Long-term freshwater time series reveals recurrent and episodic microbial dynamics driven by distinct assembly mechanisms

Hongjae Park[1,2], Suhyun Kim[1,2], Miri. S. Park[1,2], Ilnam Kang[1*], and Jang-Cheon Cho[1*]

[1]Department of Biological Sciences and Bioengineering, Inha University, Incheon, Republic of Korea. [2]These authors contributed equally to this work

[*]Corresponding authors

Jang-Cheon Cho (chojc@inha.ac.kr)

Ilnam Kang (ikang@inha.ac.kr)

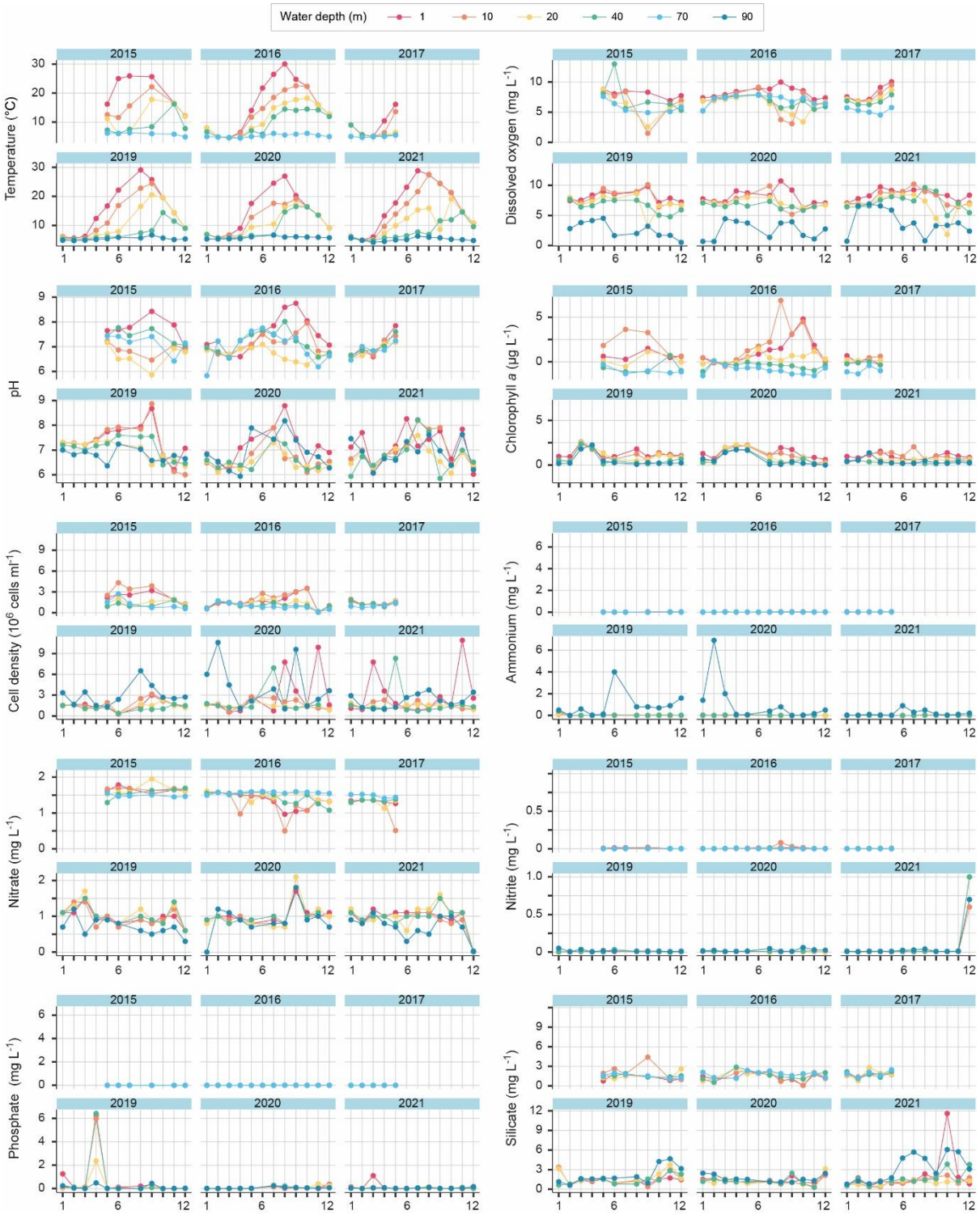


Fig. S1. Line plots for the physicochemical parameters in different water depths.

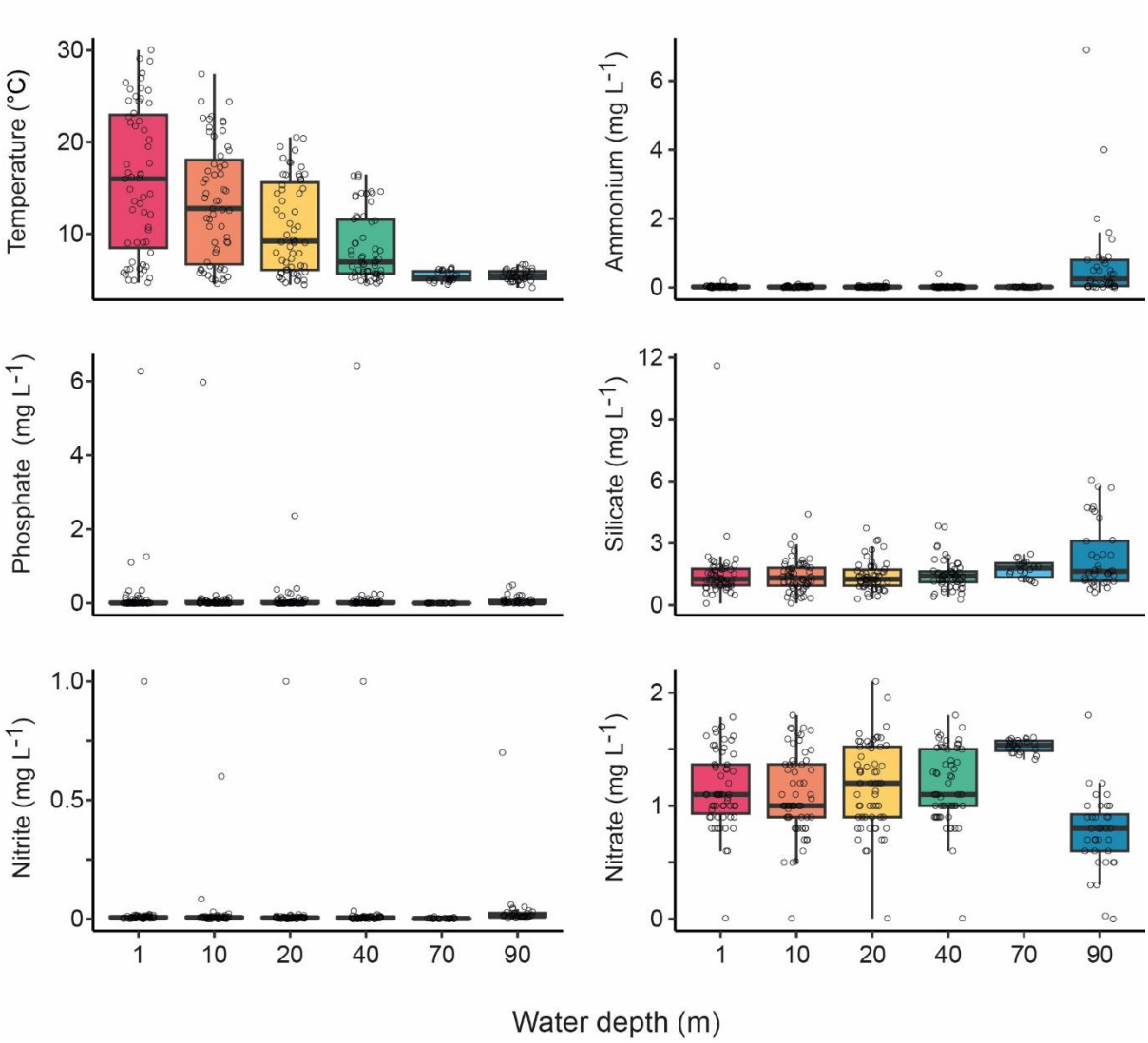


Fig. S2. Box plots for physicochemical parameters in different water depths. The lower and upper edges of the boxplots correspond to the first and third quartiles, the whiskers extend to the largest or smallest value at 1.5 times the interquartile, and the black bars across the box represent median values.

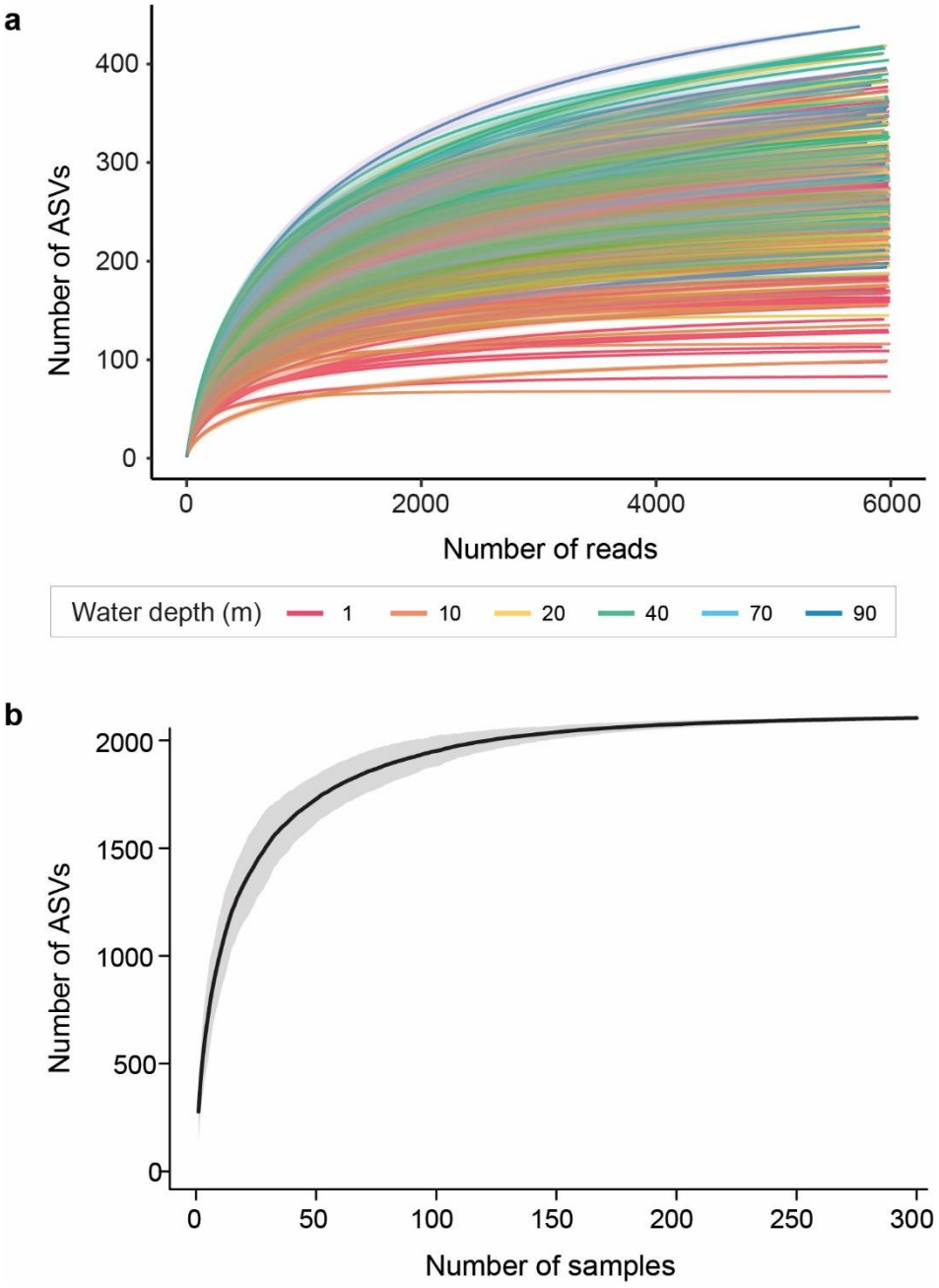


Fig. S3. Rarefaction (a) and species accumulation curves (b) for the 300 samples. Solid lines for the species accumulation curves represent observed species richness with corresponding 95 % CI intervals (shaded area)

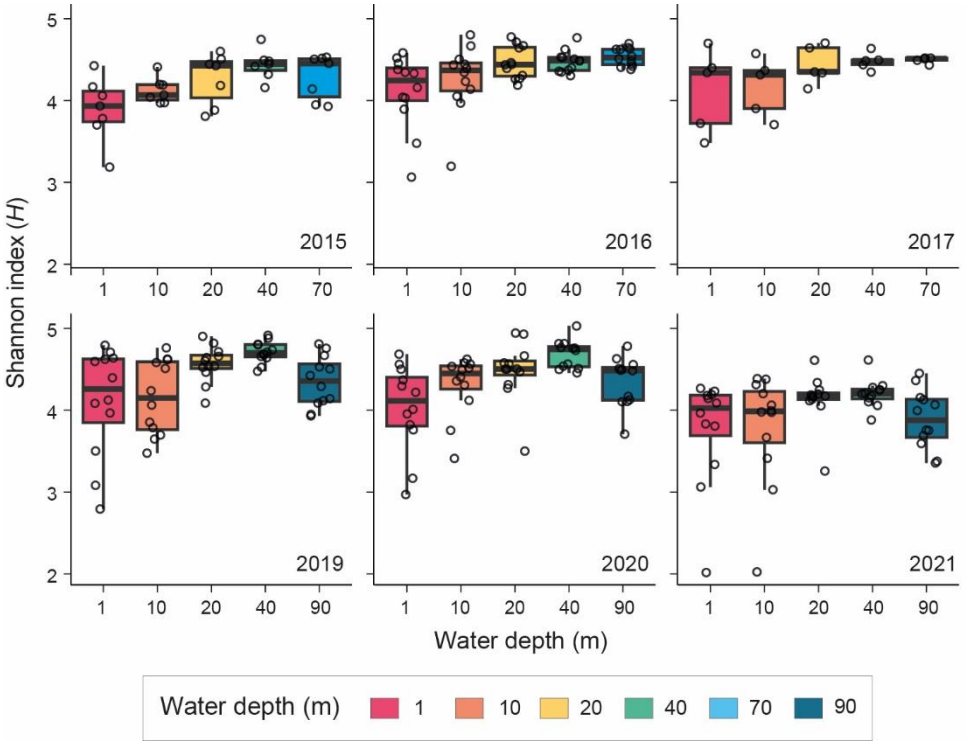


Fig. S4. Box plots for alpha diversity measured by Shannon index. The lower and upper edges of the boxplots correspond to the first and third quartiles, the whiskers extend to the largest or smallest value at 1.5 times the interquartile, and the bars across the box represent median values. Dots that exist beyond one of the whiskers represent outliers.

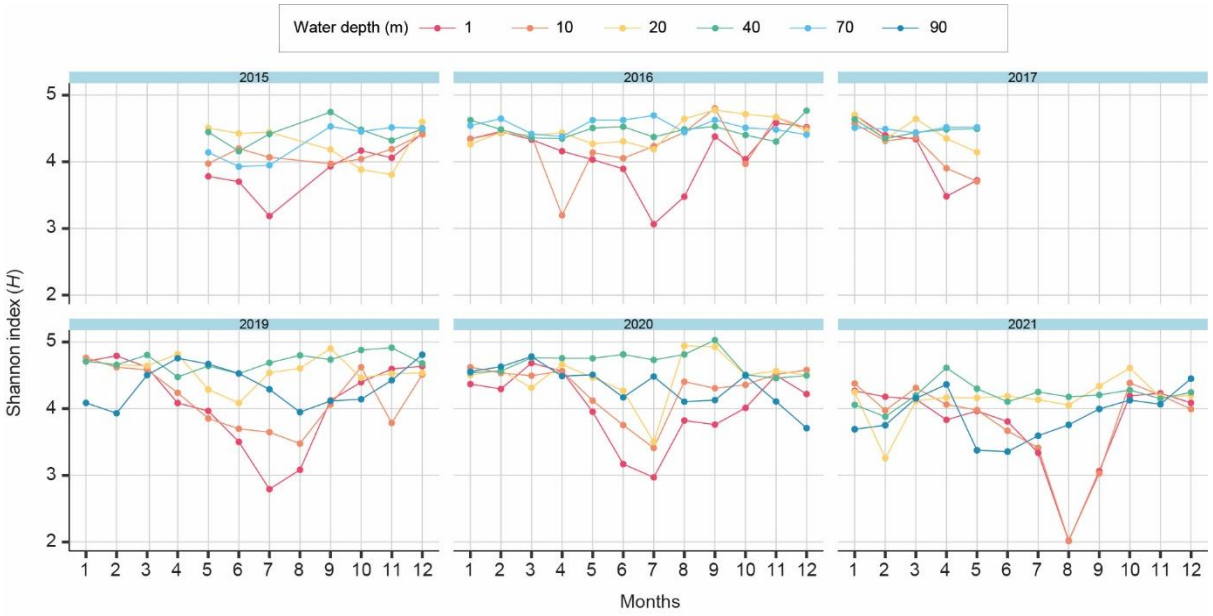


Fig. S5. Line plots for alpha diversity measured by Shannon index.

Fig. S6. Comparison of microbial abundance patterns between 70- and 90-meter depths. Columns represent sampling points and rows represent ASVs color-coded by taxonomic affiliations. Dotted rectangle highlights the near-bottom specialists. Hierarchical clustering was performed on rows using the complete-linkage method. ASVs with a maximum relative abundance greater than 3% and present in more than 20% of the samples were included in the heatmap.

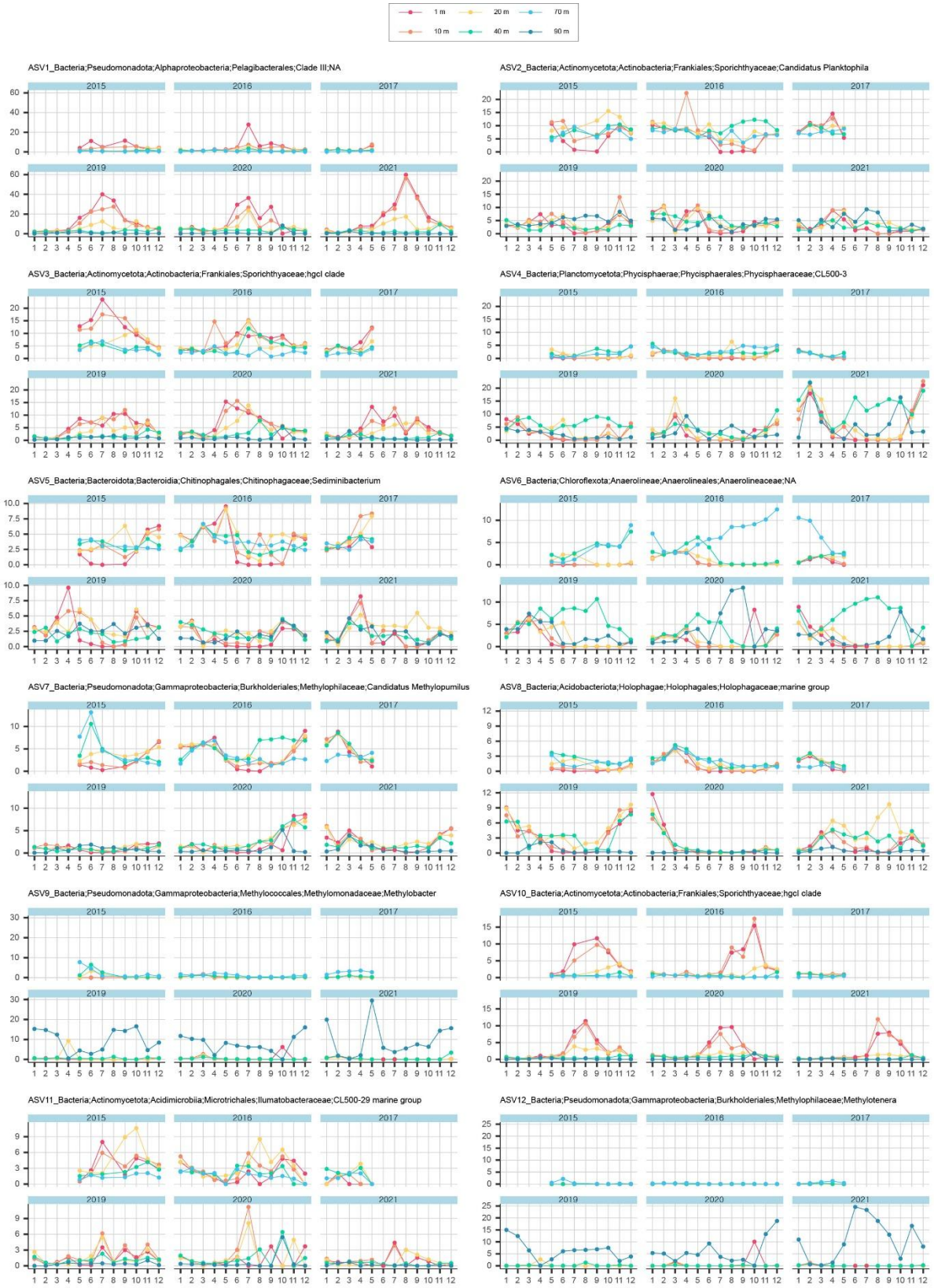
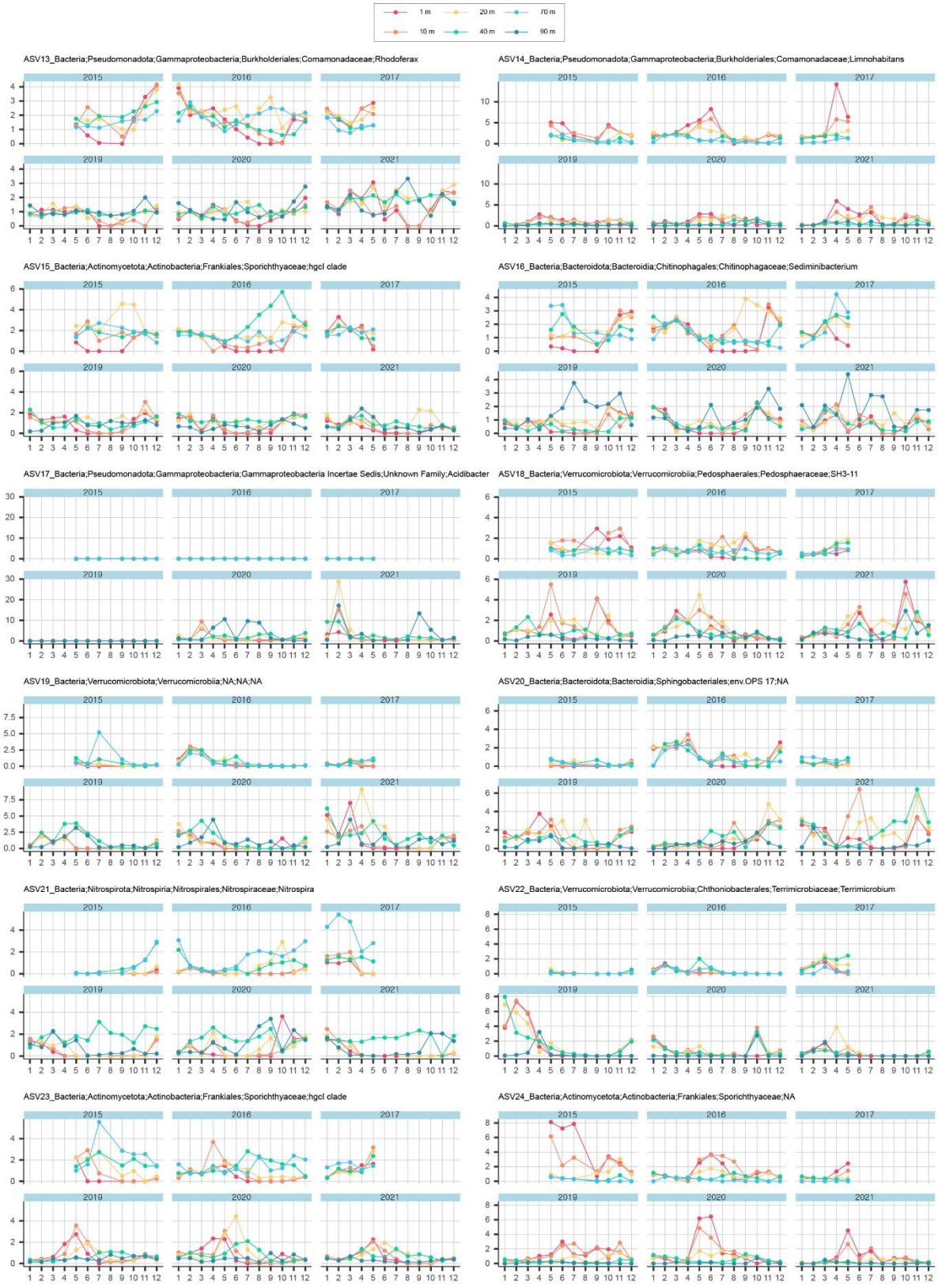
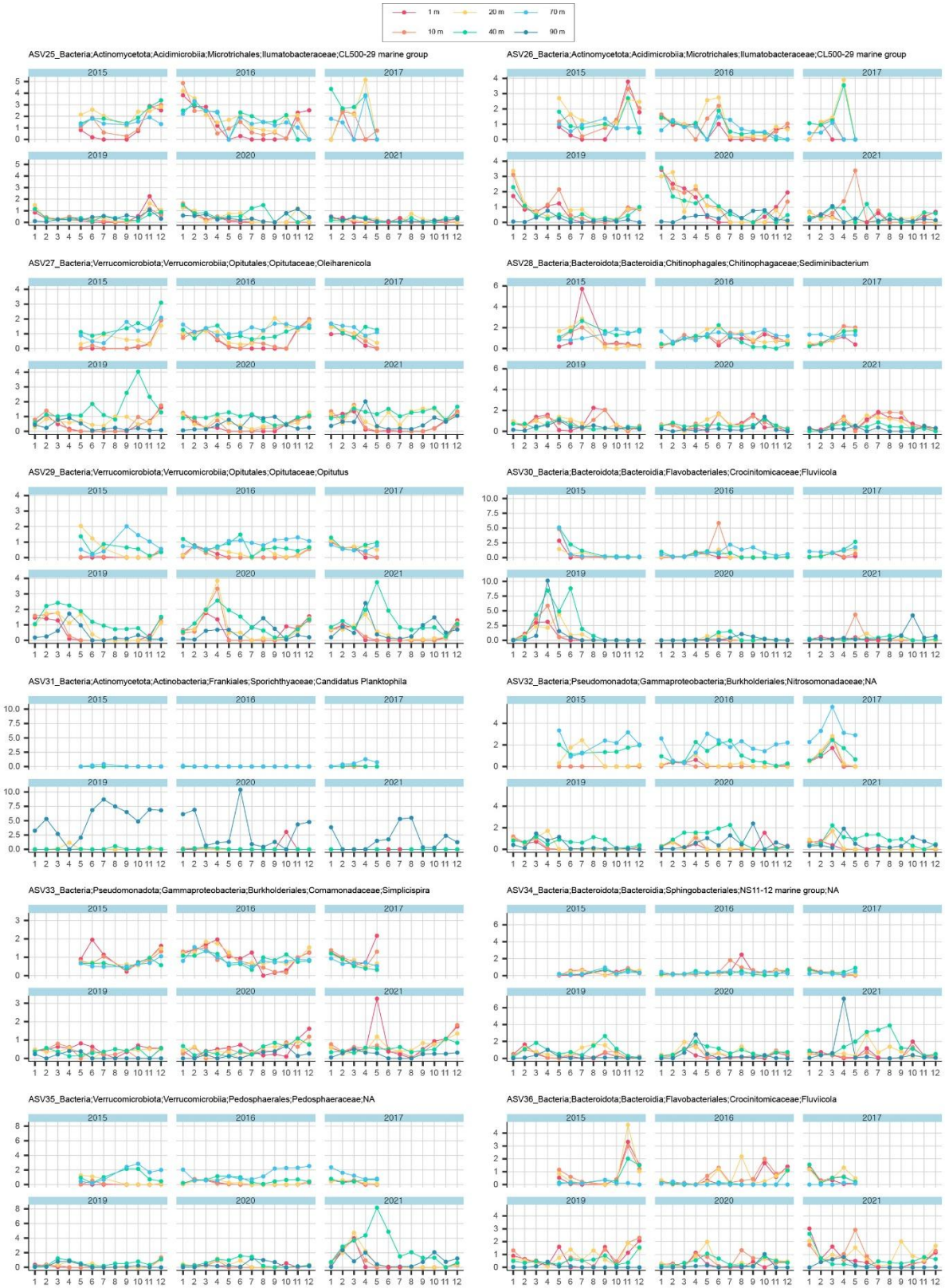
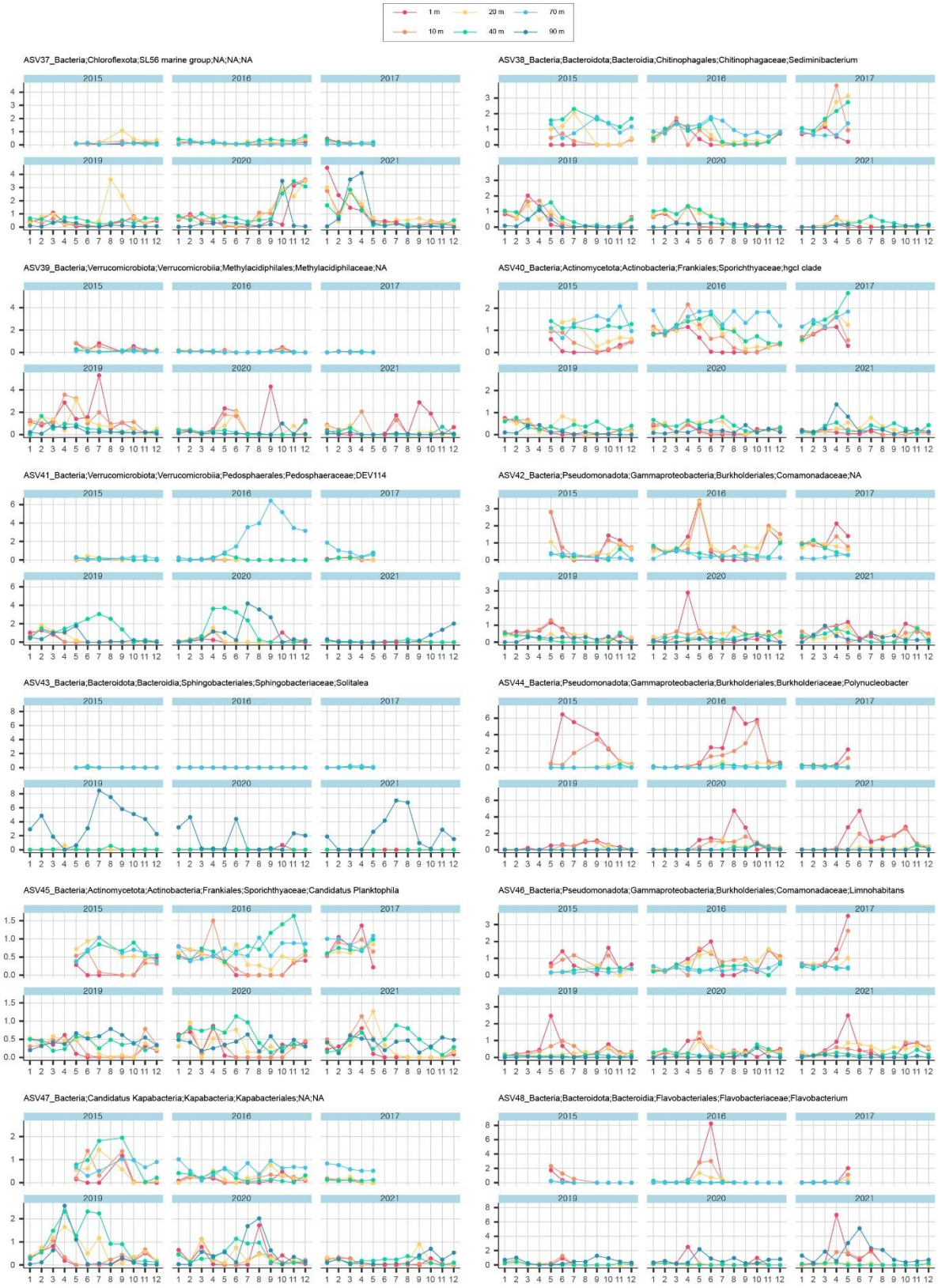
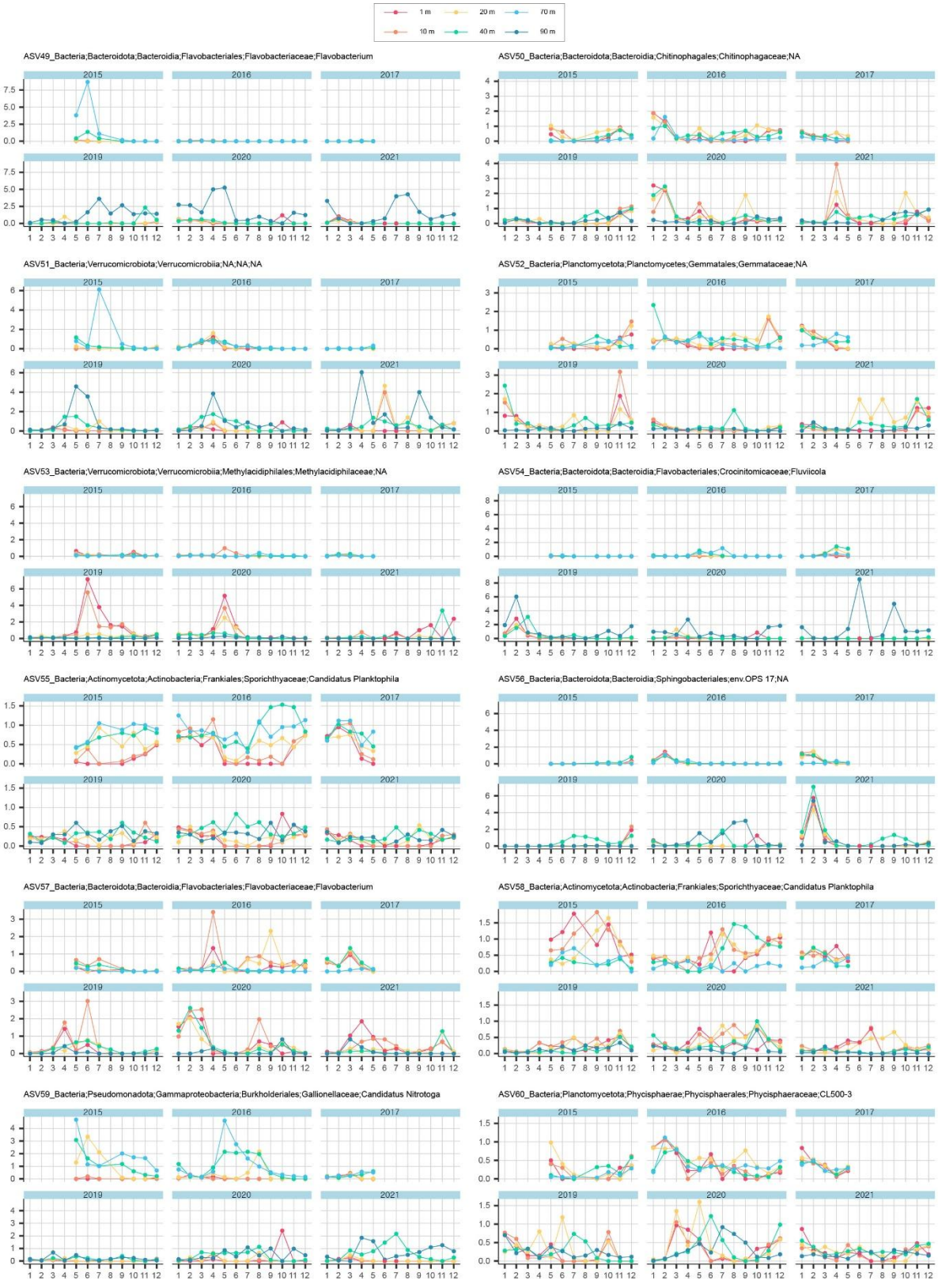


Fig. S7. Temporal changes in the relative abundance of 243 core ASVs. The x-axis indicates months, and the y-axis shows relative abundance (%).

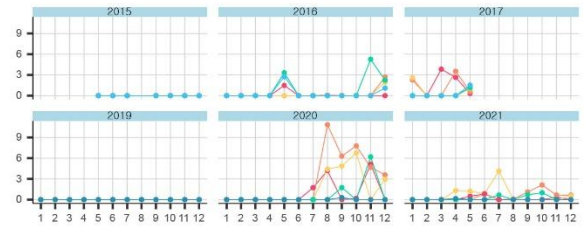

1 m
10 m
20 m
40 m
70 m
90 m
ASV13_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;Rhodoferax
ASV14_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;Limnohabitans
ASV15_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade
ASV16_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Sediminibacterium
ASV17_Bacteria;Pseudomonadota;Gammaproteobacteria;Gammaproteobacteria Incertae Sedis;Unknown Family;Acidibacter
ASV18_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;SH3-11
ASV19_Bacteria;Verrucomicrobiota;Verrucomicrobiia;NA;NA;NA
ASV20_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;env.OPS 17;NA
ASV21_Bacteria;Nitrospirota;Nitrospiria;Nitrospirales;Nitrospiraceae;Nitrospira
ASV22_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Chthoniobacterales;Terrimicrobiaceae;Terrimicrobium
ASV23_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade
ASV24_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;NA
2015
2016
2017
2019
2020
2021


1 m
10 m
20 m
40 m
70 m
90 m
ASV25_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV26_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV27_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Opitutales;Opitutaceae;Oleiharenicola
ASV28_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Sediminibacterium
ASV29_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Opitutales;Opitutaceae;Opitutus
ASV30_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV31_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;Candidatus Planktophila
ASV32_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Nitrosomonadaceae;NA
ASV33_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;Simplicispira
ASV34_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;NS11-12 marine group;NA
ASV35_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;NA
ASV36_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
2015
2016
2017
2019
2020
2021

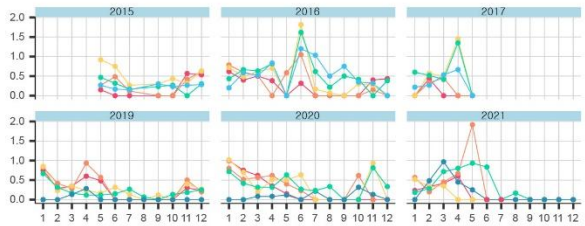

1 m
10 m
20 m
40 m
70 m
90 m
ASV37_Bacteria;Chloroflexota;SL56 marine group;NA;NA;NA
ASV38_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Sediminibacterium
ASV39_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV40_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade
ASV41_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;DEV114
ASV42_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;NA
ASV43_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;Sphingobacteriaceae;Solitalea
ASV44_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Burkholderiaceae;Polynucleobacter
ASV45_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;Candidatus Planktophila
ASV46_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;Limnohabitans
ASV47_Bacteria;Candidatus Kapabacteria;Kapabacteria;Kapabacteriales;NA;NA
ASV48_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
2015
2016
2017
2019
2020
2021


1 m
10 m
20 m
40 m
70 m
90 m
ASV49_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV50_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;NA
ASV51_Bacteria;Verrucomicrobiota;Verrucomicrobiia;NA;NA;NA
ASV52_Bacteria;Planctomycetota;Planctomycetes;Gemmatales;Gemmataceae;NA
ASV53_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV54_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV55_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;Candidatus Planktophila
ASV56_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;env.OPS 17;NA
ASV57_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV58_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;Candidatus Planktophila
ASV59_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Gallionellaceae;Candidatus Nitrotoga
ASV60_Bacteria;Planctomycetota;Phycisphaerae;Phycisphaerales;Phycisphaeraceae;CL500-3
2015
2016
2017
2019
2020
2021

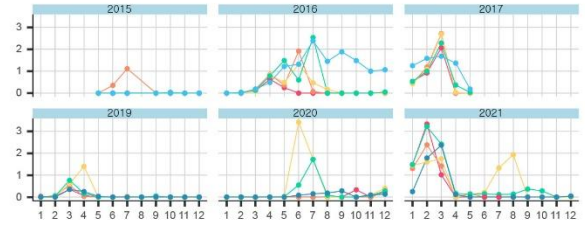
ASV61_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group



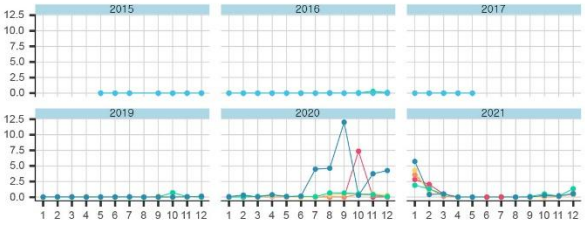
ASV62_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group



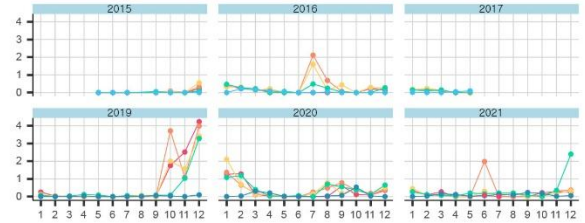
ASV63_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;env.OPS 17;NA



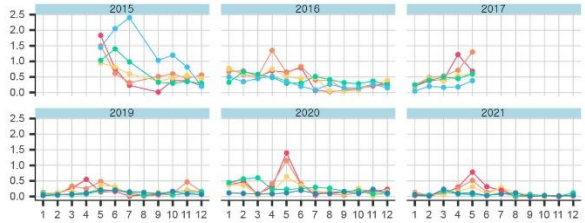
ASV64_Archaea;Thermoproteota;Nitrososphaeria;Nitrosopumilales;Nitrosopumilaceae;Nitrosarchaeum



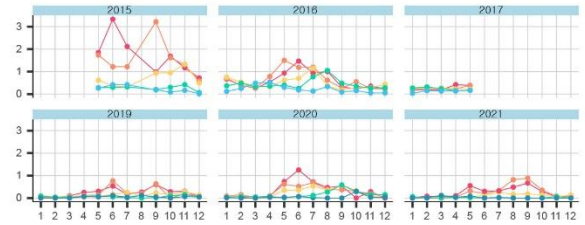
ASV65_Bacteria;Verrucomicrobiota;Verrucomicrobiia;NA;NA;NA



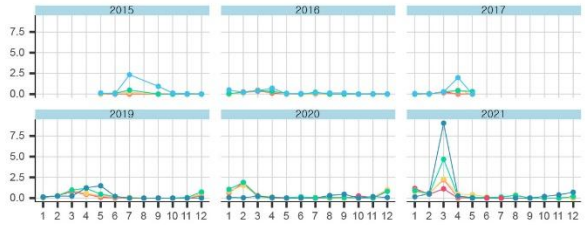
ASV66_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade



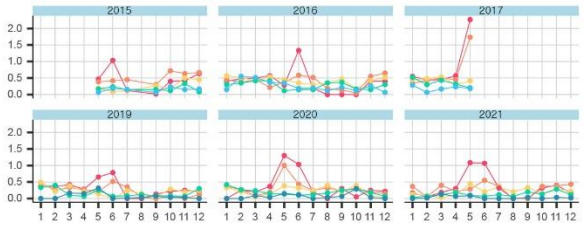
ASV67_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;Candidatus Planktophila



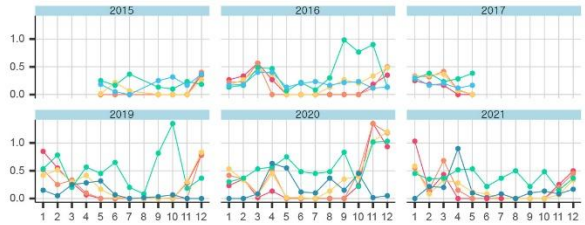
ASV68_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Chthoniobacterales;Chthoniobacteraceae;Chthoniobacter



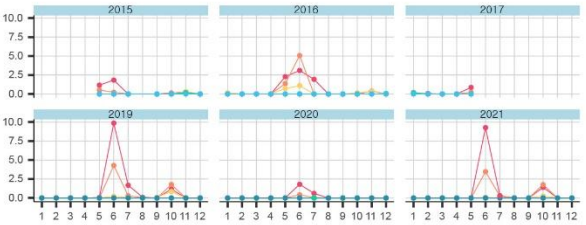
ASV69_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;NA



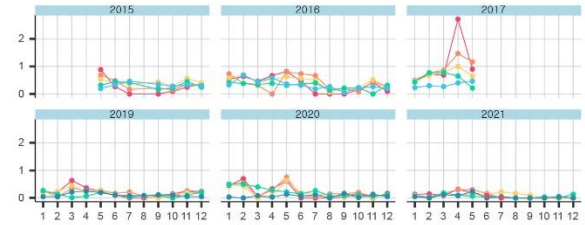
ASV70_Bacteria;Gemmatimonadota;Gemmatimonadia;Gemmatimonadales;Gemmatimonadaceae;NA

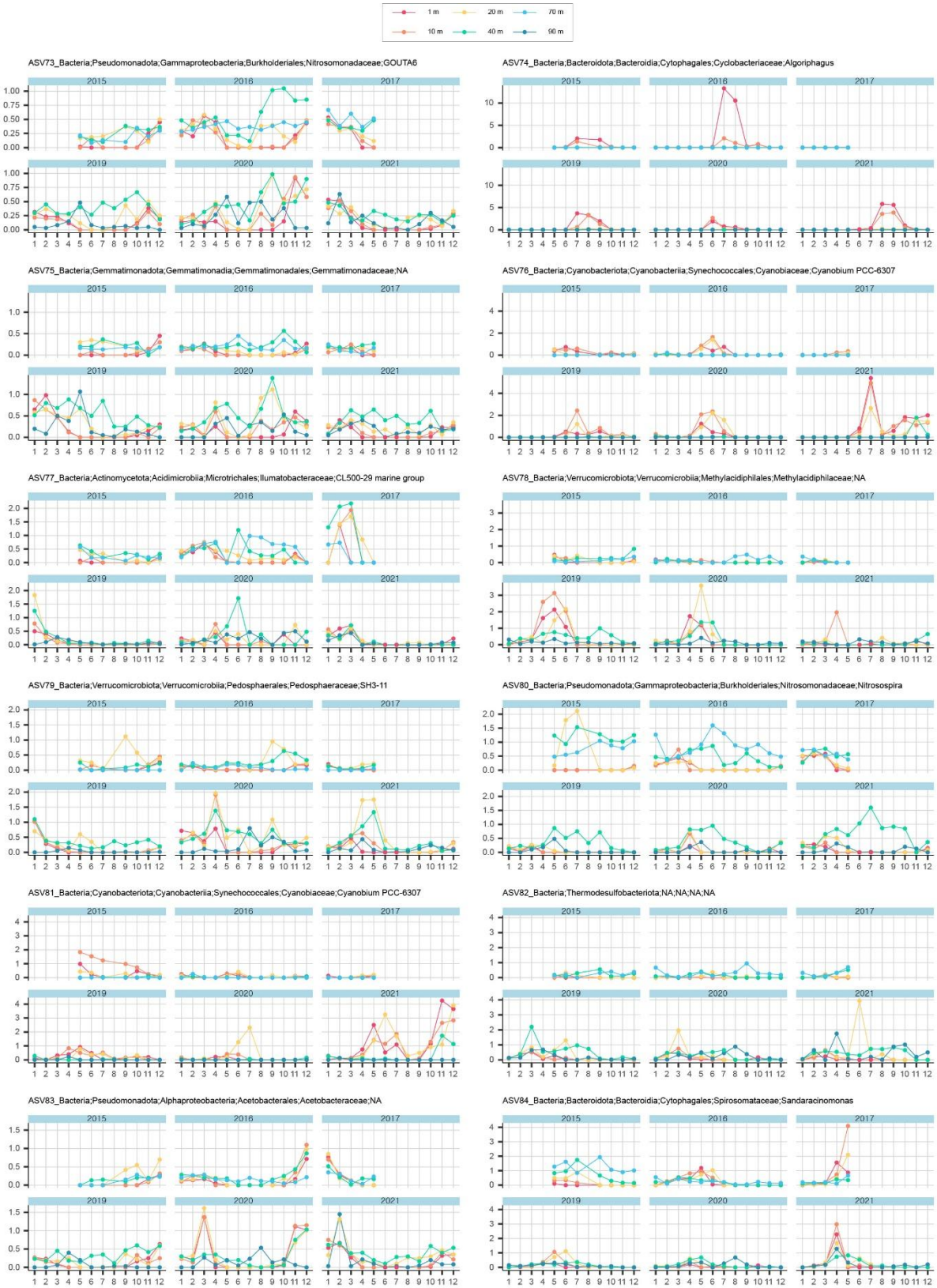


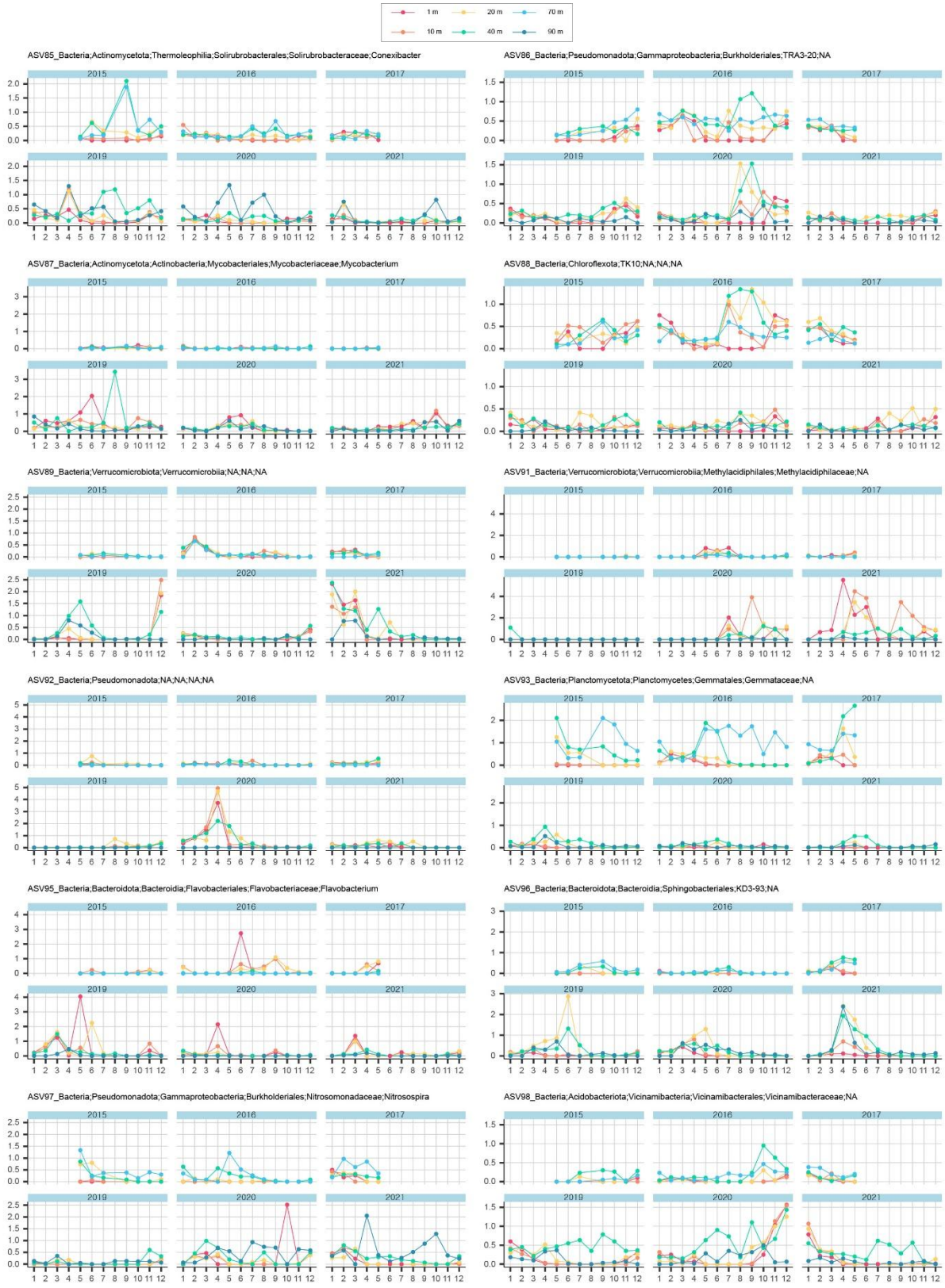
ASV71_Bacteria;Verrucomicrobiota;Verrucomicrobiia;NA;NA;NA

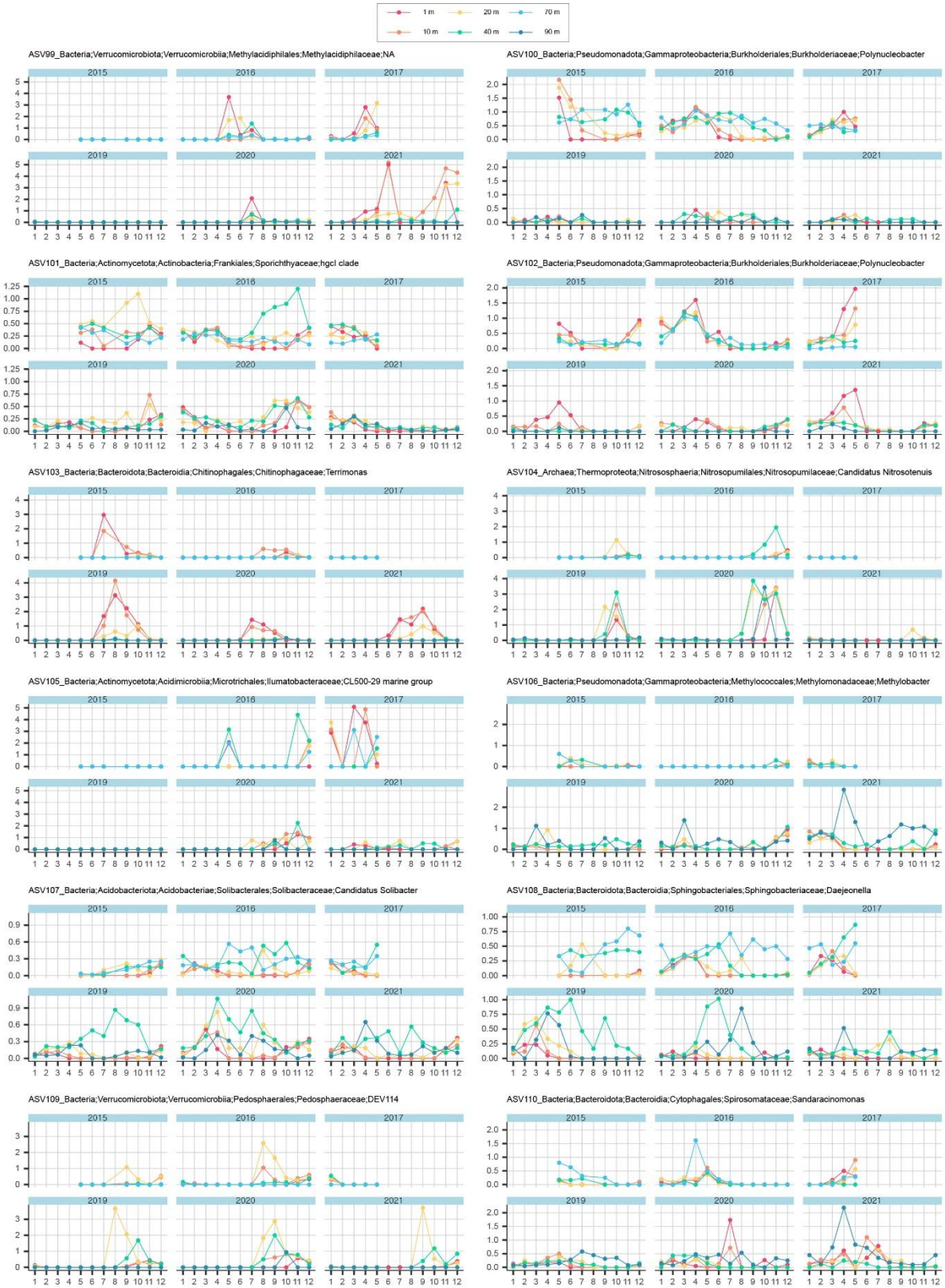


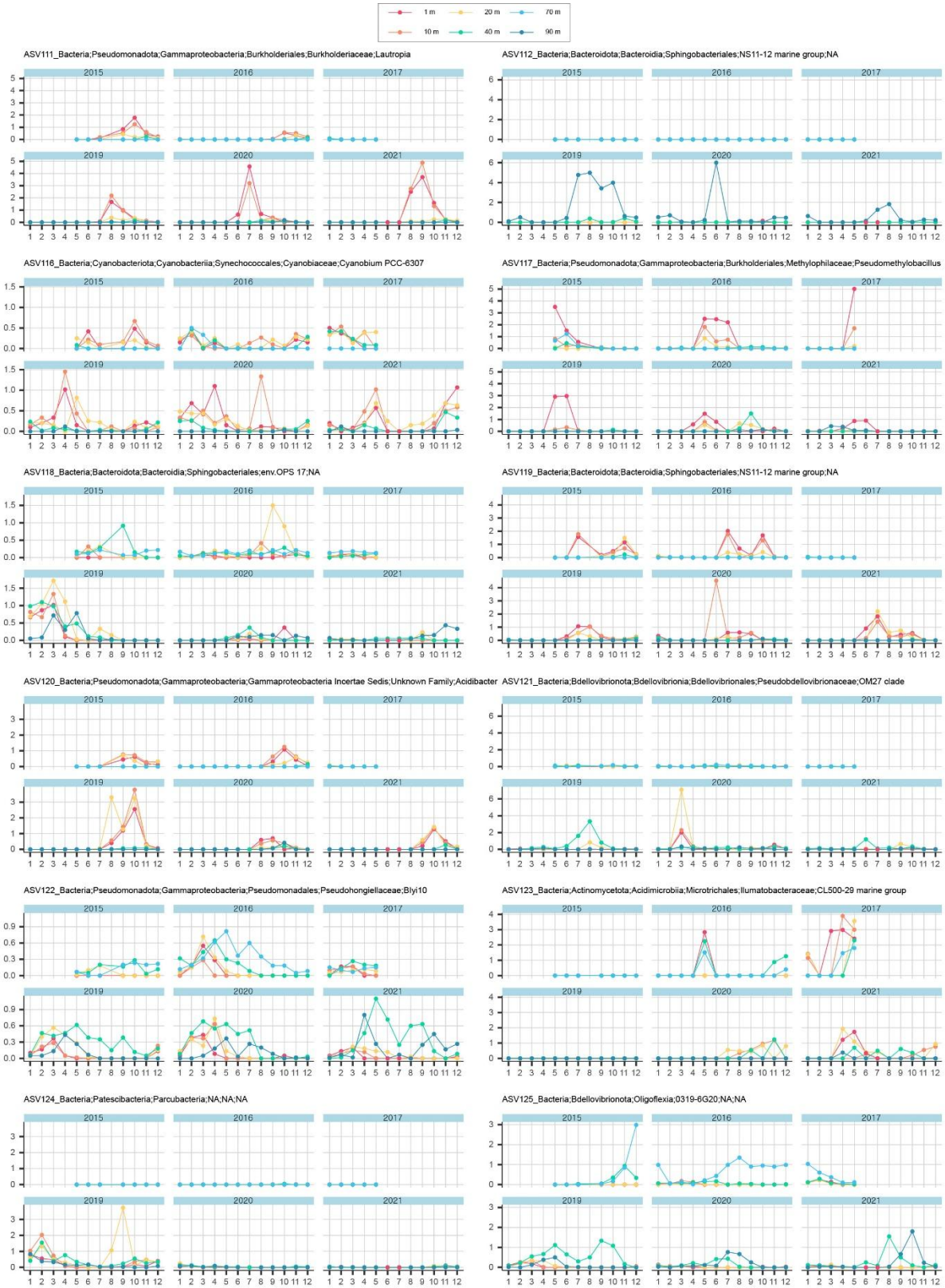
ASV72_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade

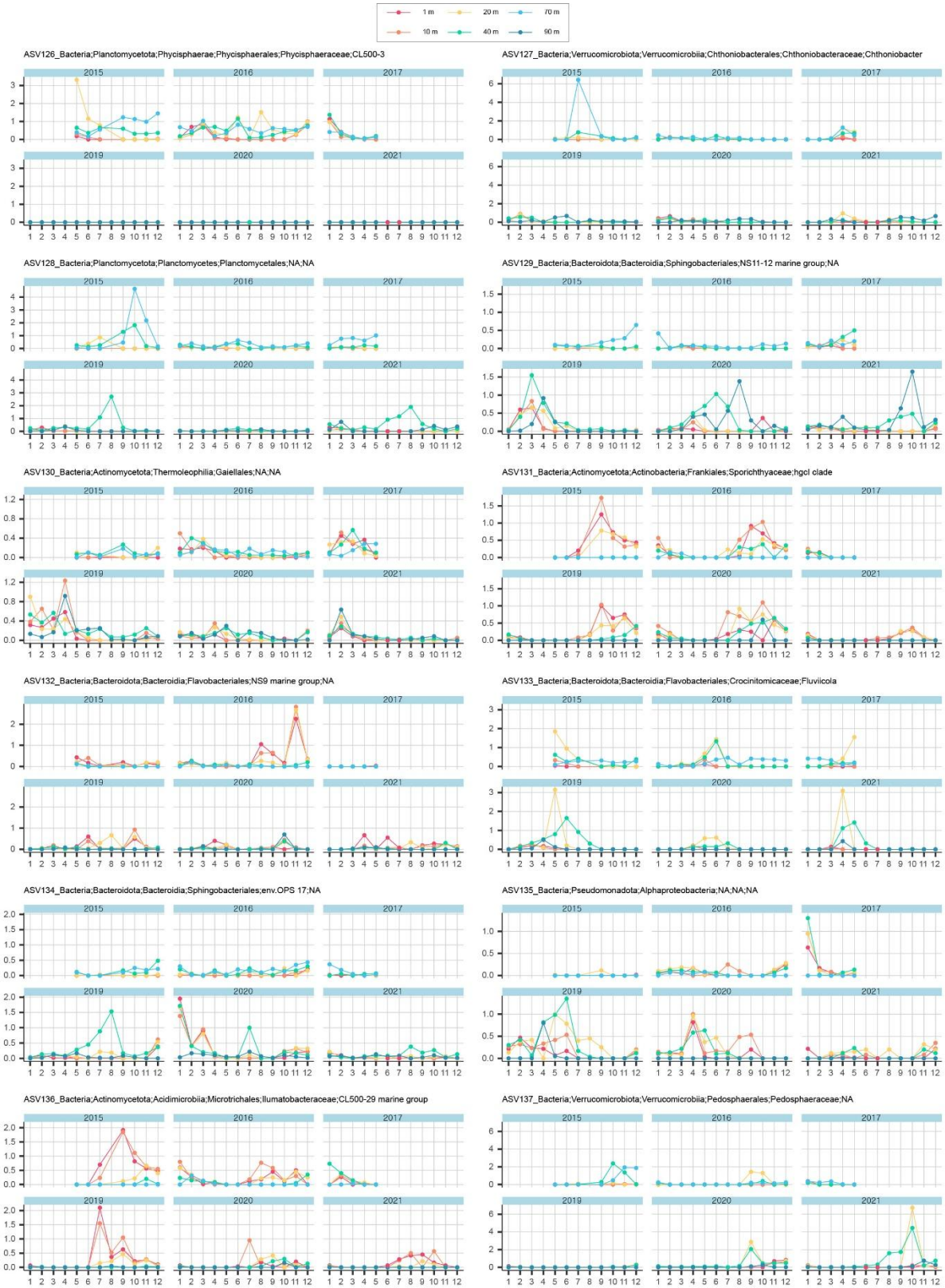


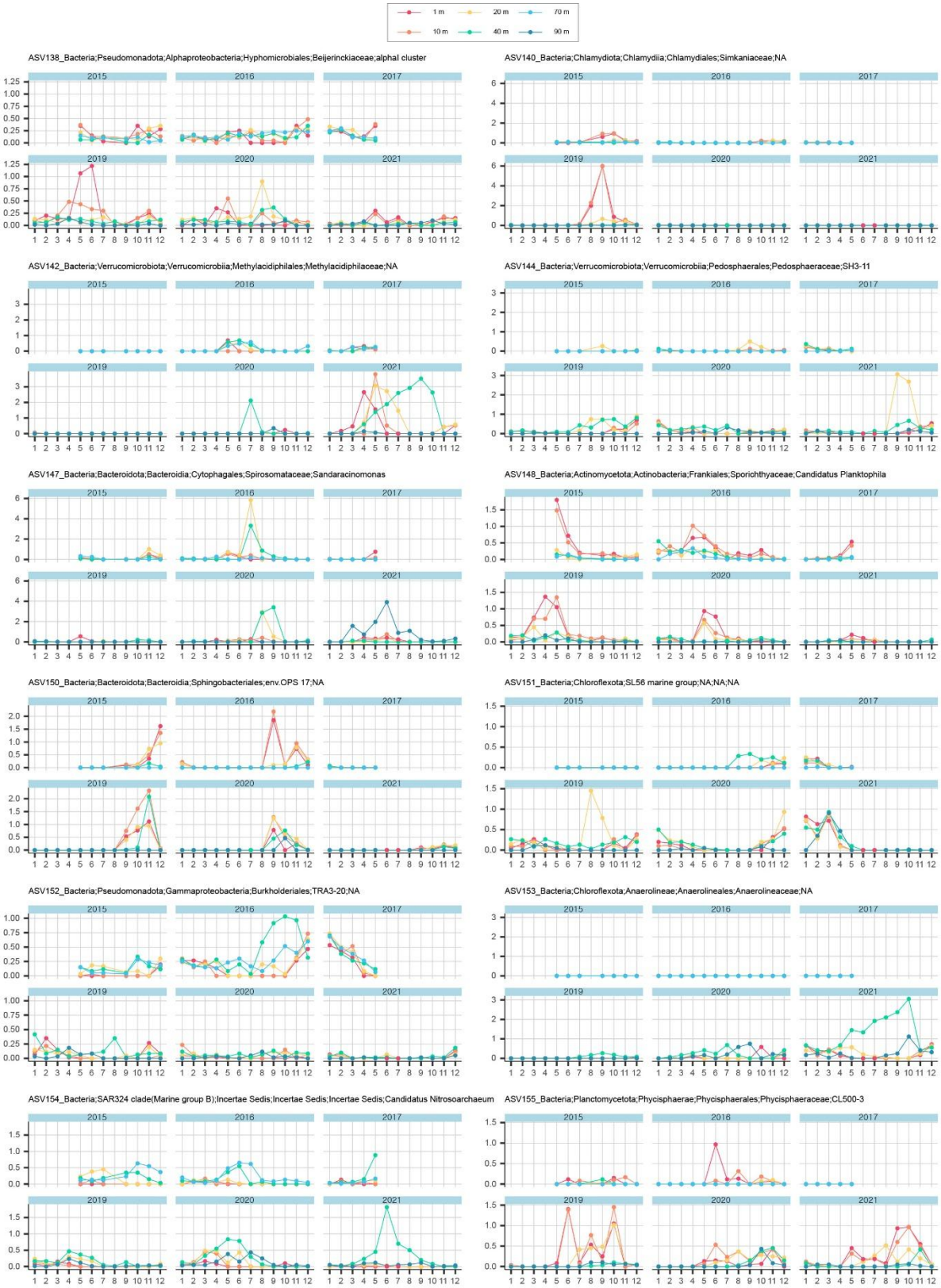

1 m
10 m
20 m
40 m
70 m
90 m
ASV73_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Nitrosomonadaceae;GOUTA6
ASV74_Bacteria;Bacteroidota;Bacteroidia;Cytophagales;Cyclobacteriaceae;Algoriphagus
ASV75_Bacteria;Gemmatimonadota;Gemmatimonadia;Gemmatimonadales;Gemmatimonadaceae;NA
ASV76_Bacteria;Cyanobacteriota;Cyanobacteriia;Synechococcales;Cyanobiaceae;Cyanobium PCC-6307
ASV77_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV78_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV79_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;SH3-11
ASV80_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Nitrosomonadaceae;Nitrosospira
ASV81_Bacteria;Cyanobacteriota;Cyanobacteriia;Synechococcales;Cyanobiaceae;Cyanobium PCC-6307
ASV82_Bacteria;Thermodesulfobacteriota;NA;NA;NA;NA
ASV83_Bacteria;Pseudomonadota;Alphaproteobacteria;Acetobacterales;Acetobacteraceae;NA
ASV84_Bacteria;Bacteroidota;Bacteroidia;Cytophagales;Spirosomataceae;Sandaracinomonas
2015
2016
2017
2019
2020
2021

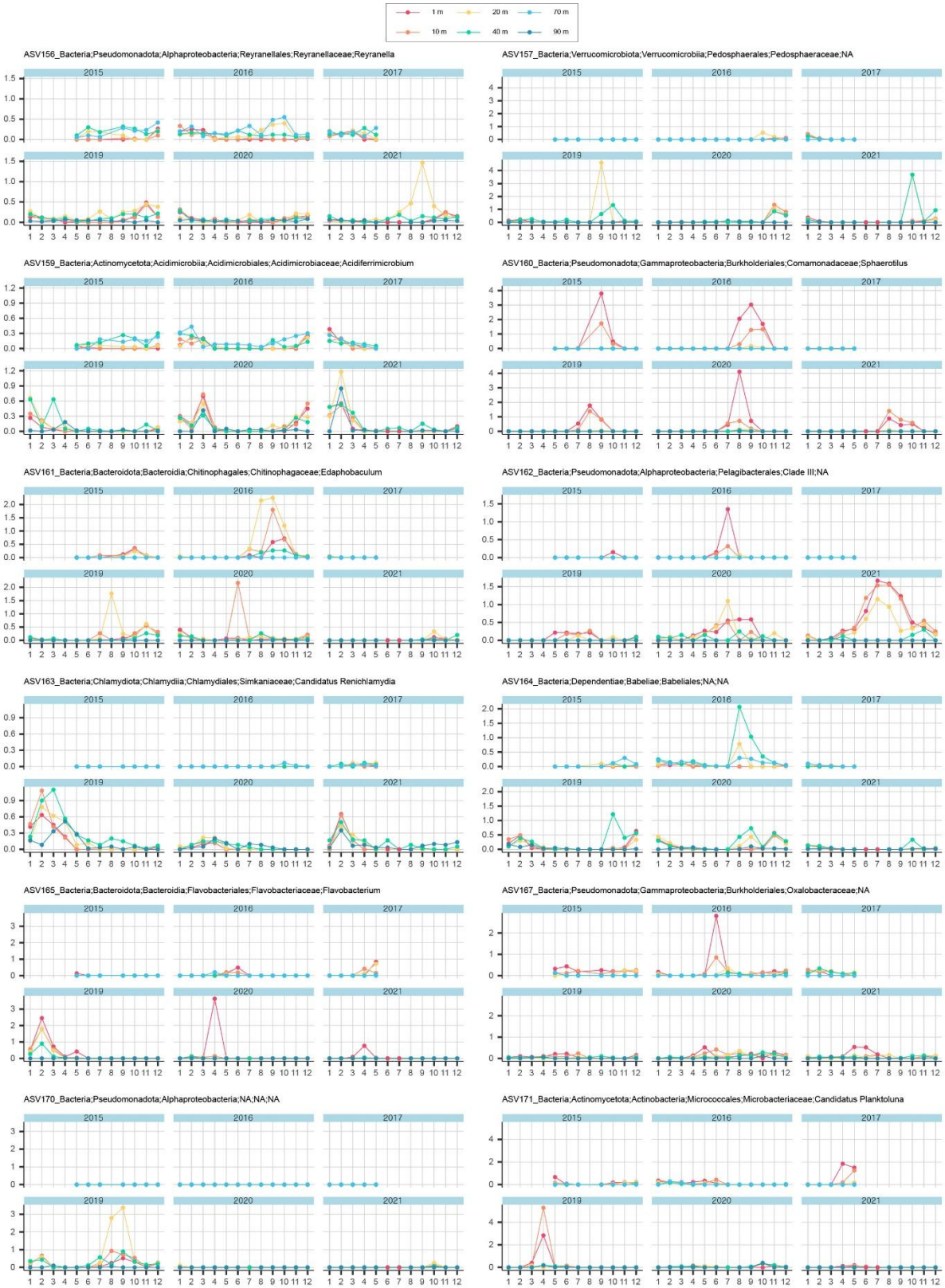

1 m
10 m
20 m
40 m
70 m
90 m
ASV85_Bacteria;Actinomycetota;Thermoleophilia;Solirubrobacterales;Solirubrobacteraceae;Conexibacter
ASV86_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;TRA3-20;NA
ASV87_Bacteria;Actinomycetota;Actinobacteria;Mycobacteriales;Mycobacteriaceae;Mycobacterium
ASV88_Bacteria;Chloroflexota;TK10;NA;NA;NA
ASV89_Bacteria;Verrucomicrobiota;Verrucomicrobiia;NA;NA;NA
ASV91_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV92_Bacteria;Pseudomonadota;NA;NA;NA;NA
ASV93_Bacteria;Planctomycetota;Planctomycetes;Gemmatales;Gemmataceae;NA
ASV95_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV96_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;KD3-93;NA
ASV97_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Nitrosomonadaceae;Nitrosospira
ASV98_Bacteria;Acidobacteriota;Vicinamibacteria;Vicinamibacterales;Vicinamibacteraceae;NA
2015
2016
2017
2019
2020
2021

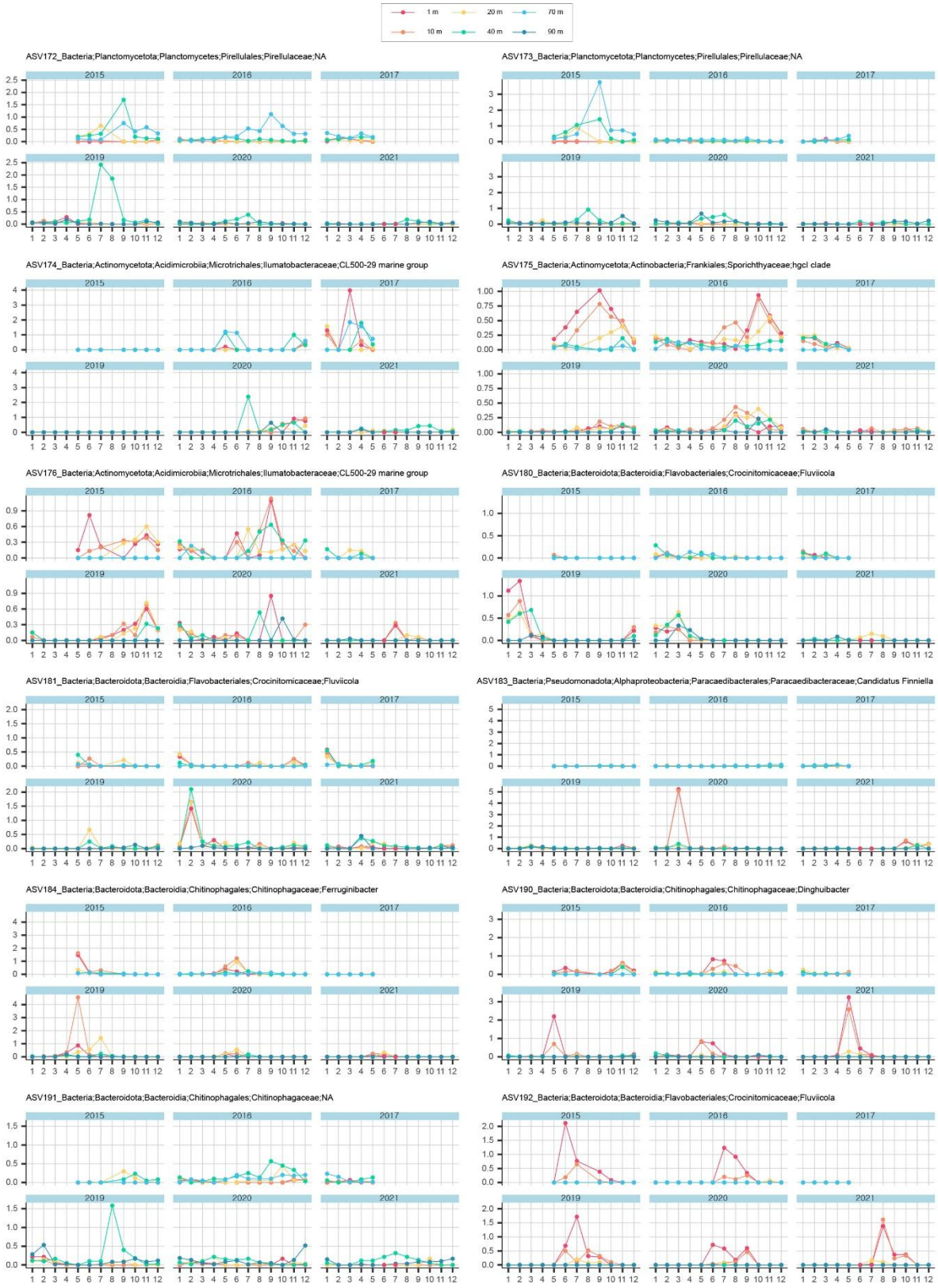

1 m
10 m
20 m
40 m
70 m
90 m
ASV99_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV100_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Burkholderiaceae;Polynucleobacter
ASV101_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade
ASV102_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Burkholderiaceae;Polynucleobacter
ASV103_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Terrimonas
ASV104_Archaea;Thermoproteota;Nitrososphaeria;Nitrosopumilales;Nitrosopumilaceae;Candidatus Nitrosotenuis
ASV105_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV106_Bacteria;Pseudomonadota;Gammaproteobacteria;Methylococcales;Methylomonadaceae;Methylobacter
ASV107_Bacteria;Acidobacteriota;Acidobacteriae;Solibacterales;Solibacteraceae;Candidatus Solibacter
ASV108_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;Sphingobacteriaceae;Daejeonella
ASV109_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;DEV114
ASV110_Bacteria;Bacteroidota;Bacteroidia;Cytophagales;Spirosomataceae;Sandaracinomonas
2015
2016
2017
2019
2020
2021

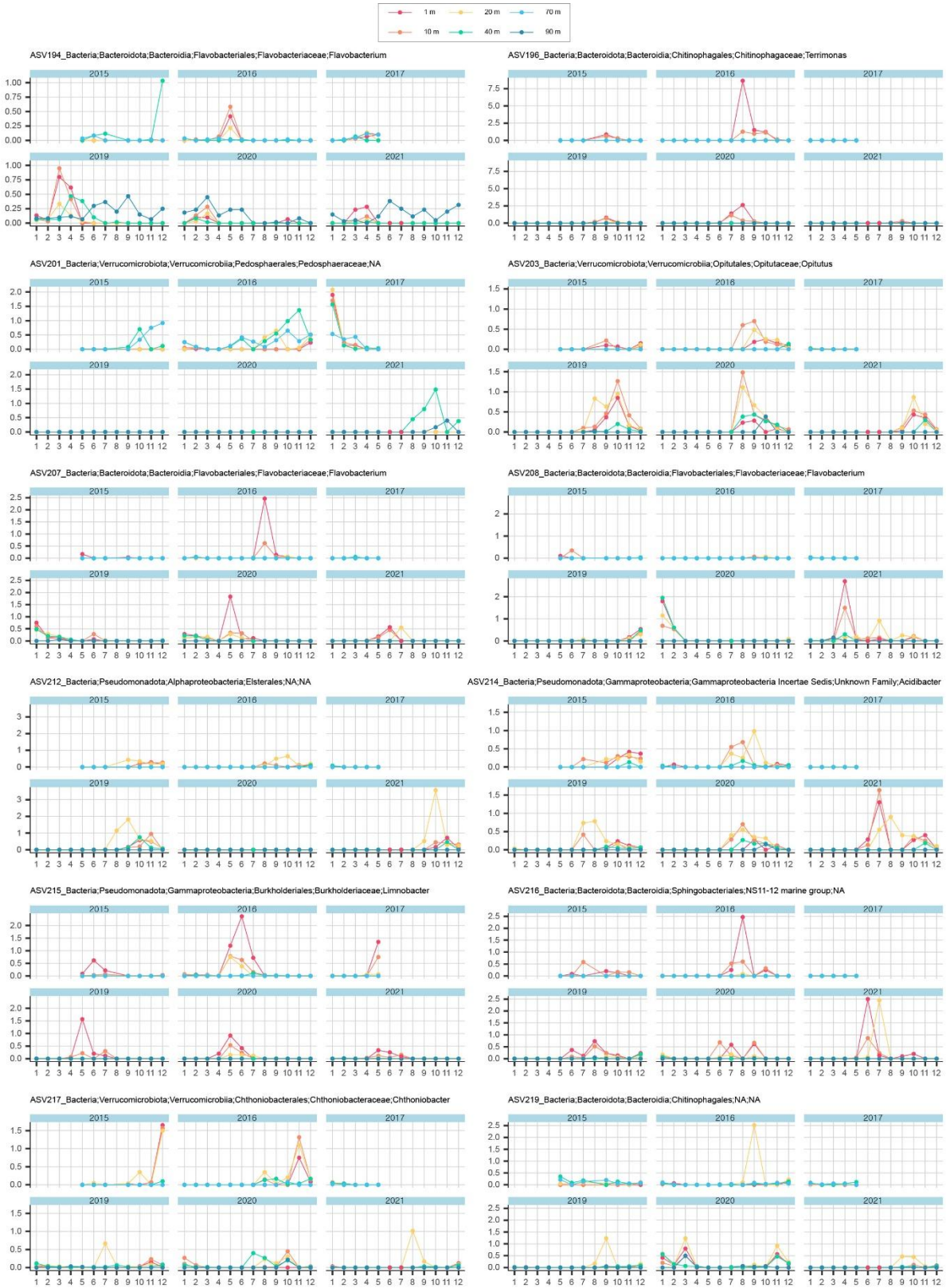

1 m
10 m
20 m
40 m
70 m
90 m
ASV111_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Burkholderiaceae;Lautropia
ASV112_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;NS11-12 marine group;NA
ASV116_Bacteria;Cyanobacteriota;Cyanobacteriia;Synechococcales;Cyanobiaceae;Cyanobium PCC-6307
ASV117_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Methylophilaceae;Pseudomethylobacillus
ASV118_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;env.OPS 17;NA
ASV119_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;NS11-12 marine group;NA
ASV120_Bacteria;Pseudomonadota;Gammaproteobacteria;Gammaproteobacteria Incertae Sedis;Unknown Family;Acidibacter
ASV121_Bacteria;Bdellovibrionota;Bdellovibrionia;Bdellovibrionales;Pseudobdellovibrionaceae;OM27 clade
ASV122_Bacteria;Pseudomonadota;Gammaproteobacteria;Pseudomonadales;Pseudohongiellaceae;Blyi10
ASV123_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV124_Bacteria;Patescibacteria;Parcubacteria;NA;NA;NA
ASV125_Bacteria;Bdellovibrionota;Oligoflexia;0319-6G20;NA;NA
2015
2016
2017
2019
2020
2021

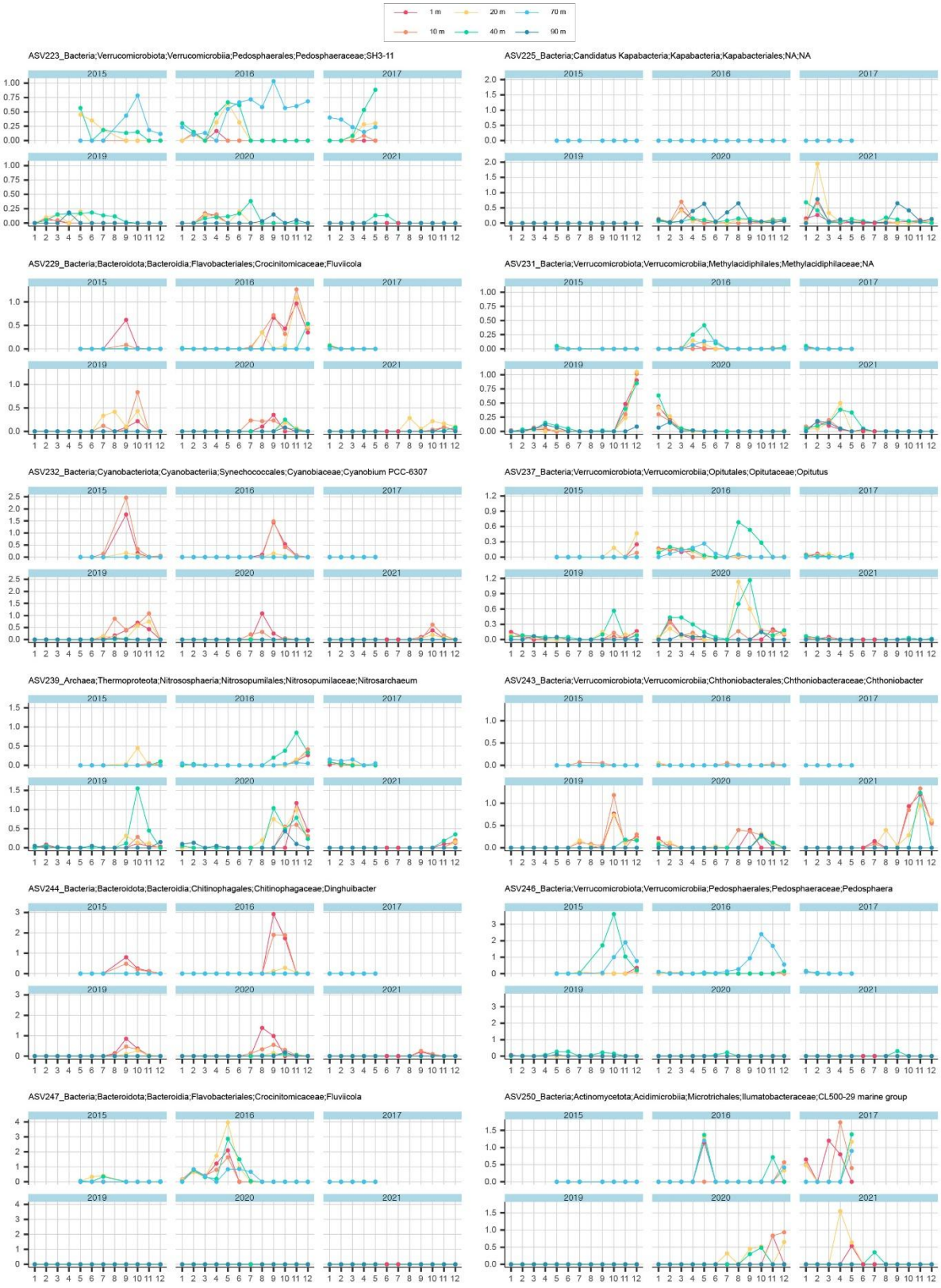

1 m
10 m
20 m
40 m
70 m
90 m
ASV126_Bacteria;Planctomycetota;Phycisphaerae;Phycisphaerales;Phycisphaeraceae;CL500-3
ASV127_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Chthoniobacterales;Chthoniobacteraceae;Chthoniobacter
ASV128_Bacteria;Planctomycetota;Planctomycetes;Planctomycetales;NA;NA
ASV129_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;NS11-12 marine group;NA
ASV130_Bacteria;Actinomycetota;Thermoleophilia;Gaiellales;NA;NA
ASV131_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade
ASV132_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;NS9 marine group;NA
ASV133_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV134_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;env.OPS 17;NA
ASV135_Bacteria;Pseudomonadota;Alphaproteobacteria;NA;NA;NA
ASV136_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV137_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;NA
2015
2016
2017
2019
2020
2021

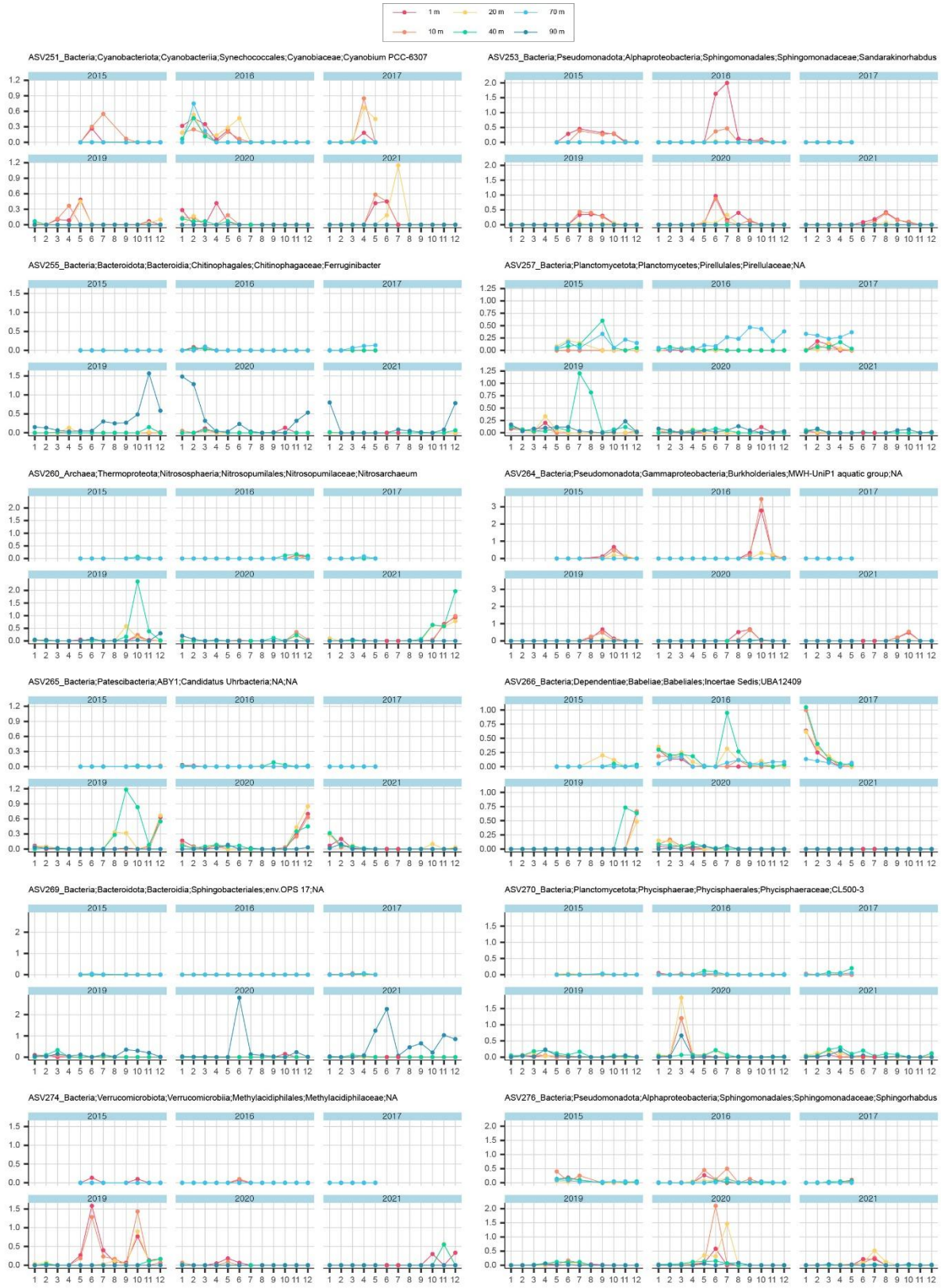

1 m
10 m
20 m
40 m
70 m
90 m
ASV138_Bacteria;Pseudomonadota;Alphaproteobacteria;Hyphomicrobiales;Beijerinckiaceae;alphal cluster
ASV140_Bacteria;Chlamydiota;Chlamydiia;Chlamydiales;Simkaniaceae;NA
ASV142_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV144_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;SH3-11
ASV147_Bacteria;Bacteroidota;Bacteroidia;Cytophagales;Spirosomataceae;Sandaracinomonas
ASV148_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;Candidatus Planktophila
ASV150_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;env.OPS 17;NA
ASV151_Bacteria;Chloroflexota;SL56 marine group;NA;NA;NA
ASV152_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;TRA3-20;NA
ASV153_Bacteria;Chloroflexota;Anaerolineae;Anaerolineales;Anaerolineaceae;NA
ASV154_Bacteria;SAR324 clade(Marine group B);Incertae Sedis;Incertae Sedis;Incertae Sedis;Candidatus Nitrosoarchaeum
ASV155_Bacteria;Planctomycetota;Phycisphaerae;Phycisphaerales;Phycisphaeraceae;CL500-3
2015
2016
2017
2019
2020
2021

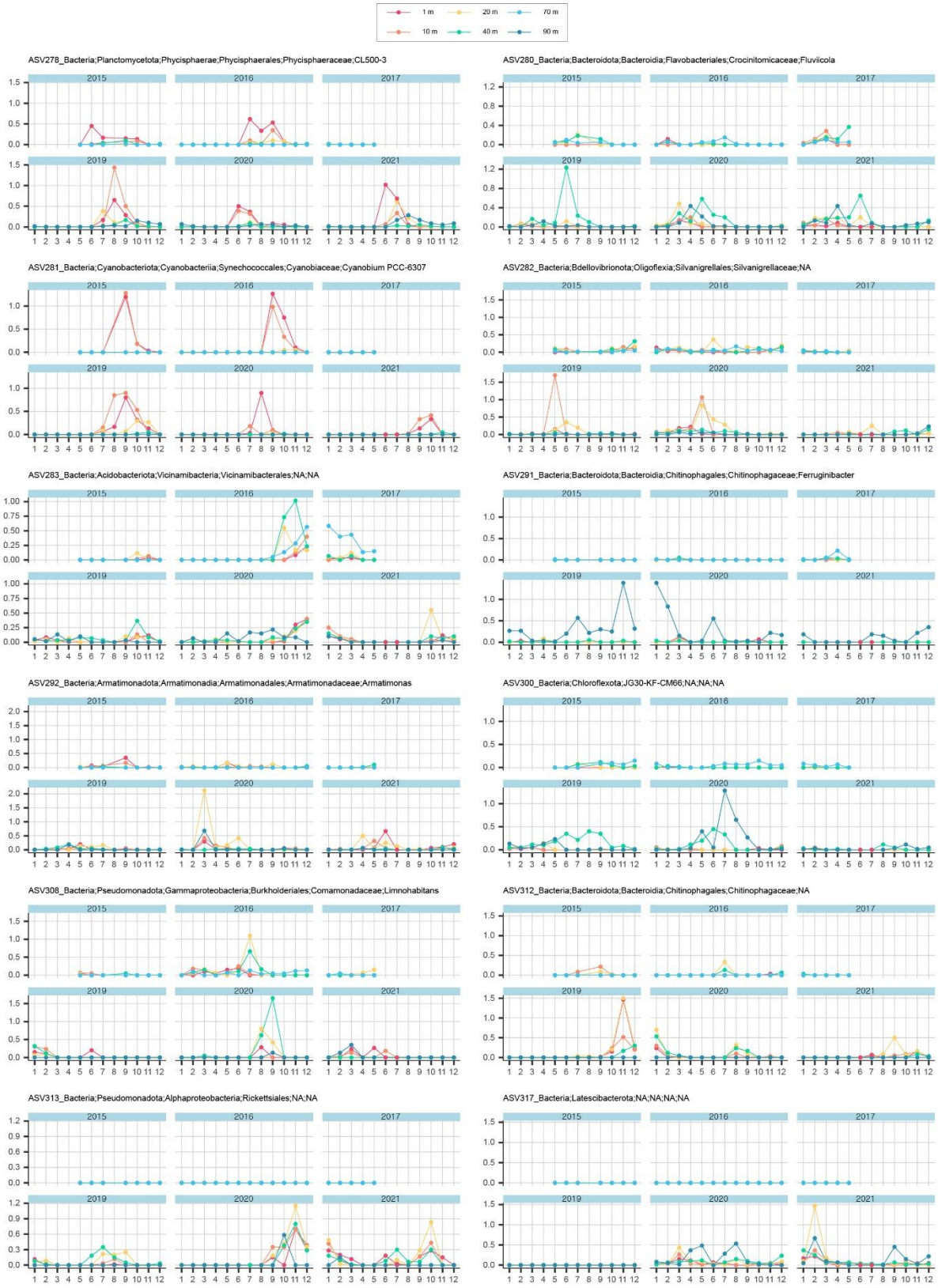

1 m
10 m
20 m
40 m
70 m
90 m
ASV156_Bacteria;Pseudomonadota;Alphaproteobacteria;Reyranellales;Reyranellaceae;Reyranella
ASV157_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;NA
ASV159_Bacteria;Actinomycetota;Acidimicrobiia;Acidimicrobiales;Acidimicrobiaceae;Acidiferrimicrobium
ASV160_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;Sphaerotilus
ASV161_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Edaphobaculum
ASV162_Bacteria;Pseudomonadota;Alphaproteobacteria;Pelagibacterales;Clade III;NA
ASV163_Bacteria;Chlamydiota;Chlamydiia;Chlamydiales;Simkaniaceae;Candidatus Renichlamydia
ASV164_Bacteria;Dependentiae;Babeliae;Babeliales;NA;NA
ASV165_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV167_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Oxalobacteraceae;NA
ASV170_Bacteria;Pseudomonadota;Alphaproteobacteria;NA;NA;NA
ASV171_Bacteria;Actinomycetota;Actinobacteria;Micrococcales;Microbacteriaceae;Candidatus Planktoluna
2015
2016
2017
2019
2020
2021

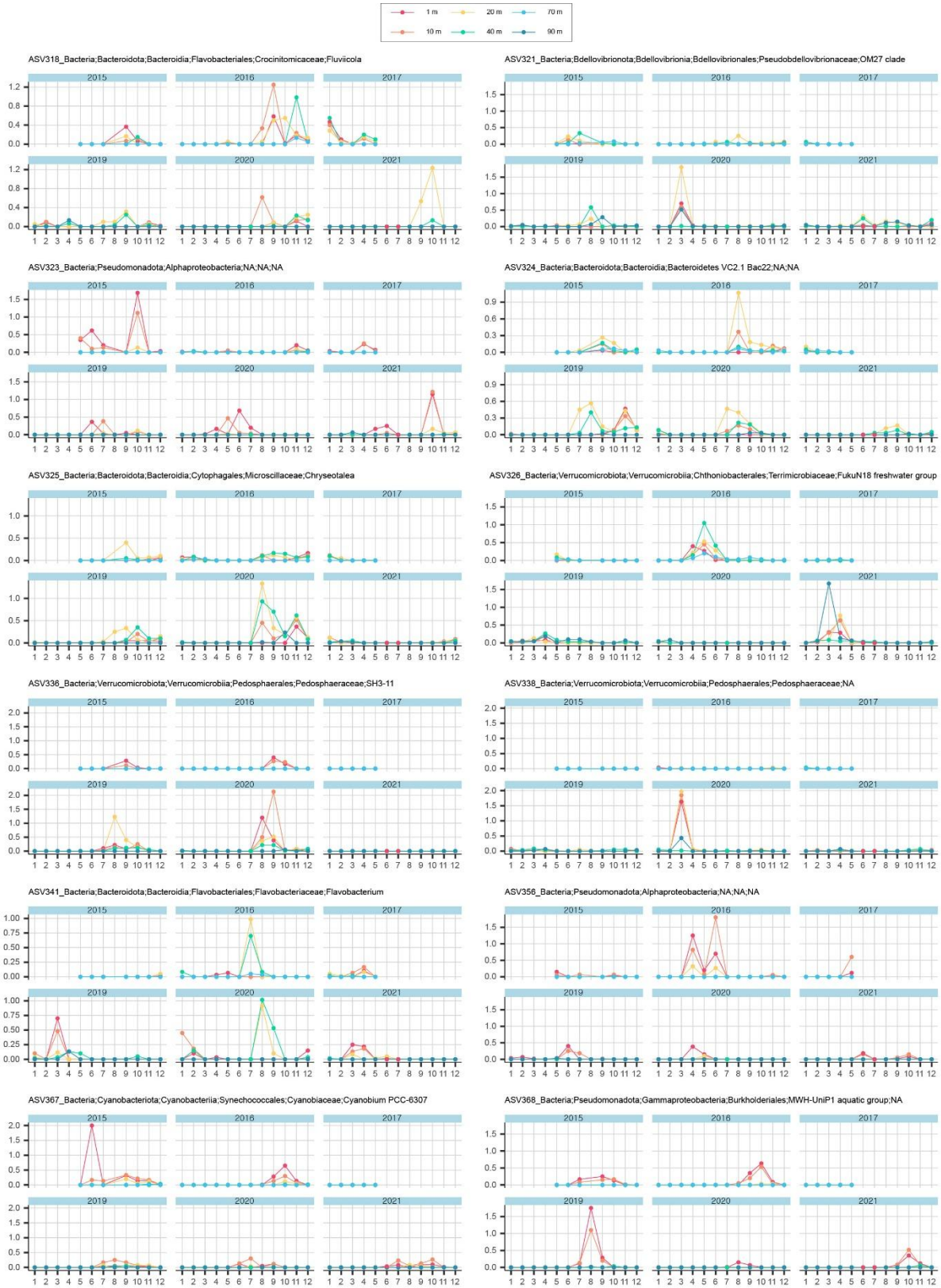

1 m
10 m
20 m
40 m
70 m
90 m
ASV172_Bacteria;Planctomycetota;Planctomycetes;Pirellulales;Pirellulaceae;NA
ASV173_Bacteria;Planctomycetota;Planctomycetes;Pirellulales;Pirellulaceae;NA
ASV174_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV175_Bacteria;Actinomycetota;Actinobacteria;Frankiales;Sporichthyaceae;hgcI clade
ASV176_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
ASV180_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV181_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV183_Bacteria;Pseudomonadota;Alphaproteobacteria;Paracaedibacterales;Paracaedibacteraceae;Candidatus Finniella
ASV184_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Ferruginibacter
ASV190_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Dinghuibacter
ASV191_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;NA
ASV192_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
2015
2016
2017
2019
2020
2021

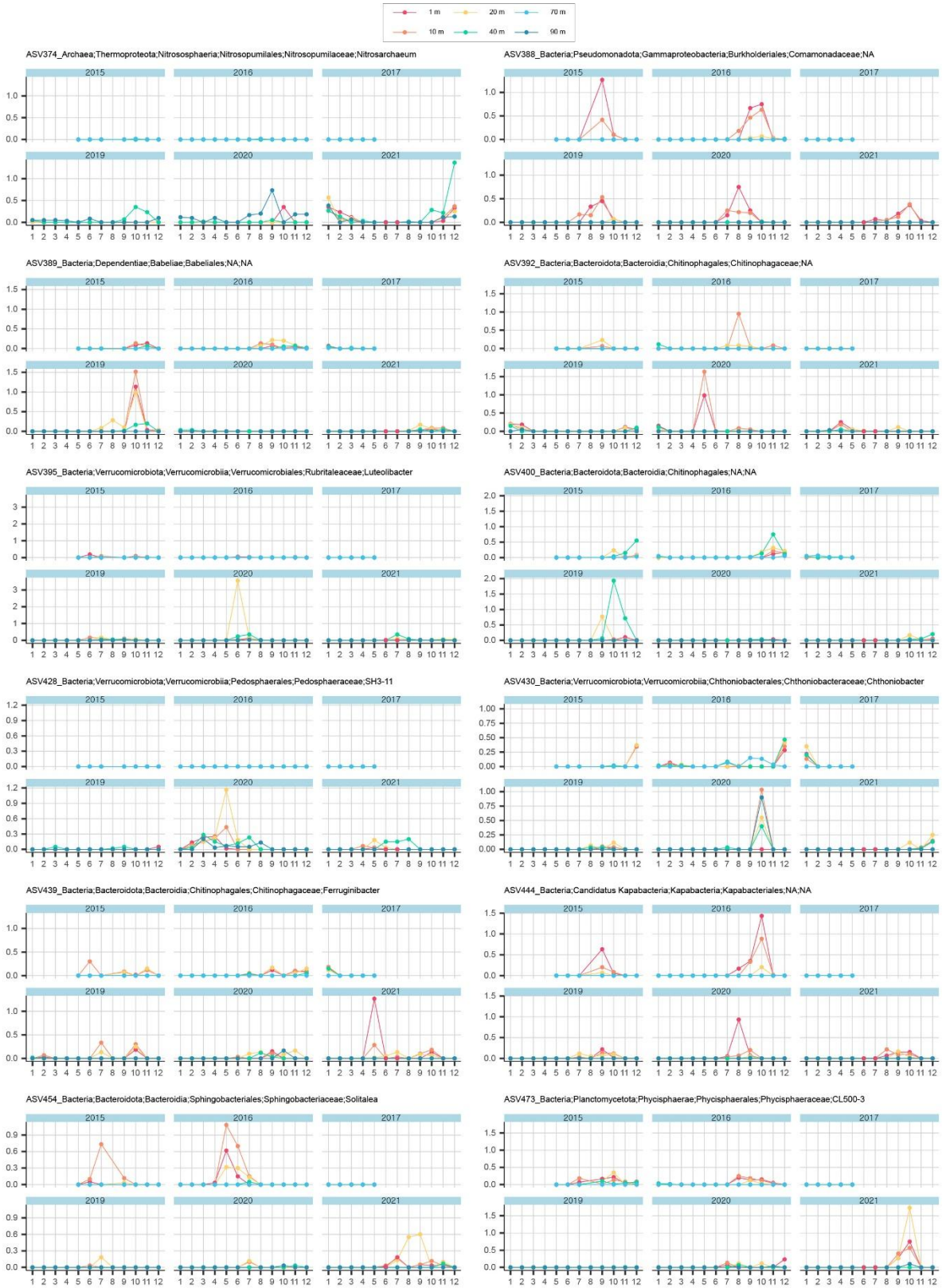

1 m
10 m
20 m
40 m
70 m
90 m
ASV194_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV196_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Terrimonas
ASV201_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;NA
ASV203_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Opitutales;Opitutaceae;Opitutus
ASV207_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV208_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV212_Bacteria;Pseudomonadota;Alphaproteobacteria;Elsterales;NA;NA
ASV214_Bacteria;Pseudomonadota;Gammaproteobacteria;Gammaproteobacteria Incertae Sedis;Unknown Family;Acidibacter
ASV215_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Burkholderiaceae;Limnobacter
ASV216_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;NS11-12 marine group;NA
ASV217_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Chthoniobacterales;Chthoniobacteraceae;Chthoniobacter
ASV219_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;NA;NA
2015
2016
2017
2019
2020
2021


1 m
10 m
20 m
40 m
70 m
90 m
ASV223_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;SH3-11
ASV225_Bacteria;Candidatus Kapabacteria;Kapabacteria;Kapabacteriales;NA;NA
ASV229_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV231_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV232_Bacteria;Cyanobacteriota;Cyanobacteriia;Synechococcales;Cyanobiaceae;Cyanobium PCC-6307
ASV237_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Opitutales;Opitutaceae;Opitutus
ASV239_Archaea;Thermoproteota;Nitrososphaeria;Nitrosopumilales;Nitrosopumilaceae;Nitrosarchaeum
ASV243_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Chthoniobacterales;Chthoniobacteraceae;Chthoniobacter
ASV244_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Dinghuibacter
ASV246_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;Pedosphaera
ASV247_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV250_Bacteria;Actinomycetota;Acidimicrobiia;Microtrichales;Ilumatobacteraceae;CL500-29 marine group
2015
2016
2017
2019
2020
2021


1 m
10 m
20 m
40 m
70 m
90 m
ASV251_Bacteria;Cyanobacteriota;Cyanobacteriia;Synechococcales;Cyanobiaceae;Cyanobium PCC-6307
ASV253_Bacteria;Pseudomonadota;Alphaproteobacteria;Sphingomonadales;Sphingomonadaceae;Sandarakinorhabdus
ASV255_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Ferruginibacter
ASV257_Bacteria;Planctomycetota;Planctomycetes;Pirellulales;Pirellulaceae;NA
ASV260_Archaea;Thermoproteota;Nitrososphaeria;Nitrosopumilales;Nitrosopumilaceae;Nitrosarchaeum
ASV264_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;MWH-UniP1 aquatic group;NA
ASV265_Bacteria;Patescibacteria;ABY1;Candidatus Uhrbacteria;NA;NA
ASV266_Bacteria;Dependentiae;Babeliae;Babeliales;Incertae Sedis;UBA12409
ASV269_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;env.OPS 17;NA
ASV270_Bacteria;Planctomycetota;Phycisphaerae;Phycisphaerales;Phycisphaeraceae;CL500-3
ASV274_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Methylacidiphilales;Methylacidiphilaceae;NA
ASV276_Bacteria;Pseudomonadota;Alphaproteobacteria;Sphingomonadales;Sphingomonadaceae;Sphingorhabdus
2015
2016
2017
2019
2020
2021


1 m
10 m
20 m
40 m
70 m
90 m
ASV278_Bacteria;Planctomycetota;Phycisphaerae;Phycisphaerales;Phycisphaeraceae;CL500-3
ASV280_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV281_Bacteria;Cyanobacteriota;Cyanobacteriia;Synechococcales;Cyanobiaceae;Cyanobium PCC-6307
ASV282_Bacteria;Bdellovibrionota;Oligoflexia;Silvanigrellales;Silvanigrellaceae;NA
ASV283_Bacteria;Acidobacteriota;Vicinamibacteria;Vicinamibacterales;NA;NA
ASV291_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Ferruginibacter
ASV292_Bacteria;Armatimonadota;Armatimonadia;Armatimonadales;Armatimonadaceae;Armatimonas
ASV300_Bacteria;Chloroflexota;JG30-KF-CM66;NA;NA;NA
ASV308_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;Limnohabitans
ASV312_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;NA
ASV313_Bacteria;Pseudomonadota;Alphaproteobacteria;Rickettsiales;NA;NA
ASV317_Bacteria;Latescibacterota;NA;NA;NA;NA
2015
2016
2017
2019
2020
2021


1 m
10 m
20 m
40 m
70 m
90 m
ASV318_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Crocinitomicaceae;Fluviicola
ASV321_Bacteria;Bdellovibrionota;Bdellovibrionia;Bdellovibrionales;Pseudobdellovibrionaceae;OM27 clade
ASV323_Bacteria;Pseudomonadota;Alphaproteobacteria;NA;NA;NA
ASV324_Bacteria;Bacteroidota;Bacteroidia;Bacteroidetes VC2.1 Bac22;NA;NA
ASV325_Bacteria;Bacteroidota;Bacteroidia;Cytophagales;Microscillaceae;Chryseotalea
ASV326_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Chthoniobacterales;Terrimicrobiaceae;FukuN18 freshwater group
ASV336_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;SH3-11
ASV338_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;NA
ASV341_Bacteria;Bacteroidota;Bacteroidia;Flavobacteriales;Flavobacteriaceae;Flavobacterium
ASV358_Bacteria;Pseudomonadota;Alphaproteobacteria;NA;NA;NA
ASV367_Bacteria;Cyanobacteriota;Cyanobacteriia;Synechococcales;Cyanobiaceae;Cyanobium PCC-6307
ASV368_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;MWH-UniP1 aquatic group;NA
2015
2016
2017
2019
2020
2021


1 m
10 m
20 m
40 m
70 m
90 m
ASV374_Archaea;Thermoproteota;Nitrososphaeria;Nitrosopumilales;Nitrosopumilaceae;Nitrosarchaeum
ASV388_Bacteria;Pseudomonadota;Gammaproteobacteria;Burkholderiales;Comamonadaceae;NA
ASV389_Bacteria;Dependentiae;Babeliae;Babeliales;NA;NA
ASV392_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;NA
ASV395_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Verrucomicrobiales;Rubritaleaceae;Luteolibacter
ASV400_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;NA;NA
ASV428_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Pedosphaerales;Pedosphaeraceae;SH3-11
ASV430_Bacteria;Verrucomicrobiota;Verrucomicrobiia;Chthoniobacterales;Chthoniobacteraceae;Chthoniobacter
ASV439_Bacteria;Bacteroidota;Bacteroidia;Chitinophagales;Chitinophagaceae;Ferruginibacter
ASV444_Bacteria;Candidatus Kapabacteria;Kapabacteria;Kapabacteriales;NA;NA
ASV454_Bacteria;Bacteroidota;Bacteroidia;Sphingobacteriales;Sphingobacteriaceae;Solitalea
ASV473_Bacteria;Planctomycetota;Phycisphaerae;Phycisphaerales;Phycisphaeraceae;CL500-3
2015
2016
2017
2019
2020
2021

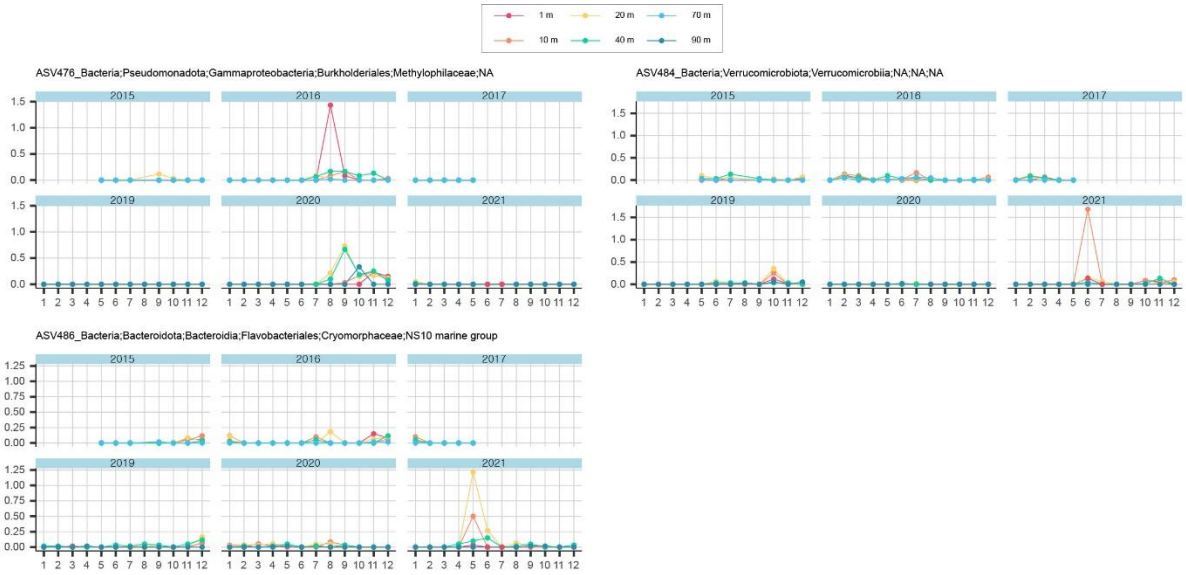


Fig. S7. (continued)

Fig. S8. Seasonal resilience at 10-meter depth. Columns represent sampling points and rows represent ASVs color-coded by taxonomic affiliations.

Fig. S9. Seasonal resilience at 20-meter depth. Columns represent sampling points and rows represent ASVs color-coded by taxonomic affiliations.

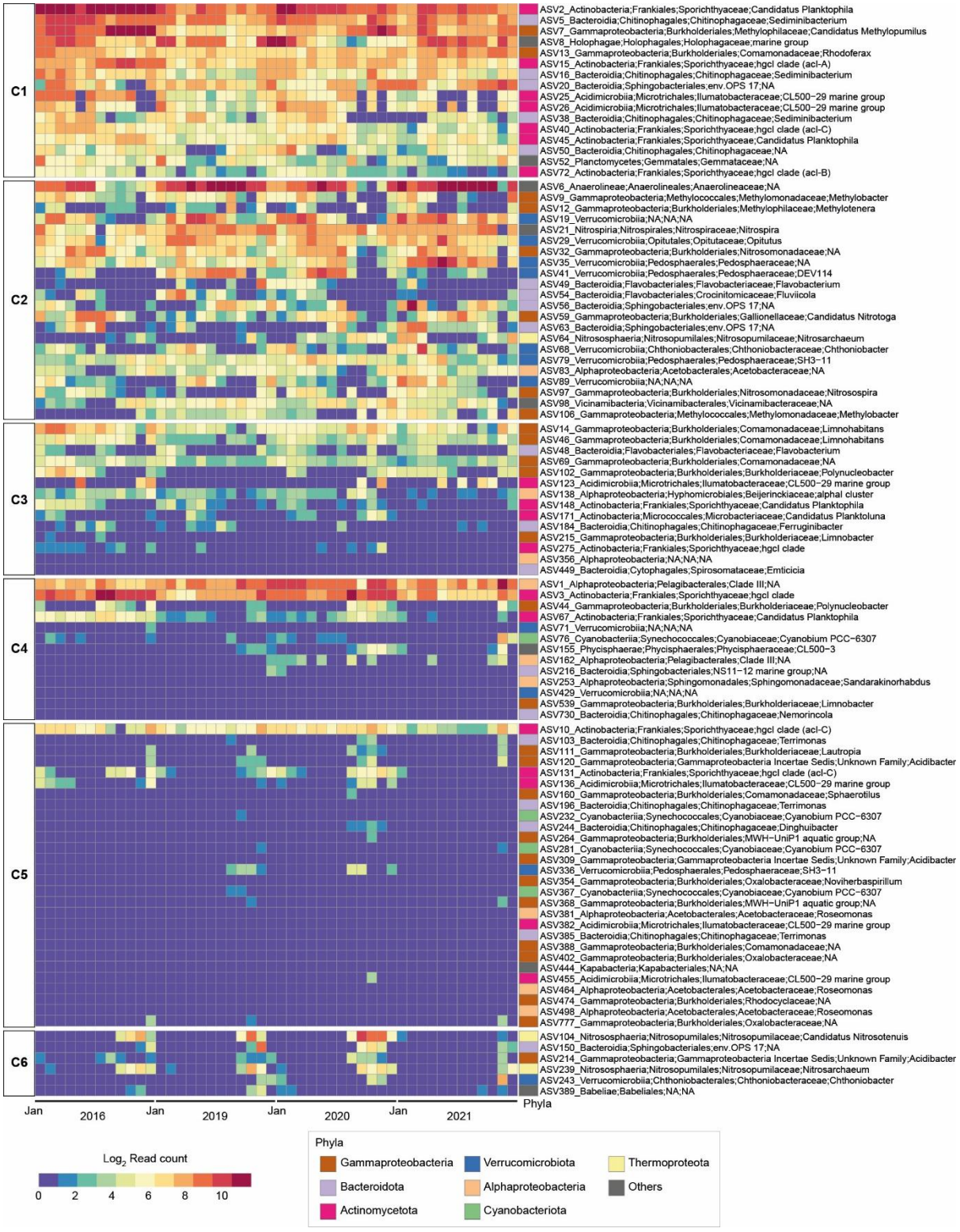


Fig. S10. Seasonal resilience at 40-meter depth. Columns represent sampling points and rows represent ASVs color-coded by taxonomic affiliations.