Supplementary material

Biofouling changes the settling dynamics of macroplastic plates

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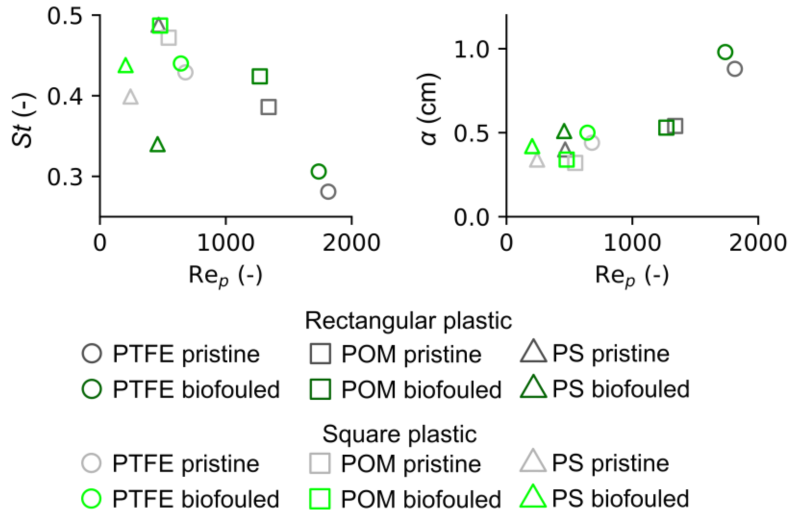

Figure S1. The average Strouhal number (St) and oscillation amplitude (α) against the particle Reynolds number (Re_P). Pristine and biofouled plates are highlighted in different colours for clarity.

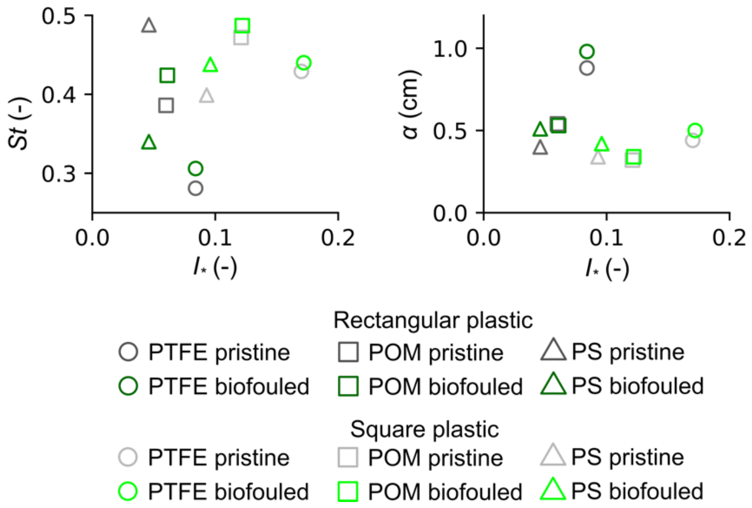

Figure S2. The average Strouhal number (St) and oscillation amplitude (α) against the dimensionless moment of inertia (I^*). Pristine and biofouled plates are highlighted in different colours for clarity.

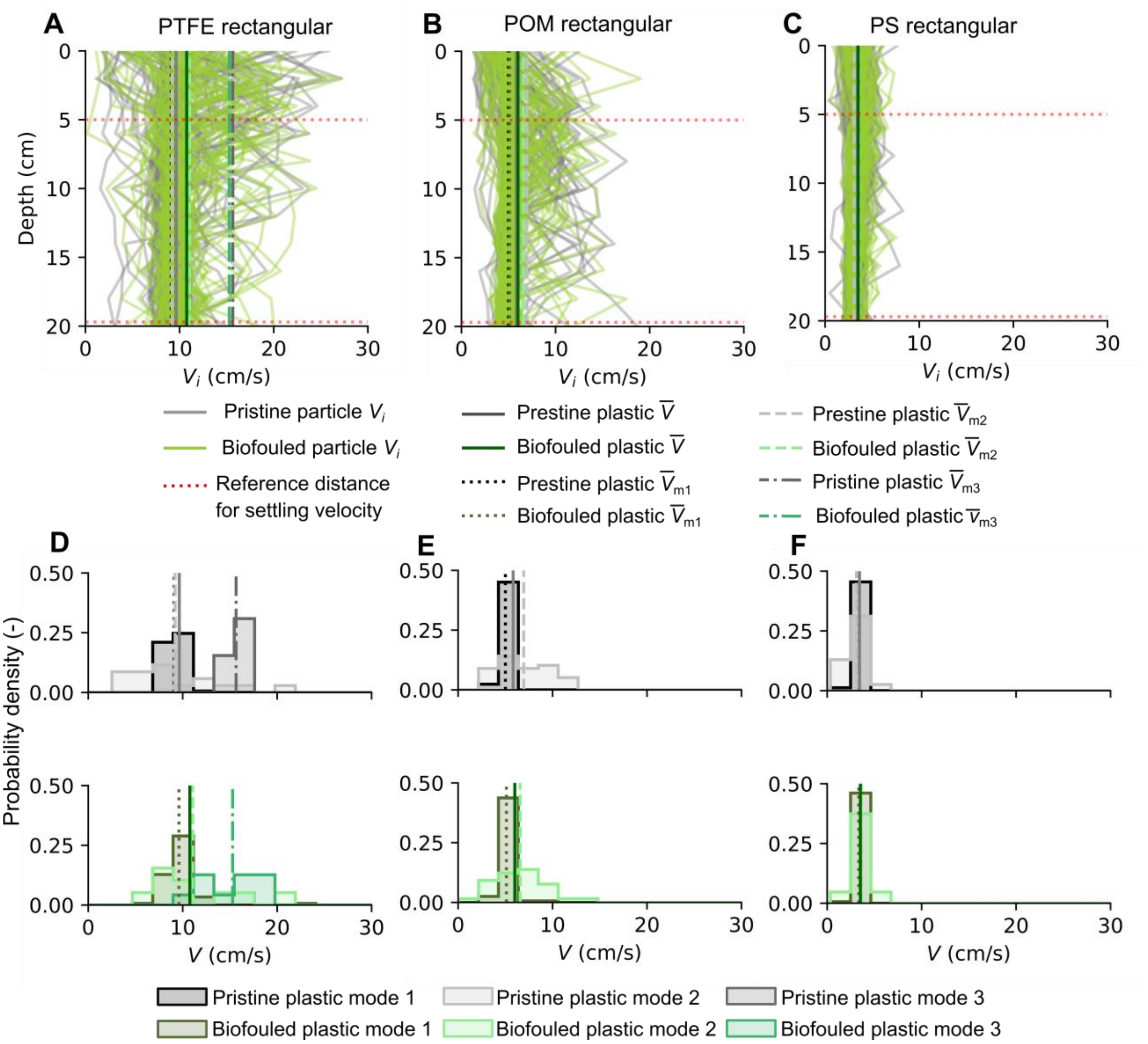

Figure S3 The instantaneous horizontal (V_i) velocity of all biofouled and pristine rectangle plates against the vertical distance travelled, considering 90 repeat tests. Vertical lines represent the average vertical ($\bar{V}$) velocity of biofouled and pristine rectangular particles, as well as the average vertical velocity of particles settling in mode 1 ($\bar{V}_{m1}$), mode 2 ($\bar{V}_{m2}$) and mode 3 ($\bar{V}_{m3}$), taken between a vertical depth of 5 – 20 cm. Transition periods were ignored during calculations of $\bar{V}_{m1}$, $\bar{V}_{m2}$, $\bar{V}_{m3}$. D-F) Probability distribution functions of particle settling velocity the various modes of vertical transport (mode 1, 2 or 3) for both pristine and biofouled plastics. Periods where the particles were in transition between modes were omitted from probability distribution

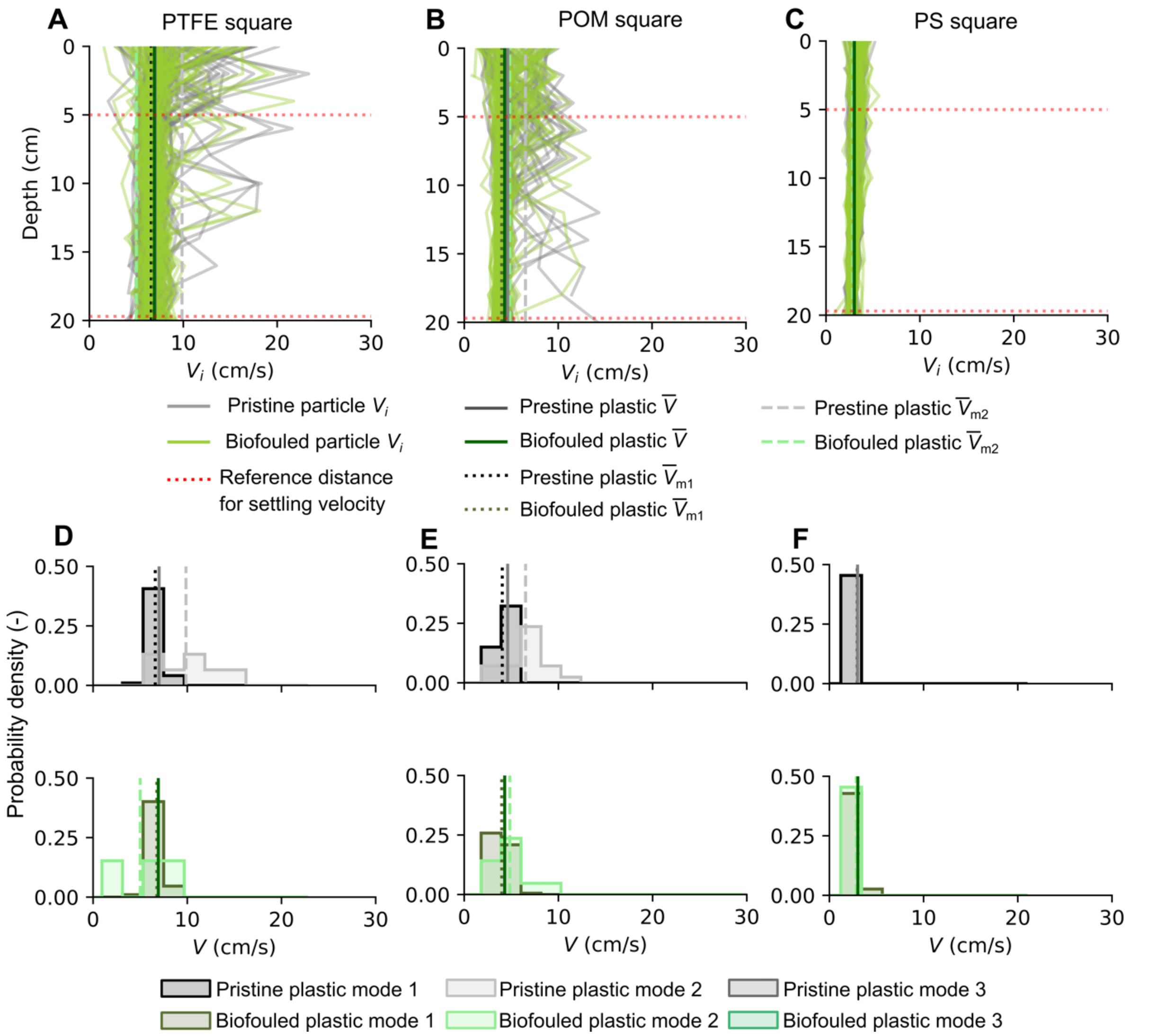

Figure S4 A-C) The instantaneous horizontal (V_i) velocity of all biofouled and pristine square plates against the vertical distance travelled, considering 90 repeat tests. Vertical lines represent the average vertical ($\bar{V}$) velocity of biofouled and pristine square particles, as well as the average vertical velocity of particles settling in mode 1 ($\bar{V}_{m1}$), mode 2 ($\bar{V}_{m2}$) and mode 3 ($\bar{V}_{m3}$), taken between a vertical depth of 5 – 20 cm. Transition periods were ignored during calculations of $\bar{V}_{m1}$, $\bar{V}_{m2}$, $\bar{V}_{m3}$. D-F) Probability distribution functions of particle settling velocity the various modes of vertical transport (mode 1, 2 or 3) for both pristine and biofouled plastics. Periods where the particles were in transition between modes were omitted from probability distribution

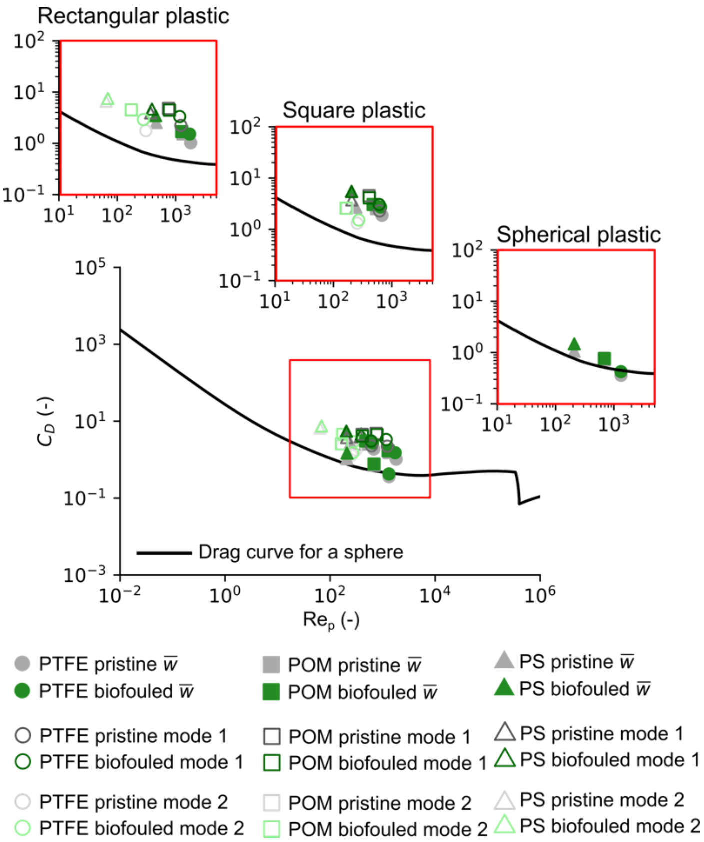

Figure S5. Drag coefficient C_d and Particle Reynolds number Re_P relationship for biofouled and pristine rectangular, square and spherical particles settling in modes 1, 2 and 3. Standardised drag curve for a sphere, following table 5.2 of [1].

Table S1. Plastic properties of pristine and biofouled particles, considering a repeat of 10 samples, in terms of density, areal average surface roughness and contact angle. p-values from a non-parametric Mann-Whitney U test comparing pristine and biofouled particles are also presented (N = 10 for all groups).

	PTFE rectangle			POM rectangle			PS rectangle		
	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value
Density ± std (kg/m^3)	1,965.15 ± 13.04	1,979.14 ± 14.94	0.064	1,403.54 ± 12.29	1,426.69 ± 16.20	0.007	1,073.18 ± 9.41	1,089.83 ± 10.78	0.003
Areal average surface roughness ± std (μm)	69.79 ± 7.76	131.2 ± 12.61	0.000	50.21 ± 3.67	103.36 ± 17.94	0.000	30.30 ± 3.47	137.7 ± 18.62	0.000
Contact angle ± std (°)	87.63 ± 2.21	68.4 ± 13.86	0.008	70.2 ± 5.86	43.99 ± 6.72	0.008	62.18 ± 4.53	36.96 ± 8.94	0.000
	PTFE square			POM square			PS square		
	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value
Density ± std (kg/m^3)	1,980.33 ± 17.08	2,009.38 ± 40.01	0.031	1,406.89 ± 10.74	1,427.11 ± 12.05	0.002	1,081.08 ± 8.85	1,118.12 ± 32.27	0.009
Areal average surface roughness ± std (μm)	61.99 ± 25.62	135.46 ± 45.76	0.002	50.4 ± 8.85	104.02 ± 36.25	0.003	44.63 ± 11.79	149.9 ± 15.66	0.000
Contact angle ± std (°)	85.15 ± 4.23	69.21 ± 10.84	0.016	68.22 ± 5.84	42.86 ± 10.11	0.008	59.27 ± 3.18	46.38 ± 8.86	0.016
	PTFE spherical			POM spherical			PS spherical		
	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value
Density ± std (kg/m^3)	2,143.12 ± 34.56	2,168.36 ± 30.64	0.050	1,332.10 ± 15.13	1,349.76 ± 14.74	0.014	1,040.80 ± 5.37	1,058.32 ± 9.38	0.001
Areal average surface roughness ± std (μm)	70.62 ± 19.92	122.24 ± 27.63	0.001	123.8 ± 23.29	146.92 ± 29.47	0.147	93.16 ± 24.47	135.01 ± 22.33	0.001

Table S2. Values of particle Reynolds numbers $\mathrm{Re_P}$ and the dimensionless moment of inertia I_* for all particles.

	PTFE rectangle		POM rectangle		PS rectangle	
	Pristine	Biofouled	Pristine	Biofouled	Pristine	Biofouled
$\mathrm{Re_p}$	1814	1738	1340	1270	466	458
I_*	0.084	0.084	0.060	0.061	0.046	0.046
	PTFE square		POM square		PS square	
	Pristine	Biofouled	Pristine	Pristine	Biofouled	Pristine
$\mathrm{Re_p}$	679	643	546	478	243	204
I_*	0.170	0.172	0.121	0.122	0.093	0.096
	PTFE sphere		POM sphere		PS sphere	
	Pristine	Biofouled	Pristine	Pristine	Biofouled	Pristine
$\mathrm{Re_p}$	1324	1320	686	686	209	210

Table S3. The average horizontal drift for anisotropic particles settling in mode 1 and p-values from a non-parametric Mann-Whitney U test comparing pristine and biofouled particles ($N > 30$ for all groups).

	PTFE rectangle			POM rectangle			PS rectangle		
	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value
Average horizonal drift ± std (cm)	1.60 ± 1.14	2.15 ± 1.30	0.000	1.42 ± 0.75	1.62 ± 0.85	0.102	0.65 ± 0.31	1.48 ± 0.76	0.000
	PTFE square			POM square			PS square		
	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value	Pristine	Biofouled	p-value
Average horizonal drift ± std (cm)	0.86 ± 0.57	0.99 ± 0.68	0.002	0.71 ± 0.33	0.77 ± 0.24	0.150	0.89 ± 0.43	1.36 ± 0.86	0.004

Table S4. Average oscillatory characteristics in terms of frequency f Strouhal number St and amplitude α anisotropic particles settling in mode 1. p-values from a non-parametric Mann-Whitney U test comparing pristine and biofouled particles are also presented (N > 30 for all groups).

	PTFE rectangle			POM rectangle			PS rectangle		
	Pristine	Biofouled	p-values	Pristine	Biofouled	p-values	Pristine	Biofouled	p-values
f ± std (Hz)	1.73 ± 0.91	1.83 ± 0.77	0.245	1.52 ± 0.54	1.67 ± 0.93	0.083	0.94 ± 0.29	0.68 ± 0.39	0.001
St ± std	0.28 ± 0.14	0.31 ± 0.14	0.064	0.39 ± 0.14	0.42 ± 0.25	0.232	0.49 ± 0.14	0.34 ± 0.19	0.000
α ± std (cm)	0.88 ± 0.3	0.98 ± 0.31	0.004	0.54 ± 0.15	0.53 ± 0.17	0.838	0.40 ± 0.13	0.51 ± 0.20	0.000
	PTFE square			POM square			PS square		
	Pristine	Biofouled	p-values	Pristine	Biofouled	p-values	Pristine	Biofouled	p-values
f ± std (Hz)	2.52 ± 1.1	2.7 ± 0.74	0.186	1.91 ± 0.72	2.08 ± 0.7	0.091	0.84 ± 0.29	0.89 ± 0.41	0.186
St ± std	0.43 ± 0.18	0.44 ± 0.12	0.031	0.47 ± 0.18	0.49 ± 0.17	0.187	0.40 ± 0.16	0.44 ± 0.20	0.031
α ± std (cm)	0.44 ± 0.13	0.50 ± 0.16	0.003	0.32 ± 0.06	0.34 ± 0.08	0.289	0.34 ± 0.13	0.42 ± 0.19	0.004

Table S5. The geometric properties of the pristine and biofouled plastic particles used in experiments, including the plastic's maximum (L_1), intermediate (L_2) and smallest (L_3) dimensions, the Corey Shape Factor (CSF) [2], calculated as $L_3 \,/\, \sqrt{(L_1 L_2)}$.

Shape	L_1 (mm)	L_2 (mm)	L_3 (mm)	CSF
Rectangle plate	20	10	1	0.07
Square plate	10	10	1	0.10
Spheres	5	5	5	1.00

Supplementary References

1. Clift, R., Grace, J. R. & Weber, M. E. Bubbles, Drops, and Particles (Dover Civil and Mechanical Engineering). 380 (1978).
2. Corey, A. T. *et al.* Influence of shape on the fall velocity of sand grains. (1949) doi:10.17616/R31NJMSY.