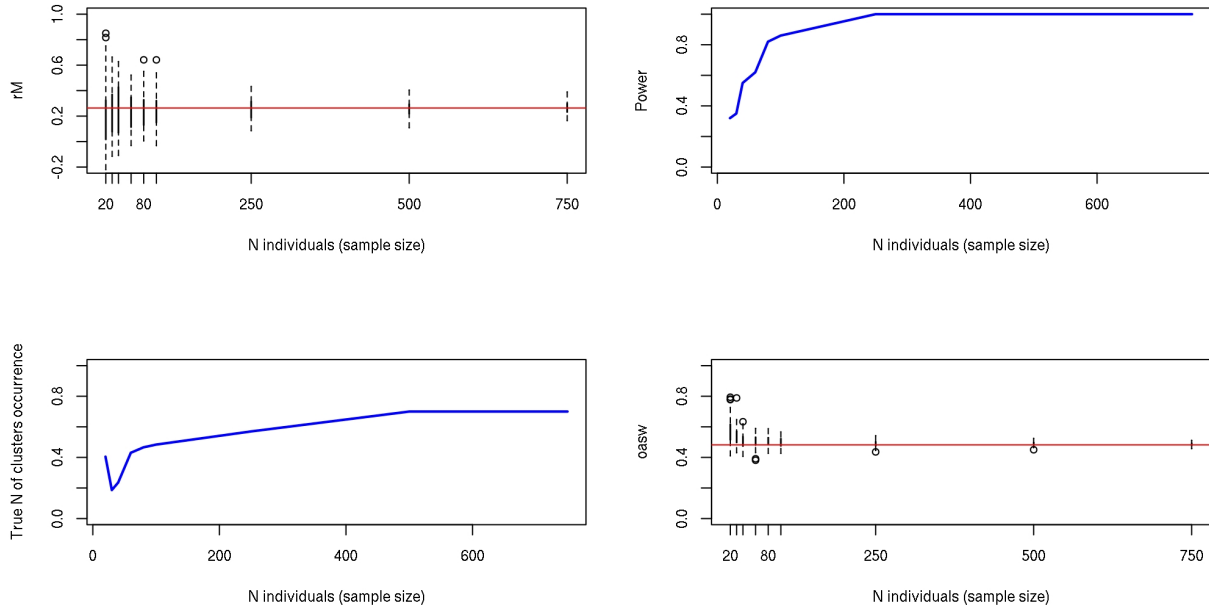


**Figure 05910-2.** Top left: simulated distribution (boxplots) and observed value (red line) of connectivity. Top right: Simulated power of the analysis (i.e. proportion of times the analyses on the subset of individuals was significant). Bottom left: Proportion of times the analysis provides the observed best number of cluster. Bottom right: simulated distribution (boxplots) and observed value (red line) of clustering intensity.
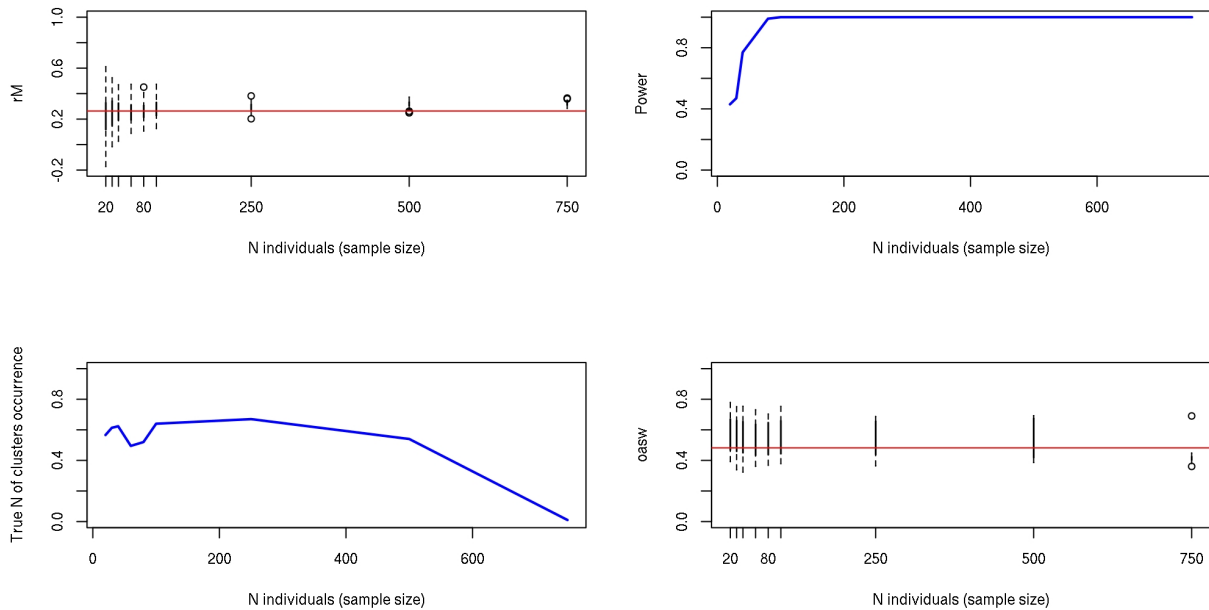


**Figure 05910-3.** Top left: simulated distribution (boxplots) and observed value (red line) of connectivity. Top right: Simulated power of the analysis. Bottom left: Proportion of times the analysis provides the

observed best number of cluster. Bottom right: simulated distribution (boxplots) and observed value (red line) of clustering intensity.



**Figure 05910-4.** Top left: simulated distribution (boxplots) and observed value (red line) of connectivity. Top right: Simulated power of the analysis. Bottom left: Proportion of times the analysis provides the observed best number of cluster. Bottom right: simulated distribution (boxplots) and observed value (red line) of clustering intensity.
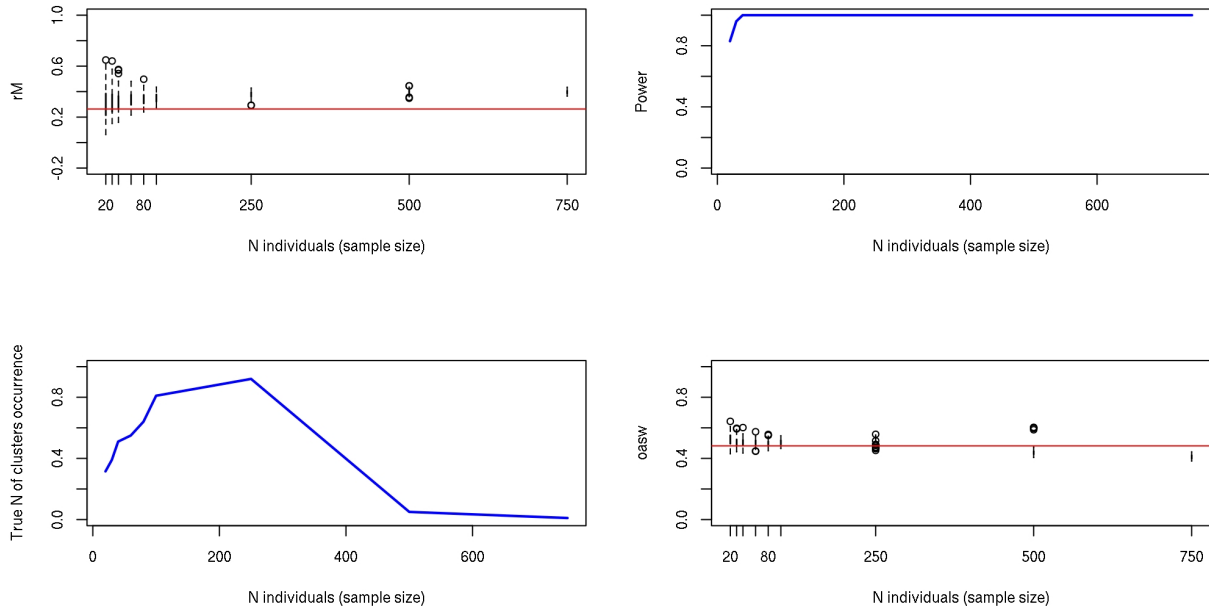
The comparison between the bootstrapped distribution of $r_M$ values from live recaptures and dead recoveries is significant (p = 0.003); Figure 05910-5).
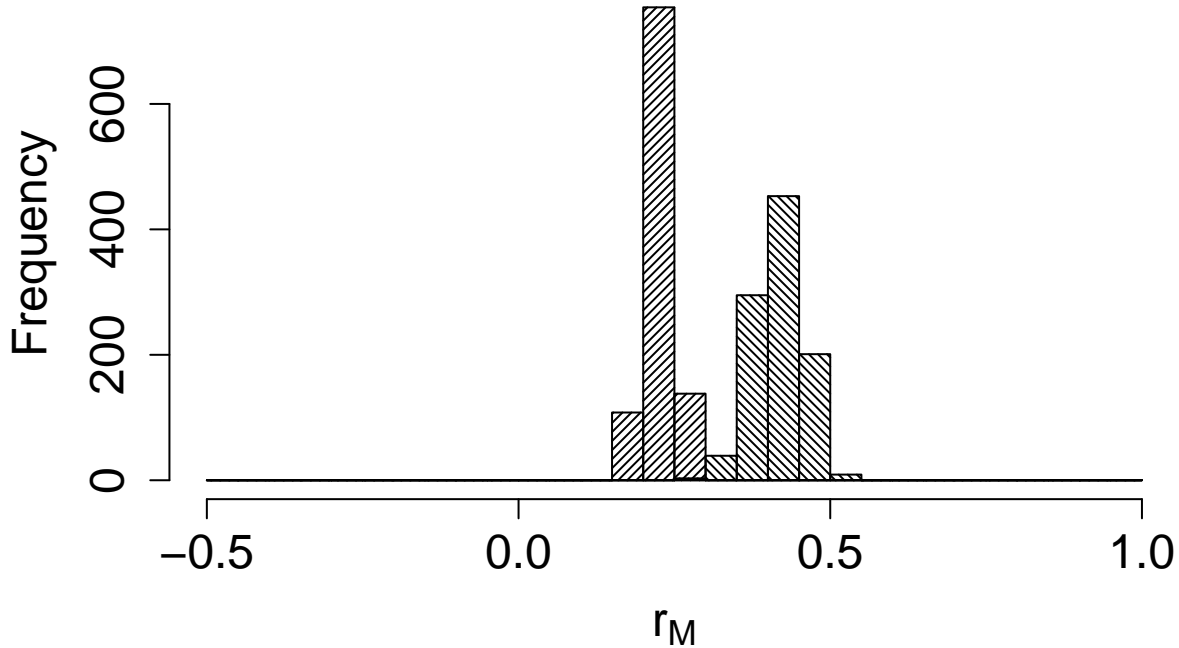
**Figure 05910-5.** Comparison between the bootstrapped distributions of connectivity value for alive recaptures (filling lines with angle=45°) and dead recoveries (filling lines with angle=375°).

## 2. Connectivity between pre-defined regions

The species shows low connectivity (MC = 0.13; MC = 0.13 when adjusted for absolute abundance) between 5 breeding regions and 13 non breeding regions (Table 05910-2; Figure 05910-6).

**Table 05910-2.** Transition probabilities between pre-defined regions. Estimated abundance (number of individuals) in each breeding region is also reported.

| Breeding region | Abundance | Non breeding region | Transition probability |
|---|---|---|---|
| Central Europe | 78006 | Central Europe | 0.020 |
| Central Europe | 78006 | North Africa | 0.027 |
| Central Europe | 78006 | North-west Europe | 0.095 |
| Central Europe | 78006 | South-central Europe | 0.007 |
| Central Europe | 78006 | South-west Europe | 0.646 |
| Central Europe | 78006 | West Europe | 0.204 |
| North Europe | 179604 | Arabian peninsula | 0.002 |
| North Europe | 179604 | Central Africa | 0.009 |
| North Europe | 179604 | Central Europe | 0.007 |
| North Europe | 179604 | East Africa | 0.021 |
| North Europe | 179604 | East Europe | 0.005 |
| North Europe | 179604 | North Africa | 0.337 |
| North Europe | 179604 | North Europe | 0.051 |

| Breeding region | Abundance | Non breeding region | Transition probability |
|---|---:|---|---:|
| North Europe | 179604 | North-west Europe | 0.030 |
| North Europe | 179604 | South-central Europe | 0.027 |
| North Europe | 179604 | South-east Europe | 0.001 |
| North Europe | 179604 | South-west Europe | 0.404 |
| North Europe | 179604 | West Africa | 0.052 |
| North Europe | 179604 | West Europe | 0.052 |
| North-west Europe | 318478 | North Africa | 0.136 |
| North-west Europe | 318478 | North-west Europe | 0.325 |
| North-west Europe | 318478 | South-west Europe | 0.479 |
| North-west Europe | 318478 | West Africa | 0.010 |
| North-west Europe | 318478 | West Europe | 0.049 |
| South-west Europe | 2875 | South-west Europe | 1.000 |
| West Europe | 258589 | North Africa | 0.075 |
| West Europe | 258589 | North-west Europe | 0.105 |
| West Europe | 258589 | South-west Europe | 0.615 |
| West Europe | 258589 | West Europe | 0.204 |
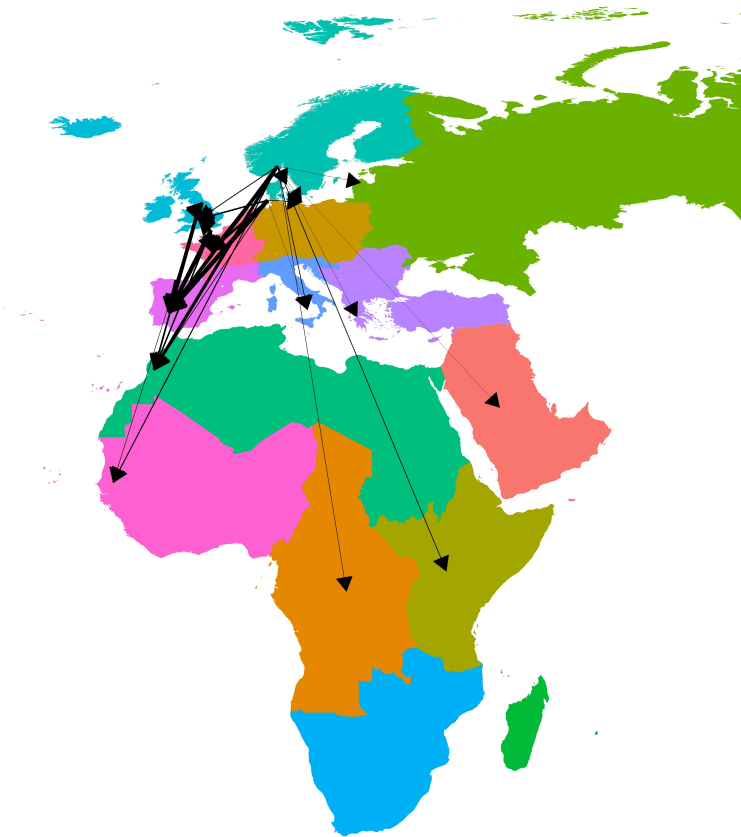


**Figure 05910-6.** Map showing pre-defined regions in different colours, with black arrows linking centroids of individual encounters in different regions. Arrow width is proportional to transition probability.

# Reference

BirdLife International and Handbook of the Birds of the World (2019). Bird species distribution maps of the world. Version 2019.1. Available at http://datazone.birdlife.org/species/requestdis.