

VIRIDIS2025
Vilnius Regulatory Delivery International Symposium

Predictive models of pollutant concentration's in mussel farms areas and artificial intelligence



EPLO-IRIDE International Conference
Major Public Risks: Achieving Effective Regulatory Supervision

Vilnius, 11 - 12 February 2025

Dott. Giorgio Smaldone

DVM-PhD

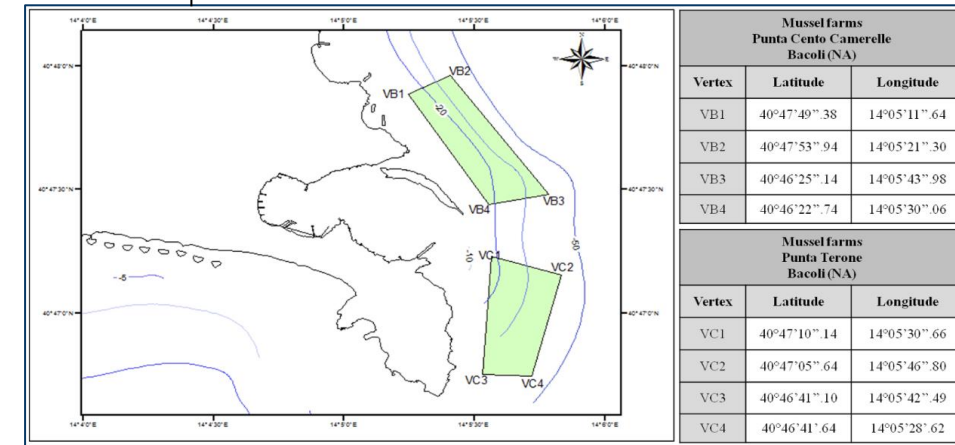
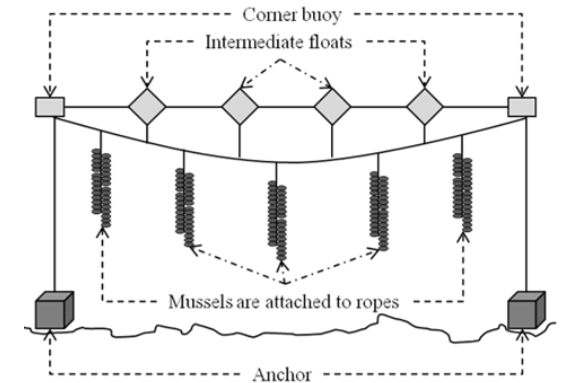
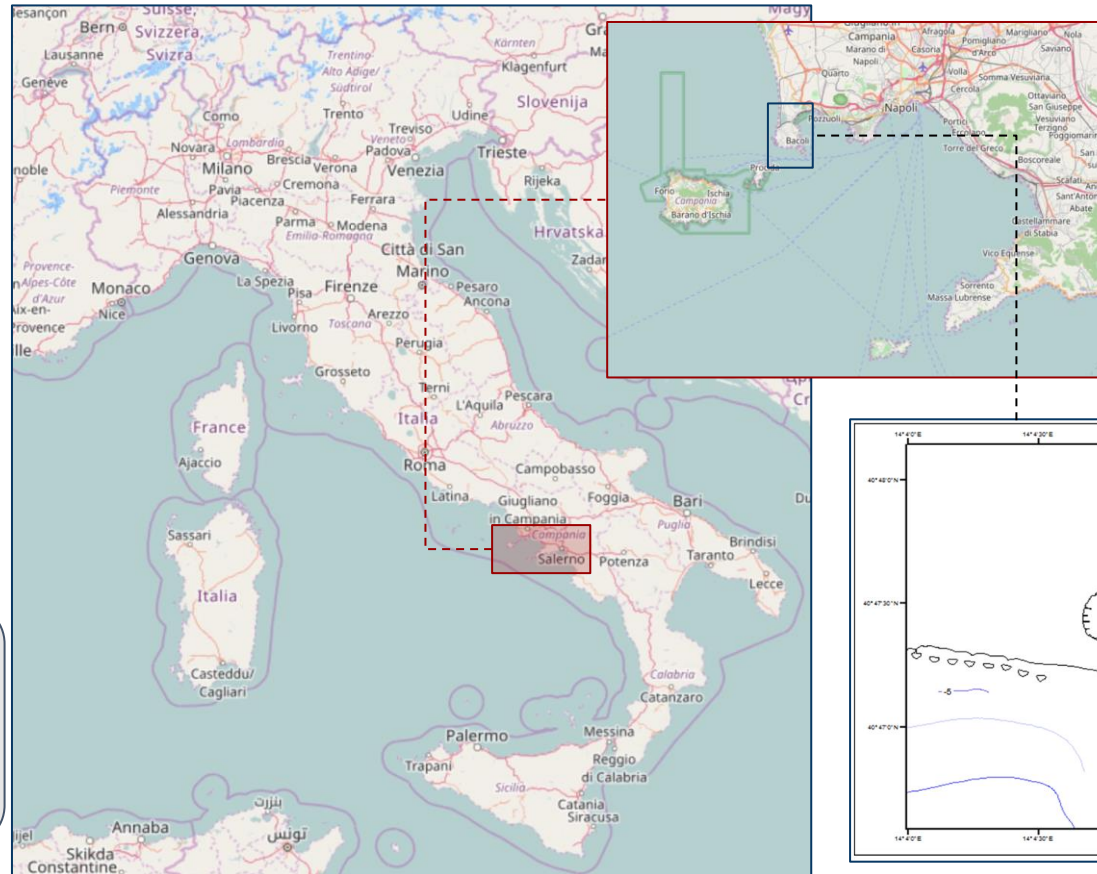
giorgio.smaldone@regione.campania.it

Introduction & Motivation

Mussels farming is an outstanding business cornerstone in the most part of Italian coastal regions.

MARKET

- Companies: 263(d)/886(r)
- Tons: ~64235 ($\frac{2}{3}$ EU prod - ISPRA)
- Euro/Kg: ~1.75 (average)
- ~112M€ (2013, Italy)

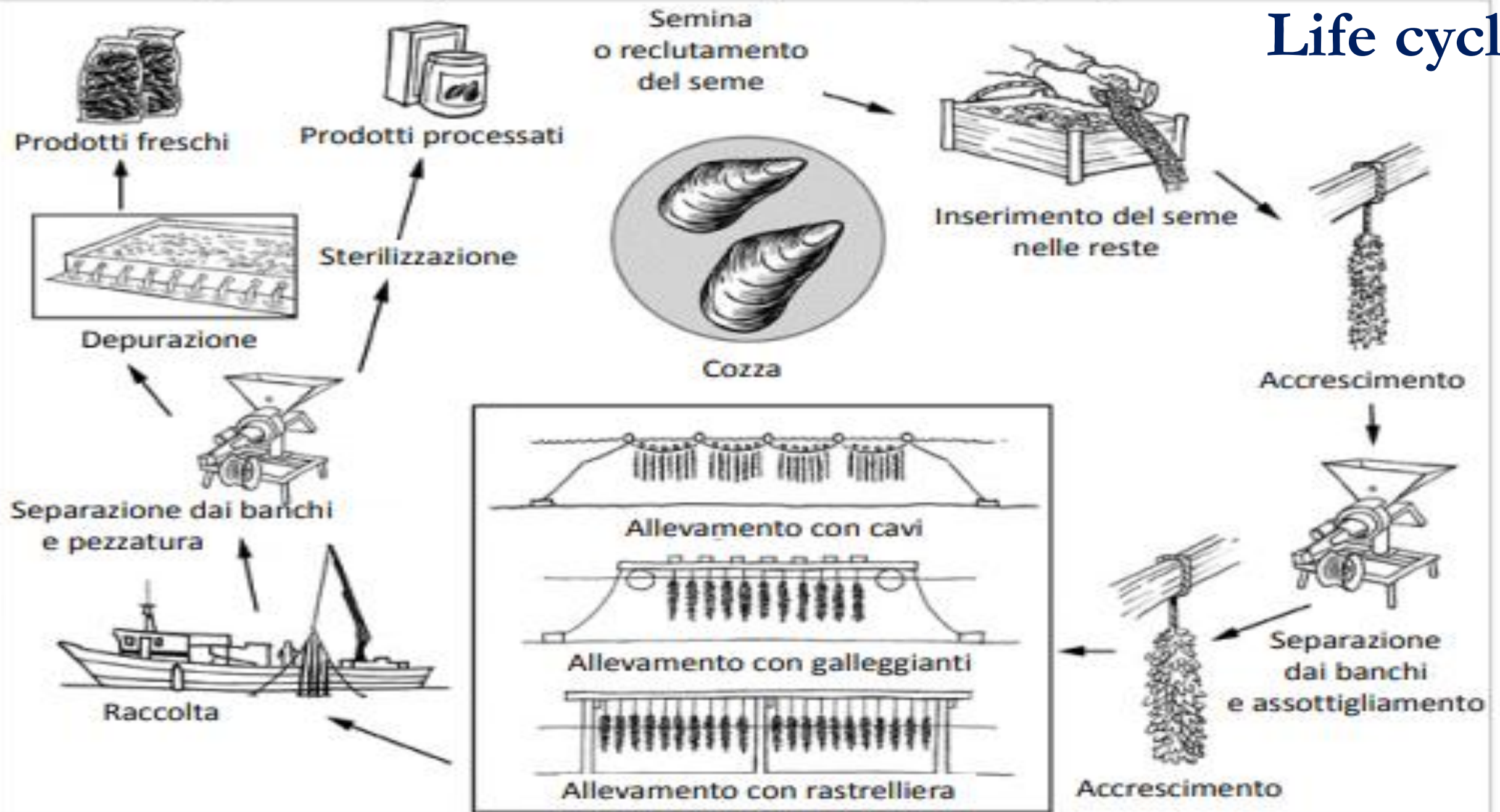


Mussel farms Punta Cento Camerelle Bacoli (NA)		
Vertex	Latitude	Longitude
VB1	40°47'49".38	14°05'11".64
VB2	40°47'53".94	14°05'21".30
VB3	40°46'25".14	14°05'43".98
VB4	40°46'22".74	14°05'30".06

Mussel farms Punta Terone Bacoli (NA)		
Vertex	Latitude	Longitude
VC1	40°47'10".14	14°05'30".66
VC2	40°47'05".64	14°05'46".80
VC3	40°46'41".10	14°05'42".49
VC4	40°46'41".64	14°05'28".62



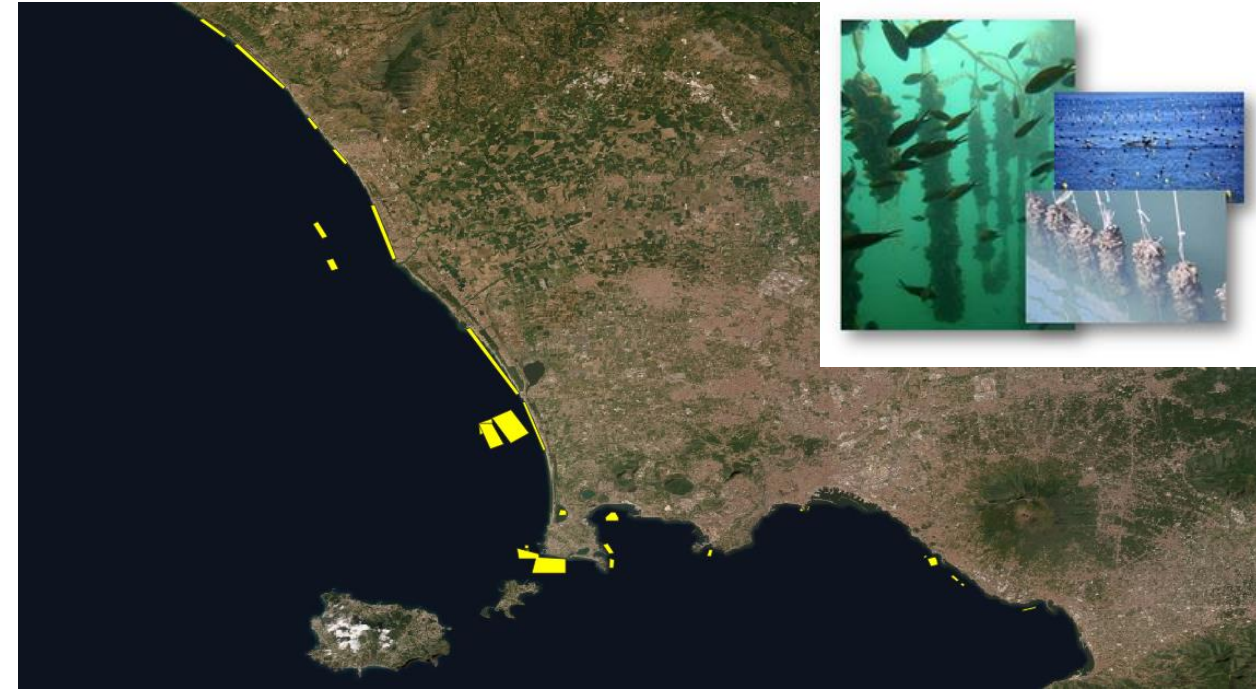
Life cycle



Fonte: FAO

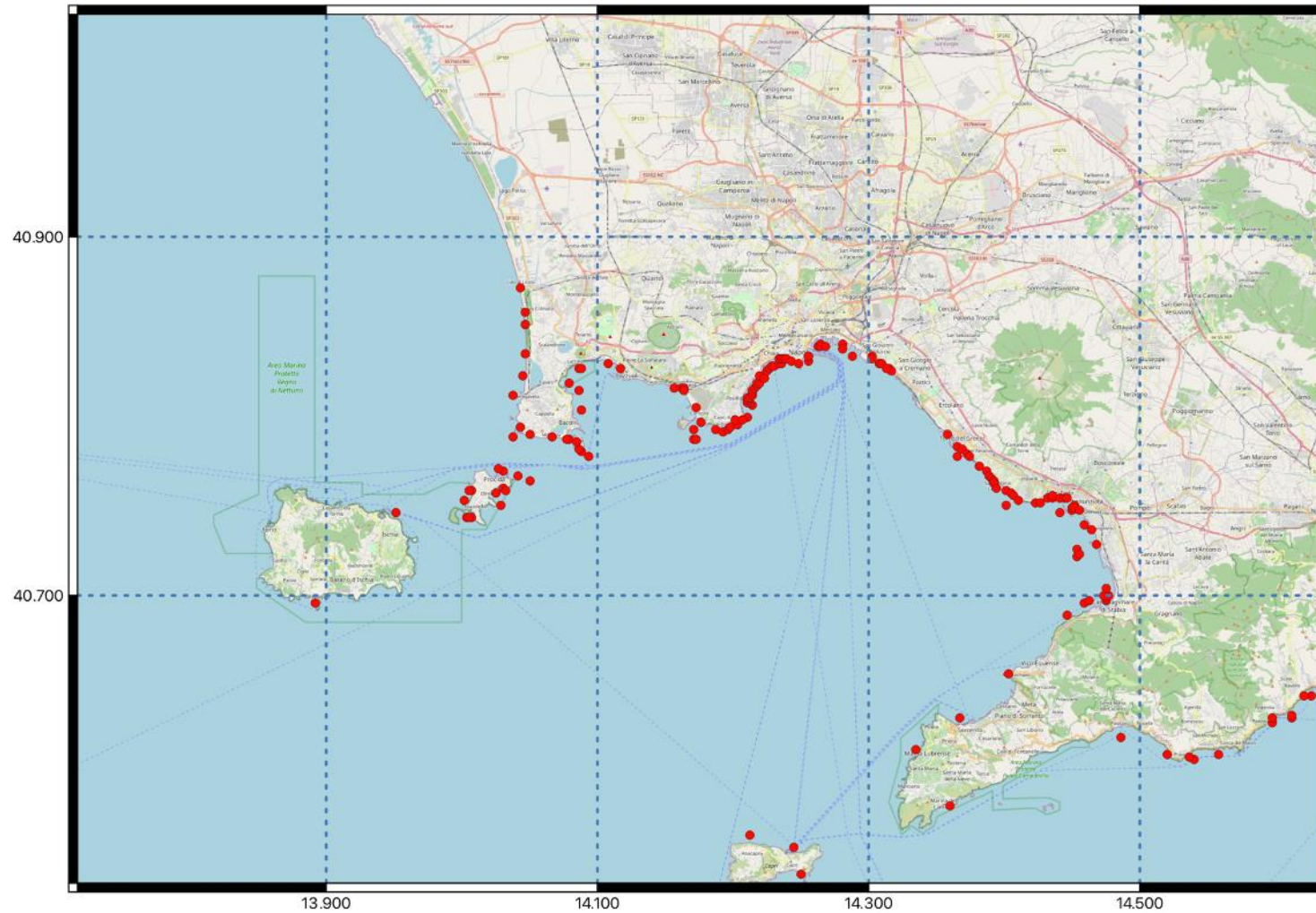
Potential Hazards

Microbiological	Escherichia coli
	Salmonella
Chemical	Mercury
	Lead
Ecotoxicological	Complezzo DSP
	Yessotossine
	Azaspiracides
	ASP
	PSP
	Radioactive nuclides



Mytilus Galloprovincialis

Introduction & Motivation



Faecal contamination may arise from a variety of sources:

- Sewage discharges (continuous or discontinuous)
- farm animals
- wildlife shipping

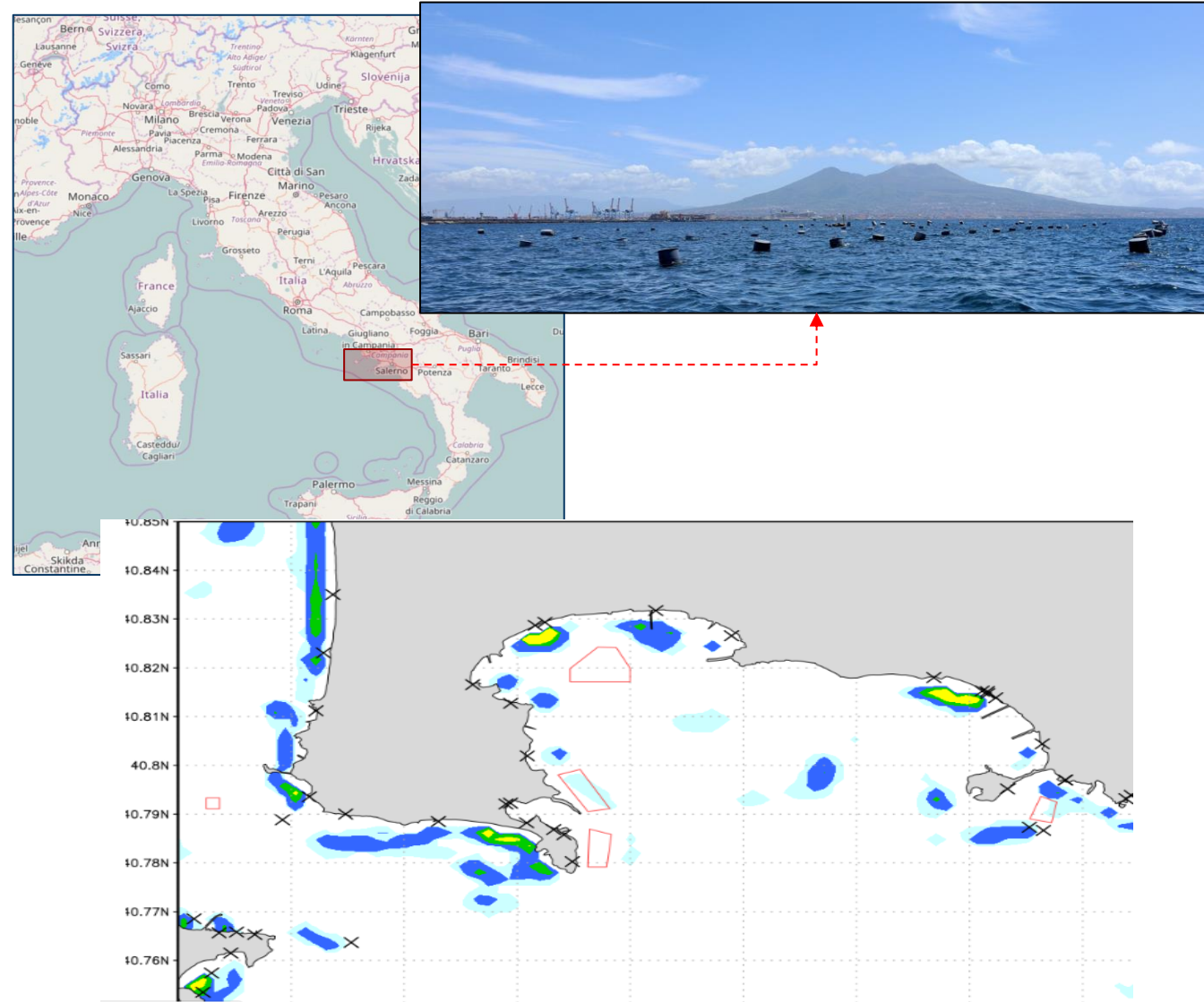
With potential deep impact of food safety and human health

Make predictions about the pollutant concentration in mussel farms areas could be of great interest

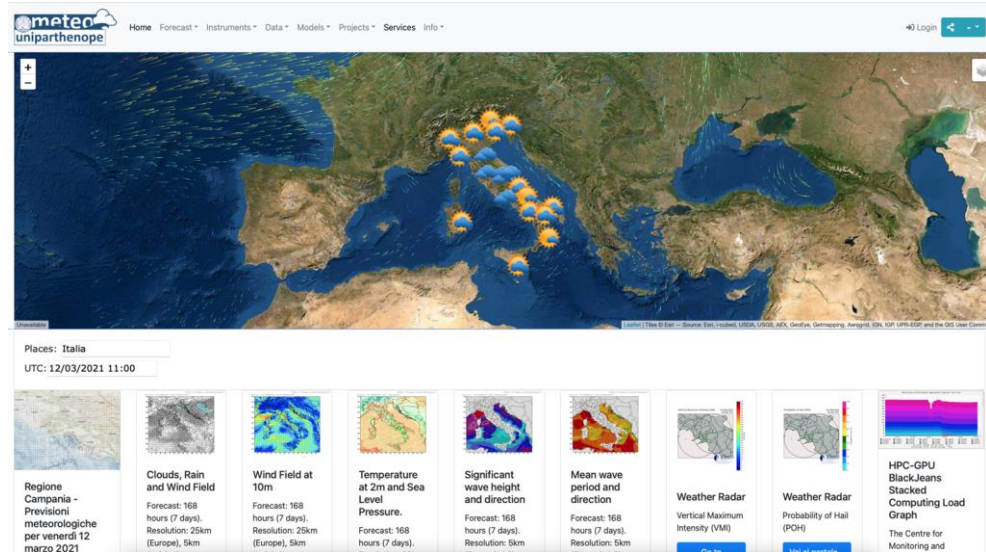
Aim of the project

Creating an integrated model to assess contamination trend in proximity of mussel farms areas in order to:

- Intercept potential risk situation
- Early detect the critical control point to be monitored
- Limit human diseases
- Limit health alerts
- Limit recall of foodstuffs from the market



The time evolution of the idea



<http://meteo.uniparthenope.it>



Center for Monitoring and
Modeling Marine and
Atmospheric applications

2012

2016

2021

2021-24

2023-28

2024-26

**Preliminary
studies**

MytiluSE -
Modelling mytilus
farming System with
Enhanced web
technologies.

MytilAI - Modelling
mytilus farming with
Artificial Intelligence
technologies
Future development



ADAPTIVE MULTI-TIER INTELLIGENT
DATA MANAGER FOR EXASCALE

MytilEX - Extended
Modelling mytilus
farming System with
High Performance
Computing and
Artificial Intelligence

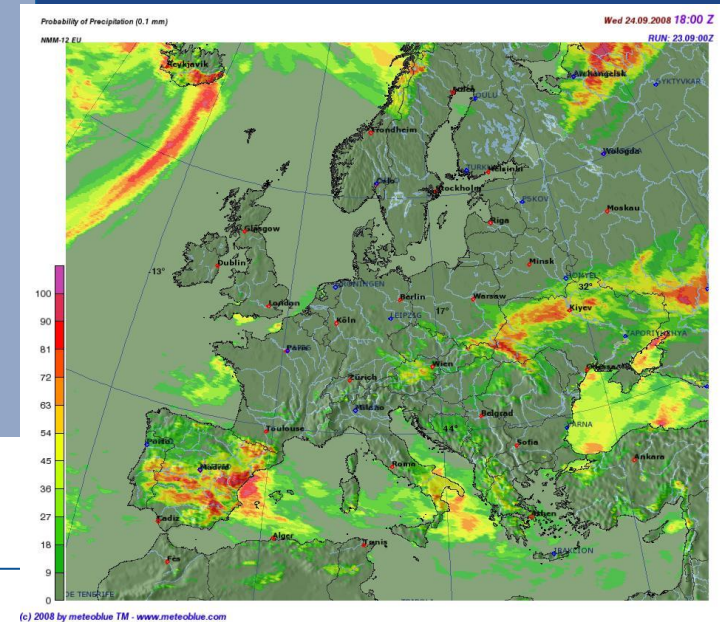
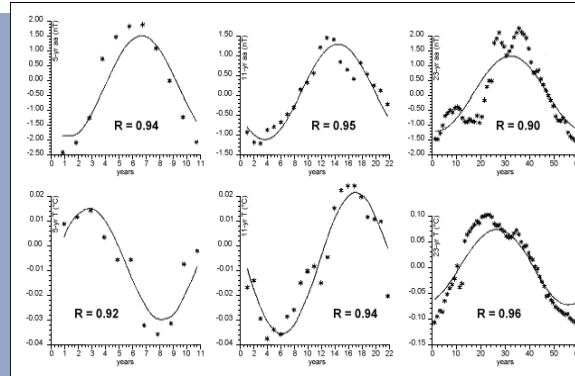
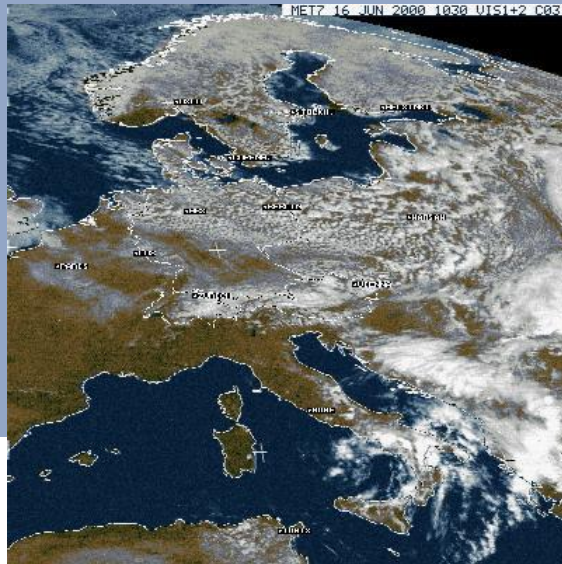
MytilX -
Modelling mytilus
farming at scale



- How the weather forecast are produced today?
 - Observations (weather stations, ...)
 - Remote sensing (satellites, ...)
 - Statistics
 - Time series analysis
 - Numerical models



...focusing
back on
weather
forecasts...

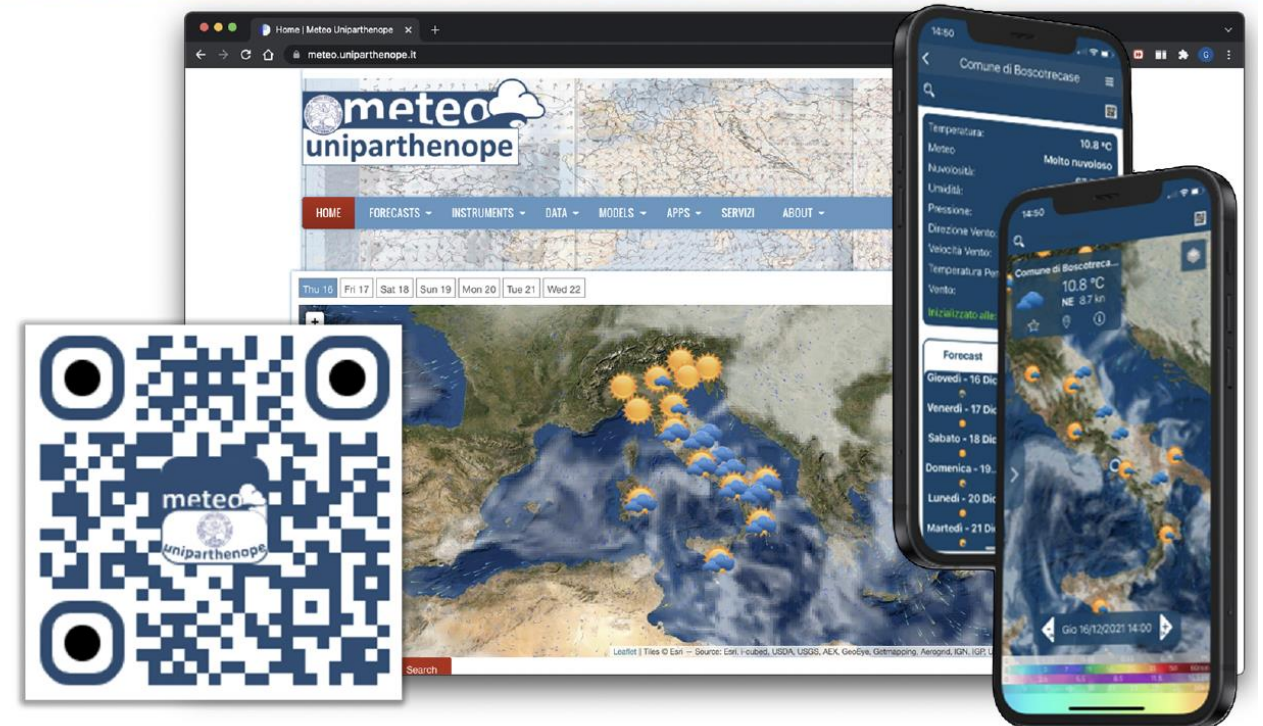


(c) 2008 by meteoblue TM - www.meteoblue.com



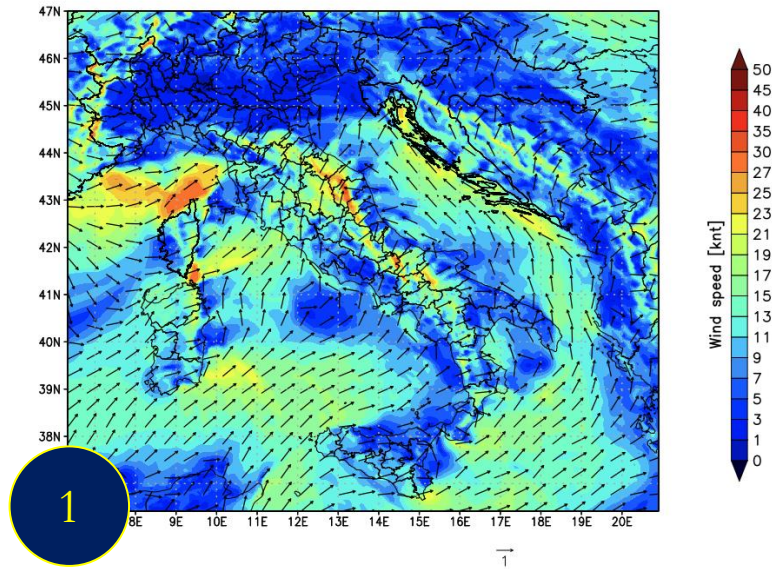
Center for Marine/atmosphere Monitoring, Modelling, and Applications

Mission: “deliver operational forecasts, predictions, and simulations for science, engineering, and management in the field of weather, ocean-dynamics, air-quality, and pollutant transport and diffusion at the sea.”

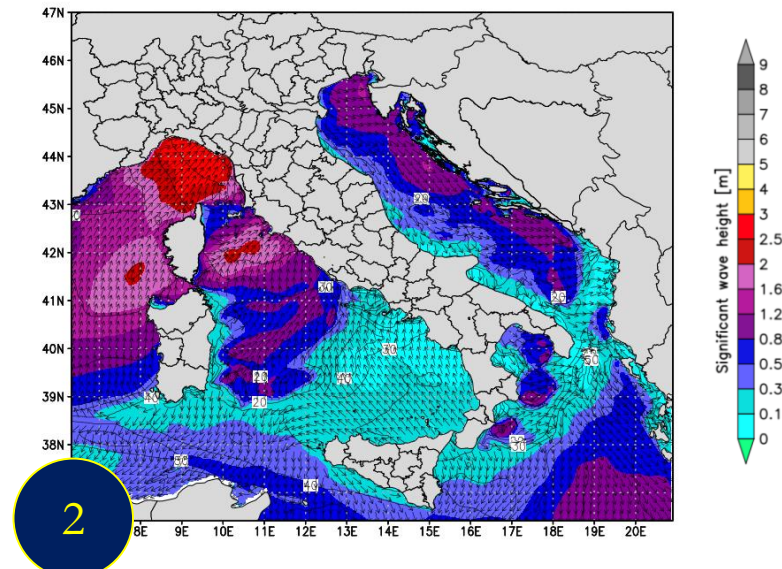


Routinary forecast

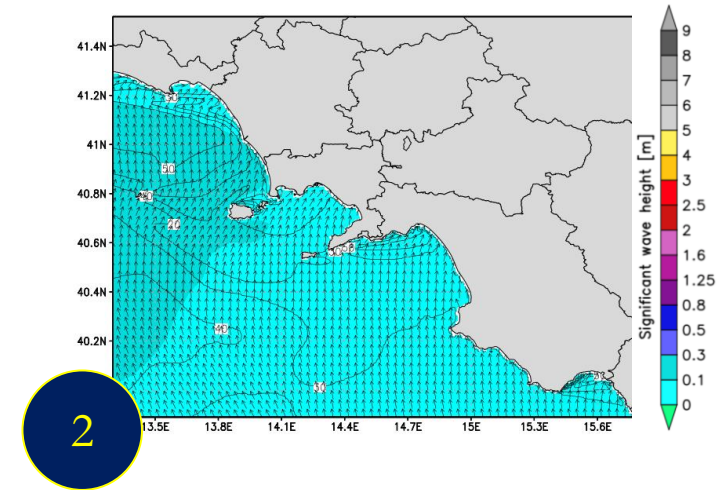
<http://meteo.uniparthenope.it>
Forecast: 11Z12MAR2021 Italia (it000/wrf5)



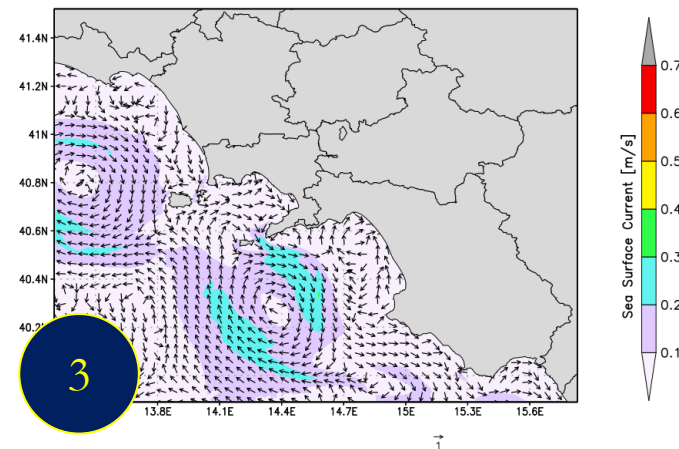
<http://meteo.uniparthenope.it>
Forecast: 11Z12MAR2021 Italia (it000/ww33)



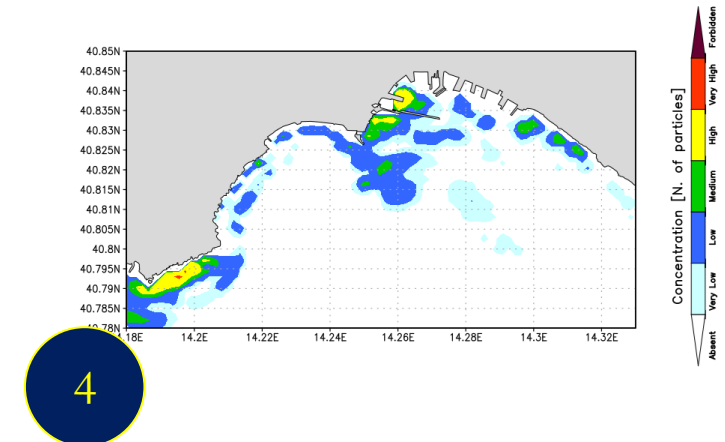
<http://meteo.uniparthenope.it>
Forecast: 11Z12MAR2021 Da Gaeta a Maratea (ca000/ww33)



<http://meteo.uniparthenope.it>
Forecast: 11Z12MAR2021 Da Gaeta a Maratea (ca000/rms3)

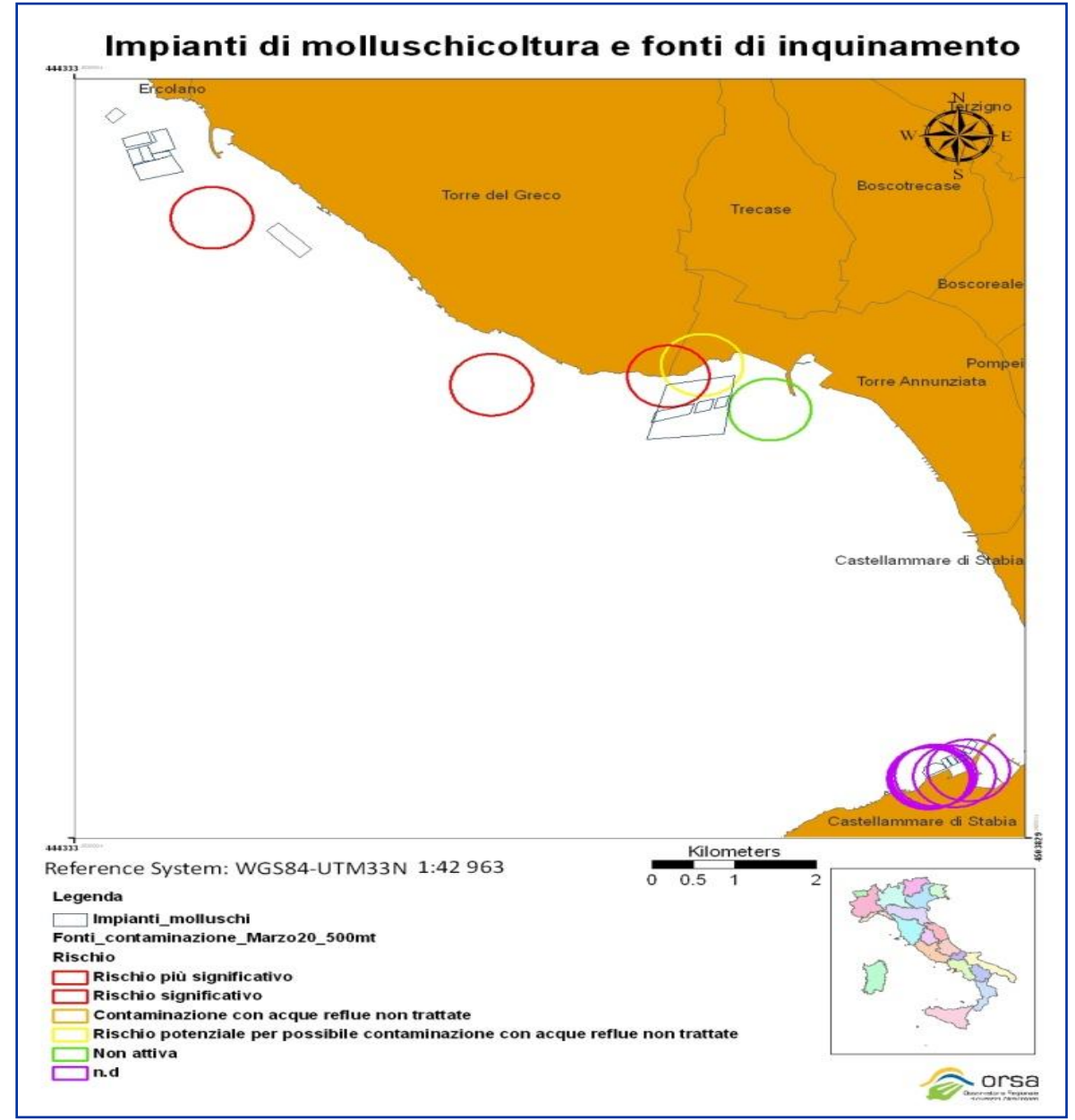
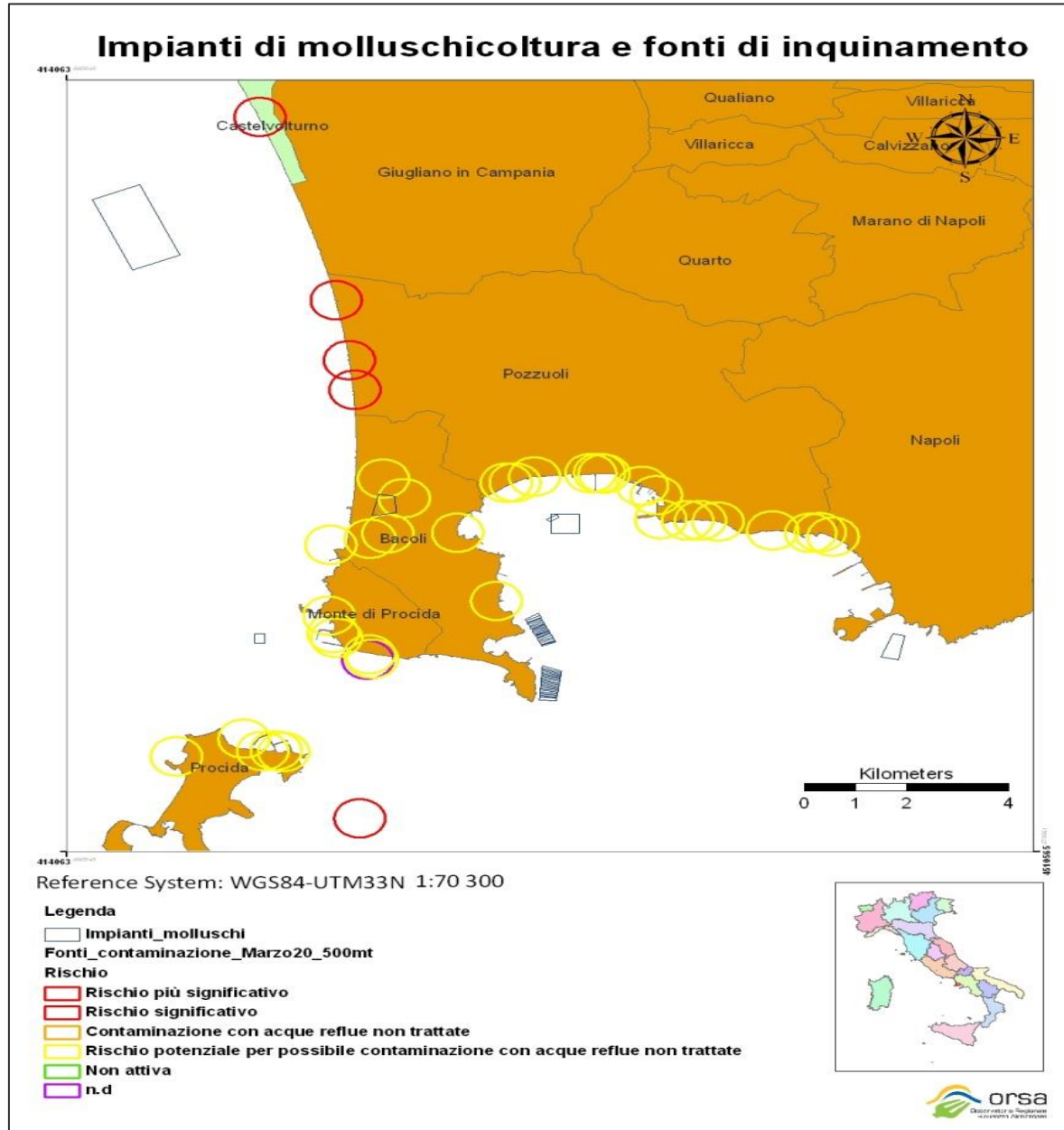


<http://meteo.uniparthenope.it>
Forecast: 11Z01MAR2021 Baia Di Napoli (ca004/wcm3)



1. Weather forecasts (168h, 1Km)
2. Wind drive sea waves (168h, 300m)
3. Sea currents (168h, 160m)
4. Inerts tracing (168h, 160m) with diffusion and transport of pollutants

Graph of all Contamination sources



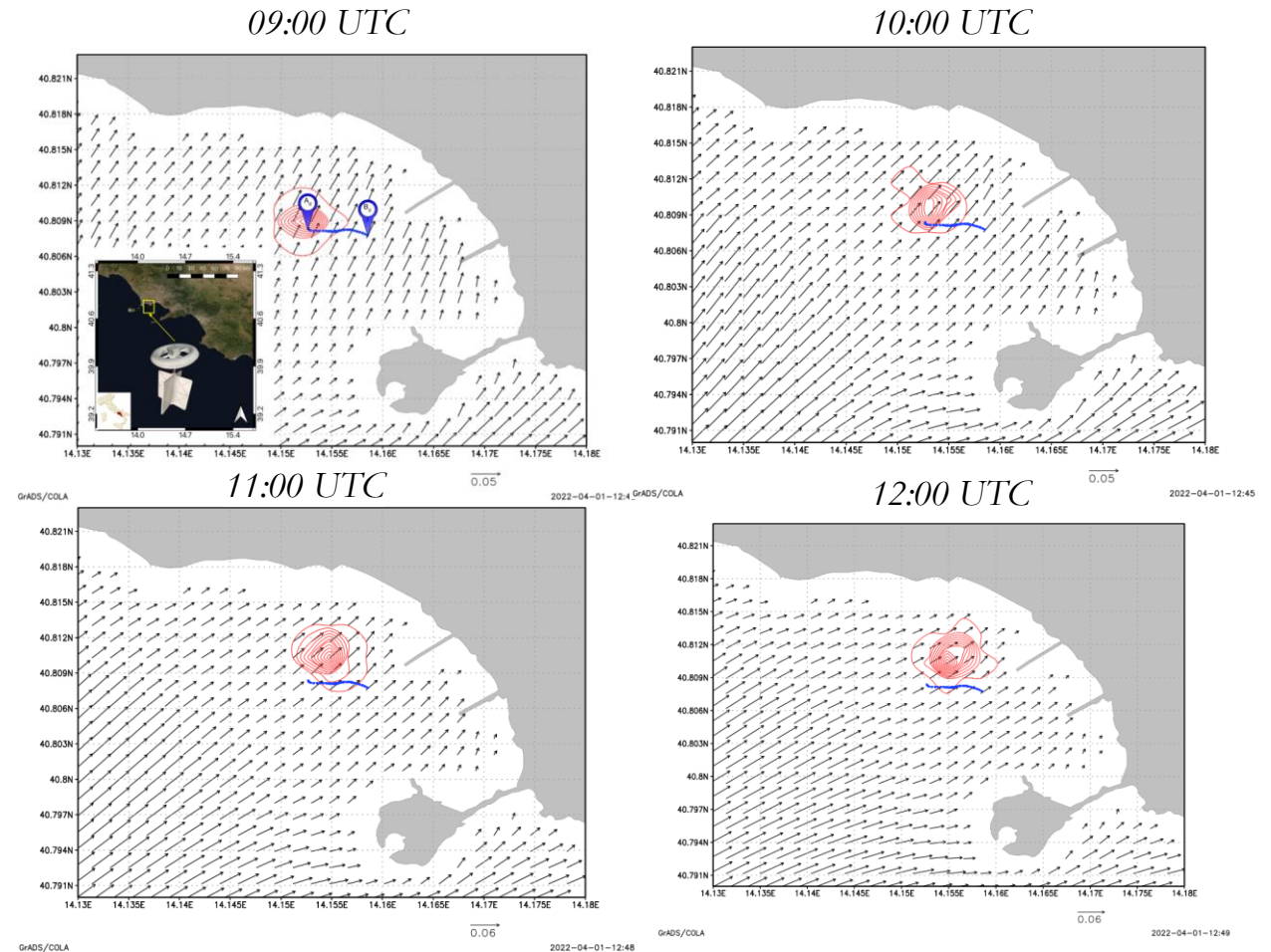
Validation phase 1: models

20K particles spilled out by a single coastal source located in the Bay of Pozzuoli (Campania, Italy), simulating the movements of a drifter buoy.

Four hours of simulation time.

Buoy's location:

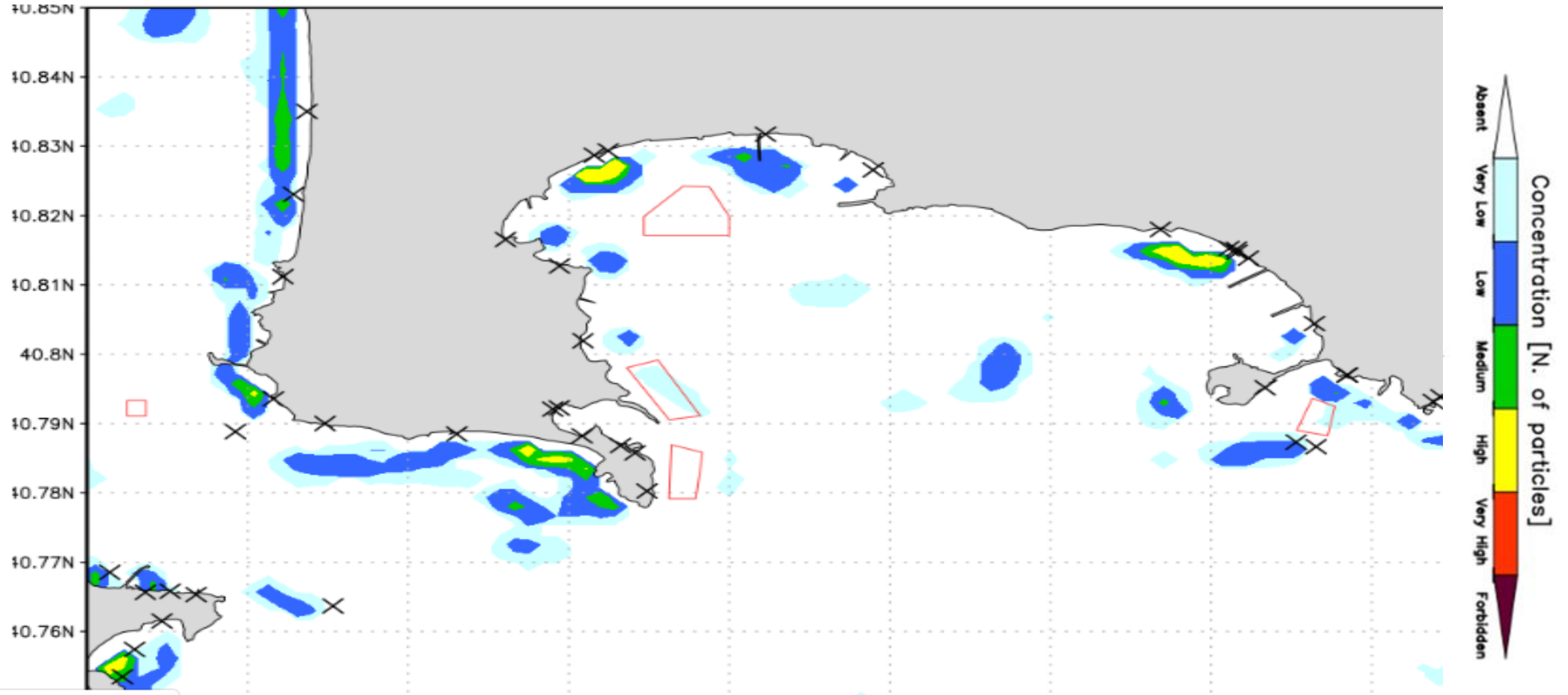
- Release:
40.808380 N, 14.152580 E
08:48 UTC
- Rescue:
40.807620 N, 14.158720 E
11:18 UTC



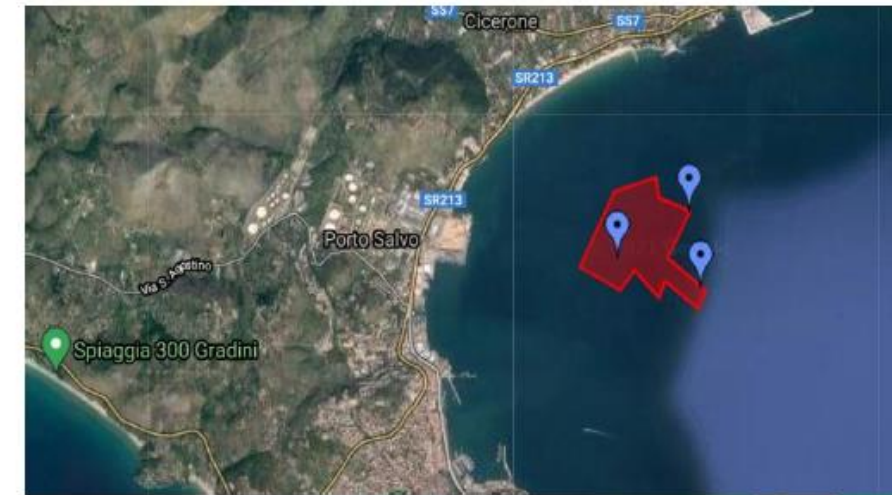
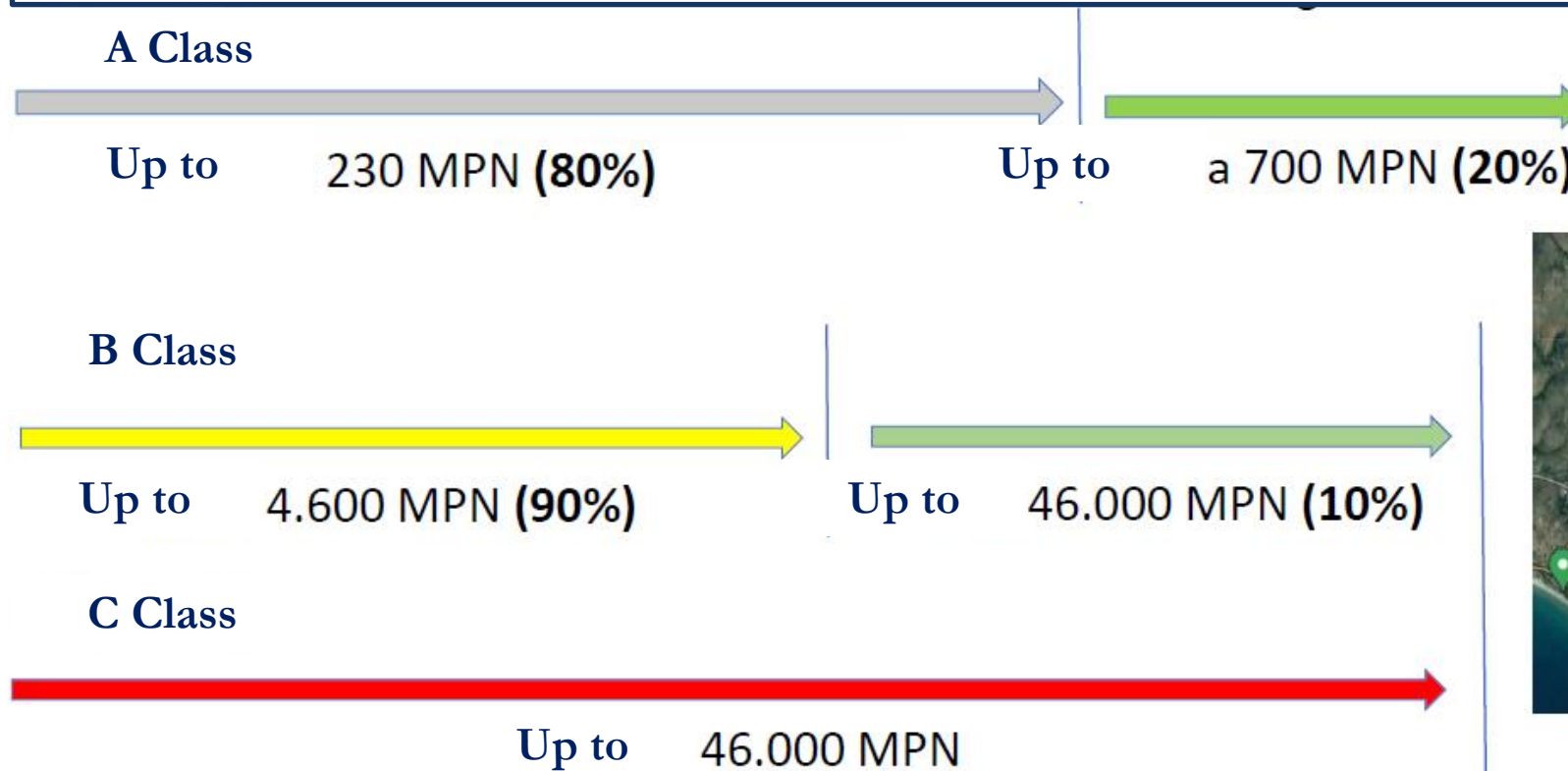
Wacomm++ lagrangian particles (red) and drifter buoy (blue) movement (West to East) under the sea state characterized by ROMS surface currents coming from SW (oriented vectors).

D. Di Luccio et al., “*Modeling passive tracers in the marine environment with high performance heterogeneous and hierarchical computing*”, Journal of Coastal and Offshore Science and Engineering (COSE), 2022 - Year I – Volume 2 (2022) – ISSN 2785-7972. https://doi.org/10.53256/COSE_220202

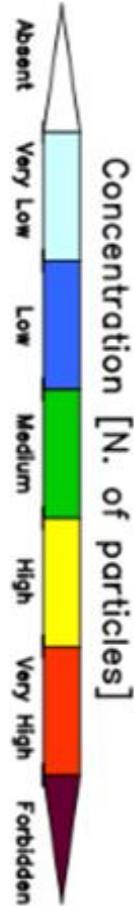
Validation phase 2: calibration



Reg. UE 2019/627
bivalve production area requirements
MPN of E. coli/100g
Salmonella absent in 25g ù

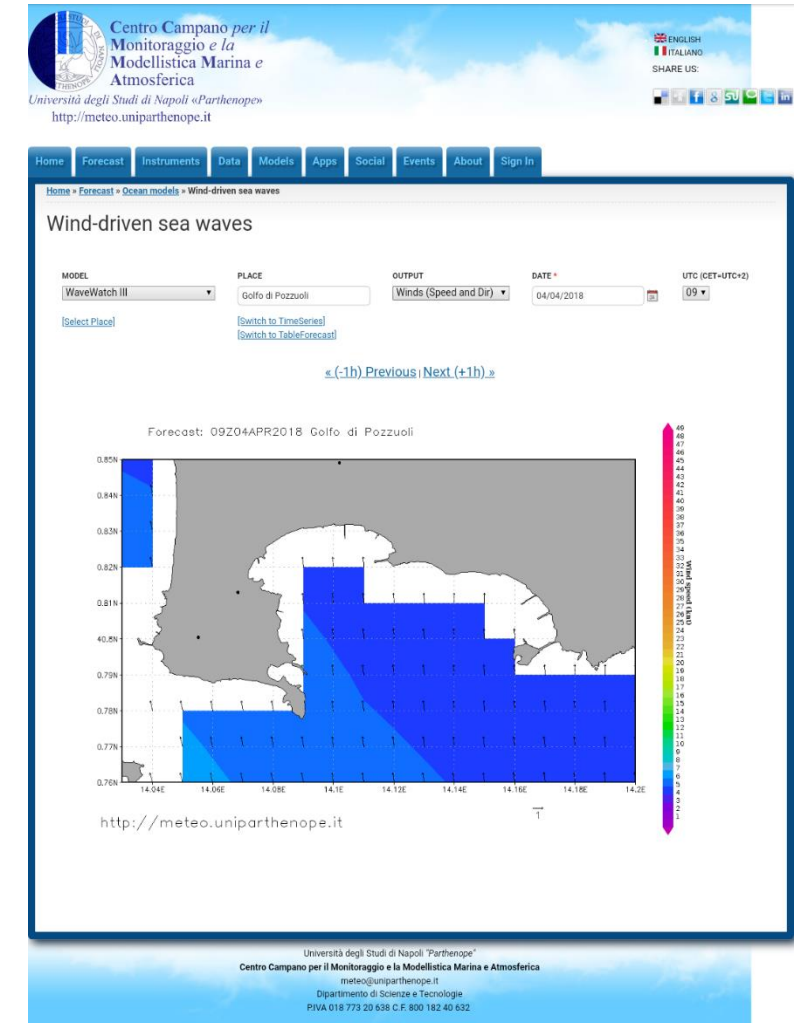
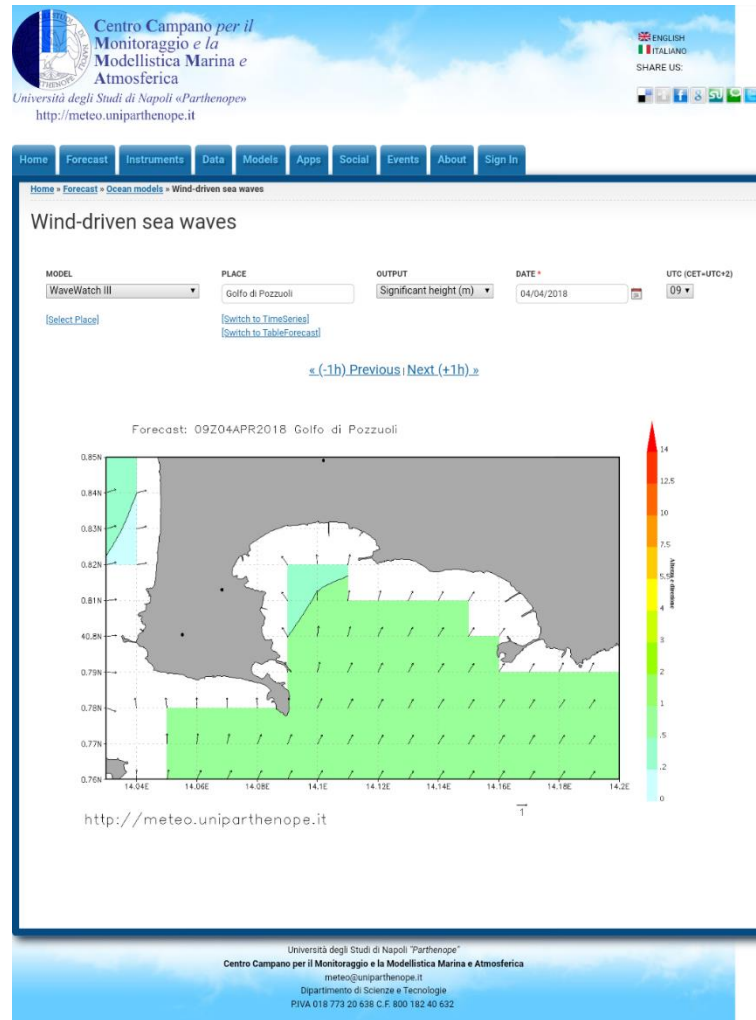


Validation phase 2: calibration and standardization



- Absent: 0
- Very low: $1 \text{ MPN} < x < 18 \text{ MPN}$
- Low: $18 \text{ MPN} < X < 230 \text{ MPN}$
- Medium: $230 \text{ MPN} < x < 700 \text{ MPN}$
- High: $700 \text{ MPN} < x < 4600 \text{ MPN}$
- Very high: $4600 \text{ MPN} < x < 46000 \text{ MPN}$
- Forbidden: $> 46000 \text{ MPN}$

Validation phase 2: calibration



Validation phase 3: mussel sampling on a fixed mussel braid

Indirizzo

GD (gradi decimali)*

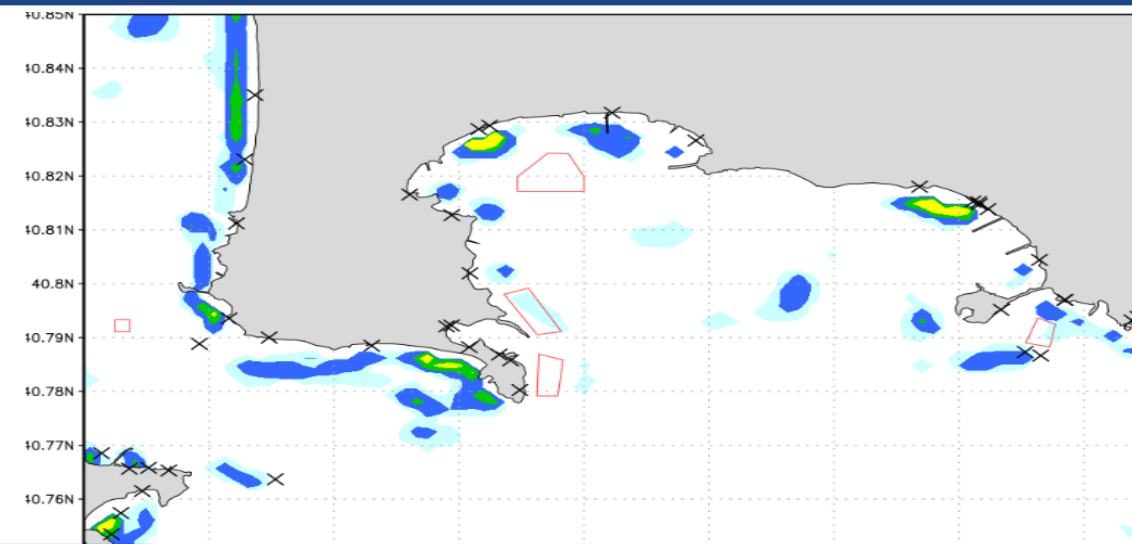
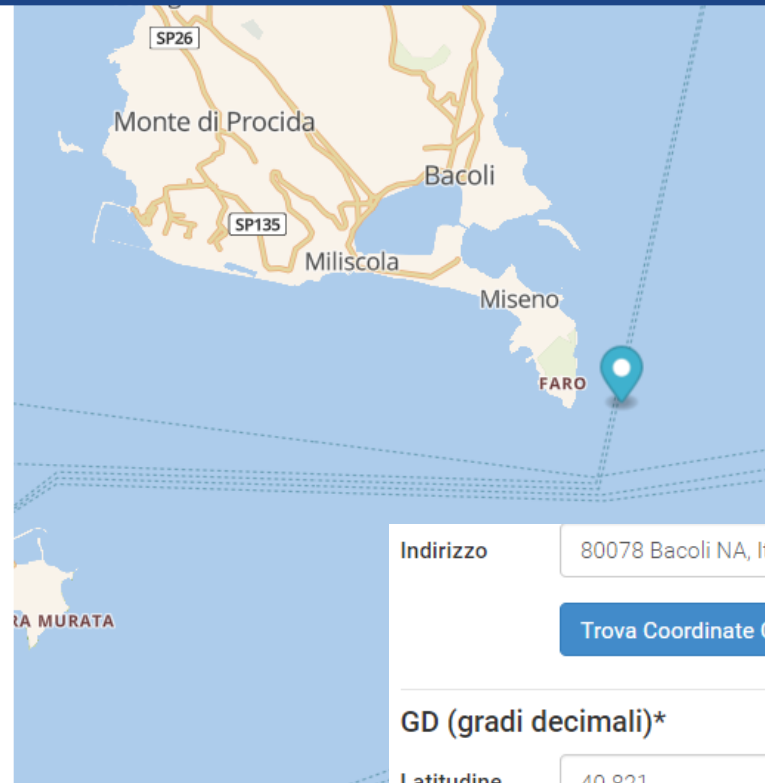
Latitudine

Longitudine

GMS (gradi, minuti, secondi)*

Latitudine ☒ N ☐ S ° ' "

Longitudine ☒ E ☐ O ° ' "



Indirizzo

GD (gradi decimali)*

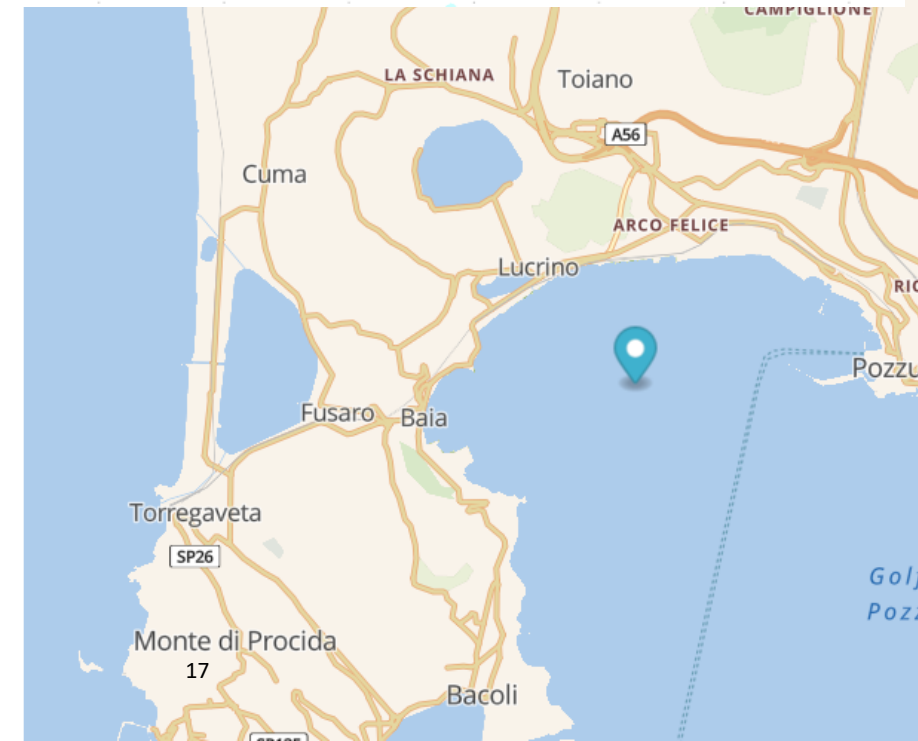
Latitudine

Longitudine

GMS (gradi, minuti, secondi)*

Latitudine ☒ N ☐ S ° ' "

Longitudine ☒ E ☐ O ° ' "



Validation phase 3: 1 year of mussel sampling in different wheather conditions

Data	Campione	Data ultima pioggia	Data ultima mareggiata	Cielo/Mare	Vento/direz	Corrente	Temperatura aria
15/11/2017	1L	14/11/17	14/11/17	sereno/ legg. mosso	brezza - SE	SE	18,7
21/11/2017	2L	14/11/17	14/11/17	sereno/ legg. mosso	brezza - SE	SE	20,7
28/11/2017	3L	26/11/17	26/11/17	sereno/piatto	assente - SE	SE	14
05/12/2017	4L	03/12/17	03/12/17	sereno/piatto	brezza - NE	NE	11
03/01/2018	5L	02/01/18	02/01/18	sereno/piatto	brezza - NW	NW	12
15/01/2018	6L	15/01/18	15/01/18	coperto/pioggia/leg. mosso	brezza - EST	EST	11
22/01/2018	7L	21/01/18	18/01/18	sereno/ legg. mosso	brezza - NE	NE	9
01/02/2018	8L	01/02/18	01/02/18	coperto/pioggia/mosso	brezza - TESO - S	S	12
12/02/2018	9L	08/02/2018	08/02/2018	coperto/piatto	brezza - SE	SE	9
21/02/2018	10L	21/02/2018	08/02/2018	coperto/pioggia/leg. mosso	brezza - NE	NE	6
29/05/2018	11L	23/05/2018	22/05/2018	sereno/piatto	assente - E	NE	25
04/06/2018	12L	23/05/2018	22/05/2018	coperto/leg. Mosso	brezza - SE	SW	25
13/06/2018	13L	09/06/2018	09/06/2018	sereno/piatto	assente - WSW	WSW	26
19/06/2018	14L	18/06/2018	15/06/2018	sereno/piatto	brezza - NE	NE	26
10/07/2018	15L	>7gg	>7gg	sereno/ leg. Mosso	brezza - NE		
31/07/2018	16L	27/07/2018	>7gg	sereno/piatto	brezza - NE	NW	30
12/11/2018	17L	06/11/2018	05/11/2018	sereno/legg. Mosso	brezza - NE	SO	15

Validation phase 3: 1 year of mussel sampling in different wheather conditions

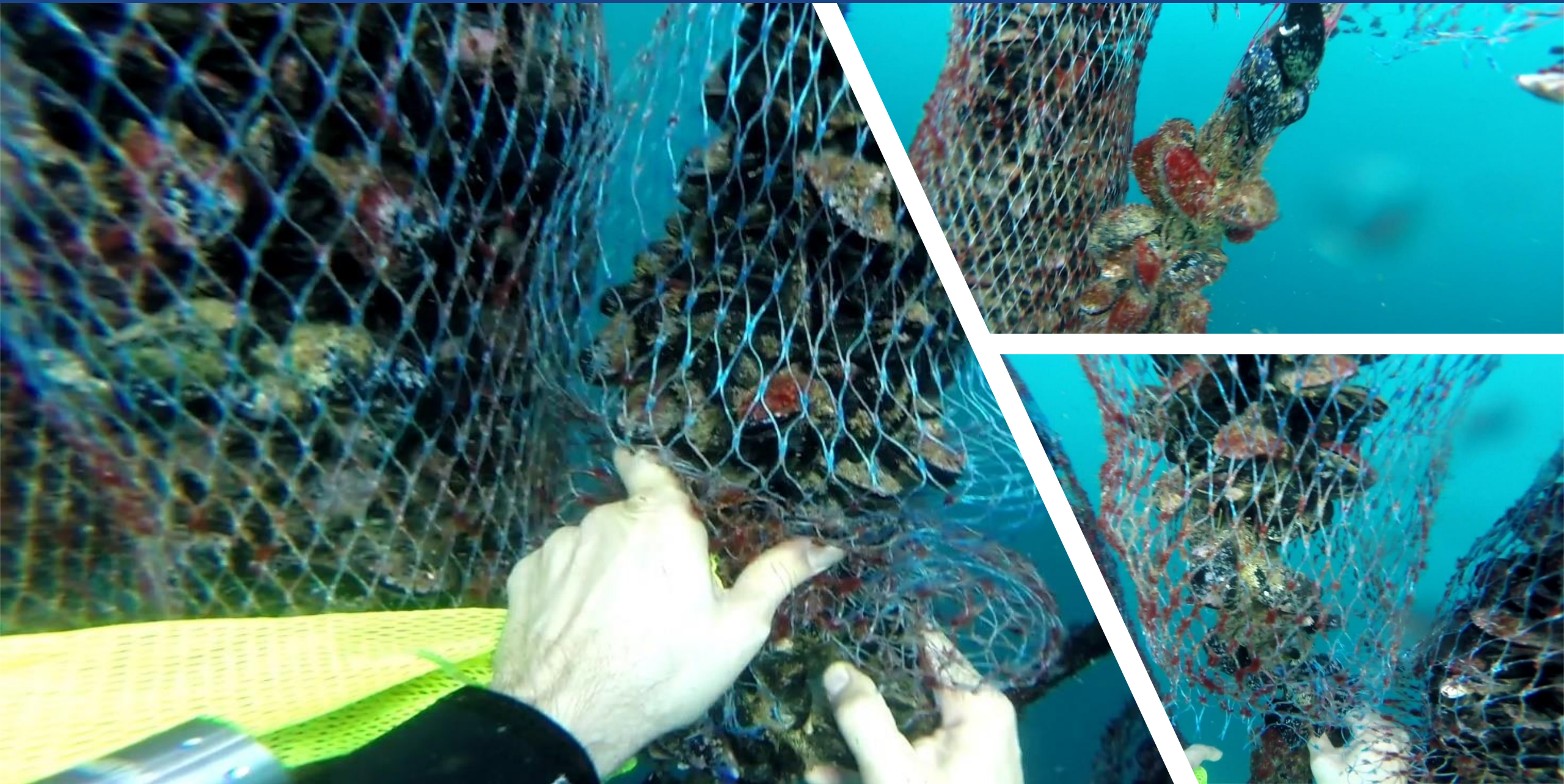
Data	Campione	Data ultima pioggia	Data ultima mareggiata	Cielo/Mare	Vento/direz	Corrente	Temperatura aria
15/11/2017	1M	14/11/17	14/11/17	sereno/ legg. mosso	brezza - SE	SE	21,5
21/11/2017	2M	14/11/17	14/11/17	sereno/ legg. mosso	brezza - SE	SE	21,2
28/11/2017	3M	26/11/17	26/11/17	sereno/piatto	assente - SE	SE	13
05/12/2017	4M	03/12/17	03/12/17	sereno/piatto	brezza - NE	NE	11
03/01/2018	5M	02/01/18	02/01/18	sereno/piatto	brezza - NW	NW	10
15/01/2018	6M	15/01/18	15/01/18	coperto/pioggia/leg. mosso	brezza - EST	EST	10
22/01/2018	7M	21/01/18	18/01/18	sereno/ legg. mosso	brezza - NE	NE	9
01/02/2018	8M	01/02/18	01/02/18	coperto/pioggia/mosso	brezza - TESO - S	S	12
12/02/2018	9M	08/02/2018	08/02/2018	coperto/piatto	brezza - SE	SE	9
21/02/2018	10M	21/02/2018	08/02/2018	coperto/pioggia/leg. mosso	brezza - NE	NE	6
29/05/2018	11M	23/05/2018	22/05/2018	sereno/piatto	brezza - E	NE	25
04/06/2018	12M	23/05/2018	22/05/2018	coperto/leg. mosso	brezza - SE	SW	25
13/06/2018	13M	09/06/2018	09/06/2018	sereno/piatto	brezza - WSW	WSW	24
19/06/2018	14M	18/06/2018	15/06/2018	sereno/piatto	brezza - NE	NE	24
10/07/2018	15M	>7gg	>7gg	sereno/leg. Mosso	brezza - NE	NE	28
31/07/2018	16M	27/07/2018	>7gg	sereno/piatto	brezza - NE	NW	28
12/11/2018	17M	06/11/2018	05/11/2018	Sereno/legg. Mosso	brezza - NE	SO	13
13/11/2018	18M	06/11/2018	05/11/2018	Sereno/legg. Mosso	brezza - NE	SO	13
28/11/2018	19M	>7gg	>7gg	sereno/leg. Mosso	brezza - NE	NE	12
12/12/2018	20M	>7gg	>7gg	sereno/leg. Mosso	brezza - NE	NE	12



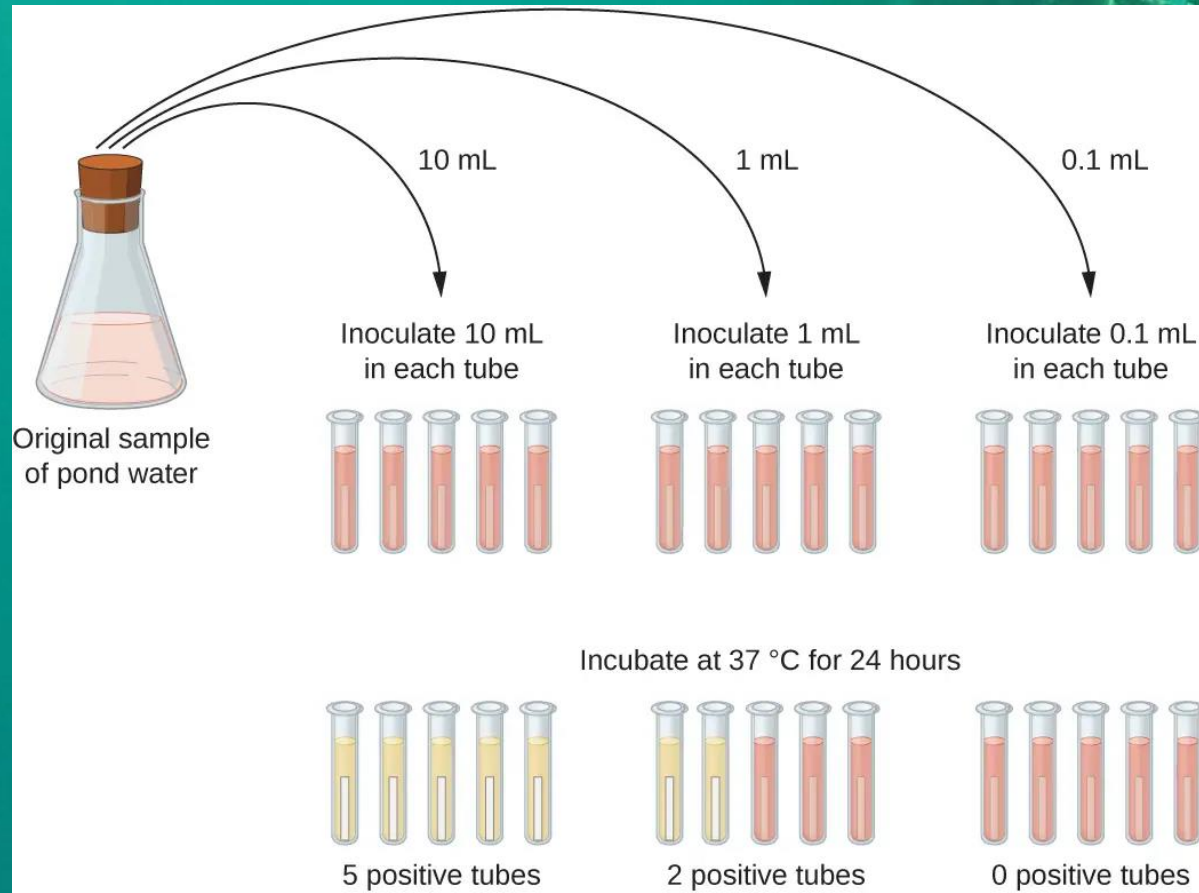
Mussel sampling along water column



Mussel sampling along water column



Evaluation of E.coli contamination at official laboratory



Phase 4: matching laboratory results to model results in order to calibrate the contamination scale

PLACE

Golfo di Pozzuoli - VET0051 (369)

PRODUCT

Diffusion and transport pollutants 120h

OUTPUT

Concentration

DATE

12/11/2018

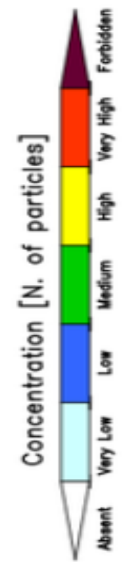
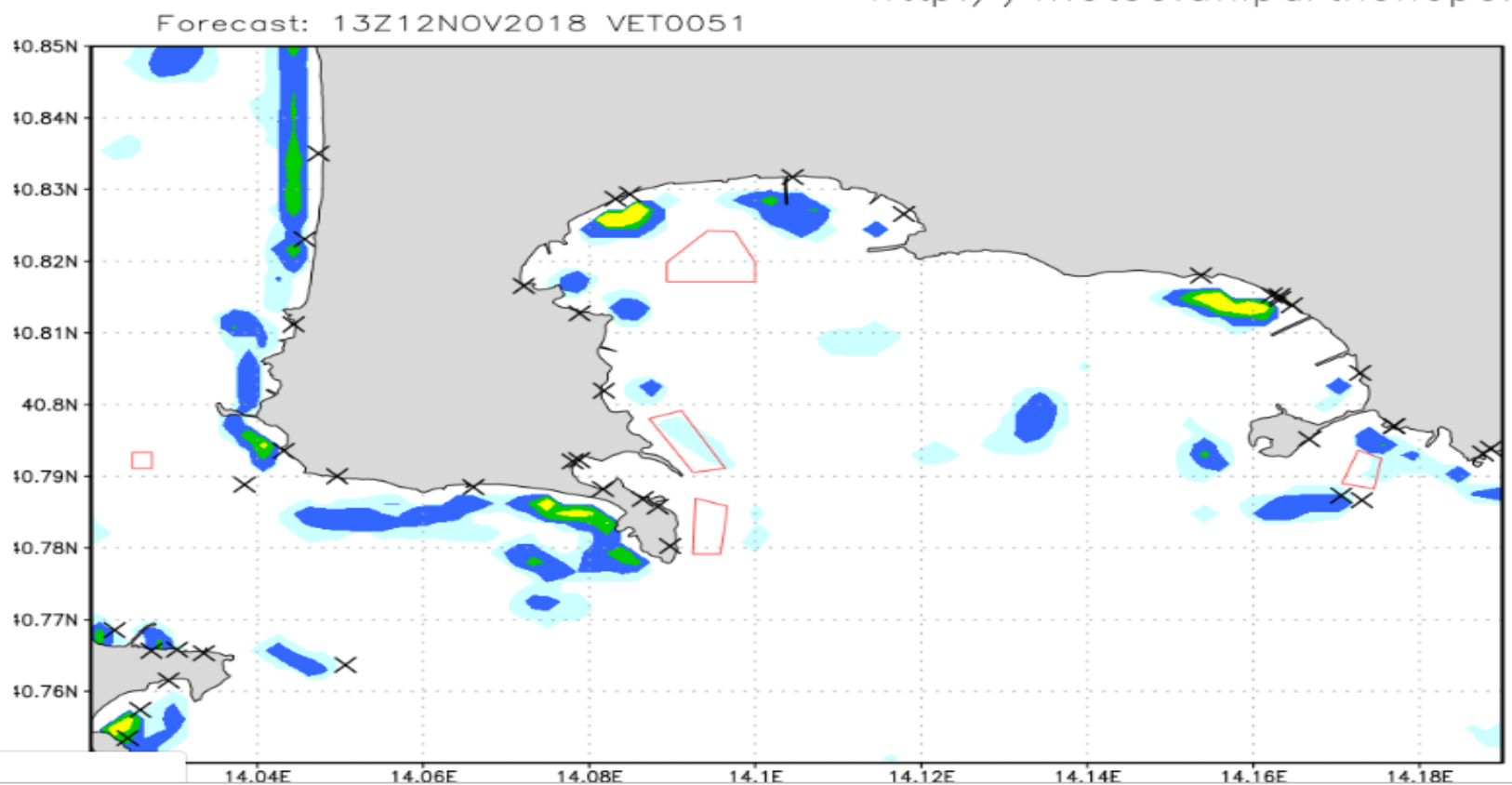
UTC (CET=UTC+1)

13

Change Visualization type

Technical

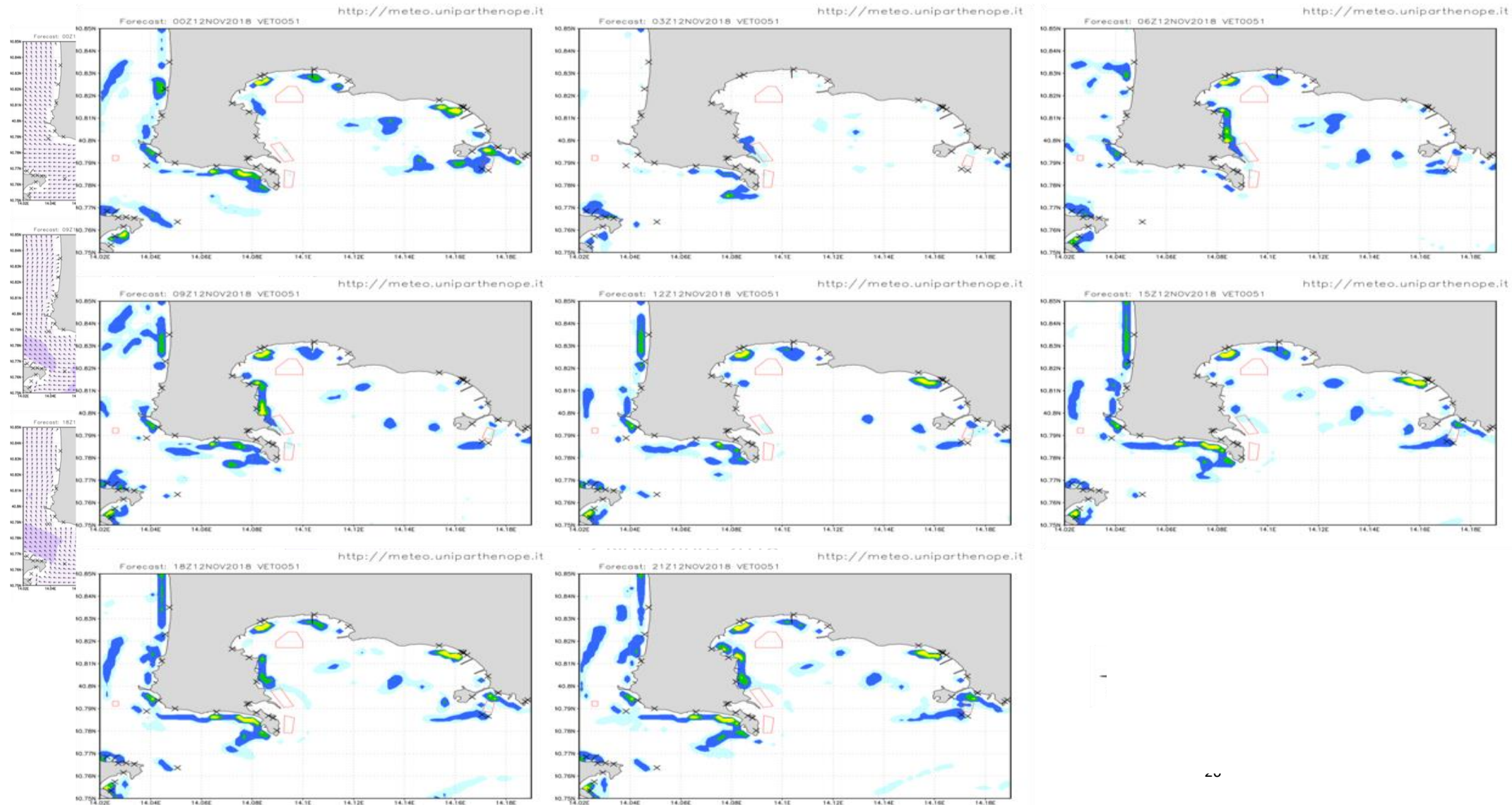
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<http://meteo.uniparthenope.it>

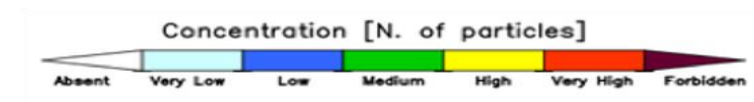
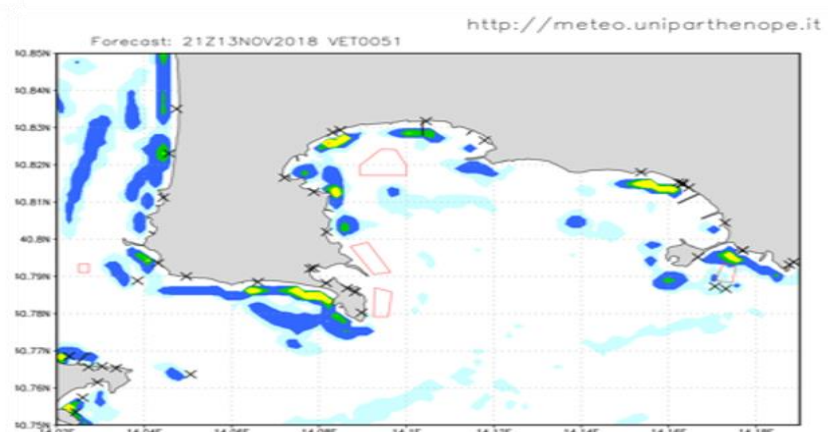
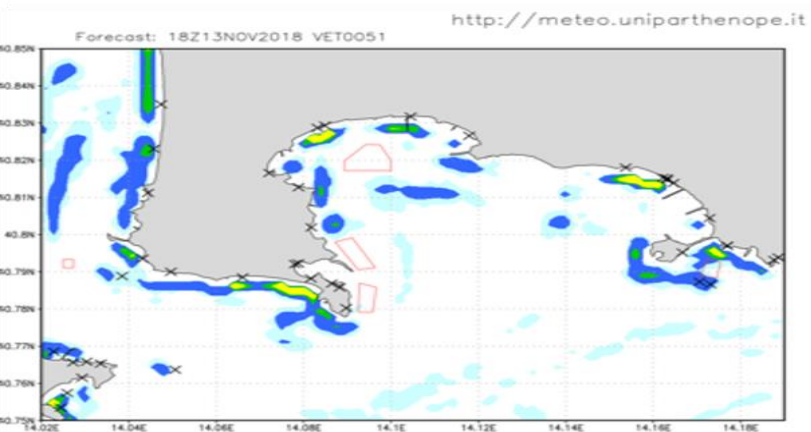
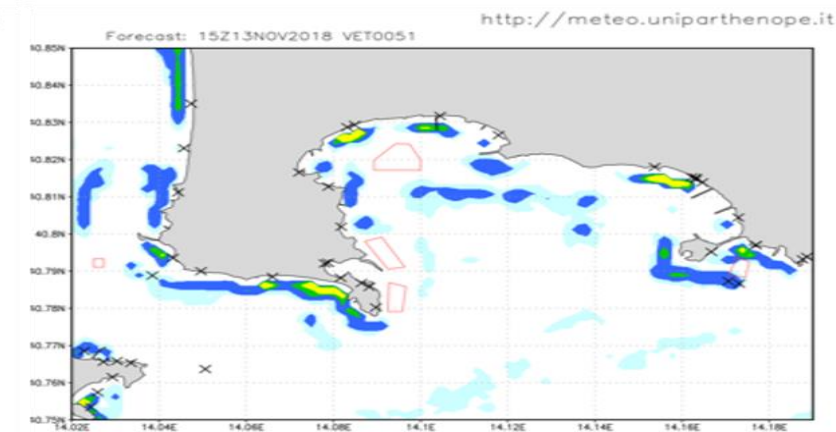
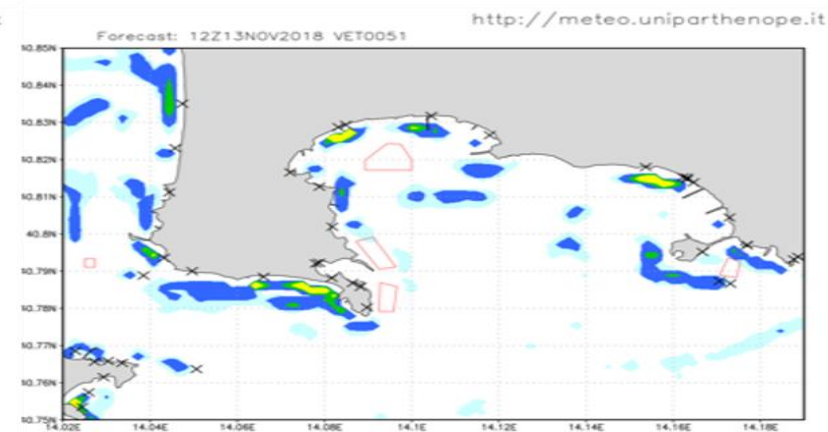
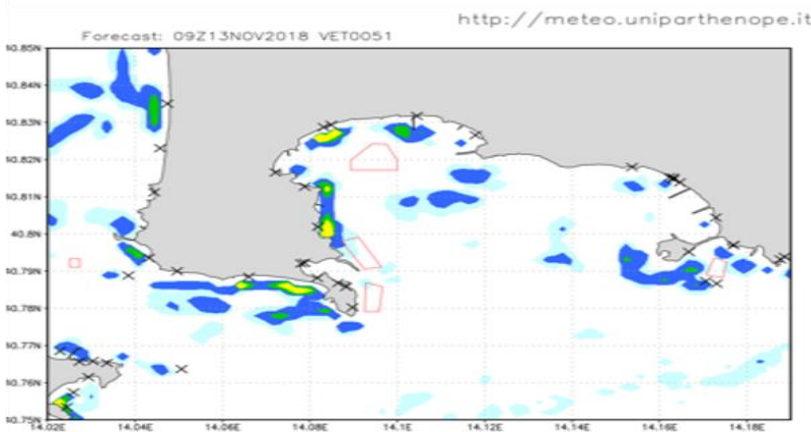
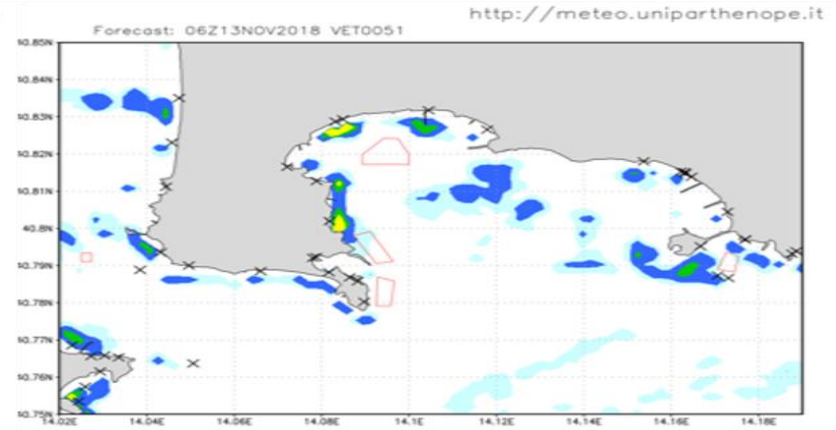
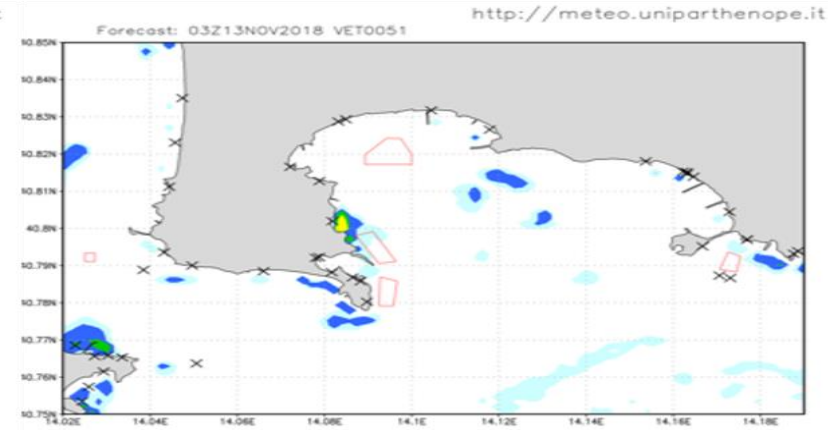
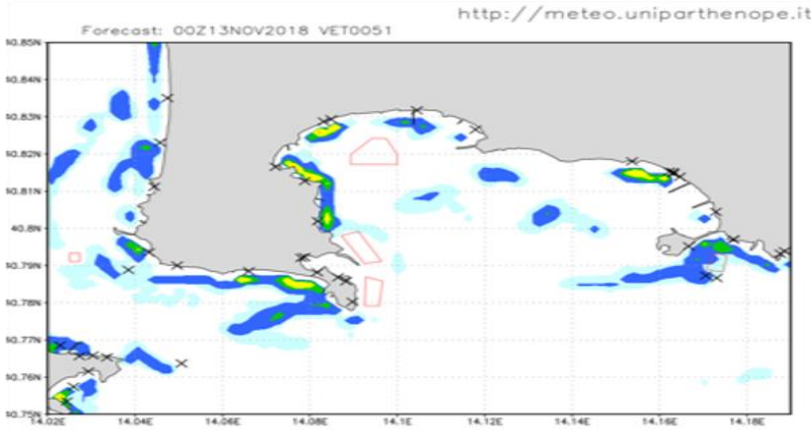


Phase 4: Comparison of exceedances of allowed levels of E. coli with the model data

DATA	CAMPIONE	E. COLI COZZE (MPN/ 100 G)	E. COLI ACQUA (MPN)	CAMPIONE	E. COLI COZZE (MPN/ 100 G)	E. COLI ACQUA (MPN)
15/11/2017	1M	18	0	1L	0	0
21/11/2017	2M	0	0	2L	0	0
28/11/2017	3M	0	0	3L	45	0
05/12/2017	4M	490	53	4L	330	0
03/01/2018	5M	20	0	5L	0	10
15/01/2018	6M	170	0	6L	78	0
22/01/2018	7M	20	0	7L	40	0
01/02/2018	8M	45	0	8L	20	0
12/02/2018	9M	40	0	9L	20	0
21/02/2018	10M	3500	207	10L	5400	164
29/05/2018	11M	18	0	11L	45	0
04/06/2018	12M	18	20	12L	18	31
13/06/2018	13M	20	20	13L	20	31
19/06/2018	14M	68	0	14L	170	20
10/07/2018	15M	330 ASL	//	15L	130	//
31/07/2018	16M	160	0	16L	45	0
12/11/2018	17M	18	0	17L	20	0
13/11/2018	18M	2200 ASL	//	//	//	//
28/11/2018	19M	<18 ASL	//	//	//	//
12/12/2018	20M	780 ASL	//	//	//	//

Phase 4: matching the sampling non compliance with model forecast: sampling NC overlap model NC

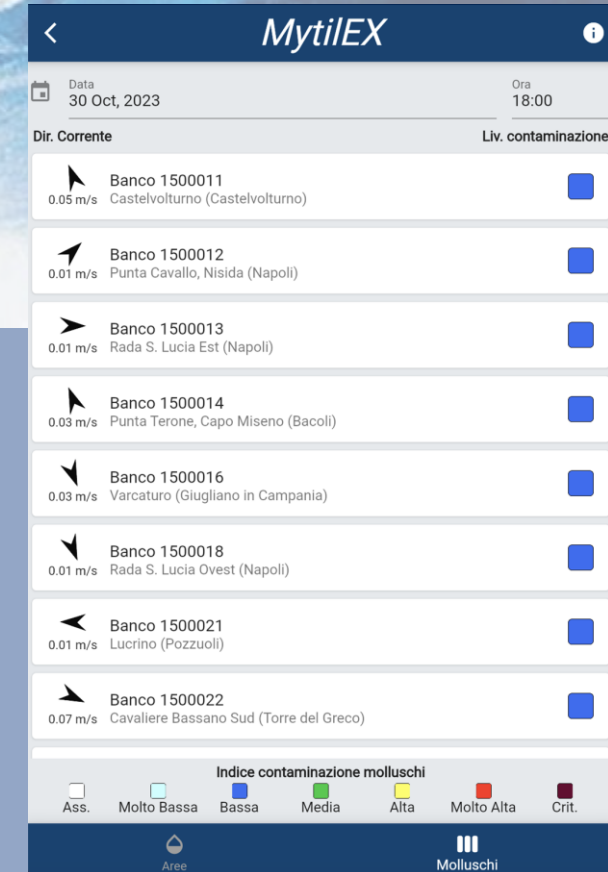
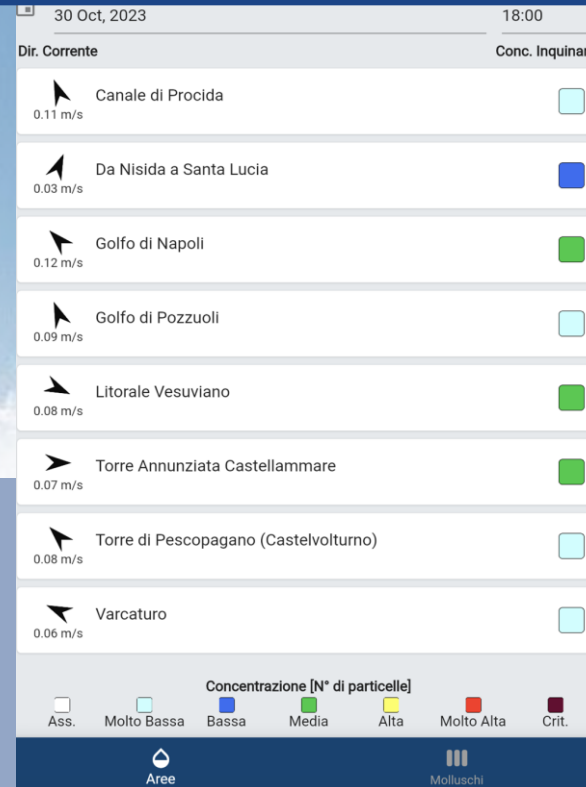
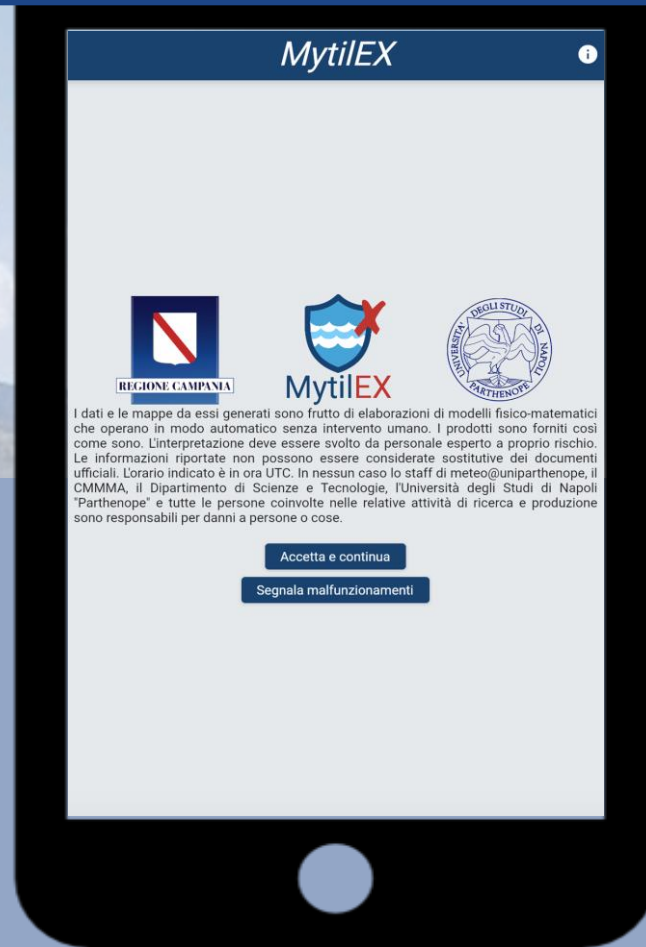




MytilEX project: development of an app



Eventually,
the MytilEX
PWA!

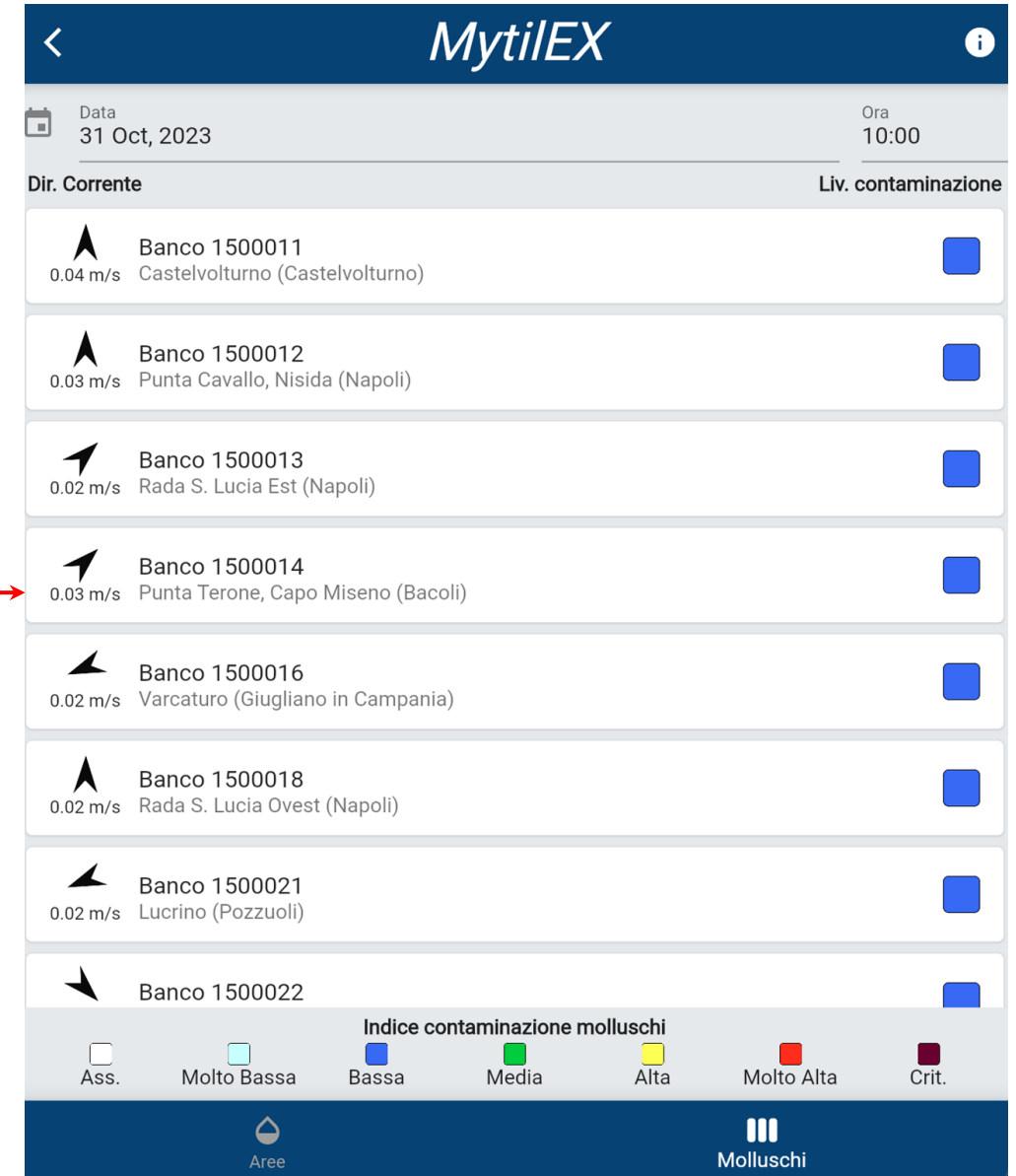


<http://meteo.uniparthenope.it/mytilex>

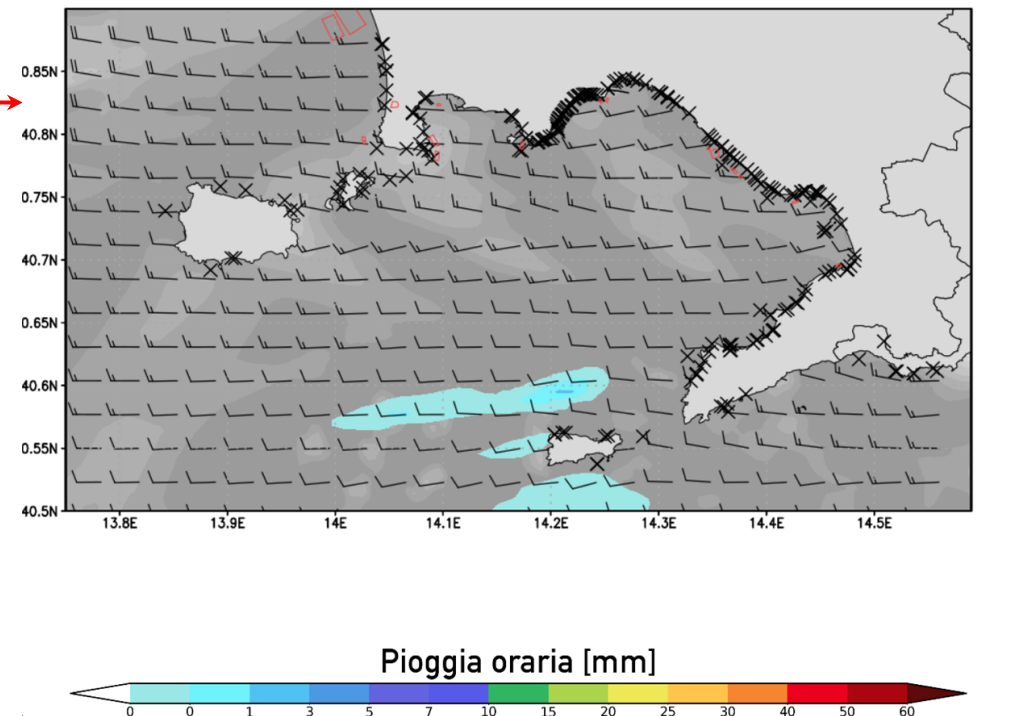
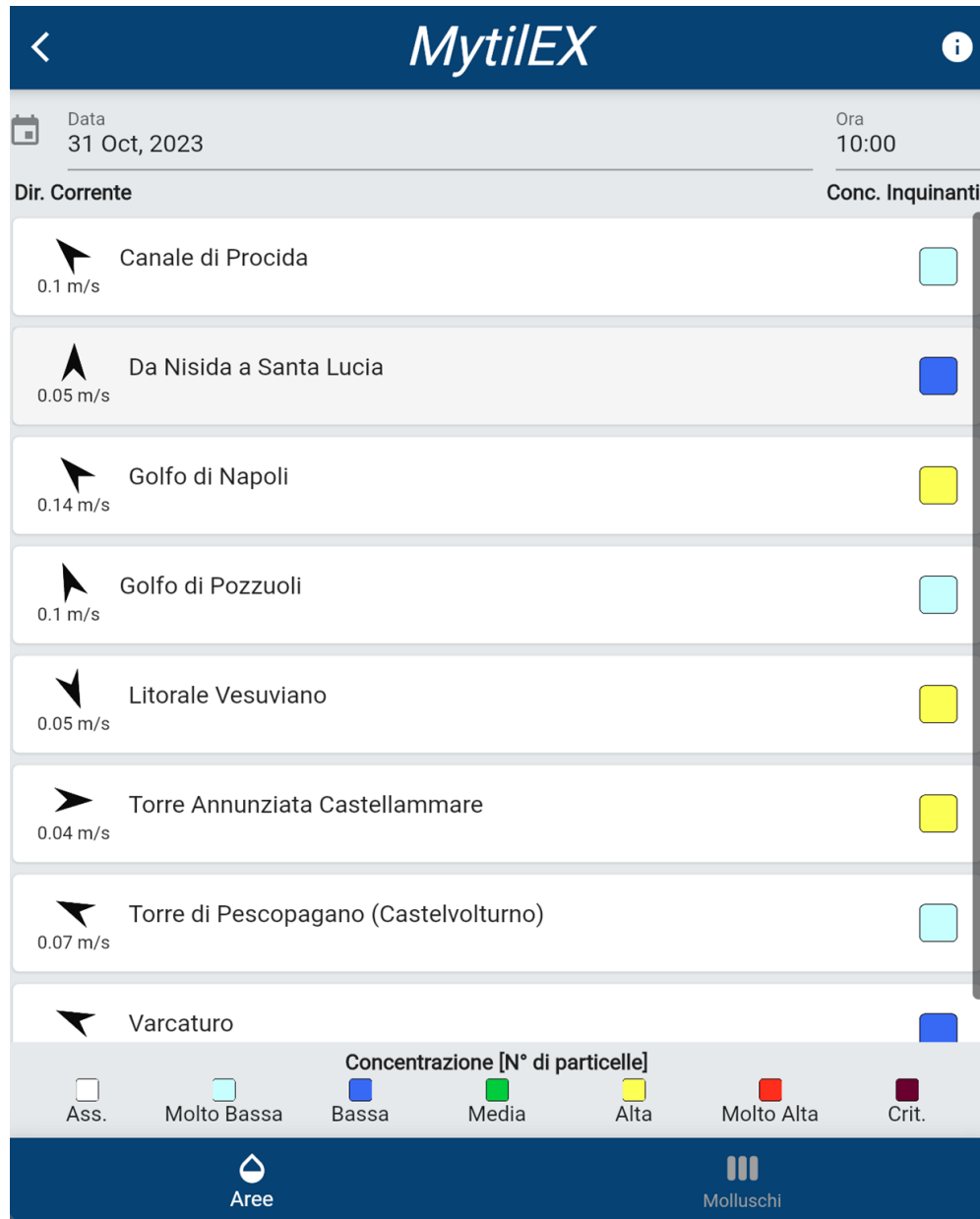
MytilEX: development of an app



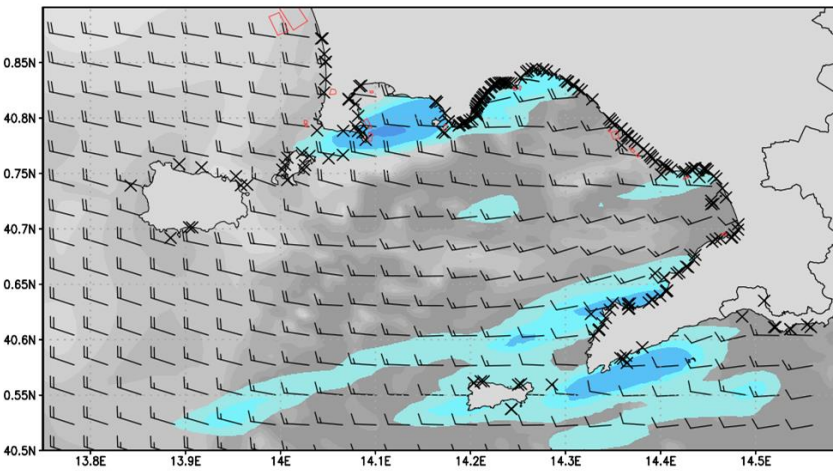
Choice of
production
area



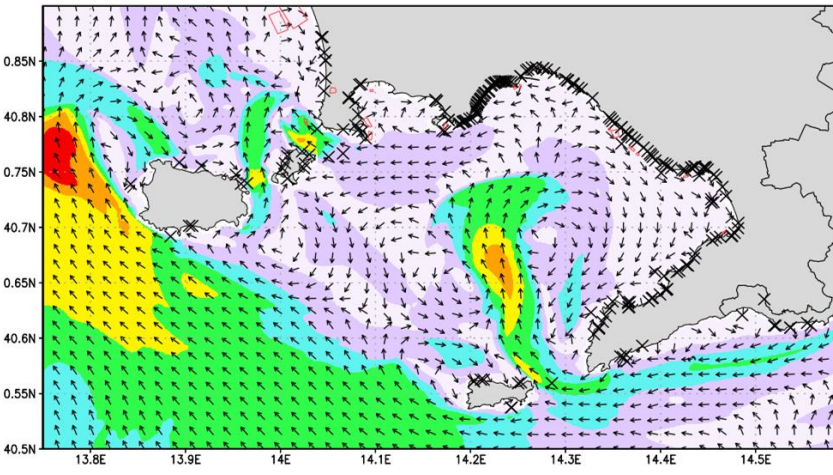
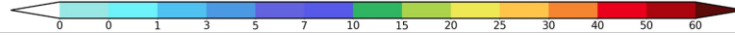
MytilEX: development of an app



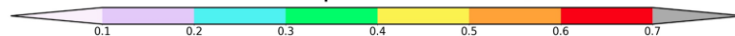
MytilEX: development of an app



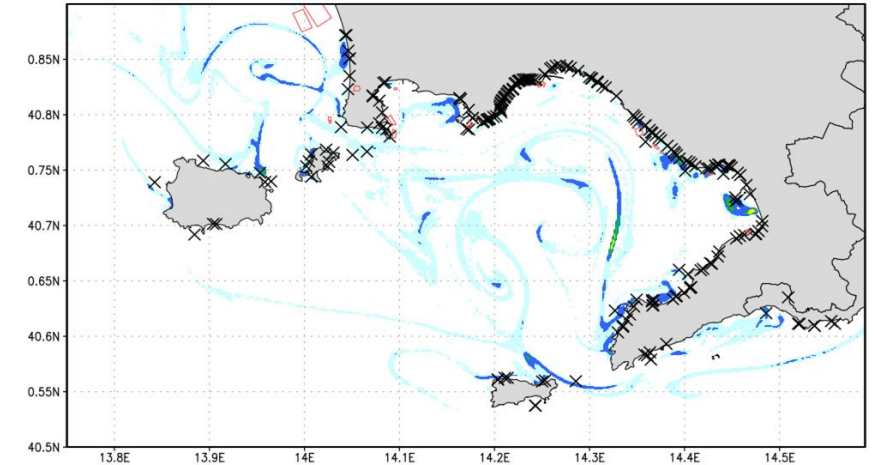
Pioggia oraria [mm]



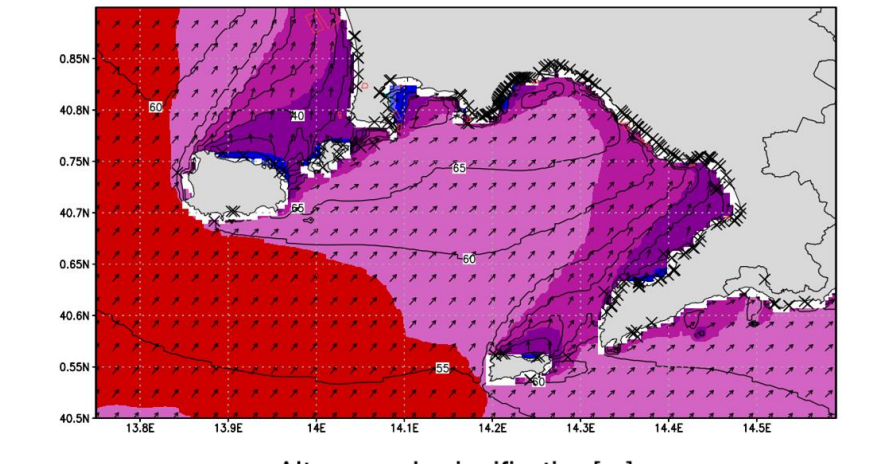
Corrente superficiale marina [m/s]



1. Weather forecasts (168h, 1Km)
2. Wind drive sea waves (168h, 300m)
3. Sea currents (168h, 160m)
4. Inerts tracing (168h, 160m) with diffusion and transport of pollutants



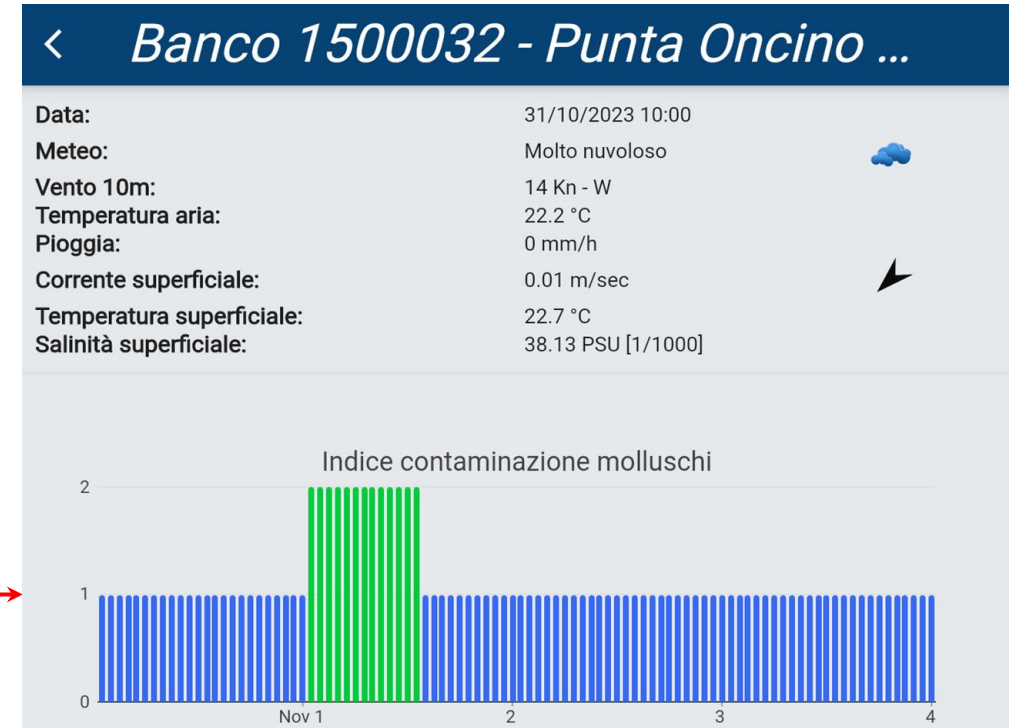
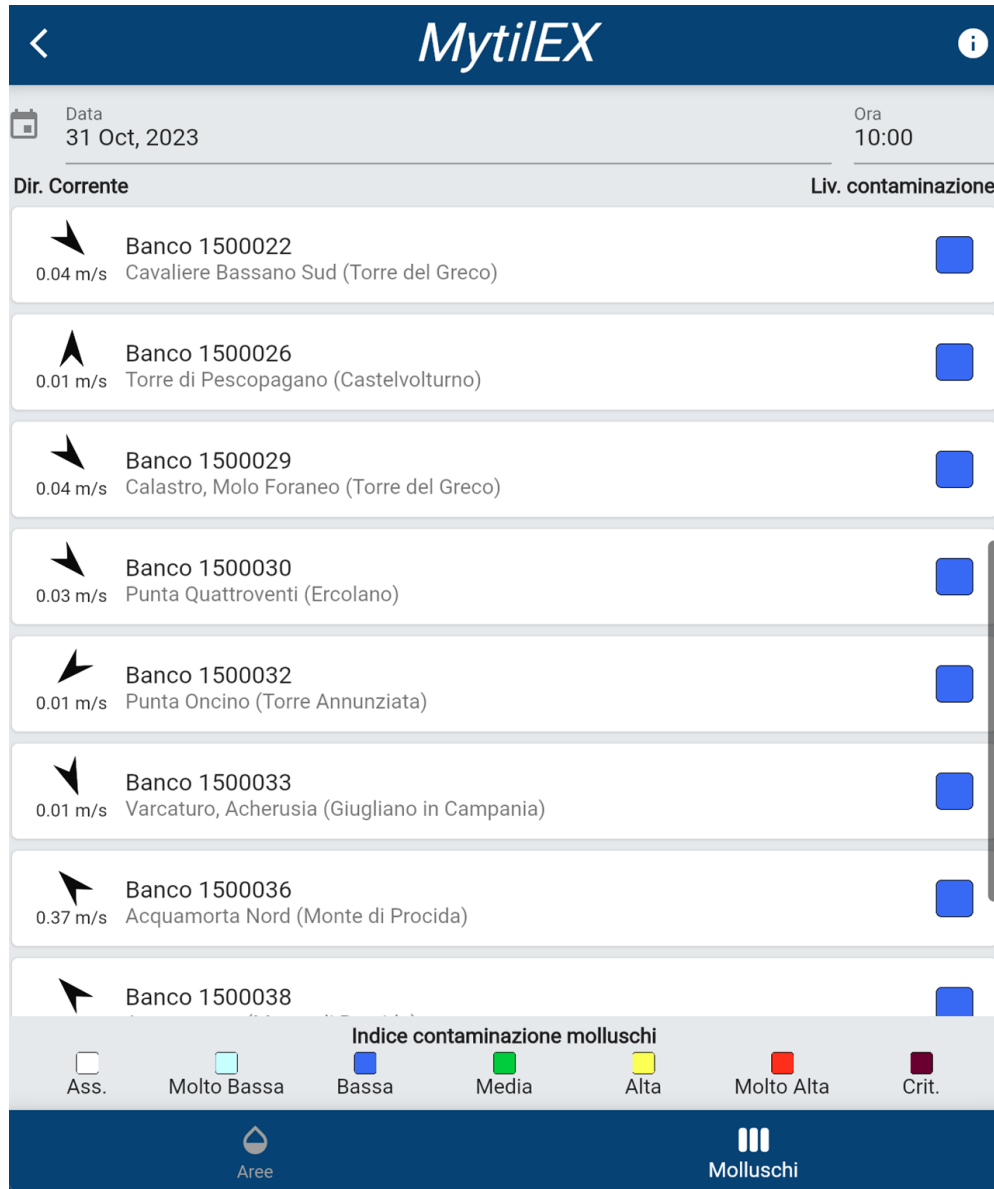
Concentrazione [n. particelle]



Altezza onde significativa [m]



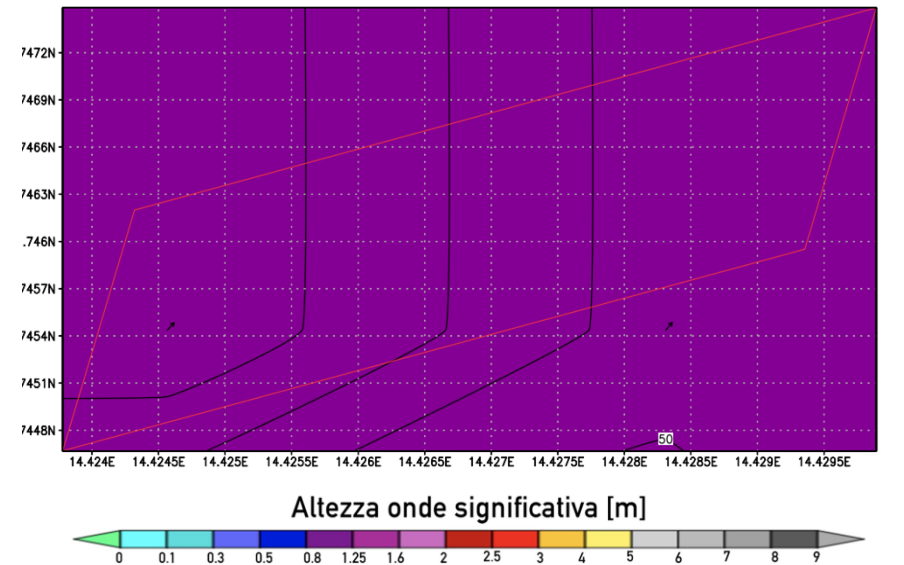
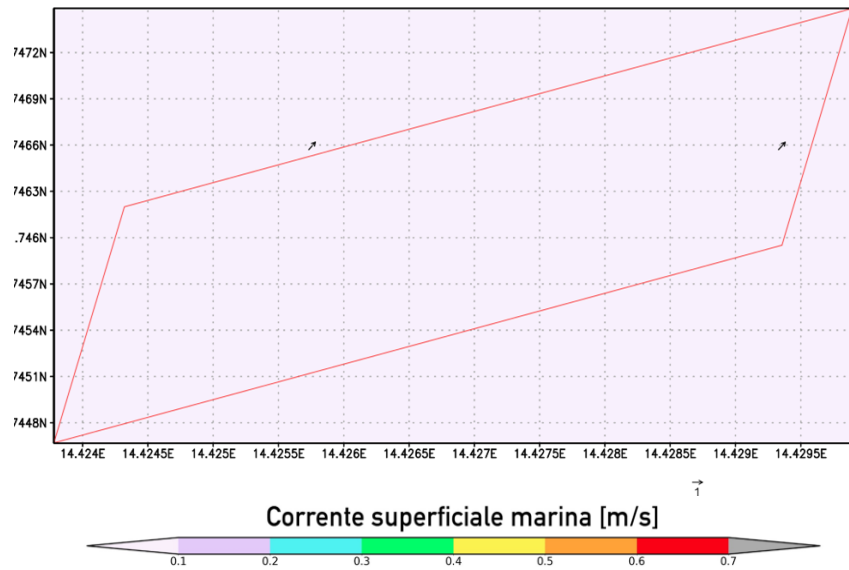
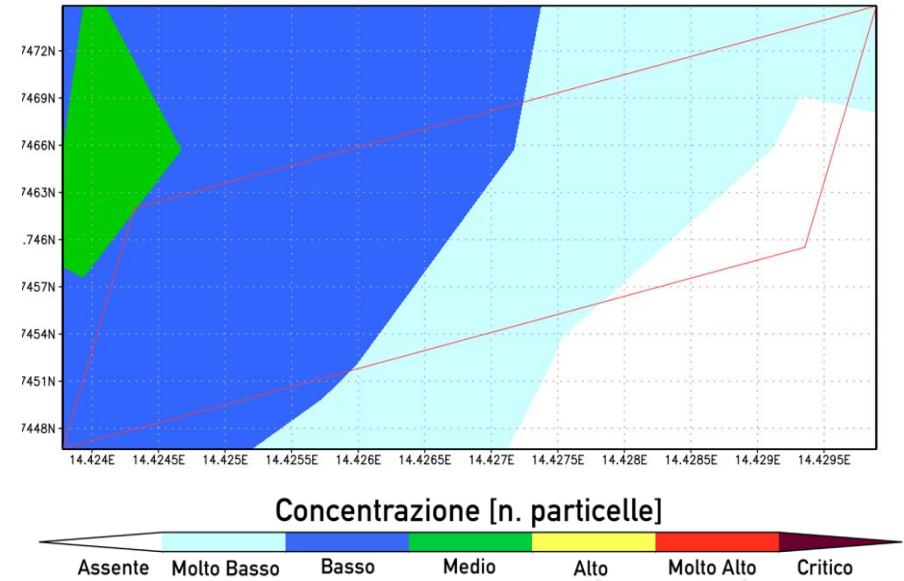
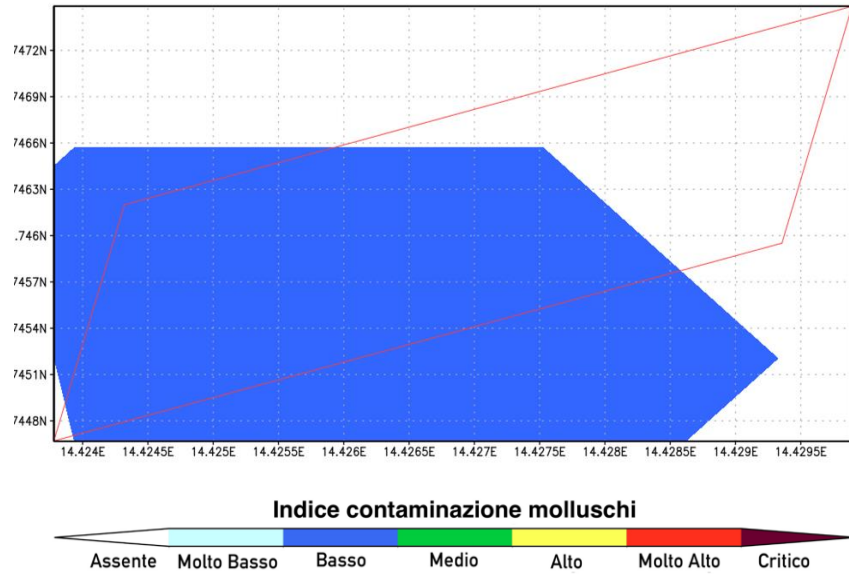
MytilEX: development of an app



1. Inerts tracing (168h, 160m)
with diffusion and transport of
pollutants

1. Particle concentration

MytilEX: development of an app



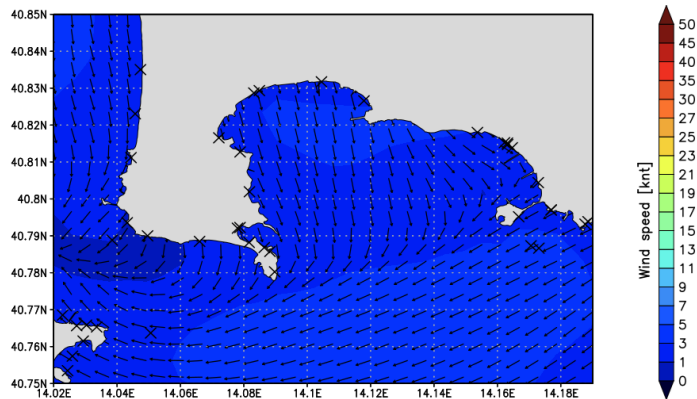
AIQUAM: Artificial Intelligence-based water QUAlity Model

AIQUAM implements an AI model for seawater quality predictions.

The model performs **time series classification** leveraging various and different algorithms and then performs a weighted majority report for predicting the best result.

It consists of training a dataset classifier to map possible inputs to a probability distribution over the class variable values (labels).

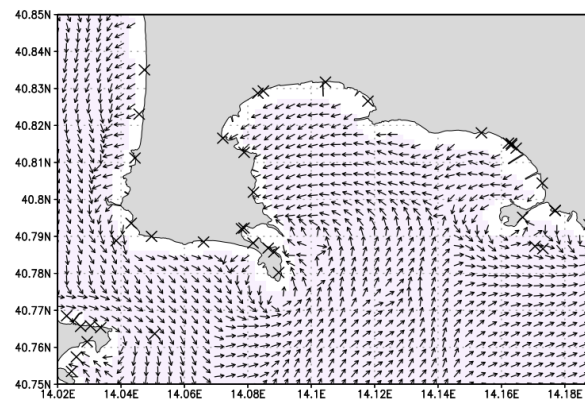
<http://meteo.uniparthenope.it>
Forecast: 01Z09FEB2022 Golfo di Pozzuoli (VET0051/wrf5)



Weather Forecasts

High Resolution
Seafloor DTM

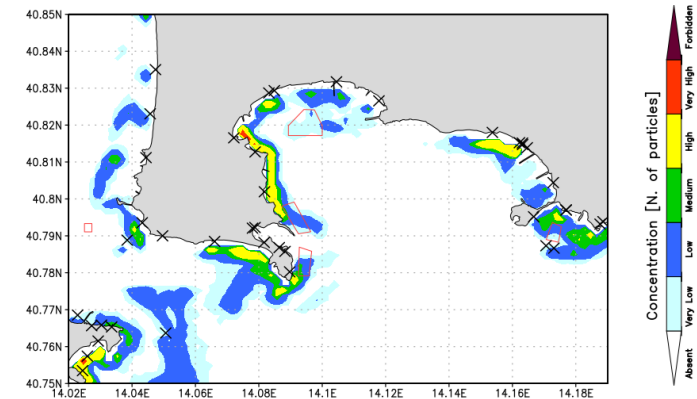
<http://meteo.uniparthenope.it>
Forecast: 01Z09FEB2022 Golfo di Pozzuoli (VET0051/rms3)



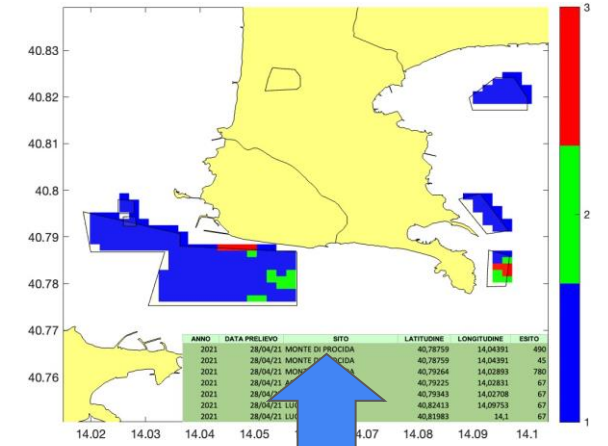
Sea Currents Forecasts

WaCom++

<http://meteo.uniparthenope.it>
Forecast: 01Z09FEB2022 Golfo di Pozzuoli (VET0051/wcm3)



Transport and Diffusion Forecasts



Mussel Contamination Prediction

A.I. - D.N.N.



Giunta Regionale della Campania
*Direzione Generale per la Tutela della Salute ed il
Coordinamento del Sistema Sanitario Regionale
Unità Operativa Dirigenziale Prevenzione e Sanità
Pubblica Veterinaria*

Al Dipartimenti di Prevenzione
delle AA.SS.LL.
Servizi Veterinari

e. p.c. Alla Direzione Tecnica del C.Ri.S.Sa.P.
ASL Napoli 2 Nord

REGIONE CAMPANIA

Prot. 2023. 0457021 26/09/2023 15,53
Mitt. : 500401 Prevenzione e sanità pubblica

Dest. : SERVIZI VETERINARI AA.SS.LL. : ORSA CAMPANIA
CRISAP ASL NAPOLI 2 NORD: UNIPARthenope DST
Classifico : 50.4.10. Sottosec. : 1-21 del 2023



All'O.R.S.A.

Al Dipartimento di Scienze e Tecnologie (DiST)
dell'Università degli Studi di Napoli "Parthenope"

All'A.R.P.A.C.

LORO SEDI

**OGGETTO: modalità di classificazione e riclassificazione specchi d'acqua ai fini della
raccolta di molluschi per il consumo umano**

Grazie per
l'attenzione!



Ogni volta che bevi latte o mangi formaggi, carne, uova, pesce, miele un Medico Veterinario si è preso cura della tua sicurezza alimentare dall'allevamento fino alla tua tavola.

La sicurezza dei cibi di origine animale è un tuo diritto. Ogni giorno i Medici Veterinari italiani si prendono cura della salute degli animali allevati e del loro benessere, controllano, ispezionano e certificano gli alimenti derivati negli stabilimenti di produzione e nei macelli nazionali. 31 mila Medici Veterinari sono al servizio dei cittadini italiani.

MESSAGGIO ISTITUZIONALE RIVOLTO AL PUBBLICO

C'È UN VETERINARIO NEL TUO PIATTO

La disinformazione sul nostro ruolo richiede una correzione di rotta. La Federazione ha realizzato una pagina per i media. Eccola in anteprima.

Ogni giorno i medici veterinari sono impegnati nella tutela della salute pubblica senza che, né il cittadino né, a volte, le istituzioni per non parlare di molto 'giornalismo', sappiano o si rendano conto di questa presenza. In tutti i campi compete certamente a molti soggetti fornire la giusta informazione quale strumento primario della conoscenza finalizzata all'esercizio della partecipazione. In una società civile e democratica votata alla crescita consapevole dei suoi cittadini l'informazione che genera salute è, a sua volta, un indicatore della salute del sistema. È sotto gli occhi di tutti come il sistema Italia sembra godere di poca salute quando si parla di sicurezza alimentare e si dimentica degli attori principali: i medici veterinari. In un momento storico di sovrapposizione a messaggi e informazioni generati da tutti (e dal contrario di tutti), senza attenzione alla disponibilità delle "conoscenze", della sicurezza alimentare parlano forze dell'ordine, cuochi, giornalisti, politici. Non i medici veterinari.

Alla Finvi compete un doppio ruolo: tutelare i cittadini, garantendo loro di potersi rivolgere ad una professione capace e consentire alla professione veterinaria di esercitare queste capacità. La disinformazione nel ruolo informativo di comunicazione della Federazione non garantisce il cittadino e non consente alla professione di esprimere al pieno le sue potenzialità. Compete sicuramente alla Federazione, nella sua veste di ente sussidiario dello Stato, fornire la giusta informazione non solo ai medici veterinari, ma anche ai destinatari del loro operato, ossia i cittadini. Siamo una grande professione senza la quale si ferma il mondo. E siamo anche una professione sana che lavora per una società sana.

"C'è un veterinario nel tuo piatto" è una proposta editoriale che diventerà manifesto, locandina, inserto giornalistico, inserendosi nel progetto politico di comunicazione della Federazione.

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