eAppendix to *Coliphages as indicators of gastrointestinal illness in recreational waters: a pooled analysis of six prospective coastal beach cohorts*

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eAppendix 1: Information to support beach classification

Avalon Beach At Avalon Beach, wastewater from a faulty sanitary sewer system discharges as submarine groundwater through the sand and is moderated by tidal conditions. The level of enterococci was similar on days with groundwater flow above and below median. However, the incidence of gastrointestinal illness was higher on days with groundwater flow above the median, especially for swimmers who swallowed water.[1] Based on these prior findings, when groundwater flow was above the median, we classified study days as human-impacted; when it was below median flow, we classified it as not human-impacted.

Doheny Beach is located at the mouth of the San Juan Creek, which drains a 347 km^2 watershed.[2] At Doheny Beach, during the spring and summer, a sand berm forms that blocks the flow of the creek into the watershed; when it was open, the creek discharged directly into the surf zone. The median levels of enterococci detected at the mouth of the creek were 316 CFU/100 mL when the berm was open compared to 10 CFU/100 mL when it was closed.[2] Similarly, diarrhea incidence was substantially higher among swimmers when the berm was open compared to when it was closed, particularly among swimmers who swallowed water.[2] When the berm was open, 71% of samples exceeded the single sample marine water quality standard (104 CFU/100 ml) compared to 5% of samples when it was closed. Given this context, we classify days when the berm was open at Doheny as human-impacted and days when it was closed as not human-impacted.

Fairhope and Goddard Beaches We considered both beaches to likely be polluted with human feces on all study days due the presence of human sources of sewage impacting the beach. These beaches were part of the National Epidemiological and Environmental Assessment of Recreational Water (NEEAR) Study. A criterion for inclusion in the NEEAR study was that beach sites were located near wastewater treatment plant discharge outfalls from facilities serving populations of 10,000 or more. The site selection process for the NEEAR studies has been described previously in detail[3] and included a detailed assessment of nearby wastewater treatment plant discharges. Goddard Beach had three wastewater treatment plants discharging to receiving streams near the beach serving nearly 80,000; Fairhope Beach was impacted by a single waste water treatment plant that served approximately 13,000.

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1 Yau VM, Schiff KC, Arnold BF, et al. Effect of submarine groundwater discharge on bacterial indicators and swimmer health at Avalon Beach, CA, USA. *Water Res.* 2014;59:23-36. doi:10.1016/j.watres.2014.03.050.

2 Colford JM Jr, Schiff KC, Griffith JF, et al. Using rapid indicators for Enterococcus to assess the risk of illness after exposure to urban runoff contaminated marine water. *Water Res.* 2012;46(7):2176-2186. doi:10.1016/j.watres.2012.01.033.

3 Wade TJ, Calderon RL, Sams E, et al. Rapidly measured indicators of recreational water quality are predictive of swimming-associated gastrointestinal illness. *Environ Health Perspect.* 2006;114(1):24-28.
Wade TJ, Calderon RL, Brenner KP, et al. High sensitivity of children to swimming-associated gastrointestinal illness: results using a rapid assay of recreational water quality. *Epidemiology.* 2008;19(3):375-383. doi:10.1097/EDE.0b013e318169cc87.
Wade TJ, Sams E, Brenner KP, et al. Rapidly measured indicators of recreational water quality and swimming-associated illness at marine beaches: a prospective cohort study. *Environ Health.* 2010;9:66. doi:10.1186/1476-069X-9-66.)

Malibu Beach is not located near any wastewater treatment facilities.[4] Regarding Malibu Beach, Malibu is similar to Doheny in that there is a creek that forms a pond behind a sand berm in summer. When the creek is flowing, the Haile et al. (1999) study demonstrated that there was increased risk of GI illness with increasing proximity to the flowing creek.[5] Given this, one would assume that when the creek flows, Malibu should be considered human-impacted. However, there are two mitigation factors. The first factor is that in the interim between the Haile study and ours, Malibu became a "designated surfing beach". This means that only surfers are allowed in the water for several hundred feet on either side of the creek mouth, and non-surfers are actively excluded by lifeguards from swimming in this area, effectively limiting exposure of our study population to areas of the beach unaffected by the flowing creek. The second factor has to do with underground transport of the freshwater plume from residential septic systems located in the Malibu Colony development, just west of the beach along the shoreline. A USGS study by Izbicki et al. (2012) demonstrated that the wooden pilings driven into the shoreline in front of the development effectively prevent the plume for exfiltrating directly to the ocean.[6] Instead, the septic plume discharges on either end of the colony, with the majority of water on the east end discharging into Malibu Lagoon and exiting via the creek. Thus, at the time of this study, we classified the portion of Malibu beach where people swim as unlikely to be impacted by human fecal contamination.

Mission Bay Beach is not located downstream of any nearby waste water treatment facilities, and there are no other known sources of human fecal contamination near it.[7]

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[4] Arnold BF, Schiff KC, Griffith JF, et al. Swimmer illness associated with marine water exposure and water quality indicators: impact of widely used assumptions. *Epidemiology*. 2013;24(6):845-853. doi:10.1097/01.ede.0000434431.06765.4a.

[5] Haile RW, Witte JS, Gold M, et al. The health effects of swimming in ocean water contaminated by storm drain runoff. *Epidemiology*. 1999;10(4):355-363.

[6] Izbicki JA, Swarzenski PW, Burton CA, Van LC, Holden PA, A E. Sources of Fecal Indicator Bacteria to Groundwater, Malibu Lagoon and the Near- Shore Ocean, Malibu. *Annals of Environmental Science*. 2012;6:35-86.

[7] Colford JM Jr, Wade TJ, Schiff KC, et al. Water quality indicators and the risk of illness at beaches with nonpoint sources of fecal contamination. *Epidemiology*. 2007;18(1):27-35. doi:10.1097/01.ede.0000249425.32990.b9.

eAppendix 2: Choice of reference group for cumulative incidence ratios

We chose swimmers recreating in water without detectable coliphage as the reference group for our primary analyses. Associations between coliphage and illness were also stronger when using non-swimmers as the reference group. Past studies have used both types of reference groups.[8] Non-swimmers do not enter the water and thus are not exposed to any pathogens in the water. As a result, they have a lower incidence of illness than swimmers (Figure 1), but they also may be different from swimmers in both measured and unmeasured characteristics. Although we can control for many of these factors some differences may be difficult to completely account for In addition, there may be greater recall bias among non-swimmers than among swimmers. Thus, we chose swimmers in waters without detectable coliphage or enterococci as our reference group to minimize unmeasured confounding and differential recall bias.

[8] Arnold BF, Schiff KC, Griffith JF, et al. Swimmer illness associated with marine water exposure and water quality indicators: impact of widely used assumptions. Epidemiol Camb Mass. 2013;24(6):845-853. doi:10.1097/01.ede.0000434431.06765.4a.

Arnold B, Wade T, Benjamin-Chung J, et al. Acute Gastroenteritis and Recreational Water: Highest Burden Among Young US Children. Am J Public Health. 2016. doi:10.2105/AJPH.2016.303279.

Colford JM Jr, Wade TJ, Schiff KC, et al. Water quality indicators and the risk of illness at beaches with nonpoint sources of fecal contamination. Epidemiology. 2007;18(1):27-35. doi:10.1097/01.ede.0000249425.32990.b9.

Colford JM Jr, Schiff KC, Griffith JF, et al. Using rapid indicators for Enterococcus to assess the risk of illness after exposure to urban runoff contaminated marine water. Water Res. 2012;46(7):2176-2186. doi:10.1016/j.watres.2012.01.033.

Wade TJ, Sams E, Brenner KP, et al. Rapidly measured indicators of recreational water quality and swimming-associated illness at marine beaches: a prospective cohort study. Environ Health Glob Access Sci Source. 2010;9:66. doi:10.1186/1476-069X-9-66.

Yau VM, Schiff KC, Arnold BF, et al. Effect of submarine groundwater discharge on bacterial indicators and swimmer health at Avalon Beach, CA, USA. Water Res. 2014;59:23-36. doi:10.1016/j.watres.2014.03.050.

eTable 1: Previous publications citing data in this study

Citation	Beaches	Enterococci	Somatic coliphage	Male-specific coliphage
Arnold BF, Schiff KC, Griffith JF, et al. *Epidemiology*. Swimmer illness associated with marine water exposure and water quality indicators: impact of widely used assumptions. 2013;24(6):845-853. doi:10.1097/01.ede.0000434431.06765.4a.	Malibu	✓		
Arnold B, Wade T, Benjamin-Chung J, et al. Acute Gastroenteritis and Recreational Water: Highest Burden Among Young US Children. textitAmerican *Journal of Public Health*. 2016. doi:10.2105/AJPH.2016.303279.	Avalon Doheny Fairhope Goddard Malibu Mission Bay	✓		
Colford JM Jr, Wade TJ, Schiff KC, et al. Water quality indicators and the risk of illness at beaches with nonpoint sources of fecal contamination. *Epidemiology*. 2007;18(1):27-35. doi:10.1097/01.ede.0000249425.32990.b9.	Mission Bay	✓	✓	✓
Colford JM Jr, Schiff KC, Griffith JF, et al. Using rapid indicators for Enterococcus to assess the risk of illness after exposure to urban runoff contaminated marine water. *Water Research*. 2012;46(7):2176-2186. doi:10.1016/j.watres.2012.01.033.	Doheny	✓		
Griffith JF, Weisberg SB, Arnold BF, Cao Y, Schiff KC, Colford JM. Epidemiologic evaluation of multiple alternate microbial water quality monitoring indicators at three California beaches. *Water Research*. 2016;94:371-381. doi:10.1016/j.watres.2016.02.036.	Avalon Doheny Malibu	✓	✓	✓
Wade TJ, Calderon RL, Brenner KP, et al. High sensitivity of children to swimming-associated gastrointestinal illness: results using a rapid assay of recreational water quality. *Epidemiology*. 2008;19(3):375-383. doi:10.1097/EDE.0b013e318169cc87.	Fairhope Goddard	✓		✓
Yau VM, Schiff KC, Arnold BF, et al. Effect of submarine groundwater discharge on bacterial indicators and swimmer health at Avalon Beach, CA, USA. *Water Research*. 2014;59:23-36. doi:10.1016/j.watres.2014.03.050.	Avalon	✓		

eTable 2: Details of enrollment and eligibility at each beach

	Avalon	Doheny	Fairhope	Goddard	Malibu	Mission Bay
Years of enrollment	2007, 2008	2007, 2008	2007	2007	2009	2003
Months of enrollment	June-Sept	May-Sept	May-Sept	June-Sept	May-Sept	May-Sept
Eligibility criteria						
No prior participation in the study	✓	✓	✓	✓	✓	✓
Family member older than	✓	✓	✓	✓	✓	✓
Home address in the U.S., Canada, or Mexico [a]	✓	✓			✓	✓
Able to speak English or Spanish					✓	
No history of swimming (face or head under water) in the ocean or in a lake in the previous 7 days						✓

[a] California beaches attract recreators from around the world. As a result, the studies at those beaches excluded people who lived far away who could not be reached by phone for follow-up, whereas individuals from Canada or Mexico could be reached for follow-up.

eTable 3: Details of water sampling at each beach

Beach	No. sampling sites	Sample volume	Depth of sample collected	Timing of sample collection	Sample type	Total coliphage samples per day	Total enterococci samples per day
Avalon	4	1 L	0.5 m	8am, 12pm, 3pm	Single	9	10-15
Doheny	5	1 L	0.5 m	8am, 12pm, 3pm	Single	EPA 1601: 13; EPA 1602: 5	13
Fairhope	3	1 L	0.3 m and 1 m	8am, 11am, 3pm	Single	18	18
Goddard	3	1 L	0.3 m and 1 m	8am, 11am, 3pm	Single	18	18
Malibu	5	1 L	0.5 m	8am, 1pm	Single	5	9
Mission Bay	6	Col: 1 L; Ent: 125 ml	0.3-0.5 m	Col: 12:30pm; Ent: 12:30pm, 1:30pm, 2:30pm, 3:30pm	Col: composite*; Ent: single	1	6

eTable 4: Details of water quality analysis at each beach

Beach	Somatic coliphage (EPA 1601)	Somatic coliphage (EPA 1602)	Male-specific coliphage (EPA 1601)	Male-specific coliphage (EPA 1602)	Enterococci
Avalon	✓	✓	✓	✓	✓
Doheny	✓	✓	✓	✓	✓
Fairhope			✓		✓
Goddard			✓		✓
Malibu			✓		✓
Mission Bay	✓		✓		✓

eTable 5: Demographics and water exposure by beach

Variable	Avalon n (%)	Doheny n (%)	Fairhope n (%)	Goddard n (%)	Malibu n (%)	Mission Bay n (%)
Individuals [a]	5912	9058	1977	2887	5540	7887
Households [b]	2536	3466	831	1561	2665	3135
Age (years)						
0-4	382 (6.5)	872 (9.7)	234 (11.8)	224 (7.9)	531 (9.6)	861 (11.1)
5-14	691 (11.7)	832 (9.2)	222 (11.2)	396 (13.9)	767 (13.8)	992 (12.8)
15-24	666 (11.3)	1058 (11.7)	330 (16.7)	463 (16.3)	1028 (18.6)	1475 (19)
25-34	1072 (18.2)	1877 (20.8)	281 (14.2)	462 (16.2)	1076 (19.4)	1340 (17.3)
35-44	990 (16.8)	1269 (14.1)	226 (11.4)	428 (15)	712 (12.9)	628 (8.1)
45-54	1375 (23.3)	2368 (26.3)	467 (23.6)	431 (15.1)	1020 (18.4)	2114 (27.3)
55-64	490 (8.3)	553 (6.1)	125 (6.3)	241 (8.5)	298 (5.4)	230 (3)
65-74	173 (2.9)	164 (1.8)	62 (3.1)	128 (4.5)	88 (1.6)	77 (1)
75+	55 (0.9)	26 (0.3)	29 (1.5)	76 (2.7)	20 (0.4)	31 (0.4)
Total	5894 (100)	9019 (100)	1976 (100)	2849 (100)	5540 (100)	7748 (100)
Sex						
Male	2594 (43.9)	4319 (47.7)	838 (42.4)	1246 (43.2)	2561 (46.2)	4334 (55)
Female	3318 (56.1)	4739 (52.3)	1139 (57.6)	1641 (56.8)	2979 (53.8)	3553 (45)
Total	5912 (100)	9058 (100)	1977 (100)	2887 (100)	5540 (100)	7887 (100)
Race						
Not white	1414 (24.3)	2837 (31.9)	690 (34.9)	1058 (36.7)	2019 (37.8)	5929 (75.6)
White	4394 (75.7)	6047 (68.1)	1287 (65.1)	1824 (63.3)	3316 (62.2)	1909 (24.4)
Total	5808 (100)	8884 (100)	1977 (100)	2882 (100)	5335 (100)	7838 (100)
Water exposure						
Any contact	4246 (71.8)	5655 (62.4)	1141 (57.7)	1351 (46.8)	3689 (66.6)	4546 (57.6)
Body contact	3743 (63.3)	4150 (45.8)	808 (40.9)	1051 (36.4)	2502 (45.2)	3022 (38.3)
Swallowed water	851 (14.4)	1166 (12.9)	275 (13.9)	213 (7.4)	551 (9.9)	988 (12.5)
Minutes swam (mean) [c]	83	79	76	46	66	118

[a] Individuals that were included in the analysis for whom water quality data was available.
[b] Households that were included in the analysis for whom water quality data was available.
[c] Self-reported minutes swam among people who had any water contact.

eTable 6: Coliphage levels stratified by whether conditions were human-impacted[a] or not[b] (PFU / 100ml)

Indicator	No. of samples	Maximum	Geometric mean	No. of non-detects
Somatic coliphage (EPA 1601)				
Not human-impacted conditions	407	1400	1.06	170
Human-impacted conditions	142	370	1.07	77
Somatic coliphage (EPA 1602)				
Not human-impacted conditions	362	174	1.05	229
Human-impacted conditions	233	386	1.09	151
Male-specific coliphage (EPA 1601)				
Not human-impacted conditions	871	37	0.88	434
Human-impacted conditions	1063	330	1.34	483
Male-specific coliphage (EPA 1602)				
Not human-impacted conditions	362	2	1.00	358
Human-impacted conditions	233	48	1.01	225

[a] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach. Conditions were always considered human-impacted at Fairhope and Goddard beaches.
[b] Not human-impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach. Conditions were never considered human-impacted at Mission Bay and Malibu beaches.

eTable 7: Cumulative incidence ratio for gastrointestinal illness and presence of coliphage or enterococci

	All conditions		Not human-impacted conditions[a]		Human-impacted conditions[b]	
	N	CIR[c] (95% CI)	N	CIR[c] (95% CI)	N	CIR[c] (95% CI)
Somatic Coliphage	n=3 beaches		n=3 beaches		n=2 beaches	
Coliphage detected	10,678	1.17 (0.97,1.42)	8,060	1.10 (0.88,1.38)	2,618	1.39 (0.95,2.03)
Enterococci > 35 CFU/100 ml	13,180	1.02 (0.83,1.26)	10,562	0.80 (0.61,1.05)	2,618	1.62 (1.15,2.29)
Coliphage detected & enterococci > 35 CFU/100 ml	13,180	1.09 (0.86,1.40)	10,562	0.80 (0.58,1.10)	2,618	1.83 (1.19,2.82)
Male-Specific Coliphage	n=6 beaches		n=4 beaches		n=4 beaches	
Coliphage detected	10,678	0.93 (0.77,1.13)	10,455	0.85 (0.68,1.06)	3,967	1.28 (0.83,1.97)
Enterococci > 35 CFU/100 ml	14,529	0.97 (0.79,1.19)	10,562	0.80 (0.61,1.05)	3,967	1.30 (0.93,1.81)
Coliphage detected & enterococci > 35 CFU/100 ml	13,180	0.96 (0.73,1.27)	10,562	0.72 (0.49,1.05)	3,967	1.48 (1.04,2.11)

The results in this table correspond to the values plotted in Figure 2.

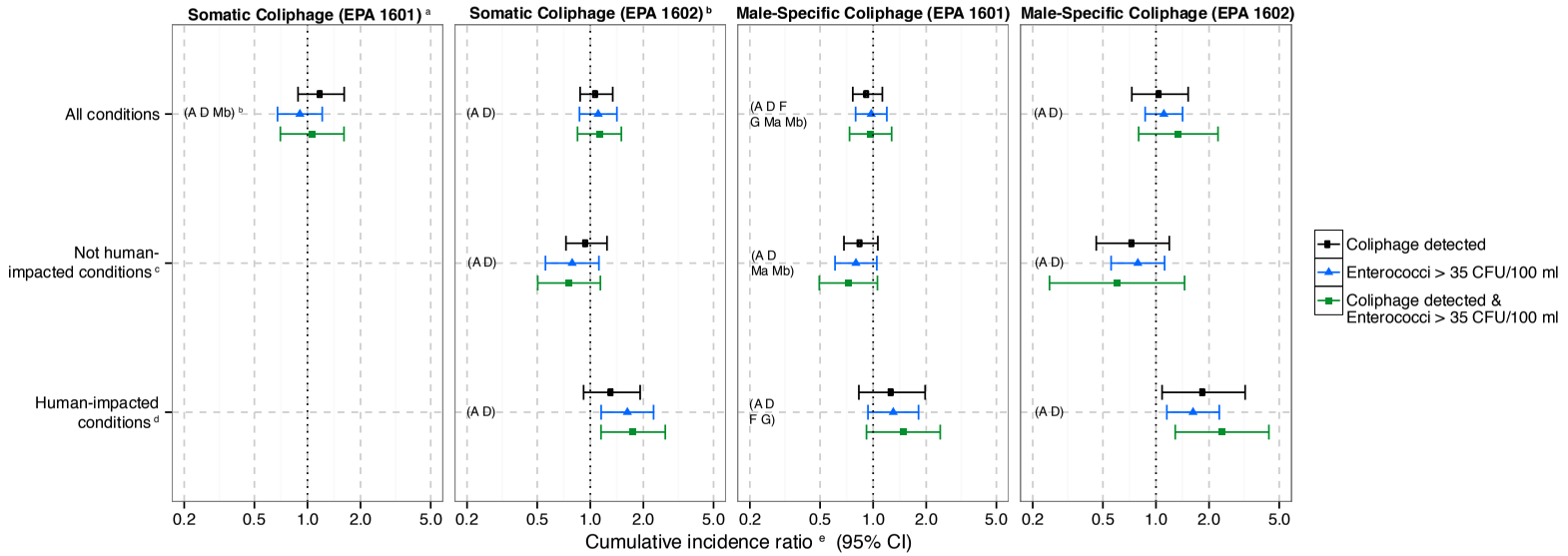
[c] Not human-impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach. Conditions were never considered human-impacted at Mission Bay and Malibu beaches.

[b] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach. Conditions were always considered human-impacted at Fairhope and Goddard beaches.

[c] CIR: Cumulative incidence ratio for gastrointestinal illness associated with the presence of any coliphage pooled across EPA 1601 and EPA 1602 assays. CIRs were adjusted for age, sex, race, presence of chronic gastrointestinal illness, any contact with animals, and consumption of undercooked eggs, meat, or fish.

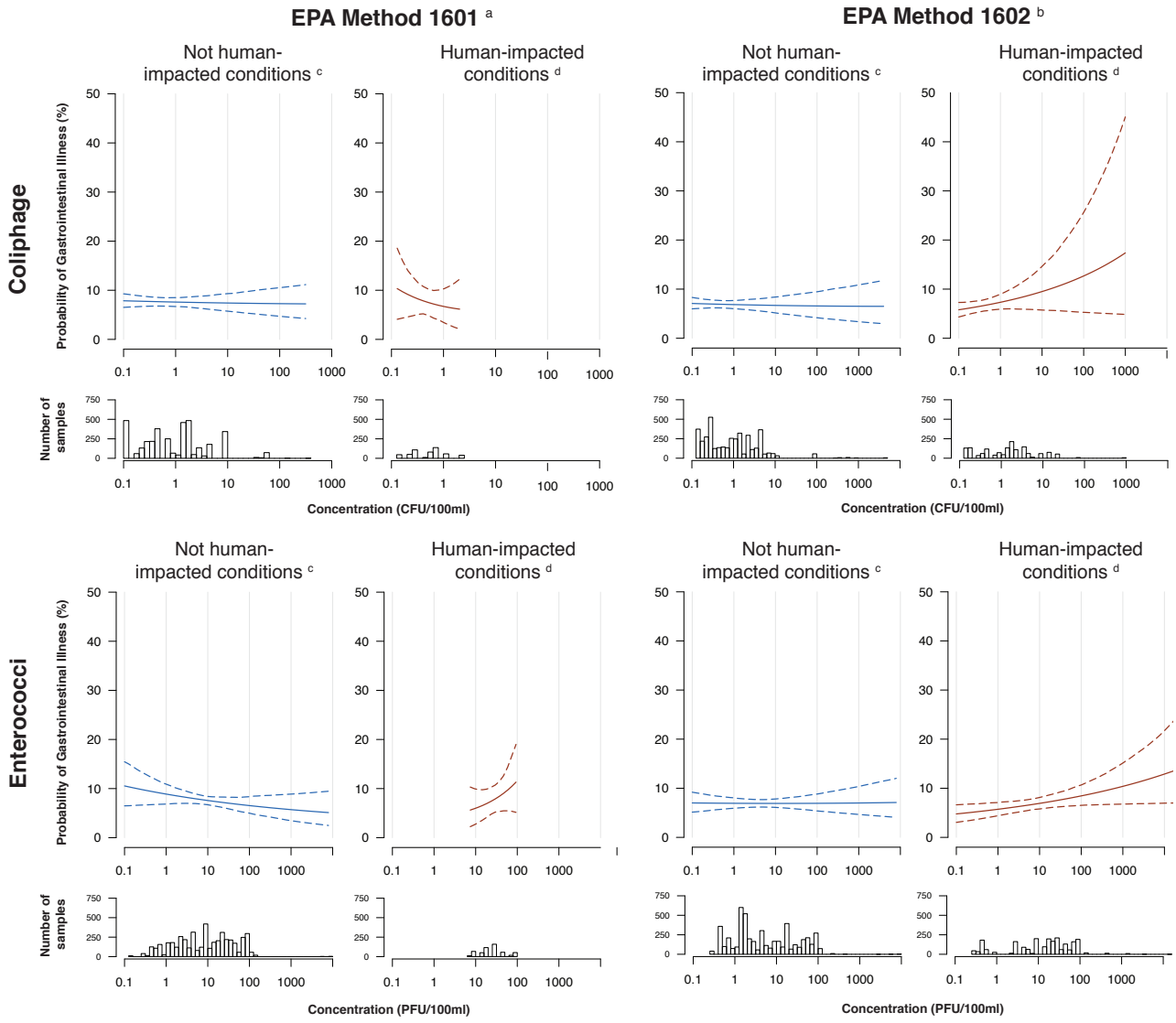
eFigure 1: Beach sites

eFigure 2: Cumulative incidence ratios for gastrointestinal illness, presence of coliphage, and enterococci level > 35 CFU/100 ml (Stratified by assay)



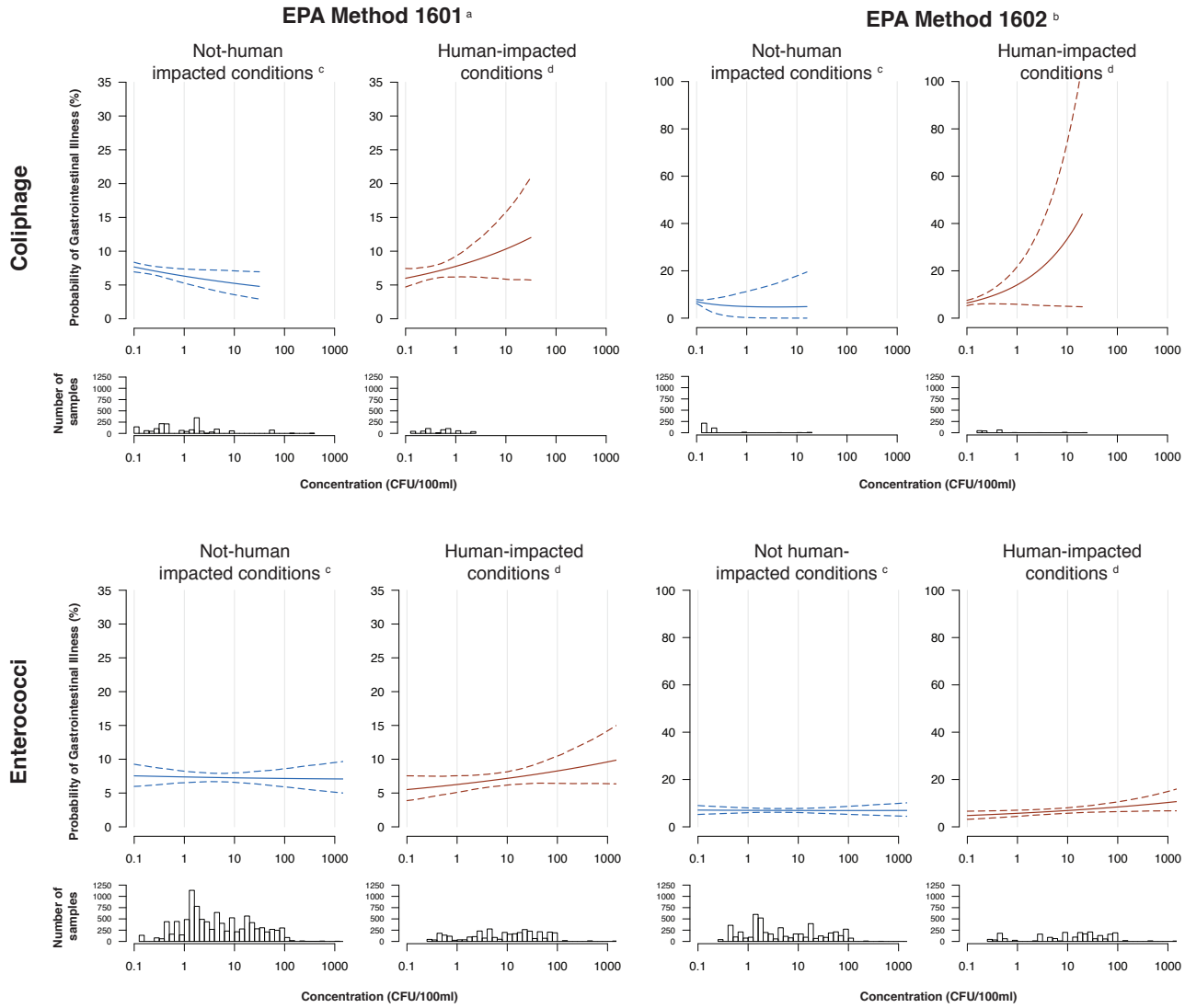
[a] Stratified CIRs were not estimated because when F- Coliphage (EPA 1601) was not present, conditions were always not human-impacted.
[b] Beaches included in adjacent point estimates: A = Avalon beach, D = Doheny beach, Ma = Malibu beach, Mb = Mission Bay beach, F = Fairhope beach, G = Goddard beach.
[c] Not human-impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach. Human fecal contamination was likely not present at all times at Mission Bay and Malibu beaches.
[d] Human-impacted conditoins: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach. Human fecal contamination was likely present at all times at Fairhope and Goddard beaches.
[e] Cumulative incidence ratios were estimated for gastrointestinal illness among swimmers and were adjusted for age, sex, race, presence of chronic gastrointestinal illness, any contact with animals, and consumption of undercooked eggs, meat, or fish.

eFigure 3: Probability of gastrointestinal illness among swimmers across levels of somatic coliphage and enterococci



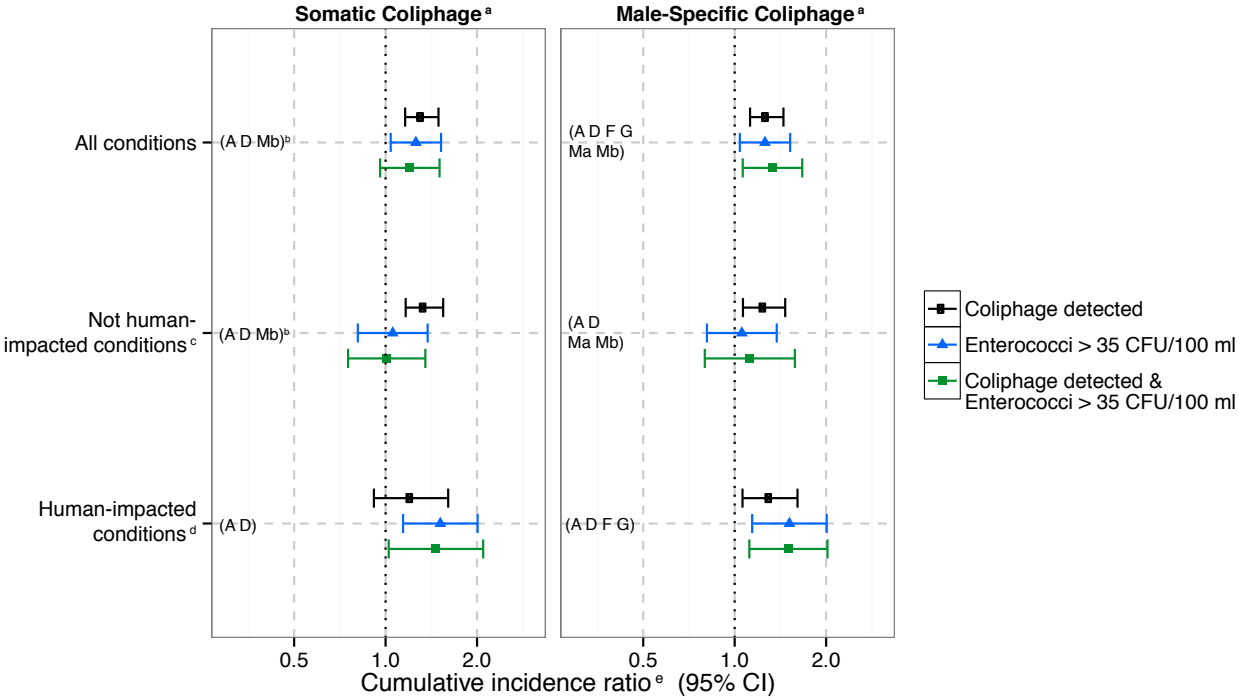
[a] Analysis included data from Avalon, Doheny, and Mission Bay beaches under not human-impacted conditions and data from Avalon beach under human-impacted conditions.
[b] Analysis included data from Avalon and Doheny beaches whether or not conditions were human-impacted.
[c] Not human-impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach.
[d] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach.

eFigure 4: Probability of gastrointestinal illness among swimmers across levels of male-specific coliphage and enterococci



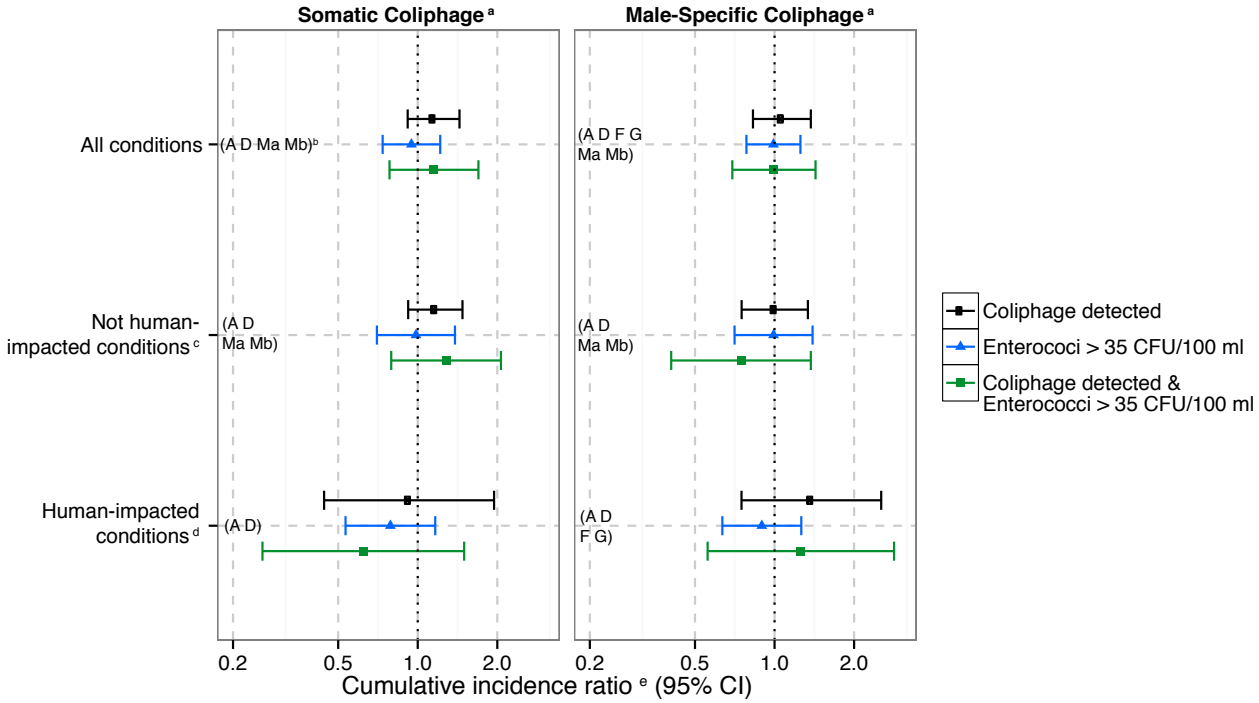
[a] Analysis included data from Avalon, Doheny, Malibu, and Mission Bay beaches when conditions were not human-impacted and data from Avalon, Doheny, Fairhope, and Goddard beaches when conditions were human-impacted.
[b] Analysis included data from Avalon and Doheny beaches whether or not conditions were human-impacted.
[c] Not human-impacted: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach.
[d] Human-impacted: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach.

eFigure 5: Cumulative incidence ratios for gastrointestinal illness, presence of coliphage, and enterococci level > 35 CFU/100 ml compared to non-swimmers



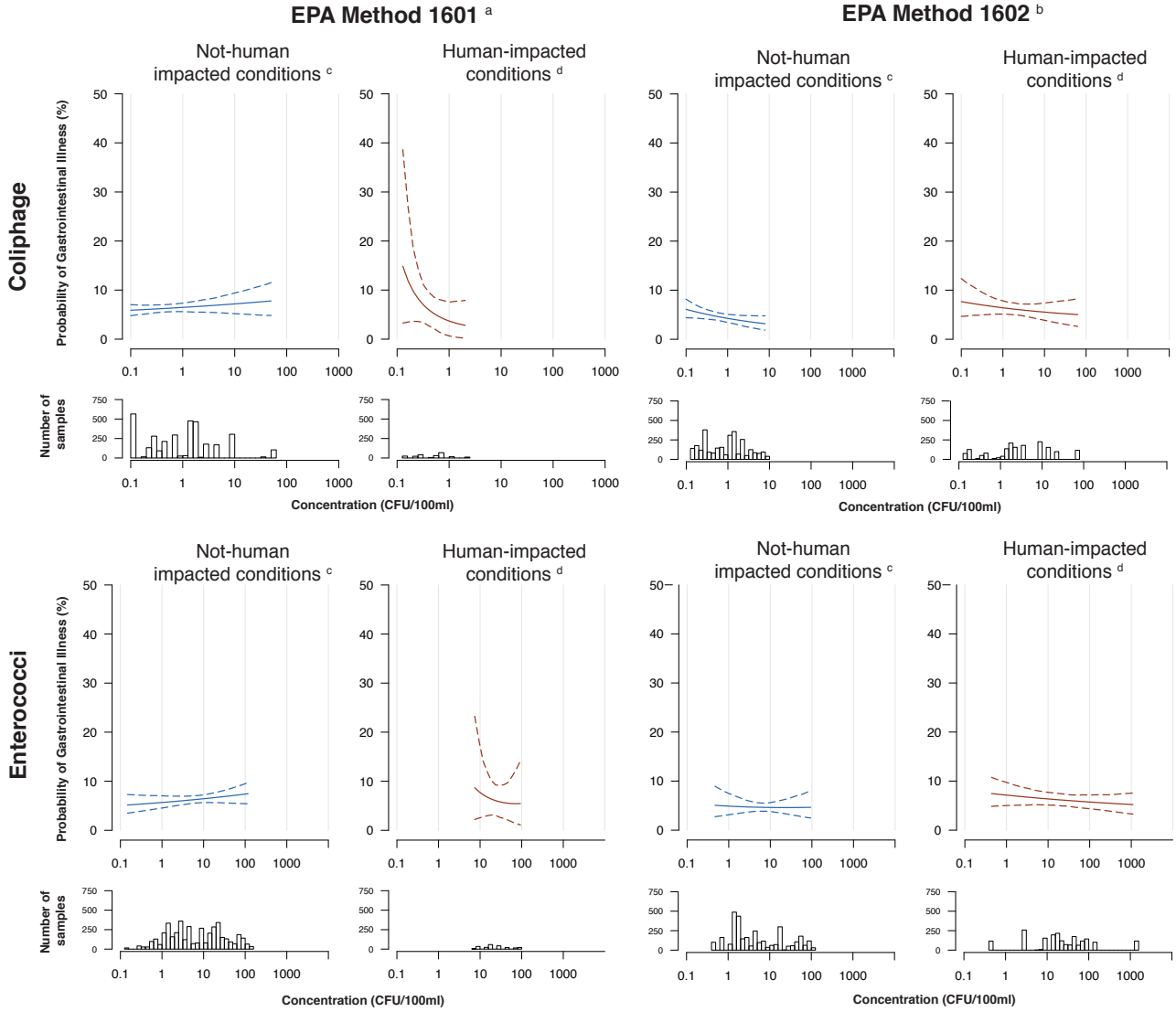
[a] These results pool across EPA 1601 and 1602 assays.
[b] Beaches included in adjacent point estimates: A = Avalon beach, D = Doheny beach, Ma = Malibu beach, Mb = Mission Bay beach, F = Fairhope beach, G = Goddard beach.
[c] Not human-impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach. Human fecal contamination was likely not present at all times at Mission Bay and Malibu beaches.
[d] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach. Human fecal contamination was likely present at all times at Fairhope and Goddard beaches.
[e] Cumulative incidence ratios were estimated for gastrointestinal illness among swimmers and were adjusted for age, sex, race, presence of chronic gastrointestinal illness, any contact with animals, and consumption of undercooked eggs, meat, or fish. The reference group is individuals enrolled at the beach who did not enter the water (i.e., "non-swimmers"). In contrast, the results in Figure 2 (and all other figures and tables) use swimmers in waters with no detectable coliphage and/or enterococci < 35 CFU/100 ml as the reference group.

eFigure 6: Negative control analysis: Cumulative incidence ratios for gastrointestinal illness, presence of coliphage, and enterococci level > 35 CFU/100 ml among non-swimmers



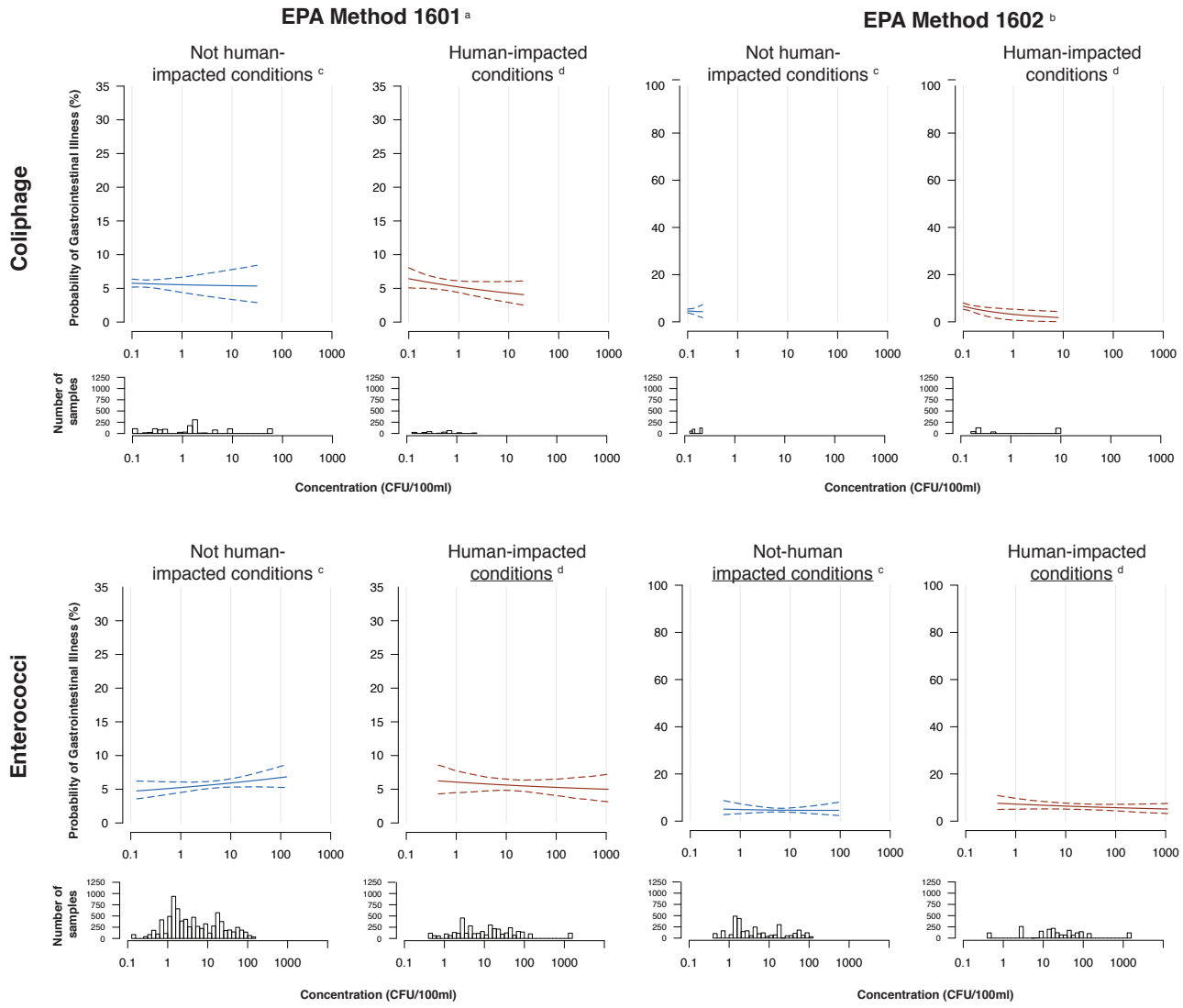
[a] These results pool across EPA 1601 and 1602 assays.
[b] Beaches included in adjacent point estimates: A = Avalon beach, D = Doheny beach, Ma = Malibu beach, Mb = Mission Bay beach, F = Fairhope beach, G = Goddard beach.
[c] Not-human impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach. Human fecal contamination was likely not present at all times at Mission Bay and Malibu beaches.
[d] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach. Human fecal contamination was likely present at all times at Fairhope and Goddard beaches.
[e] Cumulative incidence ratios were estimated for gastrointestinal illness among swimmers and were adjusted for age, sex, race, presence of chronic gastrointestinal illness, any contact with animals, and consumption of undercooked eggs, meat, or fish.

eFigure 7: Negative control analysis: Probability of gastrointestinal illness among non-swimmers across levels of somatic coliphage and enterococci



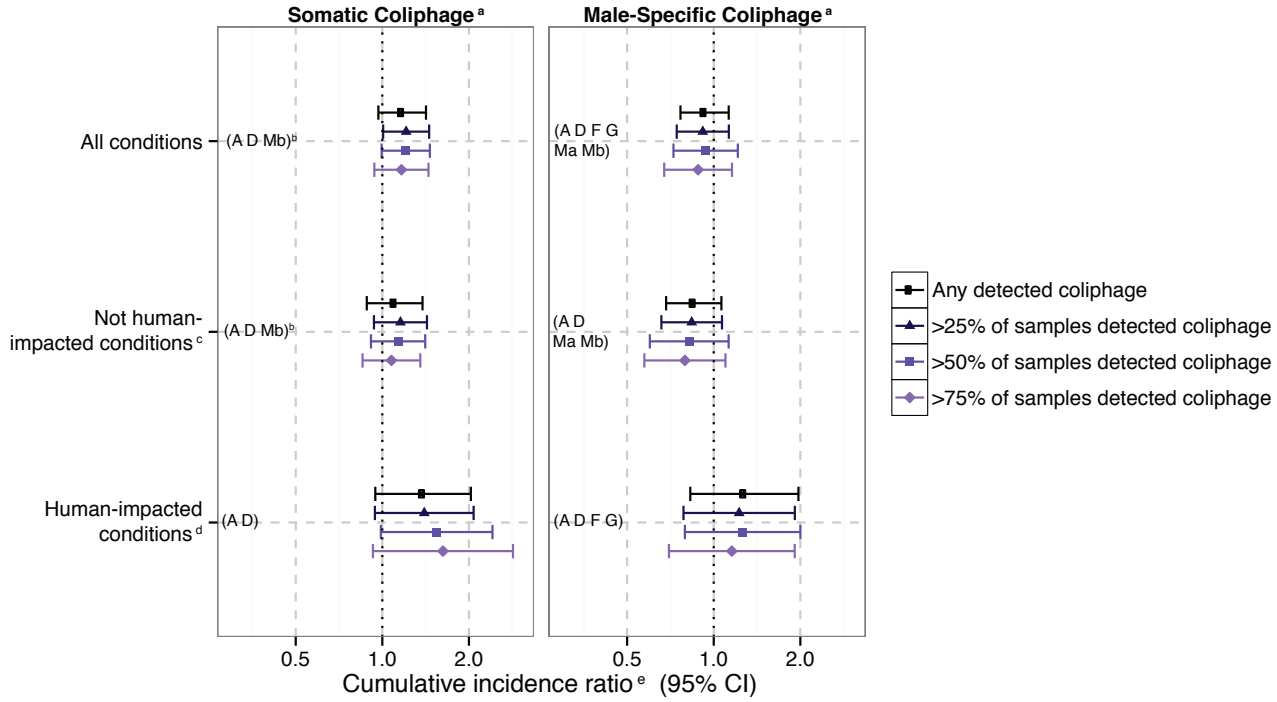
[a] Analysis included data from Avalon, Doheny, and Mission Bay beaches under not-human impacted conditions and data from Avalon beach under human-impacted conditions.
[b] Analysis included data from Avalon and Doheny beaches whether or not conditions were human-impacted.
[c] Not human-impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach.
[d] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach.

eFigure 8: Negative control analysis: Probability of gastrointestinal illness among non-swimmers across levels of male-specific coliphage and enterococci



[a] Analysis included data from Avalon, Doheny, Malibu, and Mission Bay beaches under not human-impacted conditions and data from Avalon, Doheny, Fairhope, and Goddard beaches under human-impacted conditions.
[b] Analysis included data from Avalon and Doheny beaches whether or not conditions were human-impacted.
[c] Not human-impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach.
[d] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach.

eFigure 9: Cumulative incidence ratios for gastrointestinal illness associated with the percentage of samples with detectable coliphage (reference group <25% of samples with detectable coliphage)



[a] These results pool across EPA 1601 and 1602 assays.
[b] Beaches included in adjacent point estimates: A = Avalon beach, D = Doheny beach, Ma = Malibu beach, Mb = Mission Bay beach, F = Fairhope beach, G = Goddard beach.
[c] Not-human impacted conditions: The berm was closed at Doheny beach or the groundwater flow was below the median at Avalon beach. Human fecal contamination was likely not present at all times at Mission Bay and Malibu beaches.
[d] Human-impacted conditions: The berm was open at Doheny beach or the groundwater flow was above median at Avalon beach. Human fecal contamination was likely present at all times at Fairhope and Goddard beaches.
[e] Cumulative incidence ratios were estimated for gastrointestinal illness among swimmers and were adjusted for age, sex, race, presence of chronic gastrointestinal illness, any contact with animals, and consumption of undercooked eggs, meat, or fish.