Biogeographic patterns of modern benthic shallow-water molluscs and the roles of temperature and palaeogeographic legacy

Supplementary Information 1

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Methods

Choice of grid size

Various different grid sizes are being used in biogeography studies. Costello *et al.* [1] used an approach with 5° c-squares, representing an edge length of ca. 550 km. Kocsis *et al.* [2] applied a hexagonal grid with a cell area of approximately 65,000 km², roughly equivalent to our 250 km square grid. To find an optimal grid size we performed preliminary tests. We found that a coarse grid, such as the one applied by Costello *et al.* [1], limits the level of detail that can be inferred; smaller biogeographic units may simply be overlooked. Also, it severely impacts the resolution of the analyses on the relationship between biogeographic structure and temperature and ocean currents, and accordingly, the possible interpretations. Moreover, in a coarser grid, many a cell would include more than one geographic realm (e.g., at the Strait of Gibraltar or the Isthmus of Panama).

On the other hand, a too high resolution causes many grid cells to lack data, or causes broadly sympatric species to occur in adjacent but distinct cells. For example, using a 100 x 100 km grid on our species dataset would result in 40.1% of the cells having no data. To some extent, this may be a result of excluding records with too high coordinate uncertainties (> 100 km), on the other hand some areas are indeed poorly sampled or are at least not well covered by OBIS and GBIF; some cells may only have records on genus or family level.

Our choice of 250 x 250 km (62,500 km²) is an intermediate solution, with fewer than 10% of the cells missing data (9.8%) while maintaining a sufficient resolution to reconstruct biogeographic units and make inferences about the relationship with temperature and ocean circulation patterns.

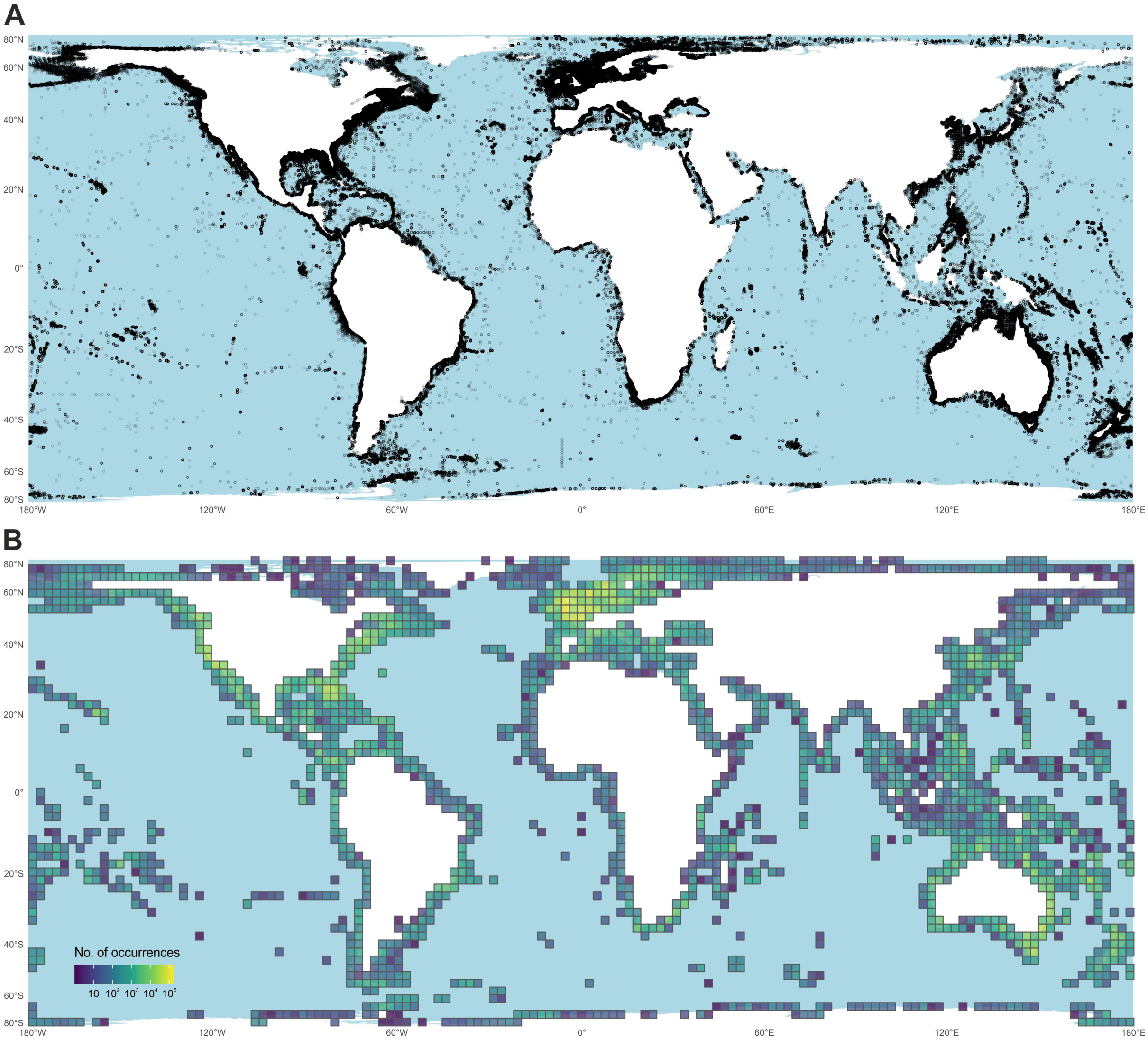

Figure S1. Combined occurrence dataset of 3,189,399 records of marine benthic shallow-water Mollusca stored in GBIF [3] and OBIS [4], shown as individual points (A) as well as a heat map giving the log-transformed number of occurrences per grid cell (B). Note the widely discrepant sampling intensities.

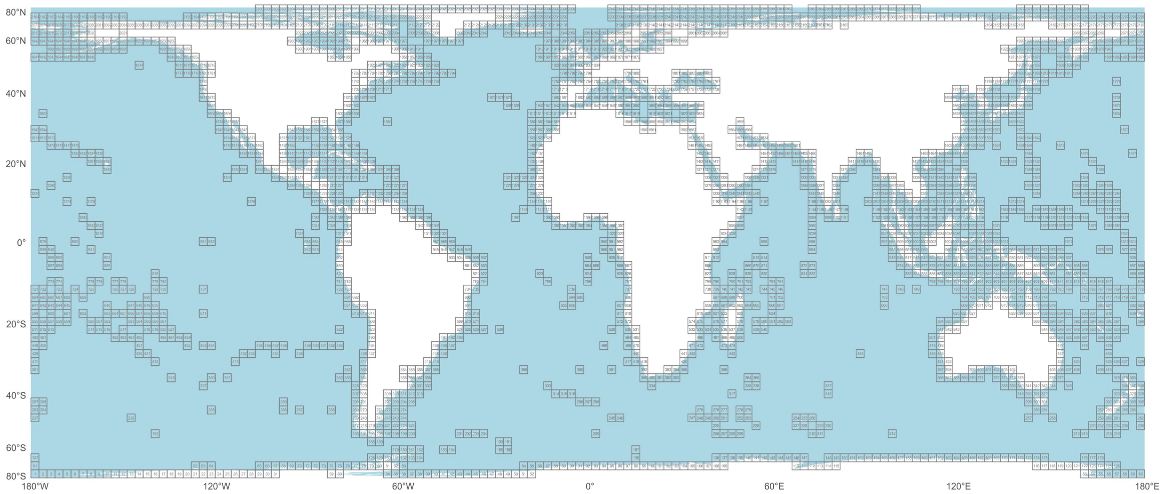

Figure S2. 250 x 250 km grid with cell IDs. Projection: Behrmann (equal-area).

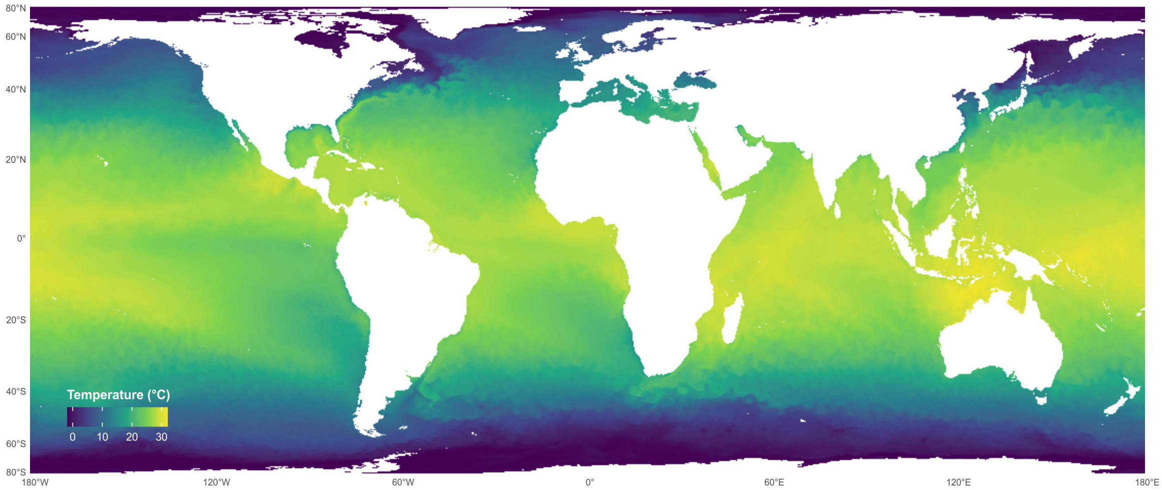

Figure S3. Global sea-surface temperature raster. The map represents the mean of monthly rasters from July 2002 to December 2019 at a spatial resolution of 0.041° [5].

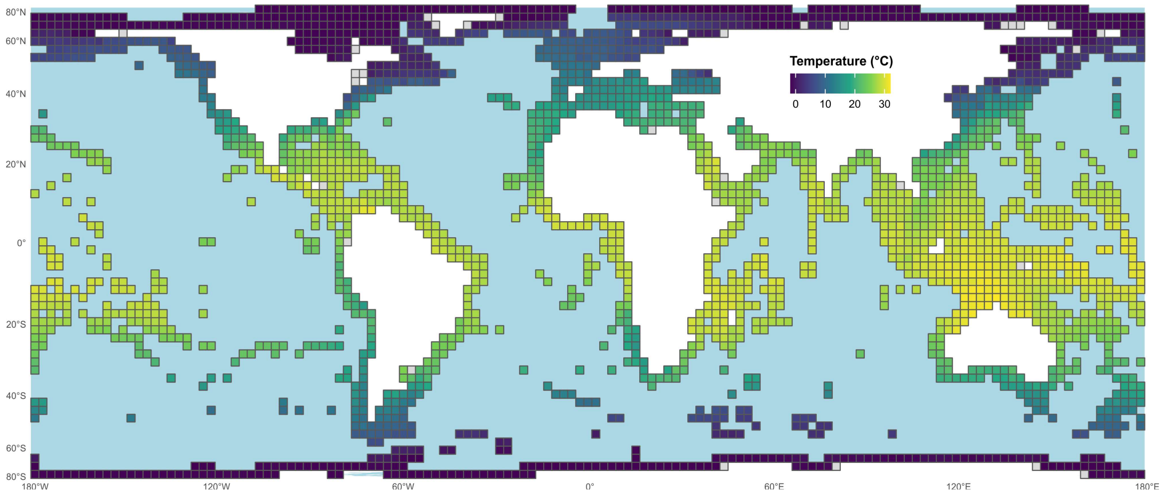

Figure S4. Mean global sea-surface temperatures for each grid cell used in this study. The underlying temperature data is the aggregated raster data shown in Figure S3.

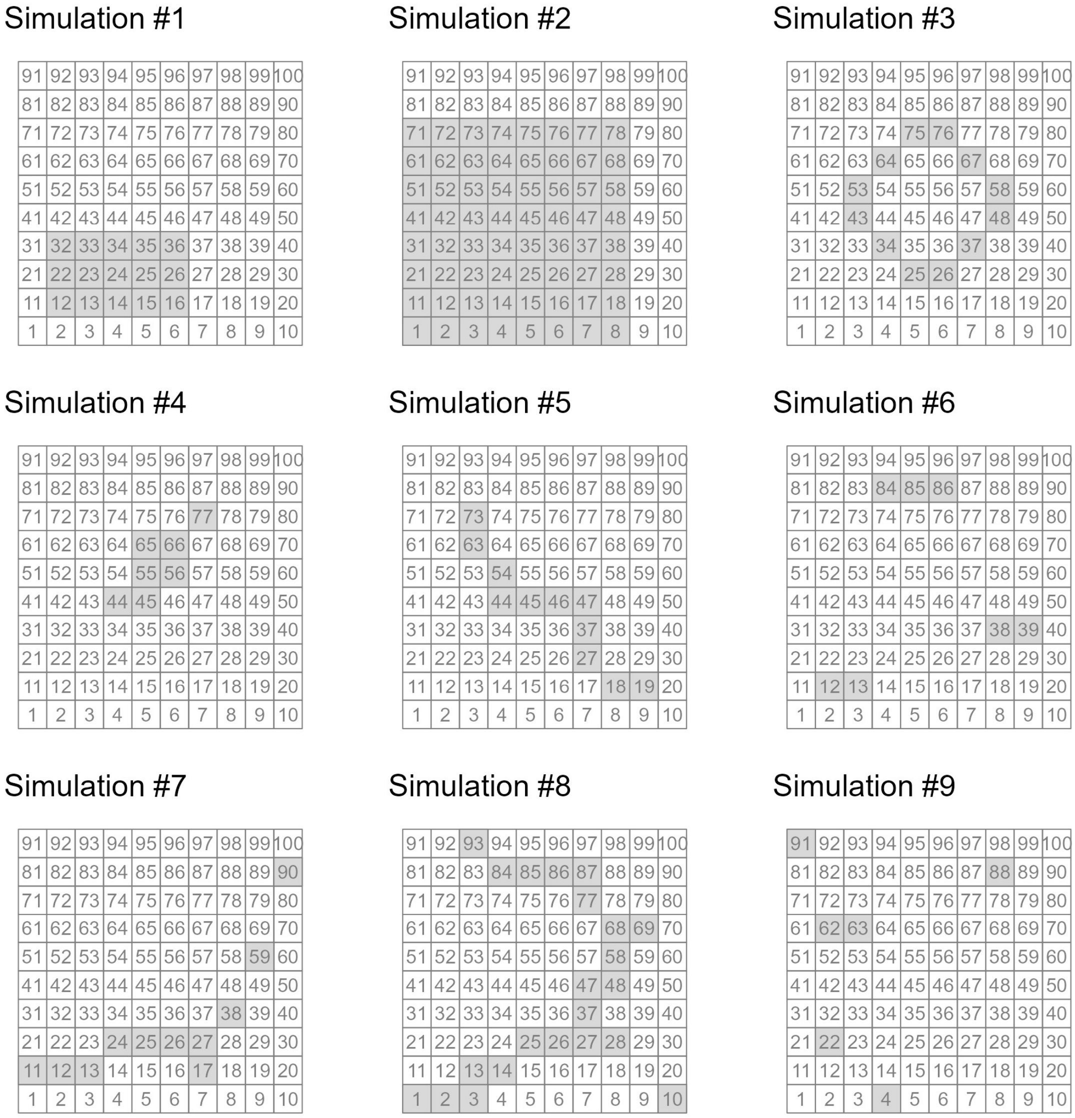

Figure S5. Nine hypothetical cluster arrangements for which I_{CC} was computed across various cell sizes (Figure S6). Simulations were created to cover a wide range of theoretical shapes and sizes of clusters, matching biogeographic regions along coastlines (with and without outliers), within inland seas or those combining several islands.

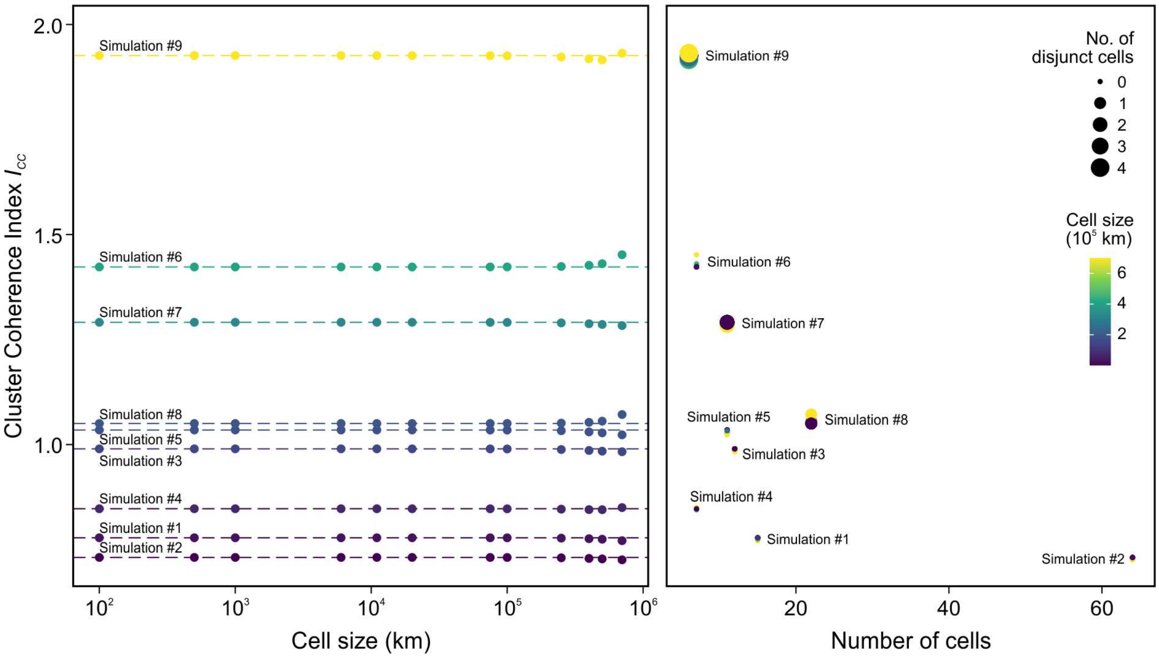

Figure S6. Outcome of the simulations of I_{CC} for the nine hypothetical cluster arrangements (Figure S5). A. Impact of cell size on I_{CC}. The index remains constant for most cell sizes, only above an edge length of 10^5 km values depart significantly. Dashed lines indicate the median values across cell sizes. B. Impact of number of cells per cluster on I_{CC}. A higher number of cells decreases the index, corresponding to the likelihood that a cluster is robust. In turn, a higher number of disjunct cells (i.e., single cells without neighboring cells of the same cluster) increases I_{CC}.

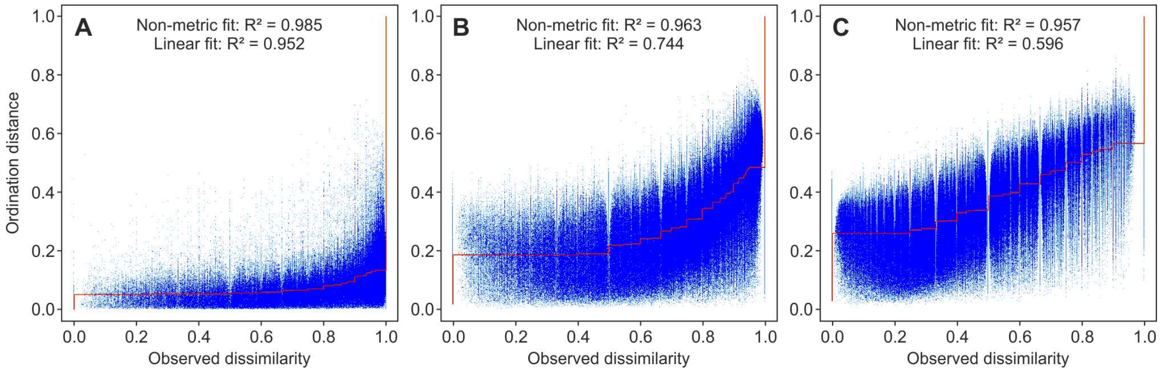

Figure S7. Stress plots for the non-metric Multidimensional Scalings (nMDS) of species (A), genera (B), and families (C).

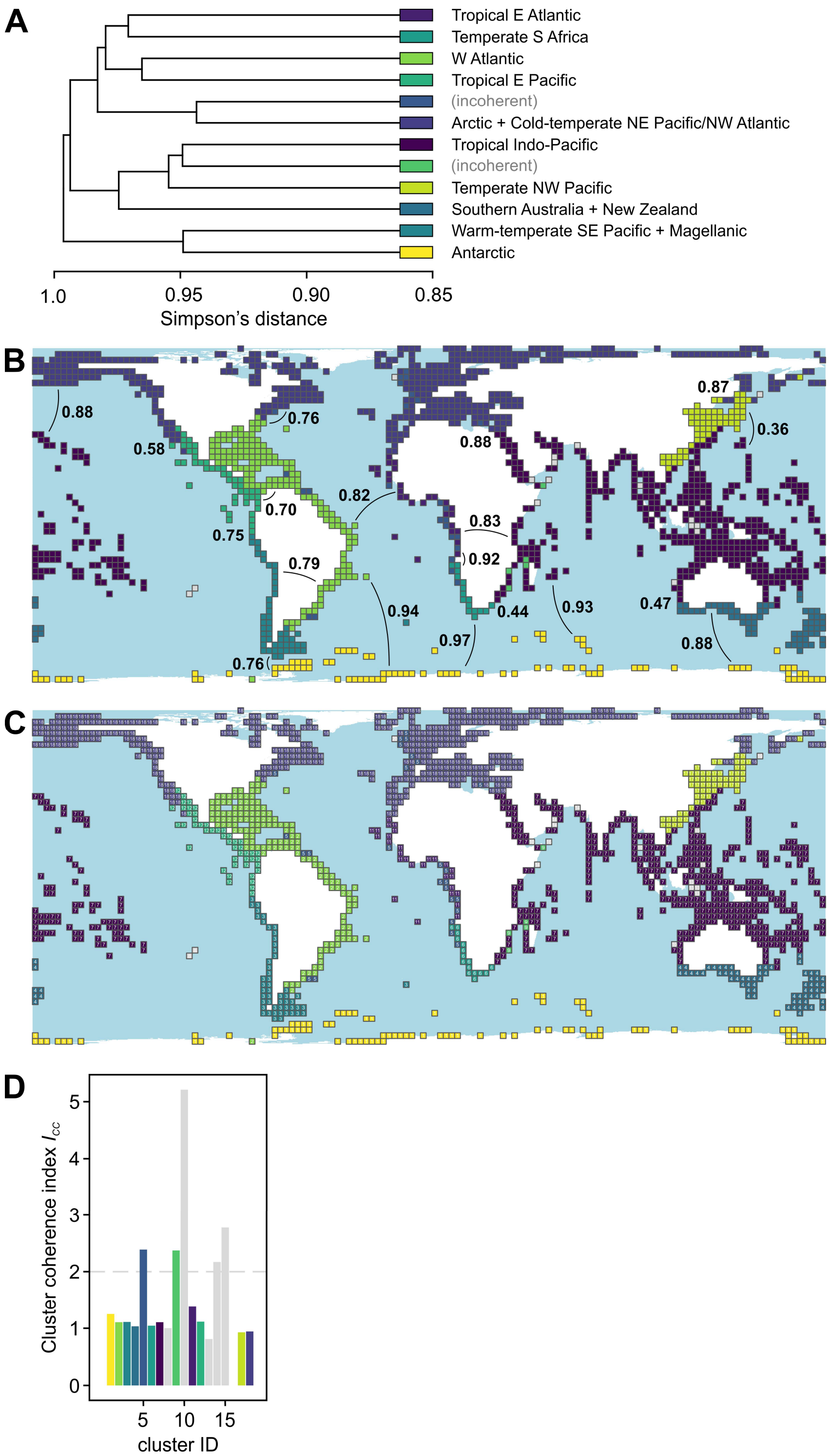

Figure S8. Supporting results of the cluster analyses for species-level data, at a Simpson's distance cut-off of 0.94. **A.** Simplified cluster dendrograms. Names of biogeographic units were chosen to match Spalding *et al.* [6] as closely as possible. Clusters found to be incoherent according to the Cluster Coherence Index I_{CC} (D) are marked gray. **B.** Distribution of clusters on the global map. Numbers on the map refer to Simpson's distances among adjacent clusters. **C.** Cluster map as in (B) but with indication of cluster IDs, for reference to (D). **D.** Cluster Coherence Index I_{CC} for each cluster. Cluster IDs as in (C); incoherent clusters marked gray. Grid and projection as in Figure 1.

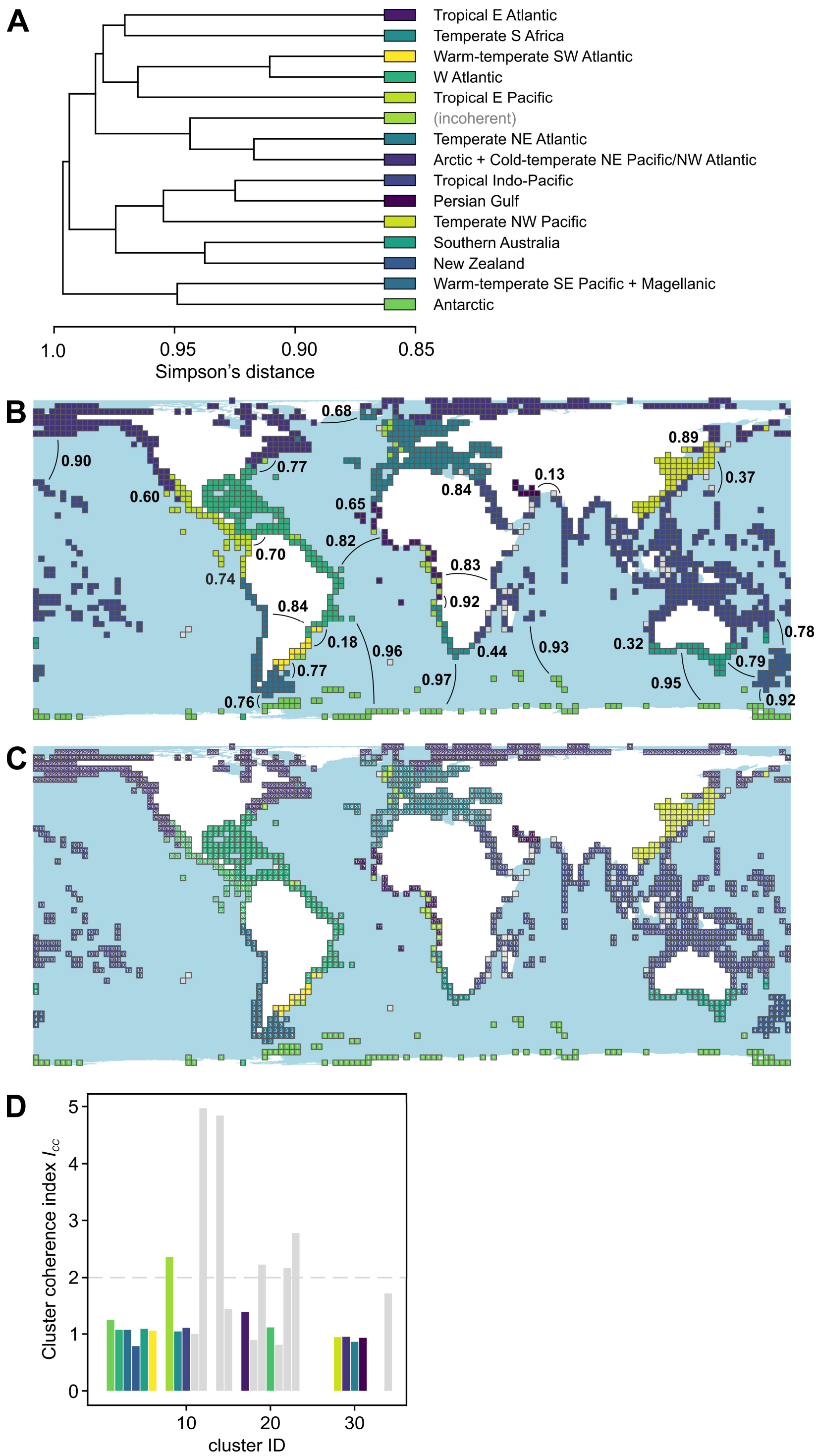

Figure S9. Supporting results of the cluster analyses for species-level data, at a Simpson's distance cut-off of 0.90. For details see Figure S8.

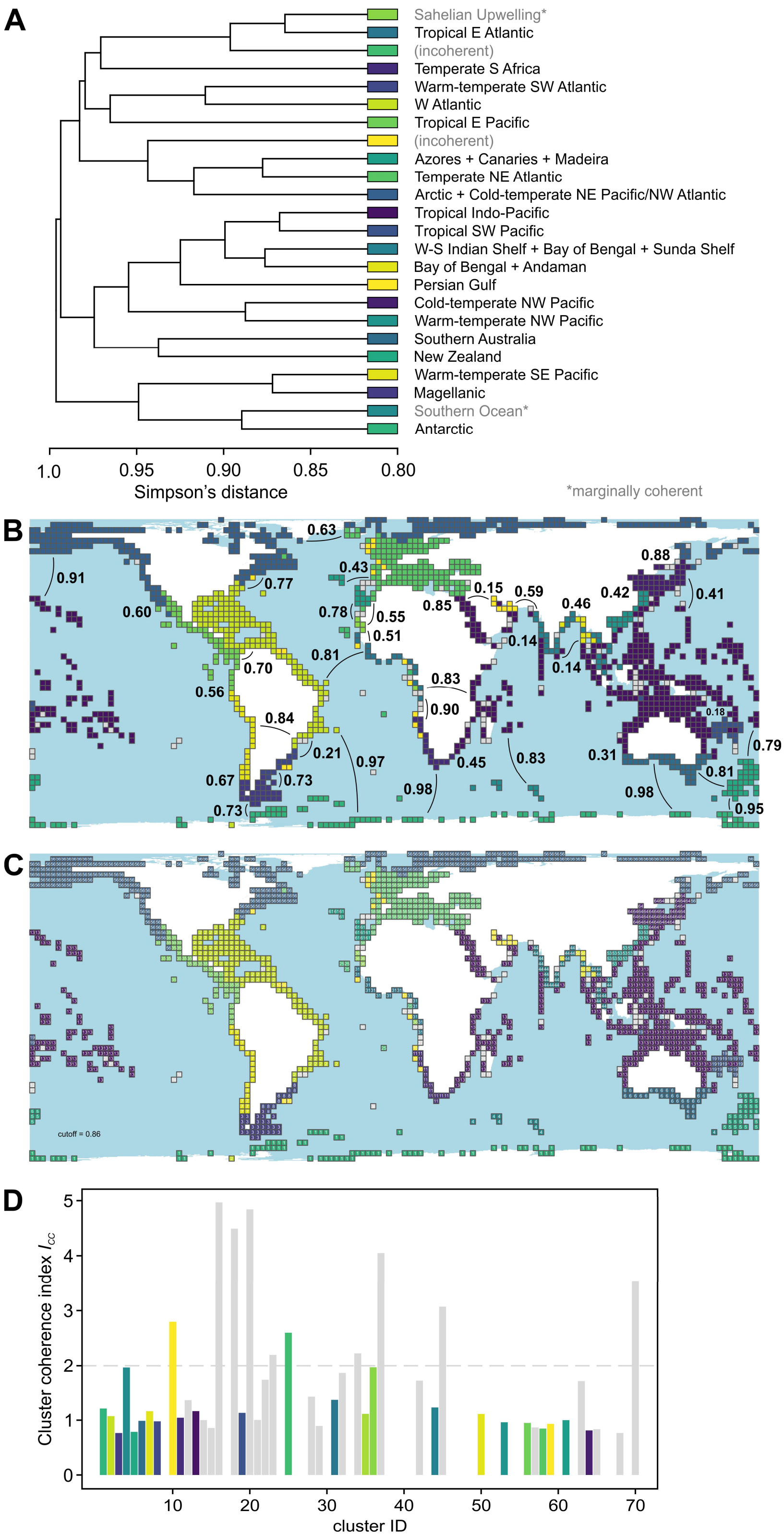

Figure S10. Supporting results of the cluster analyses for species-level data, at a Simpson's distance cut-off of 0.86. For details see Figure S8.

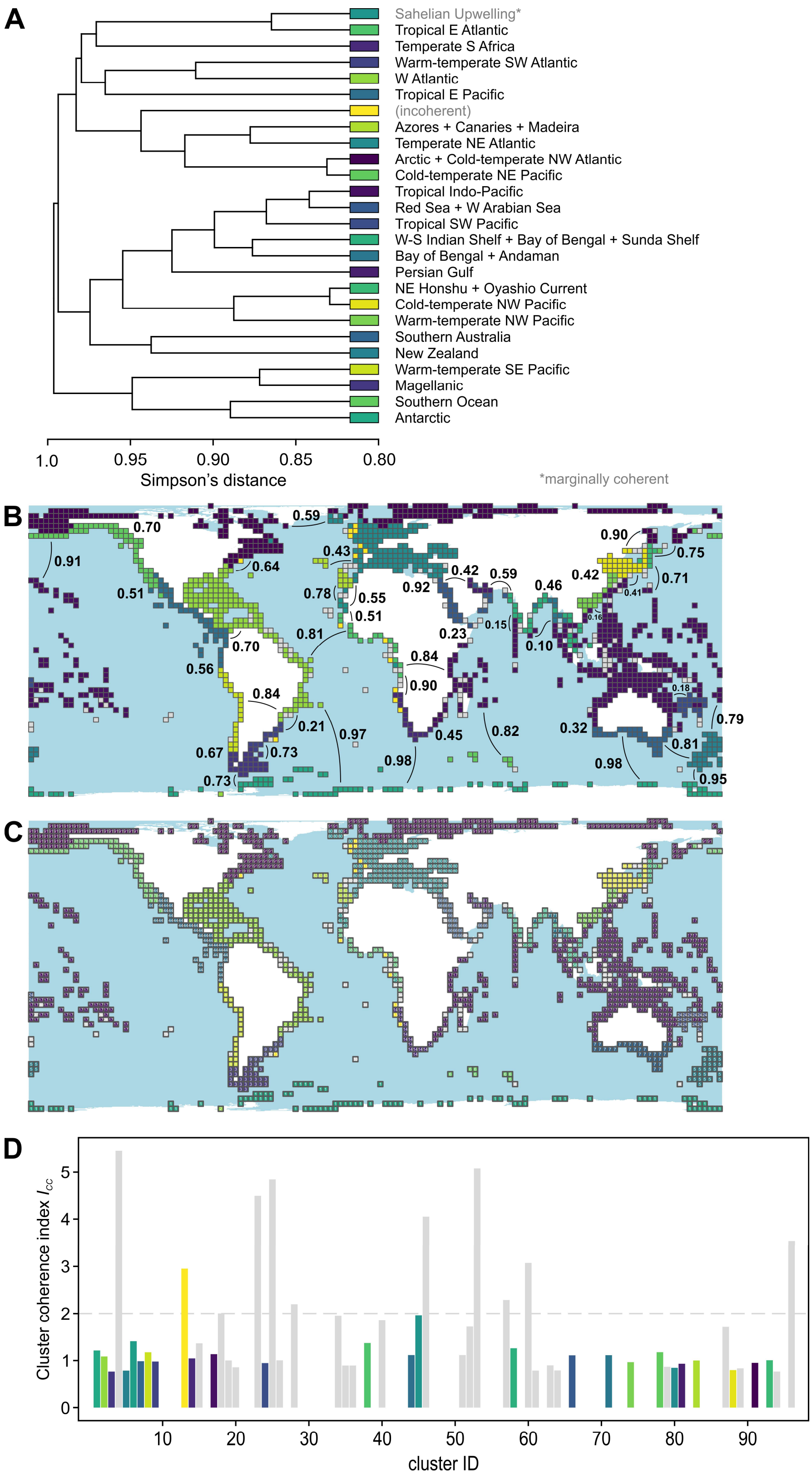

Figure S11. Supporting results of the cluster analyses for species-level data, at a Simpson's distance cut-off of 0.82. For details see Figure S8.

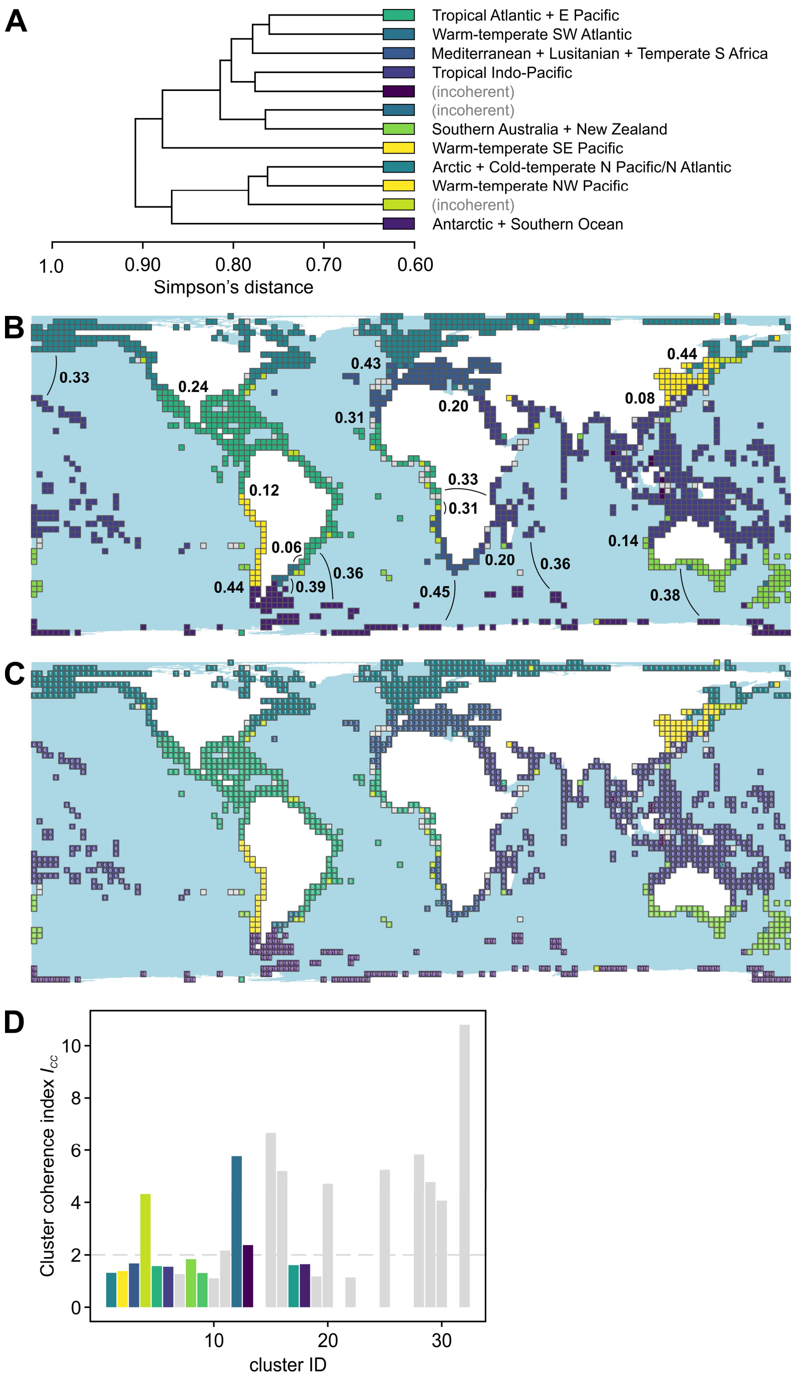

Figure S12. Supporting results of the cluster analyses for genus-level data, at a Simpson's distance cut-off of 0.75. For details see Figure S8.

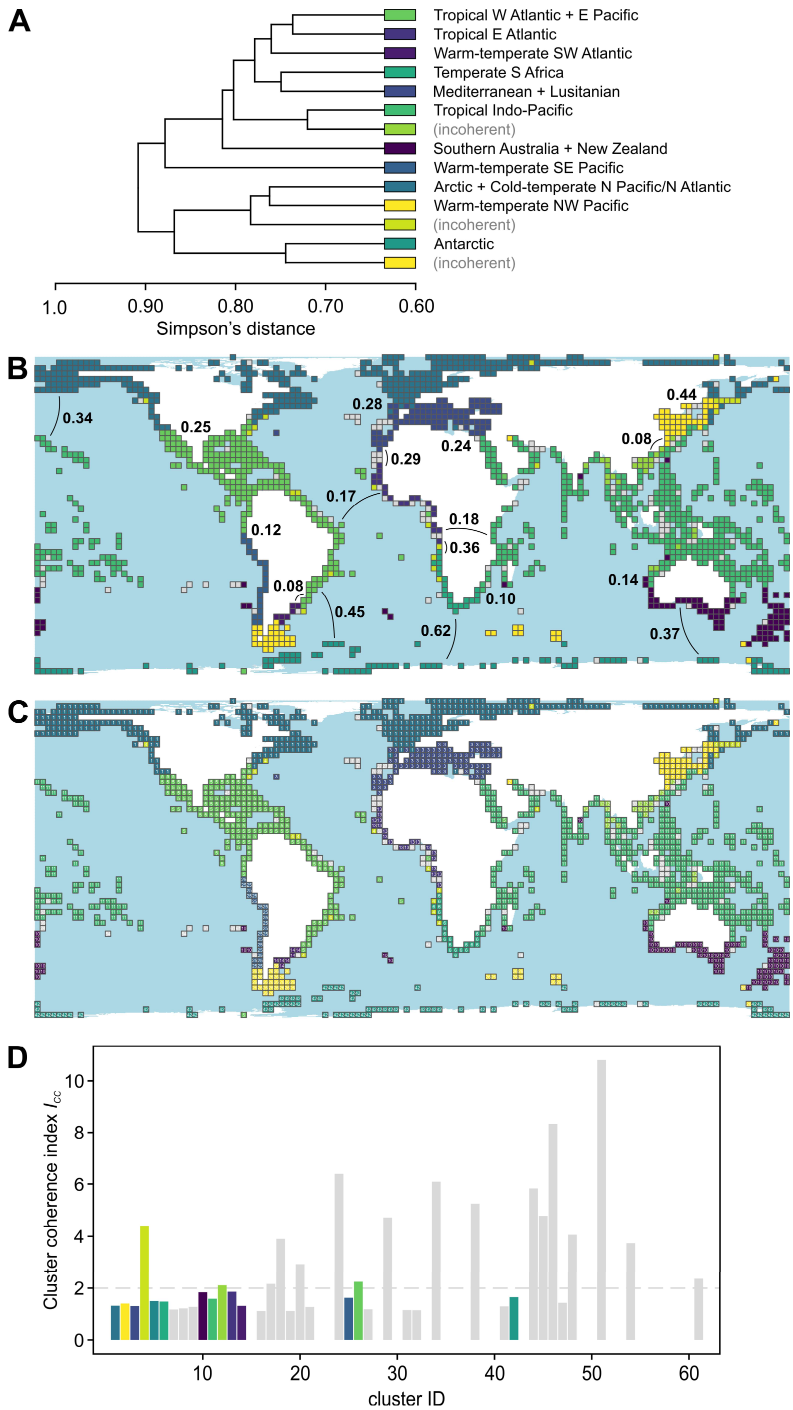

Figure S13. Supporting results of the cluster analyses for genus-level data, at a Simpson's distance cut-off of 0.71. For details see Figure S8.

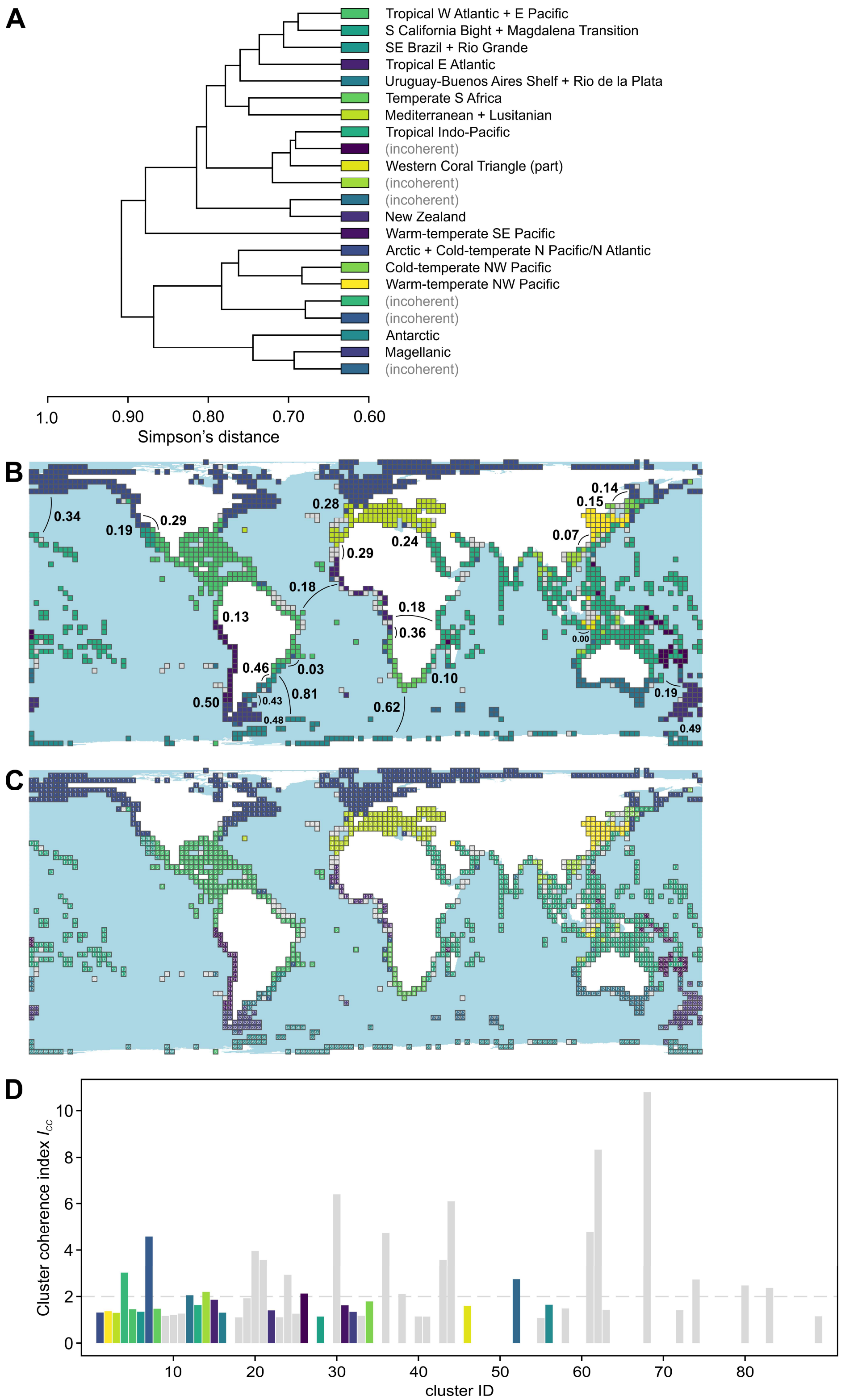

Figure S14. Supporting results of the cluster analyses for genus-level data, at a Simpson's distance cut-off of 0.67. For details see Figure S8.

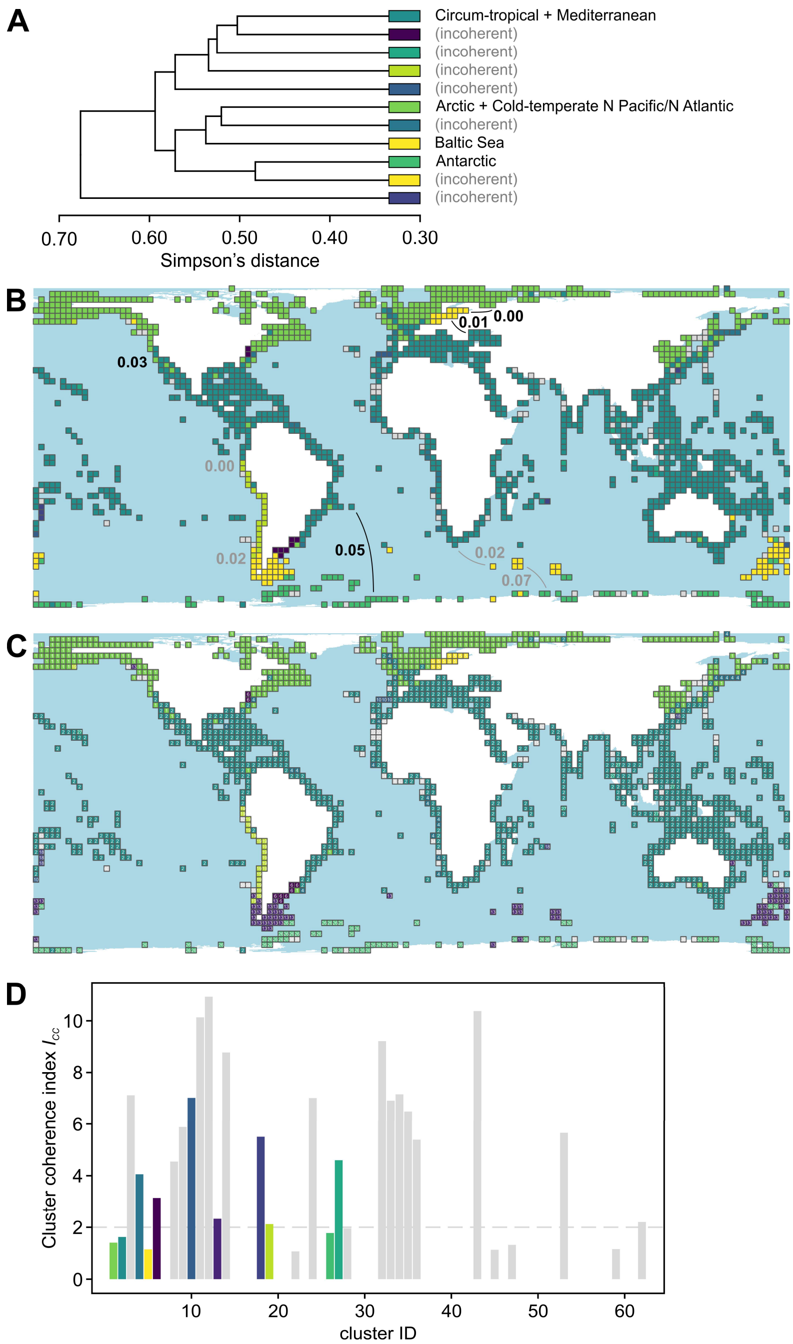

Figure S15. Supporting results of the cluster analyses for family-level data, at a Simpson's distance cut-off of 0.48. For details see Figure S8.

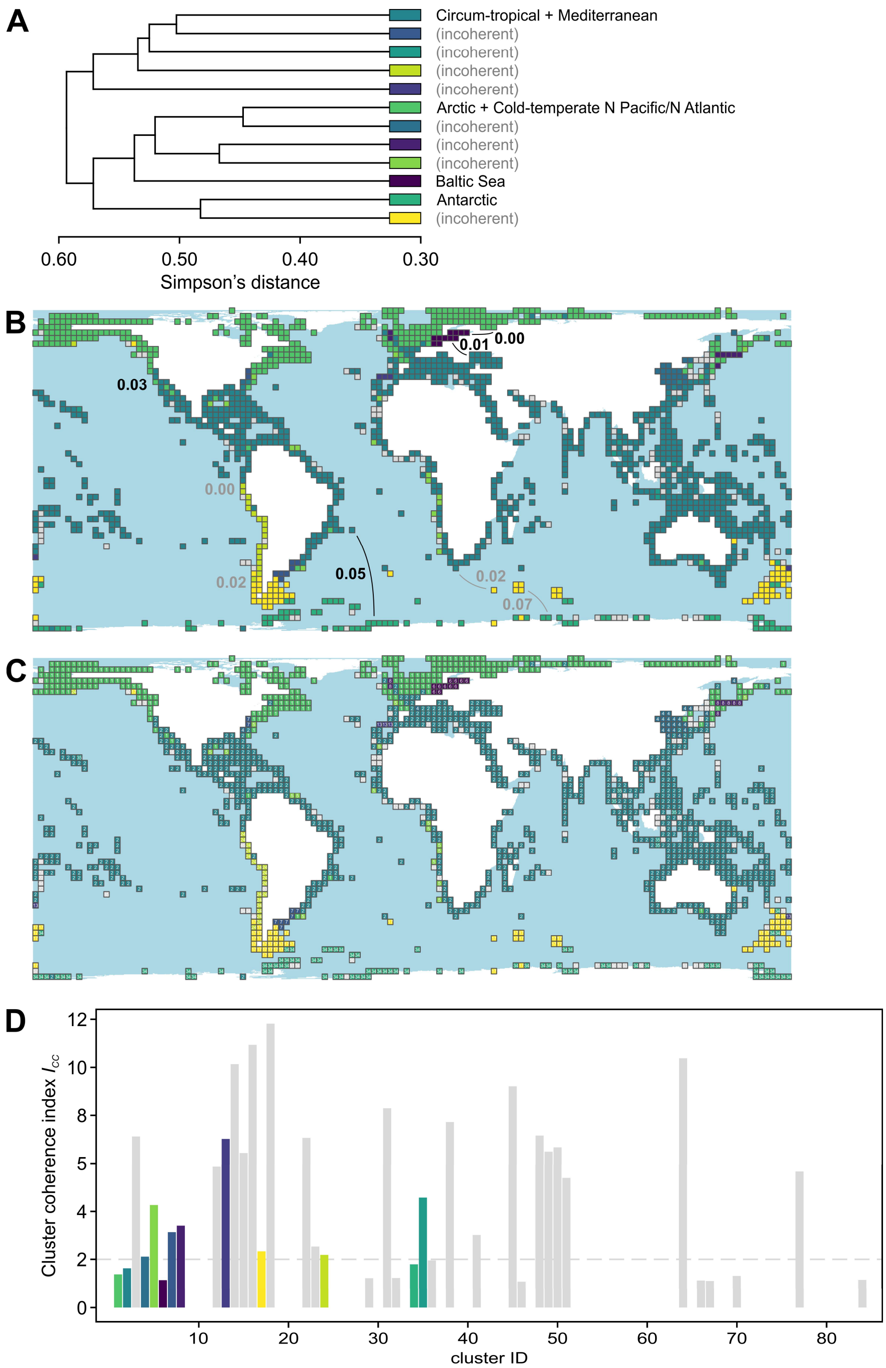

Figure S16. Supporting results of the cluster analyses for family-level data, at a Simpson's distance cut-off of 0.44. For details see Figure S8.

Table S1. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (species data, cut-off: 0.94).

Biogeographic unit	Cluster ID	No. endemics	No. species total	Endemism %
Antarctic	1	495	794	62.3
W Atlantic	2	2751	5187	53.0
Warm-temperate SE Pacific + Magellanic	3	353	944	37.4
New Zealand + Southern Australia	4	2328	5278	44.1
(incoherent)	5	163	1068	15.3
Temperate S Africa	6	580	1598	36.3
Tropical Indo-Pacific	7	8383	14260	58.8
(incoherent)	9	25	153	16.3
Tropical E Atlantic	11	422	946	44.6
Tropical E Pacific	12	1382	4030	34.3
Temperate NW Pacific	17	1057	3846	27.5
Arctic + Cold-temperate NE Pacific/NW Atlantic	18	2639	6155	42.9

Table S2. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (species data, cut-off: 0.90).

Biogeographic region	**Cluster ID**	**No. endemics**	**No. species total**	**Endemism %**
Antarctic	1	495	794	62.3
W Atlantic	2	2518	5090	49.5
Warm-temperate SE Pacific + Magellanic	3	347	935	37.1
New Zealand	4	1182	1752	67.5
Southern Australia	5	1060	3899	27.2
Warm-temperate SW Atlantic	6	33	548	6.0
(incoherent)	8	164	1053	15.6
Temperate S Africa	9	586	1598	36.7
Tropical Indo-Pacific	10	8190	14111	58.0
Tropical E Atlantic	17	422	946	44.6
Tropical E Pacific	20	1383	4030	34.3
Temperate NW Pacific	28	1032	3724	27.7
Arctic + Cold-temperate NE Pacific/NW Atlantic	29	1337	4371	30.6
Temperate NE Atlantic	30	1064	2618	40.6
Persian Gulf	31	56	458	12.2

Table S3. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (species data, cut-off: 0.86). Asterisks mark marginally coherent clusters.

Biogeographic region	Cluster ID	No. endemics	No. species total	Endemism %
Antarctic	1	377	643	58.6
W Atlantic	2	2578	5083	50.7
Magellanic	3	181	604	30.0
Southern Ocean	4	67	265	25.3
New Zealand	5	1203	1752	68.7
Southern Australia	6	995	3642	27.3
Warm-temperate SE Pacific	7	102	492	20.7
Warm-temperate SW Atlantic	8	27	433	6.2
(incoherent)	10	145	947	15.3
Temperate S Africa	11	588	1598	36.8
Tropical Indo-Pacific	13	6202	13364	46.4
Tropical SW Pacific	19	388	2302	16.9
(incoherent)	25	148	304	48.7
Tropical E Atlantic	31	219	580	37.8
Tropical E Pacific	35	1383	4030	34.3
Sahelian Upwelling*	36	31	209	14.8
W-S Indian Shelf + Bay of Bengal + Sunda Shelf	44	166	1865	8.9
Bay of Bengal + Andaman	50	30	600	5.0
Warm-temperate NW Pacific	53	77	1357	5.7
Arctic + Cold-temperate NE Pacific/NW Atlantic	56	1331	4346	30.6
Temperate NE Atlantic	58	743	2227	33.4
Persian Gulf	59	56	458	12.2
Azores + Canaries + Madeira	61	184	721	25.5
Cold-temperate NW Pacific	64	868	3139	27.7

Table S4. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (species data, cut-off: 0.82). Asterisks mark marginally coherent clusters.

Biogeographic region	**Cluster ID**	**No. endemics**	**No. species total**	**Endemism %**
Antarctic	1	389	643	60.5
W Atlantic	2	2598	5066	51.3
Magellanic	3	183	604	30.3
New Zealand	5	1218	1752	69.5
Southern Ocean	6	46	185	24.9
Southern Australia	7	997	3629	27.5
Warm-temperate SE Pacific	8	100	489	20.4
Warm-temperate SW Atlantic	9	27	433	6.2
(incoherent)	13	131	823	15.9
Temperate S Africa	14	589	1598	36.9
Tropical Indo-Pacific	17	5767	12973	44.5
Tropical SW Pacific	24	388	2269	17.1
Tropical E Atlantic	38	237	580	40.9
Tropical E Pacific	44	1384	4030	34.3
Sahelian Upwelling*	45	31	209	14.8
W-S Indian Shelf + Bay of Bengal + Sunda Shelf	58	159	1849	8.6
NE Honshu + Oyashio Current	66	218	1407	15.5
Bay of Bengal + Andaman	71	30	600	5.0
Warm-temperate NW Pacific	74	71	1333	5.3
Cold-temperate NE Pacific	78	868	3021	28.7
Temperate NE Atlantic	80	747	2227	33.5
Persian Gulf	81	57	458	12.4
Azores + Canaries + Madeira	83	189	721	26.2
Cold-temperate NW Pacific	88	710	3013	23.6
Arctic + Cold-temperate NW Atlantic	91	273	1883	14.5
NE Honshu + Oyashio Current	93	62	462	13.4

Table S5. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (genus data, cut-off: 0.75).

Biogeographic region	Cluster ID	No. endemics	No. species total	Endemism %
Arctic + Cold-temperate N Pacific/N Atlantic	1	98	1641	6.0
Warm-temperate NW Pacific	2	14	1248	1.1
Mediterranean + Lusitanian + Temperate S Africa	3	96	1760	5.5
(incoherent)	4	10	701	1.4
Tropical Atlantic + E Pacific	5	272	2301	11.8
Tropical Indo-Pacific	6	450	3046	14.8
Southern Australia + New Zealand	8	144	2021	7.1
Warm-temperate SW Atlantic	9	0	195	0.0
(incoherent)	12	2	394	0.5
(incoherent)	13	1	302	0.3
Warm-temperate SE Pacific	17	7	364	1.9
Antarctic + Southern Ocean	18	86	596	14.4

Table S6. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (genus data, cut-off: 0.71).

Biogeographic region	Cluster ID	No. endemics	No. species total	Endemism %
Arctic + Cold-temperate N Pacific/N Atlantic	1	100	1640	6.1
Warm-temperate NW Pacific	2	15	1245	1.2
Mediterranean + Lusitanian	3	45	1100	4.1
(incoherent)	4	10	665	1.5
Tropical E Atlantic + E Pacific	5	261	2227	11.7
Temperate S Africa	6	45	1196	3.8
Southern Australia + New Zealand	10	163	2021	8.1
Tropical Indo-Pacific	11	422	3015	14.0
(incoherent)	12	4	843	0.5
Tropical E Atlantic	13	15	422	3.6
Warm-temperate SW Atlantic	14	0	195	0.0
Warm-temperate SE Pacific	25	7	361	1.9
(incoherent)	26	22	453	4.9
Antarctic	42	41	342	12.0

Table S7. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (genus data, cut-off: 0.67).

Biogeographic region	Cluster ID	No. endemics	No. species total	Endemism %
Arctic + Cold-temperate N Pacific/N Atlantic	1	101	1640	6.2
Warm-temperate NW Pacific	2	13	1195	1.1
Mediterranean + Lusitanian	3	45	1097	4.1
(incoherent)	4	5	155	3.2
Tropical E Atlantic + E Pacific	5	193	2133	9.0
SE Brazil + Rio Grande	6	1	315	0.3
(incoherent)	7	3	591	0.5
Temperate S Africa	8	45	1196	3.8
(incoherent)	12	65	1758	3.7
Tropical Indo-Pacific	13	321	2985	10.8
(incoherent)	14	4	821	0.5
Tropical E Atlantic	15	15	422	3.6
Uruguay-Buenos Aires Shelf + Rio de la Plata	16	0	195	0.0
New Zealand	22	74	960	7.7
(incoherent)	26	8	1012	0.8
S California Bight + Magdalena Transition	28	3	851	0.4
Warm-temperate SE Pacific	31	7	361	1.9
Magellanic	32	19	398	4.8
Cold-temperate NW Pacific	34	2	343	0.6
Western Coral Triangle (part)	46	0	250	0.0
(incoherent)	52	3	169	1.8
Antarctic	56	41	342	12.0

Table S8. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (family data, cut-off: 0.48).

Biogeographic region	**Cluster ID**	**No. endemics**	**No. species total**	**Endemism %**
Arctic + Cold-temperate N Pacific/N Atlantic	1	8	434	1.8
Circum-tropical + Mediterranean	2	42	498	8.4
(incoherent)	4	0	266	0.0
Baltic Sea	5	0	132	0.0
(incoherent)	6	0	128	0.0
(incoherent)	10	0	156	0.0
(incoherent)	13	1	377	0.3
(incoherent)	18	0	126	0.0
(incoherent)	19	0	171	0.0
Antarctica	26	6	287	2.1
(incoherent)	27	0	148	0.0

Table S9. Number of species and degree of endemism per biogeographic unit resulting from the cluster analysis (family data, cut-off: 0.44).

Biogeographic region	Cluster ID	No. endemics	No. species total	Endemism %
Arctic + Cold-temperate N Pacific/N Atlantic	1	8	430	1.9
Circum-tropical + Mediterranean	2	44	498	8.8
(incoherent)	4	0	255	0.0
(incoherent)	5	0	246	0.0
Baltic Sea	6	0	132	0.0
(incoherent)	7	0	128	0.0
(incoherent)	8	0	119	0.0
(incoherent)	13	0	156	0.0
(incoherent)	17	1	377	0.3
(incoherent)	24	0	169	0.0
Antarctica	34	6	286	2.1
(incoherent)	35	0	145	0.0

Table S10. Simpson's distances among all clusters resulting from the cluster analysis of species data (cut-off: 0.94).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.937
1	3	0.757
1	4	0.882
1	5	0.965
1	6	0.967
1	7	0.928
1	9	0.98
1	11	0.99
1	12	0.979
1	17	0.962
1	18	0.95
2	3	0.787
2	4	0.958
2	5	0.626
2	6	0.919
2	7	0.874
2	9	0.908
2	11	0.821
2	12	0.702
2	17	0.932
2	18	0.761
3	4	0.93
3	5	0.952
3	6	0.968
3	7	0.921
3	9	0.993
3	11	0.986
3	12	0.746
3	17	0.961
3	18	0.792
4	5	0.957
4	6	0.85
4	7	0.473
4	9	0.784
4	11	0.95
4	12	0.96
4	17	0.812
4	18	0.956
5	6	0.934
5	7	0.895
5	9	0.967
5	11	0.785
5	12	0.9
5	17	0.945
5	18	0.351
6	7	0.443
6	9	0.804
6	11	0.918
6	12	0.937
6	17	0.838
6	18	0.88
7	9	0.203
7	11	0.828
7	12	0.866
7	17	0.363
7	18	0.885
9	11	0.954
9	12	0.974
9	17	0.693
9	18	0.922
11	12	0.921
11	17	0.937
11	18	0.63
12	17	0.939
12	18	0.581
17	18	0.867

Table S11. Simpson's distances among all clusters resulting from the cluster analysis of species data (cut-off: 0.90).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.962
1	3	0.757
1	4	0.917
1	5	0.946
1	6	0.953
1	8	0.966
1	9	0.967
1	10	0.928
1	17	0.99
1	20	0.979
1	28	0.965
1	29	0.957
1	30	0.966
1	31	0.989
2	3	0.842
2	4	0.956
2	5	0.954
2	6	0.177
2	8	0.632
2	9	0.922
2	10	0.874
2	17	0.822
2	20	0.703
2	28	0.932
2	29	0.771
2	30	0.805
2	31	0.919
3	4	0.944
3	5	0.968
3	6	0.772
3	8	0.953
3	9	0.97
3	10	0.921
3	17	0.986
3	20	0.743
3	28	0.96
3	29	0.807
3	30	0.947
3	31	0.998
4	5	0.787
4	6	0.964
4	8	0.977
4	9	0.955
4	10	0.785
4	17	0.979
4	20	0.969
4	28	0.929
4	29	0.969
4	30	0.963
4	31	0.956
5	6	0.971
5	8	0.97
5	9	0.86
5	10	0.315
5	17	0.956
5	20	0.963
5	28	0.819
5	29	0.974
5	30	0.947
5	31	0.736
6	8	0.894
6	9	0.962
6	10	0.892
6	17	0.951
6	20	0.792
6	28	0.958
6	29	0.812
6	30	0.892
6	31	0.996
8	9	0.934
8	10	0.9
8	17	0.785
8	20	0.9
8	28	0.946
8	29	0.537
8	30	0.464
8	31	0.991
9	10	0.445
9	17	0.918
9	20	0.937
9	28	0.842
9	29	0.936
9	30	0.897
9	31	0.852
10	17	0.83
10	20	0.867
10	28	0.368
10	29	0.904
10	30	0.843
10	31	0.131
17	20	0.921
17	28	0.939
17	29	0.864
17	30	0.654
17	31	0.987
20	28	0.938
20	29	0.6
20	30	0.93
20	31	0.941
28	29	0.89
28	30	0.922
28	31	0.651
29	30	0.679
29	31	0.976
30	31	0.891

Table S12. Simpson's distances among all clusters resulting from the cluster analysis of species data (cut-off: 0.86).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.97
1	3	0.73
1	4	0.57
1	5	0.95
1	6	0.98
1	7	0.921
1	8	0.956
1	10	0.963
1	11	0.984
1	13	0.981
1	19	0.998
1	25	1
1	31	0.99
1	35	0.986
1	36	0.986
1	44	1
1	50	0.998
1	53	0.997
1	56	0.958
1	58	0.969
1	59	1
1	61	0.988
1	64	0.991
2	3	0.853
2	4	0.943
2	5	0.956
2	6	0.953
2	7	0.837
2	8	0.21
2	10	0.607
2	11	0.922
2	13	0.882
2	19	0.943
2	25	0.803
2	31	0.812
2	35	0.704
2	36	0.775
2	44	0.888
2	50	0.9
2	53	0.91
2	56	0.77
2	58	0.802
2	59	0.919
2	61	0.727
2	64	0.929
3	4	0.713
3	5	0.927
3	6	0.97
3	7	0.673
3	8	0.727
3	10	0.947
3	11	0.969
3	13	0.955
3	19	0.998
3	25	0.997
3	31	0.993
3	35	0.907
3	36	0.99
3	44	0.99
3	50	0.998
3	53	0.988
3	56	0.914
3	58	0.95
3	59	1
3	61	0.985
3	64	0.974
4	5	0.819
4	6	0.891
4	7	0.921
4	8	0.958
4	10	0.958
4	11	0.921
4	13	0.834
4	19	0.898
4	25	0.996
4	31	0.996
4	35	0.966
4	36	0.995
4	44	0.906
4	50	0.97
4	53	0.947
4	56	0.951
4	58	0.966
4	59	0.981
4	61	0.985
4	64	0.921
5	6	0.811
5	7	0.945
5	8	0.956
5	10	0.977
5	11	0.955
5	13	0.793
5	19	0.941
5	25	0.977
5	31	0.978
5	35	0.969
5	36	0.971
5	44	0.956
5	50	0.957
5	53	0.957
5	56	0.969
5	58	0.967
5	59	0.956
5	61	0.965
5	64	0.934
6	7	0.965
6	8	0.965
6	10	0.971
6	11	0.869
6	13	0.314
6	19	0.801
6	25	0.951
6	31	0.962
6	35	0.963
6	36	0.967
6	44	0.727

6	50	0.727
6	53	0.726
6	56	0.973
6	58	0.947
6	59	0.749
6	61	0.947
6	64	0.84
7	8	0.905
7	10	0.947
7	11	0.957
7	13	0.9
7	19	0.992
7	25	0.984
7	31	0.99
7	35	0.561
7	36	0.986
7	44	0.97
7	50	0.996
7	53	0.99
7	56	0.695
7	58	0.933
7	59	0.998
7	61	0.984
7	64	0.953
8	10	0.898
8	11	0.956
8	13	0.894
8	19	0.988
8	25	0.974
8	31	0.963
8	35	0.794
8	36	0.957
8	44	0.961
8	50	0.991
8	53	0.984
8	56	0.813
8	58	0.905
8	59	0.998
8	61	0.958
8	64	0.958
10	11	0.939
10	13	0.916
10	19	0.995
10	25	0.924
10	31	0.831
10	35	0.902
10	36	0.742
10	44	0.977
10	50	0.998
10	53	0.989
10	56	0.49
10	58	0.482
10	59	0.996
10	61	0.724
10	64	0.946
11	13	0.448
11	19	0.897
11	25	0.914
11	31	0.903

11	35	0.937
11	36	0.9
11	44	0.873
11	50	0.868
11	53	0.895
11	56	0.936
11	58	0.907
11	59	0.852
11	61	0.918
11	64	0.859
13	19	0.178
13	25	0.842
13	31	0.829
13	35	0.876
13	36	0.871
13	44	0.139
13	50	0.093
13	53	0.164
13	56	0.913
13	58	0.846
13	59	0.148
13	61	0.854
13	64	0.414
19	25	0.961
19	31	0.978
19	35	0.95
19	36	0.976
19	44	0.749
19	50	0.698
19	53	0.753
19	56	0.985
19	58	0.975
19	59	0.773
19	61	0.969
19	64	0.774
25	31	0.711
25	35	0.901
25	36	0.9
25	44	0.951
25	50	0.99
25	53	0.977
25	56	0.914
25	58	0.776
25	59	0.99
25	61	0.763
25	64	0.951
31	35	0.914
31	36	0.512
31	44	0.941
31	50	0.979
31	53	0.972
31	56	0.876
31	58	0.733
31	59	0.991
31	61	0.817
31	64	0.945
35	36	0.919
35	44	0.916
35	50	0.913

35	53	0.934
35	56	0.6
35	58	0.929
35	59	0.941
35	61	0.921
35	64	0.933
36	44	0.957
36	50	0.976
36	53	0.981
36	56	0.756
36	58	0.55
36	59	0.995
36	61	0.78
36	64	0.957
44	50	0.458
44	53	0.565
44	56	0.943
44	58	0.925
44	59	0.59
44	61	0.949
44	64	0.686

50	53	0.627
50	56	0.96
50	58	0.948
50	59	0.871
50	61	0.988
50	64	0.635
53	56	0.951
53	58	0.937
53	59	0.729
53	61	0.978
53	64	0.421
56	58	0.632
56	59	0.976
56	61	0.759
56	64	0.88
58	59	0.9
58	61	0.427
58	64	0.922
59	61	0.987
59	64	0.749
61	64	0.942

Table S13. Simpson's distances among all clusters resulting from the cluster analysis of species data (cut-off: 0.82).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.972
1	3	0.73
1	5	0.95
1	6	0.508
1	7	0.98
1	8	0.92
1	9	0.956
1	13	0.98
1	14	0.984
1	17	0.981
1	24	0.998
1	38	0.99
1	44	0.986
1	45	0.986
1	58	1
1	66	1
1	71	0.998
1	74	0.997
1	78	0.969
1	80	0.969
1	81	1
1	83	0.988
1	88	0.991
1	91	0.972
1	93	0.996
2	3	0.853
2	5	0.956
2	6	0.93
2	7	0.953
2	8	0.836
2	9	0.21
2	13	0.665
2	14	0.922
2	17	0.885
2	24	0.942
2	38	0.812
2	44	0.704
2	45	0.775
2	58	0.888
2	66	0.9
2	71	0.9
2	74	0.909
2	78	0.838
2	80	0.802
2	81	0.919
2	83	0.727
2	88	0.93
2	91	0.643
2	93	0.937
3	5	0.927
3	6	0.67
3	7	0.97
3	8	0.671
3	9	0.727
3	13	0.982
3	14	0.969
3	17	0.957
3	24	0.998
3	38	0.993
3	44	0.907
3	45	0.99
3	58	0.992
3	66	0.997
3	71	0.998
3	74	0.988
3	78	0.937
3	80	0.95
3	81	1
3	83	0.985
3	88	0.977
3	91	0.96
3	93	0.987
5	6	0.919
5	7	0.811
5	8	0.945
5	9	0.956
5	13	0.976
5	14	0.955
5	17	0.794
5	24	0.941
5	38	0.978
5	44	0.969
5	45	0.971
5	58	0.957
5	66	0.962
5	71	0.957
5	74	0.956
5	78	0.975
5	80	0.967
5	81	0.956
5	83	0.965
5	88	0.935
5	91	0.984
5	93	0.985
6	7	0.93
6	8	0.914
6	9	0.957
6	13	0.984
6	14	0.908
6	17	0.822
6	24	0.87
6	38	1
6	44	0.957
6	45	1
6	58	0.886
6	66	0.892
6	71	0.968
6	74	0.93
6	78	0.978
6	80	0.978
6	81	0.973
6	83	0.989

6	88	0.897
6	91	0.973
6	93	0.978
7	8	0.965
7	9	0.965
7	13	0.968
7	14	0.869
7	17	0.316
7	24	0.802
7	38	0.962
7	44	0.963
7	45	0.967
7	58	0.727
7	66	0.753
7	71	0.727
7	74	0.725
7	78	0.977
7	80	0.947
7	81	0.749
7	83	0.947
7	88	0.836
7	91	0.975
7	93	0.959
8	9	0.905
8	13	0.965
8	14	0.957
8	17	0.904
8	24	0.992
8	38	0.99
8	44	0.56
8	45	0.986
8	58	0.971
8	66	0.994
8	71	0.996
8	74	0.99
8	78	0.706
8	80	0.933
8	81	0.998
8	83	0.984
8	88	0.953
8	91	0.943
8	93	0.989
9	13	0.963
9	14	0.956
9	17	0.896
9	24	0.988
9	38	0.963
9	44	0.794
9	45	0.957
9	58	0.961
9	66	0.984
9	71	0.991
9	74	0.984
9	78	0.928
9	80	0.905
9	81	0.998
9	83	0.958
9	88	0.961
9	91	0.845

9	93	0.993
13	14	0.931
13	17	0.919
13	24	0.994
13	38	0.834
13	44	0.938
13	45	0.742
13	58	0.974
13	66	0.989
13	71	0.998
13	74	0.991
13	78	0.888
13	80	0.412
13	81	0.996
13	83	0.728
13	88	0.947
13	91	0.447
13	93	0.968
14	17	0.452
14	24	0.899
14	38	0.903
14	44	0.937
14	45	0.9
14	58	0.873
14	66	0.869
14	71	0.868
14	74	0.894
14	78	0.97
14	80	0.907
14	81	0.852
14	83	0.918
14	88	0.859
14	91	0.952
14	93	0.976
17	24	0.181
17	38	0.84
17	44	0.879
17	45	0.876
17	58	0.147
17	66	0.232
17	71	0.097
17	74	0.163
17	78	0.914
17	80	0.857
17	81	0.26
17	83	0.864
17	88	0.408
17	91	0.915
17	93	0.712
24	38	0.979
24	44	0.95
24	45	0.976
24	58	0.754
24	66	0.719
24	71	0.712
24	74	0.757
24	78	0.99
24	80	0.976
24	81	0.782

24	83	0.969
24	88	0.774
24	91	0.993
24	93	0.981
38	44	0.914
38	45	0.512
38	58	0.941
38	66	0.964
38	71	0.979
38	74	0.972
38	78	0.953
38	80	0.733
38	81	0.991
38	83	0.817
38	88	0.945
38	91	0.893
38	93	0.998
44	45	0.919
44	58	0.915
44	66	0.914
44	71	0.913
44	74	0.935
44	78	0.508
44	80	0.929
44	81	0.941
44	83	0.921
44	88	0.933
44	91	0.866
44	93	0.957
45	58	0.957
45	66	0.976
45	71	0.976
45	74	0.981
45	78	0.962
45	80	0.55
45	81	0.995
45	83	0.78
45	88	0.957
45	91	0.775
45	93	1
58	66	0.644
58	71	0.458
58	74	0.557
58	78	0.963
58	80	0.925
58	81	0.594
58	83	0.949
58	88	0.688

58	91	0.971
58	93	0.929
66	71	0.742
66	74	0.782
66	78	0.97
66	80	0.92
66	81	0.417
66	83	0.964
66	88	0.73
66	91	0.982
66	93	0.97
71	74	0.628
71	78	0.973
71	80	0.948
71	81	0.871
71	83	0.988
71	88	0.64
71	91	0.978
71	93	0.985
74	78	0.966
74	80	0.937
74	81	0.729
74	83	0.978
74	88	0.424
74	91	0.978
74	93	0.829
78	80	0.903
78	81	0.983
78	83	0.949
78	88	0.912
78	91	0.704
78	93	0.736
80	81	0.9
80	83	0.427
80	88	0.927
80	91	0.592
80	93	0.913
81	83	0.987
81	88	0.753
81	91	0.993
81	93	0.987
83	88	0.943
83	91	0.777
83	93	0.991
88	91	0.9
88	93	0.273
91	93	0.747

Table S14. Simpson's distances among all clusters resulting from the cluster analysis of genus data (cut-off: 0.75).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.442
1	3	0.426
1	4	0.22
1	5	0.236
1	6	0.332
1	8	0.523
1	9	0.256
1	12	0.505
1	13	0.424
1	17	0.25
1	18	0.401
2	3	0.395
2	4	0.516
2	5	0.363
2	6	0.076
2	8	0.327
2	9	0.462
2	12	0.525
2	13	0.371
2	17	0.516
2	18	0.607
3	4	0.315
3	5	0.307
3	6	0.203
3	8	0.399
3	9	0.313
3	12	0.371
3	13	0.248
3	17	0.338
3	18	0.45
4	5	0.093
4	6	0.233
4	8	0.419
4	9	0.523
4	12	0.622
4	13	0.55
4	17	0.536
4	18	0.617
5	6	0.329
5	8	0.469
5	9	0.062
5	12	0.383
5	13	0.248
5	17	0.115
5	18	0.357
6	8	0.136
6	9	0.231
6	12	0.086
6	13	0.023
6	17	0.234
6	18	0.356
8	9	0.385
8	12	0.053
8	13	0.179
8	17	0.338
8	18	0.376
9	12	0.851
9	13	0.862
9	17	0.6
9	18	0.395
12	13	0.725
12	17	0.819
12	18	0.734
13	17	0.758
13	18	0.672
17	18	0.437

Table S15. Simpson's distances among all clusters resulting from the cluster analysis of genus data (cut-off: 0.71).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.443
1	3	0.279
1	4	0.197
1	5	0.249
1	6	0.51
1	10	0.523
1	11	0.338
1	12	0.528
1	13	0.31
1	14	0.256
1	25	0.252
1	26	0.38
1	42	0.421
2	3	0.545
2	4	0.504
2	5	0.374
2	6	0.481
2	10	0.326
2	11	0.079
2	12	0.338
2	13	0.46
2	14	0.462
2	25	0.521
2	26	0.561
2	42	0.637
3	4	0.406
3	5	0.206
3	6	0.484
3	10	0.396
3	11	0.238
3	12	0.581
3	13	0.287
3	14	0.379
3	25	0.454
3	26	0.541
3	42	0.579
4	5	0.089
4	6	0.546
4	10	0.417
4	11	0.229
4	12	0.647
4	13	0.5
4	14	0.59
4	25	0.562
4	26	0.651
4	42	0.623
5	6	0.34
5	10	0.476
5	11	0.328
5	12	0.374
5	13	0.168
5	14	0.077
5	25	0.116
5	26	0.3
5	42	0.453
6	10	0.278
6	11	0.1
6	12	0.378
6	13	0.355
6	14	0.431
6	25	0.482
6	26	0.528
6	42	0.62
10	11	0.139
10	12	0.217
10	13	0.365
10	14	0.385
10	25	0.335
10	26	0.338
10	42	0.374
11	12	0.018
11	13	0.18
11	14	0.241
11	25	0.247
11	26	0.309
11	42	0.401
12	13	0.547
12	14	0.626
12	25	0.632
12	26	0.735
12	42	0.789
13	14	0.605
13	25	0.684
13	26	0.758
13	42	0.827
14	25	0.6
14	26	0.405
14	42	0.79
25	26	0.474
25	42	0.681
26	42	0.418

Table S16. Simpson's distances among all clusters resulting from the cluster analysis of genus data (cut-off: 0.67).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.454
1	3	0.278
1	4	0.077
1	5	0.293
1	6	0.289
1	7	0.208
1	8	0.51
1	12	0.575
1	13	0.342
1	14	0.531
1	15	0.31
1	16	0.256
1	22	0.516
1	26	0.621
1	28	0.187
1	31	0.252
1	32	0.362
1	34	0.14
1	46	0.564
1	52	0.379
1	56	0.421
2	3	0.565
2	4	0.406
2	5	0.401
2	6	0.492
2	7	0.548
2	8	0.491
2	12	0.35
2	13	0.066
2	14	0.351
2	15	0.472
2	16	0.492
2	22	0.57
2	26	0.494
2	28	0.539
2	31	0.543
2	32	0.583
2	34	0.146
2	46	0.444
2	52	0.58
2	56	0.67
3	4	0.465
3	5	0.221
3	6	0.381
3	7	0.365
3	8	0.484
3	12	0.436
3	13	0.242
3	14	0.583
3	15	0.287
3	16	0.379
3	22	0.588
3	26	0.647
3	28	0.51
3	31	0.454
3	32	0.523
3	34	0.478
3	46	0.54
3	52	0.533
3	56	0.579
4	5	0.297
4	6	0.742
4	7	0.477
4	8	0.677
4	12	0.503
4	13	0.213
4	14	0.723
4	15	0.755
4	16	0.942
4	22	0.51
4	26	0.755
4	28	0.497
4	31	0.71
4	32	0.658
4	34	0.632
4	46	0.948
4	52	0.794
4	56	0.632
5	6	0.029
5	7	0.063
5	8	0.358
5	12	0.469
5	13	0.329
5	14	0.386
5	15	0.175
5	16	0.103
5	22	0.431
5	26	0.417
5	28	0.085
5	31	0.133
5	32	0.307
5	34	0.335
5	46	0.368
5	52	0.379
5	56	0.477
6	7	0.378
6	8	0.422
6	12	0.448
6	13	0.2
6	14	0.562
6	15	0.622
6	16	0.456
6	22	0.546
6	26	0.59
6	28	0.444
6	31	0.702
6	32	0.629
6	34	0.787
6	46	0.888
6	52	0.763
6	56	0.806
7	8	0.508

7	12	0.442
7	13	0.225
7	14	0.633
7	15	0.517
7	16	0.6
7	22	0.599
7	26	0.636
7	28	0.54
7	31	0.596
7	32	0.663
7	34	0.688
7	46	0.78
7	52	0.639
7	56	0.652
8	12	0.309
8	13	0.103
8	14	0.376
8	15	0.355
8	16	0.431
8	22	0.528
8	26	0.465
8	28	0.568
8	31	0.482
8	32	0.523
8	34	0.531
8	46	0.36
8	52	0.456
8	56	0.62
12	13	0.083
12	14	0.231
12	15	0.4
12	16	0.472
12	22	0.267
12	26	0.292
12	28	0.522
12	31	0.413
12	32	0.45
12	34	0.42
12	46	0.224
12	52	0.302
12	56	0.474
13	14	0.018
13	15	0.182
13	16	0.251
13	22	0.195
13	26	0.029
13	28	0.297
13	31	0.249
13	32	0.322
13	34	0.125
13	46	0
13	52	0.266
13	56	0.412
14	15	0.559
14	16	0.646
14	22	0.655
14	26	0.419
14	28	0.704
14	31	0.645

14	32	0.759
14	34	0.603
14	46	0.4
14	52	0.686
14	56	0.792
15	16	0.605
15	22	0.585
15	26	0.578
15	28	0.555
15	31	0.684
15	32	0.769
15	34	0.758
15	46	0.808
15	52	0.793
15	56	0.827
16	22	0.528
16	26	0.687
16	28	0.41
16	31	0.6
16	32	0.426
16	34	0.708
16	46	0.928
16	52	0.793
16	56	0.79
22	26	0.627
22	28	0.68
22	31	0.501
22	32	0.457
22	34	0.595
22	46	0.656
22	52	0.284
22	56	0.488
26	28	0.726
26	31	0.679
26	32	0.729
26	34	0.671
26	46	0.244
26	52	0.657
26	56	0.76
28	31	0.352
28	32	0.528
28	34	0.519
28	46	0.72
28	52	0.604
28	56	0.678
31	32	0.499
31	34	0.738
31	46	0.856
31	52	0.58
31	56	0.681
32	34	0.735
32	46	0.908
32	52	0.325
32	56	0.482
34	46	0.88
34	52	0.698
34	56	0.807
46	52	0.911
46	56	0.936

52	56	0.272

Table S17. Simpson's distances among all clusters resulting from the cluster analysis of family data (cut-off: 0.48).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.035
1	4	0.019
1	5	0
1	6	0.016
1	10	0.045
1	13	0.093
1	18	0.04
1	19	0.018
1	26	0.07
1	27	0.047
2	4	0.011
2	5	0.008
2	6	0
2	10	0
2	13	0.016
2	18	0
2	19	0
2	26	0.045
2	27	0
4	5	0.174
4	6	0.148
4	10	0.224
4	13	0.113
4	18	0.23
4	19	0.135
4	26	0.259
4	27	0.304
5	6	0.461
5	10	0.545
5	13	0.098
5	18	0.611
5	19	0.402
5	26	0.167
5	27	0.53
6	10	0.477
6	13	0.039
6	18	0.548
6	19	0.242
6	26	0.172
6	27	0.547
10	13	0.058
10	18	0.413
10	19	0.372
10	26	0.122
10	27	0.541
13	18	0.095
13	19	0.023
13	26	0.066
13	27	0.047
18	19	0.397
18	26	0.206
18	27	0.54
19	26	0.129
19	27	0.446
26	27	0.264

Table S18. Simpson's distances among all clusters resulting from the cluster analysis of family data (cut-off: 0.44).

Cluster ID1	Cluster ID2	Simpson's distance
1	2	0.035
1	4	0.016
1	5	0.016
1	6	0
1	7	0.016
1	8	0.008
1	13	0.045
1	17	0.098
1	24	0.018
1	34	0.07
1	35	0.055
2	4	0
2	5	0.004
2	6	0.008
2	7	0
2	8	0.017
2	13	0
2	17	0.016
2	24	0
2	34	0.045
2	35	0
4	5	0.244
4	6	0.167
4	7	0.102
4	8	0.252
4	13	0.269
4	17	0.082
4	24	0.16
4	34	0.271
4	35	0.172
5	6	0.235
5	7	0.156
5	8	0.168
5	13	0.237
5	17	0.102
5	24	0.16
5	34	0.252
5	35	0.352
6	7	0.461
6	8	0.42
6	13	0.545
6	17	0.098
6	24	0.402
6	34	0.167
6	35	0.538
7	8	0.588
7	13	0.477
7	17	0.039
7	24	0.242
7	34	0.18
7	35	0.555
8	13	0.504
8	17	0.092
8	24	0.395
8	34	0.151
8	35	0.681
13	17	0.058
13	24	0.372
13	34	0.122
13	35	0.545
17	24	0.018
17	34	0.066
17	35	0.048
24	34	0.13
24	35	0.441
34	35	0.276

Supporting References

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