FORESHELL Project: development of sanitary/weather-environmental predictive technological tools to enhance the efficiency and sustainability of shellfish farming.

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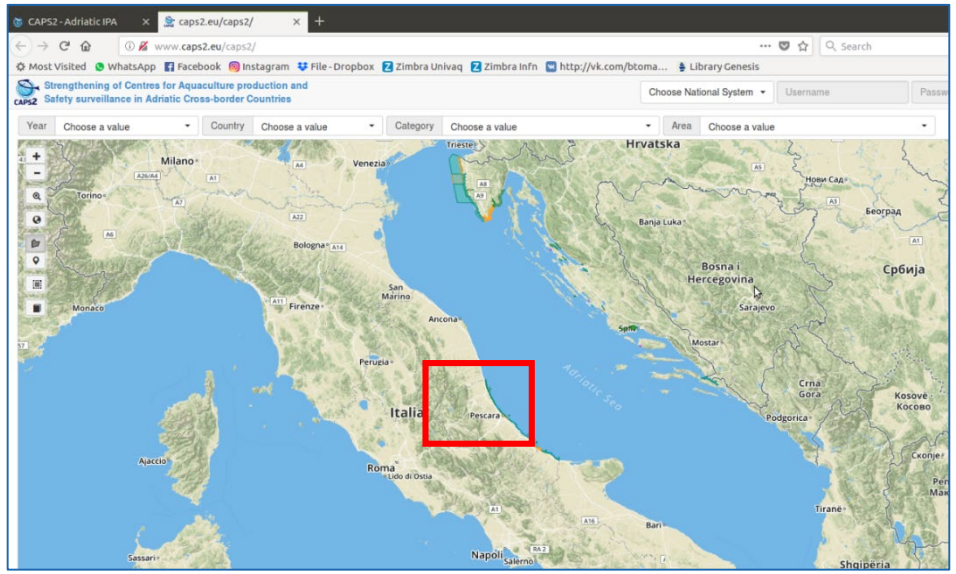
Objectives

The overall objective of the project is to innovate the shellfish farming sector by applying health and weather forecasting technological tools to improve the management of mussel farms.

Specific Objectives

1. to identify the predictive elements of the hydrological factors of the two rivers (Vibrata and Salinello) afferent to the aquaculture plant that could have a potential influence on the concentration of E. coli in the molluscs reared in the "Adriatica off shore" shellfish plant
2. to analyse the growth of mussels on the basis of environmental data collected in situ
3. provide the fish farmer with a technological solution specifically dedicated to his plant to obtain early warning signals on weather/environmental and hygienic factors that could cause losses or damage to his product.

Target Area



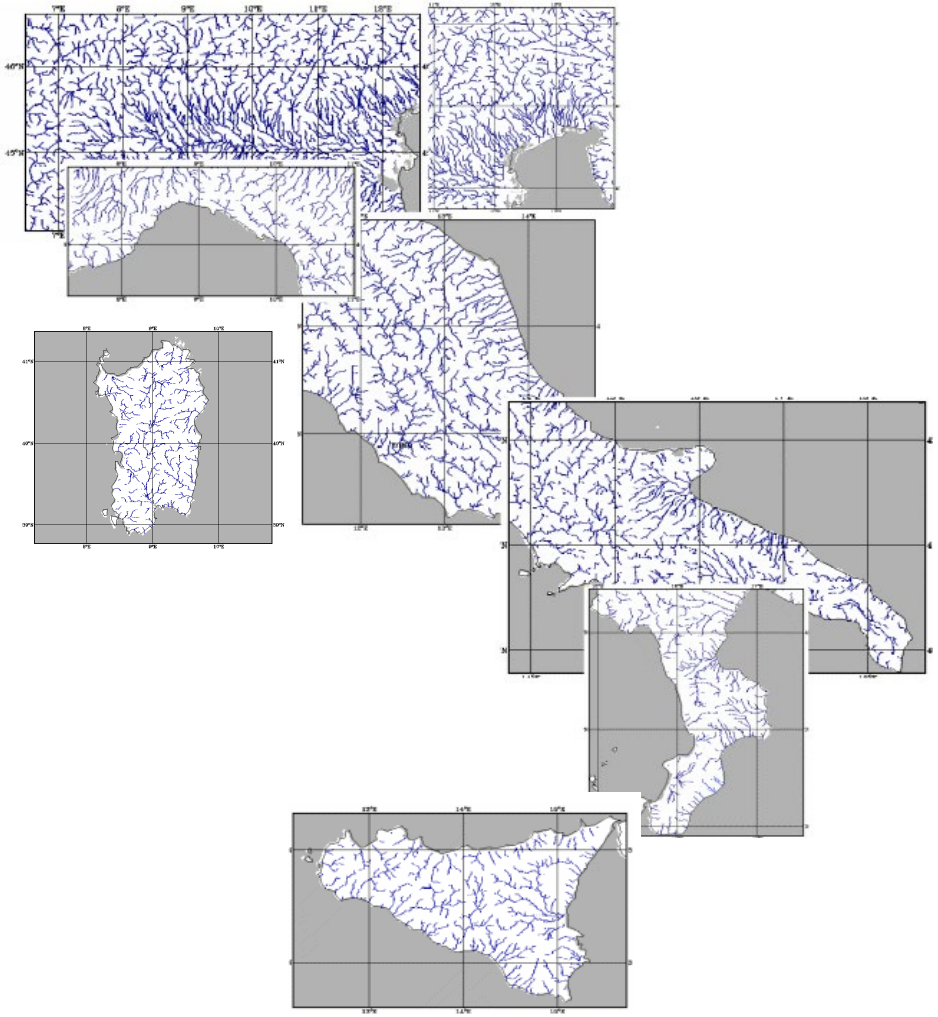
Area: Abruzzo Region with particular focus on the water catchment area of the river Vibrata and Salinello, its mouth and the production areas of molluscs "Adriatica off shore" [mussel aquaculture plants]
Period: 01/01/2017 – 31/12/2021

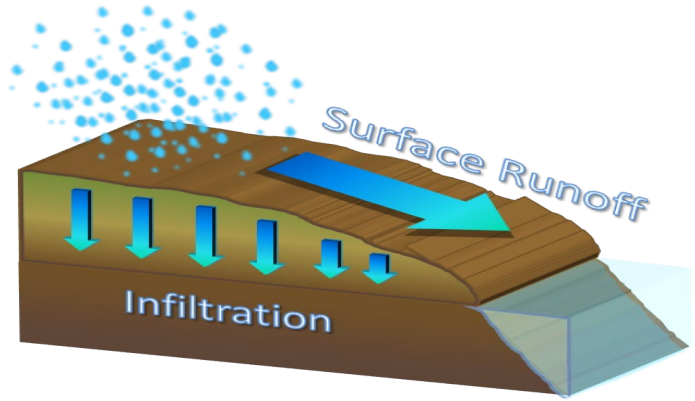
Health parameters: *Escherichia coli* in
- molluscs (Mytilus galloprovincialis) bred in the Adriatica Off-Shore S.R.L. plant
- fresh water at the mouths of the Salinello and Vibrata rivers
- seawater near the mouths of rivers

Ambiental parameters:
- ***rainfall data*** refer to the Giulianova meteorological station equipped with a rainfall sensor.
- ***time series of flow discharge*** at the mouth of the target basins of the Vibrata and Salinello rivers simulated through CHyM hydrological model

Hydrological Model

CETEMPS Hydrological Model





$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q_c$$

$$Q = \frac{S^{1/2} R^{2/3}}{n} A$$

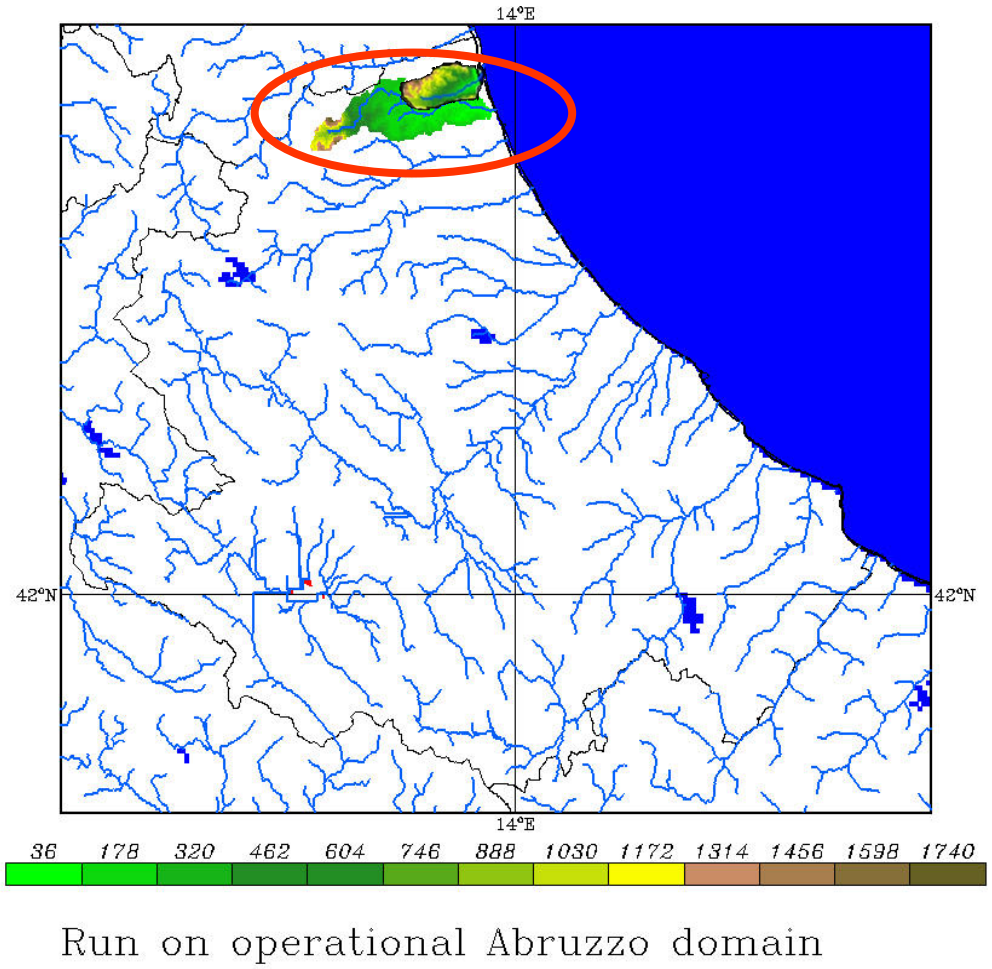
$$R = \alpha + \beta D^{\gamma}$$

Daily hydrological forecasts for the whole of Italy available at:
http://cetemps.aquila.infn.it/chymop

Colaiuda V., Lombardi A., Verdecchia M., Mazzarella V., Ricchi A., Ferretti R. and Tomassetti B. Flood Prediction: Operational Hydrological Forecast with the Cetemps Hydrological Model (CHyM). International Journal of Environmental Sciences and Natural Resources, doi: 10.19080/IJESNR.2020.23.556137

Target Basin

Reconstruction of target basins : Vibrata e Salinello



Run on operational Abruzzo domain

Vibrata basin: 110 km^2; 35 km, torrential regime.

Salinello basin: 178 km^2; 45 km, torrential regime.

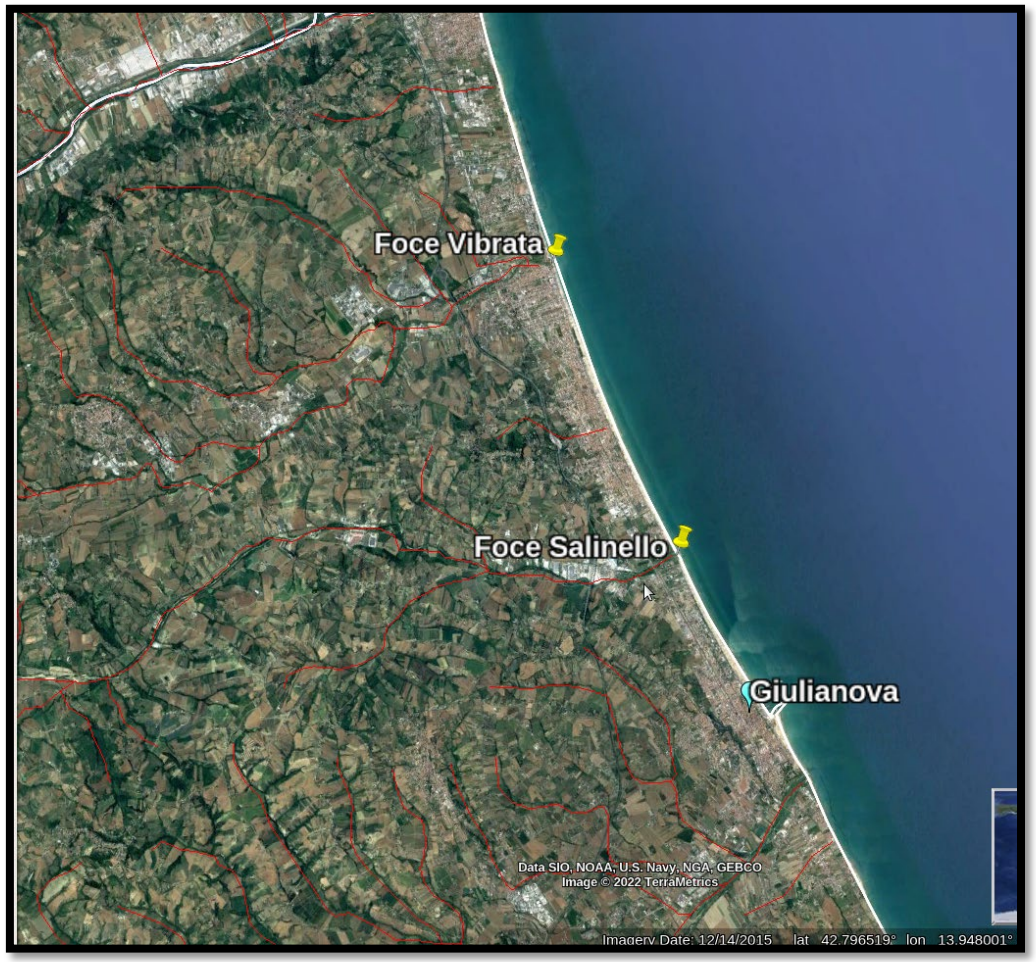
Preliminary activities

The ***health data*** were researched and analysed from the year 2017 until April 2021; for fresh water data only 2018-19 data were available.

Hydro-meteorological data refer to the period January 2017 - April 2021.

The ***rainfall data*** refer to the Giulianova meteorological station (latitude: 42,775; longitude: 13,952) equipped with a rainfall sensor, managed by the Hydrographic and Mareographic Service of the Abruzzo Region.

The ***time series of flow discharge*** at the mouth of the target basins of the Vibrata and Salinello rivers were simulated through the use of the CHyM hydrological model, suitably calibrated on the Abruzzo Region and forced with the observed data.



Selection of case studies

The study of the relationship between high concentrations of the bacterium and hydrometeorological conditions was carried out by isolating detections of E. coli greater than:

1. 500 CFU/100 ml in river water;
2. 500 MNP/100 ml in sea water;
3. 230 MNP/100 g, in farmed reference molluscs.

Each sampling thus selected, constituted a hydro-meteorological case study of which both the atmospheric conditions and the state of the hydrographic reticulum were investigated in order to identify significant flow (or precipitation) thresholds on which to base the monitoring plan.

9 case studies on the Vibrata river
16 case studies on the Salinello river

For each of them, a period of time was analysed extending up to 6 days prior to the sampling date

It is considered appropriate to set a coastal precipitation threshold value of 5 mm/6 days as the amount potentially affecting the concentration of E. coli in the 'sea' and 'freshwater' matrices.

Vibrata
From the analysis, it emerges that 77% of the cases of high bacterial concentration occur following the occurrence of a significant peak in the river flow, above its annual average. The runoff threshold identified is 2 m3/s.

Salinello
The analysis shows that 87.5% of the samplings with high E. coli concentrations occur following a significant increase in river flow. For the Vibrata basin, the flow threshold identified is slightly higher than the average annual flow and equal to 1 m3/s.

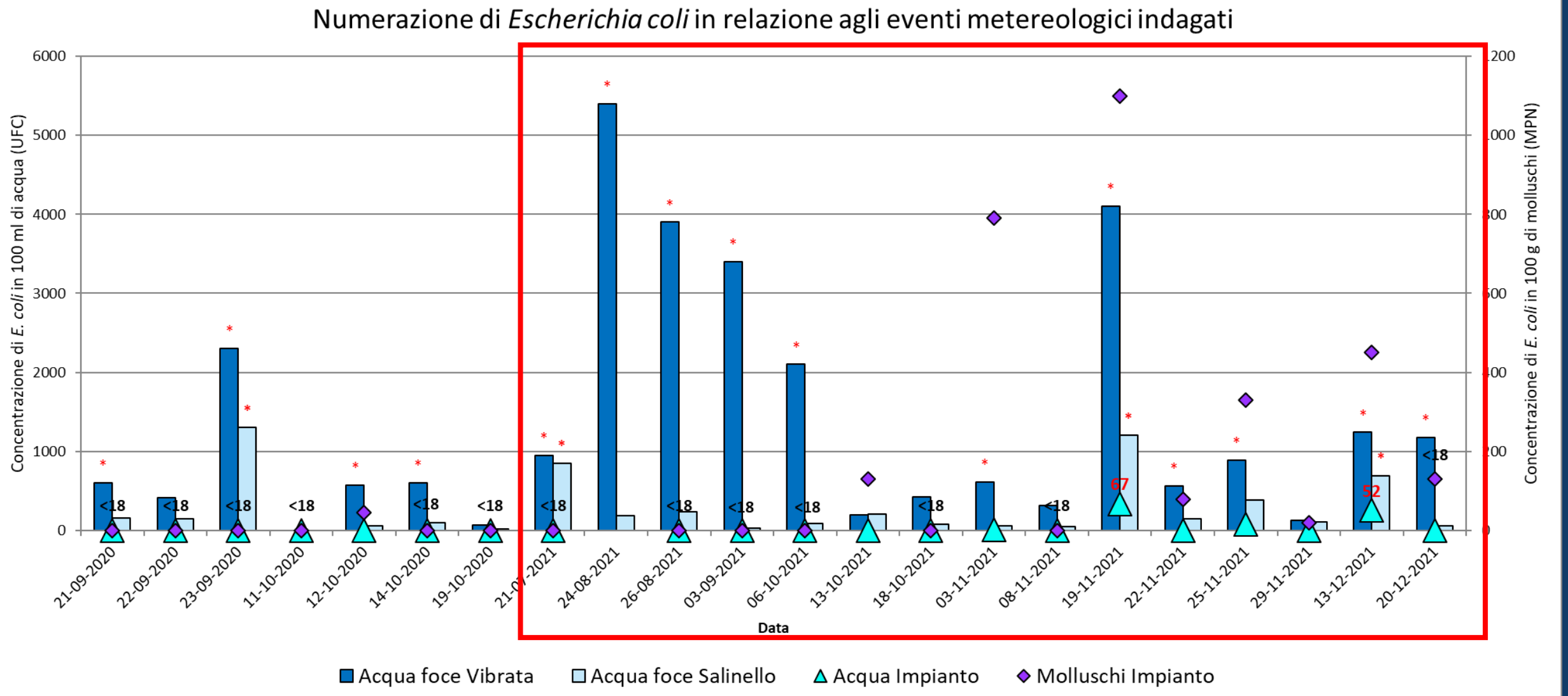
Meteo monitoring plan

In relation to the results of the correlation analysis between elevated E. coli concentrations and hydro-meteorological conditions, a monitoring plan was drawn up

Schematisation of the hydro-meteorological monitoring phases over the area of interest.

Fasi	Action	Tools	Timelines
FASE 1	Medium-term forecast	Ensemble forecast ECMWF o GFS	One time for week
FASE 2	Short-term hydrological forecast	CHyM, ECMWF 0.1°x0.1°,	Every day when disturbed conditions are forecast, with updates every 12 hours
FASE 3	Nowcasting	Sat24.com, national radar mosaic, MyDewetra platform.	On the approach of a rain event in the area of interest

Health data


Numerazione di *Escherichia coli* in relazione agli eventi metereologici indagati
Concentrazione di *E. coli* in 100 ml di acqua (UFC)
Concentrazione di *E. coli* in 100 g di molluschi (MPN)
6000
5000
4000
3000
2000
1000
0
1200
1000
800
600
400
200
0
<18
67
52
21-09-2020
22-09-2020
23-09-2020
11-10-2020
12-10-2020
14-10-2020
19-10-2020
21-09-2021
24-08-2021
26-08-2021
03-09-2021
06-10-2021
13-10-2021
18-10-2021
03-11-2021
08-11-2021
19-11-2021
22-11-2021
25-11-2021
29-11-2021
13-12-2021
20-12-2021
Data
Acqua foce Vibrata
Acqua foce Salinello
Acqua Impianto
Molluschi Impianto

Health data Related to hydro-meteo data

15 case studies for Vibrata river

VIBRATA

SAMPLING DATA	MATRIX	E. COLI CONCENTRATION	FLOW DISCHARGE PEACK	DAYS	PRECIPITATION
ANNO 2021					
21/07/2021	F	950 UFC/100 ml	38,77	4	33 mm/3gg
24/08/2021	F	5400 UFC/100 ml	0.5	1	3 mm/3gg
26/08/2021	F	3400 UFC/100 ml	1.58	1	3 mm/3gg
6/10/2021	F	2100 UFC/100 ml	1.87	0	135 mm/3gg
13/10/2021	M	130 MPN/100 gr	130.59 (7/10/2021)		
3/11/2021	F	610 UFC/100 ml	0.9	1	5 mm/4gg
3/11/2021	M	790 MPN/100 gr	0.9	1	5 mm/4gg
19/11/2021	F	4100 UFC/100 ml	69.81	3	42 mm/5gg
19/11/2021	M	1100 MPN/100 gr	69.81	3	42 mm/5gg
22/11/2021	F	560 UFC/100 ml	1.59	1	23 mm/3gg
25/11/2021	F	890 UFC/100 ml	8.0	2	22 mm/2gg
25/11/2021	M	330 MPN/100 gr	8.70	2	22 mm/2gg
13/12/2021	F	1240 UFC/100 ml	68.02	2	60 mm/5gg
13/12/2021	M	450 MPN/100 gr	68.02	2	60 mm/5gg
20/12/2019	F	1180 UFC/100 ml	0.05	0	0 mm/2gg

93% of the samplings with high E. coli concentrations occur following an increase in river flow. The identified runoff threshold of 2 m3/s identifies 60% of the high E. coli concentrations; it is probably overestimated as already a runoff of **1m3/s** corresponds to river water concentrations at the river mouths above the legislative thresholds with an increase in performance from 60% to 73%.

Health data Related to hydro-meteo data

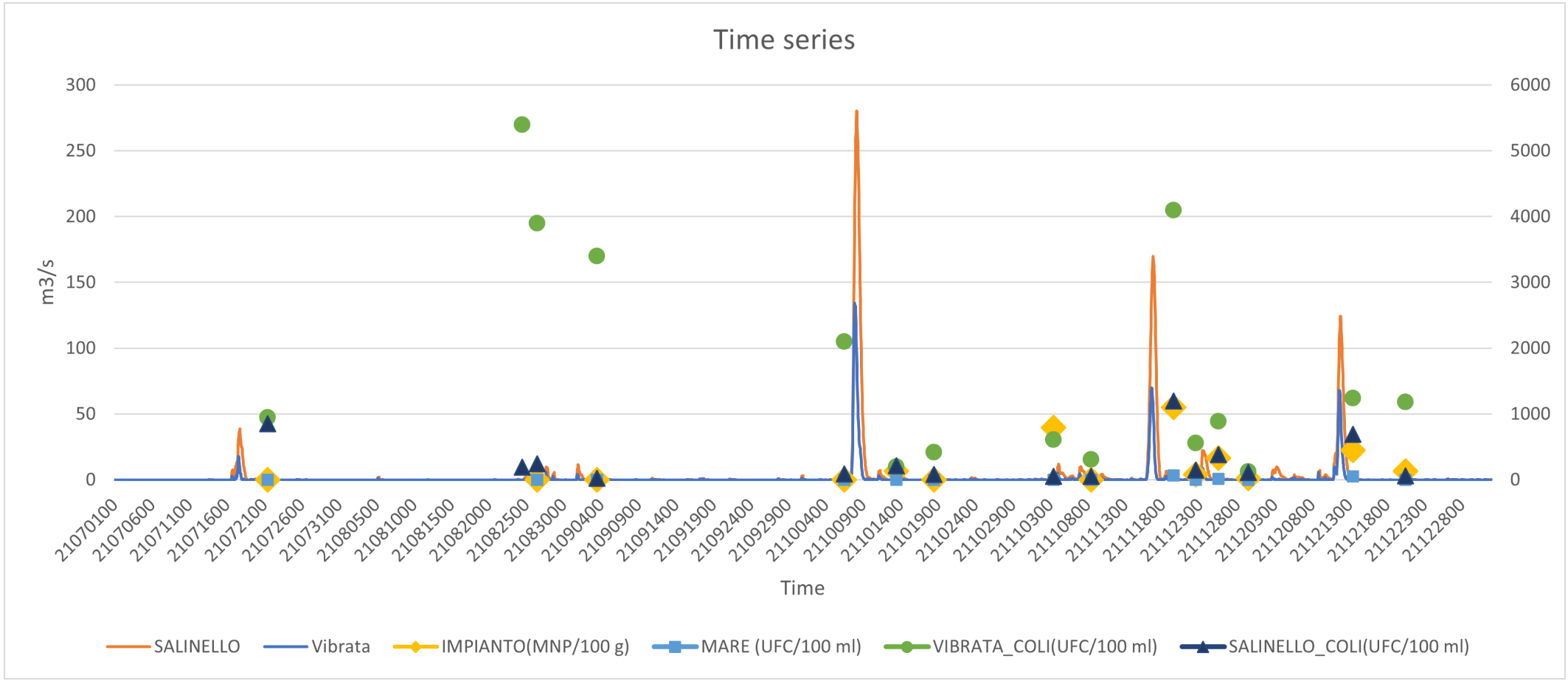
7 case studies for Salinello river

SALINELLO

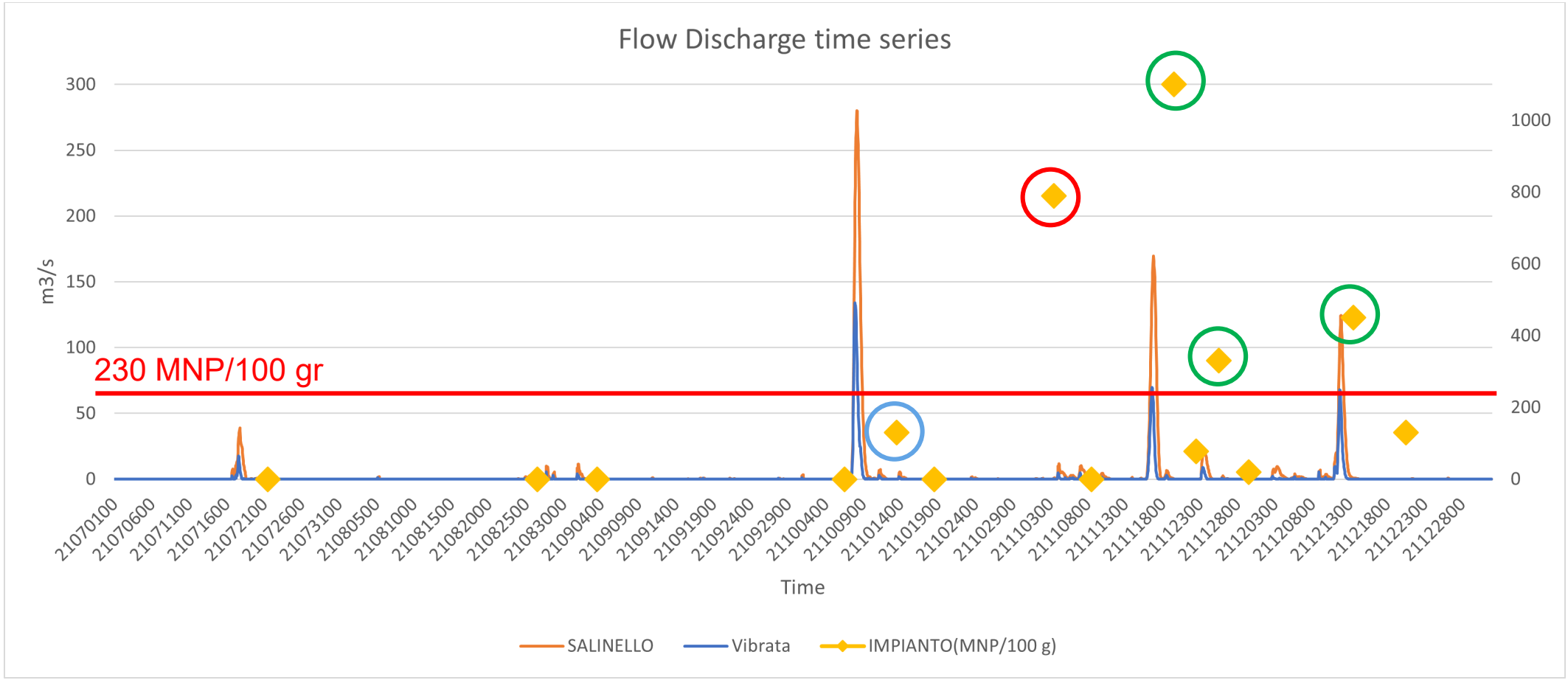
SAMPLING DATA	MATRIX	E. COLI CONCENTRATION	FLOW DISCHARGE PEACK	DAYS	PRECIPITATION
ANNO 2021					
21/07/2021	F	850 UFC/100 ml	17,78	4	33 mm/3gg
13/10/2021	M	130 MPN/100 gr	280.25 8/10/2021		
19/11/2021	F	1200 UFC/100 ml	169.66	3	42 mm/5gg
19/11/2021	M	1100 MPN/100 gr	169.66	3	42 mm/5gg
25/11/2021	M	330 MPN/100 gr	22.13	2	22 mm/2gg
13/12/2021	F	690 UFC/100 ml	124.34	2	60 mm/5gg
13/12/2021	M	450 MPN/100 gr	124.34	2	60 mm/5gg

100% of sampling with high E. coli concentrations occurs following a significant increase in river flow. The identified annual threshold of **1 m3/s** is able to effectively detect situations of hydrological stress.

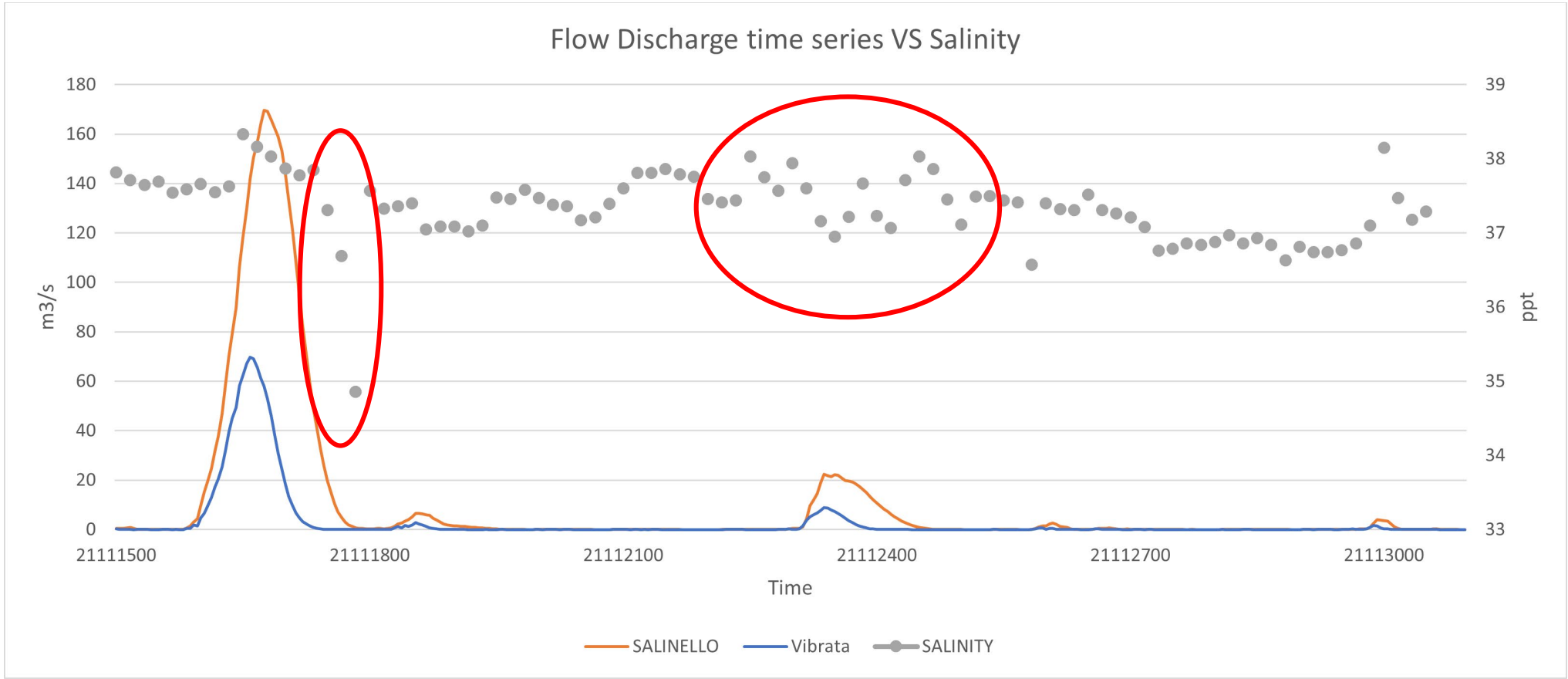
Health data Related to hydro-meteo data



Health data Related to hydro-meteo data

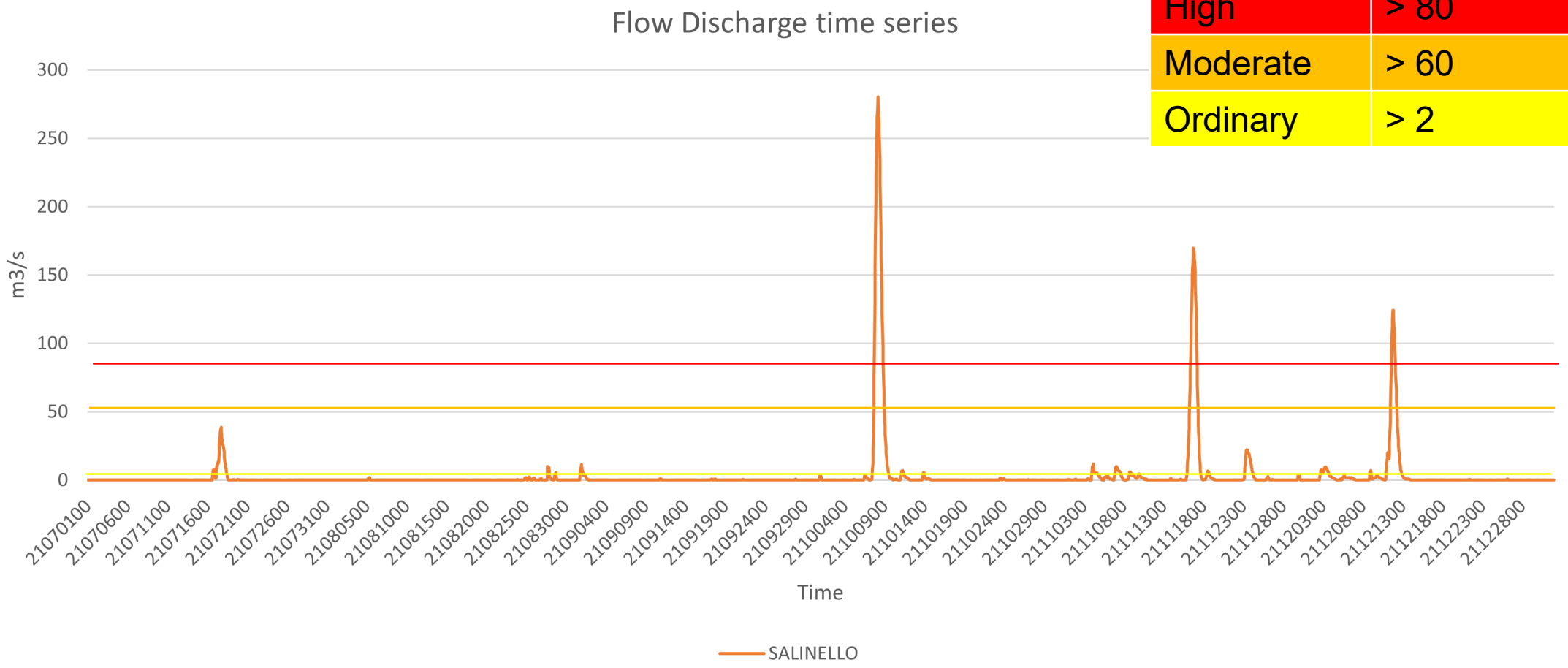


Health data Related to hydro-meteo data



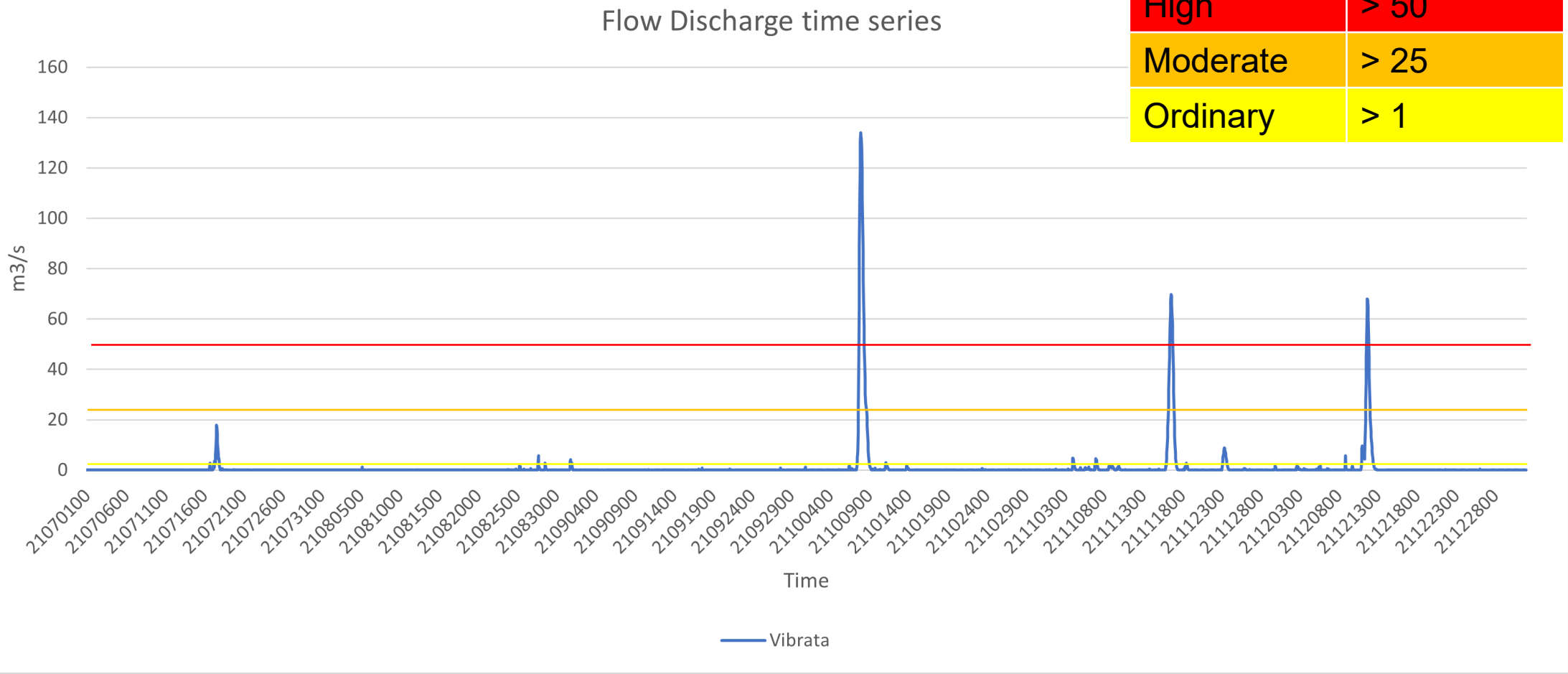
Health data Related to hydro-meteo data

Alert	m³/s
High	> 80
Moderate	> 60
Ordinary	> 2

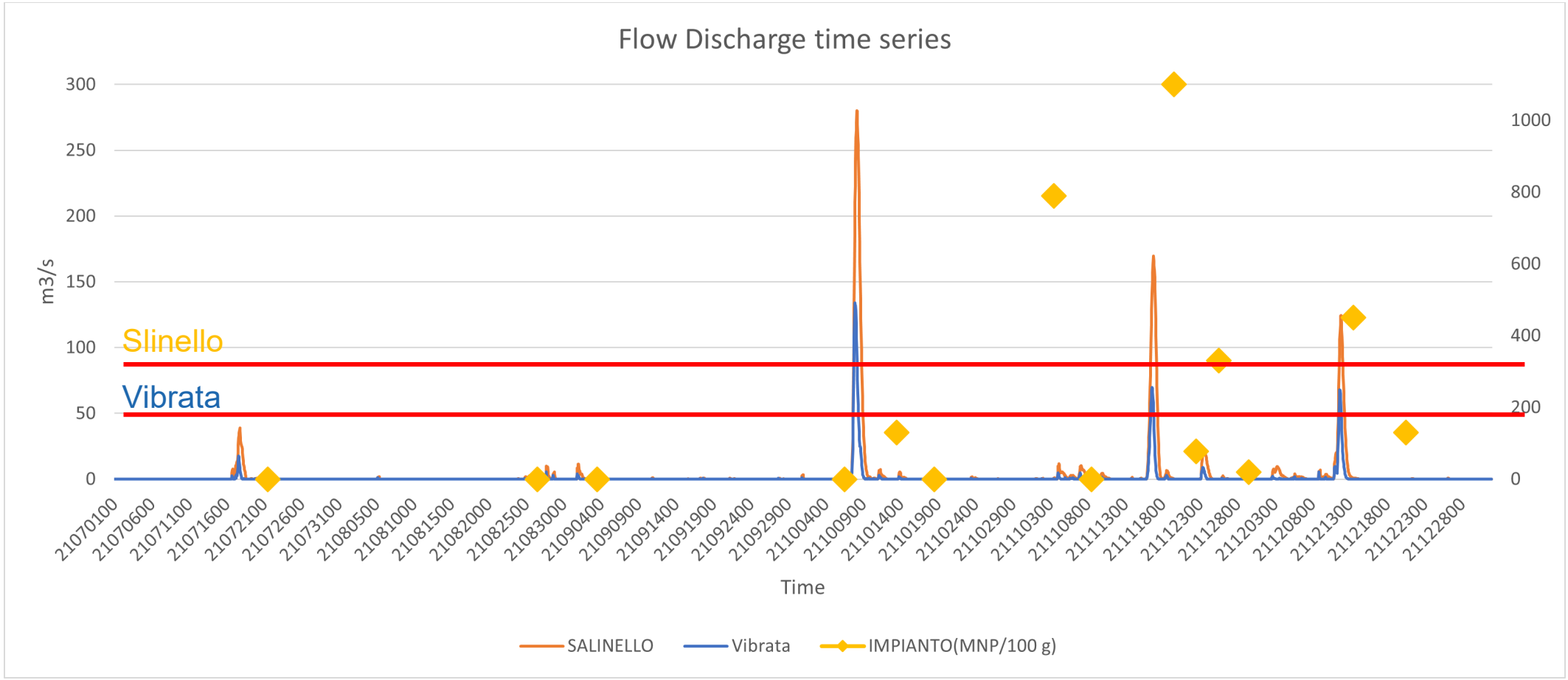


Health data Related to hydro-meteo data

Alert	m^3/s
High	> 50
Moderate	> 25
Ordinary	> 1



Health data Related to hydro-meteo data



Conclusions

By pooling different expertise, **a correlation between hydro-meteorological conditions** and the increased bacterial **concentration of E.coli in the water**, both at the mouths of rivers and in the sea, was revealed.

Through the preliminary study and analyses of past health and meteorological-environmental data, **river runoff and coastal rainfall thresholds were defined** above which a high concentration of the bacterium is recorded at river mouths and in the sea (near the mouths), which was instrumental in setting up an operational warning service for aquaculturists.

Through the measurement campaign, the estimated thresholds were verified and **it was also possible to upgrade the warning system, identifying two additional alert thresholds**: a moderate (orange threshold) and a high alert (red threshold) in order to provide the fish farmer with an increasingly effective and precise system.

This **warning system, developed within the FORESHELL project, is certainly an effective adaptation and mitigation measure** to respond to possible threats to food security due to climatic variations and to minimise economic losses.

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THANK YOU FOR YOUR ATTENTION!!