Supplementary Table S6. Benchmark results of MCC1 for SignalP 6.0, Fine-tuning ESM-2 model family, and PEFT-SP using different PEFT methods with the ESM-2 model family. The SP type indicated with the symbol † represents SP types with limited training samples. The bold value indicates the highest value for each SP type among all methods.

Method	Baseline	Fine-tuning			Prompt Tuning			Adapter Tuning			LoRA Tuning		
Backbone	SignalP 6.0	ESM2-150M	ESM2-650M	ESM2-3B	ESM2-150M	ESM2-650M	ESM2-3B	ESM2-150M	ESM2-650M	ESM2-3B	ESM2-150M	ESM2-650M	ESM2-3B
Archaea Sec/SPI	0.798	0.763	0.809	0.777	0.711	0.798	0.791	**0.842**	0.823	0.841	0.791	0.763	0.805
Archaea Sec/SPII	0.885	0.885	0.919	0.919	0.765	0.925	0.732	0.925	0.857	0.885	**0.953**	0.925	0.858
Archaea Sec/SPIII †	0.500	0.440	0.460	**0.899**	0.320	0.562	0.500	0.750	0.750	0.500	0.690	0.569	**0.899**
Archaea Tat/SPI	0.599	0.767	0.610	0.593	0.497	0.564	0.735	0.626	0.751	0.532	0.651	**0.884**	0.610
Archaea Tat/SPII †	0.880	0.886	**1.000**	0.923	0.367	0.461	0.250	0.669	**1.000**	0.867	0.750	0.961	**1.000**
Eukarya Sec/SPI	0.958	0.952	0.960	0.948	0.921	0.935	0.954	0.951	0.949	0.954	0.951	0.939	**0.960**
Negative Sec/SPI	0.856	0.822	0.864	0.870	0.773	0.791	0.819	0.875	0.869	**0.877**	0.862	0.844	0.862
Negative Sec/SPII	0.942	0.946	0.954	0.950	0.866	0.933	0.911	0.945	0.941	0.955	**0.962**	0.948	0.955
Negative Sec/SPIII †	0.899	0.971	0.962	**0.981**	0.925	0.977	0.969	0.883	0.964	0.897	0.886	0.875	0.918
Negative Tat/SPI	0.978	0.973	0.955	0.906	0.834	0.951	0.865	0.968	0.976	0.900	**0.987**	0.966	0.975
Negative Tat/SPII †	0.585	0.574	0.585	0.533	0.178	0.492	0.393	0.428	0.595	**0.601**	0.370	0.560	0.595
Positive Sec/SPI	0.868	0.885	0.915	0.905	0.847	0.800	0.867	**0.920**	0.897	0.918	0.896	0.887	0.915
Positive Sec/SPII	0.868	0.898	0.904	0.884	0.742	0.814	0.820	0.921	0.880	0.892	**0.935**	0.915	0.928
Positive Sec/SPIII †	0.951	**1.000**	0.951	**1.000**	**1.000**	**1.000**	0.951	0.928	0.969	0.969	0.937	0.928	**1.000**
Positive Tat/SPI	0.788	0.824	0.808	0.736	0.705	0.788	0.614	0.787	0.781	0.743	0.808	0.822	**0.845**
Positive Tat/SPII †	**1.000**	0.928	0.985	0.985	0.333	0.233	0.233	0.761	0.733	**1.000**	0.689	0.667	0.985
mean	0.835	0.845	0.852	0.863	0.674	0.752	0.713	0.824	0.858	0.833	0.820	0.841	**0.882**