French Hackathon in Athens 2025 - Challenges

Challenge #1

Title : Early Warning System for Marine Heatwave development and impact in Aquaculture

Category: *marine heatwaves, climate change, aquaculture, sustainability, extreme events*

Short Description

Did you know that the ocean experiences heatwaves like the atmosphere? They are called marine heatwaves (MHWs) and are prolonged periods of anomalously warm ocean temperatures, which have increased in frequency, duration and intensity over the past few decades, as a result of anthropogenically-induced ocean mean warming. But why should we care? Because, these events are responsible for severe disruptions in global and Mediterranean Sea marine ecosystems, including mass mortalities of fish species and changes in species' distributions. The ecological responses to MHWs have knock-on effects on fishery yields and the health of farmed species, leading to widespread socioeconomic impacts on coastal communities that rely on them. Therefore, this challenge invites participants to use various environmental datasets (e.g., from a Reanalysis model) together with aquaculture data to identify surface and subsurface MHWs in waters around Greece, assess their impacts on aquaculture areas, with a view to develop a MHW early warning system for aquaculture industry. Such a predictive system would serve as a valuable tool to support adaptation planning, enhance climate resilience and inform decision-making on aquaculture units of the Mediterranean Sea.

Tasks

- #Sub-Challenge1: **Identify** historical surface and subsurface MHWs in aquaculture regions across Greece. Characterise the events' intensity, duration, horizontal and vertical extent.
- #Sub-Challenge2**: Assess** the impacts of MHWs on key aquaculture indicators that reflect the health and growth of farmed fish populations.
- #Sub-Challenge3**: Develop** an early warning system that predicts the onset of a MHW in advance and informs about its potential impact on fish health and growth, based on its characteristics.

Background

The Mediterranean Sea is a recognized climate change "hotspot" area, warming at rates exceeding the global ocean average. Its large marine biodiversity is highly sensitive to environmental change and plays a vital role in supporting the economies and livelihoods of the coastal communities in the basin. In recent decades, however, scientists have observed an increase in the frequency and intensity of MHWs, affecting both surface and subsurface layers. The development of these extreme events has been attributed mainly to enhanced solar radiation, weakened winds and reduced surface heat losses, with subsurface events occurring often without evident surface warming. Under continued greenhouse gas emissions, both surface and subsurface MHWs in the Mediterranean Sea are projected to intensify throughout the 21st century, particularly in shallow, coastal regions.

In turn, elevated temperatures can disrupt physiological and ecological processes of marine species, alter their distributions and drive mass mortality events, with significant ecological and economic consequences; Fisheries are impacted through shifts in species composition and reduced catch value, while aquaculture units can face increased mortality due to thermal stress and hypoxia. Unlike wild animals that can move away from stressful conditions, farmed fish are confined to their tanks or cages and cannot escape when the environment becomes unfavorable. Depending on how severe future conditions become, MHWs could cause major losses for Mediterranean fish farms, up to 80% of their profits. Beyond fish deaths, these events can also trigger disease outbreaks and make fish unsuitable for sale, creating serious financial risks for the aquaculture industry. The complex responses of these marine ecosystems therefore highlight the need to develop early warning tools in order to better prepare and manage the impacts of MHWs on Mediterranean marine industries.

Potential Considerations

The participants may use/download other environmental dataset for the Mediterranean Sea if they wish so, such as those available from Copernicus Marine Service https://marine.copernicus.eu/ or elsewhere.

Indicative Data Sources

Participants will be provided with preprocessed datasets, tailored to the specific requirements of the challenge. The datasets are:

1) Daily temperature (0-153m) and mixed layer depth outputs between 1987-2025, extracted from the physical component of the coupled hydrodynamic-wave Mediterranean Forecasting System (Med-Physics) model, that covers the entire Mediterranean Basin, including tides. Model horizontal grid resolution is 1/24˚ (4 km) https://data.marine.copernicus.eu/product/MEDSEA_ANALYSISFORECAST_PHY_006_013/description
2) Daily & monthly aquaculture data on seawater temperature and fish species indices, such as fish mortality, growth and feeding rate, acquired from aquaculture units of Greece.
3) Atmospheric variables such as daily windspeed and shortwave radiation obtained from ERA5: https://cds.climate.copernicus.eu/datasets/derived-era5-single-levels-daily-statistics?tab=overview

The environmental variables are timeseries in netcdf format and the aquaculture datasets are provided in excel format. The data can be processed with common open-source tools such as, xarray, pandas, NumPy and Matplotlib. Each team will receive a google drive link to the dataset and a README file describing the data format, variables and coordinate system.

Recommended tools, Libraries, Useful links, Papers

-Data Processing

- cfgrib, xarray, pygrib, numpy,pandas, matplotlib, cartopy, nco, cdo
- Ncview, panoply — https://www.giss.nasa.gov/tools/panoply/

- Useful links

https://www.youtube.com/watch?v=ZxbFtINgAh8

https://www.youtube.com/watch?v=9bcbNfpu5lg

https://www.marineheatwaves.org/mhw-overview.html

-Papers:

Darmaraki, S., Denaxa, D., Theodorou, I., Livanou, E., Rigatou, D., ... et al., (2024). Marine Heatwaves in the Mediterranean Sea: A Literature Review. Mediterranean Marine Science, 25(3), 586-620.

Stavrakidis-Zachou, O., Lika, K., Michail, P., Tsalafouta, A., Mohamed, A.H. et al., 2021b. Thermal tolerance, metabolic scope and performance of meagre, Argyrosomus regius, reared under high water temperatures. Journal of Thermal Biology 100, 103063. e, 25(3), 586-620.

Atalah, J., Ibañez, S., Aixalà, L., Barber, X., & Sánchez-Jerez, P. (2024). Marine heatwaves in the western Mediterranean: Considerations for coastal aquaculture adaptation. Aquaculture, 588, 740917.

Challenge #2

Title: Mapping and monitoring marine biodiversity to increase scientific knowledge on marine biodiversity and public knowledge on marine ecosystem services

DiverSea

Category: Marine habitat mapping, biodiversity, health of marine environment

Short Description

Forty percent of the global population dwell within 100 km of the coastline. In the EU nearly half of the population live less than 50 km from the sea – these populations are continuously growing, but the ecosystems supporting them are not. In fact, coastal and marine ecosystems have experienced a barrage of negative impacts, precipitating catastrophic declines in marine species abundance and diversity, and degradation of the habitats supporting them. In addition to current goods and services coastal habitats provide, they will play key future roles for food and water security, clean energy production and climate change mitigation, including blue carbon balance. This conflict between increasing anthropogenic pressures, but concurrent societal dependence, has shifted our collective focus from one centered on use and economic exploitation to a viewpoint recognizing the critical link between societal wellbeing and sustainable ocean conservation and management.https://www.ntnu.edu/diversea

This challenge aims at filling the gaps in terms of marine biodiversity and public environmental awareness for better marine biodiversity management and protection.

(sub-)Tasks

- Sub-challenge 1: Develop a tool for automatisation of underwater ecological surveys
- Sub-challenge 2: Visualize and analyze how multiple pressures impact ecosystems
- Sub-challenge 3: Provide a decision-support tool for conservation planning

Background

Marine biodiversity provides essential **ecosystem services** (benefits in terms of goods and services that humans receive from nature and healthy ecosystems). Marine biodiversity is vital for climate regulation and human well-being. Ocean organisms—from tiny phytoplankton to whales—help capture around 25% of human CO_2 emissions through the biological carbon pump, forming a key part of the blue carbon system. Healthy ecosystems like coral reefs, mangroves, and seagrass beds protect coasts from storms and rising seas, benefiting 200 million people globally. They also support fisheries and tourism. Marine life improves water quality through natural filtration: shellfish clean water, and seagrass traps sediment. Diverse food webs maintain ecological balance, preventing harmful algal blooms and disease. The ocean's genetic diversity holds untapped potential for medicine and biotechnology, including treatments for cancer and infections.. The diversity of life in the oceans, marine biodiversity, is declining globally at an alarming rate, driven by multiple interacting anthropogenic stressors overfishing , habitat degradation and loss, pollution, eutrophication, oxygen depletion, invasive species, and ocean warming) , which are degrading marine ecosystem function, shifting species' distributions. These losses threaten the wellbeing and survival of coastal communities that fundamentally depend on the many services provided by marine biodiversity and ecosystems, including climate regulation, coastal protection, food and medicinal products, recreational activities, and livelihoods. These ecosystems also possess unique, often intangible, inherent values making them crucial to the health and wellbeing of peoples around the world. As such, safeguarding marine biodiversity and ecosystem function into the future is a task of critical importance. Therefore, Protecting marine biodiversity is essential for ocean health, climate resilience, and human survival To mitigate these impacts and maintain healthy oceans, we need sustained measurements of the status and trends of marine biodiversity and ecosystem condition to better assess the effects of human pressures and to apply this information to inform management actions and policy development https://www.marineboard.eu/marine-habitat-mapping
Potential Considerations
Indicative Data Sources

Indicative Recommended Tools
Tool used for monitoring Marine Biodiversity: ● **Underwater cameras & drones** ● **Satellite imagery** ● **Citizen science apps** ● **Environmental DNA (eDNA) sampling** ● **Databases** like OBIS (Ocean Biodiversity Information System)

Challenge #3

Title: Reduce impact of shipping industry on marine biodiversity

Category: Sustainability, Environmental Innovation, Blue Economy, Digital & Green Transition

Short Description

Develop solutions that help shipping companies, ports, or regulators to monitor, mitigate, or prevent negative impacts of shipping on marine biodiversity (e.g. noise, collisions, invasive species, chemical pollution, habitat disturbance). Use digital technologies, data, regulation, or operational changes to make shipping more "biodiversity-friendly."

(sub-)Tasks

Here's a breakdown of possible sub-tasks for a project team:

1. **Problem scoping & baseline assessment**
    - Identify key biodiversity threats from shipping in a given region (e.g. noise, ship strikes, ballast water, biofouling, underwater light pollution).
    - Collect baseline data: shipping routes, vessel types, speeds, marine biodiversity maps, habitat sensitivities, species distributions.
2. **Stakeholder analysis & constraints**
    - Map stakeholders (shipping companies, port authorities, marine conservation NGOs, regulators, insurers).
    - Identify regulatory, economic, operational constraints (costs, incentives, compliance, data privacy).
    - Determine which levers are feasible (voluntary compliance, regulation, monitoring, incentives).
3. **Solution ideation**
    - Brainstorm and narrow possible interventions: e.g. route re-routing, "quiet" ship technologies, speed reduction zones, real-time alert systems for whales, better ballast water management, hull coatings to reduce biofouling.
    - Consider digital enablers: sensors, predictive modeling, AI, IoT, digital twins, e-navigation, remote monitoring, blockchain for traceability, citizen science apps.
4. **Prototype / modeling**
    - Describe how you will create a prototype or simulation (digital twin, route optimizer, alert system).
    - Describe the expected biodiversity benefits of your model (e.g. collision risk reduction, noise reduction) under different scenarios.

- Estimate costs, implementation challenges, and tradeoffs.

5. **Business model & adoption plan**
    - Propose a sustainable business/incentive model (who pays, cost sharing, regulation, certification).
    - Use a Business Model Canvas to demonstrate the applicability of your idea
6. **Evaluation & scaling**
    - Define KPIs (e.g. reduction in collisions, noise levels, invasive species events).
    - Plan scaling to different geographies or fleets.
    - Assess potential unintended consequences and mitigation.

Background

The shipping industry, while critical for trade, exerts multiple pressures on marine ecosystems, from underwater noise disturbing marine mammals and fish to ballast water and hull biofouling introducing invasive species. Many shipping corridors pass through ecologically sensitive marine areas (e.g. migration routes, biodiversity hotspots). The transition to greener shipping (e.g. clean fuels, energy efficiency) is underway, but biodiversity considerations are often less prioritized. In addition, digital technologies and data analytics, if well integrated, can help shipping actors proactively mitigate biodiversity impacts, rather than responding after the fact. This challenge aligns with MariTech's mission to empower maritime professionals with green + digital skills and apply challenge-based intrapreneurship.

Potential Considerations

Data availability & quality: biodiversity and species distribution data are often sparse, especially in deep sea or developing regions.

Cost & ROI: shipping is a cost-sensitive industry; interventions must show economic as well as ecological value.

Regulatory fragmentation: different countries and jurisdictions may have varying rules; coordination is needed.

Operational constraints: ships have schedules, fuel constraints, safety priorities; interventions must not overly disrupt operations.

Unintended consequences: e.g. rerouting may increase fuel use or emissions, or shift impacts elsewhere.

Technological adoption barriers: legacy fleets, resistance to change, integration with existing systems.

Monitoring & verification: how to credibly measure biodiversity outcomes over time and attribute them to interventions.

Indicative Data Sources

- AIS / Vessel traffic data (shipping routes, vessel speeds, types), e.g.,
    - The Piraeus AIS Dataset for Large-Scale Maritime Data Analytics (https://datahub.digicirc.eu/dataset/the-piraeus-ais-dataset-for-large-scale-maritime-data-analytics)
    - Greek national maritime traffic data (vehicles/passengers, routes) on Greek National Access Point(https://data.nap.gov.gr/dataset/maritime-traffic-data)
    - European Maritime Safety Agency (EMSA) Data Sources (AIS, Ship details) (https://www.emsa.europa.eu/combined-maritime-data-menu/data-sources.html)
- Marine species and habitat maps, e.g.,
    - OBIS (Ocean Biodiversity Information System) data portal – global species occurrence & distribution (https://obis.org/)
- Acoustic monitoring datasets (passive acoustic sensors), e.g.,
    - MBARI Passive Acoustic Data (https://www.mbari.org/data/passive-acoustic-data/)
- Marine protected area (MPA) boundaries and sensitivity zones, e.g.,
    - EMODnet Marine Protected Areas (https://emodnet.ec.europa.eu/en/marine-protected-areas-0)
- Environmental sensor data, e.g.,
    - EMODnet Physics – in-situ ocean observations incl. turbidity, waves, currents, sea level (https://emodnet.ec.europa.eu/geonetwork/srv/api/records/379d0425-8924-4a41-a088-1a002d2ea748)
- Ballast water management records, biofouling/hull inspection data, e.g.,
    - HELCOM/OSPAR Ballast Water Exemptions Decision Support Tool dataset (https://obis.org/dataset/373bacd9-e375-4513-8e98-f2e7f63275e4)
- Port operation logs and metadata, e.g.,
    - EMODnet Human Activities – Main Ports: goods, passengers & vessel traffic (EU) (https://emodnet.ec.europa.eu/geonetwork/srv/api/records/379d0425-8924-4a41-a088-1a002d2ea748)
- Satellite / remote sensing data (e.g. sea surface temperature, ocean currents), e.g.,
    - Copernicus Marine Service (CMEMS) (https://data.marine.copernicus.eu/products)
- Weather, oceanographic data (currents, depth, bathymetry), e.g.,
    - EMODnet Bathymetry – Digital Terrain Model (DTM) for European seas (https://emodnet.ec.europa.eu/en/bathymetry)

Recommended Tools

Digital / computational

- GIS & spatial analysis (QGIS, ArcGIS)
- Route optimization / network modeling
- Machine learning / predictive models (e.g. collision risk, species presence)
- Digital twins / simulation environments
- IoT / sensor integration (acoustic sensors, underwater cameras)
- e-navigation / voyage planning systems
- Dashboard / visualization tools
- APIs for AIS / marine data integration

Intrapreneurship / design thinking

- Challenge-based learning / design sprints
- Stakeholder workshops and co-design
- Lean MVP (minimum viable product) development
- Business model canvas, value proposition design
- Pilot testing and iteration

Monitoring & evaluation

- Before-after / control-impact study design
- Statistical analysis (trend detection, inferential models)
- Cost-benefit analysis, multi-criteria decision analysis
- Verification protocols and auditing

Policy / governance tools

- Regulatory gap analysis
- Incentive mechanism design (e.g. biodiversity credits, certification)
- Multi-stakeholder governance frameworks

Challenge #4

Title: Monitoring Solutions for Marine Radioactivity

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Category: Marine Health, Sustainability, Environmental Innovation, Forecasting, Policy Making

Short Description

In this challenge, a rather broad spectrum of open problems require solutions:

- Existing monitoring solutions are based on old-fashioned approaches and are rather limited and costly.

- Monitoring near the ocean bottom is burdened by short radiation lengths requiring optimization of radioactivity-sensing instrumentation, which will perform in-situ for long periods of time
- The 3D mapping of the radioactivity fields inside the marine environment is dynamic and requires mobile vessels which will collect and transmit data in real-time
- Dose estimation on marine biota and natural ecosystems from both natural and anthropogenic sources relies on simulations, which are currently limited by the lack of measurements in such environments
- Monitoring and detecting natural hazards and human activities in the marine environment lacks reliable and continuous solutions
- Translating radiation doses in the marine environment to useful information for various stakeholders has not been extensively studied. There are no solutions “out of the box”.
- Circulation and evolution of radioactivity following up nuclear accidents or controlled releases lacks a dense grid of measurements. Forecasting the risk for the marine habitat

(sub-)Tasks

Some of the tasks include (but are not limited to) the following approaches:

- understand the distribution of radioactive substances in the oceans
- monitor the surface circulation of radioisotopes released from manmade activities (nuclear power plants controlled releases or accidents, coastal and underwater mining, seabottom drilling etc)
- monitor and illustrate correlations between radioactivity spread and weather conditions
- assess the impact of natural and manmade radioactivity on humans and marine ecosystems
- predict and/or simulate the diffusion and transport of radioactive substances in the water column
- forecast radioactive doses and inform interested stakeholders (public, officials, scientists)

Background

- Radioactivity is a natural phenomenon, stemming from fundamental principles of matter.
- Instability of matter in the universe results in emission of radiation (α-, β-, γ-rays)
- Radioactivity in the natural habitat is omnipresent, impacting the human population and the ecosystems
- Radioactivity dose can raise concerns, especially if the safety limits are exceeded
- Marine radioactivity can be monitored and assessed
- The harsh conditions in the oceans are a limiting factor requiring novel, innovative approaches in instrumentation

Potential Considerations

- Open-access data are provided by international and national agencies
- Data are not always harmonized
- There are historical records of radioactivity data around the globe, which can be used to provide visual solutions
- Simulations of circulation in the ocean (surface, bottom) can employ state-of-the-art fluid dynamics methods

- There is scarcity of visual tools for the marine environment and complete lack of tools for full 3D mapping
- Natural hazards (hydrothermal vent fields, underwater seismic activity etc) are related to radiotracer release, such as radon.
- Weather conditions are related to radioactivity transport and diffusion. Some solutions exist for the surface, but not for the depths of the ocean.
- Forecasting warnings when marine radioactivity exceeds safety limits needs a concise scheme of translating physical measurement to risk/indices.

For all solutions created during the hackathon:

- All solutions should rely on openly available datasets
- The full code developed will be made available to the organizers and judges
- Solutions can focus on both global or local problems
- The quality of presentations/pitching will be considered for the final ranking

Indicative Data Sources

- Autorité de sûreté nucléaire et de la radioprotection (ASNR)
- IAEA MARIS
- EMODnet
- Safecast.org
- Fukushima Daiichi Radwaste Analytical Data Library (FRAnDLi)
- ICRP
- any other national or international data source

Recommended Tools

Digital / computational

- GIS & spatial analysis
- Machine learning / predictive models
- Digital twins / simulation environments
- Dashboard / visualization tools
- APIs for AIS / marine data integration

Intrapreneurship / design thinking

- Challenge-based learning / design sprints
- Business model canvas, value proposition design
- Pilot testing and iteration

Monitoring & evaluation

- Before-after / control-impact study design
- Statistical analysis (trend detection, inferential models)
- Cost-benefit analysis, multi-criteria decision analysis

Policy / governance tools

- Regulatory gap analysis
- Incentive mechanism design (e.g. biodiversity credits, certification)
- Multi-stakeholder governance frameworks
- Policy shaping / cover international gap in legislation

Challenge #5

Title: *Meteo@DataGEMS*: Real-time 3D Visualisation of 3D/2D Weather Data

eosc | DataGEMS

Category: Gaming, Data Visualisation, Meteorology

Short Description

Participants are invited to transform real meteorological data, including numerical weather prediction (NWP) model outputs and in-situ measurements, into an immersive, interactive 3D experience. Using actual .grib and .txt datasets, the goal is to build a real-time rendered environment where users can freely move through space and time, exploring atmospheric phenomena as dynamic visual layers.

(sub-)Tasks

Some of the tasks include (but are not limited to) the following approaches:

- Parse and visualise .grib files (2D/3D outputs from a weather prediction model).
- Integrate weather station data from .txt files into the 3D environment.
- Perform spatial and temporal interpolation to create smooth transitions in the 3D domain.
- Develop cross-sectional or volumetric renderings of meteorological variables.
- Create a temporal navigation mechanism (e.g. time slider or playback) to explore evolving weather fields.
- Render the environment in a real-time engine (Unity, Unreal, WebGL).

- Overlay geographic and environmental layers (terrain, coastlines, land use, or hazard zones) to provide spatial context.

- Include an optional interactive analytics panel showing variable values, time series, or station comparisons as the user moves through the environment.

Background

Numerical Weather Prediction (NWP) models generate vast amounts of multi-dimensional data — from surface temperature maps to 3D atmospheric fields like wind, pressure, or humidity. Despite the scientific importance, the visualisation of such data set is often limited to static 2D plots. By transforming these datasets into an interactive, real-time 3D experience, participants can bridge science and visualisation, making weather systems tangible. Imagine flying through a dynamically evolving 3D storm or viewing temperature gradients like a living, breathing atmosphere — the challenge lies in translating data into an intuitive spatial and temporal experience.

Potential Considerations

- Efficiently handle and visualise large .grib files (data streaming, downsampling, or slicing techniques).
- Time navigation should feel natural (e.g. timeline scrubber, day/night transition).
- Balance performance and visual realism, especially for web.
- Include real geographic references (e.g. Greece or the Aegean region) for contextual grounding.

Custom Dataset Provision

Participants will be provided with a compact, ready-to-use dataset designed specifically for this challenge. The dataset includes:

- Model Output (.grib) — sample 2D and 3D fields from a numerical weather prediction model (e.g. temperature, humidity, wind, and pressure) across multiple forecast levels and timesteps.
- Station Data (.txt) — observations from automated weather stations (temperature, humidity, wind speed/direction, precipitation) with timestamps and station metadata (latitude, longitude, elevation).
- Geospatial Layers — vector files for Greece and the Aegean Sea coastlines to provide spatial context as well as the elevation dataset.

All files are structured to allow direct parsing and visualisation using open-source libraries (e.g. gdal, xarray, cfgrib, numpy, matplotlib). The dataset is small enough for local use (<2 GB total) but representative of real meteorological data.

Each participant team will receive:

- A download link to the dataset archive (.zip)
- A README.md explaining file formats, variable names, and coordinate systems

Teams are free to use only part of the data, augment it with other open sources, or interpolate and merge the two data types to produce their visualisation.

Recommended Tools

- **Game Engines**
  - Unity — https://unity3d.com/get-unity/download
  - Unreal Engine — https://www.unrealengine.com/en-US/download
  - Godot — https://godotengine.org/
  - Three.js — https://threejs.org/
  - Babylon.js — https://www.babylonjs.com/
- **Data Processing**
  - cfgrib, xarray, pygrib, numpy, matplotlib, cartopy
  - GDAL — https://gdal.org/
  - Panoply — https://www.giss.nasa.gov/tools/panoply/
  - MetView — https://confluence.ecmwf.int/display/METV/Metview
- **Visualization & Rendering**
  - WebGL — https://get.webgl.org/
  - WebXR — https://immersive-web.github.io/webxr-samples/
  - CesiumJS — https://cesium.com/platform/cesiumjs/
  - Blender (terrain modeling) — https://www.blender.org/