Forecasting Shellfish Aquaculture Threats. An Earth Observation Derived Tool Aiming at Avoiding Microbiological Public Health Hazards *Victor Niță, Răzvan Mateescu, Magda Nenciu*	**"Cercetări Marine" Issue no. 53 Pages 147-152**	**2023**
DOI: 10.55268/CM.2023.53.147		

Short Communication: FORECASTING SHELLFISH AQUACULTURE THREATS. AN EARTH OBSERVATION DERIVED TOOL AIMING AT AVOIDING MICROBIOLOGICAL PUBLIC HEALTH HAZARDS

Victor Niță, Răzvan Mateescu, Magda Nenciu*

National Institute for Marine Research and Development "Grigore Antipa", 300 Mamaia Blvd., 900581, Constanța, Romania
**Corresponding author: mnenciu@alpha.rmri.ro*

ABSTRACT

Shellfish aquaculture is of great importance in offering a sustainable food source, thus playing a major role towards achieving food security and nutrition, employment, and economic development in coastal areas. Mussel aquaculture, in particular, offers a substantial development opportunity for Black Sea riparian countries; however, a significant attention must be given to zoo-sanitary conditions and public health, considering the filter-feeding behaviour of these organisms. With the involvement of GFCM's Aquaculture Demonstrative Center (hosted by NIMRD), the microbiological classification of bivalve mollusk production and relaying areas in Romania was performed. Yet, the regular monitoring of these areas is not enough to prevent accidental contamination of shellfish farms, in case a potential harmful discharge from a wastewater treatment plant occurs. In this context, the goal of our research was to develop a prediction tool, focused on an early warning system of any possibly microbiologically loaded water discharge (*Escherichia coli*), using a downscaling of CMEMS Earth Observation data and *in situ* validation. The developed service module can give farmers the ability to predict a potential harmful outbreak and decide to harvest earlier or later and/or keep the mussels in a purification tank before marketing, in order to avoid any possible *E. coli* contaminated harvest to be put on the market involuntarily.

Keywords: aquaculture, food safety, Earth Observation, harmful discharges, early warning

AIMS AND BACKGROUND

Traditionally, Romanian aquaculture has focused on freshwater species, yet, in recent years, mariculture has become of interest for the potential culture of valuable finfish and shellfish species (Massa *et al*., 2021). Shellfish aquaculture is not developed to its full potential in the Black Sea region due to environmental constraints and an unclear legislative framework (Niță *et al*., 2019). The promotion of a scientific, technical and legislative background for this activity is absolutely necessary, with the

constant support of the GFCM Aquaculture Demonstrative Center (ADC), by regular training and advisory activities both for authorities and the private sector (Nenciu *et al*., 2020a).

In the frame of the Horizon 2020 FORCOAST project, a pilot case on mussel aquaculture was investigated. Nearshore farming infrastructures are exposed to land discharges, which in some cases carry harmful substances (e.g. *Escherichia coli,* pollutants etc.) (Nenciu *et al.*, 2020b). In this context, the main objective was to monitor the potential influence of presumed microbiologically loaded discharges on the selected mussel culture area by creating and validating an early warning system. High resolution circulation forecasts can be used to assess the likelihood of a farm being affected by particles released from potentially harmful sources (Hobday *et al*., 2016). This service aims to support the planning of quality control measures, by providing a measure of the probability for farming sites to be affected by harmful land discharge.

Ultimately, by continuous consultations with potential users in the frame of the ADC community, we refined the targeted product and the delivery manner of the service, to best support decision taking in the aquaculture implementation (site selection and multi-use) and operation (support for management decisions).

EXPERIMENTAL

For the Romanian Black Sea experimental pilot, a downscaling of the Copernicus Black Sea-Monitoring Forecasting Centre (BS MFC)-BIO forecasts (BS MFC, 2023) at a 1 km resolution was used.

The forecasting system was composed of a physical model (NEMO 3.6) (NEMO, 2023) and a biogeochemical model (BAMHBI) (Gregoire *et al.*, 2008), implemented on the North-Western part of the Black Sea, using 59 unevenly distributed vertical layers (Capet *et al*., 2016). The bathymetry was based on the General Bathymetric Chart of the Oceans grid (GEBCO, 2019) with manual adjustments along the coastlines to reflect dikes and other coastal infrastructures. The forecasting system comprised a second level centered on the Constanta-Eforie area. The horizontal resolution was 200 m, and the model was nested in the first level using the AGRIF nesting tool (Petton *et al.,* 2023) and subsequently double-nested. The bathymetry was obtained from local measurements and smoothed toward the GEBCO bathymetry at the model boundaries. Validation was made using in situ observations collected by the FORCOAST Romanian team, and satellite chlorophyll images.

For the development of this Service Module, an adapted Lagrangian Particles Tracking software was used - namely Ocean Parcels 2.0 (https://oceanparcels.org) (Delandmeter, Van Sebille, 2019). The user-tailored implementation of this service required the assignment of farming

site locations, and potential release sources. The farming site was defined as a polygon of geolocated points. The source of release was defined as the location of a potentially harmful source(s), namely the Constanta North Wastewater Treatment Plant (WWTP). Thresholds were also considered to raise alarms and defined in terms of: time elapsed since the release of the potentially contaminated particles and the fraction of the release. The Lagrangian simulation used a default time step of 10 minutes, meaning that by default, without using diffusion, 1 pollutant particle is released every 10 minutes.

The beta service module is operational and can be accessed online at: https://forcoast.netlify.app/bivalve_aquaculture.

RESULTS AND DISCUSSION

At the Romanian coast, the suitable areas for aquaculture are very few, mostly due to the lack of sheltered areas, but also because of an overlapping of uses of the maritime space and potential conflicts (Nenciu *et al*., 2023). The most suitable area is in the southern part of Constanța port, at Agigea - Eforie (Fig. 1 left). There is located the only mussel farm in Romania, which had its activity suspended for several years, due to legislative/administrative issues (Niță et al., 2020); currently, the farm resumed its activity in close cooperration with NIMRD's ADC (Fig. 1 right).

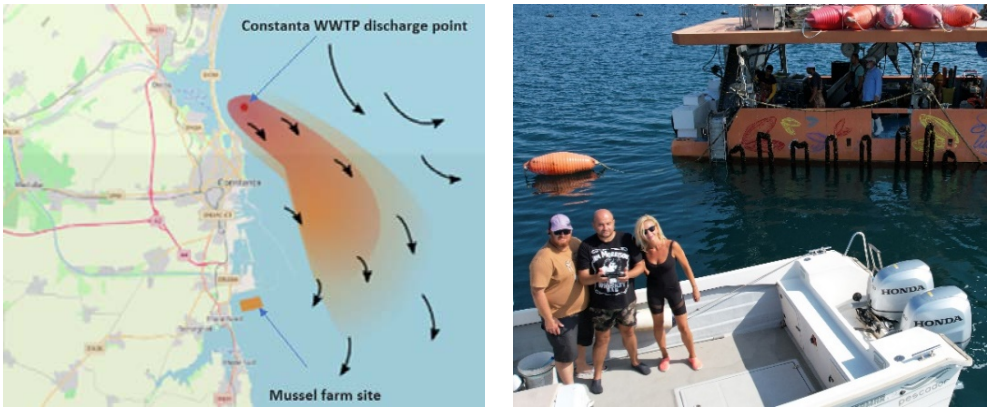

Fig. 1. Location of the mussel farm in Agigea - Eforie (left); Long-line maintenance operations (right) *(original photo)*

Due to its location south of the Port of Constanța and the discharge areas of the Wastewater Treatment Plant, the area targeted by the Romanian pilot study may be vulnerable mainly to microbiological contamination, in addition to the general variability of the Romanian coast (temperature, salinity, storms etc.). The developed forecasting model can give producers the ability to predict a potential harmful outbreak and decide to harvest earlier and or keep the mussels in a treatment tank before marketing. The service module developed enables mussel farm managers to predict

potentially harmful spills that may reach the farm site, thereby reducing operational costs.

On the basis of the particle tracks (computed from present minus 10 days to present plus best forecast time), the number of potentially contaminated particles crossing the farm is computed for diagnostics time steps of 2 hours. For each diagnostic time step, the mean age of those particles is computed (Fig. 2).

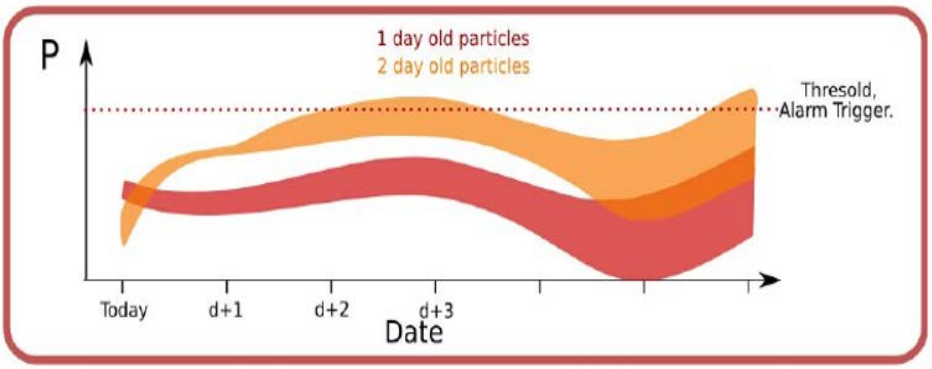

Fig. 2. Model of the potentially contaminated particle behavior in time

The service module will be made available to end users (farm managers) through mobile or desktop applications. The feedback to subscribers is provided daily on the basis of updated forecasts. It consists of a synthesis with an animated version.

CONCLUSIONS

The purpose of the developed service module (mobile and desktop application) was focused on the potentially microbiologically loaded water discharges, aiming at the characterization of the probability of contamination of the targeted location (Agigea) from land-based sources located in the northern part (discharges of the Constanța WWTP). The final objective is to avoid contamination of the mussel harvest, by triggering preventive measures in good time, thus supporting the farmers to avoid economic losses and safeguarding public health.

Acknowledgement. This research was carried-out in the frame of the FORCOAST Project ("Earth Observation Services For Wild Fisheries, Oystergrounds Restoration And Bivalve Mariculture Along European Coasts"), funded from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 870465.

REFERENCES

BS MFC (2023), Black Sea Monitoring Forecasting Centre (BS MFC). Available online: https://marine.copernicus.eu/about/producers/bs-mfc.

Capet A., Meysman F.J.R., Akoumianaki I., Soetaert K., Gregoire M. (2016), Integrating Sediment Biogeochemistry into 3D Oceanic Models: A Study of Benthic-Pelagic Coupling in the Black Sea. *Ocean Modelling*, 101: 83-100. https://doi.org/10.1016/j.ocemod.2016.03.006

Delandmeter P., Van Sebille E. (2019), The Parcels v2.0 Lagrangian Framework: New Field Interpolation Schemes. *Geoscientific Model Development*, **12**: 3571-3584. https://doi.org/10.5194/gmd-12-3571-2019

GEBCO (2019), General Bathymetric Chart of the Oceans. Available online: https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2019/gebco_2019_info.html.

Grégoire M., Raick C., Soetaert K. (2008), Numerical Modeling of the Central Black Sea Ecosystem Functioning during the Eutrophication Phase. *Progress in Oceanography*, **76**(3): 286-333. https://doi.org/10.1016/j.pocean.2008.01.002

Hobday A.J., Spillman C., Paige Eveson J., Jason R., Hartog J.R. (2016), Seasonal Forecasting for Decision Support in Marine Fisheries and Aquaculture. *Fisheries Oceanography*, **25(S1)**: 45-56. https://doi.org/10.1111/fog.12083

Massa F., Aydin I., Fezzardi D., Nenciu M., Niţă V. et al. (2021), Black Sea Aquaculture: Legacy, Challenges & Future Opportunities. *Aquaculture Studies*, **21**: 181-220. http://doi.org/10.4194/2618-6381-v21_4_05.

NEMO (2023), Nucleus for European Modelling of the Ocean. Available online: https://www.nemo-ocean.eu/.

Nenciu M., Niță V., Hamza H. (2020a), Recent Outcomes of the Shellfish Aquaculture Demonstrative Center (S-ADC). Cercetari Marine/ Recherches Marines, **50**(1): 192-197. https://doi.org/10.55268/CM.2020.50.192

Nenciu M., Niţă V., Țoțoiu A., Hamza H. (2020b), Framework for Setting-Up a Classification and Monitoring Program for Shellfish at the Romanian Black Sea Coast. *J Environ Prot Ecol*, **21**(1): 184-192.

Nenciu M., Niță V., Lazăr L., Spînu A., Vlăsceanu-Mateescu E. (2023), Fostering the Development of Western Black Sea Aquaculture: A Scientific Case Study for Finfish Cage Farming Allocated Zone Designation. *Fishes*, **8(2)**: 104. https://doi.org/10.3390/fishes8020104

Niță V., Massa F., Fourdain L., Nenciu M. (2020), Establishing the Suitability of the Agigea - Eforie Area for Designation as Allocated Zone for Aquaculture (AZA) and for Unlocking the Potentiality of Mariculture in Romania. *Cercetări Marine/Recherches Marines*, **50**(1): 152-173. https://doi.org/10.55268/CM.2020.50.152

Niță V., Theodorou J., Nicolaev S., Nenciu M. (2019), Advancing Shellfish Aquaculture as a Sustainable Food Procurement Option in Emerging Black Sea Riparian Countries: Romania Country Report. *Scientific Papers. Series D. Animal Science*, LXII(2): 364-370.

Petton S., Garnier V., Caillaud M., Debreu L., Dumas F. (2023), Using the Two-way Nesting Technique AGRIF with MARS3D V11.2 to Improve Hydrodynamics and Estimate Environmental Indicators, *Geoscientific Model Development*, **16**: 1191-1211. https://doi.org/10.5194/gmd-16-1191-2023

*** https://forcoast.netlify.app/bivalve_aquaculture