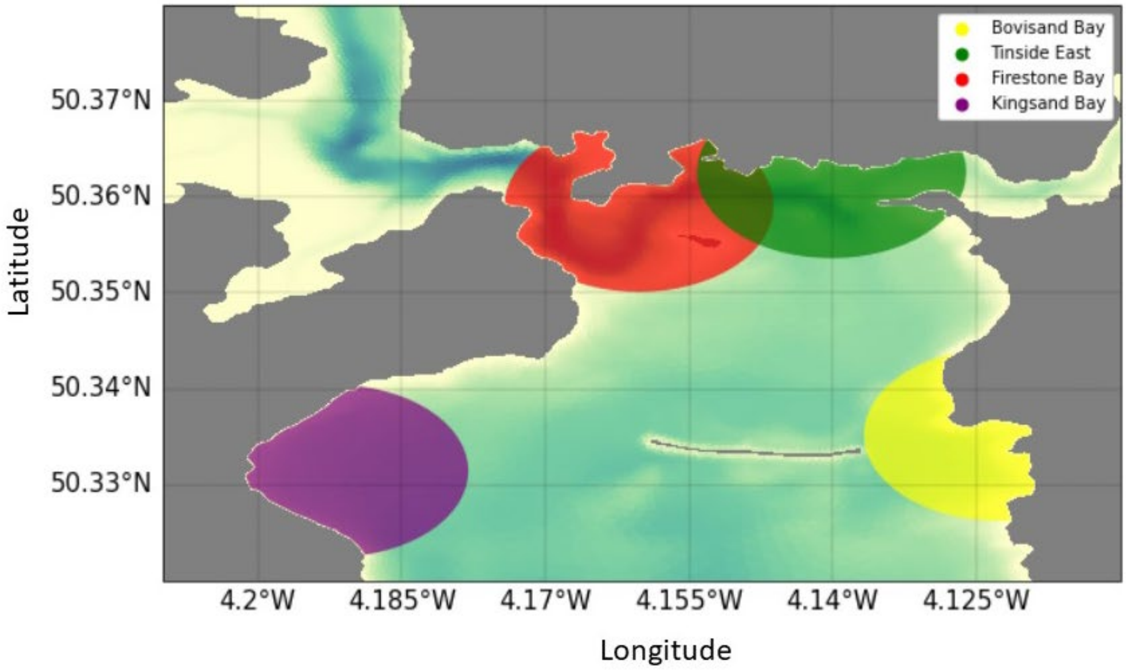
Pollution risk tool

Welcome to the MyCOAST bathing water quality index tool.

This tool has been developed by the modelling team at Plymouth Marine Laboratory to provide a daily indication of the pollution risk at designated bathing areas within Plymouth Sound. See "How it Works" section for further information.

Combined sewer overflows (CSOs) were developed as overflow valves to reduce the risk of sewage backing up during heavy rainfall, releasing diluted sewage into waterways to prevent sewage flooding homes and businesses. As such, CSOs create pathways for potential pathogens to enter the waters of the Sound, and these risks can be more pronounced where the water aggregates.

The coastal environment around Plymouth is subject to multiple uses which include heavy ship traffic (mostly through navy and ferries), recreational vessels, and diving. It is also a very popular location for 'wild swimming'. There are 4 designated bathing sites within Plymouth Sound: Bovisand Bay in the South Hams district, Tinside East (Plymouth Hoe East) and Firestone Bay (Plymouth Hoe West) in the Plymouth district, and Kingsand Bay in the Cornwall district.



Designated bathing sites within Plymouth Sound, Devon, UK.

Each of these sites is monitored by the Environment Agency under the Bathing Water Directive (2006/7/EC) for concentrations of colony forming units (cfu) of *Escherichia coli* (EC) and Intestinal *Enterococci* (IE). The Environmental Agency's methodology has no pass/fail standards for individual water samples. Instead, annual water quality indices are assigned to each site based on analysis of all samples taken over a four-year period, using the 95th and 90th percentile (depending on the classification: see table) to provide a quantitative measure of water quality.

Thresholds for the classification of bathing water quality following the Bathing Water Regulations (2013) lesiglation.

Classification	**Thresholds (percentile)**
Coastal Bathing Waters	
Excellent	EC: ≤250 cfu/100ml ; IE: ≤100 cfu/100ml (95th percentile)
Good	EC: ≤500 cfu/100ml ; IE: ≤200 cfu/100ml (95th percentile)
Sufficient	EC: ≤500 cfu/100ml ; IE: ≤185 cfu/100ml (90th percentile)
Poor	means that the values are worse than the sufficient
Inland Bathing Waters	
Excellent	EC: ≤500 cfu/100ml ; IE: ≤200 cfu/100ml (95th percentile)
Good	EC: ≤1000 cfu/100ml ; IE: ≤400 cfu/100ml (95th percentile)

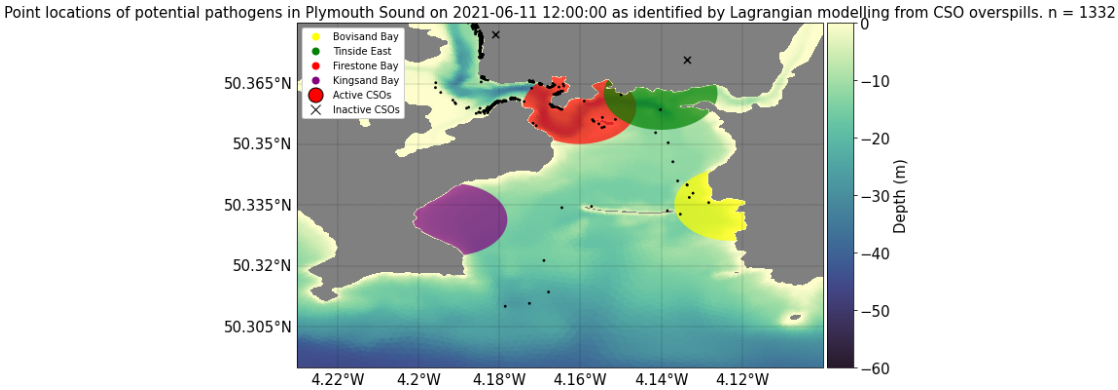
Here, we integrate the overflow sewerage network's telemetry data into pollution risk forecasts (PRFs) to provide daily pollution indictors, showing likely concentration levels of pollutants within bathing areas sourced at combined sewage overspill sites, and where and when the movement of water may aggregate these contaminants, decreasing the quality of the water. Here you will find information about the current bathing water quality conditions for the designated bathing areas in Plymouth Sound.

Pollution risk model daily output

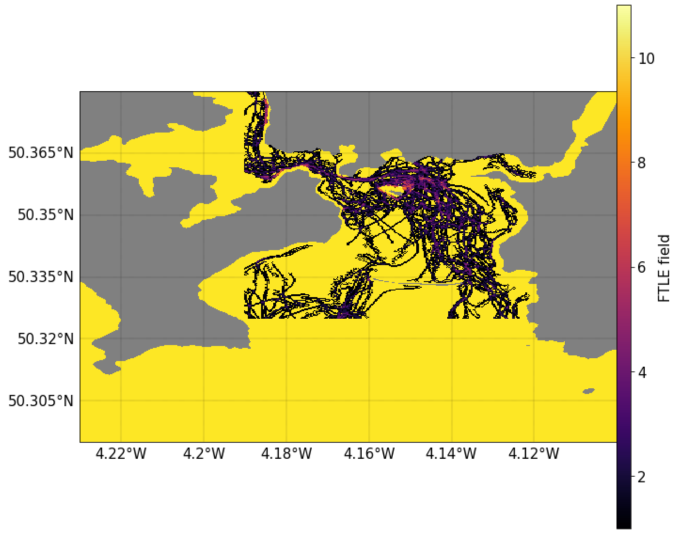
Here you see examples of our model's predictions for bathing water quality conditions in Plymouth Sound.

The quality of the bathing water is calculated from the daily output of the modelled particle concentrations and modelled water aggregation in each bathing area.

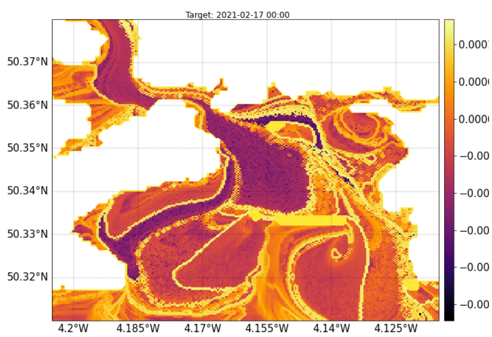
Image: Potential pathogen point locations at midday; LCS heatmap

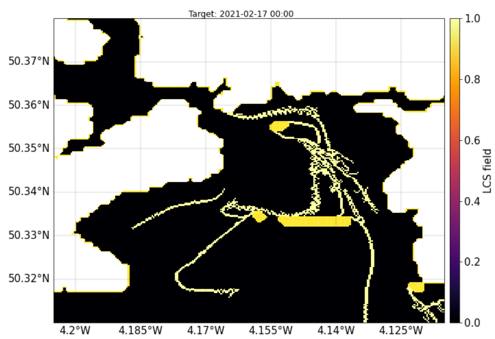


Cumulative LCS fields (midnight to midday)



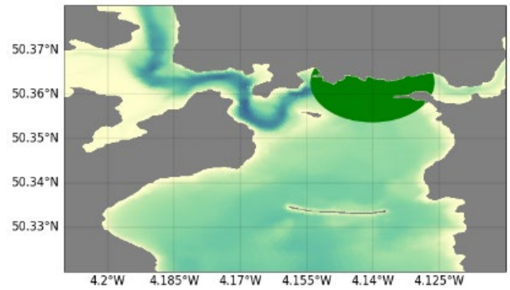
Animations: Time evolution of FTLE and LCS





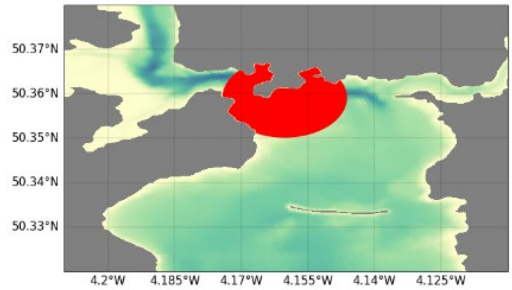
Tinside

Bathing Water Quality estimation:
Bathing water quality metric:
Modelled pollutant concentration (CSO release):
Modelled aggregation (LCS):



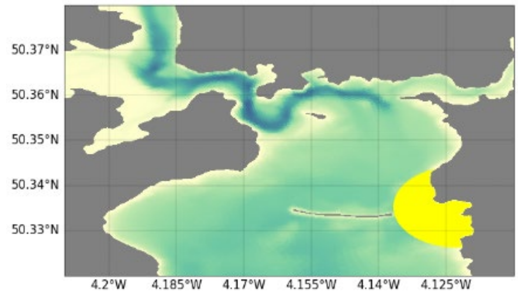
Firestone

Bathing Water Quality estimation:
Bathing water quality metric:
Modelled pollutant concentration (CSO release):
Modelled aggregation (LCS):



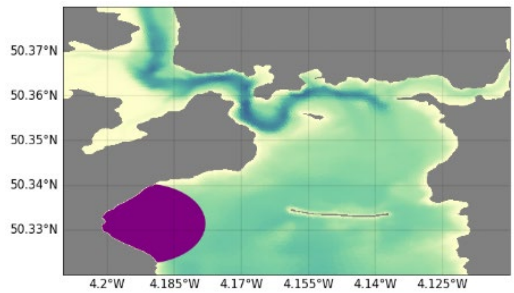
Bovisand

Bathing Water Quality estimation:
Bathing water quality metric:
Modelled pollutant concentration (CSO release):
Modelled aggregation (LCS):



Cawsand

Bathing Water Quality estimation:
Bathing water quality metric:
Modelled pollutant concentration (CSO release):
Modelled aggregation (LCS):



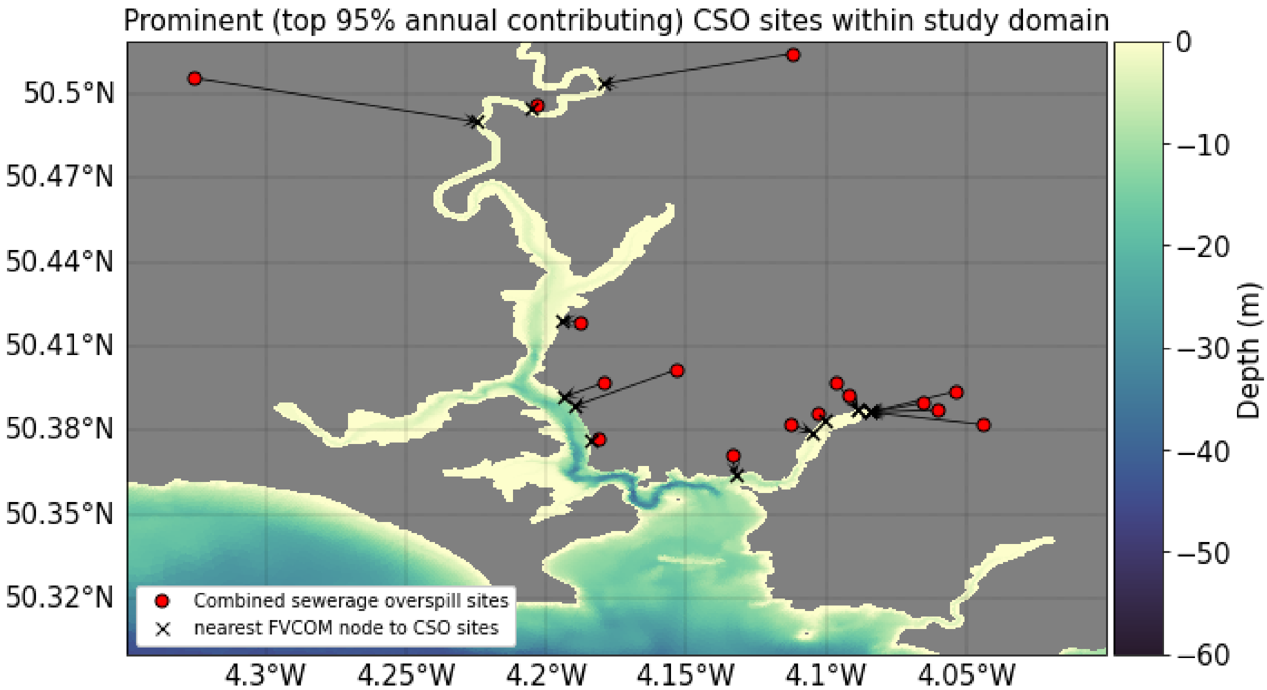
How it Works

(to go in resources)

The pollution risk tool uses Lagrangian particle tracking using Pylag to estimate 1) relative concentrations of pollutants in bathing areas coming from CSO overspills, and 2) where and when the movement of water in the Sound may act to aggregate these contaminants.

Approach 1: Tracking particles released from CSO sites

We obtained CSO overspill data from the Catchment Based Approach Data Hub and used daily rainfall estimates provided by the Weather Research and Forecasting (WRF) model to identify ‘triggers points’, i.e., the amount of daily rainfall required to trigger an overspill at each site. The 16 most prolific sites in the Plymouth catchment area were identified as potential source locations of particles. These sites accounted for 95% of the total sewage overspill in the Plymouth catchment area in 2019. On each day, when daily rainfall trigger points are released, particles are released every hour between midnight and midday from the CSO sites, weighted by the average spill length at each site taken from the Catchment Based Approach Data Hub, and tracked for 12 hours. Plots (see “Pollution risk model daily output” section) are generated from the PyLag outputs to show estimated relative concentrations of potential pathogens in each of the designated bathing sites in Plymouth Sound at midday on the current day.



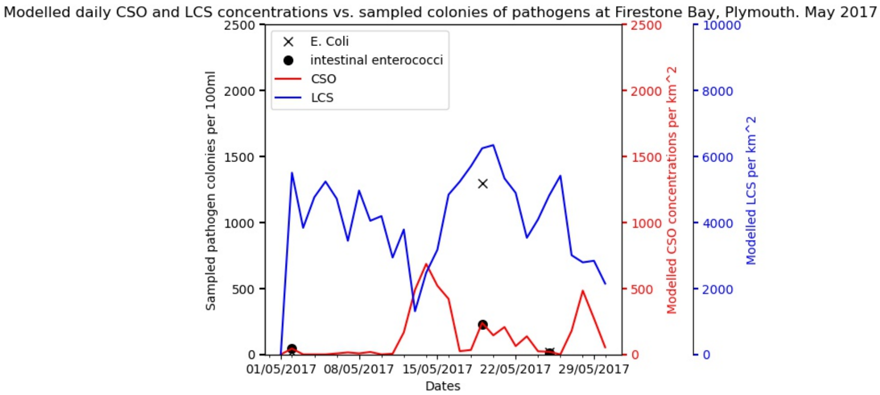
CSO sites accounting for 95% of the total sewage overspill in the Plymouth catchment area in 2019 and their nearest FVCOM nodes for particles release.

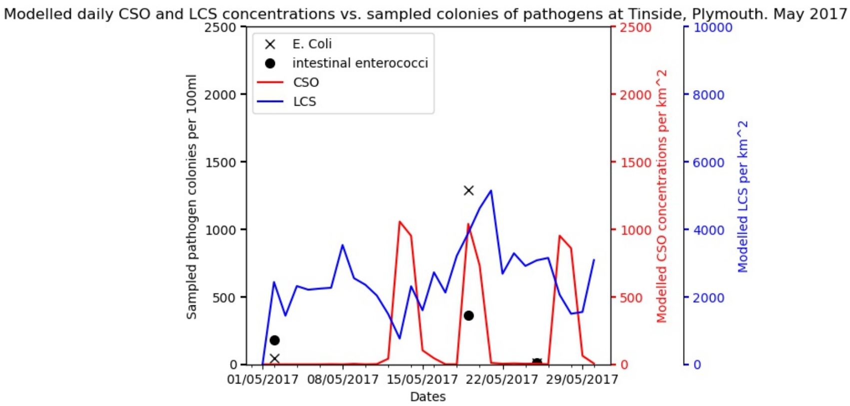
Approach 2: Identifying aggregation using Lagrangian Coherent Structures

Lagrangian Coherent structures are identified using the [MyCoastLCS](#) tool. This tool performs Finite Time Lyupanov Exponent calculations and extracts Lagrangian coherent structures from the ridges of the FTLE fields following [Shadden (2005).](#) Extracted LCS field act to provide a simplified skeleton of the overall dynamics of the study system, making them ideal tools for exploring barriers to particle transport in dynamic systems. The MyCoastLCS tool runs using the output of PyLag runs where particles are released hourly over a 24 hour period on an evenly spaced grid and back-tracked for 12 hours to display attracting barriers to Lagrangian transport. Plots and animations (see "Pollution risk model daily output" section) are generated from the MyCoastLCS tool output to show where and when the water aggregates within Plymouth Sound, and to demonstrate the time evolution of such aggregating structures in each of the designated bathing areas over the course of the current day.

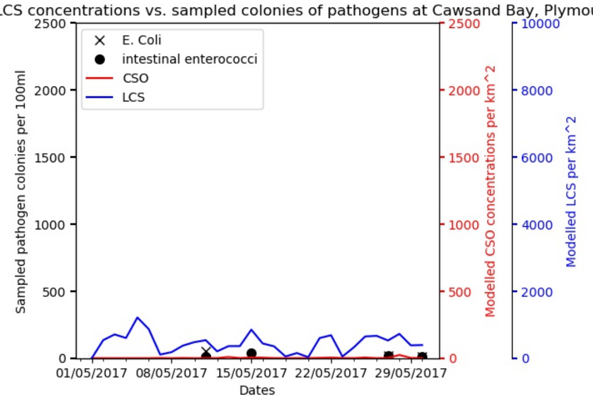
Proof of Concept

When designing the tool, we used a proof of concept approach to explore whether our model could identify known peaks in the concentration of colony forming units of EC and IE, as recorded from samples taken by the [Environment Agency](#) in May and June 2017. Here we show the efficiency of the model at predicting peaks in the concentrations of potential pathogens.

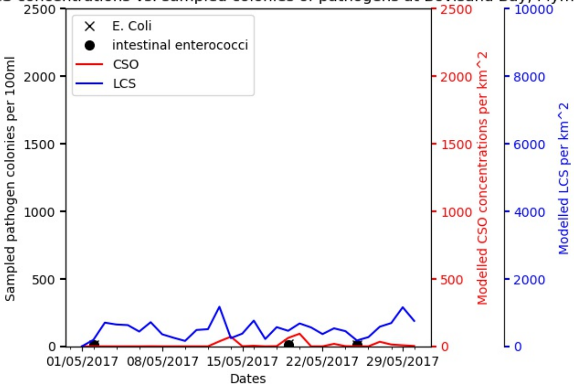




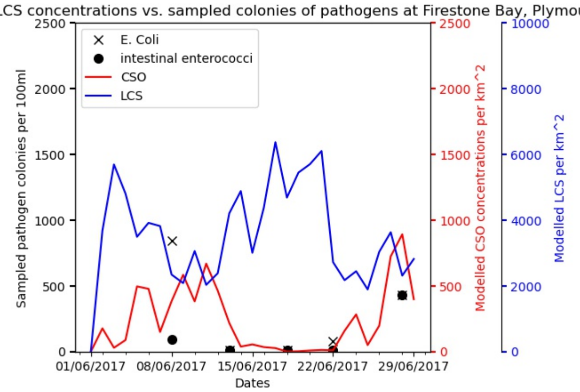
Modelled daily CSO and LCS concentrations vs. sampled colonies of pathogens at Cawsand Bay, Plymouth. May 2017



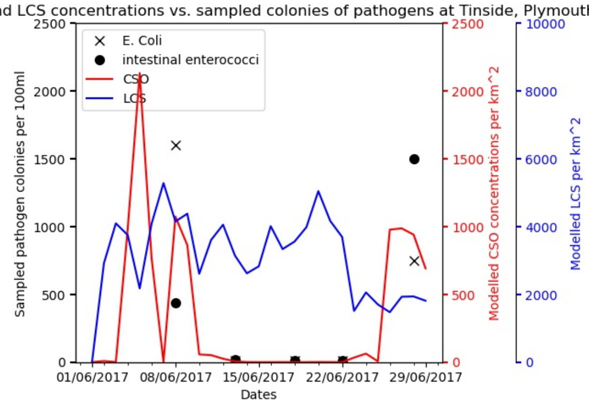
Modelled daily CSO and LCS concentrations vs. sampled colonies of pathogens at Bovisand Bay, Plymouth. May 2017

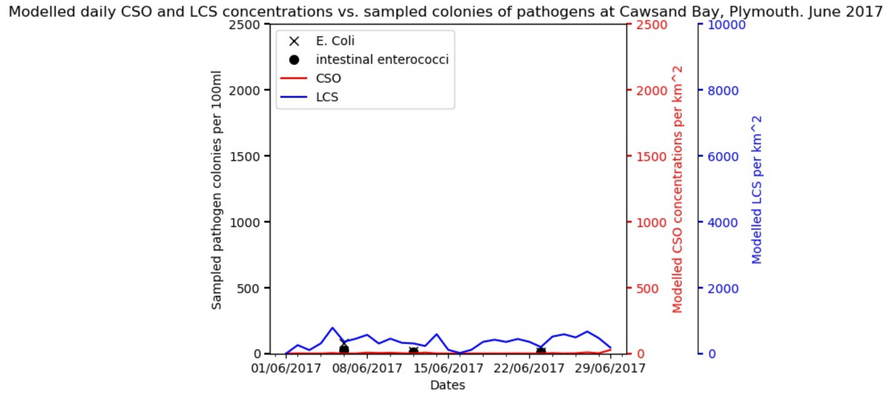


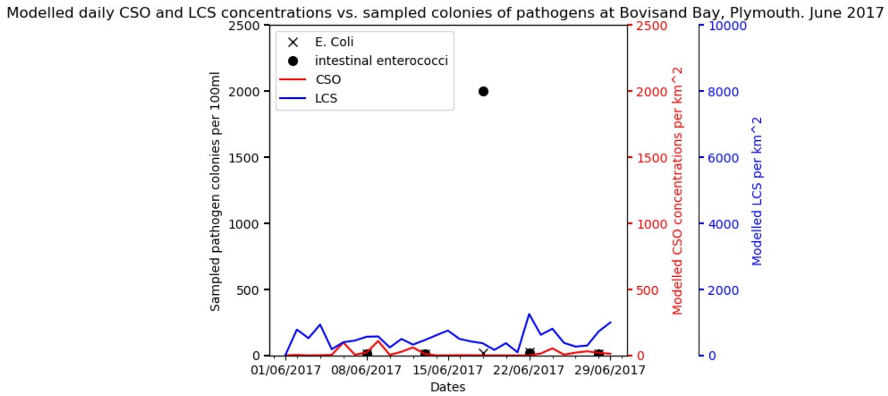
Modelled daily CSO and LCS concentrations vs. sampled colonies of pathogens at Firestone Bay, Plymouth. June 2017



Modelled daily CSO and LCS concentrations vs. sampled colonies of pathogens at Tinside, Plymouth. June 2017







A more detailed overview of the methodology used for this model and the results of the proof of concept testing will be published as a scientific paper.