Concept Note

Regional Training Workshop on Monitoring and Forecasting Marine Heatwaves in the Mediterranean and Red Sea Using Satellite Data, In-Situ Observations, and High-Resolution Earth System Modelling

Organized by: UNESCO/IOCAFRICA
In collaboration with: National Institute of Oceanography and Fisheries (NIOF), Egypt
For: IOCAFRICA Member States of the Mediterranean and Red Sea region
Location: NIOF, Alexandria, Egypt
Duration: 5 days
Dates: 2 - 6 August 2026

1. Background and Rationale

Marine heatwaves (MHWs), periods of unusually high sea temperatures lasting from days to months, have increased in frequency, duration, and intensity across the Mediterranean and Red Sea, two of the world's most climate-sensitive basins. Recent events (2022–2025) have caused coral bleaching, mass fish kills, harmful algal blooms (HABs), seagrass decline, stress on aquaculture, biodiversity loss, and disruptions to tourism and coastal economies. These impacts pose significant risks to the coastal populations and fisheries-dependent communities in the region.

Monitoring and forecasting MHWs require an integrated approach that combines satellite remote sensing, in-situ oceanographic observations, and advanced ocean–atmosphere modelling. Data from buoys, floats, tide gauges, research vessels, and historical satellite archives underpin the detection of SST anomalies and early warning systems.

Recent advances in marine heatwave science have highlighted the transformative potential of high-resolution Earth system models, which resolve ocean processes at approximately 10 km and atmospheric components at 25 km. These models have demonstrated significant improvements in predicting MHW onset, duration, and spatial extent—providing earlier detection of thermal anomalies and more accurate forecasts of intensity. Such predictive capability is vital in the Mediterranean and Red Sea, where small variations in sea temperature can lead to cascading ecological and socio-economic impacts.

Despite these advances, IOC-Africa Member States in this region often lack the capacity, tools, and harmonised protocols necessary for effective MHW monitoring, forecasting, and response. Enhancing national and regional capacity is therefore vital to protecting marine ecosystems, fisheries, public health, and coastal livelihoods.

National Institute of Oceanography and Fisheries (NIOF), one of Africa's most respected and technically proficient marine research institutions, will act as the primary host for this regional training. This initiative aligns with the IOC's Medium-Term Strategy, the UN Decade of Ocean Science for Sustainable Development, and regional frameworks under the UNEP/MAP and PERSGA.

2. Objectives

Overall Objective

To strengthen the capacity of IOCAFRICA Member States bordering the Mediterranean and Red Sea to **monitor, detect, analyze, and forecast marine heatwaves** using satellite datasets, in-situ observations, and high-resolution ocean–atmosphere models.

Specific Objectives

1. Enhance skills in accessing, processing, and interpreting satellite SST and anomaly datasets.
2. Strengthen knowledge in in-situ data collection, quality control, and integration.
3. Introduce advanced high-resolution Earth system modelling tools for regional MHW prediction.
4. Provide hands-on training in machine learning and deep learning applications for anomaly detection and forecasting.
5. Promote coordinated regional monitoring using IOC platforms such as **GOOS-AFRICA**, ODINAFRICA, and ODIS.
6. Support Member States in applying MHW forecasts to fisheries management, ecosystem protection, HAB mitigation, and public-health decision-making.

3. Expected Outputs

- A trained cohort of 20-30 specialists from IOCAFRICA Member States in the Mediterranean and Red Sea region.
- Standardised MHW detection and analysis workflows, harmonised across participating countries.
- Regional datasets, scripts, and modelling tools provided for continued national use.
- Strengthened institutional coordination between oceanography, meteorology, environment, fisheries, and public-health authorities.
- A regional roadmap for advancing a Marine Heatwave Early Warning Mechanism (MHW-EWM) under IOCAFRICA.

4. Target Beneficiaries

Priority Target Countries (IOC-Africa Member States):

- Egypt (host)
- Eritrea
- Sudan
- Djibouti
- Somalia
- Tunisia
- Morocco
- Libya
- Algeria

Applications from other IOCAFRICA member states will be considered on a special basis, and subject to availability of slots.

5. Training Modules

Module 1 – Understanding Marine Heatwaves in the Mediterranean and Red Sea

- **Definition, metrics, and classification of marine heatwaves:**
  Introduces participants to the standardized scientific framework for identifying and characterizing MHWs, including intensity, duration, and spatial extent.
- **Regional drivers and physical processes:**
  Explores the unique oceanographic and atmospheric conditions in the Mediterranean and Red Sea—such as stratification, restricted circulation, and high evaporation—that amplify vulnerability to heatwaves.
- **Ecological and socio-economic impacts:**
  Presents recent case studies from 2021–2025 showing coral bleaching, fish mortality, HAB outbreaks, aquaculture losses, and disruptions to coastal tourism and livelihoods.

Module 2 – Satellite Monitoring of Sea Surface Temperature (SST) and Heatwave Detection

- **Accessing and processing satellite datasets:**
  Practical guidance on using NOAA, Copernicus Marine Service, and ESA SST products for large-scale thermal monitoring.
- **Generating SST anomaly maps:**
  Demonstrates how to derive and visualize anomalies relative to climatological baselines to detect emerging MHW events.
- **Near-real-time detection workflows:**
  Participants apply internationally recognized methods (e.g., Hobday et al.) to detect MHW onset and classification using Python, MATLAB, or open-source tools.

Module 3 – In-Situ Observation Techniques and Data Integration

- **Overview of in-situ observation platforms:**
  Covers buoys, Argo floats, tide gauges, CTD casts, and research vessel sampling relevant to MHW analysis.
- **Data quality control and calibration:**
  Provides steps for validating and harmonising field measurements with satellite SST products.
- **Integrating remote sensing and in-situ data:**
  Shows how blended datasets improve accuracy in detecting MHW severity and subsurface thermal structure.

Module 4 – High-Resolution Earth System Modelling for MHW Forecasting

- **Introduction to coupled ocean–atmosphere models:**
  Explains how Earth system models simulate interactions between SST, winds, currents, and heat flux.
- **Advances in high-resolution prediction (10 km ocean / 25 km atmosphere):**
  Presents recent scientific improvements demonstrating enhanced accuracy in predicting MHW onset and spatial footprint.
- **Regional downscaling for Mediterranean and Red Sea applications:**
  Illustrates how these models can be tailored for localized forecasting in climate-sensitive coastal zones.

Module 5 – Machine Learning and Deep Learning Applications

- **Using historical time-series for model training:**
  Demonstrates how long-term SST datasets can be used to train ML models for anomaly detection.
- **Neural network architectures for forecasting:**
  Introduces LSTM, CNNs, and hybrid models used to forecast extreme warming events.
- **Hands-on anomaly and event prediction:**
  Participants run simple ML workflows to compare the predictive skill of their models against those of traditional models.

Module 6 – From Science to Action: Sectoral Applications of MHW Forecasts

- **Fisheries and aquaculture adaptation:**
  Shows how forecasts can inform fishing closures, aquaculture adjustments, and species vulnerability assessments.
- **Ecosystem and biodiversity management:**
  Discusses early-warning responses for coral reefs, seagrass, and sensitive habitats impacted by heatwaves.

- **Public health, HABs, and food safety:**
  Presents links between MHW-driven HABs, seafood safety risks, and waterborne health hazards, with input from the Ministry of Health and Population (MoHP) Egypt and WHO.

Module 7 – Regional Marine Heatwave Preparedness and Early Warning Roadmap

- **Identifying institutional and technical gaps:**
  Facilitated discussions to assess current monitoring capacity across IOC-Africa Member States.
- **Designing a coordinated regional response mechanism:**
  Develops shared priorities for data exchange, operational forecasting, and cross-border alerts.
- **Drafting the Regional MHW Early Warning Roadmap:**
  Participants collaboratively outline steps for continued cooperation, capacity development, and alignment with IOC and Ocean Decade frameworks.